David Spurgeon

Southern Lights

Celebrating the Scientific
Achievements of the
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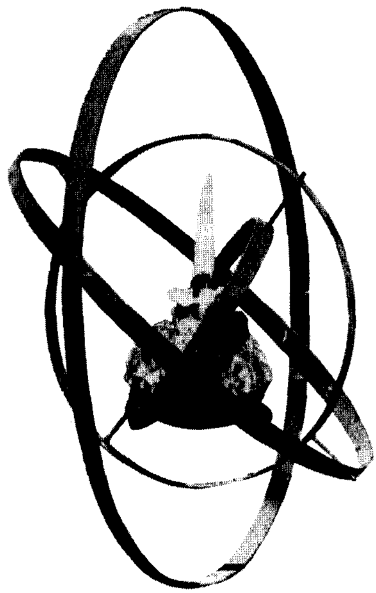
SOUTHERN LIGHTS



Depiction of a Tibetan globe-lamp. The four swivelling concentric rings serve to hold the lamp in place, always keeping it upright. The lamp was popularized in the 16th century by Girolamo Cardano, whose name was given to its method of suspension. Its first appearance in Europe can be traced to the 9th century; however, it was in China over 1 000 years earlier, in the 2nd century BC, that the lamp was invented.

SOUTHERN LIGHTS

Celebrating the Scientific Achievements of the Developing World

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INTERNATIONAL DEVELOPMENT RESEARCH CENTRE
Ottawa • Cairo • Dakar • Johannesburg • Montevideo • Nairobi
New Delhi • Singapore

Published by the International Development Research Centre
PO Box 8500, Ottawa, ON, Canada K1G 3H9

Spurgeon, D.

Southern lights : celebrating the scientific achievements of the developing world. Ottawa, ON, IDRC, 1995. ix + 137 p.

/Scientific discoveries/, /scientific progress/, /technological change/, /research and development/, /developing countries/ — /North South relations/, /traditional technology/, /international cooperation/, /comparative analysis/, /case studies/, references.

UDC: 608.1 ISBN: 0-88936-736-1

A microfiche edition is available.

IDRC Books endeavours to produce environmentally friendly publications. All paper used is recycled as well as recyclable. All inks and coatings are vegetable-based products.

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FOREWORD

For many years, science and technology have been regarded as essential tools for international development. In fact, the International Development Research Centre (IDRC) was founded 25 years ago because of the need to promote the science and technology capabilities of developing countries. Maurice Strong, then President of the Canadian International Development Agency (CIDA), who originated the idea of IDRC, said of that era: "I held the very strong conviction that scientific and technological capability was one of the prime differences between developing and more-developed countries. It was this gap — in research and development and its application — that really was fundamental, because today's research produces tomorrow's technology, and tomorrow's technology is the key to tomorrow's development" (Spurgeon 1979).

Since that time, Canada has supported research in developing countries to the tune of almost CA $2 billion[1] through IDRC — only a small fraction of the contributions of other governments and agencies internationally. Generally, however, the public seem unaware of what this financial support has helped to achieve.

[1] All monetary values are expressed in US currency unless otherwise noted.

This book is meant to give the general reader an appreciation of some notable Third World accomplishments in science and technology. It does not attempt to be exhaustive, nor does it pretend to give a balanced assessment of 25 years of support of research for development. Rather, it is more like a celebration of the scientific and technological achievements of the South — achievements that have not been sufficiently recognized in the North. It also offers an interpretation of some of the historical reasons for the different pace at which scientific and technological development has occurred in the North and the South, and some explanation of how the conduct of science and technology differs between the two.

The author, David Spurgeon, is a science journalist who has worked and traveled extensively in the developing world. The stories that he has assembled in this book cover a wide range of subjects. They illustrate how support for science and technology can benefit both the North and the South. And, as he points out, they show why the scientific contributions of the South are essential to solving some major global problems. But it is important to remember that the picture presented by this book is only part of the development story, and that support for research is only one component of development.

During IDRC's 25 years, it has become increasingly apparent that, necessary as it is to have scientists capable of doing research in developing countries, it is just as important to have people who know how to make use of the knowledge generated by research. In fact, for social and economic benefits to accrue to developing countries, the capacity to innovate is now considered equally important as the capacity to do research.

The Centre's founders were not unaware of this need. The Act that established IDRC included the goal of developing "innovative skills" as well as research skills in Third World countries. But it was only with experience that we became more aware of the importance of innovation. This knowledge led to the establishment of a Program of Research in Innovation Systems Management (PRISM) within IDRC, about 2 years ago. PRISM has two goals: to support research on the process of innovation (particularly in developing countries), and to help train Centre staff, who are predominantly scientists, to think of development in this broader context.

This appreciation of the importance of innovation skills has dominated the discussions not only of Centre staff in recent years, but also more recently of the Canadian government as it reviews the efficacy of its CA $7-billion national science and technology effort. At a time of fiscal constraint, when less rather than more money will likely be available from federal sources for support of science and technology domestically, those making national policy are convinced that support of scientific research as such will not necessarily benefit Canadians socially and economically. The principal path to such benefits will be through finding innovative ways to apply the results of research. This is increasingly being realized worldwide by those trying to promote Third World development through science and technology.

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CHAPTER 1

A NORTHERN MISCONCEPTION DEMOLISHED

Manuel Patarroyo is a 47-year-old charismatic biochemist from Colombia, South America, who has developed the world's first safe and effective malaria vaccine. Each year, malaria causes more than 400 million illnesses and between 1 and 3 million deaths, mainly among young children and pregnant women in sub-Saharan Africa. Endemic in 103 countries, in which half the world's population lives, it is considered the most important parasitic disease of humankind.

That the first vaccine to have proved effective against malaria comes from the Third World is a major triumph for Third World science and technology. It comes at a time when, despite decades of attempts by the scientists of both the North and the South to control this scourge, epidemics are increasing because mosquitoes have become resistant to insecticides and the disease organism resistant to drugs.

Patarroyo's triumph is all the more sweet for him because of the antagonism and disbelief directed at him by some of his colleagues in the North.

According to the US journal *Science* in 1993, Patarroyo had "endured 6 years of intense skepticism since 1987, when he claimed to have produced an effective malaria vaccine" (Travis 1993). Yet, by January 1995, the same journal reported that he was enjoying international fame and adoration only very rarely won by a scientist.

"The shelves of his office are sagging with prizes — 53 at last count," said John Maurice (1995) in *Science*. Among these were the United Kingdom's Edinburgh Science Medal and Germany's Robert Koch Prize, named after that country's doctor and microbiologist who received the Nobel Prize in 1905 for his discovery of the tuberculosis vaccine. In addition, two separate polls of French physicians voted Patarroyo "Doctor of the Year."

By the end of 1994, Patarroyo's victory was complete. The results of the clinical trials of his vaccine in Tanzania were published in *The Lancet*, and they more than confirmed the promise indicated by earlier trials in Colombia (Alonso et al. 1994). The Colombia trials had shown a 39% overall efficacy and a 77% efficacy among the highest risk group (1–4 year olds). Although the efficacy among the 1–5 year olds involved in Tanzania was lower (31%), the South American trials had been conducted in an area of low malaria transmission. The Tanzania trials were held where infection rates are intense: 80% of all infants are infected by the age of 6 months, and 1 in 25 is killed by the disease by the age of 5 years. Thus, the situation in Tanzania more realistically reflects the malaria threat in Africa in particular and the Third World in general.

Reached at his office in the Immunology Institute of the National University in Bogota, fresh from talks with the African trial scientists, Patarroyo was jubilant.

"My God, the results were really beautiful. We are very happy because the African trial is the toughest test any vaccine must pass. In those areas you are infected every single night by a mosquito, because all the mosquitoes are infected. In other diseases such as polio or measles, people are infected by aerosols and the amount of inoculant is relatively small, but here the mosquitoes are injecting it directly into their veins.... So this is going to be a universal malaria vaccine [and] it's very safe."

First reaction from some world malaria experts was, perhaps understandably, less ebullient than Patarroyo's, but it was definitely positive — and it contrasted greatly with the earlier skepticism. The head of the World Health Organization's (WHO) tropical disease program, Tore Gidal, called it "encouraging news, and very important in showing that it is possible to achieve protection against such a clever parasite" (Brown, D. 1994). Said Louis Miller, head of the malaria laboratory at the US National Institutes of Health, "It's wonderful that it works and it's a stimulus to the field" (Brown, P. 1994).[2]

Later comments from some scientists revived the earlier skepticism. Paul-Henri Lambert, chief of WHO's vaccine research and development unit, said of the Tanzanian results: "A 31% rate is in the gray zone, at the limit of ineffectiveness. Within this zone, things become a matter of opinion, of philosophy."

But the skepticism did not extend to potential users of the vaccine: Patarroyo said that at least 17 countries had placed orders for it, and his own government had contributed the first $8 million to start work on a $20 million production plant to produce it by 1997.

How much of the Northern attitude toward Patarroyo was due to the perception that little of value could come from Third World science? This is an open question. Professor Frank Cox, immunologist at King's College, London, who chronicled the saga for the British journal *Nature* (Cox 1993), is certain it played a part.

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[2] In March 1995 during a visit to Colombia, the Director of WHO, Hiroshi Nakajima, declared the vaccine a success. "For WHO," he said, "the questions of effectiveness and testing of the vaccine are now resolved."

"Is there any jealousy because he is a Third World figure?" I asked Cox by telephone. "Oh, yes, indeed," he replied. "I'm sure there is. There's money in this, a [possible] Nobel Prize — all this sort of thing. Great honours and glory. And I think most people in the United States felt they were beaten to the post."

In his *Science* article, Maurice (1995) said:

> Patarroyo is freewheeling, flamboyant, quixotic, and mercurial, with a penchant for hyperbole — everything that the archetypal First-World scientists shy away from. He is also a researcher from a small developing country who has achieved fame without running the heirarchical, regulatory, financial, and peer-review gauntlet that scientists from most developed countries have to face.

Patarroyo himself characterized initial opposition to his work as "intellectual racism." Behind any form of racism "there is unfortunately the incapacity to recognize that other people can do things as well as you can," he said. But he added generously, "it has helped me [nevertheless], because in these countries [where it occurs] when people see that one is carrying a heavier burden than others, immediately everybody wants to help."

With a laugh, Patarroyo noted that it took him longer to have his work recognized than to develop the vaccine. In the 10 years he spent working on malaria, it took just 4 to develop the vaccine. "The rest of the time I spent just trying to convince the whole world that it works."

Quoting his boyhood idol, Louis Pasteur, Patarroyo continued: "In every big discovery there are three stages: first, to convince yourself; second, to convince your friends; and third — the least productive but the most enjoyable one — to try to convince your detractors. And that's what I have been doing for the last 6 years."

Manuel Patarroyo's personal goal goes beyond mere self-justification. It goes beyond even his epochal achievement of developing a safe and effective malaria vaccine.

"I want the world to see that Colombia is not just drug trafficking," he has said, "that it has another side to it, and that side is good science."

To me he said: "We don't want to get rich. We gave the patent [for the malaria vaccine] to the World Health Organization for free, the only condition being that credit be given to the people of Colombia. And we don't want power. We just enjoy doing science — the development of knowledge and the possibility of helping other people."

The Patarroyo case illustrates a perception common to the North — that accomplishments in science and technology in developing countries are so negligible that to use the phrase "Third World science and technology" is almost a contradiction in terms. Knowing that the Third World is credited with only about 5% of the world's scientific production, and that its educational levels are abysmally low, most people in the North view the South as backward both scientifically and technologically.

But is this really so? In the following chapters, I attempt to show that this common Northern perception is faulty — that much of great value to both the North and the South has already resulted from the efforts of Third World scientists and technologists, and that much more can be expected in the future.

A prominent Third World scientist who shared this conviction was the late Dr Cyril Ponnaperuma, former Director of the University of Maryland's Laboratory of Chemical Evolution. Before his recent and untimely passing, Dr Ponnaperuma told me: "It is my contention that only 2% of the information generated in the South reaches the North."

This book's message is simple — 2% is not enough. If we are to solve the major global problems facing us today, it is absolutely essential that we profit from the tremendous potential of Third World science and technology.

CHAPTER 2

IS THERE REALLY SCIENCE IN THE SOUTH?

It is customary in the North to speak of the Third World as made up of "developing countries." The term has disparaging overtones, although it is not nearly as patronizing as its predecessor — "underdeveloped countries." Such terminology is at least partly responsible for the widespread belief in the North that there is not much activity in science and technology in the South. This belief is unfounded. For example:

— Brazil's first domestically made Earth satellite completed a year in orbit in 1994, and Brazil and China have contracted to launch two Earth resources satellites beginning in 1996 (NISR 1994);

— Both Indonesia and Brazil have their own aircraft manufacturing industries employing domestically trained labour;

— Malaysia manufactures its own automobiles;

- India's steel industry is the world's fifth largest and the country is a major world supplier of computer software; and
- Twelve scientists of Third World origin have won Nobel Prizes in science or medicine (Nobel Foundation 1994).

Consider also the following three examples.

In India, the International Centre for Genetic Engineering and Biotechnology is working with a novel chemical synthesis approach to develop inexpensive vaccines. It has already developed a diagnostic kit as a first step toward a vaccine for Hepatitis E, a new variety of the hepatitis virus that is rampant in developing countries and causes high mortality rates among pregnant women. The vaccine-production approach is also being used against the Hepatitis C virus. It uses as a vector an insect virus harmless to humans and inexpensive and easy to cultivate.

Professor Manley E. West, a Jamaican pharmacologist, with the aid of Dr Albert Lockhart, an ophthalmologist, developed a treatment for glaucoma using the marijuana plant (*Cannabis sativa*). Glaucoma causes impaired vision or blindness through increased pressure within the eye. Having learned that Jamaican fishers claimed a concoction of plant stems and leaves and rum improved their night vision, West and Lockhart prepared a substance called Canasol. It not only treats glaucoma by relieving the pressure, but also appears to improve glaucoma patients' night vision. Lockhart notes that the incidence of glaucoma seems lower among the rastafarians, a Jamaican religious group that uses cannabis in many of its rituals (West 1991).

Dr Salomon Hakim of Colombia developed a valve to treat hydrocephalus, a potentially life-threatening condition known popularly as water on the brain. In hydrocephalus, excessive amounts of cerebrospinal fluid accumulate in the ventricles of the brain, producing dementia, which is characterized by unsteady and slow gait and, occasionally, urinary incontinence. Dr Hakim's valve, now being used worldwide, diverts the fluid elsewhere in the body. For this achievement, he was awarded Colombia's National Prize for Scientific Merit in October 1993.

Advances in Agriculture

The Third World has also made many important scientific advances in food crop production. A large proportion of these advances have come from international agricultural research centres (IARCs), financed through and overseen by the Consultative Group for International Agricultural Research (CGIAR). Nyle C. Brady, former Director General of the first such Centre, is now a senior United Nations (UN) consultant.

Interviewed during CGIAR's 1993 "Centres Week" meeting in Washington, he said that most of the 1 700 senior scientists representing 60 nationalities in the IARCs are from the Third World, and that the research is conducted in 18 Third World locations. He concluded that many of the IARCs' accomplishments should be considered successes of Third World science.

The earliest and perhaps best-known accomplishment was the development of high-yielding varieties of wheat and rice that, together with a package of production practices, led to the "Green Revolution." Norman Borlaug, the American agricultural scientist who won the Nobel Peace Prize in 1970 for his part in this epochal accomplishment,[3] gave major credit to Indian and Pakistani scientists in his acceptance speech. He said that the All-India Coordinated Wheat Improvement Program was "largely responsible for the wheat revolution in India" that eventually led to self-sufficiency in the country's wheat production.

He also singled out Indian plant geneticist Dr M.S. Swaminathan "for first recognizing the potential value of the Mexican [dwarf varieties]," without which "it is quite possible that there would not have been a green revolution in Asia." At a 1985 meeting of the IARCs, Brady said that most of the successful varieties in the International Rice Research Institute's (IRRI) international testing program originated in the national programs of Third World countries, rather than at IRRI.

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[3] The prize was awarded to Borlaug "because, more than any other single person of this age, he has helped to provide bread for a hungry world. We have made this choice in the hope that this will also give the world peace."

Third World agricultural advances are not confined solely to the IARCs. For example, Viet Nam transformed itself from a chronic rice importer to one of the world's top three exporters in a single decade (Miller 1994). The key to its success was the 1981 introduction of a scheme that put major decision-making control in the hands of individual farmers, replacing the collective farming system established after North and South Viet Nam were unified in 1975. Dr Vo-Tong Xuan, agronomist and Vice-Rector of the country's University of Cantho, and member of the National Assembly of Viet Nam, received the 1993 Ramon Magsaysay Award for Government Service — one of Asia's highest honours — for his part in the transformation.

As another example, Chinese scientists developed genes and elements of a pollen-control system from rapeseed that has led to development of a superior crop variety with built-in disease resistance and higher seed yield. The new variety, developed in Canada in a joint research project funded by IDRC, will benefit both countries. Cultivated in China for 4 000 years, rapeseed is the country's most important oil crop and its fifth largest crop after rice, wheat, maize, and cotton. But the nutritive value of Chinese rapeseed oil is low, and the meal cannot be used for animal feed.

In Canada, however, all rapeseed is canola, a variety high in nutritional value. Since its introduction in 1974, Canadian rapeseed production has increased rapidly to the point where, in 1994, it surpassed wheat as the Prairie farmers' highest income earner. Seeds from the new variety will be released to Canadian farmers for planting in the spring of 1995.

In pisciculture, research in the 1970s by Dr Rafael D. Guerrero III, Director of the Philippine Council for Aquatic and Marine Research and Development, led to the 1994 release of a "super tilapia" — a fish six times bigger than ordinary members of the breed (*Depthnews* 1993). Tilapia is second only to milkfish as the most important cultured fish in the Philippines; it is also important throughout Asia and Africa.

Although uncontrolled reproduction in ponds leads to overcrowding, Dr Guerrero discovered that if fry are given male hormone-treated feed, 90% of the females are converted into functional males, thereby greatly reducing the reproduction rate. Freed from reproductive concerns, the fish channel all their energies into growth and become much larger. In response to fears about feeding humans fish treated with sex hormones, Welsh researchers recently discovered how to manipulate tilapia genetically so that breeding produces only males. In collaboration with Filipino scientists, this discovery led the International Centre for Living Aquatic Resources Management (ICLARM) to release the "super tilapia."

Challenging the Northern Leader

So promising were the prospects of increased agricultural production throughout the world that, in 1989, William R. Furtick, Dean Emeritus of the University of Hawaii's College of Tropical Agriculture and Human Resources, told a meeting of American university experts that he feared for the United States' traditional lead in agricultural research. "We have been leading for so long, we just assume this will persist," he said. "During the past few years the United States has gone from a major exporter of new agricultural technology to a net importer.... During the next 10 years we can expect to import most of our new technology" (Furtick 1989).

Asked in 1994 if this expectation had proved true, he answered: "Oh I think it has definitely proved true. If you look now at practically all of the genetic material in horticulture, it is coming from abroad. Practically all of the engineering technology is coming from abroad. Probably the only place where we're excelling [in the United States] is in the use of computers in agriculture."

To what sort of engineering technology did he refer?

"Equipment, machinery — look at the machinery for everything from processing to production. More and more of it is either made abroad or, as I say, painted abroad," came his answer.

Where is it coming from?

"Quite a wide diversity of areas in the world. More and more of our basic machinery is coming from Japan and the Tigers of Asia: Korea, Taiwan, Singapore, Hong Kong, China — all of them major suppliers of the equipment and technology that went into that equipment."

According to Dr Furtick, much of the world's agricultural research is now undertaken by researchers in developed countries outside North America and by Third World researchers. As well, there is considerable joint-venture activity, even in Japan. "For example," he says, "Japan is working jointly with some of the developing countries in technology development, and using the developing countries more and more as a manufacturing base for that technology for Japanese export."

Furtick urged greater US linkage with the IARCs, which he called "one of the most dynamic components of the global research system. They have become more and more a leader of the orchestra of science in developing countries, in which they've provided continuing in-service training, updating their technology capabilities, working with them to channel and direct them, and working with them so that they have become the focal point of improved technology development by the Third World country scientists."

According to Dr Furtick, although his 1989 speech was very well received, there has not been much follow-up. "President Bush's agricultural adviser sent out about 5 000 copies of it [the speech] under White House letterhead to all the American agribusinesses, and the land grant association sent around 6 000 to 10 000 copies to university and industry types all over the country. So it got an incredible distribution in the United States. There were lots of letters and telephone calls and interest in it, but basically agricultural research investment has been contracting at a faster rate in the United States ever since."

Why was this?

"Basically because agricultural research [traditionally] has been heavily [carried out] in the public sector compared to most research in the United States, and the public sector [support] has been contracting," reasoned Dr Furtick.

Recently, he said, there has been a shift, with the private sector increasing its proportion of agricultural research activity. But that trend, in turn, is partly due to the reduction of research done by the public sector.

Going Beyond Basic Needs

The scientific and technological exploits of the Third World range across a wide spectrum, as will be shown in more detail in Chapter 3. They include research in some highly advanced fields, as well as the more practical ones such as agriculture. For example:

— Brazil, China, India, South Korea, and Taiwan are each building highly sophisticated synchrotron radiation facilities. Besides their contribution to knowledge, these installations can be used industrially to make such products as computer chips.

— The electrical engineering laboratory at Fudan University in Shanghai, China, designs very large-scale integrated circuits for manufacture by firms like Samsung.

— Korea's electronics industry does extensive research on advanced semiconductors (Kinoshita 1993).

— At the University of Yaoundé, Cameroonian Professor Tonye is building prototypes of small, inexpensive satellite dishes that could be manufactured locally with local materials and used for communal television reception in African villages.

— Although the International Centre for Theoretical Physics (ICTP) in Trieste, Italy, was established primarily to promote basic research among Third World scientists, it is also involved in such practical areas as laser photonics for analyzing drinking water and in making new materials from local sources.

It is apparent that the common view of the South as a scientific and technological backwater is an over-simplification. There is no doubt that, in terms of quantity, the South lags far behind the North. More than 80% of the global scientific research and technological development effort is made by the developed countries of the West and Japan — broadly speaking, the countries of the Organisation for Economic Co-operation and Development (OECD), according to Unesco. And in 1990, there were 3 600 scientists and engineers for every million people in the North, but only 200 for every million in the South.

A Complicated Picture

Yet the picture varies enormously between different regions and countries of the South. The share of world research and development expenditure by African countries was a mere 0.2% in 1990, while, collectively, Latin America and the Caribbean's share was 0.6% and the Arab States' 0.7%, compared to Asia's 19.6%.[4]

The newly industrialized countries of East Asia are far ahead of other countries in the South; they spend more proportionately on research and development (R&D) than do some countries in the OECD. South Korea's R&D expenditure as a proportion of gross national product (GNP), for example, was 1.9% in 1990, compared to Italy's 1.1% in 1988. South Korea's goal is to reach 5% by the year 2000.

Seven developed countries (France, Germany, Great Britain, Italy, Japan, the former Soviet Union, and the United States) produce 75% of the total world scientific literature, while all the countries of Latin America contribute little more than 1%. And of these, five countries (Argentina, Brazil, Chile, Mexico, and Venezuela) are responsible for 85% of the region's output (Unesco 1993).

[4] The values for Africa and Asia exclude the Arab States in those areas.

It is also true that the South's potential in science and technology is far greater than the current reality. The following chapters will examine some of the reasons for this. And a look at some of the achievements of Southern scientists, described later in this book, should dispel any possible doubts about Third World capacities for science.

Changes Are Underway

Attitudes toward science and technology and how they are conducted in the Third World are changing significantly. The number of scientists in some Third World countries is increasing, for example. There were 4 064 full- and part-time scientists and engineers in Mexico in 1971; by 1984, the figure had more than quadrupled to 16 679, according to Unesco.

Brazil's scientific and engineering population climbed from 38 713 in 1983 to 52 863 just 2 years later, excluding military and defence personnel and those in private enterprise. Similarly, Peru had 1 925 scientists and engineers (including those in scientific services) in 1970, but a decade later there were 9 171. Venezuela's nonmilitary scientific and engineering workforce totalled 2 809 in 1973 and 4 568 a decade later. One of the most striking growths occurred in Korea, where the 18 434 figure of 1980 had more than tripled by 1988.

Women in Third World Science

All developing countries did not post increases in scientific and engineering personnel, however. In some countries — in the Philippines in the early to mid-1980s, for example — there was even a regression. Yet the number of women scientists there has been on the rise.

A 1993 study by the International Service for National Agricultural Research (ISNAR) and the Philippine Council for Agriculture and Resources Research and Development (PCARRD), reported that "women's participation in agricultural research has increased markedly in the Philippines over the past two decades," to the point where "more than half of the agricultural scientists in public-sector research are women." The study also showed that in Thailand's public sector in 1992 women comprised 44% of agricultural researchers with a master's or doctoral degree in sciences; in Sri Lanka in 1991, the proportion was 28% in 19 research institutes (ISNAR and PCARRD 1993)

ISNAR sees the increasing participation of women in agricultural science as a worldwide phenomenon. "For example," it says, "in the United States only 7% of the doctorates in science and engineering were awarded to women in the 1950s. By the 1980s, their share of doctorates in science and engineering had increased to 25%. In the Third World, agricultural research is one area where there is an increasing number of women available to professional careers, especially in Asia."

In a special 1994 issue entitled "Women in Science," *Science* showed that female researchers in a number of Third World countries are better off than their sisters in developed countries. After conducting a study of the literature and interviews with women scientists in a range of nations, *Science* reported that: "In countries now undergoing economic development, including Mexico, Argentina, and the countries of Eastern Europe, women made up from 20 to 50% of the scientific researchers, compared to fewer than 10% in the United States and northern European nations such as Germany" (Barinaga 1994).

The journal quoted Canadian astronomer Robin Kingsburgh, who completed a doctorate in Mexico, as saying that women in Mexico fare better than in Britain. "The chair of the astronomy department at the University of Mexico is a woman, as are about one-third of the faculty...compared with only 6 women of 64 faculty members in physics and astronomy at University College, London." *Science* also quoted a 1990 study by Jim Megaw, former Chairman of the Physics Department at York University in Ontario, that showed between 27 and 60% of physics students receiving doctorates in the Philippines were women, as were more than 30% of the members of Argentina's International Astronomical Union (Barinaga 1994).

Megaw's study is one of the few comparing women's representation in specific scientific disciplines worldwide. Surprisingly, it showed that countries with large physics establishments, high levels of industrial development, and strong women's rights movements — including the United States, Britain, and Canada — have among the poorest records. In these countries, fewer than 5% of physics faculty were women, and fewer than 12% of physics students receiving doctorates were women.

Why the increasing opportunity for women in some Third World countries? The ISNAR–PCARRD study cites a number of possible reasons: increased educational opportunities for women, emphasis on science in school curriculums, economic and social incentives, the relative gender neutrality of science, and the nondiscriminatory environment found in government and university research jobs.

There are, of course, off-setting factors: rarely do women in the Third World occupy decision-making positions, and the jobs in science open to them tend to be lower paying, which is why more men do not take them.

Bringing Third World Science to the Fore

The visibility of science and technology in the South is also increasing. In 1964, Abdus Salam, the Pakistani theoretical physicist and Nobel Laureate, saw the realization of his idea of an International Centre for Theoretical Physics (ICTP), which would foster advanced research, particularly among Third World scientists. Under the auspices of the International Atomic Energy Agency (IAEA) and through the generosity of Italy, the Centre was located in Trieste.

In 1983, the Third World Academy of Sciences (TWAS) — again proposed by Abdus Salam — was also founded in Trieste. The Academy is an international forum uniting the most distinguished scientists and technologists from the South "for the purpose of promoting scientific capacity and excellence for sustainable development in the South." In 1993, TWAS had 325 members from 54 developing countries, including all the living Nobel Laureates.

Since 1964, a whole complex of Third World science institutes has sprouted up along the shores of the Adriatic Sea around the Gulf of Trieste, including one devoted to genetic engineering and biotechnology, another to high technology, and another to women in science. This little kingdom of science, whose uncrowned monarch is Abdus Salam, flourishes in relative obscurity in an idyllic setting on and near the grounds of picturesque Duino Castle.

Salam is a legendary figure. Born in the small, remote country town of Jhang, Pakistan, in 1926, he was educated at Government College, Lahore, and St John's College, Cambridge. Early in his boyhood he showed academic promise, topping his province and breaking all previous records in his matriculation examinations. A devoted scholar, he earned his doctorate in theoretical physics from Cambridge in 1952. Twenty-seven years later, he, Sheldon Glashow, and Steven Weinberg of the United States won the Nobel Prize "for their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including *inter alia* the prediction of the weak neutral current."

Revered by his colleagues, Salam had only one passion other than physics: promoting scientific research in the hope of eliminating Third World poverty. The extensive programs of the institutes he has established put scientists from the South and North more closely in touch with one another; provide promising scientists in the South with research facilities necessary for their work; recognize, support, and promote excellence in scientific research in the South; and encourage research on major Third World problems. Many national academies of science have also sprung up in the South in recent years, influenced, in part, by scientists in Trieste. The African Academy, for example, has 100 Fellows.

Reversing the Brain Drain

Some Third World countries — including Argentina, Colombia, Mexico, and Venezuela — are trying to reverse the brain drain by offering their scientists incentives to return home. Colombia has a program known as Red Caldas, designed to establish connections with its scientists living abroad in the hope of repatriating them. In the spring of 1994, the Argentinean Embassy in Washington scheduled a meeting with its scientists living in the United States to strengthen their ties with Argentina. Colombia, Mexico, and Venezuela subsidize the salaries of some of their scientists who agree to work at home.

The newly industrialized countries (NICs; also known as the Asian Tigers), which for years saw a massive exodus of their scientific talent, now are seeing a majority return home as a result of the increasingly tempting opportunities opening up for them there.

"While the number of young people going abroad for advanced degrees continues to swell," reported *Science* in October 1993, "a majority are now returning home, drawn by new opportunities and improved living conditions. Even scientists who have lived in the West for decades are going back to run institutes and to help bring Asian science into the international mainstream. The once-lamented brain drain is proving to be a brain reserve of immeasurable worth" (Kinoshita 1993).

These countries are the success stories of the Third World as far as science and technology are concerned. As Sogo Okamura, President of Tokyo Denki University, and Reg Henry, Senior Lecturer in Environmental and Science Policy at Griffith University, Brisbane, Australia, said in Unesco's *World Science Report 1993:* "Today, Asia's NIC model is a paradigm of the use of science to achieve development, and one which continues to offer hope to less successful developing countries." For example:

— Beijing, China, hosts more than 2 000 enterprises developed by researchers from institutes of the Academy of

Sciences and the universities. Shanghai, its industrial capital, is home to research centres in physiology, biochemistry, organic chemistry, cell biology, lasers, and optics, as well as the country's first biotechnology centre.

— Singapore has one of Asia's foremost biology laboratories, the Institute of Molecular and Cell Biology, and is developing a 30-hectare science and technology park including residences, cultural centres, and pubs. The tiny island country has a project to link all its homes, schools, offices, universities and industries through fibre optics, and turn it into the high-tech communications centre for all Asia.

— South Korea — whose 13-year-old students beat out their counterparts from Britain, Ireland, Spain, and the United States in a mathematics and physics competition in 1989 — is building a powerful and advanced synchrotron radiation facility for the Pohang Institute of Science and Technology. A group of the country's young researchers have set as their goal two Nobel Prizes by the year 2010.

— Taiwan's Hsinchu Industrial Park contains 140 firms and the Synchrotron Radiation Research Centre, which serves firms in the park and the universities. Eight microchip manufacturers have sprung up in the past decade, turning the park into a miniature version of California's Silicon Valley.

— Hong Kong's new University of Science and Technology was created expressly to promote research to enable the territory to become a high technology-based economy.

The South's Unique Potential

Recently, the North has paid increasing attention to the scientific potential of the Third World, for example, in the search for new drugs. A flyer for the September 1994 issue of *Ethnobotany and the*

Search for New Drugs, which details the proceedings of a Ciba Foundation symposium, says:

> The potential for further discoveries is clearly enormous and ethnobotany has recently become of renewed interest in the search for novel pharmaceuticals.... The basis of ethnobotany is the vast knowledge that is traditionally the preserve of witch doctors, shamans, and tribal healers. This irreplaceable knowledge is rapidly being lost through the destruction of both natural habitats and indigenous cultures.

In 1991, in the first agreement of its kind, the world's largest pharmaceutical firm, Merck & Co., signed an agreement with National Biodiversity Institute of Costa Rica allowing the company to engage in "chemical prospecting" and to seek beneficial substances in unexplored flora and fauna. In return for $1 million to train local biologists and a percentage of royalties on any drugs it may develop from Costa Rican plants, Merck receives the rights to new microbial insect and plant drugs that may be found in Costa Rica's nature preserves. The firm will also donate part of its profits from the drugs to Costa Rica's conservation efforts.

More than 120 clinically useful prescription drugs worldwide are already derived from plants, including the anticancer agents vinblastine and vincristine, morphine, codeine, quinine, atropine, and digitalis (Abelson 1990). About 74% of them came to the attention of pharmaceutical houses because of their use in traditional medicine. Most grow in the tropics — a large proportion in the rain forests of the developing world. Yet only about 5 000 of a possible 250 000 to 300 000 plant species have been studied extensively for medical purposes.

As Christopher Joyce says in his 1994 book, *Earthly Goods: Medicine-Hunting in the Rainforest,* it is remarkable that in the history of medicinal plant-hunting

> despite thousands of years of experimentation, humans have barely touched what nature has to offer. Even the known is forgotten and then rediscovered. Take the crocus, for example, one of the plants listed in Dioscorides' famous herbal. Dioscorides recommended that a species of the flower then called *Ephemera,* later given the Latin

> name *Colchicum parnassicum*, be soaked in wine as a poultice for treating tumours. The plant, from the lily family, in fact contains colchicine, an alkaloid from which a powerful treatment for granulocytic leukemia is now made. Even the world's most common medicine can be traced to a decoction from the white willow that Dioscorides recommended for gout. It took 800 years for chemists to find what gave willow juice its analgesic effects. It was a compound called salicin. Salicin was modified to become salicylic acid, which was effective against skin diseases but which could not be taken internally. Eventually, in 1899, German chemists turned salicylic acid into acetylsalicylic acid. They called it aspirin.

As the Merck agreement shows, the North is beginning to recognize its obligation to repay the privilege of profiting from the natural resources of the South. Another example is a small Californian company called Shaman Pharmaceuticals, started up in 1992 by a young investment analyst, Lisa R. Conte.

Shaman Pharmaceuticals calls itself an ethnobotanical enterprise, and is the first and, perhaps, only firm that searches for new drug possibilities specifically among the traditional practices of indigenous peoples, mainly living in tropical forests. With the help of qualified scientific advisers, Shaman turns up promising leads and then initiates research to develop them into new drugs such as an antiviral agent to be used against respiratory diseases. Conte has promised anyone who helps in the successful development of the new drugs, including landowners, farmers and indigenous groups, a share of the profits. The company has also swapped modern medical treatment for plant information among indigenous people.

This is an area where much remains to be done. Countries of the North have long exploited traditional knowledge gained from the South without adequately compensating the communities from which the knowledge springs. And how is fair compensation determined? Joyce (1994) continues:

> If a plant-drug is found in a tract of Ecuadorian forest, it will probably make money for its North American developers and investors, but one drug may not be

enough to convince Ecuador to protect much more of its forests. Nor would it automatically guarantee a better life for people living in those forests. The rubber tappers of the Brazilian Amazon, for example, pioneered sustainable harvesting for a Western market, yet they must supplement their income from rubber with farming and other activities that clear land, and over half of these men and women are in debt and live in poverty. Indeed, no international law clearly states that indigenous people "own" their knowledge or the plants and animals they use or grow on their land. For that matter, personal ownership of such things is often alien to their way of life. To introduce the idea of profit in return for medicinal plants and traditional knowledge might make them wealthier, but it will hasten the westernization of their culture as well.

Natural Pesticides

Besides being the source of drugs, Third World plants can provide a host of other benefits. The neem tree, native to India and Burma, can provide natural pesticides with remarkable effectiveness against more than 200 species of insects, including mosquitoes (which cause malaria), the desert locust (which lays waste to agricultural crops and trees), and cockroaches (BOSTID 1992). In addition, this wonder tree contains compounds that fight tooth decay, viruses, and a variety of bacteria — and whose seed kernels can even be used to produce a potent spermicide (see Chapter 4). Indian researchers have been studying some of these characteristics for more than 70 years, but the North only began noticing them in the early 1970s.

Third World animals also hold the potential for new drugs: a chemical extracted from the skin of an Ecuadorian frog has shown itself to be a painkiller 200 times as potent as morphine. Called epibatidine, the chemical seems to work by blocking formerly unknown receptors in the brain (Emsley 1992).

A Third World Medical Alternative

Even a Third World treatment for diarrhea is now being promoted for use in developed countries. Ironically, it was first considered too primitive for modern societies. Oral rehydration therapy (ORT) makes use of a special mixture of water, sugar, and salt to replace body fluids lost — often to the point of life-threatening dehydration — in diarrhea. In the Third World, more than one-third of deaths in children under 5 years old (4 million per year) are associated with diarrhea. Diarrheal diseases account for about 30% of hospital admissions in many developing countries, where treatment involves expensive intravenous administration of fluids (Bolido 1994).

ORT, on the other hand, makes use of prepackaged mixtures that, dissolved in water, can be administered by mouth at home. It is cheap and reliable, and does not need expert, trained personnel. The United Nations estimates ORT saves the lives of a million children worldwide every year.

But diarrhea is not just a Third World problem: 16 million American children under the age of 5 also suffer from it each year, 360 000 are hospitalized and hundreds die from it. Recently the US Agency for International Development (USAID) — which for years distributed ORT packages to developing countries — began promoting use of ORT at home under Medicaid, and a national program has been started to educate doctors about it (AP 1993).

ORT was used for centuries in the Third World as a folk remedy for diarrhea, but was established on a scientific basis only in 1968, through what is now known as the International Centre for Diarrheal Research in Bangladesh. Used with dramatic success by a young Indian doctor, Dilip Mahalanabis, when cholera broke out in refugee camps during the Bangladesh war of independence in 1971, ORT finally achieved worldwide credibility. The British medical journal *The Lancet* referred to it as "potentially the most important medical advance this century."

Working Together on Global Problems

This new recognition of the South's scientific potential is good news, especially in light of the enormous problems facing us today, such as global warming, desertification, the El Niño phenomenon, and the destruction of tropical forests. These problems cannot be solved by the North alone. Developing countries cover 60% of the Earth's land mass, and many of the measurements necessary to any program of a global nature must be made there.

The North must depend on the South not only for participation in such programs, but also for the South's cooperation in preventing further destruction through, for example, attempts to reduce emission of greenhouse gases, atmospheric and water pollution, depletion of the atmospheric ozone layer, and forest preservation.

Recent findings about the contribution of biomass burning to ozone depletion highlight the need for the cooperation of developing countries. An article by Stein Manö and Meinrat Andreae in the 4 March 1994 issue of *Science* shows that bromine is 20 to 60 times as efficient at destroying ozone as chlorine, which, through chlorofluorocarbons (CFCs), has previously been considered the chief ozone destroyer. Methyl bromide is the single largest source of stratospheric bromine and, until recently, was thought to come mainly from ocean emissions and agricultural pesticides. Now methyl bromide has been found in smoke from wildfires in savannas, chaparral, and boreal forests, and the global emissions from this source are estimated to account for as much as 30% of the total. And it is in developing countries that most of this nonindustrial pollution occurs.

Ways in which the North and South can collaborate to solve these problems together will be discussed in Chapter 6. First let us examine how the South, which once led the world in science, began to lag behind the North.

CHAPTER 3

HOW THE SOUTH GOT LEFT BEHIND

Abdus Salam disputes the popularly held Northern idea that science is the creation of the Western, democratic, Judeo-Christian tradition. To substantiate his view, he quotes science historian George Sarton: "The main, as well as the least obvious, achievement of the Middle Ages was the creation of the experimental spirit and this was primarily due to the Muslims down to the 12th century."

Modern science, with its insistence on observation and experiment, is not really the legacy of Greece, contends Salam. "If anything," he has written, "it is truly a Greco-Judeo-Christian-Islamic legacy" (Lai and Kidwai 1989).

The Contributions of Islam

Barely 100 years after the Prophet Mohammed's death, Muslims were founding institutes of advanced study. The observatories of Baghdad, Cairo, and Samarkand played a major role in the development of astronomy from the 9th century onwards, as we know for example from Arabic names of heavenly bodies such as the supergiant star Betelgeuse. Muslims were prominent in the sciences until about 1450 AD, when Constantinople fell before the Turkish assault.

Salam contends that the Golden Age of science in Islam was around 1000 AD. He calls Ibn-al-Haitham "one of the greatest physicists of all time," who anticipated by many centuries Fermat's Principle (an optical law concerning the time it takes light to travel from one point to another). Ibn-al-Haitham also enunciated the law of inertia, which later became part of Galileo's and Newton's law of motion.[5]

Professor Ahmad Y. al-Hassan, former Director of the Institute for the History of Arabic Science at the University of Aleppo, Syria, and Dr Donald R. Hill, Honorary Research Fellow of University College, London, note in their 1986 book, *Islamic Technology: An Illustrated History,* that "Al-Khuwarizmi, whose name has produced the word 'algorithm,' was also responsible for laying the foundations of Islamic [and hence Western] algebra. Umar Khayyam [who died in 1131 AD] now more famous in the West as the poet 'Omar Khayyam,' made considerable progress in this field."

In *The Arabs* (1955), the great scholar Edward Atiyah says that without the work of Khayyam[6] and Al-Khuwarizmi and other Arab mathematicians, "it is doubtful whether the European

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[5] Salam notes that this same pioneer had to feign madness to escape the wrath of the ruler of Egypt when he conceived what later became the Aswan Dam, but was unable to build it because it was too advanced for the technology of the time.

[6] Khayyam was actually a Persian and wrote poetry in his native language; but for algebra, he used Arabic.

scientific revolution of the seventeenth century could have taken place when it did...and since it was this scientific revolution, together with that other revolution we call the Renaissance, and to which the Arabs also contributed, that produced the modern mind, or Western civilization, the importance of the Arab link in the chain of history is evident."

Charles Singer argues in *A History of Technology* that the major achievements in science and technology that are called Hellenistic and Roman were mainly achievements of the Near East (Singer 1958). Singer writes that in skill and inventiveness during most of the period 500 to 1500 AD "the Near East was superior to the West.... For nearly all branches of technology the best products available to the West were those of the Near East.... Technologically, the West had little to bring to the East. The technological movement was in the other direction."

The Rich and the Poor

Nor was the North always richer than the South. In fact, the reverse was once true.

"At its prime, Mughal South Asia enjoyed a standard of living higher than that of contemporary Europe," wrote Akhtar Mahmud Faruqui (1988). "Even in the post-Renaissance period, marking the beginning of Europe's recovery and subsequent mutation of science, trade between the North and South proceeded on an even keel and the two enjoyed a comparable standard of living."

Europe started to appear on the scientific scene only after 1100 AD. By that time, science had flourished at different periods in many different parts of the globe, including Egypt, Greece, southern Italy, Syria, Turkey, and later, Afghanistan, Arabia, China, India, and Persia. China and the Islamic countries had already made major discoveries in magnetism, acoustics, and optics.

According to Abdus Salam, "it was only after 1450 AD that the countries that are now called the Third World started losing ground with respect to Europe."

The Beginnings of Science

Third World achievements in science and technology occurred very early in time. There is evidence that inhabitants of Old Testament Jericho in Jordan cultivated emmer wheat and barley as early as 8000 BC. The earliest civilizations — based on complex and productive agriculture — developed in the river valleys of the Tigris, the Euphrates, and the Nile. Hard wheat was one of the crops diffused by the Arabs through the Middle East and the Muslim Mediterranean and, from there, to the Christian West. In all likelihood the Italians are indebted to the Arabs for the invention and transmission of pastas made from durum wheat.

In 2500 BC, science began in another practical form in Babylonia, with what science historian William Cecil Dampier (1966) calls "the coordination and standardization of the knowledge of common sense and of industry." An early sign of this was the issue under royal command of standards of length, weight, and capacity.

Alexandria was a centre of science before the advent of Islam, and scientists came from the Near East and eastern Mediterranean to live and study there. Engineering was represented in the extensive irrigation systems of Egypt and Iraq, and the textile factories of the Byzantine and Sassanid empires were examples of technology.

The beginnings of astronomy occurred in the Euphrates and Nile basins. In the Indus Valley in South Asia, there is evidence that, at about the same time, scientific knowledge was used in town planning, metallurgy, medicine, and surgery. In Egypt, the invention of the wheel and sailing ship advanced the country's transport system. And in India during the time of Buddha, medical schools were founded and physicians performed cataract and hernia operations.

Before the arrival of Christopher Columbus in the Americas, the Mayas, the Aztecs, and the Incas had advanced knowledge of mathematics, astronomy, agriculture, and medicine. In the New World, the first university to be founded was not in Boston, but in Santo Domingo (in the Dominican Republic).

Early Technological Advances

Ivan L. Head, former IDRC President, argues in his book *On a Hinge of History* (Head 1991) that:

> The very language of modern technology — mathematics — is a product of Southern genius. The decimal system originated in India. It was assimilated by Arab travellers during the first, golden century of Islam (630–730 AD, a period in Europe described as the Dark Ages) and carried to the Moorish territories in Spain about 750. The essential concept of zero was first derived in China. Without it, none of the great advances in theoretical mathematic and scientific reasoning would have been possible.

Three major inventions that revolutionized world history — printing, gunpowder, and the compass — came from the South. Francis Bacon said of them: "No empire, sect, or star, appears to have exercised a greater power and influence on human affairs than these mechanical discoveries."

The Chinese dominated technology until the 15th or 16th century. Printing began in China some 2 000 years ago, long before Gutenberg invented movable type (which the Koreans greatly exploited). The Chinese first used carved seals of stone, then page-sized blocks of wood in printing, and also manufactured paper 1 000 years before it was made in Europe. And in Chinese literature there are references to early forms of the compass. Beginning in the 1st century AD, there are references to south-pointing spoons carved from lodestone, and from the 11th century, there are descriptions of a fish-shaped piece of magnetized iron floated on water. The Chinese also developed the stern-post rudder for ships.

What Caused the Decline?

Why then did the South begin to lose its pre-eminence in science and technology?

The great impetus toward modern science and technology in the North began mainly in the 17th century. First came the "scientific revolution," as the North began to change the way it viewed the world. This was followed by what H.G. Wells has called the "mechanical revolution," when mechanical power began to replace muscle power and, finally, by the "industrial revolution" (Wells 1958).

This sequence was largely absent from the countries of the South. But long before, the North had begun to colonize the South, leading to what Kenyan scientist Thomas Odhiambo calls, in the case of Africa, "a 500-year hiatus" — a cultural freeze that lasted half a millennium (Odhiambo 1993). Says M.G.K. Menon (1993), immediate Past-President of the International Council of Scientific Unions (ICSU): "Due to internecine conflicts, feudal structures, a lack of tolerant and liberal attitudes, and colonial domination, the regions of the globe now known as the Third World fell behind, and except for occasional brilliant scientific work, still suffer from a lack of knowledge-based development."

Other factors, too, were at play, says Menon. Science and technology are deeply rooted in the West, but "by contrast, in the developing world there has been a lack of tolerance toward science. There has also been a lack of formal education for large segments of the population, who continue with their traditional work as in bygone centuries."

Dr A.M. Sharafuddin, 1983 winner of Unesco's Kalinga Prize for Popularization of Science, wrote in 1986 in *Impact of Science on Society* of how, in the absence of the factors leading to the industrial revolution in the Third World, they generally remained immersed in their past traditions:

> Some of these countries had glorious traditions indeed — in music and dance, arts and crafts, poetry and drama, philosophy and religion; but modern science, which flourished in the West, simply did not have a

chance to take root in these countries. Thus, throughout the eighteenth and nineteenth centuries, while the West mastered the forces of Nature and excelled in practical matters, the East — having lost much of its past glories — concentrated more on matters of the spirit.

The Arabs

In the Arab states, the decline of science was associated with weakening of the central Muslim concept of one nation unifying all Muslims, according to Fakhruddin al-Daghestani, Director of the Centre for International Studies at the Royal Scientific Society in Jordan.

"When the learned in society associated themselves with despotic leadership, freedom of expression was suppressed and the role of *Ijtihad* [independent judgment based on reason] was reduced," he wrote in Unesco's *World Science Report 1993*. "Consequently, inductive reasoning took a marginal position in culture and the motivation for scientific inquiry dwindled."

Abdus Salam says "no one knows for certain" why creative science died out in Islamic civilization, but he blames internal causes such as "the inward-turning isolation of our scientific enterprise," and "active discouragement to innovation [*taqlid*] by the fanatical attitudes of the religious establishment. The later parts of the eleventh and early twelfth centuries in Islam [when this decline began] were periods of intense politically motivated, sectarian, and religious strife."

Authors al-Hassan and Hill (1986) also blame the rise of a fanatical clerical faction with freezing science and withering its progress. The irony was that this happened just about the time scientific progress in the North was beginning.

"The tragedy of the demolition of the last observatory in Islam, established in Constantinople by Taqi al-Dinn in 1580, exemplifies this victory of the clerical faction over science," they write. "And it is deplorable to note the inherent irony of the fact that the first observatory in the West was built around the same period, by Tycho Brahe."

Following the Second World War, when the Arab states became independent, the educational system began to emphasize the learning of facts and storing of information rather than developing the power of observation and analysis. And once again the scientific ethic withered.

Latin America's Case

The evolution of science and technology in Latin America was different. Marcel Roche, President of the Interciencia Association in Washington, DC, and Editor of *Interciencia*, says that although colonial science there was not negligible, it was on the whole highly practical, not highly regarded locally, and limited to the richer colonies such as Colombia and Mexico. "There was no theoretical work comparable to that, say, of Benjamin Franklin on electrostatics," he writes in *Science* (Roche 1976).

Raimundo Villegas, Chancellor of the Academia de Ciencias de America Latína, and Guillermo Cardoza, Assistant Professor at the Universidad Central de Venezuela, write: "Science as it is known today in developed Western countries, reached the region many years after Columbus and the Spanish and Portuguese conquistadors, among other reasons because science was only just beginning in Europe at the end of the 15th century." But from the end of the 15th century until the end of the 19th century, "Latin America witnessed the arrival or the emergence of naturalists, investigators and students of nature who initiated a growing interest in science" (Villegas and Cardoza 1993).

E. Jeffrey Stann, Director of the Western Hemisphere Program of the American Association for the Advancement of Science (AAAS), noted in an interview that Latin America is "a creation of the modern age," and like the United States received an important part of its culture from Europe. But why "science somehow didn't take as it did in the United States is a mystery."

Roche has also written: "Traditionally, and following the Spanish historical model, scientific research has not been an inherent part of the Latin American culture. Learning has been by rote.... Our countries have suffered from what I have termed a 'peripheral complex,' which makes us feel that, unlike Germans, Frenchmen, Britons, and North Americans, we are not fit to do research."

Because Spanish American scientists were isolated from their European counterparts and had few research facilities, they felt it was more difficult for them than for Europeans to do science, Roche says. "They also felt keenly the disdain with which their science purportedly was being treated in the central countries."

Such comments mirror the feelings of many Third World scientists today, as shown in Chapter 6.

The progress made in Latin American science during the past 20 years suggests that Roche's remarks about Latin American scientists' lack of self-confidence are no longer entirely valid; nonetheless, they help explain the history of science and technology in Latin America.

Africa's Long Dark Night

Thomas Odhiambo, who is President of the African Academy of Sciences, blames the beginning of the slave trade in 1442 for plunging Africa into five centuries of darkness and despair. While "science has always been in Africa...ever since the dawn of human society," the slave trade depopulated and wrecked its centres of civilization (AAAS 1991). That dark age was extended by the colonial imposition of European imperialism, which lasted for a century and a half.

"The disjunction between the European-introduced education system, which eschewed science and the practical arts and broke the link between formal education and the African child's social environment, completed the descent of the Dark Age over the continent for five centuries and a half," he said. "One by one, the lights of civilization and technical progress were extinguished.

The centres of learning and scholarship in Timbuktu [in Mali] and Lamu [in Kenya], the concourse of industry and commerce in Axum [in Ethiopia] and Benin [in Nigeria], and the great centres of communication and international trade along the Guinea coast and the East African seaports — all expired and became mere legends."

These cataclysmic events led to a sociocultural and psychic pall that began to recede only in the 1950s, when Africa began to regain its independence, says Odhiambo.

India and the Far East

Colonialism also caused the development of science and technology to go awry in India and the Far East. Speaking of the scientific and technological milieu of his childhood in British India, Abdus Salam says: "The British set up something like 31 liberal high schools and arts colleges in what is now Pakistan, but for a population then approaching 40 million people, just one college of engineering and one college of agriculture...in the entire liberal arts dominated educational history of British India, there never was anything analogous to the British National or Higher National Certificates in Technology.

"The results of these policies could have been foreseen. The chemical revolution of fertilizers and pesticides in agriculture touched us not. The manufacturing crafts went into complete oblivion. Even a steel plough had to be imported from England."

Indigenous science and technology did not then exist in Pakistan, Salam says. "Any technology we needed, we bought." But even this came hedged with restrictions: "For example, no product which used this [imported] technology could be exported. And in any case, not all technology was for sale. Pakistan, for example, could not buy the technology of penicillin manufacture in 1955. My brother, together with a few other young chemists from Pakistan, reinvented the process, producing as a result of their inexperience penicillin at 16 times the world price."

The Birth of Organized Science

The organization of science in the North changed during the 19th century, when it was realized that science could no longer be left to individuals, no matter how talented. Research institutes were created and funded by governments, and industry established its own research laboratories. Such trends were foreign to the non-scientific orientation of the cultures of the South. In any case, the South was prohibited from building similar facilities because of insufficient resources and the constraints of colonialism.

The history of colonialism and exploitation of much of the Third World goes a long way to explain why the South lagged behind the North in science and technology. But however much the North can be blamed for this, the South's own responsibility for the current state of affairs must not be ignored.

As Menon and others have indicated, culture, religion, and politics were at least partly responsible for the widespread social inequalities and the massively uneven distribution of wealth and privilege seen in much of the Third World, and contributed to the lack of development of science and technology among Third World countries. Technological developments such as machines to lighten physical labour and improve the quality of life were completely unimaginable in countries where many had not only to fend for themselves, but also to perform menial tasks for the rich. And with a permanent supply of cheap human labour, the rich had no need for such machines.

Interviewed at ICTP, Pakistani physicist F. Hussain said: "There are only a few countries in the Third World where the governments have really gone out of their way to help the development of science.... In most of the Third World countries, like my own, the governments have never given any priority to education or to science. Mostly they don't want to spend money on universities and schools.... So the universities and the education system hardly gets any [money]. And they really don't care about science."

Under the circumstances, it is remarkable that the Third World has achieved anything of significance in recent years. Yet that is certainly the case, as the next chapter shows.

CHAPTER 4

THIRD WORLD ACHIEVEMENTS

In 1987, the British journal *Nature* published a paper describing a synthetic vaccine that appeared to protect monkeys from malaria (Patarroyo et al. 1987). Manuel Patarroyo's claim to have developed what would be the first vaccine to provide protection against a parasitic disease was greeted with intense skepticism.

The skepticism increased — mixed with criticism about the ethics involved — when, soon afterward, Patarroyo began testing his vaccine on thousands of Colombians, without using what were considered by the scientific establishment to be the necessary safeguards.

It didn't help that Patarroyo hadn't done what scientists are supposed to do: expose his results to the criticisms of his peers at international meetings. Nor did it help that his approach to the development of his vaccine was thoroughly unorthodox.

The result was an international controversy which "was characterized by a combination of envy of Patarroyo and outright disbelief at his results, and genuine scientific criticism," wrote Professor F.E.G. Cox of King's College London in *Nature* in 1993. Britain's Medical Research Council refused a request for a field test from one of its own African laboratories. The US Walter Reed Army Institute of Research declared it was unable to duplicate Patarroyo's vaccine production methods, and WHO studies failed to replicate his results.

Attitudes changed, however, when Patarroyo paid heed to his detractors and published data that conformed to their standards. He also began attending conferences to reply personally to his detractors' concerns. In person, his warm, open, and modest manner shone through and helped immeasurably to further his cause. Soon Britain's Medical Research Council acceded to the request of its African scientists and established a vaccine trial in The Gambia. Walter Reed scientists, after working more extensively with Patarroyo's methods, achieved identical results. And soon it became apparent that the WHO studies may have suffered from similar difficulties in arriving at a correct vaccine formulation.

By the spring of 1993, the word in the world's scientific literature was that the Colombian's vaccine might indeed be the real thing.

"[Patarroyo's] persistence now seems to have been vindicated," wrote Cox (1993) about the first large-scale trials in Colombia. "The degree of protection achieved is not dramatic. But it is the first time that such a large trial has been undertaken and there can be no doubt that a certain degree of protection was achieved.... From the point of view of public health, fewer days would be lost by sickness if everyone were immunized with a vaccine, even only a partially effective one. Malaria is a complex disease, and it may be that all it will be possible to achieve in the near future will be a tolerable level of malaria with which it is possible to live."

Part of the doubt about Patarroyo's vaccine arose because his methodology differed completely from the norm.

A complex disease, malaria poses particularly difficult problems for those trying to combat it. First of all, it can be caused by four different parasites: *Plasmodium falciparum*, which occurs in West Africa and South America; *Plasmodium vivax* and *Plasmodium ovale*, found in North Africa; and *Plasmodium malariae*, in Asia. Secondly, these parasites undergo a series of transformations: first in the mosquito, next in the liver of the person bitten, and finally, in the victim's red blood cells, where it reproduces itself.

At each stage, the organism has a different biological identity. A vaccine works by introducing something into the body that the immune system will recognize and produce antibodies to destroy. In the case of malaria, the vaccine designer has to decide which of the various biological identities will be represented in the vaccine. According to Geneva-based science writer John Maurice (1993):

> The conventional wisdom is that to be effective, a malaria vaccine would have to mobilize the cellular component of the immune system in addition to generating antibodies. Yet Patarroyo made his vaccine from peptides more likely to produce an antibody response. What's more, many researchers in the mid-1980s were pinning their hopes on a vaccine to attack the parasite in its sporozoite stage, the form in which the organism is injected into the bloodstream by a biting mosquito. But Patarroyo targeted mainly the merozoite form, which develops from the sporozoite and causes the fever and chills typical of the disease. Although his initial attempts to find a merozoite peptide that would completely protect monkeys from malaria were unsuccessful, he eventually came up with a cocktail of three peptides that showed promise, and then by a deft stroke of chemical legerdemain used two sporozoite peptides to link them in a stable form.

Patarroyo attributes his success to attacking the problem through chemical synthesis rather than genetic engineering. The problem was to synthesize the string of peptides, but genetic engineering seemed impossible because the pieces were too small. So Patarroyo decided to do it chemically. Although some of his peers acknowledged that his solution could work, they thought it would not be achieved until about the year 2025 because of the technical difficulties involved.

Patarroyo, however, had trained at Rockefeller University in the United States with Dr Robert Bruce Merrifield, who, in 1984, won the Nobel Prize in Chemistry "for his development of methodology for chemical synthesis on a solid matrix." So, Patarroyo said: "Why should we wait so long? The technology is now ready to be used, why not use it right now? And that's what happened — we made it!"

A Case of Scientific Xenophobia?

Did the fact that Patarroyo's work was done in the Third World really have anything to do with its initial rejection in the North, or would it have been received with the same scepticism had he been American, British, or Canadian?

According to a trio of authors from scientific centres in Spain, Switzerland, and Tanzania who examined this question in the international journal *Vaccine*, research strategies and investments are heavily governed by the prevailing sociopolitical context (Alonso et al. 1993). The US military has long been involved in malaria vaccine research, particularly vaccines against the pre-erythrocytic stage, in the hope of reducing the number of casualties during operations in endemic areas. This type of vaccine is unlikely to be useful to people who live in endemic areas of the Third World — particularly in sub-Saharan Africa — although it might be very useful for short-term visitors.

With the end of the cold war came budget cuts for research such as the military's vaccine work. And because of the limited financial return, the pharmaceutical industry is unlikely to undertake research into vaccines that will protect only people living in endemic areas. Stressing that Patarroyo's vaccine is unlike those researched by the US military, in that it targets the different stages of the disease-causing organism and could "be a central tool in malaria control programmes in endemic areas," the authors write:

> The history of SPf66 [Patarroyo's vaccine] is an excellent case study of the problems and position of science within development cooperation, of the sociopolitical context that shapes it, and of the confusion among scientists about their role in policy formation.... His claims have been met with a spectrum of reactions ranging from unquestioning enthusiasm, through scepticism to intellectual racism.

Noting early shortcomings of Patarroyo's work, the authors said:

> These are admittedly sound arguments which could justify a rational scepticism. However, they could equally be applied to many of the pre-clinical, clinical and field trials performed by those scientific establishments that have chosen to ignore and discredit Patarroyo's claims.
>
> A WHO/PAHO *ad hoc* committee visited Bogota in June 1990 and concluded that SPf66 merited further study. The committee recommended that independent randomized placebo-controlled trials should be carried out urgently among children living in areas of high transmission, particularly in Africa. Nevertheless, the British Medical Research Council twice refused to carry out such trials of SPf66 in The Gambia. A review of malaria research in *Time* [31 May 1993] chose to ignore totally Patarroyo's work. These are just two examples of how the story of SPf66 is governed by the sociopolitical anatomy of our time. The development of a potential malaria vaccine by the South American group, rather than by an established malaria vaccine research centre, represents a blow to the scientific establishment that believes itself to be the trustee of malaria vaccine research. An important question of ethics is surely raised when a potential avenue for the advance of science, and one which could lead to a way of controlling one of the world's most important parasitic diseases, is deliberately ignored.

Patarroyo's vaccine breaks new ground in a number of ways: it is the first to have been synthesized chemically, rather than made — like other vaccines — from dead or genetically altered pathogens such as viruses or bacteria. The vaccine is also inexpensive to make: each dose is estimated to cost 30 cents, which makes it ideal for Third World use.

"It's a pretty major breakthrough," said Pedro Alonso, an epidemiologist from Barcelona's Foundation for Biomedical Research who worked on the Tanzanian trial. "It's not only the first malaria vaccine, but the first against any parasitic disease of humans" (Brown, P. 1994).

Although Patarroyo's achievement is finally being recognized by the world's malaria experts, some indicate that it needs more work before it will be ready for widespread use. Nicholas J. White of the Oxford Tropical Medicine Research Program of Wellcome–Manidol University in Bangkok, Thailand, wrote in the 20 October 1994 issue of *The Lancet*:

> In another year, we will have the results of the other trials and a clearer idea of the overall efficiency of SPf66. Success — i.e., confirmation that Patarroyo's vaccine prevents malaria — will raise many important questions. How long will the protection last? Will the vaccine select for "resistant strains"? Is there a danger of destabilizing malaria and increasing mortality in areas of intense stable transmission? Can we improve on the present vaccine, and how about the several other vaccines also in development? We have not reached the end of the journey towards an ideal vaccine against falciparum malaria, but the SPf66 vaccine has held up well so far, and we are still on track.

Odile Puijalon, a molecular biologist working on malaria at the Pasteur Institute in Paris, put Patarroyo's advance in a broader context: "I think even if this vaccine is not in the end used on a large scale, what we owe Manuel Patarroyo is that he has proved that using long peptides is feasible, and at a reasonable price" (quoted in Brown, P. 1994).

The World's First Family-Planning Vaccine

The risk of death from pregnancy and childbirth for African and South Asian women is 200 times greater than for women in the industrialized world. In nearly every African country where surveys were conducted, at least half the married women wanted to postpone their next pregnancy or did not want any more children. And in developing countries generally, the high incidence of induced abortion reveals the need for better methods of fertility regulation.

An Indian medical researcher has developed such a method: a safe, long-lasting, and reversible vaccine. Dr Gursaran Talwar began the research in 1975 as Director of India's National Institute of Immunology, with funding from the Indian government and IDRC. The latest clinical studies show that among 88 women injected with the vaccine, only one pregnancy occurred over 821 menstrual cycles. Without the vaccine, 250 to 300 pregnancies would have been expected in such a group (Newton 1993).

"We have passed an important milestone and that is to confirm the vaccine works," said Dr Talwar. "This is the first time we've seen a birth-control vaccine that can prevent pregnancy in humans."

Although approval for widespread use of the vaccine will take considerable time, Dr Talwar hopes it will be approved before the turn of the century.

The vaccine has many advantages over other methods of fertility regulation. Unlike "the pill," it does not stop ovulation or alter the menstrual cycle — and it does not involve daily medication. Nor does it involve insertion by a doctor — and irregular bleeding — associated with IUDs (intrauterine devices). Even the new, implantable devices such as steroid packs cause irregular bleeding.

Dr Talwar's vaccine works by increasing the body's production of antibodies to the human chronic gonadotropin (HCG) — the hormone normally produced in the uterus in preparation for implantation of an embryo. By increasing the production of the antibodies, this hormonal action is blocked and embryo implantation does not take place.

The vaccine does not produce an abortion; rather, it helps prevent pregnancy. Moreover, in doing so, it simply makes more efficient a process that occurs naturally. In unvaccinated women, approximately 50 to 75% of embryos fail to become implanted in the uterus because of the presence of antibodies normally produced by the body against HCG. The vaccine increases the antibody level to a point where no embryos are implanted.

Currently, the vaccine must be administered once a month for 3 months, after which time it is effective for a year. During the initial 3 months, women must use other methods of contraception. Dr Talwar is now working on the development of a contraceptive based on a purified extract of the neem tree for use during the 3-month "waiting period." Researchers at the University of Alberta are collaborating with him to determine why and how the extract works, as it does in trials with rats and monkeys. Dr Talwar is also working on an implant that would extend the vaccine's protection from 3 months to a year.

As did Patarroyo with his malaria vaccine, Dr Talwar faced disbelief and skepticism when he proposed his pregnancy vaccine in the early 1970s. "People felt it was a fantasy," he said. "Vaccines were traditionally made for diseases, pestilence, viruses, and bacteria — not birth control." He also faced the usual skepticism concerning Third World scientists. "For a scientist in a developing country to make an original contribution, he or she has to work five times harder," he added.

To refute his critics, Dr Talwar has subjected his work to rigorous animal trials over 10 years. An international committee of the Population Council of New York has conducted toxicology studies in Brazil, Chile, Finland, and Sweden, while other studies are being carried out by WHO.

The vaccine will obviously benefit all countries, not just the South. "Many people want alternatives to current methods of contraception," says Dr Talwar. "There is no dividing line between North and South."

VACCINATING CHICKENS

An acute and highly contagious virus, Newcastle disease either kills the poultry it infects or reduces egg production and retards growth. In 1976, considering Newcastle disease the biggest threat facing the poultry industry in Malaysia, Professor Abdul Latif Ibrahim of the Universiti Pertanian Malaysia proposed studying ways to improve existing vaccines that provided imperfect protection against the disease. With support from the International Foundation for Science over 4 years, he succeeded in isolating two new clones from the virus and preparing stable new vaccines.

In 1982, Professor Latif was named Dean of the Faculty of Veterinary Medicine and Animal Science at his university, and acquired new funding for his vaccine research. Using the cloning technique, he produced a potent vaccine — which was subsequently manufactured — from the Australian strain of the Newcastle virus. In 1984 he received the first Sven Brohult Award, named after the founding president of the International Foundation for Science, for this work. Professor Latif is currently doing research, financed by the Australian Centre for International Agricultural Research, on an oral vaccine that could be fed to chickens reared in the backyards of rural areas of Malaysia and Southeast Asia.

The Conquest of Yellow Jack

Viral diseases and parasitic infections are common scourges in Third World countries, and colonizing Europeans have often been particularly hard-hit by such maladies. Yellow fever is a case in point.

It has been argued that yellow fever originated in the Caribbean and was exported to Africa. It has also been said that the first Europeans to fall victim to the disease were Christopher Columbus' crew. In his 1976 book, *Plagues and Peoples,* William H. McNeill argues the traffic went in the other direction. "Yellow fever announced its successful transfer from West Africa to the Caribbean for the first time in 1648, when epidemics broke out in both Yucatán and Havana." The transfer, he said, required establishment in the New World of a special species of mosquito — *Aedes aegypti* — which breeds only in artificial containers such as water casks, rather than in water with a natural bottom of mud or sand.

Whatever its origin, yellow fever produced sudden, serious, and often fatal fevers among Europeans in the Caribbean. In 1762, for example, over half the members of the British army who arrived to set seige to Havana fell ill within a month. In Santo Domingo 31 years later, 6 000 of the English troops sent to help in the revolt against the French Creoles died of yellow fever, while only 100 perished in the actual fighting. The English sailors nicknamed the dreaded disease "Yellow Jack" because of the jaundice it produced.

It was a Cuban doctor, Carlos Finlay, who first identified the cause of yellow fever as an infection produced by a mosquito bite. In Havana in 1881, he presented his hypothesis to the Royal Academy of Medical, Physical and Natural Sciences, and subsequently confirmed it with experimental inoculations on 100 volunteers. A US medical team later validated his discovery, and in 1898 Finlay proposed the chemical destruction of mosquito larvae in water tanks. This method was put into practice in 1901 and backed by the US Army. The last case of yellow fever in Havana was registered that same year.

Thanks to Finlay's discovery and the later development of a vaccine, yellow fever is no longer a serious threat to travelers from the North to central Africa and to South and Central America.

The Assassin Bug Strikes

A chronic disease in South and Central America is a version of the African sleeping sickness (trypanosomiasis) called Chagas' disease. In Africa, the disease is spread by the tsetse fly, while in South and

Central American it is transmitted by the blood-sucking insect *Triatoma infestans*, which carries the parasite *Trypanosoma cruzi*.[7]

Chagas' disease is found predominantly in young children and can have serious effects, including death. Some 15 to 20 million people are infected with it in Latin America, 10% of whom suffer from it chronically. The chronic phase, which appears only 15 to 20 years after the insect's bite, affects the heart, oesophagus, lower intestine, and peripheral nervous system.

The disease is named after Carlos Chagas (1879–1934), a Brazilian who studied medicine in Rio de Janeiro. Simon Flexner, the famous American doctor whose report on the US medical system led to a revolution in physician training early this century, said Chagas' work on American trypanosomiasis was the most complete made on any human disease as of 1920. According to Kean et al. (1978), in *Tropical Medicine and Parasitology: Classic Investigations*: "We know little more [about it] today. The parasite, the vector, and the disease are brilliantly described in [Chagas'] monograph."

How Chagas' Disease Got its Name

Chagas describes in this monograph how, in 1907, he and colleagues discovered the cause of the disease while conducting an antimalarial campaign during construction of a railroad.

> We had some knowledge of the existence of a hematophagic insect [called "barbeiro" by the locals] which lives in human dwellings, attacking man at night, after the lights are out, and hiding during the day in the cracks in the wall, in the roofs of the houses, in one word, in all hiding places likely to afford shelter. As a rule, the hematophagic insect is seen in greater abundance in poor dwellings, in huts with unplastered walls and covered with thatch. Their reproduction is considerable there; they are found in immense numbers in the

[7] The insect, also known as the "assassin bug," transmits the parasite by contaminating the bite wound with its infected feces.

> cracks of the walls and constitute a most remarkable threat to the lives of men who live in these dwellings. We have frequently observed men attacked by the hematophagic insect: a few minutes after the lights are extinguished in the homes, they come out of the hiding places in large numbers, to bite people, preferably in the face. When the lights are turned on, the hematophagic insects escape rapidly, thus rendering their capture difficult. The hematophagic insects will stay in the dwellings only as long as man resides there; they will disappear very quickly from deserted huts, certainly due to lack of food.

To this day there are no effective drugs or vaccines for use against Chagas' disease, so it must be prevented rather than cured. Preventive measures include keeping the blood-sucking insects from invading houses. In Paraguay, a research team funded by IDRC has concentrated on improving housing by plastering walls and filling joints between boards, smoothing roofs and ceilings, and improving ventilation and light through the installation of better doors and windows.

The key to success, however, is community involvement. Rural communities do not take the threat of a disease that strikes in 15 to 20 years seriously, when they are concerned with day-to-day survival. Nonetheless, Chagas' work has obviously been vital to controlling this scourge.

Will Chagas' Disease Invade the North?

The North does not usually regard Chagas' disease as a threat — to many it is just another Third World problem. But it is estimated that about 100 000 Central American immigrants in the United States carry the parasite in their blood, completely unaware of it (Howard Hughes Medical Institute 1993). Spread of the parasite to the United States — and beyond — through blood transfusions is not only possible, but has already occurred. Two cases were reported by 1993. Nor is Chagas' disease an isolated case: a tropical disease specialist warned a 1988 conference in Washington that many other disease-causing organisms might move northward from their native habitats as a result of global warming (see Chapter 6).

Staggering from Too Much Cassava

A few years after the Second World War, while working in the neurosurgical unit of the University of London's psychiatric institute. a young Nigerian doctor named Gottlieb L. Monekosso noticed that many patients who had been prisoners of war in Germany and Japan suffered from impaired vision, hearing, and gait. When he returned to Nigeria, Dr Monekosso said years later, "the very first patients that I saw reminded me of these descriptions; and I thought this is very funny: it looks like the kind of thing that these prisoners of war suffered from. This is happening in peacetime in an African population. I had better look at it and see what it's all about" (Nichols 1982).

What it was all about was a condition affecting about 80% of women in certain areas of Nigeria — a condition that could produce, in addition to the staggering gait, goitre, liver damage, and nerve disease. Dr Monekosso thought the condition might be caused by the victims' diets, as it had been among the prisoners-of-war. Manipulation of their diet had no effect, however. The only thing that relieved the patients was to remove them from their environment and admit them to hospital.

On a visit to London, Dr Monekosso had met a British physician who was studying the effect of cyanide in tobacco in a rare disease of the nervous system, and he and his colleagues suspected that the Nigerian patients' malady might be caused by cyanide in cassava.

This root crop, also known as manioc and tapioca, is the dietary staple not only of Nigerians, but of 200 to 300 million people worldwide. Easy to grow even in poor soils, cassava is drought tolerant, resistant to weeds and insects, and can be left in the ground without harvesting for long periods.

However, cassava also contains a substance called linamarin and a related substance, lotaustralin. Under the influence of an enzyme, these substances liberate hydrogen cyanide (prussic acid), one of the most powerful poisons known. The poison acts as a natural insecticide, protecting the plant against pests.

An African Discovery

By now, Dr Monekosso was collaborating with one of his former students, Dr B.O. Osuntokun, who used the cassava research as the basis for his doctoral thesis.

"Between us we eventually set out both the field exercises and the laboratory work which led to what is now accepted as the role of cyanide in cassava diets," Dr Monekosso said. The condition became known as "tropical ataxic neuropathy."

The researchers learned that some of the afflicted Nigerian women were eating up to 21 meals of cassava a week, with little other intake of protein. While traditional preparation methods — soaking the root in water before cooking — did much to eliminate the cyanide, it was not enough to prevent poisoning among those with a high intake. Basically, the researchers found, the problem was one of poverty. Unlike wealthier Africans, those affected could not afford high-protein food sources that provide the enzyme that destroys cyanide.

Tropical ataxic neuropathy is now uncommon in Africa. But the work of Dr Monekosso, now Regional Director for the World Health Organization in Africa, and Dr Osuntokun, now Professor of Medicine (Neurology) at the University of Ibadan and one of Africa's most prominent medical investigators, did more than virtually eliminate a serious disease. It also helped in the understanding of the metabolism of cyanide in the human body — a contribution to knowledge that will benefit people both rich and poor worldwide.

Cassava's Enormous Potential

While too much cassava can kill, too little could mean starvation for the estimated 200 to 300 million people in more than 80 countries who depend on it for nourishment. Despite its significance, cassava was long neglected by scientists.

In 1971, IDRC and CIDA undertook a cassava research program that produced remarkable results, including the identification of varieties that have quadrupled the national average yield in some countries, improvement of the crop's normally low protein content, reduction of its cyanide content through breeding programs, and control of some diseases.

The research was motivated by cassava's enormous potential. It is capable of producing more annual energy per land unit year than any other known staple food crop. As well, it has long been exported for its starch content, the characteristics of which are of special interest to the food, paper, and chemical industries. It has also been used in dried and pelleted form as animal fodder, with an energy value almost identical to that of corn.

As human food, cassava is a subsistence crop: it is highly tolerant to drought, can grow in poor soils, and is generally resistant to weeds and insects. It can be planted and harvested in any season and can be left in the ground for long periods without harvesting, which makes it useful as security against famine.

"Once regarded as a backstop crop to tide the rural poor over in 'hungry seasons,' cassava has emerged as a nutritional and commercial mainstay in sub-Saharan Africa," says the Rockefeller Foundation's 1993 annual report. "It has become both a dietary staple for almost 200 million people in the region and an important cash crop." In the 15 African countries that produce 70% of the continent's cassava harvest, this crop generates income for farmers and creates new jobs in processing, packaging, and marketing cassava products.

FARMING THE SEA

About 50 000 Chileans depend on seaweed as their main source of income. Between 1975 and 1987, the price of Chilean seaweed increased six-fold because of the high-quality agar it produces. Agar is used widely in industry, pharmacology, and food products. In 1987, the International Foundation for Science in Sweden presented the Sven Brohult Award to Professor Bernabe Santelices of Chile's Catholic University. The award recognizes Santelices' research that helps seaweed farmers to improve its management, propagation, and cultivation. His work also protects seaweed from overexploitation, as it does the marine organisms that use seaweed as a habitat.

Disease-Causing Snails and Soapberries

An estimated 200 million people in Africa, Asia, South America, and the Caribbean are afflicted by a disease called schistosomiasis (or bilharzia), and another 600 million are at risk. They become infected by bathing or wading in water that contains snails carrying parasites called schistosomes. These parasites cause a skin rash, enter the liver through the bloodstream, and may spread to other parts of the body, causing fever, diarrhea, and lung and central nervous system damage. Schistosomiasis is difficult to treat; the best way to reduce its human toll is to prevent infection by eliminating the snails that carry the parasite.

In 1964, a young Ethiopian scientist, Aklilu Lemma, was sent to the northern part of his country to investigate a serious outbreak of schistosomiasis, and to learn how the disease was transmitted from the snails to people. While there, he noticed that women washing their clothes in a small stream used the berries of a plant (locally called endod) as soap. Endod's scientific name is *Phytolacca dodecandra*, and in English is called the African soapberry plant.

"I noticed in areas, particularly where people were washing clothes with these berries of this plant, immediately below there were more dead snails floating than any other place," Lemma said. "So this aroused some curiosity that perhaps there may be a relationship between the plant and the snails. And so I collected a batch of good snails and I asked one of the ladies to see if she could drop a few of her suds from the washing basin into there. And surely, as soon as she did, it sort of bubbled up and all the snails died" (Nichols 1982).

This discovery led to years of research by Dr Aklilu and others, the results of which were published by WHO. It also gave rise to an experiment in which people suffering from schistosomiasis had endod applied to the affected areas and their contact with the snail-infected water controlled. The experiment proved successful in significantly reducing the incidence of schistosomiasis.

In 1989, Dr Aklilu and his co-worker, Legesse Wolde-Yohannes, were awarded the Right Livelihood Award (also known as "the alternative Nobel Prize") for the endod work. "The way I look at this study," Dr Aklilu has said, "is not this soapberry as such as a plant to be promoted as the solution, but the approach: a locally available product that you can mobilize your own people to either grow or produce without having to drain your hard currency which is so much needed for other purposes, a method whereby the community can actively participate."

In 1993, WHO planned large-scale African tests of endod as snail killer and detergent.

The Answer to the Zebra Mussel?

Years after Dr Aklilu's first encounter with endod in Ethiopia, a fascinating sequel began to take shape far away in the US state of Ohio. In 1990, when Aklilu was awarded an honorary degree by the University of Toledo, a biologist at the university by the name of Harold Lee became interested in the soapberry extract and found that endod could kill an adult zebra mussel 4 to 8 hours after exposure. At the same time, endod became biodegradable within 24 hours. In 1993, IDRC sponsored a lecture tour by Dr Lee to publicize his findings.

By the time Dr Lee made his discovery, the zebra mussel was a major pest in North America's Great Lakes system, fouling waterways in Ontario and Quebec and in 18 US states. Introduced by accident in 1985, the mollusc multiplied fearsomely, clogging water-intake equipment and causing enormous damage. It also threatened fisheries because it kills algae and covers rocks in spawning grounds. In 1990, the US Fish and Wildlife Service estimated that the zebra mussel would cause $2 billion damage to American fisheries by the year 2000.

The University of Toledo applied for and received a US patent on the use of endod to control zebra mussels; it is seeking a Canadian patent as well. A technology package has been developed and Dr Lee and his colleagues are currently seeking industrial partners with whom to market it. Profits will be shared by the university, Dr Lee, Peter Fraleigh (also of the university), and Dr Aklilu (currently a Visiting Investigator in the Department of Industrial Health at Johns Hopkins University).

Asked by telephone whether benefits might flow to Ethiopia, Dr Lee said he and Dr Fraleigh hope that endod might be made into a cash crop for the country. They also propose to devote at least 5% of their royalties to establishing an endod foundation whose principle goal would be to combat schistosomiasis in Africa. The university will also devote 10% of its royalties to the foundation.

Dreams of Magic Bullets

Cesar Milstein was born in Bahía Blanca, Argentina in 1927. Educated at Colegio Nacional de Bahía Blanca and the University of Buenos Aires, he earned a doctorate at Cambridge University in England. His first job was in Argentina, on the staff of the Instituto Nacional de Microbiología in Buenos Aires. He was made a Fellow of the British Council a year later, became head of his division in

1961, and in 1963 returned to Cambridge to join the staff of the Medical Research Council's Laboratory of Molecular Biology.

In 1984, Milstein was awarded the Nobel Prize for Medicine (along with Niels K. Jerne and Georges J.F. Kohler) for an enormously important discovery: how to manufacture monoclonal antibodies. Monoclonal antibodies are a sort of "magic bullet" that can unerringly seek out specific antigens (foreign agents in the body that can cause illness). With the help of these antibodies, disease-causing organisms can be identified, targeted, and killed without harming normal body cells. They can also be used to make effective vaccines against the diseases.

Before the Milstein method was developed, antibodies had been widely used in medical diagnosis to identify disease agents, but they were only available in nonspecific mixtures. The antibodies would recognize all sorts of substances in the body as foreign — from germs to chemicals from the environment — but they couldn't discriminate precisely between them.

Immunologists had long dreamed of finding a way to obtain antibodies so pure that they would be able to recognize just one particular antigen. Dream became reality when the Milstein method was developed in 1975.

According to Dr Milstein, he and his co-worker, Georges Kohler, discovered the method by accident. They were trying to understand how an organism can synthesize millions of different molecules in seemingly endless variety, as the body does with antibodies. Their research was what is called "basic" or "fundamental" research, because it was aimed not at any particular practical end, but simply at the acquisition of knowledge.

In the course of their experiments, they discovered that if they made hybrid cells from human cancer cells and cells from a mouse, the hybrids would produce only one kind of antibody. They were able to clone these hybrids — reproduce successive generations with identical genetic characteristics. They called the hybrids "monoclonal antibodies," and their experiments provided them with a practically unlimited supply of antibodies that possessed a specificity previously unobtainable.

Since this discovery, monoclonal antibodies have been used extensively in medicine, including research sponsored by USAID on Chagas' disease in Venezuela, and to produce an antivenom against Russell's Viper in Burma, where snakebites kill about 1 000 farmers every year. Monoclonal antibodies have also been used to diagnose and study virus and bacterial infections in plants.

Was Dr Milstein's work really an achievement of Third World science, given that the work was done in Britain? Perhaps not, but one can't help wondering whether he might not have achieved the same success had his native Argentina been able to provide him with the scientific environment he found in the North.

Milstein himself seemed to encourage such speculation during his presentation as winner of Unesco's 1984 Carlos J. Finlay Memorial Prize. To illustrate his strongly held opinion that basic science must be supported even in developing countries, Milstein told a story about Bernardo Houssay, the Argentinean physiologist who became Latin America's first Nobel Laureate in medicine in 1947. Houssay, said Milstein, was once asked by a journalist whether it was too much of a luxury for a country like

PRODUCING NEW CROPS THROUGH RADIATION

In 1959, the Belgian Congo (now Zaire) became the first African country to operate a nuclear reactor. Used primarily for university research and teaching, it was replaced in 1972 and again in 1974, at which time it became the most powerful research reactor in Africa. Housed in what was called the Regional Centre of Nuclear Study in Kinshasa, it was largely designed and built by local staff at one-quarter the turnkey price quoted from abroad. Radiation-induced mutation techniques using the reactor have allowed African countries biological control of plant diseases, and also to produce new varieties of soybean, maize, rice, and groundnuts.

his to support basic research. "Sir," replied Houssay, "we are an undeveloped country. We cannot afford to be without basic science."

A Different Point of View

One of the reasons why Third World scientific and technological advances go largely unnoticed in the North is that often they do not fit easily into what the media in the developed world considers news. This concept of news tends to feature such exploits as space flights, high-technology medical breakthroughs — including organ transplants and genetic engineering — and the wonders of new computer technology. Measured by this yardstick, advances in fields such as tropical or dry-land agriculture may simply be ignored by Northern media.

Yet these little-publicized advances may be far more important to people in the South — who comprise a huge majority of the world's population — than much of what passes for news in the North. Third World countries are by definition poor in terms of per-capita income. One of the chief concerns of a majority of their people is getting enough to eat. So for the more than 700 million people who do not have access to enough food to meet their needs, advances in agriculture are of enormous importance (Pinstrup-Anderson 1993). One such example concerns a process known as biological nitrogen fixation and its link to food crop production in tropical countries.

Free Fertilizer from the Air

As every home gardener knows, plants grow better when fertilized, and one of the essentials in any fertilizer is nitrogen. When we fertilize our lawns or our garden plants, we usually apply nitrogen in chemical form. Nitrogen, however, is not just available in chemical form. It can be obtained freely from the air and made available to plants by way of bacteria that exist in the root nodules of legumes. This process is called biological nitrogen fixation, and under certain conditions planting legumes and other plants together can eliminate the need for chemical fertilizers.

Chemical fertilizers are expensive to produce and require large inputs of electrical energy, thereby increasing the buildup of greenhouse gases in the atmosphere. They also contribute to water pollution. So when biological nitrogen fixation by legumes replaces fertilizers, the process helps promote food production while, at the same time, reducing global warming and water pollution.

A Tropical Bonanza

Some 40 years ago, a Brazilian scientist by the name of Johanna Dobereiner began developing sound, practical, and cost-effective methods of applying biological nitrogen fixation agriculture in tropical areas. Her work helped Brazil to produce the world's second-largest soybean crop (22 million tonnes) without the use of any nitrogen fertilizer.

In her 1989 acceptance speech as the first woman to be awarded the Unesco Science Prize, Dr Dobereiner said: "This means that we obtain annually a quantity of nitrogen from the atmosphere that is worth more than $1.5 billion. More recently we have found still more efficient rhizobial [microbial] strains which transfer most of the fixed nitrogen directly to the grains, and their introduction into commercial inoculants should provide further yield increases of at least 20% without any increase in cost."

But Dr Dobereiner's biggest challenge was to extend the biological fixation process to other important food crops, including cereals, and to grasses and sugar cane. She and her colleagues succeeded in identifying seven new nitrogen-fixing bacteria associated with crop plants, some of which enhanced plant yield in the field, especially in warm tropical regions.

Later Dr Dobereiner proved that, like soybeans, certain sugarcane varieties can obtain all their nitrogen through biological nitrogen fixation, and that the process could increase the then-current average Brazilian yield threefold.

Her work at the Brazilian Agricultural Research Corporation (EMBRAPA) enabled sustained production of corn and soybean from poor soil such as the acid savannas of not only Brazil, but of Venezuela, Colombia, Ecuador, and Peru. With the improved technology, these previously unutilized lands — nearly equal in size to all US agricultural land — produce as much corn and soybeans per acre as the best land in the United States.

In presenting the Unesco prize, Federico Mayor said the EMBRAPA work "represents a significant step toward environmentally harmless plant nutrition systems, and the alleviation of the acute world food shortage, particularly in developing countries."

Brazil is only one of many Third World countries to benefit from biological nitrogen fixation through legumes. In fact, a number of countries are promoting its use as members of the Microbial Resources Centres Network (MIRCEN) (Keya et al. 1986). These centres provide training in the methods of *Rhizobium* inoculation in Ethiopia, Kenya, Lesotho, Malawi, Rwanda, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe.

Awareness of the advantages of biological nitrogen fixation came only after the fossil fuel shortages of the 1970s (notably Australia, Brazil, and Uruguay because of their need to improve pasture land).[8] By then, world food production depended on a 40 million tonne supply of synthetically fixed nitrogen that cost between $8 and $10 billion annually. Not surprisingly, there was concern about the adequacy of the world's natural gas supply required to produce enough synthetic nitrogen by the end of the century. The environmentally conscious also worried that fertilizer left unused by crops would pollute groundwater and produce other undesirable side effects.

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[8] Australia is particularly famous in this respect. It is the major region of the world in which significant use is made of nitrogen fixation by legumes to maintain soil fertility for grain crops.

For developing countries, the advantage of having nitrogen fixed by plants is particularly important. First of all, these countries do not have the foreign exchange necessary to buy enough chemical fertilizer, and many of their farmers could not afford the fertilizer even if they had. There is a much bigger problem, however. Until recently — to meet nutritional needs — Third World farmers have moved into areas where infertile soils have not previously been used for crop production. This practice cannot continue.

"While cultivated area is still increasing in developing countries, it is doing so at a low and declining rate," said Per Pinstrup-Andersen, Director General of the International Food Policy Research Institute (IFPRI), recently in Washington. "Area expansion is no longer a feasible option for expanding food production in most of the world, and increased food production will have to come from increased yields."

Although biological nitrogen fixation is vital to the Third World, it is also becoming increasingly necessary to the world at large.

"Fertilizer nitrogen will become ever more expensive because of the increasing cost of electricity," predicted C.A. Parker, Professor Emeritus and Honorary Research Fellow in the University of Western Australia's School of Agriculture in 1986. "Furthermore, soil nitrogen is only temporarily enriched [unlike phosphate] by addition of mineral fertilizer-N. This situation can be resolved by greatly expanded use of legumes" (Parker 1986).

As populations expand and increased food production becomes even more necessary in developing and developed countries alike, the natural fertilizer techniques pioneered by Dr Dobereiner and MIRCEN will benefit us all.

Reclaiming Salty Soils

Soils with a high salt content are a problem worldwide. They cover 10% of the Earth's surface and occur in about 100 countries and regions. Salt seriously impedes agricultural production: it hardens topsoil, decreases the rate of water infiltration, and interferes with seed germination, In China, some 26.8 million hectares, or about 7% of all cultivated land, are affected by salt, most often in regions with a high potential for agricultural yield.

Beginning in the 1950s, Chinese researchers reclaimed vast areas of salt-affected soils in the Huang-Huai-Hai Plain, using a combination of water conservation and agroforestry methods (Zheng-Ming and Cheng-tao 1986). They tripled grain yields and turned the area into China's leading cotton-producing region.

As much as one-third of Pakistan's irrigated agriculture is affected by salty soils, and experts estimate that, if unchecked, the high levels of salinity could lead to abandonment of 25% of the country's cultivable land, which is sorely needed for food production.

The International Irrigation Management Institute (IIMI) in Sri Lanka says the solution for the Lower Chenab Canal system in the Punjab lies in proper management of the 19th-century irrigation system. The system's inadequacy forces farmers to use tube-wells, which exhaust the aquifers and cause salinity problems (IIMI 1993). In the meantime, Kauser A. Malik, a Pakistani scientist with the Nuclear Institute for Agriculture and Biology in Faisalabad, has developed a pasture grass to counter the situation (Malik et al. 1986):

> Kallar grass is a highly salt tolerant perennial grass that grows well even under water-logged conditions. It is deep-rooted and opens up the impermeable sodic soils; if green manured it provides considerable amounts of stable organic matter to the soil. It harbours nitrogen fixing bacteria in the rhizosphere and obtains 60–80% of its nitrogen requirement from the air.... During one summer it can provide 50 tonnes of biomass per hectare even when irrigated with brackish water. It has been shown by us and our colleagues that the biomass can be used as manure, fodder and for making pulp, biogas and alcohol. All these attributes make it a very suitable crop for introduction into saline lands where it can [not] only be used as an energy crop but also improves the soil.

Soil at Risk in the North

Deteriorating soils are also a problem for developed countries. In 1984, a report by Canada's Senate Standing Committee on Agriculture, Fisheries, and Forestry found that "on lands affected by salinization in the Prairies, crop yields have been reduced by 10 to 75%, even though farmers have increased their use of fertilizer."

When agriculture first began on the Prairies, the natural high fertility of the soils enabled farmers to produce millions of tonnes of cereal grains and oilseeds, with minimal use of fertilizer. In the early 1900s, farmers began cropping land only in alternate years. This practice, known as "summerfallowing," was introduced to store scarce water for the cropping year, to control weeds, and to restore soil fertility. Unfortunately, it achieved the opposite results. Organic matter in the soil declined, soil erosion increased, and the soil became saline at an alarming rate. These effects were cumulative, said the report.

"Recent studies have shown that as much as 40 to 60% of the organic matter present in virgin prairie soils has been 'used up' by farm production. An equally startling fact is that, although the native soils in parts of the prairies originally released up to 125 pounds of nitrogen per acre [140 kilograms per hectare] per year, the same soil today may deliver as low as 9 pounds per acre [10 kilograms per hectare] if nitrogen fertilizer has not been used. The practical result for the farmer is that he must apply ever-increasing amounts of nitrogen fertilizer in an attempt to hold production at its current level."

The Committee found that salinization reduced average Prairie crop yields by at least 50%. It estimated that, at that time, salinization cost CA $260 million in crop production and, given the rate of expansion of saline areas, farmers lost an additional CA $26 million in revenue every year.

Dr Harold Steppuhn, who is with Agriculture Canada's Research Centre in Swift Current, Saskatchewan, said that the problem is, if anything, worse today than in 1984. With the increased rainfall we have experienced in recent years, more salts have been brought to the soil's surface by evaporation.

"In some areas we're monitoring, it's just about as bad as it's ever been," Dr Steppuhn said. "It just might not be noticed so much because when it rains the salts go back in solution and go down a ways, and it doesn't look as bad."

Dr Steppuhn knows of no figures showing the cost of salinization to farmers today. He says that although the problem of salinity continues to grow, less attention is being paid to it. Farmers are less interested in the problem of salinity as they turn from wheat production to alternate crops such as canola, flax, peas, and beans. In comparison to wheat, these other crops may be less salt tolerant, thereby creating a new set of problems.

As a result of Canada's slackening interest in the problem and cutbacks in government personnel, fewer people are working on solving the problem of soil salinity.

Could the North Learn from the South?

Soil salinity problems in the North and the South are not always the same because of different climates, growing seasons, types of salts involved, economics, and land use. However, since both regions suffer similar damage from saline soils, any advances achieved by soil scientists in the South could also be applied in the North. This holds particularly true for biological control methods such as agroforestry, which are becoming more prevalent in the Third World.

Dr Bob Eilers of Agriculture Canada's Manitoba Land Resources Unit in Winnipeg, sees agroforestry as a potentially worthwhile research approach for Canada.

Agroforestry as a means of water management has been investigated in Australia, for example, he notes. Salt-tolerant tree species planted in areas that have previously been cleared of vegetation and where the groundwater level — and hence the salt content — is high, can use some of the excess water.

THAT'S A SUPER BANANA

Bananas and plantains are the staple food of 70 million Africans, as well as a highly popular food for millions of others worldwide. But these crops are threatened with extinction by rampaging diseases called Black Sigatoka and Panama race. The Honduran Foundation for Agricultural Research, with support from IDRC and USAID, recently developed a "superbanana" called Goldfinger. Resistant to these diseases, it could save the banana export industry from collapse. Capable of growing without pesticides and in areas where traditional banana varieties do not flourish, Goldfinger is a highly productive variety that has a unique and attractive flavour, and could extend the banana crop's range into semitropical or even upland areas. This new variety could ensure reliable food supplies for millions of Africans, Asians, and Latin Americans.

Eiler says that Canadian applications would have to be site specific and limited by local conditions. For example, "we pretty much cultivate all parts of the landscape and we don't have forest lots or woodlots on the prairies. But I don't even know if there's really been a search to look at trees and shrubs as a management tool for salinity. I'm not aware of it. I know that it has been done in other places, and it seems to me that there are opportunities here — not for thousands of acres but for local, site-specific applications — where it might be very applicable."

Perfecting Ancient Practices

Agroforestry is a new field of organized science based on ancient traditional Third World farming practices. It combines the growing of trees, shrubs, and other woody perennials on the same land unit with food crops and sometimes animals. It is a system that does not rely on expensive chemical inputs, yet is highly productive, protective of the environment, and — most importantly — sustainable.

Some trees are leguminous and can fix nitrogen, like Dr Dobereiner's soybean plant. This nitrogen then becomes available to the surrounding crops through the soil. Millet yields in Senegal have been reported to be 250% higher in grain and 350% higher in protein when grown under *Acacia albida* trees.

Other plants can work in the same way. Indonesians have increased production of rice from 0.7 to 1.8 tonnes per hectare in 2 years by growing it between young forest plants. And in Malaysia, rubber tree growth is accelerated when intercropped with leguminous ground covers.

When used as windbreaks, trees can protect crops and increase their production. In Niger, for example, millet yields increased by 23% when neem trees were used as windbreaks. And in northern Nigeria, farmers found that in addition to crop protection, their shelter belts provided poles, timber, and firewood, and increased fodder supplies for their animals. Together with the increase in soil fertility and reduction in soil erosion, this use of agroforestry netted them between 16 and 21% return on their investment (Spurgeon 1988).

Alley Cropping

One of the most effective agroforestry arrangements is to grow crops between rows of leguminous trees or shrubs, a technique called alley cropping. To prevent the trees from overshadowing the crops, they are pruned frequently and, when spread on the ground, the leaves and branches serve as mulch. As the leaves and branches decompose, they contribute nitrogen and phosphorus to the soil, and the trees continuously pump nutrients from deep in the soil and make them accessible to the crops.

Paul Harrison, British author of *The Greening of Africa*, describes how an Indonesian soil scientist, B.T. Kang, and his colleagues built on traditional methods of African farmers in developing alley cropping at the International Institute of Tropical

Agriculture in Ibadan, Nigeria. They found that a tree that originated in southern Mexico, *Leucaena leucocephala*, was ideal for this purpose: its leaves being capable of providing as much as 166 kilograms of nitrogen, 150 kilograms of potash, and 15 kilograms of phosphorus per hectare (Harrison 1987).

"When incorporated in the soil," wrote Harrison, "every tonne of leaves produces the same increase in maize yields as 10 kilos or more of chemical nitrogenous fertilizer," besides greatly increasing the efficiency of chemical fertilizers.

The yield also accumulates with time. In a long-term trial in sandy soil, unfertilized maize mulched with *Leucaena* prunings yielded 83% more than fertilized maize, and in the following 3 years, the alley-cropped plot continued to yield, on average, three times more than the untreated one, except for 1 year of drought. In addition, the yield was more than double the Nigerian average.

A free-lance writer with extensive Third World experience, Harrison was invited by the International Institute for Environment and Development in 1985 to look for success stories in African development projects and write about them. *The Greening of Africa* was the result. In it he called agroforestry "arguably the single most important discipline for the future of sustainable development in Africa."

How the North Benefits

Much of the scientific development of agroforestry was carried out by the International Center for Research in Agroforestry, ICRAF), which itself arose from an IDRC study. These ancient practices are now being revived, improved, and adapted in Canada by scientists at the University of Guelph, some of the projects funded by IDRC. The researchers determined that growing trees such as poplar with such crops as barley is profitable. And although planting corn with red oak or black walnut trees, for example, reduces the corn yield slightly, the walnut trees produce a valuable nut crop and the oaks help save some of the CA $100 million spent annually on

US imports. Recently, as well, farmers in Vineland, Ontario, have begun planting vegetables between rows of young peach trees.

Peter Williams, a research associate who works with the program at the University of Guelph, says agroforestry practices have been carried out in North America for many years, and were not so much adopted from the South as stimulated by the work going on there.

"There's a lot of traditional things that farmers do here that are agroforestry, like growing vegetables in apple orchards," he explained. The planting of corn among black walnut trees was a practice developed in Missouri, for example, and was probably a spinoff of pecan production in the southeastern United States.

"Pecan trees have always been grown with wide spacing and farmers have always grown cover crops or whatever between them because there's so much real estate there that they have to make some money out of it," added Williams. Just as the beginning of international interest in agroforestry saw much documentation of developing-country systems, the same is now happening in the North, Williams said. The South, therefore, provided the impetus for increased research in the North.

Work on what was called forest range management in the southeastern United States dates back 20 or 30 years, and work with walnuts in Missouri began more than 15 years ago. But the recent interest in agroforestry in the North gave researchers "a forum for their work," where previously they were probably regarded as a "fringe element."

"Agroforestry started out as a real bandwagon in the 1980s, but now that part is over, and people are accepting it," said Williams. "In the United States they are rewriting the farm bill and they're incorporating a lot of agroforestry into it. Similar things are happening in Canada. Federal and provincial programs are using the word agroforestry and are working it into their programs. It's a great label. It gives credibility to [assorted] practices such as constructing windbreaks."

Agroforestry research in the North and South is mutually beneficial. The University of Guelph has had projects in Indonesia, Sri Lanka, southern Africa, and Argentina, and scientists from the Third World regularly visit these projects to gather information valuable to their own countries.

"I've been doing some work in Argentina and what I learned there helped me with my work here," Williams said. "It's a really good interchange."

These accomplishments in science and technology offer only a sampling of the research that has been carried out in the Third World for many years. They indicate the scope of research activities, and although the emphasis often differs from similar activities in the North, the North can nevertheless benefit from them. The next chapter examines these differences and benefits more closely.

CHAPTER 5

MARCHING TO A DIFFERENT DRUMMER

The methods of science are everywhere the same; so, in that sense, science is international. The applications of science are nationally oriented, however, and the technologies are culture specific. From that viewpoint, science and technology often differ in the North and South. One of the differences is that in the South more must be done with less, and at less cost.

Health-care systems in the South cannot provide many of the services that the North takes for granted, for example. There is simply not enough money available, and in many cases there are not enough human resources.

This means that approaches toward health care in the South and North differ from one another. In some countries, until recently, the health systems attempted to copy the model of a former colonial power. That approach is changing, however, as health-care providers recognize that systems conceived for the North could be quite unsuitable for the South.

The search for cheaper alternatives in the South has sometimes benefited the North, as shown by the treatment of tuberculosis. In the 1960s, countries such as Canada controlled the disease by admitting patients to large sanatoriums for long stays. This treatment was expensive, in terms of both patient costs and lost productivity. India could not afford similar treatment, so tuberculosis patients were usually treated at home. Research by WHO in India showed that well-supervised drug treatment at home, without the bed rest and special diet considered necessary in Canada and the United States, was just as effective as hospitalization. Nor did it expose family members to any special risk, as feared. Today in the North, the old sanatoriums are closed or used for other purposes, and in both North and South treatment of tuberculosis is more effective. And it is the North that has benefited most from the massive savings the research in India proved possible with home care (WHO 1988).

Using Traditional Knowledge

Over the centuries, the countries of the South have developed their own ways of treating illness. These systems are known to international agencies as "traditional medicine." In the past, these methods were often denigrated or ignored by the medical profession in the North. Too often they were not considered worthy of notice because they were not based on the same scientific concepts as "modern medicine." Sometimes their practitioners were referred to slightingly as "witch doctors."

About 20 years ago, attitudes in the North began to change. During the 1970s, WHO, for example, set up a Working Group on Traditional Medicine. Writing in a special 1977 issue of the WHO magazine, *World Health*, the Director General, Dr Halfdan Mahler, said:

> For far too long, traditional systems of medicine and "modern" medicine have gone their separate ways in

> mutual antipathy. Yet are their goals not identical — to improve the health of mankind and thereby the quality of life? Only the blinkered mind would assume that each has nothing to learn from the other.

WHO recognized traditional medicine because most of the world depends on it for primary health care, and its practitioners constitute a potentially important resource for health-care delivery. In addition, medicinal plants used in traditional systems are very important to human health.

In 1991, WHO defined traditional medicine "as comprising therapeutic practices that have been in existence, often for hundreds of years, before the development and spread of modern scientific medicine, and are still in use today. These practices vary widely, in keeping with the social and cultural heritage of different countries" (Mahler 1991).

WHO does not blindly endorse all forms of traditional medicine. It recognizes that although many elements are beneficial, others are not, and "some are definitely harmful." WHO's role is to explore the merits of traditional systems in light of modern science to maximize useful practices and discourage harmful ones, and to promote their integration with scientific medicine.

Making Medicines from Plants

One of the most active areas of research is evaluation of plant-based traditional remedies. In India alone, 500 million people depend on plant-derived drugs for their health needs. WHO has estimated that by the turn of the century about 80% of the world's population will rely on plant-based medicines. Yet, although the importance of medicinal plants is growing, the number of plants is declining.

WHO is trying to encourage local production of pharmacologically active products as substitutes for imports and for use in national drug programs. The natural products division of the US National Cancer Institute screens thousands of plants annually for substances with anticancer activities. These plants come from the oceans and tropical forests of more than 25 countries in Africa, Asia, and Latin America (Hart 1991). Whenever possible, those who collect the specimens seek the knowledge of local healers about the plants, hoping to profit from this vast resource before both traditional medicine and the forests disappear.

"It's a race against time," says ethnobotanist Paul Cox of Brigham Young University, Provo, Utah. "I think we have only about another 20 years."

In the 1970s, Zaire established the first African national research program on traditional medicine. Sponsored by IDRC, the study by the country's national Research and Development Board — which had a department of traditional medicine for several years — involved 600 healers and 4 000 patients. The project studied how the healers operated, who they were, what plants they used in their herbal remedies, and what success they had.

By that time, many other African countries — including Benin, Ghana, Guinea, Mali, Nigeria, Rwanda, Tanzania, and Togo — had established national centres to study the plants used by healers. Dr Oku Ampofo, then Director of Ghana's Centre for Scientific Research into Plant Medicine and one of the first Western-trained doctors to take traditional medicine seriously, said that clinical trials showed that traditional African medical treatments for guinea worm (a parasite) and *Herpes zoster* (shingles) were highly effective, while there was no effective remedy for either condition in modern medicine. The traditional treatments used a concoction of roots of *Combretum mucronatum* for guinea worm, while the root bark of *Balanites aegyptiaca*, when ground into powder and made into a paste, healed *Herpes zoster* lesions within a week. He also claimed success with herbal remedies for diabetes mellitus and bronchial asthma.

Modern Science Examines Ancient Remedies

Two members of the Diabetes Research Institute in Britain's Aston University, Birmingham, reviewed traditional plant medicine treatments for diabetes, which they called "possibly the world's fastest growing metabolic disease" (Bailey and Day 1989).

They said that "since the availability of insulin, folklore medicines for diabetes have almost disappeared in occidental societies, although they continue to be the cornerstone of therapy in underdeveloped regions. Renewed attention to alternative medicines and natural therapies has stimulated a new wave of research interest in traditional practices, and the World Health Organization expert committee on diabetes has listed as one of its recommendations that traditional methods of treatment for diabetes should be further investigated."

More than 400 different plants and plant extracts have been described as reputedly beneficial for diabetics, the researchers said. Most claim hypoglycemic (blood-sugar lowering) properties, "but most claims are anecdotal and few have received adequate medical or scientific evaluation."

Yet review of 140 publications persuaded the researchers that "the study of such medicines might offer a natural key to unlock a diabetologist's pharmacy for the future." They concluded that while traditional antidiabetic plants were unlikely to produce "an orally active botanical substitute for insulin," they might lead to new ways of stimulating insulin production in diabetics through the development of new compounds. Or they might be useful "as simple dietary adjuncts to existing therapies."

Later studies by Indian medical researchers showed a leaf extract of *Gymnema sylvestre* did indeed reduce insulin requirements in some patients, as a result of an apparent increase in their bodies' production of the hormone. The researchers also found the plant extract appeared to slow the artery-hardening complications that appear in diabetics (Baskaran et al. 1990; Shanmugasundaram et al. 1990).

Why Seek Traditional Healers?

During a visit to the IDRC project in Zaire, I learned that healers seek not only the physical, but also the emotional and spiritual causes of illnesses. They view the patient's life as a whole. They live with the people they treat and in most cases know a lot about their patients and their families — and their treatment takes account of such factors.

All the healers I met seemed very different from the stereotypical view Northerners have of "witch doctors." For the most part, they were just ordinary people — unassuming and even rather humble, with a genuine interest in helping humanity. Their occupation was regarded as a trust, but it also brought them status. These healers were open about their treatment methods and, like doctors everywhere, they were willing to share their experiences.

Traditional medicine also flourishes in Indonesia. When I visited North Sumatra University, Dr Hasjim Effendy, then head of the physiology department in the medical school, said he was sometimes surprised by the effectiveness of the treatments of the *dukuns*, as traditional healers are called. They were particularly skilled in setting bone fractures and dislocations, and the healing process seemed to progress faster than with modern medical treatments.

Researchers in an IDRC-sponsored study in Indonesia concluded it was desirable to have *dukuns* participate in the health system, and recommended their integration into national health services, as was already being done in Java with *dukuns* specializing in childbirth.

There Are Differences

Dr Ampofo once explained why traditional healers so often serve their patients well (Nichols 1982):

> The approach of the traditional practitioner to his patient is quite different from what we get in Western medicine. Western doctors are interested in the disease the patient suffers from, and the traditional healer is interested in the person, making him whole completely. Sometimes in Western medicine the doctor relies mainly on laboratory reports. He may spend about two or five minutes only with the patient and just give him a prescription. There is no empathy between the two. The traditional herbalist will study a patient even for a

> couple of hours, for a whole day, before he treats that patient, taking into account the patient's religious belief, his cultural background; and I think our system is a much better approach because you deal with the whole personality and not just his disease.

More recently, the Dean of Benin University's Health Sciences Faculty, Dr Eusèbe Alihonou, said of his country's use of traditional medicine practitioners in health research (quoted in Badou 1994):

> Their inclusion represents a philosophy of building the new on the old, as the Beninois like to say. The new rope is spliced onto the old. We have to work together with traditional healers, who are great repositories of local knowledge. They are also members of their communities, just like the local peasants.
>
> By the way, we have made a point of dealing with genuine peasants, not with retirees or intellectuals who occasionally dabble in farming. Some might wonder what peasants could possibly know about research; let me assure you, they know quite a lot.... There are undoubtedly intellectuals among the peasants who know how to look for ways to solve their problems. If for no other reason, community members — peasants — must be involved in research.

But There Are also Similarities

Some of the North's medical community consider that medicine and psychiatry in the North and the South have much in common. In 1977, neurosurgeon C. Norman Shealy wrote in *Occult Medicine Can Save Your Life* (Shealy and Freese 1977):

> As I see it, physician, witch doctor, shaman, medicine men are all essentially faith healers and have always been.... A careful study by Dr Jerome D. Frank, professor of psychiatry the Johns Hopkins University, revealed that the recovery of American soldiers from schistosomiasis, a parasitic blood infestation, was dependent on the men's emotional condition; those who failed to recover were found to feel unloved and to have lost faith in their doctors. Even full recovery from

> Asian flu, as has been clearly shown by a Johns Hopkins medical team, depends on the emotional state of the patient, something which the doctor — the healer — can handle only by providing the love and faith these soldiers with *schistosomiasis* lacked.

Psychiatrist E. Fuller Torrey opens his 1973 book, *The Mind Game: Witch Doctors and Psychiatrists,* with the statement: "Witch doctors and psychiatrists perform essentially the same functions in their respective cultures. They are both therapists; both treat patients using similar techniques; and both get similar results. Recognition of this should not downgrade psychiatrists; rather, it should upgrade witch doctors."

Torrey says the term "witch doctor" apparently arose out of the 18th and 19th century European exploration of Africa, when new cultures "were rapidly assigned their proper status in The Order of Things."

> We were white; they were black. We were civilized; they were primitive. We were Christian; they were pagan. We used science; they used magic. We had doctors; they had witch doctors. This simplistic reductionism is still remarkably prevalent in our thinking about other cultures, though it is being reevaluated. It afforded an easy way to inflate the self-esteem of the white races, though, of course, at the expense of others.

Books like Shealy's and Torrey's show how, in its development of a more holistic approach during the 1970s, Northern medicine underwent a rapprochement with the methods of traditional medicine in the South. Both authors urged study of traditional medicine's approach and the integration of it and other nonscientific systems into the North's medical systems.

Today, this more open approach to healing has led to a full-fledged movement in the North called "mind–body medicine." In a 1993 compendium of essays by leaders in the field, Daniel Goleman and Joel Gurin note that "the use of these approaches is becoming more widespread and they are gaining more respect and interest from researchers in major medical institutions."

Their book was endorsed by the Fetzer Institute, a non-profit US educational organization that promotes "scientifically tested health care methods that utilize the principles of mind–body phenomena" and publishes a quarterly journal, *Advances*. At least one national conference is held annually on this theme; the US National Institutes of Health has hosted a workshop on alternate therapies; and, in 1993, the Public Broadcasting System aired a five-part series called "Healing and the Mind," sponsored, in part, by an insurance company.

The South as a Laboratory of Ideas

The difference between conditions of life in the North and the South, and in the approach often taken by scientists from these regions, have given rise to new perspectives that will benefit both. One example is Dr Osuntokun's work in coronary artery disease.

Coronary Disease and the Third World — Dr Osuntokun, whose work with tropical ataxic neuropathy was described earlier, had as his doctoral supervisor Dr Adetokunbo Lucas, former head of WHO's Tropical Medicine Program and currently Professor of International Health at Harvard University's School of Public Health.

In a telephone conversation, Dr Lucas noted Dr Osuntokun's studies showing that coronary artery disease was relatively rare among Africans until recently. Autopsies in Africa and in the United States showed great differences in the amount of fat deposits on the insides of arteries — which lead to heart attacks and strokes — between people in Nigeria, Senegal, Uganda, and the United States.

"Those studies should have been followed up because they indicated quite clearly an environmental cause to atheroma, much more strongly than I think most of the other studies had shown," said Dr Lucas. "One of them, for example, showed that among women 60 years old, about 60% of their cerebral vessels were free of atheroma [fat deposits].

"The situation is now changing dynamically in the sense that the younger generation of Nigerians are now beginning to show complications of atheromatous changes, presumably as a result of lifestyle changes such as diet and cigarette smoking. It would have been very nice if we had been able to monitor the evolution of this as a new disease in the area. In developed countries it's very difficult to define a truly low-risk group, and yet when I was a clinician in Ibadan for 16 years [from 1968 to the mid-1970s], I did not see one case of acute myocardial infarction [heart attack] in Nigeria. I was in a teaching hospital where they were doing 1 200 autopsies a year. We saw [infarctions] among British and Lebanese; [but among Nigerians] postmortem arteriograms showed arterial vessels were clean and open. That position has now changed and people are now falling down dead with acute myocardial infarction."

Alzheimer's Disease, North and South — Dr Osuntokun's more recent investigations have taken him into another field of major interest to the industrialized world: dementia of the elderly, especially Alzheimer's disease.

Developing countries currently contain more than half the world's population of elderly, and that proportion should reach 75% by the year 2020 (Osuntokun et al. 1992). Alzheimer's disease accounts for two-thirds of dementia of the elderly in Caucasian populations; but, apart from reports from China, there is little or no information on dementias of the elderly in developing countries. Osuntokun's studies suggest Alzheimer's is rare among black Africans in Africa, yet black Americans of African lineage commonly suffer from it.

"We emphasize the potential value of cross-cultural epidemiological studies of ethnic groups in different environments and with difference prevalence ratios of Alzheimer's disease, in identifying putative environmental factors for this disease," the authors say.

Comparative studies are now underway between Africa and the United States, and the researchers believe they may well reveal risk factors that are prevalent in the North, but relatively absent in the South. If it were possible to reduce the risks, the incidence of Alzheimer's could, perhaps, be reduced in both the North and the South.

Prostitutes and HIV — One of the few recent promising discoveries in the worldwide attempt to conquer AIDS (acquired immune deficiency syndrome) comes from a slum called Pumwani in Nairobi, Kenya. A project funded by IDRC and other Canadian agencies (Plummer et al. 1993) has revealed that the immune systems of some prostitutes appear to prevent them from becoming infected by HIV (human immunodeficiency virus). This finding contradicts accepted theories about the cause of AIDS: no immune responses are known that will protect the body against HIV infection.

The project's findings also contradict another tenet of current HIV knowledge — that all individuals are supposed to be equally susceptible to infection, and that the risk increases with increasing exposure to the virus.

The Canadian and Kenyan researchers found that women who had been prostitutes for the longest time seemed to have the lowest frequency of HIV infection. A small percentage of the women enroled in the study repeatedly tested negative for HIV, while a large percentage tested positive. The apparently immune group has since remained HIV negative for up to 8 years.

Searching for possible explanations, the researchers found that the apparently immune group had more, not less, potential exposure to HIV, because its members had more clients and reported no more condom use than the others. Nor did these women have fewer other sexually transmitted diseases than the other prostitutes — which could have helped explain the discrepancy because these other diseases make HIV infection more likely.

The reason for the apparent immunity remains a mystery. A similar phenomenon has been found occasionally in other countries among small groups and individuals who have avoided development of AIDS for long periods despite being HIV positive. These groups and individuals, together with the small group of Kenya prostitutes, could serve as a model for further research. Such models — currently exceedingly scarce — are vital to scientists' understanding of how HIV works. The Kenya research may prove helpful as the basis of further research that might lead to development of an HIV vaccine.

Lessons in Longevity from China

It may seem surprising that a country like China, which for decades has found it difficult to provide adequate food for its hundreds of millions of people, could teach the North anything about diet. Yet, an article in *New Scientist* (Vines 1990) reports that:

> Since the birth of the People's Republic in 1949, China has experienced a revolution in public health. In one of the great medical success stories of our century, the Chinese have largely won the battle against malnutrition, and infectious and parasitic diseases. At the death rates of the 1940s, about half the children born in China could expect to die before reaching middle age. But at current death rates, more than 90% can now expect to survive to middle age, as in the West, and China has achieved this "epidemiological transition" in less than half the time it took Britain.

The article was based on what was then the latest in a series of publications resulting from a huge nationwide survey of the causes of all deaths in China between 1973 and 1975. About 6 000 people worked on the survey, which covered 96% of the population. One of the largest epidemiological surveys ever conducted, "Diet, Life-style, and Mortality in China," was updated in 1989.

The study involved researchers from both the North and the South, and revealed some interesting contrasts between causes of death in China and Britain. Cholesterol-related diseases accounted for one-third of all deaths among middle-aged Britons whose diets were rich in saturated animal fats.

"In Britain, an average of between 40 and 45% of dietary energy comes from fat, but in rural China in 1983 only 15% did so, and virtually all that came from plant fats, not animal or dairy fats," reported *New Scientist* (Vines 1990). "As a result of this largely vegetarian, almost vegan diet in rural China, cholesterol levels are, by Western standards, extraordinarily low, and coronary heart disease is rarely recorded as a cause of death."

Richard Peto, of the ICRF Cancer Studies Unit at the University of Oxford, one of the study's collaborators, said: "The

Chinese experience shows that most of Western coronary heart disease is unnecessary."

Industrialization has brought many life-style changes to China. Consumption of animal fats, for example, has increased. This has made China a sort of living laboratory for epidemiology, where changes can be correlated with disease. Not surprisingly, the study found that increased meat consumption increased diseases such as heart attacks, cancer, and diabetes.

In a recent conversation, Dr Peto explained why developing-country studies like the one in China are valuable:

> They give us a better idea of what normality might be. In terms of epidemiology, looking at populations that differ from Western populations is useful because it shows that every disease that is common in the West doesn't have to be common. Overall, our death rates are lower than those in developing countries and we're less likely to die before middle age and in middle age, so it's not that they're healthier than us. But whatever diseases are common in the West, you can find some other population where they're not common. This is one of the perspectives that is provided by research in developing countries — that every disease that is common among us doesn't have to be. It's not normal to get coronary artery disease in middle age. It's not normal to have a lot of intestinal cancer.

Prediction: Half a Billion Deaths from Tobacco

WHO studies of tobacco consumption show how vital research in this field is. According to the WHO Collaborative Group, the developed world is responsible for most deaths from smoking during the current century. By the next century, the emphasis will shift to the developing world.

In many parts of the developing world, more than half the men are smokers, and death rates from chronic disease are already high in many parts of Asia and Latin America.

Over the past few decades, there has been a massive global increase in cigarette smoking — the chief effects of which will not be seen until the next century. Smoking causes deaths not only from lung cancer, but from many other diseases, and risk factors vary from region to region. Although the risk of death from cardiovascular diseases is not as high among Third World smokers as it is among smokers in the developed world — because of their lower exposure to other risk factors such as high blood-cholesterol levels — the high prevalence of respiratory diseases in the Third World may greatly increase vulnerability to pulmonary diseases.

In 1990, the WHO consultative group on statistical aspects of tobacco mortality, chaired by Dr Peto, reported the following in the *Proceedings of the 7th World Conference on Tobacco and Health* (WHO 1990):

> During the 1990s, there will probably be about 3 million deaths per year from tobacco. About 2 million will be in developed countries, but estimates for other countries are not yet as reliable, so the total of 3 million has an uncertainty of about one million either way.
>
> Worldwide mortality from tobacco is, however, still rising rapidly (particularly in the less developed countries), partly because of population growth but chiefly because previous large increases in cigaret smoking by young adults will have caused large increases in mortality by the time the young adults of today are middle aged.
>
> On the basis of current smoking patterns, the date when worldwide annual mortality from tobacco will exceed 10 million (of which about 3 million will then be in developed countries) probably lies sometime in about the 2020s. (Those aged 35–69 in 2025 were aged 0–34 in 1990.)
>
> Without large reductions in early smoking uptake or smoking persistence, there will probably be over 10 million deaths per year during the second quarter (2025–2049) of the next century. This would mean that over 200 million of today's children and teenagers will be killed by tobacco, as will a comparable number of today's adults, i.e. that a total of about half a billion of the world population today will be killed by tobacco. Some will already be over 70 and might have died soon anyway, but about a quarter of a billion will be 35–69, losing on average about 20 years of life.

These predictions, reported the Consultative Group, are based on the best currently available evidence of what it calls "this great epidemic." But they still need to be reinforced or modified in several different parts of the world — for example, parts of China, India, and Latin America — by large prospective studies that progressively record smoking habits over the years.

What is important is that such studies could be used to help modify behaviour and decrease smoking and, therefore, reduce the deaths produced by this worldwide epidemic.

Making Health Policy Decisions Together

The realization that it is impossible to provide everyone everywhere with high-quality, affordable health care led to the establishment of a nongovernmental organization within the UN in 1993 (Wilson 1994). Known as the Council on Health Research for Development (COHRED), it included 38 countries, agencies and organizations, and a 17-member board of directors, of whom 12 members were from developing countries.[9]

Before COHRED was formed, the world's poor rarely participated in decision-making affecting their health. The emphasis, moreover, was mainly on new technologies, rather than on providing affordable services. The Essential National Health Research (ENHR) strategy was evolved through COHRED to help mainly poor countries make difficult choices and solve problems using scientific methods that involve their own people, researchers, and decision-makers. Some countries are already using this strategy. In Benin, Professor Alihonou is the Director of the Regional Health and Development Centre (CREDESA), which is responsible for ENHR.

CREDESA has developed a community-based information system for use by local residents. Its representatives spend time in

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[9] IDRC and the Swedish Agency for Research Cooperation with Developing Countries (SAREC) were intimately involved in COHRED's formation, along with the Edna McConnell Clark Foundation in the United States and the German Agency for Technical Cooperation (GTZ).

the villages, explaining research results to residents, organizing seminars, and using songs to teach sound health principles. For example, in teaching about nutrition, health-care professionals and parents develop menus together that reflect the parents' purchasing power and the family food supply. Later, the mothers prepare the menus by themselves. These teaching methods are much more economical than traditional ones.

In Bangladesh, spurred by ENHR, a group of young researchers are trying to solve the country's basic health problems. Previous policy has largely neglected the socioeconomic aspects of peoples' lives. Under the new strategy, university lecturer Golam Azom is trying to determine the socioeconomic characteristics of drug addiction on families in a northern Rajshahi town. He wants to know what drives people to their addictions, what types of drugs they use, and the impact of drug abuse on their families. His findings should assist in finding ways to help affected families to curb drug abuse.

In Bangladesh, there are projects to assess the efficiency of health-care delivery by hospitals. Their findings will be disseminated among policymakers and the media.

In specific instances, when compared to the North, the South will be seen to be marching to the beat of a different drummer. In health systems research, where the North is considered light years ahead of the South, it seems that knowledge from the South can benefit the North. Today, both the South and the North are searching earnestly for ways to reduce escalating health-care costs. Collaborative efforts such as ENHR's approach could help both find optimal solutions to their health problems.

Toward Sustainable Development

Since the 1992 Rio Earth Summit (United Nations Conference on Environment and Development, UNCED), adoption of the principle of sustainable development has been a major Third World development thrust. Says a World Resources Institute (WRI) publication (Faeth 1993):

> Throughout the world's farming regions, such problems as salinization, erosion, soil compaction and waterlogging, water pollution and depletion, and desertification indicate that much of today's agriculture is unsustainable. The damage can no longer be ignored, not when 1.2 billion hectares of land — an area as large as India and China combined — have been seriously degraded since 1945.... If current land degradation trends are allowed to continue, farmers will be extremely hard-pressed to grow enough food, fuel, and fibre for the more populous world of the next century. Erosion alone has destroyed an estimated 430 million hectares of arable land.
>
> Without conservation measures, 500 million more hectares of the developing world's rainfed cropland may become irreversibly unproductive over coming decades. To keep up with growing demand, agriculture must be put on a sustainable footing.

Yet despite the need, there is no consensus on what agricultural sustainability means, the WRI said. The authors of its case studies devised analytical methods of quantifying the financial, economic, and environmental costs and benefits of conventional and alternative production systems. Previous comparisons have ignored the impacts of the different systems on natural resources — a critical omission. The following are among the study's findings:

— The Indian study focused on alternatives to conventional rice paddy–wheat rotation systems in a semi-arid district of the Punjab. The area requires heavy dosages of inorganic fertilizers and pesticides, repeated deep plowing, and heavy use of groundwater. Eighteen combinations of tillage, irrigation, and fertilization practices were analyzed for paddy–wheat, and three more for maize–wheat. Conventional paddy–wheat rotation was found to be more environmentally damaging, less profitable to farmers, and less economically valuable to society than alternative farming systems that conserve natural resources.

— In Chile, the study found that the existing price structure and cost–benefit ratio give peasant farmers — but not commercial farmers — financial incentives to adopt organic practices.

— In the Philippines, the benefits of natural pest control were clearest when pesticide-related health costs were accounted for. The authors proposed that national pesticide policies should greatly restrict use of the most hazardous pesticides and eliminate all subsidies on pesticide use.

— In the United States, the authors concluded that recent changes in agricultural legislation fail to provide the incentives needed to move farmers toward sustainability. The incentive structure of the farm program in fact works against sound resource management. Farmers who plant crops to control pests and manage soil fertility receive less government support than those who follow the program if the crops they plant are not on the approved list.

Insuring Food for the Future

What is being done to ensure agricultural sustainability in the Third World?

The IARCs, once criticized for heavily promoting chemical fertilizers in their "green revolution" production systems, now emphasize farming techniques that increase crop yields without compromising future productive potentials of the agricultural resource base. This is illustrated by the inclusion of two new centres devoted to research on trees: the International Center for Research on Agroforestry (ICRAF) and the Centre for International Forestry Research (CIFOR). Another example is a major project with sustainability goals established by the International Potato

Center (CIP) in the Andean highlands. The two main principles of the project are preservation of genetic diversity in the region and development of better land-use systems.

Central to CIP's genetic diversity program is the work of 73-year-old Carlos Ochoa, who for 40 years has roamed the rugged Andes mountains and valleys in search of wild potato species (CIP 1993). Ochoa has discovered 80 of 240 known wild potatoes — more than any other individual. Three have been named after him. And, for his work, he was awarded the Bernardo A. Houssay Inter-American Science Prize by the Organization of American States in Washington in 1992.

In discovering and preserving wild species, Ochoa and other collectors provide the genetic diversity enabling scientists to develop new varieties that will grow under difficult environmental conditions, produce higher yields, or resist insect pests and disease. In the Andes, there was serious danger of losing this diversity. As farmers migrated to the cities, they abandoned potato fields and terraces that had been cultivated for thousands of years, and where wild species were dying out as a result of erosion, deforestation, and the harmful effects of chemical pesticides. Many of the species Ochoa saved are now believed to be extinct in the wild — buried under volcanic ash, destroyed by bulldozers building the Pan American highway, or crushed under slums in the outskirts of Lima.

Ochoa's long searches have taken him into dangerous territory. Near the Peruvian village of Chota, a band of thieves mistook him for a treasure hunter and tried to kill him. He escaped with a wild potato species by hiding under a rocky overhang. Another time in Colombia, he rescued a wild species from destruction by a volcano that had lain dormant for years, but erupted just after he left the mountainside.

Ochoa's prize find was the potato species described by Charles Darwin in the 1830s. Ochoa found it in 1969 in the exact spot Darwin had — in a cove in the Chiloé Archipelago off the coast of Chile.

This hardy Peruvian explorer–scientist, a Fellow of the Smithsonian Institute in Washington and the Linnaeus Society, comes from an unlikely background. He is the son of a wealthy landowner, and, until joining CIP in 1971, he financed most of his own expeditions. He is a graduate in agricultural engineering from the University of Cochambaba, Bolivia, and the University of Minnesota in the United States. Before joining CIP, he was professor of plant breeding at Peru's Universidad Nacional Agraria in La Molina.

Ochoa's work is helping to solve what UNEP calls, in its 1992 publication, *Two Decades of Achievement and Challenge*, "one of the most pressing environmental and development issues today" — the loss of the Earth's biological diversity. "About one quarter of the Earth's species may be lost within the next 30 years," states UNEP. "With each species that disappears, developing countries — stewards of most of the planet's biological wealth — lose potential for sustainable development."

Fighting the loss of biological diversity and working for sustainable development does not benefit just the South. The North also depends on the Earth's biological wealth for its well-being, and, as that dissipates, its citizens will become poorer.

Managing Pests with Less Chemicals

The "green revolution" that saved millions of people from starvation and helped make a number of Third World countries self-sustaining in the production of rice and wheat, depended largely on heavy use of chemical pesticides for its success. The ill effects of pesticide overuse on the environment and on personal health are well known, and recently it has been shown that, in at least some cases, the health costs of pesticide use outweigh the economic benefits for farmers.

A major study in 1993 on the health effects of pesticide use on rice showed that Filipino farmers' earnings from crops treated with pesticides were invariably negated by the cost of treating health problems caused by the pesticide (Pingali and Rola

1993). In the place of pesticides, international institutes are now promoting integrated pest management (IPM) programs. These programs emphasize nonchemical methods of pest control, such as planting of pest-resistant varieties and the pests' natural enemies to destroy them. Pesticides are not excluded, but are used only when necessary to prevent crop and profit losses. Even then, the pesticides are selected on the basis of human and environmental safety.

Working with the International Rice Research Institute (IRRI) and the Food and Agricultural Organization of the United Nations (FAO), scientists in China, India, Indonesia, Malaysia the Philippines, Thailand, and Viet Nam are now showing that, through IPM, farmers can substantially decrease their reliance on chemicals for pest control. Farmers, local government officials, and extension and research staff participate in FAO's IPM program.

In selected Asian national programs that collaborated with the FAO program in 1990 and 1991, more than 1 million person-days of field training was undertaken (FAO 1991). Farmers' profits were calculated to have increased by more than $60 per hectare after training. In one village near Yogjarkarta, a farmers' group paid more than 25% of their monthly incomes for 3 months to support a full season of the IPM Farmers' Field School. IPM-trained farmers in West Java attained higher than national average yields in demonstration sites with 80% less pesticide use. In Bangladesh, trained farmers spent 60% less on pesticides, yet found their profits increased by 15%.

Voracious Enemies of the Green Spider Mite

Scientists in South America and Africa are also involved in helping farmers with IPM programs. The International Center for Tropical Agriculture (CIAT) in Colombia and the International Institute of Tropical Agriculture (IITA) in Nigeria are collaborating to help cassava farmers protect their crops against its most important pest: the green spider mite (CIAT 1993). This mite has spread from various parts of South America to northeast Brazil and Africa, where it has few natural enemies. It defoliates new cassava leaves, stunting the plant's growth and reducing its yield, or killing it outright.

A species of predatory mites (phytoseiids) helps control the spider mite. It does so with horrifying effectiveness — jumping onto its prey and sucking out its stomach contents, leaving nothing but a desiccated carcass. Two members of this species, originally from Brazil, were successfully established in Africa through a multinational effort organized by IITA, in collaboration with CIAT and Brazil's national agricultural research agency, EMBRAPA.

Another predatory insect farmers can breed is the *Polistes* wasp, which attacks another pest — the cassava hornworm. The wasp's technique is even more blood-curdling: it stings and paralyzes the hornworm, cuts it into strips, and carries the pieces back to the nest to feed its young.

CIAT entomologist Dr Anthony Bellotti says Brazilian farmers concoct a "green milkshake" to protect 30 000 hectares from the hornworm. "The milkshake is a homemade pesticide made from virus-infected hornworms liquefied in water with a kitchen blender. It harms only the hornworm," he explains.

Integrated pest management is currently gaining interest in the North. And the North could benefit from its use at least as much as Third World countries do — perhaps more, considering the gargantuan load of chemicals industrialized countries dump daily into the environment. But as the US part of the World Resources Institute study indicates, much more needs to be done. Perhaps much of that could be learned by the North from experience gained in the South. The next chapter will examine further the need for North–South collaboration, and particularly why it is essential if we are to solve major global problems that affect both North and South.

CHAPTER 6

SOLVING GLOBAL PROBLEMS TOGETHER

Previous chapters have illustrated how scientific and technological accomplishments in the South have sometimes benefited the North, purely by chance. The proposition put forward in this chapter is that because of the gravity and importance of certain problems that affect the population of our entire planet, these benefits can no longer be left to chance. They must be pursued deliberately, in an organized fashion, and through the collaborative efforts of both the North and South.

The Problem of Global Warming

During the summer of 1988, Canada sweltered in scorching, dry heat that destroyed crops and starved grazing cattle. Toronto baked for days under record-breaking heat in the hottest July since 1955. Great Lakes water levels sank to decade-low levels.

The heat and drought were felt in parts of the United States. And many other countries, including what was then the Soviet Union and India, experienced record-high summer temperatures (Spurgeon 1989).

Scientists had talked about the dangers of global warming for decades, and although they publicly disagreed on whether 1988's record temperatures were evidence of this phenomenon, the scorching heat finally brought their warnings home.

For example, while reports of heat and drought were appearing in the media, more than 300 policymakers, scientists, and corporate and environmental leaders from 46 countries were gathered in Toronto at a meeting sponsored by the Canadian government. The concluding statement of *The Changing Atmosphere: Implications for Global Security* (McMillan et al. 1988) reads:

> Humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war. The Earth's atmosphere is being changed at an unprecedented rate by pollutants resulting from human activities, inefficient and wasteful fossil fuel use and the effects of rapid population growth in many regions. These changes represent a major threat to international security and are already having harmful consequences over many parts of the globe.

The changes involve what is now widely known as the "greenhouse effect": the trapping of heat within the Earth's atmosphere by gases resulting from human activities. These gases act like a thermal blanket on a swimming pool, which lets the sun's rays through to the water's surface but prevents the heat from escaping. The greenhouse gases, said the conference report, would cause the world's climate to warm, altering rain and snowfall patterns, raising sea levels, and bringing more frequent climatic extremes such as heat and cold waves and storms. In turn, these changes would imperil human health, threaten food and water supplies, and increase political instability.

Two other atmospheric changes are associated with the greenhouse effect: depletion of the atmosphere's ozone layer, which protects humans and plants against excessive ultraviolet radiation from the sun, and the long-range transport of air pollutants, some of which cause acid rain. Ozone depletion increases the incidence of human skin cancers and cataracts, and depresses the body's immune response. It can also reduce the productivity of plants and harm aquatic life. Acid rain damages lakes, soils, plants, animals, forests, and fisheries and also corrodes buildings and metal structures.

In *Two Decades of Achievement and Challenge,* UNEP (1992) says: "Global warming will accelerate sea-level rise, modify ocean circulation and change marine ecosystems, with considerable socioeconomic consequences. Sea levels are expected to rise by 20 centimetres by 2030 and 65 centimetres by 2100, flooding low-lying islands and coastal areas. Cropland could disappear, water supplies could be contaminated and tens of millions of people could lose their homes."

And There Came a Great Flood

In 1987, Male, capital of the Maldives, was inundated by record-high waves. The next year, the waves swamped the island of Thulhaadhoo. Few of the country's 1 196 islands rise above 3.5 m and the majority of its people live less than 2 m above sea level. The international airport would be flooded regularly if the seas rose by only half a metre, and the staple crop, the taro root, is grown in pits dug only about 40 cm above sea level.

High tides already submerge parts of Tuvalu twice a year. Tokelau, the Marshall Islands, and Kiribati are at similar risk. The Marshall Islands' government has warned that many of its 50 000 inhabitants will be evacuated over the next few decades, and the foreign minister told the Earth Summit meeting (UNCED) that rising seas "could annihilate the Marshall Islands as effectively as a nuclear bomb" (Lean 1994).

Small Nations of the World Unite

In Nairobi in April 1994, an alliance of 36 of the world's smallest states — "the world's least likely power bloc" — met to combat the threat of rising seas, which could wipe at least seven island nations off the map (Lean 1994). The Alliance of Small Island States (AOSIS) was launched at the Second World Climate Conference in Geneva and includes countries from five continents, and the non-island nations of Guyana and Belize, which are also threatened by rising sea levels.

None of these islands contributes much to global warming: they burn little fossil fuel. They consider themselves, therefore, the most vulnerable to global warming yet the least responsible for it.

Before AOSIS was formed, small island states had little bargaining power among blocs of nations. Once they joined forces and controlled one-sixth of United Nations' votes, they found themselves courted in election campaigns for the UN Security Council. AOSIS succeeded in obtaining special recognition of island nations at UNCED in 1992, and continuing pressure led to a UN Conference on the Sustainable Development of Small Island Developing States, illustrating what joint action can accomplish.

Global warming does not threaten just small island nations. Bangladesh, with millions of inhabitants living in areas already subject to extreme heat, drought, and flooding, would suffer severely from rising sea levels. It would have to consider building extensive dikes — or moving vast numbers of people long distances from the Ganges River basin and from near the sea. Low-lying areas in other countries would also be endangered.

The Rich and Powerful Are also Threatened

Many coastal areas in well-off countries would also be threatened. In 1984, Canadian scientists started to study what would happen to certain parts of the country if the amount of carbon dioxide in the atmosphere were to double during the next 50 years, as some experts expected. Two of the probable consequences they foresaw were:

— In Charlottetown, Prince Edward Island, a 1-metre rise in sea level would inundate expensive new waterfront developments, the harbourside complex, the convention centre, and the courthouse. It would also make the main marine terminal and coastguard docks vulnerable to storm tides, flood several city streets, threaten the storm sewer system and the sewage treatment plant, and possibly leave about 225 city buildings uninhabitable.

— There would be flooding in the lower reaches of the St John River in New Brunswick, with resultant risk to residential communities, the New Brunswick Power Plant in east St John, road and rail transportation (which would isolate the city from the East), industrial facilities, and sewage and industrial waste treatment lagoons. Rich farmland along the St John River, already subject to flooding, would be further inundated.

In the United States, according to Dr Ted R. Miller of Washington's Urban Institute, "an anticipated 1-metre rise in sea level probably will require diking and pumping or raising the land surface in many urban coastal areas, including more than half of the 20 largest metropolitan areas. The cost in Greater Miami alone could exceed $600 million over the next 100 years. Northeastern cities might have to spend billions on new water sources."

New Hazards to Health

Rising sea levels will not be the only hazard produced by global warming. Dr Janice Longstreth of ICF Clement, a US consulting firm, told a 1988 Washington conference that climate change may produce ill effects on human health through a number of mechanisms. Heat stress will increase in some areas, particularly for people who already work in hot environments such as steel plants, dry-cleaning establishments, or bakeries. People with heart and respiratory diseases may suffer more, both from the heat and from increased pollution. Increased pollen production may worsen the plight of those with allergic diseases.

A hotter climate might entice disease-carrying insects northward, bringing diseases like Rocky Mountain spotted fever to Montana and Halifax, and might cause a resurgence of malaria, a problem in parts of the United States as recently as the 1930s and 1940s. *Plasmodium falciparum*, which causes the most virulent form of malaria, has become resistant to chloroquine, the most widely used and effective antimalarial drug, and malaria is already spreading uncontrollably in parts of Africa and other tropical countries. Yellow fever could also make a comeback, said Dr Longstreth, "and we don't have enough vaccine."

Dr Andrew Dobson of the University of Rochester, New York, was more dramatic in his recitation of the impact of global warming on disease-causing organisms. "Sitting waiting in Central and South America is a vast army of diseases that could move into the United States," he told the 1988 Washington conference. He called Chagas' disease "one of the nastiest," and as indicated in the previous chapter, carriers of the parasite that causes Chagas' disease have already been found among US immigrants. Dobson said the assassin bug that carries the trypanosome is also present in small numbers in the United States, in opossums, armadillos, and domestic pets. Parasitic diseases of livestock, widespread in warm climates, could also spread northward and lower the animals' productivity, Dobson said. As noted earlier, there is no cure for Chagas' disease.

"In the health field as elsewhere, we are seeing a phenomenon of globalization," wrote Dr Adolfo Martinez Palomo, Chairman of the Mexican Committee for Basic Health Research (Morissette 1994). "Diseases do not respect frontiers. Tourists from the North sometimes bring tropical diseases back to their countries. We have seen how cholera, a disease that used to be thought of as typically Asian, can now cross the oceans and take root in Latin America, causing a veritable epidemic in Mexico (now under control). There is nothing to guarantee that it will not reach the United States one of these days."

The Need for Joint Effort

The North and South must attack these worldwide problems jointly. As noted in Chapter 2, developing countries cover 60% of the Earth's land mass, and many of the observations necessary to any program of a global nature must be made there.

"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, "but the scientific effort is very uneven [in the Third World]."

Because the scientific communities there often do not have the human, institutional, or financial capabilities to carry out the necessary research, USAID set up a Program in Science and Technology Cooperation to solicit proposals for collaborative projects to investigate global climate change in developing countries. These projects, at the same time, help build the capacity of Third World science to contribute to such research (USAID 1992).

For example, in an Indian study of monsoons, which control the region's agricultural cycle, Gyan Mohan of the Indian Institute of Technology in Kanpur collaborates with T.N. Krishnamurti of Florida State University. In an African study, John Halfman and Thomas Johnson of Duke University in the United States, assisted by Kenyan graduate student Patrick Ng'ang'a, observe core samples from the bottom of Lake Turkana in northern Kenya to read a rainfall record of thousands of years. Through computer and chemical analysis of the sediments, they found evidence that may link African rainfall with the El Niño–Southern Oscillation in the Pacific Ocean, off South America. These findings may help determine whether long-term climatic change is occurring in sub-Saharan East Africa.

More Power for the South

Although gathering data on global change is important, it is absolutely essential that the South actively cooperates in reducing global warming gases.

"By 2010 the share of total energy consumption accounted for by the rich countries will have fallen below 50% for the first time in the industrial era," says *The Economist* of 18 June 1994, quoting the latest International Energy Agency scenario for world energy. "The growth in energy consumption in developing countries between 2000 and 2010 will be greater than today's consumption in Western Europe. By 2010 their emissions of carbon dioxide, the main contributor to global warming, will be almost as big as those of the whole world in 1970."

The World Energy Council, based in London, England, forecasts under a high-growth scenario that world energy demand, dominated by Latin America and Asia, will triple over the next 30 years, while in North America it will rise by only 13%. By 2020, energy use in the developing countries will account for as much as 60% of the world total, compared with 30% in the OECD.

Reducing Greenhouse Gases

Third World countries are skeptical about pronouncements by the developed world that call for them to reduce energy consumption to control greenhouse gas emissions. It is the North — not the South — that has caused most of the global warming problem through the voracious consumption of energy. Why, the South asks, should we be made to curtail our development to solve a situation we did not create?

Although logic is on their side, global warming will affect the South even more than the North, so both should take steps to minimize the effects. For developing countries to cooperate in reducing production of greenhouse gases, the North must offer them the technology for more environmentally friendly energy-production methods. It must also offer financial support for research applicable to the needs of developing countries, and encourage collaborative programs. The countries of the South will not curtail their own development for what they see as the self-interest of the North, unless there are benefits for them, as well as for the industrialized world.

Disasters Affect Us All

When major natural disasters occur, the interests of North and South coincide. These disasters kill more than 1 million people every decade and leave countless others homeless, reported the Secretariat of the International Decade for Natural Disaster Reduction (IDNDR), during the World Conference on Natural Disaster Reduction in 1994 (UN 1994). More than 90% of these victims are in developing countries.

Economic losses from natural disasters are on the rise, retarding economic growth in both the North and South. The global cost of disasters rose from $44 billion in 1991 to $60 billion in 1992, and early estimates of the losses from the 1994 Los Angeles earthquake ranged between $15 and $30 billion. Since 1990, insurance payouts in the United States from natural disasters have quadrupled those made during the 1980s. And payments made in the 1980s quadrupled those of the previous decade.

IDNDR's objective is to reduce, through concerted international action, the loss of life, property damage, and social and economic disruption caused by these disasters. Closer cooperation is needed between all parts of society, nationally, locally, and internationally, says the Secretariat.

The earthquake on 30 September 1993 in Maharashtra State in India, killed 11 000 people. A volcanic eruption in Colombia in 1985, took 22 000 lives. A 1970 tropical cyclone, combined with high tide and heavy rainfall, left more than 300 000 dead and 1.3 million homeless in Bangladesh.

Changing Old Attitudes

"We would like to modify the present and traditional emphasis on disaster relief and to stress, instead, disaster prevention and mitigation," says Dr Olavi Elo, the Finnish physician who heads IDNDR. "Scientific and engineering progress in the past decade or so — satellite data gathering, greater understanding of weather phenomena, the behaviour of the Earth's crust and plate tectonics — has made this a realistic possibility. But the technologies have to be given to the developing world where the toll in human lives is rising sharply. People need to be trained in disaster preparedness, new building construction must be earthquake-resistant, early warning systems should be generalized, countries have to assess risks and produce hazard maps."

Dr Juan A. Madrid, of the Centro de Investigación Científica y Educación Superior in Ensenada, Mexico, said in an interview at ICTP in Trieste, Italy, where he was attending a workshop for Third World countries on earthquake prediction: "Phenomena connected with the Earth have nothing to do with political boundaries. An earthquake in Baja California will affect the people in the United States, just as an earthquake in the United States will affect people in Baja California. So we have to cooperate fully. If we have something useful to scientists in the North we'll give it to them, and if we consider they have something that could be useful to us, we'll ask for it. We have had very good cooperation. Very recently, we reached an agreement with the US Geological Survey (USGS) for exchanging [sensor data] virtually in real time. We also have direct access to the files of the USGS by Internet and to the California Institute of Technology. We will expand this collaboration in future."

Dr Keilis Borok, a director of Moscow's International Institute for Earthquake Prediction Theory and Mathematical Geophysics, who has since 1983 directed the ICTP workshops, agreed on the need for North–South collaboration.

"There are areas where hundreds of millions of dollars have been spent on [seismological] observation networks, yet earthquakes have occurred unpredicted," he said in an interview. "So this is not a problem of the Third World or the First World or the Second World, it is a problem [that requires] new basic research.... We need to train the leaders [and to have] joint teams. The [Third World] potential is very strong. In a way [the scientists of the South] are not so handicapped by tradition. If you look at a strong research team in the North, [you will find that] it's often led by people from the Third World."

Dr Borok stressed the need for more basic research worldwide in earthquake prediction. I interviewed him in November 1993; 2 months later, on 17 January 1994, a major earthquake shook Los Angeles. Damage was estimated at $13 billion. Scientists had detected no warning, despite their extensive sensing networks. Exactly 1 year later, the Kobe earthquake struck Japan, with a loss of close to 5 400 lives. There was no warning, and it had been commonly supposed that this area was relatively safe from such disasters.

"A perfectly candid appraisal would be that efforts to try to do short-term earthquake prediction have not yet proved to be successful," Robert Hamilton, a seismologist at USGS, told the *Boston Globe*.

North–South Collaboration Already Exists

The major body involved in promoting scientific collaboration internationally is the International Council of Scientific Unions (ICSU). It involves scientists from more than 130 nations, and many of its constituent bodies are concerned directly with issues involving the global environment (ICSU 1993). The international research programs organized by ICSU are designed to provide policymakers with the best available scientific knowledge for setting strategies for sustainable development.

The Earth's physical climate system is studied by the World Climate Research Program, which seeks to determine to what extent climate can be predicted and how human activities affect climate. Other international studies deal with the physical, chemical, and biological processes that regulate the entire Earth system, the Earth's life systems, its peoples and their environment, the oceans, the hydrological cycle, the terrestrial ecology, and the Earth's atmosphere. As described by ICSU (1993):

> The world's nations are increasingly interdependent. They participate in a global economy, with information, technology, and culture flowing almost as freely as the air. Even more important, they share a common global environment. Coal burned in one country may influence the climate of all; a species lost in one region is available to none.
>
> Thus, all nations have vital interests in global change, and they also have much to contribute to the common understanding of the Earth system. Satellites can scan the globe but much of the information needed by researchers and policy makers can be obtained only at the Earth's surface. Laboratories, data banks, and computers produce impressive analyses but local observations and insights bring the analyses to life. Moreover, only studies focused on regional and local conditions can adequately assess the real implications for human society of environmental changes on a global scale.

Dr M.G.K. Menon cites the measurement of the greenhouse gas methane as an example of the importance of input from the South. "[Methane quantities were] wrongly estimated in what I would call Western or Northern calculations," he explained by telephone from New Delhi. "They were greatly overstated in the earlier assessments which were based on extrapolation of data from the tundra — the very high Northern latitudes — into the tropics."

Depending as it does on many local factors, the quantity of methane produced is best assessed by those familiar with Third World conditions because they live and work there, Professor Menon suggested. The same applies to other global problems such as deforestation or the maintenance of biodiversity.

ICSU's activities increasingly involve the scientific communities of both the North and South. During recent years, the organization estimates that approximately half the scientific activities it supports directly involve developing countries.

Networking Around the World

One way in which international science increasingly works is through science and technology networks. One example is the African Network of Natural Product Chemists for Eastern and Central Africa (NAPRECA), with headquarters in Addis Ababa. Affiliated with Unesco and run by researchers, it promotes research in substances derived from living organisms, disseminates information, holds training sessions, seminars and workshops, and conducts a researcher exchange (NAPRECA 1992).

The idea for the network originated in 1984, with a group of African chemists who were struck by the contrast between the intense worldwide interest in natural products and the poor state of development of science in Africa.

"The network was founded out of the sheer realization that scientists of today cannot effectively function in isolation from each other," states NAPRECA's 1984–1992 yearbook (NAPRECA 1992). "The problem of isolation is even more serious in the Third World countries."

Another networking organization is the International Organization for Chemical Science in Development. Created in Paris in 1981, this nongovernmental body serves as a framework for collaboration between scientists in the Third World and in industrialized countries, on topics relating directly to development. Subjects currently under study include synthetic chemical approaches to regulation of male fertility, treatment of tropical diseases, and applications of agrochemistry.

The working group on male fertility regulation involves laboratories in Brazil, France, Hong Kong, Mexico, Thailand, the United States, and Venezuela. Sixteen laboratories in 13 countries are involved in the tropical disease research, and five Latin American laboratories are involved in the agrochemistry project.

Getting on the Information Highway

Gaining access to current information is a major difficulty for scientists in the Third World. Even in the best-equipped health-related libraries in Africa, the most recent book and periodical acquisitions date from the early 1970s.

Fortunately, the availability of modern electronic communications technology, and networks based on it, are improving the situation. One network, HealthNet, is supported by IDRC and other agencies and allows users with a personal computer to communicate worldwide by satellite. This means that health professionals in developing countries who use the network have access not only to the major libraries in the North, but also to the professional staffs of leading medical institutions for consultation.

The Info-Med network adds another dimension — CD-ROM data bases that store enormous amounts of information on a single CD-sized disk and a subscription to MedLine, which provides access to full-text articles, abstracts, and bibliographic references. Zambia's health professionals have access to all three networks thanks to the US Health Foundation and the AAAS (Levy 1993). Even doctors located in district hospitals and research centres can have literature searches done for them.

The Third World Network

The Third World Academy of Sciences (TWAS) collaborates with and hosts the Third World Network of Scientific Organizations (TWNSO). The latter includes 26 ministries of science and technology, 39 science academies, 42 science councils, and 20 other organizations from 69 developing countries. TWNSO was created in 1988 to further the South's involvement in global science projects, among other goals. Chapters in the United Kingdom and United States link TWNSO with industrialized countries' scientific institutions.

TWAS is studying 14 proposals from countries in the South to upgrade national centres of excellence into an International

Network of Centres of Sustainable Development (Hassan 1994). The Consortium of International Earth Science Information Network has promised to support the network in its understanding of global change through its archives and telecommunications technology.

Regional Potential Is Emerging

New opportunities for North–South collaboration are increasing. For example, the US journal *Science* devoted a special issue to East Asia in October 1993, which revealed "an explosive growth of which many Western scientists may be unaware." The work of scientists in this area makes it apparent that they "have the talent and energy to do world-class science," says the journal's editorial. In contrast to lack of governmental support in the past, "a highly intelligent and purposeful effort is now being made in almost every country in that area to support basic and applied research," the editorial continues.

The journal points to "the great opportunities for exchange of ideas and personnel between Western and Asian universities," and Chang-Lin Tien, Chancellor of the University of California in Berkeley, and the first Asian American to lead a major US university, urges collaboration between the two sides. "It will not be long before the East Asian scientists will be highly visible contributors to international meetings and will be more frequent participants in international exchanges of speakers and laboratories," says the editorial.

Western Hemisphere Collaboration

In 1975, a meeting sponsored by the AAAS in Recife, Brazil, set the stage for establishing the Interciencia Association to promote collaboration between scientific communities in the United States and Latin America. In December 1993, leaders from AAAS and from 11 countries' scientific organizations (including Canada) followed up with a Western Hemisphere Collaboration Initiative. The

Initiative calls for improving scientific training and facilities in the region.

Recommendations included strengthening regional networking among institutions of science; expanding joint research projects throughout the hemisphere and between industry and academia; and working with governments to put science and technology on the political agenda.

According to AAAS President-elect Francisco J. Ayala: "The formation of a scientific bloc in the Western Hemisphere would speed up the region's economic recovery."

Making the Best of a Good Thing

These few examples illustrate that North–South collaboration is already underway — and that it can be profitable to all concerned. What remains is to build on existing networks and add new methods of collaboration in the worldwide effort to adapt to global change. Before the North and South can fully profit from such collaboration, however, the human and institutional capacities of the South must be greatly enhanced. The next chapter shows how this can be accomplished.

CHAPTER 7

WHAT NEEDS TO BE DONE

Before the countries of the South can play a significant role in helping to solve major world problems, they require:

— Adequate funding for their scientific efforts;

— Educational changes to maximize these efforts;

— Public understanding of the role of science and technology in the national culture;

— The political will to bring about the necessary changes; and

— More effective links between research and the application of its results.

Underfunding is one of the major reasons for the gap in scientific activity between the North and South. In 1990, the ratio of gross domestic expenditure on research and development (GERD) to gross domestic product (GDP) in all the major developing areas of the world — except the NICs of Asia — was less than 1%, while in the United States and the European Community it was twice that figure. Although it is true that considerable expenditure on science and technology in some leading industrialized countries is for military purposes, the discrepancy between North and South is still enormous. In the poorest countries, about 0.2 to 0.4% of GDP goes to science, compared to 3.1% in Japan (Barré and Paon 1993).

Similarly, in terms of trained personnel, developed countries have 1.9 or more scientists and technologists per 1 000 population (4.7 in Japan), while developing countries have only between 0.1 and 0.5 per 1 000. Providing more funds for science and technology and training more scientists and technologists are essential first steps in any attempt to fully utilize the scientific and technological capabilities of the developing world. Yet more money for training is not enough in itself; the money must be devoted to disciplines appropriate to these countries' needs and at appropriate levels within disciplines.

All Eyes Are on the Newly Industrialized Countries

The NICs of East Asia serve as a magnificent example of what adequate resources and deliberate policies in support of science and technology can achieve.

"Asia's investment in science and technology has skyrocketed over the past decade, outpacing even the high economic growth in the region," reports June Kinoshita in the 15 October 1993 edition of *Science*. "Since 1980, R&D spending has grown at annual rates ranging from 15.8% in Taiwan to 23% in South Korea, according to figures compiled by the US National Science Foundation. Today, the Asian Tigers spend close to $80 000 a year on each research scientist and engineer, about two-thirds of the amount in Japan and over half the amount in the United States. These countries see science and engineering as critical to their economic futures...money is being pumped into research centres, consortia, and projects that will provide foundations for future industries, such as biotechnology, microelectronics, telecommunications, multimedia, and advanced materials."

What was previously lacking in these countries, *Science's* editor-in-chief Daniel E. Koshland Jr points out, "was the governmental support and the climate of encouragement needed to provide fertile soil for those scientific talents." What has made the difference is "a highly intelligent and purposeful effort...in almost every country in that area to support basic and applied science."

Contrast this with the attitude of many in the South, as described by Dr F. Hussain of Pakistan: "There are only a few countries in the Third World where the governments have really gone out of their way to help the development of science.... In most, like my own, the governments have never given any priority to education or to science."

And consider a comment made by Abdus Salam (1992) in *Science and Technology: Challenge for the South*: "The ICs [ndustrialized countries] are expending (in GNP terms) about five to nine times more every year on S&T [science and technology] than the Third World. We in the Third World are just not serious about S&T."

Finding Money for Science

Where the funds to support science in the South will come from is a major question. The South is already greatly indebted to the North. Much of the debt should be forgiven; if the North insists on full debt repayment, the debtor nations will never be able to develop the infrastructure and human resources needed to help solve global problems.

Julius K. Nyerere, Chairman of the South Commission, has said: "In the 5 years leading to 1982, there was a net transfer through long-term lending of $14 billion from the developed countries of the North to the developing nations of the South.

"In the 5 years 1983 to 1987, however, there was — just on account of long-term debt servicing — a net transfer of over $70 billion in the reverse direction. This does not take into account

MARCHING TOGETHER INTO THE FUTURE

Science's editor-in-chief, Daniel Koshland, says that one of the great attractions of science is that its biggest revolutions ultimately come from the resourcefulness of individual investigators.

"Supporting that 'little scientist' is more expensive today than it was in Isaac Newton's day, but it is within the range that small but dedicated countries can achieve in reasonable time," Koshland says. "Scientists basically enjoy seeing other scientists succeeding and solving problems, and therefore help from international colleagues is part of the culture. It is hoped that all international scientists will walk abreast in the broad march of science."

This is already happening in agricultural biotechnology. Developing countries are aggressively adapting to local needs advances made in this field by scientists in the West, according to Robb Fraley, Vice President and General Manager for new products at Monsanto Corporation in St Louis, Missouri (Moffat 1994).

"What has stunned me is the energy developing countries are putting into [agricultural] biotechnology," he said. "The progress made in the last 18 months has been breathtaking."

Biotechnology in agriculture in the North will be used mainly to reduce costs, but at the same time it will allow the South to produce more food. Through collaborations with Northern researchers, the South has been developing disease- or pest-resistant varieties of crops such as fava beans, potatoes, papayas, bananas, and palms.

In the future, says Ralph Hardy, President of the Boyce Thompson Institute for Plant Research in Ithaca, New York, such collaboration could help protect even the South's export markets by allowing them to use biotechnology to develop a more finished product, such as genetically engineered coffee plants that produce naturally decaffeinated beans.

the very much larger amounts effectively transferred to the North through the deterioration in the terms of trade of developing countries — in other words, as a result of commodity prices going down while the prices of manufactured goods went up.... In 1988 alone, the 17 most highly indebted countries of the South made a net transfer to their Northern creditors of $31 billion!... It has been estimated that when the North raises its interest rates by one percentage point, the 17 highly indebted countries together pay an extra $4 billion in debt servicing every year. Their interest payments were [at $41 billion] one third larger in 1988 than in 1987, largely because of such increased international interest rates."

In addition to restructuring the debt, the North should ensure that a far greater proportion of aid money goes into strengthening scientific capabilities in the South.

Responsibilities of the South

The countries of the South, in turn, must be prepared to implement policies that strengthen their scientific and technological resources and lead to economic growth, just as the NICs have done. Although the North is to blame for much of the South's current situation, governments in the South must come to grips with the domestic reasons for their poverty and political instability, and these problems must be solved through internal policies. And, finally, the South must invest more in productive areas such as education and scientific research and development, rather than in nonproductive and destructive areas such as armaments.

"While the advanced countries spend about three per cent of [this] GNP on scientific research, the developing world spends 0.3. But at the same time, it spends about four to five per cent, the same amount as the First World, on defence and armaments", said the late Cyril Ponnaperuma (1993) of the University of Maryland.

According to Abdus Salam "no S&T — research, development, and their meaningful extension and utilization — is possible without a nation spending an inescapable minimum of funds on it." Even if the developing countries decided to spend on science 16% of their own expenditures on education (industrialized countries spend 16 to 40%), "this should provide the colossal figure of $12.2 billion from the South's own domestic resources, according to estimates made by the Third World Academy of Sciences," he adds.

Salam says these modest expenditures are necessary to secure a large inventory of scientists for the South, and to provide them with tools to do their work. Yet, to his surprise, he found that "such outlays are frowned upon, particularly by the economists and planners, as wasteful luxury, even after it is demonstrated that these would increase the GNP manyfold — if only by bringing about agricultural plenty and better health. No science-based development will accrue — and there will be no enhancement of GNP — unless we make these basic outlays."

Dr Manuel Patarroyo is taking advantage of the influence that development of his malaria vaccine has provided him to try to persuade the Latin American heads of state of the need to adopt what he calls "a very simple idea: one percent, one per thousand." By this he means they should invest 1% of GNP in science and have one trained scientist per thousand population.

The Need for Educational Change

A country's ability to develop a sound scientific and technological base ultimately depends on its educational system. In many countries of the South, the emphasis in the educational system bears little relationship to real needs.

In the Arab States, for example, where 42% of the population is illiterate, university students study mostly the social sciences (67.8% in 1990), leaving only 32.2% spread across all other fields. Only 9.2% studied the natural sciences in 1985 and 10.1% in 1990, while in the same years medical science and engineering students actually decreased from 9.2 to 8.1% and agricultural science students decreased from 5.5 to 4.1% (al-Daghestani 1993).

"These trends are not healthy because the present stage of development in the Arab States requires more doctors, pharmacists, nurses, engineers, agricultural scientists and other specialists to cope with the critical needs of development," says Fakhruddin al-Daghestani, Director of the Centre for International Studies at the Royal Scientific Society in Jordan.

The Arab states depend on imports for 38% of their food. The average under-five mortality rate is approximately 100 per 1 000 live births (five times higher than in industrialized countries), and about 56 million Arabs do not have access to health services. In addition, the manufacturing industry's productivity is very low.

The primary reason for the disparity in distribution of students among the various university programs must be the division of general secondary-level education into literary and scientific streams, al-Daghestani contends. Students who complete the literary stream can only enter the social sciences and humanities at university, while only those with the highest grades in the scientific stream are allowed to enrol in the natural sciences, engineering, medicine, and agriculture. "This automatically prevents around two-thirds of high school graduates in general education from going into these fields," explains Dr al-Daghestani.

He estimates that public investment in higher education in the Arab States was about 1.74% of GNP in 1990 — equivalent to 14% of their military expenditures in the same year.

Some Problems in South Asia

In many other regions of the developing world, there is also a shortage of technical personnel. South Asia is a case in point. In 1988–89, Pakistan had only 6 000 qualified research and development workers, and, in the mid-1980s, Sri Lanka had fewer than 3 000 scientists and engineers. Nepal currently has 334 scientists and engineers and 75 technicians, while Bhutan had only 17 engineers in 1987.

Another problem common to many countries of the South is the inappropriate orientation of their university science studies. Kishore Singh, a member of the International Council for Science

Policy Studies describes the problem in South Asia as follows (Lavakare and Singh 1993):

> Research in the universities is frequently too academic, lacking adequate financial support, and sometimes quality and relevance. The higher education system does not closely interact with the industrial and commercial sectors, which are in fact badly in need of S&T input.
>
> A fundamental requirement of higher technical education is to be more responsive to the world of work, rather than to produce graduates in the classical mould. This calls for well-considered measures toward curriculum development so as to cater better for socio-economic needs in vital areas such as food and agriculture, irrigation and water resources, energy, health care, the service sector, technology and environment, etc., and to bring science teaching in higher educational institutions in conventional disciplines into alignment with the rapid advances taking place in S&T.

In the Third World generally, the proportion of students taking science and engineering courses compared to those taking arts courses is in the order of 10:90; in industrialized countries, the ratio is 50:50. Abdus Salam believes that "this preponderance of the technologically illiterate is the major cause of unemployment and of the technological backwardness of the Third World."

Pakistan's Dr Hussain puts the educational problem in a somewhat different framework: "The idea of research and the idea of a university as a place of learning is still not completely established in many of the Third World countries. In my own country I think we have this inheritance from the British — during the colonial period they did set up universities there, but they thought of them more as training people to serve the colonial regime rather than as places of learning. So the concept of the university as a place of learning is just slowly developing and it might take some time."

Making Science Part of Culture

In much of the developing world, there is an inadequate understanding of the value of science. Says Thomas Odhiambo of his continent in Unesco's *World Science Report 1993*:

> We must begin from the beginning. Our children must begin to take it for granted that science is an everyday part of their play, song and existence. Our womenfolk must begin to embrace science as part and parcel of folklore and worklore. And our various publics, whether at the level of the community or the nation-state, must learn to fully integrate science into their enterprises and geopolitical roles.

After an in-depth study of Chile's scientific research and training, the Academia Chilena de Ciencias (1993) declared that: "The primary factor limiting scientific and technological development in Chile and in most other Latin-American countries is the lack of perception by their national society of the importance of endogenous science for the cultural and socioeconomic development of the country...society in general ignores the existence of a small but valuable scientific community."

Scientists versus Movie Stars: No Contest

A Filipino journalist, now director of training at the Centre for Foreign Journalists, Adlai J. Amor, told a 1986 symposium sponsored by the International Science Writers' Association that (Amor 1987):

> In Asia science stories (in the media) are perceived to lack the glamour of reportage on movie stars, politicians and the theatre. Although there are exceptions — like space flight experiments — most scientific and technological research is considered dull and unexciting, especially where applied to everyday problems of development. How to make better wood-burning stoves, how to prevent rats from eating the grain, how to make the rubber tree yield more latex, how to prevent malaria from spreading are all examples of ongoing research that receives little press attention. For reporters striving to establish reputations in journalism,

> reportage on these kinds of research will not land them in the front page. Such stories are relegated to the inside pages.

One of the problems facing Southern countries that wish to integrate science and technology into their indigenous culture is how to popularize these subjects. A scientific mind-set is foreign to some cultures, and some languages may even lack the ability to convey scientific ideas. And in the nine countries that comprise more than half the world's population — Bangladesh, Brazil, China, Egypt, India, Indonesia, Mexico, Nigeria, and Pakistan — 638 million people are illiterate (Unesco 1993).

In some countries, such as Bangladesh, science clubs for the young are effective. In the southern Indian state of Kerala, the Kerala People's Science Movement organizes annual science marches in which folk artists perform dramatic sketches on subjects such as health, education, and the environment (Sharafuddin 1986). In China, successful peasant farmers become popularizers, traveling about to educate others in the crop-production methods that brought them wealth. Agricultural scientists and technicians also visit villages, advising and helping farmers (Chenru 1986).

THE IMPORTANCE OF ROLE MODELS

What makes a young person turn to science as a career? Often it is the example set by someone who has become famous doing just that. Take the case of Colombian biochemist Dr Manuel Patarroyo.

"I was 8 years old when my father gave me a comic [book] to read," he says. "It was just a booklet, really. And that booklet had Louis Pasteur's story and I was fascinated. Then, like any other child who wants to be a priest or wants to be a policeman or a bomber or a pilot, I wanted to be a scientist and didn't want to do anything different from what Pasteur did. Since then I have devoted my life to that. And I am not going to change. I will be doing science as long as I live."

The Chinese experience has been highly successful and offers a possible model for others. Shen Chenru, a Chinese science editor, said that by the end of 1984, 93% of the counties in the country had set up 2 277 science associations, and districts and townships had established another 41 000. At county and district administration levels in 1986, there were about 60 000 popular science groups with a total membership of 3.5 million.

Raising the Status of Scientists

Jacques Gaillard, who is well known for his studies of the "sociology of science," says in *The Uncertain Quest* (1994) that "in most developing countries, research scientists do not have high social standing or prestige. Doctors and lawyers and other professionals of that level, with at most the same amount of education as the research scientists, are not only better paid but also enjoy a much higher social status."

He quotes Marcel Roche of Venezuela as saying about his country: "I know many examples of young people whose rich parents forbade them to major in sciences or to devote themselves to research often because of the low salaries or uncertain career opportunities. The bourgeois attitude to careers in science is much the same as the attitude to professions in the arts; success is reserved to very outstanding people alone, all the others being condemned to a Bohemian life of uncertainty. The profession has probably changed since the Sputnik was invented, but research is still not seen as a fully respectable profession."

Gaillard says the low wages explain why many researchers in the South supplement their incomes by working overtime on side jobs that include anything from consulting or teaching to driving a taxi. "Anyone who has spent time with Third World scientists quickly realizes that a second [or even third] job and income are vital."

Needed: a Change in Public Perceptions

If science and technology are to be adequately valued by the societies of the South, public perceptions must change. Part of that change must be achieved by promoting what the Canadian government has called a "science culture."

Gaillard contends that training enough scientists, establishing enough scientific institutions, and providing adequate funding are not enough to guarantee the scientific results needed for development.

"Going beyond the availability of resources, research activities need a certain permanency through greater recognition by society," he says. "The scientists need to find their place in a scientific community that has its own legitimate place in society.... In addition to proper status, better salaries and more adequate working conditions, the emergence of tightknit and lively scientific communities should be promoted by active academies, professional associations and scientific journals. Encouragement should also be given to activities such as national science days, science awards, science weeks for young people, annual conferences of national science associations, and also exhibits, science museums and clubs that attract young people to science and scientific careers."

Finding the Political Will to Act

Without the political elite's long-range commitment to develop science and technology as an essential part of the national culture, all attempts to lift the South out of its current quandary will fail. History has shown how the influence of great leaders has been responsible for bringing about great changes. Think of Jawaharlal Nehru in India and Chou-en-Lai in China. The participation of business and industry is also necessary, as the examples of both the NICs and Japan illustrate.

The story is different, however, in other parts of the developing world, notably Africa. Dr Odhiambo says: "African leadership in the key endeavours of its society...in scientific research and technology development...is fractured and anchorless.... A determined, long-range commitment rapidly to build up and maintain Africa's capacity for science-led development is the single most important task of the continent's leadership in the current decade and beyond."

But we must not dwell on the negative aspects of the picture. We have seen in earlier chapters how great is the progress that has already been made in the Third World in science and technology. The potential is obviously there for far greater things. We have seen also how successful cooperation and partnerships between North and South can be. Logic compels us to conclude that expanding such cooperation is essential if we are to solve the problems that face all human beings in the future.

What Experience Has Taught Us

A former UN advisory committee tried to determine the ingredients essential to building the scientific and technological capacity required by countries in different stages of development. They concluded that, first and foremost, is the ability to decide what type of science and technology is needed to meet the country's development needs. Countries must also be capable of absorbing, transferring, and using technologies, but only the more advanced societies need to create new knowledge through basic research. For each capability, countries require appropriate institutions. And there must be a balance between these activities.

What is the result of Northern countries spending billions of dollars trying to help build the scientific and technological capacities of the countries of the South? Having spent 40 years engaged in international collaboration activities, Geoffrey Oldham, Science and Technology Advisor to IDRC, concluded in a 1994 presentation to a conference jointly convened by Unesco and the Office of Overseas Scientific and Technical Research (Paris, France): "All of our efforts have had a disappointing impact on the ultimate objective. With only a few exceptions, the local scientific and technological capacity in most developing countries is not bringing the benefits of science and technology to bear, in an effective manner, on the development problems of those countries."

One possible reason, Oldham said, lay in a misunderstanding of the nature of development. The models used by donor agencies were those of their own countries, and they thought if they applied these models to developing countries, similar results would be achieved. Therefore, they sold these models to the developing world.

"There was no overall assessment of each country's needs — just a selling job by many individual donor agencies," says Oldham. "Thus, the United Kingdom helped its former colonies to build universities modeled after its own; Unesco sold science councils; UNIDO (the United Nations Industrial Development Organization) sold industrial research institutions; the Soviet countries exploited national academies to their acolytes."

"As a result, most developing countries have a collection of institutions unrelated to one another and not forming a holistic entity. In addition, many have over invested in one type of S&T activity at the expense of others. The result is an unbalanced system with many unconnected parts. It is a system capable of absorbing large sums of money with little noticeable impact on the lives of poor people in these countries. No wonder there is cynicism about the impact of science on development in the South, and an aid weariness in the North."

What can be done to rectify the mistakes of the past?

It now seems obvious that instead of trying simply to transfer Northern systems to the South, without regard to local needs, each country should have been helped to develop a strategy for its own institutions. This is the course of action that must be followed now. Each developing country must assess both its scientific and technological infrastructure and its system of innovation. What doesn't work must be discarded, and new institutions may have to be built.

Once this has been achieved, and a clear strategy for using science and technology for development has been designed by each country, donors can respond. In those responses, however, donors must coordinate their efforts much more effectively than in the past.

Need for Social Science Input

In its 25 years of attempting to build research capacity in developing countries, IDRC has learned the need to involve the social sciences. Most problems facing developing countries are economic, social, and political as much as scientific or technological. Even where there is a scientific or technological component to the problem, social and human factors are also involved, and must be considered.

For example, a Chilean research group was supported by IDRC to devise a means of providing water in a drought-ridden mountain area in the north of their country. They developed a "fog-catcher" — a nylon net that condensed the abundant fog in the area and carried the water through pipes to a small village on the desert below.

At first, the villagers were delighted with the regular flow of fresh water, but when they later realized that someone had to clean the storage tanks and repair the pipes, they quarreled about who should do it. No one involved in the design of the project had anticipated this problem, nor had they anticipated how the villagers would use the water. Rather than use it to grow vegetables and sell them to a nearby town, thereby increasing their income, the villagers irrigated their flower beds instead. Had social scientists been involved in the project design, they might have avoided these unexpected results — IDRC's social scientists have learned from the experience and now work more closely with the village people.

Another lesson learned by IDRC is that research alone is not enough to guarantee development. Strong links must be forged between the researchers and the production system, and clients or beneficiaries of the research should be involved in its design at an early stage.

To apply these lessons, developing countries may have to change the orientation of their own institutions. Rarely is an interdisciplinary approach found in the Third World.

Looking to the Future

Many of today's international institutions for scientific collaboration were fashioned in the 1930s and 1940s, and designed for a very different world than now exists.

"Although they have tried to adapt themselves over the years, many scientists believe that the time is ripe for a review of the institutional needs of international scientific collaboration, and an assessment of the adequacy of existing institutions to meet those needs," concludes Oldham. "Any such review must involve developing-country scientists."

New ways must be found, for example, to mobilize scientific and financial resources so that scientific communities in the North and South can together mount a concerted attack on global problems. New mechanisms must be found for raising the large funds needed to supplement declining aid allocations. These mechanisms might include global lotteries and taxes on international financial transactions, information flows, and air transportation.

With the implementation of such plans, not only would the North's aid efforts in support of science and technology become much more effective, but, as well, a true partnership between North and South might evolve, and the full potential of science from the South would be realized in solving our mutual problems.

ACRONYMS

AAAS	American Association for the Advancement of Science
AIDS	acquired immune deficiency syndrome
AOSIS	Alliance of Small Island States
CGIAR	Consultative Group for International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIDA	Canadian International Development Agency
CIFOR	Centre for International Forestry Research
CIP	International Potato Centre
COHRED	Council on Health Research for Development
CREDESA	Regional Health and Development Centre (Benin)
EMBRAPA	Brazilian Agricultural Research Corporation
ENHR	Essential National Health Research
FAO	Food and Agriculture Organization of the United Nations
GDP	gross domestic product

GERD	gross domestic expenditure on research and development
GNP	gross national product
GTZ	German Agency for Technical Cooperation
HCG	human chronic gonadotropin
HIV	human immunodeficiency virus
IAEA	International Atomic Energy Agency
IARC	international agricultural research centre
ICLARM	International Center for Living Aquatic Resources Management
ICRAF	International Center for Research in Agroforestry
ICSU	International Council of Scientific Unions
ICTP	International Centre for Theoretical Physics
IDNDR	International Decade for Natural Disaster Reduction
IDRC	International Development Research Centre
IFPRI	International Food Policy Research Institute
IIMI	International Irrigation Management Institute
IITA	International Institute of Tropical Agriculture
IPM	integrated pest management
ISNAR	International Service for National Agricultural Research
IRRI	International Rice Research Institute
MIRCEN	Microbiological Resources Centres Network
NAPRECA	African Network of Natural Product Chemists for Eastern and Central Africa
NIC	newly industrialized country
OECD	Organisation for Economic Co-operation and Development
ORT	oral rehydration therapy

PCARRD	Philippine Council for Agriculture and Resources Research and Development
PRISM	Program of Research in Innovation Systems Management (IDRC)
R&D	research and development
SAREC	Swedish Agency for Research Cooperation with Developing Countries
S&T	science and technology
TWAS	Third World Academy of Sciences
TWNSO	Third World Network of Scientific Organizations
UN	United Nations
UNCED	United Nations Conference on Environment and Development (Earth Summit)
UNEP	United Nations Environment Programmme
Unesco	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
USGS	United States Geological Survey
WHO	World Health Organization
WRI	World Resources Institute

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The Author

David Spurgeon is a science journalist who, through his writings and then as IDRC's first Director of Publications, was introduced to Southern researchers and their work in the early 1970s. While with the Centre, he worked and traveled extensively in the developing world, including a stint at the International Council (now Center) for Research in Agroforestry (ICRAF) in Nairobi, Kenya. Spurgeon left IDRC in 1980 to work for the United Nations Environment Programme (UNEP), where helped to produce UNEP's 10-year anniversary report: *The World Environment, 1972–1982*. From 1981 to 1983, he consulted with a number of international agricultural research centres in Africa, Australia, and the Middle East. In 1983, Spurgeon joined Unesco in the capacity of science journalist and managing editor of the quarterly *Impact of Science on Society*. In 1986, he resumed his career as a free-lance writer, and has since become a regular contributor to many popular and widely read magazines and journals, including *Reader's Digest* and *Nature* (as its Canadian correspondent). His recent books include *Secrets of the Heart: Cardiovascular Research in Canada* (Medical Research Council of Canada, 1991), *No Greater Challenge: Solving the Mysteries of AIDS* (Medical Research Council of Canada, 1989), and *Understanding AIDS: A Canadian Strategy* (Key Porter Books, 1988).

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Southern Lights

Celebrating the Scientific Achievements of the Developing World

Manuel Patarroyo, a biochemist from Colombia, South America, has developed the world's first safe and effective malaria vaccine. Ironically, it took him only 4 years to make his discovery, but 6 years to convince the world that the vaccine worked.

Is this a case of intellectual racism? Are discoveries by Third World scientists properly recognized?

Southern Lights pays tribute to the many scientific and technological achievements of scientists from the developing world — achievements that have not been sufficiently recognized in the North. Using concrete examples, author David Spurgeon illustrates the important role that science from the developing world and effective collaboration between North and South can play in solving the major global problems of today.

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ISBN 0-88936-736-1

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