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EDITOR'S NOTE

Blueprint for Action

The World Conference on Science (WCS), held in Budapest, Hungary, between 26 June and 1 July 1999, was a landmark event in the history of international fora dealing with science and society. In its plenary lectures and parallel sessions, WCS explored a range of issues likely to dominate discussions between society and the scientific community over the next century—and perhaps the next millennium. Among these issues are: the role that scientific knowledge and information plays in our modern society; the need to pursue policies based on science-based sustainable development; the rising importance of scientific ethics; and the value that all nations must place on science education, women in science and science for peace in the 21st century and beyond.

The main lesson derived from the week-long gathering in Budapest is that both governments and people must give science the highest priority. The faith in science expressed by those attending the WCS is derived from the following perception: Scientific endeavours not only boost global development and technology but shape our cultures, ways of life and even our attitudes toward the societies in which we live.

Those hailing from developing countries bear some unique responsibilities in the global quest for policies that promote science-based sustainable development. The fact is that developing countries do not spend enough on science. As a result, they should commit themselves to investing about 1 percent of their gross national product (GNP) on such endeavours. Similarly, developing countries do not spend enough on science education, which has adverse consequences for both science and society. Virtually all developing nations recognise that sufficient investments in science are not just a prerequisite for sustainable development but are necessary to create an essential form of exchange in the global community—in short, that science is one of the key forms of communication in the world today. If a nation is unable to speak the language of science, it becomes difficult—if not impossible—to communicate with other nations on matters of vital interest to our collective future.

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TWAS NEWSLETTER

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BY THE THIRD WORLD ACADEMY OF SCIENCES (TWAS)

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For such reasons, scientific capacity building assumes special significance in the developing world. Unless such efforts take hold, nations in the developing world will never reach the same level of material well-being as nations in the developed world. Equally important, to gain full entrance into the modern world, developing nations must devote more resources to science to ensure that their people attain the scientific literacy they need to face the economic and social challenges that lie ahead. Only then will they have the confidence to fully participate in the ambitious scientific and technological agenda that will be the hallmark of the next century. Only then will they have the skills to guarantee that their citizens will enjoy the fruits of innovation.

Developed nations have many responsibilities too. While these nations may be doing well today, it is important for them to encourage and support the efforts of other, less fortunate, nations in the latter's struggles to devise effective strategies for science-based sustainable development. Developed nations cannot ignore large parts of the world currently overburdened by poverty, malnutrition, illiteracy and disease. As a matter of moral responsibility and self-interest, developed nations should share their scientific and technological knowledge to improve the well-being of the world in which we all reside. New information technologies, which are transforming our world, provide unprecedented opportunities for the exchange of scientific information. The value of these technologies, however, has yet to be realized in forging science-based development strategies. International collaboration will be essential for fulfilling their potential.

The WCS's Declaration *and* Framework for Action *together offer a blueprint for a better future based on a global society dedicated not only to the material benefits that flow from scientific research but to the value that scientific inquiry places on excellence, objectivity, rigour and teamwork. The WCS did an enviable job of raising issues that must be addressed to ensure a healthy relationship between science and society in the century ahead. It also succeeded in creating a valuable road map for attaining progress in science-based development. Whether the map becomes a useful guide or is filed in government archives will be determined by the decisions and actions in the years ahead. The WCS may have pursued a large agenda but no one can deny that the agenda is worthy of our attention and support. Nothing less is at stake than a peaceful and harmonious world.*

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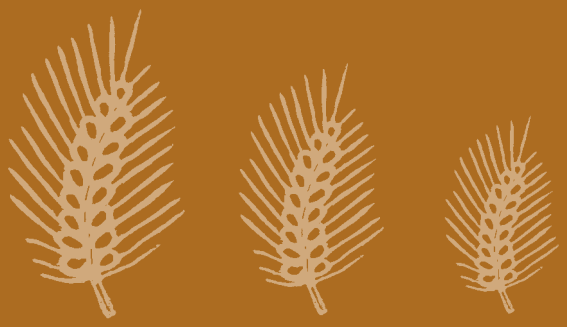
TWAS President-Elect

For additional discussions on the World Conference and observations of TWAS Fellows who were in attendance, see pp. 6-10 and pp. 11-20.



Who owns the world's life-sustaining agricultural seeds? Despite spectacular scientific and technological advances in modern times, humankind's greatest achievement in applied sciences remains the invention of organized farming that took place 10,000 years ago in Iraq, Syria and Turkey, China, the Indus-Ganges Valley and Africa. Somewhat later, the New World—most notably Latin America—added to the variety of plants and animals domesticated by ancient cultures.

Agriculture, as currently practiced in much of the developing world, is based on the toil and sweat of millions of poor peasants over thousands of years. This tradition, which has been passed from one generation to another, is founded on the noble principle that the tiller should use part of the harvest for food and part for the future propagation of the crop.

Of the 6 billion people who populate the Earth today, nearly 80 percent live in Asia and Africa, where the innate fertility of seeds is a source of celebration. Fertility and reproduction of food grains have acquired such deep spiritual significance in the psyche of both Africans and Asians that seeds are exchanged in these cultures among friends and foes alike and given as presents to travellers from far-away lands.

SELLING SEEDS SHORT

The gene pool of present-day foodstuffs is the common heritage of all human kind, although not all cultures have contributed equally to agricultural welfare. The United States, for example, has added little to the altruistic exchanges except as a recipient of germ plasm from the rest of the—often very poor—world.

Recombinant DNA technology—even if developed to its full potential—is unlikely to alter more than a fraction of 1 percent of the genomic makeup of edible plants. It is an affront to fairness for multinational corporations to claim ownership of living systems, particularly those essential for human sustenance, for such a minuscule contribution.

Apologists for genetically modified (GM) crops have contended that these crops are essential for solving our future food needs. Yet, will people who really need the food benefit from this commercially driven pursuit? That is unlikely because the traditional practice of 'sowing a part of what is reaped' is the only economically feasible option open to farmers in those parts of the world where the need for food is greatest. Indeed poor farmers will be unable to bear the cost of GM seeds because licensing arrangements require new seeds to be bought for each new planting. Furthermore, traditional seed varieties used by poor farmers may be corrupted through pollination from neighbouring fields with GM crops planted by well-off landowners. In particular, cross-pollination from crops containing the sterility gene (the so-called termination gene) could cause havoc. This gene allows seeds to germinate just one time, thus preventing their repeated use through a cunning scientific trick.

Commercial pressures on multinational corporations often force them to market products prematurely as highlighted by the tragic cases brought to the attention of the international community by a leading Indian environmentalist, Vandana Shiva, writing in *The Guardian* nearly a decade ago. Shiva is president of the Research Foundation for Science, Technology and Ecology, a non-governmental organization focusing on environmental issues. Lured by the promise of high income, Indian farmers in the province of Andhra Pradesh in southern India sowed new seed types (in this case, non-GM varieties) that failed to live up to expectations. The indebtedness spurred by this failure led thousands of farmers to commit suicide.

Although not as tragic in its outcome, the poor performance of GM cottonseeds planted in Mississippi in the United States, which were resistant to Monsanto's glyphosphate herbicide, offers another example of the shortcomings of this new technology. According to a report in *Chemical and Engineering News*, these GM seeds produced plants with deformed or missing cotton balls. Such deformities devastated the crop. Meanwhile, land sowed in conventional seeds produced a bumper harvest. Monsanto is paying several million U.S. dollars to compensate farmers for their losses. It is important to note that the legal structure for claiming damages, which cushioned the blow for U.S. farmers, is not available to subsistence farmers in the developing world.

Third World agriculture needs Western assistance—not from greedy multinationals but from benevolent publicly funded institutions and non-profit organizations that regard agriculture as the sacred heritage of all humankind. French agronomist Jean-Pierre Berlan and U.S. biologist Richard C. Lewontin in an article published in *Le Monde Diplomatique* in December 1998 expressed a like-minded sentiment when they wrote: "We should turn our back on the present European policy of allowing life forms to be patented, and declare living things to be the property of humanity."

The Third World Academy of Sciences (TWAS) does not seek to go as far as this recommendation because it could delegitimize several manufacturing processes that use living organisms for worthwhile commercial activities, including the production of insulin to combat diabetes. The Academy's main concerns are food and farming, and it invites fellow scientists to support to a resolution recently approved by the TWAS Council at the World Conference on Science in Budapest, Hungary, urging governments to pass legislation that acknowledges that *agricultural life forms belong to all of humanity and should be excluded from property rights claims*. ■

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COMMENTARY

WORLD CONFERENCE ON SCIENCE

Thousands of scientists and science administrators meet in Budapest to examine the role of science in society on the eve of the next millennium.

THE WORLD CONFERENCE ON SCIENCE, HELD IN BUDAPEST, HUNGARY, BETWEEN 26 JUNE AND 1 JULY, BROUGHT TOGETHER SOME 1800 DELEGATES FROM 150 COUNTRIES, INCLUDING 100 MINISTERS OF SCIENCE AND TECHNOLOGY.

The conference, hosted by Hungary and co-sponsored by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICSU), was the first scientific gathering of this magnitude since the United Nations Conference on Science and Technology Application for Development convened in Vienna in 1979. The Third World Academy of Sciences (TWAS) served as one of the conference's affiliate organizations with direct responsibility for organizing two of the conference's thematic sessions: "Science in Response to Basic Human Needs" and "Science for Development." (see pp. 16-20 for a detailed account of these sessions).

This global gathering, which carried the lofty subtitle "a new commitment," was designed to explore the rapidly evolving relationship between science and society on the eve of the 21st century—a relationship that has been dramatically transformed by a host of developments over the past decade, including the end of the Cold War, growing public scepticism toward science, unprecedented advances in information technologies, the accelerated pace of global trade, widening disparities in scientific expertise between the North and South and within the South itself (for example, between South America and sub-Saharan Africa), the privatisation of research and scientific information and data, and the increasing involvement of women in fields of science and technology.

At the conclusion of the week-long event, delegates approved two consensus documents that conference organizers hope will help guide scientific initiatives in the years ahead: the "Declaration on Science and the Use of Scientific Knowledge" and a "Framework for Action." Follow-up meetings are expected to take place to assess the progress that has been made in advancing both the principles and proposals agreed on at the conference.

LINKS

The Declaration of Science proclaimed that "We all live on the same planet and are part of the biosphere. We have come to recognise that we are all in a situation of increasing interdependence, and that our future is intrinsically linked to the preservation of the global support systems and to the survival of all forms of life." It went on to note that "What distinguishes the poor (be it people or countries) from the rich is not only that they have fewer assets, but also they are largely excluded from the creation and the benefits of scientific knowledge."

In light of these circumstances, the declaration asserted that "The sciences should be put at the service of humanity as a whole, and should contribute to providing everyone with a deeper understanding of nature and society, a better understanding quality of life and a sustainable and healthy environment for present and future generations." Strategies to achieve these goals, the declaration noted, should focus, among other things, "on the urgent need to reduce the gap between the developing and developed countries by improving scientific capacity and infrastructure in developing countries;" promoting "full and open access to scientific information;" and recognising "the fundamental role played by women in the application of scientific development."

"The sciences should be put at the service of humanity as a whole."

The road map for advancing these goals was laid out in the conference's framework for action, which called on participating countries to "aim at having high-quality scientific institutions capable of providing research and training facilities in areas of interest;" to increase "international collaboration, including the exchange of knowledge and expertise," through North-South and South-South scientific networks; and to fully incorporate "women scientists and other disadvantaged groups" into both national and international scientific research endeavours.

Two contentious issues touched on but not tackled directly by both the declaration and framework for action involved questions of scientific ethics and the creation of a global fund for advancing science in the developing world. In both instances, conference delegates expressed broad approval for the concepts but refrained from endorsing explicit measures to advance these goals.

ETHICS

In the opening session on Saturday, 26 June, Sir Joseph Rotblat, Founder and former President of the Pugwash Conferences on Science and World Affairs and the 1995 Nobel Laureate for Peace, urged scientists to build their agenda for the next century on a strong ethical foundation. To achieve this aim, Rotblat called on UNESCO to adopt a resolution encouraging young university-trained scientists to take a Hippocratic-type-oath upon graduation.

The suggestion sparked a great deal of discussion among delegates and the media during the first two days of the conference. By the third day, however, delegate support for a Hippocratic-type-oath dissipated over concerns about its practicality. What would happen to scientists who violated the oath? Which individuals or institutions would be responsible for its implementation? How might the credibility of the global scientific community be affected if the oath proved impossible to enforce?

As a result of these concerns, Rotblat's direct call for an oath turned into a general endorsement for the creation of ethical codes in science. "All scientists," the delegates agreed in the conference declaration, "should commit themselves to the highest ethical standards," and "each country should establish suitable measures to address the ethics of the practice of science and the use of scientific knowledge and its applications." Still another provision of the declaration asserted that "a code of ethics based on relevant norms enshrined in international human rights instruments should be established for scientific professions."

FUNDS

Another issue that captured the enthusiasm of many delegates, especially those from the developing world, but that failed to gain a concrete endorsement from conference delegates in the declaration was the creation of a global fund for the promotion of science and technology in the South.

Led by Hogbe Nlend, Cameroon's Minister of Science, and Lamine Ndiaye, Rector of Senegal's Gaston Berger University, the African delegates rallied around a proposal for using money freed from the debt relief programme, which G8 nations had announced earlier in June, to create a science and technology fund for the world's 40 least developed countries. Both Cameroon and Senegal are members of the Third World Network of Scientific Organizations (TWNSO), and Senegal will host TWAS's upcoming 7th General Conference and 11th General Meeting. The proposal for such a fund also received strong support from Atta-ur-Rahman (TWAS Fellow, 1985), Coordinator General of the 50-country Organization of Islamic Conference's (OIC) Ministerial Standing Committee on Scientific and Technological Cooperation (COMSTECH).

"The conference's [draft] agenda," Nlend noted, "deals with funding only vaguely. But for poor countries, the lack of funds is a critical issue." Atta-ur-Rahman expressed this sentiment even more strongly when he stated that "without a fund, nothing will happen."

Despite receiving broad support from the South, calls by conference delegates to launch a science and technology fund for the world's poorest nations suffered the same fate as the drive to cre-

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ate a code of ethics: Concrete funding proposals offered during the five days of discussion at the conference ultimately found expression only as a broad statement of support in the conference's concluding documents.

After emphasising the importance of national strategies and institutional arrangements in the promotion of science, the declaration asserted that "the recent initiative by the major G8 creditor countries to embark on the process of reducing the debt of certain developing countries will be conducive to a joint effort by the developing and developed countries towards establishing appropriate mechanisms for the funding of science...to strengthen national and regional scientific and technological research systems."

How can science be put to better use for sustainable development?

Put another way, in the consensus reached at the conference, delegates agreed that the debt-reduction plan of the G8 creditor nations created possible opportunities for additional funding for science and technology in the developing world; however, the delegates chose not to endorse a concrete plan for the creation of a science and technology fund despite the appeals of the African delegation and like-minded colleagues from Asia and South America.

KNOWLEDGE

On yet another issue, the role of traditional knowledge in the advancement of science, the delegates again resisted the more forceful language of some participants (who called on the conference to state unequivocally that "traditional systems of inquiry are legitimate science"), preferring more moderate language. The declaration noted that locally based knowledge systems "can make, and historically have made, a valuable contribution to science and technology." As a result, "there is a need to preserve, protect, research and promote this cultural heritage and empirical knowledge." The framework for action called on all countries to "promote better understanding of traditional knowledge systems instead of focusing only on extracting elements for their perceived utility to the science and technology system."

In short, despite the delegates' sympathetic assessment of traditional knowledge systems, they refused to assert that such traditional pathways of inquiry represent a form of scientific knowledge.

GENDER

When it came to the issue of expanding the role of women in science, conference delegates spoke with a slightly less muted voice. As stated in the declaration: "It is necessary that women participate actively in shaping the agenda for the future direction of scientific research." To assess progress in achieving this goal, the declaration called on "governments and educational institutions" to "identify and eliminate, from the early learning stages on, educational practices that have a discriminatory effect." More specifically, it asserted that "every effort should be made to eliminate open or covert discriminatory practices in research activities." It went on to declare that "measures aimed at attaining social equity in all scientific and technological activities, including working conditions, should be designed, implemented and monitored."

COMMITMENTS

Other issues aired at the conference included the proper balance between basic and applied science (delegates agreed that both are

essential for nurturing a healthy relationship between science and society); the importance of science education in primary and secondary schools (conclusion: it is a necessary prerequisite for capacity building that must be broadly accessible and gender-free); the emergence of proprietary ownership of scientific knowledge (a growing trend in this age of privatisation that poses a risk to the free exchange of information, one of the cornerstones of scientific progress); the value of interdisciplinary research (the natural and social sciences must work more closely together); and the need for increased international cooperation (yes, the more the better).

In this sprawling, yet aggressively inclusive, environment of ideas and opinions, it should not be surprising that the World Science Conference was "high on ideals and short on details," as *Science* put it.

The ultimate challenge for science in the 21st century may lie in efforts to distribute science-created knowledge.

Yet, there was one all-embracing theme that drove much of the discussion at the event: How can science be put to better use for sustainable development, especially in ways that will help reduce the gnawing gap in material wealth between the North and South? The importance of this issue, which lies at the heart of the relationship between science and society, may have been best articulated by M.S. Swaminathan (TWAS Founding Fellow), who gave one of the conference's keynote addresses.

"The pervasive poverty we witness today," Swaminathan told the delegates, "is the most serious indictment of contemporary development pathways." The poor, he noted, "have been bypassed by technological advances. They suffer from a sense of exclusion from the exciting scientific adventures we are witnessing today."

Swaminathan went on to say that "reaching the unreached and including the excluded have to be important components of the science and technology policy and strategy for the new century, if the huge stock of scientific and technological knowledge and innovations with which we will be entering the next century is to become a blessing for humankind as a whole."

He acknowledged that science and technology had increased the world's bounty over the past 500 years, and particularly over the past 50 years. He cited the unprecedented growth in the output of wheat in his home country, India, as a prime example of the contribution that science and technology has made to society. Between 1964 and 1968, thanks in large measure to the introduction of semi-dwarf strains containing Norin 10 genes, Indian wheat production rose from 10 million to 17 million tonnes per year. Thirty years later, in 1998, wheat production soared to 70 million tonnes—a 10-fold increase in output since India had gained independence in 1949. Comparable progress, he noted, has been made in the "production and productivity of rice, maize, soybean, potato, and several other crops as well as in farm animals in many developing countries around the world."

In light of these trends, science and technology, Swaminathan declared, has put "a world without hunger…within our reach." But, he added, we have not yet reached that goal, and the food-security challenge will intensify as the world's population, which now exceeds 6 billion people, continues at a pace that will place some 9 billion on Earth by 2050, according to the United Nations' Population Division.

The solution to the food security challenge lies in science and technology. "A hunger-free world," Swaminathan asserted, "will be possible if every nation pays concurrent attention to improving food availability through ecologically sustained methods of production, to enhancing access to food by promoting job-led economic growth strategy, and to ensuring the biological absorption of food in the body through the availability of safe drinking water and environmental hygiene."

Such efforts will require focusing on farming as a "knowledge-intensive pursuit and include the use of geographical information system (GIS) to target the application of water, fertilizers and pesticides on those portions of the field where they are most needed." In India, he noted, the GIS was put to use in the Dhamapuri district in Tamil Nadu, to combat malnutrition, and in the Gulf of Mannar in south India to sustain the region's biodiversity—both to good effect.

Ultimately, issues of malnutrition and biodiversity loss, Swaminathan contended, are related to problems of poverty. And it is in efforts to eradicate poverty that Swaminathan foresees science making its greatest contributions to society. Indeed he envisions the "emerging scientific revolutions" of the late 20th century blossoming into an "ecology of hope" in the next century.

The scientific revolution that Swaminathan believes could create a more bountiful and equitable world includes:

• *Gene revolution*. "Molecular understanding of the genetic basis of living organisms" could lead to "new processes and products for

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agriculture, industry, the environment, and for animal health."

• *Ecotechnology revolution*. "The blending of the best in traditional knowledge and technology with frontier technologies such as biotechnology, space and information technologies, renewable energy and new materials" could clear a path for more balanced and more equitable development strategies that are truly sustainable.

• *Information revolution*. "The rapid growth in the systematic assimilation and dissemination of relevant and timely information" has dramatically improved our ability to access the universe of knowledge and communicate through low-cost electronic networks. Such access, if free and open, could accelerate the pace of scientific progress in the developing world.

The alluring promise of these scientific revolutions will never be realised on a global scale, according to Swaminathan, unless the relationship between science and society is rewoven into patterns that make science more responsive to human needs and empower people with the scientific and technical know-how they need to improve their lives.

He cited the "village knowledge centres" currently being created in some 20 remote villages in India as a potential strategy for achieving the full promise of science in developing countries. With reliable connections to the internet and personal access to well-trained computer experts attentive to their needs, villagers will be able to acquire up-to-date information on issues related to agriculture, health, sanitation and employment—even as they learn to use the computer on their own. The system, Swaminathan contended, will connect scientists to people and people to scientists in an environment that allows each to learn from one another as both seek to address critical health, environmental, social and economic problems.

"Can we lay the foundation at this World Science Conference," Swaminathan asked delegates at the conclusion of his speech, "for the emergence of a new political, social and scientific commitment to end the irony of widespread misery and deprivation prevailing in the midst of uncommon opportunity for a better common present and future for all? In my view we can, provided every one of the nearly 2 billion persons who are enjoying a healthy and productive life will keep the following advice of Mahatma Gandhi as the guiding principle in his/her day-to-day life and work:

Recall the face of the poorest and the weakest man whom you have seen, and ask yourself if the steps you contemplate are going to be of use to him. Will he gain anything by it? Will it restore to him control over his own life and destiny?"

While the World Science Conference's ultimate impact on science and society will be measured in the years and decades ahead, the willingness of participants to raise questions like these are testimony to the more immediate value of the gathering. The ultimate challenge for science in the 20th century may have been to create a world marked by boundless knowledge, opportunity and material wealth. The ultimate challenge for science in the 21st century may lie in efforts to distribute science-created knowledge, opportunity and material wealth more equitably. In effect, to transform science's "endless frontier" into a "frontier without borders." ■

TWAS WAS THERE

TWAS was well represented at the World Conference on Science. In addition to the two thematic sessions that the Academy organized ("Science in Response to Basic Human Needs" and "Science for Development"), no less than 28 TWAS Fellows gave presentations. TWAS conference highlights included opening ceremony addresses by TWAS President José I. Vargas and TWAS Founding Fellow M.S. Swaminathan, and a plenary session address by Miguel A. Virasoro (TWAS Fellow 1994), Director of the Abdus Salam International Centre for Theoretical Physics (ICTP). In addition, the TWAS Council's decision to call for a ban on the patenting of agricultural life forms received coverage in *Nature*'s on-line daily news bulletin *(NatureNews+)*, which also prepared a profile of TWAS Founding Fellow and President Elect C.N.R. Rao (TWAS Fellow). And let us not forget that three of the driving forces behind the conference itself—Federico Mayor, Director-General of the United Nations Educational, Scientific and Cultural Organization (UNESCO); Nobel Laureate Werner Arber, President of the International Council for Science (ICSU); and Maurizio Iaccarino, conference Secretary-General and Assistant Director-General for Natural Resources of UNESCO—are also TWAS members. Mayor was elected an Associate Fellow in 1991, and Werner and Iaccarino were elected Associate Fellows in 1997.

CONFERENCE PERSPECTIVES

A wide range of opinions on the World Conference on Science offered from a large number of TWAS members

THE LARGE NUMBER OF TWAS MEMBERS WHO ATTENDED THE WORLD CONFERENCE ON SCIENCE OFFERED THE EDITOR OF THE TWAS NEWSLETTER AN OPPORTUNITY TO SOLICIT A WIDE RANGE OF OPINIONS ON THE CONFERENCE. HERE IS WHAT SOME OF THE MEMBERS HAD TO SAY.

PROGRESS: INSIDE OUT

As head of the Chinese delegation and Vice President of TWAS, I attended the World Conference on Science (WCS) in several different capacities. I also had an opportunity to deliver a keynote address in which I outlined the role of science in society from the perspective of the Chinese scientific community. I believe the WCS was a success. I have come to this conclusion based on four factors. First, the conference was convened on the eve of the next millennium, enabling it to attract the attention of governmental officials and scientists world-wide. Conference participants agreed that science and technology had been prime forces driving increased human productivity over the past two centuries and would remain prime forces behind efforts to address global problems during the next millennium. Second, conference participants concurred that science and technology are not worlds unto themselves but part of society. As a result, development and application of science and technology must conform to larger ethical principles. Third, like economics, science and technology are now global enterprises. Each new scientific discovery and technological invention is by-product of human ingenuity on a global scale. For this reason, conference participants agreed that science and technology should serve the global community and not just the needs of a few select nations. Fourth, the vigorous role played by delegates from developing countries in the conference along with the extensive media attention received by scientific institutions like TWAS are testimony to the scientific progress that has taken place in the South over the past few decades. It also indicates awareness among scientific communities in developing countries of the responsibilities they have in promoting science-based development within their own borders. As citizens of the world's most populous country, Chinese scientists are cognisant of both their role within society and of the need to encourage international cooperation for their goals to be achieved. These twin principles—the need for each country to advance science within their borders while promoting international cooperation—drove much of the discussion at the WCS. Progress on both fronts will be the key measure of the conference's success in years and decades ahead.

Lu Yong Xiang
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FAUSTIAN BARGAIN

Speaker after speaker at the conference emphasized the gap in scientific expertise and economic well-being between rich and poor nations—a gap that has been growing largely as a result of globalization. It is indeed ironic that a force many hoped would bring us closer together has actually driven us farther apart. While the conference did a good job of identifying the major problems faced by science and society on the eve of the next millennium, it fell

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short when it sought to chart an effective course for future action. We should not be surprised by this outcome. The effort by conference organizers to be inclusive may have taken the edge off many of the pronouncements in the "Declaration" and recommendations in the "Framework for Action." After all, consensus requires compromise. One issue that I was glad to see aired by Sir Joseph Rotblat in his opening ceremony address was that of the increasing pressures faced by academics due to the privatization of scientific knowledge. I am afraid that more and more scientists are selling their souls to corporate concerns in return for adequate resources to pursue their research. That is a Faustian bargain that deserves close scrutiny by the global scientific community, particularly scientists from developing countries where this trend promises to render its most adverse consequences.

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HIGH VALUE

The universal value of basic science was a major theme of the World Conference on Science (WCS), creating lively discussions and several key considerations that will hopefully be integrated into future strategies for advancing the role of science in our global society. Such value is based on this simple fact: Scientific knowledge is the same for all scientists in all countries. Yet, what is true on an individual basis has proven problematic on a regional and national level. The pursuit of science, in fact, has been a major force dividing the world between developed and underdeveloped countries. Third World countries must support basic science for a host of reasons: to establish scientific capacity for dealing with pressing problems of no immediate concern to developed countries; to reduce the science and technology gap between developed and developing countries; to participate effectively in the solution of global problems; to raise the quality of education at undergraduate and graduate levels; and to create new knowledge for improving our understanding of the world in which we live. To attain these goals, significant portions of the population must support science. This will require nations—particularly those in the South—to spend more on education, especially science education, and to engage in international projects that address economic and environmental issues through science-based studies. A fundamental principle of the WCS was that many of today's problems are global in nature and their resolution will require the involvement of scientists from all countries. Consequently, both the developed and the developing world have a stake in the future of science as a global enterprise and must work together to ensure progress takes place on all fronts. If the WCS plays a role in advancing this goal it will have proven to be a success.

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LITTLE RESPECT

One of the ironies of the current relationship between science and society is that science may be more popular in developing countries than in developed countries. At least, public respect for science seems to be higher in the South than in the North. Yet, when it comes to budgets, the opposite is true. Bridging the gap between the public's implicit support for science and the inadequate budgets that too often plague the scientific enterprise in developing countries will not be easy. Scientists in the South need to take advantage of the public's respect for science to urge governments to provide additional funds. Again this is easier said than done, but the World Science Conference (WCS) may help in this effort by illustrating the worldwide concern for strengthening the relationship between science and society. On another matter, the final conference documents—the "Declaration" and "Framework for Action"—were broadly cast. Conference organizers wanted to avoid the same fate as the last large convocation on science, held in Vienna in 1979, where some specific targets were set for a science and technology fund for developing countries. Those targets were missed by a wide margin. The conference, as a result, has been viewed less favourably. Given that experience, the carefully drawn yet vaguely stated conference goals articulated in Budapest make sense. But now that the conference has concluded, I think follow-up action should focus on a few concrete problems for which progress can be measured. That is one way the WCS could have a long-term tangible impact.

José I. Vargas
TWAS President
Special Advisor to the President of Brazil
Brasilia, Brazil

GENDER COUNTS

The World Conference on Science brought together government ministers, leaders of scientific research and academic institutions, representatives of non-governmental organizations, and renowned and not-so-renowned scientists from every corner of the globe. All were united by a common goal to lift the banner of science for the benefit of humankind. Third World representation was evident in the lectures and debates that culminated in the "Declaration" and "Framework for Action" adopted at the conclusion of the meeting. The gap in scientific advancement between developed and developing countries was a major concern of the conference as were ethical issues pertaining to the practice of science. A general feeling pervaded the gathering that the world scientific community should lead the way in redressing North-South imbalances and devising a code of ethics on science that focuses on environmental conservation and improvement in the quality of life of all people. Gender equality in science and technology was one of the foremost issues at the conference. The significant number of women in country delegations demonstrated an acceptance of the potential contribution of women to the international scientific enterprise. Organizers and participants, moreover, appeared determined to mainstream gender issues in science. Despite such progress, representatives of country delegations and non-governmental organizations expressed concerns about the persistent under-representation of women in science, but no clear strategies emerged during the meeting on how to resolve this problem. For this reason, I left the meeting convinced that the Third World Organization for Women in Science (TWOWS) must take advantage of the interest in gender issues generated by the conference and work with even greater vigour to reach its objectives.

Lydia Makhubu
President
Third World Organization for Women in Science (TWOWS)
Vice-Chancellor and Professor of Chemistry
University of Swaziland
Kwaluseni, Swaziland

WEATHERING CHANGE

Some of the challenges that humanity must address in the next century include sustainable food production, availability of freshwater in sufficient quantity and quality, and mitigation of the impacts of natural disasters. Humanity will also have to address such environmental concerns as climate change, ozone layer depletion and pollution control. In view of the increasing demands from fast growing populations, renewed commitments in science and technology are required if all nations are to experience sustained socio-economic development in environmentally friendly ways. The World Conference on Science (WCS) focused on many of these issues. However, its ultimate impact will be measured by the progress that is made in advancing these goals in the decades ahead. The geosciences that deal with the Earth's basic life systems, including air, water, sea and land, also have significant roles to play in these endeavours. Perhaps the best support that the geosciences can provide in addressing the challenges facing humankind is to predict accurately the future state of the atmosphere and, in particular, the occurrences of extreme weather and climate events with sufficient lead time to allow actions to save lives, curb property damage and protect the environment. Improvements in the prediction and early warning of extreme weather and climate events have been made possible by the enhancement of the basic global, regional and national infrastructure that comprises the World Meteorological Organization's Global Observing System. The challenge to the world community is to enhance this unique and vital observation network for the continuous monitoring of weather and climate systems, and for the protection of the atmosphere. There is also the need to maintain the free and unrestricted exchange of meteorological data and products world-wide. Concrete steps like these—both in meteorology and other scientific fields—will signal the success of the WCS.

G.O.P. Obasi
TWAS Vice-President
Secretary-General
World Meteorological Organization (WMO)
Geneva, Switzerland

PARTNERING UP

The World Conference on Science (WCS) in Budapest, Hungary, brought together a large number of scientists, governmental officials and non-governmental representatives from around the world. Participants emphasized the crucial role that science and technology play in the development process and expressed concern about the widening gap in science and technology between the developing and developed world. This ominous trend has caused increased hunger and disease, and has led to such serious global problems as deforestation, desertification and climate change. To ensure sus-

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tainable development, participants emphasized that aid from developed to developing countries should be channelled primarily to projects that foster human resource development. In addition, they stressed the importance of basic scientific research, its ties to applied research and technological development, and the need for such governmental policies as tax incentives to advance the commercialization of research and development activities. Participants welcomed the World Bank's recent efforts to promote the creation of world-class science institutes—Millennium Institutes—in the developing world. Several suggested that the Third World Academy of Sciences could play a central role in advancing this initiative by recommending the best existing centres of excellence in the developing world for selection as Millennium Institutes. An extensive network of such institutes could provide the foundation for high quality science and technology and serve as the basis for development throughout the developing world. In a key recommendation, developing countries were urged to invest 3 percent of their annual gross domestic product (GDP) on science and technology as a prerequisite for economic progress. All in all, the WCS created a strong framework for science-based sustainable development in the South. The ultimate success of the conference, however, will hinge on whether its wide-ranging blueprint for progress is transformed into reality.

Atta-ur-Rahman
TWAS Fellow (1985)
Director
H.E.J. Research Institute of Chemistry
University of Karachi
Karachi, Pakistan

DIRECTOR-GENERAL OF UNESCO REPLIES

I have read the comments appearing on the preceding pages with great interest and considerable satisfaction. The distinguished scientists who contributed those comments and who all attended the World Conference on Science (WCS) have singled out many of its positive aspects. They offer analyses of the main obstacles, challenges and opportunities ahead in the post-Budapest implementation period.

I broadly agree with their observations. Clearly, the WCS is being viewed as a *process,* rather than an event, with a preparatory and now a follow-up phase. This is the surest sign that we can—and will—forge a new relationship between science and society.

One positive outcome of the WCS process, emphasized in these

comments, is the focus given by the media to science in the South and the links between science and development. We have to sustain this focus, taking every opportunity to put over the message of the global nature of the scientific enterprise. It is the only way to keep public opinion and political opinion with us as we push science up the policy agenda.

At the WCS, I used the image of mapping to describe our undertaking. I believe we left Budapest with a clear map that we are now using to chart our course—or, rather, courses—for future action. The TWAS meeting in Dakar, Senegal, will undoubtedly chart a significant part of the route. The decision by the Italian government to strengthen TWAS will reinforce its ability to develop the South's science base, scientific networking and science-led development.

I agree entirely that the focus now has to be on a certain number of concrete problems and specific strategies. The plan that emerged in Budapest for a network of research institutes working on biodiversity, biomass and biotechnology, sponsored by TWAS in developing countries, offers the prospect of a major enhancement of scientific capacity in a crucial area for development in the South, given the rich biodiversity and high primary productivity of tropical ecosystems. South-South collaboration is an important strategy for reinforcing research.

Other concrete areas identified as requiring special attention include freshwater and the hydrological cycle, climate, oceans, coastal areas, polar regions, biodiversity, desertification, deforestation, biogeochemical cycles and natural hazards. A strategy of cooperation is advised among neighbouring countries or countries with similar ecological conditions to find solutions to common environmental problems.

UNESCO is taking the lead in a new programme, Hydrology for the Environment, Life and Policy, with a field-oriented, scientific programme addressing issues defined by user groups and policy-makers. The Valencia Centre for International Affairs will be established to promote sustainable water management, while a UNESCO International Institute for Water Education will build on the current UNESCO-International Hydrological Programme (IHP) postgraduate courses. A project is being launched on Urban Pollution of Superficial and Groundwater Aquifers in Africa and the Global Ocean Observing System (GOOS) will also be implemented in Africa as the latest addition to a global network.

Paragraph 90 of the "Science Agenda", with its seven priorities identified by six regional women's forums in the run-up to the WCS, offers a promising strategy for strengthening the presence of women and girls in science.

Several projects are already in preparation. I look forward to the close cooperation of the Third World Organization for Women in Science (TWOWS), United Nations Fund for Women (UNIFEM) and Once and Future Action Programme (OFAN) in projects that include: collecting of gender-disaggregated statistics; training programmes for statisticians and decision-makers; a guide ensuring sexual equality in national policy-making and implementation; scholarships and a secondary-school level kit for each region containing scientific experiments of interest to girls financed by the French company l'Oreal; and the creation of regional networks of women scientists and regional monitoring centres on women, science and technology in Latin America, Africa and the Arab region.

Other priorities include: improving the public understanding of science, science education, policy-making in science, intellectual property rights, data collection and processing; access to scientific knowledge; establishing a UNESCO interface between traditional knowledge-holding communities, scientists and decision-makers. Many initiatives are being launched.

I invite all our partners to join in and to let us know of other projects, so that we have a shared overview of the post-WCS phase and can continue to build up the momentum.

Federico Mayor
TWAS Associate Fellow (1991)
Director-General
United Nations Educational, Scientific and Cultural Organization (UNESCO)
Paris, France

TWAS-SPONSORED SESSIONS HIGHLIGHT BASIC HUMAN NEEDS AND ECONOMIC DEVELOPMENT

THE THIRD WORLD ACADEMY OF SCIENCES (TWAS) SPONSORED TWO THEMATIC SESSIONS AT THE WORLD CONFERENCE ON SCIENCE: SCIENCE IN RESPONSE TO BASIC HUMAN NEEDS, IN COOPERATION WITH THE INTERNATIONAL COUNCIL FOR SCIENCE/COMMITTEE ON SCIENTIFIC AND TECHNOLOGICAL COOPERATION (ICSU/COSTED), AND SCIENCE FOR DEVELOPMENT. THE FOLLOWING IS A BRIEF SUMMARY OF THE DISCUSSIONS THAT TOOK PLACE IN EACH OF THESE SESSIONS.

SCIENCE IN RESPONSE TO BASIC HUMAN NEEDS

Eduardo M. Krieger, Chair, TWAS Fellow (1995)
President, Brazilian Academy of Sciences, Rio de Janeiro, Brazil

Developing countries should seek to advance science in areas relevant to the needs of their people. Because they represent a mixed profile in terms of scientific capabilities and levels of economic development, each developing country must assume responsibility for defining its own areas of critical concern. Science, in turn, must be applied in ways to curb economic imbalances, social injustices and the inefficient uses of resources that continue to undermine the health and well-being of marginalized populations. The essential features of a good society are human development, human security and material well-being. Modern science has been a vehicle for progress, but to date industrialized nations have been its prime beneficiaries. A main challenge facing the global community in the 21st century is to extend the benefits of science and technology to people in less developed countries. To advance this goal, developing countries must nurture a critical mass of highly skilled personnel in universities capable of judging good science from bad and determining which technologies are most appropriate for their societies. Scientists in developing countries must not only be involved in first-rate international research but must address issues of critical importance to the needs of their countries. The scientific community, moreover, must be closely linked to societies' productive sectors. Brazilian researchers now author 1 percent of all scientific publications worldwide (the same percentage as South Korean scientists). Brazilian technologists, however, receive less than .005 percent of the international patents issued each year; South Korean technologists, on the other hand, receive about 1 percent of the international patents issued each year. Brazil's recent investments in science have elevated the nation's presence in academic research but not in technology. The next step is to tie scientific research more closely to sectors of society capable of turning knowledge into worthwhile products and services. ■

G. Thyagarajan, Rapporteur
Scientific Secretary, International Council for Science, Committee on Science and Technology in Developing Countries (COSTED/ICSU), Chennai, India

The number of scientists working in developing countries remains insufficient to support economic development. These countries, as a result, must develop educational strategies for increasing the number of scientists who are trained and then continue to work in the countries of their birth. At the same time, developing countries should expand support for improving their scientific and technological capabilities. New technologies offer unprecedented solutions for addressing many of the most critical issues facing developing countries today, particularly in such areas as agriculture, health, energy and the environment. Those are precisely the areas where the help of developed countries could prove to be instrumental. Developing countries, on the other hand, must devote special attention to new agricultural techniques and recent innovations in the management of water resources because those are areas where the largest payoffs are likely to occur in meeting the most basic of all human needs: food security. For people from developed nations, science and technology represent tools for increasing their levels of comfort. For developing nations, science represents the most effective means of eliminating human suffering. There is no reason why the North and South cannot work together to achieve progress on both fronts.

Essmat Ezzat, TWAS Fellow (1991)
Director, World Health Organization Collaborating Centre for Human Resource Development
Suez Canal University, Ismailia, Egypt

Health research is a powerful tool for improving the quality of life, especially in developing countries where basic health care remains a critical issue. Health care information, often in short supply in developing nations, is one of the most important by-products of health care research. In fact, such information is a prerequisite for improving the health care system. Health care, moreover, is related to economic development because an unhealthy workforce is an unproductive workforce. As a result, health care research must be strategic in the sense that it must be tailored to health care issues relevant to particular regions, nations, and localities. It must also take into account the economic and social milieu in which health care issues take root. Despite some recent advances in health care research in developing countries, 1 billion people remain without adequate shelter, proper sanitation and clean drinking water. At the same time, health care researchers in the developing world suffer from inadequate pay, poor working conditions and lack of public support for the work that they do. To bridge the gap between science and society in the developing world, we must take the necessary steps to alleviate poverty and improve the quality of life for the most marginalized populations. For these reasons, health care research must be linked to issues of food production, sanitation, clean drinking water and environmental quality as part of a larger, comprehensive strategy for sustainable development.

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M. de Jesus Limonta-Vidal, TWAS Fellow (1995)
Advisor for International Collaboration, Centre for Genetic Engineering and Biotechnology, Havana, Cuba

World population is projected to reach 8 billion by 2020 and 11 billion by 2050. Virtually all of this growth will take place in the most of impoverished regions of Africa, Asia and Latin America. Demand for food in the world's poorest, most populous, regions is expected to double by 2025. Developing countries face three interrelated problems that have been compounded by rapid population growth: food security, public health and environmental degradation. Biotechnology presents an opportunity for addressing each of these problems. In fact, biotechnology offers the best chance we have to improve crop yields and overcome the problems of malnutrition and hunger-induced disease now afflicting 800 million people in the developing world. Transgenic plants could increase yields by making plants more resistant to disease and pests. Until now, transgenic plants have been utilized largely by industrialized countries, especially in North America. In fact, the United States is responsible for nearly 75 percent of the 27 million hectares cultivated with transgenic plants, which include soybeans, corn, and tomatoes. Cuban researchers have conducted field trials for transgenic plants in sugar, papaya, tomatoes and potatoes—all with the intent of increasing the food supply. They also have studied transgenic techniques for increasing the milk production of cows and the beef weight of cattle. Biotechnology also holds promise for developing pharmaceutical products and vaccines to combat such diseases as hepatitis and AIDS. Again, researchers in the developed world have led the way in investigating the potential role of biotechnology in the development of new medicines. Cuba has made progress in this area but urges other developing nations to join its researchers in the study and application of biotechnology, which is likely to serve as an important tool for meeting basic human needs directly related to food security and health. ■

Riyad Al-Dabbagh
President, Al-Mustansiriyah University, Waziriyah, Baghdad, Iraq

Scientific values must be based on human values. That is one way to ensure that science will be used to address basic human needs. The most important elements in nature are air and water. Water is an essential ingredient for a variety of human activities: growing food; cooking; sanitation; recreation; hydroelectric power; transportation; and waste management. Water, in short, is an irreplaceable, life-giving element. Yet, we have not planned for its efficient use. As a result, both water quality and quantity throughout much of the world (and especially in the developing world) have been adversely affected. As global population continues to increase (again, especially in the developing world), competition for water resources has emerged as a critical issue in some areas. Moreover, 1 billion people do not have access to safe drinking water, and polluted water claims about 2 million lives each year. Statistics on a global scale may suggest that we have adequate supplies to meet future global needs, but water production and consumption takes place on a regional and local scale. That is why water shortages are expected to become more troublesome in the years ahead. To meet this critical challenge, we must develop strategies for improving water management, increasing water supplies, reusing waste water, providing incentives for more efficient water use, upgrading irrigation systems, training personnel and raising public awareness. Better data collection and analyses, increased international cooperation and more effective domestic water policies and programmes are all critical elements in efforts to improve water use and efficiency. ■

Keto Elitabu Mshigeni, TWAS Fellow (1987)
Professor of Botany, University of Dar es Salaam, Dar es Salaam, Tanzania

An idea first suggested and nurtured by Gunter Pauli, the Zero Emissions Research Initiative (ZERI) now forms the backbone of a world-wide network, with field offices in Switzerland, Namibia, Fiji, Indonesia, Uganda and the United Kingdom, to name just a few countries. The initiative has received support from the United Nations University (UNU); United Nations Educational, Scientific and Cultural Organization (UNESCO); United Nations Development Programme (UNDP); United Nations Environment Programme (UNEP); the government of Namibia; and the private sector. Broadly speaking, ZERI relies on scientific strategies to address issues related to basic human needs, especially issues adversely affecting the world's most impoverished individuals and communities. Specifically, ZERI seeks to turn what have been defined as waste materials into useful products. In the face of increased population, we must devise strategies that allow us to do more with the resources we have. To advance this goal, ZERI has helped sponsor a project to expand commercial uses for seaweed in Tanzania. Today, villages throughout the island of Zanzibar in Tanzania generate more income from the sale of seaweed and seaweed by-products (used in shaving cream, body lotion and tooth paste, or even eaten as a rich source of iodine) than they do from tourism. In a similar vein, ZERI has helped design a new brewery in Namibia that turns the large quantities of mineral-laden "waste water" associated with the production of beer into income-earning products—for example, to enrich soil or supplement hog feed. Other ZERI projects include investigations into earthworms for use as chicken feed; bamboo for housing material; hyacin for water purification; and even house flies, which produce maggots that can be fed to chickens and fish. ZERI, in short, promotes programmes that strive for zero waste and innovative, income-producing use of products previously considered to be waste. One of the prevailing expressions of our computer-driven age is “garbage in, garbage out.” ZERI is working to turn that expression (and more importantly strategies for economic development) into a process marked by “garbage in, products out.” ■

SCIENCE FOR DEVELOPMENT

C.N.R. Rao, Chair, TWAS President-Elect, INSA Albert Einstein Research Professor and President, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India
Mohamed H.A. Hassan, Rapporteur, TWAS Executive Director, Trieste, Italy
President, African Academy of Sciences

The gap between the North and South in the production and utilization of scientific knowledge has widened over the past three decades. At the same time, the economic, social and environmental issues confronting the global community have grown more complex and interrelated. These two forces have made scientific capacity building an urgent issue for all nations and particularly for nations in the South. Why study science? At its most basic level, science is part of the eternal human quest for knowledge based on an inherent desire to broaden and deepen our understanding of the world in which we live. But few observers would deny that science is also essential for solving concrete, real-life problems. Nations that do

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not enjoy a solid scientific base are seriously handicapped in their efforts to improve the quality of life for their citizens or develop effective strategies for the sustainable use of their resources. Science education and literacy, moreover, provide a solid base for exploring all areas of knowledge by emphasizing the importance of observation, objectivity and rational analysis. In today's world, marked by science-based technological progress, nations that fail to learn and apply the language of science have no chance to ride the accelerating currents of change that have characterized recent history. For these reasons, developing countries must give science education the highest priority, taking full advantage of the opportunities afforded by the new information and communication technologies. At the same time, they must support science-based solutions to critical social, economic and environmental problems affecting the everyday lives of their citizens; publicize science-based initiatives that have been particularly successful to strengthen public and political support for their efforts; and expand South-South and North-South networks of scientific excellence. More specifically, developing nations should strive to invest 1 percent of their gross domestic product in research and development and 6 percent in education. And they should target their scientific efforts to their societies' most pressing needs: food security; safe drinking water and improved public health, including the eradication of diseases that are due primarily to unsanitary conditions and poor, inadequate diets. ■

Muhammad Akhtar, TWAS Founding Fellow and Vice-President
Professor Emeritus, University of Southampton, Southampton, United Kingdom

To a limited extent, commercial interests have always provided a stimulus for scientific inventions. In the past, however, it was possible to strike a balance between the commercial exploitation of scientific knowledge and the principle that scientific knowledge was part of the cherished heritage of humankind, freely accessible to those with the skills and time to explore the scientific literature. Those who contributed richly to many of the great discoveries of the 20th century—for example, vaccinations, insulin, steroid hormones and organ transplants—rarely benefited financially from their endeavours. Two powerful forces have changed the dynamics between the personal acquisition and the widespread distribution of scientific knowledge: the universal acceptance of free-market principles and the expanding influence of multinational corporations. These two forces threaten the ability of less developed countries to reap the benefits of scientific progress. The tenets of the free market are intruding on all walks of life, creating situations in which even the most respectable scientists are 'bending' their research in their quest for commercial applications. The collusion between scientists and multinational corporations, moreover, is leading to the marketing of expensive "alternative" products that often amount to nothing more than more expensive "me-too" versions of existing products. Several recombinant DNA-based diagnostic kits fall into this category. The most worrisome feature of this trend, however, lies in its commercial onslaught on agriculture. Farmers around the world now use new seeds and agrochemicals whose production and distribution is strictly controlled by U.S. multinational corporations. These organizations, wielding unprecedented economic power, have marketed products about which little, if any, information can be found in peer-reviewed literature. Utilizing appropriate technologies to meet the needs of developing countries is an immensely important task requiring input from both politicians and well-trained local scientific experts. Now is an opportune time for international organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), International Council for Science (ICSU), and Third World Academy of Sciences (TWAS) to address the challenges to the developing world posed by the global presence of free-market principles and the dominance of multinational corporations. ■

Alejandro Jorge Arvia, TWAS Fellow (1988)
Director, Research Institute of Theoretical and Applied Physical Chemistry (INIFTA)
La Plata, Argentina

The success of scientific capacity in developing countries depends on several prerequisites: (1) development of a solid educational system in which talented young people are encouraged to pursue careers in science; (2) clear, consistent, long-term decisions on the part of public officials to provide funding for scientific activities; (3) incentives for scientists to tackle local problems and devise solutions that benefit people; and (4) strategies that encourage close ties between international scientific and develop organizations. The growing gap in scientific capabilities between the North and South can be attributed to differences in economic well-being, educational levels, ease of access to information, the condition of research laboratories, and the willingness of political institutions to support long-term science and technological initiatives. International organizations have a central role to play in building scientific capacity in the developing world by serving as "a communications and training bridge" between the North and South.

Attia A. Ashour, TWAS Fellow (1985)
Professor of Applied Mathematics, Cairo University, Giza, Egypt

Because developing countries are at different levels of development, it would be difficult to propose a general policy for the utilization of science and technology in the South. The existence of a critical mass of scientists is a necessary but insufficient condition for putting science to work for development. In the early stages of the creation of this critical mass, the scientists' areas of specialization are immaterial. What is more important is that a sufficient number of promising students are being trained to think critically. That outcome alone would represent an important step forward. At the same time, developing nations must nurture public support for science if the scientific community hopes to generate the financial and political support it needs to succeed. Such support cannot be obtained if the vast majority of the population is scientifically illiterate. For these reasons, a strategy to improve scientific education throughout all levels of the educational system—and especially in primary schools—is an essential prerequisite for building long-term scientific capacity. Governments in developing countries must treat scientists as "precious commodities" and offer them the recognition, financial rewards, research facilities and recognition that scientists in the North have come to expect. The South's best scientists belong to a pool of international workers who can obtain employment virtually anywhere in the world. If developing countries hope to retain the services of the scientists born in their countries, they must be willing to compete in the international job arena. Otherwise, the debilitating impacts associated with the brain drain are likely to continue. The gap in science and technology between the North and South is too large to be closed in one great leap. For this reason, developing countries would be wise to pursue a step-by-step approach in which slow but steady progress takes place through initiatives based on South-South cooperation. Such a strategy would turn the disparities in scientific and technological capabilities (for example, between India and the Congo or Brazil and Rwanda) into a tool for progress by enabling the countries in the South to learn from one another.

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Adnan Badran, TWAS Vice-President, President, Philadelphia University, Amman, Jordan

The combined forces of the free market, free trade and global electronic information networks are making the world increasingly interdependent. Of all the forces driving our global village, none is more important than science and technology. Breakthroughs in science, for example, have left an indelible mark on society in energy, medicine and biotechnology. But science has also helped raise public uncertainties and fuel a crisis in confidence over issues of environmental degradation, public health, food safety and threats of widespread destruction posed by high tech weaponry. The frontiers of science throughout much of the 20th century have been expanded either by heated conflicts or cold wars. Indeed the fruits of science have often been nurtured in hostile environments marked by distrust and bitterness. In the next millennium, all signs point to a world in which scientific frontiers will be breached by market forces. Research and development will be conducted increasingly in the private sector as corporations search for new knowledge and innovations to retain their prominent positions in the market place. As these forces take hold, developing countries could find themselves in a "scientific no-man's land" that prevents them from enjoying the economic and social benefits flowing from new scientific findings and technological breakthroughs. Recent data shows that 85 percent of total expenditures on research and development takes place among the 29 members of the Organization of Economic Co-operation and Development, which produce two-thirds of the world's goods and services. Each OECD member state invests on average 2 to 3 percent of its gross domestic product (GDP) on research and development; in contrast, developing countries on average invest less than 0.4 percent of their GDP on research development. OECD countries average 4 scientists for every 1000 people in their work force; developing countries average 0.7 per 1000. These figures highlight several critical factors for developing nations to consider when discussing the prospects for reforming their science and technology policies. First, developing nations must strengthen their educational systems and second, they must invest more in scientific research and technological development. ■

Ahmad Jalali, Iranian Ambassador, United Nations Educational Scientific and Cultural Organization (UNESCO), Paris, France

One of the most disturbing problems that beset our world is the inequality in the production of scientific knowledge. According to statistics published by the United Nations Educational, Scientific and Cultural Organization (UNESCO), only 4 percent of the world's scientific research takes place in so-called developing countries. If we consider that a disproportionate amount of this percentage is due to research efforts in just a few developing countries (for example, China, India and Brazil), then the picture becomes even gloomier. In many developing countries, the number of researchers in important scientific fields has not reached critical mass. As a result, it remains difficult for these nations to launch effective research programmes. Researchers who remain in their home countries often work by themselves, pursuing personal agendas that have little bearing on their societies. Some developing countries have yet to develop the concept of organized research, let alone establish long-term national research policies. Given these conditions, the globalization of scientific research could help scientists in the developing world to establish channels of communication with their colleagues in the developed world, creating unprecedented opportunities for redefining long-standing research agendas. On the other hand, scientific globalization could weaken the role of the state in scientific affairs and thus create a vacuum that may not filled by the nascent private sector that has emerged in developing countries over the past few decades. ■

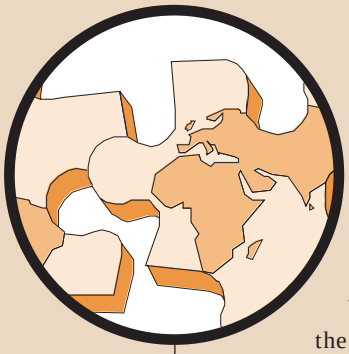
Godwin O.P. Obasi, TWAS Vice-President
Secretary-General, World Meteorological Organization, Geneva, Switzerland

Advances in science have contributed to the development of every aspect of human endeavour, transforming the food we eat, the houses we live in and the clothes we wear. Today, progress in medical sciences, transportation systems, information technologies and genetic engineering are having unprecedented impact on our ways of life. Applications of scientific knowledge have not only increased food production but made water and energy production and consumption more efficient, safeguarded the environment, and enhanced the protection of life and property. However, there is much more to learn and to do—in strengthening our food security, protecting our water supplies, improving our understanding of the impacts of natural disasters, and shedding light on such environmental problems as global warming, ozone layer depletion and transboundary transport of pollutants. Society holds high expectations for science to meet these challenges. Communities affected by tropical cyclones, storm surges, floods, droughts and other severe hydro-meteorological events want to know where and when such events will occur and how long they will last. The socio-economic impacts associated with these events often are devastating, especially in developing countries. For instance, in 1998, Hurricane Mitch destroyed two-thirds of the infrastructure in Honduras. On a global scale, in 1997-1998, the economic loss due to El Niño was estimated at US$3 billion. Likewise, climate change impacts could be significant, on issues ranging from sea-level rise to crop production. The ability of the scientific community to respond to these issues will depend in part on adequate levels of funding. Although the Tropical Ocean and Global Atmosphere (TOGA) programme represented a breakthrough in predicting climate anomalies several years in advance, additional development in modelling is essential for improvements in climate predictions. For these advances to take place, the global community should take advantage of the initiatives launched within the framework of the World Climate Research Programme, particularly those related to better monitoring of the Earth's climate system.

Gerald C. Lalor, TWAS Fellow (1987), Pro-Vice-Chancellor, University of West Indies
Director-General, International Centre for Environment and Nuclear Sciences (ICENS), Kingston, Jamaica

The major political consequence of the application of science and technology over the past several centuries has been global domination by European and European-origin civilizations. This trend is likely to continue as the knowledge gap on which it is based widens. Since the 1940s, the developing world has created many universities and research institutes, and trained many nationals at home and abroad. Significant strides have been made in certain disciplines. Yet, the criticism remains (perhaps not fully justified) that with few exceptions science and technology in the South has not contributed enough to development. The situation is particularly difficult in small countries where resources and opportunities usually are limited and the brain drain can be an especially powerful force. Jamaica has sought to address these concerns with the creation of the International Centre for Environmental and Nuclear Sciences, which has developed a multidisciplinary programme in environmental geochemistry that is based on the creation of computer-readable databases essential for development. The programme fosters local and international collaboration with universities, research institutes, regulatory bodies and the private sector on initiatives in agriculture, natural resource management and public health. The ultimate goal is to create and retain a critical mass of workers and to foster interactions with Jamaican scientists living abroad to curb the impact of the brain drain.

TWAS, TWNSO, AFRISTECH MEET IN SENEGAL



Science and sustainability will serve as the main topics of discussion during a week-long conference featuring the South's most prominent researchers and science administrators.

The Third World Academy of Sciences (TWAS) will hold its 7th General Conference and 11th General Meeting between 21-26 November 1999 in Dakar, Senegal. The overarching theme of the conference, which is being co-sponsored by the government of Senegal, is "science and technology for sustainable development in Africa on the eve of the 21st Century."

The gathering will also mark the 6th General Assembly of the Third World Network of Scientific Organizations (TWNSO), an affiliate organization of TWAS, and the 4th biennial meeting of AFRISTECH, an African-based organization dedicated to increasing awareness among the continent's decision-makers concerning science and technology's critical role in development.

"TWAS is delighted to be coming to Africa for its 7th General Conference," says Mohamed Hassan, Executive Director of TWAS and current President of the African Academy of Science. "And we are glad to be organizing the event in partnership with TWNSO and AFRISTECH."

"Africa faces great challenges," adds José I. Vargas, President of TWAS and TWNSO. "But there are also great opportunities for progress if the nations of Africa can learn to put their enormous natural resources to work through the wise application of science and technology. After a particularly bleak period, there are signs that Africa may be at the threshold of a new era. We hope that the conference helps advance the progressive agenda of Africa's small but potentially influential scientific community." Specifically, the conference will focus on:

- Strategies for building scientific and technological capacity and scientific excellence in Africa.
- Initiatives in Senegal for addressing economic and social problems through science and technology.
- Programmes throughout the South for bringing science-based development to fruition at both national and regional levels.

"One of the main objectives of the conference," notes Ahmadou Lamine Ndiaye, Rector of the University of Gaston Berger in Saint Louis, Senegal, "is to sensitize the public in Senegal and, more generally, throughout Africa, to the fundamental role that science and technology play in economic and social progress. There remains a great need for people in the developing world to understand and appreciate this role."

"International conferences," Ndiaye adds, "can help raise awareness that science, especially when tied to technology, holds the key to solving everyday problems—that it is not a luxury but an essential element in any development strategy." Ndiaye is serving as one of the local organizers of the Senegal conference. Conference highlights will include:

- An opening ceremony featuring an address by the President of Senegal, Abdou Diouf, who will remain on the podium following his talk to congratulate TWAS and TWNSO 1998 awards and 1999 medals winners.

• Invited lectures by prominent scientists from the South and North.

• Symposium and workshops on the following themes: biotechnologies for accelerated agricultural development; new and renewable energies; financing innovation and new partnerships for technological development; status of health sciences in the tropics; 21st century communication technologies; and frameworks and infrastructure essential for the basic sciences and mathematics in Africa.

• A roundtable discussion by ministers of science and technology from the developing world examining risks and opportunities for new technologies for development in Third World countries, including possible strategies for promoting the participation of women in industrial research activities.

• An exhibition sponsored by AFRISTECH exploring scientific research and technological progress in Senegal.

The conference's main conclusions and recommendations will be presented in the "Dakar Declaration on Sustainable Development Through Science on the Eve of the 21st Century," to be issued on the last day of the gathering.

For more detailed information about TWAS's 7th General Conference and 11th General Meeting, see: http://www.ictp.trieste.it/~twas/Dakar.html.

C.N.R. Rao

RAO HONOURED

C.N.R. Rao (TWAS President-Elect and Founding Fellow), who serves as the INSA Albert Einstein Research Professor and President of the Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore, India, has been awarded the Centenary Medal and Lectureship of the Royal Society of Chemistry in London; has been elected an honorary member of the Royal Spanish Academy of Exact and Natural Sciences; and has been invited to give the Halim Lecture at the Korean Academy of Science and Technology in Seoul. In a long and distinguished career, Rao has received numerous national and international awards. Among them are the C.V. Raman Award; S.N. Bose Medal; Royal Society of Chemistry Medal; Nehru Award for Science; Council of Scientific and Industrial Research (CSIR) Golden Jubilee Prize; National Academy of Sciences (USA) International Science Lecture; Sahabdeen International Award for Science, Sri Lanka; and Einstein Gold Medal, United Nations Educational, Scientific and Cultural Organization (UNESCO). Rao, who has received more than 20 honorary university degrees, is a fellow of the Indian National Academy and Indian Academy of Sciences; the Royal Society; a fellow of the Pontifical Academy of Sciences; and a foreign member of the National Academy of Sciences (USA), Russian Academy of Sciences and Czechoslovak Academy of Arts and Sciences. His major fields of interest include solid state chemistry, surface science, spectroscopy and molecular structure.

VARGAS IN NATURE

José I. Vargas, President of TWAS and TWNSO and former Minister of Science and Technology in Brazil, recently published an article in *Nature* in which he maintained that South-South cooperation, especially when linked to cooperative initiatives between the North and the South's most advanced developing countries, could hold the key to science-based sustainable development. He cited Brazil's space programme as a prime example of how this stair-stepped policy could work. Vargas notes that the origins of his nation's programme lie in the creation of the Brazilian National Space Commission, established in 1961. He goes on to say that "some 30 years later, in 1993, with the assistance from a private U.S. space firm, Brazil launched its first resource-data collecting satellite from Kennedy Space Centre. Since then, Brazil has pursued two inter-related space initiatives: the Brazilian Space Mission (MECB) and the China-Brazil Earth Resources Satellites programme (CBERS)." These efforts, employing about 1000 scientists and engineers and 2000 technicians, use satellite technology "to address down-to-earth concerns: changes in temperature, humidity and carbon dioxide concentrations in the atmosphere and real-time data on alterations in soil and water quality." Equally important, Vargas observes, the information gathered has been shared with other scientists in other developing countries through 300 data-collecting platforms built in Brazil and neighbouring countries. Brazil has also offered the information gathered by the satellites and data-collecting platforms

José I. Vargas

to African nations through the United Nations Educational, Scientific and Cultural Organization (UNESCO). For Vargas, Brazil's space programme, which began with help from the United States and is now driven in part by a partnership with China, shows "how North-South co-operation can be used to foster South-South co-operation." For a full text of the article, see "How the North can help the South help itself," *Nature* 3 June 1999. For a detailed description of the Brazilian space programme, see "Brazil Reaches for Outer Space," *TWAS Newsletter*, April-June 1997.

MEMORANDUM

The Third World Academy of Sciences (TWAS) has signed memorandums of agreement with the national science academies of Norway and the Czech Republic. "The agreements are designed to facilitate greater scientific cooperation between TWAS and these nations," says José I. Vargas, TWAS president. "They mark another step in TWAS's ongoing efforts to strengthen our ties with the North even as we continue to advance our ongoing efforts for South-South cooperation through our research grant, fellowship, associateship and joint lectureship and professorship programmes. We look forward to a long and fruitful relationship with both countries."

Li Sung Gi

LI SUNG GI

Li Sung Gi (TWAS Fellow 1988) died last year at the age of 93. Born in Changwari, in South Chonra Province, South Korea and educated at the Kyoto Imperial University in Japan, Li served as president of the Hamheung Branch of the Academy of Sciences of the Democratic People's Republic (DPR) of Korea from 1961. Earlier in his long career, he was professor at Seoul National University in South Korea (1945-1950) and a researcher at the Institute of Chemical Industry in the DPR of Korea (1950-1961). Li was a member of the Academy of Sciences of the DPR Korea and a foreign member of the Academy of Sciences of the USSR. He was awarded the People's Prize in 1959 and the Kim Il Sung Prize in 1980 and named an honorary professor of the Chang Chun Branch of the Chinese Academy of Sciences in 1986. His major field of interest was molecular chemistry. More specifically, he focused on research issues related to polyvinyl alcohol.

NEW PHYSICS CENTRE

Riazuddin (TWAS Fellow 1993) has been named the Director of the newly created National Centre for Physics (NCP) in Pakistan. The centre, which is part of Quaid-i-Azam University in Islamabad, held its first research activity in January 1999. "NCP represents the fulfilment of a dream of Abdus Salam's," Riazuddin noted during a recent visit to Trieste. "When Salam helped launch the International Nathiagali Summer College on Physics and Contemporary Needs in Pakistan in 1976, he hoped that it would eventually evolve into an international physics centre. If he were alive today, I am sure that he would be delighted to see that his vision has been transformed into reality." Pakistan enjoys a strong tradition in physics. Today, there are about 20 university physics departments located throughout the country. However, researchers in these departments often find themselves isolated from both their colleagues and major development in their fields. The NCP was launched to break this isolation by offering Pakistani physicists opportunities to work with world-class scientists from around the world. Like the Abdus Salam International Centre for Theoretical Physics (ICTP), on which it is modelled, NCP will host workshops, colleges, conferences and symposiums on subjects related to physics and mathematics. Through a cooperative arrangement with CERN in Geneva, Switzerland, NCP researchers also will participate in a small number of experimental physics activities. "With financial support from the Pakistani government and cooperative agreements with physics research centres and universities across the globe, I am hopeful that NCP can quickly become a thriving research centre," notes Riazuddin. The success of our efforts would serve as another fitting tribute to the career of Abdus Salam. For additional information about the centre, please contact the National Centre for Physics, Quaid-i-Azam University, Islamabad, Pakistan, phone: 0092 51 278693; e-mail: fayyaz@hep-qua.sdnpk.undp.org.

Riazuddin

WHAT'S TWAS?

THE THIRD WORLD ACADEMY OF SCIENCES (TWAS) WAS FOUNDED IN 1983 BY A GROUP OF EMINENT SCIENTISTS FROM THE SOUTH UNDER THE LEADERSHIP OF THE LATE NOBEL LAUREATE ABDUS SALAM OF PAKISTAN. LAUNCHED OFFICIALLY IN TRIESTE, ITALY, IN 1985 BY THE FORMER SECRETARY GENERAL OF THE UNITED NATIONS, TWAS WAS GRANTED OFFICIAL NON-GOVERNMENTAL STATUS BY THE UNITED NATIONS ECONOMIC AND SOCIAL COUNCIL THE SAME YEAR.

At present, TWAS has 512 members from 76 countries, 62 of which are developing countries. A Council of 14 members is responsible for supervising all Academy affairs. It is assisted in the administration and coordination of programmes by a small secretariat of 10 persons, headed by the Executive Director. The secretariat is located on the premises of the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy, which is administered by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Atomic Energy Agency (IAEA). UNESCO is also responsible for the administration of TWAS funds and staff. A major portion of TWAS funding is provided by the Ministry of Foreign Affairs of Italy.

The main objectives of TWAS are to:

- Recognize, support and promote excellence in scientific research in the South.
- Provide promising scientists in the South with research facilities necessary for the advancement of their work.
- Facilitate contacts between individual scientists and institutions in the South.
- Encourage South-North cooperation between individuals and centres of scholarship.

TWAS was instrumental in the establishment in 1988 of the Third World Network of Scientific Organizations (TWNSO), a non-governmental alliance of 154 scientific organizations from Third World countries, whose goal is to assist in building political and scientific leadership for science-based economic development in the South and to promote sustainable development through broad-based partnerships in science and technology.

TWAS also played a key role in the establishment of the Third World Organization for Women in Science (TWOWS), which was officially launched in Cairo in 1993. TWOWS has a membership of more than 1900 women scientists from 83 Third World countries. Its main objectives are to promote the research efforts and training opportunities of women scientists in the Third World and to strengthen their role in the decision-making and development processes. The secretariat of TWOWS is currently hosted and assisted by TWAS.

WANT TO KNOW MORE?

TWAS offers scientists in the Third World a variety of grants and fellowships. To find out more about these opportunities, check out the TWAS web-pages! Our main page is at:
http://www.ictp.trieste.it/~twas

FELLOWSHIPS

Want to spend some time at a research institution in another developing country? Investigate the South-South Fellowships:
http://www.ictp.trieste.it/~twas/SS-fellowships_form.html

GRANTS

Need funding for your research project? Take a look at the TWAS Research Grants:
http://www.ictp.trieste.it/~twas/RG_form.html
TWNSO runs a similar scheme, for projects carried out in collaboration with institutions in other countries in the South:
http://www.ictp.trieste.it/~twas/TWNSO_RG_form.html

EQUIPMENT

But that's not all TWAS has to offer. For instance, do you need a minor spare part for some of your laboratory equipment, no big deal, really, but you just can't get it anywhere locally? Well, TWAS can help:
http://www.ictp.trieste.it/~twas/SP_form.html

TRAVEL

Would you like to invite an eminent scholar to your institution, but need funding for his/her travel? Examine these pages, then:
http://www.ictp.trieste.it/~twas/Lect_form.html
http://www.ictp.trieste.it/~twas/Prof.html

CONFERENCES

You're organizing a scientific conference and would like to involve young scientists from the region? You may find what you are looking for here:
http://www.ictp.trieste.it/~twas/SM_form.html