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TWAS newsletter

THE NEWSLETTER OF THE THIRD WORLD ACADEMY OF SCIENCES

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The tragic events of 11 September 2001 led to the postponement of the 8th General Conference of the Third World Academy of Sciences (TWAS) and the 7th General Assembly of the Third World Network of Scientific Organizations (TWNSO), both of which were originally scheduled to take place in New Delhi in October 2001.

TWAS and TWNSO rescheduled their meetings for October 2002, and more than 300 scientists, largely from the developing world, participated in the three-day event. What follows are excerpts from TWAS president, C.N.R. Rao's, observations on the role that TWAS and TWNSO have played – and will continue to play – in the promotion of science, particularly in the developing world.

Moving ahead together

While the shockwaves of the terrorist attacks continue to ripple across the globe, we are convinced, more than ever, that the goals of TWAS and TWNSO to advance science in the developing world and to promote a global dialogue among scientists and scientific institutions, carry a significance that lies well beyond our activities to assist scientists and scientific institutions in the South.

Not only does the material well-being of the more than four billion people living in the South depend on effective strategies for science-based development, but the prospects for world harmony and peace become considerably brighter when people from all parts of the world discuss critical issues of common concern in an atmosphere of mutual respect and friendship. Efforts like ours help to bring us together and move us forward at the same time.

The TWAS conference and TWNSO general assembly in New Delhi placed a bright spotlight on the breadth of world-class scientific research now taking place in the developing world. TWAS medal lecturers delved into the world of molecular biology, neuroscience and immunology to present the latest findings in these fields. TWAS and TWNSO award winners examined state-of-the-art research dealing with, among other subjects, protein folding, nanotubes, hydrogen bonds, and hybrid rice technology.

The conference also analysed current scientific policies in the developing world, paying particular attention to the state of science in India. Special evening lectures explored the relationship between art and science and led participants through a colourful slide show of the

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TWAS NEWSLETTER
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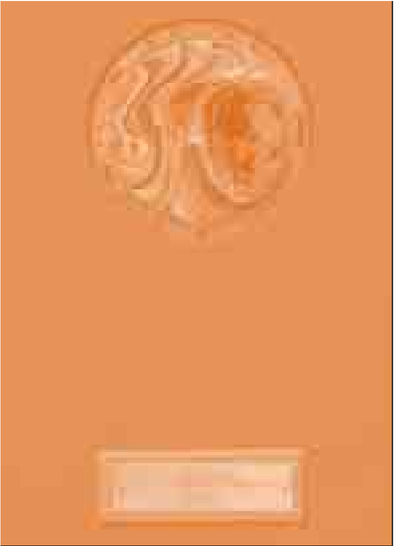

diverse floral landscape found on the Indian subcontinent, painstakingly replicated in miniature paintings. The concluding day of the conference featured a symposium on new strategies for closing the North-South divide.

From a broad global perspective, this successful three-day event was set against a backdrop of rising international tension and conflict.

From a more focused yet encouraging perspective, the event marked the culmination of two years of intensified activity for TWAS and TWNSO as both institutions gained new levels of international recognition that have led to greater influence in the global scientific community.

In 2001, under TWAS's core programme, 102 research grants and 21 prizes were awarded. At the same time, TWAS provided funds for 68 fellowships and associateship visits; sponsored 38 scientific meetings; and supported eight lectureships and professorships. Under a new programme designed to support research departments and institutions in least developed countries, annual grants of US$30,000, renewable for two additional years, were provided to six institutions – in Ethiopia, Senegal, Sudan, Tanzania, Uganda, and Yemen.

TWAS has also become increasingly involved in a wide range of activities beyond its core programmes. In partnership with the International Council for Science (ICSU) and the World Federation of Engineering Organizations (WFEO), the Academy helped organize the week-long Science Forum at the World Summit on Sustainable Development, held in Johannesburg, South Africa, in late August and early September 2002.

In addition, in collaboration with the InterAcademy Panel (IAP), which operates under the administrative umbrella of TWAS, in 2001 the Academy sponsored a workshop designed to strengthen existing science academies in Africa and to lay the groundwork for creating science academies in African nations where they do not currently exist. TWAS has also worked closely with officials from the Science Institute Group's (SIG) Millennium Science Initiative (MSI), located at the Institute for Advanced Study, Princeton University, USA, with the aim of creating a series of centres of excellence in Africa similar to the centres of excellence SIG has helped build in South America.

TWNSO, together with the Global Environment Facility (GEF), the United Nations Development Programme (UNDP) and the World Meteorological Organization (WMO), has recently published a series of monographs and launched a number of institutional networks in several areas of critical importance to sustainable development in the South, including the conservation and sustainable use of indigenous medicinal plants and the development of effective strategies for increasing access to safe drinking water. Meanwhile, under its fellowship programme for women scientists from sub-Saharan Africa and the South's least developed countries, TWAS's 'sister' organization, the Third World Organization of Women in Science (TWOWS), is now covering the cost of education for more than 150 young women scientists seeking doctorates.

Finally, under a three-year grant funded by the Global Environment Facility (GEF), TWAS has been

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named the executing agency for the START (Global Change System for Analysis, Research and Training) climate change project, whose goal is to train large numbers of scientists from the developing world for participation in global change research projects, including the broad-ranging efforts of the Intergovernmental Panel on Climate Change (IPCC).

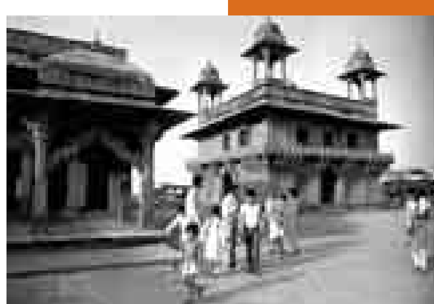
The Academy's success has been increasingly due to its close ties to other UN organizations and national scientific agencies and research institutes in both the South and North. These partners have allowed the Academy to leverage its modest resource base. That, in turn, has increased TWAS's impact and visibility.

Equally important, such partnerships have enabled the Academy to pursue its involvement in cutting-edge science policy initiatives while continuing to strengthen the activities that lie at the heart of the Academy's mandate. These core activities have largely defined TWAS's success since its inception nearly two decades ago and remain the most important aspects of the Academy's mandate and influence today.

As always, the Academy expresses its sincere thanks to the government of Italy, the Department of Research Cooperation of the Swedish International Development Cooperation Agency (Sida-SAREC) and the Kuwait Foundation for Advancement of Sciences (KFAS) for their generous contributions. We sincerely hope that we have justified their investment and we look forward to continuing our close relationships with these and other funding agencies in the future. We also look forward to building our endowment fund, which now stands at nearly US$7 million, through additional contributions and interest earnings on the endowment's principal. The US$10 million target envisioned by Abdus Salam is now clearly in sight and we firmly believe that we will reach – and perhaps even exceed – this goal within the next few years.

TWAS and TWNSO have a great deal to be proud of in terms of their contributions to the advancement of science in the developing world. But we all know that we have a long way to go to ensure vibrant, productive and sustainable science communities in countries throughout the South. Many developing countries do not have sufficient strength in science, many do not have science academies, and many do not have the infrastructure required to support modern science.

The successful meetings of TWAS and TWNSO – and, more importantly, our diverse programmatic activities – illustrate how determined we are to make a difference in a world that clearly is in need not only of the data and information that scientific research provides but the camaraderie and cultural understanding that it fosters. Let us build upon the positive developments of the past two years to rededicate ourselves once again to the goals that have marked our organizations' mandate since their very beginnings and that seem to grow in importance with each passing day.



C.N.R. Rao
President
Third World Academy of Sciences

BRIDGING THE DIVIDE

Shri Atal Bihari Vajpayee

The term 'third world' is being used less and less these days both in political and economic discussions. It has by no means lost all of its relevance but several factors over the past decade have contributed to a significant change in the world's perception of the conditions and factors that have defined the third world throughout the post World War II era.

For example, some countries previously defined as third world now defy that description. And, in fact, several have entered a fast track for development. What term, then, should we use to describe these nations?

Although the definition of third world has become complicated, one factor remains clear: Countries that have shed their third world status – or are in the process of doing so – have been greatly aided in their 'development journey' by science and technology.

In fact, advances in science and technology in the developing world have been responsible for blunting the sharp distinctions between the first, second and third worlds.

More recently, the rapid and widespread dissemination of information technologies, which carry the added benefit of being 'enabling technologies' (that is, technologies that assist all other scientific and technological endeavours), have created the potential for accelerating science-based development throughout the South. The information and communications revolution, to which India has made a significant contribution, has also enhanced cooperation and interaction among scientists throughout the world. This is a welcome development that bodes well for the future of humanity.

Despite such progress, we cannot turn our backs to the reality that large parts of the globe and substantial percentages of the world's population continue to be deprived of even the elementary benefits of development. The fact is that science and technology have yet to make an impact on the quality of lives of hundreds of millions of people in developing and underdeveloped countries.

The 'development divide' within and between nations should be a matter of great concern for all people and not just the poor. How to reduce and ultimately eliminate this divide, in fact, is one of the most pressing challenges faced by our global community in the twentyfirst century. The world needs bold political and economic strategies from both developed and developing countries to meet these challenges, which is what India and other developing countries have been consistently advocating in the United Nations and other multinational fora.

Yet, in addition to national and international political and economic initiatives, science, technology and education must play greater roles if we are to bridge the development divide successfully. The often-interrelated problems of poverty; ill-health; unemployment; ac-

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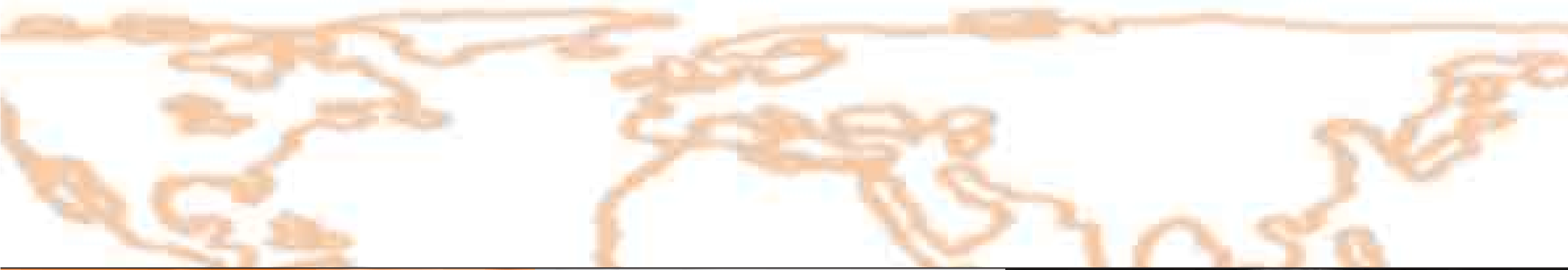

cess to clean drinking water, education and shelter; food and energy security; and environmental degradation in developing countries cannot generally be tackled by means employed in the developed world. Successfully meeting these challenges requires local solutions that rely as much as possible on local natural, human, and cultural resources.

That means, in part, integrating the rich traditional knowledge of local communities into overall science-based development strategies. Cultivating local knowledge will help scientists uncover answers to some of the most critical problems faced by developing countries. For example, the holistic traditions of health care in India and other developing countries, which is based in large measure on their rich biodiversity, have generated increasing interest and value worldwide.

The task for scientists and policy makers continues to be akin to what it was in the past: namely, how to activate science and technology – both modern and traditional – to help solve the pressing problems of underdevelopment.

Success fully accomplishing this task requires enhanced cooperation among scientists in developing countries. This is especially true because developed countries cannot be expected to devote a great deal of their research and development initiatives to solving problems that are peculiar to the developing world. TWAS has served as an important catalyst for such cooperation in the past and is now – due to its enhanced visibility and presence – poised to make even greater contributions to this effort in the future.

Promotion of science and technology has been a cornerstone of India's strategies for social and economic development since our independence. We are proud of the scientific infrastructure that we have created over the past five decades. Equally important, the government is now committed to furthering its support for our community of scientists and technologists in the future.

At the same time India has always shared its knowledge and expertise with other developing countries in a spirit of solidarity and we shall continue to do so in the years ahead.

South-South cooperation requires effort on a number of fronts: Nations, international organizations, scientific institutions, grassroots organizations and regional and local communities must all play a role.

Individually, most of the nations of the developing world are destined to be frustrated in their efforts to close the North-South development divide unless all of the nations of the developing world agree to work together to advance a scientific agenda that benefits our people. That is the goal of this conference and that is the goal of the Indian government. ■

Shri Atal Bihari Vajpayee
Prime Minister
India

MEETING IN INDIA

INTERNATIONAL MEETINGS OF TWAS AND TWNSO TAKE STOCK OF THE STATE OF SCIENCE AND TECHNOLOGY IN THE SOUTH.

TWAS's and TWNSO's biennial general meetings, which took place in New Delhi, India, in October 2002, once again showcased the enormous breadth of world-class scientific research now taking place in the South – at a moment when global events have put an intense spotlight on the role of science and technology in society.

In a world still profoundly unsettled by the 11 September 2001 terrorist attacks in New York City and Washington, D.C., and by the tension and violence that has gripped our global community ever since, 300 scientists from more than 60 nations gathered in New Delhi, India, from 19-23 October 2002, for the 8th General Conference and 13th General Meeting of the Third World Academy of Sciences (TWAS) and the 7th General Assembly of Third World Network of Scientific Organizations (TWNSO).

The event took place 12 months later than scheduled. The meetings were postponed last year due to the terrorist attacks and fears of an imminent war in Afghanistan.

Issues dominating discussions in New Delhi – namely, scientific and technological capacity building, science-based sustainable development, science and education, and South-South and South-North cooperation – have assumed even greater urgency in the face of rising international tension and violence.

Science and technology, participants agreed, not only play central roles in improving the material well-being of people throughout the world, but also serve as a forum for international cooperation and exchange helping to promote a peaceful dialogue among nations. Few other goals could be as important in today's post 11 September world.

The key question framing much of the discussion in New Delhi was how to put science to work to better serve society. It is an issue that has become central to national science policies in India, the nation that generously hosted the event. Moreover, it is an issue that has come to dominate science policy debates in much of the developed and developing world.

India's culture of science is deeply rooted within its

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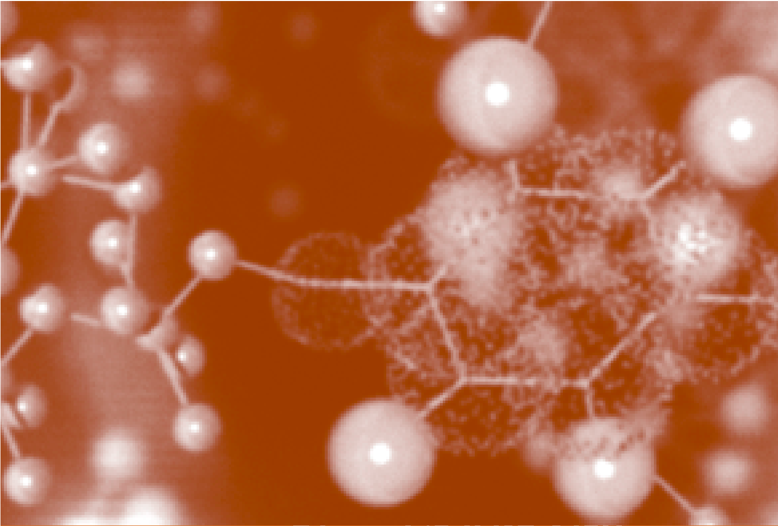

past. Today, moreover, the nation ranks among the most scientifically proficient countries in the South. In a trend increasingly mirrored throughout much of the South and North, policy makers in India have sought to devise strategies intended to place scientific research closer to societal problems. As Nobel Laureate Ahmed Hassan Zewail noted in his opening address, "India has a broad and sophisticated scientific community – but why is it that I cannot drink water from the tap?"

In many ways, participants at the TWAS and TWNSO India meetings were asking a similar set of questions: With so much excellent science taking place in the developing world, why can't science become a greater force for the promotion of material well-being and cross-cultural understanding – and, more specifically, how can TWAS and TWNSO play an even greater role in such efforts, given the increased credibility and visibility that the organizations have been able to garner in both the global scientific and policy communities over the past several years?

That is why the issue of the relationship of science to society not only provided the focal point of discussion in a half-day conference symposium examining science in India but also served as the centrepiece of conversations that took place in virtually all of the general sessions held throughout the three-day meeting.

Such discussions reflected the progress that has been made in placing science and technology at the top of policy agendas in developing countries. It also indicated how much more work needs to be done to ensure that scientific excellence and technological know-how become not just temporary props but permanent pillars underlying sustainable economic development efforts throughout the South.

The key question in New Delhi was how to put science to work to better serve society.

TWAS and TWNSO business meetings, held the weekend before the general conference and assembly, evolved largely around reports and discussions on the wide-ranging activities that have taken place since the last general conference and assembly, held in Tehran, Iran, in October 2000. These activities include:

- TWAS's central role in the organization of the week-long Science Forum that took place at the World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa, in late August and early September 2002. Working closely with the International Council for Science (ICSU) and the World Federation of Engineering Organizations (WFEO), TWAS was asked to organize two critical sessions of the Science Forum: "Capacity Building in Science and Technology" and a "High-Level Panel Discussion on the Role of Science and Technology for Sustainable Development in Africa." The Academy also contributed to two of the nine volumes published as part of ICSU's series of reports outlining issues of concern for the global scientific community related to WSSD's broad focus on sustainable development: *The*

Report of the Scientific and Technological Community to the WSSD and *Science and Technology for Sustainable Development*.

- Sustained efforts to promote scientific capacity building among merit-based science academies throughout the world. These efforts, conducted in cooperation with the Inter-Academy Panel on International Issues (IAP), whose secretariat operates under the administrative umbrella of TWAS, began with a conference on capacity building in Africa, held in Trieste, Italy, in May 2001. A subsequent workshop in December 2001, which took place in Nairobi, Kenya, led to the creation of the Network of African Sciences Academies (NASAC), that will seek to bring African scientific expertise to bear on some of the continent's most critical problems: for example, food security, poverty eradication, and the spread of such infectious diseases as AIDS, malaria and tuberculosis. Overall, NASAC hopes to play a major role in the strengthening of national science academies in African countries where they do exist and in the establishment of academies in countries where they don't. The challenge is underlined by this statistic: Of the 53 countries in Africa, only nine currently have merit-based national science academies.
- A series of TWNSO/TWAS-led projects designed to highlight innovative experiences in the use of science and technology issues in developing countries. This initiative, which began in 1999 with a grant from the United Nations Development Programme's (UNDP) Special Unit for Technical Cooperation among Developing Countries (TCDC), has witnessed significant growth over the past two years, resulting in the publication and creation of institutional networks focusing, for example, on issues related to the conservation and sustainable use of indigenous and medicinal plants (funded by TCDC) and the application of affordable and appropriate technologies for providing greater access to safe drinking water (funded by the World Meteorological Organization). Just two weeks before the New Delhi meeting, in October 2002, TWNSO/TWAS hosted a workshop focusing on successful applications of science and technology in the promotion of renewable energies (funded by the TCDC). As in the previous efforts, a network has been put in place.

TWAS'S 20TH ANNIVERSARY. *TWAS will celebrate its 20th anniversary in Beijing, China, 16-19 October 2003. The festivities will be part of the 9th General Conference and 14th General Meeting of TWAS and the 8th General Assembly of TWNSO in Beijing, China, site of the Academy's first conference held in the South, in 1987. As a result, the event will also provide an opportunity to assess the enormous changes that have taken place both in China's science community and society at large over the past 20 years. For additional information about TWAS's 20th anniversary celebrations, please contact Sandra Ravalico, TWAS secretariat, email: info@twas.org.*

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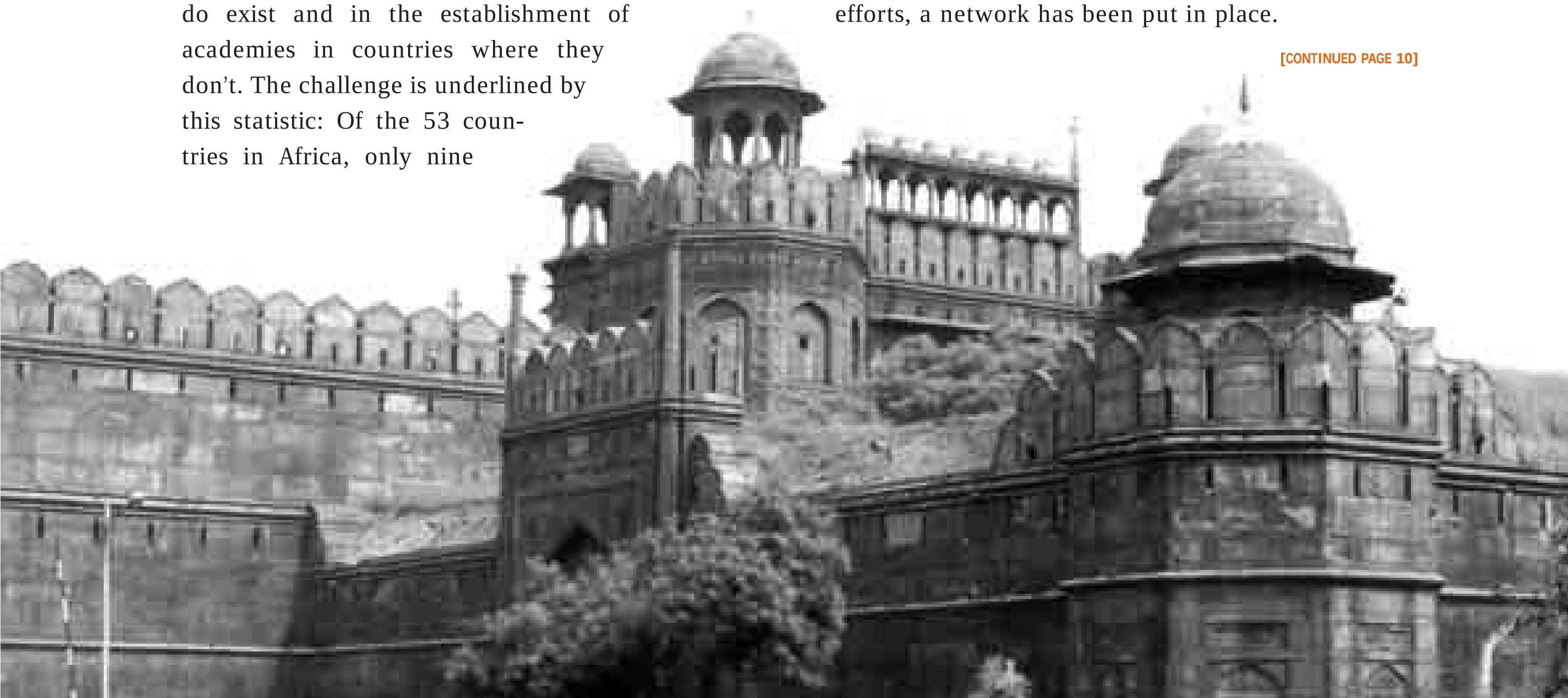

In addition, a full-length case study monograph highlighting innovative experiences in the development and application of renewable energy technologies is now being prepared.

- The largest TWNSO/TWAS project focusing on innovative experiences in the use of science and technology to address critical issues in the developing world has focused on the conservation and use of biodiversity resources in dryland regions. The project, funded the Global Environment Facility (GEF), has centred on a series of international workshops held in Ulaan Bataar, Mongolia; Muscat, Oman; Santiago, Chile; and Cairo, Egypt. More than 60 case studies have been prepared, many of which will be published by Kluwer Academic Publishers in a monograph scheduled to be released in 2003. Participants, meanwhile, have joined a network designed to promote the exchange of information and ideas dealing with this issue. The ultimate goal is to highlight and examine a wide range of initiatives that have been put in place to protect and utilize the rich treasure trove of biodiversity resources found in dryland regions – resources that too often have failed to receive the attention they deserve.

Science must become a greater force for the promotion of cross-cultural understanding.

- The strengthening of South-North cooperation, for example, through the forging of a partnership with Harvard University's Kennedy School of Government's Initiative on Science and Technology for Sustainability (ISTS). This initiative has sought to examine grass-roots sustainability efforts worldwide as part of a larger effort to create a new scientific research framework that is interdisciplinary (incorporating both the natural and social sciences), multiscale (relying on local, regional and global analyses), integrative (appreciative of the contributions of indigenous and modern science) and synergistic (attentive to the intricate relationship between science and technology). The partnership between Harvard and TWAS led to the appointment of a Harvard/TWAS Fellow for the Initiative on Science and Technology for Sustainability. The fellow is working at the Academy secretariat in Trieste as a liaison between TWAS and Harvard for follow-up cooperative activities centred on the creation of a broad-based consortium dedicated to sustainability science issues.

- In another example of South-North cooperation, TWAS, together with the Global Change System for Analysis Research and Training (START) programme in Washington, D.C., is serving as the co-executing agency for a three-year, US$7.5 million Global Environment Facility (GEF) initiative designed to help scientists from the developing world build their knowledge and skills for conducting world-class research on climate change issues. A capacity building workshop focusing on the issue of climate change vulnerability and adaptation, which was held in Trieste in June 2002, attracted more than 100 scientists. Another workshop, designed exclusively for young climate-change researchers, is scheduled to take place in Trieste in November 2003.

- Dorairajan Balasubramanian (TWAS Fellow 1997) authored a TWAS report, *Safe Drinking Water*, examining a wide range of appropriate technologies for increasing the availability of this life-giving resource in the developing world. Published in December 2001, the report focuses on national and community initiatives in such countries as Chile, India, and Kenya, that have successfully put into operation cost-effective technologies for making safe drinking water more widely available to their citizenry. Some 1 billion people worldwide – more than 15 percent of the global population – do not have access to safe drinking water. As a result, the technologies described in the report could prove invaluable for addressing one of the most critical issues facing the developing world. Given the positive response to the publication, TWAS plans to publish other reports examining significant science-based issues facing the South.

• The Third World Organization for Women in Science (TWOWS) whose secretariat operates under the administrative umbrella of TWAS, is overseeing a postgraduate fellowship programme funded by the Department of Research Cooperation of the Swedish International Development Agency (Sida-SAREC). The programme helps young women scientists from sub-Saharan Africa and least developed countries (LDCs) pursue advanced degrees in centres of excellence throughout the South. Designed as a "sandwich" programme, the students earn their degrees at universities in their home countries but spend one or two years during their four- or five-year course of study at another developing-world institution designated as centre of excellence. The strategy is intended to enable students to attain their degrees without losing contact with their native country. To date, 119 women from 33 countries have participated in the programme. In September 2002, Aderoju Amoke Osowole from the University of Ibadan in Nigeria, who had spent a portion of her time at the Indian Institute of Science's Division of Chemical Sciences in Bangalore, India, became the programme's first PhD graduate.

• TWAS provided a helping hand in launching SciDev.Net, an electronic portal dedicated to exploring science and development issues of importance to the developing world. The first meeting to discuss the launching of SciDev.Net was held at the TWAS secretariat in Trieste in the autumn 2000. The portal, which is sponsored by *Nature* and *Science* magazines in association with TWAS, was launched one year later.

In addition to these new activities, TWAS and TWNSO have continued to pursue and expand their long-standing programmes for scientific capacity building in the South. Highlights of the past two years on this front include:

• Election of 51 new members from 16 countries in 2001 and 43 new members from 19 countries in 2002. That brings the total membership of TWAS to 666. The 2001 new membership roster includes five eminent social scientists, marking the Academy's first concerted effort to include social scientists and economists among its ranks. TWAS's newly elected social scientists and economists are: Partha Sarathi Dasgupta, Faculty of Economics and Politics, University of Cambridge, UK; Miguel Leon-Portilla, *Instituto de Investigaciones Históricas, Universidad Nacional Autonoma de Mexico*; Ali A. Mazrui, Institute of Global Cultural Studies, State University of New York, Binghamton, NY, USA; Wenyuan Niu, Institute of Policy and Management, Chinese Academy of Sciences, Beijing, China; and Ismail Serageldin, *Bibliotheca Alexandrina*, Alexandria, Egypt.

• Awarding of nearly 200 TWAS research grants for 2001 and 2002. Most recently, grants have been given to Maria Corazon De Ungria, Natural Sciences Research Institute, University of the Philippines, for identifying Y-chromosome markings for both forensic casework and studies of the lineages of Philippine peoples; Silvia Susana Antollini, *Instituto de Investigaciones Bioquímicas* (INIBIBB), Argentina, for work on chemical interactions during the transmission of impulses from one nerve cell to another; Matthew Mupa of the Food and Biomedical Technology Division at the Scientific and Industrial Research and Development Centre (SIRDC) in Zimbabwe, for analysing chromatographic techniques to separate chiral – or

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mirror image – versions of drugs and other molecules; Makooma Moses Tenywa, Department of Soil Science, Makerere University, Uganda, for investigating the effects of pore sizes in soils in the stabilization of crop yields in drought-prone areas; and Aimé Pelaiz Barranco, Applied Physics Department, Havana University, Cuba, for studying the ability of ferroelectric ceramics to generate electric currents when stimulated by heat sources.

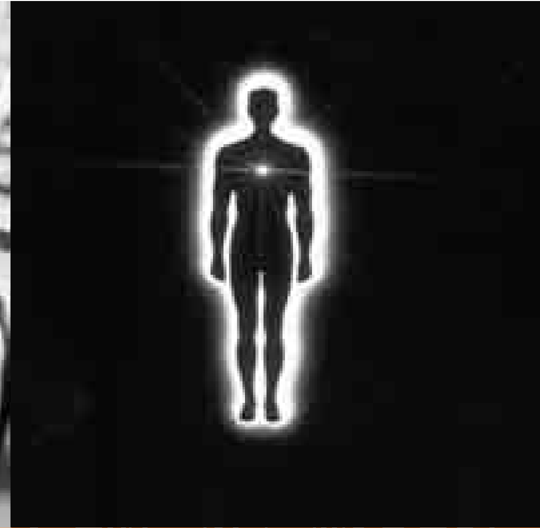
• Selection of the winners of the TWAS 2001 awards: Luiz Davidovich, Institute of Physics, Federal University of Rio de Janeiro, Brazil (physics); Kimoon Kim, Department of Chemistry, Pohang University of Science and Technology, Pohang, South Korea (chemistry); Sundararaman Ramanan, Tata Institute of Fundamental Research Colaba, Mumbai, India (mathematics); Avadhesha Surolia, Molecular Biophysics Unit, Indian Institute of Science, Bangalore, India (biology); and Rodolfo R. Brenner, Institute of Biochemical Research, National University of La Plata, Argentina (basic medical sciences).

• Selection of TWAS 2002 award winners: Deepak Dhar, Department of Theoretical Physics, Tata Institute of Fundamental Research, Mumbai, India (physics); Peng Shie-Ming, Department of Chemistry, National Taiwan University, Taipei, Taiwan, China (chemistry); José Antonio de la Peña, *Instituto de Matemáticas, Universidad Autónoma de México*, Mexico (mathematics); Wang Zhizhen (Chih-Chen), Institute of Biophysics, Chinese Academy of Sciences, Beijing, China (biology); and Ranulfo Romo, *Instituto de Fisiología Celular, Universidad Autónoma de México*, Mexico (basic medical sciences).

THIRD STRATEGIC PLAN. *A draft of TWAS's third strategic plan (for the years 2003-2008) was discussed at the New Delhi meeting. The report was prepared by Dorairajan Balasubramanian (TWAS Fellow 1997). While noting that the Academy's first 20 years have been marked by steady progress in efforts to build the capacity of scientists and scientific institutions in the developing world, the newest plan calls on the Academy to take additional measures to ensure that the voice of third world scientists gains even greater resonance both within their own nations and throughout the global scientific community. In addition to the Academy's ongoing efforts, the plan calls on TWAS to focus special attention on the needs of least developed countries and women. For a complete text of the plan, please contact Sandra Ravalico, TWAS secretariat, email: info@twas.org.*

• Additional contributions to the TWAS endowment in 2001-2002 of more than US$750,000. That brings the total amount of money in the endowment fund to US$6.7 million – more than two-thirds of the way towards its US$10 million goal. Contributions were received from China (US$500,000); Taiwan, China (US$100,000); the Brazilian Ministry of Science and Technology (US$75,000); and the National Scientific and Technology Council (CONYCYT) in Mexico (US$75,000). All contributions to the endowment fund have come from countries and individuals in the developing world.

• The launching of a new science capacity building initiative to assist scientific research units in the least developed countries (LDCs). Recipients each receive up to US$30,000 a year over a three-year period to help improve the research environment in which they work. In the programme's first year, six research units were selected from a pool of 90 applicants. The institutions are: Leishmaniasis Research Group, Institute of Pathobiology, Addis Ababa University, Ethiopia; Research Group in Electrochemistry and Polymer Science, Laboratory of Physical and Organic Chemistry and Instrumental Analysis, Department of Chemistry, Faculty of Sciences and Techniques, University Cheikh Anta Diop, Senegal; Camel Disease Research Group, Camel Research Centre, Faculty of Veterinary Science, University of Khartoum, Sudan; Physical and Applied Marine Sciences Section, Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania; Parasitology Group, Med Biotech Laboratories, Uganda;



and Polymer Research Group, Department of Chemistry, Faculty of Science, Sana'a University, Yemen.

The range of partnerships that TWAS has successfully forged over the past several years, combined with the continued strength of its conventional capacity building programmes, were fully reflected at the conference in New Delhi. Highlights of the three-day event include:

- A message (see p. 5) from India's Prime Minister Shri Atal Bihari Vajpayee, who could not attend the event due to illness. The prime minister described the complex tapestry of accomplishment and failure that now characterizes science and science-based development in the South. He noted that science and technology have largely been responsible for the advances that have taken place in many developing countries. But, as the prime minister also observed, these very forces of progress have been responsible for widening the gap between the "have" and "have nots." He called on developing nations to strengthen mechanisms for South-South cooperation as a primary means for addressing the enormous economic, social and environmental problems still found in many parts of the developing world. The prime minister's remarks were followed by invited lectures given by Nobel Laureate Ahmed H. Zewail (see p. 23), who spoke about his own personal voyage that took him from the streets of Cairo, Egypt, to the halls of the Royal Swedish Academy to receive science's most coveted award, and Bruce Alberts, president of the US National Academy of Sciences, who examined the broad role that science – and, more specifically, science academies – should play in the promotion of sustainable development.

The challenges that TWAS faces now are no less daunting than those confronted during the early years.

- A half-day session on the state of science in India explored the enormous range of scientific research taking place throughout the country in fields ranging from space to agriculture. For example Prem Shardar Goel, director, Indian Space Research Organization's Satellite Centre, Bangalore, noted how the nation's growing network of satellites are providing a host of invaluable services ranging from advances in electronic communications to assessments of natural resource hazards. Meanwhile, M.S. Swaminathan, chair, M.S. Swaminathan Research Foundation, Chennai, provided a detailed account of the progress that India has made in developing and sustaining the nation's agricultural resource base as a means of feeding its enormous population – progress that has been driven largely by science. Other presentations given by Indian scientists included examinations of the nation's information and communication technologies, health research system, biotechnology initiatives, nuclear energy research, and space and ocean sciences (see p. 18).
- TWAS medal lectures that included presentations on the intricate interplay of 'information and imagination' that drives laboratory efforts to achieve organic syntheses leading to new molecular objects (Goverdhan

[CONTINUED PAGE 14]

Metha, director, Institute of Science, Bangalore); the way in which the study of frog oocytes has increased our knowledge of brain functions (Ricardo Miledi, Department of Neurobiology and Behaviour, University of California, Irvine); and immunological efforts to cure harmful renal inflammatory reactions in Egypt (Essmat Ezzat, director, WHO College Centre for Human Resource Development, Suez Canal University, Ismailia, Egypt).

- TWAS and TWNSO award recipients, who spoke about issues ranging from the relationship of quantum optics to tomography and teleportation, to the interaction between geometry and physics, to scallop culture in China. Twelve lectures in all were given.
- A ministerial panel on science and technology management, which included presentations from 15 science and technology officials from developing countries. Highlights of the half-day event included reports from several countries, including China, Nigeria and Syria, of new strategies to build sustainable development on the foundations of science and technology. There were also calls for more South-South and South-North collaborations, as well as the long-standing need to take development policies from the 'talking' to the 'doing' stage.
- A half-day session on efforts to bridge the great divide, which Ismail Serageldin, director, *Bibliotheca Alexandrina*, Egypt, one of the main speakers at the session, called "the paradox of our time" (see p. 29). Other speakers included R.A. Mashelkar, director general, Council for Scientific and Industrial Research (CSIR), India, who explored the issue of intellectual property rights contending that conventional legal frameworks for the protection of such rights have long served as barriers to progress in the developing world without spurring scientific and technological progress in the North as much as the proponents of such protection have contended; and Phillip Griffiths, director, Princeton Institute for Advanced Studies, who highlighted the activities of the New Millennium Institute, an effort to build centres of scientific excellence. TWAS has played an important role in this project, particularly in Africa.

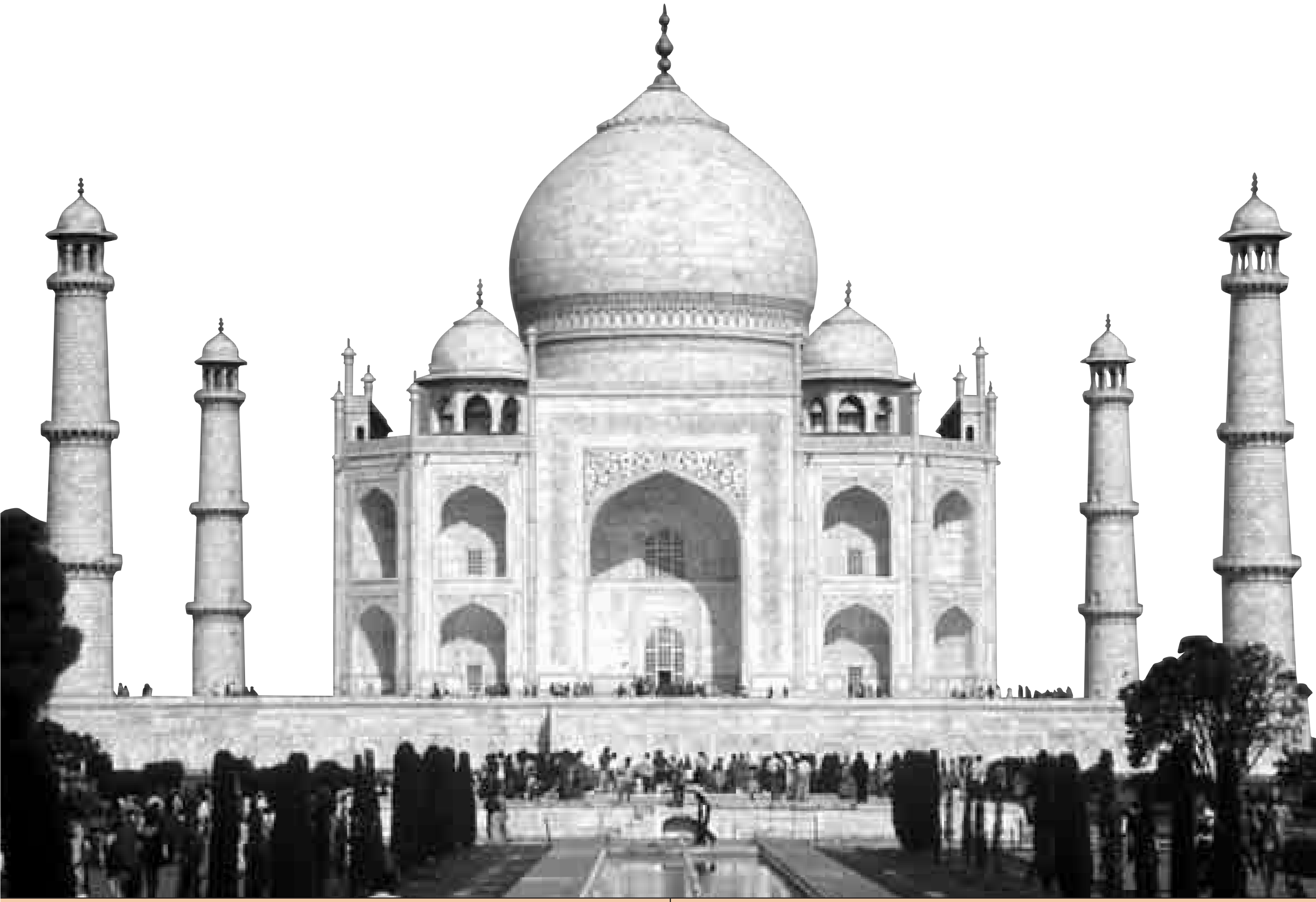
As Academy president C.N.R. Rao noted in New Delhi: "During the first decade of existence, TWAS was basically getting its feet on the ground, painstakingly

establishing procedures that would earn the Academy credibility and guide its work in the future. During the first five years of its second decade of existence, TWAS was putting its capacity-building programmes in place, seeking to devise a strategy that would be effective over the short-term yet flexible enough to meet new challenges along the way.

"Now over the past five years or so, the Academy has emerged as an institution recognized both in the South and North for the role that it plays in scientific capacity building in the developing world and, increasingly, as a unique bridge between the scientific communities in the developing and developed worlds.

"The challenges the Academy faces now are no less daunting than those we confronted during our early years of development and growth. The difference is that we are now in a position to have our voices heard and skills utilized. To take advantage of this opportunity, we must not only continue to strengthen the programmes that have defined our success in the past but also test new strategies for reaching out to segments of our community that have yet to be fully engaged – for example, women scientists, scientists working in the least developed countries, and social scientists and economists who could prove essential partners in our efforts to advance science-based sustainable goals now and in the future.

"That's where the emerging boundaries of TWAS's efforts are to be found. Our ability to reach these boundaries will help determine whether our Academy continues to expand its strength and influence in the years ahead."



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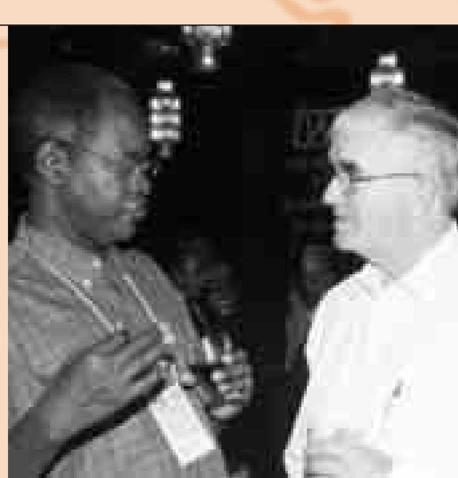

TWAS 8TH GENERAL CONFERENCE • TWNSO 7TH GENERAL ASSEMBLY

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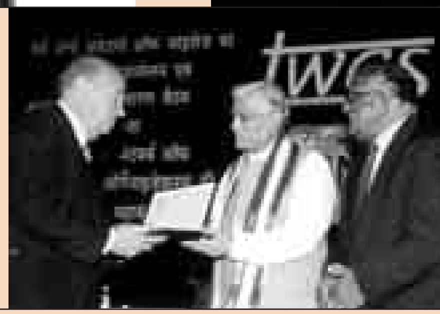


New Delhi, India, 19-23 October 2002

INDIA IS HOME TO ONE OF THE LARGEST, MOST DIVERSE AND MOST SOPHISTICATED SCIENTIFIC COMMUNITIES IN THE WORLD. WITH 400 NATIONAL LABORATORIES AND RESEARCH INSTITUTES, ALMOST 200 UNIVERSITIES, AND 1300 RESEARCH AND DEVELOPMENT UNITS IN THE INDUSTRIAL SECTOR, INDIA'S LABOUR FORCE IS ESTIMATED TO INCLUDE MORE THAN 4 MILLION TRAINED IN SCIENCE AND TECHNOLOGY.

SCIENCE IN INDIA

The TWAS 8th General Conference and TWNSO 7th General Assembly were devoted, in part, to an in-depth examination of the work and accomplishments of India's scientists and scientific agencies. Here's a brief sampling of what was presented throughout the course of the three-day meeting, which included an afternoon session on the first day devoted exclusively to science in India.

WHERE SMALL IS BIG

Sushanta Dattagupta

• The rapidly growing field of nanoscience – the study of interactions between atomic and subatomic particles – seeks to explain why the laws of physics seem to break down when examined at such 'nanoscales.' India, with its strong research traditions in theoretical physics, mathematics and modelling, has moved to the forefront of investigations in nanoscience and, more specifically, nanotechnology theory. The nation's leading centre in this effort has been the S.N. Bose National Centre for Basic Science in Kolkata, headed by **Sushanta Dattagupta** (TWAS Fellow 1999).

Nanotechnology, Dattagupta explains, will likely have broad-based applications in such technological fields as electronic switching devices and computer memory systems. Scientific breakthroughs in this field also hold promise to reduce the material size of a host of instruments and equipment saving both money and space in their manufacture and use.

That's why nanotechnology will be a main focus of research and development activities at the Bose Centre in the years ahead, Dattagupta says. Simply put, it's a research area that holds vast potential for broad-based technological applications.

Because good students often lose interest in science as they move from primary to secondary school and on to universities, the Centre is also pioneering a new educational programme that exposes students – at all levels – to the best teachers not just from the Centre, but from institutes and universities throughout Kolkata.

"Our aim," says Dattagupta, "is to instill students with a sense of excitement and wonder for science and hopefully encourage them to pursue careers in physics. The only way India can continue to strengthen and expand its scientific expertise is to develop a pool of well-trained students who can ultimately move to the forefront of nanoscience and a host of other fields at the frontiers of science. In addition to pursuing their research agendas," Dattagupta adds, "institutes like the S.N. Bose National Centre for Basic Science have a critical role to play in this training effort." ■

X-FACTOR

Mamannamana Vijayan

• Macromolecular crystallography, the science of using x-ray diffraction patterns to deduce the structures of large, biologically active molecules, has a relatively long history in India.

Initially, however, under the direction of G.N. Ramachandran (TWAS Founding Fellow), one of the giants in the field who solved the structure of the fibrous protein collagen in the 1950s, Indian scientists were sent abroad to refine their education and gain invaluable laboratory experience. Facilities in India were simply not up to the task.

That's why, between 1968 and 1971, **Mamannamana Vijayan** (TWAS Fellow 2001), currently associate director of the Indian Institute of Science, Bangalore, studied at Oxford University, UK. His mentor there was Dorothy Hodgkin, who won the Nobel Prize in chemistry in 1964 for her use of x-ray diffraction techniques to determine the structures of such critical biochemical substances as penicillin and vitamin B12.

"I was the first macromolecular crystallographer to come back to India," Vijayan explains. "I simply wanted to work here even if it meant dealing with inferior facilities. It wasn't until the early 1980s, in fact, that adequate funding was made available. But since then, research on macromolecular crystallography and other related fields has moved steadily forward at the Indian Institute of Science and other research centres."

The Institute has helped India make significant headway on two fronts: first, it has created the intellectual foundation for about a dozen research groups in macromolecular crystallography located throughout India that together now employ more than 100 scientists; and, second, it has served as a focal point of scientific interest in this field helping to shape the molecular crystallography research agenda throughout the nation.

In short, young scientists in the field no longer have to travel abroad to be well-trained and mature scientists can work in their home countries without having their research efforts compromised by dated or inadequate facilities. ■

MOLECULAR MOTION

• "I wouldn't recommend it as a policy goal, but sometimes a lack of facilities can help stimulate the creativity of scientists," says **Debashis Mukherjee** (TWAS Fellow 2001), director of the Indian Association for the Cultivation of Science. "It leaves scientists free to think and use their ingenuity."

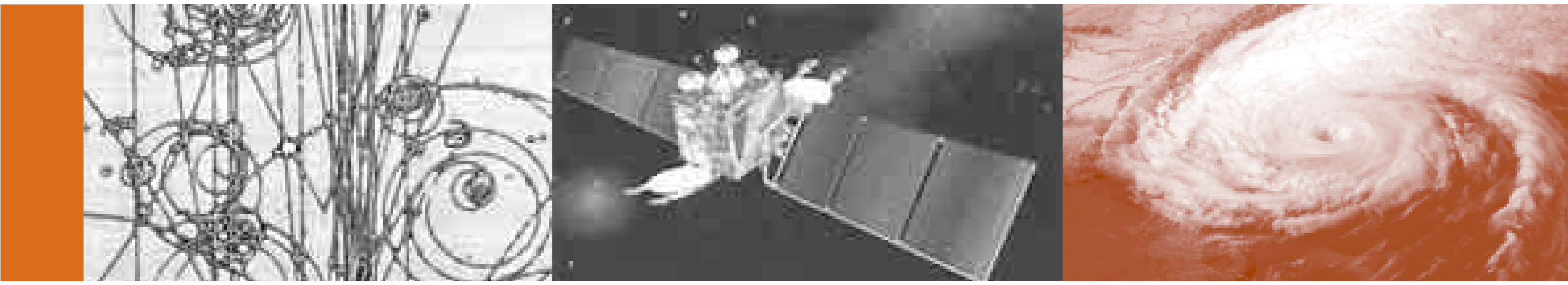
Mukherjee cites his own experience as a case in point. In 1975, without the aid of computers (or, as he would prefer to say, partially due to their absence), he produced his first groundbreaking theoretical method, which helps to explain how molecules absorb light, thus revealing important information about their spectroscopy properties. The method is now a standard tool in chemistry.

Educated in India at the Presidency College, Kolkata, and Calcutta University, Mukherjee draws on the laws of quantum and statistical mechanics to explain not only the structure of molecules but their stability, how they react to form products, how fast they react, and how much of each product is created.

Debashis Mukherjee

Stemming, in part, from his work, India is now at the forefront of this research with about 25 theoretical chemists, more than half of whom are internationally renowned. These scientists are developing theories that have increasing relevance in deciphering the function of biological molecules.

The downside of Mukherjee's "sunny" view of inadequate facilities is that scientists in the developing world often lack the resources to exploit the full potential of their work. "That's what makes South-North cooperation so important," notes Mukherjee, "not just for the developing world but for the developed world as well. With so many world-class theoretical chemists working in India," he adds, "we have a great deal to offer the global scientific community. In fact, I have colleagues from around the world who make use of the theories we have developed in India." ■



BY ANY NAME

• It is a disease that carries such a social stigma that it has experienced a name-change to conceal its true identity: Hansen's disease, a.k.a. leprosy.

Indira Nath

Even more disturbing, it is a disease that defies a straightforward description. In fact, symptoms of leprosy can range from relatively benign, localized infections to widespread permanent deformities.

The question for researchers has been: How can the same bacterium cause such different forms of a disease?

Indira Nath (TWAS Fellow 1995), S.N. Bose professor and former head of the All India Institute of Medical Sciences, New Delhi, thinks the answer could lie in the effectiveness of people's immune responses. The problem was that, when she started work in the 1970s, there was no history of immunology research in India, and leprosy was of little interest to scientists in developed countries. Obtaining laboratory supplies was also difficult.

The WHO's Tropical Disease Research Division helped, especially in getting supplies cleared through customs, says Nath, as did Rajiv Gandhi when he became prime minister in 1984. Now, with more foreign companies operating in India, and the opening up of the economy, the situation has greatly improved.

Despite these difficulties, leprosy research and treatment has advanced. Studies have been hampered, though, because the leprosy bacterium is notoriously difficult to culture in the laboratory. Drug tests on mice can take up to nine months, and attempts to develop more rapid *in vitro* cell culture methods have so far been unsuccessful.

However, because the leprosy bacterium lives inside cells, rather like the tuberculosis bacterium, scientists have been able to demonstrate similarities between the body's immune response against the two diseases. Drugs that were used to treat tuberculosis are now being used successfully in a multi-drug therapy programme against leprosy. This has reduced the disease rate in India from 24 to 7 per 10,000 of the population. But there is still a long way to go to achieve the goal of just 1 per 10,000 people.

Put another way, progress on medical research and public health fronts has enabled India's leprosy population to shrink from 4 million in the 1970s (representing one-third of the world population afflicted with leprosy) to less than one million today. Equally important, those infected with the disease now tend to experience much less severe symptoms.

Despite these encouraging signs, however, the number of new cases of leprosy has remained stubbornly consistent – some 300,000 a year in India. Thus while great advances in the diagnosis and treatment of leprosy have been made, much remains to be done to eliminate it.

"The big challenge now," admits Nath, "is to determine the immunity of a patient from a routine skin test. We need such a test to develop a vaccine."

Harsh K. Gupta

OCEANS OF RESEARCH

- India's coastline stretches for almost 7500 km, making it one of the longest in the world. As well as providing a wealth of resources, the surrounding Indian Ocean also plays a major role in India's weather, serving as a spawning area for monsoons and cyclones. Little wonder that in 1982 the Indian government decided to create the Department of Ocean Development. For many, the decision was long overdue.

Department Secretary **Harsh K. Gupta** (TWAS Fellow 1995) admits that India still lags behind many other nations in making oceanographic observations. But he also notes that efforts are underway to improve the 'observational' infrastructure by increasing, for example, the number of moored and drifting buoys. The importance of these 'data' buoys has already been demonstrated when, in May 2001, a cyclone developed near one of them. Thanks to the readings of air pressure and wind speed, meteorologists could accurately predict the storm's movements.

India is also part of a scheme to use floats equipped with sophisticated sensors to measure water temperature and salinity from depths of 1 kilometre to the surface. A global network of 3000 such floats is envisaged, with India responsible for 450 of them. "Once we begin receiving data from these floats, we will be in a much better position to test our ocean circulation models and forecast our weather," says Gupta.

Another system of ocean monitoring, developed by space researchers, is now lending a hand to Indian fishers. Together with data on the distribution of nutrients, satellite monitoring of sea surface temperatures is used to predict where schools of fish may be located. This information is then released by the Department of Ocean Development to local fishers. Catches have almost doubled, saving fishers both time and resources.

Department-related research has also led to development of three new drugs isolated from marine organisms and new extraction methods for valuable metals such as copper and nickel.

During its first two decades of existence, India's ocean research programme has produced a host of important results. By 2050, however, 50 percent of India's population could be living on or near the coast, so there is additional need for developing conservation and pollution control measures, as well as modelling techniques, that would help both scientists and policy makers devise the best strategies possible for the sustainable development of the coastline and the wealth of resources found in coastal ecosystems. The next 20 to 30 years of oceanographic research, therefore, will be critical.

ENDLESS FRONTIER

• India's successful space research programme has a very down-to-earth focus. "We are one of the world's leading countries in both remote sensing and communications," says **Prem Shankar Goel** (TWAS Fellow 2001), Director of the Indian Satellite Centre.

Prem Shankar Goel

Although the Centre's headquarters is located in Bangalore, its offices and infrastructure are spread throughout India. All told, the Centre now employs 17,000 people. Despite the size of the organisation, Goel believes that Indian space research remains both focused and cost effective. "I think we are doing much more with our budget than space agencies found in any other country," he says.

India's first satellite, INSAT-1, was launched in 1981 using mainly imported technology. Since then, however, the INSAT-2 series of satellites, launched during the 1990s, have featured in-house remote sensing technologies that have provided more and more detailed image resolution. Indeed instruments for detecting visible or infrared wavelengths of light continued to advance through 2000 and 2002, when INSAT-3B and 3C were launched. Looking ahead, the INSAT-4 series of satellites is now under development, with home television channelling capabilities and new, state-of-the-art sensors for meteorological applications.

Today India is the only country that can provide images with resolutions from 1 kilometre to 1 metre, and there are plans to increase this to 70-centimetre resolution. "This satellite will give complete coverage of the world's vegetation every two days," says Goel, "which will be useful for drought monitoring, crop stress measurements and other critical issues related to agriculture."

Such space-age technology is having positive effects on the ground in India. A trial programme providing video links between doctors in small, isolated communities and medical experts in major metropolitan centres, for example, is poised to expand rapidly. Similarly, a hydrological map of India, produced from space, has more than doubled the success rate of locating groundwater in arid areas from 45 to 93 percent, helping to provide water to some 16,000 villagers.

Over the next five years, ISRO plans 35 more launches. However, like many research organizations in the developed world, ISRO is looking for more collaboration with commercial partners. This has already been achieved with India's own launch vehicles, and, with its world-leading technologies, it is also beginning to happen in satellite development.

SCIENCE IN THE DEVELOPING WORLD

THE FOLLOWING TEXT IS BASED ON A KEYNOTE ADDRESS GIVEN BY NOBEL LAUREATE AHMED H. ZEWAIL (TWAS FELLOW) AT THE TWAS 8TH GENERAL CONFERENCE IN NEW DELHI, INDIA, ON 22 OCTOBER 2002.

I am pleased to have this opportunity to share with you some personal reflections on current issues which I believe may well be at the core of world peace and stability. Science education and development through science are the subject of my presentation and I thought I would use my own journey through two cultures, one currently developing and the other developed, to address issues of concern and what should be done to achieve progress.

As someone who was born and educated in the developing world and who has lived and worked in the developed world, I have acquired both a personal experience and a professional perspective of what it takes to do science at the frontiers of knowledge – not just science for science's sake but science that enlightens the mind and helps our societies and our global community.

In light of the misunderstandings, tensions and violence that plague our world today, I would like to reflect on the critical role that science can play by focusing on issues of concern to the "have nots" of the developing world. After all, they constitute 80 percent of the globe's population.

I was born in Egypt and educated in public schools there. As an undergraduate student at the University of Alexandria, where I earned bachelor's and master's degrees, I was not familiar with such advanced and frontier areas of research as lasers. Later lasers would play a key role in our work that led to the Nobel prize. I did not study advanced quantum mechanics, the language of the microscopic world. Later we would use this language to conduct research on time and matter at the atomic scale. I did not even know much about the Nobel Prize and, as a young boy, I did not spend a single minute dreaming that one day I might receive it.

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However, the years that I spent in Egypt as a child and young adult blessed me with a solid foundation for life's journeys based upon these unwavering principles: strength comes from excellence in basic education, especially in science; strong family values are essential for success; and societal appreciation of scholarship motivates youngsters and adults alike.

When I came to the United States, I encountered both cultural and scientific barriers. My English was poor. (In restaurants, I would confusingly ask for "desert" instead of "dessert."). My knowledge of the latest science, especially cutting-edge science, was also poor or at best shaky. There were, moreover, misperceptions of people from my part of the world that often left me distressed. Many thought I rode camels all day long in Egypt. The truth is that I had never ridden a camel in Egypt. Many also imagined that most of my fellow Egyptians drilled for oil all day long. In reality, Egypt has limited oil resources.

Leaving aside these ill-informed views, what the United States gave me was the unique opportunity to develop my potential and a wondrous sense of appreciation for achievement to which I had never been exposed. While learning English and becoming acquainted with the culture, I earned a doctorate degree at the University of Pennsylvania and soon after was appointed a research fellow at the University of California, Berkeley.

My goal, at the time, was quite basic. I wanted to learn and acquire knowledge and then return home, but not before earning enough money to buy a big fancy car – a Buick – to take back to Egypt where I had a permanent teaching position at the University of Alexandria. Through a series of circumstances, however, I eventually wound up as an assistant professor at the California Institute of Technology (Caltech). It was there that I would learn through personal experience the indispensable role that a vibrant culture of science plays in determining the future of young researchers.

There is a widespread misconception in the developing world that progress in science can be driven by buildings and slogans. That is simply not the case. As a youthful untenured professor at Caltech I was given an empty laboratory and some start-up funds. That was all, except for one other thing: enormous freedom to do what I wanted. I did not have a boss. Not even Caltech's president was my boss.

To be sure, after a judicious period of time, my work was assessed but in a thoughtful, yet vigorous, way. Caltech's faculty makes decisions on tenure. After 5 or 6 years, young professors usually know what the final decision is. If things are not going well faculty members shake young professors' hands and wish them good luck in their future endeavours which will take place at a place other than Caltech.

The freedom at Caltech proved special for one simple, yet compelling, reason: It made scholarship – and, more importantly, excellence in scholarship – the driving force on campus.

But the atmosphere was as intimidating as it was exhilarating. The first week after arriving on campus I came in contact with Richard Feynman, Murray Gell-

Mann and Max Delbrück – all Nobel Prize winners. Concluding there was no hope for me, I was ready to pack my bags and return to Egypt. But the scientific atmosphere and culture of science that found its way into every corner of the campus made it clear to me that, if I could develop to the best of my potential, I would likely earn tenure and be on my way to doing all kinds of exciting things in science.

And that is exactly what followed. I received tenure in less than two years. The university appreciated that my research group and I were opening new vistas that created real excitement among scientists around the world. We were not encumbered by bureaucracy. Tens of forms did not have to be signed; tens of seals did not have to be put on paper; and tens of personal status reports did not have to be completed. No push from high-up officials was invoked. A simple, well-defined, transparent system had been put in place – one with sufficient flexibility to ensure that achievement was rewarded fairly, efficiently and effectively.

I didn't come from Mars with a brilliant idea that would instantly win me a Nobel Prize. It doesn't work that way.

Why did I earn tenure in less than two years? I headed a research team that came up with something original. Every chemist and physicist working with molecules is interested in their structures. I had a simple idea. I suggested that with lasers and other tools we might be able to look at structural dynamics – that is, structures changing over time and on the time scale of their atomic motions. This is of enormous importance to physical, chemical and biological transformations. If you look at the work of biologists today, they display a like-minded interest as they increasingly focus their research on the relationship between structure and function. Dynamics is at the heart of this junction.

The real challenge was that when scientists do experiments on molecules they look at billions – even trillions – of molecules. How, then, can we examine the intricate dynamics of the sheer endless number of molecules (and the even more numerous individual atoms moving inside these molecules)? We turned to lasers trying to develop new techniques with new tools that would bring about the fastest camera for freezing atoms in motion – in a millionth of a billionth of a second.

Much of the conceptual progress, which brought physics and chemistry into confluence, took place at lunchtime in our faculty club, or late at night with my research group members. Each day, I could join informal roundtable discussions. Researchers – young and old, well-known and just starting out – would sit around the table discussing their work. Our research and discussions on many occasions lasted well into dawn. The excitement was everywhere!

The point is that I didn't come from Mars with a brilliant idea that would instantly win me a Nobel Prize. It didn't – and doesn't – work that way. The fanciest building is not responsible for producing breakthrough ideas. What you need is the right scientific atmosphere and the right scientific support.

The work for which I won the Nobel Prize took place in 1987. That was just 10 years after I had arrived at Caltech. The freedom I enjoyed; the camaraderie I experienced; the give-and-take that sharpened my thinking; and the keen awareness I had that my achievements would be recognized and rewarded all helped move my research forward.

That didn't mean our work wasn't scrutinized carefully. Indeed many colleagues initially reacted to our research with scepticism. Critics thought the kind of resolution that we sought (10^{-15} second) would be worthless due to the uncertainty principle that stipulates if you try to do measurements in very brief timeframes you lose information on energy, just as you lose information on the speed of an object, the more precisely you measure its position.

We nevertheless persevered in our work and eventually convinced our colleagues that the uncertainty principle actually operated in our favour. With proof in hand, the criticism was transformed into favourable recognition.

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I am convinced that the developing world – even with its limited resources – is capable of producing such an atmosphere. There are scientific centres in the South that have sufficient resources to conduct good research. It's not just a question of money. It's also a question of nurturing a scientific culture that encourages researchers to seek new knowledge and, in the process, challenges them to reach their full potential. Money counts but it must be invested in the right way and not spent on frivolous matters that ultimately have scant impact on the quality of science that is done.

In the past five years, the scientific community worldwide has published about 3.5 million research papers. Europe's share is 37 percent. The US share is 34 percent. The Asia/Pacific share is 22 percent. Other places – representing 70 to 80 percent of the world's population living largely in developing countries – have contributed less than 7 percent of these scientific articles.

What difference does this disparity in academic output make? Should only universities and research centres be concerned? Perhaps not. Consider this interesting correlation. The US contribution to the world's annual economic output is between 30 and 40 percent, comparable to its share of scientific output on a global scale. Europe's annual economic output registers a similar percentage and, like the USA, its economic output tracks its contribution to its output of scientific contributions. It's unlikely that this correlation is coincidental.

If we are aware of these trends and understand the problems that stand in the way of progress, why does the developing world have such difficulties building scientific capacity and putting science to work to improve its economic well-being?

A renaissance in thinking is needed. We need to pay more attention to education and we should invest more in science and technology. We need to lower the political barriers that stand in the way of success and to ensure that our laws do not allow political and fanatical principles to cast shadows over freedom of thought in ways that impede the use of our human resources. Women must participate as full partners in our pursuit of knowledge. The developing world possesses very capable scientists and yet, unwittingly, continues to contribute outstanding scientists to the developed world as part of the brain-drain phenomenon. At Caltech, for instance, my own research group is more than 50 percent Asian.

The developing world must create new systems of education that emphasize rational thinking.

The developing world, in brief, is rich in human resources. But to take advantage of this invaluable resource, we must develop strategies that nurture and reward the achievements of our scientists and scholars so that the best among them are encouraged to stay at home and pursue the work that their countries so desperately need. While politicians' knowledge of science may be limited (which is understandable; after all, their field is not science), politicians must promote science and its connection to development, and nurture its enormous capacity for interaction on an international scale.

The developed and developing world each shoulders responsibilities in efforts to improve the capacity of science in the South and to build better societies that will enable people to enjoy the fruits of science and technology.

First and foremost the developing world must get its house in order. We cannot just wait for the developed world to help us or accuse people there of conspiring against us. Yes, international politics play a role but people's will is a stronger force, provided the force is coherent and not dispersed by internal politics.

Specifically, the developing world must create new systems of education that emphasize rational thinking and that pursues hands-on approaches to the learning of science in ways that engage and excite young students. The objective is to build a new workforce equipped with 21st century tools of education and skills and with a belief in ethics and teamwork. Women must be included in the educational process not only because they deserve to be given an opportunity to succeed but because our societies cannot progress without them. Clearly, this may not be possible on a grand scale in a short time, but the foundation must be established properly and in a timely manner.

Developing countries, moreover, must implement a merit-based system that rewards excellence. Science in much of the developing world relies too much on seniority and puts too much decision-making into too few hands. Everything is centralized and everything needs approval. The result is a snail-paced environment in a fast-paced world.

Such long-standing problems must be addressed in an honest and clear way if we are to go forward. A merit-based system may be the only way to engage and excite young students and to convince them that what they're doing is worthwhile. In the developing world, countries must build their own centres of excellence in science and technology that are especially relevant both to their own country and the global community.

Despite its infrastructural problems, India, for example, has developed centres of excellence that have enabled its scientific community in several disciplines to become partners in international science, education, and a technology-driven economy. But no country can develop centres of excellence unless it creates the right atmosphere for researchers. That means identifying and investing in talent and putting in place a system that minimizes bureaucracy and maximizes freedom and flexibility.

Besides all the obvious benefits of science and technology, the power of knowledge enhances national pride, limits the brain drain and leads the country into effective economical participation in globalization.

The developed world also carries important responsibilities in its efforts to promote scientific capacity and excellence in the developing world. First and foremost it must reform its international aid programmes, investing less money on military hardware and instruction and more on scientific training and partnerships. International aid programmes, moreover, must be drained of politics to ensure money is available for productive North-South initiatives that could help boost science and technology in the developing world.

What will rich countries receive in return for the help they give the "have-nots"?

First, there is the moral dimension. The psychological value derived from being a generous global neighbour should not be underestimated. Even on a personal level, most of us do try to help and all major religions encourage and legitimize efforts to help the needy. It is also difficult to ignore that the prosperity of the North is in part due to natural and human resources from the South and their markets.

Second, we should acknowledge the importance of reciprocation over time. Islamic civilization gave a great deal to Europe, especially during the dark ages. The Arab and Islamic civilizations, which at the time were the world's foremost economic and scientific

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powers, were major contributors to the European Renaissance. Today it is the Muslim world that needs help and there is nothing wrong with the United States and Europe (and other developed nations) lending a hand as a modest gesture to the changing fortunes of history.

Third, there is a more practical, self-centred consideration based on the time-tested importance of having an adequate insurance policy. In the United States, I pay a great deal for insurance to protect my family against the high cost of medical care, to protect our house against fire and theft, and to protect our cars against accidents. Similarly, the developed world needs to invest in an insurance policy to help it live in a safer and more secure world.

The choice for the "haves" is clear. They have to help in a genuine and sincere manner. The choice for the "have-nots" is also clear. They first have to get their house in order and build the confidence for a transition to a developed-world status.

In a meeting with Prime Minister Mahathir bin Mohamad on a recent visit to Malaysia, I learned of the critical role that the new education system has played in the nation's rapid transition from a labour-intensive economy dependent on cheap labour to a knowledge-based economy on the doorstep of the developed world. This transition has been fuelled by the belief in building a proper base for science and technology. Malaysia has a majority Muslim population living in harmony with the Chinese and Indian population. Neither religion nor culture seems to hinder progress.

Cheap labour may have worked for developing countries in the past but it will not work in the 21st century. How can the developing world embrace such economy-transforming technologies as microcomputing, genetic engineering, and information technologies without a strong foundation in science? Does the developing world always have to wait decades before participating in global science and technology? Can't we be a part of the modern world without losing our cultural and religious identities? Despite all the political and economic problems we currently face, progress is still possible. But change from within is the first ingredient.

For the sake of global peace and stability the developed and developing world must participate as partners in a dialogue among civilizations and cultures. Such a dialogue should not be confused with slogans theorizing about conflicts between religions or cultures.

At its core, we should nurture a dialogue among the "haves" and "have nots." What's needed is visionary leadership, economic progress, and perspectives that rely on rational thinking. It is for this reason, as much as all the others, that we need global science. ■

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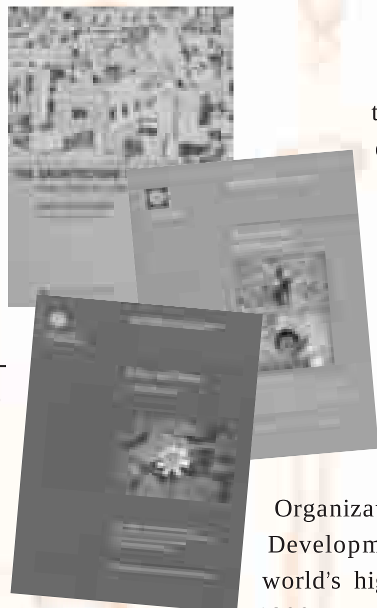
MIND THE GAP

INTERNATIONALLY RENOWNED ECONOMIST ISMAIL SERAGELDIN (TWAS FELLOW), DIRECTOR OF THE NEW BIBLIOTHECA ALEXANDRINA, AND FORMER WORLD BANK OFFICIAL, DESCRIBES HOW CHANGES IN MEASUREMENTS OF NATIONAL WEALTH COULD MAKE SCIENCE AND TECHNOLOGY AN EVEN MORE VALUABLE ASSET.

The "great divide" is the paradox of our time. Despite widespread economic well-being in many parts of the world, inequalities are growing both between and within countries.



A United Nations Development Programme (UNDP) report, published in the 1990s, noted that the top 20 percent of the world's population, in terms of wealth, received 83 percent of the world's income while the bottom 20 percent received just 1.4 percent.

Even more striking is the fact that the assets of the world's three richest people now exceed the combined gross domestic product (GDP) of the world's 48 poorest countries. And the assets of the world's 15 richest people exceed the GDP of all the nations of sub-Saharan Africa, home to more than 630 million people.

Except for the countries of east Asia, including China, which are quickly mastering the tools of science and technology, developed countries are leaving developing countries farther behind. The gap is huge and growing, propelled by vast differences in human resource capacity. As we have moved increasingly towards a global knowledge-based economy, it has become increasingly clear that the ability to embrace new technologies depends on a strong foundation in science and, moreover, that no nation can hope to achieve future and further economic growth unless it can build strong and enduring capacities in science and technology.

The 30 member countries of the Organization for Economic Cooperation and Development (OECD), which includes the world's high-income nations, have on average 1800 personal computers per 10,000 people; middle income countries, which are defined as having incomes between US$746 and US$9200, have 230 personal computers per 10,000 people; lower income countries, with an average per capita income of less than US$745, have just 1 personal computer per 10,000 people.

The ability of developing countries to enjoy the fruits of the information and communications technologies has been severely constrained by a lack of access to the very tools that make these new technologies useful. Will the "haves" and "have nots" of the past

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become the "connected" and "not connected" of the future? And will such trends only widen the ever-increasing gap between the rich and poor?

In seeking to close this gap, developing countries are doubly handicapped: first, in their starting point and, second, in the tools that they have at their disposal for catching up. The most frightening statistic of all may be this: the income gap between rich and poor nations is dwarfed by the research gap – whether measured by the percentage of individuals working as researchers within a nation, the number of scientific articles published in peer-reviewed international scientific journals, or the number of patents issued to individual scientists, research institutions and private firms.

All of this means that unless developing nations forge effective strategies for harnessing science and technology in ways that benefit their societies, the world could be facing an era marked by "scientific apartheid," with consequences as severe as the term implies.

So what can scientists and scientific institutions do to close the gap? Any efforts hold both promise and peril.

The promise is that scientists can help feed the hungry, heal the sick, protect the environment, add additional lustre to the dignity of work, and even provide meaningful opportunities for the joy of self-expression. The peril is that science and accompanying advances in technology will actually broaden the divide.

The ability to embrace new technologies depends on a strong foundation in science.

The privatization of knowledge is an issue that has not received sufficient attention at United Nations (UN) agencies, the International Council for Science (ICSU), the InterAcademy Panel for International Issues (IAP), the Third World Academy of Sciences (TWAS) and other fora in which scientific capacity building is discussed.

Today, the private sector drives about two-thirds of all new research worldwide. The percentage is even higher in the United States. Such research has been driven by intellectual property rights – at least in the eyes of many scientific institutions in the North. Because of the barriers that intellectual property rights pose to the sharing of information, we must devise effective strategies to avoid blocking access to the most advanced tools for scientific research and technological innovation, especially in the developing world.

Here's one statistic that places the challenges we face in stark relief. IBM has registered more patents than 134 countries combined. Clearly, if we harbour any hope of avoiding the unwanted prospect of scientific apartheid, we must take immediate steps to build the scientific and technological capacities of the world's least developed countries. Such measures will be immeasurably strengthened by South-South and South-North cooperation.

There is no doubt that economic growth requires sound macroeconomic policies, infrastructure improvement, human resource development, wise management of natural resources, and the strengthening of the private sector.

Progress on all of these fronts would indeed be welcome but, even if such progress took place, we would still fall far short of our goals because too much emphasis would have been placed on the macroeconomy and not enough on people. Economist Joseph Stiglitz has criticized this approach, which has come to be called the "Washington consensus," as a tried and failed remedy for alleviating global poverty and for narrowing the growing gap between rich and poor.

No one, particularly no economist, denies the importance of stable macroeconomic policies. But we must also acknowledge that stable and effective social policies are as important and, in fact, may be the ultimate keys to success. In particular, outreach and targeting strategies to empower the poor, especially

women, are urgently needed to address the global community's most pressing problems. So, too, are policies designed to protect the environment and promote public goods – critical aspects of long-term well-being that will never be tackled by the private sector because such crucial elements of our society and, yes, our economy, do not attract private investment.

In short, for too long, we have been pursuing a strategy based on the notion that economic growth will take care of everything. That is simply not true. It's the quality of that economic growth that matters the most.

Statistics show that distinct governmental policies, pursued over long periods, make a great deal of difference in how much poverty-reduction "bang" a country receives for each "buck" of growth that it generates. Between the mid 1970s and the late 1980s, Brazil, Costa Rica, Malaysia and Mexico all experienced about the same rate of average annual growth; yet Costa Rica and Malaysia enjoyed much higher unit reductions in poverty than either Brazil or Mexico.

What accounts for this discrepancy? The answer is deceptively simple yet often underplayed. The fact is, policy counts. The US economy is broadly more inequitable than the economies of European nations. At any given time, at least 11 percent of the US population lives below the poverty line; in most European countries, the percentage lies between 1 and 5. Is this difference due to a deep-seated characteristic of knowledge-based economies, which some experts claim are inherently more inequitable? Based on this notion, the US economy, as the most knowledge-based of all economies, would be the most inequitable.

Yet, before concurring with such an assessment, we should consider this: Leaving aside the effects of governmental policies – notably, income transfers and taxes – income distribution profiles in the United States and Europe are remarkably similar. Indeed the United Kingdom, France, Ireland and Belgium all register more, not less, income inequality than the United States.

The truth is that virtually all governments seek to pursue policies that reduce poverty but they do so in different ways. And the policy choices that governments make determine how effective their poverty-reducing efforts will be.

Again, economic growth is not enough. How economic growth is pursued – and, more specifically, how governments enact income transfers and tax policies – are critical factors in determining how much poverty reduction growth buys.

If policy counts in efforts to create more equitable societies, then it is also true that measurement counts. There is an old adage that states "we treasure what we measure." And to a certain extent that's true because measurement provides a target that is easily grasped, monitored and examined compared to other "less precise" qualities that are more diffuse and difficult to handle.

But if you measure the wrong things – or conversely fail to measure the right ones – you wind up with policies built on faulty information. And that, in turn, leads to undesirable outcomes. For these reasons, correctly specifying what needs to be measured and how to measure it – and then measuring it accurately – are critical prerequisites for sound policy making.

Conventional national income accounts have received a great deal of criticism – and rightfully so. Simply stated, if private sector companies did what nations do, their executives would be thrown in jail for fraud.

In other words, if you head a private company, sell off its assets and call that revenue, you would likely be indicted for misleading your investors. Yet government leaders do that all the time. For example, money spent on reseeding a forest has no value but the moment a tree is cut down it is counted as a positive contribution to GDP.

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That is a major error, committed time and again, because the accounting system, as it now stands, has no appreciation for capital cost accounting. Every measurement – whether conducted for examining purchasing power parity or developing currency exchange rate models – focuses on per capita GDP, which means that we are looking at immediate capital stocks not long-term capital flows. This critical shortcoming has led me and my former colleagues at the World Bank to argue that we must broaden the concept of national income accounts (stocks) to include "green accounting" (asset flows).

What is green accounting? It tries to take into account the physical impact, for example, of clearing a forest and then seeks to measure that impact in economic terms on future tree harvests, ecosystem well-being and public health. Or, it assesses the economic impact of industrial development – for example, in northern Mexico along the border with the United States – not just in terms of the capital investment that it brings but in terms of the pollution it creates and the adverse economic impact that may be caused by environmental degradation to the region's air, soil and water.

Green national accounts, besides being more accurate than conventional investment accounts in capturing reality, turn out to be little different in terms of their assessment of income generation. However, the methodology does make a big difference in terms of savings and investment – creating an accounting concept that has come to be called genuine savings.

For example, in a 1985 World Bank study focusing on Mexico, gross domestic investment as percentage of GDP registered at 22 percent – a respectable, indeed healthy, figure. However, when factoring in depreciation for plants and equipment, the percentage declined to 12; when considering the depletion of natural resources, it dipped to 5; and when including the degradation of the environment, it dropped to minus 2 percent. It's this last number that is considered genuine savings investment.

We followed our study of Mexico with a broader analysis for Latin America and the results were the same: Positive figures for gross domestic investment declined sharply and sometimes turned negative when we incorporated "green national accounting" procedures into our overall assessments.

Why do genuine investment savings pose such a challenge for conventional economics? The answer is that the way in which we have calculated national economic growth and well-being in the past often masks the reality of the situation, especially over the long term. Such a misleading perception of growth can spur and often perpetuate poor policy strategies that adversely effect efforts at poverty alleviation, environmental protection and public health. In short, "green national accounting" that seeks to calculate a nation's genuine savings investment rates serve as an important indicator of sustainability.

If development is really about providing people with more opportunity for freedom and choices while ensuring that all people, both now and in the future, live healthy and productive lives – or put another way, that economic development is a means not an end –

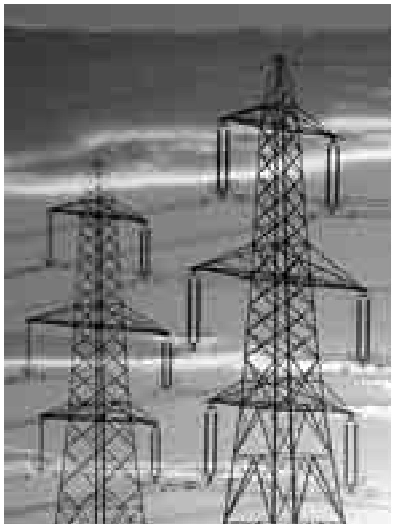
then the concerns addressed by green accounting must be accounted for when assessing a nation's present and future wealth. In short, green accounting measures what counts.

Those of us concerned with these issues have been struggling to develop a new paradigm that would bring all these diverse factors into play. We have often resorted to an analytical paradigm represented by a triangle, which takes into consideration issues related to economic, ecological and social sustainability, to convey our ideas. The economic leg of the triangle focuses on the preservation of produced assets; the ecological leg on a nation's natural resource base; and the social leg on questions of equity and national stability.

At first glance, this triangle, or if you prefer paradigm, seems a reasonable way to examine the complex issues of sustainability. Yet, while every leg of the triangle makes sense by itself, when you assemble the pieces to create a complete picture of the situation, you discover that there are subtle flaws in the image you have created.

The fact is the three legs of the triangle will not fit together unless you have a common analytical framework. And that has been difficult to build because the Brundlandt Commission's 1987 report, *Our Common Future*, sent us down the wrong path as result of its definition of societal needs. "Sustainable development," the report noted in a statement that has been reported many times since, "is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

It's an elegant statement – philosophical, admirable and beyond criticism. There's one problem, however: It's totally nonoperational. Recall that nearly 85 percent of the world's income is consumed by the top 20 percent of the population. Most of these people already have two cars, three televisions, a DVD player and on and on. What does 'meeting their needs' mean?



Policies designed to protect the environment and promote public goods are urgently needed.

The fact is we have to change the way we think about need. One way to do that is to view sustainability as an opportunity that carries many of the same characteristics outlined in the Brundlandt Commission's report but with a slightly different orientation. Sustainability, I would suggest, should be defined as giving future generations as many – if not more – opportunities than the current generation.

That definition becomes operational because it means giving future generations as much – or more – capital per person than we have today. If my son and daughter have more capital than me they have more opportunities to generate more income and services for themselves and their societies.

In developing new accounting methodologies to fit this goal, we should move beyond our prevailing definition of national wealth to include not only assessments of production capital (investment in buildings and equipment) but also of human capital (investment in people through education, health, and nutrition), natural capital (investment in sustainable resource use and conservation) and social capital (investment in institutions that enable a society to work effectively).

Sustainable development strategies would thus involve not just one but four forms of capital. Drive any of these four capital investments to zero and no production of any kind would take place.

In two World Bank studies conducted during the 1990s, in which we applied our four-asset portfolio assessments first to some 200 countries and then, in a subsequent study, to another 100 countries, we ended up with the following profile: In almost every country, production capital (or conventional economic assets) accounted for 20 percent of a nation's GDP and natural capital another 20 percent. Meanwhile, human and social capital accounted for almost 60 percent. The bottom line is this: Real growth rates are driven primarily by investments in human and social resources.

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Adopting this new accounting methodology would have a profound transformation on how economic development policies are devised, especially in developing countries. Decision makers would have to consider new kinds of indicators for development. Such indicators ultimately would lead them to think like a portfolio manager who has four different assets to manage. They would recognize that human and social capital account for more than half of the portfolio, treating them not as social costs, as we do now, but as core elements of the portfolio. The value placed on education and research would rise – often dramatically – having a significant impact on scientific research.

We must broaden the concept of national income accounts by including "green accounting."

Sustainable economic growth in both the North and South requires the creation and sustained development of scientific institutions. Basic research is not a luxury for developing countries. Advances on this front necessitate both South-South and South-North cooperation. Developing nations should also take advantage of the new information technologies facilitating information exchange.

Countries in the South must also pay attention to "brick and mortar" issues that will help lay the foundation for scientific centres of excellence that would ultimately earn their international reputations through independence, leadership and research quality and productivity. TWAS and national science academies, with the help of national governments and international donors, could play a critical role in the development of such centres.

Scientific institutions that carry the label of 'centres of excellence' must promote the values of science – honour, truth, accomplishment, integrity and imagination. Throughout the developing world, too much emphasis is placed on seniority and respect for the established order. Contrarian views must not only be tolerated but encouraged. The science curriculum at all levels of education must promote self-confidence and self-expression among teachers and students alike. Adequate financing drawing on the resources of both public and private sectors must be secured and sustained.

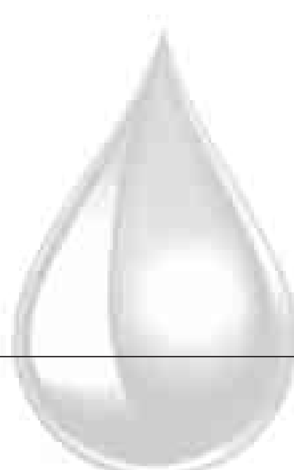
Capacity building efforts directed by governments and international agencies are, of course, welcome. So too are coherent government policies that promote excellence within the country and exchanges with individuals and institutions outside the country.

The truth is that the most effective capacity building efforts take place through working together. All those involved in building a strong and enduring foundation in science and technology in the developing countries should make collaborative initiatives a centrepiece of their efforts.

Each and every one of these recommendations is essential. In fact, they reinforce one another in ways that strengthen science and then allow its findings to be put to work to strengthen the economic and social fabric.

Step by step, the whole becomes more than sum of its parts. Propelled by such a strategy, small investments will ultimately generate large returns for the countries involved.

The take-home message is this: A nation's full range of assets, clearly measured and wisely invested, will make it possible to mobilize science and technology for the benefit of future generations. That, in turn, will give younger people the tools they need to build a better world for themselves.



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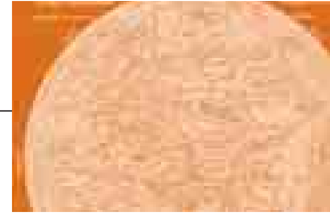


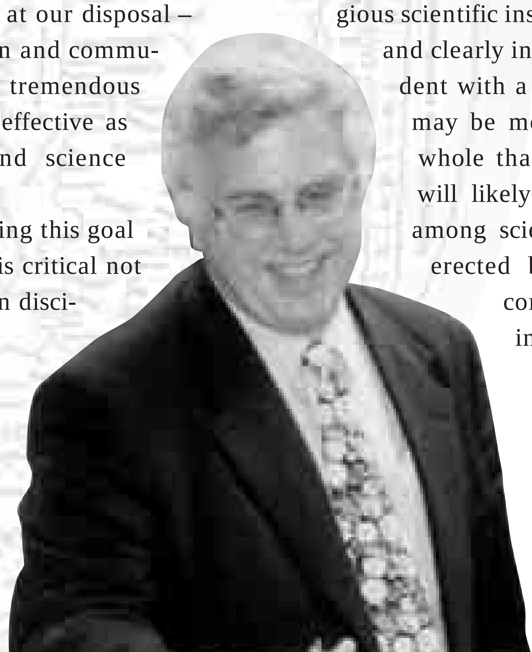
U.S. PERSPECTIVE ON GLOBAL SCIENCE

BRUCE ALBERTS (TWAS ASSOCIATE FELLOW), PRESIDENT OF THE US NATIONAL ACADEMY OF SCIENCES, EXPLORES MEASURES – BOTH LARGE AND SMALL – TO INCREASE THE VISIBILITY AND IMPACT OF SCIENCE IN TODAY'S WORLD.

Science and scientists must attain higher degrees of influence both within their nations and throughout the world – not just for the sake of their professional well-being but for the well-being of the societies in which they live and work.

To accomplish this goal, we must take full advantage of all the tools that we have at our disposal – most notably, the new information and communication technologies that offer tremendous opportunities for us to be more effective as scientists, scientific advisors and science communicators.

The barriers we face in achieving this goal are many. Leadership, of course, is critical not just among researchers in our own disciplines but among science administrators and public officials in the larger political community. We must develop an image of science, moreover, that the public finds welcoming, not frightening. The most effective way to alter public perceptions over the long term is through science education for children based on a curriculum that provides hands-on learning experience; rewards team work; and encourages teachers to coach not dictate.



A new framework for science education can only be constructed if the best scientists – and the most prestigious scientific institutions – get behind the effort and clearly indicate that providing every student with a basic understanding of science may be more important for society as a whole than for science itself. This effort will likely require a change in attitude among scientists who for too long have erected barriers between their expert communities and the larger world in which they live and work.

As scientists we have understandably focused our attention on the most 'basic' aspects of our profession – biology, chemistry, mathematics and physics. And as scientists – again understandably

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so – we have lavished praise and attention on our most prestigious institutions.

While we should never short-change the core elements of science and never diminish the value of our best institutions, we should nevertheless acknowledge that we need to pursue and recognise science done in other places as part of a comprehensive agenda for turning to science as an invaluable tool to address critical societal needs.

In other words, the applied science taking place in a broad range of institutions throughout our societies is essential if we are to meet the challenges posed by issues related to food security, energy, health and the environment.

Today we find it difficult to meet the basic needs of the Earth's six billion people. How, then, can we hope to meet the basic needs of the nine billion people expected to inhabit our planet by 2050 – a population that will include not people living in another time but many of our own children and grandchildren?

The answer lies not simply in science but in a particular science that is place-based, multidisciplinary and acknowledges the importance of social sciences. In other words, a science that defines both purpose and excellence in a broader context than has previously been the case.

Global science has made great advances over the past several decades. But as recent controversies over the underlying forces driving the HIV/AIDS epidemic in South Africa and the value and risks of distributing genetically modified food in Zambia show, global science can have only so much influence over national and local decision-making. The fact is that you cannot always rely on outside scientific advice to sway policies within a nation. Each country must develop its own indigenous scientific expertise and capacities, not only to increase the likelihood that policy makers will pay closer attention to scientific findings, but also to create an effective infrastructure for adapting global scientific knowledge to national and local needs.

An important aspect of the overall mission of science is to integrate scientific findings into policy. Politicians concentrate on short-term goals not because they are short-sighted but because the environment in which they operate demands such a focus. In contrast, science, by concentrating on long-term impacts and goals, can provide a countervailing perspective for policy makers that can help them gauge the lasting effect of their decisions on their citizenry.

Individual scientists rarely can achieve a high level of influence either within their disciplines or their larger societies solely on their own. They must have the support of effective, powerful institutions. Development of such institutions has been the hallmark of science in the North and it must become one of the principal strategic elements of science-based development in the South as well. All those involved in the promotion of science in the developing world – including national governments, international organizations, donors, and global scientific institutions – must focus on institutional capacity building as a major aspect of their efforts.

Each country must develop its own indigenous scientific expertise and capacities.

What kind of institutions are likely to prove vital for success? Universities play a central role in the training of the next generation of scientists. Research centres, often in partnership with universities, help to tie scientific research to critical societal issues and thus assist in broadening the reach of scientific endeavours. Scientific academies – self-governing institutions man-

aged directly by their membership – enjoy a set of distinct advantages based on their stability, merit-based principles, and political independence. Such enviable characteristics should provide academies with the opportunity to enjoy a powerful voice in science-based policy discussions within their own nations.

Scientific academies, however, have been largely underutilized within their societies. It is in the interest of both scientific communities and the societies in which they function to seek ways to enable science academies to develop a larger role, including becoming respected advisors to their own governments on science-related concerns.

That has been the goal of the InterAcademy Panel for International Issues (IAP). The panel, whose roots lie in an unprecedented meeting of the world's science academies in New Delhi in 1993, is dedicated to building the capacity of academies in ways that enable them to become more powerful voices within their own societies. Today, 88 academies – virtually every merit-based national science academy in the world – is a member of IAP, whose secretariat is housed under the administrative umbrella of the Third World Academy of Sciences (TWAS). IAP's efforts have been based on the simple assumption that, by sharing information and experiences and engaging in programmes designed to build skills and expertise, each institution can grow stronger in its own efforts to gain greater visibility and influence within their society.

The US National Academy of Sciences (NAS) has been an enthusiastic supporter of IAP's efforts. As a relatively well-financed and strong science academy, we are eager to work with other institutions to help build scientific and technological capacity at both national and international levels.

The NAS is part of a family of academies in the United States that includes the US Academy of Engineering and the US Institute of Medicine. Membership in the three academies totals 5000 individuals. They are among the most accomplished scientists and engineers in the United States.

The private charter, under which NAS has operated since its inception 140 years ago, includes a provision requiring the Academy to respond to inquiries made by the US government. This provision has led to the production of a continuous series of authoritative reports – now more than 200 each year – examining a wide range of science-related topics. Recent reports have focused on arsenic and safe drinking water; transgenic plants, food security and the environment; and tobacco and public health.

Each report is made available to the press and public at the same time it is sent to the government – a distribution process that helps ensure the report's objec-

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tivity, both in reality and appearance. The combination of being required to report to the government, upon request, on issues of critical national concern, combined with a process that ensures the report's objectivity, has enabled the Academy to serve as an impartial authoritative advisor on science-related issues that enjoys the confidence of both the public and government.

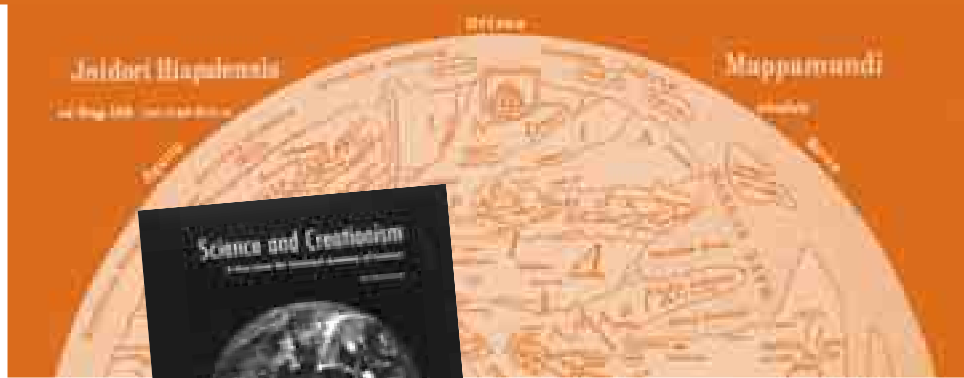
The web has now allowed us to make all of our reports – some 2500 in number – available to scientists, governmental officials and citizens worldwide. The electronic versions of these reports are equipped with sophisticated search mechanisms that allows others around the globe to discover for themselves what prominent US scientists have learned about a host of critical issues.

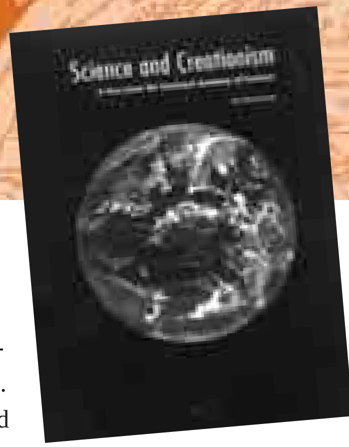
Small and impoverished nations, in particular, cannot be expected to have either the expertise or financial resources necessary to conduct comprehensive scientific research to address all of the critical issues that they face. Providing free access to scientific data and information generated by scientists in other countries could help scientists working under difficult circumstances to overcome some of the constraints that they face.

Science has always been an international enterprise. But by pooling information, in the age of rapid information exchange, science could offer the added benefit of helping all nations – rich and poor, big and small – make wise decisions based on the current state of expert knowledge.

For the past several years, the NAS has focused on two broad areas of concern: (1) boosting international ties in science, which has prompted us to develop closer relationships with science academies throughout the world, including TWAS and the Indian National Science Academy (INSA), and (2) improving science education by vigorously studying how students best learn science – in effect, making a science out of science education.

Despite the high idealism that is driving these initiatives, in the final analysis our strategy has been designed to help the US scientific community as much as the global scientific community.





Promotion of science in the developing world must focus on institutional capacity building.

Most US scientists do not know anything about Brazil, China or India, let alone Cambodia, Chile or Senegal – and they often know next to nothing about their scientific communities. It's not that our scientists are disinterested in these places and the science that is done there; it's simply that the education we receive and the jobs we hold don't usually focus on issues beyond our borders.

If NAS, on its own or more significantly in partnership with other scientific institutions, can help lower the barriers of communication and greatly increase both understanding and the involvement the US scientific community with scientific communities elsewhere, we will have made a significant contribution to both our professions and our societies.

In fact, in the post 11 September world, spreading science and the values of openness and honesty that it embodies should be widely recognized as a noble endeavour that carries benefits well beyond the material well-being that results from science-based economic development.

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Indian-born Gurdev Singh Khush (TWAS Fellow 1989), who recently retired from the International Rice Research Institute (IRRI) in Manila, Philippines, is a world-renowned agricultural scientist who is considered one of the principal architects of the "green revolution." The success achieved by Khush and his colleagues in the development of higher yielding rice varieties paralleled the enormous progress made over the past several decades in feeding the world's hungry. The ties are not incidental. Indeed IRRI's efforts to develop higher yielding rice varieties remain one of the great "science" success stories of the past half century. Khush, who was among the participants at the TWAS/TWNSO general meetings in New Delhi, India, sat down with the TWAS editor for a one-hour interview. Excerpts follow.

SCIENCE FIGHTS HUNGER

Gurdev Singh Khush

Let's begin by talking about your childhood.

I was raised on a small wheat farm in a small village in central Punjab, India. My parents, who were farmers, had a very hard life. Throughout my childhood and adolescence, I helped work the farm. In fact, the earliest memories of my childhood involve images related to our seasonal efforts to till the land, sow the seeds and harvest the crops. So early in life I developed a love for plants. Another lasting impression of my childhood is the chronic poverty that plagued farming families throughout the community, including my own. Crop yields, which were our major source of sustenance, were low and opportunities to increase yields were virtually non-existent. Fertilizers, irrigation and higher yielding varieties were not a part of the world in which I grew up. As a result, my family hardly had enough food to live on from one crop season to the next. This personal experience motivated me to pursue a career in agricultural research. I wanted to see if something could be done to help the plight of farming communities like the one in which I lived. My education began at a nearby school to which I walked 10 kilometres each day because there was no school in my village. After graduating from high school at the top of my class, I enrolled in Government Agriculture College in Ludhiana, where I earned a bachelor of science degree in 1955. I then travelled half-way around the world to the University of California at Davis in the United States to pursue a doctorate degree in genetics. I graduated from Davis in 1960 and worked there as an assistant geneticist for the first seven years of my career before moving on to the International Rice Research Institute (IRRI) in the Philippines. I ultimately chose rice genetics as my specific field of study because I thought that improving rice yields held great potential for improving the lives of hundreds of millions of people.

How would you describe the state of rice production in the developing world during the 1960s?

When IRRI introduced high-yielding and insect- and disease-resistant rice varieties in the mid 1960s, rice yields averaged 2 tons per hectare and world rice production totalled more than 250 million metric tons a year. Since then rice yields have more than doubled and production now exceeds 600 million tons. This increase has been due largely to varieties developed by IRRI and national agricultural research programs over the past 40 years – varieties now grown on more than 80 percent of the world's rice fields. IRRI's efforts helped bring about the green revolution in Asia. The continent has become not just self-sufficient in rice production, but has recently emerged as a significant exporter of rice, mostly to African countries. The benefits have extended not only to food security, but to growing prosperity and overall political stability.

Is this rice cultivated on the same amount of land now as in the 1960s?

No. Between 1960 and 2000, the land area devoted to rice production has increased by about 30 percent. However, during the same period, average rice yields have doubled from 2 to 4 tons per hectare and on good land have actually increased to 6 tons per hectare. So, what has happened is truly a revolution.

Tell me about the atmosphere at the IRRI when you arrived there.

When I moved to IRRI from the University of California in Davis, I didn't realize how fortunate the decision would be. Simply put, I wound up going to the right place at the right time. IRRI was – and remains – located in a developing country near the epicentre of the food production problem. I joined an institution that was receiving good support from the Rockefeller and Ford foundations; was staffed by excellent energetic scientists; and was led by a dynamic director, Robert Chandler. His management philosophy was to provide staff with the facilities and funds that they needed to do good work and then not to interfere with their research. He often said "the scientists are kings and that IRRI's sole purpose was to nurture and sustain an environment that would allow scientists to conduct first rate research free of distractions and hassles." At the time, IRRI had 20 staff scientists from seven different countries who worked closely with scientists working in national research programmes throughout the developing world. The environment in which we worked was superb: We had state-of-the-art equipment, well-trained technicians, and an excellent administrative support staff who helped us with housing, transportation, visas, and travel. Everything was taken care of. It was a one-of-a-kind place.

Would you agree that it was an international centre for excellence before the term was actually coined?

Yes, definitely. IRRI was really the developing world's first international centre of scientific excellence. The institute proved so successful that it spawned a network of similar agricultural research institutes worldwide under the auspices of the Consultative Group for International Agricultural Research (CGIAR), which was organized in 1971. Today 16 institutes belong to CGIAR, each of which is modelled along the lines first laid out by the IRRI. CGIAR is a loosely woven network without a constitution or bylaws. But CGIAR member institutions share a common interest and goal: to conduct worldclass agricultural research as part of a larger effort to increase global food production. While our first objective was – and continues to be – increased food production and tackling the problems of hunger and malnutrition, CGIAR member institutions have expanded their mandate to include environmental protection and poverty eradication. Our research has been multidisciplinary and multisectorial from the beginning. What began as an agricultural research initiative now touches on economics, ecology, sociology and a host of other disciplines that are all part of an ongoing effort to meet the food needs of the world's poorest people. Today the CGIAR receives funding from international donors, including the World Bank, and the governments of more than 50 developed and developing countries.

Why did IRRI and, more generally, the CGIAR decide to broaden their mandates in the late 1970s and early 1980s?

We attained a noteworthy level of success in increasing food production during the 1970s and early 1980s. By the late 1980s, however, we began to address such other issues as environmental protection and the conservation of water resources. In particular, we did a great deal of work on curbing the use of pesticides and insecticides – first, by developing plant varieties that are more resistant to diseases and insects and therefore could be grown using fewer chemical inputs and, second, by introducing integrated pest management (IPM) strategies designed to educate farmers to take advantage of 'friendly' predatory insects and innovative crop rotations to increase yields without the use of additional pesticides and insecticides.

At the World Summit on Sustainable Development in Johannesburg, South Africa, there was a great deal of concern that we had become complacent about the world's food supply. Do you agree?

To a certain extent, I think this has been the case. In the late 1990s, the donor community began to believe that global food supply problems had been largely been solved, thanks largely to the success of CGIAR programmes. Donor agencies, however, were not taking adequate account of global food requirements projected over the next 20 or 30 years. The annual rate of global population growth currently stands at about 1.4 percent and nearly 85 percent of this growth is taking place in developing countries. Many developing countries, in fact, have annual rates of population growth that exceed 2 percent. Experts estimate that, if current population growth trends continue, we will have to increase food production by some 50 percent by 2030 to feed the world's people. Compounding the problem is the fact that the annual rate of increase in food production has slowed down from 2.5 percent a year in the 1970s and 1980s to about 1.4 percent a year in the 1990s .

Doesn't that 1.4 percent increase in food production match the current rate of global population growth?

Yes, but the rate of population growth in developing countries is often much higher and that's where food security issues are most acute. Moreover, there are two additional issues that should be kept in mind when estimating future food grain requirements. First, 800 million people in the developing world presently go to bed hungry each night. If poverty-alleviation programmes succeed, the purchasing power of these people will increase and so will their demand for food. Second, as standards of living rise throughout the developing countries, consumers will start eating such high value foods as milk, eggs and meat. To produce these high value foods, animals and poultry need feed grains. It takes two, four and eight kilogrammes of feed grains to produce 1 kilogramme of poultry, pork and beef, respectively. In my home country of India, at present 5 million tons of grains are used as animal feed. Experts estimate that this will increase to 50 million tons in 2030. When it comes to issues of food security and adequate nutrition, there is a marked divide not only between developed and developing countries but also within developing countries. Let us take India again as an example. In 2002, India exported 5 million tons of rice. Yet 250 million Indians go to bed hungry. How do we overcome this paradox? The answer lies in analysing problems of hunger and economic development as interrelated issues. Stated slightly differently, to solve problems of hunger and malnutrition, we must alleviate poverty so that people can have the ability to purchase sufficient amounts of food. The focus should be on economic development so that more jobs can be created for the nation's poor. With more money in their pockets the poor could buy the food that they require to live healthy and productive lives. At the same time, food surpluses in nations like India would likely disappear.

What are the important measures that can be taken today to address the problem of hunger?

I know it sounds strange for a plant geneticist to say but the first step should be to create more employment opportunities. The second step should be to put more emphasis on population control, where we have made significant progress but critical challenges still remain. Annual population growth in India is 1.7 percent, which means that each year we have an additional 17 million people to feed – that's roughly equivalent to the population of Australia. In Pakistan, the annual rate of population growth is 2.5 percent and in several African countries – Nigeria, Kenya and Ethiopia, for example – it is even higher. Slower annual population growth would help all of these countries achieve their cherished goal of food security and economic development. Third, we must continue to use time tested methods of crop improvement as well as the emerging tools of biotechnology. I think the adverse reaction to biotechnology in both the North and South is largely based on a lack of public understanding. Too few scientists have taken the time to explain biotechnology research to their citizens or leaders. Widespread public anxiety generated by ignorance and misconceptions have become the main enemy of biotechnology in developing countries. It would be unwise not to explore potential applications of this technology for addressing global food production issues, particularly in the developing world.

What does the future hold for those involved in food security issues?

When I started my career, India and many other developing countries were at the doorstep of the green revolution. Since then, many – indeed most – nations have made tremendous progress in food production. For example, over the past four decades, India's population rose from 330 million to more than 1 billion, yet the nation has been transformed from a net importer of food grains to a significant net exporter. Put another way, India's population has increased three-fold over the past 40 years, while its grain production has increased four-fold. Equally encouraging, India now has a large number of well-trained agricultural scientists eager to meet the nation's future challenges in ensuring that its citizenry is well-fed and thus able to lead healthy and productive lives. It is indeed satisfying to note that many of India's researchers benefited from training and collaborative activities with IRRI, which has hosted more than 2000 scientists from India over the years. The strong national foundation that is now in place, combined with the government's commitment to continue to invest in agricultural research, gives me hope that India – and the rest of the developing countries – can meet the food-production challenges that lie ahead. I have been fortunate to be part of one of the most noteworthy success stories in science in recent history and I believe, with proper vigilance, we can continue to make progress in combating hunger and malnutrition in the future. Indeed, with continued effort and some luck, we may one day be able to say that the battle has been won.

WHAT'S TWAS?

THE THIRD WORLD ACADEMY OF SCIENCES (TWAS) IS AN AUTONOMOUS INTERNATIONAL ORGANIZATION THAT PROMOTES SCIENTIFIC CAPACITY AND EXCELLENCE IN THE SOUTH. FOUNDED IN 1983 BY A GROUP OF EMINENT SCIENTISTS UNDER THE LEADERSHIP OF THE LATE NOBEL LAUREATE ABDUS SALAM OF PAKISTAN, TWAS WAS OFFICIALLY LAUNCHED IN TRIESTE, ITALY, IN 1985, BY THE SECRETARY GENERAL OF THE UNITED NATIONS.

At present, TWAS has more than 660 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 9 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. UNESCO is 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 more than 150 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. ···> **www.twnso.org**

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 2000 women scientists from 87 Third World countries. Its main objectives are to promote research, provide training, and strengthen the role of women scientists in decision-making and development processes in the South. The secretariat of TWOWS is hosted and assisted by TWAS. ···> **www.twows.org**

Since May 2000, TWAS has been providing the secretariat for the InterAcademy Panel on International Issues (IAP), a global network of 85 science academies worldwide established in 1993, whose primary goal is to help member academies work together to inform citizens and advise decision-makers on the scientific aspects of critical global issues. ···> **www.interacademies.net/iap**

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:

www.twas.org

FELLOWSHIPS

Want to spend some time at a research institution in another developing country? Investigate the fellowships and associateships programmes:
www.twas.org/Fellowships.html
www.twas.org/AssocRules.html

GRANTS

Seeking funding for your research project? Take a look at the TWAS Research Grants:
www.twas.org/RG_form.html
TWNSO runs a similar scheme, for projects carried out in collaboration with institutions in other countries in the South:
www.twnso.org/TWNSO_RG.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:
www.twas.org/SP_form.html

TRAVEL

Would you like to invite an eminent scholar to your institution, but need funding for his/her travel? Examine the Visiting Scientist Programme, then:
www.twas.org/vis_sci.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:
www.twas.org/SM_form.html