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TWAS-ARO (THE ACADEMY OF SCIENCES FOR THE DEVELOPING WORLD–ARAB REGIONAL OFFICE) IS ONE OF FIVE REGIONAL OFFICES ESTABLISHED BY TWAS TO HELP DECENTRALIZE THE ACADEMY'S ACTIVITIES. TWAS-ARO REPRESENTS ALL 22 ARAB COUNTRIES. IN THE FOLLOWING ARTICLE, MOHAMED M. EL-FAHAM, DIRECTOR OF THE CENTER FOR SPECIAL STUDIES AND PROGRAMS (CSSP), AND LARA ELMALLAKH, CSSP RESEARCH SPECIALIST, AT *BIBLIOTHECA ALEXANDRINA*, DESCRIBE THE ACTIVITIES OF TWAS-ARO.

TWAS-ARO operates from the Center for Special Studies and Programs (CSSP), one of eight research centres affiliated with *Bibliotheca Alexandrina* (BA). CSSP's mission has much in common with the goals of TWAS: to promote international collaboration, support activities that enhance the careers of scientists, sponsor scientific research and increase public awareness of science and technology.

TWAS in the Arab Region

Bibliotheca Alexandrina*, the new library of Alexandria, was inaugurated on October 2002, just 200 metres from the site of the famed ancient library of Alexandria, which was destroyed in the 3rd century C.E. The latter was not only a renowned center of knowledge, housing 7,000 manuscripts in all branches of history, philosophy and science, but also a place where such prominent thinkers as Euclid, Archimedes, Hipparchus and Eratosthenes conducted research.*

Following in the tradition of the ancient library, BA is not only a library – a repository for books – but also a cultural centre that encourages and supports creative endeavours in science, art and the humanities. Its mission is to be a center of excellence for the production and dissemination of knowledge, as well as a place of dialogue, learning and understanding between cultures. Each year, the BA welcomes some 1.4 million visitors and holds more than 700 events. Ismail Serageldin (TWAS Fellow 2001 and former Vice President for the Arab region) serves as the library's director.

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REGIONAL MATTERS

Launched in 2005, TWAS-ARO is the youngest TWAS regional office. Despite its brief history, it has pursued a broad range of activities to advance science in the Arab region.

In November 2005, five months after the launch of TWAS-ARO, BA hosted TWAS's 16th General Meeting, which was inaugurated by Egypt's President Hosni Mubarak. In his speech, President Mubarak stressed the importance of bridging the gap between developed and developing countries through South-South collaboration in science.

Each year, TWAS-ARO holds an annual meeting, organized by the CSSP at Bibliotheca Alexandrina*. The meeting has recently been accompanied by a special event designed to raise the profile of the office and its activities. For example, in 2007, a conference, "A New Dawn: Arabs Looking East", drew a large audience of prominent people, including leaders in politics, business, science, technology, culture and civil society from both Arab countries and Japan. Discussions focused on potential scientific and technological collaborations and possible avenues for inter-cultural dialogue.*

In 2008, the TWAS-ARO annual meeting served as an opportune time to launch the Arab Network of Networks for Science & Technology (ANNST). The network seeks to link scientific institutions and academies across the Arab region for the purposes of strengthening regional scientific exchange and capacity building.

In addition to its high-profile events, TWAS-ARO also seeks to identify outstanding scientists from the Arab world worthy of nomination for membership to TWAS. Sixty-one scientists from the region are currently members of TWAS (three new members were elected in 2009). In addition, three TWAS-ARO members currently serve on the TWAS Council, having been elected at the TWAS General Meeting held in South Africa, last autumn. The Council members from the Arab region are: Adel El-Beltagy from Egypt; Fayzah M.A. Al-Kharafi from Kuwait, who is also vice president for the Arab region (having replaced Ismail Serageldin); and Mohamed H.A. Hassan from Sudan, long-time executive director of TWAS, who is now treasurer.

FOCUS ON YOUTH

TWAS-ARO places strong emphasis on supporting and encouraging young scientists. TWAS Affiliates, promising young scientists under 40 years of age, are appointed for five years. As part of their membership, they receive TWAS publications as well as financial support to

attend TWAS's annual meeting. The recognition afforded by the appointment helps these promising young scientists to gain greater esteem in their home countries.

The office's commitment to supporting women scientists is attested to by the fact that four of the 13 TWAS Affiliates from the region are females. In upcoming years, TWAS-ARO aims to select more young women researchers as a means of encouraging female participation in S&T in the Arab region.

Another TWAS programme dedicated to young scientists is TWAS/BioVisionAlexandria.NXT (TWAS/BVA.NXT), which was launched in 2008, during the biennial conference, BioVision-Alexandria. TWAS and TWAS-ARO provide funds for young scientists from developing countries to attend BioVision conferences, which are held on alternating years in Alexandria and Lyons, France. The conference has become a major international event for the biological sciences, attracting a diverse group of participants from government, universities and the private sector.

The young scientists who attend not only have an opportunity to network with their peers but also to hear presentations from eminent scientists and administrators from around the world. Recent speakers at BioVision have included Joel Breman, senior scientific advisor, Fogarty International Center, National Institutes of Health, USA; Indridi Benediktsson, directorate-general for Research, Health, European Commission, Brussels; and Adel El Zaim, senior program specialist, International Development Research Center-IDRC, Canada.

The upcoming TWAS/BVA.NXT 2010, to be held in Alexandria in April, will focus on the critical issue of "Publishing Scientific Papers in the Developing World". Some 100 young scientists from developing countries, including those in the Arab region, will be selected to participate in the event. Plans also call for representatives from international publishing companies to attend.

In 2009, TWAS-ARO established the Young Arab Scientists (YAS) Prize to recognize the achievements of young scientists from the region and to encourage other young scientists to strive for excellence in their research. The first YAS prize was given to Walid El-Sharoud, assistant professor of microbiology at Mansoura University Mansoura, Egypt. His work focuses on microbiology, food safety and bacterial physiology.

TWAS REGIONAL PRIZE

In 2009, the TWAS Regional Prize, recognizing achievements in the building of scientific institutions in the Arab region, went to Adnan Badran, former

Prime Minister of Jordan and currently president of Petra University. Badran was honoured for his leadership in establishing a number of eminent scientific institutions in Jordan, including the Higher Council for Science and Technology (HCST), which helps to guide all scientific institutions in the country. He also spearheaded efforts to expand two private universities in the country – Philadelphia and Petra Universities.

In 2008, the TWAS Regional Prize for Development of Educational Material and School Science Curricula, was given to Saouma BouJaoude, professor of education at American University of Beirut, who received the award for his outstanding publications on the subject of science education. The TWAS Regional Prize 2007 for Public Understanding of Science went to Adnan Hamoui, professor of mathematics, Department of Mathematics and Computer Science at Kuwait University, and editor-in-chief of the Arabic edition of Scientific American*, who was recognized for his outstanding work in translating scientific journals into Arabic.*

PUBLIC ENGAGEMENT

One of the primary responsibilities of TWAS-ARO is to promote science, not just within the scientific community but also among the larger public. To achieve this goal, the regional office, in partnership with the CSSP, organizes a broad array of lectures, seminars, workshops and conferences on topics ranging from public health, to information technology, to environment and agriculture. Participants at these events come from a wide spectrum of

THE SUPERCOURSE PROJECT

In January 2009, the Bibliotheca Alexandrina *and the World Health Organization (WHO) Collaborating Centre in Pittsburgh, Pennsylvania, USA, launched the Science Supercourse project. The initiative is designed to build an internet archive of powerpoint presentations in four main scientific fields: medicine and public health, agriculture, engineering and the environment. The presentations are compiled from the internet through a system designed by the BA's information and communications technology department. The primary goal of the Science Supercourse project is to provide free-of-charge the most up-to-date information to educators, scholars and scientists in developing countries. A DVD, containing more than 3,600 lectures, is being distributed worldwide. To date, more than 10,000 people have viewed the lectures. For additional information, see* www.pitt.edu/~super1.

society. Some events are designed for youngsters and others for adults. More specialized activities are held for the scientific community and government officials.

In early 2009, for example, TWAS-ARO, again in partnership with the CSSP, organized a conference on bioethics for public officials from Egypt. The goal was to lay the groundwork for creating a national committee on this important issue. A pair of workshops on intellectual property rights and development and copyright protection in the digital age were held later that year.

SCIENCE IN SOCIETY

The important role that scientific capacity building plays in development cannot be ignored, especially in the Arab region. Yet, advocates of science must recognize that we live in tumultuous times and that this is nowhere more evident than in the Arab region. As a result, advocates must accept that efforts to promote science may have to take a back seat to more pressing issues.

Other matters of immediate import, whether economic, social or political in nature, pose a daunting challenge for institutions such as TWAS and Bibliotheca Alexandrina*. That's because day-to-day circumstances present significant obstacles to those seeking to raise the profile of science in their countries and regions. Nevertheless, long-terms solutions to the problems that undermine progress will not be devised without the insights that only science can provide. The work of TWAS-ARO may sometimes go largely unappreciated, but that doesn't diminish its significance.* ■

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For additional information on TWAS-ARO, see www.bibalex.org/twasaro

EDUCATIONAL CHANGE IN PAKISTAN

OVER THE COURSE OF NEARLY A DECADE, ATTA-UR-RAHMAN (TWAS VICE PRESIDENT FOR CENTRAL AND SOUTH ASIA AND TWAS FELLOW 1985) WAS THE DRIVING FORCE BEHIND A SERIES OF REFORMS IN HIGHER EDUCATION IN PAKISTAN THAT DRAMATICALLY TRANSFORMED UNIVERSITY TEACHING AND RESEARCH ACROSS THE NATION. IN THE FOLLOWING ARTICLE, HE OUTLINES THE MAJOR CHANGES THAT HE HELPED TO BRING ABOUT AND THE IMPACT THAT THEY HAVE HAD ON HIGHER EDUCATION IN PAKISTAN.

Atta-ur-Rahman served as the Chairman of the Higher Education Commission (a Ministerial post) from 2002 to 2008, and as the Federal Minister of Science and Technology from 2000 to 2002. He is currently the Coordinator General of COMSTECH (the Organization of Islamic Conference's (OIC) Standing Committee on Scientific and Technological Cooperation).

We live in a world in which knowledge and innovation drive socio-economic development. This irreversible trend has touched virtually every aspect of our society. As a result, I am convinced that one of the most significant measures that any country – and particularly developing countries – can take is to develop a comprehensive strategy for educational reform capable of unleashing the creative potential of its young people. The cornerstone of such efforts must lie in giving the highest priority to higher education, science, technology and innovation.

Following my appointment in March 2000 as the Federal Minister for Science and Technology in Pakistan, I was able to convince the federal government to increase the development budget for science and technology in Pakistan by 6,000% over the next two years. The annual development funds, which rose from about USD2 million in 2000 to about USD120 million in 2002, allowed the ministry to launch a large number of projects in Pakistan, including the establishment of several new universities and the creation of national commissions of biotechnology and nanotechnology. In 2002, the ministry also financed the acquisition of an educational satellite for distance learning as part of a virtual university system that currently enrols about 30,000 students.

The ministry also helped lead the way to improve Pakistan's archaic information technology (IT) infrastructure. For example, in 2001, there were only 300,000 mobile telephones in Pakistan, a country with about 170 million people. New policies introduced by the ministry triggered a boom in

mobile telephone use. The most notable reform was the introduction of the "Calling Party Pays or CPP" regime in which the person making the telephone call – and not the person receiving it – pays the call charges. Today, there are an estimated 96 million cell phones in use in Pakistan.

At the same time, the ministry took steps to dramatically reduce bandwidth costs for 2-megabite lines from USD87,000 per month in 2000 to USD3,000 per month by 2003. Internet use, which could be found in only 29 cities and towns at the beginning of the decade, spread to more than 1,000 cities and towns. The IT sector was given an economic boost via a 15-year tax holiday and removal of all taxes on computers and related equipment.

HIGHER VALUES

In autumn 2002, the government enacted a law establishing a federal Higher Education Commission (HEC) as an autonomous body led by a chairperson who held a ministerial position and reported directly to the prime minister. I was appointed the first Chairman of the Commission. Between 2002-2007, the development budget of the higher education sector rose 2,400%, – climbing in real terms from USD13 million to USD300 million. This allowed a number of significant steps to be taken to improve the nation's higher education sector.

The most important step was the creation of a broad-ranging programme to foster high-level training for university faculty. As a result of this initiative, more than 5,000 doctoral-level scholarships for study in technologically advanced countries have been awarded, based on a highly competitive and transparent system centered on rigorous nationwide testing. To date, some 3,000 indigenous PhD scholarships have also been awarded. Both initiatives have been funded by HEC.

With funds totalling USD150 million, Pakistan's Fulbright Scholarship programme, which is jointly sponsored by the Higher Education Commission and the US Agency for International Development (USAID), is the world's largest Fulbright programme. About 200 Pakistani students have been able to attend universities in the United States.

Students studying for PhD degrees at universities in Pakistan have also had the opportunity to carry out a part of their studies in technologically advanced countries under "sandwich" PhD programmes funded by HEC, which allow them to spend part of the time in the US and part of the time in Pakistan.

A large post-doctoral training programme was also launched so that students completing PhD degrees in Pakistan could improve their knowledge and skills through additional training abroad. About 500 students have taken advantage of this initiative.

About USD1 billion dollars is being spent on human resource development initiatives that focus on post-university career-development and providing well-paying job opportunities in teaching and research. For example, to ensure

that the brightest scholars return to Pakistan after foreign training, faculty salary schemes have been dramatically restructured. Full professors can now earn up to USD5,000 per month. At the same time, the income tax rate has been reduced from 35% to 5%.

This means that some professors take home monthly paychecks that are five times those earned by

the government's federal ministers. International experts are involved in this reform under a performance-based tenure track system that involves two evaluations over a six-year period.

A "buffer programme" was also begun to provide scholars returning from studying abroad with wide-ranging opportunities to immediately assume faculty positions after coming home. Returning scholars have also been encouraged to apply for research grants of up to USD100,000 one year before their return, with the requirement that the project should involve collaboration with a foreign institution. Again these initiatives have been funded by HEC.

A comprehensive digital library has been established enabling students in public-sector universities to have free access to 45,000 textbooks and research monographs from 220 international publishers and 25,000 international journals. This is regarded as one of the best digital libraries anywhere in the world. Access to sophisticated instrumentation has been provided through the creation of university-based central instrumentation laboratories with HEC paying for the services.

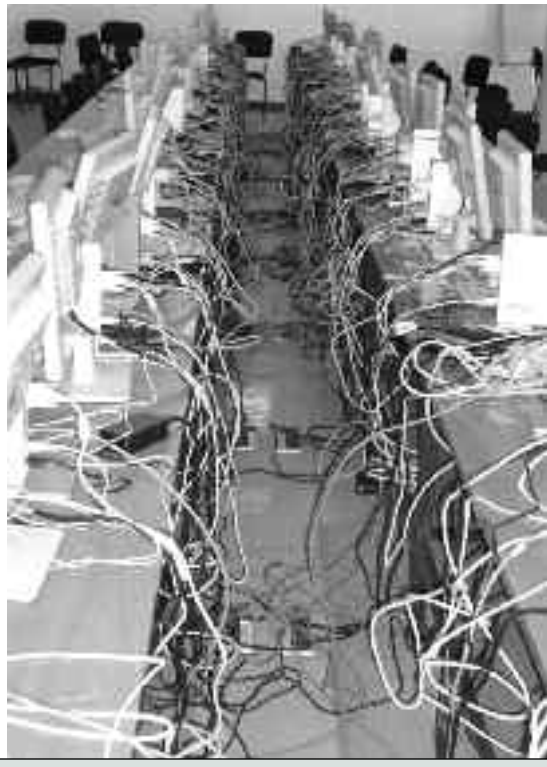
QUALITY MEASURES

Special attention has been given to the quality of education. Quality assurance cells have been set up in universities and a number of accreditation councils have been established to oversee the quality of education being delivered. In addition to expanding the range and quality of instruction in Pakistan's existing university system, an additional 51 new universities and degree-awarding institutes were created between 2000-2008. A four-year undergraduate curriculum programme has replaced the previous two-year undergraduate curriculum, enabling the degrees to become internationally recognized.

The results of these efforts are most clearly represented in numbers that measure the scope and output of Pakistan's scientific enterprise.

Research output from the nation's universities expanded from approximately 600 research papers per year in 2,000 to about 4,200 research papers in 2008. Even more importantly, there has been a 1,000% increase in citations in peer-reviewed international journals.

University enrolment has tripled from only 135,000 in the year 2003 to about 400,000 in 2008. This increase has not come at the expense of quality. Indeed quantity and quality have gone hand-in-hand. From the year of Pakistan's independence in 1947 to 2003 not a single Pakistani university was ever ranked among the top 600 universities in the world. Today, five Pakistani universities are, including the National University of Science and Technology, which has a standing of 350, according to the *Times Higher Educa-*

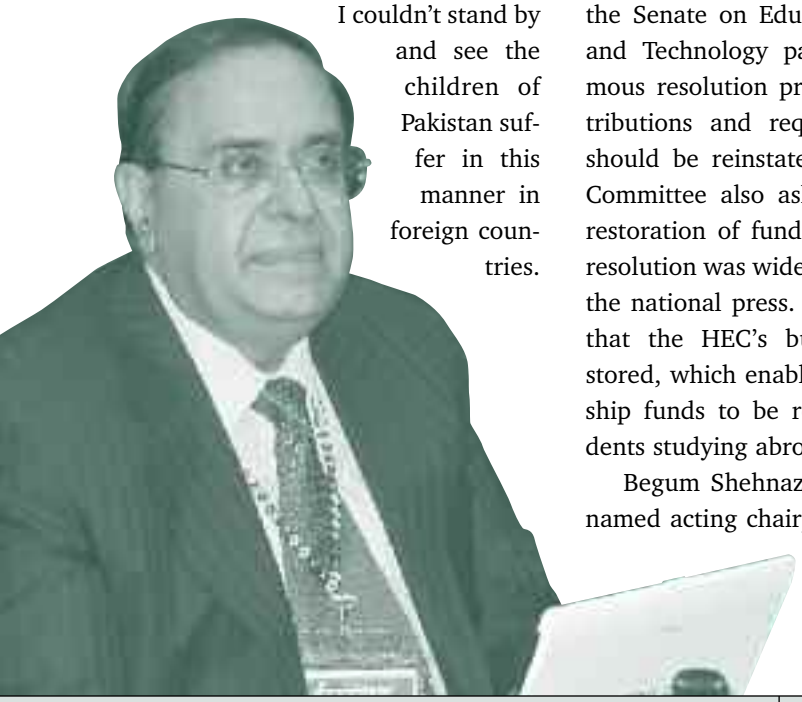


tion world rankings. In the natural sciences, Karachi University is ranked at 223.

It is for all these reasons that the World Bank has called the dramatic advances in higher education in Pakistan "a silent revolution." USAID and the British Council have also published detailed positive reviews. In an article entitled "The Paradox of Pakistan," *Nature* magazine commented on the two contrasting facets of the country – terrorism, on the one hand, and an outstanding higher education programme, on the other.

OPTIMISM AHEAD

In September 2008, the new government withheld the release of funds to the higher education sector. This directly affected some 4,000 students who had been sent abroad on government scholarships. Most of these students were from poor families, and I couldn't stand by and see the children of Pakistan suffer in this manner in foreign countries.



I therefore sent a message to President Zardari, requesting him to arrange for the release of funds or I would have no option but to step down from my position as Chairman of the HEC. The response that I received from the President was that I should resign, which I did in October 2008.

This, interestingly, had a very positive impact. The Committee of the Senate on Education, Science and Technology passed a unanimous resolution praising my contributions and requesting that I should be reinstated. The Senate Committee also asked for urgent restoration of funds to HEC. This resolution was widely publicised in the national press. The result was that the HEC's budget was restored, which enabled the scholarship funds to be released to students studying abroad.

Begum Shehnaz Wazir Ali was named acting chairperson. She remained in that position until a new chairperson, Javaid Laghari, was appointed in October 2009. Both have strongly endorsed the programmes that I initiated and, in fact, have continued to expand them.

So looking ahead I have every reason to be optimistic. The team that I put together at the HEC is still in place. A supportive minister and secretary presently lead the Ministry of Finance. Both understand the critically important role that science, technology and innovation play in development.

Pakistan is making rapid progress in the higher education sector and I have every reason to look ahead with a certain degree of optimism. I can only hope that the changes become more visible in its impact on Pakistani society in the years ahead. ■

Atta-ur-Rahman
Coordinator General
COMSTECH
Islamabad, Pakistan

IAP MEETS IN LONDON

THE INTERACADEMY PANEL (IAP), A GLOBAL NETWORK OF MERIT-BASED SCIENCE ACADEMIES HEADQUARTERED IN TRIESTE, ITALY, HELD ITS 2010 GENERAL ASSEMBLY AT THE ROYAL SOCIETY IN LONDON IN JANUARY.

The meeting, which marked the inaugural event for the Royal Society's 350th anniversary, brought together representatives from IAP's 104 science academy members. Major agenda items included the election of a new executive board and the charting of a broad course over the next three years based on the blueprint outlined in IAP's second strategic plan. The assembly was preceded by a two-day conference on biodiversity.

The UN has designated 2010 as the International Year of Biodiversity. In light of this year-long event, the IAP conference examined a wide range of issues related to the conservation and sustainable use of the world's vast treasure trove of biological resources, which are increasingly under threat from global development, rising levels of pollution and climate change.

Founded in 1660, the UK's Royal Society, one of the world's oldest science academies, is also among the most revered scientific institutions, with a membership that has included such scientific luminaries as Isaac Newton, Charles Darwin and Albert Einstein.

But the society's history is only part of the story. By any measure – the steadfast support it gives to its nation's research community, its dedication to science education and public understanding of science, its ability to advise policy makers, its international outreach and its standing among other institutions with similar mandates – the Royal Society is among the most effective and respected science academies in the world today.

With such a distinguished past and present, the Royal Society's elegant headquarters at Carlton House Terrace overlooking St. James Park in the heart of London, provided an ideal setting for IAP's 2010 General Assembly. As Mohamed Hassan, IAP's new co-chair, observed in his closing remarks, "we hope that IAP, which is now 17 years old, has as much to celebrate on the occasion of its 350th anniversary in 2344 as the Royal Society does this year."



IAP General Assembly highlights include:

- The election of a new IAP executive committee for 2010-2012. The 11-member committee will consist of the science academies of Chile, China, Egypt, India, Malaysia and Mexico in the developing world, and Australia, France, Italy, the United Kingdom and the United States in the developed world.
- The selection of the co-chairs for the IAP executive committee, each of whom will serve for three years beginning in 2010. Mohamed Hassan, president of the African Academy of Sciences and executive director of TWAS, was elected co-chair representing academies from the developing world. He replaces Chen Zhu, Minister of Health, who had served in that capacity for the past six years. Howard Alper, Chair of the Government of Canada's Science, Tech-

CHEN ZHU'S FAREWELL

Chen Zhu's six-year tenure as IAP co-chair came to an end at the IAP General Assembly in London. In his farewell address, Chen Zhu described, often in personal terms, his enthusiasm for the organization and his hopes for IAP's future. Brief excerpts of his address follow.

My tenure as IAP co-chair has been six years filled with action...

The executive committee has been remarkable for producing ideas and guiding the procedural work – for example, drawing up clear guidelines for applicants for IAP funds and establishing review and evaluation committees. A programme and strategic planning committee has also been put in place to ensure that proposals are properly considered for funding. A publications committee has compiled and disseminated a collection of all IAP statements. And our membership committee has overseen a significant growth in members...

Scientists often cannot provide the 'yes' or 'no' answers that politicians and the public demand. And when scientists admit to even a small degree of uncertainty, they risk having their advice disregarded or, even worse, derided. Scientists realize that the scientific aspects of any one issue have to be balanced by political leaders with other priorities, and also by how the decision will be accepted by the public...

I find IAP to be an amazing organization – a family of science academies working together for the development of science and the search for scientific solutions to global issues...

It has been a pleasure working with all the members of our great family and especially IAP co-chair Howard Alper. I thank you all for your support and look forward to my continued involvement in an organization that has a bright future.

nology and Innovation Council and visiting executive at the International Development Research Centre, was re-elected to serve another three-year term as co-chair, representing academies from the developed world (see box, 'Chen Zhu's Farewell', p. 12).

- The official acceptance of 10 new member academies, which brings IAP's total membership to 104. The newest members are from Afghanistan, Germany, Kosovo, Lebanon, Mauritius, Montenegro, Mozambique, Nicaragua, South Korea and Sudan.
- The approval of IAP's revised statutes and second strategic plan for 2010-2012. The plan sets out three overall objectives: to position IAP as a widely recognized provider of high quality, independent global science advice to governments and international organizations; to support major programmes on scientific capacity building, science education and science communication; and to assume a lead role in efforts to improve the effectiveness and impact of international cooperation in science. (The complete text of the statutes and strategic plan may be reviewed at *www.interacademies.net*).
- The announcement that Albert Koers will become the interim director of IAP on 15 April. A lawyer by training, Koers previously served as the executive director of the InterAcademy Council (IAC) in Amsterdam. He has also worked as a consultant to IAP, helping to draft the organization's statutes, rules of procedure and two strategic plans.
- The approval of a communiqué on biodiversity,

SCIENCE AND DIPLOMACY

"The essence of scientific progress is not just transformational but disruptive – the focus is on great inventions and scientific breakthroughs," says David Miliband, UK foreign secretary, who spoke at the plenary session of the IAP conference on biodiversity.

"Conversely, the essence of diplomacy is to maintain order."

Miliband also noted that the world of international relations is experiencing a revolution that could be likened in its impact to the revolution in global science when quantum mechanics replaced Newtonian physics as the organizing framework for scientific thought. International relations, he claimed, "is experiencing its own quantum shift".

Diplomacy, Miliband observed, "has long been premised on the idea of a 'balance of power'. It was a world in which the international system tended toward equilibrium and self-correction as states sought to balance each other's economic and military strengths" in ways that seemed to follow the principles that framed Newtonian mechanics.

In contrast, "a defining feature of our world today is the tendency toward uncertainty, mirroring the world of quantum mechanics." Miliband pointed to the complex feedbacks that are driving climate change and the asymmetric tactics of terrorist organizations. Both are fuelling chronic uncertainty and instability across the globe in dramatically different ways.

In contrast to the world of diplomacy in the 19th and 20th centuries, which was dominated by nation-states, Miliband noted that international relations today involves many players, including nongovernmental organizations, multinational corporations, and the media and social networking sites, all of which "constrain and shape the preferences and actions of states". He suggested that this shift was akin "to the move from Newtonian mechanics, predicated on globes in orbit around each other, to the world of quantum mechanics that sees a more subtle and complex interplay of different forces".

This prompted Miliband to cite another emerging feature of international relations in the 21st century: interdependence. This trend in diplomatic affairs, he said, also resembles the "shift from Newtonian science, modelled on discrete independent systems, to quantum mechanics, which accepts that everything is interconnected".

[CONTINUED NEXT PAGE]

At a time of dramatic change, Miliband maintained that the world of diplomacy needs the world of science to help it address critical global issues.

"Scientific progress", he contended, "can achieve breakthroughs that diplomacy cannot match", whether the issue is commercially viable carbon capture and storage systems designed to mitigate climate change, or the genetic improvement of crops to alleviate hunger.

Science, he also observed, "can help forge consensus where there is political division". He cited, as examples, the historic role of science in helping to create the verification regimes, which made nuclear arms agreements possible during the Cold War, and the creation of CERN in the 1950s, which helped to build bridges between European nations following World War II. Miliband suggested that science could help "break down barriers of the 21st century, particularly those between Western and Muslim-majority countries".

In addition, Miliband noted that science has the power to "shift debates and catalyze political action". Such shifts, he said, will be needed if we are to successfully address global issues like climate change and biodiversity loss. In particular, scientific collaboration will be essential to better understand the risks and solutions related to the coming age of resource scarcity. "Mobilizing action and preventing new tensions from arising" will depend in part on these efforts.

But having science support diplomacy is only one side of the equation, noted Miliband. On the other side, diplomacy can – and should – support science. This is true not only in the financing of large scientific projects that are too expensive for any one nation to fund. The Human Genome Project, the International Thermonuclear Experimental Reactor and the Large Hadron Collider represent large-scale, multi-billion dollar projects that require international collaboration and financing. On a smaller scale, diplomacy also plays a crucial role in the exchange of scientists and the profusion of ideas through visa regulations and intellectual property rights agreements.

All of this means that "politics and science need to come closer together – not for politics to smother science, but instead to be informed by its potential". ■

which examined science and policy knowledge gaps and presented recommendations for improving the society-policy interface. Plans call for the communiqué to be revised and presented as an IAP statement to the Convention of Biological Diversity at one of its international meetings, scheduled to take place this autumn (see box, p. 15).

The conference was the first international event to take place during the International Year of Biodiversity.

AT THE CONFERENCE

A two-day conference on biodiversity, held prior to the IAP General Assembly, examined a broad range of issues related to the protection and sustainable use of the world's natural resources. More than 200 scientists from around the world were in attendance. The conference, subtitled "integrating ecosystem services into biodiversity management", was the first international event to take place during the UN-designated International Year of Biodiversity, a year-long examination of this critical issue that will culminate with a special high-level meeting at the UN headquarters in New York City in September during the UN's General Assembly. The September meeting will be followed closely by the Nagoya Biodiversity Summit in Japan, to be held in October, where member states will seek to adopt a new strategic plan for implementing the UN Convention on Biological Diversity.

Highlights at the IAP conference on biodiversity included:

- A keynote address by David Miliband, the UK foreign secretary, who spoke enthusiastically about the need for the scientific and policy communities to work more closely together to meet the daunting challenges of the 21st century, which he cautioned could be an era marked by resource scarcity. "Politics and science", he said, must join forces, "not for politics to smother science, but instead to be informed by its

BIODIVERSITY COMMUNIQUÉ

At the conclusion of the IAP General Assembly, the members unanimously agreed to a communiqué that outlined the conclusions of the conference and offered a broad outline of the issues that were discussed. Excerpts follow.

'Biodiversity' is the term used to describe the variety of life, at all levels from genes to species and to ecosystems, and is valued by people and cultures for reasons ranging from the aesthetic to the economic.

Biodiversity is being lost at increasing rates, largely as a result of human activities. Loss of biodiversity threatens the ecosystems that play a central role in supporting vital Earth systems upon which humanity depends. Ecosystem services are the benefits people obtain from ecosystems through provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual and recreational benefits; and supporting services such as nutrient cycling. Every person in every country depends on these ecosystem services and the biodiversity that underpins them; these links are most direct for the poorest and most vulnerable peoples.

The loss of biodiversity has many consequences beyond the loss of species. A reduction in the diversity of life affects many who value nature for its own sake, but the loss of biodiversity may also have serious and hard-to-reverse direct impacts on human well-being. When biodiversity is depleted it can lead to significant ecosystem degradation, reduced productivity and lower resilience.

Increasingly, society is concerned about food and energy security, and the ability of natural and managed ecosystems to respond to environmental change. Biodiversity underpins many key ecosystem functions, including their ability to adapt to change, although the details are often not well understood. The increasing rate of global biodiversity loss necessitates prioritizing research and policy interventions that will identify and protect ecosystem function and the biodiversity on which it depends.

For the complete text of the communiqué, including a list of recommendations for policy-makers and scientists, see www.interacademies.net.



GIVING NATURE'S CAPITAL ITS DUE

"We have consistently underestimated – in fact, virtually ignored – the value of natural resources when assessing the economic wealth of nations," said Partha Dasgupta (TWAS Fellow 2001), speaking at the IAP conference on biodiversity. Dasgupta is a professor of economics at the University of Cambridge and the Sustainable Consumption Institute at the University of Manchester, UK.

A key problem, he noted, is that "we continue to rely on indicators that not only overestimate the level of a nation's economic well-being, but also mask its unsustainable use of nature's bounty."

"We have historically measured wealth in terms of manufactured capital (roads, bridges and communications systems), human capital (knowledge and health) and social capital (administrative and legal systems)."

But wealth also depends on natural capital – resource-based ecosystems (for example, forests, fisheries, wetlands and aquifers) that aid in the production of food, fuel and fresh water. Indeed much more than money is at stake. The world's health, livelihoods, social well-being and security all depend on a healthy and productive environment.

Dasgupta, who is one of the world's leading figures in the field of ecological economics, has conducted path-breaking research showing that per capita wealth actually declined in South Asia between 1970 and 2000 even though the Human Development Index recorded a sharp increase in the region's per capita gross domestic product (GDP).

"Markets," Dasgupta asserted, "don't function well – indeed they often don't function at all – for ecological assets." Consequently, he encourages the creation of resource-sensitive "shadow prices" as a way to account for the value of ecological systems.

"We may never get such prices entirely right," he acknowledged, "but we can establish a range of prices" that will more accurately reflect a nation's economic well-being for both current and future generations. He observed that such assessments display a nation's "inclusive wealth," not only because they gauge the value of resources in the production of goods and services, but also because they take into account the needs of future generations.

According to Dasgupta, the two most important policy questions that public officials and economists can ask are these: "How are we doing" and "What should we be doing?" Assessments based on the concept of inclusive wealth, Dasgupta said, transform "these two questions into one" by emphasizing both the significance of sustainable resource use and the ethical responsibility that today's citizens have for the well-being of future generations.

In short, it places human welfare at the centre of a nation's economic development assessments (helping to address the question "how are we doing") and strategies ("what should we be doing"). In the process, it focuses as much attention on the future as it does on the present.

Such "people-first" considerations, Dasgupta maintained, have not carried much weight in more conventional models and strategies for development. For both our sake and the sake of our children, he concluded, it's time that they did. ■

potential“ (see sidebar, ‘Science and Diplomacy’, p. 13).

- The morning session of the conference’s first day focused on a broad range of concepts related to biodiversity lying at the interface of science and policy. Such concepts include natural capital (calculating the economic value of biodiversity and natural resources in ways that would allow such concepts to be incorporated in accounting systems that assess a nation’s wealth); ecosystem services (the broad range of goods and services – for example, the provision of food, safe drinking water and clean air – that depend on healthy and productive natural environments); and the ability to manage international spaces where no single national government has jurisdiction – for example, the oceans, the polar regions and the earth’s atmosphere (see insert, ‘Giving Nature’s Capital Its Due’, p. 16).
- The afternoon session was devoted to a series of case studies that included an overview of ecosystem assessments in southern Africa that have drawn on the path-breaking work of the Millennium Ecosystem Assessment to frame the analysis; a discussion of the ecological challenges confronting the Boreal forests in Canada, which have been placed at risk as a result of expanding efforts to extract oil from the tar sand deposits found beneath the forests; and initiatives to introduce sustainable agricultural and forestry practices in eastern Tanzania in ways that would provide adequate incomes to local populations while leaving a light footprint on the environment. The case-study presentations showed that many of

Natural resources face enormous pressures as global population continues to grow.

the concepts and analytical tools developed by both economists and ecologists at a theoretical level have become common features of resource policies now being devised to manage ecological systems in a sustainable fashion. But the studies also showed that the world's natural resources face enormous pressures as global population continues to grow (it is expected to increase from 6.8 billion people today to more than 9 billion by 2050), and as the demand for food, water, energy and minerals inexorably climbs to meet the expectations of the developing world's rising middle class, a trend that is especially pronounced in such large developing countries as Brazil, China and India.

International treaties require nation-states to share their sovereignty.

MITIGATING NATURAL DISASTERS

The tragic earthquake that struck Haiti in January measured 7.0 on the Richter scale and left at least 150,000 dead. Yet, as horrific as it was, it was by no means an isolated event. Over the past five years, epic natural disasters have struck the United States, Pakistan, Myanmar and China, indicating that once-in-lifetime events of massive death and destruction have become more common than we think.

How can science play a more effective role both in understanding and predicting these events and in devising measures, including the creation of space-based monitoring networks and early warning systems, which will help curb their impact?

These questions first captured the attention of the Inter-Academy Panel on International Issues (IAP) following the tsunami that struck the coast of the Indonesian island of Sumatra in December 2004. The tidal wave, triggered by a deep-ocean earthquake that measured 9.3 on the Richter scale, resulted in 300,000 fatalities.

What happened in Sumatra prompted IAP to launch a major natural disaster mitigation programme in February 2005, less than three months after the event. The activity, led by the Chinese Academy of Sciences, now includes participation from 11 member academies.

Guo Huadong, director general of the Center for Earth Observation and Digital Earth of the Chinese Academy of Sciences, spoke about this IAP programme at the panel's General Assembly.

"IAP's efforts," he noted, "have focused on the role that science and technology can play in addressing critical issues related to the management of natural disasters. Specifically, we have examined the current state of science and technology in understanding and predicting earthquakes, tsunamis and other natural disasters." At times, as Guo explained, his fellow researchers have also offered constructive science-based recommendations to address disaster management issues.

A 2009 IAP report, Natural Disaster Mitigation – A Scientific and Practical Approach*, stated that natural disasters were responsible for nearly two million deaths and economic losses totalling more than USD1 trillion over the past 60 years. The report also showed that certain kinds of disasters have had a greater impact than others. For example, storms and earthquakes have been responsible for more than 90% of the world's disaster-related deaths. The situation is similar when it comes to economic losses. Just four types of disasters – storms, earthquakes, floods and droughts – are responsible for more than 90% of disaster-related economic losses.*

- The conference's second day examined the international treaties and frameworks that have been enacted over the past half-century as part of a broader effort to better manage the world's ecosystems. While a number of instruments have been put in place – including the Law of the Sea, the Ramseur Convention on Wetlands (1971), the Convention on International Trade of Endangered Species (1973), the Conventional on Biological Diversity (1992), and the International Treaty on Plant Genetic Resources for Food and Agriculture (2001) – conference speakers noted that significant gaps, overlaps and ambiguities have undercut their effectiveness. The treaties have been built on good intentions, participants observed, but they have often been compromised by weak implementation. Yet, despite their shortcomings, conference speakers spoke largely in favour of these institutions. They noted that such instruments, which represent a dramatic reform in governance requiring nation-states to share their sovereignty, are among the most important mechanisms we have for dealing with global biodiversity issues, especially in places that are not under the jurisdiction of national governments. The speakers also called for strengthening the conventions' scientific advisory boards and for devising strategies that promote greater collaboration among the international secretariats. They noted such measures could help foster greater harmony among the existing agreements and regulations, helping to make them more effective.
- Several of the discussions on the second day returned full circle to the concepts discussed the previous day. For example, a number of talks exam-

At the same time, natural disasters have not been evenly distributed across the globe. Indeed studies have shown that more than 70% of all natural disasters since 1950 have taken place in Asia. Not surprisingly, more than 70% of the adverse economic impacts have taken place there as well. Overall, 95% of deaths caused by natural disasters have occurred in the developing world.

In its examination of broad trends in the occurrence and impact of natural resource disasters, the IAP report found that, compared to the previous decade, economic losses resulting from storm surges and cyclones doubled during the first five years of this century, totalling some USD275 from 2000 to 2005. The good news is that the number of deaths due to flooding has declined significantly.

Both of these trends, said Guo, "show that human behaviour often plays a part – in fact, a large part – in the impact of a natural disaster." The rising costs of storm surges and cyclones are due, in no small measure, to the dramatic growth in population in coastal areas. At the same time, the declining number of deaths caused by flooding is due, in no small measure, to improvements both in land-use planning and emergency management.

On the science and technology front, Guo noted, the development of more sophisticated earthquake monitoring networks and tsunami early warning systems have improved our ability to respond to pending natural disasters.

At the same time, Guo cautioned, scientific understanding of the mechanisms that spur earthquakes and tsunamis remains inadequate. "Thanks to science we have a much better understanding of the forces that set the conditions for earthquake-caused natural disasters. Yet, we still do not have sufficient knowledge to predict when they will occur. And, as the recent events in Haiti show, not knowing when such disasters will take place can have tragic consequences."

"Emergency response and relief is what is most needed in Haiti in the aftermath of this terrible event," said Guo. Science can help by providing detailed satellite images of the devastation that has taken place, which will undoubtedly serve as an important tool in the relief efforts.

But, as Guo also noted, "science can play an even more prominent role in the future by helping to improve monitoring and detection technologies, and by devising better ways to integrate scientific observations and data to allow us to create better models for forecasting the impacts of the natural disasters that will inevitably take place." ■

ined efforts to introduce "green accounting" for assessing wealth-generation in developing countries. Such initiatives have sought to more accurately weigh the adverse impact of economic development policies that compromise the long-term health of ecosystem services and place resource use on an unsustainable path. Many of these initiatives have also closely examined the links between biodiversity and ecosystem well-being to ethical questions related to equity and poverty alleviation, based on the assumption that the world's poor, especially those living in rural areas, rely almost exclusively on such resources for their survival. Another presentation examined the role that the Reducing Emissions from Deforestation and Forest Degradation in Developing Countries initiative (UN-REDD Programme) could play in efforts to reduce greenhouse gas emissions. The programme calls on wealthy countries to provide payments to resource-rich yet economically poor countries to pursue sustainable development strategies that keep the forest and ecosystems in place. That, in turn, would allow forests to continue to serve as sinks for carbon dioxide and other greenhouse gases. The Intergovernmental Panel on Climate Change (IPCC) estimates that deforestation contributes nearly 20% of the overall greenhouse gases entering the atmosphere – a percentage that exceeds the yearly emissions generated by the transportation sector.

SUSTAINING HOPE

Any one of a host of ecological indicators shows that the health of global resources is in decline. For example, according to the most recent scientific studies and field surveys, the rate of extinction among species worldwide is 1,000 times higher than the fossil record.



Moreover, the projected rate of extinction is on track to be 10 times higher than the current rate.

Unprecedented development, especially in the emerging economies of the developing world's largest and richest countries, is converting large tracts of open space into housing and commercial and industrial sites. Rising levels of consumption, most notably in China and India, are placing additional pressure on global resources and fuelling a dramatic rise in prices for basic commodities, including food. This, in turn, is adversely affecting the world's poorest people, whose dependence on natural resources is most immediate and whose vulnerability to increased global demand for these resources is most acute.

Biodiversity is not simply a resource challenge. It's also a diplomatic challenge.

Yet, it is also true that historical patterns of development and consumption in the developed world have been largely responsible for the loss of biodiversity and the damage that has been done to ecosystem services. For example, on a per capita basis, the United States produces four times more greenhouse gases each year than China.

All of this means that biodiversity and ecological well-being is not simply a resource challenge. It's also a diplomatic challenge of the first order. That makes the International Year of Biodiversity an event of critical importance that extends far beyond the scientific community. As the UN maxim for this yearlong event notes: "Biodiversity is life. Biodiversity is our life."

Over the past several decades, a great deal of work has been done at both the local and regional levels in assessing the state of biodiversity and managing the health of ecosystems. Yet much of this work has yet to reach a scale that makes it truly global in reach and impact. That will be one of the challenges facing researchers who study biodiversity and those involved in the UN International Year of Biodiversity. How can the scope of biodiversity and ecosystem studies be broadened in ways that address the issue on a global scale without compromising the site-specific investigations that supply the details and insights necessary to shed light on these issues? And, more generally, how can the science and economics that have helped us understand this compelling, yet endlessly complex issue, be communicated to a larger public in ways that move the discussion from science conferences and workshops to government offices and communities across the globe.

Successfully addressing such challenges may well determine whether the science that informs our understanding of biodiversity creates a durable foundation of knowledge that allows policy makers and the public to appreciate the scope of the challenges – and that ultimately leads to resource practices that do not place the well-being of future generations and, ultimately, our planet at risk. ■

TRIESTE SCIENCE PRIZE 2009

THE 2009 ERNESTO ILLY TRIESTE SCIENCE PRIZE RECOGNIZED THE OUTSTANDING CONTRIBUTIONS OF TWO SCIENTISTS WHO HAVE DEDICATED THEIR CAREERS TO METHODICALLY MAPPING THE INTRICATE RELATIONSHIPS BETWEEN AGRICULTURE, CLIMATE AND THE ENVIRONMENT, ESPECIALLY IN THE DEVELOPING WORLD.

***Pramod Kumar Aggarwal**, ICAR National Professor at the Indian Agricultural Research Institute in New Delhi, was honoured for his studies on the impacts of climate change on agriculture, especially in India. Aggarwal has used a variety of approaches, including crop simulation models, field experiments and risk analyses, to examine the complex relationship between agriculture and climate.*

***Carlos Clemente Cerri**, Professor at the Centre for Nuclear Energy in Agriculture (CENA) of the University of São Paulo (USP), Brazil, was honoured for conducting research that has broken new ground in detailing the extent of carbon exchange taking place between the soil and atmosphere in the midst of rapid development in the Amazon – investigations with global implications for understanding climate change.*

AGRICULTURE AND CLIMATE CHANGE IN ASIA

"Agriculture provides a livelihood for a large portion of the people in South Asia," says **Pramod Aggarwal**, a region that is home to nearly 22% of the world's population, including 40% of the world's poor. He notes that historically South Asia has suffered from "frequent climatic extremes – leading to widespread droughts, floods, famines and poverty". The region, in fact, suffered major droughts in 1979, 1987, 2002 and 2009. In the past year alone, changing rainfall patterns in Aggarwal's home country of India caused extreme drought followed by extreme flooding.

"Global climate change," he adds, "is likely to compound the problem."

Recent studies show that global climate change in India could lead to crop losses of 10% to 40% by the end of this century due to rising temperatures, more

variable rainfall and declining water supplies for irrigation. Aggarwal observes that "India could lose 4 to 5 million tonnes of wheat with every degree Centigrade rise." Dairy production will also be affected as a result of the stress cattle experience because of rising temperatures. Estimates suggest a loss of 1.5 million tonnes of milk by 2020.

In the light of such troubling scenarios, Aggarwal warns that "producing sufficient food to meet the growing demand in South Asia will be a challenging task".

Different approaches

The potential impact of climate change on agriculture should be viewed from two main perspectives, Aggarwal says. "First, mean changes in temperature and rainfall, and, second, variability in weather", including the weather extremes that India and much of the world has been experiencing lately.

Scientific knowledge and new technologies, particularly biotechnology, may allow us to effectively respond to the challenge posed by weather variability. What is more worrisome, Aggarwal maintains, is the second challenge.

"Weather extremes pose significant threats to food security". This requires a different set of strategies, including improving land and water management, intensifying food production systems, and investing in the country's adaptive capacity.

"In the short term," Aggarwal says "simple adaption strategies – for example changing planting dates and using more drought-resistant plant varieties – should help reduce agricultural losses."

Aggarwal's research suggests that greater climate variability will ultimately require more aggressive mitigation and adaptation measures, including developing new genotypes and devising alternative water management systems to lighten agriculture's footprint on the environment.

Yet, what is simple in theory can be very difficult in practice. Indian farmers, who already struggle to generate profits, will likely be reluctant to adopt new strategies unless economic incentives exist for them to do so.

On the bright side, he says, "we must not forget that, in many developing countries, where climatic extremes are common, farmers have demonstrated the capacity to adapt and survive." Their practices could provide valuable lessons for the future.

Science has an important role to play in meeting these challenges. "Possible strategies to increase adaptive capacity", he maintains, "include developing crop genotypes capable of tolerating adverse climate conditions, developing weather advisory services for farmers, and improving land and water use management policies." In particular, locally relevant research must be strengthened in the most vulnerable regions.

Global climate change in India could lead to crop losses of 10% to 40% by the end of this century.

"Science alone", Aggarwal is careful to point out, "cannot guarantee the livelihoods of millions of vulnerable poor farmers", whose contribution to global warming is negligible. In addition to more research into adaptation and mitigation strategies, "effective responses will require capacity building, regional cooperation and adequate funding." New innovative models of cooperation and partnerships to secure global funds for adaptation research and development will also be needed.

Aggarwal's research has focused on developing crop simulation models.

Simulation models

Aggarwal's research has focused on developing crop simulation models. Such models help researchers devise estimates of future crop yields, taking into account several interrelated factors, including soil conditions, rainfall levels and damages inflicted by crop pests.

Crop simulation models have been used not only to help farmers increase yields, but also to better understand the trade-offs between increased food production and environmental impacts. Responding to rising concerns over global climate change, researchers have also developed simulation models that factor climate change into the analysis.

But few of these models, Aggarwal says, have been capable of "fully integrating data on global change impacts, greenhouse gas (GHG) emissions and soil carbon and nitrogen dynamics". In addition, many have failed to completely factor in growth and yield losses due to insects and diseases.

In 1997, Aggarwal's research group at the Indian Agricultural Research Institute (IARI) responded to the need for more sophisticated models that could take climate change into account by developing a generic dynamic crop simulation model (called InfoCrop) that simulates all major processes of crop growth, soil water, nutrient balance, GHG emissions and crop–pest interactions. To date, the group has trained more than 250 researchers in crop modelling.

"The InfoCrop model", he explains, "simulates the effects of weather, soils, agronomic management (including planting, irrigation and harvesting practices) and major pests on crop growth, yield, and soil carbon, water and nitrogen levels, and the associated environmental impacts". Moreover, it can be used for a variety of applications at field, farm and regional levels.

"Many scientists," he adds, "now use InfoCrop to estimate potential yields and yield gaps". The model takes account of climatic variability, good management practices and potential losses due to disease and pests.

Just as simulation models are more successful when they include as many variables as possible,

PRAMOD AGGARWAL

Aggarwal was born in New Delhi, India, in 1954. A graduate from the University of Delhi, he obtained his PhD in Life Sciences from the University of Indore, India, followed by a second PhD from Wageningen University in the Netherlands.

He was the coordinating lead author for the chapter "Food, Fibre and Forest Products" in the Fourth Assessment Report (2007) of the Intergovernmental Panel on Climate Change (IPPC). He is a fellow of the National Academy of Sciences, India, and of the National Academy of Agricultural Sciences, India.

assessments of land capacity benefit from the same comprehensive approach. In the late 1990s, Aggarwal and his colleagues developed a methodology for assessing the carrying capacity of land (the maximum livestock and/or crops that it can sustainably support) by integrating biophysical factors such as soil, climate and water with such socio-economic factors as land

holdings and commodity prices. In addition to simulation models of various crops and livestock, the methodology relies on field surveys, remote sensing and geographic information systems (GIS), and crop optimization techniques to examine options for sustainable land use that will meet the goals of maximizing food production, employment and income, while not depleting natural resources.

Leading the way

Aggarwal established the IARI crop growth-modelling group in 1988 to study the relationship between increased crop yields and the environment. "Our first project", he recounts, "was to develop a simulation model for various scenarios for wheat growth (called WTGROWS), which performs well for a wide range of subtropical and tropical agro-environments."

From 2004 to 2009, Aggarwal led the Indian Council of Agricultural Research's (ICAR) project to assess the vulnerability of Indian agriculture to climate change, providing much-needed scientific leadership in responding to India's climate change challenge. The national network, the first of its kind in the developing world, brought together 15 institutes to address this crucial issue. It aimed to quantify the sensitivity of crops, forests, livestock and fisheries to global climate change.

"The best way to minimize the adverse impacts of climate change", Aggarwal underlines, "is to develop adaptation strategies. But to do this, we need more research. More research, in turn, requires additional funds".

Effective adaptation measures will not be cheap, he concedes. "But inaction would be more costly. It takes 10 to 20 years to develop and disperse a new crop variety to farmers. The time to act is now."

SOIL AND CLIMATE IN THE AMAZON

Carlos Cerri's career has been dedicated to gauging the effects of agricultural land use on global warming in the tropics. He has paid special attention to the role of soils in carbon emissions in his native Brazil.

Soils are important because they are a natural storehouse for carbons. Twice as much carbon is stored in soils as in vegetation or the atmosphere. "Conventional agricultural practices", Cerri explains, "as well as land use changes, result in degraded soils, reducing their capacity to store carbon."

Cerri's studies on carbon exchange between the soil and atmosphere in the Brazilian Amazon have been especially valuable because of the scale of land development in the region. More than 600,000 square kilometres of tropical forest (an area three times the size of Greece) have been converted to farm and grazing land in the Amazon. This has had significant impacts on the intricate soil–plant–atmosphere system.

Deforestation

Cerri has been a pioneer in quantifying changes in soil carbon stock changes and greenhouse gas (GHG) emissions from soils and vegetation due to the conversion of native forest and savannah to agriculture and animal husbandry in the Brazilian Amazon.

In the early 1990s, his research examined the environmental impact of Amazonian deforestation, with an emphasis on GHG emissions. Cerri and his colleagues calculated the gains and losses of carbon in the soil-plant-atmosphere system using forest and pasture samples of different ages from Brazil's Amazon basin. By treating soil, plants and atmosphere as an integrated system through which water, carbon and other elements pass, soil scientists can obtain a clearer picture of what is going on in each component. Specifically, Cerri's team quantified the biomass of different types of Amazonian tropical forests and the rate of GHG emissions due to slash-and-burn agriculture.

One of Cerri's current research areas is the impact that agricultural expansion has on GHG emissions in the region. The goal is to use the science to develop innovative agricultural technologies capable of mitigating global warming.

"Intensive land use in the Amazon," he says, "has several adverse effects on both the environment and crop production if the right practices are not adopted." Reduction in soil organic matter results in emission of gases (chiefly CO_2) to the atmosphere and ultimately increased global warming. The sustainability of the soil is also affected, since its quality has been altered.

"The consequences," he says, "are erosion, reduction in nutrient availability for plants and lower water retention." This, in turn, reduces crop productivity and, ultimately, the sustainability of the soil-plant-atmosphere system.

Theory to praxis

To help counter such negative trends, Cerri has developed an innovative research methodology and accompanying technology, since adopted by scientists in many parts of the world, to measure the amount of carbon dioxide that is released by ploughed soil and decomposing plant matter.

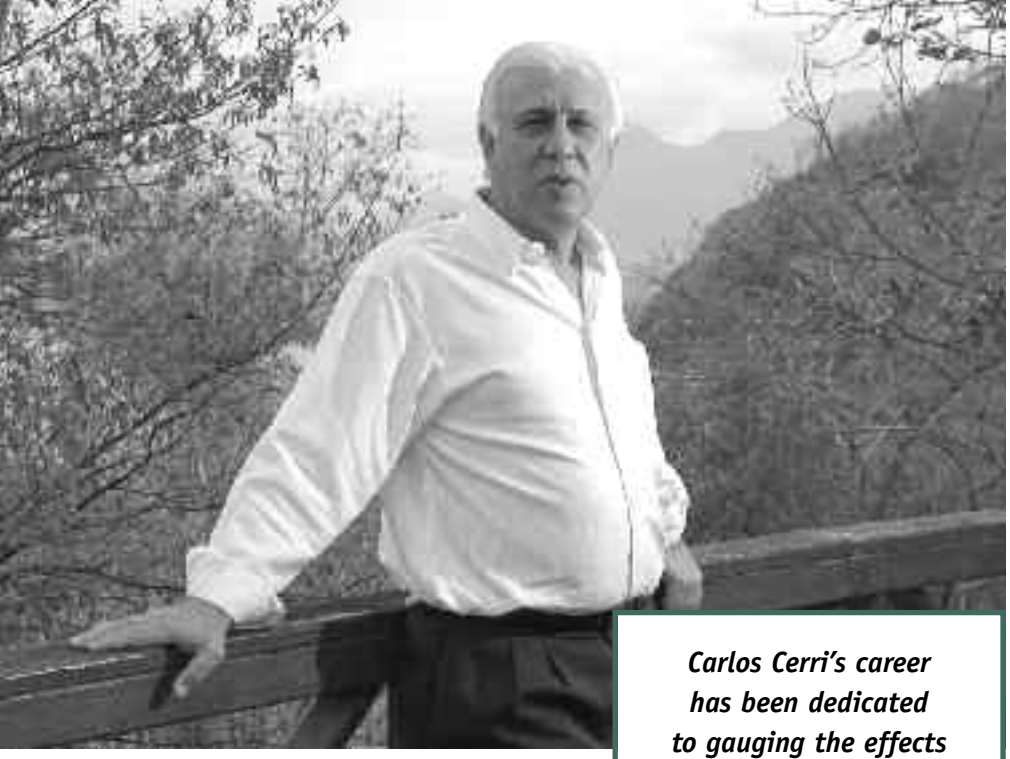
"The adoption of 'best management practices', such as 'no till' farming, where crops are grown without disturbing the soil with tillage", Cerri says, "can partly reverse the process of degradation." Tillage is a key factor, because it breaks down the soil organic matter, releasing stored carbon into the atmosphere

Cerri's studies have shown the effectiveness of such best practices, in particular demonstrating the benefits of zero tillage and minimum tillage farming and of 'no burn' sugar cane harvesting, over conventional methods of tilling and burning – in terms of both reducing GHG emissions and enhancing carbon sequestration in soils.

In addition to improving soil productivity locally, such practices represent a good option for mitigating

ERNESTO ILLY TRIESTE SCIENCE PRIZE

The Ernesto Illy Trieste Science prize, now in its fifth year, is designed to honour the developing world's most eminent scientists who have not yet received other prominent international awards. It is awarded annually and rotates among various fields of science. This year's award honours contributions in the field of climate change and its impact on agriculture in developing countries; the 2010 prize will be for the field of renewable energies for environmentally sustainable industrial technologies. Generously funded by Trieste-based premium coffee producer ***illycaffè****, and awarded under the High Patronage of the Presidency of the Republic of Italy, the prize is named in honour of the late president of* ***illycaffè****, Ernesto Illy. For additional information, see* www.twas.org.



Carlos Cerri's career has been dedicated to gauging the effects of agricultural land use on global warming.

global warming in the region. However, to assess the total gain, he cautions, other gases, "especially nitrous oxide emitted by fertilization, will need to be taken into account".

Not content to do groundbreaking research in this important area, Cerri has also been a leading advocate for the adoption of best agricultural practices as a means of reducing agriculture's impact on global warming.

Estimate, innovate, explore

"I began my scientific career by focusing on soil organic matter dynamics," Cerri says, "in particular characterizing the humus" – the organic component of soil, comprised of decomposing leaves and other plant material and microorganisms – found in different natural ecosystems and land uses in Brazil.

While it may not generate headlines, the information gathered and synthesized in such efforts is invaluable to other scientists. In the same vein, Cerri pioneered estimates of soil microbial biomass (SMB) activity in both native and cultivated soils in Latin America. More recently, he carried out an estimation of total organic carbon in the soils of Brazil.

In the early 1980s, Cerri designed equipment to follow and measure the carbon flux in the soil-plant-atmosphere system, using carbon-14/carbon dioxide ($14C\text{-}CO_2$) as a tracer. With this equipment, he could analyse plant stresses due to increasing CO_2 concentrations and temperatures under low soil water-holding capacity.

Cerri's innovation continued when, in 1985, he developed a method to determine the origin of soil carbon by enabling researchers to quantify how much carbon from the atmosphere has been introduced into the soil via crop residues and how much carbon, in turn, has been emitted from the soil into the atmosphere. Tracing the origin of carbon emissions will help other scientists to find ways of controlling and reducing such emissions.

Cerri has lately turned his attention to examining the carbon footprint of biofuels, such as ethanol. His aim is to help assess the role of biofuels in curbing greenhouse gas emissions.

"Brazilian agriculture has a great opportunity to contribute to mitigating climate change by producing biofuels," Cerri explains. For this to work, however, biofuel production must be "environmentally friendly, so as to maximize the fossil fuel offsets."

"We are currently quantifying the agricultural carbon footprint of biodiesel from oil crops (including soybean, palm oil and castor oil) and of ethanol from sugarcane." The team is also studying the feedback of climate change on agricultural soils. Laboratory experiments and simulation models are being used to quantify the emission of CO_2 and other greenhouse gases to the atmosphere.

Taking stock

At present, Cerri currently coordinates a large research initiative in the Brazilian Amazon: The Global Environment Facility (GEF) Soil Organic Carbon (GEFSOC) Project. The project, designed to assess soil organic carbon stocks and change at national scale, covers 1.2 million square kilometres in Brazil's two most heavily deforested states, Rondonia and Mato Grosso.

Cerri notes that project researchers have developed a "system for estimating soil organic carbon (SOC) stocks and changes under changing land use and climate sce-

Aggarwal and Cerri approach the problem of climate change from the ground up.

narios" by integrating environmental techniques (for example, soil property characterization, geographic information systems, remote sensing, geostatistics, modelling approaches) and associated human dimensions such as those involved in the Human Development Index (for example, life expectancy, literacy rates and living standards).

Project objectives include quantifying carbon sequestration potential in tropical soils; estimating soil carbon stocks; and, ultimately, quantifying the impact of changes in land use on carbon sequestration in soils to improve policies for optimizing resource use. More than 30 research workers and students from Brazil and other countries are participating in the project.

Cerri also coordinates the "Biogeochemical consequences of agricultural intensification in the Amazon basin", a project that is sponsored by the US National Aeronautic and Space Administration (NASA).

CARLOS CLEMENTE CERRI

Cerri earned his master's degree and PhD in soil science and environment in 1974 and 1979, respectively. He has published more than 150 scientific papers in peer-reviewed international journals, written over 30 book chapters and edited 5 books. He teaches graduate courses on agriculture and climate change and has advised more than 40 master's and PhD students from Brazil and abroad.

"One of the best ways to gain a greater appreciation of soil-atmospheric may lie in using space-age technologies that enable us to draw a more comprehensive picture of the changing nature of our soils and the impact that these changes are having not only on the soils themselves but also on atmospheric conditions, including global warming."

SOLVING PROBLEMS

Developing countries are responsible for little of the world's greenhouse gas emissions. Yet, they are disproportionately at risk for the adverse impacts of climate change. Not only do they often lack adaptive capacity to cope with expected climate impacts, the majority are located in the tropical and sub-tropical regions, vulnerable to climate extremes. Moreover, their populations largely depend upon subsistence agriculture, which may be hard hit by changing rainfall patterns, floods and droughts.

Elaborating truly effective strategies will require an underlying scientific knowledge base – of the sort that Cerri and Aggarwal have been building throughout their distinguished careers. In seeking to meet the challenges posed by the interactions between climate and agriculture, both scientists share a commitment to finding solutions that work. Whether applying innovative technology or learning from traditional approaches, measuring carbon exchange between the soil and the atmosphere or estimating crop yields, adopting 'no till' practices or employing sophisticated simulation models, Aggarwal and Cerri approach the problem of climate change from the ground up. The science that they do gives us reason to hope that we might be able to rise to the occasion to address some of the most critical issues of our time. These issues involve the most elemental aspects of Nature's greatest gifts: the air that we breathe and the soil that serves as the basis of our nutrition and health. ■

LIDIA BRITO WAS NAMED THE HEAD OF UNESCO'S SCIENCE POLICY DIVISION IN OCTOBER 2009 AND BEGAN HER NEW JOB IN DECEMBER. SHE SUCCEEDS MUSTAFA EL TAYEB, WHO HAD HEADED THE DIVISION SINCE 1996.

Brito has extensive experience in a broad range of areas that includes scholarly research, university teaching and administration, and public policy management at the highest levels of government. Her areas of expertise include higher education, science, technology and innovation, and information and communications technologies for development.

She received her undergraduate degree in forestry engineering from Eduardo Mondiane University in Mozambique and MA and PhD degrees in forestry science from Colorado State University in the United States. After working as a professor of forestry at Eduardo Mondlane University, she was named the university's deputy vice chancellor in 1998.

SCIENCE POLICY IN UNESCO

In 2000, Brito was appointed Mozambique's first Minister of Higher Education, Science and Technology, where she served for five years, helping to develop a national strategy for higher education and a broad framework for helping to link science to sustainable development in Mozambique. After stepping down as minister, she returned to Eduardo Mondlane University.

Brito has also served as an advisor to the mayor of Maputo, Mozambique, for strategic planning and external relations and as a team leader and consultant in major projects in Mozambique for municipal development and the environment. She has been appointed to a number of international boards, including the United Nations University (UNU) Council and the African Forest Forum's Governing Council.

Several weeks after joining UNESCO, Brito met with the editor of the TWAS Newsletter *in her office in Paris to discuss her hopes and expectations for UNESCO's science policy division in the years ahead. Edited excerpts of the interview follow.*

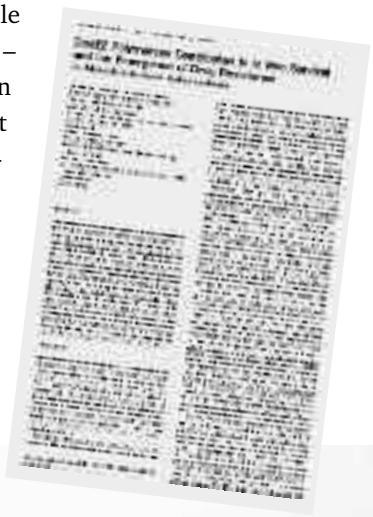
Why did you take the job?

On a personal level, I have been interested in science policy in all of its ramifications throughout my career, and I have been fortunate enough to examine the issue as an academic, an advisor and a government official. So, in a real sense, I have made science policy my life's work. The position at UNESCO offered a wonderful opportunity for me to continue on this path.

In addition to the intellectual challenges that are inherent in such pursuits, I think it is critical to explore – and take advantage of – the critical role that science policy plays within the broader issue of sustainable economic development. I am particularly interested in this issue from the perspectives and needs of poor countries.

Why do I think national science policies are so important to the future well-being of countries, especially developing countries (and, most especially, countries in sub-Saharan Africa), where policy infrastructures are weakest?

The answer is multi-faceted. First, effective national science policies not only set the stage for economic development but also help to foster a vision that is essential for transmitting knowledge and innovative ideas from classrooms and laboratories to industry, commerce, health and other sectors of society. Effective polices are also essential for helping to identify the unique attributes of countries and for aligning strategies and resources with that uniqueness. Without such frameworks, it would be difficult to sustain public interest and investments in long-term development initiatives. Second, effective science policies help to forge valuable connections among nations. That, in turn, encourages international exchange and collaboration that not only spurs development but also promotes greater understanding and respect for other cultures. Third, effective science policies help to set benchmarks that enable experts to measure the progress that a nation is making – or is failing to make – in promoting science-based development. Fourth, effective science policies aid in the creation of blueprints that enhance efficiencies and speed the development process, helping to ensure that funding is well spent and used to improve peoples' lives. And, fifth, effective science policies help to build national confidence, which can spur support for innovation and, perhaps more importantly, enthusiasm for the future. The truth is that while effective science policies proceed through a complex, sometimes bewildering, process that requires endless patience and fortitude, the outcomes emerge in plain sight for all to see. Effective science policies, in short, can help provide a pathway to a better society.



These are some of the key reasons why I think devising effective national science policies are so important, particularly for developing countries.

How did UNESCO help your policy efforts in Mozambique?

UNESCO made a significant difference in my efforts to promote higher education and science-based development in Mozambique during my tenure as minister. My country benefitted from UNESCO's presence and assistance in many ways. For example, we often turned to the organization's existing policy frameworks (which amounted to policy guidebooks) and relied on their indica-

Rosino/Flickr

tors (which amounted to proven evaluation markers) to develop and assess the policies that we put in place. In addition, we took advantage of UNESCO's knowledge networks to learn from the experience of others. My colleagues and I attended numerous UNESCO-sponsored meetings to become as knowledgeable as we could about effective science policy strategies. I can say without qualification that UNESCO was one of my ministry's most important partners.

Now, I am hoping that in my new capacity as head of UNESCO's science policy division, I can help other countries in their efforts to develop effective national science policies by drawing, in part, on my experience as an outsider to strengthen UNESCO's already excellent initiatives. In fact, I view it as my duty to help other countries in the way Mozambique was helped in the past.

What are UNESCO's strengths?

UNESCO, I believe, enjoys several institutional strengths that are unmatched by any other international organization.

First, it serves as an unrivalled source of information on best practices in science policy in the developing world, and also as a source of information on other areas that are interrelated to science policies, such as education, ethics and culture. Much of this information has been assembled in partnership with the countries that UNESCO has assisted. As a result, the information does not consist of reports done at arms' length to the actual challenges, but is comprised of hands-on accounts of government initiatives detailing what has worked and what hasn't. UNESCO has also succeeded in promoting South-South collaboration in science policy through its international workshops and conferences, which serve not only as sources of valuable information but also as wellsprings for networking.

Second, UNESCO, largely as a result of its science policy initiatives, has forged strong ties to governments throughout the developing world. It has also worked closely with nongovernmental organizations, international agencies and, increasingly, the private sector. It has more

UNESCO

than 60 years of experience in convening high-level officials and in fostering dialogue among nations in education, science and culture. These are enviable attributes that should not be underestimated when addressing critical issues in today's contentious world.

Third, UNESCO is a truly multi-disciplinary organization. From its inception, the organization has had the broad, but unique, mandate to promote education, science and culture. In today's world, when so many problems require multi-disciplinary responses, this broad mandate should be viewed as a major strength. That doesn't mean, of course, that UNESCO has the resources to address all of the world's critical problems. But it does mean that when the organization focuses on an issue – whether it is ensuring access to safe drinking water, expanding educational opportunities for all children or preserving natural habitats or cultural sites – it can do so from multiple perspectives and with extensive levels of expertise that are likely to be critical to overcoming complex challenges and advancing key policy objectives.

What I think is most unique about UNESCO, however, is that its activities touch people directly. What UNESCO does – and how it chooses to advance its lofty goals – engages emotions and stirs passions. Few other organizations, especially international organizations, can make such claims. It's a unique attribute that UNESCO should promote even more than it does.

What initiatives do you hope to pursue at UNESCO?

Well, as you know, I am new to the position. So, I would be reluctant to propose any major initiatives at this early date. My first order of business, however, is to do no harm and to ensure that the science policy division's most successful programmes – and there are many – are not neglected and continue to prosper. In short, as a first step, I think it will be important to build upon UNESCO's, and more specifically, the science policy division's strengths.

It's clear that I have a deep interest in science policy and intend to build upon the progress in developing science policy frameworks that UNESCO has helped to achieve, especially among countries in the developing world. I would also like to increase the visibility of the science policy division both within the organization and among UNESCO's member states.

There are, of course, other areas within the science policy division's existing portfolio that I also hope to strengthen and expand. These include efforts to utilize science not only for development but also for diplomacy – that is, to take advantage of scientific exchange to improve

relations among nations. This would fit directly into UNESCO's broad mandate to advance peace. In addition, UNESCO has played a central role in promoting education at all levels, and I would like to work more closely with the education sector to more fully integrate science education into their initiatives, especially in primary and secondary schools. The same is true of issues related to gender and education where much has been done yet much remains to be done, especially when it comes to girls and science education. I would also like the science policy division to devote more time and resources to issues related to the popularization of science and to determine whether there are additional ways in which we can broaden our efforts to strengthen science journalism in developing countries. Again this is an area where much work has been done, yet where additional efforts would be welcome. One of the most important lessons I learned as minister is that public understanding of science and, more specifically, of the central role that science plays in economic development, is essential for success. And, finally, I think it is essential to expand existing strategies for scientific and technological capacity building to encompass initiatives that embrace innovation in a systematic and sustainable way. It is important that the scientific and technological knowledge and skills that are developed within each nation ultimately lead to products and services that benefit people and improve living conditions, especially for poor people. Innovation, especially when it is married to science and technology (as it must be in the 21st century), is a valuable policy device for turning knowledge into concrete action.

I have outlined an ambitious agenda, and I am sure that priorities will have to be established to ensure that the science policy division's goals can be met. That, in fact, will likely be one of the most formidable challenges that I face: to create an agenda that draws on UNESCO's strengths and expands its reach and impact, but which does not become so expansive as to place our objectives at risk. Since we cannot – indeed do not want to – implement this agenda on our own, it will be shaped in large part by the partnerships we forge. Strong partners lead to better outcomes, and it is better outcomes that will ultimately determine the level of our success. Therefore, to a certain extent, our priorities will be influenced by our discussions with others.

At the same time, it is also true that many of UNESCO's core values will also determine how far we will be able to advance our agenda. These values include an uncompromising emphasis on excellence, a willingness to listen to others and engage in dialogue, and a strong ethical compass that fully recognizes the principles inherent in equity, democracy, accountability and transparency. Of course, none of this will be achievable without adequate resources and incentives, sturdy legal frameworks and active networks that enable individuals and institutions to learn from one another.

And that brings me back to the issues surrounding the development of effective science policies. The ultimate goal, I believe, is to create an enduring national system of science *and* innovation that is able to respond to the development challenges of the country, or region, and at the same time to build knowledge bridges with the rest of the world. This system, if it is to be sustainable, cannot be imposed from the outside but must be deeply connected to society. Yet, for many poor countries that have neither the resources nor the experience to create such a system, the question is often where to begin. That's why I believe the work of UNESCO – and its efforts to foster knowledge and networks – is so important.

What kind of relationship do you hope to have with TWAS?

Again this will entail expanding our existing framework for collaboration instead of constructing an entirely new one. That's because the relationship has been both strong and gaining additional strength under my predecessor Mustafa El-Tayeb. TWAS's greatest attributes lie with its networks – both for individual scientists and scientific institutions. These networks represent the best of science in the South and provide extraordinary opportunities for collaboration. My hope is that UNESCO can take even greater advantage of these networks in the future. Because of its global connections, TWAS has played – and can continue to play – a vital role in helping UNESCO to know the main actors in scientific research. The Academy can provide entrée into some of the principal sources of scientific knowledge in the developing world. And it can help us link our experience in science policy with the work of the scientists themselves in ways that can advance our shared agenda of accelerating science-based development throughout the South. I know that UNESCO's science policy division – and, more generally, UNESCO's science sector – have worked closely with TWAS in the past, and I am convinced that our relationship will only grow stronger in the future. I am particularly optimistic about the prospects for collaboration between UNESCO and TWAS through the Consortium for Science, Technology and Innovation in the South (COSTIS), which was officially launched last autumn at the World Science Forum in Budapest and is dedicated to bringing scientists and scientific policy makers together to create an even stronger foundation for science-based development in the developing world. As I mentioned earlier, this is a matter of intense personal interest for me and a primary aspect of the work I will be doing as head of UNESCO's science policy division. So, to my friends and associates at TWAS, I can only say that I look forward to many collaborative activities that will help advance our common agenda and goals. ■

TARGETING TB IN SOUTH AFRICA

SOUTH AFRICAN RESEARCHER VALERIE MIZRAHI (TWAS ASSOCIATE FELLOW 2001) STUDIES THE GENETIC MAKEUP OF THE BACTERIUM THAT CAUSES TUBERCULOSIS (TB). SHE HOPES TO FIND NEW TOOLS FOR THE DIAGNOSIS, TREATMENT AND PREVENTION OF THE DISEASE.

Tuberculosis, once believed nearly eradicated, has undergone a global resurgence in the past two decades, fuelled by the HIV epidemic as well as the emergence of drug-resistant strains. According to the World Health Organization (WHO), the air-borne disease was responsible for the deaths of more than 1.7 million people in 2007, with more than 1.3 million new TB cases reported. Moreover, WHO estimates fully one-third of the world's population (more than 2 billion people) are infected with the TB bacilli. The risk is that, for individuals with compromised immune systems (such as those with HIV), these latent bacteria will reawaken into active TB.

The good news, Valerie Mizrahi says, is that "recent advances in genomics and the molecular biosciences" are allowing researchers to investigate the biology of the TB bacillus at "a level previously unimaginable."

Mizrahi, director of the Molecular Mycobacteriology Research Unit (MMRU), in Johannesburg, South Africa, is investigating the genetic secrets of *Mycobacterium tuberculosis*, the bacillus that causes TB, so that new drugs and vaccines can be developed. Her lab examines the mechanisms of DNA metabolism (including how TB cells repair and replicate themselves) involved in the evolution of drug-resistant strains of TB and in the pathogen's ability to resuscitate from a dormant state.

DRUG RESISTANCE

A major factor in the resurgence of TB – and one particularly worrisome to public health officials – has been the emergence of multi-drug-resistant strains. To help control the spread of the disease, scientists need to better understand how *M. tuberculosis* acquires such resistance. In 2003, research by Mizrahi and Helena Boshoff, "an outstanding postdoctoral fellow" in Mizrahi's lab, revealed how mutations in the TB bacillus led to drug-resistant strains.

"As far as we know," Mizrahi explains, "all drug resistance in *M. tuberculosis* is mediated by chromosomal mutagenesis – *i.e.* by mutations in genes that are in some way linked to drug action."

"It is now understood", she continues, "that when *M. tuberculosis* infects its human host, the pathogen's DNA is significantly damaged." The adverse conditions it encounters include attacks by the host's immune system. In scientific terms, the pathogen undergoes "genotoxic stress", in which "lesions are produced in the chromosome that must be repaired for it to survive."

In many bacteria, such genotoxic stress triggers mechanisms that help the organism tolerate the damage until it can be repaired. These involve specialized "DNA-copying" enzymes that allow the lesion to be bypassed during replication of the chromosome. This, in turn, allows the pathogen to survive.

However, Mizrahi and her colleagues discovered that the enzymes that do this work in *M. tuberculosis* "copy the DNA in an error-prone way that introduces mutations". Most of these mutations are harmful to the pathogen. But some are beneficial, enabling it to deal with stress – or to resist antibiotics.

Boshoff, working first with Mizrahi and subsequently with US researcher Clifton E. Barry III (in his laboratory at the US National Institutes of Health), identified the specific enzyme that, when responding to chromosomal damage in the bacillus, "copies DNA in a sloppy manner", leaving drug-resistant mutations in its wake. The findings of Mizrahi, Boshoff and Barry – published in the journal *Cell* – were hailed as a significant breakthrough.

Mizrahi's lab is also investigating "the molecular mechanisms underlying the ability of *M. tuberculosis* to resuscitate from a state of dormancy". By constructing a "panel of mutant strains of the bacillus that lack genes implicated in resuscitation from dormancy in other bacteria", MMRU members Bavesh Kana and Bhavna Gordhan have "produced an important resource for investigating the phenomenon of TB resuscitation."

A FORMIDABLE PATHOGEN

The global resurgence of TB has been chiefly driven by the HIV epidemic. "Immune deficiency", Mizrahi explains, "severely compromises an individual's ability to control TB infection". The result is an increased incidence of TB in the population. The "lethal synergy between TB and HIV" can be seen, she says, in the large percentage of TB cases in many sub-Saharan countries – "the global epicentre of dual infection" – which coincide with HIV infection. Indeed, nearly one-half of TB cases in South Africa are in HIV positive individuals.

The evolution and spread of strains of *M. tuberculosis* that are resistant to first- and second-line TB drugs has compounded the problem. A main cause of drug resistance, Mizrahi says, is patients failing to adhere to

their complicated and lengthy treatment regimen, which involves taking four drugs for two months, then two of the drugs for four more months.

"The TB bacillus is an absolutely formidable pathogen that is exquisitely adapted to life in its human host," Mizrahi says. While an estimated 2 billion people worldwide are infected with *M. tuberculosis,* most are able to control the infection effectively. Yet, she continues, "reactivation can occur many decades after a person has been infected. In other words, the bacteria are able to lurk for many years in an individual without causing illness, only to 'reawaken' at some point in the future."

MUCH TO LEARN

Little is known about the physiological state of TB bacilli during 'asymptomatic' latent TB infection, Mizrahi notes. "Are the bacilli 'dormant' in the real sense of the word, or are they replicating, albeit slowly? We don't know."

"Until we are better able to understand this state and find ways to kill the bacilli in latently infected individuals," she says, "TB will remain a problem as it continues to arise within the massive reservoir of latently infected people in the world today."

MMRU AND SOUTH AFRICA

The Molecular Mycobacteriology Research Unit (MMRU) was established in 2000 with the mission to "develop and apply genetic tools to identify, validate and characterize novel drug targets and vaccine candidates for TB." The research unit is jointly funded by the Medical Research Council of South Africa (MRC), the National Health Laboratory Service (NHLS) and the University of the Witwatersrand (WITS).

South Africa is in a unique position, Mizrahi notes, because it is both a "high-burden country" and "an African country with a well-established scientific, technical and medical infrastructure". This, she explains, "places a particular responsibility on the country to contribute significantly to global research efforts that are aimed at developing new tools for controlling TB."

The situation in the country is particularly troubling because of the high incidence of both HIV and TB. "South Africa has the highest annual incidence and prevalence of TB in the world," she explains. ('Prevalence' refers to the number of current cases per population; 'incidence', to the number of new cases.) "With only 0.7% of the world's population," she continues, "South Africa has an astonishing 28% of the

Nearly one-half of tuberculosis cases in South Africa are in HIV positive individuals.

M. Shoul/WHO/STB/Colors Magazine

global number of HIV+TB cases, and 33% of such cases in the African Region."

As elsewhere, the TB crisis in sub-Saharan Africa has been worsened by the emergence and spread of multi-drug resistant (MDR) and extensively drug resistant (XDR) strains. MDR-TB does not respond to standard first-line drugs; XDR-TB occurs when resistance to second-line drugs develops on top of MDR-TB. "South Africa", she adds, "ranks fourth in the world for MDR-TB cases."

Given such worrisome figures, Mizrahi says, "the urgency of the need for new and improved tools for the diagnosis, treatment and prevention of TB cannot be over-stated."

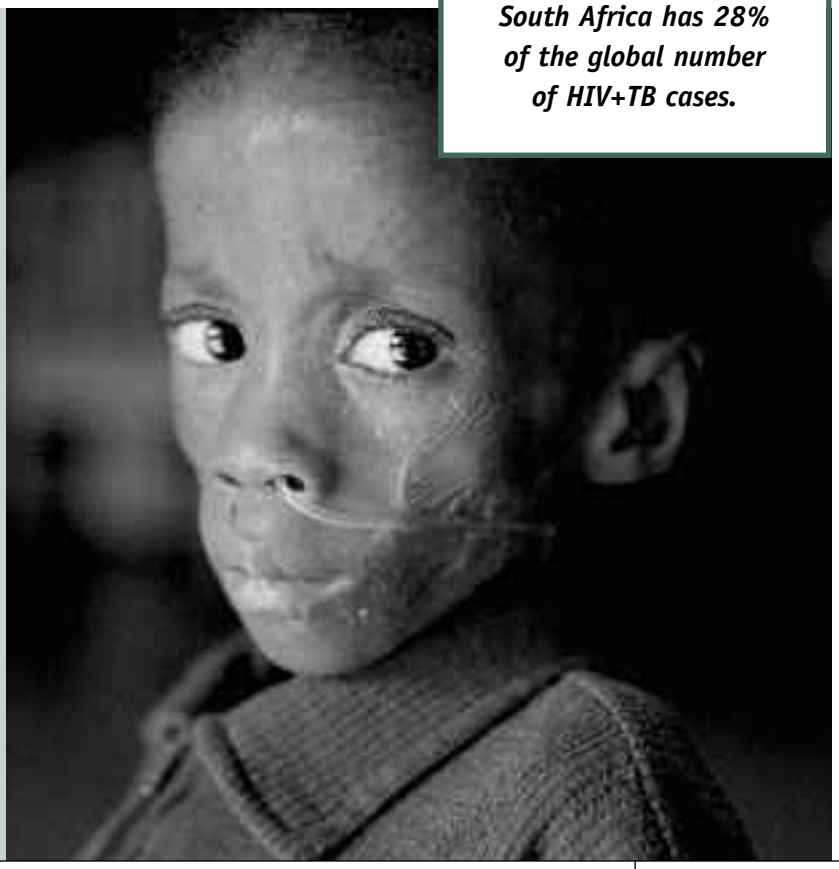
INSPIRATIONAL FIGURES

Born in Harare, Zimbabwe, in 1958, Valerie Mizrahi earned her PhD in chemistry at the University of Cape Town, South Africa, in 1983. She then went to the United States for postdoctoral work at Pennsylvania State University, where she remained until 1986. After a stint with the pharmaceutical giant SmithKline French Research & Development, she returned to South Africa in 1989.

Realizing upon her return that it would be difficult to stay competitive in the field in which she had been working in the US, she began looking for new areas of opportunity. "TB research struck me as ideal, for a number of reasons," she says. "First, I wanted to work on a health problem of importance and significance in Africa. Second, the mycobacteriology field seemed wide open and full of promise as a result of exciting developments abroad."

Mizrahi decided to visit two scientists who "were blazing new trails in TB research" – Stewart Cole, then at the Pasteur Institute in Paris, and William R. Jacobs, Jr., at the Albert Einstein College of Medicine in New York, a pioneer in mycobacterial genetics. Meeting these inspirational figures and learning about the work they were doing convinced her that she should go into the field.

With only 0.7% of the world's population, South Africa has 28% of the global number of HIV+TB cases.



M. Shoul/WHO/STB/Colors Magazine

In addition to her role as director of the MMRU, Mizrahi is a research professor at the University of the Witwatersrand's Medical School and co-director of the Centre of Excellence for Biomedical TB Research of the Department of Science and Technology (DST) and National Research Foundation of South Africa.

She has received numerous recognitions for her research work, including the 2000 UNESCO-L'Oréal 'For Women in Science' prize for Africa, the 2006 DST Distinguished Woman Scientist Award, and the 2006 Gold Medal of the South African Society for Biochemistry & Molecular Biology. She is a two-time recipient (in 2000 and 2005) of an International Research Scholar grant from the Howard Hughes Medical Institute (USA) – the only South African and one of only three scientists from Africa to have received this grant, and she is

WHO/STB/Colors Magazine/M. Shoul

a Fellow of the Royal Society of South Africa and member of the Academy of Science of South Africa.

DISEASE OF POVERTY

A main goal of Mizrahi's laboratory is to identify possible new vaccine candidates and drug targets. "A drug target", she explains, "is an enzyme that performs some function that is essential for the growth of the pathogen." Identifying novel drug targets in turn paves the way for developing novel TB drugs.

"In the case of TB, we know that about 600 of the 4,000-odd genes in the genome of *M. tuberculosis* are required for its growth." To be a valid drug target, an enzyme must be able to be acted upon in two ways. First, the enzyme's function must be able to be inhibited by an antibiotic. Second, "the step in the biochemical pathway that is catalysed by the enzyme must also be amenable and vulnerable to chemical inhibition".

Mizrahi is "reasonably optimistic" about the prospects of progressively reducing TB as a threat. "My optimism", she says, "stems from the fact that major scientific advances of the past 15 years have transformed the way scientists are researching the development of new tools for the diagnosis, treatment and prevention of TB."

Yet, tempering her optimism is the fact that "TB is a disease of poverty that preys on the socially disadvantaged. Until such time as the most vulnerable members of our society can enjoy a better quality of life, this disease will, unfortunately, continue to flourish."

Indeed, the vast majority of TB deaths are in the developing world, with Asia and Africa being the hardest hit. Africa alone accounts for more than a quarter of the global TB burden, with an estimated 2.4 million TB cases and 540,000 TB deaths annually.

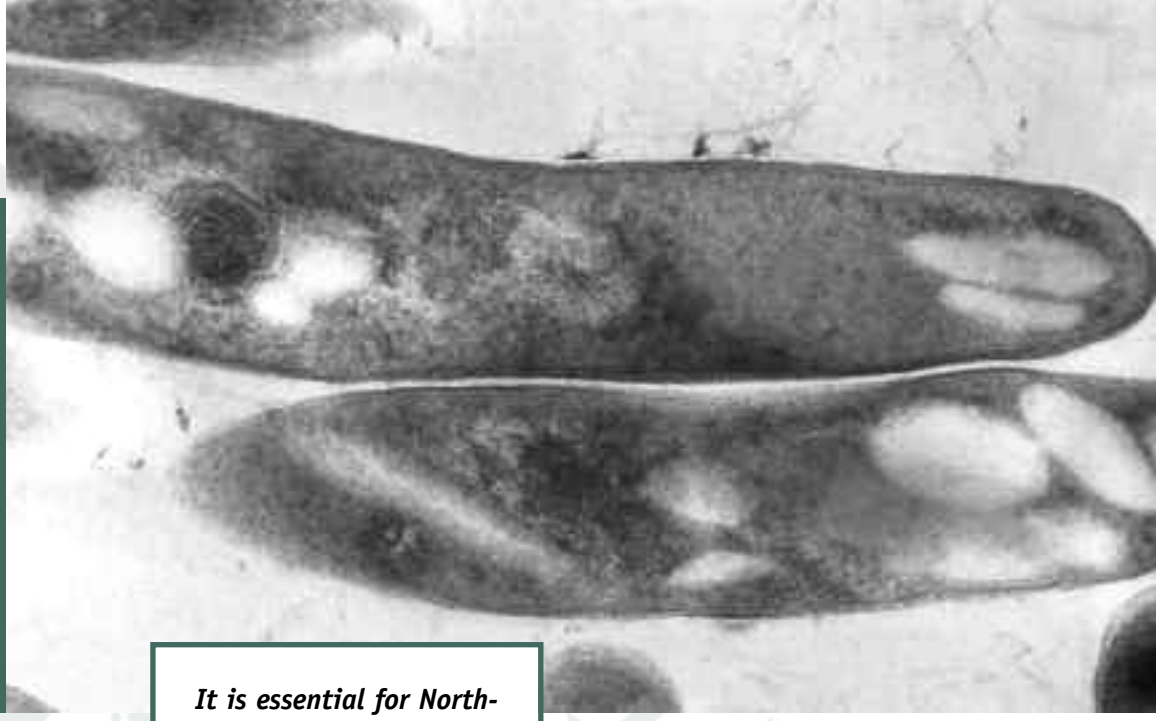
As a scientist, Mizrahi finds "it very humbling to work in the field of TB research because although science is absolutely necessary, it is not sufficient to tackle a problem of the magnitude of TB."

SCIENCE IN SOUTH AFRICA

The situation for researchers in South Africa, Mizrahi says "is significantly better today than 10 or 20 years ago. Improvements, she explains, "have come from the opening up of the science system from an inward-looking system focused primarily on ensuring military supremacy and economic self-sufficiency in the apartheid era, to an outward-looking vision" in which the country "takes its place as a fully-fledged member of the international scientific community."

The first democratic elections in 1994, she adds, brought "unparalleled opportunities for South African scientists in terms of funding and collaboration (largely North-South, but more recently, South-South as well)."

"Science has been quite prominent in the national agenda", she says. Additional funding has been used to create national centres of excellence in S&T and to support a research chairs initiative. Such schemes



It is essential for North-South collaborations to be structured as true partnerships.

"have been helpful, but they must be sustained and further developed if they are to have a long-term impact."

A greater challenge will be to continue to overcome long-entrenched inequalities. "One of the major problems that continues to plague the system", she says, "stems from the generally poor quality of primary and secondary education in South Africa – undoubtedly, one of the most pernicious legacies of apartheid."

Other problems – such as the aging and deteriorating infrastructure of its universities – are not unique to South Africa. Money for basic equipment remains scarce, and as a result it is increasingly difficult to remain internationally competitive.

As elsewhere, science is not seen as an attractive career in South Africa, Mizrahi adds. "High school graduates who are talented in mathematics and science are drawn to more lucrative careers in medicine and engineering, for example." This leaves a very small pool of students interested in careers in scientific research.

COOPERATION IS KEY

Mizrahi emphasizes that organizations like TWAS play an important role in helping South Africa and other developing countries to build their science base, particularly by encouraging both South-South and North-South cooperation, which she says "are absolutely crucial".

"North-South cooperation has created opportunities for funding and exchanges on a scale that was previously unimaginable," she adds. Her own experience has shown that involving graduate students and post-docs in North-South collaboration "helps ensure that the pace and standard of our work is internationally competitive."

Mizrahi has been involved in a number of international training initiatives that have provided opportunities for students from southern Africa to train in top labs in the USA. This, she says, "does wonders for confidence-building among students who have been raised in a geographically and scientifically isolated part of the world and fosters a real sense of belonging to the global research enterprise."

Yet, to be most effective, she stresses, "it is essential for North-South collaboration to be structured as true partnerships." Otherwise, "imbalances in power, influence and resource undermine the role and contributions of partners from the South". Such imbalances, she says, are problematical and can be damaging in the long run.

"My dream is to see the centre of gravity for research in certain areas – infectious diseases, for example – shift to the South." Yet, she admits that the only way that this will happen is for strong centres in the South "to take responsibility for setting and managing the research agenda." She says she understands this will take some time, but that "some of the signs I see are encouraging". ■

LESSONS IN LEARNING

BUILDING CAPACITY IN THE BASIC SCIENCES IS CRITICAL TO THE FUTURE SUCCESS OF AFRICA, SAYS PHILLIP A. GRIFFITHS (TWAS ASSOCIATE FELLOW 2000), PROFESSOR OF MATHEMATICS AND FORMER DIRECTOR OF THE INSTITUTE FOR ADVANCED STUDY IN PRINCETON, NEW JERSEY, USA. GRIFFITHS ALSO CHAIRS THE SCIENCE INITIATIVE GROUP (SIG), AN INTERNATIONAL TEAM OF SCIENTIFIC LEADERS AND ADVOCATES DEDICATED TO FOSTERING SCIENCE IN DEVELOPING COUNTRIES.

G. Gordon/UNESCO

"The deeper we seek, the more is our wonder excited."

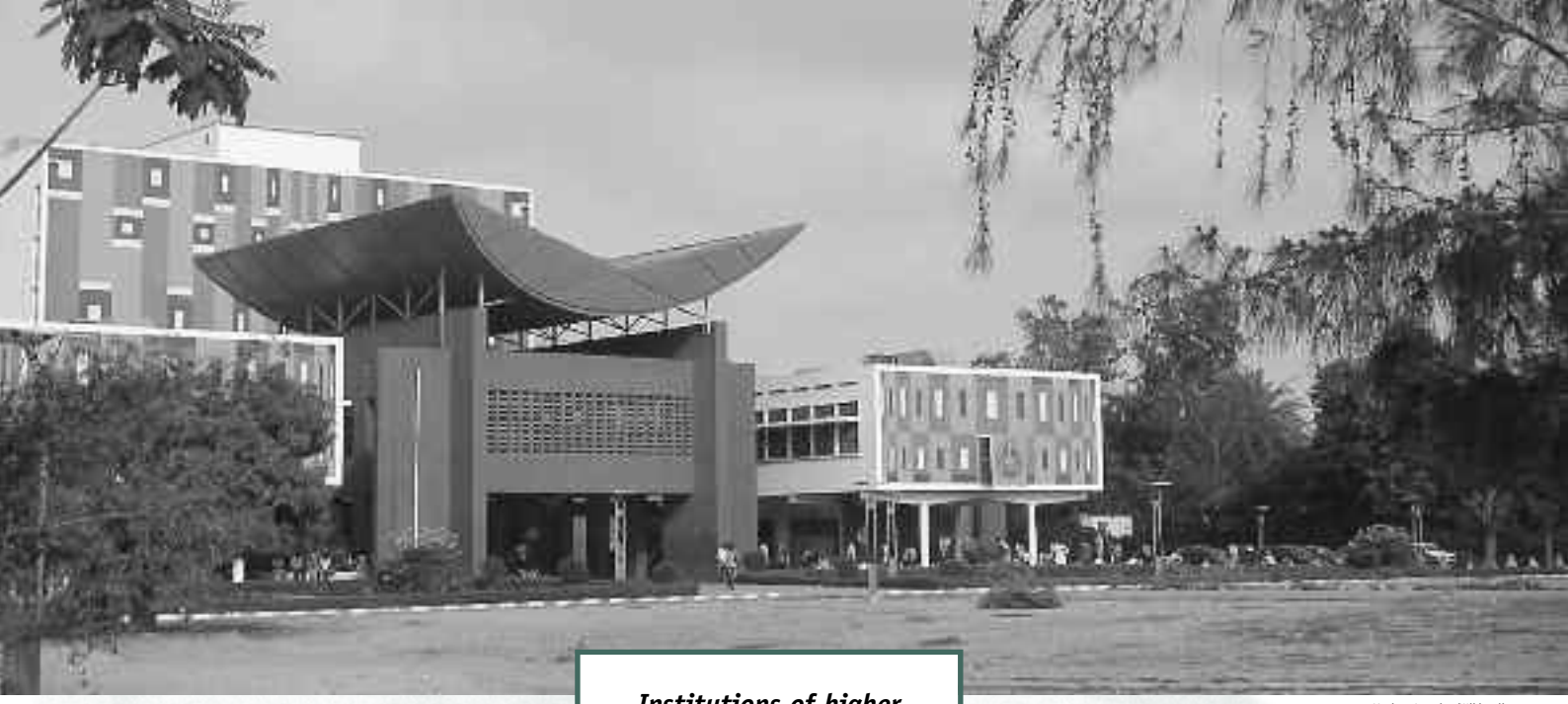
Abdus Salam, Nobel Prize acceptance speech, 1979

Abdus Salam was a brilliant physicist and a devout Muslim who found harmony between his genius and his faith. He was a visionary who often observed that "scientific thought is the common heritage of mankind" and who fervently believed that each country, even – indeed, especially – the poorest, must develop its own scientific talent.

Salam contended that fundamental scientific inquiry could do more than bring wonder and self-respect to a developing nation. It could also help to drive the economic growth that was so desperately needed.

Salam was far ahead of his time. While a few economists, beginning with Robert Solow in the 1950s, reasoned that knowledge – especially scientific and technical knowledge – was a prerequisite for economic development, major donors and development banks have only recently incorporated this belief into their mandates and missions.

Over a decade ago, the World Bank, in its *World Development Report for 1998,* contended that knowledge is one of the most important "global public goods." A subsequent science and technology (S&T) strategy paper took this notion a step farther, asserting that scientific knowledge produces economic and social benefits. In today's knowledge-based world, it is widely accepted that S&T provides essential underpinnings for



Myriam Louviot/Wikipedia

Institutions of higher education provide the keys to basic research skills.

economic growth as well as the intellectual ground from which to address educational, environmental, health and other critical needs.

LEARN TO EARN

Institutions of higher education provide the keys to basic research skills in ways that can promote sustainable growth.

Yet, universities in developing countries, especially in Africa, are struggling to recover from decades of underfunding, civil unrest and brain drain. According to the *Webometrics Ranking of World Universities*, published twice yearly by the National Research Council of Spain, the highest-ranking university in Africa is the University of Cape Town, at number 349 (out of 4,000 universities included in the survey). The highest-ranking sub-Saharan university, outside South Africa, is Cheikh Anta Diop in Dakar, at number 3,038. Similarly, not a single African university outside of South Africa appears in the *Top 500 Universities* ranking published last year by Shanghai's Jiao Tong University.

A recent survey by the African Network of Scientific and Technological Institutions details the problems faced by these universities. On average, about 40% of the posts in S&T training institutions are vacant largely because of low funding, a poor image of science as a career, losses to HIV/AIDS and brain drain. The International Organization for Migration recently estimated that Africa lost one-third of its professionals to the developed world between 1960 and 1987, and that up to 23,000 academics and 50,000 middle and senior managers leave the continent each year. Only 50% of the staff in S&T training institutions have PhDs. The scarcity or absence of journals, textbooks, equipment and library facilities reduces the ability of staff to do research and publish. In only one of three departments across disciplines does more than one-half of the staff have office computers (in one university, the figure is 2%). More than one-half of all laboratory equipment (much of which is more than 25 years old) cannot be used for modern experimentation.

Specific examples of the challenges faced, which have been provided by the institutions themselves, include the following:

- *Faculty depletion*. At Makerere University, Uganda, the number of faculty positions in August 2007 was 1,796, but only 1,052 of those were filled. At the University of Dar es Salaam, Tanzania, for the first time, teaching positions were being filled in 2007 by staff with only bachelor's degrees. At Kenyatta University, Kenya, of 730 academic staff, only 31 are full professors and 48 are associate professors. At the University of Nairobi, Kenya, graduate students in physics are offered tenure in return for teaching. The same is true at Makerere.
- *Skewed age profiles*. A disproportionate number of lecturers in Africa are approaching retirement age.

At Kenyatta University, 28 of the 31 full professors are more than 50 years of age. At Kyambogo University, Uganda, only 22 of the 417 academic staff have doctorates and nine are past "mandatory" retirement age.

- *Demand for education*. Demand for education in Africa is soaring. So much so that universities cannot keep up with it. According to the *Global Educational Digest*, published by UNESCO, student enrolment in higher education in sub-Saharan Africa increased from 660,000 in 1985 to more than 3.4 million in 2005. This trend exacerbates the lack of professors and forces universities to turn to less experienced lecturers and tutors.
- *Low salaries*. While faculty salaries have improved at some institutions, such as the University of Nairobi, they remain too low to attract and retain new staff at many others. The average salary for full professors in all fields of study at Eduardo Mondlane University in Mozambique is USD1,000 a month.
- *Competition from private universities*. Soaring demand has encouraged the growth of private universities that emphasize such fields as business and accounting. Most private universities offer few or no courses in science or engineering. Those that do draw on staff from public universities whom they attract with higher salaries. For example, except for the director, the 11 members of the mathematics faculty at Eduardo Mondlane University also teach at private institutions. This doubling up on teaching responsibilities further reduces faculty time for research and mentoring. Nigeria has some 30 new private universities. Ghana has six public and 10 private universities, all founded within the past decade.

SYSTEMIC APPROACH

The situation for higher education in Africa might look bleak, but it is far from hopeless. Most institutions recognize the challenges they face, and some have begun to reform their policies. For example, to help address the country's chronic skills shortage, Zambia is considering eliminating the mandatory retirement age of 55 years for faculty in the sciences. The University of Nairobi has doubled faculty salaries twice in the past eight years.

As universities and donor organizations increase efforts to bolster basic higher education, it is important to remember that S&T will not by itself be sufficient to meet Africa's daunting challenges. We have seen how the rapid growth of the 'Asian tigers' in the 1970s and 1980s was not initiated by endemic research strength, but by imported technology. Basic research was emphasized only after a sound technological base had been created. The development of excellent primary and secondary school systems and broad-based training for faculty (often through study abroad) also provided a sturdy foundation upon which to build excellence in the basic sciences.

African leaders recognize that efforts to strengthen national capabilities in S&T depend on a systemic


Kisumu Ndogo/SkyscraperCity

approach. A conference held in Arusha, Tanzania, in May 2008 adopted the slogan "mainstreaming STI into the development process." Conference organizers saw their objective as strengthening not only S&T, but also 'innovation.'

For more than a decade, I have led the Science Initiative Group (SIG) at the Institute for Advanced Study in Princeton, New Jersey, USA. SIG is an international team of leading scientists dedicated to fostering science in developing countries. In seeking to build S&T capacity in developing countries, SIG has carefully examined other development models. Foremost among these are the programmes of TWAS and several originating in northern Europe, especially Sweden's International Science Programme (ISP).

Each of these programmes contains at least four major elements designed to develop systemic, and not just academic, capacity. These elements are local leadership, a national innovation system, government support and extensive networking with other institutions and the international scientific community. The approach focuses not only on the creation of knowledge, but also on fostering an environment in which knowledge is disseminated, used and transformed into new products and services.

Native-born scientists and engineers are best qualified to identify and address urgent national challenges. Governments are best situated to set general priorities, including aspects of S&T. Instead of determining research topics and strategies abroad, successful programmes should depend on national and local leaders for capacity building, education and research.

Science and technology add value to society only if they are part of a 'national innovation system' that increases the ability of a nation's institutions and infrastructure to create and commercialize new products for economic and societal use. Major elements of such a system include the following: human resources fostered by a national commitment to education at all levels; government institutions that sustain basic research, legal structures and physical infrastructure; and an entrepreneurial environment that nurtures small start-up firms, protects intellectual property and promotes the creation of venture capital.

An early goal of such a system, especially for poor countries with underutilized natural resources, is to create more value-added exports. As the private sector gains strength, other aspects of the innovation system will grow in importance. In sub-Saharan Africa, outside South Africa, countries have few small- and medium-sized enterprises, which can only thrive in a supportive environment. It is essential to begin planning for them by developing support mechanisms and laying the groundwork for technology-intensive clusters of academia, government and private enterprise that have proven so powerful for scientifically advanced countries.

Government enthusiasm for S&T-based development is crucial. This includes support at the presidential and ministerial levels, especially at ministries of finance. A significant example is the USD35-million Millennium Science Initiative in scientific research and education funded by the World Bank in Uganda. The priority status given to the programme by President Museveni and the Ministry of Finance provided early momentum to the effort, the primary objectives of which are to develop human resources and infrastructure for research, with complementary attention to university-industry linkages and support services.

Similarly, Rwanda has adopted an ambitious S&T

development programme, thanks largely to the personal involvement of President Kagame. In February 2008, the president addressed the plenary session of the American Association for the Advancement of Science (AAAS) annual meeting in Boston: "I believe in the power of science to transform our societies. But in Rwanda our institutions remain feeble. We have neither a strong private sector for demand, nor institutions to meet that demand. But we do have the will. For seven years we have been laying a sound foundation for S&T. The public sector will play a leading role while other pillars gain strength." Rwanda now spends 1.6% of its gross domestic product (GDP) on S&T and plans to increase this to 5% by 2021.

Other governments in Africa are beginning to display commitment to S&T. At the 2008 Arusha conference, Tanzania's Minister of Science and Technology, Peter Msolla, said his government "is determined to invest in STI" by focusing on research and development, retaining talent at home, and forging partnerships abroad. The responsibility for success, he stated, "lies primarily with national governments."

Science and technology add value to society only if they are part of a 'national innovation system'.

Even the best universities in sub-Saharan Africa lack a critical mass of students and faculty in fields of S&T. While these universities might have the will to build capacity, it will take time and resources to attract and train new students and faculty. A valuable complementary strategy is to link these scientists with related institutions and their peers in Africa and around the world.

The ISP's success, based on more than 45 years of experience, has emphasized long-term support for fellowships, equipment purchases and locally requested fields of study. It has curbed brain drain by the use of a 'sandwich model' that offers 1-year visits to Uppsala, Sweden, as long as the recipient remains affiliated with his or her home institution, where the degree is conferred. Lennart Hasselgren, who initiated ISP's programmes that now include chemistry, mathematics and physics, emphasizes the need for long-term support. ISP, for example, has funded one group for 32 years. Annual grants range from USD10,000 to USD140,000. ISP fellowships have helped to produce 58 doctoral and 246 master's theses, and 328 papers in international journals.

RISE PROGRAMME

Past experience has shown the power of knowledge-sharing.

Such sharing serves as the basis for the RISE programme developed by SIG, funded by the Carnegie Corporation of New York and managed jointly by SIG and the African Academy of Sciences. RISE is built on SIG's earlier experience with the Millennium Science Initiative, funded primarily by the World Bank.

The objective of RISE is to prepare PhD-level scientists and engineers in sub-Saharan Africa through university-based research and training networks. The programme supports five networks, each consists of universities in at least three countries. Each network is expected to grant a minimum of 15 PhD and master's degrees over four to six years.

An international selection committee chose the five networks from among 48 proposals from scientists in 29 countries. Each network will receive approximately USD800,000 over 30 months, with funding likely to continue for an additional three years.

The proposals vividly illustrated how many functional and imaginative African networks already exist in such critical areas as clean drinking water, renewable energy, geophysics, information technology and natural products. The impulse to collaborate is strong, and applicants appear to welcome the opportunity to form partnerships with groups that have complementary skills and expertise.

The networks, selected in fall 2008, are the following:

- African Natural Products Research and Training Network – AFNNET
- African Materials Science and Engineering Network – AMSEN
- Southern African Biochemistry and Informatics for Natural Products Network – SABINA
- Sub-Saharan Africa Water Resources Network – SSAWRN
- Western Indian Ocean Regional Initiative – WIO-RISE

All of the networks have moved ahead with energy and enthusiasm. Many of them enjoyed a head start, guided by past partnership experiences. Our objective is to make the RISE versions even more effective.

For example, in the Western Indian Ocean network on marine sciences, one node is in Mozambique, where participants are eager to get on with the task of modernization after years of ruinous civil war. They are especially keen to add RISE to a web of partnerships they have formed over the years.

According to Antonio Hoguane of Eduardo Mondlane University: "Long before RISE, we belonged to several networks and regional organizations. So the people in the marine sciences know each other and share interests. We have been part of UNESCO's Intergovernmental Oceanographic Commission (IOC) since 1982, and we have partners in Mauritius, Madagascar, Tanzania, the Seychelles, South Africa, and other communities around the western Indian Ocean. One of our RISE graduate students, Avelino Langa, will study geoinformatics under Dubi, focusing on fluid dynamics of coastal structures. We expect that he will develop the skills to advise not only our government, but also the governments of our partners, on coastal erosion and other issues."

Hoguane expressed many advantages of partnerships and networks, especially in sharing resources, instrumentation and people: "None of us can afford to have all the people we need in one country," he said. "Partnerships and networks also avoid duplication and ensure complementarity. They can help build common understandings that allow us to speak with a single voice when negotiating with donors or other organizations. This is critical for us, because other countries don't always understand African issues. For example, their idea of building capacity is to teach us their knowledge. Our problem is not so much a lack of knowledge as a lack of resources, including human resources. We know what we want to do and what we need. What we need are the resources to do it."

There can be no economic advancement without the creation of knowledge.

Likewise, positive benefits are already obvious in the water network, SSAWRN. One scientist who participated in this network was Francis Arimoro, a postdoctoral student who developed an interest in stream biology in his home country of Nigeria.

His primary research interest is to use aquatic insects as indicators of water quality. However, at his home institution, Delta State University in Abraka, his department had virtually no instruments – not even a compound microscope, which is essential to identify small insects.

Papaf Mwenyewe/SkyscraperCity



Support from RISE has given him the opportunity to work in a well-equipped laboratory, at Rhodes University in South Africa, where he is now adapting a stream bio-assessment protocol from an existing local system. He has written four papers on his work – two of them published – as well as a review and book chapter. He looks forward to applying his work at home in Nigeria.

The Southern African Biochemistry and Informatics for Natural Products (SABINA) network has also been built on a foundation of productive partnerships. One of its leaders is Zeno Apostolides, a professor of biochemistry from the University of Pretoria, who for many years has studied the chemistry of tea in partnership with the Tea Research Foundation (TRF) of Central Africa, in Malawi.

One of his collaborators has been Nicholas Mphangwe, a plant breeder at TRF. Producing tea, like other agricultural activities, has become a high-tech enterprise, requiring advanced skills. Mphangwe has an MSc from the University of East Anglia, but his mentor is preparing for retirement and has urged Mphangwe to earn a PhD. Until the advent of RISE, this was impossible financially. Mphangwe is now working in Pretoria with Apostolides and others, learning to identify genetic markers that will allow rapid selection of desirable tea strains.

One gratifying effect of these networks is to link enthusiastic but inexperienced students with senior mentors. For example, in early 2009 a young man named Lloyd Nyemba joined the Centre of Excellence in Strong Materials at the University of the Witwatersrand in Johannesburg, South Africa, as part of the African Materials Science and Engineering Network (AMSEN). A native of Zimbabwe, Nyemba had majored in mechanical engineering but had no opportunity to advance his career. He took a chance and followed his brother and sister to Namibia, where he met Frank

SCIENCE INITIATIVE GROUP

The Science Initiative Group (SIG) is an international team of scientific leaders and advocates dedicated to fostering science in developing countries. Its current projects are as follows:

- *The Carnegie-IAS Regional Initiative in Science and Education (RISE) develops human capacity through science and technology training and research in a regional context in sub-Saharan Africa, enabling individuals to use S&T to contribute to national and regional economic development.*
- *The Millennium Science Initiative (MSI) is an international initiative designed to build capacity in modern science and engineering. Highly adaptable to circumstances, the MSI achieves its mission through a variety of vehicles, among them competitively chosen centres or networks of excellence in scientific research and training.*
- *The Global Science Corps (GSC) will place scientists and engineers ("GSC Fellows") from developed countries at universities and research institutes in developing countries for one-year terms to share expertise and collaborate with local partners.*

For additional information, see sites.ias.edu/sig.

Julien Carnot/Wikipedia

Strengthening universities must be considered just a first step in capacity building.

Kavishe of the University of Namibia, who asked if he might be interested in working on carbon nanotubes in South Africa. Nyemba, who had barely heard of this lively new field, immediately said yes. He began his studies under Lesley Cornish at Wits and has since moved on to other cutting-edge research.

AMSEN has also helped Odilon Ilunga, a refugee from the war-torn Democratic Republic of Congo, who made his way to Namibia after working briefly as an engineer in a copper concentrating facility. His dream of moving ahead in his career was postponed when he was forced to stay in a camp for refugees. Nevertheless, he was able to gather a sufficient amount of materials to study and began to teach science to other refugees. He even started a small metallurgical lab to practice and demonstrate refining technique.

When Ilunga was finally allowed to leave after several years, he was offered a job in the remote copper mining town of Tsumeb, where he advanced rapidly to become co-manager of metallurgy. But he missed the academic and teaching environment he loved. So, in 2008, he journeyed to the University of Namibia. There he found Frank Kavishe, who was setting up the country's first faculty of engineering and needed talented engineers. Ilunga not only qualified for the graduate programme, but was the only metallurgist in Namibia. When the RISE competition was announced shortly after that, the University of Namibia was accepted as part of AMSEN, and Kavishe saw a natural fit. Ilunga would strengthen the network through his interest in purifying Namibian copper, while benefiting from using the advanced equipment at the University of the Witwatersrand, an AMSEN partner.

CHALLENGES AHEAD

The development of the RISE networks, of course, does not come without challenges. One challenge is language. In Mozambique, two of the students eager to work with SSAWRN have a tenuous command of English. One has sought out a tutor at a foreign consulate in Maputo; the other worries that the language barrier will limit his career, despite his determination. And RISE still lacks participants from Francophone countries.

Another problem is that students from institutions with weak infrastructures may not be able to continue their work at the same level when they return home. This is a worry, for example, of Agostinho Vilanculos of Mozambique, who plans to model rainfall in the Zambezi River basin. Although he is using a new technique to model stream flow from satellite cloud data, the Zambezi does not have the weather stations he needs to correlate his mathematical results with actual field conditions. A related problem is that students need 'bridge' support after returning home so that momentum does not flag and they can continue to keep up-to-date on their research and publish.

Some problems are more procedural, but no less troubling. These are caused by bureaucratic barriers that hinder the movement of students between countries, and variations in costs and requirements between institutions and countries. RISE has to strengthen its investment in administration to address these problems.

If there is a common weakness in the networks, it is a lack of access to the private sector and other potential partners outside academia. This is to be expected

in countries where technical skills at all levels have been neglected for many years. That is why the strengthening of universities must be considered as just a first step in capacity building.

In February 2007, the World Bank, which has taken a leadership role in STI capacity building in Africa, held a global forum in Washington, D.C., where many African scientists and development experts spoke about their experiences. Speakers emphasized innovative ways to develop technical and vocational skills, to boost the private sector's capacity to find, adopt and adapt existing technologies that are not being fully utilized, to use these skills and technologies to generate more knowledge-intensive, value-added goods and services, and to build post-primary education and scientific-research systems that contribute in meaningful and measurable ways to the national development strategy. The World Bank held a follow-up Forum in 2009, and is now preparing recommendations for further, more substantive steps in this area.

KNOWLEDGE FIRST

There can be no economic advancement without the creation of knowledge. Yet knowledge becomes economically valuable only when it is disseminated in a useful form. Each country must develop its own endemic capacity if it is to stay at the forefront of modern science, but it must also develop mechanisms for disseminating and using that knowledge to serve its own interests and those of the region as well. These dual objectives must be linked if sub-Saharan Africa is to compete globally.

The success of the RISE networks will rest largely on the determination of African governments. While many institutions and individuals will play essential roles, only governments can build and sustain the foundation of basic science that is needed to anchor and stimulate economic growth and to enrich society.

Once a strong foundation in basic science is in place, sub-Saharan Africa will be ready to take full advantage of its rich mineral resources, maturing political institutions, abundance of native talent and eager-to-help diaspora.

From such a foundation, young Africans will be able to earn degrees in mathematics, physics, chemistry and biology that will help sub-Saharan Africa to assume its rightful place at the table of nations. Young Africans, moreover, will be able to probe the "dazzlement" of science, narrowing the gap between the North and the South, and bringing sub-Saharan Africa closer to Abdus Salam's vision of attaining "a bounty and a grace" for which thanks can be rendered "with a humble heart". ■

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SCIENCE ADVISER

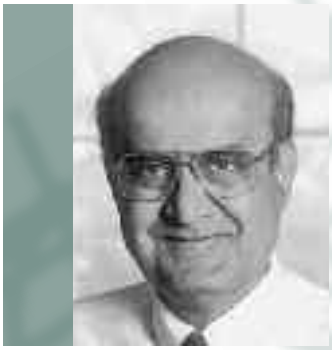
• **Abdul Hamid Zakri** (TWAS Fellow 1996 and Council Member) has been appointed science adviser to the government of Malaysia. As adviser, he will chair the country's Science and Research Council and be responsible for enhancing networking between the Malaysian government and domestic and international science organizations. Zakri directs the Centre for Global Sustainability Studies and holds the Tuanku Chancellor Chair at *Universiti Sains* Malaysia. He also serves as a member of the Arab Fund Fellowship Programme, the Senior Advisory Group on Technical Assistance and Cooperation at the International Atomic Energy Agency (IAEA) and on the executive board

Abdul Hamid Zakri

of the International Council for Science (ICSU). He previously directed the United Nations University's Institute of Advanced Studies (UNU-IAS) and co-chaired the Millennium Ecosystem Assessment.

FOREIGN ASSOCIATE

• **L.K. Doraiswamy** (TWAS Fellow 1997) has been elected a foreign associate to the US National Academy of Engineering. The election recognizes his impact on the field of chemical reaction engineering. Doraiswamy is Anson Marston Distinguished Professor in the Department of Chemical and Biological Engineering, Iowa State University, and former director of the National Chemical Laboratory. His previous honours include the VAVIK Prize for Chemical Science, the Federation of Indian Chambers of Commerce and Industry (FICCI) Award, the Padma Bhushan and Om Prakash Bhasin awards as well as the Richard H. Wilhelm Award from the American Institute of Chemical Engineers. He is a member of the Indian Academy of Science, the Indian National Science Academy and the National Academy of Sciences, India.



L.K. Doraiswamy

RAMKISSOON INDUCTED

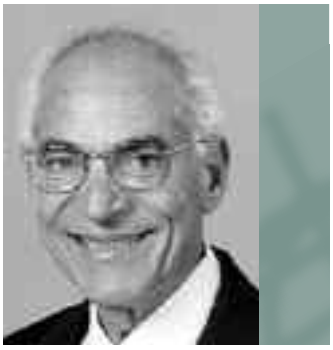
• **Harold Ramkissoon** (TWAS Fellow 2003) was inducted into the European Academy of Sciences and Arts in Salzburg, Austria, in March. He is the first member from the Caribbean and Central America region to receive this honour. Ramkissoon is professor emeritus of the University of the West Indies, Trinidad and Tobago, and executive secretary of CARISCIENCE, a subregional network of scientists dedicated to improving graduate, postgraduate and research and development programmes in the Caribbean. His research work has contributed to the understanding of micro-polar and micro-continuum fluids and Marangoni instabilities, and he has played a pivotal role in the advancement of Caribbean science. Ramkissoon is also a fellow of the Caribbean Academy of Sciences and corresponding member of the Cuban Academy of Sciences and the Venezuelan Academy of Sciences. He was previously awarded the Chaconia Gold Medal,

Harold Ramkissoon

the second highest national award in Trinidad and Tobago, the Academic Gold Medal from Simon Bolivar University in Venezuela and the First Caribbean Community (CARICOM) Science Award.

BOARD OF DIRECTORS

• **Farouk El-Baz** (TWAS Fellow 1985), director of the Center for Remote Sensing and research professor in the Department of Electrical and Computer Engineering at Boston University, has been ap-



Farouk El-Baz

pointed to the board of directors of the US Civilian Research and Development Foundation (CRDF). His appointment was based on his successful "research and teaching accomplishments, his in-depth knowledge of the Middle East, North Africa and the Gulf regions, and his commitment to international cooperation in science and engineering." In addition, El-Baz received the first "World Water Masters Award" from the International Desalination Association in December 2009. The award acknowledges his scientific achievements, provision of water and humanitarian endeavours. El-Baz was recognized for his pioneering work that led to the location of water resources in deserts, especially in the Darfur region of Sudan.

WOMAN SCIENTIST OF THE YEAR

• **Atya Kapley** (TWAS-Chinese Academy of Sciences (CAS) fellowship recipient 2007) was awarded

Atya Kapley

the Woman Scientist of the Year Award from the Biotech Research Society of India in December 2009. The honour recognizes her pioneering work and achievements in the field of environmental biotechnology. Kapley is a scientist in the Environmental Genomics Unit at the National Environmental Engineering Research Institute, Council for Scientific and Industrial Research (CSIR) in Nagpur, India. She received her BSc in botany, zoology and chemistry from Osmania University in 1986, her MSc in biosciences and biotechnology from the University of Roorkee in 1988, and her PhD in life sciences from Hyderabad Central University in 1992. During her TWAS-CAS fellowship, she worked with Min Yang at the Research Center for Eco-Environmental Sciences, State Key Laboratory of Environmental Aquatic Chemistry at the Chinese Academy of Sciences in Beijing, China

HONORARY DOCTORATES

• **Ismail Serageldin** (TWAS Fellow 2001) was awarded two honorary doctorates from Azerbaijan: one from the Azerbaijan Cooperation University and another from the Institute of History of the National Academy of Sciences of Azerbaijan. Serageldin is director of the Library of Alexandria (*Bibliotheca Alexandrina*, BA) and chairs the boards of directors of each BA-affiliated research institute and museum. He also serves as chair and member of many advisory committees, including *Insititut d'Egypte*, the Indian National Academy of Agricultural Sciences and the European Academy of Sciences and Arts.

Ismail Serageldin

C.N.R. Rao

INTERNATIONAL MEDAL

• **C.N.R. Rao** (TWAS Founding Fellow and Past President) was awarded the August-Wilhelm-von-Hofmann Medal for his outstanding contributions in chemistry by the German Chemical Society. This is the first time that an Indian scientist has been awarded the medal, which has gone to Nobel laureates and leaders in chemical research. The medal will be presented at the European Chemical Congress in Nuremberg in August 2010. Rao is national research professor, Linus Pauling research professor and honorary president of the Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore, India. His previous honours include the Hughes Medal of the Royal Society, London, UNESCO's Einstein Gold Medal, an honorary fellowship at St. Catherine's College, University of Oxford, distinguished research professorship at the University of Cambridge and the Khwarizmi International Award from the government of Iran.

WHAT'S TWAS?

TWAS, the academy of sciences for the developing world, is an autonomous international organization that promotes scientific capacity and excellence in the South. Founded as the Third World Academy of Sciences by a group of eminent scientists under the leadership of the late Nobel Laureate Abdus Salam of Pakistan in 1983, TWAS was officially launched in Trieste, Italy, in 1985, by the Secretary General of the United Nations.

TWAS has more than 900 members from 90 countries, 73 of which are developing countries. A 13-member Council is responsible for supervising all Academy affairs. It is assisted in the administration and coordination of programmes by a secretariat, headed by an Executive Director and located on the premises of the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. The United Nations Educational, Scientific and Cultural Organization (UNESCO) is responsible for the administration of TWAS funds and staff. A major portion of TWAS funding is provided by the Italian government.

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 science and scholarship.

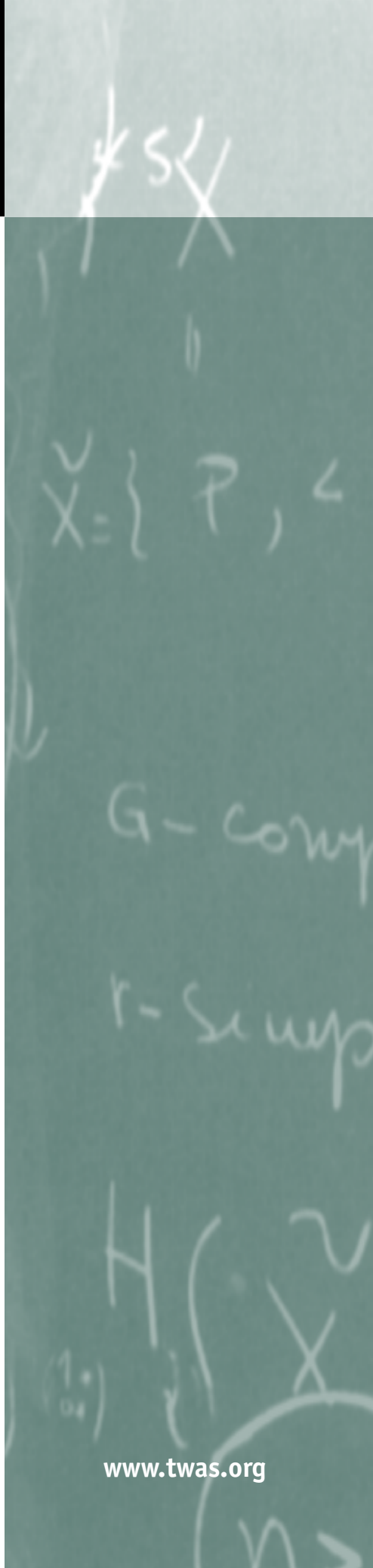
In 1988, TWAS facilitated the establishment of the Third World Network of Scientific Organizations (TWNSO), a non-governmental alliance of some 150 scientific organizations in the South. In September 2006, the foreign ministers of the Group of 77 and China endorsed the transformation of TWNSO into the Consortium on Science, Technology and Innovation for the South (COSTIS). COSTIS's goals are to help build political and scientific leadership in the South and to promote sustainable development through broad-based South-South and South-North partnerships in science and technology. **costis.g77.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 2,500 women scientists from 87 developing 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 100 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**

The secretariat of the InterAcademy Medical Panel (IAMP), a global network of 65 medical academies and medical divisions within science and engineering academies, relocated to Trieste in May 2004 from Washington, DC, USA. IAMP and its member academies are committed to improving health worldwide, especially in developing countries.

www.iamp-online.org



www.twas.org