TWAS 25TH ANNIVERSARY

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KFAS

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THE TWENTY-FIFTH ANNIVERSARY OF TWAS TOOK PLACE ON 10-13 NOVEMBER IN MEXICO CITY. THE EVENT PROVIDED AN OPPORTUNITY FOR THE ACADEMY TO ASSESS BOTH ITS OWN ACCOMPLISHMENTS AND THE PROGRESS THAT HAS BEEN MADE IN BUILDING SCIENTIFIC AND TECHNOLOGICAL CAPACITY IN THE SOUTH.

In the following article, TWAS's executive director, Mohamed H.A. Hassan, examines one of the major challenges now facing science in the South: the growing gap between scientifically proficient and scientifically lagging countries in the developing world.

One World of Science

When TWAS was established, a great divide existed between the science-rich North and the science-poor South. A quarter-century later, advances in biology, materials science, and information and communications technologies, among other fields, have further split the global scientific community into three worlds: the North, the surging South, and the stagnant South. The global community now faces the critical challenge of preventing lagging countries from falling even farther behind.

The United States continues to dominate global science. In 2007, US scientists published nearly 30 percent of the articles appearing in international peer-reviewed scientific journals, which is comparable to the percentage a quarter-century ago. But China, responsible for less than 1 percent of publications in 1983, has recently surpassed the United Kingdom and Japan to become the world's second leading nation in scientific publications. China now accounts for more than 8 percent of the world's total, whereas India and Brazil produce about 2.5 and 2 percent, respectively, of the world's scientific articles.

All told, scientists in developing countries generate about 20 percent of the articles published in peer-reviewed international journals. It is gratifying to see such progress made by the surging South. But we cannot ignore the fact that these advances have been largely limited to just a few countries. The top five performers (China, India, Brazil, Turkey, and Mexico) contribute well over half of the scientific publications from the South. By contrast, sub-Saharan Africa, a region of 48 countries, produces just 1 percent of the world's scientific publications.

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ICTP Campus, Strada Costiera 11
34014 Trieste, Italy
tel: +39 040 2240327
fax: +39 040 224559
e-mail: info@twas.org
website: www.twas.org

EDITOR
Daniel Schaffer

ASSISTANT EDITOR
Tasia Asakawa
Brian Smith

MANAGING EDITOR
Gisela Isten

DESIGN & ART DIRECTION
Sandra Zorzetti, Rado Jagodic
www.studio-link.it

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The building of scientific capacity is a main reason for the South's economic progress. Several developing countries – for example, Brazil, China, India, and even Rwanda – now spend 1 percent or more of their gross domestic product (GDP) on science and technology.

Indeed, over the past 5 years, the economies of the developing world have grown at a faster pace than those in the developed world, and investment in science and technology has a lot to do with it. We see this impact in the emergence of Brazil as a leader in the development of biofuels. We see it in India's increased capacity in information and communications technologies. And we see it in the growing prowess of China in nanoscience and nanotechnology.

Increased scientific capacity is not just good for the developing world; it benefits the entire world. For example, the Chinese SARS Molecular Epidemiology Consortium cooperated with international groups to trace the evolution of the SARS virus from an animal to a human pathogen after the outbreak of 2003. The Southern African Large Telescope (SALT) near Cape Town, South Africa, the largest single telescope in the Southern Hemisphere, has boosted research in astronomy and astrophysics internationally since it became operational in 2005. And innovative efforts to devise sustainable uses for biodiversity by the National Institute of Biodiversity (INBio) in Costa Rica have served as models for institutions in both the South and North for the past two decades.

The point is, in our global world, improved scientific capacity anywhere has the potential to help everyone everywhere. The global scientific community should care about countries that remain scientifically deficient. The progress that has been achieved represents only partial success. Resting on our laurels now will only increase the risk that inequities within the developing world will grow, further marginalizing scientifically lagging countries.

The 25th anniversary of TWAS is an opportunity to applaud the success of those developing countries that are building their scientific capacity. But we must not allow the scientific success of some developing countries to overshadow the troubling scientific stagnation in others.

Enabling global science to truly flourish will require making one world of science. TWAS's ultimate vision – a world in which humanity is dedicated to solving common global problems together – can only be realized when all countries have attained scientific proficiency. ■

Mohamed H. A. Hassan
TWAS Executive Director
Trieste, Italy
mhassan@twas.org

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CELEBRATING SCIENCE

OVER THE PAST QUARTER CENTURY, TWAS HAS EMERGED AS A LEADING INSTITUTION IN INTERNATIONAL SCIENCE AND AS A KEY VOICE FOR SCIENCE IN THE SOUTH. TWAS PRESIDENT JACOB PALIS LOOKS BACK AT THE ACADEMY'S BROAD-RANGING EFFORTS TO FOSTER SCIENCE IN THE DEVELOPING WORLD – AND FORWARD TO THE CHALLENGES THAT LIE AHEAD.

TWAS began with 42 members. Today membership stands at 871. Nearly 85 percent of fellows are from developing countries – a clear sign that scientific capacity in the developing world is growing.

Many factors have propelled this welcome trend, including governments' increasing commitment to invest in science and technology, the rise of new information and communication technologies (ICTs), and better working and living conditions for scientists in the South – all of which have encouraged researchers to pursue their careers at home.

The Academy is proud of the contributions it has made to these advances. It has helped to promote science among both policy-makers and the public and, equally importantly, it has helped to raise the profile of individual scientists in the South.

Election to TWAS confirms a scientist's contributions to his or her field. It also bestows prestige and recognition. The membership process is highly competitive – fewer than 25 percent of nominated scientists become members each year. As a result, the Academy can justifiably claim that its members represent the best of science in the South.

Through its research grants programme, TWAS has also helped thousands of scientists at critical junctures in their careers. More recently, it has expanded this programme to fund research teams in 80 scientifically lagging countries.

By assisting both individuals and institutions, TWAS's research grants provide broad support for science and society in the developing world.

With backing from TWAS, for example, the Faculty of Science and Technology at the University of Mali is helping improve water quality using nanofiltration. Similarly, the Institute of Pathobiology at Addis Ababa University in Ethiopia is conducting much-needed research into sustainable control strategies for diseases like leishmaniasis and schistosomiasis.

By funding research groups in countries that are least proficient in science, TWAS hopes to narrow the gap between countries' scientific

capacities, not just between the North and South, but also within the South itself.

TWAS prizes in basic sciences celebrate the careers of top scientists in the developing world. The Trieste Science Prize, sponsored by illycaffè, recognizes and rewards the developing world's most eminent scientists. The 2008 winners of the prize are Beatriz Barbuy, honoured for expanding our understanding of the chemical composition of stars, and the Indian engineer and physicist Roddam Narasimha, honoured for his seminal work in fluid dynamics.

VOICE FOR THE SOUTH

Over the past quarter century, the Academy has provided a strong voice for the scientific community in the South, helping to shape policy debates within developing countries.

TWAS has accomplished this through various means, including funding for research and scientific exchange, support for scientific conferences and meetings, and the sponsorship of workshops that offer scientists and decision-makers critical training opportunities and guidance on such topics as safe drinking water, biodiversity and renewable energy.

The Academy is also involved in projects like the EuroAfriCa-ICT consortium, funded by the European Union, which uses information and communication technologies to promote collaborative research between European, Caribbean and African institutions. Such projects help developing countries build important inroads into cutting-edge technologies and ensure that they participate in today's most critical scientific debates.

SOUTH FOR SOUTH

Most importantly, perhaps, TWAS serves as a bridge for South-South cooperation and support in science. The Academy's South-South fellowship programme for postgraduate and postdoctoral students is potentially one of the most far-reaching initiatives for scientific capacity building in the South. Each year, 250 fellowships are made available in Brazil, China, India, Malaysia, Mexico and Pakistan to young students from other developing countries.

If TWAS can sustain and expand the number of fellowships, it could help train thousands of young scientists. This would significantly widen the scope of scientific knowledge in the least developed countries. The sense of solidarity that the programme creates among developing countries could help forge a common sense of purpose extending well beyond each nation's scientific community.

THE ROAD AHEAD

But while TWAS has achieved much over the past 25 years, much more remains to be done.

The Academy must continue to raise the profile of science in developing countries that do not yet fully embrace and promote scientific capacity building. Overcoming the South-South divide is likely to be one of the fundamental issues for science in the developing world in the years ahead.

To assist this effort, the Academy must be a place where ideas can be shared and discussed. Scientists in the South have much to contribute to issues such as climate change, energy supply, biodiversity loss and emerging infectious diseases – issues that directly affect their countries' well-being.

TWAS must also continue to assist young and mid-career scientists. The future of science belongs to the next generation of these professionals, and we must help them achieve their full potential.

Finally, the Academy must expand its role as a bridge between the South and North to help advance scientific research and to develop effective international policies.

TWAS' silver anniversary is a time to celebrate, not a time to rest on our laurels. I am confident that the Academy's next 25 years will be even more fruitful as we continue to apply lessons we have learnt to meet future challenges for the benefit of science and societies across the developing world. ■

Jacob Palis
TWAS President
Rio de Janeiro, Brazil
jpalis@impa.br

A similar version of this article originally appeared in the webportal scidev.net, 10 November 2008. See http://scidev.net/en/opinions.

TWAS'S 19TH GENERAL MEETING

THE 25TH ANNIVERSARY CELEBRATION AND 19TH GENERAL MEETING OF TWAS WAS HELD BETWEEN 10 AND 13 NOVEMBER 2008 AT THE HEADQUARTERS OF THE MEXICAN ACADEMY OF SCIENCES IN TLALPAN, A FAST-GROWING BOROUGH OF MEXICO CITY RISING HIGH ABOVE THE URBAN EXPANSE BELOW.

Nearly 350 scientists from more than 50 countries attended the conference to examine the state of science in the developing world and to analyse TWAS's current and future role in building scientific capacity in the developing world.

When Abdus Salam asked nine of the most eminent scientists from the developing world to meet at the Pontifical Academy of Sciences in Rome, Italy, in October 1981, he had this simple idea in mind: to launch an academy of sciences that would honour and support scientists from the South.

But like most simple ideas with high purpose, efforts to turn the concept into action proved even more difficult than initially imagined – and no one had suggested that the task would be easy in the first place. Salam, never one to despair in the face of difficulty, could have been forgiven had he concluded that this concept would never come to be. After all, two years after he first broached the idea, all he had to show for his efforts were more than 100 rejection letters from potential funders.

Now, fast forward 25 years to the TWAS Jubilee Anniversary conference in Mexico City held on 10–13 November 2008. Nearly 350 eminent scientists participated, including two Nobel Laureates and an Abel Prize winner. The conference covered a broad range of topics in science and science policy. There was, for example, a high-level policy forum on strategies for South-South cooperation in science, a series of Jubilee lectures presented by eminent scientists examining cutting-edge research issues, and a number of sessions reflecting on the role that science could play in addressing critical social and economic needs in the South.

Among the highlights of the TWAS 25th anniversary celebration and 19th General Meeting were:

- The opening ceremony, which included speeches by Josefina E. Vázquez Mota, secretary, minister for public education, Mexico; Marcio Nogueira Barbosa, deputy director-general, United Nations Educational, Scientific and Cultural Organization (UNESCO); Barbara Bregato, consigliere, Ministry of Foreign Affairs,

Italy; Juan Carlos Gutiérrez, director-general, Mexican National Council for Science and Technology (CONACYT); Rosaura Ruiz Gutiérrez, president, Mexican Academy of Sciences; and Katepalli R. Sreenivasan (TWAS Fellow 1998), director, Abdus Salam International Centre for Theoretical Physics (ICTP).

- An address by TWAS President Jacob Palis, 'TWAS: Then and Now', describing the Academy's past and future challenges on the occasion of TWAS's anniversary. The address highlighted the Academy's accomplishments and outlined the need for TWAS to devote special attention to such issues as South-South cooperation and support for women and young scientists in the years ahead.
- A panel discussion that explored 'Strategies for Promoting South-South Cooperation for Education and Research'. Those participating in the panel included Tan Tieniu, deputy secretary general, Chinese Academy of Sciences; M.G.K. Menon, founding member of TWAS and adviser to the Indian Space Research Organization; Turner T. Isoun (TWAS Fellow 1985), former federal minister of science and technology in Nigeria; Atta-ur-Rahman, coordinator general, the Organization of Islamic Conference's Standing Committee on Scientific and Technological Cooperation (COMSTECH) and former federal minister of higher education in Pakistan; and Mosibudi Mangena, minister of science and technology in South Africa.

Nearly 350 scientists from more than 50 countries attended TWAS's 25th Anniversary celebration.

- A symposium, led by J.P. Laclette, immediate past president of the Mexican Academy of Sciences, on the current state of science and technology in Mexico (see pp. 26–27) that described the strengths and weaknesses of scientific research in virtually every major scientific field in the conference's host country.
- A series of Jubilee lectures, including presentations by Mario Molina (TWAS Associate Fellow 1996), professor of atmospheric chemistry at University of California, San Diego, USA, and a Nobel Laureate in chemistry (1995), on the impact that human activities, particularly the burning of fossil fuels, are having on the atmosphere and the measures that should be taken to confront this global environmental crisis; Harold Varmus, president of the Memorial Sloan-Kettering Cancer Center and Nobel laureate in physiology or medicine (1989), on recent advances in cancer research that have enhanced our understanding of the disease and provided renewed hope for effective treatments; Martin Rees (TWAS Associate Fellow 2007), professor of cosmology and astrophysics and Master of Trinity College, Cambridge, UK, and Crafoord Prize winner 2005, on anticipated developments in space research over the next quarter century that will expand our understanding of the cosmos and help stir human imagination in ways that only exploring our universe can; and Srinivasa S.R. Varadhan (TWAS Associate Fellow 1988), professor at the

JUBILEE CAMPAIGN

TWAS announced that it has launched a new endowment fund campaign in conjunction with its 25th anniversary. The Academy has set a target of US$25 million by 2012. To help reach this goal, an endowment campaign committee was established at the meeting in Mexico. The committee consists of Jacob Palis (President), C.N.R. Rao (Immediate Past President), Mohamed Hassan (Executive Director), Bai Chunli (Vice President), Ali Al Shamlan (Council Member), Philip Griffiths (Associate Fellow 2000) and Harold Varmus (Nobel laureate in physiology or medicine in 1989). For additional information about the Jubilee Endowment Fund Campaign, contact mhassan@twas.org.

Courant Institute of Mathematical Sciences, New York, and 2007 Abel prize winner, on large mathematical deviations and their applications to both expanding human knowledge and addressing everyday challenges.

- A series of symposia covering a broad range of issues in science and examining, including new directions and perspectives in chemistry, climate change, mathematics, nanoscience and physics.
- The announcement of the winners of the TWAS 2008 regional prizes, which are given by the Academy's regional offices. The development of educational material and school science curricula were the categories for this year's competition. The winners, each of whom was given a US$3,000 cash prize, were: in Latin America and the Caribbean: Carlos Bosch, founder of Mexico's Mathematical Olympiad and 'La Ciencia en tu Escuela' (Science in Your School) programme; in Central and South Asia: Arvind Kumar, senior professor and director of the Homi Bhabha Centre for Science Education (HBCSE), Tata Institute of Fundamental Research, in Mumbai, India; in East and South-East Asia and the Pacific: Gong Peng, head of the Scientific Education Department of Northeast Yucai School (NEYC) in Shenyang, China; in the Arab region: Saouma BouJaoude, chair of the Department of Education and professor of Science Education at the American University of Beirut (AUB), Lebanon; and in Africa: Moyra Keane, academic advisor in the science faculty of the University of the Witwatersrand, South Africa. Next year's regional prizes will be given to individuals who have made significant contributions to institution-building efforts in the sciences.

The Academy's membership now totals 909, coming from 90 countries.

- The granting of TWAS Young Affiliate status to promising scientists under the age of 40 who live and work in developing countries. Twenty-four scientists (up to five chosen by each of TWAS's regional offices) were selected for this honour. This marked the second year of the Academy's Young Affiliate programme. Fifteen of the Young Affiliates attended the conference, where they were officially welcomed to TWAS. They also were given an opportunity to lecture about their research. Topics ranged from examining

the role of synaptic collapse in memory loss, as experienced in Alzheimer's disease, to determining the distribution of objects in space based on data derived from an integrated network of radio telescopes stationed across the globe. The Young Affiliates programme is one of several initiatives that TWAS plans to expand over the coming years to help ensure that the next generation of scientists in the developing world receives the recognition and support that it needs and deserves, not just for career advancement but for the benefit of their societies.

- The election of 41 new members to the Academy. The new members, who were chosen from 167 candidates, include two scientists from Ethiopia and one from Uzbekistan. Scientists from Brazil, Cuba, China, Jamaica and India were also elected. The Academy's membership now totals 909, coming from 90 countries. Official membership certificates were also given to the 44 scientists who had been elected to TWAS in 2007. Some 25 members travelled to Mexico City to receive their certificates in person.
- The organization of the second 'exchange' meeting among the coordinators of TWAS's five regional offices. Those in attendance included: Varadachari Krishnan (TWAS Fellow 1996), Hindustan Lever research professor at Jawaharlal Nehru Centre for Advanced Scientific Research, representing the Regional Office for Central and South Asia (TWAS-ROCASA) in Bangalore; Thomas Egwang (TWAS Fellow 1997), executive director, African Academy of Sciences, representing the Regional Office for Sub-Saharan Africa (TWAS-ROSSA) in Nairobi, Kenya; Fu Shuqin, Director, International Organizations, Chinese Academy of Sciences, participating on behalf of Bai Chunli (TWAS Fellow 1997 and current TWAS vice-president for east and south-east Asia), executive vice-president, Chinese Academy of Sciences, who is

the coordinator of the Regional Office for East and Southeast Asia and the Pacific (TWAS-ROESEAP) in Beijing; Luiz Davidovich (TWAS Fellow 2002), professor of physics at the Federal University of Rio de Janeiro, participating on behalf of Carlos Aragão de Carvalho (TWAS Fellow 2002), also a professor of physics at the Federal University of Rio de Janeiro and coordinator of the TWAS Regional Office for Latin America and the Caribbean (TWAS-ROLAC) in Rio de Janeiro; and Mohamed M. El-Faham, director of the Centre of Special Studies and Programmes, Bibliotheca Alexandrina, representing the Arab Regional Office (TWAS-ARO) in Alexandria, Egypt. The broad-ranging discussions focused on the need to foster even greater interaction among the offices. There was also a call for the offices to assist TWAS national chapters as part of a greater effort to increase awareness of TWAS among a larger circle of scientists, especially scientists working in poorer developing countries and in isolated, inadequately funded scientific institutions.

Specifically, attendees urged an assessment of the procedures for the selection of regional prize winners to ensure that as many scientists as possible were made aware of the prize; the sponsorship of grant-writing workshops for young scientists to enable them to better compete for grants and fellowships; the organization of additional meetings of TWAS grantees to generate additional interaction among youthful researchers; and the development of a strategy to better identify young scientists who remain unfamiliar with the Academy's full range of activities, especially by taking advantage of the opportunities afforded by the success of the TWAS Young Affiliates programme, the TWAS Regional Conferences for Young Scientists, the TWAS fellowships and research grant schemes, and TWAS Young Scientist Prizes at the national and regional levels. Participants also asked the TWAS secretariat to prepare templates for a standardized work plan and budget sheet that could be adapted to the needs of each regional office in order to promote a uniform way of sharing information.

- The awarding of TWAS Prizes to eight eminent scientists from the developing world: in the agricultural sciences, Muhammad Arshad, director, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan; in biology, Lucia Mendonça Previato, professor, Instituto de Biofisica Carlos Chagas Filho at Universidade Federal do Rio de Janeiro, Brazil; in medical science, Sergio D.J. Pena, professor, Departamento de Bioquimica e Imunologia, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil; in the earth sciences, Paulo Artaxo, professor, Institute of Physics, University of São Paulo, Brazil; in the engineering sciences, Chih-Kung Lee, professor, Institute of Applied Mechanics, National Taiwan University, Taipei, Taiwan; in mathematics, Shrikrishna Dani, senior professor, School of Mathematics, Tata Institute of Fundamental Research, Mumbai, India; in chemistry, Kankan Bhattacharyya, professor, physical chemistry department, Indian

> ***TWAS members were given ample opportunities to express their opinions and concerns.***

Association for the Cultivation of Science, Kolkata, India; and in physics, Jie Zhang, president, Shanghai Jiao Tong University, China.

- Presentations by the Trieste Science Prize winners for 2007: Beatriz Barbuy (TWAS Fellow 2007), professor at the Universidade de São Paulo, Brazil, who won in the category of earth, space, ocean and atmospheric sciences, and Roddam Narasimha (TWAS Fellow 1988), chair of the Engineering Mechanics Unit at the Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore, India, who won in engineering sciences. The Trieste Science Prize is generously funded by illycaffè, one of the world's pre-eminent coffee manufacturers. Barbuy and Narasimha had previously spoken about their award-winning research at the Trieste Science Prize 2008 ceremony in September in a public event that was held in conjunction with the 75th anniversary of illycaffè in Trieste. The presentations in Mexico, which were tailored to a more scientific audience, provided a more detailed examination of their findings and explored where their research efforts might lead in the future.
- Presentations of TWAS Medal Lectures for 2007 and 2008: José de la Peña (TWAS Fellow 2003), professor, Institute of Mathematics, National Autonomous University of Mexico; M.R.S. Rao (TWAS Fellow 2002), president, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore; Anwar Nasim (TWAS Fellow 1987), science advisor to the Organization of Islamic Conference's Standing Committee on Scientific and Technological Cooperation (COMSTECH), Islamabad; and Keto Mshigeni (TWAS Fellow 1987), vice-chancellor, Hubert Kairuki Memorial University, Dar es Salaam, Tanzania. The latter two scientists had been selected to deliver Medal Lectures in 2007. They were unable to attend the meeting in Trieste and came instead to the General Meeting in Mexico.

Like all previous general meetings, TWAS members were given ample opportunities to express their opinions

TLALPAN STATEMENT, ISSUED AT THE CONCLUSION OF TWAS'S 19TH GENERAL MEETING

We scientists, gathered here at the Mexican Academy of Sciences, in Casa Tlalpan, Mexico City, hereby state that it is strategically important to reinforce scientific, technological and innovation systems to contribute to the creation of a more integrated, free and fair society.

- *Considering: The insufficient number of researchers and the insufficient investment in science and technology in developing countries, as a proportion of the gross domestic product (GDP) compared with research and development (R&D) systems in the industrialized world;*
- *Acknowledging: That these numbers are increasing in some developing countries;*
- *Realizing: That the impact of this scientific research in relation to world scientific production is generally low, and that this impact is even lower when one moves from the realm of scientific knowledge to knowledge that is applied to critical social and economic needs;*
- *Thereby conclude:*

Science and technology should play a much more important role in public policies or decision-making.
The migration (brain drain) from poor to rich countries should be reduced.
The contribution of the private sector to R&D should be increased.

- *And propose the following course of actions:*

– Call on governments in developing countries to steadily increase investment in science and technology to at least ome percent of GDP.
– Urge governments, universities, research centres and private industry to jointly promote and encourage the production of problem-solving scientific knowledge in such critical areas as health, climate change, energy, social development, security and sustainability.
– Emphasize education and research as key elements in facilitating the sharing of experiences, technology transfer and the exchange of students, professors, researchers and administrative personnel.
– Promote the creation of both basic and applied knowledge by balancing academic values with economic and social goals and by reconciling the role of entrepreneurs with the objectives of higher education and research institutions.
– Recognize science and technology as central elements that contribute to democracy and social and economic equity. Foster cooperation to take advantage of scientists who were raised in the South but who are now working in the North.

and concerns, both informally and during a two-hour general assembly. And, as in all previous meetings, the members had no shortage of ideas and comments on how the Academy might strengthen its activities and programmes in the future. Much of the discussion focused on how TWAS, by building upon 25 years of experience and a growing reputation in the international scientific and development communities, could move forward even more effectively in the future and ultimately exert an even greater impact on the building of scientific capacity in the South.

Farida Habib Shah (TWAS Fellow 2002), chief executive officer (CEO) of Novel Plants and BioIT Technologies in Malacca, Malaysia, asked if the Academy would be willing to dedicate a certain number of openings for new TWAS members for women each year. She lamented the fact that only two women (one from Brazil and one from Cuba) had been elected this year as TWAS members and said that it might be wise for the Academy to take a more proactive role in ensuring that women scientists were well represented. Hassan noted that this was a good suggestion worthy of consideration, but that the Academy's selection process has been (and must continue to be) gender blind. Palis added that all TWAS members should do their best to identify and nominate excellent women scientists and that he hoped gender imbalances could be addressed without resorting to altering current selection procedures.

Manju Sharma (TWAS Fellow 1995) stated that, since capacity building was a priority for TWAS, the

Academy should consider setting up a "TWAS Silver Jubilee Centre for Capacity Building in Science and Technology", perhaps structured along the lines of the International Centre for Genetic Engineering and Biotechnology (ICGEB) in Trieste. The centre, she said, could consist of member states willing to pay annual dues to help fund its activities. Sharma noted that such a centre might help bridge the gap between the natural and social sciences and serve as a vehicle for the promotion of science, technology and innovation.

Ashok Kumar Vijh (TWAS Associate Fellow 1987), research head of the Hydro-Quebec Institute of Research in Canada, asked why no members had been elected to TWAS in the social sciences during the past two election cycles. He was especially concerned by this turn of events given the Academy's desire to nurture multidisciplinary collaborations and expand its efforts to make scientific capacity building an integral part of sustainable development efforts in the South.

The Council decided that the Academy would elect a maximum of 45 new members in 2009.

Ismail Serageldin (TWAS Fellow 2001), director of the Library of Alexandria in Egypt and chair of the Academy's Social and Economic Sciences Committee, responded by saying that the nominations had been too few in number and that more attention needed to be paid to soliciting and evaluating potential candidates so that the best researchers and scholars could be elected. Serageldin also remarked that the initiative posed significant challenges for an organization like TWAS, which had focused on the natural sciences since its inception. He also mentioned that the criteria for excellence are somewhat different for the social sciences than for the natural sciences, making it difficult to apply the same rules to both. For example, he noted that the area of 'grey literature' – reports prepared by and for government and international organizations, including the UN – did not carry the same weight in academia as articles published in scholarly journals. Nevertheless these publications often exerted a tremendous impact on science-based policy discussions and decisions. Should researchers who write such reports be considered for membership to TWAS? As far as Serageldin was concerned, the answer is yes. Therefore nominators should take into account not only published papers, but also 'grey literature' reports, articles and monographs. Hassan proposed that members search among their own academies of arts and sciences to identify suitable social scientists for nomination.

Following the discussion on the social sciences, Vijh also asked what outreach activities TWAS was undertaking to help bridge the gap between science and technology, a gap that often seemed to be larger in the developing world than in the developed world. Palis replied that the standing committee on biotechnology had proposed that just such links – bridges, if you will – be forged in this field. Hassan added that TWAS, in collaboration with the United Nations Development Pro-

gramme (UNDP) and the United Nations University Institute for Advanced Studies (UNU-IAS), has published a decade-long series of monographs highlighting "successful experiences" in the use of science and technology to address critical social and economic needs in the developing world. Nevertheless, he added, TWAS should not rest on its laurels but instead encourage all centres of excellence to engage in real-life projects. To this end, he continued, TWAS had put together five proposals (on dryland biodiversity, safe drinking water, renewable energy, medicinal and indigenous food plants, and nanotechnology) aimed at linking centres of excellence in the South.

Juan Roederer (TWAS Associate Fellow 1991), professor emeritus of the Geophysical Institute at the University of Alaska, stressed that TWAS should work with universities worldwide to persuade them to undertake programmes that connect the hard and soft sciences in truly interdisciplinary projects. Jagdish N. Srivastava (TWAS Fellow 1991), editor-in-chief of the *Journal of Statistical Planning and Inference*, highlighted the emerging area of 'logic fields' applied to consciousness. He noted that this is a truly interdisciplinary field with potentially broad implications for mental health, the study of the brain and our understanding of neurology. He therefore urged TWAS to take an interest in it.

TWAS deserves credit for helping to raise the profile of both science and scientists in developing countries.

Dorairajan Balasubramanian (TWAS Fellow 1997 and currently the Academy's secretary general), director of research of L.V. Prasad Eye Institute in Hyderabad, India, noted that, several years ago, the field of biology in the listing of TWAS's membership roster was divided into four categories, but that there had been few nominations in the neurosciences and systems biology categories. At the same time, such large fields as chemistry and physics were listed as a single discipline and not divided into subfields. A committee, comprised of himself, Hernán Chaimovich (TWAS Fellow 2000) and Mohamed Hassan, had been appointed to explore the issue. The committee recommended that biology should be divided into only two categories. The first comprised of structural biology, biochemistry, biophysics, cell and molecular biology; the second of the biology of organisms and systems. In addition, under the proposal, neurosciences would be merged with medical sciences, and earth sciences would be merged with astronomy and space sciences.

Balasubramanian also spoke about the age distribution of TWAS fellows. Of the 880 members, more than 250 are over 70 years of age, and more than 300 are over 60. The aim, he said, is to rebalance this skewed demographic over time by increasing the number of 'younger' scientists elected to the Academy. As a first step in this process, TWAS will no longer accept nominations of anyone older than 70, and he urged members to nominate younger scientists. Balasubramanian also noted that the Council had decided that the Academy

SOUTH AFRICA NEXT

South Africa will generously host the TWAS 20th General Meeting. Mosibudi Mangena, Minister of Science and Technology in South Africa, made the announcement at the opening session of the TWAS meeting in Mexico City. The meeting will take place in Durban on 19–23 October. For additional information, please contact the TWAS secretariat at info@twas.org.

would elect a maximum of 45 new members in 2009, with at most five of these being Associate Fellows.

Hassan added that nominations were being sought for scientists from scientifically and technologically lagging countries, which continue to be under-represented in TWAS. He noted that just as the Academy had a disproportionate number of older scientists, it also had a large number of scientists from Brazil, China, India and other large developing countries. He hoped that this issue could be addressed by making a strong and determined effort to solicit candidates from across the developing world. He said such an effort was critical if the Academy was to be true to its mandate to serve science throughout the South.

All in all, this has been an eventful 25 years for the Academy and, as the four-day conference in Mexico celebrating TWAS's 25th anniversary clearly showed, the Academy's future holds great promise.

"TWAS", as Palis said to the members, "deserves credit for helping to raise the profile of both science and scientists in developing countries". It has done so by assisting thousands of scientists at critical junctures in their careers and serving as a voice for the scientific community in ways that have showcased the importance of science and technology for development.

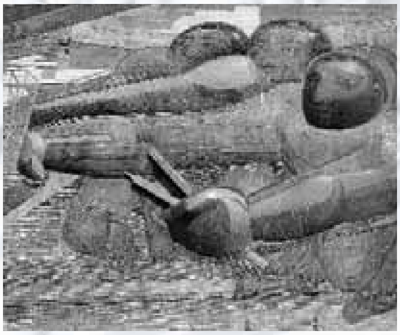
The Academy's past, he observed, speaks to its success. But on the occasion of its Jubilee anniversary, he maintained, it is the future that should be foremost in our minds. In that spirit, Palis said that "TWAS must continue to work to help raise the profile of science in developing countries that have yet to fully embrace policies for scientific capacity building." It must also, he added, "continue to assist young and mid-career scientists at critical junctures of their careers and to serve as the champion for science-related issues not just in the South but throughout the world". ■

TWAS 19TH GENERAL MEETING

Mexico City, Mexico, 10–13 November 2008

SCIENCE IN MEXICO: MIDDLE MATTERS

WHEN TWAS WAS LAUNCHED A QUARTER CENTURY AGO, THE STATE OF SCIENCE AND TECHNOLOGY (S&T) IN THE SOUTH WAS VIRTUALLY THE SAME EVERYWHERE. ALL DEVELOPING COUNTRIES SUFFERED FROM SIGNIFICANT – SEEMINGLY INSURMOUNTABLE – DEFICITS IN SCIENTIFIC CAPACITY.



Over the past 25 years, issues related to scientific capacity have become much more complex and difficult to describe. Some countries – most notably, Brazil, China and India – have made significant progress in laying strong foundations for S&T. Meanwhile, other countries – notably, countries in sub-Saharan Africa and those with predominantly Muslim populations – have found themselves lagging farther behind as they struggle to keep pace with advances in scientific know-how and capability in an era marked by unprecedented scientific discovery. As a result, when it comes to S&T (and economic development too), it is no longer possible to speak of the developing world as one world. Indeed the developing world is now many worlds.

Within this broad spectrum of scientific capacity, there are a growing number of developing countries that are neither scientific high performers nor scientific stragglers. Such countries, in effect, are in the middle of the scientific pack. TWAS estimates that about 100 developing countries fall into this category. Although they have not often received the attention that they deserve, they are nonetheless critically important to the future of science in the South – and to the economic and social well-being of hundreds of millions of people.

Mexico, which hosted TWAS's 25th anniversary conference in Mexico City, on 10-13 November 2008, is among them. The following article provides a brief overview of the state of S&T in Mexico, exploring what this means not only for Latin America's second-most populous country but also for other countries that share the same status in scientific capabilities.

Mexico is not only a nation with more than 100 million people but it also boasts the world's 14th largest economy. Its annual gross domestic product (GDP), according to the World Bank, was nearly US$900 billion in 2007. That was slightly smaller than South Korea's and slightly larger than Australia's.

NATIONAL COUNCIL OF SCIENCE AND TECHNOLOGY (CONACYT)

*The National Council of Science and Technology (*Consejo Nacional de Ciencia y Tecnología*, CONACYT) is the government agency responsible for supporting science and technology (S&T) research and development and creating S&T policies in Mexico. Created in 1970, it has helped spark two national reform efforts and the passage of two national laws to promote the development of S&T. The second law, approved by the Mexican Congress in 2002, called for the nation to spend at least 1 percent of its GDP on S&T development by 2006. CONACYT now aims to lead efforts to increase this to 2 percent by 2025 and to transform Mexico into a top-ranked S&T nation. To achieve these goals, CONACYT plans to promote scientific research in such areas as information and communication technologies (ICT), biotechnology, advanced materials, industrial design and processes, and urban and rural socio-economic infrastructure development.*

Much of Mexico must contend with a semi-arid and arid climate (the amount of productive agricultural land in Mexico is limited to just 15 percent of the land base). Yet, it is also a nation that enjoys substantial natural assets. Corn, avocado, cacao, pumpkin, cotton, peanuts and tobacco all originated in Mexico and continue to be widely cultivated. Home to 10 to 12 percent of the world's biodiversity, Mexico, ranks fifth in the world. Mexico also enjoys large deposits of gold, silver and copper, and significant reserves of oil and gas. It has extensive forest reserves and endless coastlines that face both east towards the Atlantic and west towards the Pacific.

For all of these encouraging signs of aggregate wealth and bountiful resources, Mexico is also a nation plagued by chronic poverty and disturbing levels of economic inequality. Annual per capita income stands at nearly US$9,000, which is the highest in Latin America. Yet, the United Nations estimates that 40 percent of Mexico's population lives in poverty, and nearly 20 percent in extreme poverty. Twenty million Mexicans – equal to 20 percent of the native-born population – reside in the United States, including an estimated 12 million who have migrated there illegally.

Mexico boasts the world's 14th largest economy.

The nation's economy has grown at an annual rate of nearly 3 percent since 2000. But growth has not been sufficient to keep pace with the employment needs of its youthful population (half of the nation's population is younger than 25 years old). While the official unemployment rate is just 3.7 percent, those with secondary school and university degrees are finding it difficult to find jobs as the economy continues to be largely driven by low-wage, low-skill jobs in agriculture, mining, minerals and manufacturing. The recent turmoil in the financial markets and sharp downturn in the global economy have only exacerbated this problem.

Many of the nation's most educated and skilled workers are often forced to pursue their careers abroad, creating a serious brain drain problem. Government efforts to improve the economy, moreover, have been handicapped by low tax revenues (the government collected only 9 percent of its gross national product in taxes for 2007), bureaucratic red tape and corruption, and an over-reliance on oil revenues, which account for 40 percent of the federal budget. Government finances, consequently, have tended to rise and fall with the price of oil, which has

NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO (UNAM)

*The National Autonomous University of Mexico (*Universidad Nacional Autónoma de México, *UNAM), established in 1910, is the largest university in Latin America. Its main campus, University City, which was named a UNESCO heritage site in 2007, includes buildings designed by famed architects Mario Pani and Domingo García Ramos and works of art by Diego Rivera. UNAM also maintains satellite campuses in the metropolitan area of Mexico City and in several other Mexican cities, as well as four small campuses in the US and Canada. UNAM offers degrees in a full range of disciplines and is recognized as the nation's pre-eminent institution of higher education. Fields of study in which it is particularly strong include mathematics and physics. UNAM alumni include five Mexican presidents and three Nobel laureates (Alfonso García Robles for peace, Octavio Paz for literature, and Mario Molina for chemistry). Other prominent scientists who have graduated from UNAM are Luis E. Miramontes, co-inventor of the contraceptive pill, Rodolfo Neri Vela, the first Mexican to travel in space, and Guillermo Haro, co-discoverer of Herbig-Haro objects.*

made long-term planning and sustained investments in knowledge-based sustainable development difficult to achieve.

SCIENCE LIKE SOCIETY

What can be said of Mexican society can also be said of Mexican science. Mexico, in brief, is a middle-income country with a scientific community that lies mid-stream in the international spectrum of scientific competency.

Science in Mexico is strong in a number of areas. For example, it enjoys an international reputation in astronomy, biology, chemistry, health research, mathematics and physics. But it is also true that the number of scientists in these and other fields is generally low. Thus even in the nation's most prominent fields of study, the burden of excellence is shouldered by a few individuals.

Overall, the nation has a total of about 40,000 scientists. Of these, some 15,000 have been selected, through a highly competitive process, as members of the National Research System (NRS), established in 1984 and now home to the nation's elite scientists.

NRS scientists work in the best institutions – for example, the National Autonomous University of Mexico (UNAM); research centres supported by the National Board of Science and Technology (CONACYT), which now number 27; the National Institutes of Health supported by the Ministry of Health; the Centre for Research and Advanced Studies (CINVESTAV); the Universidad Metropolitana Autónomo (UAM); and the College of Mexico (COLMEX).

As employees of these elite institutions, professors receive excellent salaries (eminent scientists earn

US$5,000 a month; the nation's top scientists earn up to US$10,000 a month), due largely to the extra income they receive for publishing in international peer-reviewed journals, mentoring graduate students and organizing high-profile conferences (all of which can boost their salaries by 40 percent).

As many as two-thirds of the doctoral students find positions in either the United States or Europe.

NRS scientists work on state-of-the-art research projects, publish widely and serve on the editorial boards of leading journals. They are often asked to participate in international research projects and generally lead exciting and fulfilling professional careers comparable to those led by their colleagues in Europe and the United States. These scientists, in short, are part of the global scientific community.

For researchers outside of the NRS system, however, the story is vastly different. Their classrooms and laboratory facilities are in much poorer condition, their salaries are much lower and their opportunities to participate in international activities much more restricted. Moreover, because they often reside in isolated settings and carry heavy teaching loads, they find it difficult to interact and exchange ideas with others in their field – a factor that is critical to a successful career in science.

Such limitations help to account for significant brain drain among the nation's younger scientists. Mexico's 'top' young scientists may seek positions in the nation's elite universities and research centres and hope to be selected into the entry category of the NRS several years after they graduate (although many immediately move to the United States and Europe). The rest, however, are confined either to second- or third-tier universities or ultimately seek employment either outside of academia or abroad. CONACYT estimates that more than half – and as many as two-thirds – of the nation's doctoral students find positions in either the United States or Europe.

While Mexico has recently redoubled its efforts to promote science and technology (between 1990 and 2007, the number of publications authored by Mexican scientists grew from less than 1,500 to nearly 7,000), progress on the ground remains slow and, in terms of the nation's overall scientific enterprise, has been largely confined to rhetorical support.

For example, Mexico's science and technology law, approved by Congress in 2002, called for 1 percent of the nation's annual gross domestic product to be spent on science and technology (S&T) by 2006. Over the past two decades that figure has never exceeded 0.4 percent, and in 2007 it was just 0.33 percent. This percentage ranks last among the 30 industrial countries that belong to the Organisation for Economic Co-operation and Development (OECD), and it is far below the average investments made by neighbouring countries in South and Central America, which stand at 0.67 percent of annual GDP. In aggregate terms, spending on S&T in Mexico totaled US$3.2 billion in 2007. To reach the 1 percent threshold, spending would have to rise to US$9 billion.

Mexico has long discussed the need to turn its scientific knowledge into products and services that can boost the economy. On the positive side, the nation is among the leaders in the developing world for obtaining international patents. In 2005, for example, the World Trade Organization reported that native-born Mexicans had acquired 136 patents, placing it fifth among developing

MEXICAN AUTONOMOUS INSTITUTE OF TECHNOLOGY

*The Mexican Autonomous Institute of Technology (*Instituto Tecnológico Autónomo de México*, ITAM) was founded in 1946 as a private research university in Mexico City. In 1963, the government officially recognized it as an autonomous university. Initially focusing on economics and business, its academic programmes have expanded to include applied mathematics, law, computer science, social sciences, information and communications technology, and industrial and business engineering. It has become one of Mexico's pre-eminent institutions of higher education, with 38 academic programmes, 537 professors and lecturers and over 5,000 students. ITAM alumni include the current president of Mexico, Felipe Calderón Hinojosa, five ministers of finance and three ministers of energy.*

countries (if you include foreigners working for international firms in Mexico, the figure skyrockets to 9,500). Yet, it is important to put this figure in perspective. In the same year, China acquired nearly 2,500 international patents, and worldwide more than 130,000 patents were issued. This means that Mexico could claim ownership for less than 0.001 percent of the world's patents.

About two million students attend universities in Mexico. That represents about 20 percent of the population between the ages of 19 and 24. UNAM, with a student population approaching 300,000, is the largest university in Latin America and one of the world's largest universities.

About two million students attend universities in Mexico.

Mexico's growing university student population and the increasing strength of its research system are encouraging signs that suggest the nation is taking significant steps to help meet the demands posed by science-based development and ultimately to succeed in today's highly competitive global economy. Yet, it is important to note that only 3 percent of the students attending Mexico's universities major in scientific disciplines. The percentage of students seeking degrees in engineering is even lower.

Mexico, moreover, only produces about 2,100 PhDs each year (and less than 40,000 masters' degrees, as estimated by CONACYT). These are paltry totals for a nation with more than 100 million people. In comparison, Brazil produces 10,000 PhDs each year. Nevertheless, the growth of doctorates in Mexico is impressive when viewed from a historical perspective. In the early 1960s, for example, there were just 20 physicists with doctorates in Mexico; today, there are more than 1,500. Overall, Mexico has just 3.3 scientists for every 10,000 residents. In the United States, the ratio is 74 scientists for every 10,000 residents. In Brazil, it is 4.5.

Mexico's expenditures per researcher are comparable to other developing countries, exceeding, for example, per-capita investments in Argentina, Chile and Turkey. This again suggests that Mexico has too few sci-

entists but that its best scientists are well treated and are given the resources they need to succeed.

The nation's scientific community, moreover, is highly concentrated in the Federal District in and around Mexico City, one of the world's largest metropolitan areas and home to 20 million people. More than 30 percent of the nation's scientists live and work in the Federal District. This same pool of scientists are responsible for more than one-third of all the scientific articles published by Mexican scientists in international peer-reviewed journals. The gap is even wider between Mexican scientists who are members of NRS and those who are not. By some estimates, NRS researchers account for 85 percent of all articles published by Mexican scientists in international peer-reviewed journals. Such a skewed distribution of scientific and technological expertise means that Mexico has its own domestic S&T divide separating the 'haves' in the Federal District and NRS from the 'have-nots' in the rest of the country.

The structure of science in Mexico has led some critics to conclude that the country has built a policy framework that cares more for its eminent scientists than for science itself. Or, put in a slightly different way, it is a system where eminent scientists do better than the nation's scientific enterprise as a whole. As a result, Mexican science is marked by pockets of excellence and a small cadre of world-class scientists in a select number of fields. Overall, however, the nation's scientific community remains weak and plagued by a debilitating disengagement between research and society.

ROAD AHEAD

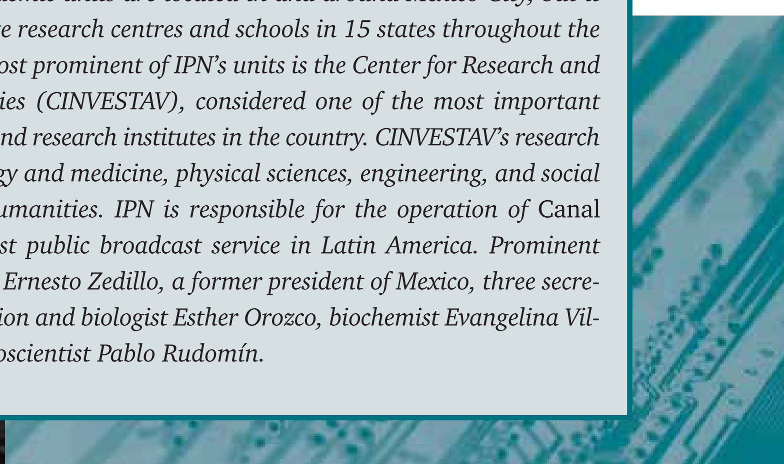
Middle-income countries with mid-level scientific capacity such as Mexico all face a similar set of challenges that must be met if they hope to build upon their promising but largely unfulfilled efforts to create a durable foundation for science-based sustainable development.

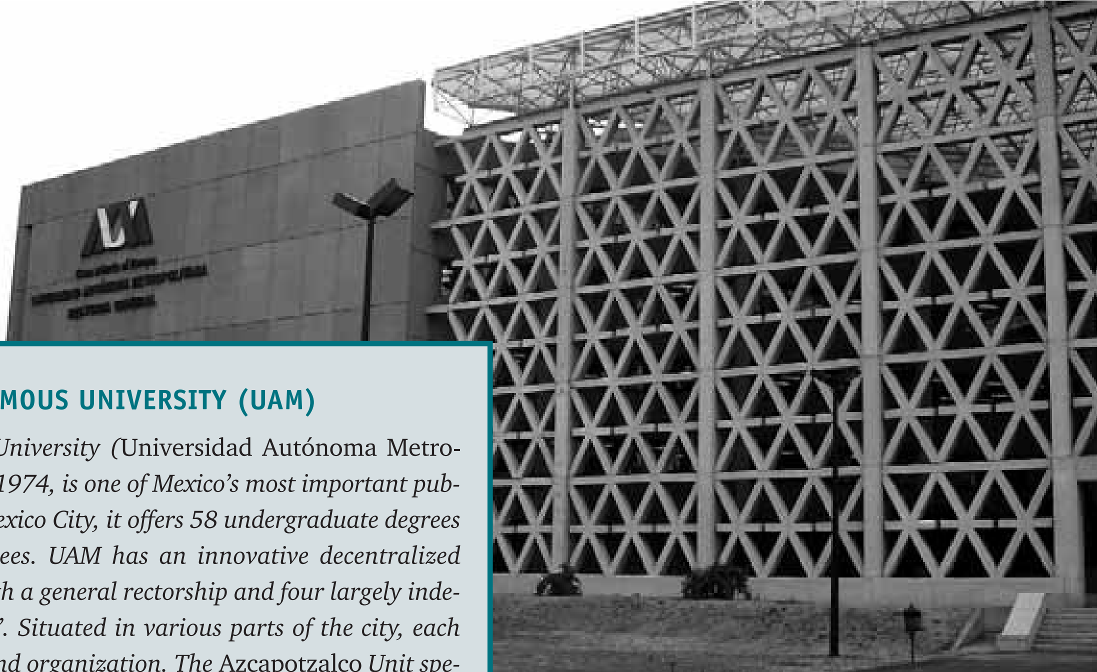
First, developing countries in the middle of the scientific pack must move from a system that supports individual scientists to one that emphasizes institutional development across the nation. In Mexico, the concentration of research capacity in the Federal District has serious consequences for both science and society and raises critical questions about its long-time sustainability in the face of deep-seated national inequities in capacity. Science in Mexico must mean more than simply science in Mexico City and the surrounding metropolitan area.

Second, developing countries in the middle of the scientific pack must develop strategies for encouraging and rewarding the private sector to invest in research and development. In Mexico, less than 20 percent of the investment in research and development comes from the private sector. Compare that figure to 70 percent in the United States. Of course, there can be no private-sector investment if the private sector remains small and if high-technology industries remain largely relegated to

NATIONAL POLYTECHNIC INSTITUTE (IPN)

*The National Polytechnic Institute (*Instituto Politécnico Nacional*, IPN), founded in 1936 in Mexico City, is one of the largest and finest public universities in the country, with more than 170 undergraduate and graduate programmes and 87,000 students. It also sponsors several high schools. Most of its academic units are located in and around Mexico City, but it also has satellite research centres and schools in 15 states throughout the country. The most prominent of IPN's units is the Center for Research and Advanced Studies (CINVESTAV), considered one of the most important post-graduate and research institutes in the country. CINVESTAV's research areas are biology and medicine, physical sciences, engineering, and social sciences and humanities. IPN is responsible for the operation of* Canal Once*, the oldest public broadcast service in Latin America. Prominent alumni include Ernesto Zedillo, a former president of Mexico, three secretaries of education and biologist Esther Orozco, biochemist Evangelina Villegas and neuroscientist Pablo Rudomín.*





METROPOLITAN AUTONOMOUS UNIVERSITY (UAM)

*Metropolitan Autonomous University (*Universidad Autónoma Metropolitana*, UAM), founded in 1974, is one of Mexico's most important public universities. Located in Mexico City, it offers 58 undergraduate degrees and 35 graduate-level degrees. UAM has an innovative decentralized administrative structure, with a general rectorship and four largely independent campuses, or 'units'. Situated in various parts of the city, each unit has a particular focus and organization. The* Azcapotzalco *Unit specializes in applied research in industry and industrial design. The* Iztapalapa *Unit focuses on basic sciences and engineering. The* Xochimilco *Unit specializes in agricultural and animal health. Created in 2005, the* Cuajimalpa *Unit is the newest campus, and focuses on the humanities, with an interdisciplinary approach. The three older campuses each have about 10,000 students. Between 1999 and 2003, UNAM published 12,667 articles in international journals with an impact factor of 3.1, the highest in the country.*

the oil and gas industry, which, as a nationalized industry in Mexico, is in the hands of the government. Mexico, in short, must grow a diverse set of knowledge-based industries and must give industrialists – indeed entrepreneurs – the incentives and rewards that they need to invest in R&D. Otherwise low-cost, low-skilled labour will remain the nation's most significant competitive advantage in the global marketplace. That's no way to successfully navigate the challenges of economic growth in the 21st century.

Third, mid-level developing countries must also devise programmes that offer sufficient financial support to students who desire to pursue degrees in S&T. Observers speak of a North-South divide in science. But there is also a growing domestic divide within many developing countries between science and non-science professions, as many of a nation's brightest students opt for careers in business and medicine where opportunities have been brighter and incomes higher.

Fourth, mid-level developing countries must invest in initiatives that help raise public understanding and appreciation for the critical role that science plays in economic and social well-being. Such efforts should include bolstering the scientific curriculum in schools and expanding opportunities for adults to learn more about science through the media and state-of-the-art science museums. In a recent OECD survey, students in Mexico ranked last in reading, mathematics and science, a clear sign that the nation will not have the educated labour force that it needs to compete successfully in the global economy.

And, fifth, developing countries in the middle of the scientific pack must expand the capacity of government to address issues related to science-based development. The latter issue may be the most crucial of all. Scientific advances, it is true, take place in classrooms and laboratories. But those classrooms and laboratories will never be built and maintained, especially in developing countries, unless there is strong support from government.

When you think of the state of science and technology in Mexico a quarter century ago (at the time of TWAS's birth) and look at its status today, you cannot help but be impressed by the progress that has been made. Brazil, China and India have rightfully garnered global attention for the rapid and broad advances that they have made in scientific capacity building. But progress, as Mexico and other countries illustrate, has taken place in many places and on many fronts.

The question for Mexico – and the other 100 developing countries that are neither scientific high-performers nor scientific laggards – is this: How can they continue to make advances in their efforts to build national scientific capacity and, at the same time, help to ensure that high-level scientific research is not limited to a cadre of elite individuals but instead is pursued by many well-trained scientists in institutions nationwide? In effect, the key issue is how to make scientific excellence an integral part of society that reaches into all corners of the nation.

Scientists in Mexico and other mid-level scientific countries no longer feel like second-class citizens. And the support that they receive – in terms of excellent incomes, good working conditions and the freedom to pursue their own research agendas – indicates that these feelings are well-founded. Indeed by several measures, including publication output, many of Mexico's elite scientists, are as productive as colleagues in high-performing scientific countries, including the United States.

Mexico's elite scientists are as productive as colleagues in high-performing scientific countries.

But scientists in Mexico and other mid-level countries are not present in sufficient numbers within their societies to ensure the creation and expansion of dynamic scientific communities that can play central roles in promoting sustainable economic growth.

Just as Mexico must address issues of equity in its economy, it must also address issues of equity in its scientific enterprises, related to geography (building scientific capacities beyond major urban areas), age (providing more opportunities and support to young students eager to study science), and gender and indigenous people (offering opportunities and support for women and members of minority populations who want to pursue careers in science).

This is not just an ethical issue but also one that could determine the future vitality of science in the developing world, ensuring that the North-South gap in scientific capacity is not simply replaced by a South-South gap characterized by progress for some developing countries and stagnation and ultimately hopelessness for others. ■

THE NATIONAL INSTITUTES OF HEALTH

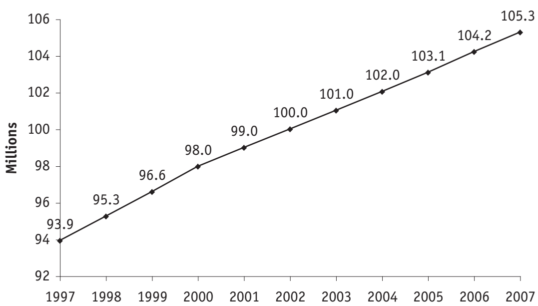
*Mexico boasts one of the most extensive and well-integrated networks of national institutes of health in the developing world. Its 12 national institutes make a significant contribution to the health care of the Mexican people carrying out world-class research, training high-level human resources and encouraging the incorporation of new knowledge into practice. The institutes cover such fields as cancer, cardiology, medical sciences and nutrition, neurology and neurosurgery, pediatrics and psychiatry, thereby assuring that Mexican health care professionals have access to the most recent research in their fields, while also promoting scientific development in the country. One of the more prominent of these institutes is the National Institute of Public Health (*Instituto Nacional de Salud Publica*, NIPH), the nation's leading institution of public health education and research. Founded in 1987, the institute groups together four research centres. The Center for Population Health Research (CISP) develops epidemiology and health systems research for use by policy- and decision-makers. The Center for Research on Infectious Diseases (CISEI) focuses on bacterial, viral, fungal and parasitic diseases. It works in conjunction with the Center for Malaria Research (CIP). The newest of the four, the Center for Research on Health Systems (CISS), studies health systems within their social context. NIPH's Academic Secretariat coordinates Mexico's School of Public Health. The institute combines bio-medical, population and health research with human resource development. It works in collaboration with state and federal authorities, as well as with the World Health Organization (WHO) and the United Nations Joint Programme on HIV/AIDS (UNAIDS). NIPH's headquarters are located in Cuernavaca, 70 km south of Mexico City, in the state of Morelos.*

MEXICO: TRENDS IN

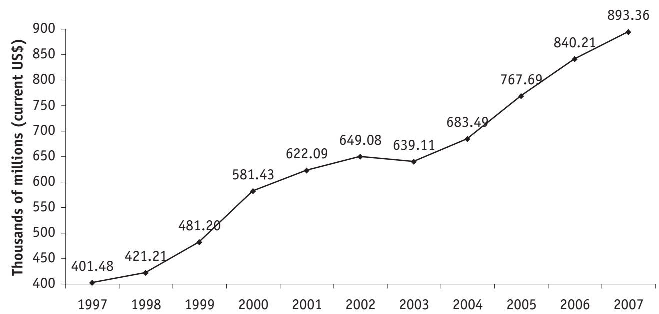
A statistical profile of trends in science

Mexico, host for the 25th anniversary celebration of TWAS, stands squarely in the middle of the global spectrum when it comes to scientific and technical capacity as well as economic and social well-being. The following series of graphs offers a snapshot of the current state of the science, technology and innovation in a country that Rosaura Ruiz-Gutierrez and Juan Pedro Laclette, the current and previous presidents, respectively, of the Mexican Academy of Sciences, have called "the world's poorest rich country"... or, if you are inclined to be more pessimistic, "the world's richest poor country". While much attention has been paid to the developing world's high and low performers, the critical issues related to scientific capacity building may be most clearly revealed in countries like Mexico, where lessons of success and failure stand side-by-side.

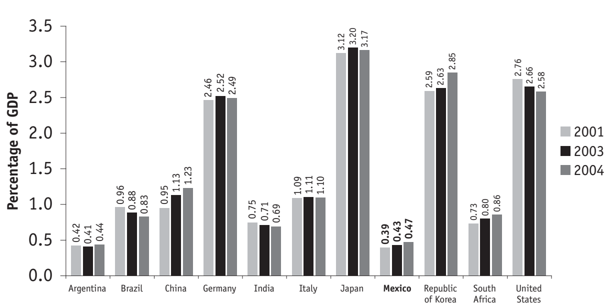
POPULATION[1]



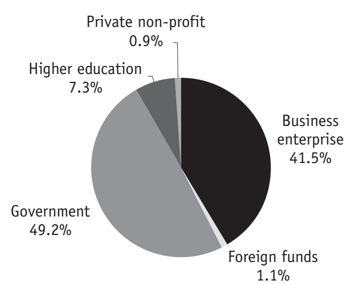
GROSS DOMESTIC PRODUCT (GDP)[1]



R&D EXPENDITURES IN SELECTED COUNTRIES[2]



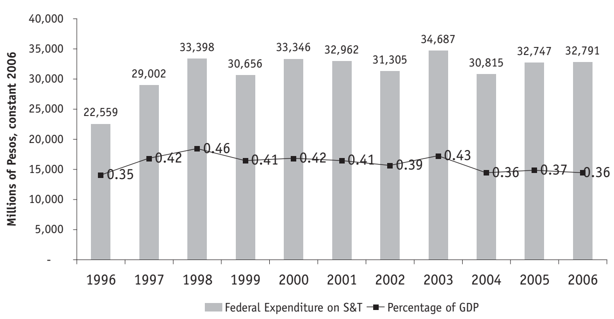
GROSS DOMESTIC EXPENDITURE ON R&D BY SOURCE OF FUNDS (2005)[3]



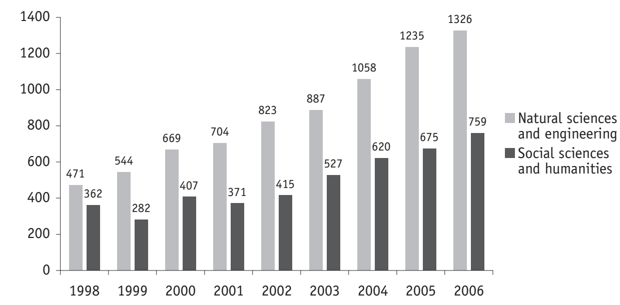
SCIENCE AND SOCIETY

and society in Mexico over the past decade

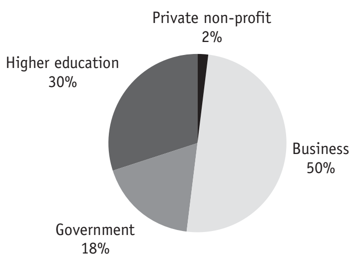
FEDERAL S&T EXPENDITURE[3]



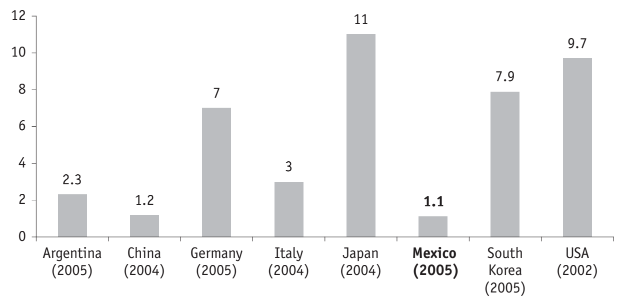
DOCTORAL DEGREES BY FIELD[3]



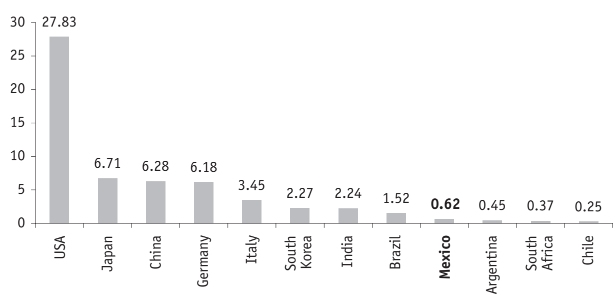
R&D PERSONNEL BY SECTOR (2005)[3]



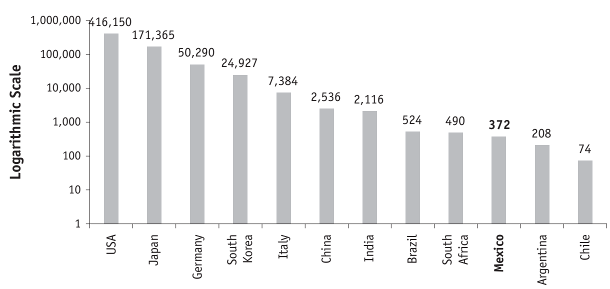
RESEARCHERS PER 1,000 LABOUR FORCE IN SELECTED COUNTRIES[3]



WORLD SHARE OF SCIENCE AND ENGINEERING PUBLICATIONS, SELECTED COUNTRIES AVERAGE 2003-2007[4]



US UTILITY PATENTS (GRANTED FOR INVENTIONS), SELECTED COUNTRIES AVERAGE 2003-2007)[5]



Sources: 1 - The World Bank Group, 2007; 2 - UNESCO; 3 - CONACYT, Mexico; 4 - TWAS; 5 - US Patent Office

GRANTS FOR RESEARCH

RESEARCH UNITS IN SCIENCE- AND TECHNOLOGY-LAGGING COUNTRIES ARE TOO OFTEN PREVENTED FROM REACHING THEIR FULL POTENTIAL BY A LACK OF RESOURCES. SINCE 2002, THE TWAS GRANTS FOR RESEARCH UNITS PROGRAMME HAS ASSISTED INNOVATIVE RESEARCH GROUPS IN THEIR EFFORTS TO ADDRESS THEIR COUNTRIES' DEVELOPMENT CHALLENGES.

Building on the success of its Research Grants Programme for individual scientists, in 2002, TWAS launched a project to recognize, support and promote the best research units in the world's least developed countries (LDCs).

TWAS's Grants for Research Units in LDCs programme is designed to advance one of the Academy's fundamental goals – to build and sustain research groups in the least developed countries. The aim is to help achieve a critical mass of innovative and highly qualified scientists who, by working on their nations' real-life problems, can contribute to sustainable development.

Thanks to support from the Swedish International Development Cooperation Agency's Department for Research Cooperation (Sida/SAREC), the grant programme was expanded in 2006 and made available to research groups not only in the 50 LDCs, but also in some 77 countries identified by TWAS as lagging in S&T capacity.

Each group receives a grant of up to US$30,000 for a one-year period (renewable for two additional years, subject to favourable evaluation). In 2007, TWAS funded 17 research groups in 13 countries – comprising 11 first-time awards and six renewals.

In what follows, we profile two TWAS-supported research units that are carrying out chemical and pharmacological studies of plants indigenous to their countries – the Democratic Republic of the Congo and Indonesia – in the search for new treatments for malaria and other diseases.

Natural product research and malaria

Each year more than 500 million people worldwide become seriously ill with malaria, and more than 1 million die from the disease, according to the World Health Organization (WHO). Some 90 percent of these deaths occur in sub-Saharan Africa; of these, most are children under the age of five. What make these statistics even more disturbing is that malaria is both preventable and curable.

Since 2004, the treatment of choice for malaria has been a natural product originally used in traditional medicine (TM). Artemisinin, which is derived from the plant *Artemisia annua*, was rediscovered by Chinese researchers screening traditional Chinese medicines in the 1970s. As with its predecessor quinine – another plant-based drug used in TM, and for over a century the only effective treatment for malaria – the success of artemisinin underlines the importance of research on natural products and traditional medicines (see box below).

Each group receives a grant of up to US$30,000 for a one-year period.

Two recent TWAS grants support research units – in Indonesia and the Democratic Republic of the Congo (DR Congo) – are seeking new plant-derived treatments for malaria as well as other major diseases. Both Indonesia and DR Congo are among the 17 'Like-Minded Megadiverse Countries' (LMMC), a group of countries formed in 2002 that the United Nations Development Programme (UNDP) has identified as being "rich in biological diversity and associated traditional knowledge."

Despite artemisinin's effectiveness, finding alternative treatments for malaria is important for two reasons. First, as happened with quinine and chloroquine, there is the likelihood that malaria parasites will develop resistance to the new drug. Indeed, to slow the development of any resistance, WHO recommends that artemisinin be used in combination with other drugs, in so-called artemisinin-based combination therapies (ACTs). Second, because the cultivation of *Artemisia annua* requires at least six months, and the extraction, processing and manufacturing of the final product an additional five months, artemisinin supplies

MALARIA REMEDIES FROM CHINA AND PERU

Artemisinin was rediscovered in the early 1970s when the Chinese government directed scientists to work on the 'task of combating malaria' (also known as 'Task #523') by searching through ancient works on traditional Chinese medicine.

Among hundreds of items screened was the unassuming shrub Artemisia annua *(annual wormwood), which the fourth-century Taoist alchemist Ge Hong (in his handbook 'Emergency Prescriptions to Keep Up One's Sleeve') recommended for fevers and malaria. While Ge Hong's more esoteric interests extended to methods for "rendering serpents and tigers harmless" and walking on water, he knew his medicinal plants. Researchers discovered that* Artemisia annua *did indeed possess potent antimalarial properties, and within a few years they had succeeded in isolating its active ingredient, called artemisinin.*

After years of hesitation, in 2004, international organizations including WHO, UNICEF and the Global Fund for AIDS, Tuberculosis and Malaria realized the efficacy of the drug and urged countries where malaria is endemic to adopt artemisinin-based therapies. Artemisinin has since replaced chloroquine as the preferred antimalarial.

Prior to the development of the synthetic drug chloroquine, in the 1940s, the only effective treatment for malaria had been quinine. Quinine is derived from the bark of the South American cinchona tree, and was being used as early as the 16th century by the Peruvian Indians to treat fevers. Jesuit missionaries brought cinchona bark back to Europe in the late 17th century, where it quickly became the primary treatment for malaria. In 1820, two French scientists succeeded in isolating the active alkaloid in the bark and named it quinine.

have been insufficient to meet global demand, and the treatment is costly. ACTs cost at least 10 times as much as traditional malaria drugs such as chloroquine.

By assisting the two research units profiled below, TWAS is supporting research that allies modern science and the latest technology with traditional medicine and the sustainable use of the developing world's biodiversity, in the search of treatments for diseases that affect millions worldwide. It is all part of the Academy's larger efforts to promote scientific excellence in the South.

BIODIVERSITY IN INDONESIA

"There is a remarkable variety of tropical flora in Indonesia," says Euis Hakim, Professor of Natural Product Chemistry at the Bandung Institute of Technology (ITB).

Indeed, this South-East Asian nation, an archipelago of some 17,000 islands (of which just under 1,000 are inhabited) spread out between the Indian and Pacific Oceans, is the world's second-largest mega-centre of biodiversity.

In 2007, Hakim's Research Group on Natural Product Chemistry, based in ITB's Department of Chemistry, in Bandung, Indonesia, received a TWAS Grant for Research Units to carry out chemical and biological evaluations of plants for potential antimalarial properties.

Although it covers only 1.3 percent of the Earth's land surface, Indonesia (with 40,000 species) possesses 10 to 12 percent of all known plant species, ranking first in the world for the number of palm species (400). "These bio-resources," Hakim says, "contain a vast number of chemicals with potentially immense value to humankind."

For the past fifteen years, Hakim's group has been conducting chemical and biological studies of indigenous Indonesian plants in the hopes of discovering new chemicals that will prove effective against infectious diseases, especially malaria.

"Malaria remains one of the most serious of global health threats," says Hakim. "Artemisinin has been extremely important, as less-expensive, traditional treatments such as quinine and chloroquine have become ineffective with the emergence of drug-resistant organisms. But the costs of producing it are quite high and production is limited."

BIODIVERSITY, TRADITIONAL MEDICINE AND SUSTAINABLE DEVELOPMENT

According to the World Health Organization (WHO), some 80 percent of the world's population use herbal medicines, and 25 percent of modern pharmaceuticals are made from plants first used traditionally. The use of traditional medicine (TM) is particularly important in the developing world. WHO estimates, for example, that up to 80 percent of the African population relies upon TM for their primary health care, while 50 percent of medicines sold in China are traditional herbal remedies. In 1996, in recognition of the value of African TM, WHO urged that it be integrated into the continent's public health systems.

The rediscovery of Artemisia annua*'s antimalarial activity highlights the importance of research into both natural products and the world's traditional medicines. It also adds urgency to calls to preserve the Earth's biodiversity, particularly in those developing countries, like the Democratic Republic of Congo and Indonesia, which are biodiversity rich but where the pressures of development are resulting in rapid species loss.*

Plant-based drug development based on traditional knowledge and local biodiversity has the potential to help solve developing countries' persistent health crises while at the same time contributing to their sustainable development. Medicinal plants can become cash crops, as Artemisia annua *has in China and Vietnam, and profits from the development of new drugs can be considerable.*

Alternatives to artemisinin

"In our efforts to discover a new class of plant-derived chemicals for the treatment of parasitic malaria," says Hakim, "we have studied several tropical plants endemic to Indonesia, in particular *Artocarpus*." The unit has investigated more than a dozen species of the genus *Artocarpus* (a member of the *Moraceae*, or mulberry, family), including the breadfruit (*A. altilis*) and jackfruit (*A. heterophyllus*) trees.

"Many species of *Artocarpus* are commonly used in traditional medicine in South-East Asia," Hakim adds. "For example, *A. heterophyllus* is used to treat fevers, stomach-ache and boils."

Indonesia possesses 10 to 12 percent of all known plant species.

Thanks in part to TWAS support, Hakim's research group has succeeded in isolating many phenolic compounds, primarily flavonoids with novel structural types, from *Artocarpus*. "Many of these flavonoids," she explains, "have unique features. Thus, we can guess that many of the medicinal properties of *Artocarpus* are due to these prenylated flavonoids found only in *Moraceae*." In view of these preliminary results, Hakim's team decided the *Artocarpus* species would be a good target for discovering new antimalarial lead compounds for pharmaceuticals.

"We have discovered and characterized more than 60 phenolic constituents to date, including 27 new chemical compounds," says Hakim. More importantly, she adds, "preliminary investigations indicate some of the compounds obtained from *Artocarpus* possess an antimalarial activity potentially equivalent to that of artemisinin."

Such positive results, she says, "show the necessity of continuing evaluation on this very specific class of natural chemicals characteristic of these particular plants." With funds from the TWAS Research Unit Grant, the group can continue its promising work.

"We are very optimistic about finding alternatives to artemisinin," Hakim says. The compounds that the group is looking at "are simpler in chemical terms" than artemisinin, she adds, and, in addition, "can be obtained from relatively large tropical trees."

Indeed, the stately breadfruit and jackfruit trees typically grow to 20 metres in height. In contrast, the wormwood shrub (from which artemisinin is derived) grows to less than three metres. If the group succeeds in deriving an effective antimalarial from *Artocarpus*, the cost of producing it should be lower, and supplies more abundant, than artemisinin.

Pushing boundaries

Hakim's unit has expanded its range of studies over time to include chemical profiling, pharmacology, plant tissue culture and biotechnology. Though they have "a relatively well-equipped laboratory," the TWAS grant allowed the purchase of additional equipment, including an incubator, biosafety cabinet and 46-litre lab storage vessel.

The group has gained recognition for its studies on several families of Indonesian indigenous plants, including *Moraceae* (mulberry), *Lauraceae* (laurel), and *Diptrocarpaceae* (dipterocarp). On the strength of its research work, it has recently been invited to participate, as co-investigator, in a five-year collaboration (2008–2013) with a research unit at the University of California, Berkeley (USA), sponsored by the International Cooperative Biodiversity Groups Program (ICBG).

"We hope to continue to push the boundaries of natural products chemistry research of Indonesian bioresources," says Hakim, "and to generate new knowledge, and so maintain our position at the forefront of the study and innovative utilization of these resources."


photo by B. Betzelt

> *We hope to continue to push the boundaries of natural products chemistry research.*

Sustainable use of biodiversity

"The TWAS grant will benefit our unit significantly," Hakim says. "It will allow us to build up our group and continue to develop our chemical and biological inventories of Indonesian plants for their sustainable utilization."

Indonesia has the world's third-largest contiguous area of tropical forests, which are among the planet's most diverse and biologically rich. Yet, it also has among the highest rates of tropical forest loss. According to the Indonesian government, since 2000, the nation has lost nearly 2 million hectares of forest each year. Such rapid deforestation, Hakim says, means time is of the essence when it comes to inventorying the tropical forest's bioresources for potential natural products.

Training additional hands to help in the task will also be crucial. And to this end, Hakim's unit is using some of the TWAS funds to develop the chemistry department's graduate studies programme.

"TWAS's support has allowed us to provide research grants for some of our doctorate students," she says. Without such assistance, she says, these promising young scientists, who have so much to contribute to their country's future, might never get such an opportunity. One testimony of the groups' growing reputation is that it now receives international applications to do doctoral and postdoctoral studies, with candidates from countries including Bangladesh, China, India and Malaysia.

Hakim is herself a graduate of the Bandung Institute of Technology, having received her doctorate degree from the institute in 1994.

The needs of the country

"The Indonesian government has now fully embraced science and technology," Hakim says. Through the ministries of national education and of research and technology, the government provides funding for research and development, has established postgraduate programmes in science and technology at Indonesian universities, and is setting up networks between a number of university research groups.

Yet, for the nation's researchers, obstacles remain. "Scientific researchers lack social prestige, remuneration is below levels of expectation and satisfaction, and there is inadequate communication between the scientific sector and other sectors of society," she says.

Moreover, Hakim adds, "Indonesian researchers are often more influenced by the international scientific community, in which many of them were trained, than by the national community." Consequently, they "tend to choose subjects on the basis of outside models rather than the specific needs of the country."

All the same, she says, "attitudes are slowly changing. And the national science policy bodies – including government departments, academic and research institutions – set up to promote research are having a positive effect on scientists' motivation."

Hakim is optimistic, both for her research unit and her country. "These native Indonesian plants we are investigating – in the genus *Artocarpus, Cryptocarya, Hopea, Macaranga*, etc. – are the source of unique chemicals with great potential for novel antimalarial drugs," she says.

Should the group succeed in finding new antimalarial compounds, she adds, "it would greatly benefit the socio-economic development of the country".

Hakim's plans for the future, she says, include "developing the unit into a 'centre of excellence' by continuing our research on structural chemistry, biosynthesis and biotransformation, combined with applied research, and increased collaboration with other research groups, both in Indonesia and abroad."

"We believe the knowledge and experience we are acquiring as a unit," Hakim says, "will open limitless possibilities for original work for the development of chemical science."

BOTANY IN DR CONGO

Virima Mudogo, Professor of Chemistry at the University of Kinshasa, in the Democratic Republic of the Congo (DR Congo), is convinced that his country's wealth of biodiversity and traditional medicinal knowledge, when allied with modern science and the latest research technology, can yield new solutions to the country's persistent health crises and poverty.

The DR Congo is, like Indonesia, one of the 17 members of the 'Like-Minded Megadiverse Countries' group. The Central African nation's 19 distinct ecosystems support some 11,000 plant species. Moreover, according to the WWF (formerly known as the World Wildlife Fund), more than a thousand of these species are found nowhere else on Earth.

With a landmass of 2.3 million km^2, DR Congo is the world's 12th largest country, about one-fourth the size of the United States. Yet, with an annual per capita GDP of US$300, it is also one of the world's poorest and least developed countries (LDCs).

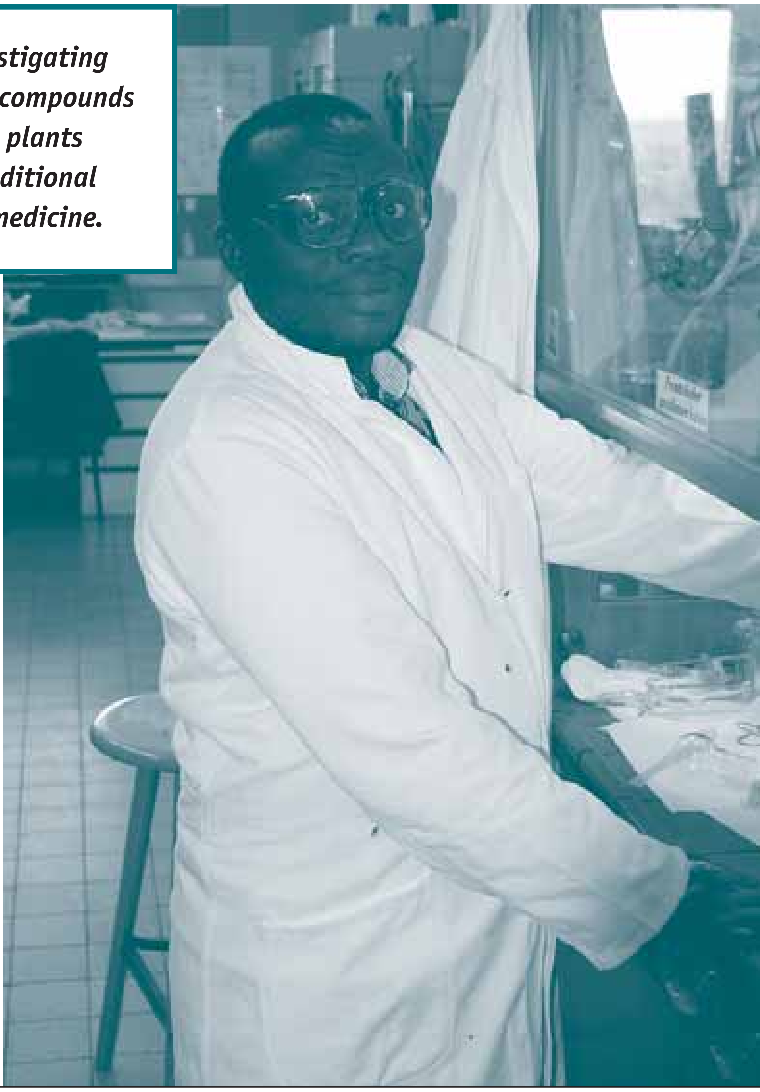
Traditional knowledge, modern science

"We are investigating the chemical structures and bioactive compounds of several plants used in traditional Congolese medicine," says Mudogo, "in the hope of developing novel drugs for malaria and other infectious diseases and for sickle-cell anaemia." Bioactive (or biologically active) chemical compounds are those that have an effect on living organisms, and thus potential medicinal uses.

Mudogo's research group, based in the Department of Chemistry of the University of Kinshasa, DR Congo, has received two TWAS Grants for Research Units (in 2004 and 2007) to support ongoing chemical and pharmacological investigations of a number of native plant species, selected on the basis of local ethnobotanical knowledge.

The research unit, which has pursued this research since 2002, began the project by surveying medicinal plant vendors in several markets in Kinshasa and Lubumbashi, to obtain from them the names of plants

We are investigating the bioactive compounds of several plants used in traditional Congolese medicine.



traditionally used to treat malaria and sickle-cell anaemia (drepanocytosis). "The vendors," Mudogo says, "mentioned more than a dozen plants used to treat drepanocytosis alone."

Malaria is endemic in DR Congo. According to WHO, the disease kills nearly one in ten children in the country every year, accounting for 45 percent of childhood mortality. In 2003, some 4.4 million people in the country were infected with the disease, and 16,500 died.

Sickle-cell anaemia represents another serious health problem in the region, affecting 300,000 sub-Saharan children every year. A chronic, inherited condition, drepanocytosis causes red blood cells to become sickle-shaped. It is considered to be fatal; most who suffer from it will die between the ages of 40 and 55.

Antisickling activity of basil

"Our aim in this project," says Mudogo, "is to study the bioactive compounds of these Congolese plants, and their biosynthetic origins," that is, how the plants produce these compounds. To do this, the team is using chromatographic and spectroscopic techniques, which allow them to separate the plants' complex mixtures of molecules into chemical compounds. They can then identify these compounds and measure the concentrations of any bioactive ingredients.

In their search for a cure for sickle-cell anaemia, Mudogo's group has tested more than 25 plants.

In their search for a cure for sickle-cell anaemia, Mudogo's group has tested more than 25 plants for their sickling reversal activities, including the common culinary herbs lemon grass (*Cymbopogon citratus*) and basil (*Ocimum basilicum*), which the Congolese have traditionally used to treat coughs, fever, malaria, sickle-cell anaemia and diarrhoea.

While many plants (including *C. citratus*) showed little or no antisickling activity, the results for others were quite promising. Basil shows particular potential to restore sickled cells to normal shape. "The ethanolic extract of *O. basilicum* exhibited a normalization rate of sickled cells of more than 50 percent," Mudogo explains. "The aqueous extract of the plant showed an even higher rate, over 70 percent." An extract of the leaves of *Alchornea cordifolia* (iporuru) also exhibited significant antisickling activity, with a normalization rate of nearly 75 percent.

So far, the group has established the antisickling activity of 11 Congolese plants, including *Ceiba pentandra*, *Annona senegalensis*, *Morinda lucida* and *Hymenocardia acida*.

The unit is also researching the photochemical degradation of the anthocyanins of basil, iporuru, *Morinda lucida* and *Annona senegalensis*. "This photochemical degradation," Mudogo explains, "is believed to be the basis of these plants' anti-drepanocytosis activity." Anthocyanins are the pigments responsible for the red and purple colours of a number of fruits, vegetables and flowers. "We are able to observe the photochemical degradation of the plant extracts by exposing them to a UV lamp," Mudogo adds.

Little-known vine

In their search for plant-based antimalarials, the research unit is investigating several species of Congolese *Ancistrocladus* for potential antimalarial activity. This tall, woody vine – which grows exclusively in the African and Asian tropical rainforests – was only recently discovered by researchers doing random screening for plants with bioactive compounds.

Though the vine has so far been little-studied, certain species of the genus have been shown to possess significant antibacterial activity against malaria parasites. Mudogo is hopeful one of the Congolese species of the genus may possess similar properties. *Ancistrocladus* was unknown in traditional medicines, Mudogo says, and its discovery underlines the importance of preserving the biodiversity of the tropical rainforests.

The Congo Basin has the world's second-largest rainforest (after the Amazon), constituting approximately one-fifth of the planet's remaining tropical forest. Scientists believe that thousands of plant species remain undiscovered in the world's rainforests, many of which risk being lost as a result of deforestation for agricultural land clearing.

Building capacity unit by unit

The grant from TWAS has been crucial, Mudogo says, and not just for his research unit, but for the University of Kinshasa as a whole, for which, since 2005, he has served as vice president, in addition to his research work and teaching duties.

"With TWAS's support," he says, "we have been able to train five talented young DR Congo scientists at the graduate level, as part of a larger effort to develop staff." Students working towards their MSc and PhD will be involved in research involving experimental chemistry and will also participate in seminars and conferences.

The TWAS grant also permitted Mudogo's group to purchase laboratory equipment needed for the chemical investigations, most importantly a spectrophotometer with which to perform spectroscopic investigations, as well as expendable laboratory supplies and literature. "This new equipment is most welcome in our institution," he says, "and it is now being used also by professors, senior scientists and students outside of our unit, both from our university and other institutions."

As such, Mudogo says, "the benefits of this grant constitute a real contribution to scientific capacity building in our country." The support of TWAS, he adds, is particularly important because of the general lack of research funding in DR Congo. "Unfortunately, the current situation for science researchers in our country is far from comfortable. Indeed, it is worsening. Our government doesn't give grants to researchers, and it remains very difficult to get foreign grants or scholarships here."

Based on the research work done with the support of the TWAS grant, Mudogo and his team have published articles in such international peer-reviewed journals as the *Journal of Organic Chemistry*, *Journal of Medical Sciences*, *International Journal of Pharmacology*, and *Phytochemistry*.

The group does not work in isolation. "In collaboration with the Department of Chemistry of the University of Botswana and the Institute of Organic Chemistry of the University of Würzburg, Germany," Mudogo says, "our unit is making real progress in the search for phytomedicines for malaria and sickle-cell anaemia."

The ultimate goal of the group's research, he says, is to "isolate natural products through total synthesis" that could eventually be made available as pharmaceuticals for these two diseases. Success in discovering such bioactive chemical compounds from indigenous plants, Mudogo emphasizes, could "prevent much suffering and also contribute to reducing the poverty in our country." ■

ALL IN THE FAMILY

WITH A MEMBERSHIP UNITING MORE THAN 900 SCIENTISTS FROM 90 COUNTRIES, TWAS IS BY ITS VERY NATURE A COLLABORATIVE ORGANIZATION. THE INTERACADEMY PANEL ON INTERNATIONAL ISSUES (IAP) IS THE ONE OF ITS CLOSEST PARTNERS.

In addition to its strong links with the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Abdus Salam International Centre for Theoretical Physics (ICTP), TWAS is closely affiliated with several Trieste-based organizations, including the Third World Organization for Women in Science (TWOWS) and the InterAcademy Medical Panel (IAMP), for which it provides administrative support and serves as the secretariat.

TWAS also works closely with the InterAcademy Panel on International Issues (IAP), a global network of 98 science academies worldwide, launched in 1993. TWAS, in fact, has hosted the IAP secretariat since May 2000. IAP's primary goal is to help member academies work together to inform citizens and advise decision-makers on scientific aspects of global issues.

IAP also seeks to bring member academies together to consider the scientific aspects of the problems the world faces today. While science and technology (S&T) play an ever-increasing role in our lives, traditionally most science academies have rarely engaged in public discourse and policy discussion. IAP, which, like TWAS, receives generous funding from the Italian government, was founded to help change this situation.

In addition to its flagship programme, which focuses on building capacity for science academies (particularly in developing countries), IAP supports several other projects coordinated by groups of member academies and regional networks. In what follows, we take a look at the IAP initiative on the science education of children.

SCIENCE EDUCATION FOR CHILDREN

Interest in studying science is declining among youth worldwide. This is a cause of concern not just for the scientific community but also for policy-makers. It is especially important for young people to be attracted to the sciences in developing countries, where the hope of achieving sustainable development will largely depend upon training upcoming generations in S&T.

Recognizing that the future depends upon the education of youth, IAP has created a programme devoted to improving science education at the pre-secondary level and to attracting more young people to the sciences. IAP's Science Education of Children project promotes the adoption of 'inquiry-based science education' (IBSE), which features a 'hands-on', problem-solving approach, in which students perform experiments, are encouraged to think critically, and become active participants in the learning process (see box, page 38).

The objective of IAP's programme, says its coordinator Jorge Allende, "is to demonstrate the virtues of the IBSE method" to member academies and to advocate the

TWAS FAMILY

TWAS played a key role in the establishment of the ***Third World Organization for Women in Science (TWOWS)****, which, launched in 1993, counts more than 2,700 members representing over 80 countries in the South. Its main objectives are to promote women's leadership in science and technology in the South and to strengthen their participation in science-based development. Its secretariat is hosted by TWAS. For additional information, see:* www.twows.org.

The ***InterAcademy Medical Panel (IAMP),*** *an association of the world's medical academies and medical divisions of science academies, was established in 2000 and comprises 64 member academies. It aims to strengthen the role of academies in building scientific capacity for health, and in providing advice to national governments and international organizations. In 2004, IAMP relocated its secretariat to the TWAS headquarters. For more information, see:* www.iamp-online.org.

For additional information on the ***InterAcademy Panel on International Issues (IAP)****, the third member of TWAS's immediate family, see:* www.interacademies.net*; on IAP's Science Education of Children programme, see:* www.interacademies.net/CMS/Programmes/3123.aspx.

creation of IBSE initiatives in schools. In particular, the programme seeks to generate regional efforts in the Americas, Africa and Asia, and to stimulate collaboration among the academies of each region focusing on applications of the 'hands-on' teaching method.

The programme "is essentially catalytic," explains Allende. "Like other IAP initiatives, it channels many of its activities through regional networks of academies." With the Chilean Academy of Science as IAP's lead academy for this project, the science education programme has prompted activities in some 20 national academies.

In addition to its role as a catalyst and as advocate of the IBSE approach, last year IAP formed an International Oversight Committee to provide assistance to its member academies in evaluating and comparing the practices and outcomes of IBSE programmes being carried out around the world. "So far," Allende says, "the committee has provided advice to the Chilean and Colombian programmes."

The Academy tries to sow the seeds of future inquiry-based teaching programmes. "Right now the greatest challenge for the science education programme," Allende says, "is to obtain support for pilot projects in other countries, especially in Africa."

Once a new IBSE project begins to take root, IAP leaves the details of establishing the programme to the individual academies. "National academies are encouraged to engage ministries of education, teachers associations and community leaders to help support and finance a project," Allende explains.

In its role as a clearing house for information and best practices on IBSE, IAP maintains an interactive internet portal, 'Teaching Science', in cooperation with the International Council for Science (ICSU), highlighting national curricula in science education (*www.icsu.org/8_teachscience/icsu-iap*).

DECLINING INTEREST

In advocating the adoption of inquiry-based education methods, IAP has two goals: to improve the quality of pre-secondary science teaching and to attract more young people to science.

The latter goal is crucial. That's because, despite the growing importance of S&T in today's world, many countries are witnessing a worrisome decline in interest in studying these subjects among youth. A recent study by the Organisation for Economic Co-operation and

NEW APPROACH TO TEACHING

In the past two decades, a new approach to teaching science to children has been gaining support worldwide. 'Inquiry-based science education' (IBSE) involves a 'hands-on' approach, where students learn by doing – performing experiments, making predictions and testing hypotheses.

Taking advantage of their great curiosity, the method encourages children to think critically and to formulate questions and explanations (i.e., theories). In this way, students not only learn science but develop scientific habits of mind.

While students in traditional science classes also conduct experiments, these are mostly used to illustrate concepts that have already been presented by the teacher. In the hands-on approach, they are part of the process of discovery. IBSE does not do away with all lectures and reading assignments, of course, but emphasizes the children's active participation and inquiry.

In addition to developing reasoning and problem-solving skills, children in inquiry-based classes show significant improvement in their reading and writing abilities. The IBSE method requires students to record the results of experiments, and the effort required to articulate their ideas builds children's verbal skills. Another plus: teachers report that the IBSE approach is also helping more girls to become interested in science.

Development (OECD), for example, reveals that the percentage of graduates pursuing a PhD in S&T has declined in all European countries.

While there are, no doubt, many reasons for the decline in interest (including public perceptions of scientists in society and lower income potential compared with other fields), it is widely agreed that a chief cause is the way science is taught in schools.

"This decline in interest in science among youth," says Yves Quéré, former co-chair of IAP, "is a result of two main factors: students tending to think of science as both more difficult and more boring than other subjects, and salaries being lower in science than in other fields."

For this reason, Quéré says, "it is crucial to show very early on – that is, to young children – that science is not more difficult than, say, history or languages; and that, moreover, when presented as an exploration of the natural world, it is exciting."

In the traditional science classroom, teachers lecture on abstract concepts and the history of scientific progress, while students take notes and are expected to learn facts and figures by rote. Children too often get the impression that science is a dry, unimaginative subject, having little to do with their lives.

Because these traditional teaching methods are also the norm in the developing world, there is a concern that these countries' prospects for development through scientific advancement are being hindered by a failure to fully engage young people in science.

Allende believes that the IBSE method will not only encourage more young people to go into science, but that it will also help bridge the gap between scientists and lay people. "Teachers tell us that many children in IBSE classes express a desire to become scientists," he says. "Yet, even those students who don't actually do so will be more likely to develop an appreciation of the values of science and scientists."

PREPARING FUTURE CITIZENS

IAP recommends that children begin to be taught science at the primary level (4 to 6 years of age), or even in nursery school (3 to 5 years). There is ample evidence that children, even at a very young age, are capable of building upon their natural curiosity to develop logical thinking.

In addition to nurturing budding young scientists, effective science education opens children's minds to the wonders of the natural world and the elegance of scientific investigations. By developing rigour of thought, inculcating scientific ethics, and teaching the value of cooperation, it also helps to build responsible citizens.

"Inquiry-based science education trains children's minds in the critical thinking needed to handle the complexities of today's global and knowledge society," Allende says. The provision of such an education "will help ensure that future citizens will understand and respect science and scientists, and possess the values of rigorous assessment and tolerance of opinion that are inherent to scientific inquiry and necessary for the well-being of society."

Inquiry-based science education trains children's minds in critical thinking.

CHILDREN IN CHILE

As well as serving as coordinator for IAP's Science Education programme, Allende directs the Chilean 'Inquiry-Based Science Education for Children of Elementary Schools' programme. Launched in 2003, with the support of the Chilean Academy of Sciences and the Ministry of Education, Chile's programme began in 24 schools in the poorer neighbourhoods of Santiago, the country's capital.

Today it includes 260 public schools, both rural and urban, located in all 15 regions of the country, reaching 90,000 underprivileged children from kindergarten to the eighth grade. The programme, Allende explains, "is aimed at children aged 6 to 13 years, who are taught chemistry, physics and biology using the inquiry-based approach."

"Unlike traditional methods of teaching science in Chile," Allende adds, "which emphasize lecturing and have few hands-on components, children in the IBSE programme are given problems to solve and are encouraged to form their own theories, which they then test by conducting experiments."

The project "has been extended to schools for children with learning disabilities," Allende says. "We are now drawing up plans to expand the programme in the next three years to cover 300,000 children, which is 15 percent of the total number of primary school students in Chile," he adds.

KIDS LIKE EXPERIMENTS ...

"Children really enjoy this new type of science class," says Allende. "They like learning by doing and working in groups. They are highly motivated to ask questions and to search for new areas in which they can apply the concepts they have learned."

Indeed, the success of the inquiry-based method was immediately apparent during the 2003 pilot project phase. On the days the children had science class, attendance increased. There were even some parents who came to the school asking to see the experiments their children had told them about.

Educators, of course, must be retrained to adopt the new methods. "Initial and sustained professional development of the teachers in applying the methodology – as well as provision of the right materials – are essential components for the success of this type of education," Allende says.

IBSE IN THE WESTERN HEMISPHERE

Among the regional IBSE initiatives IAP has helped to launch is that of the Inter-American Network of Academies of Sciences (IANAS), a regional network of science academies in the Western hemisphere. IANAS was founded in 2004, and in the same year it launched the IAP-assisted Regional Programme in Science Education, which organizes science education courses, workshops and fellowships in 15 countries in the Americas.

In November 2007, the IAP/IANAS Science Education Programme was named a Hemispheric Initiative by the Ministers and High Authorities of Science and Technology, of the Organization of American States (OAS), at their first meeting, in Lima, Peru. Besides strengthening existing IBSE initiatives in the region, says Jorge Allende, the IAP/IANAS programme has launched new projects in Bolivia, Panama, Peru and Venezuela.

... BUT SOME TEACHERS NEED CONVINCING

Reforming science education and adopting the IBSE method does not happen overnight however. "Dramatically changing the way science is taught takes time," says Quéré.

Teachers often resist the change. "Many pre-secondary teachers, worldwide," he explains, "prefer either not to teach any science at all, or to do it in a very conventional way (writing a scientific concept on the blackboard that the children have to learn by heart)."

Yet, once they have tried the IBSE method, Quéré says, "teachers are impressed by the students' excitement." The enthusiasm of the children is obvious. "When you visit a classroom in which the IBSE method is used," he says, "whether it is in Colombia, France, Malaysia, Senegal or Sweden, you see right away that the children no longer think of science as boring. They just like it."

"The enthusiastic reaction of the kids," adds Allende, "obviously results in a very positive attitude of the teachers, who are likewise greatly stimulated by the new approach." As one teacher explains, "when we would give lectures only, it could be hard to keep students' attention. Now, they are very eager to do the experiments, to ask questions, and to discover new things."

In 2007, the coordinators of the Chilean programme were invited to report on their success to the Chilean House of Representatives' Education Committee. "What prompted the invitation," says Allende, "was the experience of a congressman who had visited a local school. He asked the children what was their favourite subject. They all shouted out at once, 'Science!'."

Dramatically changing the way science is taught takes time.

LA MAIN À LA PÂTE IN FRANCE

Georges Charpak, the 1992 Nobel Prize winner in physics, introduced the IBSE method to France in 1996. Charpak was a colleague of Leon Lederman, who had originated the method in the 1980s, in poor neighbourhoods in Chicago (USA). Lederman received a Nobel Prize in physics in 1988.

Charpak, together with Yves Quéré and Pierre Léna (members of the French Academy of Sciences), launched the *La Main à la Pâte* (literally, 'hands in the dough') programme with the support of the French Academy of Sciences and the Ministry of Education.

The goal of *La Main à la Pâte* is to renew and develop science teaching in primary schools in France, while also contributing to the same goal internationally. It recommends teachers implement an inquiry-based approach that combines exploration of the world, experimentation and reasoning, and mastery of language. The initiative, explains Quéré, "seeks to develop curiosity, creativity and critical thinking."

In collaboration with the IAP Science Education Programme and the French Academy of Sciences, *La Main à la Pâte* has been widely implemented abroad. The programme's staff is regularly asked to collaborate with and train foreign delegations, organize training sessions, and contribute to the renewal of science teaching internationally.

"The international activities of *La Main à la Pâte*," notes Quéré, "are an integral part of IAP's Science Education Programme." The French programme has cooperative agreements to improve science education with more than 30 countries around the world. Among its best-established international collaborations are those with Brazil, Cambodia, China, Colombia, Egypt and Serbia.

In 2007, the *La Main à la Pâte* team, together with the French Academy of Sciences, published *The International Action of La Main à la Pâte: Teaching Sciences at Primary School*. The booklet provides an overview of the initiative's many international activities and describes success stories (copies are available at: *www.inrp.fr/lamap/index.php?Page_Id=1179*).

LEARNING BY DOING IN CHINA

The most successful *La Main à la Pâte* international cooperation initiative has undoubtedly been that with China, which began shortly after the French project was launched.

China's 'Learning by Doing' programme, launched in 2001, aims to reform pre-secondary science education in the country. Historically, says Wei Yu, director of the Research Centre for Learning Science, Chinese Ministry of Education, "pre-secondary science education was based largely on children memorizing information."

HISTORY OF AN IDEA

The IBSE approach originated with Nobel laureate Leon Lederman, who oversaw its application in schools in the poorer neighbourhoods of Chicago, Illinois (USA), in the early 1980s.

Following the success of this programme, in 1985 the Smithsonian Institution and the US National Academies of Sciences established the National Science Resources Center (NSRC), which has assisted more than 700 school districts in the country to adopt IBSE programmes.

The NSRC – whose stated goal is to improve the learning and teaching of science both in the US and throughout the world – extends its work internationally through IAP.

In 1996, Nobel laureate Georges Charpak founded the La Main à la Pâte *programme in France, which has had great success introducing the IBSE method, not only to the majority of French pre-secondary schools, but also, in collaboration with the IAP Science Education Programme, to several countries around the world.*

A joint initiative of the Chinese Ministry of Education and the Chinese Association of Science and Technology (CAST), Learning by Doing benefits from the expertise of scientists and researchers in learning-related neuroscience, as well as educators.

In 2002, the French Academy of Sciences and the Chinese Ministry of Education began an exchange programme between *La Main à la Pâte* and Learning by Doing, headed by Wei. Collaboration has included the translation into Chinese of textbooks, initially developed by *La Main à la Pâte* and now jointly.

After a pilot phase involving four cities (Beijing, Nanjing, Shanghai and Shantou) and 44 schools, the Chinese Ministry of Education approved a broad national initiative for the IBSE project. Some 200,000 school children, in 400 schools in 20 cities, are now involved in the programme, says Wei.

UNIVERSAL APPEAL

One of the virtues of inquiry-based science education is that it can be adapted to a nation's specific cultural and educational requirements. IAP's International Oversight Committee encourages those involved in initiatives around the globe to share their experiences in adapting the method to their particular country or region.

"The universality of science is an essential ingredient of this international collaboration and endeavour," says Quéré. "The names of the programmes may differ, but the method is essentially the same everywhere."

"Another appealing aspect of IBSE," he adds, "is that the developed world is no farther ahead on this than the developing world." Teachers from the North and South can therefore have a very balanced dialogue.

Moreover, the method is well adapted for developing countries. "It does not require a lot of money," Quéré explains. "For example, in Brazil, scales and small balances commonly used in experiments can be bought for less than US$1 each. And many local materials (plants and minerals) can be used."

Inquiry-based education is rapidly gaining advocates around the world. "An increasing number of workshops and symposia," says Quéré, "makes it clear that there is a growing trend, worldwide, to adopt the IBSE methods."

"IAP has played a crucial role in this expansion," he adds.

By helping to reform and improve pre-secondary scientific education and to attract more young people to science, the IAP Science Education programme is investing in our common future.

"Scientists have always known that science can be fun and exciting," says Allende. "It is just a matter of letting young students in on the secret." ■

PEOPLE, PLACES, EVENTS

REAPPOINTED MINISTER

• Peter Msolla (TWAS Fellow 1989) has been re-appointed Tanzania's Minister of Communication, Science and Technology. Msolla, who earlier served as professor of veterinary medicine and deputy vice chancellor of Sokoine University of Agriculture in Morogoro, Tanzania, has also been Minister of Agricultural and Food Security and Co-operatives and Minister for Higher Education, Science and Technology.

Peter Msolla

BLUE PLANET

• José Goldemberg (TWAS Fellow, 1990) has been awarded the 2008 Blue Planet Prize by the Asahi Glass Foundation (Japan). The Prize, established in 1992, bestows two awards each year to individuals and organizations that have made significant contributions to addressing global environmental problems. Each recipient receives 50 million yen (US$500,000). Goldemberg was honoured for helping to formulate policies that have improved energy use and conservation; for devising the pioneering concept of "technological leapfrogging"; and for exhibiting strong leadership in preparation for the 1992 Rio Earth Summit. He is professor of physics at the University of São Paulo and visiting professor at the International Academy of the Environment in Geneva, Switzerland. Goldemberg is a member of the Brazilian Academy of Sciences, the Academy of Sciences of the State of São Paulo and the Brazilian Association for the Advancement of Science.

José Goldemberg

BACK ON THE RANGE

• Elly Sabiiti (TWAS Fellow 2001), professor of crop sciences and former dean of the Faculty of Agriculture at Makerere University, Uganda, has been re-appointed to the Continuing Committee of the International Rangeland Congress (IRC). He also serves as IRC vice president for sub-Saharan Africa. In addition, Sabiiti has won Uganda's Presidential Science and Technology Education Excellence Award for helping to advance our understanding of the ecological dynamics of rangelands and for science education and institutional building in the agricultural sciences. In addition, he is a recipient of the Makerere Vice Chancellor's Innovation and Academic Excellence Award for 2007/2008, which was given to him for his research on dryland husbandry. Sabiiti serves as vice president of the Uganda National Academy of Sciences, president of the Association of Uganda Professional Agriculturalists and chair of the TWAS Advisory Committee on Agricultural Sciences. He is a member of 15 professional societies and a fellow of the African Academy of Sciences.

Elly Sabiiti

HEVESY MEDAL AWARD

• Syed M. Qaim (TWAS Associate Fellow 2001) has received the Hevesy Medal Award 2008 for his outstanding research on chemical isomer shifts in Mössbauer spectroscopy and for pioneering fundamental investigations on complex particle emissions and isomer distributions in nuclear reactions. He is also being honoured for his outstanding studies on nuclear data related to fusion reactor technology and medicine and for the development of novel cyclotron radionuclides for medical applications. Qaim is advisor to the Institute of Nuclear Chemistry, Research Centre Jülich, and professor of nuclear chemistry at the University of Köln, Germany. Qaim's other honours in-

Syed M. Qaim

clude the Eötvös Medal and Honorary Fellowship of the Hungarian Physical Society; Becquerel Medal of the Royal Society of Chemistry, London; Medal of Honour from the Egyptian Atomic Energy Authority; and the Sitara-i-Imtiaz, Pakistan.

BEST LETTER

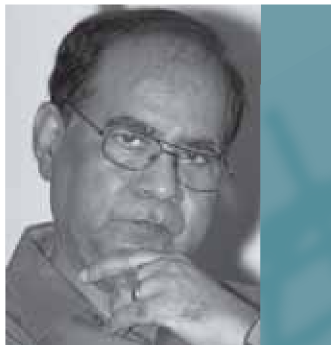
• Farouk El-Baz (TWAS Fellow 1985) and Eman Ghoneim, both professors at Boston University, USA, were given the Taylor and Francis Best Letter Award by the Remote Sensing and Photogrammetry Society of the United Kingdom

Farouk El-Baz

for their research paper, "Largest crater shape in the Great Sahara revealed by multi-spectral images and radar data," published in the *International Journal of Remote Sensing* in 2007. El-Baz is research professor and director of the Center for Remote Sensing at Boston University. He has received many honours, including four honorary doctorates, Egypt's Order of Merit, the Human Needs Award by the American Association of Petroleum Geologists, AAAS's Award of Public Understanding of S&T and NASA's Exceptional Scientific Achievement Award. He is a member of the US National Academy of Engineering and the African, Arab, Islamic and Hassan II Academies of Science.

MEMORIAL AWARD

• Baldev Raj (TWAS Fellow 2006) was awarded the 2008 Professor Jai Krishna Memorial Award. The annual award is given to an eminent

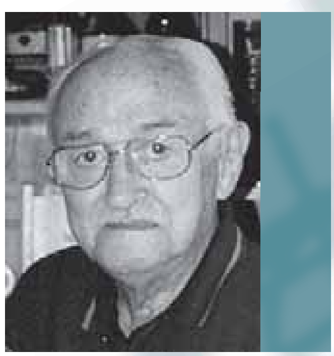


Baldev Raj

engineer by the Indian National Academy of Engineering. Raj has also been inducted into the German National Academy of Sciences Leopoldina in engineering physics. He is a distinguished scientist and director of the Indira Gandhi Center for Atomic Research in Kelpakkam, Tamil Nadu, India.

IN MEMORIAM

• Gustavo Hoecker Salas (TWAS Fellow 1988), professor in the Faculty of Medicine, University of Chile, Santiago, passed away in August 2008 at age 93. Hoecker Salas was educated in Chile and the UK and served as full professor and first dean of the Faculty of Sciences at the



Gustavo Hoecker Salas

University of Chile in Santiago. He was also director of the Chagas Research Project at the World Health Organization, Special Programme for Research and Training in Tropical Diseases. For his contributions to the medical sciences, he was given the National Science Award and elected a fellow of the Chilean Academy of Sciences.

• Ibrahima Diop-Mar (TWAS Fellow 1987), one of Africa's most eminent medical doctors and scientists, passed away in August 2008 at age 87. Diop-Mar was the director general of the Islamic World Academy of Sciences in Amman, Jordan. He was educated in Dakar and in Bordeaux, France, where he obtained a diploma in tropical medicine and a state doctorate in medicine. For his achievements in the medical sciences, he received the UN Medal, Congo; Commandeur, Ordre Nationale du Lion Senegalais; Com-

Ibrahima Diop-Mar

mandeur, Palmes Academiques Francaises; and Officier, Legion d'Honneur, France. He was a member of the French Academy of Medicine and the African Academy of Sciences, and was founding fellow of the Islamic World Academy of Sciences.

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**

WANT TO KNOW MORE?

TWAS and its associated organizations offer scientists in the South a variety of grants and fellowships. To find out more about these opportunities, check out the TWAS website: **www.twas.org**

FELLOWSHIPS

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

TWOWS offers postgraduate fellowships to women from least developed countries (LDCs) and other countries in sub-Saharan Africa: **www.twows.org/postgrad.html**

GRANTS

Are you a scientist seeking funding for your research project? Then take a look at the TWAS Research Grants scheme: **www.twas.org/mtm/RG_form.html**

Is your research group seeking additional funds? See if it is eligible to apply under the TWAS Research Units programme: **www.twas.org/mtm/research_units.html**

EQUIPMENT

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

TRAVEL

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

CONFERENCES

Are you organizing a scientific conference and would like to invite guest speakers from developing countries? You may find the help you need here: **www.twas.org/mtm/SM_form.html**