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*twas*

# TWAS newsletter

NEWSLETTER OF THE ACADEMY OF SCIENCES FOR THE DEVELOPING WORLD



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**A NEW TRIESTE-BASED INTERNATIONAL SCIENCE PRIZE HONOURING OUTSTANDING SCIENTISTS FROM DEVELOPING COUNTRIES PROMISES TO BESTOW PRESTIGE AND VISIBILITY TO DESERVING RESEARCHERS LIVING AND WORKING IN THE SOUTH.**

TWAS, the Academy of Sciences for the Developing World, and illycaffè, one of the world's premier coffee manufacturers, have launched the Trieste Science Prize. The announcement took place in November at the TWAS 15<sup>th</sup> General Meeting in Trieste, Italy.

The prize, which carries a US\$50,000 cash award, is designed to honour the most eminent scientists in the developing world. The first two prizes will be awarded in 2005 in the fields of physics and biology. In subsequent years, prizes will be given in the fields of mathematics and medical sciences (2006), chemical and agricultural sciences (2007), and earth and engineering sciences (2008).

The 2005 prize winners will be announced this autumn.

"The Trieste Science Prize," notes C.N.R. Rao, president of TWAS, "is in many ways a sym-

bol of Trieste's growing reputation as a 'city of science', especially among countries in the developing world. On a global scale, the prize will give much needed recognition to the best scientists in the South."

Among the international science institutions that call Trieste their home are the Abdus Salam International Centre for Theoretical Physics (ICTP), the International Centre for Genetic Engineering and Biotechnology (ICGEB), the International Centre for Science and High Technology (ICS), the Third World Network of Scientific Organisations (TWNSO), the Third World Organisation for Women in Science (TWOWS), the InterAcademy Panel on International Issues (IAP) and the InterAcademy Medical Panel (IAMP).



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# TWAS, illycaffè launch Trieste Science Prize

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*“The primary purpose of the prize,” notes Mohamed H.A. Hassan, TWAS’s executive director, “is to highlight the enormous contributions that developing world scientists are making to international science. Only three scientists living and working in the developing world have received the Nobel Prize since its inception more than 100 years ago. We hope that the prize will help raise the visi-*

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*bility of the world-class science now being conducted by scientists in the South. This trend, which has picked up a great deal of momentum over the past decade, is likely to accelerate even more in the near future.”*

*“illycaffè,” notes Andrea Illy, the company’s chief executive officer, “is delighted to be sponsoring the prize. The nature of our business has allowed us to nurture close relationships with coffee growers throughout the developing world. We have long recognized that the well-being of our business depends on the well-being of our business associates, many of whom reside in the South.*

*“That’s why for many years, illycaffè has adopted a business strategy that calls for increasing the know-how of coffee growers. The strategy, which culminated with the creation of courses and seminars on the science of coffee growing co-sponsored by the University of São Paulo, Brazil, and the funding of experts who have conducted field demonstrations and on-site workshops in Colombia and Guatemala, has worked as well for us as it has for our partners. We also fund annual award programmes to honour the best coffee growers. This year’s competition drew more than 800 applicants and the winner received a cheque for US\$10,000.*

*“Our experience,” continues Illy, “has reinforced our belief that the only way to effectively address the problems of the developing world is through transferring knowledge and recognizing and rewarding excellence. For these reasons, illycaffè is delighted to partner with TWAS in sponsoring the Trieste Science Prize”*

*For additional information about the Trieste Science Prize see [www.twas.org](http://www.twas.org).*



# ANNIVERSARY PLUS ONE

C.N.R. RAO DESCRIBES WHY 2004, COMING ON THE HEELS OF TWAS'S BANNER 20TH ANNIVERSARY YEAR, PROVED TO BE SUCH A GOOD YEAR FOR THE ACADEMY IN ITS OWN RIGHT.

**T**WAS's 20<sup>th</sup> anniversary celebration in Beijing, China, in 2003, hosted by the Chinese Academy of Sciences, was a singular event. It would indeed be difficult to replicate the excitement, visibility and impact accompanying the full range of Academy activities that took place during our anniversary year.

However, 2004, in its own right, has also been an eventful year for TWAS.

The year was highlighted by two high-profile events: one that took place in January and the other that took place in November.

6 January 2004 was a historic day for the Academy, as the Italian government unanimously voted TWAS's annual budget into permanent law, thereby ensuring the Academy's long-term survival and financial well-being.

The Italian government has been extraordinarily generous in its support of TWAS ever since the Academy's inception 21 years ago. But

funding has usually come in one-year allotments.

Now that the Italian government has passed the TWAS budget into law, funding for the Academy will be on much firmer ground, ensuring financial stability in the years and decades ahead.

This stability carries responsibilities and opportunities.

I can state unequivocally that TWAS will embrace both – through the creation of stronger and more wide-ranging programmes; through more numerous and effective partnerships with other scientific organizations; and, most importantly, through a renewed commitment to put science to work to improve the economic and social well-being of people living in the developing world.

On 19 November 2004, as the close of the year approached, TWAS experienced another major event, when, at a ceremony held in the town hall of Trieste, illycaffè – in the presence of Trieste's mayor and other public officials – announced

that it would sponsor the Trieste Science Prize. illycaffè has asked TWAS to administer the awards competition, representing an unusual, and welcome, display of a public-private partnership for the advancement of science in the South (see pages 2-3).

The prize is important for many reasons – not the least of which are the prestige that it will bring to Trieste, the 'city of science', and the opportunities that it will provide to showcase the contributions that prominent scientists living and working in the developing world have made to the global scientific community.

The US\$50,000 cheque accompanying each of the two Trieste Science Prizes that will be given annually will make the awards among the most prestigious given to scientists in the South.

Thus, thanks to the generosity of the Italian government, TWAS began 2004 on a high note marked by a historic event in Rome that will ensure the Academy's future.

And, thanks to the generosity of one of Trieste's most prominent and socially responsibly corporate citizens, illycaffè, TWAS concluded 2004 on another high note marked by a new awards programme that promises to bring even greater visibility both to Trieste and the Academy – and, more importantly, that will help advance the core goal which has driven TWAS for the past two decades: the promotion of scientific excellence in the developing world.

sponsored by the governments of Brazil, China and India. The closing date for the first round of applications was 31 October. Recipients of the first fellowships will be announced later this spring. Some 150 promising young scientists will benefit from this programme by participating in research programmes in centres of excellence in the three sponsoring countries. Pakistan has agreed to sponsor an additional 20 fellowships and efforts will continue to bring additional nations on board.

- Launching of TWAS regional offices in Brazil, India and Kenya, which join TWAS's regional office in China, as part of an on-going effort to strengthen the Academy's presence at the regional level (see pages 23-26). Each of these offices – Egypt will soon be added to the list – will work closely with the TWAS secretariat in Trieste on a range of activities. These activities include: helping to identify and bring to the attention of the TWAS secretariat eminent scientists within their regions, especially scientists from nations that have not been well represented in the Academy; hosting regional conferences and workshops; and informing young scientist about the opportunities afforded to them by the Academy's research and fellowship grants programmes.

- Implementation of the second round of TWAS grants for research units in least developed countries (LDCs). The programme is designed to give a significant boost to research units that have done admirable work under difficult conditions. The effort is part of the Academy's strategy to target funds to people and places in the developing world where they are most needed. To date, some nine research units in LDCs have been given three-year grants of up to US\$90,000 to assist their work.

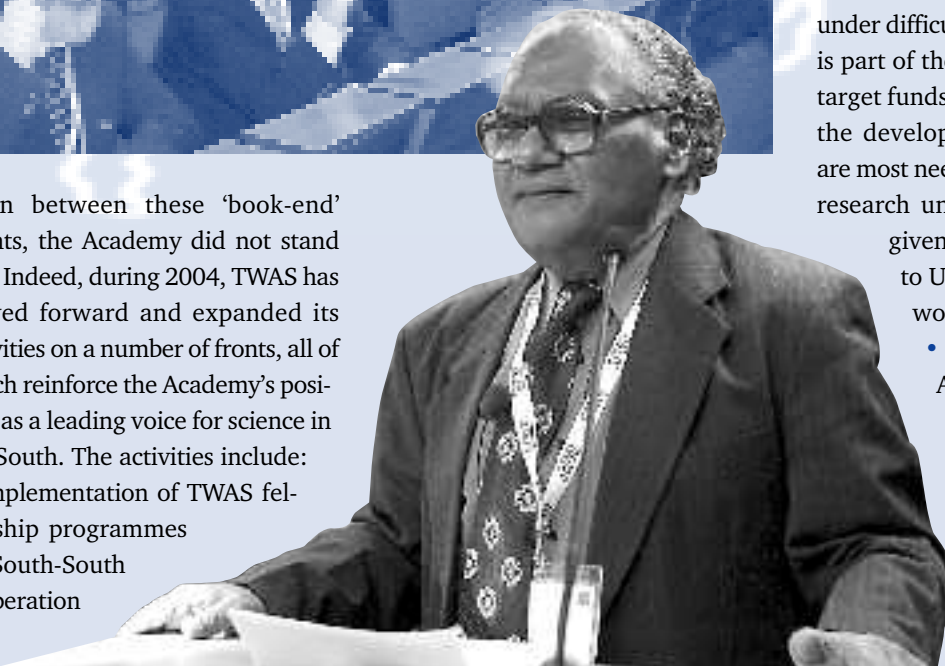
- Arrival of the Inter-Academy Medical Panel (IAMP) secretariat from the US National Institutes of Health in Washington, DC (see pages 49-50). IAMP is a global network

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In between these 'book-end' events, the Academy did not stand still. Indeed, during 2004, TWAS has moved forward and expanded its activities on a number of fronts, all of which reinforce the Academy's position as a leading voice for science in the South. The activities include:

- Implementation of TWAS fellowship programmes for South-South cooperation



[CONTINUED PAGE 6]

## NAME CHANGE

*TWAS has changed its name. Reflecting the growing visibility and impact of TWAS in science, participants at the 15<sup>th</sup> General Meeting agreed to rename the organization TWAS: the Academy of Sciences for the Developing World. We thank the membership for the year-long discussions that took place leading to this change in nomenclature. As several members noted, the Academy's mission and goals remain unchanged: the promotion of science in the South and an unwavering commitment to science-based development throughout the developing world.*

of more than 50 medical research academies or medical divisions within science academies. IAMP joins the Trieste-based Third World Network of Scientific Organizations (TWNSO), the Third World Organization for Women in Science (TWOWS), and the InterAcademy Panel on International Issues (IAP). These organizations form part of an expanding constellation of scientific institutions dedicated to the advancement of global science, particularly the advancement of science in the South, that now function under the administrative umbrella of TWAS.

- Publication of the TWAS Strategic Plan (2004-2008), which provides a roadmap for the Academy for the next five years. The plan calls on TWAS to extend its efforts from the promotion of science in the South to the promotion of science-based sustainable development. The goal is to help developing nations to apply scientific knowledge and know-how in ways that effectively address critical social and economic issues. This will require greater Academy interaction with policy communities through-

out the developing world and greater public visibility. The success that TWAS achieves on these fronts will depend not only on efforts to enhance the work of the scientific community but on efforts to enhance the role of science in society.

Whatever progress TWAS has achieved in meeting its goals over the past two decades has been due in large measure to its ability to leverage its modest resources by joining with other institutions to address issues of common concern. We are indeed fortunate to have such a large number of generous partners and close friends, including the Italian government, our main funding agency; the United Nations Educational, Scientific and Cultural Organization (UNESCO), which serves as our administrator and allows us to be a proud member of the UN family; and the Abdus Salam International Centre for Theoretical Physics (ICTP), which for so many years has provided us with a home in Trieste.

The success of the Academy's research and training programmes

has been due largely to the generosity of many partners from around the world, including the Swedish International Development Cooperation Agency (Sida); the Kuwait Foundation for the Advancement of Science (KFAS); the OPEC Fund for International Development; the Global Environment Facility (GEF) in Washington, DC; the United Nations Development Programme (UNDP) in New York; the United Nations Environment Programme (UNEP) in Nairobi; and the World Meteorological Organization (WMO) in Geneva.

We thank them all and look forward, in the years ahead, to strengthening our ties with these and other admirable organizations that share our goals and our dreams.

At the same time, the Academy would like to express its appreciation to its more immediate family in Trieste that includes not only ICTP but the International Centre for Genetic Engineering and Biotechnology (ICGEB) and the International Centre for Science and High Technology (ICS) that help to make Trieste 'the city of science'.

I am convinced that, by working together, we can have an even greater impact in the years and decades ahead and justify in even greater terms the investment that has been made in our enterprise. ■



# TWAS IN TRIESTE 2004 AND BEYOND

THE 15TH GENERAL MEETING OF TWAS WAS HELD IN TRIESTE  
LAST NOVEMBER, MARKING THE CONCLUSION TO ONE OF THE MOST SUCCESSFUL  
YEARS IN THE ACADEMY'S HISTORY.

The 15<sup>th</sup> General Meeting of TWAS, newly renamed the Academy of Sciences for the Developing World, took place in Trieste, Italy, from 22-26 November 2005. More than 200 scientists from around the world – the majority of whom were members of TWAS – attended.

The meeting was held on the campus of the Abdus Salam International Centre for Theoretical Physics (ICTP) overlooking the Adriatic's azure sea-sky landscape in northeast Italy. ICTP, which generously hosts the TWAS secretariat, also offered its facilities for this meeting, which was the largest gathering of members at a general meeting in the 21-year history of TWAS.

Highlights of the meeting included:

- TWAS members agreed to change the name of TWAS from the 'Third World Academy of Sciences' to the 'Academy of Sciences for the Developing World'. The acronym remains the same. See sidebar on page 6 for details.
- Sixty-eight eminent scientists from 32 countries were elected to TWAS. For the first time, the list



included scientists from Azerbaijan, Benin and the Palestinian Territories. Successful candidates were chosen from more than 200 nominations, the largest number of nominations ever received. Total TWAS mem-

bership now stands at 770. For a complete list of the new members see [www.twas.org](http://www.twas.org) and click on the 'Membership' link.

- Announcement that TWAS had awarded some 40 research grants in 2004. The recipients were chosen from a pool of more than 250 applicants, the largest number of applicants in the Academy's history. The council also announced the awarding of 21 TWAS Prizes for Young Scientists, which were given in cooperation with national science academies and research councils in developing countries.

- An official announcement that the governments of Brazil, China and India have agreed to sponsor 50 fellowships a year for graduate and post-graduate students from developing countries to study at universities and research centres in their respective nations. The programmes will be administered by TWAS.

Pakistan announced that it will also join this initiative and provide 20 grants each year. With this expanded number of fellowships, TWAS's South-South exchange initiative has become the largest programme of its kind in the world. "TWAS," observed Jacob Palis, the Academy's secretary general, "is becoming a mini-university with an outreach that stretches across the developing world." Other countries from the developing world are soon expected to join Brazil, China, India and Pakistan in this effort. For additional information about TWAS fellowship programmes, see [www.twas.org/Exchange](http://www.twas.org/Exchange).

- An official announcement that illycaffè will sponsor the Trieste Science Prize. The prize, which carries a

cash award of \$50,000, will be given annually to two eminent scientists from the developing world who have lived and worked in the South throughout their careers. The first two prizes, to be awarded in autumn 2005, will be in the fields of biology and physics and astronomy. Prizes in subsequent years will be given in mathematics and medical sciences (2006); chemical sciences and agricultural sciences (2007); and earth, space, ocean and atmospheric sciences and engineering sciences (2008). The latter will mark the end of the first four-year cycle with a return to the fields of biology and physics and astronomy in 2009. For additional information about the Trieste Science Prize, see pages 2-3 or visit [www.twas.org](http://www.twas.org).

## BEYOND TWAS: TWNSO

*The 15<sup>th</sup> annual meeting of the executive board of the Trieste-based Third World Network of Scientific Organizations (TWNSO) was held on 23 November in conjunction with the TWAS General Meeting. Participants, who included the ministers of science and technology from Iran and Senegal, engaged in a lively and lengthy discussion of TWNSO's accomplishments and future directions. Participants welcomed three new members into the TWNSO network: the Mongolian Academy of Sciences, the Uzbekistan Academy of Sciences and the Natural Resources Council of Swaziland. That brings the total number of TWNSO members to 162, largely ministries of science and technology, research councils and science academies. Participants also expressed strong support for TWNSO's partnership with the United Nations Development Programme's Special Unit for South-South Cooperation (UNDP-SCC) in the 'best practices' project, which is now in its sixth year. The project has resulted in the organization of a series of workshops – six in all – and the publication of the same number of books, which are available through the UNDP in New York ([tcdc.undp.org/widenew/sharingsearch.asp](http://tcdc.undp.org/widenew/sharingsearch.asp)). In addition, TWNSO's five-year Global Environment Facility- (GEF) sponsored project, examining successful examples of the conservation and wise use of biodiversity in dryland regions, came to a successful conclusion in 2004. Five workshops (in Italy, Mongolia, Oman, Chile and Egypt) and two books (published by Kluwer Academic Press and the UNDP-SSC) mark the major accomplishments of the project. TWNSO is now in the process of finalizing a follow-up GEF grant proposal that is designed to put into practice many of the excellent examples of successful applications of science and technology described in the recently completed project. The grant proposal will be submitted to GEF in 2005. In addition, participants agreed to begin publication of a twice-a-year 'TWNSO Update' outlining the activities of members (the first edition of the two-page information sheet was issued in January). They also agreed to establish a committee that would be responsible for drafting a strategic plan to help guide the organization over the next five years. For additional information about TWNSO, see [www.twnso.org](http://www.twnso.org) or contact [info@twnso.org](mailto:info@twnso.org).*





- An update on TWAS's regional offices, which are now actively operating in four (soon to be five) regions of the developing world: in Beijing under the Chinese Academy of Sciences for the Asian region; in Bangalore under the Jawaharlal Nehru Centre for Advanced Scientific Research for central and south Asia; in Rio de Janeiro under the Brazilian Academy of Sciences for Central and South America; and in Nairobi under the African Academy of Sciences for Africa. The offices, all of which are less than two years old (the African regional office opened in September 2004), have held conferences and symposia, launched awards programmes for young scientists, developed websites, and publicized and distributed information about TWAS programmes both to scientists and scientific institutions throughout their regions. The TWAS regional office for the Arab region will be officially launched at a meeting organized by the *Bibliotheca Alexandrina* in Alexandria ([www.bibalex.org](http://www.bibalex.org)) on 2-3 June 2005, marking the fulfilment of a key goal set in the Academy's strategic plan for 1997-2000 (see pages 23-26).

- The first-ever joint meeting between the TWAS council and the International Council for Science's (ICSU) executive board, held on 21 November, to discuss possible avenues of greater cooperation. C.N.R. Rao, president of TWAS, and Jane Lubchenco, presi-

dent of ICSU, presided. TWAS and ICSU have often exchanged ideas and worked together in the past (for example, on the Visiting Scientist Programme and in the organization of the World Conference on Science in Budapest in 1999 and the World Summit for Sustainable Development held in Johannesburg in 2002). Participants agreed that joint meetings should take place once a year or once every two years to foster even stronger ties between the two organizations. Representatives of TWAS and ICSU also agreed that the organizations' newly formed regional offices in the developing world offered excellent opportunities for TWAS-ICSU collaboration. For additional information about ICSU, see [www.icsu.org](http://www.icsu.org).

- TWAS Medal Lectures for 2004 were given by E.S. Ayensu (Ghana) on the biological sciences and the future of Africa; J.L. Morán-López

(Mexico) on magnetism in nanomaterials; and S. Riazuddin (Pakistan) on successful efforts to breed insect-resistant rice and cotton plants in his native country (see pages 14-18). In addition, there were special lectures by Phillip A. Griffiths, former director of the Institute of Advanced Study, Princeton University, on the Millennium Science Initiative (MSI), which is seeking to build world-class science in the developing world through the nurturing of centres of excellence, and by Anthony Cheetham, professor of physics at the

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University of California, Santa Barbara, on the International Center for Materials Research at the University of California, Santa Barbara, which will offer its first courses in 2005. See [www.msi-sig.org](http://www.msi-sig.org) and [www.icmr.ucsb.edu](http://www.icmr.ucsb.edu).

### BEYOND TWAS: TWOWS

*Informal discussions about the Third World Organization for Women in Science (TWOWS) took place throughout the TWAS General Meeting. Consistent praise was expressed for TWOWS's post-graduate fellowship programme for young women scientists from least developed countries, sponsored by the Swedish International Development Agency's (Sida) Department for Research Cooperation (SAREC), that was launched in 1998 and has now awarded grants to more than 214 female students, including 17 in 2004. TWOWS's third general assembly and international conference, 'Women's Impact on Science and Technology in the New Millennium', will be held in Bangalore, India, 21-25 November. For additional information, see [www.twows.org](http://www.twows.org) or contact [info@twows.org](mailto:info@twows.org).*

**Least developed countries should remain a focal point of the Academy's concern.**

- The announcement of the winners of the TWAS Prizes for 2004: Mohammad J. Malakouti (Iran) in agricultural sciences; Jorge Kalil (Brazil) in biology; Miguel A. Blesa (Argentina) in chemistry; Adolpho J. Melfi in earth sciences; Li Aizhen (China) in engineering sciences; Long Yiming (China) in mathematics; Shiv Kumar Sarin (India) in medical sciences; and Spenta Wadia (India) in physics.

- The announcement of the TWAS Medal Lecturers for 2005: Eugenia del Pino Veintimilla (Ecuador); Raghunath A. Mashelkar (India); and Ahmed H. Zewail (USA/Egypt). The lectures will be given at the next TWAS General Meeting that will take place at the *Bibliotheca Alexandrina* in Alexandria, Egypt, in late autumn 2005.

While the full range of activities examined at the TWAS General Meeting reflected the growing strength and vitality of the Academy and, more generally, science in the developing world, it was also clear from ongoing discussions that much more work remains to be done.

TWAS president, C.N.R. Rao, noted that scientific institutions in the world's least developed countries (LDCs) have been largely relegated to the status of 'bystanders', failing to participate in the encouraging trends for scientific advancement that have taken place in a number of developing regions over the past two decades – most notably in Asia and South America. For



**BEYOND TWAS: IAP**

*With funding from the Italian government made permanent in 2004, the InterAcademy Panel on International Issues (IAP) has expanded its 2004-2006 agenda to include such issues as water, biosecurity, access to scientific information and genetically modified organisms. This is in addition to IAP's existing programmes devoted to capacity building for science academies, child and women health issues, and science education. The coming year includes a full agenda with workshops planned for Bogotá, Dakar, Islamabad, Paris, Stockholm and Trieste. For additional information about IAP, see [www.interacademies.net/iap](http://www.interacademies.net/iap).*

this reason, Rao claimed that LDCs should remain a focal point of the Academy's concern. "The TWAS grants programme for LDCs, which recently awarded grants to scientific institutions in Bangladesh, the Congo and Mali," he noted, "marks an important step forward in the Academy's campaign to assist the South's least fortunate scientists and scientific institutions." Rao also stated that funding for this initiative, which now supports nine research institutions, "remains woefully inadequate, especially when you consider that we have received more than 150 applications. Inadequate funding has meant that we have had to turn down a large number of worthy applicants." To increase the percentage of successful candidates, he said that TWAS would seek to expand the funding base in the future, soliciting support from both governmental organizations and private foundations.

Shamsher Ali (TWAS Fellow 1989, Bangladesh), citing fast-declining student enrolments in science and

mathematics as an unwelcome trend that has gripped the developed world but is now taking hold in the developing world too, urged TWAS to focus greater attention and resources on science education. Shamsher asserted that if enrolments continue to fall, TWAS could find itself in a position in which "the number of fellowships that the Academy has to offer exceeds the number of worthy scientists who apply."

Howard Alper (TWAS Associate Fellow 2003, Canada) observed that access to digital libraries "helps to level the playing fields between scientific institutions in the North and South" and that TWAS could play a key role in expanding such access. Alper also urged TWAS to support mentoring and exchange programmes, modelled after a successful programme in Canada, that could help increase



[CONTINUED PAGE 12]

the presence of positive female role models for young women who have an aptitude for science but who have shied away from pursuing their interests.

Muhammed Ashraf (TWAS Fellow 2003, Pakistan) concurred with Alper's remarks and added that "virtual classrooms and instruction could prove a boon to science education in remote areas of the developing world." He also noted that women continue to be underrepresented in the global science community.

R.A. Mashelkar (TWAS Fellow 1993, India) maintained that TWAS should pay greater attention to sup-

***TWAS should pay greater attention to supporting research that focuses on critical problems in the developing world.***

porting scientific research that focuses on solving critical problems in the developing world. Such efforts should concentrate, for example, on science-based strategies for tackling the diseases of the poor or analysing the impact of intellectual property right regimes on investment and entrepreneurial activities in the South. He noted that "the world spends far more on research on bio-terrorism than it does on combatting diseases that afflict the poor." Mashelkar said that one reason for this "imbalance in expenditures" was insufficient pressure from the scientific and medical communities to increase public expenditures on issues of importance to the poor. This problem, he added, afflicted both the South and the North.

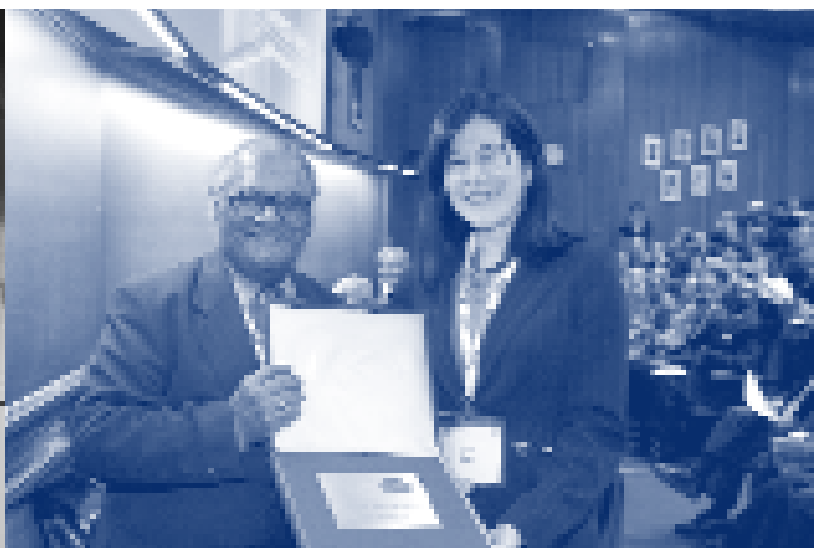
Dorairajan Balasubramanian (TWAS Fellow 1997, India) spoke about the need to develop implementation strategies for action points outlined in TWAS's 'Safe Drinking Water' report, published in 2002.

Jorge Allende (TWAS Fellow 1985, Chile) agreed and urged the Academy to place even greater emphasis on developing South-South cooperative programmes that engage scientific institutions in LDCs.

José Vargas (TWAS President 1996-2000, Brazil) noted that several projects in Brazil, including governmental efforts to use satellite images to identify sources of safe drinking water, could be linked to

#### IN MEMORIAM

*TWAS lost five members in 2004: Sivaramakrishna Chandrasekhar (India), Founding Fellow; Luis Eduardo Mora-Osejo (Colombia), Fellow 2001; Thomas Adeoye Lambo (Nigeria), Founding Fellow; Kamaluddin Ahmad (Bangladesh), Fellow 1989; Mu Shik Jhon (Republic of Korea), Fellow 1988; and Yasutomi Nishizuka (Japan), Associate Fellow 1998. We will miss their friendship and camaraderie and extend our condolences to their families and friends.*



projects in other developing countries seeking to increase their supplies of safe drinking water.

Heneri A.M. Dzinotyiweyi (Twas Fellow 1988, Zimbabwe) observed that 20 of the 37 TWAS research grants in 2004 were given to biologists, 9 to chemists, 5 to physicists and 3 to mathematicians. He expressed concern about the imbalance among disciplines.

Mohamed H.A. Hassan (Twas executive director) confirmed these figures but also noted that 60 percent of the research grant applications were in the field of biology. He said TWAS offers less support to physicists and mathematicians largely because it receives fewer applications in these fields.

Adnan Badran (Twas Fellow 1991, Jordan) added that the discipline imbalances found in TWAS's applicant pool were consistent with the imbalances that other organizations were experiencing.

All in all, the discussions at the TWAS 15<sup>th</sup> General Meeting spoke of a trend that has been unfolding for some time and now seems to be gaining even greater momentum: Differences in scientific capacity are becoming more pronounced, with some nations progressing at a rapid pace while others are either stalled or increasingly lagging behind. The challenge for TWAS, as the Academy's president, C.N.R. Rao, noted,

is "to retain its long-standing focus on excellence while continuing to target its limited resources on scientists and scientific institutions most in need."

## CONFERENCES NEXT

*The 16<sup>th</sup> General Meeting of TWAS will take place at the Bibliotheca Alexandrina in Alexandria, Egypt, from 29 November to 3 December 2005. The TWAS 10<sup>th</sup> General Conference and 17<sup>th</sup> General Meeting is scheduled to take place in Mexico in 2006. The TWAS 18<sup>th</sup> General Meeting will be held in Pakistan in 2007.*

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"A trend marked by contradictory impulses signalling that things are paradoxically getting better and worse at the same time offers both challenges and opportunities," Rao went on to say. "Most significantly," he contended, "the changing circumstances suggest that South-South cooperation in science is now poised to become the focal point of scientific capacity building efforts in the developing world. Such cooperation could turn this paradox into a force for good by enabling developing countries that are proficient in science to help those that continue to lack scientific capacity.

"TWAS," Rao noted, "is positioned to serve as a bridge between the scientific 'haves' and 'have-nots' in the developing world; by capitalizing on its excellent reputation the Academy can help to channel an ever-larger pool of resources and expertise towards those who need the most help." ■



EACH YEAR, TWAS AWARDS THREE MEDALS TO ACADEMY MEMBERS WHO ARE ACTIVELY ENGAGED IN GROUND-BREAKING RESEARCH. THESE SCIENTISTS ARE INVITED TO PRESENT THEIR WORK AT THE ANNUAL TWAS GENERAL MEETING. BRIEF SUMMARIES OF THE THREE 2004 TWAS MEDAL LECTURES, PRESENTED AT TWAS'S 15TH GENERAL MEETING IN TRIESTE LAST NOVEMBER, FOLLOW.

# TWAS MEDAL LECTURES

## MAGNETIC NANOMATERIALS

The physical and chemical properties of most substances have now been defined at both the macroscopic level and the level of individual atoms and molecules. In contrast, the properties of systems with dimensions lying between these two extremes are not well understood. So-called nanostructured materials, with one or more dimensions in the order of nanometres ( $10^{-9}$  metres) – measurable in terms of just a few atoms – follow neither the ‘classical’ laws of chemistry and physics relating to their boiling point, melting point, electrical properties and so on; nor can their properties be predicted using the theories of solid state and condensed matter physics.

These unique properties of nanomaterials – which have only been synthesized by design in the last few decades – have the potential to be applied in a whole new range of applications. Indeed, this new field of research – nanotechnology – is seen as a technological revolution. One application of nanotechnology is the creation of new magnetic materials capable of storing vast amounts of data.

Carbon nanotubes were among the earliest nanostructures to be identified. These tubes can be considered as rigid, cylindrical nano-containers that are able to host gases or solids. Using either wet chemical or arc discharge techniques, nanotubes can be filled with various metals, metal oxides and metal carbides. However, in most cases, the encapsulated solid is not ferromagnetic.

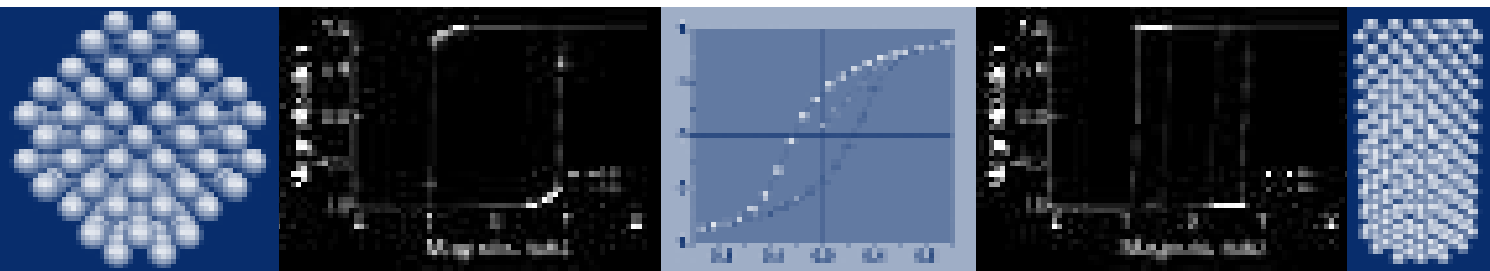
In contrast, thermolytic techniques that make use of the decomposition of organic precursors over such metals as cobalt, iron and nickel have been used successfully to fill carbon nanotubes with these ferromagnetic metals. This same method has also been used to generate arrays of aligned nanotubes filled with pure ferromagnetic crystalline nanowires orientated along a preferred axis. The carbon coating also prevents the oxidation of the metal inside, thus avoiding contamination that would reduce the magnetic strength and integrity of the wire as well as the data storage capacity of the system.



J.L. Morán-López

These arrays of iron wires inside carbon nanotubes exhibit magnetic coercivities, or magnetic strength, 10 to 30 times larger than bulk iron and could be used as high-density magnetic storage media holding more than 50 gigabits per square inch of data. Ideally, each wire would correspond to an information bit.

In our laboratory, we have synthesized, characterized and measured the magnetic properties of aligned iron-filled carbon nanotubes. The main feature that we measure is the hysteresis loop of the material. This is a measure of the induced magnetization in the material and the applied external magnetic field. In ferromagnetic materials, as the applied magnetic field increases, the



induced magnetization reaches a saturation value. Then, if the applied field is removed, the magnetization induced in the material remains. To decrease this magnetization, it is necessary to apply the magnetic field in the opposite direction. As the applied field is increased in the opposite direction, the magnetization of the material eventually reverses until it once again reaches saturation. This process can be repeated back and forth, giving rise to a loop known as the hysteresis loop.

Using compact arrays of iron-filled nanotubes in which each tube stands vertically on a substrate – which gives the whole array the appearance of a carpet – we have shown that it is possible to obtain square hysteresis loops that result in unexpectedly high magnetic storage densities, of the order of terabits (or 1,000 gigabits) per square inch. We have also modelled our system based

on theories that include magnetostatic exchange interactions and dipolar interactions. To the best of our knowledge, this is the first time such a system has been so carefully studied both experimentally and theoretically. We envisage that results will lead to unexpected magnetic properties in nano-structured arrays, thus paving the way for novel storage applications.

However, we need to develop more reliable models for calculating the magnetic properties of nano-dimension systems as a function of their composition, geometrical structure, size and temperature. In addition to developing the full potential of nanostructures, we must still learn how to produce them in a more controlled fashion. ■



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## INSECTICIDAL BACTERIA

The pesticidal properties of the soil-living bacterium, *Bacillus thuringiensis*, have been used for decades and the recent upsurge in organic farming in many countries has seen its use increase. The insect-killing component of the bacterium is known as the crystal, or Cry, protein. Upon ingestion, the Cry protein dissolves and disrupts the integrity of the insect's gut – specifically a structure known as the brush border, or the part of the intestinal epithelium covered with finger-like microvilli.

However, not all Cry proteins are the same. Scientists have known for several years, for example, that some strains of *B. thuringiensis* are able to kill the larvae of certain Lepidoptera, or moths, but have no effect on Coleoptera, or beetle, larvae. Other strains, however, are specific to beetles and have no effect on moth larvae.

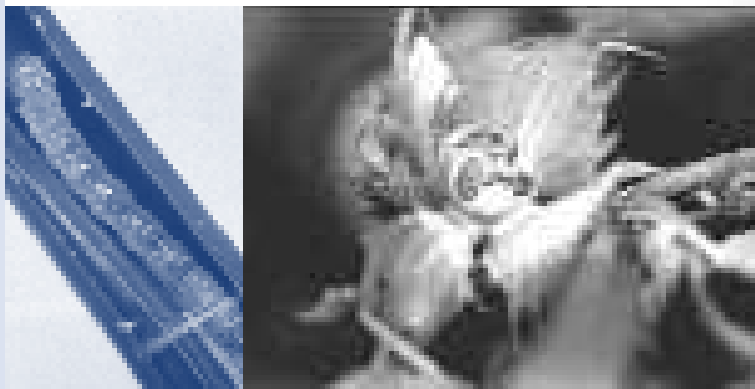
This narrow range of activity has proven useful in the development of genetically modified (GM) crops. In fact, some of the first varieties of GM crops to be commercialized were cotton and maize containing *B. thuringiensis* cry genes that protected the plants against bollworm and stem borer pests.

Scientists at my centre at the University of Punjab, Pakistan, have made an extensive search for new and novel cry genes. Some 1,200 samples of

*B. thuringiensis* collected from different ecological environments have yielded 1,000 isolates, 650 of which have been characterized for their Cry protein and cry gene content. Their bioactivity has also been tested against five lepidopteran pests: the rice leaf-folder (*Cnaphalocrocis medinalis*), rice yellow stem borer (*Scirpophaga incertulas*), cotton pink bollworm (*Pectinophora gossypiella*), cotton spotted bollworm (*Earias vitella*) and the American bollworm (*Heliothis armigera*).

Whereas 60 percent of the isolates were found to contain the cry4 version of the gene and 33 percent the cry1A version, both of which have been well characterized, some seven percent of the isolates were found to contain other cry gene types. Of these 45 isolates, five have shown an unusual host range for pesticidal activity and the sequences of their cry genes have revealed little or no homology to known cry gene sequences. One isolate in particular, designated CMB1, produces a Cry protein with chemical properties unlike other, more common, Cry proteins, and with effective insecticidal activity against rice leaf-folder and cotton spotted bollworm.

Using molecular biological techniques, four selected cry genes were altered slightly to optimize their expression in







**Sheikh Riazzudin**

plants without affecting their insecticidal properties. Experiments also showed that Cry1- and Cry2-type proteins recognize different binding sites on the host's brush border. DNA 'cassettes' containing both *cry1* and *cry2* genes were produced and then introduced into cotton and rice plants using transformation and tissue culture techniques developed in our laboratory.

Laboratory analyses of the resulting transgenic plants confirmed that they had inherited resistance to the target insects. Small-scale field trials in which non-transformed and genetically modified indica Basmati rice lines were artificially infested with yellow stem borer larvae showed that the *cry* genes helped protect the transformed lines, leading to significant yield increases.

To further refine the transformation protocol, the *cry1Ac* gene was put under the control of different promoters, short genetic sequences that determine where in the plant the gene under their control will be expressed. Using the PEPC promoter, for example, resulted in the Cry protein being expressed only in the plant's green tissues, with little or no accumulation in the rice grain. Likewise, using the BP10 promoter, the protein accumulated only in the pollen. In both cases, bioassays performed on different parts of the plant demonstrated tissue specificity in the expression of the *cry* gene in transgenic rice. In this way, the expression can be targeted to the green tissues preferred by the caterpillars, leaving the grains, consumed by people, free of the pesticidal protein (even though the Cry protein is not harmful to humans or other mammals).

Other studies to assess potential impacts of the release of such modified rice plants on the wider environment have failed to raise any doubts about their safety. We have found no evidence of the *cry* gene escaping from rice, nor any effect on non-target insects or natural enemies of rice pests. Indeed, developmental studies on spiders reared on yellow stem borer that had been fed Cry-containing rice leaves have shown no increase in mortality compared to the control group.

Although these transgenic lines have proved effective against insect pests and safe for release into the environment, doubts remain over their commercial viability in Pakistan owing to problems with consumer acceptability. It is likely that several years will elapse before farmers will be able to benefit from growing these insect-resistant lines. ■

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### **BIOLOGICAL SCIENCE IN SUB-SAHARAN AFRICA**

How can sub-Saharan Africa take advantage of the unprecedented advances in the biological sciences now taking place across the globe? Equally important, how can sub-Saharan African scientists participate as true partners in these efforts?

The answer to these questions lies in devising 'leapfrogging' strategies that draw their strength from the new information technologies.

Such strategies would enable African scientists to tap into the wealth of information and instructional material now available on the internet.

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The goal for sub-Saharan Africa is not necessarily to catch up with the advanced industrial countries but to develop biological science and technology capabilities that can promote sustained economic development and lead to effective poverty reduction programmes.

Advances in molecular biology, genetics, biotechnology and information technology set the stage for faster and more effective strategies for addressing biological issues in agriculture and food processing and provide new techniques for tackling problems in health and disease. By embracing recent advances in the biological sciences, sub-Saharan Africa could not only better meet critical public health and environmental needs but it could also take steps to help improve the capabilities of its scientific community.

However, the challenges are enormous and cannot be ignored:

- Research institutes and universities, despite gallant efforts, remain weak and chronically underfunded.
- The brain drain problem continues (Ghana, for example, trains 130 doctors a year, half of whom leave for other countries, often in the North, to pursue their careers. Ghana is, in effect, subsidizing the health services of much richer nations).
- Communicable diseases, led by HIV/AIDS but including malaria, sleeping sickness, river blindness and schistosomiasis, undermine the health of millions and sap the vitality of the economy throughout the region.
- Ecological damage worsens as rising demand for resources places even greater stress on the environment (in 1900, Ghana's forests covered 8 million hectares; in 2000, forest coverage had been reduced to 1.6 million hectares).

For these reasons, efforts to promote the biological sciences in sub-Saharan Africa should focus on three primary objectives:

- Applications of biological knowledge to the management and sustainable use of living resources, especially to meet the region's food requirements.
- Use of biological knowledge to improve our understanding of those health problems and diseases that are critically important to the region's population.
- Broadening of knowledge of biological sciences among the region's researchers so that they can fully participate in international projects and programmes in this rapidly growing field.

These objectives are driven by a vision and a mission for the pursuit of the biological sciences in sub-Saharan Africa within the context of extraordinary developments in the field, on the one hand, and an alarming degradation of biological resources on the continent, on the other. ■



**E.S. Ayensu**

TWAS Newsletter, Vol. 17 No. 1, 2005



◆◆◆ **E.S. Ayensu**

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*President, Council for Scientific and Industrial Research*

*Accra  
Ghana*

# DISCOVERING THE DECCAN

THE VOLCANIC TERRAIN OF INDIA'S DECCAN PROVINCE OFFERS ONE OF THE WORLD'S LARGEST OUTDOOR LABORATORIES FOR THE STUDY OF ONE OF NATURE'S PRIMAL FORCES.

**T**he Deccan Traps, consisting of a layer of solidified lava flows more than 2,000 metres thick and covering more than half-a-million square kilometres in west-central India, are one of the largest volcanic provinces in the world. Understanding the geology of this vast region, however, has required studies on a microscopic scale. Kaigala Venkata Subbarao of the Indian Institute of Technology, Mumbai, India, has examined the area's rocks for more than 30 years – work that helped win him the 2003 TWAS Prize in Earth Sciences. Along with the other 2003 TWAS Prize winners, he was invited to present an overview of his research at the TWAS 15<sup>th</sup> General Meeting in Trieste in November 2004.

The lava flows of the Deccan Traps in west-central India cover more than half-a-million square kilometres. That's an area around the size of Spain. The vast eruptions that cause such flows, says Subbarao, cannot only move continents but may also be responsible for mass extinctions such as the one that caused the demise of the



dinosaurs some 65 million years ago. Indeed Subbarao believes that it was Deccan volcanism itself that drove the dinosaurs to extinction.

“Until 170 million years ago,” explains Subbarao, or Subbu to his friends, “the Earth’s continents, as we know them today, were linked together in one great continent – Gondwana. This supercontinent began breaking up when a rift opened between what is now Africa and Antarctica. The rift

was caused by a plume of hot rock rising from the Earth’s lower mantle and deforming the lithosphere – the 100 kilometre-thick layer comprising the Earth’s upper mantle and crust.

“Likewise,” continued Subbarao, “120 million years ago, another ‘hot spot’ forced Africa and Latin America apart and, in so doing, created the Atlantic Ocean.”

It was yet another mantle plume, centred on the island of Reunion off the coast of Madagascar, that forced the Indian subcontinent away from the coast of Africa towards the Asian continental plate. The collision

between these two plates caused the uplifting of the Himalayas.

“Another range, possibly more spectacular than the Himalayas, is hidden beneath the Indian Ocean,” added Subbarao. “Created by the same mantle plume, it is three times the length of the Himalayas and runs from the Gulf of Arabia to Tasmania.”

Ironically, analysis of these massive geological upheavals that have shaped the surface of the globe has been carried out at the microscopic – and even atomic – scale.

### ISOTOPIC ANALYSIS

Scientists have long known that the make-up of the mantle of the Indian Ocean is very different from that of the Atlantic or Pacific Oceans, but what they had not been able to determine is the origin of the Indian Ocean’s rocks.

“Using isotopes of strontium, we have shown the connection between the rocks of the Deccan Traps and samples taken from the ocean floor between the Deccan Traps and along the Maldives Ridge to Reunion,” explained Subbarao.

Isotopes have identical chemical natures but different masses owing to different numbers of neutrons in their nuclei. Strontium, for example, exists in forms having an atomic mass of 84, 86, 87 and 88.

“These values are not affected by changes in temperature or pressure,” explains Subbarao. “Therefore, the proportion of one isotope in relation to another can help us to ‘fingerprint’ the origin of rock samples. In our case we measured the ratio of strontium 87 to strontium 86 from rocks collected from the bed of the Indian Ocean.”

As expected, the ratio of strontium isotopes varied little between rocks taken from Reunion and the Deccan Traps – locations now separated by some 5,000 kilometres.

“We concluded that these rocks all had the same origin – and that the origin was from a mantle plume centred on Reunion,” says Subbarao.

### MAGNETIC MEASUREMENTS

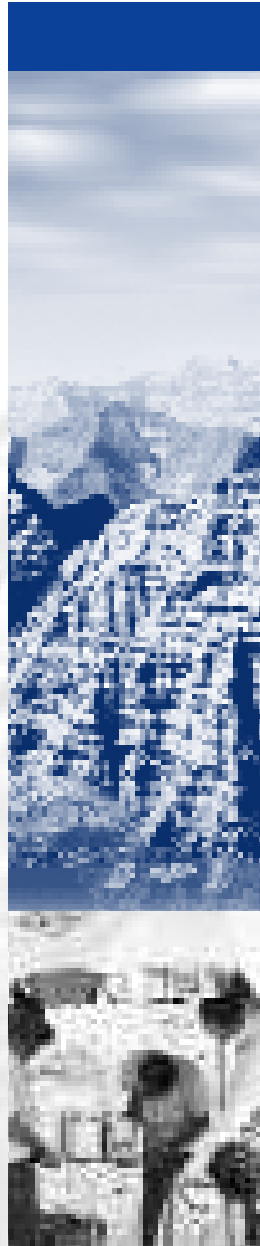
But knowing the origin of the rocks gave no clues of their age. Just when – and for how long – did the magma of the Deccan erupt to the surface of the globe and create the magnificent landforms associated with this area of east-central India? E.M. Forster, for example, used some of the region’s famous caves, full of historic carvings, as a pivotal location in his novel *A Passage to India*.

To determine the age of the rocks, Subbarao turned to another ‘fingerprint’ or ‘barcode’. The planet Earth has two magnetic poles – one in the north and one in the south. Throughout human history – and for millennia

before – this has been the case. But it has not always been so. Every so often, the Earth’s magnetic poles switch so that the geographical North Pole hosts the magnetic south pole and vice versa. Such events have happened more than 100 times since the beginning of the Cretaceous period, more than 140 million years ago. Some of these polar ‘cross-overs’ are very brief – geologically speaking – while others are much longer. During the middle of the Cretaceous period, for example, there was no change in the Earth’s magnetic polarity for some 35 million years.

“The geomagnetic polarity time scale, or GPTS as it is known, is now well documented,” explains Subbarao. “This meant that if we could determine the polarity of the magnetism in different layers of the Deccan rocks, we could match up these changes with the known GPTS, much like police detectives match fingerprints taken from a crime scene with those in their database.”

The volcanic activity of the Deccan was not the violent, eruptive type that is associated with volcanoes such as Vesuvius that destroyed the Roman city of Pompeii in AD 79, Krakatoa that erupted in Indonesia in 1883 or Mount St. Helens that erupted in the United States in 1980. Instead, the molten magma oozed gently up to the surface and spread out before cooling. In this way, separate eruptions formed layer upon





**K.V. Subbarao**

layer of rock that can be dated from the oldest at the bottom to the youngest at the top. The presence of magnetic elements in the rock, particularly iron, also means that, as the rock cooled, magnetic domains within it lined up with the Earth's magnetic field. In effect, this created a stratified record of the polarity of the Earth 'frozen' in time. Fortunately for Subbarao, millennia of weathering and the erosive action of rain and rivers has created steep-sided cliffs, thus exposing these sequential layers of rock and making it relatively easy to obtain samples.

Subbarao has been analyzing the magnetic orientation of the Deccan's rocks for more than 30 years. Initially, he relied on an astatic magnetometer – a device that had to be used inside a specially-designed hut to protect it from the Earth's current magnetic field.

"Nowadays we use a spinner magnetometer, which is a much more sophisticated device. It is made of non-magnetic components and has a built-in shield, making it much easier to use in the field," adds Subbarao. "But both devices give the same results. Indeed, we still use both systems because, with the astatic magnetometer, it is easier to see how the device works and to explain the process to students."

Basically, the device contains two bar magnets with their like poles facing each other. One of these magnets

is fixed, while the other is suspended so that it can turn. This second magnet also has a mirror attached. To take a reading, a sample rock is inserted between the two magnets in a known orientation. The magnetism of the sample causes the suspended magnet to pivot. This deviation is measured by shining a light

beam on the attached mirror, which is reflected through a greater or lesser angle depending on the magnetism in the sample. By inserting the rock sample in different orientations and taking several readings, the alignment of the magnetic domains in the rock can be calculated.

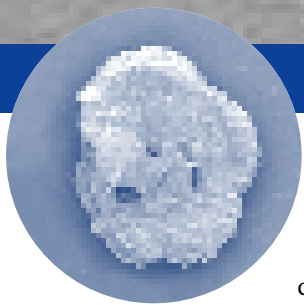
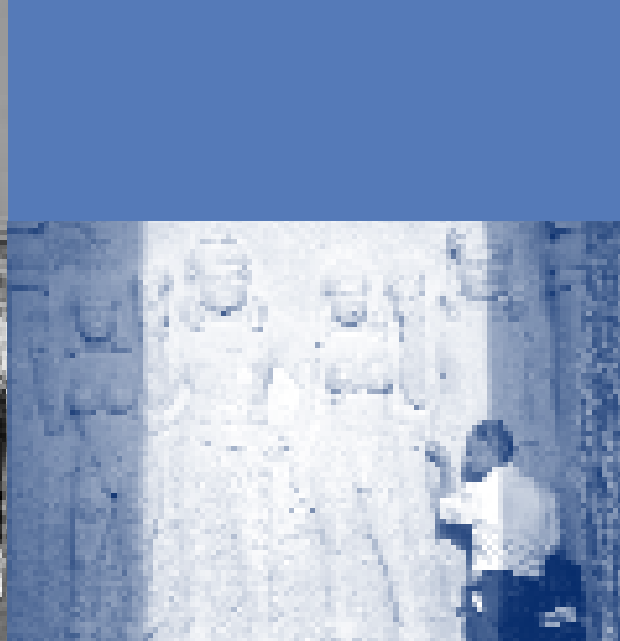
Subbarao's work on the magnetism embedded in the Deccan's rocks

is regarded as a *tour de force* in the world of geology and was cited as one of the reasons for him being awarded the 2003 TWAS Prize in Earth Sciences.

After thousands of measurements, Subbarao was able to deduce that, during the entire period of the Deccan eruptions, there were only two reversals of the Earth's magnetic field. Mapping these to the fingerprint of the known magnetic reversals dated the Deccan eruptions to 65 million years ago.

To both geologists and palaeontologists, this date has a special significance. It marks the boundary between the

***Subbarao's work on the magnetism embedded in the Deccan's rocks is regarded as a tour de force in the world of geology.***



Cretaceous and Tertiary periods of geological history. Before this so-called KT boundary, dinosaurs flourished. After it, dinosaurs were extinct.

## DINOSAUR DEMISE

Although the aim of Subbarao's work has not been to hypothesise on the cause of the extinction of the dinosaurs, it is a subject that creates intense interest both within the scientific community and the public – and therefore is a subject that is hard to avoid.

The mass extinction that occurred at the KT boundary was responsible for wiping out not only the dinosaurs, but also many other life forms. One such creature, the tiny *Abatomphalus mayaroensis*, a type of plankton, thrived for more than 400,000 years in the primaevial Indian Ocean. Indeed, it is present in the layers of sedimentary rocks that lie below the Deccan rocks, and is also found in thin layers of calcareous rock sandwiched between layers created by subsequent Deccan flows – until the KT boundary, set at 65 million years ago, that is. Beyond that, as with the dinosaurs, there are no further records of *A. mayaroensis*.

Many people are familiar with the hypothesis that the mass extinction that occurred at the KT boundary was

caused by the impact of a giant meteorite that crashed into the Earth in the Gulf of Mexico.

“There is good evidence to support this hypothesis,” admits Subbarao, “but the fact that the maximum activity of Deccan volcanism correlates exactly with the KT boundary is, I believe, significant.”

Subbarao and his colleagues are now trying to model the probable effects of the Deccan eruptions based on

the effects of eruptions that have occurred more recently. For example, in 1783, the Laki volcano in Iceland erupted and spread such poisonous gases as sulphur dioxide and hydrogen chloride around the globe. Dusts and aerosols emitted into the atmosphere also reflected solar radiation and caused the Earth's surface to cool.

***“Deccan volcanism – and not the impact of a meteor – caused the extinction of the dinosaurs.”***

“If this is what a medium-sized volcano in Iceland could do over the course of a year or two, imagine what the combined effects of the volcanic activity of the Deccan – taking place over thousands of years – would be,” adds Subbarao. “I am convinced that Deccan volcanism – and not the impact of a meteor – caused the extinction of the dinosaurs.” ■

*There is a saying among news editors that a journalist is only as good as his or her contacts. The same could be said of an organization such as TWAS that relies on providing information to scientists throughout the developing world. The scientific strength of our new members, the fellowships that we award and the research programmes that we fund depend on the Academy reaching the maximum number of candidates and then selecting the best. To help with this exercise, TWAS has established a suite of regional offices throughout the South. Four of these offices, in Brazil, China, India and Kenya, are up and running, with another, designed to serve the Arab region, to be inaugurated later this year in Egypt. Overviews of the current and future activities of the regional offices were presented to TWAS Members during the 15<sup>th</sup> General Meeting held in Trieste last November. Here's a summary of what was said.*

# REACHING OUT

## **TWAS Regional Office for Central and South Asia Bangalore, India**

The TWAS Regional Office for Central and South Asia (TWAS ROCASA) covers Afghanistan, Azerbaijan, Bangladesh, India, Kazakhstan, Kyrgyzstan, Nepal, Pakistan, Sri Lanka, Tajikistan, Turkmenistan and Uzbekistan.

The office was inaugurated during a two-day meeting held on 27-28 September 2004 in Bangalore, India. The meeting, hosted by both the Jawaharlal Centre for Advanced Scientific Research (JNCASR) and the Indian Institute of Science, focused on general theme of 'Science Development and Education' and was attended by 67 TWAS members.

Among the lectures was an inaugural address by TWAS president, C.N.R. Rao on 'The Future of Science', and presentations by Yuan Tseh Lee (TWAS Fellow 1986; Nobel Prize for Chemistry 1986) on 'Education for Students in the Globalized World', Raghunath Anant Mashelkar (TWAS Fellow 1993) on 'Intellectual Property Rights and the Rights of the Poor', Goverdhan Mehta on 'Building Science and Technology Capacity: Challenges before Developing Countries', and Khadg Singh Valdiya (TWAS Fellow 1995) on 'The Rivers of Asia: A Top Priority'.

Other sessions were designed to allow TWAS Fellows to discuss such topics as 'science and development' and 'scientific capacity building'.

A session outlining TWAS's latest initiatives, chaired by Varadachari Krishnan (TWAS Fellow 1996 and coordinator of the regional office), TWAS executive director, Mohamed Hassan, and C.N.R. Rao, enabled members to express opinions and concerns about the activities of regional office. Members agreed to hold an annual meeting in different countries of the region to promote more active participation. The delegation from Pakistan expressed its willingness to host the next meeting in Pakistan, possibly Islamabad, in 2005. Members from Sri Lanka also announced that TWAS ROCASA will support annual prizes for young scientists in the region and programmes for the popularization of science. TWAS has agreed to commit funds to the prize.

Thanks to generous support from the Department of Science and Technology, New Delhi, the Council for Scientific and Industrial Research (CSIR), New Delhi, the Indian National Science Academy, JNCASR, Bangalore, and the Indian Institute of Science, Bangalore, TWAS ROCASA was successfully launched and several programmes have already been put in place. ■

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### **TWAS Regional Office for East and Southeast Asia Beijing, China**

The TWAS Regional Office for East and Southeast Asia, hosted by the Chinese Academy of Sciences (CAS), has developed a full range of activities. An agreement, signed in early 2004, between TWAS and CAS, enables TWAS to manage a programme that allows 20 postgraduate students, 15 postdoctoral researchers and 15 experienced scientists to work in CAS laboratories for up to one year. Many applicants have found out about the scheme from the regional office's website, which was launched last year in both Chinese and English.

The regional office has also helped organize scientific conferences in China with many delegates coming from developing countries in the region. Among these conferences was the 'Third International Symposium on Extreme Weather and Climate Events: Their Dynamics and Prediction', held in Beijing in October 2004. More than 100 participants from India, Pakistan, South Korea and Thailand, as well as Australia and the United States, attended.



Other programmes to promote economic development and scientific cooperation in developing countries, particularly China's neighbours and countries in sub-Saharan Africa, are being discussed with the relevant agencies of the Chinese government. The Chinese government has indicated that it is ready to increase funding for scientific cooperation with developing countries over the next few years. Other projects being planned by CAS, and that will likely involve TWAS, include the provision of expert training in a variety of scientific disciplines.

The Regional Office for East and Southeast Asia also promotes the core activities of TWAS – its prizes and associateship and fellowship schemes – as well as those of its affiliated organizations, the Third World Network of Scientific Organizations (TWNSO), the Third World Organization for Women in Science (TWOWS), the InterAcademy Panel on International Issues (IAP) and the InterAcademy Medical Panel (IAMP). The office is actively seeking to identify and nominate eminent scientists for TWAS membership or awards.

Future plans include organizing a meeting for TWAS members in the region to develop a strategic plan and to discuss issues of common concern. There are also plans to hold public lectures and workshops on scientific issues. ■

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### **TWAS Regional Office for Latin America and the Caribbean Rio de Janeiro, Brazil**

The Regional Office for Latin America and the Caribbean was launched during the annual meeting of the Brazilian Academy of Sciences, held in Rio de Janeiro in June 2004.

A website, which was designed by staff of the Brazilian Academy, is now online. It contains relevant news articles, including items from all the regional academies of science. In addition, TWAS members from the region are listed on the website along with their contact details.

Initial efforts have focused on providing information and orientation for students interested in the TWAS fellowship programme in Brazil, based on an agreement between TWAS and the Brazilian National Research Council (CNPq) that provides up to 40 postgraduate fellowships and 10 postdoctoral fellowships each year. A database of all the research institutions qualified to host these TWAS-CNPq fellowships is now online in English, Portuguese and Spanish and provides information on the specialities of each institution.

Plans for 2005 include publicizing TWAS activities and programmes, continuing regular contacts with TWAS members in the region, and soliciting nominations for TWAS fellowship and award programmes. The regional office will also organize topical regional meetings and seek to increase the interaction between academies of science in the region.

The office is also soliciting financial support for a prize for young scientists from the region which it hopes to launch this year. ■

coordinator ❖❖❖ **Carlos A. Aragão de Carvalho** (TWAS Fellow 2002)  
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## **TWAS Regional Office for Sub-Saharan Africa Nairobi, Kenya**

The Regional Office for Sub-Saharan Africa, hosted by the African Academy of Sciences (AAS), was launched last September in Abuja, Nigeria, during the AAS General Assembly. Several TWAS Fellows from Africa attending the AAS meeting also attended the launch.

A work plan has been prepared, including the launch of a series of TWAS public lectures in Nairobi to begin in 2005. Work is also under way to build a database of the most accomplished scientists in the region and nominate several of them for TWAS fellowships, awards and prizes.

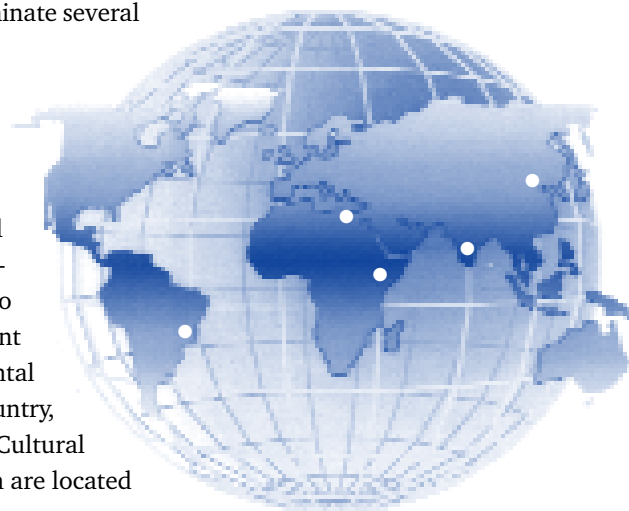
In addition, an administration officer, Jackie Olang, visited TWAS's headquarters in Trieste for two weeks in October 2004 to learn more about the Academy's programmes and operations.

A symposium will be organized on a topic of regional importance, as will meetings with the media to promote awareness of TWAS activities. There are plans to meet representatives of the United Nations Environment Programme (UNEP), which is the only intergovernmental organization with its headquarters in a developing country, and the United Nations Educational, Scientific and Cultural Organization (UNESCO) regional office, both of which are located in Nairobi.

The International Council for Science (ICSU) now has a regional office in South Africa and discussions have been held concerning how these two regional offices can collaborate with one another.

A prize for young scientists from sub-Saharan Africa will also be instituted in 2005. In addition, a website will be designed and an electronic newsletter published. The first annual general meeting of TWAS members from sub-Saharan Africa will also be held next year in conjunction with the 20<sup>th</sup> anniversary of AAS. ■

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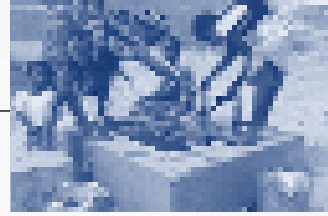


## **TWAS Regional Office for the Arab Region Alexandria, Egypt**

The TWAS Regional Office for the Arab Region will be hosted at the *Biblioteca Alexandrina*.

TWAS members from the Arab region will be invited to attend the launch of the office on 2-3 June 2005. Immediately following this meeting, members will be invited to participate in a meeting, also being hosted by the *Biblioteca Alexandrina*, to celebrate the centenary of the discovery of the theory of relativity by Albert Einstein. ■

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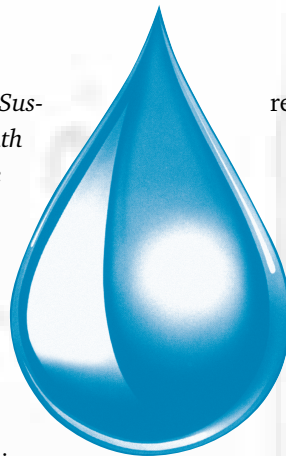
# SAFE DRINKING WATER

**MORE THAN A BILLION PEOPLE – OR MORE THAN 15 PERCENT OF THE WORLD'S POPULATION – LIVE THEIR DAILY LIVES WITHOUT ACCESS TO SAFE DRINKING WATER. A WORKSHOP HELD IN TRIESTE FROM 24-26 AUGUST 2004, ORGANIZED BY TWSO AND SPONSORED BY TWAS, THE UNITED NATIONS DEVELOPMENT PROGRAMME'S SPECIAL UNIT FOR SOUTH-SOUTH COOPERATION (UNDP-SSC) AND THE WORLD METEOROLOGICAL ORGANIZATION (WMO), EXAMINED BOTH TRADITIONAL AND MODERN METHODS OF PROVIDING SAFE DRINKING WATER.**

**I**n 2002, prior to the World Summit for Sustainable Development in Johannesburg, South Africa, Kofi Annan, secretary general of the United Nations, identified five areas that are key to improving the quality of life of people across the globe and especially in developing countries. These five areas, collectively known as WEHAB, are water, environment, health, agriculture and biodiversity. It is no accident that water is the first item on the list. Simply put – life on Earth cannot exist without it.

From space, Earth appears blue because of the large amount of water present on the planet's surface.

However, for many people, especially those living in developing countries, such distant views can be deceptive. Some 98 percent of the Earth's water is salt water and is not suitable for human consumption. Of the



remaining two percent that is fresh water, less than half is available for use by the planet's six billion people.

In the developed North, access to safe drinking water is rarely a problem. Most people just turn a tap – one of many in every home – to receive seemingly unlimited quantities of clean, fresh water.

In contrast, some 40 percent of the world's population lives with supplies of water classified as either 'limited', 'scarce' or 'stressed'. This water must not only be used for drinking, but must provide for other needs – washing, cooking and irrigation – as well.

But a simple lack of water is not the only problem. In some areas, such as the Amazon Basin, there is, in fact, ample water. The problem is that it is not always clean – free from chemical pollutants and disease-causing organisms.

Access to safe drinking water is at the heart of many health and other sociological and development issues. Among children, for example, higher frequency of diarrhoea leads to fewer days at school and a more limited education. In some African countries, children are often required to travel long distances to collect water for the family instead of attending school.

In other words, without access to safe drinking water, many children are unlikely to reach their true potential.

There are, however, suitable technologies available around the world – many developed in the South, and some very simple – that can be applied more widely to solve these problems.

The aim of the Trieste workshop was to bring together scientists who have developed and helped disseminate these methods to local communities. As with a previous water issue-focused workshop, held in Trieste in November 2000, the case studies will be edited into a non-technical format for publication in the UNDP-SCC, TWAS, TWNSO *Sharing Innovative Experiences* series. In this way, lessons learned from the discussions will be disseminated to a wider audience, including policy-makers, relevant nongovernmental organizations and other stakeholders, in both developed and, more importantly, developing countries. The book will highlight the role of community involvement in drinking water issues, which, until now, has largely been ignored at the policy level.

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#### TWNSO SAFE DRINKING WATER ADVISORY BOARD

- Dorairajan Balasubramanian (TWAS Fellow 1997; L.V. Prasad Eye Institute, Hyderabad, India, and principal author of the TWAS report: *Safe Drinking Water: The Need, the Problem, Solutions and an Action Plan*)
- Mohamed El-Ashry (TWAS Associate Fellow 1990; ex-chief executive officer and chair of Global Environment Facility)
- Luis Marin (chair, Water Network, Mexican Academy of Sciences)
- Mohan Munasinghe (TWAS Fellow 1994; chair, Munasinghe Institute for Development, Colombo, Sri Lanka)
- Abdin Mohamed Ali Salih (TWAS Fellow 2002; UNESCO Tehran office, Iran)
- Mohamed Mahmoud Tawfik (chief of Hydrology Division, World Meteorological Organization, WMO)

Invitations for the submission of short proposals to attend the workshop were sent out to 185 institutions in the South working on water-related issues. More than





50 proposals were received. Of these, 21 were selected by the advisory board (see box) to prepare full-length case studies describing their ‘innovative experiences’ and to attend the workshop. Representatives of 20 institutions came to Trieste to present their work and take part in discussions.

Following the format set by previous TWNSO workshops in its other programmatic areas, two guest speakers set the scene for the meeting. Mohamed El-Ashry spoke on *The Global Challenge of Water Resource Management* and Richard Meganck, rector of the Institute for Water Education (UNESCO-IHE) based in Delft, the Netherlands, examined whether *The South Can Learn from the North or Do They Need Their Own Drinking Water Policies?*

**Some 40 percent of the world’s population lives with supplies of water classified as ‘limited’, ‘scarce’ or ‘stressed’.**

## OUTCOMES

At the conclusion of the workshop, delegates agreed to create the TWNSO Safe Drinking Water Network to help the exchange of knowledge and information and further the discussions that took place during the workshop. Advisory board member, Luis Marin, *Instituto de Geofísica, Universidad Nacional Autónoma de México* (UNAM), agreed to establish and oversee the network for three years. It is now up and running as an internet newsgroup. All 185 institutions that were invited to submit proposals to attend the workshop have been invited to join. Other interested institutions can sign up to the newsgroup at [groups.yahoo.com/group/twnsosdwn/](http://groups.yahoo.com/group/twnsosdwn/). A Mem-

orandum of Understanding has been finalized between UNDP-SSC and WMO committing these sponsor organizations to supporting the network.

Another significant outcome of the workshop is an agreement between TWAS and the Mexican Academy of Sciences. The Mexican Academy of Sciences has been offering 10 fellowships for Latin American students working on water-related issues to study at UNAM. Now – in collaboration with TWAS – the Mexican academy is extending this programme to students from all developing countries. TWAS has agreed to pay travel costs while the Mexican Academy of Sciences and UNAM cover on-site expenses.

Finally, TWAS, the Water Centre for the Humid Tropics of Latin America and the Caribbean (CATHALAC, located in Panama) and the Mexican Academy of Sciences are discussing the creation of an award for South-based scientists working on water-related issues. It is hoped the winner of the first such prize will be announced at the Fourth World Water Forum to be held in Mexico in 2006. ■

# TURNING SALT WATER INTO FRESH WATER

**I**n his epic poem, *The Rime of the Ancient Mariner*, Samuel Taylor Coleridge wrote: “Water, water, every where, And all the boards did shrink. Water, water, every where, Nor any drop to drink.” Of course, Coleridge was talking about seawater – but problems with the salinization of groundwater, the intrusion of seawater into over-exploited coastal aquifers and the natural presence of brackish water in groundwater sources near the sea means that the problems faced by the becalmed ancient mariner also face millions of people in developing countries today. At the TWNSO Safe Drinking Water workshop, Pushpito Ghosh of the Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar, India, described an efficient technique for removing the salt from brackish water.

Seawater typically contains between 30,000 and 35,000 parts per million (ppm) of total dissolved solids (TDS). Such a high concentration of salts can be damaging to the kidneys and cause other health problems. Ideally, water for drinking should contain less than 1,000 ppm of TDS.

Seawater can be made potable in desalination plants, but these are often expensive to run since they rely on a high input of energy to boil the water and then collect the distilled steam. The water-scarce, but oil-rich, countries of the Arabian Gulf lead the world in the application of seawater desalination.

Another way to desalinate water is to use reverse osmosis.

Osmosis is the process by which water passes through a semi-permeable membrane from a dilute to a more concentrated solution. The process takes place without any input of energy. Reverse osmosis (RO), however, involves high pressures to force pure (or nearly pure) water through a semi-permeable membrane, leaving behind any dissolved chemicals in the original solution.



**Pushpito Ghosh**

***CSMCRI scientists have developed more efficient reverse osmosis plants that are now meeting the water requirements of several communities.***

However, owing to limitations in membrane technology, RO cannot be used if the water to be desalinated contains too much salt. This means that seawater cannot be used as a source of drinking water unless the pressure applied is very large, which, in turn, requires more sophisticated and costly equipment and membrane modules, which is impractical for small, remote villages.

In addition, electricity is needed to provide the power to drive RO systems but areas that lack safe drinking water also often lack a reliable source of electrical power.

Scientists at the Central Salt and Marine Chemicals Research Institute (CSMCRI) have responded to these challenges by developing more efficient RO membranes and adapting indigenous technologies to supply power to the RO units. CSMCRI RO units are now meeting the water requirements of several rural communities in India.

## NEW MEMBRANE

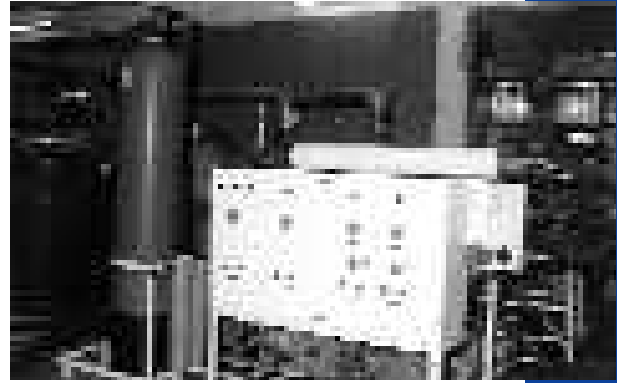
The capacity of any RO system depends on two main characteristics of the semi-permeable membrane: the flux, or rate at which it allows desalinated water to flow through, and the salt rejection efficiency, a measure of how slowly the pores in the membrane become clogged.

Initially, such membranes were based on cellulose acetate. In the early 1990s, however, CSMCRI developed a thin film composite (TFC) RO membrane but the flux was not considered high enough for practical situations. Institute scientists intensified their research in this area to produce a TFC membrane with an increased salt rejection efficiency of around 95 percent and an increased permeation rate of 60 to 68 litres per square metre per hour. This made the new TFC membranes ideal for brackish water applications and brought down the capital cost of desalination plants by almost half.

The first of these single-step RO plants used to desalinate brackish groundwater was established in the village of Mocha in Gujarat, western India, in January 2000. The plant, which has operated continuously since, has an output of 1,800 litres per hour and caters to the needs of some 2,000 villagers.

Data from another plant installed in the village of Kisari, also in Rajasthan, show that the use of the single-step RO process dramatically improves the quality of brackish water, from a TDS level of nearly 2,000 ppm to less than 150 ppm. By reducing the TDS, levels of unwanted chemicals such as fluoride and nitrate were brought within safe limits. In addition, as the RO system also removes bacteria and other microorganisms from the water, local school teachers have reported that many ailments previously suffered by children in the village have been virtually eliminated.

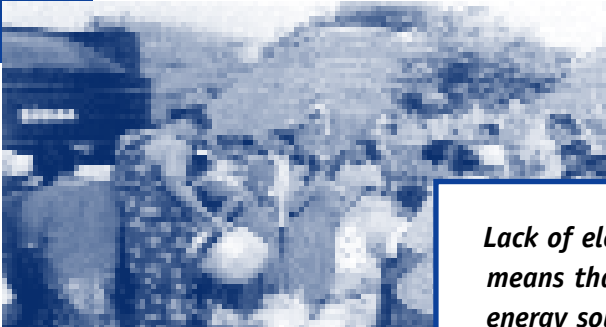
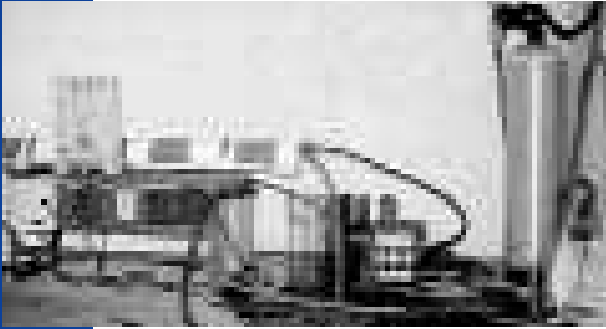
After two years of successful operation, the Kisari RO plant in Rajasthan received national television news coverage in a programme titled “Sweet Success” that acclaimed the project as one of the “greatest success stories of Indian science and technology in rural India”. The television programme also highlighted the health benefits, including the reduced frequency of ailments among children and the expectation of reduced fluorosis problems owing to the reduced fluoride content in water, and improvements to the local quality of life due to such factors as cleaner water for cooking which makes for tastier and healthier food.



## TWO-STAGE SYSTEM

Despite these successes with brackish water, there were still technological hurdles to overcome in adapting the TFC membrane to deal with desalinating seawater.

RO membranes developed and commercialized by such large multinational companies as the Dow Chemical Company and DuPont typically have a very high (more than 99 percent) salt rejection efficiency and are operated at pressures in excess of 800 pounds per square inch (psi). Compared to these more expensive



***Lack of electrical power means that alternative energy sources must be used to provide safe drinking water.***

membranes, CSMCRI's TFC membrane has both advantages and disadvantages. Although it has a lower salt rejection efficiency (of around 95 percent), it does have a high flux, which allows the possibility of desalinating water at more fuel-efficient low pressures (less than 600 psi).

As a result of this finding, CSMCRI scientists explored the possibility of developing a two-stage seawater desalination process. In the first stage, the aim was to reduce the salinity from more than 30,000 ppm to between 5,000 and 6,000 ppm. In the second stage, this permeate would be further desalinated to achieve a salinity of less than 1,000 ppm.

With financial assistance from the local government, the first prototype two-stage RO unit was installed in the village of Nelmadur in Ramanathapuram district, an area in the state of Tamil Nadu that faces an acute shortage of drinking water. Since it is a coastal area, seawater and highly brackish underground water is plentiful. However, villagers have been forced to fetch fresh water from another village located three kilometres away. Large RO desalination plants have been installed in the district but replacement membrane modules are expensive and maintenance costs are high. Large, centrally managed

plants also add to the cost of transporting water to end-users. Smaller plants, such as the prototype two-stage RO unit installed by CSMCRI scientists, located in individual villages or catering to a cluster of villages, are therefore an attractive option.

Analyses of water from the plant in Nelmadur, which has been operational since April 2004, confirm that the two-stage system reduces the TDS of the input seawater from more than 36,500 ppm to about 1,000 ppm, making it suitable for drinking. The plant now operates seven hours a day, using 7,500 litres of seawater to produce 3,000 litres of water suitable for human consumption. Today, some 2,000 people in 290 families are benefiting from the plant.

### **ANIMAL POWER**

Just as many villages in remote rural areas lack access to safe drinking water, they also lack access to a reliable electricity supply, especially the three-phase power required for medium-to-large RO desalination systems. In addition, in the aftermath of natural disasters such as the

supercyclone that hit Orissa in October 1999, the earthquake that struck Kutch in January 2001 and the tsunami of December 2004 that devastated many regions bordering the Indian Ocean, a lack of electrical power means that alternative energy sources must be used to relieve the immediate crisis of the availability of safe drinking water.

One option is to use a traditional source of power – draught animals. Oxen, donkeys and other animals are common in many villages and, especially in the summer months when the requirement for drinking water is more acute, are typically under-utilized.

CSMCRI, therefore, has developed a 'speed increaser' or accelerator that allows its high flux RO unit to be interfaced with power supplied by oxen.

The problem with using oxen to power an RO unit is that the input power has a low speed (about two revolutions per minute, rpm) and high torque (the oxen are connected to the machinery via a 4-metre shaft) whereas the output requires a high speed and low torque. This conversion has been achieved by designing an accelerator that is attached to the input shaft. The accelerator



comprises three sets of gears and produces an output of some 200 rpm. This output is fed, via a crankshaft, to a high-pressure pump that forces 20 litres per minute of feed or input water containing up to 5,000 ppm of TDS into the RO membrane unit designed for brackish water.

In trials carried out on a prototype model at CSMCRI in Bhavnagar, the loss of energy due to friction in the system, which increased the animals' workload, was identified as a major problem. However, this was overcome by replacing a wooden roller with a wheel and tyre assembly that supported the weight of the driveshaft. Additional studies have shown that oxen can work up to six hours a day provided they are given occasional rest periods. Using this system, the peak performance measured was 780 litres of drinking water produced per hour, while the average performance was 600 litres per hour.

At the request of the Public Health Engineering Department of West Bengal, an animal-powered RO unit was set up in February 2004 to treat saline pond water with 4,200 ppm of TDS. Test results have confirmed that the unit has reduced the turbidity, salinity and arsenic content of the water, making it safe to drink.

The animal-powered RO unit is also finding applications in other areas. One system is being installed in the Sundarbans Tiger Reserve area in northeast India where its quiet running will not disturb the peace of the natural environment. In such arid areas as Rajasthan in northwest India, camels are more common than oxen. Therefore, in collaboration with Rajasthan Mines and Minerals, CSMCRI scientists are now adapting the ox-powered system to run on camel power.

## SAFE DRINKING WATER AND THE ASIAN TSUNAMI

*On 26 December 2004, exactly four months after the TWNSO Safe Drinking Water workshop, a massive tsunami, centred off Banda Aceh on the island of Sumatra in Indonesia, devastated many coastal communities around the Indian Ocean. As always in cases of natural disaster, among the first priorities of the relief teams were to provide safe drinking water and to restore local water sources (many wells, for example, had become filled with seawater). Although TWNSO was not directly involved in these efforts, several workshop delegates, including Pushpito Ghosh of CSMCRI, lent their expertise to the relief efforts.*

*Within two weeks of the disaster, CSMCRI had installed an RO desalination unit at Akkaraipettai in Nagapattinam District, the worst affected part of the Tamil Nadu coast. The unit, installed in the institute's coach and powered by a generator, was providing 20,000 litres of safe drinking water a day from a brackish well. Other units have also been installed at Campbell Bay and Car Nicobar on the Nicobar Islands, near the epicenter of the earthquake that caused the tsunami.*

*Chitra Parameswar of CDM, a global engineering, consulting, construction and operations company with offices located worldwide (see [www.cdm.com](http://www.cdm.com)), spent one week touring affected parts of Sri Lanka, meeting with representatives from central and local government water and sanitation agencies, provincial council officials and development organizations. She has developed a network of contacts in the country and is*

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[CONTINUED PAGE 34]

helping to draw up recommendations for the rebuilding of water and sanitation infrastructure in affected areas. "Current tentative estimates of the requirements for all provinces come to about US\$400 million," says Parameswar, adding that "both the public and private sectors in Sri Lanka are well aware that it is in the best interests of their people, especially the rural poor, that the current focus on their island be used not just for disaster relief, but to generate momentum to secure commitments for sorely-needed long-term development assistance." For additional information, contact: parameswar@cdm.com.

Luis Marin of the Instituto de Geofisica, Universidad Nacional Autónoma de México (UNAM), in his capacity as member of the board of directors of the Association of Ground Water Scientists and Engineers (AGWSE), a division of the United States-based National Ground Water Association (NGWA, see [www.ngwa.org](http://www.ngwa.org)), sent a document on 'Water Well Disinfection' containing advice and guidelines for water management authorities and local communities on how to restore their tsunami-affected wells. To make the document more effective, it has been disseminated, by TWNSO and other organizations, for translation into the local languages of the areas hit by the tsunami. To further utilize the expertise of more than 10,000 AGWSE members, similar documents are being planned. "What we need now is input from people in affected regions concerning what technical information is required by local communities," adds Marin. For additional information, contact: [lmarin@mail.com](mailto:lmarin@mail.com).

The accelerator is also being adapted so that the animal-powered unit can be used to desalinate not just brackish water, but also seawater. Eighty to 100 litres of potable water can be produced per hour from seawater but the total output needs to be increased if the technology is to be made practical. Improving the efficiency of the accelerator will also reduce the load on the draught animals.

## WHERE NEXT?

Critics initially dismissed CSMCRI's efforts to use RO technology in villages since many plants previously installed by private companies (albeit using different types of membranes) have been abandoned. Linked to this, decision makers continued to believe that RO plants were expensive to build and inefficient and were unaware that the technology had advanced. Now, CSMCRI's improved technology makes the costs of establishing RO plants more attractive. In addition, thanks to the success of the various prototype RO units and coverage in the national press and on television, the central government of India and several regional governments have begun to look more favourably on desalination than they had in the past. Indeed, many government officials have visited desalination plants and have come away impressed by the quality and the taste of the water being produced.

A measure of the impact of CSMCRI's RO units is the number of requests for new installations, both large and small. For example, CSMCRI is in discussions to install a plant in Rajasthan capable of producing 0.5 million litres of drinking water per day from mine water. In addition, the government of West Bengal has asked CSMCRI to install three plants, each with a capacity of 5,000 litres per hour, and the Tamil Nadu Water Supply and Drainage Board has asked for the installation of five plants for the treatment of saline to highly saline water with capacities ranging between 0.1 and 0.5 million litres per day. The district administrator of Ramanathapuram, where one of the prototype units was installed, has placed orders for additional units. CSMCRI will also be demonstrating their camel-operated RO unit to the border authorities in the highly arid Barmer district of Rajasthan. The ultimate aim is to deploy the unit in border areas where brackish water is available but where, for want of appropriate technology, drinking water is currently transported in over long distances.





### PAY AS IT FLOWS

Despite these successes, CSMCRI scientists believe that the technology of the RO units can be further improved. In a project sponsored by the Indian government's Department of Science and Technology, for example, CSMCRI scientists are redesigning the two-stage sea-water RO unit so that both the first and second stage operations proceed simultaneously. As well as speeding up the process, it is estimated that this would help maximize output and reduce capital and operating costs by 25 percent. There are also plans to introduce a nanofiltration step to pre-treat water entering the RO units. By reducing the TDS entering the first membrane unit, and therefore the osmotic pressure, the energy required to operate the units would be reduced. In addition, lowering the hardness of the water would help prevent the formation of scale deposits on the RO membrane and prolong its working life. At the same time, efforts are continuing to increase the RO membrane efficiency still further.

CSMCRI scientists are also working on the development of an appropriate Pelton wheel, an efficient type of water wheel, that can recover and reuse the hydraulic energy locked up in the high-pressure reject water, further reducing the load on the draught animals in the animal driven RO units.

There are also questions concerning the sustainability of the units that have been installed. One issue that needs to be tackled, for example, is the disposal of highly saline reject or waste RO water, particularly in inland areas.

A model must also be developed for financing the installation of RO units and to cover their long-term operation.

***The central government of India and several regional governments have begun to look more favourably on desalination.***

One proposal is that national and regional governments should subsidize the installation of RO units with the balance of funds being supplied by donor agencies or bank loans. A nominal charge could be levied for the water (for example, US\$1 per family per month), which would be used to repay loans and cover routine operation and maintenance costs.

Villagers in Tamil Nadu have been surveyed and are receptive to paying a charge for their water to cover operational and maintenance expenses.

In many isolated rural areas, the concept of paying for water is a novel one. However, during the TWNSO workshop, case study after case study confirmed that villagers were willing to pay a fee to ensure long-term access to safe drinking water once the benefits of the clean water supply had been clearly demonstrated. In contrast, without such a levy, schemes to provide safe drinking water to local communities were often destined to fail.

# GROWING PROFITS FROM PLANTS

WHILE INDIA'S COMPUTER SOFTWARE INDUSTRY HAS COME TO SYMBOLIZE THE NATION'S EMERGENCE AS A MAJOR PLAYER IN GLOBAL SCIENCE, RAPID ADVANCES ARE TAKING PLACE ON OTHER FRONTS AS WELL. THE NATIONAL CHEMISTRY LABORATORY'S WORK ON MEDICINAL PLANTS IS A CASE IN POINT.

**D**arshana Zaveri, a graduate student at Harvard University's Kennedy School of Government, worked as an intern at TWAS last summer under a grant funded by the David and Lucille Packard Foundation. The internship was part of a larger project, led by the Initiative for Science and Technology for Sustainability (ISTS), located at Harvard University, that has resulted in a series of conferences, workshops and publications as well as the creation of a website (see [sustsci.harvard.edu](http://sustsci.harvard.edu)) all focusing on issues related to science-based sustainable development. Zaveri's internship enabled her to travel to her home country to examine the enormous progress that India has recently made in melding traditional plant knowledge with modern scientific practices. Much work remains to be done but India is well on its way to becoming a key international player in this potentially lucrative area of science, and the National Chemistry Laboratory, in Pune, India, has emerged as one of the leading players.

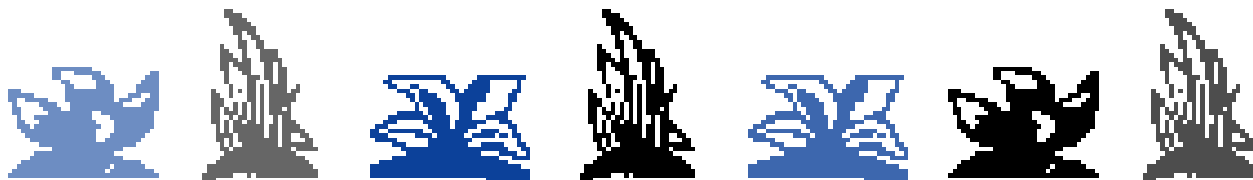


The use of medicinal plants is as old as civilization itself and the practice remains as popular today as it was a millennium ago.

In fact, nearly 80 percent of the world's population depends on traditional medicines for its primary health care. And while the use of medicinal plants is most common in

developing countries, over the past several decades demand for natural products – both for cosmetic and medicinal purposes – has sharply increased in developed countries as well.

Despite the long-standing and widespread use of pharmaceutical applications, scientists have yet to scratch the surface of medicinal plants. Less than 1 percent of the 500,000 higher plants in existence have been examined for their therapeutic properties. That's because separating and identifying the thousands of individual chemical components that plants contain has been a technically challenging, time-consuming and labour-



intensive process. Follow-up activities, designed to identify which components are pharmacologically active, have proven even more difficult.

Thanks, however, to rapid advances in technologies designed to isolate chemicals from plants, many institutes have begun to expand their plant research programmes. Scientists at the National Chemistry Laboratory (NCL) in Pune, India, for example, have initiated an innovative approach to drug discovery that brings together traditional knowledge and medicinal chemistry with automated biological testing methods.

### EXCELLENT FOUNDATION

In many ways, NCL embodies the breathtaking progress that Indian scientific institutes have made over the past several decades – and especially over the past few years.

Established in 1950 as part of India's Council for Scientific and Industrial Research (CSIR), NCL was projected to be India's premiere chemistry research centre. Over the past 55 years, it has lived up to its initial billing. Today the institute provides consulting services to numerous clients both in India and abroad. Staff expertise ranges from organic and polymer chemistry to fuel cells and biotechnology. Medicinal plant research is just one of the many disciplines practiced.

In the chemical sciences, each year NCL awards the largest number of PhDs, files the most domestic and international patents, and publishes the second highest number of articles in India.

Having built a formidable reputation for excellence in research, NCL has recently turned its attention to developing novel pharmaceutical products. K.N. Ganesh, head of organic chemistry and one of the lead researchers in charge of drug discovery, is optimistic about NCL's new ventures.

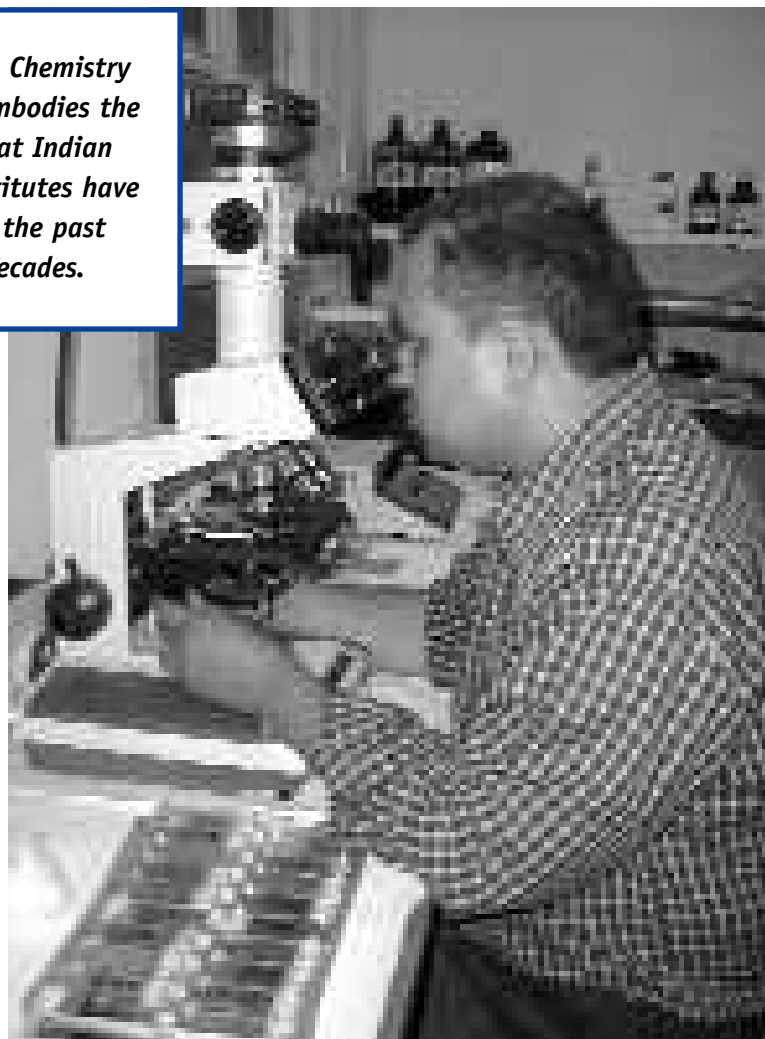
"When it comes to pharmaceutical research," he explains, "we have some distinct advantages. For exam-

ple, the institute is located in India's Western Ghats region, one of the world's 18 biodiversity 'hot spots' harbouring a treasure trove of medicinal plants. The institute also trains some of the best organic chemists in the country. And, as part of the CSIR network, comprised of 38 national laboratories, NCL can tap the strengths of its institutional partners to broaden the depth and range of its own scientific team."

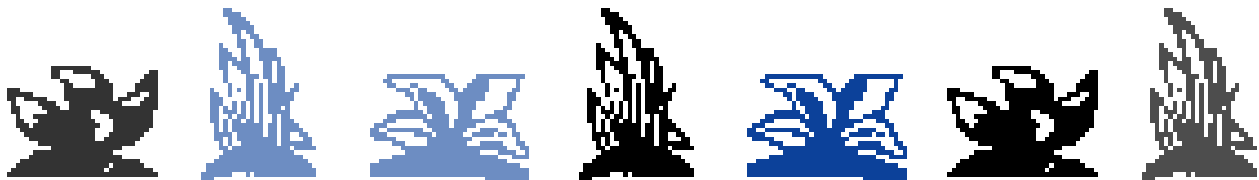
In the past, however, NCL's drug discovery strategy has lacked integration, particularly between the fields of chemistry and biology that would help move laboratory research to the drug counter. Most of its scientists,

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*The National Chemistry Laboratory embodies the progress that Indian scientific institutes have made over the past several decades.*



[CONTINUED PAGE 38]



including Ganesh, are keenly aware of this problem. “Early attempts at isolating chemical components from plants, although often successful, remained an esoteric and largely intellectual exercise,” he says. “Results were published in prestigious scientific journals but invariably failed to yield products of real medicinal value.”

The natural products group, responsible for medicinal plant work, echoes his opinion. S.P. Joshi, who received her doctorate from NCL 20 years ago and is now a principal investigator within the group, is at once proud and despairing about her experiences in this field. “The extraction of ingredients from plants is a time-consuming and error-prone process,” she explains, “and the level of complexity poses a continual challenge.” Other researchers in the group echo similar sentiments adding that even successful attempts have often been stymied at a later stage due to the lack of infrastructure for testing biological activity.

Things, however, are rapidly improving. One flight down from NCL’s reception and main offices, an integrated nexus of state-of-the-art research and development facility is being built. In 2000, when the insti-

tute celebrated its 50<sup>th</sup> anniversary, its parent organization, CSIR, gave NCL a generous financial grant that enabled it to construct an avant-garde integrated research complex named the Combi Chem Bio-Resource Centre.

The centre has quickly emerged as an excellent example of how melding indigenous knowledge of medicinal plants with knowledge of synthetic chemistry carries the potential of yielding drugs with unique therapeutic value. Success depends on integrating chemistry with biology, which allows hundreds of chemical compounds derived both from plants and artificially created in the laboratory, to be produced and tested for their ability to treat different diseases.

#### DRUG DISCOVERY

Tuberculosis (TB) poses a serious public health threat in many developing countries, including India, but finding remedies for TB does not have the same profit potential as finding remedies for diseases more commonly associated with the developed world,

such as arthritis and heart disease. As a result, international pharmaceutical companies have remained largely on the sidelines when it comes to TB research.

Ayurvedic literature, India’s indigenous medical practices and, more generally, local folklore, describe plants that have been used to cure TB. The challenge for successfully utilizing this information on a large scale involves targeted drug making. Simply put, the chances of success are amplified when all the chemicals from potentially relevant plants are tested for their impact on combatting TB.

The critical question is one of capacity. How can researchers isolate the hundreds, even thousands of

***The challenge for successfully utilizing India’s indigenous medical practices on a large scale involves targeted drug making.***



chemicals, that make up each of the plants and test them quickly and efficiently?

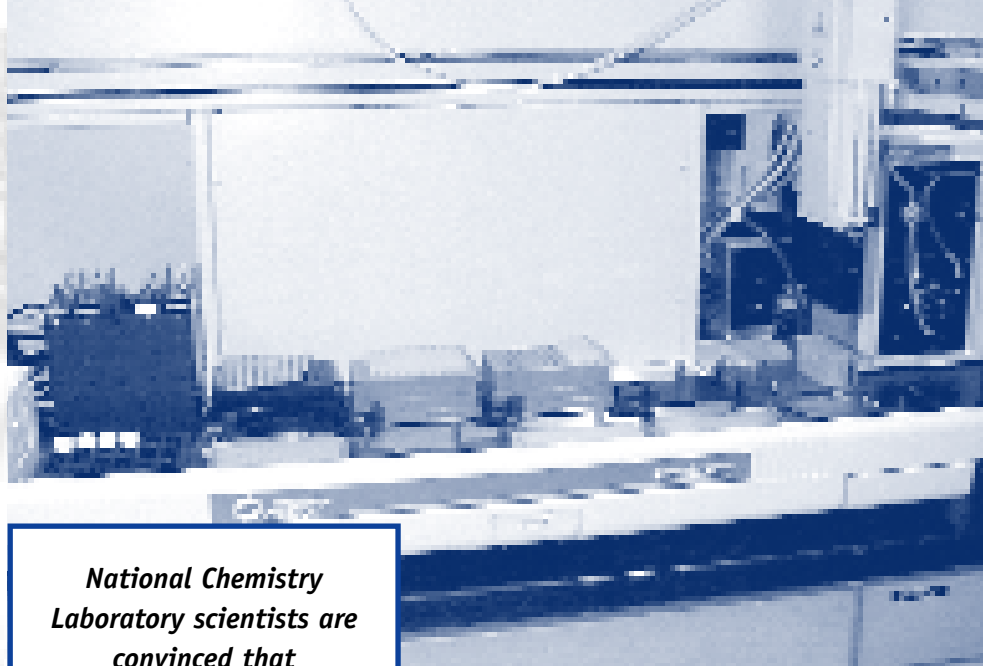
That's where Combi Chem Bio-Resource Centre's distinctive approach adds true value. The centre's contribution lies in incorporating three sophisticated instrumental technologies that function together in the drug discovery process.

One of these technologies involves the 'sepbox', an instrument that automatically separates plant extracts into individual chemical components. Another instrument, a 'parallel synthesizer', produces hundreds of different molecules by making small changes to a single compound.

Both instruments spawn 'libraries' of molecules that can be subsequently tested for their activity against different diseases using the third instrument, a high-throughput robot named 'Biomek 2000'.

NCL scientists are convinced that automation will revolutionize the search for plant-derived drugs. For example, a technician manually separating a plant extract into its component parts can take up to 6 months to complete the job; the sepbox does the same job in just 24 hours. More importantly, it divides each extract into 500 parts. Thus the once difficult task of obtaining purified compounds from plants is now possible on a routine basis.

The same goes for biological testing. Clearly, the higher the number of compounds tested, the greater the chance of finding some compounds that warrant addi-



***National Chemistry Laboratory scientists are convinced that automation will revolutionize the search for plant-derived drugs.***

tional study. Once again the bottleneck is the ability of humans to perform this work in a reasonable amount of time. Even with modern

equipment a technician can test an average of just 50 compounds a day. In contrast, Biomek 2000 can test up to 10,000 compounds a day. The automated system simply replicates a long-established procedure but does so in a manner that allows thousands of compounds to be tested for many different diseases in a very brief time, significantly boosting the chances of success.

Many Indian institutes have developed expertise in various fields of medicinal research but few have managed to combine the power of automation with traditional know-how. Building such capacity requires a significant financial investment. A sepbox, for example, costs US\$1 million. Thus it should come as no surprise that NCL is one of only four institutes in India with the sepbox technology. In fact, the instrument at NCL is a

### **PRACTICING MEDICINE: THE CRAFT**

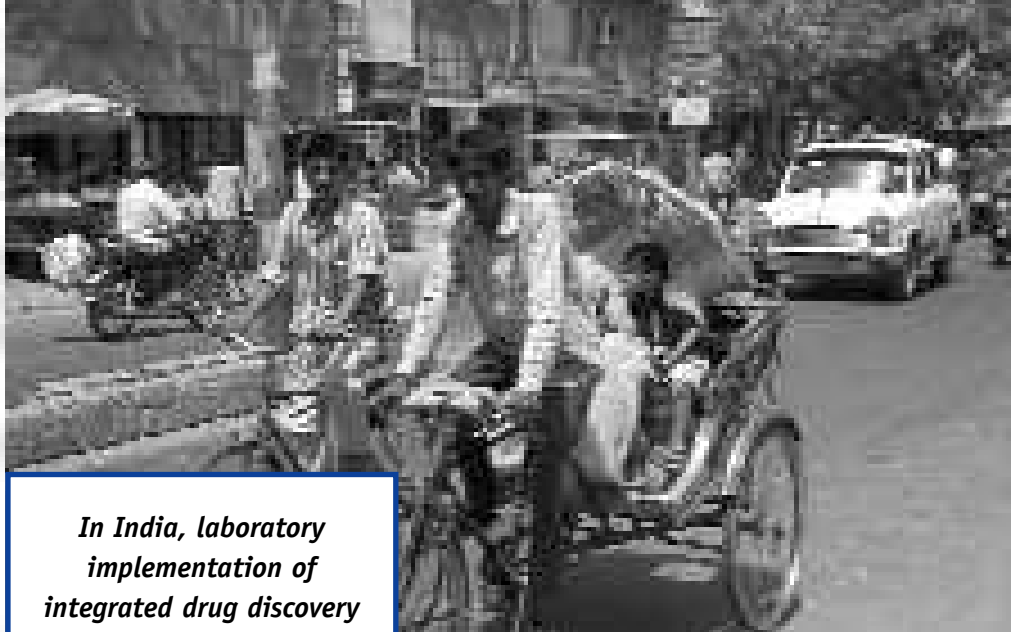
*Traditional Medical Practitioners (TMPs) are an important source of information for researchers attempting to sift through hundreds and thousands of plants known to have therapeutic properties. Pulse doctors, plying their craft within the boundaries of an ancient school of medicine called 'Ayurvaidyashala' (school of Ayurveda), can identify the medical history of a patient based on their pulse and then prescribe herbal treatments. These TMPs have agreed to impart their knowledge to NCL scientists on condition of absolute secrecy. NCL researchers, in turn, have collected the plants and are in the process of isolating their chemicals in the centre's laboratories.*

one-of-kind in India, capable of separating much larger quantities of raw material than the other three.

As a result of this capacity, NCL has enjoyed widespread media coverage. Ganesh explains: "Advocates view NCL and the Combi Chem Bio-Resource Centre as places to develop skills and facilities for multiple purposes that will ultimately provide opportunities for building indigenous technology capable of competing at a world-class level."

### PLANS AHEAD

Despite initial enthusiasm and the hard work that has gone into setting up the Combi Chem Bio-Resource Centre, several critical challenges remain stubbornly in place. Getting the infrastructure up and running has been a slow and drawn-out process that is not yet complete. For example, it has taken nearly 2 years to build the high-throughput screening system and most of the biological testing still remains in the design stage. The sepbox has been used just once and only about 500 synthetic compounds have been created using the par-



***In India, laboratory implementation of integrated drug discovery from medicinal plants is being increasingly embraced.***

allel synthesizer.

One obstacle to quick implementation has been the absence of 'wet labs', specifically designated areas for growing cells and bacteria. Another obstacle has been the limited number of personnel with the skills to run complex experiments. Recent new recruits have helped overcome the latter problem. For example, Dhi-man Sarkar was hired from Astra Zeneca in Bangalore, India, for his expertise in high throughput screening, and Srinivas Hootu, a skilled combinatorial chemist, was lured back from the Rockefeller Institute in New York.

NCL also enjoys the loyalty of many talented staff members who have decided to forego – or at least postpone – lucrative careers in private industry for the freedom and satisfaction that work in an academic environment can engender. Still, as a government laboratory in a developing country, NCL cannot always offer the compensation needed to attract and retain the best talent. Limited financial resources sometimes affect the quality of the work environment as well. For example, each run of the sepbox costs US\$10,000, a primary reason why only one run has taken place to date. Such realities make partnerships with industry inevitable.

NCL has grand ambitions for the Combi Chem Bio-Resource Centre. For example, plans call for the construction of an additional 1000 square metres of space that will be dedicated to the centre's integrated drug discovery efforts. The space will be used for wet labs, a pharmacology laboratory to test viable drug candidates in animals, and research facilities for conducting state-of-the-art investigations into the way human proteins interact

### A GOLDEN TRIANGLE

*In India, both the scientific concept and laboratory implementation of integrated drug discovery from medicinal plants are being increasingly embraced at the institutional and national level. The Council for Scientific and Industrial Research's (CSIR) Integrated Programme for the Discovery and Development of New Bio-Actives is one example of this effort. Designated the Golden Triangle project, it promises to capitalize on the strength of India's ancient medical arts and the abundant scientific know-how within the country by bringing all the parties together to focus on the same goal: drug development. For additional information about this new programme, see [www.csir.res.in](http://www.csir.res.in).*





with chemicals.

Part of the financing for the expansion will likely come from the government but most will be self-financed and attained largely through collaborations with private companies. Ganesh notes that “one way to generate funds may be through the leasing of our high throughput facilities.” Raising the prospects for such public-private partnerships is indicative of how far Indian institutes have come in recent years. In the past, private companies pioneered new technology. Today that role is increasingly being played by public organizations like NCL.

### TECHNOLOGY TO POLICY

Successful commercial exploitation of medicinal plants could pose a serious risk to biodiversity. Environmentalists have already rung alarm bells about the rate at which tropical forests and other ecosystems that are rich in plant resources (grasslands, savannas, coastal plains and drylands) are being depleted and, in some instances, destroyed.

Policy makers and scientists are taking such warnings seriously. NCL's own conservation efforts are unfolding in two distinct and complementary directions. First, the centre is augmenting plant drug discovery with ‘combinatorial’ chemistry. The advantages of this approach is that once a promising biological activity has been identified it can be chemically replicated in the laboratory. This is particularly helpful when the plant is a threatened species or when it cannot be harvested in a sustainable manner as was the case with taxol, an extract from the bark of the yew tree used to treat cancer that generated some US\$250 million in sales in 2004.

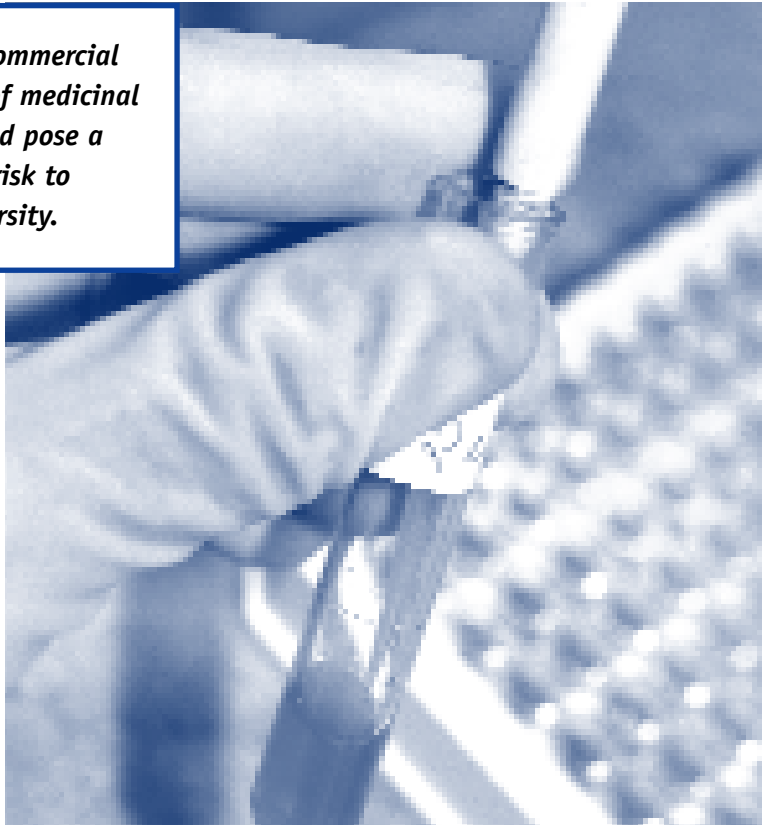
Another way to minimize the indiscriminate use of plants in the wilderness is to cultivate plants that have commercial value specifically for large-scale drug production. Once again advances in science, this time in

molecular biology, are transforming a well-established practice. A common attribute of medicinal plants is that they often require specific environmental conditions to reveal the active chemicals that are inherent in their makeup.

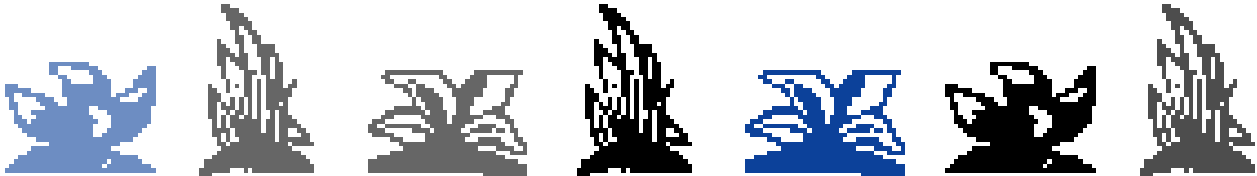
Take, for example, the case of the species *Caultheria fragrantissima* whose product methyl salicylate (commonly called oil of Indian wintergreen) is used as a painkiller. It grows both in the northeast and Western Ghats region of India. Scientists in NCL's plant biotechnology group used genetic information to discover that the version growing in the northeast produces significantly larger quantities of methyl salicylate than its counterpart from Western Ghats. Such information is useful in identifying the best plant variety for cultivation. The next steps – genetically modifying it so that it produces even more of the active ingredient and transferring the product to people of the region – could help local

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**Successful commercial exploitation of medicinal plants could pose a serious risk to biodiversity.**



[CONTINUED PAGE 42]



populations attain a sustainable livelihood.

### PLANT MINING MATTERS

Mining plants for 'single molecule' drugs has assumed enormous scientific, social and economic significance. While global health care needs have rapidly multiplied, conventional allopathic medicine is failing to deliver effective and less toxic treatments in a sustained manner.

Scientifically, medicinal plants provide a new avenue for research and development. In fact, such plants offer developing countries the opportunity to build their own scientific capacities. Economically, local communities could benefit enormously from cultivating the plants for commercial use. Socially, greater use of medicinal plants in the creation of effective pharmaceutical products would help meet the health needs of citizens in both the developing and developed world.

To encourage science-based investigations of medicinal plants,

***Medicinal plants offer developing countries the opportunity to build their own scientific capacities.***

policy makers will have to create favourable conditions for progress. The Indian government, for example, is trying to overcome past piecemeal approaches to medicinal plant research through institutional changes. Efforts are in place to integrate the divergent strategies of agencies that fund plant based research – for example, the National Medicinal Plants Board, the Indian Council for Medical Research, the Department of Biotechnology (DBT) and the Department of Science and Technology (DST) – into a comprehensive complementary approach for drug discovery. Over the past 5 years, funding for drug development in India has increased substantially.

The Indian government is clearly viewing its medicinal plants as a potential source of wealth. And so too are India's scientists. As Renu Swaroop, director at DBT, notes, "our current research goal is to take molecules from plant extracts to their logical conclusion as pharmaceutical products."

As the NCL case study shows, all of the pieces for successful drug discovery and commercialization are now in place. For India to effectively tap its vast storehouse of plant resources, it must now devise an effective strategy for enabling its deep-seated indigenous knowledge to work in concert with its growing capacity in modern science. ■

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# BARRED FOR LIFE

A NEW PROJECT, LAUNCHED BY THE SMITHSONIAN INSTITUTION WITH FUNDING FROM THE ALFRED P. SLOAN FOUNDATION, HOPES TO ACCELERATE THE PACE OF SPECIES IDENTIFICATION. THE BARCODE OF LIFE INITIATIVE WILL SEEK TO TRANSFORM TAXONOMY INTO A RAPID-RESPONSE DISCIPLINE DESIGNED TO ADDRESS A HOST OF ENVIRONMENTAL AND SOCIETAL CONCERNS. THE DEVELOPING WORLD COULD BENEFIT GREATLY FROM THIS EFFORT.

The great 19<sup>th</sup> century physicist and mathematician, Lord William Thomson Kelvin, once described taxonomists as nothing more than “stamp collectors”.

Yet, as Lord Robert May, president of the Royal Society, recently noted, taxonomists play a central role in addressing some of the most critical science-related issues of our time, including the protection of ecosystems and the preservation of biodiversity. Their work, he observes, provides “the foundation for conservation and all environmental action.”



The problem with taxonomy, May notes, has nothing to do with either its potential usefulness to society, which is considerable, or its level of intellectual difficulty, which is formidable. The problem instead is related to the pace at which the work is done – a pace that has been painstakingly slow.

Over the 250-year history of taxonomy, some 1.8 million species have been identified. Meanwhile, scientists estimate that between 10 and 30 million species inhabit the Earth. That means at the current rate of species identification, it could take 4,000

## CONSORTIUM FOR LIFE



The Consortium for the Barcode of Life (CBOL), established in May 2004, is an international collaboration of biological inventory sites, biological repositories, herbaria, natural history museums, research agencies and zoos. The consortium currently has 52 institutional members in 25 countries. Individual representatives include academic and commercial experts in bioinformatics, computer science, genomics, molecular biology and taxonomy. CBOL's mission is to rapidly accelerate the compilation of DNA barcodes of species, establish a public library of sequences linked to named species, and promote the development of portable devices for DNA barcoding. The consortium is supported by a grant from the Alfred P. Sloan Foundation. For additional information, see [barcoding.si.edu](http://barcoding.si.edu).



years to complete the job. Or, put another way, we have likely identified less than 10 percent of the species that inhabit our planet. The truth is that even as we search for life on other planets, we know surprisingly little about the diversity of life here on Earth.

At a more immediate level, policy makers focusing on environmental protection often require critical information about biodiversity and habitat loss in a matter of days or weeks, not the months or years that taxonomists often need to formulate a response.

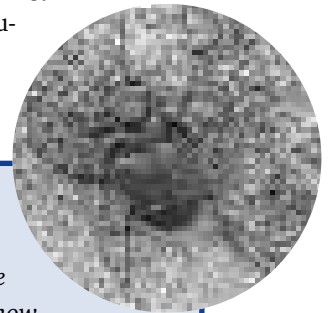
In effect, the pace of taxonomy is out of sync with the pace at which decisions are made in today's world. The result is that taxonomy, however elegant and compelling a science it is, has become an increasingly marginalized pursuit tainted by a dusty, almost quaint, image.

That image – and, more importantly, the pace at which species are identified – may soon be radically transformed thanks to the advent of a promising DNA-related technology labelled 'barcoding'.

The technique, uncovered by Paul Herbert, professor of zoology at Guelph University, Canada, less than three years ago, focuses on a small uniform segment of the mitochondrial genome – 600 to 650 base pairs of the cytochrome c oxidase I gene (COI) – that offers a unique 'barcode' or 'tag' for species identification, particularly among animals.

Rather than carefully examining the characteristics of an organism, searching for elements that would distinguish it as an individual species, thanks to barcoding, scientists can now turn to short DNA sequences that reveal species-specific differences. The process, moreover, is capable of identifying a species in its many forms – for example, from eggs to larvae to adults, and from seeds to flowers to roots and stems.

In a sense, barcoding adds technology to morphology, supplying another valuable instrument for detection in the taxonomist's toolkit, complement-



## NEEDS AND EMPHASIS

*As history shows, the identification of species is no easy task. To date, only 1.8 million species have been identified. That represents a small percentage of the total number of species on Earth. Just how small a percentage is subject to debate because estimates of the total number of species range widely from 10 million to 30 million species. Taxonomists believe that there are 10 times more plant species than vertebrates and 100 times more invertebrates than vertebrates. At the same time, it is estimated that one-third of all taxonomists work on vertebrates, one-third on plants and one-third on invertebrates. As a result, part of the effort to make species collection and identification more relevant for environmental conservation entails encouraging young taxonomists to pursue research careers in categories of species that 'really count' but that have long been neglected. For example, it is estimated that there are tens of hundreds of thousands of species of fungi alone.*

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ing descriptive features based on shapes and colours with digital printouts detailing their unique genetic makeup.

Barcoding – both as a science and a tool – served as the major theme of the First International Conference for the Barcoding of Life held at the Museum of Natural History in London from 6-9 February 2005. The gathering brought together more than 220 experts in plant and animal taxonomy, forensic sequencing, environmental genomics and information management from 44 countries. While the majority of participants came from developed countries, some 35 were from the developing world, including representatives from Costa Rica, China, Morocco and South Africa.

“Barcoding,” explains David Schindel, executive secretary of the Consortium for the Barcode of Life (CBOL),

***Thanks to barcoding, scientists can now turn to short DNA sequences that reveal species-specific differences.***

### BARRED BIRDS

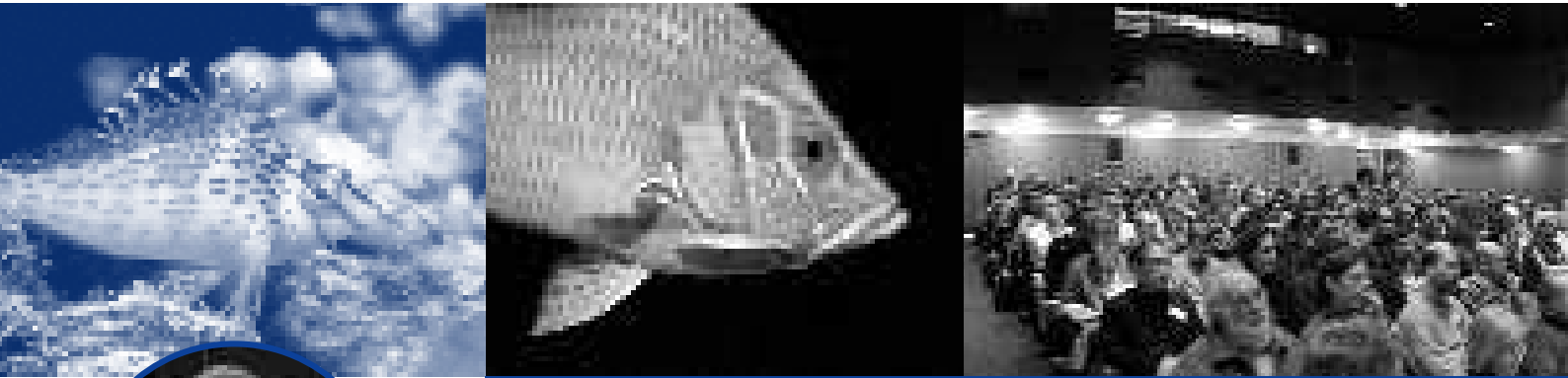
*The world’s first comprehensive initiative to barcode all of the species of a major taxonomic group will focus on birds. The initiative, which has been organized by Rockefeller University and the Smithsonian Institute in the United States, University of Guelph in Canada, and Allan Wilson Centre in New Zealand, will seek to collect and electronically store the world’s 10,000 known bird species over the next five years. The majority of barcode species will be derived from taxonomically verified species housed at museums and other biological institutions in the form of bird skins and frozen tissues. As Mark Stoeckle, guest investigator with the Program for Human Environment at Rockefeller University, notes: “Birds have been carefully studied for decades and are well documented. As a result, they make an ideal test group to measure how accurate barcoding species can be.” For additional information about the Barcoding Birds of the World project, contact Mark-Stoeckle@nyc.rr.com.*

the lead organizer of the conference, “could have a profound impact on ecological management in the developing world and play a key role in the protection of biodiversity. That’s because the technique is not only much easier to learn than conventional taxonomy, which takes years of study and observation to master, but also because it’s much faster and cheaper to do.”

Equally important, because barcoding standardizes the process of species identification, advocates anticipate it will help improve the efficiency of global efforts to single out and name the thousands of new species that are found each year, helping to turn taxonomy from an individual into a collective effort. “That’s why,” Schindel adds, “we

view TWAS as an important member of the consortium. We hope that the Academy can assist us in partnering with universities and research laboratories in the developing world in ways that will help build both barcoding capac-

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**David Schindel**

ity and applications throughout the South.”

Experts estimate that the cost of identifying a species, which now averages about US\$3 a sample in the North and US\$15 a sample in

the South (samples in the developing world must often be sent abroad for identification), could fall to less than fifty cents a sample. Equally important, samples from unknown species could be identified at a local or regional laboratory or museum (or even in the field) instead of having to be shipped to institutions in London or New York, which is often the case today.

The savings in money and time could prove particularly important to developing countries, which often do not have the financial resources or laboratory facilities to identify species on their own. “For this reason,” Schindel explains, “CBOL is keen to build the scientific capacity of institutions in the South in ways that would enable them to conduct their own barcoding work.”

Barcoding’s value, proponents contend, will extend well beyond the identification of species for the sake of science and the environment. The technique, for example, could be used to verify that the fish in a can of tuna is really tuna and not a blend of tuna and by-catch. Or it could test for the presence of banned species in animal feed, which could help control the spread of mad cow disease. Barcoding has even attracted the interest of the airline industry, which can apply the technique to identify birds that are swept into engines during take-offs and landings posing a risk to both airplanes and passengers. Such encounters between planes and birds take place

more than 3000 times a year in the United States alone. The hope is that scientists will be able to identify the species of bird caught in the plane engine, which barcoding can do from scattered feather fragments, and then use that information to locate the birds’ primary habitat, ultimately shoos the birds away from the runways.

Like any tool, barcoding has its limitations and will by no means replace the education and skills that taxonomists have brought to science over the past 250 years. The technique, for example, has proven more

### **BARRED FISH**

*Members of the Consortium for the Barcode of Life (CBOL), in collaboration with the Census of Marine Life headquartered in the United States, have launched a project to collect and electronically store the DNA barcode sequences of the 15,000 known marine fish species and the 8,000 known freshwater fish species. The goal is to complete the project by 2010. As Paul Herbert, professor of zoology at Guelph University in Canada and the first scientist to discover the unique value of species identification conveyed through barcodes, observes: “DNA barcoding of fish could be used for conservation, enabling us to monitor quotas and by-catch and provide a more detailed understanding of fish and their ecological relationships.” For additional information about the Fish-Barcoding of Life project, see [www.barcodinglife.org](http://www.barcodinglife.org).*



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reliable in identifying animal species than it has in identifying plant species. Moreover, barcoding cannot always draw reliable conclusions about the uniqueness of young or newly diverged species (for example, orangutans) or rapidly evolving ‘species swarms’ (for example, cichlid fishes). In such circumstances, barcoding often fails to render a definitive judgement on whether slight differences within the 600 to 650 base pairs of the mitochondrial genome represent a distinction within or between species. Such cases require additional study and the careful eye and expertise of well-trained taxonomists.

Barcoding could prove particularly useful for scientists in the developing world. “In my country,” says Daniel Okeyo, professor of zoology and botany, University of Hare, South Africa, “taxonomy is an ageing profession. Many of the practitioners are old and many of the species that have been collected have been stored away for decades – often without having been appropriately labelled. Making matters worse, a large number of samples were stored in formaldehyde, which has likely damaged the DNA.” As a result, existing collections will have to be carefully re-examined to ensure their integrity and new field surveys will have to be conducted to obtain a true picture of South Africa’s biodiversity. “Barcoding,” Okeyo hopes, “will make this difficult and time-consuming process possible.”

José A. Clavijo Albertos, professor of botany and director and curator of the Museum of the Agricultural



***TWAS can assist the consortium in partnering with universities and research laboratories in the developing world.***

Zoology Institute in Maracay, Venezuela, notes that Central and South America, unlike Europe and the United States, do not have a

large number of dedicated amateur collectors of plant and animal species. “What we do have is a large group of well-trained taxonomists with advanced university degrees who have done an excellent job of identifying the continent’s wealth of biodiversity under trying circumstances.”

Clavijo Albertos, whose museum is home to one of the largest collection of plant species in Central and South America, hopes that barcoding can make initiatives for species identification more rapid and less expensive. “That would obviously aid our taxonomists,” he says. Equally important, Clavijo Albertos anticipates

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[CONTINUED PAGE 48]



***Barcoding all of life will likely be a cheap undertaking as far as international science projects go.***

that barcoding will help “enhance public knowledge of – and ultimately support for – the region’s biodiversity.” Clavijo Albertos believes that one of the primary benefits of barcoding could take place in the field of public education, especially if the increased pace and breadth of identification of species leads to the widespread publication of field guides designed for students and everyday citizens.

“Barcoding all of life,” notes Herbert, who many consider the ‘godfather’ of barcoding, “will likely be a relatively cheap undertaking as far as international science projects go.” The total projected cost will be less than US\$1 billion. “For that relatively modest investment” (the human genome project, in contrast, cost nearly US\$3 billion),” he adds, “we could dramatically accelerate the pace of species identification – a process that would carry wide-ranging benefits for the global environment,

food security, public health and education, and the protection of biodiversity. I and many of my colleagues in the field clearly think it would be well worth the investment.” ■

*For additional information on the Consortium for the Barcode of Life, contact* ❖ **David Schindel**

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## **CODED COSTA RICA**

*The Instituto Nacional de Biodiversidad (INBio), a non-profit research organization linked to Area de Conservación Guanacaste in Costa Rica, and the National Museum of Natural History and Smithsonian Institute in the United States, have signed a memorandum of understanding to develop protocols and equipment to barcode 8,000 plant species in Costa Rica, representing two-thirds of the nation’s flora and covering nearly all of the nation’s ecosystems. Other institutions participating in this project include the Royal Botanical Gardens at Kew, United Kingdom, and the Missouri Botanical Garden, USA. The project, which is expected to be completed by 2008, will barcode dry plant specimens currently stored in Costa Rica’s herbaria as well as conduct ‘voucher’ field surveys. This represents the first effort to barcode the full range of a nation’s plant species. For additional information, see [www.inbio.ac.cr](http://www.inbio.ac.cr).*





# IAMP TO TRIESTE

**THE SECRETARIAT OF THE INTERACADEMY MEDICAL PANEL (IAMP) HAS RELOCATED TO TRIESTE. IAMP JOINS TWAS, TWNSO, TWOWS AND IAP AS PART OF AN EXPANDING NETWORK OF INTERNATIONAL SCIENCE ORGANIZATIONS DEDICATED TO SCIENTIFIC CAPACITY BUILDING.**

The secretariat of the InterAcademy Medical Panel (IAMP), a global network of 52 medical associations or medical divisions within national science academies, has moved to Trieste, Italy. IAMP arrives from Washington, D.C. where it previously operated under the administrative umbrella of the Institute of Medicine of the US National Academies. Under the new arrangement, IAMP will be administered by TWAS, the Academy of Sciences for the Developing World.

“We are delighted that this transfer has taken place,” says David Challoner, co-chair of IAMP’s executive committee and foreign secretary of the Institute of Medicine of the US National Academy of Sciences. “We believe that the move will help IAMP broaden both the range of its activities and its geographic reach, especially among medical research associations in the developing world.”

“The move to Trieste,” adds Guy de Thé, who co-chairs IAMP’s executive committee with Challoner, “will enable IAMP to work more closely with the other international scientific institutions that already operate there, including TWAS, the International Centre for Genetic Engineering and Biotechnology (ICGEB), the Inter-



Academy Panel on International Issues (IAP), the Third World Network for Scientific Organizations (TWNSO) and the Third

World Organization for Women in Science (TWOWS).”

“The proximity of these institutions and the partnerships that are likely to ensue should help advance the agenda of each,” adds de Thé. “We are confident that the arrangement will prove mutually beneficial to IAMP and the other international science organizations in Trieste.” de Thé is a former eminent research scientist at the Pasteur Institute in Paris.

IAMP, which was established in 2000 at the IAP World Conference of Scientific Academies in Tokyo, Japan, is designed to help strengthen its member organizations as part of a larger effort to build scientific capacity for improving global health, especially in developing countries. IAMP also seeks to provide independent scientific advice to national governments and international organizations for the purposes of promoting effective science-based public health care policies.

“IAMP’s most important project to date,” notes Challoner, “has been the Disease Control Priorities Project (DCPP).” The initiative, a follow-up to a similar project that took place a decade ago, provides a comprehensive



comparative cost analysis of disease control strategies. The project's ultimate goal is to help policy makers devise cost-effective public health policies in their nations. Funded by a US\$3.5 million grant from the Bill and Melinda Gates Foundation, DCCP is a joint effort of the Fogarty International Centre of the US National Institutes of Health, the World Health Organization (WHO) and the World Bank. Its findings are scheduled to be published in 2006.

Other IAMP projects include a statement on controlling infectious diseases, issued in March 2002; the organization of a workshop on emerging infections and antibiotic resistance held in Paris, also in March 2002; and participation with IAP on the development of a website devoted to issues related to the health of mothers and children (see [www.mother-child.info](http://www.mother-child.info)).

"IAMP's relocation to Trieste, and a generous grant from local government authorities in Trieste and the surrounding region to help finance a series of programmatic initiatives, will enable the organization to expand its reach and influence," says de Thé.

***IAMP's relocation to Trieste will help the organization expand its reach and influence.***

As a first step in this effort, IAMP's executive board met in Paris in December 2004 to begin devising a programmatic agenda for the organization. The December meeting coincided with a meeting of the IAP executive board in order to discuss possible avenues of cooperation between the two institutions.

"After extensive consultation with our membership," notes de Thé, "we hope to develop a detailed programme of activities for the next two years and I anticipate that we will be up-and-running with a full agenda by next autumn."

"The move to Trieste," says Chal-loner, "puts IAMP in an excellent position to begin to advance an ambitious programme and to do so in ways that could prove to be of particular value to the developing world. As a global organization that has been in existence for just four years, we think we are off to a good start." ■

*For additional information about IAMP:  
website: [www.interacademies.net/iamp](http://www.interacademies.net/iamp)  
email: [iamp@twas.org](mailto:iamp@twas.org)*

# FOUNDING FELLOWS REMEMBERED

LAST YEAR, TWAS MOURNED THE LOSS OF TWO OF ITS FOUNDING FELLOWS. SIVARAMAKRISHNA CHANDRASEKHAR, BORN IN INDIA IN 1930, PASSED AWAY ON 9 MARCH, AND THOMAS ADEOYE LAMBO, BORN IN NIGERIA IN 1923, PASSED AWAY ON 16 MARCH.

## BUILDING BETTER CRYSTALS

**Sivaramakrishna Chandrasekhar**, widely known by his colleagues and friends simply as ‘Chandra’, was educated at Nagpur University in his home country of India, and the University of Cambridge in the United Kingdom. He returned to India in 1961 to help establish the school of physics at the University of Mysore. There he developed an interest in liquid crystals – a relatively new and unexplored area of science that he was to pursue for the next half century.

In 1971, after another spell in the UK, Chandrasekhar again returned to his home country, this time to establish a research laboratory at the Raman Research Institute, Bangalore.

“The term liquid crystal,” wrote Chandrasekhar, “signifies a state of aggregation that is intermediate between the crystalline solid and the amorphous liquid.” During the

early 1970s, research into such liquid crystals focused mainly on rod-like molecules. Chandrasekhar’s seminal finding were ‘discotic’ liquid crystals, so-called because of their circular shape. This allows the molecules to stack, like poker chips, into vertical ‘crystal towers’. However, because each tower is separate, each crystal can flow around and past other crystals as in a liquid.

Since Chandrasekhar’s discovery, some 2,000 new discotic compounds have been synthesized. One of the unusual properties of discotic liquid crystals is that they bend light to a different extent (that is, their refractive index changes) depending on which axis the light is traversing. This makes them useful as coatings for visual displays. Other light-related applications of discotic liquid crystals include high-resolution light scanning, solar cells, ferroelectric switches and optical storage devices.



S. Chandrasekhar

Together with colleagues at the Raman Research Institute and elsewhere, Chandrasekhar made additional contributions to our knowledge of the properties of liquid crystals, particularly their behaviour under increased and reduced pressures. For example, liquid crystal behaviour can be induced in materials that are not liquid crystals at atmospheric pressure and, conversely, liquid crystal behaviour can be suppressed by the application of pressure.

His international standing in liquid crystal research meant that his book, entitled *Liquid Crystals* and published in 1977, instantly became

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[CONTINUED PAGE 52]

recommended reading for any one interested in the subject. An updated second edition was published in 1992, a year after he founded the Centre for Liquid Crystal Research in Bangalore.

Honours received by Chandrasekhar during his career include being elected a Fellow of the Indian National Science Academy in 1978 and a Fellow of the Royal Society of London in 1983. In 1994, he was also awarded the Society's Royal Medal for his discovery of discotic liquid crystals. The Niels Bohr-UNESCO Gold Medal in 1998 recognized not only Chandrasekhar's scientific achievements but also his contributions to the advancement of science in developing countries and science teaching.

As recently as November 2002, Chandrasekhar helped organize – and attended as an honoured guest – a meeting on discotic liquid crystals at the Abdus Salam International Centre for Theoretical Physics (ICTP), the organization that hosts TWAS in Trieste and dedicates itself to keeping physicists in developing countries up-to-date with the latest advances in their field.

### IMPROVING MENTAL HEALTH

**Thomas Adeoye Lambo** was born in Abeokuta, Nigeria, in 1923, one of more than 30 children of a Yoruba chief with 12 wives. He studied medicine at Birmingham University in the United Kingdom before obtaining advanced degrees from London University's Institute of Psychiatry.

One of his first research projects, assigned by the government of Nig-

eria, was a study of the mental health of his fellow African students in London. Among his conclusions was that only an indigenous African psychiatry could deal with the African psyche.

On returning to Nigeria in 1950, he was appointed director of Africa's first mental hospital, the Aro Hospital for Nervous Diseases. Based on his findings in London, he proceeded to employ practitioners of traditional medicine (known as 'witch doctors' at the time) to help patients, all the time monitoring their methods.

In another break with the perceived scientific wisdom of the day, Lambo lodged mental patients, together with a family member, in the community surrounding the hospital rather than in the hospital itself. According to his analysis, not only did a village-based cure cost less than a stay in hospital, but it was qualitatively better – even patients that didn't recover totally were able to function better on their own. "Just as there is no single religion, there is no single way to practice medicine," claimed Lambo.

Between 1963 and 1971, Lambo held a variety of other positions, including professor of psychiatry and head of the Department of Psychiatry, Neurology and Neurosurgery at the University of Ibadan, Nigeria, becoming dean of the Medical School in 1967 and vice chancellor of the university itself in 1968.

Thanks to Lambo's pioneering work, psychiatry has developed not only in Nigeria, where many of today's professors and researchers were once his students, but also



**Thomas A. Lambo**

throughout Africa. *Psychiatric Disorders among the Yoruba* (a Nigerian tribe), which Lambo co-authored in the early 1960s, has become essential reading for all African psychiatrists and students of African psychiatry.

In 1971, Lambo moved to Geneva and took up the post of assistant director general at the World Health Organization (WHO). Within two years he became deputy director general, a post he held until 1988.

On retiring in 1988, Lambo dedicated himself to re-building the reputation of the Aro Hospital for Nervous Diseases, which, after several years of military rule, had become a centre for the treatment of drug addicts and no longer had the reputation for cutting-edge research into the psychological problems of Africans that it once had.

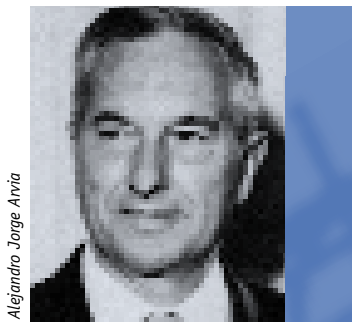
Among the various honours bestowed on Lambo were the Order of the British Empire (OBE) in 1962, the Haile Selassie African Research Award in 1970, and the Nigerian National Order of Merit, 1979. As well as being a TWAS Founding Fellow, he was also elected a member of the Pontifical Academy of Sciences, Rome, Italy, and an honorary member of the Swiss Academy of Medical Sciences. ■



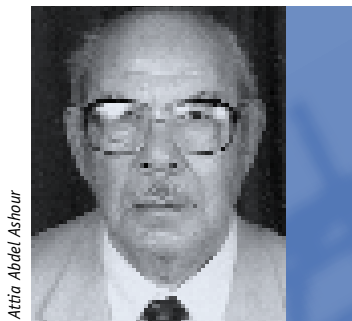
## HONOURS, APPOINTMENTS, AWARDS

A number of TWAS members have received honours and awards over the past few months:

- **Alejandro Jorge Arvia** (TWAS Fellow 1988) has been re-elected president of Argentina's National Academy of Exact, Physical and Natural Sciences.
- **Attia Abdel Ashour** (TWAS Fellow, 1985) has been awarded the Mobarak Prize for Science, the highest honour given to scientists in his native Egypt.



Alejandro Jorge Arvia



Attia Abdel Ashour

- **Atta-ur-Rahman** (TWAS Fellow 1985) has been re-appointed director of the Organization of Islamic Conference's Standing Committee on Science and Technology (COMSTech), a post he will now hold until June 2008. He has also been elected an honorary member of the National Academy of Sciences of the Republic of Korea.

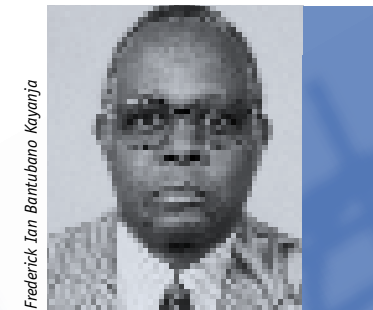


Tariq Salim Durrani

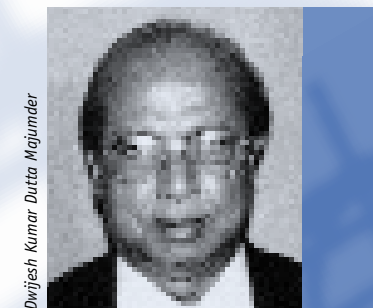
- **Tariq Salim Durrani** (TWAS Associate Fellow 1995) has been appointed to the post of Distinguished National Professor by Pakistan's Higher Education Commission for a two-year period. Under the agreement, he will spend six months each year helping with research and teaching at various universities in the country.
- **Farouk El-Baz** (TWAS Fellow 1985) has been awarded the Nevada Medal by the US-based Desert Research Institute for his work on environmental remote sensing. In addition, the Lebanon-based Arab Thought Foundation has presented El-Baz its Pioneer Award for his "research and his role in improving the future of the Arab world."
- On the occasion of the 40<sup>th</sup> anniversary of the Abdus Salam International Centre for Theoretical Physics (ICTP), celebrated in Trieste, Italy, last November, **Mohamed H.A. Hassan** (TWAS executive director) received the Order of Merit of the Republic of Italy. The award was given for his "commitment to developing scientific excellence in the South."
- **Frederick Ian Bantubano Kayanja** (TWAS Fellow 1988), vice-chancellor of the Mbarara University of Science and Technology, Uganda, and chair of the governing board of the Inter-University Council of East Africa, received the *Commandeur de l'Ordre*

*des Palmes Academiques* from the government of France, an award created by Napoleon Bonaparte in 1808 to recognize academic excellence.

- **Dwijesh Kumar Dutta Majumder** (TWAS Fellow 2000), renowned for his work in cybernetics, computer science and information technology and currently professor emeritus of the Indian Statistical Institute, Calcutta, received the Lifetime Contribution Award in Engineering and Technology from Indian National Academy of Engineering.
- The Osmania University, Hyderabad, India, has honoured **Calyampudi R. Rao** (TWAS Founding Fellow) by naming an institute after him. The C.R. Rao Advanced Institute of Mathematics, Statistics and Computer Science focuses on research in basic science, data mining and quality control. The institute will also aim to improve teaching and learning in schools.
- **Elly N. Sabiiti** (TWAS Fellow 2001), professor of crop science at



Frederick Ian Bantubano Kayanja



Dwijesh Kumar Dutta Majumder



# PEOPLE, PLACES, EVENTS



Ely N. Sabiti

Leader in Economic Development', for his promotion of "community-based solutions to famine in India".

## MEXICAN FELLOWSHIPS

- Thanks to two agreements with organizations in Mexico, TWAS will offer an additional 40 fellowships each year. Mexico's National Council on Science and Technology (CONACYT) has agreed to create a programme of 30 fellowships a year, comprising 20 postgraduate scholarships leading to a PhD and 10 post-doctoral fellowships. The fellowships, which are open to young scientists from developing countries other than Mexico, will be hosted by institutions of higher education in Mexico. As with other TWAS fellowship programmes, funded by Brazil, China, India and Pakistan, TWAS will be responsible for administering the programme and will pay the cost of travel to and from Mexico. On-site expenses, including a monthly stipend, will be covered by the collaborating organization, in this case, CONACYT. In addition, TWAS and the Mexican Academy of Sciences are finalizing an agreement whereby the two partners will offer 10 fellowships a year to postgraduate students seeking to study water-related issues, including the social sciences and earth sciences. These three-year postgraduate fellowships, hosted by the *Universidad Nacional Autonoma de Mexico* (UNAM), will lead to a PhD degree.

## YEAR OF PHYSICS

- The World Year of Physics, celebrating the centenary of Albert Einstein's *annus mirabilis*, or 'miracle year', was officially launched at UNESCO's Paris headquarters on

13 January 2005. The inauguration session featured a video message from UNESCO director general, Koichiro Maatsura. Among the scientific presentations that followed were lectures by five Nobel Laureates. TWAS president, **C.N.R. Rao** also spoke on the 'Chemistry-Physics Interface over the Decades' and **K.R. Sreenivasan** (TWAS Associate Fellow 1998 and director of the Abdus Salam Inter-



national Centre for Theoretical Physics, ICTP) spoke on 'Physics for Development'. A round table discussion on the 'Public Perception of Physics' included three TWAS members: **Ana Maria Cetto** (TWAS Fellow 1999), **Chen Jia'er** (TWAS Fellow 2001) and **José Luis Morán-López** (TWAS Fellow 1991). **Carlo Rubbia** (TWAS Associate Fellow 1992) took part in a panel discussion on 'Physics and the Socio-economic Challenges of the 21<sup>st</sup> Century'.



K.R. Sreenivasan

Makerere University, Uganda, has been elected a new member and vice president of the Uganda National Academy of Sciences (UNAS). UNAS has also agreed to host a new TWAS national chapter.

- **Jagadish Shukla** (TWAS Associate Fellow 1995), president of the Institute of Global Environment and Society, Maryland, USA, has been awarded the 2005 Carl-Gustaf Rossby Research Medal by the American Meteorological Society for his "fundamental contributions and inspired leadership in understanding the variability and predictability of the climate system on seasonal to inter-annual timescales."
- **Monkombu S. Swaminathan** (TWAS Founding Fellow), founder and chair of the M.S. Swaminathan Research Foundation, Chennai, India, was named in the 2004 Scientific American 50 Awards, run by *Scientific American* magazine, as a 'Policy



Piyapong Niamsup



## YOUNG SCIENTISTS

- **Piyapong Niamsup**, Chiang Mai University, Thailand, has been awarded the 2004 TWAS Prize for Young Scientists by the Thai National Research Council. Niamsup, a mathematician interested in discrete dynamics of rational functions, was presented with a certificate of merit, a bronze plaque and a cheque for US\$2,000 by the council's deputy secretary-general. The award ceremony was attended by high-ranking university officials as well as Niamsup's colleagues and members of the press.

## NEW NETWORKS

- TWAS, as the lead academy in the InterAcademy Panel's (IAP) programme on capacity building for young academies, has been instrumental in the creation of two new regional networks of science academies. In March 2004, at a meeting

Atta-ur-Rahman



held in Islamabad, Pakistan, and supported by TWAS, the academies of science of the Organization of Islamic Conference (OIC) member states agreed to form the Network of Academies of Sciences in OIC Countries (NASIC). Some 15 national organizations form the core of the network, along with the Arab Academy of Sciences and the Islamic Academy of Sciences. The first president of

Jorge Allende



NASIC is Pakistan's federal minister of science and technology, **Atta-ur-Rahman** (TWAS Fellow 1985).

- The inaugural meeting of the Inter-American Network of Academies of Sciences (IANAS) took place in Santiago, Chile, in May 2004. Some 17 national and regional organizations agreed to establish the network. Hernan Guralnik (Brazilian Academy of Sciences) and **Howard Alper** (Royal Society of Canada, TWAS Associate Fellow 2003) were elected co-chairs. IANAS also selected two programmatic activities. The Science Education Programme will be coordinated by **Jorge Allende** (Chilean Academy of Sciences, TWAS Fellow 1985), who also coordinates the IAP programme on the same subject. The Water Programme will be coordinated by the Brazilian and Mexican academies. **Jose Galizia Tundisi** (TWAS Fellow 1997), who also coordinates the IAP Water Programme,

and **Luis Marín**, a member of the TWNSO Safe Drinking Water advisory board (see pages 27-35) were appointed co-chairs.

## PUBLICATIONS

- TWAS, in collaboration with various partners, has recently published several reports and books, including:

*Promoting Life Sciences* – the conclusions of a workshop hosted by TWAS in November 2003 (see 'Promoting Life Sciences in the Developing World', *TWAS Newsletter* vol. 15, no. 4, pages 24-29). The publication, produced in collaboration with the European Molecular Biology Organization (EMBO), the Human Frontier Science Programme (HFSP) and the Wellcome Trust, can be downloaded from the TWAS website.

*Building Scientific Capacity: A TWAS Perspective*, a 13-point programme for boosting the scientific and technological capacities of developing countries, can be downloaded from the TWAS website.

Building Scientific Capacity



*Sharing Innovative Experiences volume 9: Examples of the Successful Conservation and Sustainable Use of Dryland Biodiversity* is available from TWNSO and downloadable from the United Nations Development Programme Special Unit for South-South Cooperation's (UNDP-SSC) website, [tcid.undp.org/experience/vol9/content9new.asp](http://tcid.undp.org/experience/vol9/content9new.asp).

# WHAT'S TWAS?

**THE ACADEMY OF SCIENCES FOR THE DEVELOPING WORLD (TWAS) 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 700 members from 81 countries, 66 of which are developing countries. A Council of 13 members is responsible for supervising all Academy affairs. It is assisted in the administration and coordination of programmes by a small secretariat, headed by the Executive Director. The secretariat is located on the premises of the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. UNESCO is responsible for the administration of TWAS funds and staff. A major portion of TWAS funding is provided by the Ministry of Foreign Affairs of Italy.

The main objectives of TWAS are to:

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

TWAS was instrumental in the establishment in 1988 of the Third World Network of Scientific Organizations (TWNSO), a non-governmental alliance of 160 scientific organizations from developing countries, whose goal is to assist in building political and scientific leadership for science-based economic development in the South and to promote sustainable development through broad-based partnerships in science and technology. ❖ [www.twonso.org](http://www.twonso.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 2,000 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](http://www.twows.org)

Since May 2000, TWAS has been providing the secretariat for the InterAcademy Panel on International Issues (IAP), a global network of 90 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](http://www.interacademies.net/iap)

The secretariat of the InterAcademy Medical Panel (IAMP), an association of 52 academies of science and medicine, relocated to Trieste in May 2004. IAMP and its member academies are committed to improving health worldwide, especially in developing countries. ❖ [www.interacademies.net/iamp](http://www.interacademies.net/iamp)

## WANT TO KNOW MORE?

TWAS and its affiliated 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](http://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](http://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](http://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](http://www.twas.org/mtm/RG_form.html)

Is your institution seeking funds to collaborate with a research institute in another country in the South? The TWNSO grants programme may be able to provide support:

[www.twonso.org/grants.html](http://www.twonso.org/grants.html)

## EQUIPMENT

But that's not all TWAS has to offer. For instance, do you need a minor spare part for some of your laboratory equipment – no big deal, really – but you just can't get it anywhere locally? Well, TWAS can help: [www.twas.org/mtm/SP\\_form.html](http://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](http://www.twas.org/hg/vis_sci.html)

## CONFERENCES

Are you organizing a scientific conference and would like to involve young scientists from the region? You may find the help you need here:

[www.twas.org/mtm/SM\\_form.html](http://www.twas.org/mtm/SM_form.html)