EARLIER THIS YEAR, SAUDI ARABIA BEGAN CONSTRUCTION ON THE KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KAUST). THE GRADUATE-LEVEL RESEARCH UNIVERSITY, RISING ON THE SHORES OF THE RED SEA ABOUT 170 KILOMETERS (100 MILES) NORTHWEST OF MECCA, WILL BE FUNDED THROUGH A MULTIBILLION-DOLLAR ENDOWMENT. BILLIONS MORE WILL BE INVESTED IN THE CAMPUS.

The Promise of KAUST

Plans call for the construction of not just classrooms and laboratories but shops, housing, parks, playgrounds, schools for families with children and a golf course, yacht club and marina. An ecosystem sanctuary intended for both research and recreation will grace the campus coastline.

Excellence, openness and educational gender equality are at the heart of initiative. The aim is to create a world-class center of knowledge and research marked by the free flow of information and critical assessments of ideas and discoveries. The university is expected to begin functioning in 2009.

To create a strong 'intellectual bench' even before the institute opens its doors, KAUST has launched a Discovery Fellowship programme providing full tuition, stipends and computer allowances to students currently majoring in fields of science and technology at their home universities in Asia, Europe, the United States and elsewhere. After graduation, recipients will enter KAUST as master degree students where they will also receive full fellowships. The programme was announced the first week in September and applications will be accepted through the first week in November. The initial class is expected to consist of between 250 and 350 students.

KAUST has also launched a Global Partnership Research Programme designed to forge partnerships with leading research institutions across the globe. To date, Woods Hole Oceanographic Institution, the Institut Français du Petrole *in France, the National University of Singapore, the Indian Institute of Technology in Bombay and the American University in Cairo have signed on. The programme is expected to spend US$1 billion over the next decade establishing such relationships.*

CONTENTS

TWAS NEWSLETTER
Published quarterly with
the support of the Kuwait Foundation
for the Advancement of Sciences
(KFAS) by TWAS, the academy of
sciences for the developing world
ICTP Campus, Strada Costiera 11
34014 Trieste, Italy
tel: +39 040 2240327
fax: +39 040 224559
email: info@twas.org
website: www.twas.org

TWAS EXECUTIVE DIRECTOR
Mohamed H.A. Hassan (Sudan)

EDITOR
Daniel Schaffer

ASSISTANT EDITOR
Peter McGrath

MANAGING EDITOR
Gisela Isten

SUPPORT STAFF
Tasia Asakawa

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

PRINTING
Stella Arti Grafiche, Trieste

KAUST will also establish Academic Excellence Alliances that are designed to draw faculty from top-ranked universities to its campus by offering two- to five-year contracts at pay rates competitive with the world's best institutions of higher education. The faculty is eventually expected to reach 600.

In short, what took Cambridge and Harvard universities centuries to accomplish, KAUST hopes to do in a matter of years.

Saudi Arabia is not alone in such efforts. Governments across the Islamic region are now on a fast track to build what they hope will be world-class centres of knowledge creation and centers of research and training excellence.

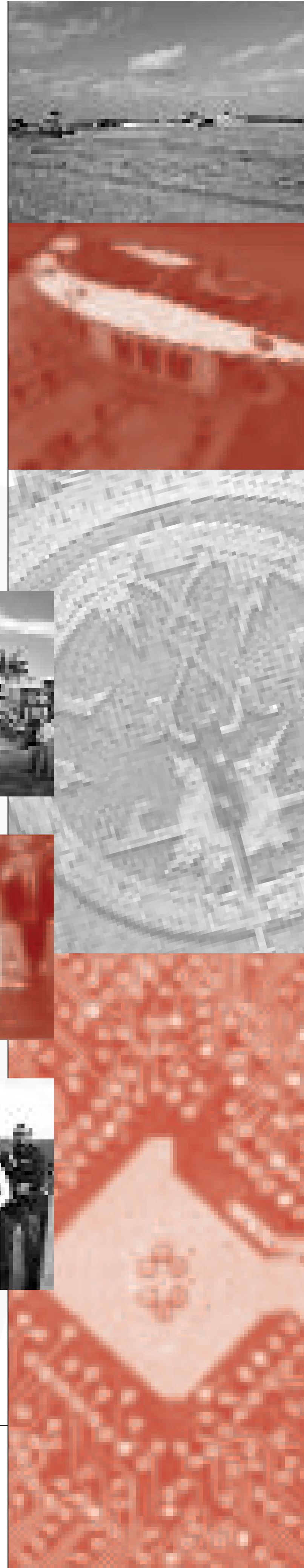
For example, in partnership with universities in the United States, the United Arab Emirates and Qatar are building new university campuses that they hope will provide outstanding education. Over the past four years, the government of Pakistan has increased the budget for higher education sevenfold to nearly US$500 million. In cooperation with several European countries, the Higher Education Commission has also launched a multi-billion-dollar Pak-European initiative designed to create nine world-class engineering universities staffed with European faculty and administrators.

Such efforts are long overdue. By virtually any standard, the Islamic region, home to 1.4 billion people or more than 20 percent of the world's population lags far behind the rest of the world in scientific output.

The 30 nations that belong to the Organization for Economic Co-operation and Development (OECD), which includes the world's highest income countries, spend on average about 2.3 percent of their gross domestic product on research and development. The 57 nations that belong to the Organization of Islamic Conference (OIC), a global network of countries with predominantly Muslim populations, spend on average 0.6 percent. Nations with strong research capabilities have more than 5000 researchers per one million people. The average in OIC countries is 500. The most recent global ranking of universities, prepared by Shanghai Jiao Tong University, ranks only two universities in OIC countries among the world's top 500 – Cairo University and the University of Istanbul.

The statistics are endless and all lead to one indisputable conclusion: Knowledge creation, especially scientific and technological knowledge creation that fosters a greater understanding of our natural world and lays a firm foundation for solving critical social and economic needs, is rare in the Islamic region.

The key questions moving forward are these: What can be done about the paucity of knowledge creation in the Islamic region? And will the recent flurry of construction activity, especially in the Persian Gulf, make a difference?



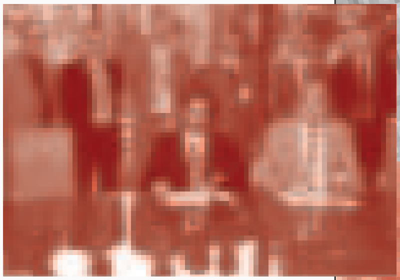
The Islamic region enjoys a great deal of diversity and some countries are doing better than others when it comes to knowledge acquisition and creation. Turkey, for instance, is quietly upgrading the quality of its higher education system. Today, scientists in Turkey account for nearly half of the region's publications in peer-reviewed international journals. Iran has pursued a strategy over the past three decades based on sustained investments in higher education. As a result, its university population has increased 20-fold from 100,000 in 1979 to more than 2 million today.

Two central issues, however, cloud all of this promising news. Can science and technology flourish in an environment where openness, transparency and merit-based rewards are not ingrained within the larger society? And can this science and technology then be successfully applied to strategies for sustained economic growth when only minimal channels exist for risk-taking and entrepreneurial pursuits?

The scientific community cannot shoulder primary responsibility for dealing effectively with these broader societal issues. These issues, after all, reside within the larger political and cultural sphere. But the region's leading scientific institutions and most prominent scientists can and must play a vital role in illustrating the importance of science to society and in demonstrating how science can serve as a vital tool for sustainable growth.

Such goals can be advanced by supporting high-level research that attracts global attention; by pursuing research projects that address issues of critical importance to society; by providing the best possible instruction to students; and by speaking out on behalf of science in larger public settings.

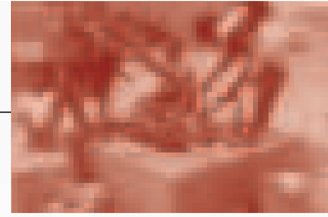
Whether such 'small bore' measures can have an impact over the long-term remains an open question.



And the same holds true for the unprecedented investments in science and technology that are taking place among a growing number of countries in the Islamic region. Can well-funded world-class science and technology enterprises flourish in environments that remain largely unreceptive to free and open inquiry, rigorous and transparent evaluations of performance and productivity, and the promotion of gender equality?

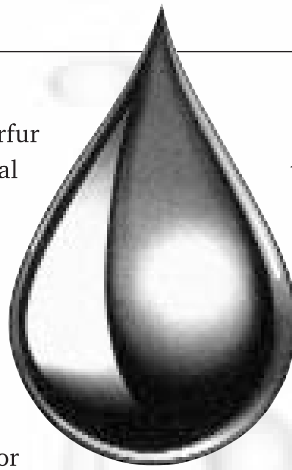
Put another way, can science function as a fundamental tool for reform, or can it only operate effectively in environments that have already experienced fundamental reform?

Current trends in funding for science in the Islamic region, especially in the Persian Gulf region, suggest that we are about to find out.



WELLSPRINGS OF HOPE IN DARFUR

THE SUDANESE GOVERNMENT RECENTLY INVITED THE GLOBAL COMMUNITY TO PARTICIPATE IN A HUMANITARIAN INITIATIVE TO DRILL '1,000 WELLS FOR DARFUR'. EFFORTS TO SUPPLY WATER TO ALL THOSE IN NEED IN THIS STRICKEN REGION COULD HELP SECURE A DURABLE PEACE AND CREATE A BASIS FOR SUSTAINABLE ECONOMIC GROWTH, SAYS FAROUK EL-BAZ (TWAS FELLOW 1985), THE ARCHITECT OF THE PLAN.



The United Nations Environment Programme (UNEP), in its report Sudan Post-Conflict Environmental Assessment *that was published earlier this year, announced that the war in Darfur, which has claimed more than 250,000 lives and displaced an estimated 2.5 million people, is due in part to water shortages from years of unrelenting drought.*

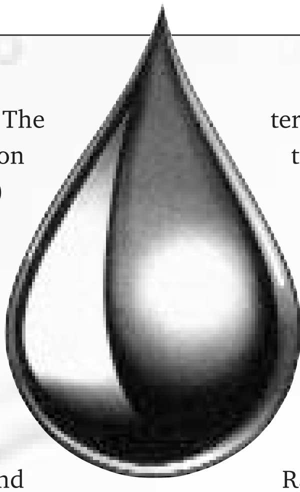
The report concluded that chronically sparse rainfall over the past two decades has fractured the centuries-old harmonious relationship forged between farmers and nomadic herdsmen. As water supplies have dwindled, water sharing has become more difficult. Growing competition for this vital resource ultimately sparked tensions that flared into violence and death.

The pictures of death and despair that have monopolized news reports on Darfur over the past several years have, however, recently been countered by hints of hope for a better future. Analyses of satellite images made by Eman Ghoneim and myself at the Center for Remote Sensing at Boston University in the United States allowed the mapping of boundaries of a former lake in Northern Darfur that existed during wetter climate phases in the past.

The ancient shorelines, rendered invisible by time and the forces of nature, may hold the key to uncovering substantial groundwater supplies that could serve as a source of peace and stability in this stricken region.

Here's why we think this may be so. Groundwater wells were drilled in a similar ancient basin located across the border in southwestern Egypt. These wells now provide sufficient supplies of water for human consumption and crop production. Developments that took place in Egypt a decade ago inspire hope for a more stable future in Darfur.

Based on this information, in June 2007, the Sudanese government announced that it would spearhead the initiative of '1,000 Wells for Darfur' and it called on governments and international organizations worldwide to participate in the effort. Since then, the Egyptian government has pledged



to drill 20 wells. The United Nations Mission in Sudan (UNIMS) also plans to drill several wells. If water is found beneath the dry lake, it would bring great relief to a region racked by extreme drought and battered by war.

HIDDEN WATER

Darfur is located in the eastern Sahara of North Africa, a region that includes much of Egypt, Sudan and Libya. This vast desert belt, which is characterized by rolling sand dunes interspersed by strips of soil covered by gravel, includes some of the driest regions on Earth. Meteorologists estimate that local solar energy could evaporate water at 200 times the pace of yearly rainfall.

In the few oases with meteorological stations, rainfall has been extremely rare and unpredictable. For example, a station at Siwa Oasis in western Egypt records rain only once in 20 to 50 years. Such rain-starved conditions have forced inhabitants of these regions to depend on groundwater resources to meet all their needs.

Geological and archaeological data, however, indicate that the whole of the eastern Sahara enjoyed much wetter climates in the past. Sand found today in inland basins is likely to have been transported there by rivers and streams. Some of the water may have seeped into the underlying porous sandstone to be stored as an aquifer in a groundwater basin. During dry conditions, wind would spur the formation of sand dunes and sheets atop the basins. Over time, alternating wet-and-dry climate periods ultimately buried the surface topography in a sea of sand.

Radiocarbon dating and geo-archaeological investigations indicate that the eastern Sahara last experienced a moist period between 10,000 and 5,000 years ago. Uranium-series techniques have identified five palaeo lake-forming episodes that took place from 350,000 to 10,000 years ago. Each of these episodes roughly correlates with an interglacial period.

The scientific evidence we have uncovered indicates that desert sand in southwest Egypt and Northern Darfur was born by water and later shaped by wind. As a result, the large accumulations of Saharan sand offer telltale signs of the existence of substantial sources of groundwater below.

SPACE DATA

In 1985, TWAS sponsored one of the first meetings examining this theory in Khartoum, Sudan. Since then, increasingly sophisticated satellite instruments have generated more and better data. In Northern Darfur, we used high-resolution multispectral images, including NASA's Landsat Enhanced Thematic Mapper Plus (ETM+) images; radar images, including those obtained by Radarsat-1, an Earth observation satellite of the Canadian Space Agency; and three-dimensional data obtained by the Shuttle Radar Topography Mission (SRTM), a joint effort

by the US Department of Defense and the US National Aeronautics and Space Administration (NASA).

Data collected by these sensors were grouped in a Geographic Information System (GIS) matrix so that the information could be merged. As a result, we were able to gain a better understanding of the region's surface and subsurface topology and to present, with increased confidence, an understanding of the sequence of events that explain how and why the terrain has been altered over time.

EGYPTIAN REFERENCE

Southwest Egypt displays nearly the same features as Northern Darfur. Indeed a vast, flat, sand-covered area straddles the border between Southwest Egypt and Northwest Sudan. This expanse has been named the 'Great Salima Sand Sheet' after the Salima Oasis, which lies on its eastern border. The region is a depressed basin covered by sand deposits with a few interspersed solid rock exposures.

Radar images acquired from space revealed that five rivers and streams, originating from highlands to the west and southwest, penetrated the region, indicating the accumulation of groundwater in the eastern, lower-most section. Exploratory wells, drilled by the Egyptian government in 1995, were closely monitored for five years to confirm the presence of large amounts of groundwater.

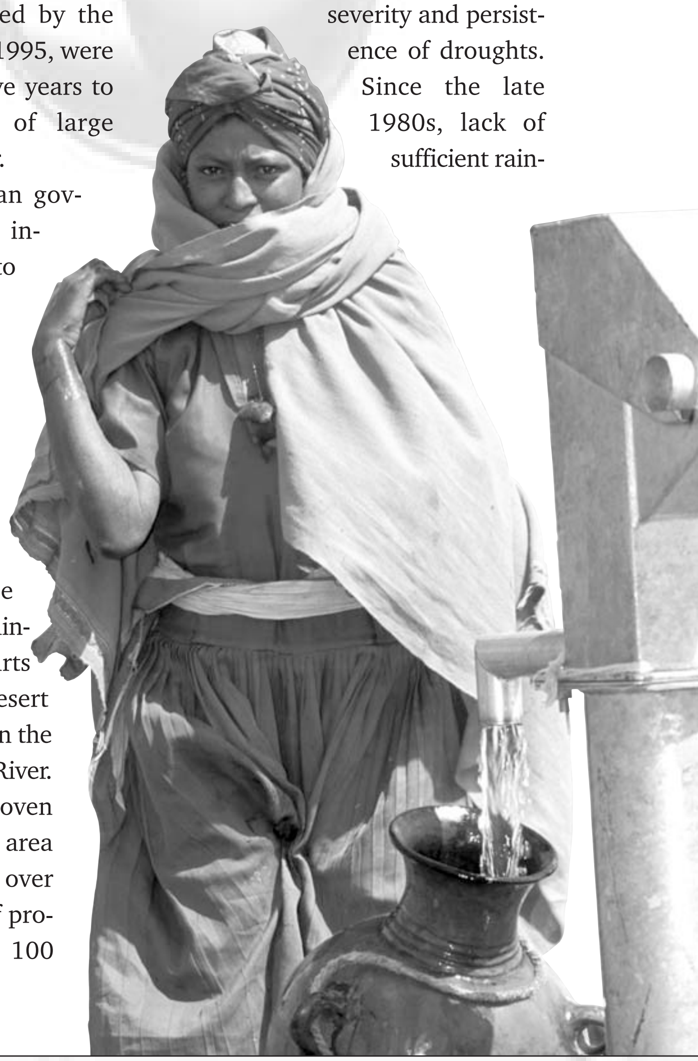
In 2000, the Egyptian government began offering investors an opportunity to lease land plots of 10,000 acres for agricultural development.

Today, farms profitably cultivate wheat, chickpeas, peanuts and other crops. Plentiful supplies of groundwater have been found in the underlying sandstone. Salinity levels of just 200 parts per million make this desert groundwater sweeter than the surface water of the Nile River. Experts estimate that proven resources of water in this area will support agriculture over 600 square kilometres of productive land for some 100 years.

The unveiling of an ancient lake site, attained through the study of satellite images, has been critical in the development of groundwater resources in Egypt. Similarly, analyses of the space-borne data relating to Northern Darfur suggest that water might underlie the dry lake expanse of more than 30,000 square kilometres.

NO TIME TO WASTE

There is no doubt that groundwater is badly needed not only for Darfur's farmers, but also for the region's nomadic tribes. Both have been adversely affected by the severity and persistence of droughts. Since the late 1980s, lack of sufficient rain-



water and the resulting famine have caused repeated migrations and social unrest.

Scarcity of water in this parched land, coupled with growing populations, has pushed nomadic tribes south in search of fresh water supplies. This has sparked prolonged violent conflicts with the region's sedentary farm populations.

New water resources are urgently needed to stabilize and develop the region, and to provide hope for a better future. If successful, the '1000 Wells for Darfur' initiative would have the added benefit of providing a tangible illustration of how advanced space technology can be used to solve a humanitarian crisis.

I met with Omar Al-Bashir, president of Sudan, in late June 2007 to discuss our research findings. Following the meeting, the government of Sudan publicly announced the launch of the initiative in Khartoum. I also met with Ban Ki-Moon, secretary-general of the United Nations, in July 2007 at the UN secretariat in New York. He too expressed strong support for the effort. Both leaders fully realize how effective measures designed to make adequate supplies of water available to this drought-stricken region could help ease the pressures on the people of Darfur.

Farouk El-Baz

In the past few years, many voices from around the world have been raised on behalf of the helpless farmers in the Darfur region. Recent developments focusing on potential groundwater supplies could provide direct and tangible help.

Now is the time for all concerned governments, international organizations, nongovernmental organizations, corporations and individuals to rally around this rare opportunity to improve the lives of dispossessed people.

The Sudanese government has launched this humanitarian endeavour and has asked others to join in the effort. During a visit to Sudan, in September, the UN secretary-general discussed the initiative with government officials. He underscored the necessity for coordinating well-site selection and drilling activities. Supervision by the UN and its agencies assures accountability on behalf of the international community. Donations should now make their way.

The door has been opened for a meaningful and concerted effort to save Darfur. Let us work to transform this wellspring of hope into a reality. Water gives life. In Sudan, it could help bring peace to a war-torn region as well. ■

> ***Farouk El-Baz*** *(TWAS, 1985)*
Research Professor and Director
Boston University
Center for Remote Sensing
Boston, Massachusetts, USA
Adjunct Professor
Faculty of Science
Ain Shams University
Cairo, Egypt

LIFE SCIENCES IN THE SOUTH

MOHAMED HASSAN, EXECUTIVE DIRECTOR OF TWAS, EXAMINES THE DRAMATIC GROWTH OF THE DEVELOPING WORLD. THIS EXPANSION IN GLOBAL RESEARCH CAPABILITIES PROMISES TO PRODUCE ENORMOUS BENEFITS IN A WIDE VARIETY OF FIELDS RELATED TO AGRICULTURE AND PUBLIC HEALTH.

Diversity rules in the life sciences. It serves as the essence of the discipline itself and, increasingly, as the driver behind policies intended to strengthen the growing impact of the life sciences on society.

Biodiversity is particularly important in the developing world. That's true in an ethical sense because biodiversity is the foundation of global environmental well-being. By serving as able stewards of their treasure trove of biodiversity, developing countries make invaluable contributions to the entire world.

And that's also true in a material sense because biodiversity directly enhances the economic well-being of developing countries by generating wealth through the wise and sustainable use of unique and irreplaceable resources. The developing world, according to Conservation International, is home to 29 of the world's 34 "hotspots", representing the richest and most diverse natural reservoirs of plant and animal life on Earth.

For too long, government, the private sector and, yes, even researchers in the developed world were responsible for setting the agenda for the protection and wise use of biodiversity and, more generally, research and development in the life sciences. Combined with the limited capabilities of scientific institutions in the South, the North's research dominance created a kind of "life sciences colonialism" that prevented developing countries from drafting their own research agendas and, equally important, from applying the ever-expanding knowledge base in the life sciences to aid their societies and boost their economies.

BIOLOGY'S CHANGING NATURE

The nature of biological research has changed over the past two decades, and especially since the beginning of this century. The fact is that a growing number of developing countries have dramatically expanded their capacity to conduct basic research and to apply that research to such critical issues as food security, public health and environmental protection.

In the last two decades of the 20th century, the key challenge faced by developing countries resided in building basic scientific capacity, largely to avoid falling further behind the expanding capabilities in the developed world. That meant providing adequate funding for education and training and for constructing laboratories that could fulfill the needs of faculty and students alike.

Today, these challenges remain stubbornly in place in many developing countries. Nevertheless, more and more developing countries have passed a threshold of basic competency and are now seeking to strengthen and broaden what has become a firm foundation in research.

Argentina, for example, has successfully weathered years of political and economic turmoil to sustain broad competency in the life sciences. This is reflected in the number of articles published by Argentinean scientists in peer-reviewed international journals and the nation's global leadership in the cultivation of GM crops. Argentina's experience offers a valuable 'take-home' lesson for other developing countries: Scientific competency is difficult to displace once it has taken root. The nation's most revered scientist, Alberto Houssay, won the Nobel Prize in 1947 in medicine and physiology. His fellow countrymen, Luis Leloir and Cesar Milstein, biochemists, won the prize in 1970 and 1984, respectively. The global recognition they received helped establish an honoured tradition in the life sciences in Argentina that remains to this day.


Luis Leloir


Cesar Milstein

Other success stories include China, which has built a formidable infrastructure in the life sciences in just two decades, demonstrating growing capabilities in bioinformatics, genomics and stem cell research. In 1986, for example, China launched the National High Technology R&D Programme. The programme has since provided funding for some 20,000 researchers and administrative staff in more than 3,000 research institutions. India has developed a profitable pharmaceutical industry that has manufactured an impressive list of recombinant vaccines against polio, rabies, hepatitis B and typhoid. Brazil has focused its efforts on training young scientists and on applying its growing expertise in the life sciences both to take advantage of its unmatched biodiversity and to become a world leader in biofuels. Malaysia has efficiently raised its skill levels in the life sciences and is now seeking to build a vibrant commercial sector in the fields of biotechnology and genetic engineering. South Africa has emerged as sub-Saharan Africa's primary centre of research and development in the life sciences. Cuba has become one of the leading developing nations in the life sciences, earning an international

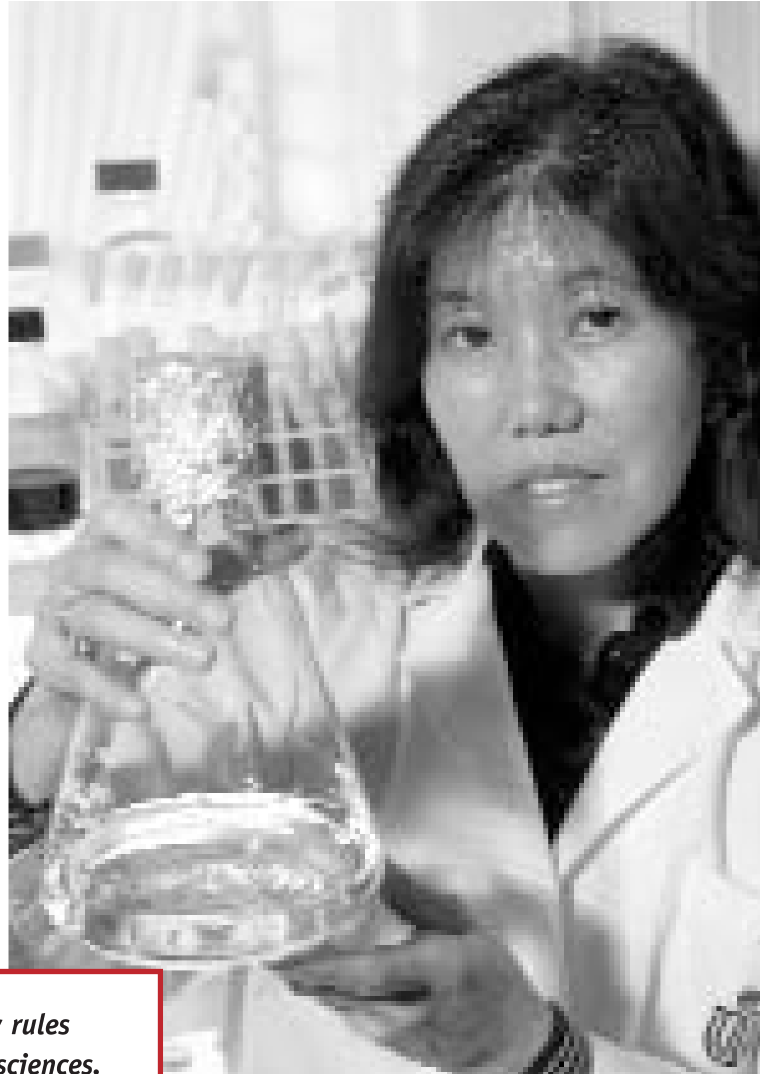
reputation for the development and manufacture of vaccines.

This welcome change in the scientific competence of developing countries can also be seen in the increasing number of universities and research institutes that have created or expanded departments in biology and such related fields as bioinformatics and genetic engineering.

Brazil's Oswald Cruz Foundation and Butantan Institute have played leading roles in the nation's growing prowess in the life sciences, particularly biotechnology. China's Beijing Genomics Institute and the Chinese National Human Genomes Center operate state-of-the-art sequencing facilities and have participated fully in international efforts to advance these fields, including the Human Genome Project (making China the only developing country to do so). The Indian Institute of Science's broad portfolio of research initiatives includes immunology and reproductive biology for vaccine development to combat malaria and tuberculosis. India's National Institute of Immunology and Institute of Microbial Technology have acquired international reputations for their work on biomedicine, diagnostics and protein structure.

We also see this change in competence in the small but steadily increasing number of private firms that are engaged in selling agricultural and health-related biotechnology products and services both within their own countries and abroad.

In 1993, Brazil was home to 76 biotechnology firms; by 2004, the Brazilian Association of Biotechnology estimated the number of core biotechnology firms to be 150; other sources have placed the number at more than 300. China's estimated 130 plus biotechnology firms – some state-owned commercial enterprises, others small private firms – benefit from a huge population that allows for domestic clinical assays and a large pool of students who have often been trained oversees but increasingly are returning home to pursue their careers. India's 350 plus private firms are aggressively seeking to move up the innovation ladder from companies that manufacture inexpensive generic versions of existing pharmaceuticals to companies creating new high-value products. Shantha Biotechnics is the first company in India to produce a recombinant DNA hepatitis-B vaccine, on its own. It also created India's first 4-in-1 vaccine against diphtheria, tetanus, pertussis and hepatitis. Cuba, home to some of the best life science research centres in the developing world, has created 'commercial' divisions in its state-owned institutions for the sale of vaccines to combat meningitis B, hepatitis B and pneumonia.



Diversity rules in the life sciences.

CROP CULTIVATION

The most visible display of this change has taken place in the cultivation of genetically modified (GM) crops. Since the US Food and Drug Administration licensed the world's first GM crop, *Flavr Savr* tomato, in 1994, the amount of farmland devoted to GM crops worldwide has doubled each year. The total now exceeds 100 million hectares. More than 10 million farmers in 22 countries now grow GM crops.

The use of biotechnology in agriculture is largely viewed as a trend confined to the developed world. However, a statistical profile of agricultural biotechnology creates a more intricate portrait of a rapidly changing field.

Eleven of the 22 countries that grow GM crops are developing countries. Argentina is second only to the United States in hectares cultivated in GM crops. Brazil is third. In 2006 India supplanted China as number four on the list. Paraguay, South Africa, Uruguay and the Philippines are each in the top 10. By some estimates, 90 percent of all farmers now using GM crops are small, resource-poor farmers in developing countries. And more than 40 percent of the agricultural land devoted to GM crops is in the developing world.

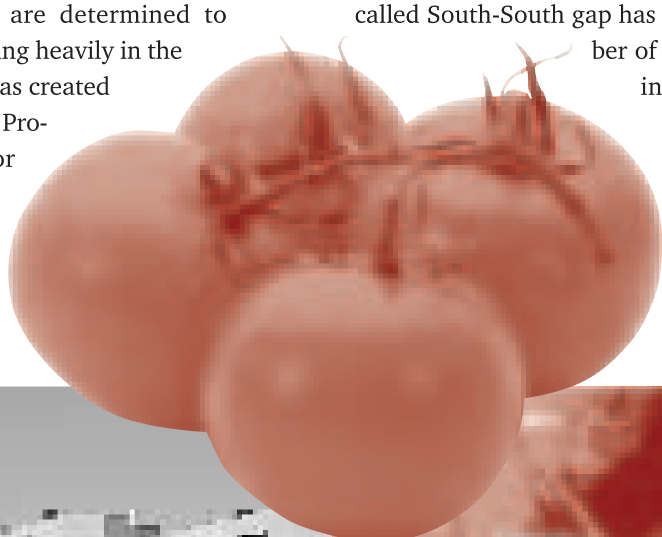
As this rapid-paced survey suggests, in the minds of many political leaders in the South, the life sciences in general and biotechnology in particular are on par with information and communication technologies, representing a truly transformational knowledge base that serves a fundamental role in national efforts to build successful societies capable of competing in today's global economy.

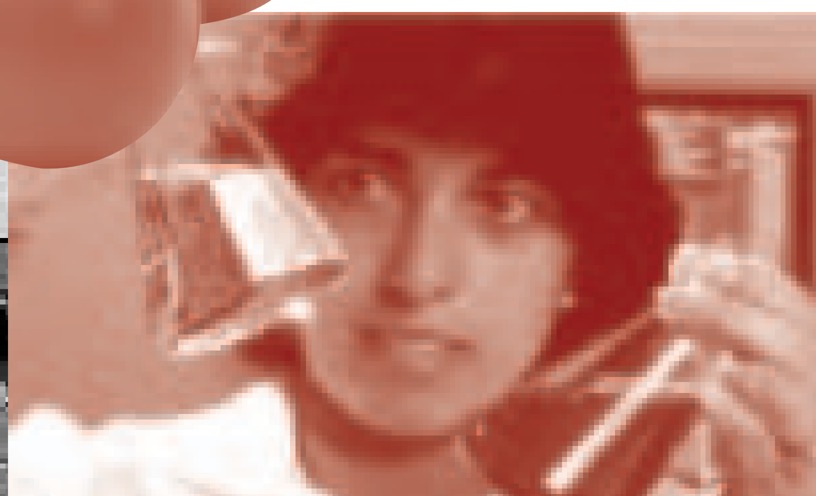
MIND THE GAPS

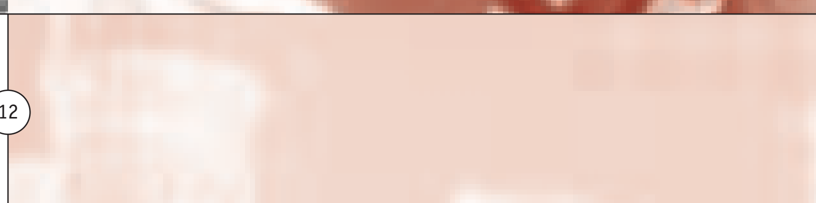
The North-South capacity gap in the life sciences has indeed narrowed. But it has by no means disappeared. Top-ranked universities in the developed countries still lead the way and many are determined to extend their lead by investing heavily in the field. Harvard University has created a Center for Genomics and Proteomics and a Center for Imaging and Mesoscale Structures as part of a US$200 million investment in scientific education and research. Yale University recently announced it would build state-of-the-art laboratory facilities for its department of molecular, cellular and developmental biology as part of a US$500 million initiative to boost the university's science and engineering programmes. In spring 2006, the UK Biotechnology and Biological Research Council awarded a grant of more than US$50 million to launch three new centres of integrative systems biology at the universities of Edinburgh, Nottingham and Oxford. And, of course, international corporations, both in agriculture (for example, Syngenta and Monsanto) and pharmaceuticals (for example, Novartis and Glaxo-SmithKline), that were the first to profit from advances in biotechnology are determined to remain world leaders in such efforts.

As a result, many universities and research institutes in the developing world will have to move ahead at full speed if they are not to lose ground to shrewd and aggressive developed world institutions and corporations that currently lead the pack.

At the same time, a new gap in capacity has emerged between scientifically proficient developing countries and scientifically lagging developing countries. A so-called South-South gap has surfaced because the number of developing countries making significant strides in building scientific capacity remains small. Among the most notable countries are Argentina, Brazil, Chile, China, India, Malaysia, Mexico and







South Africa. Conversely, the number of countries that have not made significant strides is large and includes most of the countries in sub-Saharan Africa and countries with predominantly Muslim populations.

The fundamental challenge facing the scientific community now is to devise innovative strategies that bring all developing countries into the "biological fold" in ways that enable all to take full advantage of advances in the field to curb poverty and improve the quality of life for their people.

PUBLIC AND PRIVATE AFFAIRS

Even developing countries that have successfully strengthened their scientific capacity have proven more adept at building their knowledge base than at applying the knowledge that their scientists acquire to address societal concerns. The most critical shortfall in these efforts has been an inability to forge strong linkages between universities and research institutes, largely funded by governments, and the private sector, which is admittedly weak in most developing countries.

For example, experts estimate that more than 60 percent of global research and development in biotechnology is funded by the private sector. Yet, even among the most advanced developing countries, the private sector has made only marginal contributions to such efforts, which remain almost exclusively public affairs.

The fundamental challenge is to devise strategies that bring all developing countries into the "biological fold".

To gain parity with the developed world, developing countries will need to strengthen and stimulate the private sector and then encourage the creation of durable partnerships among government, research institutes and nascent private companies. This is beginning to take place in several countries, notably Brazil, China and India and, to a lesser extent, Malaysia and South Africa. But the pace of reform must quicken if the capacity gap between the North and South is to close at a more rapid and even pace.

As the life sciences continue to become stronger in developing countries and as applications of the ever-expanding knowledge base gain greater presence across the South, the dialogue between the scientific community and society will no doubt intensify.

This should come as no surprise. The life sciences touch upon some of the most fundamental issues that we face: for example, the meaning and definition of life and the role that human ingenuity can play in altering living organisms. At a more practical level, advances in the life sciences raise critical questions about the tradeoff between the potentially broad benefits and possible exposure to unknown risks that genetically modified organisms and cloned animals pose for society in terms of food supplies, the environment and public health.

Given what is at stake, it would indeed be surprising if the public did not have a deep interest in developments in the field.

While health-related advances in the life sciences have generally received widespread public support, agricultural biotechnology has spurred a great deal of controversy. Scientists contend that the arguments made by grassroots organizations are often based on emotion, not

reason, and that simplistic contentions, devoid of scientific content, sometimes pressure public officials to pursue misguided policies. Take the case of Mexico, where an internationally orchestrated campaign has compelled government officials to impose a nationwide moratorium on the commercialization of transgenic plants and experimental field testing for techniques developed in Mexico.

ADVICE AND CONSENT

Scientists in both developed and developing countries increasingly find themselves operating in a world of fact and feeling, rationality and emotion. As experts in the field, they should not be shy about speaking out against viewpoints that they feel ignore scientific truths. Rather than viewing public discussions as fruitless distractions, scientists should welcome such engagements as opportunities to speak out about the importance of their work beyond the familiar confines of the scientific community.

National, merit-based science academies represent an often-neglected but potentially significant set of institutions that could play a vital role in helping to build capacity in the life sciences in developing countries and in bridging the science-society gap in the biological sciences.

The public often thinks of these institutions, if it thinks of them at all, as exclusive clubs dedicated to the well-being of their members – places where eminent scientists politely exchange ideas and socialize at a leisurely, gentlemanly pace.

But science academies are also places of extraordinary scientific talent and expertise. They have only recently begun to change their ways, seeking to make the storehouse of knowledge that their members possess more accessible and useful to society.

Science academies could ultimately serve as responsible intermediaries between society and science – knowledge-based brokers for the public good – that help explain the complexities of the life sciences to lay citizens while simultaneously forging useful linkages between the scientific community and the public. Giving independent, unbiased advice to government on science-based issues of critical importance to society may prove to be the most significant contribution that science academies can make.

Science academies are places of extraordinary scientific talent and expertise.

IN AFRICA

The most critical place to do this may be Africa, where issues related to the life sciences have become hotly contested as the continent gains interest and capabilities in utilizing the life sciences to advance its own social and economic well-being.

Measures taken across Africa during the past few years indicate that the continent is increasingly determined to control its own destiny in both the development and application of science. This is particularly the case when it comes to the life sciences and such applications as GM crops and the development of molecular-based pharmaceuticals based on knowledge of indigenous and medicinal plants.

In 2003, the first ministerial meeting of the New Partnership for Africa's Development (NEPAD) called for Africa's leaders to seek a common position on biotechnology. In 2005, the African Union (AU) established a 14-member high-level group, co-chaired by Calestous Juma (TWAS Fellow 2005), director, Science, Technology and Globalization, Harvard University, and Ismail Serageldin (TWAS Fellow 2001), director, Bibliotheca Alexandrina in Egypt, to advise AU members on how advances in biotechnology would affect agriculture, health and environment in Africa.

The panel's report, *Freedom to Innovate: Biotechnology in Africa's Development*, which was released earlier this year, analyses the opportunities and risks that the life sciences – and, more specifically, genetic engineering – pose for the world's poorest region.

This public debate is good for the life sciences and good for the sciences in general. It is emblematic of the public's increasing involvement in science in Africa.

Such involvement speaks well for the future of science across the continent. It may at once help to make science in Africa more relevant and more accountable, trends that could prove a boon to both Africa's scientific community and society alike.

THE ONE CONSTANT

In a potentially path-breaking article published in the 14 June edition of *Nature* by the ENCODE Research Consortium (accompanied by 28 papers published in the June 2007 edition of *Genome Research*), a group of eminent scientists questioned a fundamental principle of modern biology by declaring that the human genome may not be "a tidy collection of independent genes" with distinct sections of DNA linked to a particular function.

The conclusion, if confirmed by additional research, would apply not only to the human genome but also to the genomes of all living organisms. As a result, it would directly challenge the "one gene, one protein" principle that has pushed the frontiers of life science since the term biotechnology first came into vogue in the 1960s.

In its place, the consortium suggests that gene networks, not individual genes, may well determine protein function, calling into question this long-standing gene-centric view and opening up new uncharted avenues of research and understanding. The authors, in short, suggest that the life science community may have to reconsider its "views about what genes are and what they do."

As the life sciences continue to evolve at an unprecedented rate, this much is certain: Diversity does indeed rule – in science, government, nongovernmental organizations, the private sector and, most notably in nature.

And that makes this much true as well: The only sure way to deal with this diversity is through greater capacity – capacity to know, learn, and apply the world's growing expertise in wise, productive and safe ways. This is especially true in the life sciences where advances in research and technology are likely to shape and reshape our world in untold ways in the years ahead. ■

> ***Mohamed H.A. Hassan***
Executive Director, TWAS
Trieste, Italy

An abbreviated version of this article was published in Cell *131, 2 November 2007*

DRUG RESEARCH IN INDIA

INDIA'S CENTRAL DRUG RESEARCH INSTITUTE (CDRI) WAS OFFICIALLY LAUNCHED IN 1951 AS ONE OF THE FIRST INSTITUTES OF THE COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR), INDIA'S EXTENSIVE NETWORK OF RESEARCH AND DEVELOPMENT LABORATORIES DESIGNED TO PROVIDE A SOLID SCIENTIFIC AND TECHNOLOGICAL FOUNDATION FOR SUSTAINABLE GROWTH.

Today CDRI employs about 1,000 staff, including some 200 scientists and 400 technicians. It has an annual operating budget of about $6 million, which it receives from the Indian government. CSIR also obtains some US$2 million a year from outside sources, including royalties from the sale of six commercialized products.

What follows is a brief profile of the institute, prepared as part of a project funded by the David and Lucile Packard Foundation that is designed to highlight the success that has been achieved by a growing number of research centres in the South. The full text of the profile is available from the TWAS secretariat.

"CDIR'S mandate has three main parts," explains C.M. Gupta. These mandates are to carry out basic research relevant to drug development, develop new drugs, and serve as a focal point for education and training.

Today, CDRI graduates can be found at all levels in the continually expanding Indian pharmaceutical industry. The institute's graduates are also well represented on the staff of such multinational drug companies as Eli Lilly and Pfizer.

"We are the only place in India where, under one roof, you can find a department that conceptualizes a new drug molecule, screens it and puts it through the required toxicological tests and pre-clinical and clinical trials," says C.M. Gupta.

Such diversity could result in a research focus with each department concentrating on its own particular research interests. However, the well-defined 'chain' of departments means that the entire process – from drug discovery and development to clinical trials and commercialization – is coordinated from beginning to end.

The process starts with the Division of Medicinal and Process Chemistry, which is responsible for discovering and designing new lead compounds with the potential to become commercial drugs. The division

C.M. Gupta

contains some 30 scientists, 100 research fellows and 50 technicians. That brings the total number of staff to 185, which makes this the largest division in CDRI's largest department.

"The progress of the institute is directly proportional to the output of this division," claims Chandan Singh, head of the division.

"We are the starting point of the whole programme," continues Singh. "We not only synthesize new compounds but also analyse natural products, including those found to be interesting through random screening and those listed in Ayurveda and other systems of traditional medicine."

"One strength of the CDRI drug discovery programme is the traditional knowledge base that we have here in India," confirms C.M. Gupta. "We try to use this throughout all research areas.

Even so, Singh stresses that the search for new drugs isn't confined to screening natural products.

"Previously we were more vigorous in looking into natural products," he explains. "But many of the scientists who did that work have retired. We are placing more focus now on synthetic chemistry because it can get us quicker results. There is also a middle road – the synthetic modification of natural products. If we find an interesting lead compound in a natural product, we can work entirely from chemical synthesis based on literature searches and other information, modifying the functional chemical groups to develop more effective compounds."

CDRI employs about 1,000 staff, including some 200 scientists and 400 technicians.

Such an expansion of traditional scientific thinking – in this case the 'improvement' of nature – has led to the development of several of CDRI's successful products.

As in any drug discovery programme, each individual compound or, for natural products, standardized plant extract, must be screened for its biological activity. There are literally thousands of such screening tests to select from. But CDRI focuses on some 200, targeting its search for useful compounds on three main areas of research:

- Reproductive health, and devices and drugs for birth control.
- Tropical and infectious diseases, especially tuberculosis and malaria. There are also research groups working on such parasitic diseases as filariasis and leishmaniasis.

Chandan Singh

• Age-related diseases such as hypertension. These diseases, once regarded as problems only in developed countries, are now rising to epidemic levels in India.

Once scientists in the Division of Medicinal and Process Chemistry have identified a lead compound or interesting plant extract, it is passed to other departments, including the Division of Pharmaceutics.

"Our work starts after the primary screening," explains Satawayan Singh, the division head. "Its aim is to standardize plant extracts and fractions and to determine the correct doses, form and route of administration to animals and humans."

Among the main processes carried out by the Division of Pharmaceutics is the standardization of plant extracts. Plants contain a wide range of chemicals, each with concentrations that can vary during the plant's life cycle.

Some chemicals may be present at higher levels in young leaves, for example, or during flowering or fruit ripening. Some may also be harmful. Efforts to develop pharmaceutical products from plant extracts must rely not only on a detailed knowledge of what is present in the extract, but also of the relative concentrations of the different components.

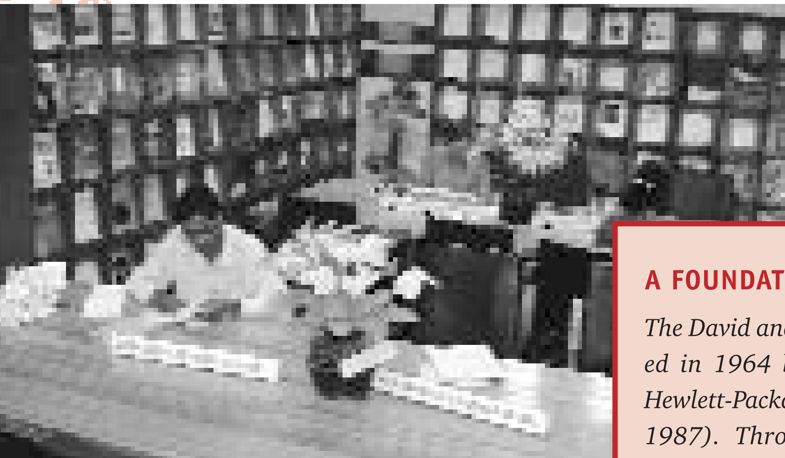
CDRI graduates can be found at all levels in the continually expanding Indian pharmaceutical industry

Many sophisticated instruments are used in these analyses, including a high performance thin-layer chromatography (HPTLC) machine. During the secondary screening process, different fractions of plant extracts are separated using HPTLC. The biological and toxicological activities of each fraction are then evaluated. Unlike most modern drugs, the activity of a herbal drug or plant extract may rely on a mixture of compounds. HPTLC allows the component compounds of different batches of extracts to be compared, giving not only their relative chemical properties (a guide to their identity that can be checked using standard control compounds), but also their relative concentrations.

"We can therefore standardize herbal extracts, with maximum and minimum limits for each component," says Singh.

CDRI scientists were the first to develop and patent a 'non-single compound' drug – the hypolipidaemic or cholesterol-lowering *Gugulipid*, which contains about a dozen components.

Before this, the isolation of pure molecules from plants and their further development to modern drugs constituted the basic objective of natural product research. This changed, however, when CDRI scientists developed *Gugulipid* as a standardized extract of the Ayurvedic remedy, *gum guggulu*, derived from *Commiphora mukul*. Laboratory tests, however, revealed that *gum guggulu* contained toxic components, so an active



fraction was isolated and standardized. It is now available as an 'allovedic' drug – *Gugulipid* – having completed all the necessary safety tests and clinical trials for it to be registered as a modern pharmaceutical.

This second example of 'expanded scientific thinking' marked a change in approach – or a new strategy – not only for CDRI, but also for other organizations involved in developing pharmaceutical products from natural sources.

"For such potential herbal drugs," adds Singh, "we take about 10 batches of standardized extracts that are used for the different analyses we carry out". Following these tests, the standard specifications are agreed upon and fixed.

The Division of Pharmaceutics also conducts research to develop the most effective delivery system for a candidate drug. In particular, the department has expertise in the development of oral controlled release pharmaceuticals and nasal and transdermal drug delivery systems.

Satawayan Singh

"We are aiming to develop a pill, to be taken once every 12 to 14 hours, that will slowly release the active compound, rather than a pill that must be taken every 3 to 4 hours," explains Singh. "Such a formulation will depend on the physical parameters of the active pharmaceutical ingredient, or API, including the physico-chemical properties of the formulation – the type of polymer and other so-called 'excipients' used as binders and diluents in the formulation."

A FOUNDATION OF HOPE REALIZED

The David and Lucile Packard Foundation (www.packard.org) was created in 1964 by David Packard (1912–1996), the co-founder of the Hewlett-Packard Company, and his wife, Lucile Salter Packard (1914–1987). Throughout their lives in business and philanthropy, the Packards sought to use private funds for the public good, giving back to a society, which enabled them to prosper. The Packard Foundation focuses its giving in the following areas: improving the lives of children, enabling the creative pursuit of science, advancing reproductive health, and conserving and restoring earth's natural systems. The Packard Foundation has provided TWAS with funds to produce a series of booklets that highlights successful scientific institutions in the developing world and explains how their research has been sustained over a number of years and is helping their nation's achieve sustainable economic growth. The Academy is grateful for their support. For additional information about the David and Lucile Packard Foundation, see www.packard.org.

Each lead compound identified must also pass a battery of toxicological tests.

"The Division of Toxicology is the only place in India offering complete facilities under one roof," says Sudhir Srivastava, head of the division. "We have the capability to carry out the full range of toxicity studies to conform to the requirements of international regulatory authorities for the development of new drugs and vaccines."

The division is composed of seven scientists, six technicians, eight support staff and six laboratory atten-

Sudir Srivastava

dants and animal handlers. Among the scientists are experts in systemic toxicology, focusing on histopathology (including Srivastava himself), clinical biochemistry, haematology, hypersensitivity, and reproductive and developmental toxicity.

"In the past 40 years, we have carried out toxicity studies on more than 60 candidate drugs and vaccines. The protocols we follow are based on guidelines issued by the Organization for Economic Cooperation and Development (OECD). However, our approach is flexible and comprehensive – it adapts to changes quickly and complies with the requirements of other important regulatory bodies," explains Srivastava. Most tests are performed routinely on animals such as mice, rats and rabbits, although in vitro assays using cultured cells are also used.

"The subject is always evolving with newer and better methods," says Srivastava. "Nowadays we are using fewer animals and moving more towards cell-based systems."

Standard operating procedures (SOPs) have been developed for all tests and are adhered to rigorously to ensure good laboratory practice (GLP) – an issue close to Srivastava's heart. "These procedures cover instructions from the simplest to the most intricate of scientific techniques as well as administrative procedures," he explains. "Written protocols are strictly followed during the study and any deviation from these protocols is recorded in detailed amendments to the study report."

Toxicity reports include such information as the objective of the study, the composition and stability of the substance being tested (the division possesses facilities for such analyses), and descriptions of both the tests and test results.

"These reports are signed by the study director and other senior staff and consultants," adds Srivastava.

Once the toxicological properties of a lead compound or standardized herbal extract have been worked out, the potential drug product is passed to the Division of Pharmacology where its safety profile is further examined.

"First, we carry out six or seven main tests," explains Ram Raghubir, head of the division. "Then we decide which other tests need to be done. In all, we have 85 different screening tests available in the department."

These tests previously centred on animal experiments. As with other organizations involved in drug development, however, there has been a move towards more cell and molecular target-based tests.

In addition, the CDRI drug-testing regimen initially followed the Indian government's regulatory system.

Now, however, with the international market in mind, CDRI's protocols comply with the requirements of the European Union countries and the United States and, in particular, to tie in with the regulations of the Organization for Economic Cooperation and Development (OECD) and the Center for Drug Evaluation and Research (CDER) of the US Food and Drug Administration (FDA) through the International Conference on Harmonization (ICH) guidelines.

In addition to the acute toxicity tests, staff in the Division of Pharmacology carry out seven other basic tests: behavioural activity studies; studies on the central nervous system; checking haemodynamic characteristics such as heart rate and blood pressure; examining gastrointestinal function, including gut motility and gastric irritation that could lead to the formation of stomach ulcers; urine tests for metabolites; interactions with other drugs; and isolated tissue studies, for example, on the ileum and uterus.

As is true in other departments, in addition to working on the institute's drug development 'chain', scientists in the Division of Pharmacology also carry out their own research. The major research and development

Ram Raghubir

The trials follow International Conference on Harmonization (ICH) guidelines, which mean that patients must give their prior informed consent before taking part in the studies.

focus is the discovery and development of new lead compounds and products for diseases of the cardiovascular and nervous systems, as well as age-related disorders.

Ram Raghubir, for example, is now studying the molecular mechanisms that lead to cerebral stroke. The long-term goal of such basic research is tied to the institute's overall drug development programme. In this case, Raghubir is testing the effects of a new herbal preparation in preventing and reversing the damage caused by reduced blood supply to the brain. Experiments performed on rats suggest that the extract could be both preventative and curative – making it a potential 'blockbuster' drug.

The final experimental 'links' in the drug development chain are the clinical trials. At CDRI, these are conducted by the Division of Clinical and Experimental Medicine, which hosts four scientists, all of who are doctors of medicine. The division is headed by Omkar Asthana.

Standard operating procedures have been developed and are adhered to rigorously.

Clinical trials are divided into three stages.

"In phase I trials, clinical studies are performed on healthy volunteers to check for drug safety and tolerability," says Asthana. "In phase II, we carry out controlled, limited trials to check the efficacy of the drug on patients suffering from the target ailment." Phase III trials are large, multi-centric studies and can involve hundreds of such patients." Phases II and III also involve the use of a control standard drug that is used to compare the efficacy of the new drug.

Development of an antimalarial drug, α/β arteether, now being marketed successfully in India and Africa, involved 28 healthy volunteers for the phase I trial, 49 malaria-infected patients in the phase II trial, and 478 patients at several centres throughout India where the disease is endemic in the phase III trial.

Such procedures not only require adequate planning – usually in collaboration with other research institutes and hospitals – but are also expensive. In the case of an antimalarial compound, treatment lasts for three days, by which time the parasites are removed from

Omkar Osthana

the blood. "With drugs to treat hyperlipidaemia and diabetes, however, due to the nature of the diseases, the drugs must not only be less toxic, but treatments can go on for months or even years. Thus there are quality-of-life issues to take into account," explains Asthana. "The duration of our clinical trials has to reflect this."

Over the years, the number of drugs entering the CDRI clinical trial programme has varied.

"In the 1970s, we performed 10 to 12 phase I trials, but only half of this number during the 1980s. Part of the reason was that five or six of the compounds we tested in phase I trials were taken forward into phase II trials. In the 1990s, phase III trials came on line," explains Asthana.

Through 1998, 12 drugs successfully completed phase III clinical trials and were licensed for use in India. Since then, as emphasized by the work being carried out by other divisions at CDRI, clinical trials are now designed in accordance with more strict international regulatory guidelines

"India is opening up and we need to look for licensing outside the country. As a result, it is important for us to follow international standards," adds Asthana.

There has also been a shift in the selection criteria for drugs that will be put through clinical trials, with decisions increasingly based on commercial viability and risk-benefit analyses.

"Since the 1990s we have been looking for novelty among the products we develop," says Asthana. "We must be able to show that we hold the intellectual property rights to the drug. We have, for example, dropped a promising anthelmintic drug from phase II trials because all the information on it had already been published. In such a case, we could not find any commercial company willing to take on the risk of producing it.

India is opening up and we need to look for licensing outside the country.

"The policy has changed," confirms Chandan Singh, head of Medicinal and Process Chemistry. "Earlier, we developed compounds to the point of clinical trials. Now we do not develop a lead compound unless the industry is interested. It would be considered money wasted. Previously, the government was more liberal and wanted us to do everything. Now, as with many governments in the developed world, the Indian government is of the opinion that industry should fund near-market research."

"For this reason, we focus on lead compounds that are better – in the sense of being more effective, safer and cheaper – than the currently available drugs, even if we hold the rights," adds Asthana. A lead synthetic molecule developed by CDRI scientists in the 1970s that had useful anti-filariasis properties, for example, was dropped during phase II clinical trials when it was shown to be no better than the current market leader.

This focus on international markets, the filing of patents in the US and EU, and the identification of partner companies willing to help develop new lead compounds is the work of a separate fully-fledged division in the CDRI drug development chain: the Technical Information, Industrial Liaison and Planning Division, headed by Zaka Imam.

"This division has four main responsibilities," he says. "First is planning, monitoring and evaluating the institute's research progammes. This is based on a five-year plan that we submit to our headquarters in New Delhi for approval. Then, each year, we must prepare an annual report and a work plan that includes a budget for the following year.

"The second area is business development," continues Imam. "This is something we build into every research programme. Whether it is aimed at the development of new lead compounds or new processes, we try to link each project with a business development objective, a sponsored or collaborative project, or a commercial product. We also offer training courses that have been attended by developing-world scientists on World Health Organization (WHO) fellowships.

Zaka Imam

"We have a policy to protect our intellectual property. This is an area in which we are becoming increasingly active. In January 2005, for example, the new World Trade Organization (WTO) product patent regime came into force, affecting those Indian pharmaceutical companies that make generic drugs. To protect our intellectual property, therefore, we have started filing patents in EU, Japan, the United States and elsewhere. Our strategy is targeted, however. For example, our antimalarial drugs will only be protected by patents primarily in those countries where malaria is endemic. This helps us keep down the costs of filing international patents.

"Finally, this division is also responsible for organizing international collaborations," adds Imam. "These are often coordinated through the Indian government or as part of CDRI or CSIR programmes. The division also coordinates training of institute staff in various disciplines, including management."

Thus the Technical Information, Industrial Liaison and Planning Division plays an integral part in the institute's drug development chain. Indeed the most important 'link' in the chain may be the link between the publicly funded research institute and private companies. Without such a link, the fundamental research being carried out in the institute's laboratories would be unlikely to develop into commercial products.

CDRI – by any measure – is a thriving institute that has not only developed and produced effective pharmaceuticals but, in doing so, has helped Indian companies overcome technological challenges and, therefore, has contributed to the country's economic development.

> For additional information about CDIR, see www.cdriinida.org

> For a copy of the complete CDRI report, contact info@twas.org

THIS OCTOBER, THE ROCKEFELLER FOUNDATION HOSTED A WEEK-LONG CONFERENCE EXAMINING THE ROLE OF WOMEN IN SCIENCE AND THE MEASURES THAT MIGHT BE TAKEN TO IMPROVE THE STATUS OF WOMEN IN BOTH SCIENTIFIC RESEARCH AND SCIENTIFIC DECISION MAKING THROUGHOUT THE DEVELOPING WORLD. THE EVENT TOOK PLACE AT THE ROCKEFELLER RETREAT IN BELLAGIO, ITALY. THE THIRD WORLD ORGANIZATION FOR WOMEN IN SCIENCE (TWOWS) WAS ASKED TO ATTEND AND WAS REPRESENTED BY KAISER JAMIL, PRESIDENT OF TWOWS AND DIRECTOR OF THE SCHOOL OF BIO-TECHNOLOGY AND BIO-INFORMATICS AT MAHATMA GANDHI NATIONAL INSTITUTE OF RESEARCH AND SOCIAL ACTION IN HYDERABAD, INDIA.

WOMEN IN SCIENCE

The conference was co-organized by the American Association for the Advancement of Science (AAAS), the Consultative Group on International Agricultural Research (CGIAR, EMBRAPA (the Brazilian Research Corporation), L'Oreal, the Massachusetts Institute of Technology (MIT) and the United Nations Educational, Scientific and Cultural Organization (UNESCO). To set the stage for the meeting and provide valuable backup material, Jamil was asked to respond to a series of questions designed to profile her own experience and to describe the work and impact of TWOWS. The material served as background information for the discussions that took place in Bellagio. Excerpts from Jamil's response follow.

Family and passion...

I'm the eldest daughter in a family with six children. My mother was a teacher and my father a principal. Both of my parents encouraged us to learn. All of us studied hard and all of us went to college. After receiving my undergraduate degree, my parents urged me to become a doctor. But the competition to get into medical school was intense and, besides, I already knew then I would prefer research to clinical work. So I decided to go to graduate school to earn a master's degree in biology.

As a scientist I do what I love: Study in a variety of interrelated fields, interact with colleagues and travel widely. I work with like-minded people from across the globe, sharing knowledge to address challenges of common concern. It has been very fulfilling and very exciting. You must have passion to do this work. If you don't, you can't motivate people to put your ideas and ideals into action.

Success and circumstances...

When I received my doctorate degree in the early 1970s, I was already married with children. My family and children came first; work second. After my children were grown, I returned to my career full-time.

Gender has also played a role in the way my career has progressed. There were few women where I worked and none in leadership positions. My female colleagues and I had to do better than the men to prove that we could make the grade. We often heard snide remarks. But we carried on, overcame the hurdles and the snickers, and ultimately succeeded.

Gentlemen and lady...

I have worked for more than 25 years at the Indian Institute of Chemical Technology in Hyderabad. I did my post-doctorate in Sydney, Australia, and spent time as a visiting scientist in Paris, France. I've traveled many places to attend workshops and conferences. Wherever I have gone, men have always outnumbered – and, I might add, outshouted – women. Evidence of gender discrimination has been present in subtle and not-so-subtle ways. As head of my department, I was the only woman in a high-level position for many years. At meetings, the director would address his senior staff as "lady and gentlemen".

Mandates and measures...

I've been a member of TWOWS since 1988. In 2005, I was elected president at TWOWS's third general meeting in India. I succeeded Lydia Mahkubu who had been the organization's first and only president. It was an honour to have the membership express such confidence in my leadership. It was a challenge to follow in the footsteps of Lydia. She has done so much for TWOWS and, more generally, for women in science throughout the developing world.

I met with the newly elected executive board of TWOWS immediately following my election. At the impromptu meeting in India, we exchanged ideas on future activities and discussed potential funding opportunities. TWOWS is

TWOWS: THUMBNAIL SKETCH

TWOWS is the first international forum to unite eminent women scientists from the South for the purposes of strengthening their role in the development process and for promoting their representation in scientific and technological leadership.

The idea of establishing a Third World organization for women in science was first discussed at the Conference on the Role of Women in the Development of Science and Technology in the Third World convened by TWAS and the Canadian International Development Agency (CIDA) in Trieste, Italy in October 1988. Participants at the conference, which included 218 leading women scientists from 63 developing countries, recommended that a study group be established to explore the possibility of creating the organization. The study group was subsequently formed. At a meeting, also held in Trieste, in March 1989, the group decided to establish the Third World Organization for Women in Science (TWOWS).

The official launch of TWOWS took place at its First General Assembly held in Cairo, Egypt, in January 1993. The Kuwait Foundation for the Advancement of Sciences (KFAS) sponsored the event. TWOWS's Second General Conference, supported by the Foundation for Research Development (FRD) and the Department of Arts, Culture and Science & Technology of South Africa, was held in Cape Town, South Africa in February 1999. TWOWS's Third General Assembly, which was hosted by the Department of Science and Technology, Government of India, was held at the Indian Institute of Science, in Bangalore, India, in November 2005. The Fourth General Assembly of TWOWS is scheduled to take place in Beijing, China, in 2009.

grateful to TWAS for hosting our secretariat. We are also grateful to the Swedish International Development Agency (Sida) for funding our fellowship programme for young women scientists from least developed countries (LDCs) and sub-Saharan Africa. To date, the programme has helped more than 200 young women scientists seeking advanced degrees in a variety of scientific fields. Some of the women are enrolled in universities in their home countries but receive a great deal of their training at universities or research centres in other developing countries that have agreed to participate in the programme. TWOWS also provides grants to members to go to conferences and workshops and invites members to attend the general assembly. We do a lot but we could do a lot more if we had additional resources.

TWOWS's mandate is to improve the status of women in science in the developing world and to promote efforts to place women in leadership positions. The organization's membership currently exceeds 3200. That makes TWOWS the largest organization of its kind. The vast majority of our members are women scientists from the developing world. But we also welcome both males and institutions from the North and South. You could say we are a gender-focused yet gender-free organization. We only ask that you share our goals. There is no fee to join. However, we have begun to encourage members to give voluntary contributions.

Over the past two years, TWOWS has made a special effort to encourage young women to join the organization. Some have become very active. We have emphasized the creation of national chapters to decentralize our activities and extend our reach. India, for example, has created a



national chapter that is now linked to the Indian Women Scientists Association. We have sought to actively involve women entrepreneurs. Successful women not only possess valuable skills and experience but also serve as role models. That is why we have organized meetings between female scientists who belong to TWOWS and women who have achieved success in other fields. Such women, of course, lead busy lives. Yet they have been happy to contribute in whatever ways they can. This suggests to me that women may view competition and cooperation differently than men.

Gender and roles...

Women have many roles: wives, mothers, caregivers for elderly parents, workers. In the developing world, the challenges women face are complicated by problems of poverty. That is true in my home country of India and in many other developing countries as well. In my recent travels as TWOWS president, I have heard heartbreaking stories from women – brave women – struggling for survival and dignity in Asia, South America and sub-Saharan Africa, where the problems are most acute. These stories of suffering demand our attention and demand much of science.

TWOWS focuses on issues of critical importance to women, it deals with the challenges of poverty and wealth creation, it encourages women to exchange their experiences, it calls for improving education for girls, and it promotes the building of scientific capacity. At conventional academic meetings, critical issues are often examined in the abstract. TWOWS-sponsored meetings, in contrast, offer opportunities for members to learn more about the real problems and hardships affecting our daughters, sisters, colleagues and friends. TWOWS meetings also allow participants to explore strategies for helping women attain the knowledge and skills they need to meet the challenges of everyday life.

Networks – electronic and otherwise...

TWOWS is a vibrant network comprised primarily of women from the developing world. The organization's success is largely due to the shared concerns of its members and to their passionate commitment to advance the



organization's goals. Limited financial resources have impeded our progress. TWOWS's strategic plan and its efforts to seek additional programmatic funding represent efforts to address this concern. We have also had difficulty developing effective global communications. TWOWS is now taking steps to take full advantage of electronic communications, most notably the internet. The immediate objective is to strengthen interaction among our members and the executive board. The long-range goals are to facilitate decision-making and speed the process by which proposals are submitted to potential funders. We also plan to use electronic communications to assess the progress being made on projects that have been funded. Members of the executive board already know and trust each other. Greater use of electronic communications will enable them to work on issues more effectively.

Trends and impact...

Over the 18 months that I have served as president of TWOWS, I have witnessed a growing awareness of our activities among our members and a growing interest in TWOWS among other organizations. TWOWS's regional offices have also reported a rise in the number of women who are involved in the organization's regional activities. Such trends are more prevalent in some countries and regions than others. For example, developments in Asia have been more encouraging than developments in Africa, and developments in China and India have been more encouraging than development in Bangladesh and Pakistan. So we know we have a lot more work to do to ensure that all of our members benefit from our programmes.

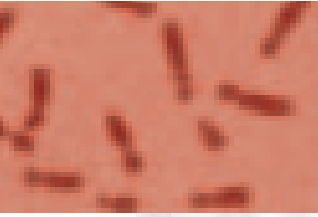
Uniqueness and change...

TWOWS is a unique organization. Our goal – to help women scientists in the developing world succeed both as researchers and leaders – is easy to appreciate and understand. Gender discrimination, unfortunately, is a widespread problem that adversely affects women and societies. It must be overcome. But TWOWS also understands that women alone cannot solve this problem. That is why the organization also welcomes not only men but also institutions that share our goals to join us in our efforts. And that is why we welcome not just scientists but government officials, entrepreneurs, teachers and grassroots activitists into the organization. Our primary goals are to expand research and training opportunities for as many young scientists as possible and to help ensure that they can reach their full potential. These steps, in turn, are designed to help us realize our dream of helping all developing countries become places where men and women can lead healthy, fulfilling and prosperous lives. We firmly believe that this dream cannot be realized unless nations support efforts to educate and train young women scientists who are eager to learn and only ask to be given the opportunity to do so.

I think that at some basic level successful women in developing countries are self-made women. They have had to overcome many hurdles to get where they are and they have had to balance many competing issues – both personal and societal – to move ahead. As in my case and so many others, women cannot – indeed do not want – to live lives defined by a single fidelity to work. Virtually all professional women struggle to balance their devotion to family with their commitment to their careers. That is what makes the experience of women unique. Mentoring is critical in such a conflicting environment. It helps young female scientists better understand the issues – and emotions – that they are likely to face in the years ahead and it provides them with role models who can help them navigate this difficult terrain.

Regions and nations...

TWOWS has an international mandate that calls for helping women scientists throughout the developing world. In the past, it has not focused on particular countries or regions. Yet the organization fully recognizes that a great deal has changed since its inception nearly two decades ago and that some developing countries have fared better than others when it comes both to scientific capacity building and applications of science to development. It has also come to realize that the organization's effectiveness can be enhanced by decentralizing its activities and placing greater responsibility in regional and national chapters – what political scientists call 'devolution' but what TWOWS calls commonsense. Therefore it has become a core element in its strategic plan to call for greater emphasis on regional and national activities and for linking broadbased initiatives to the 'localized' needs of the scientists and scientific institutions it is seeking to help. That is why we have moved to target our resources to those most in need and that is why we are increasingly emphasizing the importance of South-South cooperation in science. The status of women in science in every developing country continues to be our overall concern but increasingly we are seeking to give the most help to women scientists in countries and regions that have failed to keep pace with others. You could say that TWOWS's long-standing goals have remained unchanged but that our tactics have been altered to meet the changing circumstances of science in the developing world – circumstances that affect not just nations and not just the scientific community but also women scientists who are seeking to live their lives and build their careers without sacrificing one for the other.

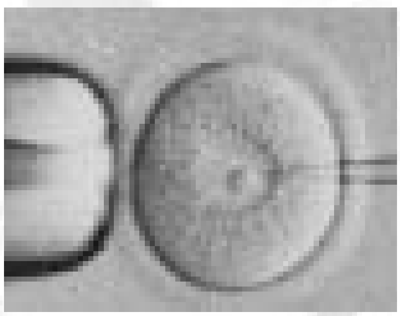


FEATURE

FROM SWEDEN WITH BIOLOGY

THE VISITING SCIENTIST PROGRAMME, A JOINT INITIATIVE OF TWAS, ICSU (INTERNATOINAL COUNCIL FOR SCIENCE), UNESCO (UNITED NATIONS EDUCATIONAL, CULTURAL AND SCIENTIFIC ORGANIZATION) AND UNU/IAS (UNITED NATIONS UNIVERSITY/INSTITUTE FOR ADVANCED STUDY), ENABLES EMINENT SCIENTISTS FROM DEVELOPED COUNTRIES TO VISIT INSTITUTIONS AND RESEARCH GROUPS IN DEVELOPING COUNTRIES, ESPECIALLY LEAST DEVELOPED COUNTRIES (LDCS).

The programme's goals are to nurture scientific exchanges and to forge long-term collaborations that ultimately help to build the capacity of scientific institutions in the South. In late 2006, Abul Mandal, a Bangladeshi-born Swedish national who is a distinguished researcher in the school of life sciences at the University of Skövde in Sweden, journeyed to Bangladesh to lecture at Rajshahi University. A first-hand account of his two-week visit follows.



I arrived at Rajshahi University on the morning of 15 December after a 26-hour flight from Skövde, Sweden. I was greeted warmly at the airport by Shahinul Islam, an assistant professor with the university's Institute of Biological Sciences (IBSc).

Although weary, I was eager to get going. I knew from the start that it would be a rewarding visit, certainly for me and I hoped for my hosts as well. I also knew that I would not be working under the same conditions that I had left behind in Sweden. It was clear that Rajshahi University had knowledgeable and dedicated researchers. But it was equally clear that these researchers were working under very trying conditions.

I had spent several weeks before my departure reading up on my home country of Bangladesh, which is a small country covering an area of just 144,000 square kilometres. That is just slightly bigger than Greece.

Bangladesh may be small in area but it is large in population. That means it is crowded, especially in cities and along the coastline (which in Bangladesh is often one and the same). Nearly 160 million people live there. That is just 20 million fewer than live in Pakistan, a country more than five times as large. Indeed, with a

population density of nearly 1000 people per square kilometre, Bangladesh is among the world's most crowded nations.

Bangladesh came to be through a pair of secessions. The first, in 1947, led to the creation of India and Pakistan, which were formed from the British protectorate that had been in place for two centuries. Nearly 25 years later, following a bloody civil war that left nearly 30 million people dead, East Pakistan gained independence from Pakistan, emerging as the nation of Bangladesh in 1971.

With about 25,000 students and 1000 faculty members, Rajshahi University, which was established 53 years ago in East Pakistan, is now Bangladesh's second largest university (only Dhaka University located in the nation's capital city is larger). Situated along the western border not far from India, Rajshahi is without question the most prominent university in the region.

Rajshahi University is Bangladesh's second largest university.

In addition to its seven faculties and 40 departments, the university is home to five research institutes, including the Institute of Biological Sciences (IBSc). Established in 1989, IBSc, the university's largest institute, is the nation's only research institute to offer advanced degrees in the biological sciences. It does this not by drawing on its own faculty, but by linking its core curriculum to faculty in such university departments as biochemistry, botany, molecular biology, genetics, pharmacy and zoology. IBSc has about 40 faculty members, including six who have earned doctorate degrees. The latter currently oversee the work of nine doctoral students and seven master's degree students.

In addition to its classroom activities, the institute houses advanced research laboratories in plant biotechnology, molecular biology and plant tissue culture. Laboratory investigations are complimented by field tests and trials that take place on a 300-hectare plot of land located on the campus. The institute also has a well-stocked library largely dedicated to the fields of biotechnology and molecular biology. The library provides faculty and students access both to print material and electronic information.

I first became aware of IBSc in July 2005 at a conference on plant biology held in Seattle, Washington, USA. There, I met Islam, the person who was later to pick me up at the airport. At the time, Islam, who had received his PhD at IBSc, was a postdoctoral student at the University of Niigata in Japan. He is now an assistant professor at the institute.

In Seattle, Islam was eager to tell me about IBSc's research projects. While he proudly discussed the insti-

tute's accomplishments, he was not reluctant to mention IBSc's chronic money problems.

The plant biotechnology arsenic project in which he is involved captured my attention since I do similar research at my home institution. Islam asked if collaboration between IBSc and University of Skövde was possible. I told him to get in touch with me after he completed his postdoctoral studies.

In late summer 2006 I received an email from Abdul Bari, head of plant biology at IBSc, saying that the Visiting Scientist Programme, overseen by TWAS and several other international science organizations, might provide a good avenue for the two institutions to work together. I submitted my application to the TWAS secretariat and six weeks later I was informed that it had been accepted. Within four months I was on a plane to my home country.

A DNA sequencer costs more than US$130,000 – far beyond IBSc's operational budget.

IBSc's research group focuses its efforts mainly on plant cell and tissue culture. The group is also engaged in several plant biotechnology and molecular biology projects. Having spent my entire academic career in the developed world, I had no idea what it was like to be a researcher in a poor developing country such as Bangladesh.

IBSc researchers are highly skilled. Most have been educated in institutions in developed countries. But their ability to do world-class research is handicapped by inadequate facilities and limited funding. Laboratories remain poorly equipped and even more poorly maintained. Faculty grants do not exist. External funds are difficult to obtain. Teaching requirements leave little time for research and salaries are so low that faculty often take second jobs to make ends meet.

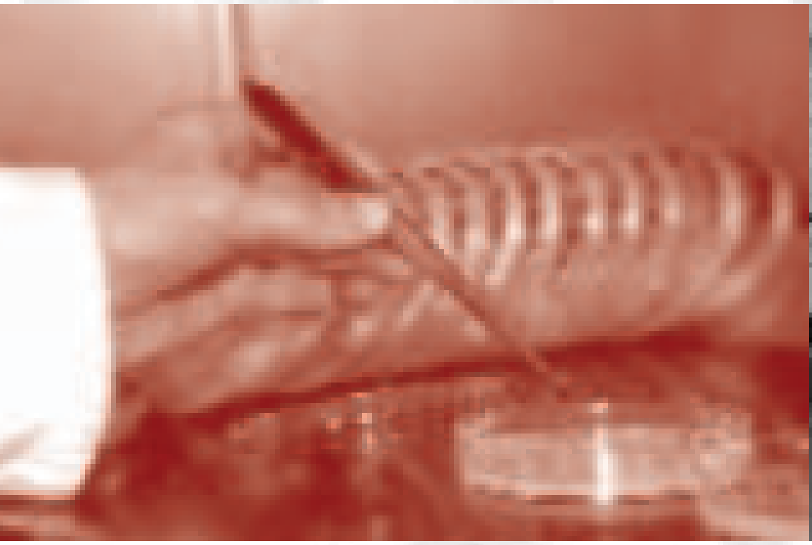
What happens when scientists are unable to fully utilize their education and training at home?

Three options are possible and not one speaks well for the future of science in their home countries. Researchers can remain at home struggling to make the best of a bad situation often by abandoning their research and focusing on teaching; they can become disillusioned with their lives as scientists and seek opportunities in other fields; or they can lose hope and emigrate elsewhere.

Their plight, whether played out at home or abroad, not only has adverse personal consequences but, more generally, affects the quality of university education and research, undermining the contributions that science can make to society and, consequently, the level of support that citizens are willing to give to science.

Experiments in plant molecular biology require sophisticated high-tech equipment such as DNA/protein sequencers, DNA/protein micro array detectors and polymerase chain reactors (PCRs). A DNA sequencer, for example, costs more than US$130,000, far beyond the operational budget of IBSc. A PCR costs US$13,000 at minimum, still too much for institutes like IBSc to afford. The consumables needed to conduct the experiments – for example, enzymes, pipettes, and protein purification and sequencing kits – are also expensive.

Then there's the added cost of building and maintaining a greenhouse able to operate under closely monitored temperatures, humidity and light. Research on genetically modified plants, moreover, must meet government standards for biosafety. That means laboratory and field experiments on genetically modified organisms (GMOs) must be performed under strictly regulated conditions.



All of this costs money – money that universities like the University of Rajshahi and institutes like IBSc do not have.

IBSc researchers do not have access to a greenhouse to conduct experiments on genetically engineered plants. In fact, funds for the construction of a greenhouse have never been included in either the university or departmental budgets.

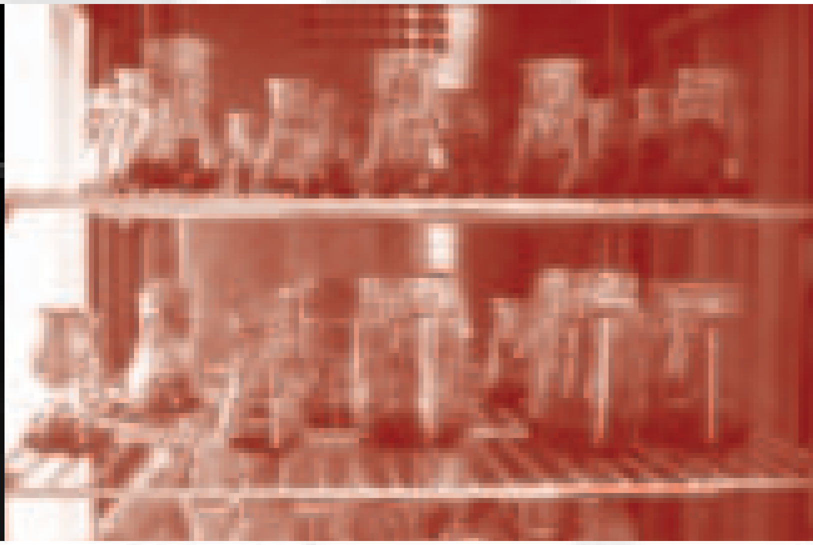
It is true that not every university in the developed world has a greenhouse. But those that don't usually have access to plant growth chambers equipped with computers that electronically regulate the conditions required for growth. In Bangladesh, yet again, money is the issue. Medium-sized growth chambers cost at least US$45,000, which places the chambers beyond the reach of IBSc.

During my visit, I gave two seminars. The first focused on my own research on plant genetic engineering and crop improvement at the University of Skövde. The second seminar highlighted possible opportunities for Bangladeshi students to pursue university degrees in biology in Sweden.

In addition to the seminars, I participated in several group meetings to discuss potential avenues of cooperation between the University of Skövde and Bangladeshi universities and research institutes, most notably the Bangladesh Agricultural University in Mymensingh, Dhaka University, Rajshahi University and the Bangladesh Agricultural Research Institute and the Bangladesh International Rice Research Institute, both in Gazipur.

One IBSc project of particular interest to me was exploring the genetic modification of a new variety of rice that was designed to prevent arsenic contamination. Such efforts, if successful, could boost both the health and prospects for food security in Bangladesh where millions of people depend on rice as a primary staple of their diet.

Arsenic contamination is mainly due to groundwater contamination, which is particularly prevalent in south-western Bangladesh. Tube-wells, which provide drinking water for millions of people in the region, pump groundwater up through the arsenic-laced bedrock of the Brahmaputra River, which once posed no public health threat but now does. Indeed the bedrock's contamination has been unwelcomed fallout of the Green Revolution and its reliance on large-scale irrigation. Drawing down the groundwater aquifer has increased arsenic concentrations, endangering the lives of those who depend on groundwater as the primary source of their drinking water. The World Health Organization (WHO), which estimates that 30 to 70 million have been adversely



affected, has described the tragic situation along the Brahmaputra River in Bangladesh as "the largest poisoning of a population in human history." To make matters worse, researchers now fear that high concentrations of arsenic in rice straw, eaten by both cattle and birds, may eventually increase arsenic exposure even more among Bangladeshis through plant-animal-human pathways.

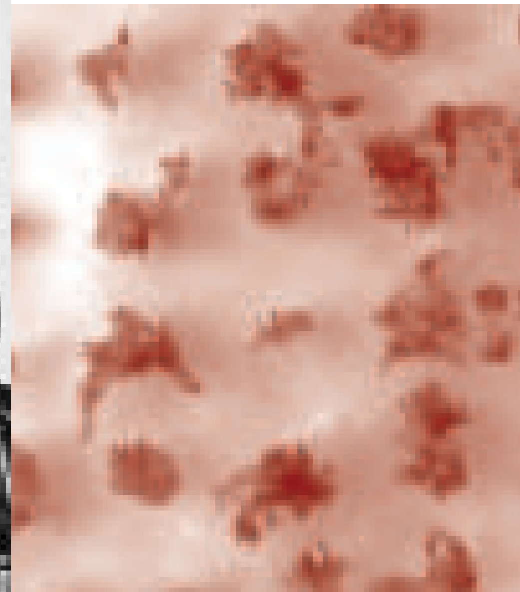
IBSc's arsenic project may not only help curb the health risks posed by arsenic contamination but also enhance the quality of the environment. Unfortunately, a chronic lack of funding for the purchase of laboratory equipment and consumables has put the project at risk. Shortfalls in funding could be overcome by grants from international organizations such as the World Health Organization (WHO), the UN Food and Agricultural Organization (FAO) and the United Nations Development Programme (UNDP). Collaboration with universities and research institutions both in Bangladesh and abroad could help attract and leverage outside funds.

Financial support, of course, is a critical issue. But so too is the need to nurture an atmosphere that will stimulate researchers to seek new knowledge and reach their full potential. An emphasis on excellence is the only way to guarantee that funding, once received, will be sustained.

I admire the IBSc's scientific and technical staff. Despite the chronic problems they encounter, they continue to conduct significant research. Bangladesh, like many other poor countries in the developing world, is rich in human resources. But for these researchers to reach their full potential, they need long-term and consistent help from international organizations.

The short-term Visiting Scientist Programme, sponsored by ICSU-TWAS-UNESCO-UNU/IAS, makes an invaluable contribution to the promotion of scientific collaboration between developed and developing countries. But it must be complimented by longer-term efforts that encourage scientists in developing countries to stay at home and not to use their contacts in the developed world to seek employment abroad.

One measure that the Visiting Scientist Programme may want to consider is a 'follow-up' programme that



would enable scientists from the host institution in the South to come to the visiting scientist's institution in his or her home country in the North for stays that could last two to three months.

Such programmes would help scientists in the developing world keep abreast of the latest advances in their fields while remaining attached to their home institutions. I believe that the University of Skövde would be eager to participate in such an initiative.

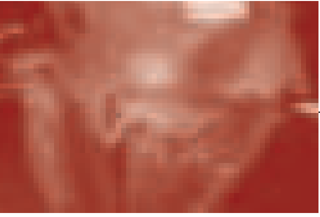
My visit to the IBSc was brief. But the memories I have of this experience will last a lifetime. Beyond my own personal rewards and satisfaction, the visit has led to the development of a joint research project on arsenic contamination of rice in Bangladesh that promises to keep our collaboration alive. Despite obstacles posed by distance, distractions (both personal- and work-related), and a bout of political unrest in Bangladesh in January 2007, scientists at IBSc and the University of Skövde are putting the finishing touches on a joint research proposal that will be submitted to the Swedish International Development Agency's Department for Research Cooperation (Sida/SAREC).

If successful, our collaborative investigations into arsenic contamination will be placed on a firmer foundation that should prove beneficial for both institutions. More importantly, it could spur progress in addressing one of Bangladesh's most critical environmental and public health problems. Meanwhile, as another positive outcome of my visit, six graduate students at IBSc have been admitted to the University of Skövde's international masters degree programme in biomedicine. The students will begin their studies this autumn.

WHO has described the situation as "the largest poisoning of a population in human history."

All in all, I would call my visit a very productive one that carries long-term implications for North-South collaboration in science. That's exactly what those who created the Visiting Scientist Programme had in mind when they launched this initiative in 2003. I am delighted to be playing a small part in turning their vision into a reality. ■

> ***Abdul Mandal***
School of Life Sciences
University of Skövde
Skövde, Sweden
email: abul.mandal@his.se



A FEVER PITCH

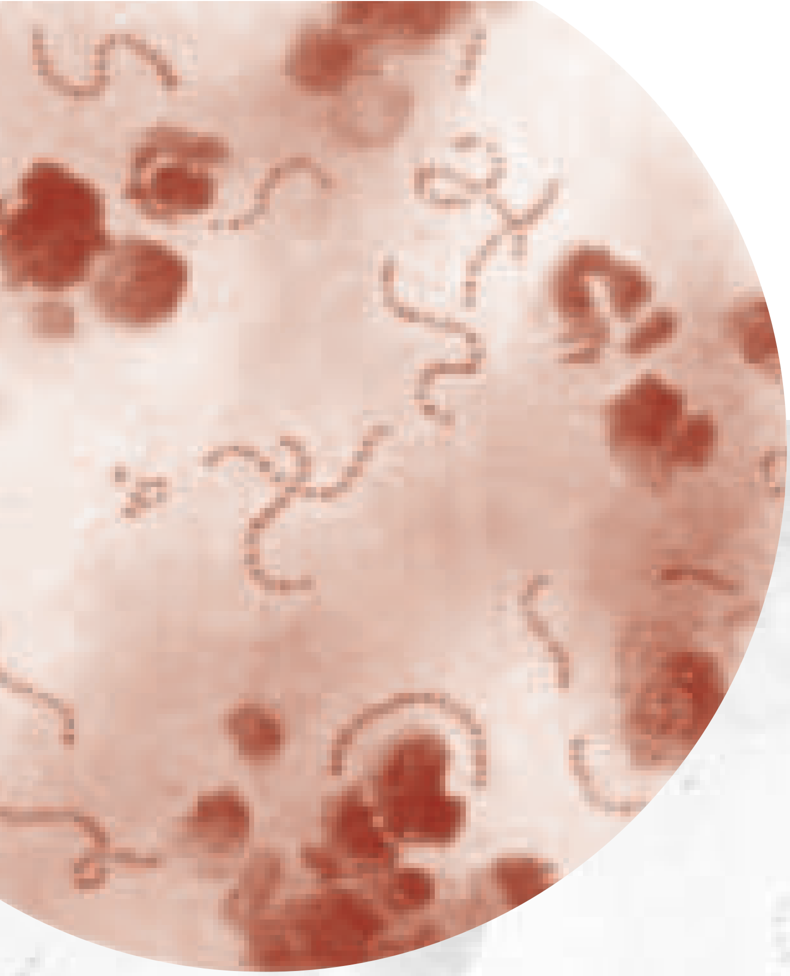
INCIDENTS OF RHEUMATIC FEVER AND HEART DISEASE DO NOT GENERATE AS MUCH PUBLIC CONCERN AS HIV/AIDS, MALARIA AND TUBERCULOSIS. BUT IT IS A DISEASE THAT AFFECTS MILLIONS OF PEOPLE, MOSTLY IN SUB-SAHARAN AFRICA. ANTHONY MBEW, PRESIDENT OF THE MEDICAL RESEARCH INSTITUTE IN SOUTH AFRICA AND CO-CHAIR OF THE INTERACADEMY MEDICAL PANEL (IAMP) EXPLAINS HOW AFRICA HAS BEGUN TO PURSUE PUBLIC HEALTH MEASURES TO COMBAT A DEBILITATING AND SOMETIMES DEADLY DISEASE THAT CAN BE PREVENTED THROUGH EFFECTIVE POLICIES AND WELL-KNOWN MEDICAL TREATMENTS.

When we think of infectious diseases that afflict the most vulnerable people in the world's poorest countries (and especially poor people living in sub-Saharan Africa), we often think of HIV/AIDS, malaria, and tuberculosis. But there are plenty of other infectious diseases that wreak havoc as well. These diseases may not be as devastating in terms of their absolute numbers of victims, but they nevertheless represent a severe, sometimes deadly, blow to those who suffer from them.

Rheumatic fever and heart disease, a systemic inflammatory ailment occurring largely in children and young adults, is an infectious disease that no longer captures global media attention. That's because the developed world largely conquered the disease in the mid 20th century. It was once common in the United States and Europe but it is no more.

Yet a lack of public awareness of the disease's impact does not minimize the danger that it poses. Medical researchers estimate that more than 15 million people worldwide are affected by the disease and that there are nearly half a million new cases each year.

More than 15 percent of these cases, some 2.5 million people, are comprised of children between the ages of 6 and 15 living in the developing world. Indeed rheumatic fever and heart disease are among the developing world's largest killers of children, and they count poor, malnourished, ill-cared-for children among their most



LOWERING TEMPERATURES

"Rheumatic fever and rheumatic heart disease are diseases of poverty. They are diseases of children. They are unrelated to lifestyle. They kill people in the prime of their lives and they are almost entirely preventable using demonstrated strategies that are cheap and cost effective."
IAMP background report, Reducing Rheumatic Fever and Rheumatic Heart Disease, June 2007.

likely victims. More than 350,000 lives are claimed each year and hundreds of thousands suffer from impaired health and disability.

The World Health Organization (WHO) estimates that the disease affects 1 to 2 percent of the school-age population in impoverished developing countries. Put another way, poor children in poor countries are 100 to 200 times more likely to suffer from the disease than children in developed countries. And it goes without saying that there's a big difference between a 1 percent rate of infection and a 0.01 percent rate of infection.

Rheumatic fever and heart disease are among the developing world's largest killers of children.

Symptoms of the disease include high fever, inflamed and arthritic joints, long-lasting rashes and such neurological dysfunctions as uncontrolled facial twitching. This is bad enough, seriously undermining the quality of life of those who suffer from the disease. But repeated bouts with rheumatic fever, which is largely due to an inability to obtain adequate medical treatment for strep throat (*streptococcal pharyngitis*), often leads to rheumatic heart disease. That, in turn, can cause permanent, sometimes fatal, damage to the heart muscle and valves.

An estimated 60 percent of all open-heart surgeries in the tropical regions of Africa are performed on heart valves that have been damaged by rheumatic heart disease. Although startling, the percentage is actually misleading when seeking to understand the overall impact of the disease. That's because a vast majority of patients with rheumatic heart disease in Africa are too poor to undergo surgery, which can cost up to US$5,000 to perform. Once rheumatic fever has progressed to rheumatic heart disease, surgery is the only option. Without it, you eventually die.

What makes the disease particularly tragic is the fact that it is entirely preventable. Even if the first or second incidence of rheumatic fever cannot be stopped, once early episodes are diagnosed additional bouts of fever can be prevented through a series of penicillin injections.

The average monthly cost of treating rheumatic fever with penicillin is US$2 – a paltry sum that can generate a large return in public health.

Yet 50 percent of the people in sub-Saharan Africa live on less than US$1 a day. It should come as no surprise, then, to learn that victims often go untreated and that repeated episodes of rheumatic fever eventually lead to rheumatic heart disease.

Penicillin, which was discovered in 1928, may be considered one of the world's first miracle drugs. But the ability to successfully treat a disease like rheumatic fever usually depends on social, not clinical, factors. For example, rising family incomes carry with it the ability to pay for doctors and drugs. At the same time, as nations become wealthier, they improve their public health care systems, which make it more likely that the disease will be treated at an early stage.

In many sub-Saharan countries, half the population or more is under 20 years of age. Poverty and poor health systems conspire with the region's youthful demographics to make rheumatic fever and heart disease a serious public health issue.

In 2006, the Pan African Society of Cardiology (PASCAR), a group of African health experts who have joined together in an effort to eradicate rheumatic fever and heart disease within our lifetime, launched a programme designed to address the clinical and public health issues associated with the ailment. The programme has sought to raise awareness about both the disease and the treatment options available to the public and healthcare workers; it has emphasised the need for enhancing the quality of information available to citizens through increased research and reporting; and it has urged reforms in public policies to spur improvements in health care facilities at the regional and national level. In short, the programme has called for a series of measures designed to more effectively prevent and treat the disease.

The ability to treat a disease like rheumatic fever usually depends on social, not clinical, factors.

Proponents estimate that full implementation of the programme could slash the incidence of rheumatic heart disease in Africa by 80 percent – from 300,000 to 600,000 new cases annually. In addition, it could help decrease the number of maternal deaths by curbing the added risks posed to pregnant women affected by the inflamed heart muscles that the disease often causes. It could also help reduce the incidence of stroke among young people who are currently at risk due to damaged heart valves.

With funding from the World Heart Federation, PASCAR held its first All Africa Workshop on Rheumatic Fever and Rheumatic Heart Disease in Drakensberg, South Africa, in October 2005, which was attended by more than 40 medical practitioners. This event was followed in 2006 with the launch of two pilot projects in Cape Town.

Drawing on the knowledge and know-how of doctors, nurses, medical researchers and social workers, the project has sought to raise public awareness of the disease through a nationwide public information campaign led by South Africa's Department of Health. The campaign culminated in the organization of a 'nationwide rheumatic fever awareness' week, held from 7-13 August 2006. The success of PASCAR's public information campaign has laid the groundwork for expanded media activities in 2007. Indeed it is likely that rheumatic fever awareness week will become an annual event.

Over the long haul, PASCAR hopes that it will be able to live up to its name by expanding its efforts beyond the borders of South Africa to the entire continent. The organization welcomes the assistance that has been provided by the Trieste-based InterAcademy Medical Panel (IAMP) and, more specifically, the panel's decision to join the World Heart Federation in making the 'control of rheumatic fever and rheumatic heart disease in devel-

IAMP PLANS

The Trieste-based InterAcademy Medical Panel (IAMP), headquartered in Trieste, Italy and operating under the administrative framework of TWAS, is a global network of 64 medical academies and medical divisions within science and engineering academies dedicated to improving global public health. In addition to focusing on efforts to mitigate the incidence of rheumatic fever and heart disease, the IAMP programmatic agenda for 2007-2010 includes new programmes designed to study and propose strategies for reducing maternal and perinatal mortality in low-income countries, to improve scientific writing for young scientists and clinicians, to combat emerging infectious disease and compare health care quality from a global perspective. It also includes continued support for the internet-based mother-child health international network. For additional information about IAMP, see www.iamp-online.org.

oping countries' one of its major initiatives for 2007-2010. IAMP's recognition of this health problem will certainly help bring recognition to our efforts.

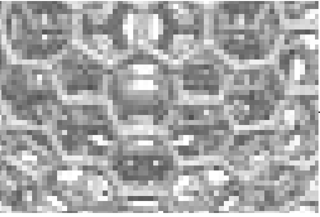
The world, particularly the developing world, face many critical public health problems. Rheumatic fever and heart disease may not be high on the list of concerns. Nevertheless they are diseases that affect millions of people, particularly poor, young people in developing countries. With the development of comprehensive strategies to improve public awareness and with efforts to adopt and expand long-proven measures for effective clinical treatment, it is well within our reach to dramatically curb the incidence of this disease. The fact that the disease was largely conquered in Europe and the United States 50 years ago tells us so.

Rheumatic fever and heart disease are public health challenges that do not depend on revolutionary breakthroughs in medical research or practices to be overcome. Success, instead, will be determined by sustained political will, adequate training of health care providers and increased awareness among parents, children and teachers. Plans for routine screening, adequate supplies of penicillin and the creation of disease registries to identify and manage known cases will go a long way to keeping the disease in check.

All of this can be implemented relatively inexpensively within existing health care systems. The issue, then, is not whether it can be done, but whether it will be.

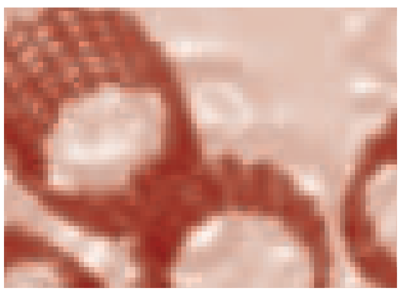
> ***Anthony Mbewu***

President, Medical Research Council in South Africa
Cape Town, South Africa
Co-Chair, InterAcademy Medical Panel
Trieste, Italy



NANO RISING IN THE SOUTH

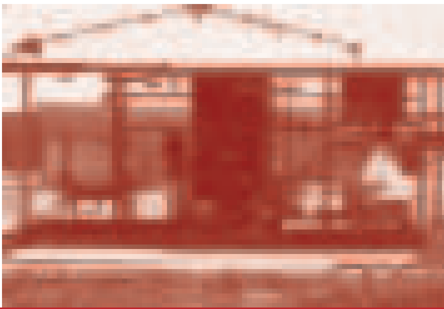
NANOSCIENCE AND NANOTECHNOLOGY, THE STUDY AND ENGINEERING OF MATTER AT THE ATOMIC AND MOLECULAR SCALE, COULD BE THE NEXT BEST THING IN SCIENCE AND TECHNOLOGY. MANY COUNTRIES, INCLUDING DEVELOPING COUNTRIES, ARE BETTING THIS IS JUST THE BEGINNING OF MUCH BIGGER THINGS TO COME, AND THAT NANOSCIENCE AND NANOTECHNOLOGY COULD HAVE AN EVEN GREATER IMPACT ON SCIENCE AND SOCIETY THAN THE RECENT REVOLUTIONS IN INFORMATION AND COMMUNICATION TECHNOLOGIES OR BIOTECHNOLOGY.

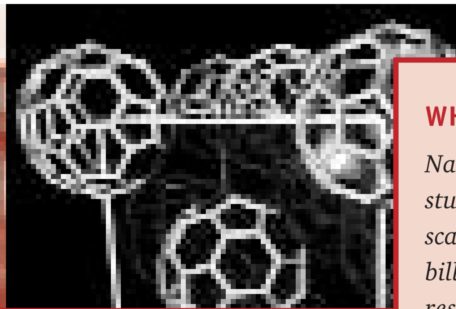


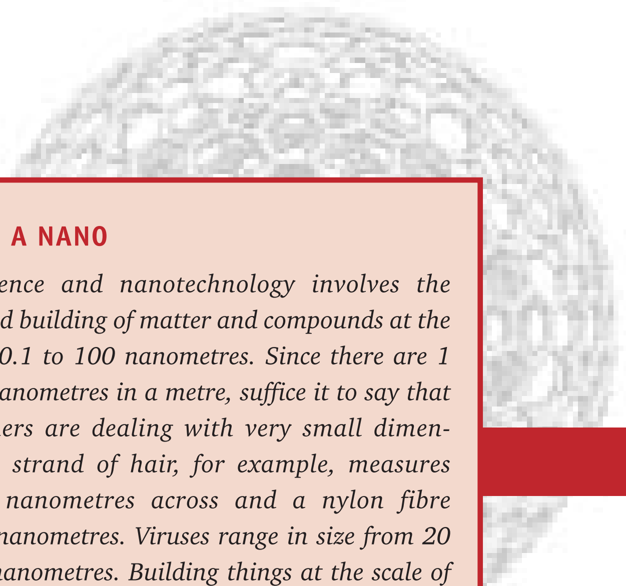
In February 2007, TWAS organized a 90-minute session at the American Association for the Advancement of Sciences (AAAS) annual meeting in San Francisco, California, on "these tiniest of things that could have the biggest of impacts". Titled the "Big and Small of It: Nanotechnology in the Developing World," the conference session explored the state of nanoscience and nanotechnology research and development from the perspective of three developing countries: India, Mexico and South Africa. The AAAS International Office in Washington, DC, and the United Nations University Institute for Advanced Study (UNU/IAS) in Tokyo, generously provided funding for the event. The following is based on the presentation of J.J. Molapisi, manager of Emerging Research Areas in South Africa's Department of Science and Technology, given in San Francisco.

Although individual scientists in South Africa have been investigating nanoscience and nanotechnology since the field's initial days of discovery in the early 1970s, it was not until 2006 that the government of South Africa announced a comprehensive strategy for advancing nanoscience and nanotechnology. Drafted by the Department of Science and Technology (DST) following 12 months of consultation and study, South Africa's parliament officially launched the strategy in April of last year.

The national strategy for advancing nanoscience and nanotechnology carefully builds on the foundation established by South Africa's overall system of innovation, which has sought to improve research facilities and to create a workforce well versed in advanced technologies. The ultimate goal of the nation's blueprint for







innovation is not just to expand the borders of scientific inquiry but also to improve the quality of life for all citizens. At the same time, it hopes to strengthen South Africa's global economic competitiveness.

As with other sectors of the innovation policy, success in nanoscience and nanotechnology will largely be defined by the ability to develop and commercialize new products and services. Therefore a primary goal of the strategy is to bolster collaboration among universities, research institutes and the private sector for the purposes of growing the national economy.

Two clusters – social and industrial – will serve as the basis of South Africa's research and development efforts in nanoscience and nanotechnology. The goal of the social cluster is to improve the delivery of such basic needs as water, energy and health.

South Africa is the richest and most scientifically advanced nation in sub-Saharan Africa. Indeed with a gross domestic product of US$200 billion, South Africa ranks 27th among nations in terms of wealth. Nevertheless, an estimated 12 percent of the population (some 5 million people) still does not have access to safe drinking water and 30 percent does not have electricity. Life expectancy in South Africa has fallen to 43 years for males and 42 for females, a disturbing indicator of the devastating impact of HIV/AIDS.

Success will largely be defined by the ability to develop and commercialize new products and services.

The government is making a determined effort to improve health and living conditions across the nation, especially for its most impoverished and marginalized citizens. It is pursuing these goals on several fronts and hopes that investments in nanoscience and nanotechnology can contribute to this overall effort.

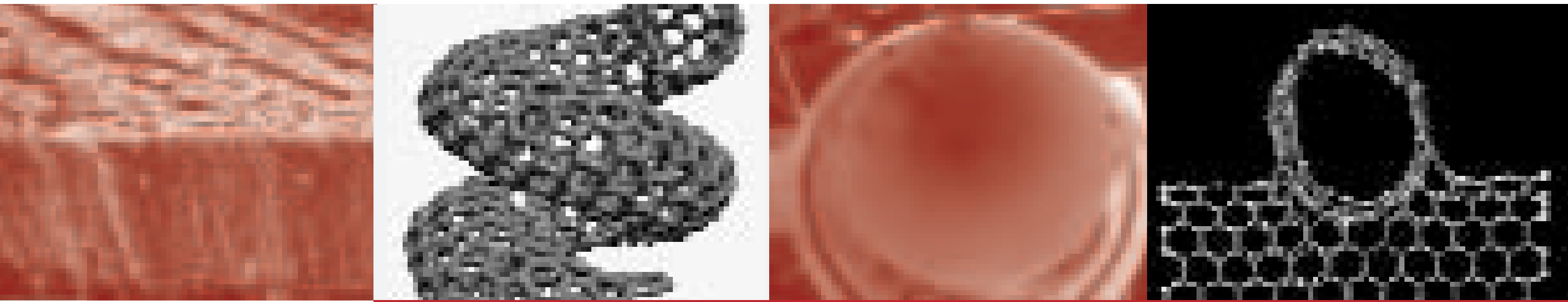
WHAT'S A NANO

Nanoscience and nanotechnology involves the study and building of matter and compounds at the scale of 0.1 to 100 nanometres. Since there are 1 billion nanometres in a metre, suffice it to say that researchers are dealing with very small dimensions. A strand of hair, for example, measures 50,000 nanometres across and a nylon fibre 30,000 nanometres. Viruses range in size from 20 to 300 nanometres. Building things at the scale of nature's own building blocks – that is, one atom and one molecule at a time – provides an opportunity to fabricate materials and devices with great precision and purpose. As the Nobel Laureate Richard Smalley (Chemistry 1996) noted: "The impact of nanotechnology on health, wealth and the standard of living for people will be at least equivalent of the combined influences of microelectronics, medical imaging, computer-aided engineering and man-made polymers in this century." It's estimated that some 40 countries are currently investing in nanoscience and nanotechnology.

Nanotechnology, for example, could spur the production of cheaper, more effective water filtration systems that would increase access to safe drinking water, and the development of more targeted, slow-release nano-encapsulated pills that could prove beneficial in the treatment of HIV/AIDS, tuberculosis and other infectious diseases.

The goal of the industrial cluster, in contrast, is to explore how nanoscience and nanotechnology can enhance the global competitiveness of South Africa.

The chemical industry, mining and the manufacture of advanced materials have been identified as sectors likely to reap the most benefits from national investments in nanoscience and nanotechnology. These benefits include, for example, more cost-effective mining techniques and more efficient procedures for the processing of minerals and ores.



By pursuing this strategy, the government hopes to build on the nation's industrial strengths and fully integrate its nanoscience and nanotechnology policy into its overall efforts for sustained economic growth.

CAPACITY

To implement the strategy, South Africa's Department of Science and Technology has developed a 10-year plan for capacity building designed to vastly upgrade both the facilities and expertise for nanoscience and nanotechnology research and development. The parliament has allocated US$26 million to implement the plan over the next three years. Specific programmes include:

- *Acquiring equipment.* The strategy calls for the purchase of advanced instruments aimed at creating a physical infrastructure capable of supporting first-class basic research and the development of new nano-products and -services.

- *Building human capital.* The strategy recognizes that advances in nanoscience and nanotechnology require the development of a highly trained workforce capable of pursuing excellent research, developing internationally competitive products and implementing effective marketing programmes. The centrepiece of this provision is the creation of endowed chairs at universities and research institutes. Those who receive these appointments will be expected not only to conduct their own research but also to supervise students. The strategy also calls for the funding of university-based postgraduate programmes designed to support students seeking advanced training. The government anticipates that this will help create a critical mass of expertise in a broad range of nano-related fields that can be sustained for decades to come.

- *Creating national centres for nanotechnology and a national centre for innovation in nanotechnology.* One of the centrepieces of South Africa's nanoscience and nanotechnology strategy is the creation of national nanotechnology centres – facilities designed to provide researchers with advanced instrumentation for the design, synthesis, modelling and fabrication of nanotechnology products. The centres are intended to be multi-disciplinary in nature and solution-driven in purpose. Not only will they have ample resources to hire their own research and support staff, but they will also be open to scientists and technologists in universities and research institutes in South Africa and elsewhere. The first two centres, which will be located at Mintek, South Africa's leading mineral and metallurgical research and engineering institute in Randburg, and at the Council for Scientific and Industrial Research (CSIR), one of the nation's principal multi-disciplinary scientific and technology research and development centres in Pretoria, are scheduled to open this year. In addition to these centres, the government hopes to create a world-class institute for nanotechnology innovation focusing on the commercialization of nano-based products. This institute will also be open to scientists from around the world.

- *Supporting flagship projects.* While the strategy will focus on strengthening South Africa's overall capacity in nanoscience and nanotechnololgy, it will also provide fund-

J.J. Molapisi

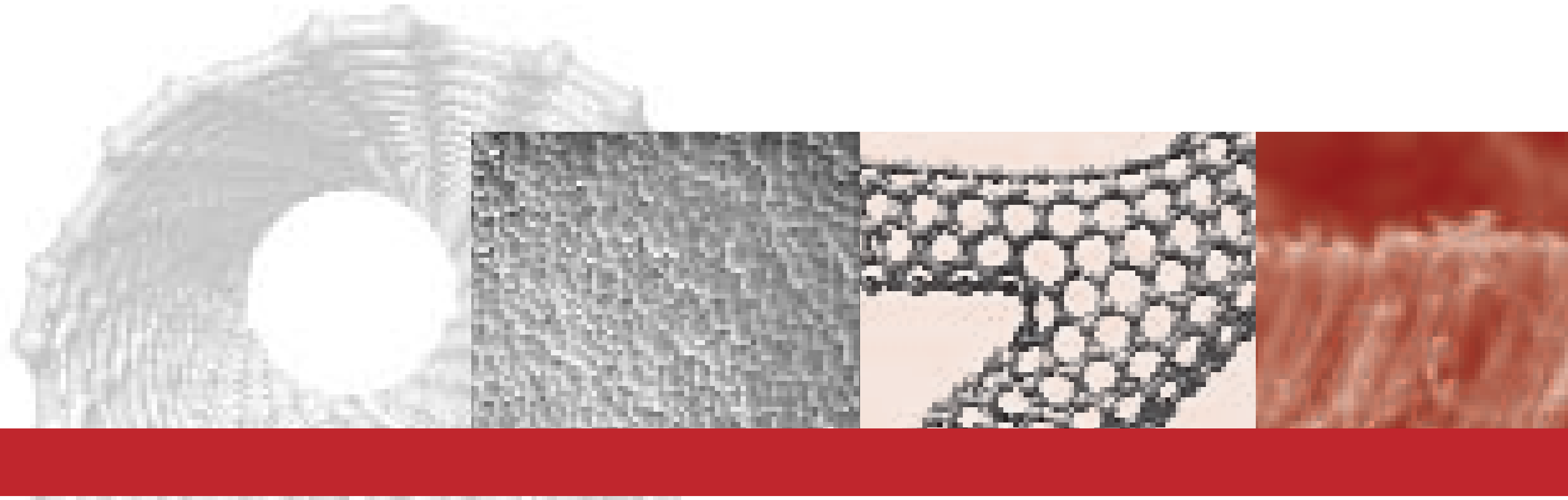
ing for 'flagship' projects intended to showcase the ways in which nanoscience and nanotechnology can enhance the quality of life for all citizens in such areas as water, energy and health. These projects include, for example, the development of nano-drug delivery systems designed to combat tuberculosis.

- *Promoting citizen involvement.* The strategy states that the public should be directly involved in the development and implementation of the nation's nanoscience and nanotechnology policies and programmes. This is not only the right thing to do in a democracy; it is the smart thing to do. Public suspicion and fear of a new technology often impedes its development. The wariness and, at times, disdain that large segments of the public have displayed for biotechnology and genetic engineering in Europe and Africa offers a cautionary tale for proponents of nanoscience and nanotechnology. It suggests that communication with the public offers the best way forward, especially during the early stages of research and development. That's why one of the key elements in South Africa's nanoscience and nanotechnology strategy calls for broad public access to information and unfettered debate on the nation's nano-policies and programmes. South Africa's DST, together with other stakeholders (universities, research institutes and private firms), is developing a comprehensive suite of public awareness programmes aimed at fostering public discourse. The programme is scheduled to begin this year and to be in full swing by 2009.

- *Protecting health and safety.* Nanoscience and nanotechnology hold great promise for improving the lives of all South Africans. Nevertheless, like any new field of research (and especially one with the potential for so many real-world applications), nanoscience and nanotechnology pose potential risks that have yet to be sufficiently scrutinized. Some critics, for example, contend that nano-particles could adversely affect the linings of lungs much like asbestos fibres do, leading to potential health dangers. Other critics suggest that nano-particles are likely to be long-lived in

NANO ELSEWHERE

In addition to J.J. Molapisi, two other experts spoke at the AAAS session. José L. Morán López (TWAS Fellow 1991), founding director of the Institute for Scientific and Technological Research at San Luis Potosi, Mexico, stated that scientists and small scientific groups in Mexico are conducting excellent research on nanoscience and nanotechnology largely in university departments and institutes dedicated to basic fields of study in chemistry and physics. Moran-Lopez observed, however, that Mexico does not have a broad-based national policy or funding strategy, which limits the scope of research as well as the ability of scientists to tie their efforts to the nation's economic development efforts. D.D. Sarma (TWAS Prize Winner in physics in 2006), professor of physics and chair of the Centre for Advanced Materials at the Indian Association for the Advancement of Science in Kolkata, stated that the Department of Science and Technology, in India's Ministry of Science and Technology, launched a nationwide nanoscience and nanotechnology initiative in 2001 and that India currently spends about US$40 million a year on nano-research and nano-development. Sarma observed that while the major research facilities are located in Bangalore, Chennai, Delhi, Kolkata and Puna, individual projects stretch from Chandigarh in the north to Thiruvanantapuram in the south. In addition, there is growing emphasis on linking research to development in fields ranging from the next generation of transistors to more efficient water filtration systems. Copies of each of the AAAS presentations are available from the TWAS secretariat at info@twas.org.



the environment and we currently do not have enough information to know what impact these particles could have on our ecosystems. Advocates of nanoscience and nanotechnology cannot ignore such public concerns for both moral and practical reasons. In fact, advocates and scientists alike must proceed cautiously both to gain public trust and to ensure that no harm is done to either public health or the environment. It is therefore necessary to institute policies that support comprehensive research in a broad range of fields both in the natural and social sciences, including nano-safety, -reliability and -risk management. South Africa's national strategy sets aside 5 percent of its overall funds for such purposes.

> ***South Africa's nanoscience and nanotechnology strategy calls for broad public access to information.***

RESEARCH

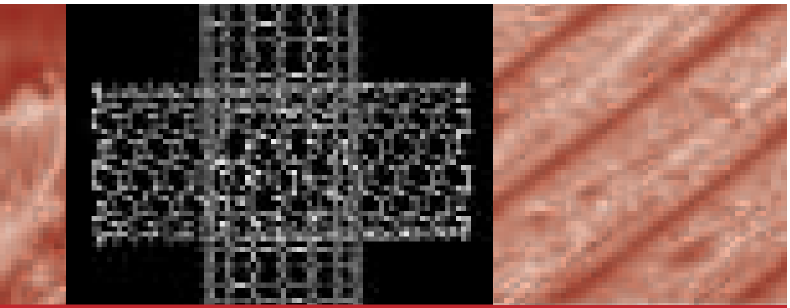
South Africa's overall national innovation programme not only seeks to build infrastructure and nurture an expert labour force, but also to support specific projects designed to create products and services that have a direct impact on the economy and society.

That is also the case for the nation's nanoscience and nanotechnology strategy. Indeed successful efforts to build institutional and individual capacity in science and technology since the collapse of apartheid in the early 1990s have now made it possible to jump-start projects in nanoscience and nanotechnology that have direct applications to social well-being and financial prosperity. Existing scientific and technological capacity, in effect, has enabled the strategy for advancing nanoscience and nanotechnology to get off the mark quickly. Examples of such projects include:

- *Expanding access to safe drinking water.* Projects include the development of nanostructure electrocatalytic membranes and zeolite adsorbents for water purification; magnetic nano-particles and nano-fibre devices for the removal of toxic elements and organic pollutants; and nano-membranes to boost the efficiency of water filtration systems. The University of Western Cape Town, the University of Stellenbosch and North-West University have engaged in such research, as has South Africa's Water Research Commission.

- *Improving public health.* Projects include development of platinum and gold-based nano-complexes as possible anti-HIV agents; nano-organo-metallic compounds as potential treatments for chloroquine-resistant strains of malaria; and development of nano-tubes, nano-fibres and encapsulated nano-particles as potential delivery systems for insulin and anti-malarial and anti-retroviral drugs. Both Mintek and the CSIR, South Africa's designated national nanotechnology centres, have made significant strides in developing slow-release nano-encapsulated drugs for combatting infectious diseases. The University of Witwaterrand and the University of Limpopo, among others, are also working in this field.

- *Enhancing the delivery of renewable energy:* Broad-based investigations are taking place for the development of inorganic-based nano-membranes to lower the cost and improve the efficiency of hydrogen fuel cells and photovoltaic solar cells and panels. Mintek, CSIR, the University of Johannesburg, the University



of Western Cape and the University of Zululand, among others, are involved in these initiatives.

- *Expanding the use of advanced materials and improving the extraction and processing of minerals and metals:* Projects include research and development of nanoparticle alloys with ultra-hard characteristics capable of withstanding extremely high temperature and pressure for use in drill bits for mining and the study of nano-polymers for the manufacture of ultra-hard coatings for use in adhesives and paints. Efforts will also be made to advance 'nano-beneficiation' (the process by which minerals and metals are separated from waste) of gold and platinum. South Africa is the world's largest producer of both gold and platinum. As a result, improved extraction and processing methods could have an enormous impact on the economy. CSIR, Mintek, the University of Stellenbosh, and iTemba Labs, among others, are engaged in this research.

VISION

Nanoscience and nanotechnology are among the hottest, if not the hottest, scientific fields in the developed world. By some estimates, the European Union, Japan and the United States are each spending more than US$1 billion a year on nano-research and nano-development.

But what is also true, yet less well known, especially outside the global scientific community, is that a number of developing countries are also investing in the field in the hopes that they will be able to compete in this new but rapidly developing area of science and technology which holds great promise for spurring social improvement and sustained economic growth.

Peter Singer, Sun Life Chair in Bioethics and Director of the Joint Centre for Bioethics at the University of Toronto, and his team of researchers who have done extensive studies on nanoscience and nanotechnology in the developing world, have divided developing countries into three broad categories to better understand the state of nano-affairs in the South. The UN Task Force on Science, Technology and Innovation for the Millennium Development Project, in its 2005 report *Innovation: Applying Knowledge to Development*, subsequently adopted the same framework.

According to Singer's paradigm, there are 'front-running' developing countries – most notably, China and India – where you will find relatively large government projects, a growing number of patents and the marketing of products.

There are 'middle-ground' developing countries – Brazil, Chile, the Philippines and Thailand – where you also find government projects and a substantial number of research groups but limited industry involvement and commercialization.

And there are so-called 'up-and-coming' developing countries – for example, Argentina and Mexico – where you will not find much in the way of government-organized funding strategies, but where you do have strong and growing research groups dedicated to nanoscience and nanotechnology.

South Africa is listed among the middle-ground countries. It's not a bad place to be but, as the nation's comprehensive strategy for advancing nanoscience and nanotechnology, illustrates, it's not a place where South Africa wants to be for long.

Rapid implementation of the strategy's most significant provisions suggests that South Africa could soon join advanced developing countries like China and India. That, at least, is the hope of the South African government. Nanoscience and nanotechnology, the government has concluded, simply carry too much potential for improving social and economic well-being for the nation to be left behind. We firmly believe that we are off to a good start in a race where only those who fail to participate are destined to lose. ■

> ***J.J. Molapisi***
Manager
Emerging Research Areas
Department of Science and Technology
Pretoria, South Africa

PEOPLE, PLACES, EVENTS

NEW HEALTH MINISTER

• **Chen Zhu** (TWAS Fellow 1999) has been appointed China's Minister of Health. He is the second non-Communist Party member to assume a post in a state ministry or department. The first was Wan Gang, Minister of Science and Technology, who took office in April. Chen has also been elected foreign associate of the


Chen Zhu

Institute of Medicine, US National Academies for the major contributions that he has made to the advancement of the medical sciences, health care and public health. Chen serves as co-chair of the InterAcademy Panel on International Issues (IAP), vice president of the Chinese Academy of Sciences (CAS) and director of the Shanghai Institute of Hematology at Rui Jin Hospital and Shanghai Centre for Systems Biomedicine. He is a foreign associate of the French Academy of Sciences and foreign member of the Max-Planck Society, Germany.

CONGRESSIONAL MEDALLIST

• **Norman Borlaug** (TWAS Associate Fellow 1985) has received the US Congressional Gold Medal, the nation's highest civilian honour. Widely regarded as the "Father of the Green Revolution", US president George W. Bush spoke of Borlaug's career as a living testament to how


Norman Borlaug

"one human being can change the world". M.S. Swaminathan (TWAS Founding Fellow), Borlaug's longtime colleague and friend and the first recipient of the World Food Prize in 1987, gave the keynote address at the award's ceremony in which he described Borlaug as "one of the greatest Americans and humanists of all times". Borlaug is one of only five people to have received the Nobel Peace Prize, the US Medal of Freedom and Congressional Gold Medal. The other four are Nelson Mandela, Elie Wiesel, Mother Teresa and Martin Luther King, Jr.

FUZZY STATISTICIAN

• **Sankar K. Pal** (TWAS Fellow 1998) has been elected a fellow of the International Fuzzy Systems Association (IFSA). Pal is director and distinguished scientist of the Indian Statistical Institute. He


Sankar K. Pal

founded the Institute's Machine Intelligence Unit and the National Centre for Soft Computing Research in Calcutta. He is a fellow of all four Indian science and engineering academies, the Institute of Electrical and Electronics Engineers and the International Association of Pattern Recognition. He has received a number of other honours, including the G.D. Birla, O.P. Bhasin and S.S. Bhatnagar awards.

ROYAL FELLOW

• **Calestous Juma** (TWAS Fellow 2005) has been elected an honorary fellow of the Royal Society of Engineering in London, UK, for his work on the role that engineering has played in development. Juma is professor of international development


Calestous Juma

and director of the Science, Technology and Globalisation Project at the Kennedy School of Government, Harvard University, USA. He is also a member of the US National Academy of Sciences, the Kenya National Academy of Science, the New York Academy of Sciences and the World Academy of Art and Science. Juma is a recipient of the Pew Scholars Award, the UN Global 500 Roll of Honour and the Henry Shaw Medal.

PEOPLE, PLACES, EVENTS

SECRETARY GENERAL

• **Jean Claude Autrey** (TWAS Fellow 2004) has been appointed secretary general of the International Society of Sugar Cane Technologists. This follows his retirement as director of the Mauritius Sugar Industry Research Institute in Reduit, Mauritius. In his new capacity, Autrey will advise institutions in Mauritius and Africa on a variety of sugar-related topics, especially the use of sugar cane in the production of bioenergy. As a world authority on sugar cane research, he has served on and chaired various national and international bodies and has carried out consultancies in more than 20 countries. For his work, he has been named Commander of the Order of the Star and Key of the Indian Ocean.

Jean Claude Autrey

BOOK AWARD

• *Dry: Life Without Water* (Harvard University Press, 2006), edited by Ehsan Masood, a freelance science writer and director of The Gateway Trust in London, and Daniel Schaffer, public information officer of TWAS, was named a finalist in the 2007 Independent Publisher Book Awards competition. More than 2,500 books were part of the competition. *Dry* features stories illustrating the diverse lifestyles that people currently lead in the dry regions of the world and the strategies that they have developed to cope under conditions of water scarcity.

OBITUARIES

• **Godwin Patrick Olu Obasi** (TWAS Fellow 1996) passed away on 3 March 2007 in Abuja, Nigeria. As Secretary-General of the World Meteorological Organization (WMO) from 1984 to 2003, he was at the forefront in drawing world attention to the issue of climate change, notably in convening the Second World Climate Conference, held in Geneva, Switzerland, in 1990. He played an important role in the negotiations leading to the establishment of the United Nations Framework Convention on Climate Change, the United Nations Convention to Combat Desertification, the Intergovernmental Panel on Climate Change, the World Climate Research Programme, the Global Climate Observing System and the Vienna Convention on the Protection of the Ozone Layer and its Montreal Protocol. Obasi's name is closely associated with scientific breakthroughs in his field of specialization, atmospheric dynamics, including experiments related to the West African monsoon and global atmospheric research. He was honoured by many professional meteorological and hydrological societies, academies of sciences and universities throughout the world.

Godwin Patrick Olu Obasi

• **Gallieno Denardo** (TWAS Associate Fellow 2000) died on 23 July 2007 at age 72. Denardo was an esteemed physicist who served as professor of relativity at the University of Trieste and a long-time consultant at the Abdus Salam International Centre for Theoretical Physics

Gallieno Denardo

(ICTP), where he was instrumental in founding and then leading both the Office of External Affairs (OEA) and broad-ranging research and training activities on lasers and optics. Denardo also served as secretary of the Committee of Physics for Development for the International Union for Pure and Applied Physics (IUPAP) and as a member of the board of directors of the Trieste International Foundation for Scientific Progress and Freedom. He collaborated on several TWAS activities, often serving on review committees for the Academy's research grants programmes. In recognition of his accomplishments, he received honorary degrees in physics from the University of Pécs in Hungary and the University of Cape Coast in Ghana.