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Sharing Matters

MAKE IT FREE TO MAKE IT PAY. THAT CONTRADICTORY NOTION SEEMED TO BE THE OVERARCHING THEME AT THE US NATIONAL ACADEMY OF SCIENCES' (NAS) MEETING, 'THE CASE FOR INTERNATIONAL SHARING OF DATA: A FOCUS ON DEVELOPING COUNTRIES', HELD AT NAS'S HEADQUARTERS IN WASHINGTON, DC, ON 18-19 APRIL.

The meeting was organized in collaboration with the US Committee on Data for Science and Technology, which is part of the NAS Board on Research Data and Information, and the International Council for Science (ICSU) Committee on Freedom and Responsibility in the Conduct of Science (CFRS).

Farouk El-Baz (TWAS Fellow 1985), research professor and director of the Center for Remote Sensing at Boston University, USA, and adjunct professor at Ain Shams University in Cairo, Egypt, explained in the symposium's opening session that for years the Landsat programme, launched in 1972 and jointly managed by the US National Aeronautical and Space Administration (NASA) and the US Geological Survey (USGS), charged fees for access to its data.

As El-Baz also noted, it's not as if the data remained filed away in largely unused archives. Each year, a broad range of users, both in the United States and across the globe, agreed to pay the required fees to gain access to Landsat's database, which consists largely of images of Earth from space that offer a unique portrait of global changes in agriculture, forestry, urban development, wetlands, and soil and water resources.

But the fees generated just USD5 to USD10 million a year in revenues, while the project itself has cost some USD5 to USD10 billion to build and maintain over the past 40 years. "There was no chance that the Landsat programme would ever generate sufficient revenues to pay for itself," noted Curtis E. Woodcock, professor of geography and environment at Boston University, USA.

Then, in 2008, NASA and USGS agreed to provide free and open access to Landsat's database. Usage increased 100-fold the following year. "For the first time," Woodcock observed, "we are finally getting our money's worth." The investment, in short, was paying off in much higher levels of use.

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Open access to data, like that provided by the Landsat programme, has obvious benefits for scientists in the developing world. "It levels the playing field for researchers regardless of the country in which they live. And it contributes to economic development as well," noted Roberta Balstad, co-chair of the US National Research Council Board on Research Data and Information. Yet, as Michael Kahn, research fellow at the National Research Foundation (NRF) in South Africa, observed: in too many instances, large gaps have separated "academic hunters" in developed countries from "data gatherers" in developing countries.

To create a more level playing field and narrow the research divide between 'hunters' and 'gatherers', a growing number of national and international organizations, including the World Meteorological Organization (WMO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the European Union (EU), the US National Science Foundation (NSF) and the Organization for Economic Cooperation and Development (OECD), to name just a few, have voiced strong support for open access. The goal is to make the enormous volume of data, now totalling some 1,250 billion Gigabytes and increasing at a pace of more than 50% a year, readily available to all researchers.

Over the past several years, the roster of open access participants has expanded in both the public and private sectors, ranging from the Massachusetts Institute of Technology's (MIT) Open Source Initiative, to India's Open Source Drug Discovery (OSSD) programme, to the Beijing Genome Institute (BGI).

But, as participants at the symposium asserted, open access to data is by no means free, and there are significant barriers that continue to stand in the way of progress, especially for developing countries.

For example, there are issues related to finances and training. Satellites and broad bandwidth cables used to gather and transmit the data are expensive to build and maintain. In addition, data analysis and interpretation is a labour-intensive exercise that calls for highly educated and skilled researchers, statisticians and computer scientists.

Recent developments, including the installation of three submarine cables along the coast of Africa in just the past year, have boosted data speeds fourfold and reduced prices by 90%. This suggests that the 'hardware' challenge is increasingly being met and will likely be overcome in the years ahead.

Yet, as Atta-ur-Rahman (TWAS Fellow 1985 and Vice President for Central and South Asia), who is a former minister of science and technology and federal commissioner of higher education


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in Pakistan, noted: "Many developing countries continue to lack a critical mass of researchers to utilize the growing volume of data and information that is now available."

There are also regulatory and policy issues related to intellectual property rights and privacy, especially for data collected by private-sector firms used to acquire international patents.

In addition, there are issues related to security. Advocates of open access, noted Balstad, are not proposing that institutions allow unfettered access to sensitive data that could place a nation's or global security at risk.


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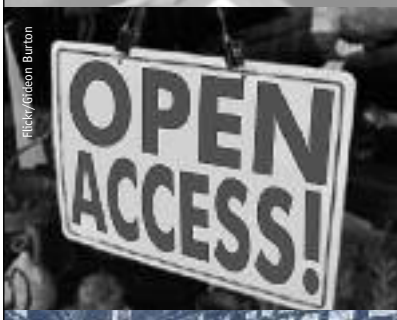
And there are issues related to culture – both within societies and professions. Some countries and professions, noted Elaine Collier, assistant director for clinical research at the US National Institutes of Health's (NIH) National Center for Research Resources, are more open than others and all governments – not to mention private firms – hesitate to give free access to data and information that cost hundreds of millions, if not billions, of dollars to acquire and manage. Meanwhile, the intensely competitive world in which scientists work sometimes make researchers reluctant to share data for fear of not receiving their due for their accomplishments.

Despite these obstacles, participants at the symposium saw reason for optimism. For example, Yang Huanming, co-founder and president of the Beijing Genomics Institute (BGI), outlined the contributions that his institution has made to the sequencing of the genomes of rice, chickens, silkworms, pandas, cucumbers, maize, soybeans and an expanding list of micro-organisms.

Such success stories bode well for the future, suggesting that not only the volume and range of data, but also the number of scientists in developing countries utilizing this data, will continue to increase – although not as quickly as advocates would like. As Yang observed in remarks designed to highlight the benefits of sharing: "The entire world has benefitted from China's initiatives, but it has been Chinese scientists who have benefitted the most."

"When you make data available, it can make a huge difference in the quality of peoples' lives," noted El-Baz. "The benefits derived from data-based analysis and policies are likely to be most acutely experienced by people in developing countries. That's why it's so important to continue to expand free and open access to scientific data." ■



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An abbreviated version of this article has been published at www.scidev.net/en/features

For additional information about the NAS meeting, 'The Case for International Sharing of Data: A Focus on Developing Countries', see sites.nationalacademies.org/PGA/biso/PGA_061353.

SUSTAINABLE WELL-BEING IN AFRICA

MENTION AFRICA, AND DIVERSITY IS NOT THE FIRST WORD THAT COMES TO MIND. YET, AFRICA IS A LARGE AND DIVERSE CONTINENT THAT DEFIES SIMPLE DESCRIPTIONS.

People from outside Africa often see it as a place that lends itself to simple, straightforward and often unflattering characterizations. From the outside looking in, the only clear line of division in Africa lies between North Africa and sub-Saharan Africa. Otherwise, the continent is usually seen as one. The true portrait is quite different, however.

Africa consists of 53 countries. In contrast, South America has 12 countries, North America 23, Europe 47 and Asia 50. How similar are Sudan and South Africa? Liberia and Lesotho? Mauritania and Madagascar?

But it's not just geographical and political boundaries that reflect the continent's diversity. Africa's varied ecology and vast treasure trove of resources also speak to the continent's wide-ranging diversity. It has, for instance, 14 ecological zones ranging from dry desert to humid rain forest and it is rich in diamonds, oil, gold and copper.

THE POVERTY LINE

Yet Africa is also a continent that has been persistently overburdened by poverty.

Poverty, in fact, remains Africa's chronic affliction defying a broad range of remedies that have been pursued by governments at home and by funding agencies from abroad. According to the World Bank, no fewer than 43 of the continent's countries are low-income countries and, according to the UN Conference on Trade and Development (UNCTAD), no fewer than 35 of the continent's countries are least developed countries (LDCs).

Poverty, in short, is the characteristic that makes many observers conclude that Africa lacks diversity. In their eyes, Africa is simply poor and no more.

Aggregate statistics and global economic rankings, of course, are also mirrored in the low incomes and chronic social ills that afflict the people who live there. More than 70% of all Africans live on less than USD2 a day. More than 26 million Africans are infected with HIV and an estimated 2.5 million Africans die each year of AIDS. Nearly 1 million Africans fall victim to malaria. Over 40% of all Africans do not have access to safe drinking water.

WHAT HAPPENS IN AFRICA...

What happens in Africa is, no doubt, of consequence first and foremost to the people of Africa. Yet what happens to Africa is also of consequence to the rest of the world.

That's because Africa is home to nearly 1 billion people or nearly

15% of the world's population. The population is currently experiencing an annual growth rate of 2.5%, which makes it the world's fastest growing continent. Its population, in fact, could double by 2050.

Africa, moreover, is also comprised of a huge landmass covering more than 30 million hectares. Only Asia is larger. Indeed Africa's landmass is 2 million hectares larger than Europe, the USA and Australia combined.

CHALLENGES, CHALLENGES

Africa is not only economically challenged. Not surprisingly, it is also scientifically challenged. African countries spend on average just 0.3% of their gross domestic product (GDP) on research and development (R&D) compared to a global average of 1.7%. Africa has just 164 researchers per one million population compared to a global average of nearly 1,100 researchers per one million population.

Put another way, with nearly 15% of the world's population, Africa has just 2.2% of the world's researchers. Each year, not surprisingly, it produces just 1.5% of the peer-reviewed scientific publications.

When it comes to patents, the situation is even more troublesome. The World Intellectual Property Organization's 2008 *World Patent Report* noted that only 26 of Africa's 53 countries filed patents in 2007 and in 20 of those countries the number of patents filed was fewer than four.

Less than five decades ago, South Korea was an impoverished country with a per capita GDP of USD1,630 and it had virtually no scientific infrastructure. Today, South Korea has a per capita GDP that exceeds USD20,000. It spends 2.3% of GDP on research and development (with plans to spend 5% of GDP by 2012) and has more than 3,000 researchers per one million population. A country with only 50 million people, South Korea is far outdistancing every country in Africa – and indeed the continent in the aggregate – in both scientific capacity and economic growth.

ALL IS NOT BLEAK

Yet, while troubles abound, all is not bleak in Africa. In fact, some recent trends have been encouraging. For example, in the five years preceding the international financial meltdown in 2008, GDP in Africa grew at an annual rate of more than 5%, and over the past two years many countries in Africa have been able to weather the shockwaves of the global downturn better than many northern countries, including the United States.

Meanwhile, the number of African countries that have taken significant steps to strengthen their scientific capacity has continued to rise.

Nigeria, for example, has invested in space technology to improve its ability to monitor changes in its environment. South Africa, meanwhile, has invested significant resources in nanotechnology to enhance its capabilities in providing access to safe drinking water and to advance its efforts in promoting renewable energy.

IMPEDING PROGRESS

But a host of intractable issues continue to stand in the way of whatever progress has been made. Africa may be slowly moving ahead but strong headwinds continue to hold back the continent's efforts to embark on an enduring path for economic development.



Among the compelling questions that Africa faces are these: Is the progress that has been made, however commendable and encouraging, commensurate with the scope of the problems? Are the measures sustainable? Will the advances ultimately be shared by all African countries or confined to the continent's larger and relatively more prosperous countries? Will Africa follow a path toward science-based sustainable development similar to the one that has recently unfolded in Asia, where China and India have led the way and where other countries in central and southern Asia have been buoyed by their success? Or, will it establish its own, uniquely African, paradigm for growth?

STEP BY STEP

Where should Africa start in its quest for sustainable economic development? In many ways, it already has. For nearly a decade, efforts to create a pathway for sustainable growth have focused on fundamental issues that were concisely articulated at the World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa, in 2002. These challenges, presented under the acronym WEHAB, include water, energy, health, agriculture and biodiversity. Since then, climate change has been added to the list.

The key issues facing Africa, as it seeks to improve the economic and social well-being of its people, may be clear and straightforward. But how to best address these issues is not. In other words, identifying the issues, in many ways, has been the easy part, while effectively doing something about them has been another, more troublesome, matter.

That's because the challenges that Africa faces are complex and often interwoven. Answers, moreover, lie not only in science but also in a broad range of intractable social and economic challenges that must be addressed in the political arena as much as in the laboratory.

Take, for example, the issue of biodiversity. Experts in developed countries tend to view the issue of biodiversity as a question of species survival and landscape protection with long-term implications for economic and social well-being.

In Africa, however, biodiversity is a more immediate concern since so many people depend on their environment and nearby natural resources for their survival.

Put another way, in Africa, when it comes to biodiversity (and so many other issues), the focus is local and the timeframe immediate.

In terms of global warming, the international community tends to worry about questions concerning the ability of societies to adapt to warmer climates or the impact that rising sea levels and more intense storms will likely have on heavily populated coastal areas.

Again, for Africa, the impact is more immediate. Warming temperatures could pose critical risks to agricultural productivity and undermine efforts to promote food security. Indeed, according to most experts, Africa is the continent most vulnerable to climate change due to its fragile ecosystems and its lack of capacity to adapt to the changes that will accompany significant modifications in climate.

For example, as temperatures rise and rainfall decreases, the sandy soils found in Africa's dry and semi-dry regions are more likely to be transported from their current locations and carried away to distant places. Indeed soil experts have concluded that Africa currently exports 50 million tons of soil and dust particles each year.

Robbing Africa of its topsoil will have direct, on-the-ground consequences for Africa. However, as these soil and dust particles are carried air-borne to Europe and South America, they will also bring environmental problems to people living there. In today's world, distinctions between local and global impacts are becoming increasingly blurred.

A number of other fundamental societal challenges are also most acute in Africa, including access to safe drinking water and the ability to connect to reliable sources of energy.

All of these issues require indigenous capacities in science and technology if they are to be addressed effectively. Yet the continent's current levels of scientific knowledge and technical skills are exceedingly weak and its financial resources scarce.

Some 3 billion people worldwide use coal, charcoal, firewood, agricultural waste and dung to

cook – and over 20% of these people reside in Africa. More than 1.5 billion people worldwide live without access to electricity – nearly 40% of whom are in Africa.

The use of traditional energy sources poses risks to public health related to indoor air pollution and fire hazards. And a lack of access to electricity, of course, limits educational and economic opportunities – and places significant constraints on the quality of life.

GAP CLOSING

The 2010 UNESCO *World Science Report* concludes that the gap in scientific and technological capacity between the developed and the developing world is closing. For example, the developing world's share of articles in science, medicine and engineering rose from 30% in 2002 to 38% in 2010.

Nevertheless, as these percentages also suggest, the gap remains significant (three-quarters of the world's population continues to generate just one-quarter of its scientific knowledge). The gap, moreover, remains particularly acute in Africa, the world's most scientifically lagging continent.

Only four of the top 20 countries that the Institute for Scientific Information (ISI) lists as the preeminent producers of peer-reviewed articles in science and engineering are classified as developing or, more accurately, as countries with emerging economies. These countries are China, India, Brazil and Turkey. South Korea and Taiwan, which rank among the world's wealthiest and most scientifically capable countries, are also on the list. Indeed, the presence of the latter two countries, both of which were poor, countries until recently, illustrates just how quickly investments in science and technology can reduce poverty and propel efforts for sustainable economic development. The lessons conveyed by these countries offer hope for Africa.

Yet, at the same time, it could be argued that the gap in science and technology is not only widening between African countries and developed countries, but that it is also widening between African countries and other developing countries. Advances in scientific and technological capacity in the South are being led – indeed, in many ways, monopolized – by just a few countries, including China, India, Brazil, South Africa and Turkey as well as Argentina, Chile, Mexico and Malaysia.

In 1994, China produced some 1% of the articles published in peer-reviewed international journals – a third less than Switzerland, which had just 7 million people (compared to 1.2 billion people in China). Yet, by 2007, China accounted for more than 7.5% of the world's articles published in international peer-reviewed scientific journals. That moved China into second place behind only the United States, which produced nearly 26% of the world's peer-reviewed articles in 2007.

Meanwhile, Africa was producing just 1.5% of the world's scientific publications in 2007. South Africa, the continent's indisputable leader in science, accounted for more than one-quarter of this small percentage and nearly half of all the scientific publications in sub-Saharan Africa. Egypt, which ranked second in publications in Africa, accounted for nearly one-fifth of the continent's scientific articles.

The sad truth is that 30 of Africa's 53 countries were together responsible for just 0.08% of the global output of peer-reviewed scientific publications – a paltry amount confirming that most African countries had virtually no presence in the global scientific community.

STEMMING BRAIN DRAIN

While Africa has not been entirely left out of the positive economic trends that have taken place among developing countries over the past decade, it has nonetheless not kept pace with developments in science and technology in Asia and South America (or, for that matter and not surprisingly, economic growth rates in either of these two continents).

Brain drain remains a more serious problem in Africa than anywhere else both because of the small size of its S&T workforce and the willingness – indeed eagerness – of its scientists and other educated professionals to move out of Africa for better pay and working conditions.

The continent, in short, continues to lose its top scientists and engineers, whose presence and contributions it needs most to provide science- and technology-based so-



lutions to its most fundamental social and economic challenges.

Six of the top ten countries with the highest percentage of emigrated educated citizens are in Africa. More medical doctors of Ethiopian origin practice medicine in Chicago, Illinois, USA, than in Ethiopia itself. There are more Malawian medical doctors living and working in Manchester, UK, than in all of Malawi. According to a recent survey, 60% of all African postgraduate students currently attending school in the UK have no intention of returning to Africa.

REVERSAL IN FORTUNES

So, what is to be done?

Commitments must be fulfilled both by the governments in Africa and governments and international aid agencies outside of Africa.

Calls for African countries to spend at least 1% of their gross domestic product (GDP) on research and development date back to the Vienna Programme of Action in 1979. Since then, the same calls have been echoed repeatedly at conferences focusing on science and economic development in Africa, most recently at the AU summit in 2007. Nevertheless, only Rwanda and Tanzania currently meet the 1% threshold figure and both have attained this level of investment in the past few years. South Africa, despite being the continent's scientific powerhouse, spends just 0.92%. The average expenditure across the continent is just 0.3% of GDP.

In 2005, the Group of 8, a network of the world's richest countries, which has recently expanded to the Group of 20 (as a reflection of the changed world in which we live), agreed to grant USD8 billion to strengthen universities and research centres in Africa over 10 years. Yet, only a fraction of that money – less than USD200 million – has been spent.

While domestic investments in research and development continue to be short-changed and international commitments to assist Africa's own efforts to build scientific and technological capacity remain unfulfilled, the continent spends an estimated USD4 billion each year to hire foreign consultants.

Clearly, training an indigenous workforce skilled in science and technology and providing opportunities for them to address critical societal problems would have multiple benefits for the continent.

KNOWLEDGE GOES GLOBAL

We live in a global knowledge society. Therefore it stands to reason that countries with acute shortages of knowledge workers will find themselves marginalized – and impoverished – in today's world.

Broad comprehensive efforts must be undertaken at both the national and continental levels to improve the conditions of Africa's universities and research facilities.

Equally important, comparable efforts must be made to curb the 'brain drain' phenomenon. This will require dramatic increases in investments in science and technology on the part of Africa's government as well as such pan-African organizations as the African Union (AU).

Indeed the AU's efforts to develop a pan-African university system deserve encouragement and support. Yet, the regional approach at the heart of the initiative has faced difficult challenges for cooperation that have yet to be overcome. Will the host countries where the hubs of the system are



to be located be willing to fully share their facilities with other countries? Conversely, what level of resources will other countries be willing to invest in a system driven by hubs that lie beyond their borders?

External funding can also aid in Africa's efforts to rebuild its universities and research facilities. For example, the Regional Initiative in Science and Education (RISE), based at the Princeton Institute for Advanced Study in the US and supported by the Carnegie Corporation of New York, is nurturing African-based research networks for both faculty and students alike in such fields as material science, engineering, biochemistry, natural products, access to safe drinking water and coastal and marine resources.

Regional and international cooperation can undoubtedly help raise the quality of education and research in African countries. The effort, moreover, can play a critical role in enabling Africa's scientists to acquire the knowledge and skills they need to advance the Millennium Development Goals (MDGs). It can also serve as a platform that helps to integrate Africa's scientists into the global scientific community.

Yet, whether such collaborative efforts achieve the level of funding and organization that is required to meet the scope of the problem remains to be seen.

OPPORTUNITIES TO TAP

As stated earlier, Africa is not without assets and opportunities.

It is a continent that is rich in natural resources. It has a vast storehouse of biodiversity. It has a broad base of indigenous knowledge of the local ecology and natural resources. Governments in a growing number of African countries have become increasingly democratic. And it has a large diaspora that has increasingly expressed interest in working with their colleagues in Africa.

There are, moreover, several specific fields with vast economic potential where Africa has a distinct advantage over other regions of the world. With sufficient scientific capacity, these areas could become models of success that both governments and scientists throughout Africa could point to as examples of how science and technology can help boost sustainable economic development across the continent.

Take, for instance, the prospects for solar energy. By some estimates, less than 1% of the world's deserts could produce enough electricity to meet current levels of world consumption. Energy experts, moreover, estimate that there are sufficient supplies of solar energy in North Africa and the Middle East to generate 500 gigawatts (GW) of electricity, enough power meet 15% of Europe's current power needs.

The Desertec Foundation, which is being assisted by a consortium of public-private interests that includes such multinational giants as Deutsche Bank, Siemens and Munich Re, is developing a business plan that is designed to supply solar-powered electricity to both North Africa and Europe, perhaps beginning as early as 2015. The plan will call for blanketing large swatches of desert lands – up to 17,000 square hectares – with solar collectors and wind turbines that will be linked together with thousands of kilometres of power cables, including cables stretching underneath the Mediterranean Sea from North Africa to Southern Eu-

rope. In November 2009, Morocco announced its first contribution to Desertec would consist of a USD9 billion, decade-long initiative that would ultimately generate two gigawatts of power.

Meanwhile, both Nigeria and South Africa are investing in space science and technology initiatives that are designed to monitor environmental change and the changing state of natural resources. Such efforts could help South Africa assess the risk posed by forest fires and to pursue strategies that would seek to minimize that risk in the most fire-prone areas. Similarly, it could help Nigeria monitor the levels of water pollution in waterways, especially those in urban areas and in mining and mineral districts.

Biotechnology is another frontier technology that holds great promise for improving the social well-being of poor people, especially in its potential for raising agricultural productivity and improving public health. The same is true of nanoscience and nanotechnology, which focuses on manipulating matter at the atomic scale.

Nanotechnology, for example, has the potential to provide inexpensive water filters that could vastly increase access to safe drinking water in Africa. Researchers at North-West University in South Africa have constructed a pilot water treatment plant in Madibogo, a village in the remote arid region of North West Province. Nanostructured membranes are serving as the basis of state-of-the-art nanofilters for the low-cost purification of water. The initiative also sponsors community-wide classes and workshops to increase the public's ability to maintain the plant in the future, thus ensuring that safe drinking water will be available after the researchers depart.

PEOPLE FIRST

Africa's most important resource has – and always will be – its people. More than 40% of its population is under the age of fourteen.

Indeed the future of Africa lies with its youth who await the education and training they will need to compete in the global knowledge-based economy of the 21st century.

As the populations of Europe and the United States age, and as China seeks ways to overcome the consequences of its one-child policy, Africa's demographic profile holds great promise to be its strategic advantage in the years ahead (perhaps only India has a comparable advantage).

But demography is not destiny. It will take enormous investments in education, starting with primary school and continuing through postgraduate studies, to fulfil the promise of its younger citizens. It will take increased funding for building classrooms and laboratories where students can learn. It will take adequate salaries and career-long training for teachers to help guarantee that instructors have the incentives and skills to do a good job. It will take continued investments in information and communication technologies to ensure that the information and data that researchers need to succeed are easily accessible. It will take targeted aid from external sources that helps to supplement the investments of Africa's governments and pan-African institutions. And it will take a long-term view of a better future, bolstered by political stability and efficient and innovative administration that puts the people's welfare first.

Yes, we live in a time of unprecedented change where knowledge is king. But we also live in a time when principles that have been the hallmarks of successful societies for centuries remain critical elements of progress.

That is Africa's challenge: to embrace the 21st century with a determination that enables it to take advantage of the unprecedented opportunities that advances in science and technology provide. Yet, to do so in ways that will allow it to meet the critical social and economic needs of its people to not only improve their lives in the near term but also to give them hope for an even better future for their children. ■

Mohamed H.A. Hassan
former executive director of TWAS
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public information officer of TWAS

The article is based on a presentation given at the UNESCO Chair International Science Conference on Technologies for Development in Lausanne, Switzerland, in February 2010.

IN BRIEF

Recent news from the TWAS Public Information Office based on research and capacity-building activities that are being pursued by TWAS members and partners.

CITIES AND WATER IN AFRICA

"The most critical problems related to water in Africa are often found in cities," says E. Salif Diop (TWAS Fellow 2010). An expert in global water and environment issues, Diop currently heads the Ecosystems Section of UNEP's Division of Early Warning and Assessment in Nairobi, Kenya. He serves as the first chair of UNESCO's integrated coastal and marine cluster at the University of Cheikh Anta Diop in Dakar, Senegal.

"Rapid urbanization in Africa has placed enormous pressure on the continent's urban water supplies," says Diop. "Urban slums, which account for about 60% of Africa's total urban population, pose a particular challenge."

"Municipal governments in Africa," he notes, "lack the skills and resources to build adequate water and sanitation infrastructures capable of serving their growing urban populations." In fact, even the most basic wastewater and solid disposal services are often unavailable. Untreated wastewater degrades the environment and often leads to the spread of water-borne diseases.

"Effective solutions to urban Africa's water challenges," Diop maintains, "can only take place by improving the water and sanitation infrastructure and by promoting integrated water and sanitation management."

Diop stresses that solutions must be devised at the local level through a participatory approach involving all stakeholders. "Community-based strategies," he says, "are essential."

He maintains that 'soft engineering' – the application of ecological principles and practices (for example, wastewater treatment and basic recycling of solid waste) – is essential for addressing urban Africa's most acute water-related problems, especially in the city's most impoverished areas.

Diop adds that "soft-engineering principles could be used to lower pollution levels in shallow wells, which the urban poor often rely on as the primary source of their water supply. Such principles can also serve as the basis of initiatives that use solid waste as a valuable energy source for small-scale, community-based biogas and electricity generation."

Although urban water challenges facing Africa today may seem overwhelming, Diop's work and experience suggest otherwise.

"Solutions to Africa's urban water problems are available," he says. "Improved drainage systems, more adequate sanitation facilities, and effective efforts to reuse and recycle both solid waste and wastewater can have a dramatic effect on the well-being of Africa's increasing number of urban residents." ■

MOLECULAR MATTERS IN ARGENTINA

Gabriel Rabinovich, a researcher at the National Research Council in Argentina (CONICET) and a professor at the University of Buenos Aires, seeks to identify the role that galectins, proteins that bind beta-galactoside or sugar, play in disease regulation. For his efforts, he received the 2010 TWAS Prize in the Medical Sciences.

As Rabinovich explains: "Galectins help to determine the course and intensity of critical diseases. If we can better understand how they perform this function, we are likely to find more effective ways to treat these diseases."

Rabinovich, who was born and raised in Córdoba, Argentina, earned an undergraduate degree in biochemistry in 1993

and a doctorate degree in cellular and molecular immunology from the National University of Córdoba in 1999.

"I have had numerous opportunities to conduct research abroad," says Rabinovich, who is currently a part-time visiting professor at the University of Baltimore in the United States in addition to his permanent post at home. "I have also received a number of offers for positions in other countries that I have declined. These offers were especially tempting in the late 1990s when Argentina experienced an economic meltdown that severely restricted funding for research."

"I'm glad I stayed here in Argentina. I have been able to work with an excellent team of scientists conducting research that could dramatically change the way we treat and manage serious, complex diseases."

Specifically, Rabinovich and his research team have focused their attention on how galectins build molecular bridges. Galectins play a key role in such diverse functions as cell adhesion, cell migration, and even cell death or apoptosis.

"One of the first key findings encouraging me to pursue this line of research," says Rabinovich, "was evidence that synthetic galectins created in our laboratory could alleviate chronic inflammation by sustaining the survival of T-cells."

Then, a few years later, Rabinovich conducted research demonstrating that galectins help cancerous tumours evade the immune response. "By showing that tumour cells produce excessive amounts of galectins and that they use these proteins as battering rams against T-cells," he says, "we revealed how cancer cells could hide from the body's first line of defence." The same findings have also held true for Hodgkin's lymphoma.

Rabinovich has published more than 120 articles in peer-reviewed journals. Equally important, his research has provided an intellectual framework to help clinicians better

understand and combat critical diseases. His work has been supported by the John Simon Guggenheim Foundation in the United States. In addition, he has been honoured by the Mizutani Foundation and Cancer Research Institute in Argentina, where he also received the Bernardo Houssay Award.

Rabinovich's latest research points to the existence of what he calls a "tolerance circuit" – a molecular mechanism that seems to play an important role in a variety of regulatory functions, including the growth of tumours and chronic inflammatory disease. "The circuit," he adds, "might even be a factor in compromising the immune system of a mother during pregnancy to more easily accept the fetus and allow the pregnancy to proceed to term."

"Galectins," he says, "seem to fine-tune many different biological processes within our bodies. The roadmap to better health and longer lives," he adds, "may depend on uncovering the complex behaviour of these sugar-binding molecules." ■

COTTON FUTURES IN UZBEKISTAN

The value of cotton extends well beyond the plant's fibres. The plant's thick green leaves and thin, yet sturdy, stems not only nourish and support the cotton bolls (the plant's oval-shaped fruit), but are also used for mulch and animal feed. In addition, cottonseeds are crushed and distilled into one of the world's most popular vegetable oils, used for soap, cosmetics, pharmaceuticals and plastics.

"There's nothing like cotton," says Ibrokhim Y. Abdurakhmonov, a professor at the Institute of Genetics and Plant Experimental Biology, which is part of the Uzbekistan Academy of Sciences. Abdurakhmonov shared the TWAS Prize in Agricultural Sciences in 2010 for his research examining the molecular biology of cotton.

As Abdurakhmonov notes, cotton is at risk. While troublesome and destructive, it's not the pests – caterpillars, aphids and flies – that pose the most serious long-term risk, he says. Nor is it a loss of land to development or the depletion of topsoil that is at the heart of the problem.

Instead, Abdurakhmonov points to the use of a limited number of cultivars, each with the same germplasm, as the key threat to future cotton yields. "It's narrowing the genetic diversity," he says. "That makes cotton plants highly vulnerable to pathogens and insects."

"Over the past half century, Uzbek cotton farmers have repeatedly planted the same cultivar, 'Tashkent'," says Abdurakhmonov. Drawing on seeds from the same gene pool has not only compromised the size and quality of cotton yields; it has also placed the health of cotton plants at risk since genetic diversity makes the plants stronger and more resilient.

Abdurakhmonov and his colleagues use molecular biological techniques to examine the germplasm of Uzbekistan's cotton. They do this to uncover the precise location of individual genes in the DNA. In the language of molecular biology, Abdurakhmonov and his colleagues map QTLs (quantitative trait loci) to identify specific genes that govern, for example, fibre quality, the timing of flowering and leaf defoliation, and the structure and strength of stems and roots.

"As you might expect," Abdurakhmonov notes, "this is a demanding task." First of all, it requires access to state-of-the-art molecular biological equipment and advanced scientific knowledge to appreciate and understand what is revealed. He and his colleagues, for instance, apply RNAi (RNA interference) to 'knock out' or 'silence' (that is, disable) a specific gene by blocking the corresponding RNA – the messenger molecule that carries the information stored in the DNA to the protein-making machinery within the cell.

By 'silencing' a specific RNA gene, scientists can explore the proteins' functions and examine the consequences of the gene's absence. This is especially important because, as researchers have learned, there is not a one-to-one relationship between a gene and its biological and chemical function. Instead, biological and chemical function results from an intricate series of interactions among multiple proteins. Environmental impacts, moreover, can alter these interactions in ways that scientists do not yet understand.

With nearly 1.5 million hectares of cotton under cultivation, Uzbekistan is the world's third largest cotton exporter. Only the United States and Australia export more. The research being conducted by Abdurakhmonov thus has important implications for both the nation's farmers and overall economy.

"If Uzbekistan's cotton crop is to remain sustainable over the long term," Abdurakhmonov maintains, "we will have to broaden the genetic diversity of commercial cotton crops. That's the best insurance policy we have to protect cotton from pathogens and pests."

Genetic diversity depends first and foremost on an understanding of the structure and behaviour of proteins, and the way in which proteins work together to create specific biological and chemical traits. The study of cotton's genetic makeup is a fascinating research challenge, says Abdurakhmonov. "But it also has significant implications for broad segments of Uzbekistan's society and economy." ■

Flickr/Old Shoe Woman

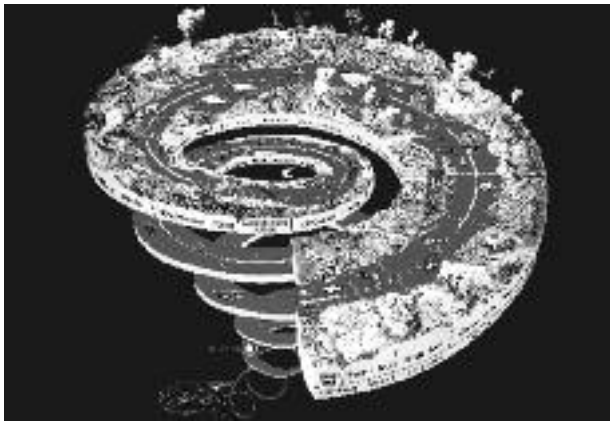
ROCKY PAST

Italian-Brazilian scientist Umberto Cordani has a passion for dating rocks. His research not only sheds light on the intricate dynamics of our planet but also helps us better understand the geological stresses facing the Earth today.

Rocks may chip and crack, but they do not age. At least, they do not age the way humans do.

Experts, however, can determine the age of rocks by using high-technology dating techniques that delineate young rocks from old ones.

Umberto Cordani, professor emeritus at the University of São Paulo's (USP) Institute of Geosciences in Brazil, is a world-renowned Earth scientist with a sterling reputation in the field of geochronology – the science of determining the age of rocks, sediments and fossils.



"Geochronology," explains Cordani, "is not just a research exercise for the sake of knowledge. It provides key insights into the behaviour of our planet over the 4.6 billion years of its existence."

Such insights can help scientists better understand the dynamics that, for example, drive continental drift and cause mountains to rise. Rock dating can also unlock critical information about the ecological impacts of development, climate change and other human activities that leave a deep footprint on Earth's ecology. Cordani, who is the founding director of the USP's Laboratory of Geochronology, has been a researcher there for more than 40 years. He was elected a TWAS Fellow in 1990.

Cordani was born in Italy. His family, like many other families in Italy, moved to Brazil in 1949. In the 1960s, he was accepted to the University of California at Berkeley, USA, where he studied under the tutelage of John Reynolds, an internationally renowned physicist who developed a mass-spectrometer that relied on the "potassium-argon method" to measure the age of rocks and minerals.

"The radioactive isotope potassium 40," Cordani explains, "undergoes natural radiogenic decay, ultimately turning into argon 40, a gas that accumulates inside rocks. Reynolds' mass-spectrometer allows scientists to measure the level of this argon isotope in rocks. That, in turn, provides a reliable measure of the rocks' age."

Cordani's thesis, which he completed in 1968, not only confirmed the young age of volcanic rocks found on two Brazilian oceanic islands, Fernando de Noronha and Trindade (as previously suggested by Cordani himself), but also validated a method that became the gold standard for geochronologists.

A year earlier, Cordani, with colleagues from the Massachusetts Institute of Technology (MIT) in the USA, published a paper in *Science* magazine that concluded rocks in Northeast Brazil and West Africa exhibited very similar ages. This finding helped to verify the theory of plate tectonics, which explains why the upper layer of our planet, or lithosphere, shifts and faults.

Cordani, who has authored more than 120 research articles, books or book chapters, is well known among his colleagues for editing *Tectonic Evolution of South America*, a landmark publication in the field of geotectonics.

"Development and environment," Cordani notes, "are part of the same equation. We must understand the Earth's dynamics to successfully address such critical issues as water and soil conservation, desertification and deforestation. Greater understanding of the Earth's dynamics will prove essential for meeting the social and economic needs of a growing population without placing excessive pressure on the Earth's resources."

"As global population and wealth continue to increase, science-based insights into geological stress will become even more important," Cordani says. That is why he has recently turned his attention to training a new generation of scientists conversant in Earth's geology – an initiative that he is pursuing with the same enthusiasm and commitment that he has applied to his lifelong study of rocks. ■

ROMAIN MURENZI, TWAS'S NEWLY APPOINTED EXECUTIVE DIRECTOR, OFFICIALLY ASSUMED HIS POST ON 1 APRIL. HE SUCCEEDS MOHAMED H.A. HASSAN, WHO LED THE ACADEMY FOR A QUARTER CENTURY. IN THE FOLLOWING INTERVIEW, MURENZI SPEAKS ABOUT THE CHALLENGES AND OPPORTUNITIES THAT HE ENVISIONS TWAS WILL BE FACING IN THE YEARS AHEAD.

ROMAIN MURENZI TALKS ABOUT TWAS

Romain Murenzi, born in Rwanda in 1959, was raised and educated in Burundi, where his family moved when he was just three years old. He received his undergraduate degree in mathematics, as well as a teaching certificate, from the University of Burundi in 1982, spending the early years of his career as a high school teacher. He earned national recognition for his teaching ability and accomplishments, first as an instructor in an all-girls' school in the province of Gitega and later at the two most prominent high schools in Burundi's capital city of Bujumbura.

Eager to pursue his dream to acquire a doctorate degree in theoretical physics, Murenzi applied for a bourse du tiers monde *(fellowship for the Third World) from the Catholic University of Louvain in Belgium. His first application was rejected. The reviewers described him as an "excellent high school teacher that Burundi could ill afford to lose."*

For the next four years, Murenzi pursued his doctorate studies, earning a PhD in theoretical physics in 1990. The following year, he was appointed to a postdoctorate research and teaching position at the University of Paris 7, where he remained until 1992.

He then moved across the Atlantic Ocean to join the faculty at Clark Atlanta University, where he was named chairperson of the physics department in 1999. He received tenure one year later. At Clark Atlanta University, Murenzi not only continued to teach but also pursued his research interests in quantum mechanics and image and video processing.

Rwanda's civil war in the mid-1990s, which claimed more than one million lives, was a continual source of anguish for Murenzi who desperately wanted to return to his home country to help. Between 1996 and 2000, he travelled to Rwanda each summer to lead a seminar and teach at the National University in Butare. He also became involved in efforts in the United States to help Rwanda.

Largely unknown to him at the time, his activities attracted the attention of Rwanda's president, Paul Kagame. In March 2001, he received a surprise phone call from Rwanda inquiring whether he would be interested in serving as the minister of education. Although never having been involved in politics, he accepted the offer, and in early August, he took up the post of Minister of Education, Science, Technology and Scientific Research. He continued in this position until 2006 when he was named Minister in the Office of the President in Charge of Science and Technology as part of a government reorganization plan.

During the years that Murenzi served as minister, Rwanda launched a comprehensive strategy for science-based development that would transform his home country into one of the success stories of Africa. Rwanda currently spends 1.6% of its gross domestic product (GDP) on science and technology, a level that is expected to rise to 3% over the next five years. At the same time, its national economy grew at a rate of nearly 7% per year between 1998 and 2008, a rate comparable to the pace of growth in China and India.

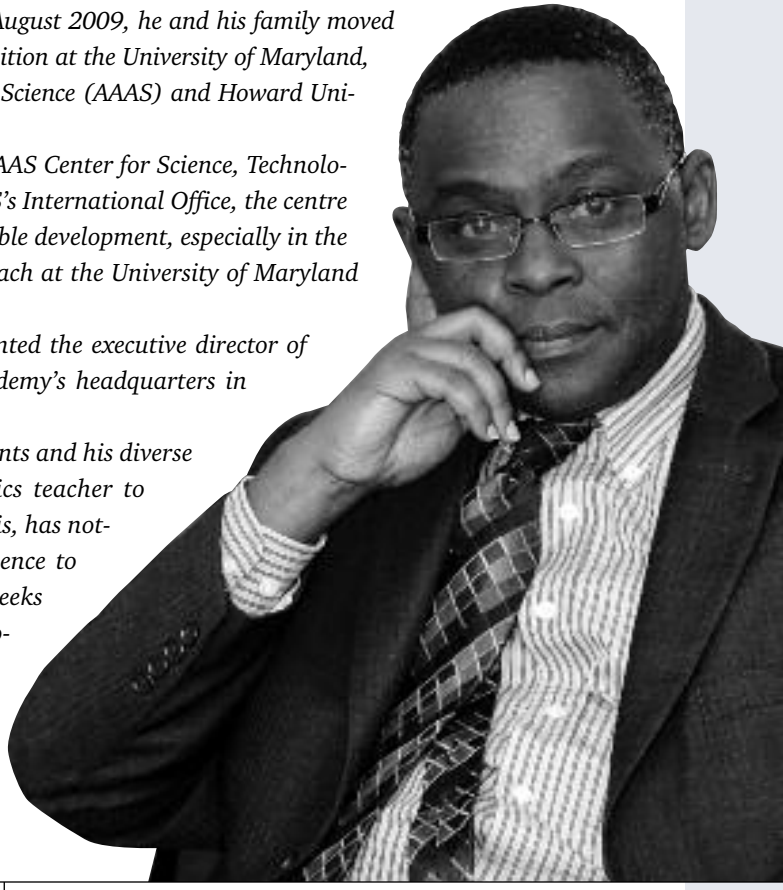
In the spring 2007, his family learned that his youngest son had autism. Unable to find the medical care that his son needed in either Rwanda or neighbouring countries, he asked President Kagame to relieve him of his duties. In August 2009, he and his family moved to the United States, where he acquired a joint position at the University of Maryland, the American Association for the Advancement of Science (AAAS) and Howard University.

In July 2010, he was named director of the AAAS Center for Science, Technology and Sustainable Development. As part of AAAS's International Office, the centre focuses on issues related to science-based sustainable development, especially in the developing world. Meanwhile, he continued to teach at the University of Maryland and Howard University.

Then, in February 2011, Murenzi was appointed the executive director of TWAS. Two months later, he arrived at the Academy's headquarters in Trieste, Italy, to begin his tenure.

Murenzi's inspiring career spans three continents and his diverse experience ranges from high school mathematics teacher to minister of science. As TWAS President, Jacob Palis, has noted, "Professor Murenzi has the skills and experience to lead the secretariat in the years ahead as TWAS seeks to expand its efforts to build scientific and technological capacity in all developing countries."

Six weeks after his arrival, Murenzi sat down with TWAS's public information officer to discuss a broad range of issues related to the Academy. Excerpts follow.



How do you feel about assuming the helm at TWAS? What does it mean for you?
I am extremely honoured and humbled to have been chosen to head such a distinguished organization as TWAS. The appointment means a great deal to me at both a professional and personal level. My career as a scientist and researcher truly began to take shape when I received *une bourse du tiers monde* (a fellowship for the Third World) from the Catholic University of Louvain in Belgium. I also fondly remember participating in activities organized by the International Centre for Theoretical Physics' (ICTP) Aeronomy and Radiopropagation Laboratory in Trieste, which proved enormously helpful and instructive during the early years of my career. In a sense, my appointment as the head of TWAS gives me an opportunity to give something back. I am particularly eager to help ensure that young scientists in developing countries are afforded the same opportunities to pursue – and realize – their dreams as I was given a quarter century ago.

What do you think will be your short- and long-term priorities for TWAS?
My priorities will continue to take shape as I learn more about the Academy and its activities in the months ahead. However, I know this much from my time on the TWAS Council, where I served as vice president for Africa, and now during my brief tenure as executive director: TWAS's mandate has remained remarkably consistent since its inception. Simply stated, the Academy has supported and promoted scientific capacity building and excellence in the developing world. The core element of this effort has resided in the election of eminent scientists. Over the years, the Academy has also supported a broad range of programmes that includes research grants, fellowships and prizes. It has organized general assemblies that have become signature events in assessing the state of science in the developing world. And, it has forged strong ties with many other international scientific organizations that share TWAS's aspirations and goals, including the Organization for Women in Science for the Developing World (OWSDW), IAP, the global network of science academies, and IAMP, the InterAcademy Medical Panel. Increasingly, it has focused its attention and resources on addressing the needs of young scientists and it is now taking steps to extend more responsibilities to its regional offices as part of a larger effort to decentralize its activities and bring its programmes and activities closer to the scientists and scientific institutions that it is trying to help. In addition, over the past several

years, it has partnered with other organizations beyond the conventional circle of collaborators it has worked with in the past – notably, the European Union, Microsoft Research and Elsevier.

TWAS has an enviable track record of success. I hope to strengthen those areas where the Academy has gained an international reputation and expand those areas where it has raised its profile and presence in recent years. This means ensuring that we continue to elect the developing world's most eminent scientists as members of TWAS and that we continue to expand the reach and impact of the Academy's programmatic initiatives. I am particularly eager to strengthen our efforts to assist young scientists and to extend greater responsibilities to TWAS's regional offices. In my estimation, the future of TWAS lies, in large measure, in helping the next generation of scientists and in decentralizing its activities.

There are several relatively unexplored areas that I would also like to pursue. First, I plan to seek opportunities to work more closely with scientific institutions in developed countries. I have a large number of colleagues and associates in both Europe and the United States who have expressed a great deal of interest in working with TWAS. We have entered a new era of global science, marked by growing scientific capacity in the developing world and a significant closing of the North-South divide in science. TWAS is well positioned to serve as a bridge between the South and North in a wide range of scientific fields and I plan to take advantage of the growing opportunities for global collaboration. Such efforts, I am convinced, will help broaden the reach and impact of the Academy. I also plan to expand TWAS's presence in areas related to science policy, again with partners in both the South and the North. My hope is to extend the Academy's reputation for excellence by raising TWAS's profile in fields such as science diplomacy and science education.

What role does science play in the development strategies of developing countries?

Science, of course, plays a critical role in development. In fact, in today's world, science goes hand-in-hand with development. Nevertheless, it is important for the scientific community to recognize that in the political arena, it is development that is the top priority and that policy makers largely view science as a tool that helps to advance the economic and social well-being of people. That is something that became eminently clear to me during my tenure as minister of science and technology in Rwanda. There is little doubt that a country's economy can be spurred by commodity production and the advantages bestowed by low-cost labour – at least in the short term. But over the long term, when it comes to sustainable development, there is no substitute for science, technology and innovation (STI). STI is an irreplaceable force for dealing with such critical issues as food and energy security, climate change, the spread of infectious disease and biodiversity loss, and it is key to building a strong

and resilient economy. In short, we live in a world where STI are essential for both poverty alleviation and wealth creation. No country, no matter how poor, can close its eyes to this reality. The emerging economies of Brazil, China, India, Malaysia, Mexico, South Africa and Turkey – to name just a few in a growing list of success stories – indicate that STI is no longer the province of just the North. And, I might add, the experience of my own country of Rwanda over the past decade shows that STI is now a primary force for positive change in poor countries too. This irreversible trend, both in attitudes and applications of science to development, presents profound challenges and opportunities for TWAS as it seeks to build upon its hard-earned reputation as the 'voice of science in the South'. I plan to focus a great deal of my attention and time on how TWAS can successfully navigate the new world of science that is emerging across the globe – not just to benefit the Academy but, more importantly, to advance science-based development in all countries. I believe that we have a rare opportunity to make historic changes in the role that science plays both in developing countries and in addressing critical challenges related to the global economy and the environment. I hope that TWAS can help ensure that this opportunity is not missed.

What are the key challenges for STI in the developing world that TWAS can help address?
There are, of course, the conventional challenges of promoting scientific capacity building and scientific excellence. TWAS's track record of success should help it continue to be an important presence in these areas. Indeed I am confident that the Academy will be able to expand its research grants and fellowship programmes in the years ahead. But there are additional challenges related to leadership and financing that must also be addressed, especially if the Academy hopes to scale up its efforts in ways that can have an even greater impact in the future. In these areas, TWAS can play an important role as an advocate and counsellor. But the key to success ultimately lies at the national level and will be determined largely by the commitment that each country is willing to make to policies that advance science-based development. Countries that have had success in building their scientific capacity and in growing their economy – for example, Brazil, China, India and my own country of Rwanda – have enjoyed strong and consistent leadership dedicated to science-based development. These countries have emphasized science *and* development, not just one or the other, and have focused on the intricate, synergistic relationship between the two. History also teaches us that without sufficient financial resources, there are limits to what leaders can do, regardless of how skilled and innovative they may be. The good news is that there is a growing number of success stories in the developing world that can serve as models for others. TWAS, which has long been an advocate of South-South cooperation in science, can play an important role in fostering scientific exchange and in

encouraging countries to learn from each other's experience. TWAS, of course, has done this throughout its history. But I believe that the Academy now has an unprecedented opportunity to help advance these goals on a much larger scale. This will require TWAS to devise initiatives that meld science to development in new and innovative ways both through its programme and communications initiatives and in partnership with others.

What role will partnerships play in TWAS's efforts?

In the past, TWAS has successfully leveraged its budget to accomplish things that did not seem possible given the Academy's modest scale and scope. TWAS has done this largely with the help of the Italian government, which has generously provided a reliable source of core funding since the Academy's creation, and through collaboration with institutions that share the Academy's goals. I hope to continue – and indeed expand – this effort. This will mean working more closely with ICTP, IAP, IAMP, OWSDW and other Trieste-based scientific institutions. It will also mean working with such international scientific organizations as the American Association for the Advancement of Science (AAAS), the US National Science Foundation (NSF), the UK's Royal Society and others. And it will mean seeking funding from the World Bank, the African Development Bank, the US Agency for International Development (USAID) and the Japan International Cooperation Agency. Again, TWAS's unique and successful track record suggests that it could assume an important role as an 'institutional broker' helping, for example, to oversee the administration of bilateral and multi-institutional fellowship programmes in ways that bolster transparency and minimize a duplication of effort.

The Academy, in short, will need to address the challenges – and take advantage of emerging opportunities – on a number of fronts, while remaining committed to its key goals: the promotion of science and technology for the purposes of improving the economic and social well-being of people in the developing world. As an organization that operates under the administrative umbrella of UNESCO and that receives its core funding from the Italian government, TWAS represents a worthy example of international collaboration in science serving the larger interests of society. In many ways, the principles that have guided the Academy throughout its history will guide the Academy in the years ahead as TWAS continues to pursue a broad-based agenda that seeks to meet the challenges of science and development in the developing world. ■

CLIMATE CHANGE RESEARCH

2010 WAS A TURBULENT YEAR FOR CLIMATE CHANGE RESEARCH. THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC), WHICH JUST THREE YEARS BEFORE HAD SHARED THE NOBEL PEACE PRIZE WITH FORMER US VICE PRESIDENT AL GORE, WAS BUFFETED BY A SERIES OF ALLEGATIONS THAT CAST DOUBT IN THE PUBLIC'S MIND ABOUT THE ORGANIZATION'S IMPARTIALITY AND TRUTHFULNESS.

In August 2010, the InterAcademy Council (IAC), the Amsterdam-based organization that "produces reports on scientific, technological and health issues related to the great global challenges of our time," published Climate Change Assessments: Review of the Processes and Procedures of the IPCC.

As the title suggests, the report focused not so much on the immediate controversies surrounding the IPCC but more on how the organization could strengthen the ways in which it governs its overall operations and manages the publication of its reports.

In the following article, Roseanne Diab, executive officer of the Academy of Science of South Africa, who served as vice chair of the IAC review committee that produced the report, explains the committee's findings and recommendations.

Climate change is undoubtedly the scientific issue of our time. Its potential impact spans a broad range of fundamental societal concerns that include, for example, biodiversity, ecology, energy use, food security and public health. Adequately addressing the challenge requires strategies that speak to financial accountability and equity both between countries and across generations.

While global trends in climate change have become increasingly evident (at least for scientists), the impacts, especially on a regional and local scale, remain highly uncertain. Perhaps most importantly, climate change raises critical questions about rendering effective policy decisions in the face of enormous uncertainties – and the role that the scientific community should play in such efforts.

The vast majority of scientists agree on this much: changes in temperature and rainfall, instigated by the release of greenhouse gases into the atmosphere due largely to human activities, will have a profound impact on the state of the Earth's ecology and resources. Such impacts, moreover, will likely pose critical challenges and risks to human well-being as well.

Yet this much recent experience also tells us: devising an effective global strategy for dealing with such a complicated issue will not be easy and, in fact, may not be possible.

HIGH STAKES

What makes the stakes so high and therefore raises core ethical issues, is that the poorest and most vulnerable people living in developing countries will undoubtedly be the most adversely affected by climate change.

It is poor people who have a limited ability to adapt to climate change and it is poor people who depend on weather-dependent subsistence agriculture – and, more generally, natural resources – for their survival and well-being. Changes in temperatures and rainfall patterns and intensity will affect us all. But it will affect some more than others.

Climate change is undoubtedly the scientific issue of our time.

So, how should the climate change community proceed in exploring such a complex and contentious issue? This has been the fundamental challenge that the IPCC has had to confront in publishing its reports over the past two decades.

The prevailing notion among the scientific community has been to set out the facts as best it can – to highlight the most recent research findings but to acknowledge that vast gaps in knowledge and uncertainties continue to exist.

Nevertheless critics have increasingly contended that some scientists affiliated with the IPCC have strayed into the world of advocacy.

In 2010, these varying perceptions of how the IPCC operates reached a boiling point with the unauthorized publication of private email messages written by IPCC-affiliated scientists. Critics vociferously claimed that the emails revealed the prejudices and unmasked the true intentions of climate change scientists.

BACKGROUND

The World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) established the IPCC in 1988 to help inform policy decisions on mitigation and adaptation options relating to climate change.

Through periodic assessment reports on the state of climate science and the potential impacts of climate change, the IPCC has built a commendable reputation for its competence in summarizing the level of global knowledge concerning the issue. In 2007, the scientists contributing to the IPCC were collectively awarded the 2007 Nobel Peace Prize, together with Al Gore, the former vice president of the US and 'star' of the widely distributed film *Inconvenient Truth*, which has been seen by millions of people worldwide.

However, against a backdrop of the increasing politicization of the climate-change discussions and reflecting the high stakes involved, the IPCC assessment reports have come under intense public scrutiny. Increasingly, controversies have erupted over the accuracy of its conclusions and the perceived bias of its findings.

POLITICAL VORTEX

The IPCC found itself in a political vortex in late 2009 when incriminating emails and documents hacked from the University of East Anglia's server were published in the media. Critics alleged that the emails were evidence of collusion among scientists to: withhold information that did not conform to their preordained conclusions about the seriousness of the problem; ignore or recalculate data that failed to support the case for global warming; and thwart the publication of papers written by authors who questioned global warming in scientific journals.

'Climategate', as it was popularly known, coupled with some widely publicized errors in the IPCC fourth assessment report, such as statements that Himalayan glaciers would melt by 2035, damaged the credibility of the IPCC and threatened to undermine public confidence in the reports' findings.

CALLING ON IAC

In the wake of these controversies, United Nations (UN) Secretary-General Ban Ki-moon and IPCC chair Rajendra K. Pachauri asked the InterAcademy Council (IAC) to conduct an independent review and recommend ways to improve the IPCC's processes and procedures.

IAC was selected, in part, because it represents the collective expertise and experience of merit-based national science academies from around the world. IAC, in the eyes of the UN and IPCC, had both the knowledge and standing to offer an expert, impartial assessment of the panel's efforts.

The IAC review, conducted between April and August 2010, benefitted from discussions with IPCC and UN officials, as well as with scientists holding

wide-ranging views of IPCC processes and procedures. A broadly disseminated questionnaire yielded more than 400 responses from researchers across the globe.

SUCCESS BUT...

The IAC review committee concluded that the IPCC process had been an overall success. Indeed the review committee stated that IPCC deserves a great deal of credit for raising public awareness about climate change issues. The committee also praised IPCC for sustaining the involvement of the 194 participating governments and for maintaining the enthusiastic commitment of thousands of scientists over the past two decades – all of whom made their contributions on a voluntary basis.

By creating a unique and productive partnership between scientists and governments, the IAC review committee noted that IPCC has raised the level of scientific debate on a global scale and helped to influence the science agendas of many countries – all for the better.

IPCC found itself in a political vortex in late 2009.

Nevertheless, the IAC review committee was critical of many of IPCC's governance and management procedures and processes.

To overcome the IPCC's shortcomings, the committee offered a number of key recommendations to strengthen how the organization both governed itself and interacted with the public. It observed that the IPCC has consistently failed to keep pace with the growing public demand for accountability and transparency that has taken place since IPCC was created in 1988.

Specifically, the review committee concluded that IPCC's management structure was not fully equipped to respond to the intense public and media interest in its work and, more generally, the debates engulfing the issue of climate change, which were becoming more heated and intense.

To address such shortcomings, the committee called for the creation of an executive committee to guide and evaluate the IPCC's decision-making process on a continual basis; the appointment of an executive director to oversee the IPCC secretariat in Geneva, Switzerland, and manage its day-to-day operations; the adoption of stringent conflict of interest guidelines for participating scientists to avoid the appearance of deriving personal benefits from being affiliated with IPCC; and a broad expansion of communication efforts to better inform the public and effectively respond to the media.

In addition, the review committee recommended one-term, non-renewable appointments for the IPCC chair and its three working group co-chairs, corresponding to the timeframe of one assessment.

The committee reasoned that each of these voluntary positions is held for lengthy, six-year terms. Appointing new chairs and co-chairs once every six years would help generate fresh perspectives and foster a working environment that would encourage innovative approaches for the challenges that would arise during each new round of the assessment reports.

FOLLOWING GUIDELINES

The review committee found that adequate policies and guidelines were largely in place for the production of the assessment reports. However, the committee

concluded that these policies and guidelines were not always followed or applied consistently by the three working groups.

For example, the mistaken conclusion that there was a "high probability" that the Himalayan glaciers would disappear by 2035, as reported by working group II, was attributed to a failure of the review process.

IPCC procedures require that all chapters undergo two formal reviews: the first solely by experts appointed as reviewers and the second by a mix of scientific experts and government representatives. In some cases, there is also an informal review of the preliminary text before the formal review process takes place.

At minimum, two review editors are appointed for each chapter. They are responsible for ensuring that the chapter's authors address the reviewers' comments, especially those involving controversial issues.

Reviewers, in fact, questioned the report's conclusion that glaciers in the Himalayans would disappear by 2035. Yet, the comments were inadequately considered and the error slipped through.

The committee concluded that stronger enforcement of existing IPCC review procedures would minimize the chance of errors cropping up. It therefore recommended strengthening the role and authority of the review editors. The committee also urged that review editors take steps to ensure that the reports fully reflect disagreements among scientists and that full consideration be given to alternative views. More specifically, the committee recommended that lead authors be required to explicitly document that they have considered the full range of scientific views concerning each of the issues that has been examined.

GREY AREAS

The use of grey literature from unpublished or non-peer-reviewed sources – for example, reports by government agencies and nonprofit organizations – has proven to be particularly controversial.

On balance, the review committee found that such information is both relevant and appropriate. Yet, it strongly urged that IPCC's guidelines for evaluating grey literature be revised and strictly enforced to ensure that unpublished and non-peer-reviewed literature is sufficiently vetted for accuracy and that this literature is appropriately tagged as non-peer-reviewed information in the report.

The committee also called for more consistency in how each working group characterizes uncertainty. It found that in the fourth assessment each working group used a variation of IPCC's "uncertainty guidelines" and that the guidelines themselves, once published, were not always followed. For example, the report of working group II contains many statements that were assigned "high confidence", yet the group presented little evidence to support the conclusions.

The committee recommended that in future assessments, working groups avoid presenting numerical

COMMITTEE TO REVIEW THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

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quantified assessments (for instance, stating that there is a 95% certainty that an event will occur or a trend will unfold) when the evidence fails to support such precise findings. Instead, the committee recommended that the working groups avoid probabilistic statements and instead present descriptive qualified statements of their understanding of an issue – and then explain both the amount of evidence that is available to support such a statement and the level of agreement that exists among experts (for example, using such terms as "high agreement" and "much evidence").

The need for transparency was another critical issue that surfaced during the IAC review, particularly in interviews with scientists.

A number of scientists who participated in the IPCC process contended that they did not fully understand the process by which the information was collected and reviewed. Equally important, they complained that the procedures used to select working group co-chairs and authors remained largely opaque and often inscrutable.

To address these shortcomings, the IAC review committee recommended that the selection become much more transparent.

AND FOR DEVELOPING COUNTRIES...

Both IPCC participants and observers have expressed concerns about the limited level of involvement by scientists from developing countries ever since the IPCC's inception.

Developing countries now represent nearly 70% of the IPCC member states.

It is important to note that important progress has been made in addressing this challenge over the past two decades. The progress is in part due to strenuous efforts by the IPCC and in part due to the growing commitment to science and science-based development among developing countries.

For example, governments in developing countries now represent nearly 70% of the IPCC member states. Their presence has given the South a strong voice in general discussions about the direction of the IPCC. Nevertheless, when it comes to the detailed research agendas formulated by the scientific community, progress to date has been much more limited. Indeed more than 75% of the authors of the IPCC's assessment reports still live and work in developed countries.

The committee noted that full participation by developing countries is necessary to build worldwide trust, confidence and ownership in the process, and to ensure that the effort takes full account of the interests

Full participation by developing countries is necessary to build worldwide trust, confidence and ownership in the process.

and needs of all countries.

The lack of participation by scientists from developing countries can be attributed to the chronic challenges faced by scientists in poor countries with weak scientific infrastructures. These challenges include the exclusive use of English to communicate during the preparation of the working group reports, a lack of support by their home institutions, limited access to literature, and the small number of qualified scientists working on climate-change issues.

In the interviews that were conducted during the IAC review, many African scientists drew attention to their isolation and the difficulties that they have faced in participating in the IPCC process while maintaining heavy teaching loads and having limited, often delayed, access to the data and literature. Overcoming these challenges will require extensive investment in human capital and scientific infrastructure in developing countries.

POSTSCRIPTS

The IPCC considered the findings of the IAC review report at its plenary session in Busan, South Korea, in October 2010. It agreed to implement many of the recommendations immediately, including the report's recommendations on how to deal with discussions of uncertainty and the conditions under which to include grey literature.

In addition, the IPCC agreed to create a task group to examine the full range of issues related to the establishment of an executive committee, as well as possible reforms in the governance of the secretariat and the selection and responsibilities of the chair and co-chairs.

At its annual meeting in Abu Dhabi, held in May 2011, the IPCC agreed to having report editors and authors complete a form declaring any conflicts of interest and to establish a system for identifying errors that would allow for input from both the scientific community and public.

In addition, the IPCC agreed to continue to permit non-peer-reviewed literature to be cited in the reports but only when it could be shown to be scientifically and technically valid. Print and broadcast media, as well as blogs and social networks, would not be considered acceptable sources of information for IPCC reports. And the IPCC agreed to establish an executive committee that would have an oversight role in the management of the reports.

Preparations for the fifth assessment report, which is scheduled for publication in 2014, are under way. The IPCC has expressed hope that the report will benefit from the efforts of the IAC.

As Harold T. Shapiro, chair of the IAC review committee, noted in the preface to the report: "IPCC can remain a very valuable resource, provided it can continue to highlight both what we believe we know and what we believe is still unknown and to adapt its processes and procedures in a manner that reflects both the dynamics of climate science and the needs of public policy for the best possible understanding of a changing global climate, its impacts and possible mitigation initiatives." ■

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To review the complete text of the IAC report,
Climate Change Assessments: Review of the Processes and Procedures of the IPCC,
see reviewipcc.interacademycouncil.net.

ICTs IN KOSOVO

BUILDING SCIENTIFIC CAPACITY, BASED ON A STRONG FOUNDATION IN INFORMATION AND COMMUNICATION TECHNOLOGIES, IS A KEY TO A BETTER FUTURE FOR KOSOVO, SAYS LULE AHMEDI, ASSOCIATE PROFESSOR OF ELECTRICAL AND COMPUTER ENGINEERING AT THE UNIVERSITY OF PRISHTINA. AHMEDI SPOKE ABOUT THE STATE OF SCIENCE AND DEVELOPMENT IN KOSOVO AT THE TWAS-IAP CONFERENCE, 'PROMOTING REGIONAL COOPERATION IN SCIENCE, TECHNOLOGY AND INNOVATION IN THE BALKANS'.

Kosovo's history spans thousands of years. It dates back to antiquity when it belonged to a region called Dardani. Over the centuries, Kosovo has been part of the Roman, Byzantine, Bulgarian, Serbian and Ottoman empires. The Albanians consider Kosovo their native land and themselves the descendants of the ancient Illyrians, the indigenous people of Kosovo. The Serbs consider Kosovo the cradle of their culture.

In February 2008, the Kosovo Assembly declared independence. In October 2008, the UN General Assembly formally asked the International Court of Justice to provide an advisory opinion on the issue of Kosovo's independence and, in July 2010, the court ruled that the Assembly's decision "did not violate" international law. Some 70 countries now recognize Kosovo's status as an independent country.

Recent efforts to build capacity in information and communication technologies (ICTs) in Kosovo provide a stark illustration that life goes on even under the most difficult of circumstances. It also shows that efforts to promote science and technology and, more specifically ICTs, could help Kosovo overcome its chronic state of poverty and isolation.

Kosovo is small. It covers just 10,000 square kilometres and it is home to some 2 million people.

As of 2008, surveys revealed that a mere 114 people in Kosovo worked on research issues related to ICTs and that just 17 of these people held doctorate degrees. The University of Prishtina, Kosovo's largest university, is the only public-sector institution conducting ICT research and development (R&D).

The paltry amount of ICT R&D is lamentable. It restricts the knowledge base needed to advance ICTs, particularly for software engineering. It denies the government the knowledge workers that it needs to devise effective strategies for expanding ICTs. It limits the data and information necessary to assess trends in ICTs. And, it reflects, in its own way, the shortcomings of Kosovo not only in this vital area of science and technology but, more generally, in global efforts to promote science-based development.

But shortcomings in R&D have not prevented Kosovo from making progress on the ICT front. The government has assisted this effort by passing laws and regulations that have facilitated the development of ICTs, including a law on "information society services" that gives electronic documents the same legal status as paper documents, and a law on the "protection of personal data", which makes it a crime to utilize personal information on the web without legal consent.

In 2010, the government also introduced a five-year plan for developing ICTs. The plan is designed to help boost economic growth and enhance the quality of life of all citizens. A large part of the effort will focus on improving the management and distribution of government information. The goal is to ease bottlenecks and raise public awareness of government policies and programmes.

As for Kosovo's research community, the plan calls for initiatives to facilitate timely access to information and to draw scientists and scientific institutions in Kosovo closer to Europe's research community. Other goals include placing information and images of Kosovo's historic monuments on the internet to promote scholarly research, citizen awareness and tourism.

Plans are one thing; money is quite another. That's why it is encouraging to note that financial investments in Kosovo's ICT infrastructure are also rising.

A survey conducted in 2007 (the latest year for which information is available) shows that there are less than 100 private ICT firms in Kosovo and that these firms – many of which are no more than one- or two-person operations – provide employment for between 400 and 600 people.

Yet, equally important and on a more optimistic note, surveys show that investments in ICTs have been climbing at an annual rate of 30% and could total more than USD135 million by the end of this year.

More than 75% of the investment continues to be for hardware. The remaining 25% is equally divided between purchases of software and services. This is a reflection of the early state of ICT development in Kosovo. The physical infrastructure must be built before demand for ICT software and technical services can be expected to grow – and Kosovo has not yet reached that stage of ICT development.

Just over one-third of the population in Kosovo is currently connected to the internet. That compares to nearly 70% of the population in France and nearly 55% in Italy. Nevertheless, this low percentage belies the rapid pace of growth that is now taking place. In fact, the number of internet users increased from 22% in 2008 to 36% in 2010.

Kosovo has three major internet providers – iPKO, Post-Telecom of Kosovo (PTK) and Kujtesa. These

providers not only report that household internet access is increasing rapidly, but that internet penetration in business and industry is attaining new heights. Indeed it could be argued that internet use by the business sector is driving ICTs forward through its demand for access (including broadband access), its emphasis on high-quality service and the need to conform to international standards.

As is true for other regions that have been slow to develop their ICT capacity, Kosovo's late start has provided some advantages in its current efforts to catch up. For example, less than 5% of the population has landline phone service. People instead have opted for mobile phones, which are now used by more than 75% of the population.

The ability to embrace such 'leapfrog' technologies holds great promise for quickly narrowing the gap between Kosovo and more technologically advanced places. This will likely be a boon to Kosovo's efforts to take advantage of the scientific capabilities and know-how in places with more advanced ICT capabilities – and ultimately to become more fully integrated into the larger European community.

Strengthening ICT capabilities is now a high priority for the government.

INVESTING IN PROGRESS

A study funded by the European Union (EU), *National Background Report on ICT Research for Kosovo for 2009-2013*, examined areas in which Kosovo might be ready to advance ICTs in the short term, as well as areas in which it might be possible to take advantage of ICTs in the future – all based on the current state of ICT research and development.

Areas listed in the report where Kosovo could take immediate advantage of ICTs to improve the efficiency and productivity of operations include ICTs for e-government, e-learning and e-business. Areas listed in the report where Kosovo might be able to take advantage of ICTs in the future include e-health. The report also emphasized the need for additional R&D for advancing internet and broadband use, adapting technologies to better ensure privacy protection for commerce and trade, and expanding the scope and impact of software engineering.

Indeed the report called for investments that would strengthen the capacity of Kosovo's ICT specialists to engage in state-of-the-art software development. Such efforts, the report concluded, would spur the creation of products and services tailored to Kosovo's ICT needs and enhance Kosovo's ability to participate in the global ICT marketplace.

Kosovo's government currently uses ICT services for management and budgeting. Electronic voting also takes place in Kosovo's government assembly. In addition, citizens can make payments online through e-services offered by Post-Telecom of Kosovo and other large billing firms.

To date, the electronic portals that have been introduced have been simple pay portals which do not offer the full range of interactivity that users in the EU and other regions with more sophisticated ICT infrastructures have come to expect. The ability of internet users to browse and purchase products and services online remains limited.

Similar limitations also exist for e-learning. Several universities have built a basic e-learning infrastructure that is capable of receiving and downloading

information from around the world. But the dynamic interactive learning environments that are now present on many campuses with advanced electronic communications infrastructure have yet to arrive in Kosovo. The ICT infrastructure in primary and secondary schools is even less advanced.

As for e-business and e-health infrastructure and services, Kosovo remains a step behind some of its neighbouring countries and many steps behind the pace of progress in the EU, the Americas and growing parts of Asia and South America.

Strengthening ICT capabilities in these sectors is now a high priority for the government. For instance, the current healthcare strategy calls for the creation of an electronic healthcare information system by 2015. Whether Kosovo has the R&D capacity to put such a system in place in such a brief time is an open question. At the very least, it will require significant investments in both infrastructure and the training of personnel.

In 2010, Kosovo established a strategic framework for research.

ROLE OF RESEARCH

In 2010, Kosovo established a strategic framework for research, *The National Research Programme of the Republic of Kosovo*, that includes five priority areas: natural resources; energy and the environment; agricultural production and food security; medical research; social and economic studies; and linguistic, cultural and historic studies. In addition, it designates ICTs as a cross-cutting priority of critical importance to each of the other focus areas.

The strategy emphasizes the need for research to contribute directly to economic growth and the social well-being of the people. It maintains that such an approach is not only the right thing to do in light of Kosovo's need to expand the economy and reduce the level of poverty, but that it is also in the self-interest of the research community. Seeking to address society's critical needs would help generate support for research and provide an important justification for additional funds in the future.

ACADEMIES IN THE BALKANS

Last autumn, TWAS and IAP, the global network of science academies, organized an international workshop focusing on 'The Role of the Academies in Promoting Regional Cooperation in Science, Technology and Innovation (STI)". More than 60 participants from 19 countries, including presidents and representatives of academies in Albania, Belarus, Bosnia-Herzegovina, the Czech Republic, Kosovo, Macedonia and Montenegro were in attendance. Representatives from the Italian Ministry of Foreign Affairs and the Italian Ministry of Education, University and Research (MIUR) also participated.

A primary goal of the conference, noted Mohamed Hassan, then executive director of TWAS and currently co-chair of IAP, was "to showcase the breadth and depth of scientific knowledge that currently exists in the Balkans in a variety of fields, including information and communications technologies, biotechnologies, climate change, environmental risks and natural hazards, nanotechnology and physics and astrophysics."

The conference, which also included a large number of Italian scientists, was designed to provide a broad platform for the sharing of information and ideas.

The workshop's concluding session examined the role that the academies in the Balkans play in providing evidence-based information to governments.

"Countries in the Balkans have experienced a period of dramatic change over the past two decades," noted Hassan. These changes have had a significant impact on the relationship of the region's academies to society.

"The traditional frameworks under which academies in the region have operated," he added, "have largely been reformed and replaced by forces that have dramatically realigned the academies' relationship not only to government but also to other sectors of society."

As conference participant Ivos Slaus, director of the Southeast European Division of the World Academy of Art and Science in Zagreb, Croatia, noted in a statement drafted following the conference: "Science academies in the Balkans are eager to play a pivotal role at the interface of science, governance and economics. This involves more than giving advice. It also entails the sustained active involvement of scientists – through their science academies and other scientific institutions – to ensure that the best scientific information and insights are provided for helping to solve critical social problems. Through their own efforts and in collaboration with such institutions as TWAS and IAP, the science academies of the Balkans are dedicated to helping their societies achieve greater economic well-being."

Ljubisa Rakic, vice president of the Serbian Academy of Science and Art, observed that "Balkan science academies have to develop a long-term strategy to play an important role in the public advisory system. The academies," Rakic added, "must preserve their stability and independence to be of superior standing in society and give sound advice."

To move forward, the strategic framework programme recommends that Kosovo's research community:

- Establish international standards for the evaluation and production of its grant proposals and research reports, seeking the engagement of scientists and scholars from abroad.
- Broaden its interaction with the European research community by increasing the number of joint research projects and exchange programmes. (This would not only help strengthen Kosovo's research base but also improve its administrative and managerial capabilities.)
- Build a national R&D information system, readily accessible to institutions in both the public and private sectors. (The system would provide vital statistics on research trends both within Kosovo and across the globe.)
- Train the next generation of scientists both within Kosovo's university system and through joint master's and doctoral programmes with foreign universities, especially those in Europe.

- Support the creation of electronic libraries that would put Kosovo's research community in touch with the latest scientific information and funding opportunities.

STRATEGIC VISION

With the formulation of the strategic framework, Kosovo has established a pathway for economic progress that is realistic and doable. It calls for capacity building efforts that begin with raising the level of scientific expertise through strengthening the scientific infrastructure, offering competitive grants to promising scientists and providing stipends to study elsewhere (especially with colleagues in Europe). It voices support for the establishment of a fund to entice Kosovo's scientific diaspora to work with colleagues in their home country.

Kosovo has established a pathway for economic progress that is realistic and doable.

At the centre of this strategy is a focus on building and expanding Kosovo's ICT infrastructure as an enabling force that would help overcome the isolation that has plagued the scientific community and that would pave the way for collaborating with colleagues not only in Europe but also across the globe.

The strategy notes that, at some point, attention could be turned to such long-term goals as building centres of excellence and innovation, establishing thematic programmes in science and technology in areas of national importance, and developing university-industry partnerships for the development of science-related products and services.

But the strategy recommends that these goals should only be sought once Kosovo's scientific capacity passes a threshold of success marked, for example, by ample training and job opportunities, fully-equipped laboratories, a growing number of articles published in peer-reviewed journals, and active participation of its scientists in international workshops and conferences.

Kosovo enjoys an enviable strategic position in southeast Europe and could serve as a vital crossroads for trade and scientific and cultural exchange. Some 70% of its population is less than 35 years old, which gives it the most youthful population in Europe. Its people, moreover, are multilingual (the national languages are Albanian, Serbian and English). There is no denying that political tensions and uncertainties remain. Nevertheless, the region currently enjoys a period of relative calm making progress possible.

Strong investments in science and technology will be necessary to place Kosovo on a path of sustainable development. There is no better place to start than in improving the ICT infrastructure. ■

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FUN WITH NUMBERS

QUEENA NGO LEE-CHUA, THE PHILIPPINES' SCIENCE COMMUNICATIONS QUEEN, IS TEACHING HER COUNTRYMEN AND COUNTRYWOMEN TO LOVE SCIENCE AND MATHS. THE TWAS REGIONAL OFFICE IN EAST AND SOUTH EAST ASIA (TWAS-ROESEAP) RECENTLY RECOGNIZED LEE-CHUA'S EFFORTS BY AWARDING HER THE 2010 PRIZE FOR THE POPULARIZATION OF SCIENCE.


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"Help, I have a teenage daughter who is flunking maths!" "Help, I'm a high school student who hates trigonometry!" "Help, I'm a teacher in the hinterlands who doesn't have sufficient resources."

That's the way most of the letters begin that Queena Ngo Lee-Chua receives from readers of her weekly science and education column 'Eureka!' in *The Philippine Daily Inquirer*.

The calls for help would even be louder, were it not for Lee-Chua, the maths-cum-psychology major who has become the Philippines' science communications queen.

"I've been writing this column for 20 years, and readers still ask the same questions!" she exclaims.

In her columns she has written about how to prepare for examinations, what parents should look for when hiring a tutor and tips for teachers wanting to spice up their lessons. Still, her readers clamour for more information and advice.

To say she is 'prolific' would be an understatement. In addition to her column for the *Inquirer* she also writes a monthly column on homework for *Working Mom Magazine*. She once hosted a television show, *'Fun with Math'*, and has published more than 20 books on topics ranging from science and maths to parenting and financial matters.

Add to that a full-time job teaching and conducting research in mathematics and psychology at the country's *Ateneo de Manila University*, and Lee-Chua's curriculum vitae reads like it belongs to someone much older than her 40-odd years.

She has received an avalanche of awards for her teaching, research and journalism. In 2005, *Marie Claire* magazine chose her as one of the 25 "most incredible" women in the Philippines. In 2008, the

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THE PHILIPPINES AT A GLANCE

The Philippines, comprised of more than 7,000 islands, may be famous for its natural beauty, friendly people and crystal clear waters. But it is also a natural disaster "hotspot" visited upon by earthquakes, volcanic eruptions and typhoons. Rising sea levels and global warming threaten the country's coastal populations and bountiful coral reefs.

The islands were a Spanish colony for more than 300 years, and most Filipinos remain devoutly Catholic. The early 20th century saw a takeover by the United States until independence in 1946.

Post-colonial rule has been marred by corruption. Two of the country's leaders have been deposed by mass demonstrations, so-called "people power" revolutions – the first in 1986 and the second in 2001.

The Philippines export electronics, clothing, food, chemicals and timber. But despite a buoyant economy, many Filipinos live in poverty. The country has the highest birth rate in Asia, and its 92 million strong population could double within three decades.

The country's 2007 science budget only corresponded to 0.14% of the gross domestic product (GDP), significantly less than 0.69% of the GDP in neighbouring Malaysia and 2.12% of GDP in Singapore. Opportunities for science and technology professionals in the country are meagre, forcing many to go abroad to find work.

Department of Science and Technology (DOST) in the Philippines honoured her as one of the country's great scientists. And last year, she won the TWAS Regional Office in East and South East (TWAS-ROESEAP) prize for the popularization of science (for information about the other winners, see 'Popularizing Science in the Developing World', p. 38).

Lee-Chua's love of science – and maths in particular – is not par for the course in the Philippines. While students in many Asian countries excel in science and maths, her country scores dismally in international tests. The two times the Philippines participated in the international Trends in International Mathematics and Science Study (TIMSS), it scored third from the bottom (see 'Maths in the Philippines', p. 41).

"Maths is the most disliked subject in the school curriculum in the Philippines. The students are not only anxious about it, they actually detest it," Lee-Chua explains.

MINDFUL OF MATHS

So how did she come to study maths at university? Simply put, she liked it. Her choice was between maths or the arts because she also liked writing and reading. But some wise words from a counsellor tipped the scales in favour of maths. "If you want to write," the counsellor advised, "you don't need a degree to do it. But if you want to go deep into maths, then you probably need expert guidance."

For Lee-Chua, maths was also a refuge from the turbulent society she grew up in. In 1986, the year before she graduated with a bachelor's degree, the 20-year reign of the authoritarian president Ferdinand Marcos came to an end in a series of peaceful protests known as the "People Power Revolution". Although Lee-Chua was involved in the political movement, she longed for something more stable.

"We were campaigning for many things, and I was part of that. But I didn't want to pursue studies in


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fields like political theory or economics, which seemed just as confusing as the world around me. In mathematics, there are definitive proofs and answers. It provided an academic and a personal refuge," Lee-Chua explains.

HOMEWARD BOUND

When she graduated *summa cum laude* in 1987, her maths career seemed to be on the verge of a sharp turn in direction. She was offered scholarships to pursue higher maths studies in the United States, but her family put a stop to her dreams of going overseas.

"Although I'm Filipino, I'm of Chinese descent, and my parents were extremely protective. I'm the eldest, and they told me that if I were to go to the US for graduate studies, there was a good chance that I would never come back.

Mathematics provided an academic and a personal refuge.

"They were probably right," she admits. "And so, when they demanded that I stay, I decided to heed their warning."

Nevertheless Lee-Chua's academic advisors cautioned her against entering postgraduate study in maths solely in the Philippines. While working out what to do next, Lee-Chua began teaching mathematics at the university after graduation.

LEE-CHUA'S TOP FIVE TEACHING TIPS

Real-life. *Students always want to know why they are supposed to learn something. At the start of a course, I explain to the students the real-life applications of what they are about to learn. But I also tell them that they will not be able to fully understand the applications until they have completed the course.*

Humming along. *For algebra, instead of memorizing the formulas, I tell the students to put it into a song that they like, or to turn the formulas into a rap. It helps them remember them, and it's fun!*

Story lines. *Variation is the key to making classes fun. I sometimes ask students to write short stories on maths. I may ask them to surf the internet for maths poems, maths riddles or maths jokes.*

Nerds no. *The people who came up with the maths formulas we study were not nerds. Look at how handsome Galois, the 19th century French mathematician, conducted himself and how he died in a duel! If we have time, I may ask students to dramatize the lives of these people.*

Compound interest. *After the financial crisis I felt we needed to teach financial literacy at the most basic level. So, I gave my students lessons on how to calculate compound interests and why they should pay off their credit card bills in full. I even arranged for my students to see* Wall Street 2*, the movie with Michael Douglas, and discussed the picture's overarching themes in class.*

POPULARIZING SCIENCE IN THE DEVELOPING WORLD

The TWAS regional prizes, which are awarded by TWAS's five regional offices, carry a USD3,000 cash award. In 2010, the prizes were given to individuals who have made outstanding contributions to improving public understanding and appreciation of science.

In addition to Queena Ngo Lee-Chua, who received the award from the TWAS regional office in East and South East Asia and the Pacific (TWAS-ROESEAP), the other prize-winners are:

Elias Baydoun / TWAS Arab Regional Office (TWAS-ARO)

Elias Baydoun is professor of biology and biochemistry at the American University of Beirut in Jordan. Following the completion of postgraduate studies at the University of Cambridge, UK, he assumed a key role in the early development of Yarmouk University. In addition to his appointment as associate biology professor, he was assistant to the president, director of planning and development, and director of personnel. He later moved to the American University of Beirut, becoming chair of the department of biology at a critical phase in its development when he was the only full-time faculty member with a doctoral degree. More recently, he has organised a series of international scientific meetings leading to the creation of the Arab Academy of Sciences. Baydoun's other contributions include preparing biology curricula and textbooks for secondary schools and community colleges in Oman, writing biology textbooks for the ministry of education in Jordan and leading a project on health education in Jordanian schools. He has also translated into Arabic the region's most widely used university-level textbook in biochemistry.

Mahaletchumy Arujanan / TWAS Regional Office for East and South-East Asia and the Pacific (TWAS-ROSEAP)

Mahaletchumy Arujanan is executive director of the Malaysian Biotechnology Information Centre (MABIC). She is recognized for her role in promoting public understanding of science for human resource development. Under Arujanan's leadership, more than 50 institutions, including universities, research institutes, government agencies and ministries, have been engaged in programmes for public understanding of science. Arujanan has helped build MABIC into an internationally recognized biotechnology information centre. With support from the ministry of education, she was the first individual to organize hands-on biotechnology workshops for teachers. She has involved Islamic scholars in discussions of the critical role that public acceptance plays in advancing applications of biotechnologies. Mahaletchumy is Malaysia's only science communicator who conducts media workshop to ensure journalists have a basic understanding of biotechnology. Through her work, Arujanan has reached scientists, policy makers, industry officials, regulators, media representatives, religious leaders, teachers and students.

Guillermo Chong Díaz / TWAS Regional Office for Latin America and the Caribbean (TWAS-ROLAC)

Guillermo Chong Díaz is a professor of geology in the department of geological sciences at Chile's Catholic Uni-

Coming face-to-face with the aversion that most students had for maths helped her to realize something unexpected yet extraordinarily important for the future direction of her career: "I realized that I didn't need more maths skills," she says. "What I really needed was more psychology skills to teach students who were so anxious about being bad at maths." She discussed the problem with professors and they suggested she study psychology.

Psychology could not be any more different than maths. Nevertheless, Lee-Chua found that she enjoyed the subject precisely because it provided her with the

versity of the North, and director of two scientific museums: the Humberto Fuenzalida Geological Museum at the Catholic University of the North and the Museum of the Atacama Desert. He is widely recognized for his promotion of the public understanding and popularization of science through his teaching, books and efforts to establish the two scientific museums that he currently heads. Díaz, a university professor for more than 35 years, has written over 170 scientific articles. He has also published two children's books on geology. Díaz has received the National Prize in Geology in 2003, the CONICYT (Chile's National Commission for Scientific and Technological Research) Prize Explora *in 1997 and the Bicentennial Medal sponsored by the Regional Governor of Antofagasta, Chile, in 2010.*

Arvind Gupta / TWAS Regional Office for Central and South Asia (TWAS-ROCASA)

Arvind Gupta works at the Muktangan Science Centre for Children located at the Inter-University Centre for Astronomy and Astrophysics in Pune, India. He is recognized for his role as a science popularizer and toymaker. Gupta has organized thousands of workshops in India and abroad, and has appeared on numerous television programmes showing viewers how to make science toys from discarded materials. He shares his passion for books and toys through his popular website arvindguptatoys.com. After earning a bachelors' degree from the Indian Institute of Technology (IIT) in Kanpur and working at Tata Motors, Gupta joined a village science teaching programme for children in Hoshanagabad, Madhya Pradesh, where he relied on ordinary things to do science. His first book Matchstick Models and Other Science Experiments *was translated into 12 Indian languages and sold more than 500,000 copies. He has written 17 books and translated another 100 books on science, environment and education in Hindi, and has organized science workshops for children and teachers in over 2000 schools across the country. Arvind's outstanding contributions to the design of science teaching aids for young children has been recognized by UNESCO, UNICEF, MIT Media Lab and International Toy Research.*

Felix Konotey-Ahulu / TWAS Regional Office for Sub-Saharan Africa (TWAS-ROSSA)

Felix Konotey-Ahulu is the Dr. Kwegyir Aggrey distinguished professor of human genetics at the University of Cape Coast, Ghana, and a physician and genetic counsellor in sickle cell disease and other haemoglobinopathies in the UK. He is recognized for his outstanding contributions to sickle cell disease research, especially for his efforts to increase public awareness about this disease. He traced the hereditary sickle cell disease in his own family back to 1670 and was the first to teach Ghanaians and the world that hereditary rheumatism was, in fact, sickle cell disease. He later gave public lectures that stressed one in three Ghanaians in Ghana and in the diaspora carry a beta globin gene that produces sickle haemoglobin 'S', haemoglobin 'C' or 'haemoglobin others'. He has encouraged people to determine their carrier status and has written Sickle Cell Disease: The Case for Family Planning. *He continues to conduct genetic counselling. His websites www.sicklecell.md and www.konotey-ahulu.com provide valuable information for people worldwide who are concerned about this disease.*

tools that she need to understand her student's deep-seated dislike for maths.

A master's degree in counselling psychology was followed by a doctorate degree in clinical psychology that she received in 1995. Her doctoral dissertation focused on the psychological dynamics of family businesses. "I was ready to start doing something on maths learning, but a management professor persuaded me to try looking into how family businesses thrive in the Philippines. Since my father was a businessman, I felt that this could be a good topic for a thesis," she says.


Flickr/advriter


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Queena's thesis was published in a book titled *Successful Family Businesses*. It won the Outstanding Monograph Award from the Philippines National Academy of Science and Technology in 2001.

More recently, Queena's research has examined the psychology of maths and science learning. "I guess you could say that I experimented on my students," she laughs, "since many of my insights were derived from careful observations of my students in the classroom."

She has also investigated mathematical knowledge among indigenous tribes in the Philippines. "Several of them know basic maths. I looked at geometry in their art, their counting systems based on body parts, and their rhymes and games."

As for Filipinos' aversion to maths, Lee-Chua believes there are historical reasons. "Spain, which colonized the Philippines, didn't think it was necessary to teach the natives maths or science. That colonial mindset seeped deep into our culture. We still struggle because of that."

Her research once even brought her in close contact with the messy world of international politics. A few years ago, she assisted the government of the Philippines on how to deal with the country's claim to the Spratly islands – a cluster of islets in the South China Sea whose ownership is disputed by several countries, including China.

The diplomats wanted Lee-Chua and a US-based colleague, José Cruz, to use game theory to model whether the Philippines should turn to diplomacy, military intervention or both to defend its claim over the islands. The models suggested both approaches were needed, Lee-Chua says. "A diplomatic intervention on its own would not work – China would laugh at us, and a military conflict, we could simply not win." So, we suggested a combined military and diplomatic approach.

I hope I am a role model.


Flickr/Jonas Pietes

Lee-Chua says that she was happy to see the project come to an end. She went into maths because it was safe and secure, not to play war games. "Quite frankly, I fretted about doing this kind of research," she says.

WRITING IT DOWN

Her writing came about at the same time as her interest in psychology. "One of my professors was a columnist for the *Inquirer*. I remember complaining to her that there were no science stories in the newspaper. She gazed at me and said: 'That's because nobody wants to write about science. Why don't

http://momabouttownd avao.blogspot.com/

MATHS IN THE PHILIPPINES

Asia produces some of the most mathematically literate students in the world. So it may come as a surprise that the Philippines scores abysmally in international mathematics studies.

Both times it participated in the Trends in International Mathematics and Science Study (TIMSS), the Philippines came third from the bottom. Out of the 38 participating countries in 1999, only Morocco and South Africa received lower scores. Four years later, in 2003, the Philippines retained its third-lowest score even though 46 countries participated. This time, only Morocco and Tunisia had lower scores.

Several reasons have been given for the Philippines' low scores, including overcrowded classrooms, a lack of interest among students and low educational levels among parents.

you?' So I wrote a story with the title 'Why be afraid of maths?' and sent it to the paper."

The *Inquirer* published the story in March 1991. Lee-Chua was an overnight success. "The editor called me the following week telling me that I was their most popular writer, and that they had received piles of letters addressed to me. She offered me my own column three months later. My first book, which was a compilation of my early articles, was published in December that year."

What readers say about her writing is not always positive. "I remember writing about evolution and Darwin. Wow, did I get hate mail from the creationists!" Articles about genetic engineering also led to a barrage of disparaging comments. "I wrote about the pros and cons of genetically modified crops and tried to be as balanced as possible. However, I ended up getting hate mail from both sides," she says.

But she also receives fan mail. "I even have a fan club," she says sheepishly. Her youngest fan is five years old. "She wrote that I am her idol!"

Does she see herself as a role model? "I hope I am a role model," she says. Her son Scott certainly seems to think so. The 12-year old is a maths whiz. He has also published three books – travel guides to foreign countries written for children. "My editor chanced upon an account my son had written about his trip for his family and friends. When she read it, she wanted Scott to write travel books from the perspective of a child. She said that there were no travel books written for children by children, so she urged him to try to do one."

Lee-Chua maintains that she gets her energy from her students.

"I genuinely care for them, even if they can sometimes be a handful and a nuisance." She is convinced all students are hungry for knowledge.

"They've been given a bad rap and have often been scolded for not listening. But they do. When they come to my class they are noisy, but once you attract their interest, they don't want to leave. They might despise maths when they first come through the door, but I am convinced that they despise it less when they leave for the next grade."

For Lee-Chua, the Philippine's maths queen, it all adds up to a better life for both her and her growing list of admirers – one that she plans to continue to pursue with the same purpose and dedication that she has maintained for the past two decades. ■

FISHING FOR A FUTURE

FOR THE PAST 50 YEARS, A RELATIVELY SMALL SOUTH AFRICAN RESEARCH INSTITUTE, THE SOUTHERN AFRICAN INSTITUTE FOR AQUATIC BIODIVERSITY (SAIAB), HAS SPEARHEADED EFFORTS TO STUDY AFRICA'S FISH FAUNA AND THEIR ECOSYSTEMS.

Some of the world's least studied ecosystems lie off the coast of Africa. This is especially true along the east coast, where the warm waters of the western Indian Ocean support a rich diversity of life.

As in many other parts of the world, the vitality of Africa's oceans, rivers and lakes, and the contributions that they make to the economy, are threatened by overfishing, pollution and climate change. A scarcity of knowledge about these ecosystems, moreover, makes the impacts posed by these threats difficult to predict.

For the past 50 years, the South African Institute for Aquatic Biodiversity (SAIAB) has sought to deepen the continent's knowledge of its vast and prolific water worlds, earning the institute well-deserved reputation for its efforts both at home and abroad.

SAIAB has just eight permanent scientific staff members. But the institute casts a net well beyond its resources, not just because of its skilled and dedicated staff but also because of the value of its international networks and partners.

SAIAB, for example, offers postgraduate training in ichthyology (the study of fish) and aquatic biodiversity in partnership with Rhodes University's Department of Ichthyology and Fisheries Science. In addition, it oversees programmes to teach fisheries officials in South Africa and other Southern African Development Community (SADC) countries how to identify fish, understand their importance and preserve vulnerable aquatic ecosystems.

The institute also contributes to policy discussions on issues related to the sustainable management of aquatic biological resources. This is a growing challenge in Africa, where booming populations and intensive development have exerted unprecedented pressures on rivers, lakes and other waterways.

The institute's budget is modest, particularly as research facilities go. For 2009-10, it was ZAR34 mil-



lion (USD2.5 million), with the government providing just under one-third of the total.

Research contracts and grants thus account for a large portion of the funding. The latter comes from a variety of sources, including individual government departments, universities, nongovernmental organizations and private firms.

SAIAB spends about 40% of its government funding on research. It spends a third on administration and a quarter on communications and managing its collections.

Despite limited resources, SAIAB participates, and often takes the lead, in large-scale research projects. That should come as no surprise. The institute's history not only reveals a flair for the dramatic but also a resilience and level of productivity that have made it one of Africa's most successful scientific institutions.

The institute's history reveals a flair for the dramatic.

FISHING FOR FAME

On 22 December 1938 a trawler fishing the waters off South Africa's eastern coast caught something astonishing in its nets: a coelacanth, a fish thought to have become extinct during the Cretaceous period that ended 65 million years ago.

"I would not have been more surprised if I had seen a dinosaur walking down the street," said JLB Smith, the South African chemistry professor who introduced the "living fossil" to the rest of the world.

Smith and his wife Margaret, who were also colleagues, worked in the chemistry department at Rhodes University in Grahamstown, in what is now South Africa's Eastern Cape province. They named the fish *Latimeria chalumnae* after the Chalumna River near where it was caught and Marjorie Courtenay-Latimer, the museum curator who had notified Smith of the find.

The coelacanth is one of the most significant zoological discoveries of the 20th century. It propelled the Smiths to fame overnight and went on to shape the course of South African marine science.

At the time the coelacanth was discovered, Rhodes University did not have a dedicated department of ichthyology. But following the discovery, JLB Smith was asked in 1946 to head a new department, backed by a fellowship from the newly formed Council for Scientific and Industrial Research (CSIR).

Smith's fish collection became the heart of what is today the largest collection of specimens in Africa. It also became the centrepiece of South Africa's national fish collection, which is housed at SAIAB.

The grant Smith received from the government did not cover the cost of his expeditions. For that, he would raise funds by tapping his extensive network of officials and private donors in southern Africa. His tireless efforts generated a global response and opened up Africa's aquatic ecosystems to international study.

The fate of ichthyology in Grahamstown hung in the balance when Smith died in 1968. The CSIR wavered over whether to fund the department without



the renowned man at the helm. There were even suggestions to move the fish collection to either Durban or Cape Town.

Margaret, Smith's widow, however, persuaded the CSIR to create a separate institute within Rhodes to house the collection. Shortly after her husband's death, Margaret became the first director of the newly named JLB Smith Institute of Ichthyology. She would hold the post until 1982.

From 1961 to 1986, the number of known species of marine fishes in South Africa grew by nearly 60% from 1,400 to 2,200. Under Margaret's leadership, the university also constructed a building on Somerset Street that it still occupies. The collection was kept in the building's basement until a new facility was constructed next door in 2007.

DURING APARTHEID

Beginning in the 1960s, international scholars engaged in an academic boycott of South Africa to protest the country's apartheid regime. This isolated South Africa's scientists from the rest of the world. Researchers at the JLB Smith Institute were restricted from travelling to many countries, particularly in Africa.

"Namibia and Botswana would let us in reluctantly. But Zambia, Swaziland, Lesotho and Mozambique were out of bounds," says Paul Skelton, the institute's current director.

When Skelton became director in 1995, a year after the first democratic elections, he saw the opening up of Africa to South African scientists as an historic opportunity. "It liberated us. The political shackles had been shed," he says.

But at the same time that South Africa was enjoying redemption in the eyes of the world, the JLB Smith institute faced a new challenge.

During apartheid, the institute had essentially been funded as a museum. The new government regarded museums as a holdover from colonial times, and wanted all museums outside of Cape Town and Johannesburg to be handed over to local governments. For the institute, this would have meant ending up as a provincial museum in the Eastern Cape.

"It would have been the kiss of death," notes Alan Whitfield, the institute's current chief scientist, who at the time was its senior ichthyologist. We would have been starved of funding and status, and lost much of our staff as a result, he believes.

South Africa has had virtually no inland fisheries.

Skelton managed to persuade the government that the institute deserved national status and, in 1999, it was declared a NRF research facility – a move that guaranteed core funding and confirmed the institute's status as an internationally competitive facility. The decision also brought a welcome boost in staff morale, since the conditions of employment were more favourable than those for an independent entity.

To fulfil its role as a national research facility, the institute had to redefine its mission. Scientifically, it would become more outward looking and thus would be required to focus more attention on providing services to 'customers', including policy makers and

educational experts residing far beyond Rhodes University.

To reflect this broader mission, in 2003 the institute changed its name to the South African Institute for Aquatic Biodiversity (SAIAB). The decision was not universally popular, especially in Grahamstown, where some thought it folly to relinquish the globally recognised 'JLB Smith' brand.

In retrospect, "it was the right choice," Skelton says. Since then, SAIAB has gone from strength to strength.

FISH COLLECTIONS

SAIAB's fish collection, which houses more than 80,000 lots, is the largest in Africa. Indeed the collection is one of the largest in the world. The oldest specimen, dating back to 1880, is a flathead mullet (*Mugul cephalus*). It was given to Smith by David Jordan, a collector based in California. The oldest South African fish in the collection is a large-scale yellowfish (*Labeobarbus marequensis*), collected in 1887 in Pretoria.

Other prized specimens include several coelacanths and a 1.5 metre great white shark with albinism, a congenital condition characterised by the absence of skin pigmentation that leaves the skin a translucent white. It is the only preserved specimen of its kind, caught by an Eastern Cape fisherman in 1996.

Researchers rely on the National Fish Collection for a variety of reasons, including investigations into taxonomy, systematics (the study of fish diversity and the evolutionary relationships between populations and species) and genetics research. Not surprisingly, children love to come and see the strange and wonderful creatures on display.

In recent years, the collection has been expanded to include other aquatic organisms besides fish. For example, a private collection of amphibians was recently added that contains frog specimens from southern Africa. The database also includes South Africa's national collection of diatoms – single cell organisms – which is housed at North West University in Potchefstroom.

RESEARCH AT SAIAB

Ecosystems. Fish systematics was the main research focus of the JLB Smith Institute for Ichthyology when it was established 50 years ago. Over time, however, its research mission has expanded to encompass the wholesale study of aquatic ecosystems – from freshwater systems to the deep ocean. "Our scope is much broader than before," says Alan Whitfield, SAIAB's chief scientist.

The field of systematics has also undergone dramatic changes in recent years. The advent of genetic analysis has challenged the traditional, appearance-based means of classification. Modern fish systematists now must be as well versed in molecular genetics as in morphology.

So why is systematics important? To begin with, aquatic ecosystems have enormous economic importance. In most societies, fish are a mainstay of the diet and, unlike livestock that are farmed in corralled areas, they are by and large taken straight from their natural habitat.

With overfishing and exploitation threatening fish stocks in many parts of the world, it is more important than ever to understand how this precious resource

can be used sustainably. Such understanding is particularly vital in developing countries.

Paul Cowley, a senior aquatic biologist at SAIAB, is pioneering new techniques for monitoring fish that spend part of their lives in estuaries.

Traditional ways of monitoring fish include fish tagging, which provides information on growth rates, movement patterns and seasonal migrations. Such information is needed to manage fisheries successfully.

There are several active marine fish tagging projects in South Africa. The largest, the Oceanographic Research Institute (ORI) project, relies on volunteer anglers to tag fish. SAIAB's 082 TAG FISH project, meanwhile, focuses on specific species and/or fish dispersal from designated study sites, such as marine protected areas or estuaries.

In addition to conventional plastic dart tags, Cowley and his group use sophisticated telemetry equipment to track and monitor the movement of fish equipped with acoustic transmitters. The signals are captured by receivers moored in estuaries along the Eastern Cape coast.

Freshwater fish. As an arid country with few lakes, South Africa historically has had virtually no inland fisheries. The native freshwater species are small and when Europeans first settled in the country, they brought with them their own sporting fish — trout and bass in particular.

These invasive species today pose one of the biggest threats to South Africa's endemic freshwater fish. SAIAB's biologists have studied the effects of these species on the local fauna and also evaluated ways of preventing them from spreading into pristine rivers.

There are ways to control and eradicate alien species. One method is to use *Rotenone*, a compound produced from the Derris root that kills invasive fish but does not adversely affect the well-being of birds, mammals or humans.

However, widespread resistance to the wholesale eradication of these species from the economically important recreational fishing industry makes it unlikely that such control measures will ever be taken.

Climate change poses a huge threat to both freshwater and marine fish.

Climate Change. Climate change poses a huge threat to both freshwater and marine fish. Not surprisingly, it has emerged as a core area of research at SAIAB.

"Fish are sensitive to climate change," says Nikki James, a SAIAB researcher who is pioneering ways of modelling the likely effect of climate change on the distribution of fish in South Africa.

Thus far there have been no signs of change in the abundance of species along the South African coast, she says. However, this could rapidly change as surface temperatures rise in coastal areas.

James modelled the effect of three climate change scenarios outlined by the Intergovernmental Panel on Climate Change (IPCC) on two fishes living along the South African coast: the white steenbras, which enjoys temperate seas and can be found from the Orange River on the west coast to southern Kwa-Zulu Natal on the



east coast, and the robust mullet, a tropical fish that keeps to the warm waters from the Eastern Cape up the coast towards Mozambique.

All IPCC scenarios anticipate significant changes in the range of the two fish species. As sea temperatures rise on the east coast, the mullet is likely to migrate farther south. Meanwhile, the range of the white steenbras will become more restricted as many of its estuary-located nurseries are transformed into inhospitable breeding grounds.

Changes in the natural ranges of fish species will have huge societal impacts. Popular angling species like white steenbras draw tourist money to remote areas, and poor coastal communities increasingly rely on fishing for their subsistence.

There are signs, for example, that climate change could be disrupting the sardine run that takes place along South Africa's east coast between May and July each year. This "greatest migration on earth" – when millions of pilchards spawn in the waters off Cape Agulhas, the southernmost point of Africa, and swim north along the coast – is hugely important financially.

Lately, SAIAB research associate Stephanie Plön discovered that dolphins caught in shark nets off the KwaZulu Natal coast have mackerel, not sardines, in their stomachs, indicating a change in the available prey.

The sardine run is not only a boon to coastal communities – it also sparks a feeding frenzy off the coast, with sharks, dolphins, seals, seabirds and whales pushing the fleeing fish into enormous "bait balls" from which few escape. Drastic changes in the sardine run could thus have profound financial and ecological effects.

Sea Currents. Since apartheid ended, SAIAB has engaged more actively with researchers in the rest of the African continent. This has enabled the institute to use its considerable resources and expertise to help build capacity in neighbouring countries.

SAIAB has sought to advance this goal largely

This article is based on a report prepared for TWAS's ongoing 'Excellence in Science' series consisting of profiles of research institutions in developing countries. Previous case studies in this series include the Centre of Biotechnology of Sfax in Tunisia; the Institute of Medicinal Plant Development in Beijing, China; the Malagasy Institute for Applied Research in Antananarivo, Madagascar; the National Institute of Biodiversity in Santo Domingo de Heredia, Costa Rica; the Central Drug Research Institute in Lucknow, India; and the Ifakara Health Institute in Tanzania. The series was initially funded by a generous grant from the David and Lucile Packard Foundation. Other partners have included the United Nations Development Programme's Special Unit for South-South Cooperation (UNDP-SSC), the Global Environmental Facility (GEF) and the Science Initiative Group (SIG). To review the case studies online, see www.twas.org. For a print copy of the booklets, contact info@twas.org.

through its flagship marine programme, the African Coelacanth Ecosystem Programme (ACEP), conducted in collaboration with the Agulhas-Somali Current Large Marine Ecosystem (ASCLME) initiative, which SAIAB hosts across the road from its main building.

The project involves a five-year collaboration among nine countries along the western Indian Ocean: Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa and Tanzania.

An estimated 56 million people in these countries depend on the resources of the two large marine ecosystems that are the focus of the project: the oscillating Somali Current, which drives the waters off the horn of Africa eastward in winter and west in summer, and the Agulhas Current, which sweeps down the coast of Mozambique towards South Africa.

Recreational fishing is big business in South Africa.

The project is funded by the Global Environment Facility (GEF). Its first phase, which concentrates on regional data collection, has included two research cruises on the Norwegian research vessel *Dr Fridtjof Nansen*.

Researchers have only recently realised that the water moving through the channel between Mozambique and Madagascar, which was previously assumed to be a simple current, is in reality a system of eddies moving southwards. This phenomenon, which the ASCLME project will study, could vastly increase our understanding of regional weather patterns and marine life.

The project will also investigate how water flows over the Mascarene Ridge that stretches for 2,200 km between Mauritius and the Seychelles. The ridge's islands, banks and shoals form a long shallow shelf that acts as a barrier against the current. That, in turn, effects nutrient distributions and energy flows.

The ASCLME project will not only collect data, but also form the basis of joint policy making between governments within the region. The second phase will produce a strategic action plan to safeguard the marine ecosystems in the western Indian Ocean.

Recreational Fishing. Recreational fishing is big business in South Africa. The focus in freshwater angling is often on 'alien' species, including bass and trout, but native species such as carp and tilapia also have their fans.

"Overall, angling is worth millions to the economy," says Olaf Weyl, an aquatic biologist at SAIAB who works on the ecological impacts of alien fishes. "It's bigger than rugby, cricket and football combined," he notes.

SAIAB is working with all stakeholders to devise a strategy that both protects the fisheries and provides ample opportunities for recreational fishing – a compromise that both the anglers and the conservationists would find acceptable. "If we can get this right, it could be a very good tool for conservation," says Ernst Swartz, a freshwater biologist at SAIAB.

FUTURE BRIGHT

What's next for SAIAB?

Expansion – both in terms of funding and the number of staff – is high on the institute's wish list.

In Skelton's view, over the next decade, the insti-

tute will have to focus on continuing to fulfil its core mission as a national research hub.

There is still a vast amount of science that needs to be done, he adds. "The South African marine floor and ocean ecosystems have never been studied in detail. As a result of the strides that have been made, especially in the past five years, we can provide opportunities for scientists from all over – and not just from our institute – to use our facilities and equipment, including our new ROV (Remotely Operated Vehicle), to advance the frontiers of science."

SAIAB also has to deliver on its mandate to have a more ethnically diverse staff. And, it will clearly want to keep building on its networks in Africa, using its resources to empower researchers in other parts of the continent.

Broad, detailed studies are needed to create a better overview of Africa's aquatic biodiversity and to establish a baseline so that threats to ecosystems can be detected rapidly. Meeting the growing demand for goods and services created by an increasing population and greater wealth will require additional resources, Skelton adds. "We will need to grow. Perhaps, one day, we'll have twice the number of permanent researchers that we do today."

But even if SAIAB triples in size, quadruples its budget and acquires additional offices in Cape Town or Durban, its outward-looking, collaborative ethos will not change, says Skelton.

"We'd want to keep the same far-reaching collaboration model that we use today. In short, we will continue to be an internationally renowned institute doing world-leading research."

Scientifically, SAIAB's national and international impact belies its small size and, as a national research facility catering to the needs of a young democracy, it is already delivering significant benefits to science and society. As the story of SAIAB shows, in science, biggest does not always mean best.

The story also illustrates how hardship can breed excellence. From the years of isolation to the strategically challenging post-apartheid years, SAIAB and its staff emerged from South Africa's political upheavals stronger and better.

With its well-managed collection, SAIAB is also a beacon of hope for the rest of the continent. In an article for South Africa's popular science magazine *Quest*, published in 2007, Skelton wrote that it's time for African countries to expand their own expertise and traditions in natural history and national species collection. Without such progress, he writes, African biodiversity will remain "a global feast at which African scientists will be uninvited bystanders, without the facilities to earn the respect or recognition that is their due".

To overcome the problems that the continent faces in the area of aquatic biodiversity – water shortages, pollution, unscrupulous development, overfishing, acidification, alien invasive species, and a lack of understanding of the ecosystems – will require local knowledge and local solutions.

Africa's scientists, policy makers and local communities have a real chance to avoid wasting the considerable economic and environmental resources that aquatic ecosystems represent.

By promoting scientific programmes and showing policy makers that aquatic ecosystems provide a wealth of products and services to their societies that they simply cannot afford to lose, SAIAB has a key role to play in this effort. ■

NEW CAS PRESIDENT

• **Bai Chunli** (TWAS Fellow 1997) has been elected president of the Chinese Academy of Sciences. He succeeds Lu Yongxiang (TWAS Fellow 1990), who will continue to serve as vice president of the National People's Congress and co-chair for the InterAcademy Council (IAC). Bai, a renowned chemist and leading nanoscientist, has been executive vice president of CAS since 2004. He is widely credited for playing a leading role in the rapid development of nanotechnology in China. He has served as vice president of the China Association for Science and Technology (CAST), president of the Graduate University of CAS (GUCAS), director of the Academic Division of Chemistry, member of the Executive Committee of the Presidium of the Academic Divisions of CAS, and currently serves as vice president of TWAS. As president of CAS, Bai will lead the academy through an ambitious ten-year scheme known as "Innovation 2020" that will focus on space science, information technology, energy and health. Pilot projects initiated this year will be in seven key areas: nuclear fusion and nuclear waste management; stem cells and regenerative medicine; calculating the flux of carbon between land, oceans and atmosphere; materials science; information technology; public health; and the environment.

Bai Chunli

NEW NASAC PRESIDENT

• **Robin Crewe** (TWAS Fellow 2009), president of the Academy of Science of South Africa (ASSAf), was elected president of the Network of African Science Academies (NASAC) at the 6th NASAC General Assembly, held in Cape Town, South Africa, on 11 November 2010. Crewe succeeds Mohamed H.A. Hassan (TWAS Fellow 1985 and former executive director). During his tenure, Crewe plans to focus on the following key challenges: the revitalisation of NASAC's governance structures; the creation of science academies in countries where they currently do not exist; expanding opportunities for science academies to offer policy advice at the national and continental levels; and strengthening the long-term sustainability and impact of the network. A ten-year strategic plan is currently being developed to guide and position NASAC as an effective and formidable African body to advance science, technology and development across the continent. Crewe will be assisted by NASAC's executive committee consisting of vice presidents Oyewusi Ibidapo-Obe (TWAS Fellow 2009), president of the Nigerian Academy of Science, Paul Mugambi, president of the Uganda National Academy of Sciences, and Mostapha Mosto Bousmina, chancellor of the Hassan II Academy of Science and Technology in Morocco; secretary general Amadou Lamine Ndiaye (TWAS Fellow 1999), president of the Senegal Academy of Sciences and Arts; and treasurer Shem Arungu-Olende, secretary general of the African Academy of Sciences.

Robin Crewe

PALMES ACADEMIQUES

• **Sospeter Muhongo** (TWAS Fellow 2004) was awarded the *Ordre des Palmes Académiques* by the French government. Muhongo is the founding regional director of the International Council for Science's Regional Office for Africa (ICSU-ROA) in Pretoria, South Africa, serving in that capacity until 2010. He currently chairs the department of geology at the University of Dar Es Salaam (UDSM) in his native Tanzania and is an honorary professor at the University of Pretoria in South Africa. Muhongo obtained a BSc in geology from UDSM in 1979 and a Ph.D. from *Technische Universität Berlin*, Germany, in 1990. His previous honours include the First Robert Shackleton Award for Outstanding Research in Precambrian Geology of Africa and National Award for Out-

Sospeter Muhongo

standing Research in S&T in Tanzania. He was named European Geologist by the European Federation of Geologists in 2006. He is a member of several scientific societies in Africa, the United States, United Kingdom and China.

2010 SAE FELLOW AWARD

• **Pradeep Rohatgi** (TWAS Fellow 1989), distinguished professor of materials engineering at the University of Wisconsin-Milwaukee (UWM)

Pradeep Rohatgi

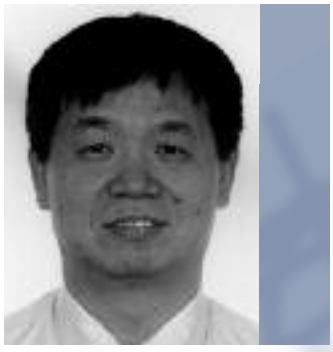
and founding director of the UWM Center for Composites and the Center for Advanced Materials Manufacture at UWM, has received the Society of Automotive Engineers (SAE) 2010 Fellow Award for his internationally recognized leadership in research, development, education and institution-building for the processing and characterization of low-cost, ultra-light and energy-efficient cast metal matrix composites. He has recently extended his research on the synthesis of metal matrix nanocomposites, and is working on smart and self-healing composites for transportation applications.

NEW NAS MEMBERS

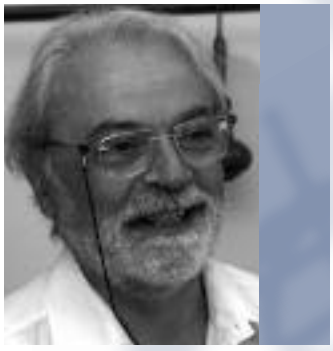
• **Louise Johnson** (TWAS Fellow 1999), **Li Jiayang** (TWAS Fellow 2004) and **Erio Tosatti**, have been

Louise Johnson

elected as foreign associates of the US National Academy of Sciences (NAS). Johnson is David Philips professor in molecular biophysics at the Laboratory of Molecular Biophysics, Oxford University, Oxford, United Kingdom. Li is vice president of the Chinese Academy of Sciences (CAS) and professor at the CAS Institute of Genetics and Developmental Biology in Beijing, China. Tosatti is a physicist with Abdus Salam International Centre for Theoretical Physics' (ICTP) Condensed Matter and Statistical Physics Section and professor of physics at the International School for Advanced Studies (SISSA) in Trieste, Italy. He served as the acting director of ICTP in 2002-2003.



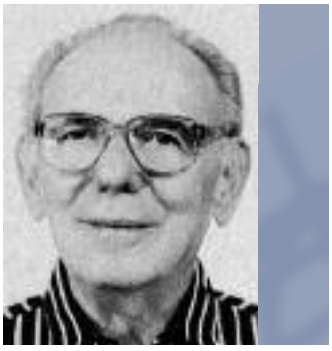
Li Jiayang



Erio Tosatti

IN MEMORIAM

• **Jayme Tiomno** (TWAS Fellow 1996) died on 12 January 2011 at the age of 91. Tiomno was educated at State College, Muzambinho, the Brazilian Federal University, Rio de Janeiro, and Princeton University,



Jayme Tiomno

USA, where he obtained his PhD in physics in 1950. Until his death, he was professor emeritus at the *Centro Brasileiro de Pesquisas Físicas* (CBPF) in Rio de Janeiro. He was one of the founders CBPF and also helped to create the Brazilian Physics Society (SBF). His scientific work in experimental and theoretical physics was honoured by several awards that he received during his career, including the Moinho Santista Prize for Exact Sciences in 1957 and the Grã-Cruz, National Order of Scientific Merit of Brazil in 1994.

WHAT'S TWAS?

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

TWAS has nearly 1,000 members from 90 countries, 73 of which are developing countries. A 13-member Council is responsible for supervising all Academy affairs. It is assisted in the administration and coordination of programmes by a secretariat, headed by an Executive Director and located on the premises of the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. The United Nations Educational, Scientific and Cultural Organization (UNESCO) is responsible for the administration of TWAS funds and staff. A major portion of TWAS funding is provided by the Italian government.

The main objectives of TWAS are to:

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

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

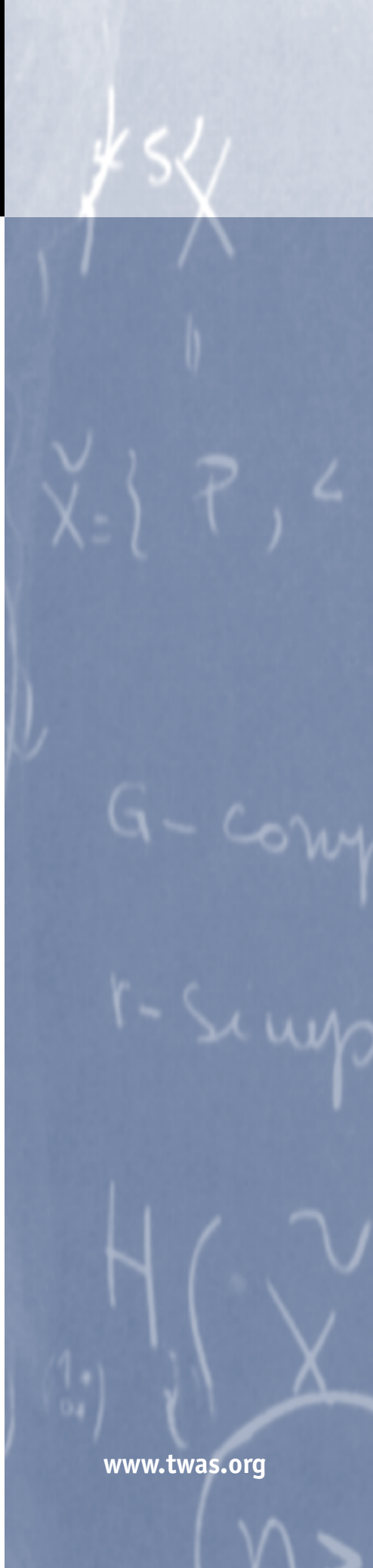
TWAS also played a key role in the establishment, in 1993, of the Organization for Women in Science for the Developing World (OWSDW, formerly the Third World Organization for Women in Science, TWOWS). Some 3,200 women scientists from more than 90 countries in the South are members of OWSDW, making it the largest organization of women scientists in the world. Its main objectives are to promote the leadership of women in science and technology in the South and to strengthen the participation of women in science-based development and decision-making. The secretariat of OWSDW is hosted and assisted by TWAS.

⋯⇢ **www.twows.org**

Since 2000 TWAS has provided the secretariat for IAP, the global network of science academies. IAP, which was established in 1993 as the 'InterAcademy Panel on international issues', unites more than 100 science academies worldwide; provides high-quality independent information and advice on science and development to policymakers and the public; supports programmes on scientific capacity building, education and communication; and leads efforts to expand international science cooperation.

⋯⇢ **www.interacademies.net/iap**

Since 2004 TWAS has also hosted the secretariat of the InterAcademy Medical Panel (IAMP), an association of the world's medical academies and medical divisions of science academies. IAMP is committed to improving human health worldwide through the coordinated action of its 69 members. ⋯⇢ **www.iamp-online.org**



www.twas.org