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Torchbearer for science in the south

TWENTY-FIVE YEARS AFTER TWAS WAS ESTABLISHED, SCIENCE JOURNALIST YOJANA SHARMA, WRITING FOR SCIDEV.NET, DISCUSSES HOW CLOSE THE ACADEMY IS TO ACHIEVING ITS AMBITIOUS GOALS.

It was a challenge almost as daunting as combating global poverty itself – help scientific researchers in developing countries catch up with researchers in the most advanced countries. But TWAS, the academy of sciences for the developing world, remained undaunted. Twentyfive years on, it is taking stock of its efforts.

Founded by 41 eminent scientists in 1983, TWAS now has more than 900 members. Eighty-five percent are from developing countries and 16 are Nobel Prize winners.

Although it depended for many years on one donor, the Italian government, it set up an endowment fund in 1993, which has grown to more than US$12 million and which TWAS hopes will expand to US$25 million.

"There are serious scientists involved, which means governments pay attention to it," says Peter Collins, of the Royal Society, the UK's national academy of science.

The world has changed radically in the past 25 years. China and India are emerging as major scientific nations. There has also been progress in Latin America, particularly Brazil, Argentina and Mexico. And communications technology has made many developing country scientists less isolated, although the digital divide threatens to leave the poorest countries even further behind.

But education and training remain significant concerns. A recent TWAS survey found that 80 countries do not have the means or capacity to develop their science sector, and most of these are in sub-Saharan Africa.

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HONOUR THE BEST

An early TWAS goal was to identify and honour the best 'Third World' scientists (TWAS's original name was the Third World Academy for Sciences) and convince them that their work is as important as that of their colleagues in the North. Scientists in developing countries suffer from poor pay, inadequately equipped laboratories and isolation. Often there are few rewards for staying.

So TWAS has established a number of prizes, for women scientists and for young scientists under 40. And alongside research grants, the organization also offers fellowships and travel grants to improve contacts between individual scientists and institutions in the South.

The prizes make a difference, says Filipino microbiologist Maria Corazon De Ungria, who recently won a TWAS Young Scientist Prize and has a TWAS Research Grant for her work on DNA testing, setting up her own DNA analysis laboratory at the University of the Philippines. "Because the TWAS prize is an international award, it showed that the work my lab is doing is recognized in the Philippines and overseas. It does add to an individual's credibility," she says.

For Beatriz Barbuy, a Brazilian astronomer whose work has made a major contribution to studies of how the chemical composition of stars evolves, the 2008 Trieste Science Prize, supported by the coffee manufacturer illycaffè, was her first award ever, despite a distinguished career. She says she often regretted returning to Brazil after completing her doctorate in France, but the award made her return worthwhile. "I think the prize will help to raise funding. We have proposed an institute for astronomy in Brazil," she says. Several months after receiving the Trieste Science Prize, Barbuy won the L'Oréal-UNESCO Awards for Women in Science.

TWAS awards and fellowships also help scientists to network. Maurice Tchuente, Cameroon's former Higher Education Minister and one of Africa's most prominent researchers in computer science, was elected a TWAS fellow in 1999 and awarded the CNR Rao

Prize for Scientific Research at TWAS's 25th anniversary celebration, held in Mexico City last November. He says: "The prize opened up new horizons, including invitations to international seminars."

"It was during a meeting organized by TWAS that I met researchers from neighbouring countries working in the same area as myself. Their collaborative networks had grown from their time spent studying in the North and were therefore disconnected from mine", Tchuente says.

SMALL SECRETARIAT

TWAS is also lauded for its work, with support from the InterAcademy Panel (IAP) and other organizations, in helping set up national and regional academies of science and strengthen their ability to advise science and education ministers.

"Governments pay lip service to science. A lot of political action is useless if there is no follow up," says Ernesto Lara Lupercio, general secretary of the Mexican Mathematical Society and himself a TWAS Young Scientist Prize winner.

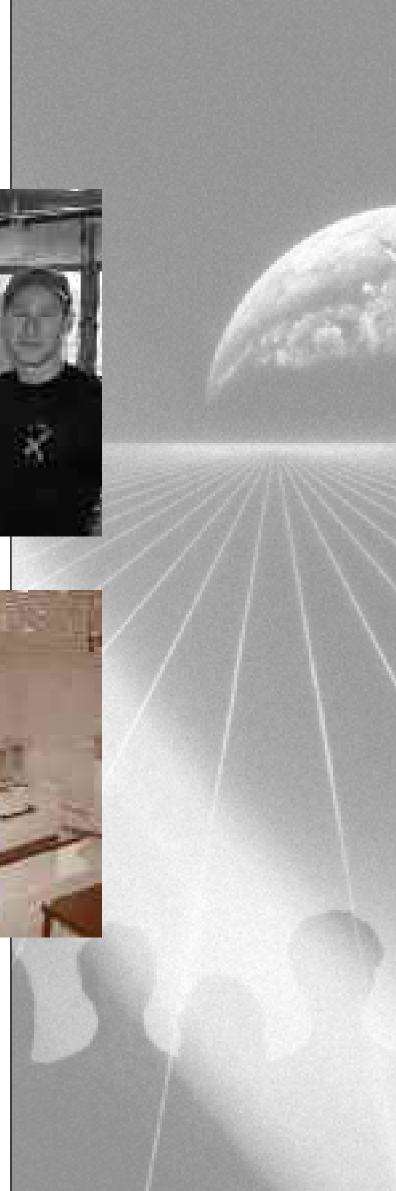
TWAS has been adept at getting together science policy makers and politicians from different countries. Lupercio says that this can help correct some of the problems, but the effect of what TWAS is doing is "microscopic", because the problems are so very deeply ingrained in many Latin American and other poor countries. "With their budget, their intentions are extraordinarily ambitious," he says.

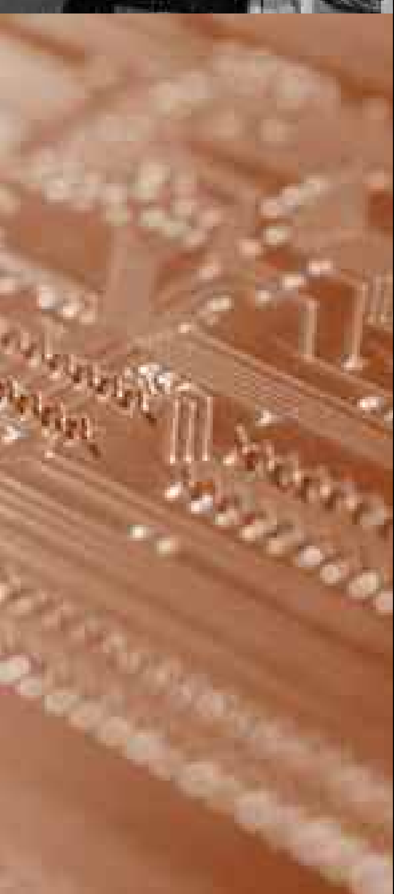
TWAS's budget is over 30 times smaller than that of the Royal Society, and its dozen-strong secretariat staff is dwarfed by the Royal Society's 134.

It is clear that TWAS alone cannot convince the world's politicians that science is important for development.

But Mohamed Hassan, executive director of TWAS, believes that many academies in the South, including the Network of African Science Academies (NASAC), which TWAS has supported, are now gaining momentum and will be important in tackling problems in science-poor regions.

"The biggest challenge of all is to make science work for society," he says. "We need scientists and we can use scientific capacity to





solve problems. We need centres where the problems are – in developing countries themselves."

Michael Ståhl, director of the International Foundation for Science in Stockholm, whose own organization provides research grants to many scientists in the developing world, agrees. "There is a great need for a 'critical mass' of scientists in developing countries, and TWAS has been instrumental in identifying many top scientists," he says.

This is important if another TWAS vision is to be realized: fostering scientific research on major developing world problems.

Perhaps crucially, many TWAS awardees over the past 25 years are active in national and regional science academies, and even in major international science bodies.

"The TWAS award is certainly not irrelevant to my recent election as secretary general of the International Council for Science (ICSU)," Tchuente says. "Organizations like TWAS have developed a unique expertise in interdisciplinary and transnational problems that can be dealt with through science and are not easy to tackle nationally."

SOUTH–SOUTH SUCCESS

Hassan concedes that TWAS's biggest failing so far has been in North–South cooperation. There is little to show for 25 years of shuttling around the world.

But there has been one grand and perhaps unexpected success. "South–South cooperation is TWAS's most important accomplishment," Hassan says. "It was difficult because the best students – and we were looking for the best – wanted to go to advanced countries in Europe and to the United States."

So TWAS identified the best institutions in developing countries and publicized them, encouraging students and staff to stay rather than head to the North.

And now there is a new impetus in South–South cooperation. "Some developing countries are moving very fast in developing their science infrastructure. The best thing that TWAS did was to make full use of that," says Hassan. "We have negotiated postgraduate programmes with six countries – Brazil, China, India, Malaysia, Mexico and Pakistan – who thought, rightly, that this was a win-win situation."

With more than 250 scholarships in these countries available for students from the poorest countries, particularly Africa, Hassan describes it as "the largest South–South initiative for cooperation in science". TWAS has helped these countries step into a breach never filled by Europe or the United States. ■

This article, written by Yojana Sharma, was originally published in the webportal *SciDev.Net*, 10 November 2008 and updated 13 November 2008. See www.scidev.net.

TWAS IN EAST AND SOUTHEAST ASIA

FU SHUQIN, DIRECTOR OF THE TWAS BEIJING OFFICE, DESCRIBES THE WIDE-RANGING ACTIVITIES OF THE TWAS REGIONAL OFFICE FOR EAST AND SOUTHEAST ASIA AND THE PACIFIC (TWAS-ROESEAP). THE OFFICE, HEADQUARTERED AT THE CHINESE ACADEMY OF SCIENCES IN BEIJING, WAS LAUNCHED IN 2003 AS TWAS'S FIRST REGIONAL OFFICE.

Ever since Deng Xiaoping, the former leader of China, first announced the nation's "reform and opening-up", and called on China to seek "truth through facts" in 1978, China has attached great importance to South-South cooperation in science and technology as a prerequisite for sustainable economic growth both in China and other developing countries. Indeed science and technology was one of the four focal points of "modernization" cited by Deng as pillars of progress – together with agriculture, industry and national defense.

It should come as no surprise then to learn that South-South collaboration in science and technology was a major theme of TWAS's 2nd General Conference held in Beijing in 1987, and that Chinese officials announced at the conclusion of the conference that China would provide a special fund for South-South cooperation.

Today, China continues to exemplify – and indeed expand – upon its long-standing commitment to scientific cooperation and exchange through the efforts of the TWAS Regional Office for East & Southeast Asia and the Pacific (TWAS-ROESEAP), based on an agreement signed by CAS and TWAS in 2003.

Located at the CAS headquarters, the activities of TWAS-ROESEAP include:

- Assessing the vitality and effectiveness of TWAS's activities in the region.
- Sponsoring public lectures by eminent scientists on issues of regional and global concern.
- Organizing regional workshops dedicated to the sharing of information and ideas on such topics as extreme weather and climate events and scientific and technological capacity building in the developing world.
- Implementing the TWAS-CAS fellowship programmes.
- Promoting the TWAS associateship scheme at centres of excellence in China.
- Supporting the CAS-TWAS-WMO (World Meteorological Organization) Forum and Young Scientists Conference in the region.

- Identifying eminent scientists in the region for TWAS membership and awards.
- Maintaining a website highlighting issues and ideas emanating from both the headquarters of TWAS secretariat in Trieste and TWAS-ROESEAP in Beijing.
- Publishing a newsletter in English and Chinese.

To fulfill these tasks, the office focuses on the following activities:

- *Identification of eminent scientists in the region for TWAS membership nominations*. Efforts are made annually to identify outstanding scientists for TWAS membership and younger scientists who are qualified to become TWAS Young Affiliates. TWAS-ROESEAP, which represents 27 countries in the region, currently has a membership of 210 TWAS fellows and associate fellows, and 10 young affiliates.
- *Nomination of eminent scientists for TWAS awards and regional prizes.* Eminent scientists are identified and nominated by colleagues and associates for TWAS awards and TWAS regional prizes. Every effort is made to create as large a pool as possible of potential candidates. Thirty-five regional scientists have received TWAS prizes in various research fields, including agricultural sciences, biology, chemistry, mathematics and physics, Earth sciences and engineering sciences. Of special note is the honour given to Lu Yongxiang (TWAS Fellow 1990), president of CAS, who was awarded the Abdus Salam Medal for Science and Technology in 2006. He was the first Chinese scientist to receive this award.
- *TWAS-CAS Fellowship Programme.* Apart from supporting South-South scientific exchanges and collaborative research, training courses and international conferences, TWAS-ROESEAP also devotes a great deal of attention to fostering scientific and technological cooperation among developing countries, not just within the region but across the developing world. At the TWAS 14th General Meeting in Beijing in 2003, Lu Yongxiang, who was then serving as vice president of TWAS, announced that CAS would fund postgraduate, postdoctoral and visiting scholar fellowship programmes in partnership with TWAS. Following this announcement, in 2004 TWAS and CAS implemented three joint fellowship programmes. Up to 50 fellowships are currently offered each year: 20 postgraduate fellowships, 15 fellowships for postdoctoral research and 15 fellowships for visiting scholars. Postgraduates and postdoctoral students spend from six months to one year studying and conducting research at leading Chinese universities and research centres. Visiting scholars spend from one to three months at a CAS research institution. As of December 2008, more than 200 scientists from 30 countries and regions had been awarded TWAS-CAS fellowships. Of these, 63 were postgraduate students, 59 were postdoctoral researchers and 70 visiting scholars. Among the recipients is Emeka Emmanuel Oguzie

South-South collaboration was a major theme of TWAS's second general conference in Beijing in 1987.

from Nigeria, who was named a CAS-TWAS postdoctoral fellow in 2006. Oguzie conducted research at the CAS Institute of Metals Research, where he studied the effect of non-toxic organic molecules on acid-based corrosion in iron and steel. In early 2008, Oguzie, who was selected as a TWAS Young Affiliate the previous year, was appointed as associate dean of the Federal University of Technology, Nigeria. Another recipient is F.M. Aminuzzaman from Bangladesh, who was awarded a CAS-TWAS Postdoctoral Fellowship in April 2008. The fellowship has allowed Aminuzzaman to continue his research on nematophagous fungi in search of a fungal gene that could be bioengineered to control plant parasitic nematodes.

- *TWAS Associateship Scheme at Centres of Excellence*. To date, China sponsors 39 internationally recognized centres of excellence listed in TWAS's 2007 *Profiles of Scientific Institutions*. More than 60 scientists, from over 20 countries that are largely but not exclusively located in Asia, have worked at these centres. Scientists have come, for example, from Bangladesh, Brazil, Cameroon, Congo, Cuba, Egypt, Ghana, India, Indonesia, North and South Korea, Kuwait, Malaysia, Nigeria, Pakistan, Syria, Thailand and Vietnam. All 15 CAS centres of excellence (as designated by the Chinese government) are active in the programme. In particular, the International Centre for Climate and Environment Sciences (ICCES), part of the Institute of Atmospheric Physics (IAP), has welcomed more than 15 scholars to the associateship scheme. Their research has focused on such fields as climate change and air pollution. The programme consists of field experiments and mathematical modelling studies. Specific topics include the impact of climate change on regional water resources and ecosystems, and the monitoring and prediction of air quality on local to regional scales.

Fu Shuqin

- *Supporting the annual CAS-TWAS-WMO Forum.* Climate challenges such as global warming, decadal climate variabilities and short-term climate anomalies, as well as such extreme weather events as cyclones, tornadoes and hurricanes, all impact human welfare and economic development, especially in poor countries. For example, on 3 May 2008, Cyclone Nargis struck Burma, causing 130,000 deaths and US$10 billion in property damage in its wake. To facilitate the study of climate science, the annual CAS-TWAS-WMO Forum for Physico-Mathematical Problems Related to Climate Modelling and Prediction (CTWF) was launched in 2000. The aim is to bring together high-level mathematicians, physicists and atmospheric and oceanic scientists to exchange ideas, examine problems and devise suitable methodologies and solutions. Each year, CTWF concentrates on a single theme. CTWF's 7th International Workshop, held in Kunming, Yunnan Province, China, in September 2008, examined the Development of a Regional Earth System Model and its Application. More than 60 participants attended, including scientists from China, Pakistan, Nepal, India, Vietnam, Malaysia, Thailand, the United States, the United

Kingdom, France, Germany, Italy, the Netherlands, Japan, South Korea, Germany and Australia. CTWF's 8th International Workshop, scheduled to take place in August 2009 in Lanzhou, Gansu Province, will focus on Dust Aerosol and its Climatic and Environmental Impact.

- *Annual Meeting of Chinese TWAS Fellows.* TWAS-ROESEAP organizes annual meetings of Chinese TWAS Fellows. The purpose of the meetings is to promote inter-regional cooperation in accordance with the broad goals for scientific exchange outlined in TWAS's strategic plan. The 2008 annual meeting, held in Beijing, drew 60 members. In addition to discussions on how to better identify eminent scientists in the region for TWAS membership, awards and regional prizes, participants also talked about how to increase the involvement of China's scientists and scientific institutions in TWAS activities by, for example, organizing joint workshops, training courses and conferences for young scientists.
- *Organization of Workshops and Training Courses.* TWAS-ROESEAP also holds joint workshops and training courses on issues of common concern to promote the role of science and technology for sustainable development in the region. Since 2000, it has organized 20 workshops and training courses on such topics as environment and agriculture development. The most recent activity, a training course for Field Research Station Building for S&T Administrators from Developing Countries, took place in June 2008 at the CAS Institute of Botany in Beijing. More than 20 administrators from Mongolia, Pakistan, Myanmar, Nepal, Egypt, Nigeria, Kenya, Vietnam, Cambodia and North Korea, participated in the event, which included a field trip to the Inner Mongolia Grassland and Eco-Environmental Observation Station. The course reflected TWAS-ROESEAP's growing interest in issues related to science administration and policy. A Workshop on Cutting-Edge Methods and Techniques in Protein Research for scientists from developing countries is scheduled to take place in July 2009.
- *Publishing newsletters and workshop proceedings*. An English and Chinese bi-annual newsletter (www.beijing.twas.org.cn) detailing information about TWAS and its associated organizations, is published both in print and electronic format and distributed to regional members of TWAS, the Third World Organization for Women in Science (TWOWS), the InterAcademy Panel (IAP) and researchers at CAS institutes.

China will also serve as the host of the next TWOWS general assembly in the summer of 2010.

In addition to activities related to TWAS, TWAS-ROESEAP also collaborates on initiatives that are administered by TWAS's partner organizations headquartered in Trieste, Italy, most notably the Third World Organization for Women in Science (TWOWS).

For example, CAS and TWOWS jointly sponsored



an International Workshop on Women for Science in Beijing in August 2007. A key outcome of the meeting was the establishment of a TWOWS China National Committee that included key members from various organizations in China, such as CAS, the All-China Women's Federation (ACWF) and the China Association for Science and Technology (CAST). CAS and TWOWS also signed an agreement to launch a CAS-TWOWS Training Fellowship programme. Under this initiative, CAS Chengdu Institute of Biology, Lanzhou Institute of Modern Physics and Beijing Institute of High Energy Physics received three women awardees from Yemen, Sudan and Nigeria in 2008. The three awardees will remain in China for four years of study. China will also serve as the host of the next TWOWS general assembly scheduled to take place in the summer of 2010.

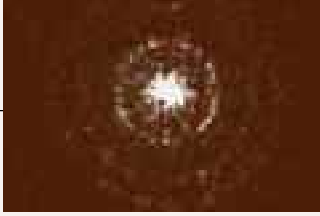
On 18 December 2008, China celebrated the 30th anniversary of a national decision to open itself to the world and to embark on a journey of economic reform. Standing before 6,000 people in the Great Hall of the People in a ceremony commemorating this historic decision, President Hu Jintao said that "Reform and opening up are the fundamental causes of all the achievements and progress we have made." The President also noted that "Standing still and regressing will lead only to a dead end."

Over the past three decades, China has relentlessly sought to expand its economy, often achieving an annual growth rate in national gross domestic product exceeding 10 percent. A major element in this effort has been its commitment to building up the nation's scientific and technological capacity. As President Hu observed at the 30th anniversary celebration: "We must adhere to the correct direction of reform and opening up so as to build a system that is full of vigour, highly efficient, more open and with a favourable environment for scientific development".

South-South cooperation is one avenue through which we are pursuing our overall goal of sustainable growth.

For all of the benefits that science and technology has bestowed on China, it is important to note that the nation's capacity building efforts have not stopped at its borders. These efforts, in fact, have been driven by an abiding principle that collaboration is not only the right thing to do but, equally important, that it is a strategy that helps all and harms none.

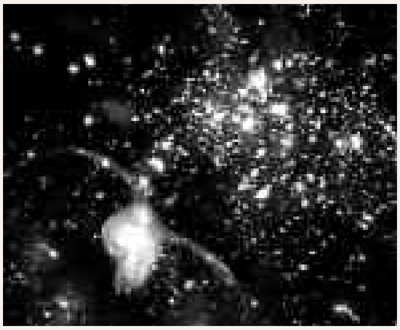
South-South cooperation is one of the main avenues through which we are pursuing our overall goal of achieving sustainable economic growth. It is driven by the belief that regional and global problems of economic poverty, environmental degradation and energy security can only be achieved if we join together in efforts of mutual benefit. Chinese scientists have contributed to the development of science and technology in developing countries. The nation is commit-



WORLDS BEYOND OUR OWN

IS LIFE ON EARTH ALL THAT IS? MARTIN REES (TWAS ASSOCIATE FELLOW 2007), PRESIDENT OF THE ROYAL SOCIETY AND PROFESSOR OF COSMOLOGY AND ASTROPHYSICS AND MASTER OF TRINITY COLLEGE, CAMBRIDGE, UK, EXAMINES THE CURRENT STATE OF COSMOLOGY AND ASTRONOMY AND DISCUSSES WHAT MAY LIE AHEAD IN OUR CONTINOUS JOURNEY TO UNDERSTAND THE WORLDS BEYOND.

The famed science fiction writer and futurist Arthur C. Clarke (TWAS Associate Fellow 1987), who died last year at the age of 90, said his greatest wish was to see the discovery of alien life. Sadly, he didn't. However, he did live long enough to compare some of his predictions with reality, especially regarding space.



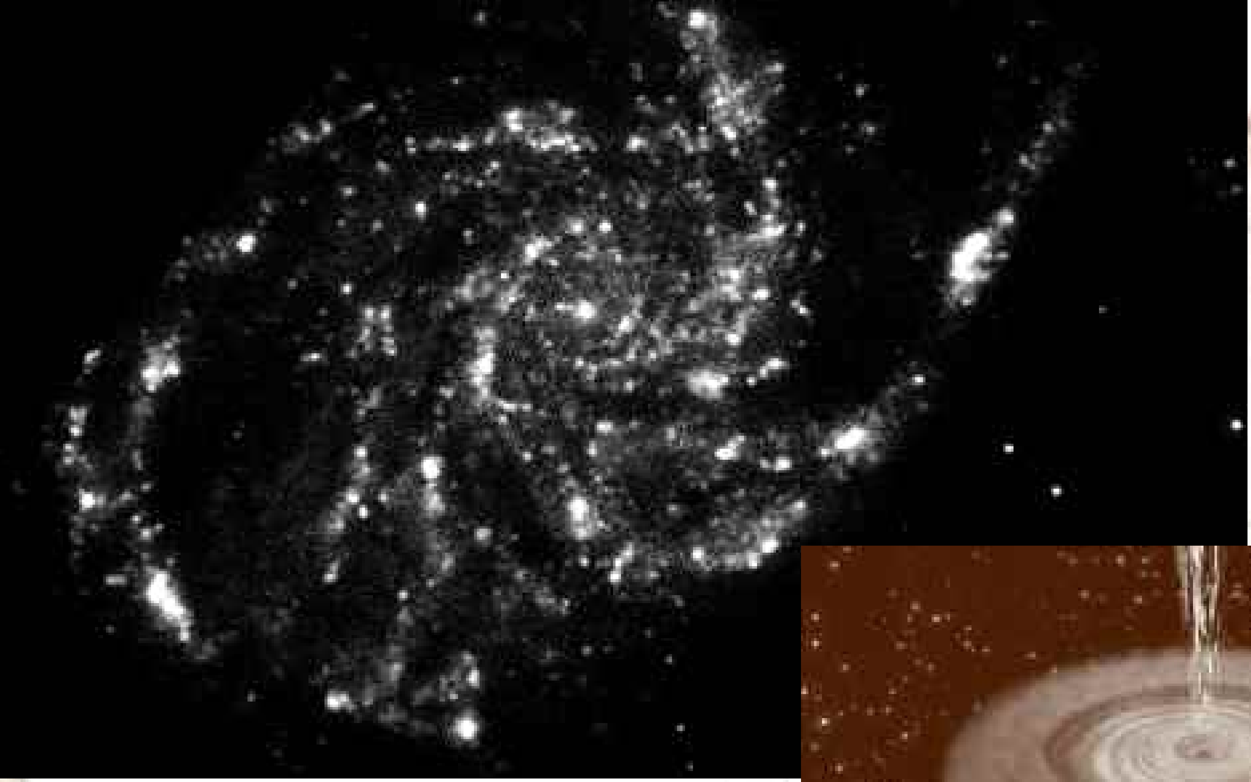
Clarke, of course, was not the first person to think about space travel. Among those who did was Isaac Newton. Newton calculated how fast a cannonball would need to be fired for its trajectory to curve downwards at the same rate as the Earth's surface curved. That would allow the cannonball to stay in orbit.

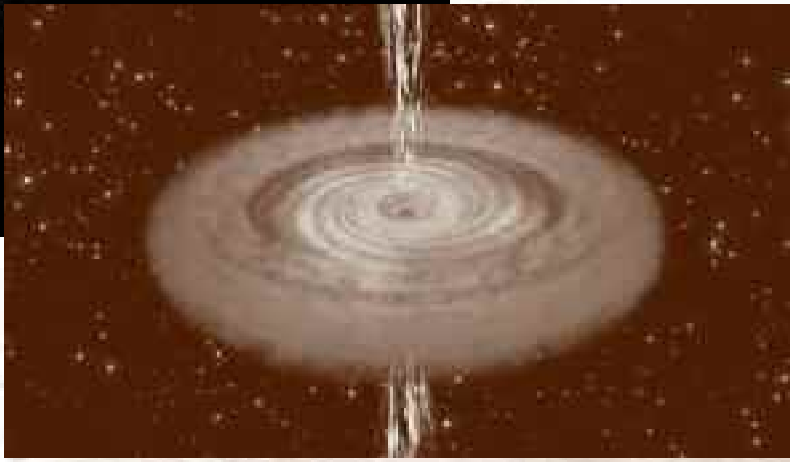
Needless to say, the required force vastly surpassed the capabilities of the artillery of Newton's day. This feat, however, was achieved in 1957 when the Soviet Union launched the first *Sputnik*.

In the 1960s, manned spaceflight skyrocketed from fantasy to reality. Since then, however, its glamour has faded. Only those who have now reached middle-age can remember the grainy television pictures of astronaut Neil Armstrong's 'one small step'. And it's been over 35 years since Jack Schmidt and Eugene Cernan, the last men on the Moon, returned to Earth.

Many of us watching then expected a lunar base, even an expedition to Mars, within 30 years. But the race to the Moon soon became an end in itself – virtually a stunt – driven by superpower rivalry. The impetus was lost.

Today the US Apollo programme seems a remote historical episode: School children learn that America landed men on the Moon, just as they learn that the Egyptians built the Pyramids. The motivations seem almost as mysterious in the one case as in the other.





Robotic exploration of space, however, has taken off. Unmanned probes to other planets have beamed back pictures of diverse and distinctive worlds. The most remarkable triumph of robotics may be the Huygens probe, which parachuted onto Saturn's giant moon Titan without any 'real time' control (radio signals from Earth would take hours to reach Titan).

Within a century, flotillas of tiny robotic space crafts may well explore and map the entire solar system. Robots and 'fabricators' will become commonplace, allowing large construction projects using raw materials that need not necessarily come from Earth.

Let's now widen our gaze beyond our Solar System to other stars. Since the 1990s, we've learned something that has made the night sky far more interesting: Stars aren't mere twinkling 'points of light'. In fact, many are orbited by retinues of planets, just like the Sun. Most such planets are not detected directly but rather by the way they cause the star that they orbit to wobble around the barycentre, the centre of mass around which two orbiting bodies revolve. This method of observation has been used to discover hundreds of extra-solar planets, mainly 'giant' planets – objects the size of Saturn or Jupiter. But we're especially interested in possible 'twin-s' of our Earth – planets the same size as ours, orbiting other Sun-like stars while being exposed to temperatures in which water neither boils nor stays frozen. Detecting such planets is a real challenge.

Today the US Apollo programme seems a remote historical episode.

We can see their shadow – a star dims slightly when a planet moves in front of it – that is, when a planet is 'in transit'. The Kepler spacecraft, launched on 6 March 2009, may be able to find many such objects.

Nevertheless, we would like to see these planets directly and not just their shadows. But that's difficult to do. To realize just how difficult, suppose an alien astronomer with a powerful telescope was viewing the Earth from, say, 30 light years away – the distance of a nearby star. Our planet would seem, in astronomer Carl Sagan's phrase, a 'pale blue dot', very close to a star (our Sun) that greatly outshines it – a 'firefly' next to a 'searchlight'. The shade of blue would be slightly different, depending on whether the Pacific ocean or the Eurasian land mass faced the observer. The far-away astronomers could infer the length of the 'day', the seasons, the gross topography, and the climate. By analysing the faint light, they could perhaps even surmise that it had a biosphere.

Within 20 years, telescope arrays in space, or a new generation of huge telescopes on the ground, will likely allow us to detect planets the same size as our Earth, orbiting other Sun-like stars.

Will there be life on any of them? We know too little even to assess whether this is likely. We don't

understand how life began here on our Earth, which now provides a habitat for an enormous variety of creatures, from slime mould to bonobo monkeys (and, of course, humans). Searches for life beyond our Solar System will justifiably focus on Earth-like planets orbiting long-lived solar-type stars.

Should we succeed one day in verifying the existence of alien life, it would influence our concept of our place in Nature as profoundly as Darwinism has over the last 150 years or Copernicus did in the 16th century. Yet, we should not hold our breath for success.

Even if simple life were common in the Universe, it is of course a separate question whether it would likely evolve into anything we might recognize as intelligent or complex. The Search for Extra-Terrestrial Intelligence (SETI) programme, involving literally millions of people, is an excellent example of 'citizen science'. We may one day detect a signal from space that's clearly artificial. On the other hand, such searches may well fail and we may find that there's no galactic community to 'plug into'. Earth's intricate biosphere may be unique.

Such knowledge may be disappointing. But it would have its upside. Our tiny planet could then be the most important place in the Galaxy, even a 'seed' from which life could spread through the entire Galaxy.

STARS AND GALAXIES

Our Solar System was formed by a condensing, slowly spinning cloud. We can now see places (the Eagle Nebula, for instance) where stars (and probably planets) are still forming. And we see stars dying, some 'relatively quietly' as planetary nebulae – as our Sun will in 6 billion years – and some 'explosively', as supernovae.

Our Galaxy is a kind of ecosystem where stellar gas is processed and recycled through successive generations of stars. Beginning with pristine hydrogen, this process generates the elements of the periodic table. All the carbon, oxygen and iron on Earth, and in our bodies, is ash from long-dead stars. We are the 'nuclear waste' from the fusion power that makes stars shine. In a very intimate sense, the cosmos is part of our environment.

We've made immense progress in understanding galaxies. We know that, in addition to the stars and gas that we can see, galaxies contain dark matter and that black holes lie invisible at their centres. Telescope surveys not only offer samples of galaxies for statistical analysis but allow us to study how galaxies are clustered. And we can probe far back into the past. Amazing images, like the Hubble Ultra-Deep Field, reveal many hundreds of faint smudges even in a small patch of sky less than one-hundredth the area covered by a full moon. Each faint smudge of light is an entire galaxy, which appears so small and faint only because of its distance. Light from these remote galaxies was first emitted up to 12 billion years ago. What we see is a scene from the past, when they were just being formed. Indeed some appear to us as consisting mainly of glowing diffuse gas that hasn't yet condensed into stars.

Quasars are the brightest objects for spectroscopic study. The existence of quasars shows that a great deal had happened by the time our universe was just one-tenth of its present age. Some large galaxies had already assembled and accumulated in their centres black holes whose masses are millions of times that of our Sun.

How can we probe even farther back towards the predicted 'first light' and thereby perhaps gain independent clues about the early growth of galaxies? Various prospects for obtaining such information should be within sight in the next decade.

We do not expect to see any stellar systems of the past as large and luminous as present-day galaxies. But there is hope of detecting 'subgalaxies' if they are gravitationally 'lensed' by clusters of galaxies along the line of sight, which act as Nature's own telescopes.

Individual supernovae may outshine these subgalaxies. Their detection may need to await the James Webb Space Telescope (JWST) planned for launch in 2013, or the next generation of ground-based telescopes. There is, however, a group of objects, much rarer than supernovae, which is luminous enough to be found by large-area searches: gamma-ray bursts. Such ultra-remote objects may, in fact, signify that massive stars formed early and then died explosively during the first one billion years of the Universe. Indeed gamma-ray bursts might signal the formation of 'seed' black holes. NASA's Swift satellite has already detected two such bursts, opening a new window onto the early history of the Universe.

Our Galaxy is a kind of ecosystem where stellar gas is processed and recycled through successive generations of stars.

What happened before galaxies formed? Even the more cautious among us are confident that our Universe is the expanding aftermath of a 'big bang' that took place nearly 14 billion years ago. The most compelling evidence is that all space is warmed to 3 degrees above absolute zero by weak microwaves – the diluted and cooled afterglow of its densely hot beginning.

COSMOLOGIC SPECULATIONS

We can divide cosmic history into three parts. The prevailing physics in the first trillionth of a second lies beyond the powers even of the new Large Hadron Collider (LHC) at CERN in Geneva, Switzerland, to simulate. This remains the intellectual domain of string theorists and inflationary cosmologists. But what we know about the phases from a millisecond to recombination (during which the light elements and the radiation spectrum formed) deserves to be taken as seriously as anything geophysicists tell us about the early history of Earth. However, at some era after recombination, structures condensed outward and evolved into the intricate assemblage of galaxies, stars and planets that we see around us.

IYA2009

The United Nations has declared 2009 as the International Year of Astronomy (IYA2009), calling for a year-long celebration to coincide with the 400th anniversary of the first recorded astronomical observations with a telescope by Galileo Galilei and Johannes Kepler's publication of Astronomia nova.

It was in 1609 that Galileo first turned one of his telescopes to the night sky and made the remarkable discoveries that would change humankind's understanding of its place in the Universe – craters and mountains on the Moon, a myriad of stars invisible to the naked eye, and moons orbiting Jupiter. The same year, Kepler published his famous work, in which he described the fundamental laws of planetary motions.

IYA2009 will promote the creation of international networks to foster a global appreciation of the value of astronomy as a unifying activity for humanity. It also aims to convey the excitement of personal discovery, the pleasure of sharing fundamental knowledge about the Universe and our place in it, and the merits of the scientific method.

The International Year of Astronomy 2009 is an initiative of the International Astronomical Union and UNESCO, which has been designated the lead agency. The UN Resolution establishing IYA2009 was submitted by Italy, Galileo's home country and the core founder of TWAS.

For additional information, see: www.astronomy2009.org

Research into these ‘recent’ phases of cosmic evolution finds itself in a similar situation to other environmental sciences – the basic laws are known, but everything is complicated by nonlinearity and feedback, comparable to what we experience with weather.

We’d like to understand why the Universe was ‘set up’ with its particular geometry, fluctuation and mix of ingredients. The answer probably lies right at the beginning, maybe even the first 10^{-44} second. I’d like to venture a few comments, though they should be preceded by this warning: they are speculative.

First, we might ask: How big is the Universe? Is it even bigger than we can observe? We can only see a finite volume, a finite number of galaxies. That is essentially because there’s a horizon, a ‘shell’ around us, which is delineated by the distance that light could have travelled since the big bang. But that shell has no more physical significance than the circle that delineates your horizon if you’re in the middle of the ocean. We can expect far more water – and far more galaxies – beyond the horizon.

Our Universe seems destined to expand forever, rather than to collapse in on itself in a few tens of billions of years. The fact that the observable Universe appears flat to us suggests, by way of the ocean analogy, that we’re nowhere near any ‘edge’. The volume of space-time within range of our telescopes – what astronomers have traditionally called ‘the Universe’ – might only be a tiny fraction of the aftermath of our big bang.

Space probably goes on much further. Indeed space could go on forever – more like an infinite ‘flat Earth’ than a finite round one. Our Universe, in fact, may be vast enough to harbour an infinite number of duplicates of ourselves. In such a Universe, there would be room enough to exhaust all possibilities – absolutely everything that could happen would happen somewhere.

But that’s not all. ‘Our’ big bang may not be the only one. An option to consider is brane worlds – many universes embedded in a higher dimensional space. Bugs crawling on a large sheet of paper, in their two dimensional universe, would be unaware of other bugs on a separate sheet of paper. Likewise, we would be unaware of our counterparts in another universe only a millimetre away – if that millimetre were measured

in a fourth spatial dimension – since we are imprisoned in just three.

Another theory is 'eternal inflation'. What we've traditionally called 'the Universe' could be just one patch of space-time in a vast cosmic archipelago. This hugely expanded cosmic perspective takes Copernican modesty one stage further. To put this on a firm footing, we'll need a unified theory of all the forces.

The laws and constants of physics seem the same everywhere we can observe, even in the most distant galaxy. But the observable domain – what we've traditionally called 'the Universe' – may be just an infinitesimal part of reality.

Our Universe may be vast enough to harbour an infinite number of duplicates of ourselves.

Four hundred years ago, Johannes Kepler thought that the Earth was unique, and its orbit was a circle related to the other planets by beautiful mathematical ratios. We now realize that even within our Galaxy there are perhaps billions of stars with planetary systems. Earth's orbit is special only insofar as it's in the range of radii and eccentricities compatible with life.

Maybe we are due for an analogous conceptual shift but on a far grander scale. Our big bang may not be any more unique than planetary systems are. And its parameters may be 'environmental accidents', like the details of the Earth's orbit. In this enlarged cosmic perspective, what we have traditionally called fundamental constants and laws could be mere parochial bylaws in our cosmic patch. They might derive from some overarching theory governing the ensemble but not be uniquely fixed by that theory.

The hope for neat explanations in cosmology may be as vain as Kepler's numerological quest. Our Universe isn't the neatest and simplest. It is, instead, a seemingly arbitrary mix of ingredients in a parametre range that enables us to exist.

We don't know if these theories are right. What could give us confidence in unobservable domains? The answer is clear. We'll believe in them if they are predicted by a theory that gains credibility because it accounts for things we can observe. We believe in quarks and in what general relativity says about the inside of black holes because our inferences are based on theories that have been corroborated in other ways. A challenge for 21st century physics is to decide whether there have been many big bangs rather than just one and, if so, how many universes they may have led to.

These still unsettled debates are, of course, important. Nonetheless, for 99 percent of scientists, they are irrelevant. That's because the task of chemists, geophysicists and biologists is to understand the complexity that's the eventual outcome of cosmic processes.

To understand why flows go turbulent, or why waves break, subatomic details are irrelevant. We treat the fluid as a continuum (and even if we could solve Erwin Schrödinger's equation for every atom of a turbulent fluid, it wouldn't offer any insight into turbulence).

Stars are simple: they're so big and hot that their content is broken down into simple atoms. None match the intricate structure of even the smallest insect.

CONSENSUS AND CONTROVERSY

Observational progress settles old controversies and enlarges consensus. But these advances bring into focus new questions that could not have been asked previously. We're all flummoxed. In the coming decades, there are three types of challenges.

The first is to seek to understand why our Universe is the way it is. This involves fundamental questions that may demand major conceptual advances in physics.

But there is a second aim that may not require new physics, yet is as dauntingly complex as any environmental science: How, from simple beginnings described by a few parameters, did our Universe evolve into the cosmic habitat we see around us? We can identify the key stages in the emergence of structural complexity: the first particles (protons and neutrons); the first stars and galaxies; the synthesis of the elements of the periodic table in stars; and the formation of planets around later-generation stars. This opened the way, here on Earth, to the formation of a biosphere and the emergence of brains capable of pondering their origins.

And there is a third question: Has this happened repeatedly or is intelligent life unique to Earth? The former option makes the Universe more interesting, although the latter would boost our cosmic self-esteem. How much of what is now science fiction will become science fact?

Our Sun formed 4.5 billion years ago, but it has 6 billion more years before the fuel runs out. It will then flare up, engulfing the inner planets and vaporizing whatever remains on Earth. Our solar system is barely middle-aged, and if humans avoid self-destruction, the post-human era beckons. Any creatures witnessing the Sun's demise 6 billion years hence, here on Earth or far beyond, won't be human. They will be as different from us as we are from bacteria.

But, even in this ultra-compressed timeline – extending billions of years into the future, as well as into the past – this century may be a defining moment. It's the first in our planet's history where one species – ours – holds Earth's future in its hands, and could jeopardize not only itself but life's immense potential.

In just a tiny sliver of the Earth's history – the last one-millionth part, a few thousand years – the patterns of vegetation altered much faster than before. This signalled the start of agriculture. The pace of change accelerated as human populations rose. But then there were other changes, even more abrupt. Within 50 years – little more than one-hundredth of a millionth of the Earth's age –carbon dioxide levels in the atmosphere began to rise fast. The planet became an intense emitter of radio waves as a result of the total output from TV, cell phone, and radar transmissions. And, something else unprecedented happened. Small projectiles lifted from the planet's surface and escaped the biosphere completely. Some were propelled into orbits around the Earth and some journeyed to the Moon and planets.

What might be witnessed in the next 100 years? Will a final spasm be followed by silence? Or will the planet itself stabilize? And will some of the objects launched from the Earth spawn new oases of life elsewhere?

The choice depends on us. And few things better inspire us with a commitment to our fragile planet and its future. Possibilities once believed to be restricted to the realms of science fiction have shifted to the centre of respectable scientific debate. From the first moments of the big bang to the mind-blowing possibilities for alien life, parallel universes and beyond, scientists are led to worlds even weirder than those envisaged by Arthur C. Clarke. ■

MAKING A CASE FOR THE SOCIAL SCIENCES

TWAS IS AN ORGANIZATION COMPRISED LARGELY OF NATURAL SCIENTISTS. OF ITS 900-PLUS FELLOWS, ONLY 17 ARE ECONOMISTS OR SOCIAL SCIENTISTS.

In the following article, Ismail Serageldin (TWAS Fellow 2001 and Vice President for the Arab region) explores what the imbalance in membership between the natural and social sciences may mean for the future of the Academy and what might be done to forge a closer relationship between the two.

Throughout its history, TWAS's primary goal has been to build scientific and technological capacity in the developing world. Yet, since its inception, the Academy has also been concerned about using science and technology to improve the economic and social well-being of people in the South. To fully achieve this goal will require insights and understandings that can only be provided by the social sciences.

But who at the Academy cares about the social sciences? I pose this question to stimulate an important debate among TWAS Fellows. Although I serve as chair of the TWAS membership section on the social and economic sciences, what follows should be understood as a personal statement and not an official view of the Academy.

I will begin by stating my key points and defining the terms I will use. I will then explore what I believe to be a profound disconnect between the natural and social sciences and conclude by offering several modest proposals on how TWAS might improve the relationship between these two broad branches of knowledge.

Why should we differentiate between the economic and non-economic social sciences? Part of the answer lies in the intellectual traditions of each discipline. Historically, economics has been more quantitative, predictive and prescriptive than other social sciences. Economic journals, moreover, are also closer to the natural sciences in how they handle quantitative information and citations. For these reasons, I will largely leave

economics out of the discussion and in the remainder of the article refer to the social sciences as a shorthand reference to the non-economic social sciences.

Forging collaborative frameworks between the natural and social sciences poses significant challenges.

KEY POINTS

- First: TWAS, by its mission, mandate and accomplishments, is 'the academy of sciences for the developing world'. One of the Academy's primary objectives is to help developing countries harness the best of science to solve real-life problems. To meet this objective, however, TWAS needs more than the expertise of natural scientists and economists. It also needs the insights and skills of social scientists: sociologists, anthropologists and political scientists.
- Second: Forging collaborative frameworks between the natural and social sciences poses significant challenges in methodology, and especially in the use of quantification. Methodology often depends on the issues being addressed. It is thus important to note that the issues addressed by the natural and social sciences, while complementary, are indeed different. Yet it is also important to note that differences in methodology do not make one methodology superior to another. Furthermore, the natural and social sciences need each other if effective responses to developmental problems are to be achieved.
- Third: Significant differences exist between how the natural and social sciences use quantification, publish their findings and cite each other's work. Because of these differences, TWAS will have to consider additional evaluation criteria in nominating and assessing potential members of the social disciplines. Specifically, the Academy's evaluation criteria should include not just peer-reviewed publications but the findings of empirical research and fieldwork found in the 'grey literature' sponsored by governments and international organizations.
- Fourth: TWAS should promote inter-disciplinary projects that would enable TWAS members in the natural sciences to work with colleagues from the social sciences to address issues of critical concern to the developing world: for example, climate change mitigation and adaptation; food and energy security; biodiversity loss; public health; and the challenges posed by rapid urban growth.

TERMS OF REFERENCE

What are the social sciences and how do they differ from the natural sciences?

The short answer is that there is no universally accepted definition. An examination of university curricula and publications shows a broad area of overlap between the social sciences and humanities and, in some instances, between the social sciences and natural sciences as well.

Anthropology, for example, includes biological anthropology, which is closely related to the natural sciences. Yet, it also includes cultural anthropology, which is linked to the humanities. Similarly, psychology is a broad discipline that often draws on the natural sciences to construct its intellectual framework but then relies on the social sciences for its applications. Such is the case with biological psychology, which, like clinical medicine, is viewed as a natural science with social science applications. Social psychology, meanwhile, is considered part of the social sciences, and neuropsychology part of the natural sciences.

In my own classification scheme, the social sciences include anthropology, sociology, psychology, political science and economics, and contain such subfields as social psychology and political economy. Such disciplines apply a scientific approach to examine and explain human behaviour, transactions between people, and the organization of communities and societies.

Never have we needed the social sciences more.

Some natural scientists say that the very arbitrariness of such efforts at definition cast doubt on the rigor of these fields. However, before attacking their colleagues in the social sciences, natural scientists should remember how their own definitions of research have evolved over the past century: Who today would postulate with unerring precision where the boundaries between chemistry and biology lie? Or, more generally, between fundamental and strategic research? Indeed, who would say that worrying about such boundaries is itself a productive use of our time?

But it is also true that precision in terminology and conceptual clarity is essential to intellectual discourse. No one in the basic sciences would dream of engaging in a scientific discourse without a minimal grasp of the subject under discussion. Precise definitions must be mastered: Mass is not the same as weight; the mean of distribution is not the same as its mode; uncertainty is not risk.

In general, the social sciences have a strong track record of keen insights and grand theories. They also rely on a sturdy foundation of literature that has helped shape perceptions of community, society and human behaviour. The magisterial *International Encyclopedia of Social & Behavioral Sciences*, edited by N.J. Smelser and P.B. Baltes and published in 2001, catalogues the broad sweep and the significant contributions of the social sciences over the decades.

Why, then, is there a continuing perception that the natural sciences, economics and the applied disciplines (agricultural, engineering, environmental studies and medicine) are essential to policy-making and governance, whereas the social sciences are not?

The answer lies in part in the 'economic paradigm' of development that has dominated thinking over the past three decades. In the 1960s and 1970s, this paradigm replaced the 'engineering and technologist paradigm' that prevailed in the first half of the 20th century.

This paradigm shift paralleled the rise of assessments that focused on broad investment programmes, not individual projects, and emphasized sectoral and macro-economic policies, not engineering and technical know-how. The collapse of centrally planned economies and the severe debt crisis faced by many poor countries in the 1980s and 1990s put the economic paradigm in an unassailable position. Markets and the private sector were not just accepted as key elements in the development equation, but were elevated to a universal, timeless creed in some quarters.

Yet both natural and social scientists have always recognized that development is a people-centered and gender-conscious process. Many have shared a common belief that the market's ruthless efficiency as a heartless distributor of resources ought to be tempered by a caring and nurturing state, and that strong and effective government is essential to development. Today, many natural and social scientists also recognize that sustainability is an essential dimension of development that requires melding the concerns of economists with those of anthropologists, sociologists and political scientists.

Indeed never have we needed the social sciences more; yet never have the gaps between natural science and non-economic social science been more profound. We face major challenges that require not only the best of the natural sciences and economics, but also the best of the social sciences. These challenges include:

- *Globalization*, which is the predominant trend of our time. Globalization challenges existing concepts of culture and national identity. It brings wrenching changes in lifestyles and drastically overhauls patterns of production and consumption. In many countries, it is fraying the social fabric as much as the industrial revolution did 200 years ago.
- *Poverty*, whose alleviation is a complex issue made even more complex by the times in which we live. Efforts to address this issue require multidisciplinary approaches that incorporate the insights and expertise of both the natural and social sciences.
- *Gender*, which may be among the most complex challenges faced by natural and social scientists who focus on development issues. It involves biology and society. It permeates all human relationships. It is the quintessential issue for trans-disciplinary work, spanning the full range of scientific and scholarly investigations from evolutionary biology to feminist studies.
- *Environment,* which requires a broad understanding of science, policy and human behaviour. Policies and programmes are unlikely to be effective unless they take account of not just the magnitude of a problem but also of how people behave. Unless one believes that price signals and economic incentives are all that are required, the critical role of the non-economic social sciences is obvious.
- *Migration and culture.* While we have largely succeeded in opening the world to the free movement of capital, goods and services, there remains enormous resistance to the movement of labour. Economic research shows that migration benefits the global economy and, with rare exceptions, helps recipient nations to grow their economies. Nevertheless, the issue still poses enormous challenges to a country's national identity and often sparks domestic tensions between 'native' and 'immigrant' populations. Again the case for thoughtful inputs from the non-economic social sciences is evident.

Although solutions to our global problems require increasing input from the natural sciences, it is equally true that science alone cannot solve these problems. As a result, we increasingly find ourselves trying to negotiate the difficult terrain of collaboration, which requires assistance from many different perceptions of their disciplines.

METHODS MATTER

The methodologies driving the study of the natural sciences and economics are well known. But the methodologies behind the social sciences are not.

The social sciences use forms of knowledge that differ substantially from the natural sciences. One of the primary forms of knowledge in the social sciences is the narrative. It is difficult to understand conflict between nations without understanding the different historical narratives that divide people, lead to hatreds and sometimes end in violence. For example, it is not possible to address the Palestinian-Israeli conflict without an appreciation of their different perceptions of their historical narratives.



The natural sciences and economics can and do use narrative as well. Such analysis is buttressed by evidence, of course, but it is still a narrative in its basic form. Take, for example, studies of the theory of biological evolution, which can be seen as a broad-based narrative that acquires increasing detail with additional research. Simply put, it is a rich narrative that becomes ever richer. Whether we talk of 'punctuated equilibrium' (as proposed by Stephen Jay Gould and Niles Eldredge) or of 'more continuous evolution' (as proposed by Richard Dawkins and Yan Wong) doesn't really change the overall narrative of evolutionary theory, which stands firm. Thus the method of adopting a narrative as a framework for formulating knowledge should not pose any problem for the natural sciences.

But natural scientists and, at times, decision-makers have criticized the social sciences on three important counts: their inability to predict and prescribe (which I think has no justification); their infatuation with post-modernist celebrities (which carried some weight in the past but is now largely behind us); and their tendency to favour qualitative over quantitative techniques (which again carries some weight but, as I touched on earlier, fails to consider that the methodology which is chosen must suit the problem that is being addressed).

Concern for development means concern for the future. While it may be interesting to examine a detailed and even insightful analysis about why the Somali state failed, decision-makers would find such analysis more useful if it had a predictive dimension that could tell them whether countries facing similar challenges would also unravel.

Predictive analysis by itself, however, is not enough. There is also a need for prescription – what to do to prevent unwelcome outcomes or to mitigate the adverse impacts that have already occurred. A brilliant report of socio-cultural determinants of fertility in Africa, published in the 1990s, concluded that fertility decline in Africa was likely to be much slower than experts believed. However, the report stopped short of proposing what to do about it. Should policy-makers design alternative programmes? Abandon current family planning efforts? Continue the initiatives underway but accept slower outcomes than hoped for? By being predictive but not prescriptive, the report was less useful than it might have been for decision-makers with policy and budget responsibilities. For policy-makers, knowing is not enough; they need to know what to do – in other words, what the options are.

POST-MODERNISM

In recent years, post-modernists, drawing on works in philosophy and literary criticism, have questioned virtually every insight made by their colleagues working in more conventional fields of science and scholarship. However, they have yet to create a convincing alternative paradigm of their own. In fact, many theoretical sociologists, by embracing the post-modernist gobbledygook of such practitioners as Jacques Lacan and Gilles Deleuze, would find it difficult to agree on a basic conceptual framework for their discipline.

I do not hide my staunch opposition to post-mod-

> ***We must recognize the excellent work of those who conduct fieldwork or write reports for UN agencies.***

ernists who claim that scientists are simply practitioners of another 'discourse' who harbour their own agendas. In the view of post-modernists, this makes scientists no different than other interest groups and power brokers.

Such a perception is not only wrong; it is destructive. Post-modernists have substituted clever word games for rigorous analysis and, despite an occasional flash of insight, they frequently come across as no more than superficial name-droppers who misuse and abuse the language of science.

Alan Sokal, in his famous (or, if you prefer, infamous) article, "Transgressing the Boundaries: Towards a Transformative Hermeneutics of Quantum Gravity", published in *Social Text* in 1996, shockingly demonstrated the intellectual shortcomings of post-modernists. Sokal pulled off a world-class hoax by concocting an article (including its mind-bending title) that deliberately substituted big words and impenetrable sentences for serious thought. Nevertheless the article was published and, in the process, exposed the shallow intellectualism of post-modernism.

By allowing such silliness to take hold, post-modernists have seriously damaged the reputation of the social sciences. While plagiarism and the falsification of data periodically surfaces throughout academia, no natural science department (or economics department or, for that matter, social sciences department dedicated to serious thought) would tolerate such shenanigans for so long and then watch passively as a scientist in another field exposes such bad behaviour.

BEYOND POST-MODERNISM

Beyond the tragic-comedy of post-modernism, there are deeper questions that stand between the natural and social sciences – questions that deal with differing methodologies and, more specifically, the way in which quantitative and qualitative analysis is used.

The social sciences – most notably, sociology and political science – are founded on strong theoretical foundations in addition to a broad body of empirical studies. Substantial forays into quantification and measurement are also common, even if the nature of these investigations allows for only limited experimentation.

Some scholars, for example T.J. Fararo, have contended that the rich traditions of sociological research share conceptual components. Today, newer methodologies, such as process studies, ethno-methodology and network analysis, are being incorporated, further enriching the field. But that is not the entire picture. Most social scientists remain reluctant to generalize. Anthropologists, who study Africa's Bushmen, for example, do not often generalize their findings to the behaviour of Canada's Inuit or native tribes in the Amazon.

For developing countries, we must also recognize the excellent work of those who conduct fieldwork or who write reports for UN agencies – work that can be as empirical and often more pragmatic than academic studies. Take the research reports of the World Bank, which I am most familiar with from my tenure with the Bank between 1972 and 2000.

The Bank is best known for its economic studies. But it has done superb research in sociology and anthropology too. More than a decade ago, Michael

Cernea, the leader of the Bank's non-economic social science practitioners, catalogued this research in an annotated bibliography spanning the years 1975 to 1993. The Bank has since produced many more reports. Yet, natural scientists are prone to dismiss such publications (so-called 'grey' literature) because they have not been published in peer-reviewed scientific and scholarly journals.

There are, as well, many unheralded publications written by researchers in developing countries that remain largely unknown – and uncited – in the peer-reviewed literature. Indeed citations can be deceiving. Some post-modernists have become widely cited international celebrities. But the truth is they have contributed little to solving the real problems of people living in the developing world – and, as the Sokal hoax has shown, they may not be contributing much to scholarship either.

ON PURPOSE

Peter Singer, a well-known professor of medicine at the University of Toronto, has observed that at a very fundamental level, all scholarship has three common characteristics: a purpose, a significance, and a method. If our purpose includes helping developing countries to harness the best of science for solving their problems, then the significance, in a real-world context, is assured. The challenge becomes selecting the most appropriate methods.

While precision is related to quantification (when well done), and quantitative methods have gained hegemony even within many of the social sciences, the right methodology often depends on the research question that is being asked. Questions of prediction lend themselves to quantitative methods. Questions of meaning and explanation lend themselves to qualitative methods. Neither method is better than the other. The truth is both are often needed to address complex, multi-dimensional problems.

In starker terms, applications of science to address critical social and economic needs that are devoid of social and cultural understanding are likely to fail. Take the challenges posed by HIV/AIDS to public health. To counter the spread of this infectious disease, we certainly need to know the genetic makeup of the virus and understand its vectors. But such medical knowledge is not enough. We also need to understand the sexual behaviour of individuals living in diverse cultures; to appreciate the capacities of different health-care systems; and to examine the financial implications of effective prevention and treatment programmes. All of this knowledge is crucial for devising effective medical trials that conform to the social and cultural values of their clientele. The shutting down of HIV Tenofovir trials in Cambodia is just one example of what happens when insufficient attention is paid to the concerns of the local population. The bottom line is this: The natural and social sciences must be partners in efforts that seek to put science to work to improve the economic and social well-being of people.

CROSSING DISCIPLINES

Universities, research institutes, funding agencies and international organizations (such as TWAS), all increasingly recognize that conventional discipline-based 'silos of knowledge' are no longer the best way to tackle real-life problems. The most interesting research being done today takes place between and among disciplines. Scientists, scholars and, I might add, policy-makers are increasingly recognizing that such critical problems as poverty, gender discrimination and environmental degradation are multi-dimensional, complex challenges that require inputs from a broad range of disciplines.

There are growing numbers of institutions trying to turn this perception into a reality. Top-level universities have created world-class cross-discipline institutes – for example, the Earth Institute at Columbia University and the BioX complex at Stanford University, USA – to promote interaction between disciplines in ways that effectively address critical social, economic and technical challenges. Even more radical reforms are underway. Olin College of Engineering, founded in 2001 in Needham, Massachusetts, USA, has eliminated discipline-bound departments to encourage its students to think creatively about engineering and to embrace the 'discipline' not simply as a technical pursuit but as a social enterprise designed to improve lives. The King Abdullah University of Science and Technology, near Jeddah, Saudi Arabia, which expects to open in the autumn of 2009, has replaced traditional departments with four interdisciplinary research institutes: biosciences, materials sciences, energy and the environment, and computer sciences and mathematics.

Whether these are just passing fads or the wave of the future will soon become apparent. But it is clear that greater inter-disciplinarity will command a great deal of attention in the future, especially in efforts designed to bring research to bear on critical social and economic problems.

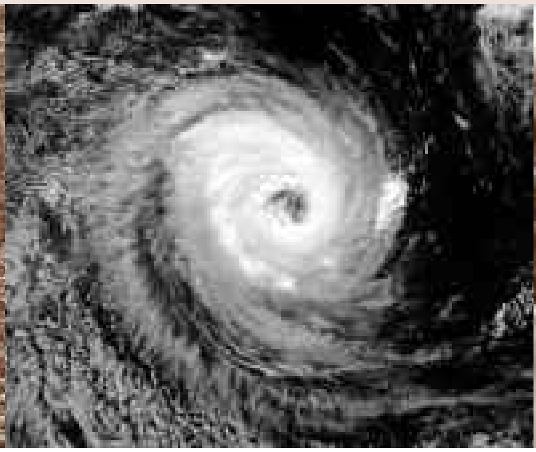
The nature, scale and complexity of the challenges we face require that many people have the ability to work not only across disciplines but also within inter-disciplinary areas. Indeed, there are presently three major ways of organizing collaborative work among disciplines: inter-disciplinary, multi-disciplinary and trans-disciplinary strategies.

The most interesting research being done today takes place between and among disciplines.

Inter-disciplinarity represents a team approach to organizing intellectual inquiries in a rapidly evolving field. The pace of change within the field often means that aspects of the challenge cannot be addressed within existing knowledge frameworks.

Multi-disciplinarity reflects an effort to set varying disciplines to work without integrating them. Each discipline, as a result, yields discipline-specific results. Together, they attack an issue on many fronts.

Trans-disciplinarity represents an approach in which a philosophy or conceptual construct dissolves boundaries between disciplines and offers an overarching intellectual framework that transcends specific fields of study. This approach includes, for example, intellectuals who study such diverse fields as art and literature through the lens of Marxist ideology.

WHY CARE?

Why should natural scientists care about the social sciences? The simplest answer is this: Because effective responses to the needs of humanity require inputs from these disciplines.

Yet, even if we embrace the social sciences, how should excellence be determined? Here we must accept a slight variation from the way in which excellence is determined in the natural sciences. We should measure it not just in terms of publication in peer-reviewed journals but also by the influence that the publications have on practitioners in the field and by the publications' usefulness to experts in other disciplines.

Excellence, in short, should be determined by the usefulness of the techniques that have been developed and implemented, by the fresh insights that have been made, and by the ability of the findings to influence public policy discourse.

Excellence should be determined by usefulness.

The impact of economic theory is at least partly measured by such criteria and there is no reason to believe that non-economic social sciences cannot be subject to the same process of evaluation. Excellence in both theory and practice, under such criteria, will be determined by what works on the ground – that is, by what concepts and practices prove effective in solving problems.

SOME MODEST PROPOSALS

And that brings me to my concluding remarks about what TWAS members should do about the social sciences when determining the makeup of the Academy's membership and programmes. I recommend several actions:

- *Recognize grey literature*. One of the primary difficulties encountered by TWAS's social and economic group since its inception in 2001 has been a lack of qualified candidates for membership. To date, only 17 economists and social scientists have been elected to the Academy. In 2008, not a single candidate was nominated. One way to increase the potential pool of candidates for election to TWAS would be to recognize the contributions that non-economists among the social scientists make in influencing policies and addressing real-world problems. That, in turn, means that greater weight must be placed on the value of grey literature.
- *Reach out to women and young practitioners*. The Academy has made significant strides in reaching out to young scientists and it has taken important steps in recognizing women scientists as well. Such efforts should be extended to economists and social scientists. The payoff could be substantial, especially when considering that these disciplines tend to attract more women and to be more popular among students than the natural sciences.
- *Launch inter-disciplinary initiatives.* The TWAS Council should consider sponsoring reports and projects that require teams of researchers to work together. Such panels, comprised largely of TWAS members, should be inter-disciplinary or multi-disciplinary in nature and embrace economists and social scientists as full and equal members. ■

LIFE-RENEWING HOPE IN AFRICA

IN 2007, KETO ELITABU MSHIGENI (TWAS FELLOW 1987), VICE CHANCELLOR, HUBERT KAIRUKI MEMORIAL UNIVERSITY, DAR ES SALAAM, TANZANIA, WAS NAMED A TWAS MEDAL LECTURE RECIPIENT.

At the TWAS 25th anniversary conference in Mexico City, held in November 2008, Mshigeni spoke on a topic that has been at the centre of his research over the past four decades: the unique and intriguing biodiversity in his native Africa. In his talk, Mshigeni also outlined the measures that he believes should be taken to ensure that Africa's rich heritage of natural resources is wisely used and conserved for the benefit of the continent's most valuable resource: its people.

Mshigeni is one of Africa's most respected botanists. His illustrious career has been distinguished not only by his vast knowledge of his primary area of expertise – biodiversity – but also by his decision to spend virtually his entire career in Africa.

Mshigeni obtained his bachelor of science degree from the University of East Africa, Dar es Salaam University College, in Tanzania, in the 1960s. In the early 1970s, he went to the United States, where he earned a PhD in botanical sciences at the University of Hawaii. Returning to Dar es Salaam University College, he served as professor of botany and founding director of postgraduate studies. At the University of Namibia in the 1990s, Mshigeni held the post of founding pro-vice chancellor for academic affairs and research. In addition, he became the founding UNESCO/UNU chair for ZERI (the Zero Emissions Research Initiative) in Africa, and director of the UNDP regional project on sustainable development and biodiversity in Africa. Mshigeni is a member of the editorial board of the African Journal of Ecology *and editor-in-chief of* Discovery and Innovation, *which is published by the African Academy of Sciences. He has received the Boutros Boutros Ghali Prize and the African Academy of Sciences/CIBA Prize for Agricultural Biosciences. He is also an elected fellow of the World Technology Network.*

"Africa is rich, and there is hope." How can such a positive image of Africa be drawn in the face of the chronic despair that afflicts the continent? After all, Africa is the world's poorest region. Some 700 million people – nearly 70 percent of the population of Africa – live on less than US$2 a day. It is also a place

plagued by debilitating diseases – some which have existed for centuries, and others which have emerged only recently. An estimated 25 million Africans are infected with HIV/AIDS, more than 60 percent of the world's total. Ninety percent of the world's malaria victims are also in Africa, a figure that grows by one million people each year. Adding to the misery, more than 40 percent of Africans do not have access to safe drinking water and 70 percent do not have access to electricity.

Despite these dismal statistics, it is true that 'Africa is rich', and that 'there is hope.'

That hope exists in the vast marine resources of Africa, which boasts a 30,500-kilometre coastline that harbours a treasure trove of untapped biota and other resources.

That hope exists in the continent's unique position of equilibrium over the equator, which could provide Africa with a reliable source of solar energy, powering the continent in an environmentally sustainable way in the 21st century. No other continent has such a comparative geographical advantage.

That hope also exists in the continent's dynamic and life-sustaining rivers – for example, the Nile (the world's longest river), the Congo (second only to the Amazon in water discharge), the Niger and the Zambezi. These rivers not only have the potential to provide bountiful supplies of freshwater to meet basic health and sanitation needs, but also to serve as the basis for sustainable development.

Along the equatorial belt are lush tropical rainforests, especially in the Congo River ecosystem, which support biota providing reliable sources of food, traditional medicines and timber. Africa's tallest equatorial highlands display sublime year-round snow-caps and arresting vistas with a vast potential for ecotourism. One of the botanical surprises in the forest ecosystem, *Thaumatococcus danielli*, a bountiful under-forest canopy plant, produces exceptionally sweet berries 2,000 times sweeter than sucrose. The sweetening biocompound is not a polysaccharide but a protein, *thaumatin*.

The mysterious forest elephant, *Loxodonta cyclotis*, is also found in the equatorial forest ecosystem. With its prized pink-tinted ivory tusks, it is smaller than the more common open savannah elephant, *Loxodonta africana*; yet, it is every bit as intriguing. The extraordinary goliath frog, *Conraua goliath*, the largest frog on earth, weighing more than 3 kilos, illustrates the endless, eye-catching wonders of the continent's biodiversity. Similarly, Africa's termite nests, which may reach up to six metres, present arresting surprises. They contain a stable and effective 'air-conditioning system' that would humble even the world's best construction engineers. Many termite nests also include intricate gardens of tasty edible mushrooms. All of this is due to the efforts of tiny, blind worker termites from which we can learn the power of organized teamwork. The most notable wonder in these subterranean termite gardens, however, is *Termitomyces titanicus*, a spectacular edible mushroom, whose fruiting cap spans one metre in diameter.

Africa is rich, and there is hope.

The point of this discussion is not just to highlight Africa's striking diversity of plants and animals. Rather, it is to emphasize the potential that Africa's rich biodiversity harbours for sustainable development and economic prosperity.

The continent's biological richness, while a reflection of nature's bounty, could also propel sustainable economic growth. For example, the cactus-like plant *Hoodia gordonii*, in the Kalahari ecosystem, contains a biochemical compound (p57 molecule) that scientists have recently confirmed works as a natural appetite suppressant. Large pharmaceutical firms, such as DMD Pharmaceuticals, Alkemists Pharmaceuticals, Naturex and Ethno Africa UK Ltd, are currently seeking ways to commercialize the biocompound, hoping to earn hundreds of millions of dollars from its therapeutic value in addressing one of the world's great public health problems – obesity, which currently afflicts some 300 million people worldwide, including an increasing number of people in the developing world.

Then there is *Welwitschia mirabilis* in Africa's Namib Desert, which has extraordinarily large leaves and an unusual ability not just to survive but also to thrive in the forbidding environment of the earth's oldest desert. The renowned 19th-century scientist Friedrich Welwitsch, who assembled one of the first comprehensive catalogues of Africa's flora, described the plant as "the most beautiful and majestic phenomenon that tropical Africa has to offer". Could *Welwitschia mirabilis*, which is found only in Africa, supply a storehouse of genes for drought-, pest-, and disease-resistance? Could it hold a genetic key for longevity? Some of the bigger *Welwitschia* plants living in the Namib today are over 1,500 years old.

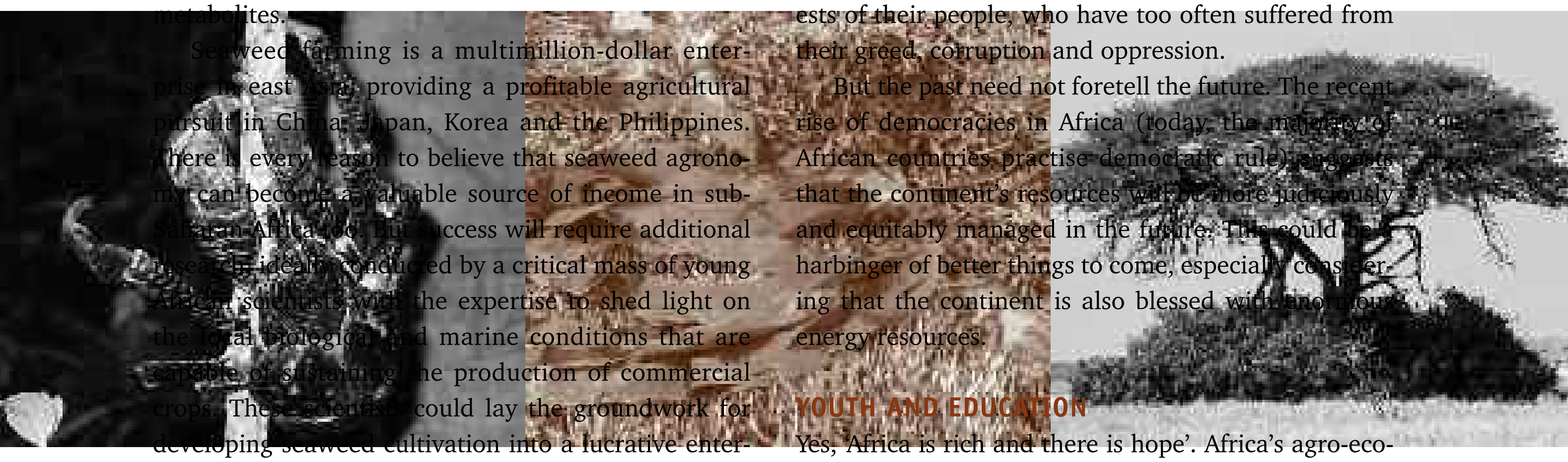
Then there is also the Namib Desert elephant. How can such a huge mammal, weighing up to 6,000 kilos, survive in the harsh environs of Namibia's Kaokoland and Damaraland, where annual rainfall rarely exceeds 20 millimetres? Do Namib desert elephants, and their diets, hold secrets on how to live in forbidding environments, where water is scarce and becoming even scarcer as a result of climate change and global warming?

The wonders of Africa's tropics and deserts are matched by those of the continent's dryland savannah, home to the majestic African baobab, *Adansonia digitata*. This intriguing tree has leaves that can be eaten as a nutritious vegetable, fruit pulp rich in vitamin C and tartaric acid, seeds that are as nutritious as peanuts and strong-fibered bark that can be used to make cloth and even construction material.

On Seychelles' two islands – Praslin and Curieuse – we find another botanical wonder, the coco de mer (*Lodoicea maldivica*), with leaves that span 10 metres long and 4 metres wide, and strange-shaped seeds that weigh up to 30 kilos and can take up to a decade to mature. Such startling phenomena have earned the African palm a place in the *Guinness Book of World Records*.

On Chumbe Island, in Zanzibar, Tanzania, residents and visitors can come face-to-face with a strange, cat-sized creature climbing atop tall coconut trees. But the creature is not a cat, nor is it a mammal. Rather, it is a hefty arthropod, the coconut crab (*Birgus latro*), in search of a meal. Relying on its strong claws, this one-of-a-kind crab, the earth's largest land arthropod, can crack open the coconut's crusty shell and feast on the white coconut meat inside. Imagine its strong claws getting hold of your toe.

The nearby sea is home to the cultivated seaweed *Eucheuma*, which has wide-ranging applications as a gelling, thickening and emulsifying agent. Since it grows extremely rapidly (it can be harvested within four weeks after planting), *Eucheuma* holds great promise as a profitable quick-return-on-investment commercial product. Meanwhile, the edible seaweeds *Porphyra* and *Laminaria* show great promise for possible cultivation in the cool marine waters of Namibia. The former could be farmed for the manufacture of a wide range of nutriceuticals, taking advantage of its rich proteins, vitamins, inorganic minerals and other metabolites.



Seaweed farming is a multimillion-dollar enterprise in east Asia, providing a profitable agricultural pursuit in China, Japan, Korea and the Philippines. There is every reason to believe that seaweed agronomy can become a valuable source of income in sub-Saharan Africa too. But success will require additional research, ideally conducted by a critical mass of young African scientists with the expertise to shed light on the local biological and marine conditions that are capable of sustaining the production of commercial crops. These scientists could lay the groundwork for developing seaweed cultivation into a lucrative enterprise without harming the environment.

TOURISM, MINERALS AND ENERGY

There is also the alluring potential of ecotourism. The Serengeti plains, Mount Kilimanjaro and Ngorongoro caldera in Tanzania, and the Etosha ecosystem in Namibia (to cite a few prominent examples), are environments of startling beauty. They are also home to stunning plant and animal species that provide unforgettable experiences for those who visit Africa to personally see them.

Africa has fossilized treasures, too, that date back to the age of the dinosaurs and to the earliest traces of *Homo sapiens*. While some of these treasures were illegally confiscated during the colonial era and are now on display in museums in Europe and the United States, Africa still offers visitors glimpses of unique biological and cultural phenomena that can be found nowhere else on earth. *Saintpaulia ionantha*, the popular African violet, a beautiful easy-to-grow indoor plant, which generates millions of dollars annually in the industrialized world, was first smuggled to Germany from Tanzania's Usambara mountains. There are many plants of comparable glory still growing in the wild in Africa.

The continent is also endowed with rich soils and a broad spectrum of minerals, including copper, diamonds, gold, platinum and uranium, as well as coal, iron ore and petroleum. European colonizers and others from outside of Africa have often exploited these natural resources for their own enrichment, paying scant attention to the well-being of local residents. At the same time, many of Africa's post-independence governments have often failed to act in the best interests of their people, who have too often suffered from their greed, corruption and oppression.

But the past need not foretell the future. The recent rise of democracies in Africa (today, the majority of African countries practise democratic rule) suggests that the continent's resources will be more judiciously and equitably managed in the future. This could be a harbinger of better things to come, especially considering that the continent is also blessed with enormous energy resources.

YOUTH AND EDUCATION

Yes, 'Africa is rich and there is hope'. Africa's agro-ecological regions also show great potential for biofuel energy production. The continent has abundant freshwater and marine resources, as well as rich tropical forests, woodlands and grasslands teeming with life. Its coastlines are among the most magnificent and inviting in the world – with beaches often pristine and largely untouched by people.

The greatest source of hope for the continent's future lies in its people.

But the greatest source of hope for the continent's future lies in its people. Today, Africa's population stands at more than 900 million. It is increasing at a rate of 2.4 percent per year and projected to reach 1.5 to 2 billion by 2050. It is, moreover, a youthful population, with two-thirds of the inhabitants under the age of 25.

The combination of rapid population growth and a youthful population creates endless possibilities for development. But only if the right polices are put in place to nurture, guide, inspire and reward Africa's youth.

Africa's population has some unique characteristics beyond its youthfulness. Some 70 percent derive their livelihoods from agriculture, compared with 62 percent in Asia, 50 percent in South America, 8.5 percent in Europe, and 5 percent in North America. Africa's farmers, moreover, have a very low level of education.

A lack of education, which impedes the use of new scientific knowledge, technology and innovation, is one of the primary reasons for the low yields that plague Africa's agriculture. Other reasons for low crop yields include the lack of adequate infrastructure, limited access to seeds and fertilizers and poor storage facilities. Currently, post-harvest crop losses in Africa often exceed 40 percent, compared to 10 to 30 percent in Asia.

Inadequate knowledge and poor facilities for waste management also generate a huge amount of lignocellulosic crop residues: cereal straw, sugar cane bagasse and cotton seed husks, which are traditionally discarded as waste or burnt, causing environmental degradation. With appropriate knowledge and technology, huge biomass crop residues can be used productively as organic substrates for cultivating high-value edible and medicinal mushrooms, as is done in China, which currently produces 14 million tonnes of edible, tasty, nutritious (and medicinal) mushrooms using similar lignocellulosic crop residues.

Africa has a natural resource base that experts agree is capable of feeding its growing population. Yet, it has remained a net importer of food, and also the world's only continent where large segments of the population find themselves at risk of malnutrition and hunger. Indeed Africa's under-five mortality rate far exceeds that of other regions; some 5 million African children under the age of five die each year. Experts attribute nearly a half of these deaths to malnutrition.

GOVERNANCE AND CORRUPTION

Political stability and good governance would help address the continent's food security problems. Africa must not allow its leaders to repeat the plunder and pillage of such despots as Mobutu Sese Seko of the Democratic Republic of Congo, who shipped billions of dollars to his personal bank accounts in Europe while wilfully neglecting the needs of his people at home.

Although a number of African nations have recently enacted encouraging reforms in governance, corruption and mismanagement continue. The inability of the lucrative mining sector to provide adequate economic dividends to the people of Africa is directly related to the issue of poor governance, which allows multinational corporations to profit from the exploitation of these valuable mineral resources.

Moreover, over-dependence on foreign experts (whether administrators, scientists, engineers or technologists) has stymied Africa's efforts to develop its

TWAS MEDAL LECTURES

Since 1996, TWAS has been awarding 'TWAS Medal Lectures' to members in recognition of their achievements in their primary fields of research. The recipients lecture on a main aspect of their work at TWAS annual conferences, and are presented with a plaque, as a token of appreciation. For a complete list of TWAS Medal Lecture recipients, see www.twas.org. *To date, 33 scientists have received the award.*

own capacities in critical fields. A chronically under-financed educational system has led Africa to rely on non-Africans with the requisite knowledge and training to do the job. The presence of outside experts, in turn, has meant that few openings are available for Africans in technical and other highly skilled fields that require advanced training.

Africa desperately needs to train a critical mass of its own scientists, engineers, technologists and health professionals if it hopes to gain control of its own natural resources. It must also offer them ample employment opportunities, incentives and an enabling working environment. And it needs to build a modern transportation infrastructure, provide adequate social services, and make clear its commitment to generating rapid scientific and technological advancement.

Yes, 'Africa is rich, and there is hope'. But its richness and hope has been – and continues to be – undermined by poverty, exploitation, corruption, mismanagement and negligence.

Nevertheless the hope and the riches that we see are not just on the horizon: they are visible in a growing number of African countries. For example:

- In Tanzania, the government has been waging an effective campaign against corruption, while dramatically increasing its investment in education, science, technology and innovation. Its transport is also rapidly improving – particularly, its roads and ports.
- In Namibia, the government has made significant investments in education, science, technology and innovation. More specifically, it is pioneering technological developments in freshwater and marine fish farming. As an intriguing sign of hope, the University of Namibia's Sam Nujoma Marine and Coastal Resources Research Centre, at Henties Bay on the Atlantic coast, recently inaugurated a state-of-the-art mariculture research complex in collaboration with the United Nations University's Institute for Natural Resources in Africa (UNU-INRA). It is expected to grow into a centre of excellence for seaweed farming, fish farming and marine technology for Africa and the South at large.
- In Botswana, the government has initiated a broad-ranging effort to promote in-country expertise in diamond cutting and polishing. The goal is to develop and sustain national capacity building in this field, so that the citizens of Botswana (instead of foreign interests) can benefit from value-addition innovations inspired by the country's enormous diamond treasures.

Africa desperately needs to train a critical mass of its own scientists, engineers, technologists and health professionals.

LOOKING AHEAD

Africa's leaders should not be content with planning for short-term improvements in the daily living conditions of their people (and timing these to mainly coincide with general elections). Instead, they must dream about – and devise – long-term development plans that lead to fundamental economic and social change, by drawing on the continent's deeply rooted indigenous knowledge and resources. The leaders of Africa would do well to heed the wise advice of an anonymous Chinese poet who, nearly 2,500 years ago, wrote: "If you are thinking one year ahead, plant a seed. If you are thinking 10 years ahead, plant a tree. If you are thinking 100 years ahead, educate the people." And I would like to emphasize: If you are thinking *more than 100 years* ahead, educate the people in science and technology fields.

The power to develop Africa, and to enable Africans to live lives of dignity and fulfilment free of impoverishment and despair, lies largely in Africa's own hands. The journey begins with the conservation and wise use of Africa's abundant natural resources and requires a unity of purpose and a spirit of teamwork and coordination. Here there is much we can learn from the work of the humble African termites

mentioned earlier: The 'insect skyscrapers' they build provide an exceptionally efficient and effective air-conditioning system that is perfect for the specific requirements of the mushroom species they cultivate.

Ultimately, however, the journey's success will depend on the continent's ability to nurture, educate, train and inspire its people. That means Africa must build a solid foundation of high quality education at all levels. It must invest adequately in science, technology and innovation. It must devise effective ways to use its vast reservoir of human resources, and it must chart a course that enables the continent to transform its broad base of indigenous knowledge into lucrative enterprises that generate tens of thousands of jobs with liveable incomes.

K.E. Mshigeni

Africa's natural resources have yet to be fully explored. Indeed they remain only partially understood and appreciated. New species of biota continue to be discovered each year.

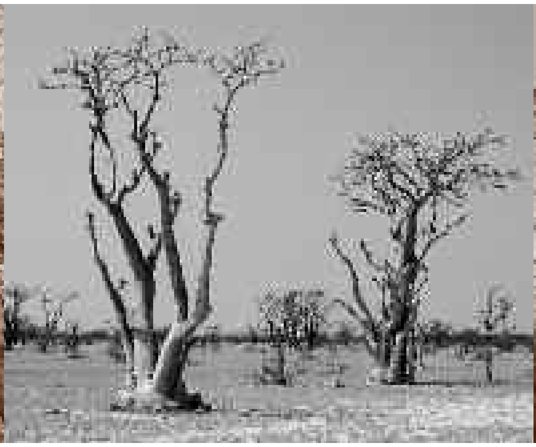
It is also true that unstable development and poor conservation practices have degraded many of the continent's ecosystems and placed an increasing number of them at risk. Now climate change is exacerbating the problem. Some of Africa's species are likely to disappear before they are even documented.

We cannot afford to see what happened to the dodo of Mauritius (*Raphus cucullatus*) repeated. This poor flightless bird was hunted by colonizing powers to extinction and lost forever. To help ensure that history does not repeat itself, there is a critical need to educate and train a critical mass of researchers in the biological sciences and related fields, who can play an active role in researching, documenting, monitoring, analysing and promoting public awareness of Africa's great biological resource heritage. A special fund for this purpose should be established by the African Union in partnership with governments of both the North and South.

OPPORTUNITY PLUS

The goliath frog, coconut crab, African baobab, *Termitomyces titanicus* edible mushroom, and *Welwitschia mirabilis*, to cite just a few examples of the continent's unique and bountiful diversity, should not be viewed just as biological wonders. Instead, they should be embraced as a primary source of the continent's sustainable future, and as part of the world's heritage.

When I see the *Saintpaulia*'s violet blue flowers at the entrance to Tanzania's Amboni caves still growing in the wild, I am sadly reminded of the magnitude of commercial earnings being generated annually in the industrialized world based on this African botanical treasure. It is then that I realize that Africa needs to dream, crystallize visions, and be more innovative in transforming the vast natural resources and indigenous knowledge it has, into value-added marketable products that provide sustainable and dignified livelihoods.


Public awareness needs to be increased about the untold value and opportunities these resources present. Teams of well-trained scientists need to be formed so these resources can be more intensively researched. Research institutes need to be established and strengthened, and policies need to be devised and implemented to ensure that the research findings, and the enormous wealth of Africa, benefit all Africans, both today and in the years ahead.

This will require the involvement of international organizations such as TWAS – and indeed the entire family of United Nations organizations. It will necessitate bilateral assistance that is well targeted and steadfast. And it will call for the active participation of such pan-African organizations as the African Union. But most importantly, it will demand the unwavering commitment of Africa's national governments, and the African people themselves.

The power to develop Africa lies largely in Africa's own hands.

Nurturing the sustainable development of Africa is within Africa's reach, but only if Africa itself proves to be sufficiently visionary, innovative and creative; and only if it embarks on a renewed journey of development that taps Africa's greatest attributes – its human and natural resources. ■

MEDICINAL PLANT RESEARCH IN MADAGASCAR

FOR MORE THAN 40 YEARS, THE *INSTITUT MALGACHE DE RECHERCHES APPLIQUÉES* (IMRA) HAS BEEN INVESTIGATING MADAGASCAR'S TRADITIONAL MEDICINES AND FOOD PLANTS, SUCH AS THE JAVA PLUM, WHICH, DESPITE THEIR NUTRITIONAL AND MEDICINAL VALUE, HAVE BEEN UNDERUSED BY LOCAL PEOPLE.

Albert Rakoto Ratsimamanga (TWAS Founding Fellow), the late research director at the Centre National de Recherche Scientifique (CNRS) and a pioneer of scientific research in Madagascar, founded IMRA in 1957. At its inception, IMRA was a non-governmental organization. But in 1993 it was granted 'foundation' status following a government decree. This status has helped to stabilize the institute's funding.

Today, IMRA is among Madagascar's leading research institutions. It is by far the best-equipped centre in Madagascar dedicated to biodiversity conservation and the discovery of drugs from natural products. In addition, the institute maintains a strong network of collaborations with like-minded institutes in both the developing and developed world.

Currently under the guidance of Suzanne Urverg Ratsimamanga (TWAS Fellow 1989), Albert Ratsimamanga's widow and collaborator, IMRA has developed pharmaceutical products from endemic indigenous plants that are used to treat asthma, cardiovascular problems, diabetes, gastrointestinal ulcers, leprosy, malaria, nephrolithiasis (kidney stones) and wounds.

In addition, as a collaborative centre of the World Health Organization (WHO), IMRA has contributed to national economic development by training researchers and students, educating and assisting the local population, and conserving and protecting biodiversity. IMRA employs a permanent staff of about 150 and provides temporary and seasonal employment to some 15,000 people, mostly from rural areas. It also

has its own medical clinic that offers free medical care to patients.

HALF CENTURY OF PROGRESS

In 1957, Albert Rakoto Ratsimamanga invested royalties from his scientific discoveries to establish the *Institut Malgache de Recherches Appliquées* (IMRA), a centre of scientific research and training built on six hectares of land located near the capital city of Antananarivo. In addition to IMRA's headquarters, Ratsimamanga created 14 'annex stations' focusing on the collection of plants and reforestation, and relying on the local, rural population for its development and maintenance. In all of these initiatives, he successfully combined basic medicinal plant research with the conservation and protection of biodiversity.

Ratsimamanga's ultimate goal was to create an institute that focused on understanding the mechanisms by which local medicinal plants and medical practices could serve as the basis for inexpensive, yet effective, treatments for diseases afflicting the poorest and least fortunate people of Madagascar. At the same time, he hoped such efforts could provide livelihoods for the local population and help preserve Madagascar's unique natural flora and fauna.

The institute's short-term objectives have focused on promoting medicinal plant compounds and indigenous foods to advance public health and spur sustainable economic development. In the field of nutrition, for example, IMRA has produced foods to combat calcium and protein deficiencies and to counter malnutrition, especially among new-borns and young children.

As IMRA has grown, cutting-edge research and the commercial production of pharmaceutical products have remained tightly linked. To date, the institute has developed and formulated about 40 plant-based drugs to improve nutrition and combat a wide range of diseases in Madagascar. These include Cortine Naturelle, an adreno-corticol drug; Madecassol, a wound-healing agent based on extracts from the plant Centella asiatica; Madeglucyl to treat diabetes; Madetussyl to suppress coughing; malagashanine to combat chloroquine-resistant malaria; and trehalose monomycolates (TMM) to fight leprosy.

In addition, over the past half century, IMRA has developed numerous therapeutic preparations used to treat such ailments as arterial hypertension and asthma. The development of the safe anti-diabetic medicine, Madeglucyl, from *E. jambolana*, which is now widely used both nationally and internationally, represents the institute's most outstanding success story and helped to make IMRA a globally recognized research centre.

Today, the institute enjoys a well-deserved reputation for excellence in research and collaborates with many groups, including science and health ministries, research centres and universities not only in Madagascar but also in other African nations, Europe and the United States. It has also forged partnerships with such major pharmaceutical companies as Sanofi-Aventis and Hoffman LaRoche Switzerland. Indeed IMRA's portfolio of partnerships and scientific successes has attracted many talented Malagasy researchers to the institute, several of whom had previously settled in Europe.

S.U. Ratsimamanga

DISCOVERY AND DEVELOPMENT

"IMRA is an excellent example of how scientific research can be integrated with healthcare, conservation and commercial production", says Philippe Rasoanaivo, IMRA's director of scientific research.

To achieve these goals, IMRA maintains well-equipped departments and laboratories for analysing and standardizing plant-based drugs and essential oils to combat, for example, cancer, diabetes and malaria. Its multidisciplinary fields of investigation include biodiversity, drug discovery from plants, marine animals and microorganisms, and phytopharmaceutical formulation. One of IMRA's main achievements has been a computerized compilation of the ethnomedical uses of more than 6,500 plants growing in Madagascar, which is regularly updated thanks to continual ethnobotanical fieldwork. In addition, the institute maintains a free healthcare centre with a medical analysis laboratory and four field stations for the cultivation of endemic medicinal and endangered plants.

"Patents and widely cited publications are testimony to the productivity of research investments", explains Philippe Rasoanaivo. "However, such investments do not help poor countries unless the research is turned into tangible products or improved practices and policies. At IMRA, we have taken drug discovery research projects to the market place while, at the same time, strengthening our research capacity and training activities."

For example, the investigation of the African holly (*Ilex mitis*), under an International Foundation of Science (IFS) research grant awarded to Rasoanaivo in 1978, led to the local marketing of a wound-healing drug trade-named Fanaferol.

Following the sudden resurgence of malaria in Madagascar in the mid-1980s, people returned to the large-scale use of herbal remedies. A shortage of conventional drugs forced many Madagascans to rely on medicines from more than 200 plants to fight malaria. This in turn triggered scientific interest in Madagascar, whose long isolation from neighbouring countries had created a unique mix of plants and animals.

About this time, Rasoanaivo was awarded a second IFS grant for phytochemical studies of alkaloid-bearing plants, mainly species belonging to the *Strychnos* genus. During his research, Rasoanaivo discovered that rural people in Madagascar were treating malaria with chloroquine, a drug to which many strains of the malaria parasite have become resistant – together with a decoction (a boiled-water induced extract) made from various plants. This led to the discovery of alkaloids with unique structures that markedly enhance the action of chloroquine.

IMRA enjoys a well-deserved reputation for excellence in research.

Tazopsine is the first naturally occurring compound that is active in the liver stage of malaria parasites. It is important because there are few alternative drugs that tackle this stage of the parasite's life cycle, which precedes the fever-causing blood-infecting stage. The discovery of this new class of molecules could lead to the

development of a true causal prophylactic drug. The treatment targets the early stages of malaria infection when liver-stage parasites are much less numerous than blood-stage parasites. This makes it more difficult for the parasite to develop the drug resistance that hampers conventional malaria treatment programmes. Additional investigations are now underway to bring derivatives of these compounds into drug development and clinical trials.

RESEARCH DEPARTMENTS

IMRA's three main departments – research, production and export, and clinics – function in an integrated manner.

In the Department of Research, the drug discovery and development process starts with the ethnobotany section, in charge of collecting and identifying plants. Plants are then extracted with appropriate solvents and submitted to a panel for biological screening. Different laboratories collaborate closely to put products through biological screening procedures that lead to the purification and identification of the agents responsible for the biological activity and a preliminary understanding of the compound's mechanism of action.

Madagascar is considered one of the world's 25 'biodiversity hotspots'.

Two phytochemistry laboratories focus on extraction, fractionation and purification of a range of plant-derived molecules. Bioactive compounds are sent to Europe for spectral data recording and the results are sent back to IMRA through internet facilities for data processing. Three pharmacology laboratories, headed by Suzanne Ratsimamanga and Adolphe Randriantsoa, focus on various tests, including *in vitro* tests, conducted on cellular, parasitic and microbial cultures; isolated organ tests; assessments of blood pressure and the respiratory system *in vivo*; and anti-diabetic tests *in vivo*.

In addition to medicinal cosmetics, essential oils and food additives, the Department of Production and Export manufactures about 40 plant-based drugs to meet the local population's current health needs. These are the result of careful research and are distinguished by their efficacy, absence of toxicity and low price, which makes them affordable to the Malagasy people. The Department of Clinics operates a health centre that provides free medical examinations and inexpensive biomedical tests. Operated by Kiban Cheuck, director of the Biomedical Department, the clinic is frequented by the neighbouring population and by many Malagasy who live farther away. Medical examinations are conducted free of charge, a policy that has been in place since 1957. Doctors frequently examine 30 to 40 patients a day.

"IMRA is a centre for the poor. Yet others who are not poor come for the quality care and services we provide," explains Cheuck. "The benefit is that a patient can do everything in one day. You can't find this even in the US or in other developed countries. Our medical services are done quickly, well, and inexpensively."

At the clinic, phytomedicines (or plant-based medicines) are preferred over modern drugs. "We use phytomedicines first and modern medicines second", con-

DAVID AND LUCILE PACKARD FOUNDATION

The David and Lucile Packard Foundation was created in 1964 by David Packard (1912–1996), co-founder of the Hewlett-Packard Company, and his wife Lucile Salter Packard (1914–1987). Throughout their lives in business and philanthropy, the Packards sought to use private funds for public good. Guided by the founders' values, the foundation that bears their names supports both people and organizations with the aim of enabling the creative pursuit of science; conserving and restoring the Earth's natural systems, improving the lives of children; and advancing reproductive health. For additional information, see www.packard.org.

firms Cheuck. "If I don't know the plant that can treat the sickness, then I treat the patient with a generic drug. The only limit is what we don't yet know about the plants."

PROTECTING BIODIVERSITY

Madagascar is considered one of the world's 25 'biodiversity hotspots' along with the other Indian Ocean islands that split off from the African continent some 160 million years ago. This long period of isolation led to the evolution of thousands of endemic species found nowhere else on Earth. Indeed some 98 percent of Madagascar's land mammals, 91 percent of its reptiles and 80 percent of its flowering plants are endemic. Madagascar's flagship species, the lemurs, are 100 percent endemic and include 33 different species.

The protection and preservation of Madagascar's unique fauna and flora have always been primary objectives at IMRA. In addition to IMRA's headquarters near the capital city, the institute's founding director, Ratsimamanga, created 14 annex stations that focus on the sustainable collection of medicinal and aromatic plants and the replanting of denuded areas of forest.

At several of the annex stations entire villages participate in such IMRA activities as the gathering of plants and production of essential oils. At the Ampanatoamaizina station, for example, the entire village of some 170 people is involved in planting the aromatic tree, *Melaleuca viridiflora*, which provides an antiseptic essential oil. The village operates two stills set up by IMRA. Local residents have been trained to use the stills and produce the essential oil that is then sold to IMRA.

In this way, an isolated rural village that previously had few resources now generates a sufficient income for its residents without damaging the surrounding forest (IMRA provides courses for local people on the sustainable collection of plants). By involving local people in such activities, IMRA has raised the income of thousands of rural families by as much as 50 percent, in addition to cultivating and protecting many endemic plant species.

The Ethnobotanical Unit, directed by Madagascar's most eminent specialist in systematic botany, Armand Rakotozafy, is dedicated to the collection of the country's endemic plants, particularly those that are endangered. Rakotozafy has an encyclopaedic knowledge of most of the plant species that exist in Madagascar, information that is vital to the safeguarding of its biodiversity.

Each year, the Ethnobotanical Unit organizes 10–15 field expeditions to collect endemic plants, both those with medicinal properties and those that are

FIVE PROFILES

With funding from the David and Lucile Packard Foundation TWAS has published in-depth profiles of five scientific institutions in the developing world. In addition to IMRA, these institutions are: the Central Drug Research Institute in Lucknow, India; the National Institute of Biodiversity in Santo Domingo, Costa Rica; the Centre of Biotechnology of Sfax, in Tunisia; and the Institute of Medicinal Plant Development in Beijing, China. For copies of these profiles, please contact the TWAS secretariat at info@twas.org.

endangered. The goal is to cultivate them in the botanical garden or at one of the annex stations. In 2006, IMRA scientists collected 400 samples of plants for research purposes for cataloguing in the herbarium and for the production of pharmaceuticals. Local traditional healers often accompany these expeditions to share their empirical knowledge of Madagascar's medicinal plants.

Back at the laboratory, the plants are examined and the information, including their vernacular names, ethnobotanical uses and scientific identification, is entered into a database. Of Madagascar's 12,000 plant species, to date some 6,500 have been identified and catalogued. This data is rapidly becoming a valuable information resource not only for the conservation of the island's biodiversity, but also for scientists seeking potentially useful plant compounds.

JAVA PLUM

For more than 40 years, IMRA has been investigating the traditional medicines and food plants of Madagascar that, despite being nutritionally and medically valuable, are often overlooked and underused by local people. The discovery of an anti-diabetic drug from the local java plum tree, *Eugenia jambolana*, by Albert Rakoto Ratsimamanga and Suzanne Urverg Ratsimamanga, has become one of IMRA's most interesting and successful research projects.

In 1965, the two began to work with local traditional healers. Their curiosity was aroused when they came across a simple way of diagnosing diabetes: healers were asking their patients to urinate close to an anthill and then observing how the ants reacted. Ants usually avoid urine, but the urine of people suffering from diabetes contains a great deal of sugar that attracts the insects. Patients with sweet-tasting urine (at least to the ants) were thus diagnosed as diabetic and prescribed *E. jambolana* by the healers. Once the scientists discovered this, they began to conduct laboratory work on the potential medicinal properties of this plant.

From 1967 until 1985, the Ratsimamangas studied and experimented with *E. jambolana* at both IMRA and the National Centre of Scientific Research (CNRS) in Paris, France. Trials conducted over several generations showed that Madeglucyl did indeed alleviate the symptoms of diabetes. Additional tests showed that the drug is not toxic, does not cause cancer and has no other detrimental side effects.

In 1984, the Ratsimamangas patented their discovery of the antidiabetic properties of *E. jambolana* in France. Additional tests have since established that a formulation, now sold under the trade name Madeglucyl, is stable and consistently effective as a treatment for diabetes.

In 1996, a second license granted the product international recognition. In December 1997, Madeglucyl was registered as a licensed medicine in Madagascar. At present, some 6,000 diabetic Malagasy patients receive Madeglucyl, most of them free of charge, as part of the on-going clinical trial process. More recently, diabetic patients in Germany and the United States have become involved in the ongoing trials.

In addition to providing an effective anti-diabetic drug and the royalties that such success brings, the java plum (or rotra, as it is known in Madagascar) has been made into jams, jellies and health drinks that provide a valuable source of nutrition. Although traditional healers had successfully used the fruit to relieve symptoms of diabetes, its full potential had never been exploited, due to a general lack of knowledge and interest. Until IMRA launched its project to evaluate the potential of *E. jambolana* in 1970, much of this valuable resource had been ignored and wasted.

Now, through IMRA's efforts, java plums are preserved to produce a range of tasty and healthy foods that are rich in sugars, mineral salts, vitamins, anthocyans, flavonoids and other beneficial compounds.

In the past, java plum trees were often felled for timber or fuel or to clear land for crop cultivation. Since the plums' medical uses have become well known, such destructive practices have declined. At the same time, rural people have generated extra income from seed collection (in Madeglucyl production, the seeds are the most important part of the tree and must be collected and processed when they are at the correct stage of ripeness).

It took IMRA several years to devise an efficient seed collecting system. The problem proved complicated because the plant products that the institute needs perish very quickly. The answer was to train local people in the best ways to collect and dry the seeds. The work is relatively easy and the pay is good. By 1998, annual harvests of 20 tons were being gathered during relatively short collection seasons.

Successful drug discovery, based on natural products, requires multidisciplinary partnerships.

PARTNERSHIPS

IMRA maintains a strong network of collaborations with local, African and Northern institutes. As scientific research director, Philippe Rasoanaivo, points out: "The science of natural products is multi-faceted. As a result, successful drug discovery, based on natural products, requires multidisciplinary partnerships marked by complementary expertise."

Rasoanaivo cites as an example IMRA's collaboration with Italian and French institutions to find an effective drug for use in the treatment of malaria in Madagascar. The research programme focused on the search for naturally occurring compounds that could reverse the chloroquine resistance of certain malarial parasites. The collaborative effort resulted in the discovery of several chemosensitizing alkaloids. One, named malagashanine (isolated from the Malagasy plant *Strychnos myrtoides*), has been targeted as a candidate for further development.



In 1999, following the creation of the Research Initiative for Traditional Anti-Malarial Methods (RITAM) in Tanzania, IMRA collaborated with the *Hôpital Pitié-Salpêtrière*, Paris, to screen plant extracts against the hepatic stage of malaria. Based on the results, in July 2004, the French institute CNRS signed a protocol with the University of Antananarivo for a bioprospecting programme, appointing Rasoanaivo head of the project in Madagascar.

IMRA also encourages commercial partnerships. "Pharmaceutical companies based in Europe, North America and elsewhere ask us to collaborate with them because they are interested in drug discovery", explains Suzanne Urverg Ratsimamanga. "They are also interested in endemic plants. They often discover new molecules in IMRA's collection of plants."

STAYING TRUE TO THE VISION

The goal of founder Albert Rakoto Ratsimamanga was to create an institute that focused on understanding the ways by which local medicinal plants and medical practices could serve as the basis for inexpensive, yet effective, treatments for the poorest and least fortunate people of Madagascar, while preserving Madagascar's natural flora and fauna. Suzanne Urverg Ratsimamanga is attempting to stay true to the vision of her late husband while continuing to develop IMRA into a globally recognized 'centre of excellence'.

The institute, therefore, has been fortunate to have her leadership following the passing of Albert Rakoto Ratsimamanga in 2001.

Thanks to IMRA's current partnerships – especially those that result in royalties from commercial companies – allied to Madagascar's rich, endemic flora, the continued success of the institute is virtually guaranteed. However, increasing IMRA's income to maintain its operations will be a challenge, and increasing access to materials, equipment and scientific literature in what is one of the world's 50 least developed countries (LDCs) remains a major obstacle.

In addition, given that the leadership of the institute has remained 'in the family', so to speak, since its inception in 1957, IMRA's preparation of future leaders and key personnel will also be critical to its future success. The employment of eminent scientists such as Philippe Rasoanaivo and Armand Rakotozafy, the institute's ability to attract indigenous talent back from abroad, and its effective training programme suggest that IMRA's future is in good hands – for the benefit of science in general and the health of the Malagasy people in particular. ■

The continued success of the institute is virtually guaranteed.

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YESTERDAY'S DREAMS, TODAY'S CHALLENGES

LAST NOVEMBER, TWAS CELEBRATED ITS 25TH ANNIVERSARY AT A GALA FOUR-DAY EVENT IN MEXICO CITY. THE SILVER JUBILEE CONFERENCE MARKED 1983 AS THE OFFICIAL LAUNCH DATE OF TWAS. BUT THE FIRST MEETING TO DISCUSS THE POSSIBILITY OF CREATING AN ACADEMY FOR SCIENTISTS FROM THE DEVELOPING WORLD ACTUALLY TOOK PLACE IN OCTOBER 1981 AT THE PONTIFICAL ACADEMY OF SCIENCES IN ROME.

TWAS's birth was preceded by a lengthy incubation period marked by uncertainty and doubt about whether the organization would ever get off the ground. Abdus Salam, TWAS's founder, may have been an ideal person to lead the charge for the creation of TWAS. Yet, despite his credibility and fame, the first 100 letters that Salam sent out soliciting external support for the initiative received this heartfelt reply, 'we wish you well in your endeavour', punctuated by this disquieting refrain: 'we are sorry we cannot help you'.

One of the earliest behind-the-scenes advocates for TWAS was Ronald Léger, who at the time served as a programme director for the Canadian International Development Agency (CIDA). Even before the Academy's creation, Léger provided two small grants, enabling Salam to plan and organize TWAS's founding meeting. He then championed TWAS's first major grant – CA$500,000 from CIDA. Without Léger's help (and the Italian government's generous US$1.5 million grant that followed soon after CIDA's decision), TWAS would likely have remained an intriguing idea – much discussed but never realized.

In late November, Mohamed Hassan, executive director of TWAS, contacted Léger, now living in retirement in his native Canada, to ask if he would be interested in coming to the Academy's 25th anniversary celebration in Mexico City, to see what had become of the institution that he played such an important role in creating. Not

wanting to relive the past, Léger was hesitant at first. But curiosity – and Hassan's gentle persuasion – ultimately led him to say yes.

The following article, which Léger wrote soon after the conference, provides a personal reflection of his involvement with the Academy during its initial years of development. He also offers his observations on the Academy today, based largely on what he saw and heard in Mexico City.

As a 'passionate outsider', I was one of the first to encourage and support Abdus Salam in his efforts to launch TWAS, then known as the Third World Academy of Sciences. As a follow-up to the inaugural meeting of the Academy's nine co-founders, held at the Pontifical Academy of Sciences in Rome, Italy, in 1981, Salam lost no time in trying to turn this dream into reality. However, nearly two years of intense effort on his part had led only to disappointment – sparking resistance from within the developing world's small scientific community and eliciting no support at all from potential external funders.

Upon hearing about Salam's enthusiasm for the creation of a third world science academy, many scientists from the South said they would prefer to be elected to science academies in the developed world. In fact, many viewed their potential association with a third world organization as an impediment to their careers (the implication was that their colleagues would view a third world connection as a sign of third rate ability). During my first visit to Trieste in 1982, Abdus Salam showed me a thick file containing more than 100 refusal letters from donor and UN agencies, academies and ministries of science and technology. Not a single response offered financial support – or even hinted that it would ever be forthcoming.

At the time, I was a programme director with the Canadian International Development Agency (CIDA). Like other aid agencies, prevailing beliefs and actions seemed to dictate that science was not one of the developing world's 'basic needs'. At most, potential benefactors in the North believed that only 'appropriate technology transfers' would help promote the development of poor countries. What was meant by 'appropriate' remained largely ill-defined.

I was impressed by the extraordinary atmosphere on display at the International Centre for Theoretical Physics (ICTP), which Salam had founded 20 years earlier with funding from the Italian government. The Centre was a beehive of activity – a dynamic yet orderly institution; intuitive yet systematic and efficient to a fault given its worldwide reach and multicultural dimensions.

By 1982 (indeed even much earlier), there was no question that ICTP was an enormous success. More than 3,000 exchanges per year were taking place between scientists in the North and South at the Centre. ICTP's presence in Trieste left little doubt where TWAS, if it ever came to be, would be located – alongside the institution that had become the world's foremost international centre dedicated to building scientific capacity in the developing world. There, shoulder-to-shoulder with ICTP, TWAS would benefit from the inspirational leadership of Salam.

It wasn't the ICTP's first-rate facilities and exquisite seaside campus that impressed me the most. Rather, it was Salam's dedication to help developing world scientists to work for their native countries and to strengthen scientific institutions there. ICTP was a place to acquire the knowledge and skills to make this happen.

This emphasis on the benefits to be derived by developing countries gave me an opportunity to encourage and support Salam's efforts to create TWAS under CIDA's broad mandate to promote "institution building". That, in fact, was the focal point of my programme.

ICTP's presence in Trieste left little doubt where TWAS would be located.

TWAS'S TO-DO LIST

TWAS, as Salam envisioned it, would be designed to recognize, honour and support scientists from the South. On the one hand, the Academy would play an important psychological role by helping to build confidence among developing world scientists and by assisting them in gaining a more prominent place in society. On the other hand, the Academy would provide concrete benefits – for example, access to scientific journals to enable them to keep abreast of the latest advances in their fields; foreign currency to purchase laboratory equipment and spare parts; and scientific networks to overcome the isolation that often handicapped their research.

In short, TWAS would not only recognize and support scientists, however important these factors would be; it would also focus its efforts on promoting the work of scientists, especially scientists in the poorest countries and regions.

Ronald Léger

I also thought TWAS could help spur the creation of scientific centres of excellence, modelled after ICTP but with broader scientific mandates that extended beyond physics and mathematics. These would be state-of-the-art centres that others could look up to and learn from. Together, on that memorable day in his office in 1982, Salam and I cited four worthy possibilities – Bangladesh, Sudan, the Sahel region and Haiti – that could provide homes for centres of excellence to assist the poorest of the poor in science.

Three years later, in 1985, CIDA provided initial financial support, through TWAS, to launch the African Academy of Science (AAS). Once again, CIDA's mandate to boost institution building in developing countries justified this action. And, once again, it was our confidence in the extraordinary work of an extraordinary individual that led to this decision.

In this case, Thomas Odhiambo and the leadership role he had played in the creation of the International Centre of Insect Physiology and Ecology (ICIPE) in Nairobi, Kenya, was what impressed us. Odhiambo, who was also a vice-president of TWAS, described AAS as an organization that would have the same broad objectives as TWAS, except that it would focus exclusively on Africa. I was immediately convinced of its value and became an enthusiastic supporter of the effort.

The story of the launching of the Third World Organization for Women in Science (TWOWS) is also worth recounting despite the fact that it emerged from an unmet challenge – and a sense of frustration – that remains stubbornly in place to this day.

The original idea was not to create a separate organization for women scientists but to develop strategies that would better integrate the concerns of women scientists into the discussions and policies of TWAS and other international networks and institutions. I had expressed to Salam on several occasions my own dissatisfaction and the dissatisfaction of CIDA about the way in which TWAS was dealing with gender issues – or, perhaps more accurately, not dealing with gender issues. Why, I asked, were there so few women scientists in TWAS? And, why did the absence of women seem to elicit so little concern?

At a meeting in Trieste in 1987, Salam agreed to establish a task force of five women from the scientific community, asking its members to review the status of women scientists and make concrete proposals on how the situation might be improved. I agreed to fund not only this fact-finding initiative but also efforts to implement the recommendations that the task force would propose. However, I agreed to do so only if no men were involved in their deliberations. The members nevertheless asked Mohamed Hassan, who was then the executive secretary of TWAS (and who now serves as the executive director) to be its secretary. I guess they considered him gender neutral, and I happily agreed to this exception.

The TWAS-CIDA Conference on the Role of Women in the Development of Science and Technology in the Third World, which took place in Trieste in October 1988, was, as far as I know, the first conference ever held exclusively for women scientists. The organizers originally planned for 50 participants. However, the enormous response (more than 300 letters requesting to attend were received) led TWAS and CIDA to invite some 200 women scientists to this path-breaking event.

TWAS is one of the world's foremost institutions for scientists and scientific institutions in the South.

In his presentation at the conference, Salam enthusiastically acknowledged the high calibre of the scientific presentations and proffered his full support for efforts to promote women scientists in the South. In my remarks, I reiterated what Salam and Hassan had revealed to me: that the more than 300 women scientists who had asked to attend the conference displayed higher scientific credentials, on average, than scientists requesting to attend TWAS conferences.

The concluding sessions of the conference focused on "where do we go from here?". By now, the points of discussion were familiar to me. I had heard them before in conversations leading up to the event. Do women scientists need a separate organization to promote their interests? Wouldn't it be better and more fruitful to work within existing institutions?

The conference itself had helped to answer these questions by the enthusiasm displayed by the participants and their insightful discussions and debates. A year later, the Third World Organization for Women in Science (TWOWS) was established as an autonomous organization (although with close ties to TWAS). The secretariat, like those of ICTP and TWAS, was placed in Trieste.

Twenty years on, the number of scientists belonging to TWOWS exceeds 3,000. The vast majority of members are women, but not all, and they come from both the developing and developed world. TWOWS membership is more than three times that of TWAS. Yet, few TWOWS members are active in TWAS. More significantly, TWOWS has yet to influence trends in the international scientific community at the level that the founders and early advocates had hoped.

In parallel with the TWOWS conference, TWAS also organized the inaugural meeting of the Third World Network of Scientific Organizations (TWNSO). I had the privilege of briefly attending this meeting. Salam fervently believed TWNSO would eventually emerge as the most important of all the institutions belonging to the Trieste-based scientific networks. The organization, consisting of ministries of science and technology, research councils and academies of science, was designed as the diplomatic arm of TWAS. It represented an innovative way to help shape science policy and provide a powerful voice for securing additional funding for science and technology in the developing world.

TWNSO, like TWOWS, has served a valuable purpose but, like TWOWS, it never gained the presence or strength to exert a powerful influence on the critical issues it was created to address. In 2006, TWNSO was supplanted by the Consortium of Science, Technology and Innovation in the South (COSTIS). As was the case for TWAS a quarter century ago, COSTIS has experienced a long incubation period. The official launch of the organization, I learned in Mexico City, will hopefully take place in 2009.

Since the inaugural meetings of TWOWS and TWNSO in Trieste in October 1988, I had not attended any TWAS-related activities until my participation at the Academy's 25th anniversary last November 2008. However, I periodically followed TWAS's progress on the Academy's website and sometimes heard about the Academy when I crossed paths with Hassan. I was especially gratified to learn from Hassan, when we met in Brazil in 1997 at the Rio+5 Conference organized by Earth Council, that the TWAS endowment fund, which we had so often talked about, had exceeded US$1 million. That figure has recently reached US$12 million, and an endowment fund campaign has now been launched with the goal of reaching US$25 million by 2012.

FAST FORWARD

It is as a passionate yet distant observer that I describe the following accomplishments of TWAS and its various networks. Many of these observations may seem obvious to those who have paid attention to the Academy's activities over the years; other observations may be less so.

First, TWAS and its extended network of scientific organizations, including TWOWS and, more recently, the InterAcademy Panel and the InterAcademy Medical Panel, have become respected voices and preeminent knowledge centres devoted to the training of scientists and the strengthening of scientific institutions in the developing world. Increasingly, these networks have also served as a bridge for the discussion of critical issues in scientific communities in both the South and North. The networks have the capacity to influence decision-making around the world, especially when it comes to matters of science-based sustainable development. That so many prominent science institutions and networks are headquartered in Trieste reinforces the knowledge base that it represents and provides the institutions with the added credibility and self-confidence they need to successfully fulfil their mandates. The synergy generated by the proximity of these institutions has no equivalent in the world of science.

Second, the integrated network has emerged as a driving force for international cross-cultural exchange, understanding and cooperation. Today, TWAS is one of the world's foremost institutions for scientists and scientific institutions in the South. The Academy has succeeded not only because it does things that few other institutions do, but also because it does them so well. In fact, TWAS has been responsible for designing many of the most important scientific networks, coalitions and exchange programmes for South-South and South-North exchange that have become the cornerstones for scientific capacity building. The South-South exchange programmes, especially for young scientists, are among the most impressive in the world.

Third, TWAS, despite its modest and uncertain beginnings, has built a significant and secure funding base, thanks to the Italian government's long-standing

commitment to provide core funding for the Academy and TWAS's own endowment fund. This has not only enabled the Academy to engage in long-term planning but it has also given it the confidence and flexibility it needs to explore new initiatives and to act swiftly when challenges and opportunities present themselves.

Fourth, TWAS's relationship with the United Nations Educational, Scientific and Cultural Organization (UNESCO) – the Academy is both part of UNESCO and a non-profit association led by its members – gives TWAS the credibility and backing of a UN agency, yet the freedom to operate on its own.

Fifth, TWAS has mastered the difficult challenge of maintaining a continuity of purpose despite being immersed in an environment marked by rapid change. Think of the state of science in the developing world at the time of the Academy's creation. Now think of the state of science in the developing world today.

In light of the dramatic changes that have taken place, TWAS's mandate has remained remarkably the same: to build scientific capacity in the South. It is the Academy's tactics that have changed, and therein lies the key to the Academy's success.

The ability of TWAS to remain attuned to its fundamental principles yet flexible in how it seeks to achieve its goals is due to two factors: leadership and a culture of self-evaluation. Change within the Academy has been a constant, but it has always taken place within the spirit and vision of its founders and in response to the evolving needs of science in the South.

WHERE ARE THE LIMITS?

TWAS's accomplishments are well recognized. However, the Academy, not surprisingly, has shortfalls and limitations too. I will confine my discussion below to factors directly related to the Academy's primary mission and *raison d'être*: the promotion of science in the South with special focus on the poorest countries.

Some of the most perplexing problems are as old (indeed even older than) TWAS itself; low representation among women, younger scientists and scientists from the poorest developing countries. TWAS has acknowledged and discussed these shortcomings for years. It has even introduced programmes to address them. But the problems persist.

As for women, their low representation has nothing to do with their scientific credentials, as clearly demonstrated since the 1988 women's conference in Trieste.

As for younger scientists, it is interesting to note that such indisputable world-class scientists as Albert Einstein, Marie Currie and Abdus Salam himself would likely have had to wait their turn to be elected to TWAS (standing on the sidelines until their fifties or even sixties to receive the honour). This chronic deference to age is even more astonishing when you consider that basic scientists, who often make their major contributions to global knowledge before they reach age 30, founded the Academy.

As for scientists from poor and scientifically lagging countries, they are the ones who would benefit most from an affiliation with TWAS. The Academy would benefit as well. Indeed TWAS cannot hope to meet the major challenges it faces today (for example, the growing disparity in scientific capacity within the South) without the direct involvement of scientists from the poorest, most marginalized developing countries

The above limitations, I believe, could stem from the same handicap: TWAS's membership election system (based on co-option or the appointment of individuals by agreement with other members) – or at least by the way the system has evolved within the Academy. One should be reminded that a temporary co-option system was suggested by the co-founders simply to form the "initial group of members". Most members now recognize that such a system is neither very feminine, or youthful, or well represented by scientists from the poorest developing countries.

A better balance in membership could possibly be created through the introduction of an invitation-based membership procedure based, of course, on meritorious and scientific credentials. TWAS now has the means, the databases and the intertwined networks it needs to successfully implement this procedure without compromising its uncompromising allegiance to excellence.

Another limitation has to do with language. TWAS, like most international scientific organizations, functions exclusively or primarily in English. However, in some of the poorest countries, such as those in the Sahel, even scientists do not function well in English. If TWAS is going to take up the challenge of science centres in the Sahel, then it may have to find the ways and means, directly or through its networks, to deal with the language issue affecting many of the poorest countries within sub-Saharan Africa.

IF NOT TWAS, WHO?

I am convinced that TWAS is now in a unique position to turn one of the Academy's original dreams into a reality by helping to build state-of-the art centres of scientific excellence in the world's poorest regions, most notably the Sahel.

The challenges in the Sahel are greater today than they were 25 years ago, when TWAS first appeared on the scene. The poorest countries have become even poorer and face even greater handicaps due, for example, to out-of-date classroom facilities and laboratories. This situation was fully recognized at the TWAS 25th anniversary conference in Mexico City.

Meeting such a challenge will require TWAS to make major long-term commitments. The task is monumental. But I believe the Academy has the credibility, know-how and international and African networks to take it on. In addition, it is not starting from scratch: various efforts are in place and others are underway.

TWAS therefore could play a key role as a facilitator. But it could do even more by helping, for example, to build modern communication systems; serving as a clearing house for the sharing of information-rich data bases; increasing the participation of Sahel scientists in South-South and South-North exchange programmes; analysing the experiences of others; and overseeing the creation of an archive detailing the work of successful centres of excellence.

TWAS's mandate has remained remarkably the same: to build scientific capacity in the South.

Indeed many TWAS members and networked institutes in the emerging South are now in a position to assist the Sahel by drawing on their expertise, know-how and training and research experience. Hassan's position as both the executive director of TWAS and president of the AAS would add strength and credibility to this effort.

The benefits of such an initiative would go first and foremost to scientists in the developing world. But it would also help raise the profile of the Academy as a key player in building scientific capacity in the South, especially in the world's poorest regions, where the assistance of TWAS is most needed.

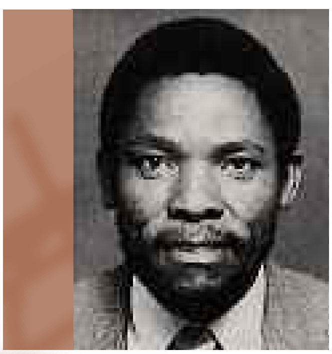
If the Academy does not help the poorest, who will?

TWAS, I am convinced, is up to the test. It has rarely turned its back to daunting challenges in the past and there is no reason to believe it will do so now. As a long-time admirer of the organization, I think my faith is well placed. ■

PEOPLE, PLACES, EVENTS

NEW SCIENCE MINISTER

• **Heneri Amos Murima Dzinotyiweyi** (TWAS Fellow 1988) was sworn in as Zimbabwe's new Minister of Science and Technology Development on 13 February. Dzinotyiweyi was nominated for the post by Prime Minister Morgan Tsvangirai as part of a new bipartisan government. Dzinotyiweyi has pledged to address problems directly related to the country's ailing research institutions and to take steps in slowing scientific brain drain. Dzinotyiweyi obtained his MSc and PhD at the University of Aberdeen, UK, in mathematics, and has previously served as full professor and dean of science at the University of Zimbabwe and chairman of the Zimbabwe Integrated Programme (ZIP), the Southern Africa Mathematical Sciences Association, the Scientific Council of Zimbabwe and the Industrial Development Committee of the Research Council of Zimbabwe.



Heneri Amos Murima Dzinotyiweyi

FIRST AAMPS/IFS AWARD

• **Philippe Rasoanaivo** (TWAS Fellow 2005) received the First Association of the African Medicinal Plants Standards Committee (AAMPS)/ International Foundation for Science (IFS) Award. The awards ceremony took place at the WOCMAP (World Congress on Medicinal and Aromatic Plants) in Cape Town, South

Philippe Rasoanaivo

Africa, in November 2008. Rasoanaivo is professor at the School of Polytechnics, University of Antananarivo and research director at the *Institut Malgache de Recherches Appliquées*, Antananarivo, Madagascar (see pp. 35-42). He is a natural products chemist involved in drug discovery from plants and has discovered several bioactive compounds. Rasoanaivo is a member of the Malagasy Academy and winner of the Malagasy Academy 75th Anniversary Award; Madagascar Ministry's Research Award 2000; Sven Brohult Award 2001 International Foundation of Science; and the first CNR Rao Prize for Scientific Research. He was appointed *Grand Croix de Deuxième Classe de l'Ordre National Malgache* in 2006 and *Chevalier des Palmes Académiques Françaises* in 2003.

MOU

• **Mohamed Hassan**, TWAS executive director, and **S. Riazuddin** (TWAS Fellow 1993), executive director of the Asia-Pacific International Molecular Biology Network (A-IMBN), have signed a memorandum of understanding (MOU) to promote cooperation in molecular biology and biotechnology. The MOU, which was signed in Mexico City at the TWAS 25th Anniversary celebration in November 2008, calls for TWAS and A-IMBN to work together to advance national biotechnological capabilities throughout the Asian-Pacific region by jointly developing projects to be submitted to national/regional and international funding agencies.

HEAD OF NOAA

• **Jane Lubchenco** (TWAS Associate Fellow 2004) has been appointed head of the US National Oceanic and Atmospheric Administration (NOAA). Lubchenco is a distinguished professor of zoology at Oregon State University and past president of the International Council of Scientific Unions (ICSU). Her discoveries of fundamental ecological and evolutionary relationships among animals and plants in complex coastal systems have helped advance scientific understanding of factors affecting species distribution, abundance and diversity. Her recent work has shown how coastal oceanographic features can affect local community structures and dynamics. She is a fellow of the US National Academy of Sciences, American Philosophical Society, the Royal Society and *Academia Chilena de Ciencias*.

Jane Lubchenco

GENOME VALLEY AWARD

• **Marc Van Montagu** (TWAS Associate Fellow 2001) was awarded the 2009 Genome Valley Award by the

Chief Minister of Andhra Pradesh, India, Y.S. Rajasekhara Reddy, at the opening ceremony of BioAsia 2009 held in Hyderabad, India, on 1–4 February 2009. Van Montagu is professor emeritus and director of the Institute Plant Biotechnology for Developing Countries, Ghent University. His co-discovery (with the late Jeff Schell) of the Ti-plasmid and gene transfer mechanism between agrobacterium tumefaciens and plants opened a new area of investigation in the research and development of crop varieties and helped to advance the field of plant molecular genetics as a tool for sustainable agricultural production.

Marc Van Montagu

MAX PERUTZ CHAIR

• **Samar Hasnain** (TWAS Fellow 1997) has been named the Max Perutz Chair of Molecular Biophysics at the University of Liverpool. The announcement took place on 26 September 2008 at the University of Liverpool's School of Biological Sciences. Hasnain, who received his PhD in 1977 from the University of Manchester, has held several previous positions including: professor of molecular biophysics and biomolecular sciences, Liverpool John Moores University; head, molecular biophysics, Science and Technology Facility Council's Daresbury Laboratory; founding editor and co-editor, *Journal of Synchrotron Radiation*; lecturer, applied physics, University of Karachi; and coordinator, North West Structural Genomics Centre, UK. He is also a fellow of the UK's Institute of Physics and the Royal Society of Chemistry.

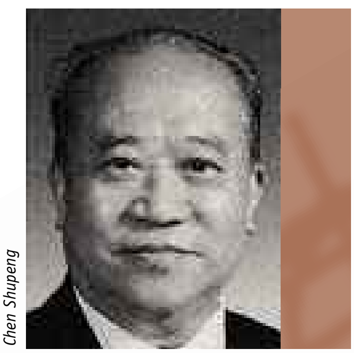
Samar Hasnain

IN MEMORIAM

• **Seyyed Hossein Mirchamsy** (TWAS Fellow 1992) passed away in December 2008 at age 92. Mirchamsy was born in Isfahan, Iran, on 21 March 1916, and was educated at Tehran University, the *Ecole Nationale Vétérinaire* in Alfort, Paris, and the *Institut Pasteur* in Paris. Throughout his long career, he served in several key positions at Iran's Razi State Serum and Vaccine Institute from 1942 to 2001: fellow of research and development; head of the department of bacterial vaccines; associate director of the Division of Human Biology; and head of the department of human viral vaccines. For his work in vaccines, he was also honoured with a number of awards, including the Alborz and the Khwarizmi Awards. He was a member of the Iranian Academy of Science, Tehran; Iranian Academy of Medical Sciences, Tehran; and the International Association of Biological Standardization, Geneva.

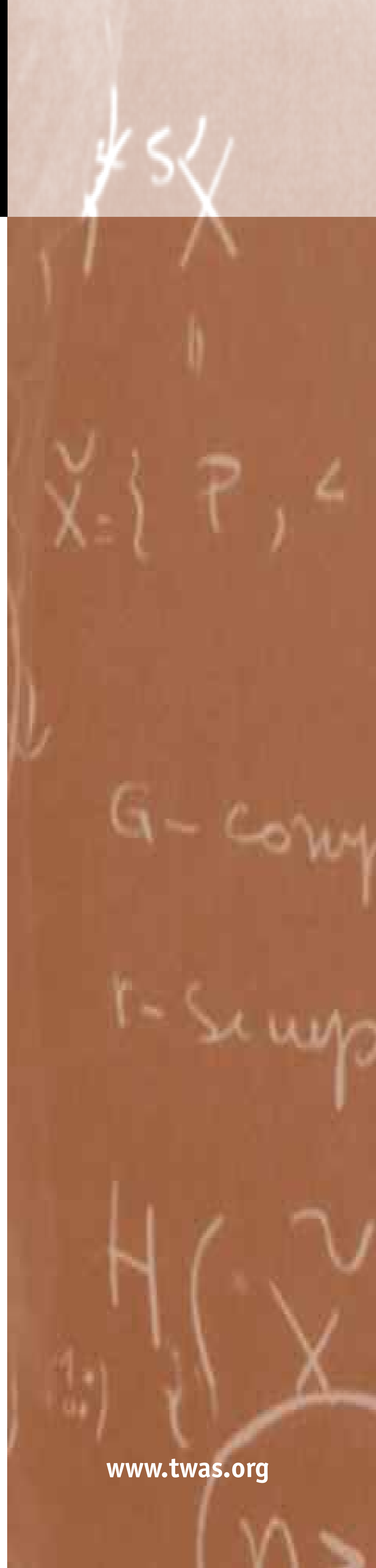
Seyyed Hossein Mirchamsy

• **Chen Shupeng** (TWAS Fellow 1992) died in November 2008 at age 88. He was a research scientist at the State Key Laboratory of GIS, Institute of Geography and Resources Research, Chinese Academy of Sciences (CAS), and director and honorary director of the Institute of Remote Sensing Application, CAS. He also directed the Yunnan Institute of Geography and was full member of the Geographic Data Acquisition Committee and the Commission on Modelling Geographical System of the International Geographic Union. Shupeng was a recipient of several national awards of Progress of Science and Technology; the Q.M. Miller Cartographic Award by the American Geographic Society; and the Gold Carl Mannerfelt Medal of the International Cartographic Association. He was an academician of CAS and the International Eurasian Academy of Sciences.



Chen Shupeng

WHAT'S TWAS?



TWAS, THE ACADEMY OF SCIENCES FOR THE DEVELOPING WORLD, IS AN AUTONOMOUS INTERNATIONAL ORGANIZATION THAT PROMOTES SCIENTIFIC CAPACITY AND EXCELLENCE IN THE SOUTH. FOUNDED AS THE THIRD WORLD ACADEMY OF SCIENCES BY A GROUP OF EMINENT SCIENTISTS UNDER THE LEADERSHIP OF THE LATE NOBEL LAUREATE ABDUS SALAM OF PAKISTAN IN 1983, TWAS WAS OFFICIALLY LAUNCHED IN TRIESTE, ITALY, IN 1985, BY THE SECRETARY GENERAL OF THE UNITED NATIONS.

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

The main objectives of TWAS are to:

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

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

TWAS also played a key role in the establishment of the Third World Organization for Women in Science (TWOWS), which was officially launched in Cairo in 1993. TWOWS has a membership of more than 2,500 women scientists from 87 developing countries. Its main objectives are to promote research, provide training, and strengthen the role of women scientists in decision-making and development processes in the South. The secretariat of TWOWS is hosted and assisted by TWAS. ···> **www.twows.org**

Since May 2000, TWAS has been providing the secretariat for the InterAcademy Panel on International Issues (IAP), a global network of 100 science academies worldwide established in 1993, whose primary goal is to help member academies work together to inform citizens and advise decision-makers on the scientific aspects of critical global issues. ···> **www.interacademies.net/iap**

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

www.twas.org