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EDITORIAL

TWAS IS DEDICATED TO BUILDING SCIENTIFIC AND TECHNOLOGICAL CAPACITY IN THE SOUTH, INCLUDING CAPACITY IN MEDICAL RESEARCH. THE ACADEMY REMAINS AS FIRMLY COMMITTED TO THAT CAUSE AS IT HAS EVER BEEN, AS EVIDENCED BY ITS GRANTS, PRIZE AND SCIENTIFIC EXCHANGE PROGRAMMES.

Caring for Health in the Developing World

These programmes have recognized and rewarded such individuals as Peter Mugyeni, director of the Joint Clinical Research Centre and visiting professor at Mbarara University in Uganda, and Sergio Henrique Ferreira, professor emeritus at the University of São Paulo Medical School in Brazil.

The Academy's programmes have supported research in such medical fields as emerging infectious diseases and strategies for improving the health of mothers and children, a project that it conducted in partnership with the InterAcademy Medical Panel (IAMP), a network of medical academies and medical divisions within science academies that, like TWAS, is located in Trieste, Italy.

As is true throughout the world, in developing countries health care involves questions of ethics and economics. Health-related issues just don't tug at the heartstrings; they pull at the purse strings too. And, equally important, for progress to be sustained, initiatives must focus not only on research but also on the challenges posed by health care delivery.

Indeed the economics of health care takes place at two levels.

First, a healthy workforce is also a productive workforce. For example, the fact that more than 10 percent of South Africa's workforce – an estimated five million people – are afflicted with HIV/AIDS and that 350,000 South Africans die each year as a result of the disease is both a human and an economic tragedy. By some estimates, the pandemic will lower South Africa's total gross domestic product (GDP) by more than 15 percent than where it would have otherwise been by 2010.

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Second, the health care sector also provides employment for well-skilled workers who occupy positions that can often weather the vicissitudes of the economy. Consequently, health care potentially provides an important building block for sustained economic growth. As Jim O'Neill, chief economist for Goldman Sachs, has written, by serving as a reliable source of domestic investment and spending in the world's fastest growing economy, China's recent announcement to expand health insurance to hundreds of millions of more people over the next three years could prove to be "the most important development in the world economy" in this time of global economic recession and sluggish recovery. In short, what's good news for the health of the Chinese people may turn out to be good news for the global economy. That's because to improve the health of its people and to grow its economy, the Chinese government has pledged to spend 850 billion renminbi (US$125 billion) over the next three years.

Yet, as recent experience shows, it's also true that a nation's economic status does not necessarily determine the quality of its health care. Cuba provides an important case in point. This small island country, which has an annual per capita *income of just US$4,200, has a health care system that, by many indicators, is comparable to or – in some instances – even exceeds the performance of health care systems found in many developed countries.*

With 6.5 doctors per 1,000 people, Cuba has one of the highest ratios of doctors per capita *in the world and more than twice the ratio than either the United States (2.5) or Canada (2.1). Life expectancy in Cuba is 78 years, compared to 77 in the United States and 80 in Canada. And Cuba's infant mortality rate is 5.3 per 1,000 live births, compared to 6.3 in the United States and 5 in Canada. With more than 70,000 physicians, Cuba has also used its medical prowess to strengthen its diplomatic ties, dispatching more than 17,000 doctors to foreign countries at any given time. At the same time, more than 20,000 medical students from around the world attend medical school in Cuba, most free of charge.*

Sri Lanka is another notable example. Despite its poverty and political tensions, Sri Lanka has successfully implemented a low-budget programme to improve health care during pregnancy and infancy that has sharply reduced mother-and-child mortality rates. Thanks in large measure to a comprehensive system of maternal and child health clinics and midwife home visits, Sri Lanka is on track to meet the UN's Millennium Goal to reduce under-five child mortality by two-thirds by 2015.

The challenges faced by health care communities in developing countries are in many ways more complicated than the challenges faced by developed countries. That's because many developing countries must deal with what health experts have labelled 'the double disease' burden. On the one hand, developing countries must grapple with diseases that have historically been associated with poverty, including the deadly persistence of such infectious diseases as malaria and tuberculosis. On the other hand, as people in developing

countries improve their living standards, these countries must increasingly grapple with such 'life-style' ailments as cardiovascular diseases, cancer and diabetes. The double disease burden places additional pressure on developing countries to effectively deliver adequate health care services.

Arne Hoel/World Bank

In a larger sense, the broad range of disease challenges in developing countries also makes it imperative for health care policies and programmes to be based on detailed assessments of the state of public health (all measures to improve a country's health must be data- and evidence-based). And, at the same time, it means that the steps taken must be cost-effective (all public health measures need to be designed to obtain the highest possible returns on the investments in terms of saved and healthier lives). In developing countries, in particular, money spent inefficiently can cost lives.

So, what would an efficient health care system look like? It would invest a sufficient amount of resources in a nation's public health infrastructure, including its hospitals, clinics and dispensaries. It would concentrate on improving the health care delivery system. It would increasingly refocus its concerns from therapeutic to preventative medicine. And it would strengthen its ability to monitor the origin and spread of diseases, particularly infectious and communicable diseases. All of these goals, of course, depend on well-trained clinicians and medical researchers.

And this brings us back to the first point. TWAS is primarily concerned about capacity building for science and technology in the developing world. Good health care, of course, depends on good doctors, pharmacists, nurses, midwives, technicians and researchers. Put another way, health care, for all of its scientific and technical prowess, remains largely a profession driven by well-trained practitioners. And such well-trained people often have a wide range of options when it comes to employment that extends well beyond their national boundaries. A recent study has shown that about 65,000 African-born physicians and 70,000 African-born nurses are working in developed countries. That is about 20 percent of the African-born physicians and 10 percent of African-born professional nurses.

We often think that the state of a nation's public health depends largely on good health research. But it is equally true that good health research depends on effective medical practices – and the national economic and social well-being that this brings. ■

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A similar version of this article was published in Public Service International *14 (see* www.publicservice.co.uk*).*

SMALL GRANTS LOOM LARGE

A RECENT EVALUATION OF THE TWAS RESEARCH GRANTS PROGRAMMES FOR INDIVIDUAL SCIENTISTS SHOWED HOW SMALL GRANTS CAN MAKE A BIG DIFFERENCE IN THE CAREERS OF RESEARCHERS FROM POOR COUNTRIES. IN THE FOLLOWING ARTICLE, SUJATHA BYRAVAN, SENIOR FELLOW AT THE CENTRE FOR DEVELOPMENT FINANCE IN CHENNAI, INDIA, WHO CONDUCTED THE SURVEY AND WROTE THE REPORT, PRESENTS SOME OF THE LESSONS THAT CAN BE LEARNED FROM TWAS'S EXPERIENCE IN SMALL GRANT GIVING.

For more than three decades, beginning with a declaration emanating from the UN Conference on Science, Technology and Development, held in Vienna in 1979, poor countries have been encouraged – indeed the countries themselves have often pledged with great fanfare – to set aside at least 1% of their gross domestic product (GDP) for science and technology. The ultimate goal, both science advocates and political leaders have repeatedly emphasized, is to lay a strong foundation for science-based economic growth and development.

While efforts to achieve this goal have been slow in coming, over the past several years several large developing countries, most notably, Brazil, China and India, have passed the 1% threshold. Nevertheless, many other developing countries, particularly those in sub-Saharan Africa, have not (in some countries, expenditures for science have actually declined).

TWAS has identified some 80 countries as scientifically lagging countries. Not surprisingly, these countries are among the world's most impoverished.

These mixed trends have led proponents of scientific capacity building in the developing world to continue to search for ways to turn their rhetoric into reality. At the same time, donors have continued to look for ways to provide grants both to scientists and scientific institutions that would help promote the careers of individuals and, over the long term, create fertile ground for nurturing an enduring culture of science in poor countries.

THINK SMALL

Modern science is expensive. Yet, for scientists in many developing countries, even small grants, if properly managed, can prove to be as effective as large ones. This is the unmistakable lesson that emerges from a recent study of the TWAS research grants programme for individual scientists who are less than 45 years old. The programme has been in continuous operation since 1986, just three years after TWAS was launched.

The study examined the overall procedures that have been put in place to administer these grants and also looked at how the grants have been implemented in broad aggregate terms. The primary goals of the study were to highlight areas of strength and propose strategies for improvement.

To date, nearly 2,000 scientists have been awarded TWAS research grants. Recipients have been chosen from a pool of more than 7,500 applicants. That translates into a success rate of just over 25%. Funds for the grants have come from two sources: core funding for TWAS provided by the Italian government and programmatic grant money from the Swedish International Development Agency (Sida).

Thus far, scientists from 79 countries have received grants. The largest number has come from Latin America and the Caribbean, followed by Asia and the Pacific and then Africa and the Arab region.

The average grant totals just USD7,000. Scientists can use the funds to purchase instruments, scientific literature and consumables.

The grants have been given almost exclusively in the basic sciences, nearly half in biology, a quarter in physics, 20% in chemistry and 7% in mathematics.

Applications from men far outnumber those from women in all subjects. However, women applicants have enjoyed the same success rates as men. As a result, the study suggests that special efforts should be made to attract more qualified women to apply, especially in physics, chemistry and mathematics.

MAKING A DIFFERENCE

Based in part on interviews with recipients, the study indicates that small grants can often have a lasting positive impact on the careers of scientists, especially those living and working in poor countries. As one recipient noted, the grant served as "a pillar of my research career".

But the survey also showed that donors must be mindful of some key factors for these grants to achieve their maximum effect.

Timing, for example, is critical. Simply put, youth can be well served with little money in ways that older scientists may not. To a young scientist, even a modest grant can prove quite helpful and have a lasting impact on his or her career. At the very least, it sends a positive signal at a critical juncture in a scientist's career. Indeed seed funding for exploratory research that is made available in the first few years after the awarding of a PhD can propel a career to greater heights. Such funding also becomes a magnet for other financial assistance and awards. Moreover, it creates opportunities to attract and train students and to improve the quality of research.

In other words, grants often beget grants as capacity strengthens and productivity increases. As one recent grantee noted, "one of the best roles that TWAS can play is to provide seed money that allows young scientists to cultivate new ideas, in part by leveraging other sources of money."

Maximum flexibility should also be built into the grant programme. Grants should preferably be open-ended, with scientists being allowed to use the money for the purchase of materials for their research and/or for expenses such as fieldwork and travel as they see fit.

Scientists also benefit from support that is less prescriptive in terms of whether the award is for basic or applied research and the

area or topic that they can pursue. In return, of course, scientists must accept the need for transparency and accountability.

Another key point is that grants should be given, whenever possible, to teams of scientists that are preferably organized as research units focusing on clearly delineated challenges. Such units, over time, have the potential to form a nucleus around which science flourishes and attracts more talent.

Nevertheless, when there are very few scientists in a given country or in a particular field of research, grants to individual scientists can prove of immense value. Targeting areas of research where synergies already exist is ideal. But helping individual scientists may be where the grant programme must begin.

The final key point is that donors should emphasize excellence in the selection of awardees; yet, they should not sacrifice the good for the perfect, especially when it comes to proposals from scientifically lagging countries.

We may view excellence in science as a universal goal, which it is. But the reality is that, when it comes to small grants, it may be necessary on occasion to measure excellence on a sliding scale.

BE PRACTICAL

There are also some practical considerations that can be easily taken into account to help strengthen the impact of a grant well beyond the specific funding provisions of the agreement. For example, as part of the terms of the grant, the donor and the institution in which the awardee works should agree that items purchased with the grant money remain at the institution if and when the awardee leaves. This easy-to-implement grant provision can contribute a great deal to institutional capacity building.

As is well known, a broad range of challenges exist for those pursuing science in less developed countries, where inadequate funding, poor working conditions and scant job opportunities are often the reality.

For example, during a workshop in Nairobi held as part of this study, scientists from sub-Saharan Africa noted that there were a number of problems at the national level that have impeded scientific development.

These problems include a lack of institutional capacity to support research, inadequate in-country funding and no national roadmaps directing how science can contribute to development. Increasingly, however, regional opportunities are emerging that could help overcome national shortcomings. Donors should take advantage of such opportunities and encourage grantees to do the same.

For instance, there are growing regional knowledge networks as well as increasing interest among the scientific diaspora to participate in scientific activities in their home countries. These interactions, which do not require a great deal of funding, provide scientists with opportunities for learning and growth.

Efforts to promote collaboration might entail, for example, organizing regional workshops for their grantees or sponsoring visits from scientists living in other countries. These strategies are central to the TWAS grants programme. But perhaps more than anything else, grant givers should encourage donors to be nimble and eager to try new ideas and launch pilot programmes.

Donors should also seek to persuade governments to remove existing barriers such as high customs duties on scientific instruments, strengthen scientific research councils, and establish such councils where they do not exist.

THINK SMALL

While some developing countries such as Brazil, China and India are now on a fast track to building scientific capacity, much work remains to be done in scientifically lagging countries, particularly in sub-Saharan Africa. The lessons that TWAS has learned in small grant giving can help donors find more effective ways to help such countries.

Money is important. But how, where and when the money is spent may be even more important when it comes to generating large returns on limited investments. As the TWAS experience shows, small grants can indeed loom large in the careers of many scientists. ■

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UNIVERSITIES ACROSS AFRICA

JEAN-PIERRE O. EZIN, THE AFRICAN UNION COMMISSIONER FOR HUMAN RESOURCES, SCIENCE AND TECHNOLOGY, OUTLINES A STRATEGY FOR REVIVING THE CONTINENT'S SYSTEM OF HIGHER EDUCATION BY CREATING A PAN AFRICAN NETWORK OF UNIVERSITIES FOR POSTGRADUATE TRAINING.

"*Everything has been said since there have been men living on Earth and thinking for over 1,000 years*."

This quote, drawn from the musings of 17th century French Bishop Jaques-Benigne Bossuet in his celebrated volume, *Oraisons Funèbres* (Funeral Orations), could well apply to contemporary discussions concerning the role of science and technology (S&T) in economic development, especially in the developing world.

Indeed, over the past half century, it seems that everything which needs to be said has been said: yes, S&T is essential for development; yes, developing countries need to spend more on S&T; yes, S&T needs to be more closely integrated into national strategies for sustainable growth; and, yes, the global society in which we live demands that each nation nurture a scientifically skilled workforce, as well as scientifically literate citizens, if it hopes to build a society marked by economic and social well-being.

There are, moreover, a growing roster of once poor and backward countries that have successfully built a strong foundation in S&T in ways that have spurred rapid and sustained economic growth – most notably, Japan in the post World War II era and China in the first decade of the 21st century.

Today, more than ever, governments across the developing world are singing the praises of S&T and devising broad, comprehensive strategies to advance science-based sustainable development. Brazil, India, Singapore and South Korea are among the countries that have fully embraced S&T as fundamental tools for economic growth. An increasing number of other countries are now determined to follow in their footsteps.

WHAT ABOUT AFRICA?

It is no secret that African countries have lagged behind others in building scientific capacity and in putting science to work to lift their national economies and the well-being of the entire continent. What is less well known, however (at least outside of the circles of international science), is that Africa has often spoken out forcefully about the need to promote S&T. The failure has lied not in too few calls for action, which have been articulated on numerous occasions, but on the inability to transform the lofty rhetoric into concrete action.

It is no secret that African countries have lagged behind others in building scientific capacity.

In 1979, for example, a group of African intellectuals, meeting in Monrovia, Liberia, recommended, in a statement to the continent's heads of states, that each African nation devote at least 1% of its gross domestic product (GDP) to S&T. Two years later, Africa's political leaders at a meeting of the Organization of African Unity (OAU) in Lagos, Nigeria, unanimously endorsed a declaration, which came to be known as the Lagos Action Plan, which also called on each African country to invest 1% of its GDP in S&T. In 1987, Africa's leaders gathering once more, this time at a conference in Brazzaville, the Republic of Congo, again proclaimed that each African country should make the 1% S&T principle the keystone of its economic development strategy.

Yet, it was also at this conference that Abdus Salam, the Pakistani-born Nobel Laureate and founding president of TWAS, delivered a presentation with this probing title: "Does Africa really desire science?" In this talk, Salam glumly suggested that a gnawing gap existed between the rhetoric emanating from conferences devoted to science and development in Africa and the reality on the ground.

Recent history does indeed suggest that all that needs to be said about science, technology and development in Africa has been said. And, while 30 years represents a brief moment compared to Bossuet's 1,000-year frame of reference, it is nevertheless a substantial stretch of time in our fast-paced modern world

THE AU-TWAS YOUNG SCIENTIST AWARD

The AU-TWAS Young Scientist National Award, launched this year, will provide an annual cash prize of USD5,000 to promising scientists, under the age of 40, who come from any AU member state. Modelled on the TWAS awards for young scientists from developing countries, it is designed to recognize the scientific achievements of young researchers and encourage them to strive for excellence in their careers. For more information, including eligible requirements, applications forms and deadlines, see www.twas.org.


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AFRICAN UNION AND ITS COMMISSION

The African Union (AU), comprised of the continent's 53 countries, is Africa's principal institution for advancing social-economic development. As a continent-wide organization, it focuses on the promotion of peace, security and stability in Africa as prerequisites for implementing its full agenda. An AU assembly, comprised of heads of states and government or their duly accredited representatives, establishes the AU's policies. The African Union Commission (AUC), led by a chairperson and deputy chairperson, consists of eight departments that manage the AU's affairs on a day-to-day basis.

The AUC's Department of Human Resources, Science and Technology supports the development, harmonization, coordination and implementation of policies and programmes in African Member States and Regional Economic Communities (RECs) in the following areas: science and technology (S&T), information and communication technologies (ICT), education, and youth empowerment and capacity building.

For additional information, see www.africa-union.org.

– a time that has been marked by soaring statements yet halting steps when it comes to efforts to achieve results-oriented action in building scientific capacity in the world's poorest continent.

Who can argue against the lament levelled by those who have been disappointed with Africa's progress and who firmly believe that Africa needs to do much more to build its scientific capabilities and to promote science-based development? Just consider a meeting of the AU's executive council held in January 2006 in Khartoum, Sudan, where the Consolidated Plan of Action for Science and Technology in Africa was officially adopted. A key recommendation of the plan was for each African country to spend at least 1% of its GDP on S&T. Why would anyone have confidence in a proclamation calling for the fulfilment of an often-stated goal that has remained unmet for nearly four decades?

Statistics published in 2007 showed that of the 53 countries that belong to the AU, only Rwanda has reached the 1% threshold in S&T expenditures. On average, African countries invest just 0.3% of their GDP on S&T, one-tenth the share of GDP devoted to S&T expenditures in a number of developed countries.

It should be no surprise, then, to learn that only three universities in Africa are listed among the top 500 in Shanghai Jiao Tong University's 2009 global ranking of universities. All three are in South Africa, by far the continent's leading scientific and economic country, with a level of S&T spending that lies just below 1%. That is more than three times the average national S&T expenditure on the continent.

Each African country must improve the quality of its system of higher education.

WHAT'S TO BE DONE?

So what measures should be taken to help Africa build its scientific capacity building – steps that could lead the continent on a path towards sustainable economic growth?

Countries across the globe now recognize that universities are prime drivers of economic growth. Like many developing countries, each African country – and


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the continent as a whole – must improve the quality of its system of higher education to help combat chronically high levels of poverty, reduce widespread environmental degradation and successfully grow the economy in ways that instil hope and, over time, prosperity.

The reform agenda for Africa's universities should focus not just on facts and figures (conveying information), but on innovation and creativity (fostering critical thinking and novel applications of knowledge that positively impact society). And it should emphasize both undergraduate and postgraduate training. The goal, in brief, should be to train future generations of experts and citizens with the knowledge and skills they need to address critical social problems.

A university where research is nonexistent, insufficient and/or misdirected undermines the institution, both in its relationship to the global community of higher education and the responsibility that a university bears in helping its nation achieve economic and social progress. Indeed, a poor system of higher education is a detriment to society. That's because the absence of satisfactory universities makes it difficult, if not impossible, to build a sufficient storehouse of knowledge and innovation to ensure that economic and social progress can take place.

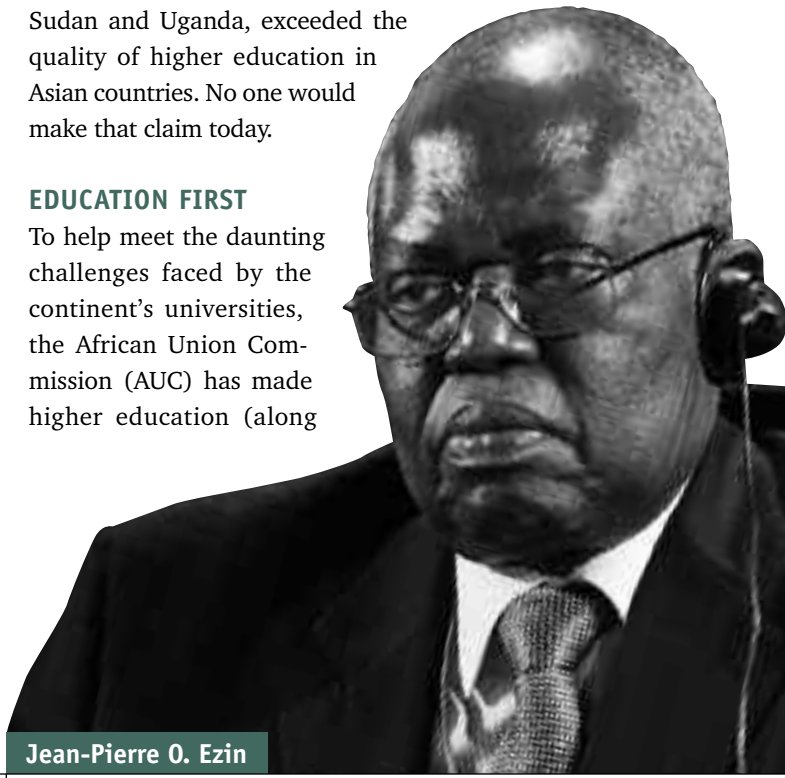
Even in those countries in Africa where modest advances in research have occurred, such progress has not always led to improved education and training. Neither has it resulted in greater collaboration among African scientists. Most African countries have yet to build a critical mass of researchers or nurture an environment for learning that allows for the seamless integration of research, training and public service.

As a result, success has often been measured by the work of individual scientists. Many of the continent's most accomplished scientists, moreover, have forged closer ties with colleagues abroad than with colleagues at home.

Perhaps even more disheartening, current trends seem to be going in the wrong direction. Over the past several decades, the quality of education and training (not to mention the state of the classroom and laboratory facilities) in many Africa universities has actually declined – for both undergraduate and postgraduate training. In the 1970s, the quality of higher education in several African countries, notably Sudan and Uganda, exceeded the quality of higher education in Asian countries. No one would make that claim today.

EDUCATION FIRST

To help meet the daunting challenges faced by the continent's universities, the African Union Commission (AUC) has made higher education (along


Jean-Pierre O. Ezin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Arne Hoel/World Bank

with peace, stability and security) a focal point of its overall development strategy for Africa. Moreover, to help improve the state of postgraduate education across the continent, the AUC has lent its full support to a Pan African University (PAU) initiative.

The hope is that PAU can play a leading role in restoring the effectiveness and image of Africa's system of postgraduate education, largely by developing regional knowledge centres, or nodes, directly linked to field units. The goal is to create a hub-and-spoke matrix that extends the reach of quality postgraduate teaching and research to the most remote areas of the continent.

To be successful, Africa's universities must compete and cooperate.

Overall, PAU aims to:

- Assist Africa's economic development by both expanding and strengthening scientific research.
- Enhance the exchange of data and information, largely through scientific networks.
- Increase the mobility of researchers and students.
- Foster collaboration between universities and industry.

More specifically, PAU aims to facilitate the training of a critical mass of researchers, engineers, technologists and teachers in disciplines and professions that are likely to be essential to Africa's future success: water and energy (including a focus on the impact of climate change); earth and life sciences; space science; technology and innovation; governance; and the social sciences and humanities. These five areas were selected for their relevance in meeting the priority needs of Africa.

The strategy driving the PAU calls for training and research to take place at institutes for advanced studies (IAS) located in the continent's five primary geographical regions: north, west, east, central and south. The first institute will focus on space science and the second on water and energy research.

Each of the institutes will be responsible not only for on-campus instruction but also for overseeing satellite units that will be established in several different countries within the region. Each satellite unit, in turn, will have its own faculty, departments and research centres.

The project will cost an estimated USD65 million to fully implement. As a result, efforts to realize PAU's lofty goals will require significant financial support from the AU, Africa's national governments, international donors and the private sector.

TIME IS NOW

The time has come – indeed it's long overdue – to develop high-level postgraduate training and research facilities throughout Africa. Such facilities will play a key role in closing the gnawing S&T gap both between countries and regions within the continent and between Africa and other continents.

PAU will seek to achieve this goal by promoting and rewarding teaching and research excellence through rigorous and transparent competition. Yet, because centres of excellence are so few in number and so scattered, PAU will be designed to encourage the sharing


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OTHER EDUCATIONAL INITIATIVES

In addition to its efforts to reform Africa's system of higher education by creating a pan-African network of universities (PAU), the African Union Commission (AUC) is engaged in a number of additional measures designed to promote science, technology and innovation across the continent, including an:

- *EU-AU African research grants programme for scientists.*
- *African Observatory of Science, Technology and Innovation to monitor scientific and technological (S&T) development in Africa and to serve as a central repository for S&T statistics.*
- *AU Scientific Research Council to help guide science-based economic development throughout the continent.*
- *AU training programme for the training of science journalists.*

For additional information about the initiatives, see www.africa-union.org.

of personnel, equipment and material. Such collaborative efforts should be facilitated by new information and communication technologies.

The fact is that for Africa's universities to be successful, they must compete and cooperate – both among themselves and among universities and research centres across the globe. And that is what PAU's institutes and satellite units will be required to do – strive for excellence through collaboration and competition, which at first glance may seem contradictory, but in Africa's case are complimentary.

Progress, given the decades of neglect and decline, will not be easy. But rebuilding Africa's universities, and more specifically its postgraduate training programmes, is a fundamental prerequisite for economic progress. Indeed countries with too many poorly educated citizens and too few highly trained scientists and technologists will be condemned to a future of economic underachievement and despair.

Africans have known this for a long time. And, from this perspective, as I noted in the opening paragraph of this article, perhaps all that needs to be said has been said. Yet, as has been clearly revealed by Africa's experience in higher education over the past several decades, knowing and doing are two different things.

The PAU provides an attractive – and, equally important, a practical blueprint for moving ahead on one of the continent's most critical issues – raising the quality of postgraduate training and research. Indeed, by helping to create a strong foundation for science-based sustainable economic development, progress in reforming Africa's ability to provide excellent postgraduate education could help facilitate improvements on many other critical fronts.

It could, in short, prove to be a fundamental underpinning of national well-being and serve as a primary source of the continent's ability to compete successfully in today's global economy. ■

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MOHAN MUNASINGHE (TWAS FELLOW 1994), CHAIRPERSON OF THE MUNASINGHE INSTITUTE FOR DEVELOPMENT IN COLOMBO, SRI LANKA, AND DIRECTOR-GENERAL OF THE SUSTAINABLE CONSUMPTION INSTITUTE AT MANCHESTER UNIVERSITY, UK, IS ONE OF THE WORLD'S PRE-EMINENT RESEARCHERS ON ISSUES RELATED TO ENERGY, SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE.

Munasinghe has been a senior energy advisor to the government of Sri Lanka, an advisor to the US President's Council on Environmental Quality and a senior manager at the World Bank. As vice chair of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR4), he also shared the 2007 Nobel Peace Prize. In the months leading up to the 2009 Copenhagen summit on climate change, he provided expert advice to the Danish Prime Minister's office.
In an hour-long phone interview with the editor of the TWAS Newsletter*, Munasinghe spoke about his disappointment with the outcome of the Copenhagen Conference of the Parties (COP 15). He also proposed a series of practical steps that could be taken by civil society and business across the globe to help tackle global climate change issues. Excerpts follow.*

CHANGED CLIMATE

What were your expectations going into the Copenhagen climate conference?
I came to Copenhagen with low expectations. There had been some encouraging discussions held at the UN conference of the parties (COP13) that took place on the Indonesian island of Bali two years before. But it turned out that these discussions only fuelled false expectations. By the summer of 2009, if not before, it was clear that any agreements on significant issues would be difficult to achieve. The meeting in Copenhagen (COP15), which drew more than 50,000 people (some estimates put the figure at 100,000), was heading into rough waters even before it started. It's not surprising then, given the forces of resistance it was facing, that the conference nearly collapsed.

In retrospect, global climate change policies reached their high point decades ago with the approval of the UN Framework Convention on Climate Change (UNFCC) in Rio de Janeiro in 1992, which I helped to draft. The Kyoto Protocol, which was approved in Japan in 1997, is the only international climate agreement that includes legally binding national commitments to reduce greenhouse emissions. And even the Kyoto agreement had serious shortcomings. The reductions in emissions that were called for were modest (and, in truth, not enforceable), and the agreement itself was never ratified by the United States, the world's largest emitter of green-

house gases until China surpassed it last year. On a *per capita* basis, greenhouse gas emissions in the US still exceed *per capita* emissions in China by a factor of four.

Over the past several decades, scientists have conducted a great deal of research on climate change, and their findings have been admirably synthesized in a series of reports issued by the Intergovernmental Panel on Climate Change (IPCC), where I have been privileged to serve 20 years, most recently as a vice chair. There have also been many international workshops and conferences, not to mention events held by high-level government officials. Moreover, prior to Copenhagen, the European Union (EU) agreed to cut emissions by 20% compared to 1990 emission levels, and said it would boost that figure to 30% providing rich countries (designated as Annex 2 countries in the Kyoto Protocol) agreed to comparable reductions. Several large developing countries with emerging economies, most notably Brazil, China and India, also said they would pursue voluntary cuts ranging from 24% to 45%, based on 2005 emission levels.

In the days leading up to the conference, the US, meanwhile, said it would cut its emissions by 17% based on 2005 levels. That amounted to a mere 4% cut relative to 1990 levels. It was a paltry figure, compared to what Europe had offered, and it reflected the current lack of political will in the US despite the election of President Obama and heavy Democratic Party majorities in both houses of Congress.

All these pronouncements provided scant hope that something tangible would be accomplished in Copenhagen. In fact, the sharp downturn in the global economy, sparked by the worst financial crisis since the Great Depression of the 1930s, dimmed the prospects for meaningful progress on the climate change front. Simply put, it made both developed and developing countries unwilling to embrace policies that they believed would burden their weakened economies. Equally important, it made rich countries reluctant to commit sufficient levels of funding to help the most vulnerable developing countries withstand and adapt to the climate change impacts that they will inevitably face.

Let me give you an example of the severe shortcomings of the Copenhagen conference by focusing on one of the few decisions that has been hailed as a success: the creation of an international fund, stocked with money from rich countries, to help poor countries adapt to the changes in temperature, precipitation patterns, storms and sea level rise that will be induced by climate change.

Studies show that these countries will need some USD200 billion a year over the next 10 to 20 years to address this challenge. In Copenhagen, the rich countries pledged USD30 billion over the next 2 to 3 years, and agreed to provide USD100 billion a year from 2020 onward. That means the very best that can be hoped for is a fraction of what is needed. And the announcement of this fund in Copenhagen has been cited as one of the few successful outcomes of the conference.

What do you make of the document signed at the conclusion of the Copenhagen conference?

The accord was put together in the final hours of the conference by five nations – the United States, China, India, Brazil and South Africa. Yet, officials (including many heads of state) from 192 countries, the same number that is in the UN, attended the conference. The two-page document contains no framework for action, no timelines or benchmarks for measuring progress and, most importantly, no legally binding commitments requiring countries to act for fear of international sanctions or penalties. It's all based on good will, voluntarism and self-policing. Although there is a broad statement of principles, claiming that efforts will be made not to allow average global temperatures to rise more than 2 degrees Celsius before the end of the century, any specific targets for cutting emissions are voluntary and have been placed solely in the hands of the national governments themselves.

There has been talk of picking up the pieces and reaching a more meaningful agreement in Mexico at the next annual convention of the parties in December 2010. But I am not optimistic. The same economic and political forces that scuttled the prospects for an agreement in Copenhagen will continue to be at play – and, in fact, could prove even more prominent – in the months ahead. Few economists expect the global economy to grow at a rapid clip in 2010, and even fewer anticipate significant job growth, especially in rich countries.

What impact will the outcome at Copenhagen have on greenhouse gas emissions in the future?

As I stated earlier, countries signing the accord in Copenhagen agreed that increases in average global temperatures should not exceed 2 degrees Celsius by the end of this century.

The consensus among scientists is that for this to happen, the level of greenhouse gases in the atmosphere must be capped at no more than 400 to 450 parts per million (ppm). Today, emission levels stand at 385 ppm (compared to 280 ppm before the Industrial Revolution in the 17th Century). If these levels continue to rise at their current pace, it's possible that average global temperatures will increase by as much as 4 degrees Celsius by 2100. That would be a disaster for all the reasons that have been analyzed in the scientific literature and discussed in the media. Extreme weather events would become commonplace, sea levels would rise, many dry environments would become even drier, many wet locations would become even wetter, coral reefs would likely disappear and species loss would accelerate.

We do have a window of opportunity to put in place the technologies and policies that are needed to the curb emissions by the amount that is required. But that window is closing fast and could be shut tight by 2020 unless we act quickly.

Here's the problem. The voluntary cuts in emissions that countries tentatively agreed before and during Copenhagen add up to only a 15% reduction in emissions. That's the best we can hope even if all the countries live up to the public pledges they have made.

Yet, scientific studies indicate that a cut of at least 40% relative to 1990 emission levels will be necessary to prevent average global temperatures from rising more than 2 degrees Celsius. That leaves a 25% gap between the minimum reductions required by the best available science and the modest voluntary plans that have been laid out to achieve this goal. Most significantly, the gap translates into increases in average global temperatures of about 4 degrees Celsius. This far exceeds the 2 degrees Celsius now widely accepted as the danger point for climate change impacts.

What can be done, particularly by the scientific community, in light of the disappointing outcome in Copenhagen?

I know that I've presented a bleak picture of what the future might hold. Yet I am not as pessimistic as you might think. Progress in meeting the difficult challenges posed by climate change can be achieved, but it will depend on several factors, some of which are scientific and some that are not.

The scientific community must work much harder to provide country-specific information about the potential impacts of climate change. There has been a great deal of research on global trends in greenhouse gas emissions and the impact this is having on climate and on socio-economic and environmental systems. But what really counts for people and therefore politicians is the impact that climate change will have at the regional, national and local levels. That's where political decision-making comes forcefully into play. Or, to state it more directly, that's where political will is needed to turn talk into action.

Scientific studies must also focus less on mitigation and more on issues related to vulnerability, resilience and adaptation. The level of greenhouse gases currently in the atmosphere, together with the increases that are expected to occur over the next several decades, mean that significant climate-change impacts will undoubtedly take place, regardless of what is done. Ironically, the most severe impacts will be felt in the poorest nations in the tropics, which are least responsible for past emissions that have created the climate problem. The scientific community can play a key role in assisting policy-makers by conducting studies that identify vulnerabilities and outline concrete policy responses for enhancing resilience and adaptation among the poorest and most vulnerable.

The key is to develop science-based strategies that integrate adaptation and mitigation within an overall strategy for sustainable development. That would allow effective policies to reap benefits beyond those related to climate change. This is particularly true for resource-scarce developing countries that are the most vulnerable to climate change impacts. In brief, we need to take significant steps in the near term that not only help make poor communities 'climate-change resistant', but that also offer a blueprint for solving existing problems such as poverty, malnutrition, sickness and resource scarcity.

One proven methodology to effectively integrate multiple issues into sustainable

development strategy is the "sustainomics" framework, which I first presented at the 1992 Rio Earth Summit. Its first principle is "making development more sustainable", which encourages immediate action based on existing knowledge. Many of our present activities are obviously unsustainable, and simply correcting them gives us momentum. Effective measures include mitigating greeenhouse gas emissions by planting trees or conserving energy with more efficient lighting. This approach also gives us a simple operational test for all our actions. That is, do they make development more (or less) sustainable?

The second principle of sustainomics requires us to give balanced consideration to the three main dimensions of sustainable development – economic, social and environmental. The economic dimension, of course, is very important, especially for the poor. But we also have to make development more sustainable. On the environmental side, we must minimize the depletion of natural resources and environmental pollution. The social aspect is more subtle. At the community level, it involves building social capital – the glue that binds communities together.

Third, sustainomics requires changes in our thought processes. The analysis must transcend conventional boundaries imposed by disciplines, values, space, time, stakeholder viewpoints, and lifecycles. Transdisciplinary analysis must include not only the natural sciences but also economics and the social sciences and many other disciplines. Unsustainable values such as greed need to be replaced by more moral and ethical considerations. Spatial analysis must range from the global to the local, while the time horizon must extend to decades or centuries. Participation of all stakeholders, including representatives from government, the private sector and civil society (through inclusion, empowerment and consultation) is important. Analysis needs to encompass the full lifecycle of products and processes.

The scientific community must continue to do good science. But, at the same time, it must improve its ability to defend its findings and engage the public in serious broad-ranging discussions on climate change risks and challenges.

The public is much more aware of climate change today than it was just a few years ago. But that hasn't erased doubts about the level and immediacy of the risks that climate change poses, particularly when compared to other pressing matters, notably the need for jobs and economic growth. Recent controversies over unflattering email messages exchanged by prominent climatologists have damaged the credibility of climate change research and placed climatologists on the defensive. The same is true concerning claims about rapid glacial retreats in the Himalayas, which were published in the IPPC's most recent reports and subsequently withdrawn.

Moreover, climate change sceptics and their political allies continue to challenge the conclusions of mainstream researchers. And, of late, the public seems more inclined to listen.

For all these reasons, it is important for mainstream climatologists to present a clear and forthright case to the public that cli-

mate change is real and that its impacts will be widespread and significant. It is equally important for scientists to explain the broad base of knowledge upon which their conclusions are drawn on and to present possible options for effectively addressing these challenges.

While the outcome in Copenhagen suggests that it may be difficult to achieve progress on the political front, civil society and business could play an important role in facilitating meaningful reforms. The truth is that we know a great deal about greenhouse gas emissions, alternative energy use and more sustainable patterns of development. We also know there are many citizens, nongovernmental organizations and corporations that want to do the right thing. Indeed there are large markets for climate friendly products and services that have yet to be tapped.

Unfortunately, we have become stuck in a mindset that thinks it will be necessary to make huge investments to combat climate change. But it is possible to start small and build from there, based on what we already know. There are untold ways we can make our consumption and production patterns more sustainable through increased recycling, greater emphasis on energy efficiency and alternative energy use, and improved transportation. We can also pursue strategies that provide better price signals to help curb practices that adversely impact the climate and thereby pose long-term threats to environmental and societal well-being. As the campaign to curb cigarette smoking has shown (especially in the United States), it is also possible to change behaviour through public relations campaigns that emphasize the personal benefits that can be derived from taking the advice that is being offered.

All of this can be done without international protocols and treaties. The cumulative impact of these measures could be significant, not just in terms of cutting greenhouse gas emissions but also in creating a sense of forward motion that instils optimism and enthusiasm.

I am not suggesting that we should abandon efforts to achieve broad global agreements for curbing greenhouse gas emissions. But, given the outcome of the Copenhagen conference, it's clear to me that we should push forward with bottom-up strategies that complement conventional top-down solutions.

What would you say to scientists in the developing world? Are there changes that the scientists in the South should consider to become more effectively involved in climate change issues?

As I mentioned before, doing good science is the paramount consideration. That's true for researchers both in the developed and developing worlds. But, as I also indicated, the way forward may lie with addressing the climate-change issue at the local and regional levels. As a result, there is a great need for scientists from developing countries to focus on the immediate needs of their home countries. Science is a global enterprise, and scientists from the developing countries have too often measured their success by the level of recognition they receive from global scientific institutions (and, I might add, their colleagues in the North).

This is understandable given the history of science over the past 500 years. But such attitudes have also meant that, in the developing world, a significant gap has developed between professional excellence and societal needs. To address this gap, I would propose that developing countries emphasize the importance of doing science within the social context of their own countries. Efforts must be made to respect, recognize and reward research not just at the global level but also at the national, regional and local levels.

Despite the disappointing outcome at Copenhagen, do you think progress in combating climate change can be achieved?

I remain optimistic. That's what we all need to do. First of all, the alternative is unthinkable. Failure to address the challenges posed by climate change will have catastrophic consequences, and I am firmly convinced that we cannot – and therefore will not – let climate change wreak havoc on our societies. Second, I am very impressed by the younger generation both in developed and developing countries. They seem to understand – and support – the policies we need to enact more than the adults who are currently in charge. Perhaps they understand even more than their parents that their future is at stake. We can only hope that their youthful attitudes, energy and commitment will not be tarnished by age and disappointment. Third, it's important to keep in mind that over the past two years, governments have found USD5 trillion to stimulate a global economy so wracked by greed and mismanagement that it brought us to the brink of collapse. In contrast, the cost of addressing global climate change challenges would be far less, and would only have to be kept in place for several decades until we made a successful transition to a low-carbon future.

The point is, it would take a fraction of the world's wealth to turn back climate change and there could be worthy by-products, as well, in terms of improved energy efficiency, new technologies and secure, well-paying jobs. The money is there, the public support for reforms is there, especially among the youth, and the momentum to achieve meaningful reform, I believe, is there, despite what happened in Copenhagen. We need to re-adjust our sights from the rarefied air of international diplomacy to the plain ground truth found in civil society and the private sector. The world would do well to capitalize on the confluence of forces now in place that are pushing for reform. That didn't happen in Copenhagen. But it doesn't mean it won't happen in the future. We have to encourage our leaders to follow the path that many of their people, including the young, are now focusing on. It's a campaign we all need to engage in, and one in which the scientific community has a key role to play. ■

CITY LIFE IN THE 21ST CENTURY

FOR THE FIRST TIME IN HUMAN HISTORY, IN 2008 MORE PEOPLE WERE LIVING IN CITIES THAN IN FARMS OR RURAL VILLAGES. THIS MARKED A DEMOGRAPHIC SHIFT THAT SOME ANALYSTS CLAIM IS AS SIGNIFICANT AS THE DEMOGRAPHIC SHIFT FROM HUNTERS AND GATHERERS TO FARMERS AND SETTLERS THAT TOOK PLACE SOME 10,000 YEARS AGO. HANS VAN GINKEL (TWAS ASSOCIATE FELLOW 2005), FORMER RECTOR OF THE UNITED NATIONS UNIVERSITY (UNU), EXPLAINS THE CHALLENGES THAT OUR URBAN WORLD POSES FOR BOTH PEOPLE AND THE ENVIRONMENT – NOW AND IN THE FUTURE.

Humankind currently faces multiple crises. Just a partial list of the world's daunting challenges includes the worst global financial meltdown since the 1930s; the growing spectre of climate change and environmental disasters; accelerating species loss; rising incidences of infectious diseases spread by both old and new viruses; and chronic conflict and hunger.

These problems are often interrelated, and so too must be their solutions. The immediacy of the problems demands immediate responses, yet the complexity of the problems requires the full measure of our expertise and resources.

There are other challenges, however, that may not seem as compelling but may nevertheless prove to be as urgent in the years and decades ahead. Among these is urbanization – a challenge that, at one and the same time, impinges upon every daunting issue mentioned above and creates its own unique set of demands.

In many countries, a rural mindset – reinforced by a deep-seated rural mythology – continues to hold sway in both political circles and the public arena. This mindset is often as enduring in developed countries as it is in developing ones. And it has proven to be just as immutable in countries and regions where the majority of people now live in cities, as it is in those places that still have large rural populations.

Yet, facts and circumstances present a different story, placing the reality at odds with the mythology.

AN URBAN WORLD

For the first time in human history, in 2008, more than half of the world's 6.6 billion people were living in cities. It is difficult to grasp just how swiftly this trend has unfolded. In 1900, less than 10% of the world's population was urban; a half century later, fewer than one billion people were city dwellers. It took tens of thousands of years for the majority of humankind to become agriculturalists and pastoralists, leaving their past as hunters and gatherers behind; yet, it took merely one century for the transition from rural to urban areas.

Urbanization in the 20th century largely took place in developed countries. Today, however, it is a global phenomenon that is, in fact, occurring most rapidly in developing countries. In Latin America, some 80% of the population now lives in cities. In Asia, demographers estimate that some 2.4 billion people will reside in cities by 2050, compared to 1.6 billion today. In Africa, the world's most rural continent, the urban population is expected to rise threefold from less than 300 million to more than 900 million by 2050.

Hans Van Ginkel

The UN estimates that the global population will reach 9 billion people by 2050 and that virtually all of this growth will take place in cities in developing countries. In real numbers, this means that more than two-thirds of the world's population – some 6.4 billion people – will be living in cities within the next four decades, up from 3.3 billion today. Currently, more than one million people worldwide move to cities each week, adding some 70 million people to urban environments each year.

The march towards urbanization is inevitable. History has shown that, while development begins with improvements in agriculture, sustained development cannot be based on agriculture alone. Industry, trade, transportation and education are essential. All of these activities rely on urban centres for their nourishment and growth. Urbanization, as a result, is very much part of the development 'model' of our present and future global society. From this perspective, rural dominance is transitory and urban dominance is inevitable.

More than half of the world's 6.6 billion people live in cities.

The formidable link between sustainable economic growth and cities is due, in part, to the fact that incomes in agriculture are low. It is, of course, possible to generate high incomes in agriculture, but rural wealth only takes place on large, capital-intensive farms with few workers in relation to the hectares under cultivation. The US and the Netherlands rank number one and two in the world in agricultural exports in terms of value, yet employ only 2% and 3%, respectively, of their work force in agriculture. As these statistics suggest, successful development generates a continuous flow of labour out of agriculture and into other sectors. Indeed a primary source of urbanization is rooted in advances in agriculture.

FORCES AT WORK

The growth of urban populations is based on three different, though interrelated, processes. The first, as mentioned above, is a predictable pattern of 'rural-urban migration' marked by the movement of workers

The march towards urbanization is inevitable.

from agricultural pursuits to other, usually urban-based, employment opportunities.

The second factor is that urban migrants are usually young. This was the case in London in the 18th century, New York City in the 19th and 20th centuries and Mumbai today. Young citizens not only live longer but also have families. This, in turn, adds momentum to the city's population growth trends. And while the cities' birthrates tend to fall over time, those in the surrounding countryside do not. Thus, as cities grow and annex land at their periphery, they continue to expand their population base. In the process, large numbers of rural people come to be reclassified as "urban".

Finally, as cities emerge as national and international hubs (that is, global centres of industry, commerce, finance and public administration), they often attract migrants from abroad. That has certainly been the case for world's largest, most cosmopolitan cities. The broad demographic trends at work help to explain the recent growth of 'megacities' – urban constellations of 10 million residents or more. In 1950, New York City was the only urban metropolis with more than 10 million people. In 2000, there were 18 megacities. By 2025, experts anticipate that there will be a total of 27 such cities.

What is compelling about the growth of megacities is not just their size but also where they are emerging with increasing frequency. While in the 20th century we rightfully associated the world's largest cities with the world's richest and most industrialized countries, in the 21st century, virtually all of the world's megacities are emerging in developing countries. Such trends, which offer a vivid reminder that urban growth is now a global phenomenon, have important implications for the social and environmental well-being not just of the inhabitants of these oversized cities but the entire planet.

A simple statistic can help convey the ecological challenge that megacities pose: The 20 million people living in the greater metropolitan area of Mexico City (the world's second largest megacity, after Tokyo) currently draw an ever-increasing portion of their water supply from sources more than 200 kilometres from the city's centre. What does this logistical challenge say about the city's well-being and its ability to respond to such risks as drought, climate change, damaged water mains and the transmission of pathogens? What does such an arrangement mean for the area surrounding Mexico City, which finds itself relinquishing its precious resources for the 'greater good' of the nation's urban residents who live so far away? Some 20% of Mexico's total population lives in Mexico City. How can public officials devise effective strategies for sustainable growth in the face of such a massive demographic imbalance?

Megacities certainly attract attention. But does that mean large cities – or, for that matter, cities of any size – represent the primary source of the problem? Isn't the real issue population growth and distribution as well as unsustainable resource use and consumption? There are certainly large and growing problems related to water, sanitation, air pollution and housing that need to be solved. However, urbanization, in and of itself, may not be at the root of the problem. The problem, instead, could lie with enormous population growth, that will result in some 9 billion people living on the tiny planet Earth by mid-century, compared to 6.7 billion today.

A part of the challenge could also lie in the world's production and consumption patterns. In view of the rising living standards in the developing world, most

The future well-being of humanity resides in cities.

notably in China and India, it is clear that the developing world cannot develop along the same lines as the developed world has if the Earth is to be placed on a sustainable trajectory for growth in the 21st century. The ecological footprint will simply be too large for the planet to absorb. Yet, that conclusion also elicits an ethical question of the utmost importance: Why should the people of any nation be denied the same of levels of social and economic well-being that have been achieved by people in the North?

When viewed from this perspective, cities are not a primary source of the problem but may actually be a principal part of the solution. That's because cities, despite their daunting population figures and the high levels of congestion and pollution associated with them, are where people live most efficiently – where, in effect, humanity's ecological footprints on a *per capita* basis tread most lightly.

URBAN CONSTELLATIONS

It's not just that the future of humanity that resides in cities. The truth is that the future well-being of humanity resides in cities. The issue therefore is not urban *per se*. It's a foregone conclusion that the world will live this way. The issue, instead, is what kind of cities – or, more precisely, what kind of urban constellations – will we live in?

With 36 million inhabitants, Tokyo is by far the world's largest 'megacity'. It is, in fact, almost twice as large as New York, Mexico City, Mumbai or São Paolo. Nevertheless Tokyo is also viewed as one of the world's most livable cities.

Urbanization is a well-studied phenomenon, thanks largely to the 300-year evolution of cities in the developed world, where the primary elements of development have moved from transportation, to industry, to commerce, and ultimately to finance and administration. We cannot expect cities in developing countries to replicate what happened in the developed countries. Indeed, as noted above, we don't want cities in developing countries to develop in this way.

The growth of cities in the developing world, in fact, presents two additional challenges. The first is that the pace and the dimensions of change is unprecedented. The second is that those who live in and those who manage cities in the developing world are largely unprepared for what is to come (and, more significantly, the speed at which it is coming), and thus do not have sufficient time to learn by doing. The urban infrastructure – water, sanitation, energy and transportation systems, health facilities and housing – in virtually all developing world cities is grossly inadequate for even the existing population. But the unprecedented rate of urbanization likely means that officials will not have sufficient time to garner either the experience or resources to manage the change. As a result, governance strategies will have to be developed that engage citizens in finding adequate solutions to the challenges that they face. Efforts to solve all problems through regulations will not be sufficient.

Moreover, national governments have historically associated poverty with rural areas. As a result, governments have funded few programmes to assist cities. The glaring truth is that too little attention in the South has been paid to strategies for guiding urban growth.

Public officials and researchers in developing countries have often underestimated and even denied the importance of urbanization for development. The prevailing attitude has been that urbanization is a 'second-

tier' problem that can await our attention until more pressing problems are resolved, including reductions in poverty, adequate access to safe drinking water and sanitation, and improved public health. There is even a notion that the problems of urbanization will dissipate as developing countries grow wealthier, inferring that urban problems are, in effect, problems of poverty.

This perception partly explains why policy interventions have rarely addressed the root causes of urban problems, and why, in some instances, the policies themselves are wrong-headed.

MEETING THE CHALLENGE

Yet, when it comes to cities, the news is not all bad. The challenges may be great but they are not unmanageable. One reason is that the preponderance of future urban growth will be taking place not in 'megacities', but in smaller, 'second-tier' cities with less than 1 million, or even 100,000, people. Moreover, even growth in these smaller cities is likely to be 'cellular' – that is, based on the development and eventual merger of distinct urban spaces of varying densities. The result will be the creation of urban continuums and not separate urban entities. As we can see in night-time photos of Earth from space, the earthly surface below is increasingly mirroring the universe of stars above, creating what can best be described as a series of 'urban constellations'.

Such a concept stands in stark contrast to the historic notion of a city having a center and clear limits or boundaries. Cities, in fact, should no longer be looked at as autonomous entities of, say, one, five or ten million people. Instead, they should be viewed as nodes within a network – places characterized by endless webs of interconnected populations, landscapes and activities. Put another way, instead of thinking in terms of urban *or* rural, we should think in terms of urban *and* rural.

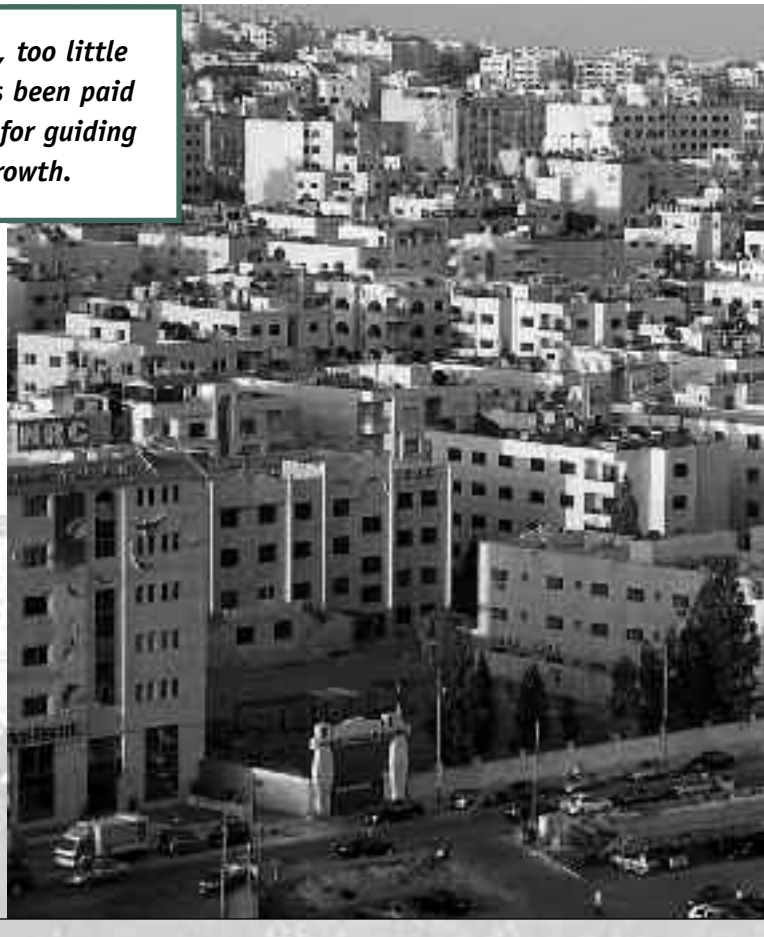
This new amalgamated landscape, marked by the emergence of large populated regions interacting with their hinterlands and beyond in ever-more complex and kaleidoscopic patterns, is our global future. The compelling issue is not how to reverse this trend (we cannot), but how to adapt to it in ways that lead to healthy, productive and rewarding lives for the largest number of people.

There are many difficult issues to consider. What impact will this urban growth have on the environment? How can we mitigate this impact and make urban spaces more sustainable? What, indeed, are the forces driving urban growth and change? How can these forces be directed and controlled? What can we do to curb the risks and vulnerabilities that societies, particularly poor societies, face in their rush to urbanize? And where will applications of science and technology prove essential?

COLLECTIVE ACTION

Less than 3% of the Earth's land mass is urbanized. Yet urban environments generate nearly 80% of the carbon emissions and, account for 60% of the water consumption. The aggregate ecological footprint of urban dwellers – on soil, air, water cycles and even climate – are hundreds of times larger than the actual size of the urban areas themselves. Yet, the impact per person is

In the South, too little attention has been paid to strategies for guiding urban growth.



While every place may be different, all cities share common concerns.

often much smaller than those of rural residents. And that's where hope for the future lies. The places with greatest densities of population – and therefore the greatest overall impact on resources and the environment – are also the places where the greatest efficiencies in resource use reside. And, we might add, they are the places where greatest human resources for addressing ecological issues also are found.

Indeed, appropriate forms of urbanization ensuring wise and sustainable land use patterns and efficient resource use and consumption may be the best chance we have to create a better future for current and future generations. The key challenge is how to optimize improvements in quality of life, especially in the quality of life for poor people, while reducing ecological footprints, especially the ecological footprints of wealthy people (who are the greatest consumers).

The world's cities – and especially cities in developing countries – not only face immediate economic, social and environmental challenges but also such long-term challenges on how to manage their growth in responsible and effective ways. Science and technology will be critical to this task in many different areas, ranging from ensuring clean air and improving existing transportation systems to devising effective mitigation and adaptation strategies for climate change and biodiversity loss.

Creating sustainable urban futures – which in the 21st century really means creating sustainable futures for everyone – represents one of the most pressing challenges for institutions such as TWAS and the United Nations University (UNU). Given the number of people affected, there may be no more important agenda to pursue in the years ahead.

From a research perspective, urbanization poses a multi-disciplinary challenge that calls on the collective expertise of ecologists, geographers and urban planners, as well as economists, sociologists, political scientists, lawyers, architects, engineers and scientists. It is, in short, a challenge for both the natural and social sciences.

Research topics abound. How can we mitigate the ecological impacts that will inevitably take place at the urban-rural interface where population growth will pose the greatest challenge to the natural environment? How can we optimize investments in infrastructure for both people and the environment? How can public health be improved? Education? Housing?

Access to safe drinking water, adequate food supplies at affordable prices, sanitation and housing will all remain critical issues, especially for urban residents in developing countries. So, too, will issues such as poverty reduction and climate change.

Science and technology will be critical to addressing all of these challenges. As a result, place-based research, comprehensive policy recommendations and options, and detailed description of best practices all must be developed, documented and distributed as part of a comprehensive research agenda that enables policy-makers to learn from – and apply – the experience of others.

While every place may be different, all cities share common concerns that allow us all to learn from one another. It may be the world's cities that have charted the best blueprint for progress. The great cities, after all, are the products of imagination, initiative, hard work and collective action. It is precisely these virtues that will be needed to drive a broad-based science-based research agenda capable of meeting the urban challenges that lie ahead. ■

WHERE SCIENCE MEETS TRADITION

AS PART OF A LARGER EFFORT TO PROMOTE THRIVING SCIENTIFIC INSTITUTIONS IN DEVELOPING COUNTRIES, TWAS, WITH SUPPORT FROM A NUMBER OF DONORS, HAS BEEN ENGAGED IN A DECADE-LONG INITIATIVE TO PROFILE SUCCESSFUL SCIENTIFIC CENTRES IN THE SOUTH. THE IDEA IS TO HELP POLICY-MAKERS AND ADMINISTRATORS AT RESEARCH CENTRES TO LEARN FROM THE EXPERIENCES OF OTHERS.

With a generous grant from the David and Lucille Packard Foundation, TWAS has recently conducted comprehensive profiles of five highly successful scientific institutions in the developing world. The following is a brief summary of the work of one of these centres of excellence: The Institute of Medicinal Plant Development (IMPLAD) in Beijing. The complete 55-page booklet can be obtained from the TWAS Secretariat at info@twas.org.

Some 4,600 years ago, Huang Di, known as the 'Yellow Emperor', wrote what is believed to be the earliest text describing Chinese medicine. In his 'Canon of Internal Medicine', the emperor introduced the concepts of yin and yang (or a body in balance) and the five elements (earth, fire, metal, water and wood), which remain at the core of traditional Chinese medicine (TCM) to this day.

Although such concepts may not stand up to modern scientific scrutiny, many TCMs and Chinese medicinal plants are being adopted by other medicinal philosophies, including modern allopathic medicine, as practiced in developed countries. Ginkgo biloba, which is used to improve blood flow and shows potential applications in the treatment of Alzheimer's disease, and ginseng, reputed to help the body cope with stress, are just two examples.

TCM continues to be an important component of the Chinese national health care system. One reason for this has been the support of the Chinese government, which, in 1957, established the Institute of Materia Medica, to study the resources, properties and preparations of TCMs.

In 1983, the Chinese government restructured a medicinal plant cultivation station at the Institute of



Materia Medica to create the Institute of Medicinal Plant Development (IMPLAD), established under the auspices of the Chinese Academy of Medical Sciences (CAMS) and the Peking Union Medical College (PUMC).

IMPLAD's remit is to help ensure the continued existence of the valuable heritage of TCM by applying the tools of modern science to ancient tradition. "The principal aims of the institute," explains Shi-lin Chen, IMPLAD's acting director, "are to protect, develop and utilize medicinal plant resources using modern scientific techniques."

In addition to its wide use in China, TCM has been steadily growing in appeal around the world. Its holistic approach to treatment provides people in many developed countries with an alternative to Western allopathic medicine.

This increasing demand for TCMs raises several issues. First, many medicines are collected from wild sources without any regulation. As a result, many populations of wild medicinal plants are under severe pressure and becoming endangered. Second, because the raw materials are often collected from a variety of sources, the active compounds within the medicines may vary in quantity, causing the medicines to vary in quality and effectiveness. Finally, there is a need to convince global markets of the effectiveness and safety of such traditional remedies using scientific principles.

VALIDATION AND SUSTAINABILITY

"In 1983, when IMPLAD was inaugurated, there was a staff of just 60 people," notes Chen. "We now have more than 600 staff, including 150 professors and associate professors, 120 postgraduate students and one member of the Chinese Academy of Engineering. Yet, we are still a very young institution, with more than 80 percent of our project investigators under 45 years old. These young scientists have a high level of education and are energetic researchers."

In the context of international calls for the conservation and sustainable use of natural resources, the Chinese government renewed its commitment to the institution in 1996, funding a major research programme aimed at the conservation of the country's wild medicinal plants.

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.

The growing global market for TCMs meant that many threatened species were under increasing pressure. It also meant that China's medicinal plants were an increasingly valuable economic resource, which, to be fully exploited, would require improved quality-control standards and scientific validation. The government's 2002 report 'Outline of Modernized Development of Chinese Medicine (2002–2010)' addressed both concerns, calling for continued development of the traditional medicine industry, while identifying as a 'key task' the sustainable use of herbal medicinal resources.

Traditional Chinese medicine represents a rich heritage dating back more than 4,000 years.

For the past decade, IMPLAD has benefited from the Chinese government's realization that the institute is ideally suited to handle both challenges: scientifically validating TCMs and improving quality control so as to exploit international markets. At the same time it works to ensure the conservation and sustainable use of the country's medicinal plant resources.

IMPLAD's research focuses on evaluating Chinese herbal products, medicinal plants and fungi, chiefly in the areas of neuropharmacy, immunology and cardiovascular health. TCMs for gastrointestinal, bacterial and inflammatory conditions, as well as cancer, are also tested. In addition, the institution is seeking to develop new methodologies and technologies for pharmacology and toxicology.

The institute's research typically begins with taxonomy: identifying a plant used in TCM to study. Next, chemistry comes into play, as researchers isolate, extract and identify any active components. Quality-control follows, in which herbal components are standardized and checks on other attributes, such as shelf life, are made. Finally, pharmacology and toxicology studies are carried out to determine standard formulae and dosages and to test for positive effects as well as any undesired side-effects.

ORGANIZATION

The headquarters of IMPLAD are located in the Zhongguancun Scientific and Technical Zone of Beijing, a 100-square-kilometre science park known as China's Silicon Valley. IMPLAD lies within an area of 65 hectares that houses the laboratories and administrative offices, an ornamental garden featuring many examples of plants used in TCM, production facilities for spin-off companies and fields for plant propagation and horticultural trials.

In addition, IMPLAD has established three branches in the subtropical zone of southern China, where climatic conditions allow a different range of medicinal plant species – some 3,000 in total – to be grown. These centres are located on the island of Hainan and in the provinces of Guangxi and Yunnan, both of which border Vietnam. Indeed, the medicinal plant garden at IMPLAD's Guangxi branch is the largest in Asia and among the largest in the world.

At the Beijing site, research is divided into five departments, focusing on the following scientific disciplines:

- Medicinal plant cultivation.
- Resources and conservation.
- Natural medicine chemistry.
- Pharmacology and toxicology.
- Biotechnology.

MEDICINAL PLANT CULTIVATION

Established in 2004, the Research Centre of Medicinal Plant Cultivation is the most recent addition to IMPLAD's focus areas. The department consists of three sections: cultivation technology, plant conservation and seeds. Its research focuses on:

- Identification and characterization of new species of medicinal plants.
- Standardization and quality control of seeds.
- Development of standardized cultivation techniques.
- Prevention and elimination of diseases and insect pests.

Every successful commercial crop begins with quality planting material, and a major IMPLAD programme is dedicated to the improvement of seed quality.

"Whereas most crops are available as well-characterized varieties," explains Xianen Li, head of the Research Centre of Medicinal Plant Cultivation, "medicinal plants are usually sown as heterogeneous mixtures by farmers using what they have saved from their previous crop." As well as increasing the risk of carrying over pests and diseases from the previous season, such mixtures often have poor agronomic qualities. For example, germination rates might be low and not all seeds will germinate at the same time. This leads to crops that do not mature evenly and a final product with variable quality.

To address these challenges, IMPLAD scientists have collected germplasm of many medicinal crops from farmers' fields and have begun to identify the best breeding lines in order to develop standard varieties.

"These varieties will have greater uniformity, improved properties in terms of their active medicinal ingredients, and higher yields," states Li. "One species that we are working on," says Jian-he Wei, a professor focusing on the breeding of medicinal plants, "is *Platycodon grandiflorum* (jie geng or balloon flower)." This species is used widely in Chinese medicine to treat lung and throat conditions by inhibiting coughs and reducing phlegm. "We are trying to breed new varieties by developing hybrids through cross-fertilization."

Allied to the use of molecular markers for breeding purposes and chromatography methods to identify and measure the concentrations of active ingredients, such research can also help to distinguish between factors that are genetically determined and qualities of the plant that are affected more by environmental conditions.

"Once we have obtained seeds of a standard variety, it is also important that we can guarantee how those seeds will grow," says Li. IMPLAD is therefore developing a quality profile for each variety that includes the germination rate, thousand grain weight (a measure of how much stored 'energy' is contained in a batch of seeds), varietal purity, and cleanliness (*i.e.*, the absence of soil debris, weed seeds or other potential contaminants).

"Our aim is to produce seeds of guaranteed quality for a number of medicinal plants for distribution to farmers throughout China," states Li.

RESOURCES AND CONSERVATION

The Research Centre of Resources and Conservation has been designated a 'National Key Laboratory', meaning that its facilities and expertise are among the best in the country.

As well as being responsible for the maintenance of the 3,000 species of living plants distributed between



IMPLAD's headquarters in Beijing and the three branches in southern China, the department also oversees IMPLAD's collection of preserved plants, animals and minerals with medicinal properties.

"The herbarium collection is 40 years old and is derived from the collection of the original Institute of Materia Medica," says Baoli Li, the curator of the museum. "At IMPLAD, we have some 90,000 samples of more than 7,000 plant species." These specimens are preserved between sheets of paper in a specially designed room to prevent them from becoming damp and deteriorating. In many cases, species in the collection are represented by more than one specimen as they have been collected from different regions of the country and therefore their medicinal properties may differ, Baoli explains.

Also under Baoli's stewardship are some 13,000 dried or pickled samples of plants – mostly preserved in antique-looking jars – as well as animals and minerals. "Nearly everything in the Chinese pharmacopoeia is present in this collection," continues Baoli, "including the 500 or so medicines in common use in China today."

As a National Key Laboratory, the Research Centre and its herbarium and other collections are an invaluable resource, not only for the institute's own scientists, but also for researchers from across China and elsewhere who wish to compare specimens that they are working on with well-characterized specimens in this unique reference collection.

One of the main contributions of the department is its survey of the country's medicinal plants. Its researchers use modern techniques including remote sensing, geographical information systems (GIS) and global positioning systems (GPS) to investigate the natural distribution of medicinal plants. The centre also runs the National Medicinal Plant Gene Bank, for which they have collected more than 20,000 viable seeds specimens.

NATURAL MEDICINE CHEMISTRY

What may be called the 'drug development pipeline' begins in the Research Centre of Natural Medicine Chemistry, which consists of four sections: phytochemistry, natural products chemistry, analytical chemistry and pharmaceutics. Headed by Jian-min Chen, the department employs 10 professors, 10 associate professors and 13 support staff.

There is a need to convince global markets of the effectiveness and safety of traditional remedies.

"Our aim is to isolate and identify active compounds from natural products," says Chen. "Chinese traditional medicine has also combined different plants into compound formulae, so we are also interested in identifying the effective fractions from these mixtures and developing compound-formula medicines ourselves."

Whereas allopathic medicine targets specific receptors, TCM is aimed at bringing the whole body into balance. "Preliminary studies suggest that, although the mode of action of TCMs differs from Western medicines," says Chen, "they do work. We are



now trying to find specific evidence for this 'balance' within the body."

To date, thousands of chemical entities have been isolated from natural products, and many have been subjected to pharmacological screening. "From these, we have identified some interesting lead compounds," adds Chen. "We hope to develop some of these into actual medicines."

IMPLAD scientists, for example, have identified a new chemical entity in celery (*Apium graveolens*) for treating strokes that has been approved by the SFDA (the Chinese national drug agency, the standards of which are adapted from the European Union and US Food and Drug Administration models). An active compound isolated from *Pueraria lobata* (also known as kudzu) shows promise in the treatment of blood circulation problems.

Traditional Chinese medicine has been steadily growing in appeal around the world.

The department's researchers have also been given responsibility for establishing quality control systems for TCM. "Because the composition of the key botanical ingredients can vary significantly between batches," says Chen, "it is difficult to control the quality, efficacy and safety of many TCMs."

The final task of the centre is drug formulation and delivery. Rather than relying on traditional methods, IMPLAD scientists are investigating modern drug delivery systems such as the inhalation of aerosols or the ingestion of slow-release capsules to improve the efficacy of the active compound.

PHARMACOLOGY AND TOXICOLOGY

The Research Centre for Pharmacology and Toxicology consists of four sections: pharmacology, molecular pharmacology, pharmacokinetics and toxicology.

"Our department uses both *in vitro* and in *vivo* techniques in pharmacological and pharmakinetic research," says department director Xin-min Liu. "We are responsible for evaluating the safety of natural products and TCMs, and especially their effects on neurology and psychiatry, as well as the digestive, endocrine and immune systems, and the blood vessels that serve the brain."

"In the past decade," Liu says, "in collaboration with the Chinese Cosmonaut Training Centre, we have developed important computer-aided control and image-analysing systems for pharmacological research." Such systems as the water maze allow researchers to observe the behaviour of laboratory animals under the influence of various drugs. Using these analysis tools, says Liu, researchers can "combine the advantages of bio-informatics, pharmacology, molecular biology and electro-engineering, with the specialized knowledge of traditional Chinese medicine."

"To date, we have screened over 50 Chinese herbs for their efficacy in treating cognitive deficiencies, depression and insomnia, cardiovascular complaints, hypertension and stroke, as well as for anti-cancer properties (against ovarian and cervical cancer and leukaemia)," adds Liu.

As one of the principle experts responsible for drafting and designing national policy on the modernization and internationalization of TCM for the Chinese Ministry of Science and Technology, Liu says, "The scientists in the department could also become a bridge between Chinese government agencies and foreign scientists in international cooperation efforts in TCM research. Currently, we actively cooperate with Canada, Luxembourg, Pakistan, Peru and the UK, especially on the pharmacology of nerve cells and anticancer agents, which receive strong support from the government."

BIOTECHNOLOGY

The Research Centre of Biotechnology consists of four sections: molecular biotechnology, fermentation biotechnology, mycorrhizal biology and molecular ecology. Its 12-member staff, currently headed by Shun-xing Guo, focus their research on: molecular biotechnology of medicinal plants; fermentation biotechnology of medicinal microorganisms; and tissue culture and cytobiology of medicinal plants.

The department's laboratories are packed with sophisticated equipment. For example, its electron microscopy suite can carry out histochemistry research (which combines biochemistry and histology techniques to study the chemical constitution of cells and tissues), with an automatic microtome for making sequential sections of tissue preparations, a fluorescence microscope and a transmission electron microscope. The molecular laboratories contain equipment for doing polymerase chain reaction (PCR) amplification of target DNA sequences and electrophoresis to help separate and identify them, a centrifuge and an ultra-low-temperature freezer. The biochemistry laboratory is equipped with a UV-visible spectrophotometer and high-performance liquid chromatography (HPLC) apparatus. A high-pressure steam sterilizer, fermenter, freeze drying equipment and various incubators are also available.

To date, the department has collected and carried out research on several thousand samples of medicinal fungi.

GLOBAL COLLABORATION

One measure of IMPLAD's increasing impact in the world of medicinal plant research is its active involvement in international academic exchange and cooperation with more than 50 countries. To date, it has sent

more than 30 researchers abroad – for example, to France, Germany, Japan, North Korea, South Korea, the United Kingdom (UK) and the USA – for training, study and collaborative research. In addition, IMPLAD researchers have participated in nearly 100 international conferences and academic exchanges.

IMPLAD has also collaborated with a number of prestigious institutions, including Harvard University (USA), the University of British Columbia Brain Research Centre (Canada), Hong Kong Baptist University (China), Karachi University (Pakistan), Cayetano Heredia University (Peru) and the Institute of Materia Medica (Vietnam). Among its more active collaborations are those with the Royal Botanic Gardens, Kew (UK) and the World Health Organization (WHO).

IMPLAD was designated a WHO Collaborating Centre for Traditional Medicine in 1986. In this capacity, its goals include:

- Developing training programmes within the framework of IMPLAD projects for developing countries.
- Undertaking the exchange of personnel between China and other countries to facilitate mutual progress in relevant areas of science and technology.
- Pursuing cooperative research projects in which IMPLAD participates as a partner.

As the WHO Collaborating Centre in China, IMPLAD has welcomed more than 300 overseas delegations, involving more than 1,000 scientists, to participate in academic exchange. It has also hosted the training of 20 foreign scientists from such countries as Canada, India, Japan, Nepal, North Korea, Peru, South Korea, the UK and Vietnam.

LOOKING AHEAD

Despite its progress over the past 10 years, IMPLAD is not content to rest on its laurels. In fact, the institute has set out an ambitious plan for its future development that includes:

- Establishing a demonstration centre for the cultivation of medicinal plants;
- Creating a test centre for so-called 'green crude drugs' (cultivated without the use of chemical pesticides) to promote the standardization of TCM and medicinal raw materials;
- Continuing research in new cultivation techniques so that wild plants do not need to be harvested;
- Advancing research in medicinal plant germplasm resources and the breeding of improved varieties.



To achieve these aims, IMPLAD is actively seeking research partners in other developing countries. The institute's researchers believe that, with their experience in preparing traditional medicines for the modern market, they can help other developing countries develop their own traditional medicines to scientific standards.

Xin-guo Zhang, IMPLAD's head of foreign affairs, explains that "many developing countries rely on traditional medicines. Just as the Chinese government has invested heavily in the research, development and promotion of TCM, so there is great potential for economic benefits for developing countries if they were to follow the same policy." To utilize such biological resources effectively, however, requires investment in scientific research so that the quality and efficacy of the medicines developed can be assured.

IMPLAD's research focuses on evaluating Chinese herbal products, medicinal plants and fungi.

A VALUABLE HERITAGE

Traditional Chinese medicine represents a rich heritage dating back more than 4,000 years. As a government-supported institution, IMPLAD is, in effect, the official guardian of this invaluable cultural inheritance. This means that, in addition to government support, it benefits from its access to enviable resources. These include its herbarium, which, with its 90,000 samples, contains nearly everything in the traditional Chinese pharmacopoeia. It also includes the extensive knowledge and expertise of individuals such as IMPLAD's honorary director, Pei-gen Xiao.

At the same time, IMPLAD is a young, dynamic institution with a research staff well trained in the most advanced techniques. Indeed, this combination of hoary tradition with modern science is what defines the institution and sets it apart from many other research centres in the developing world.

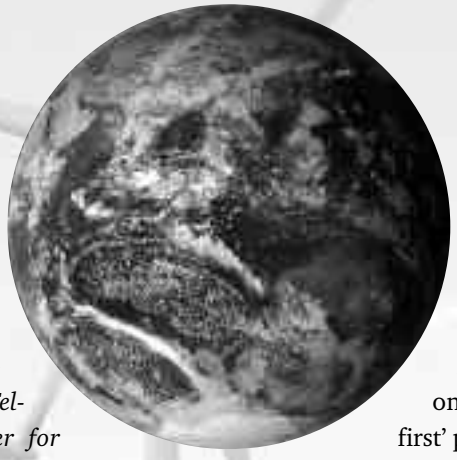
The institute's three branches in southern China extend the range of biodiversity available for its researchers to study. Also, IMPLAD benefits from its international connections, for example with WHO and Kew Gardens.

"IMPLAD is a national institution, whose principle task is undertaking basic research for national research projects," explains Zhang. Although it has great strengths in researching medicinal plants, continues Zhang, IMPLAD "has yet to realize its advantages in the area of innovation and intellectual property development. The challenge it faces is how to couple research with the development of new commercial applications."

The growing global market for TCMs means that they represent a potentially valuable economic resource for China. Thanks to many years of government support, the major restructuring of the institution in 1983, and a young and committed workforce, IMPLAD is well placed to play a key role in scientifically validating, standardizing, and ensuring quality control of TCMs. By doing so, it will not only help build China's export market for herbal remedies – while maintaining and, hopefully, improving the health of the Chinese people – but also help to ensure the continued survival of this ancient heritage. ■

NEW SOURCE OF POWER

BENEATH THE SAND OF THE OIL-RICH ARAB COUNTRIES OF IRAQ, KUWAIT, BAHRAIN, QATAR, SAUDI ARABIA, THE UNITED ARAB EMIRATES AND OMAN LIE AN ESTIMATED 725 BILLION BARRELS OF PETROLEUM. THAT'S ROUGHLY 50% OF THE WORLD'S PROVEN RESERVES.



But oil is not the only energy resource in these countries. The region is also richly endowed with sun and wind. It may sound implausible, but long-range energy policies could transform this region into a global centre of renewable energy. Farouk El-Baz (TWAS Fellow 1985), director of the Center for Remote Sensing and research professor in the Department of Electrical and Computer Engineering at Boston University, USA, explains how visionary leaders in the region have taken the first steps to turn this dream into reality.

In 2009, following a worldwide competition that included bids from Austria, Germany and Denmark, the UN selected the United Arab Emirates (UAE) to host the International Renewable Energy Agency (IRENA).

How could a small country on the eastern coast of the Arabian Peninsula, a federation of seven emirates with a total population of just 6 million, be chosen from a field of nations such as Germany, which has invested billions on wind energy, or Denmark, which has earned global recognition for dramatically reducing its dependence on fossil fuels through smart 'people-first' planning and steady support for public transportation?

The answer, in part, lies in the foresight and persistence of UAE's founder, Sheikh Zayed Bin Sultan Al Nahyan, who was determined to set his country on a rapid path of environmentally sound economic development.

I first met with Sheikh Zayed in 1974, just two years after he founded the UAE, when I was invited to speak about the scientific results of the US Apollo missions to the Moon. At the time of Apollo, I worked for Bellcomm, Inc., a subsidiary of AT&T that assisted the US National Aeronautics and Space Administration's (NASA)

Manned Space Flight Systems Office. My job was to aid the planning of the scientific exploration of the Moon. Among my responsibilities were the selection of the lunar landing sites and the training of Apollo astronauts in lunar orbital observations and photography.

At that meeting, Sheikh Zayad thoughtfully said: "I hope that you will apply what you learned from Apollo to study the Earth and to protect its environment."

Although he died in 2004, his legacy continues to drive his sons and his people to beautify the natural environment and protect and preserve nature for future generations. UAE's successful bid to host IRENA is a reflection of the country's dedication to the broad principles of sustainable development and testimony to its far-sighted policies.

The UN has selected the United Arab Emirates to host the International Renewable Energy Agency.

To date, 143 countries and the European Union (EU) have signed IRENA's statutes. IRENA's interim offices are in Abu Dhabi. UAE has agreed to provide USD22 million in annual support to IRENA through 2015. In addition, the Abu Dhabi Fund for Development has offered USD50 million in annual loans to finance renewable energy projects in developing countries that IRENA will initiate and jointly manage. That amounts to a financial commitment of USD250 million over the next five years.

Hélène Pelose, a French citizen born in Montreal, Canada, has been elected the first director-general of IRENA. At the agency's inaugural ceremony, which took place in this past January, Pelose acknowledged the paradox of having a "green organization" in an oil producing country. But she added that having the agency's secretariat located in a developing country would likely prove even more significant to worldwide efforts to promote renewable energy. She bluntly told the audience that: "It is common knowledge that there will be an end to oil. It is an outcome that cannot be avoided." The future of energy, in short, will lie in renewables.

IRENA's permanent offices will be strategically located in the center of Masdar, home to Abu Dhabi's clean technology cluster currently under development on the outskirts of the UAE capital. Sultan Ahmed Al Jaber chief executive officer of the Abu Dhabi Future

Energy Company, which is establishing Masdar in hopes of creating a model "green" city in the desert sands. If all goes according to plan, Masdar, which in Arabic means "source", will integrate the entire renewable and clean technology lifecycle – from research to commercial use – with the aim of creating clean energy solutions on a large scale. Masdar hopes to illustrate that protecting the environment can be done without inhibiting development.

That this effort is being led by Abu Dhabi's leaders indicates that the region's executives are not closing their eyes to the future but seeking solutions to the energy challenges that will dramatically reshape the post-oil world.

There will be an end to oil. The future of energy will lie in renewables.

ENERGY FUTURES

During the past two years, Abu Dhabi has organized the World Future Energy Summit in January. The summit, held under the auspices of Sheikh Mohamed Bin Zayed Al Nahyan, Crown Prince of Abu Dhabi, has become a significant event for energy experts worldwide. In 2010, it drew some 3,000 participants, including public officials, corporate executives, representatives of grassroots organizations and researchers. Among the high-level dignitaries participating in the event were Olafur Grimsson, president of Iceland; Karolos Papaulin, president of Greece; Mohamed Nasheed, president of the Maldives; Recep Erdogan, prime minister of Turkey; Dato Sri Abdul-Razak, prime minister of Malaysia; Felipe de Barbon y Grecia, Crown Prince of Spain; and Frederick Christian, Crown Prince of Denmark. More than 20,000 visitors also came to see the exhibits.

In his opening address, Sultan Al-Jaber expressed the need for international cooperation in the growing field of renewables, noting that "by working together, we can push the field into a new frontier of discovery." More specifically, he urged greater collaboration between the public and private sectors. In particular, he observed that the private sector "must champion the transfer of technology to drive real change."

The summit included six plenary forums that covered such topics as the future of energy research and development, sustainable buildings, and carbon cap-

EXHIBITING THE FUTURE

Exhibits at the World Energy Summit in the UAE from 17 to 20 January focused on renewable energy and included a number of displays by solar energy companies and research centres. Many exhibits explored innovative research efforts that have led, for example, to the production of thin-sheet solar energy collectors that can be rolled out as if they were wallpaper. The sheets not only reduce the cost of producing, transporting and installing solar panels, but can be manufactured in various tints to appeal to different tastes, and are easily laid on roofs or sides of buildings. All of this comes at just a 10% drop in energy efficiency compared to conventional solar panels. Future research promises to reduce this efficiency gap even more.

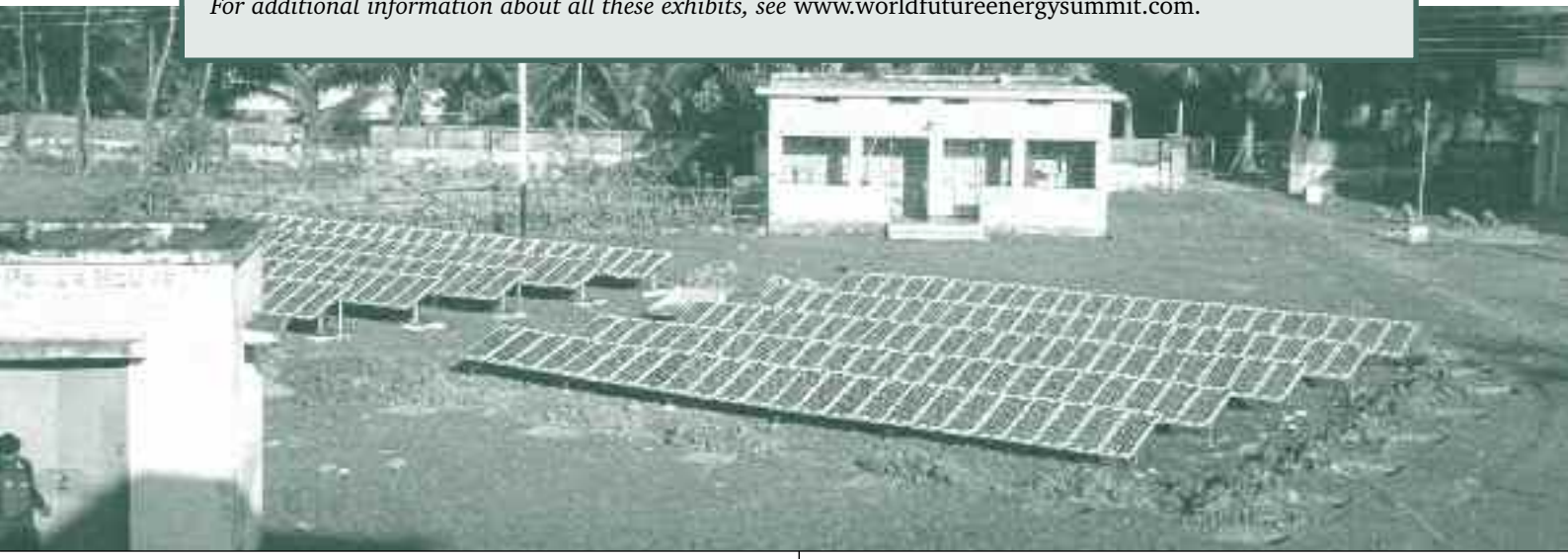
An unusual application of lightweight solar energy collectors introduced a concept for a model plane that could be powered by solar energy. The solar collectors, placed on the plane's exceptionally long wings, would supply energy to run the engines during the day and also create sufficient energy for battery storage that could power night flights. Such an invention could change the world of flight.

New directions for wind energy were also on display. Emphasis was placed on modelling techniques to allow the capture of more wind. Three years ago, the UAE initiated a wind energy programme to supply electricity to one of its islands. The project had mixed results. At a height of 10 metres, the windmills proved unable to generate sufficient supplies of energy on a continual basis to be commercially viable. Thus, more modelling of wind direction and speed is required. The exhibits focused on work currently being done in this area.

Not surprisingly, oil companies also had a presence at the exhibits, mostly focusing on the prospects for CO_2 sequestration. The process basically requires (1) removing CO_2 from the exhaust of fossil-fuel burning water desalination or electricity generating plants; (2) separating the CO_2 and reducing its volume for transport in pipelines; and then (3) injecting the CO_2 underground, preferably into oil-producing, geologic formations. The latter can be depleted oil or gas reservoir rocks, where CO_2 injection might increase oil production by increasing pressure on the remaining, hard-to-extract reserves.

Oil companies are also examining the potential of biofuels. Exxon-Mobil, for example, sponsored an exhibit on biofuels derived from algae that can be grown on land or in water. Because the algae consume CO_2 during the process, it could help reduce greenhouse gas emissions. In addition, production of algae-derived biofuels would not compete with agricultural commodities and thus have no impact on food supplies and prices. According to researchers, algae-derived biofuels could yield 2,000 gallons of fuel per acre per year compared to 650 gallons for palm, 450 for sugar cane, 250 for corn, and 50 for soy. If this process can be made commercially viable, it could play a significant role in the global energy future.

For additional information about all these exhibits, see www.worldfutureenergysummit.com.



ture and storage. In addition, there were six roundtable discussions on topics ranging from a sustainable knowledge economy to the way forward on international climate change policy. Overall, the event included 60 public presentations as well as a public exhibition highlighting what could be done to curb the environmental impacts of energy use.

MASDAR INSTITUTE

The city of Masdar will rely on new technologies to provide all of its services. This effort, of course, requires a great deal of planning, research and development. It should therefore be no surprise that the Masdar Institute of Science and Technology (MIST) was one of the first institutions created in the city. It was set up with the help of the Massachusetts Institute of Technology (MIT).

MIST is dedicated to graduate training and research in alternative energy, environmental technologies and sustainability. The inaugural academic semester in September 2009 included 88 students from 22 nations. Students from the UAE represented the highest percentage of participants. The faculty, which totalled more than 20, hailed from 12 countries.

MISR offers master's degrees in engineering systems and management, information technology, mate-

ZAYED ENERGY PRIZES

The Zayed Future Energy Prizes were announced on the evening of the second day of the World Future Energy Summit. This annual award, launched in 2008 and funded by the government of Dubai through the Mubadala Development Company, celebrates achievements in innovation, long-term vision and leadership in efforts to promote renewable energy and sustainability. The 2010 award ceremony took place in Emirates Palace and was hosted by Hala Gorani of CNN. The jury was headed by Rajendra Kumar Pachuri, chair of the Intergovernmental Panel on Climate Change (IPCC) and included Susan Hockfield, president of MIT, and Hélène Pelose, director-general of IRENA. The winners were:

Winner: USD1.5 million to the Toyota Motor Corporation. Toyota was honoured for the development of the groundbreaking fuel efficiency system of the Prius, the world's first mass-produced hybrid vehicle. Kazuo Okamoto, vice chair of Toyota Motor Corporation, accepted the prize.

Finalist: USD350,000 to Syntech Power Holdings Company, China, the world's largest manufacturer of silicon solar modules. Zhengreng Shi, founder and CEO of the company, accepted the award.

Finalist: USD350,000 to International Development Enterprises, India. The company supplies low-cost irrigation systems to farmers in India, which have saved 500 million litres of diesel fuel and reduced CO_2 emissions by 1.8 million tones over the past two decades.

For additional information, see www.zayedfutureenergyprize.com.

rials science and engineering, mechanical engineering, and water and environmental engineering. Future plans envision degree-granting programmes in electrical power engineering and microsystems. A PhD programme will be launched later this year.

Strict admissions requirements led institute officials to fear that local university graduates would not fare well in the admissions process. To avoid this, MIST developed a pre-master's programme to prepare local students for the graduate record examinations (GRE) and Test of English as a Foreign Language (TOEFL), which play such an important role in determining a student's academic standing and thus prospects for acceptance. The programme also organizes courses to help students improve their critical thinking and research and communication skills. Preparatory courses in the institute's main fields of inquiry are also offered.

Could we be at the cusp of a new era?

POWER SHIFTS?

I have devoted a good portion of my career to issues related to scientific capacity building in the Arab region, where I was born and to which I have often returned. The events that have transpired in the region over the past few years, most notably the hosting of IRENA and the launch of the "green city" of Masdar give me great hope that we are entering a new phase of development in the region – a time when science and technology will be at the centre of the region's policies for sustainable growth. Other measures bolster this hope. For example, the launching of King Abdullah University of Science and Technology (KAUST) in Saudi Arabia and private universities and research parks, particularly in Qatar and Oman.

Could we be at the cusp of a new era? Are we witnessing the beginning of a new phase of science-based development in the region, and could this transformation be a sign of a larger shift in the balance of science and power from the West to the East?

What has taken place thus far represents small steps, especially when compared to the scope of the shift I am hinting at. Nevertheless, these steps could be part of a fundamental transformation of global science – and the wealth that it brings. Only time will tell. ■

CERTIFICATE OF APPRECIATION

• **Surender Singh** (TWAS-UNESCO Associate 2008–2011) was awarded a Certificate of Appreciation by the Association of Agrometeorologists for his research on "Emerging Challenges for Chickpea Production System Under Current Ecological Changes." The certificate was given at the National Seminar on Agrometeorology: Needs, Approaches and Linkages for Rural Development" in Hisar, India. Singh obtained his MSc and PhD in agrometeorology at Haryana Agril University (HAU). Singh previously received the Dr VD Kashyap Gold Medal for Best Young Researcher in 2001–2002. He is now a scientist and associate professor of agrometeorology at HAU.

Surender Singh

VANNEVAR BUSH AWARD

• **Bruce Alberts** (TWAS Associate Fellow 2001) has received the 2010 Vannevar Bush Award from the US National Science Board for his lifetime of service to science and technology in the USA. Alberts, professor emeritus in the Department of Biochemistry and Biophysics at the University of California, San Francisco, has served as president of the US National Academy of Sciences. He is now the editor-in-chief of *Science* and co-chair of the InterAcademy Council (IAC). His previous honours include the Eli Lilly Award

Bruce Alberts

of the American Chemistry Society, the Baxter Award of the Association of American Medical Colleges and the Gairdner Foundation International Award.

GERMAN ACADEMY OF SCIENCES

• **Jacob Palis** (TWAS President and TWAS Fellow 1991) was elected a member of the German Academy of Sciences Leopoldina in April. Palis is professor at the *Instituto Nacional de Matemática Pura e Aplicada* in Rio de Janeiro, and president of the Brazilian Academy of Sciences. He has served in various capacities at the International Mathematical Union, the International Council for Science, the ICTP Scientific Council, ETH-Zürich, and, currently, *Collège de France*. His previous awards include the Brazilian National Prize for Science & Technology, the Interamerican Prize for Science and the International Tartufari Prize in

Jacob Palis

Mathematics, *Accademia Nazionale dei Lincei*, Rome.

GOYAL PRIZE AND DSC

• **Swaminathan Sivaram** (TWAS Fellow 2000) has been awarded the Goyal Prize by Kurukshetra University, India, for his contributions to applied sciences. He has also been given a honorary doctorate of

Swaminathan Sivaram

science by Purdue University in Indiana, USA. He is director of the National Chemistry Laboratory in Pune, India. He is one of India's leading researchers in polymer chemistry, especially in the areas of controlled synthesis of polymers, transition metal catalyzed polymerization of olefins, and new chemistry and catalysts for high performance condensation polymers. Sivaram has previously been awarded the Distinguished Alumnus Award of the Indian Institute of Technology (IIT), Kanpur, and Padma Shri, Government of India.

NATIONAL ACADEMIES

• **Farouk El-Baz** (TWAS Fellow 1985) was appointed chair of the steering committee of the 2010 US National Academies Keck *Futures Initiative* (NAKFI) on imaging science. Launched in 2003 by the US National Academies and the W.M. Keck Foundation, the Futures Initiative is

a 15-year effort to stimulate interdisciplinary inquiry and to enhance communication among researchers, funding agencies, universities and the public. The topic of the 2010 initiative is imaging science in its various applications, including biomedical and environmental monitoring. El-Baz is director of the Center for Remote Sensing and research pro-

Farouk El-Baz

fessor in the Department of Electrical and Computer Engineering of Boston University, Boston, USA, as well as adjunct professor at Ain Shams University in Cairo, Egypt.

2010 ICTP PRIZE

• **Shiraz Minwalla** (TWAS Affiliate 2008–2012) was awarded the 2010 ICTP Prize given in honour of Nicola Cabibbo, the renowned theoretical high energy physicist. Minwalla was recognised for his outstanding contributions in the field of string theory and gauge/gravity duality. His most recent work has included obtaining equations of nonlinear fluid dynamics in 3+1 dimensions from Einstein's equation for black-branes in 5-dimensional anti-de-Sitter space as well as a study of weak field black hole formation in asymtotically anti-de-Sitter spacetimes and its relation to the thermalization process in the dual conformal field theory. Minwalla was awarded the

Shiraz Minwalla

President's Gold Medal when he graduated from the Indian Institute of Technology Kanpur in 1995 and earned his PhD at Princeton University. He served as assistant professor at Harvard and is now a faculty member in the Department of Theoretical Physics at the Tata Institute of Fundamental Research in Mumbai, India.

IN MEMORIAM

• **Mohammad Innas Ali** (TWAS Fellow 1989) died at his home in Bangladesh on 3 May. He was 96. He held many positions, including professor and head of the Department of Physics at Dhaka University (1948–1963). He also led two Pakistan delegations to the UN Conference on Peaceful Uses of Atomic Energy in Geneva and three Bangladesh delegations to the International Atomic Energy Agency (IAEA) General Conferences. He

Mohammad Innas Ali

was a member of the Expert Committee of the Organisation of Islamic Conference (OIC) that led to the founding of the Islamic Foundation for Science, Technology and Development (IFSTAD) and president of the Bangladesh Academy of Sciences from 1988–1992. In recognition of his work, he was given the Bangladesh Independence Day National Award for Science and Technology, named a National Professor and granted the Lifetime Achievement Award in S&T from the Bangladesh Academy of Sciences.

Arturo Falaschi

• **Arturo Falaschi** (TWAS Associate Fellow 1996) passed away at his home in Tuscany, Italy, on 1 June at the age of 77. Falaschi, who obtained his MD from the Faculty of Medicine at the University of Milan, was the first director-general of the International Centre for Genetic Engineering and Biotechnology (ICGEB) in Trieste, Italy. For several years, he also served as director of research of Italy's national research council CNR. He was ICGEB distinguished scientist and professor of molecular biology at *Scuola Normale Superiore* in Pisa. For his accomplishments, he received the Gold Medal from the Italian Minister for University and Research and the Tesla Medal from the Government of Serbia and Montenegro.

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.

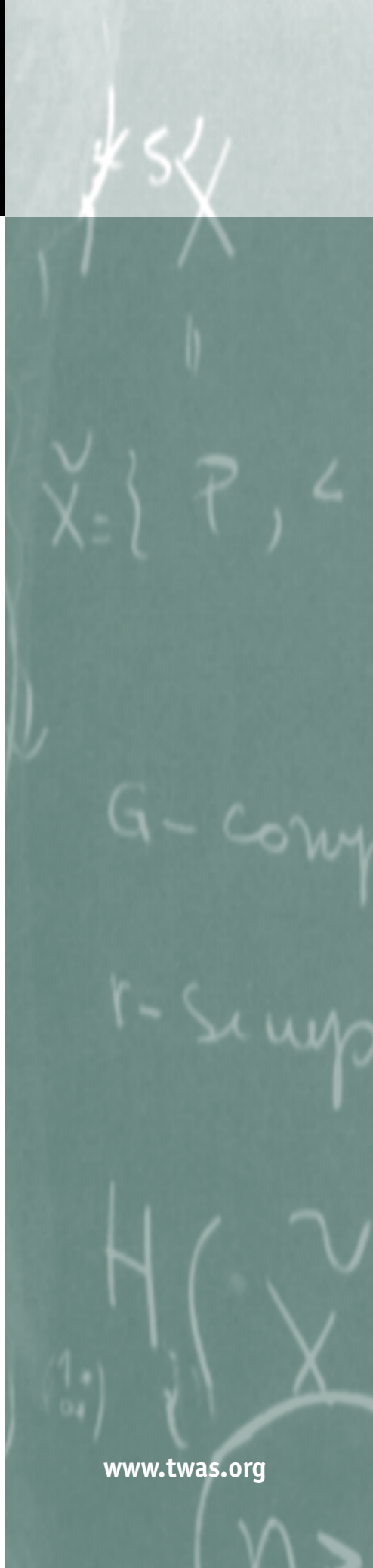
In 1988, TWAS facilitated the establishment of the Third World Network of Scientific Organizations (TWNSO), a non-governmental alliance of some 150 scientific organizations in the South. In September 2006, the foreign ministers of the Group of 77 and China endorsed the transformation of TWNSO into the 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