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TWAS newsletter

THE NEWSLETTER OF THE THIRD WORLD ACADEMY OF SCIENCES

Focus on sub-Saharan Africa

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THIS SPECIAL ISSUE OF THE *TWAS NEWSLETTER*, PREPARED IN COOPERATION WITH THE AFRICAN ACADEMY OF SCIENCES (AAS), EXAMINES THE STATE OF SCIENCE AND TECHNOLOGY (S&T) IN SUB-SAHARAN AFRICA. IN MANY WAYS, IT REFLECTS THE CHANGING NATURE OF S&T IN THE DEVELOPING WORLD AND THE CHALLENGES THAT TWAS ITSELF FACES IN LIGHT OF THESE CHANGES.

Why Sub-Saharan Africa?

Why sub-Saharan Africa?

The stakes could not be higher. While scientists tend to think that the best places to examine science are places where the best science is taking place, sub-Saharan Africa provides a textbook case of the consequences of the absence of science within a society. Clearly, trends in economic and social development, public health and environmental quality spell disaster not just for sub-Saharan Africa but for the rest of the world. There is, in fact, no better place to examine the relationship of science to society than in a place where the relationship has been strained and, in fact, made distant.

There is also an ethical dimension to these issues. Those who enjoy the material comforts that have been made possible largely through the discovery and application of science and technology have a moral obligation to assist those who continue to be burdened by the absence of S&T. As TWAS's founding president Abdus Salam noted more than three decades ago, "science is the common heritage of all mankind."

There is, however, an element of self-interest as well. Simply put, in an age of terror, the world ignores the problems of poverty and hopelessness at its own peril. S&T, by offering endless opportunities to promote dialogue among nations, are among the best tools for combating the conditions that breed despair and anger.

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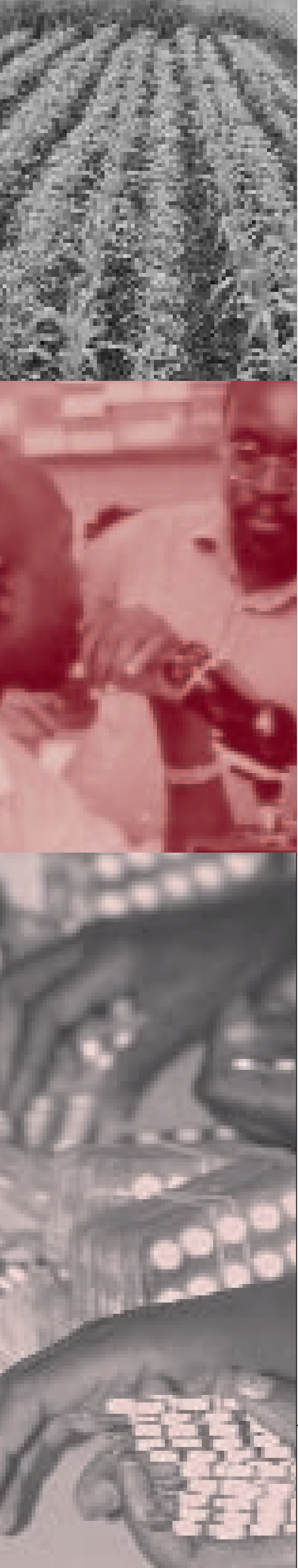

Examples of the central role played by science and technology in economic development in the South abound. It is not surprising – especially to the membership of TWAS – that nations which have recently made impressive gains in improving the living conditions of their citizens (Brazil, China, India and, earlier, South Korea, to name several noteworthy examples) are also nations that have invested more in science and technology.

These nations offer valuable lessons to other developing countries, especially those in sub-Saharan Africa, which struggle with the daunting task of addressing immediate social and economic needs while seeking to invest in long-term policies and programmes aimed at sustained growth.

Why TWAS?

The Academy's mandate, from its beginnings in the early 1980s to the present, has focused on promoting excellence in S&T in the developing world. When TWAS was launched in 1983, S&T throughout the South was in a dismal state. Today, the situation is much different – and, in many ways, much improved. As mentioned above, a number of nations in the developing world – and I am delighted to report that this number is rising – are embracing S&T as a crucial means of fostering sustained economic growth. Yet other developing countries have been left behind, most notably those in sub-Saharan Africa, where 34 of the world's 50 least developed countries (LDCs) are located.

TWAS's success over the years has been due not only to its ability to push its mandate forward but also its ability to adapt and redirect its programmes in the face of changing circumstances. One of the most important challenges faced by TWAS – challenges that have shifted to the forefront of its agenda in the past five years or so – is how to reformulate the Academy's initiatives from a broad-based assault on the dismal state of science throughout the South to a more targeted approach that seeks to boost science in places where it has yet to take hold, and to do this without compromising the Academy's commitment to scientific excellence.

We see this reformulation taking place in TWAS's efforts to identify excellent scientists in countries that are not well represented in the Academy's membership. Only 10 percent of TWAS's membership comes from LDCs while more than 33 percent of the membership hail from Brazil, China and India. Meanwhile, just 8 percent of the membership comes from sub-Saharan Africa. For this reason, we have called on our membership to identify and nominate qualified scientists from countries that are under-represented or are not included at all. The Academy plans to pursue this strategy vigorously in the years ahead. In fact, TWAS's most recent strategic plan (2004-2008) calls for nearly doubling the number of scientists from LDCs over the next four years.

We also see this reformulation in the launch of TWAS's special research grants programme for scientific institutions in LDCs (see pages 34-39). The programme, which provides up to US$30,000 a year for three years to scientific institutions in LDCs that have done excellent work under trying conditions, began in 2002. More than 90 applications were received and six were funded, including five from sub-Saharan Africa. We believe that the programme offers an opportunity to transform these institutions into regional centres of scientific excellence that can ultimately make significant impacts on scientific capacity building and science-based development.

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And we see this reformulation in the role that TWAS plays in the work of other institutions that operate under its administrative umbrella, including the Third World Network of Scientific Organizations (TWNSO), the Third World Organization for Women in Science (TWOWS) and the InterAcademy Panel on International Issues (IAP).

The efforts of these organizations reflect, in their own way, the Academy's commitment to the advancement of science through a strategy that seeks to avoid the creation of a developing world that is divided into scientific 'haves' and 'have-nots'. A sampling of these efforts include:

- *TWNSO's programme to promote networking among scientific institutions that are addressing such critical issues as access to safe drinking water, the conservation of dryland biodiversity and the wise use of indigenous and medicinal plants (networks that encourage the participation of scientific institutions in LDCs).*
- *TWOWS's post-graduate fellowship for young women scientists from LDCs and sub-Saharan Africa (a programme sponsored by the Swedish International Development Agency, SIDA), which has thus far assisted more than 200 researchers.*
- *IAP's efforts to build the scientific capacity of merit-based science academies in the developing world, which has led, for example, to the creation of the Network of African Science Academies (NASAC).*

Why now?

The Academy believes that now is a good time to take a careful look at science in sub-Saharan Africa not because of the difficult situation there, but because of the many good things that are happening. There are signs that sub-Saharan Africa – or, at least, several nations within the region – have finally decided to pursue long-term strategies designed to build S&T capacity as a necessary prerequisite for sustained development. These efforts are being assisted by Northern donors that have committed themselves to the same overall goals.

The articles that follow provide readers with a sense of the enormous effort that is now underway to bring S&T to sub-Saharan Africa in ways that will allow the nations of the region to weave a culture of science directly into the fabric of their societies.

The challenges and responses outlined in this special edition of the TWAS Newsletter *parallel the challenges and responses that have shaped this Academy from its earliest days. In a way, when we look at sub-Saharan Africa, we are looking at the heart and soul of the Academy itself.* ■

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SCIENCE IN AFRICA: LESSONS TO LEARN

WHILE OTHER REGIONS OF THE WORLD HAVE ENJOYED SIGNIFICANT ADVANCES IN SCIENCE AND TECHNOLOGY – NOTABLY ASIA AND SOUTH AMERICA – SUB-SAHARAN AFRICA SEEMS TO HAVE LOST GROUND. WHAT CAN THIS REGION LEARN FROM THE SUCCESS OF OTHERS?

As an African-born scientist who has devoted much of his career to the promotion of science and technology (S&T) in the developing world, I have been heartened by the recent progress that has been made in building scientific capacity in the South.

Brazil, China, India and Mexico, for example, have all made great strides in developing and utilizing S&T as part of a larger effort to promote sustainable economic development. Consequently, more than one-half of the people residing in the developing world now live in scientifically proficient countries or countries that are well on their way to becoming so. That's a far cry from the circumstances that existed when the Third World Academy of Sciences (TWAS) was created in 1983.

As an African-born scientist, however, it is painful for me to say that Africa – and particularly sub-Saharan Africa – has failed to participate in these encouraging trends. In fact, the state of science in sub-Saharan Africa has largely declined over the past three decades and, not surprisingly, so too have standards of living.

Yet recent developments suggest that sub-Saharan Africa is finally reawakening to the indispensable role that S&T, especially home-grown S&T, plays in a nation's economic and social well-being. This special edition of the *TWAS Newsletter*, which has been prepared in cooperation with the African Academy of Sciences (AAS), takes a close look at the budding scientific renaissance in sub-Saharan Africa.

As in other parts of the developing world, the charge for S&T is being led by the region's larger and relatively wealthier nations – notably Nigeria and South Africa.

As in other parts of the developing world, it is being accompanied – or perhaps more accurately, preceded – by other reforms that include advances in democracy and economic liberalization.

And, as in other parts of the developing world, the scientific advances throughout the region have been uneven, to say the least, both between and within countries. Indeed, in sub-Saharan Africa, the advances have been much more tentative and the prospects for long-term success much more problematic.

The region faces three key problems that need to be addressed satisfactorily if meaningful progress is to continue in nations where it has taken root and spread to nations where it has not.

First, there is the issue of scientific capacity. Sub-Saharan Africa, a victim of decades of neglect and misguided policies (sometimes self-imposed), is woefully lacking in sci-

[CONTINUED PAGE 6]

entific capacity, even when compared to other parts of the developing world. Universities must be improved, laboratories upgraded and teaching reinvigorated, all for the purposes of creating a critical mass of well-trained scientists within each country capable of conducting first-class research and training.

Second, there is the issue of weak institutions – both those that fund science and those that do science. As a result, ministries of science and technology must be given both the authority and adequate budgets to develop effective S&T policies and programmes. Similarly, universities and research centres must be granted the freedom and resources to develop vigorous curricula and nurture an open, innovative environment where classroom study and laboratory experiments can take place and bear fruit.

Third, there is the issue of the disconnection between science practice and science policy. For the past three decades, the science that did take place in sub-Saharan Africa was not only severely limited in scope but also often carried out in isolation from the region's critical economic and social problems. Such a separation between science and society must be overcome, not only for the sake of society but for the sake of science. Only when the public benefits directly from science will sustained public support be forthcoming.

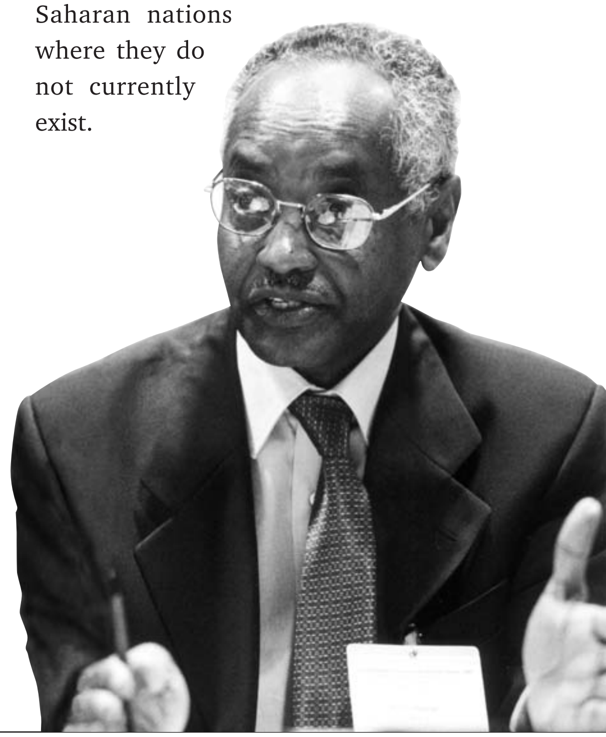
Given the difficult challenges that sub-Saharan Africa faces, what strategies should be pursued to promote both science and science-based economic development? What, in short, would represent a reasonable roadmap for success?

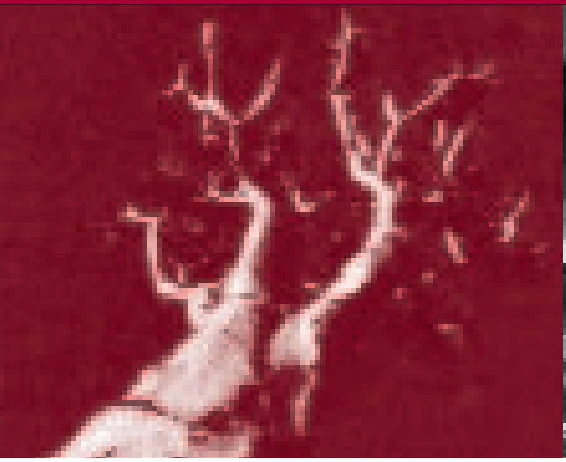
First, each nation should develop a national plan for S&T research and development that includes a detailed assessment of funding needs, a blueprint for institutional improvement and a set of concrete steps necessary to enhance public awareness of the benefits of S&T.

South Africa and Nigeria have developed such plans and, by systematically implementing them, have made noticeable progress over the past several years in efforts to build an infrastructure for S&T capable of addressing their nations' needs. Other nations – both large and small – should develop their own national plans for S&T that are more than rhetorical, 'feel-good' documents and actually lay out achievable goals within specified timeframes.

Second, sub-Saharan Africa should forge regional cooperative networks that enable both scientists and scientific institutions to share information and expertise and to learn from each others' experience.

The creation of the Network of African Science Academies (NASAC) is a recent example of networking in sub-Saharan Africa worthy of note. Formed in 2001 and headquartered at the AAS in Nairobi, Kenya, NASAC is an association of the region's nine merit-based science academies that seeks to build the capacity of academies through a cooperative strategy emphasizing the exchange of information and ideas among its members. NASAC also assists the creation of merit-based science academies in sub-Saharan nations where they do not currently exist.





Likewise, the efforts of the New Partnership for Africa's Development (NEPAD) to create centres of scientific excellence in a variety of fields – centres that will open their doors to scientists throughout Africa – has the potential to significantly improve the training and research capabilities of the entire continent. Pan-African science networks devoted to such critical topics as indigenous and medicinal plants, biotechnology, information technology, and the prevention and treatment of HIV/AIDS and other infectious diseases should also be encouraged as a way of enabling universities and research facilities to maximize their intellectual and financial resources.

Third, sub-Saharan Africa should pursue partnerships in science and technology with other developing nations. Indeed South-to-sub-Saharan Africa scientific cooperation is likely to grow in the future as scientifically proficient developing nations seek to partner with the region. The S&T initiative between Brazil and the Portuguese-speaking African nations of Angola and Mozambique, launched in 2003, could serve as forerunner of similar exchange efforts in the years ahead.

At the same time, it is possible to foresee partnerships in space science develop between China and Nigeria as both nations continue to invest in such areas. Still other partnerships between, say, Brazil and Uganda in areas related to biotechnology are becoming increasingly conceivable. The TWAS Fellowships for Postdoctoral Research and Advanced Training, which recently received funding from the governments of Brazil, China and India, also promises to benefit scientists from sub-Saharan Africa by enabling young researchers to receive training in centres of excellence located in those countries in the South with the most advanced scientific infrastructures.

Fourth, sub-Saharan Africa should pursue partnerships in science and technology with developed countries. Such partnerships should focus on the training of researchers so that the region is able to tap the scientific expertise of the North for the purposes of building its own expertise. The Millennium Science Institute (MSI) in Africa, led by the Science Institutes Group (SIG) and funded largely through the World Bank, is one example of how such strategies could work (see pages 58-64). So, too, is the African Institute for Mathematical Sciences (AIMS),

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which is located in Cape Town, South Africa and operated through a partnership largely forged between universities in the United Kingdom and the host nation (see pages 65-70). The US$20 million, 10-year grant recently awarded to the US National Academy of Sciences by the Bill and Melinda Gates Foundation to boost the capacity of science academies in Africa is yet another recent example of Northern donors seeking to invest in long-term strategies that ultimately help develop the scientific and technological expertise which sub-Saharan Africa needs to succeed.

The days of mega-projects designed by Northern engineers and implemented by Northern consultants have come to a close. The most far-sighted donors today are dedicated to helping Africa help itself.

This special issue of the *TWAS Newsletter*, with the help of our colleagues at AAS, examines many of these efforts. All suggest that Africa, while having not yet turned the corner when it comes to science and science-based development, may finally be heading in the right direction – if not everywhere, at least in some places.

Whether it can continue on this path remains to be seen. But for now sub-Saharan Africa has set out an appropriate set of principles that promise a better future than the failed policies of the past.

These principles include the need for sustained commitment and funding from national governments; an emphasis on excellence and the creation of a rewards system that ensures that the best scientists and best scientific institutions receive the most recognition and support; and a firm belief that if sub-Saharan Africa is to join other developing nations and regions that have learned to harness science for development, it must set its own agenda and then be willing to see it through.

Others can help but sub-Saharan Africa's renaissance in S&T must ultimately begin – and end – at home. That is the lesson conveyed by other developing nations that are now on the way to joining the North as true partners in S&T research and development and that is the lesson that sub-Saharan Africa must embrace for itself in the years ahead. ■

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SCIENTISTS LIVING AND WORKING IN AFRICA – FROM VENERABLE PRESIDENTS OF NATIONAL ACADEMIES TO PROMISING YOUNG STUDENTS WORKING TOWARDS HIGHER DEGREES – OFFER THEIR VIEWS ON THE MAJOR CHALLENGES FOR SCIENCE IN SUB-SAHARAN AFRICA AND THE STEPS REQUIRED TO ADDRESS THEM.

AFRICAN SCIENTISTS ON AFRICAN SCIENCE

TOWARDS A CULTURE OF SCIENCE

Among the major challenges facing science in sub-Saharan Africa today are the absence of a scientific culture and the lack of commitment to science by political leaders.

The notion of ‘cause and effect’ has yet to be ingrained in sub-Saharan Africa’s population and its political leaders. Unfortunately, belief in mysterious and supernatural causes, tribalism and nepotism still influence some political decisions. To counter this, leaders must embark on programmes of science education at all levels, following the model of several Asian countries where investment in science has paid off handsomely.

In addition, some leaders depend too much on their former colonial masters for their nations’ scientific development. In reality, former colonies are still regarded primarily as suppliers of raw materials and markets for their science. The so-called transfer of technology is a myth. Sub-Saharan Africa must turn increasingly towards the scientifically developed Third World countries, including China and India.

The region has its fair share of scientific talent, but talented scientists cannot flourish because of a lack of scientific infrastructure. As a result, the best scientists are often lost to other places as part of the ‘brain drain’ phenomenon.

Leaders should create ‘science villages’ or ‘villages of excellence’ with special working conditions for gifted and returning scientists. These scientists would then be able to prime the ‘science engine’ helping science in sub-Saharan Africa move ahead. With the political will, it can be done.

Finally, sufficient financial resources must be diverted for developing science. In the short term, about half of the present inflated defence budgets could be used to meet nations’ science needs. ■

V.A. Ngu
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Yaoundé, Cameroon

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ACTION NOW

Young scientists in sub-Saharan Africa who have the ability, aptitude and perseverance to do well in their national higher educational systems and to become eligible for doctoral or post-doctoral fellowships abroad have few incentives to return to their home countries. Neither their governments nor governments and funding agencies in developed countries where these young scientists are pursuing their careers seem to have a real interest in making it possible for this highly significant 'talent diaspora' to successfully re-enter their native science systems as productive working scientists. Those who return often become science administrators but not primary investigators who can help build productive research groups to address nationally relevant scientific questions.

Even so, talented scientific leaders do emerge in sub-Saharan Africa with the ability to develop centres of excellence in their home environments. Ample evidence shows that such centres can become engine-rooms for the development of science. Yet governments persist in 'sprinkling' their available funds uniformly across mostly lacklustre scientific entities, shrinking back from the kind of investments that are often made for expanding military capacity.

To address the haemorrhaging of home-grown talent, successful scientists in their home countries or returning from abroad should be given generous support, including access to modern equipment and excellent facilities. Achieving this will require concerted action by home-based universities, research institutions and indigenous funding agencies as well as appropriate interventions by wealthy donors in developed countries. Ideally, new agencies could be created to support good scientists, modelled, for example, on the National Science Foundation (NSF) and National Institutes of Health (NIH) in the United States or the Wellcome Trust in the United Kingdom.

Centres of scientific excellence created by outstanding scientists on their home turf significantly affect many aspects of a nation's science system. Their positive image helps inspire high school, undergraduate and postgraduate students; they challenge the acceptance of mediocrity in other research institutions; they generate sound and mutually beneficial North-South collaboration; and they allow the scientific opportunities uniquely present in developing countries to be fully explored by local – yet world-class – investigators. ■

Wieland Gevers

Wieland Gevers
President, Academy of Science of South Africa (ASSAf)
Cape Town, South Africa

POWERLESS SCIENCE

I am writing this message under the most stressful conditions that you can imagine for a scientist. For the past three hours I have tried to reply to your email but the power has been going off and on every minute.

Scientists in sub-Saharan Africa generally suffer from a lack of funds and expertise. In addition, we face the following problems:

- Regular power failures. Power-cuts not only delay our work, but lead to stored samples being damaged or degraded.

• Poor transportation infrastructure. Bad roads make journeys tedious and time-consuming. Cancelled or delayed flights can lead to the thawing of frozen specimens.

• Isolation and absence of library and database facilities. Access to the internet is impossible or difficult in many places due to both power failures and slow connections.

• Lack of basic materials. Shortages of reagents, including such essential ones as deionized water, occur on an almost daily basis.

• Lack of education. Involving communities in research projects that require prior informed consent is especially difficult due to low levels of education and poor understanding of science.

I will send this message now before the power goes off again. ■

Aline E. Mekeu Noutcha

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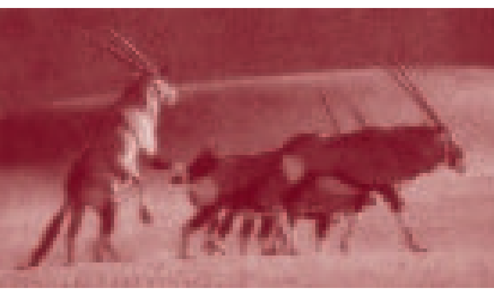

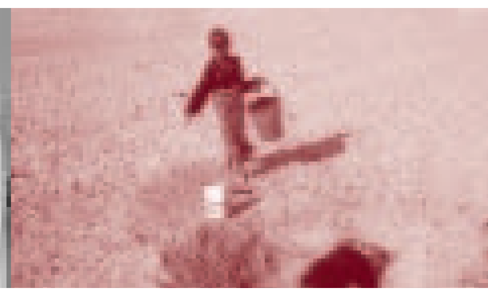

GROWING SCIENCE

The challenges confronting science in sub-Saharan Africa are enormous and must be addressed before meaningful development can take place. While not overlooking the effects of poverty, war and diseases, the major challenges facing sub-Saharan African science include improving the infrastructure, reversing the 'brain drain', changing certain government policies and increasing the number of women pursuing careers in science.

In sub-Saharan Africa, government policies often overlook the role of science in development and thus little is done to improve scientific infrastructure. This discourages talented scientists from carrying out research in their native countries, leading them to take their talents abroad or to search for higher-paying positions in civil service or business. Less than 0.3 percent of the world's scientists come from sub-Saharan Africa, largely because of poor career orientation and the lack of postgraduate training programmes that could attract people into scientific careers. In addition, women are often bound by customs and traditions that limit their educational and career oppor-

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tunities. Those who earn science degrees are often discouraged from advancing their careers because of family and financial pressures.

Other problems lie in the lack of accessibility to frontline scientific journals and the inability to apply scientific knowledge to local problems.

To address these challenges, successful scientific institutions need to be identified and encouraged. These 'growth points' must have direct access to foreign funding and enjoy close collaboration with institutions abroad, enabling them to develop into 'centres of excellence'.

Extra support for scientific research and the availability of modern research facilities with upgraded computer systems and internet connections will encourage scientists working abroad to return home and apply their research skills to local problems. To ensure continual progress in science throughout sub-Saharan Africa, successful scientists who have returned home should share their international experiences with prospective young scientists to encourage them to pursue their own scientific careers. Sub-Saharan Africa has a wealth of untapped intellect that needs to be utilized to drive a much-needed African renaissance. ■

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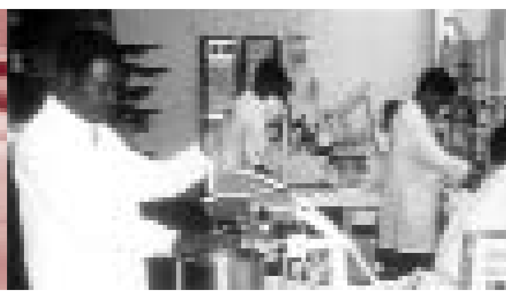


MAKING SCIENCE RELEVANT

Science should be made relevant by addressing the needs of people. For this to take place, capacity must be developed, particularly in the basic sciences. As a chemist, I view chemistry as a basic science that contributes significantly to the alleviation of poverty by directly impacting public health, food security and the environment. Therefore, the biggest challenge for sub-Saharan Africa is to marshal its resources to enhance capacity. The second major challenge is to find ways of sharing the limited human resources, experiences and facilities that are available in the region. There are many competent scientists in sub-Saharan Africa, many of whom were trained abroad. Nevertheless most never realize their full potential. That's because – after trying to solve problems associated with the developed world – on returning home they find themselves in work environments that are inadequate and not in line with their previous experience. Under these circumstances, it is all too easy for them to give up on their scientific careers. Science teaching and research focused on sub-Saharan Africa's needs and carried out in the region will go a long way to enhancing the region's indigenous scientific capacity and have knock-on effects beneficial to all of sub-Saharan Africa. ■

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MAKING SCIENCE A PRIORITY

Compared to other regions around the globe, in sub-Saharan Africa, science is given a low priority. Among the many challenges facing the development of science in the region are:

- Poor support, both politically and financially. In most sub-Saharan countries, science budgets are too low and too unpredictable, making medium- and long-term planning difficult. That, in turn, affects the development of science. Scientists, moreover, are poorly paid. As a result, many opt for alternative careers or accept jobs abroad.
- Separation of scientists from policy makers. Scientists have long-term goals; policy makers short-term goals. In addition, scientists, the key stakeholders in devising innovations based on science and technology, often work in isolation from policy makers. As a result, policy makers often regard science as a low priority and provide it with little support.
- Ageing of the scientific workforce. Young scientists have not been encouraged to work with senior professors. The knowledge possessed by these professors will soon be lost, presenting additional challenges to science in the region. Many scientists, both young and old, have also lost their lives to the HIV/AIDS pandemic.

To address these challenges, governments must increase their budgets for science in ways that are predictable, thus fostering effective planning that will improve the quality and quantity of science. Linked to this is the need for governments to increase scientists' salaries to entice them to remain at home and help foster the development of science in the region, including the careers of young scientists who, in turn, should be encouraged to focus on issues relevant to the region. Finally, international donors should apply more resources to expanding the development of science in sub-Saharan Africa, especially by supporting efforts to reverse the brain drain. ■


Riziki Silas Shemdoe

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ROOTING SCIENCE IN CULTURE

Science and technology are alive in Africa. What has hindered their broad expression is the promotion of modern Western science over African concepts of knowing and doing, which are ingrained in African culture. Establishing science and technology roots within African culture and incorporating indigenous knowledge into modern science will improve the wider application, success and acceptance of science in Africa.

The African duality of character, one traditional, the other modern and aspiring for the western ways of life, has also produced an incoherency in governance. For example, there is not a single African government that fails to recognize the importance of science and technology as instruments for socio-economic development. However, few African nations have viable science, technology and innovation policies. Links between policy makers and scientists are weak and must be strengthened. Experience with the implementation of reports published by the Intergovernmental Programme on Climate Change (IPCC), for example, demonstrates the low level of penetration of scientific concerns among African governments. The increase in aridity in Africa due to climate change has failed to catalyse the adoption of new programmes. As a result of these weaknesses, there is a lack of sustained funding for science and technology in Africa. Funding based solely on donor contributions is neither viable nor sustainable.

Other challenges are posed not only by the scarcity of water but the lack of clean drinking water. Africa will only reduce the magnitude of possible water scarcity disasters if it uses science, technology and innovation to improve the management of its water resources.

Shem O. Wandiga

Another challenge requires a paradigm shift in science courses to include the social sciences and humanities. A critical look at the science of sustainability propels us to design new curricula for students at all levels of education.

Lastly, several new frontiers of science require immediate emphasis and development in Africa. These include information and communication technologies, materials science, nanoscience, neuroscience and space science. But before these areas can be developed, priority must be given to strengthening sub-Saharan Africa's capacity in the basic sciences. ■

Shem O. Wandiga
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INDICES OF DEVELOPMENT

Africa continues to perform poorly according to many indices of development. Of the 30 poorest countries in the world, 25 are in Africa. Of the world's poorest people, 32 percent live in sub-Saharan Africa. The region is plagued by droughts, famines, civil strife and wars. Agriculture yields are low and have not kept pace with population growth. Of all cases of infectious diseases, nearly 80 percent are in sub-Saharan Africa and about 75 percent of HIV/AIDS cases worldwide are in this region. The United Nations Development Programme's (UNDP) most recent *Human Development Report* uses a new index to capture how well a country is creating and diffusing technology and building its human skills base. Of the 24 countries categorized as low human development countries, two-thirds are in sub-Saharan Africa.

Among the major problems adversely affecting Africa's development is the migration of qualified professionals from the continent – the 'brain drain'.

A.M. El Hassan

A suitable instrument for addressing the challenges facing African countries is a commitment to the Millennium Development Goals, which include targets to be reached by 2015. Among these, the alleviation of poverty, resolving conflicts, investment in science and technology, and North-South and South-South collaboration are key indices for determining progress towards sustainable development in Africa. ■

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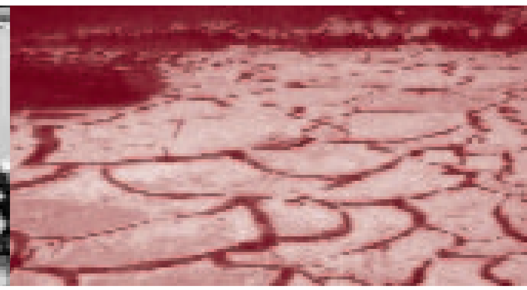

STRATEGIC VISIONS

Sub-Saharan Africa has entered the 21st century facing formidable problems. Elsewhere in the world, innovation in science and technology has led to dramatic improvements in life expectancy and advances in medical treatments, energy efficiency and communications. Sub-Saharan Africa, however, is still plagued with food and nutrition insecurity, poverty, ignorance and disease. Other challenges include globalization, which is further marginalizing the poor, the HIV/AIDS pandemic, political conflicts, lack of critical human capital, unsustainable economic programmes, and climatic change, which is affecting populations not only across Africa but other continents as well.

To counter these problems, sub-Saharan African countries should develop pragmatic but visionary strategies for sustainable economic growth and invest sufficient resources to develop critical high-level indigenous human capital with the prerequisite scientific skills. Since agriculture is the engine of socio-economic development, there should be more investment in this area. In addition, there is a need to promote good governance that includes provisions for improved health care delivery. ■

Mathew Luhanga
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[CONTINUED PAGE 16]

Francis O. Ogbe

TRANSFORMING SCIENCE... AND SOCIETY

Science in sub-Saharan Africa faces numerous challenges, most of which stem from human attitudes and differ from one country to another. However, inadequate research funds and facilities, lack of a skilled human resource base, and a poor communication infrastructure are problems common to the region as a whole. An unequal distribution of wealth has spurred corruption, which has, in some cases, brought about financial mismanagement by scientists and heads of universities and research institutions. In addition, governments have often displayed a lack of interest in and even indifference to scientific research. There is also apathy on the part of the private sector to invest in research. Not unexpectedly, the private sector is more interested in quick financial returns, which do not usually occur with scientific research. Therefore the private sector in sub-Saharan Africa does not consider investment in research worthwhile. Potential end users of research are also largely indifferent to scientific findings. This is mainly due to the high level of illiteracy and poor mechanisms for the dissemination of research results.

If successful reforms are to take hold, a positive change in attitude is necessary for sub-Saharan African governments, the private sector and even scientists.

Governments should encourage, promote and facilitate scientific research through policies that motivate scientists and tackle their nations' illiteracy levels. Corruption should be discouraged and funds distributed equally among all sectors, including research institutes and universities. The limited financial resources made available in this way will, if prudently managed, will help spark a transformation in scientific research in the region. International donors and the private sector in sub-Saharan Africa must also support science by investing in human resources and laboratory and communications infrastructure. Above all, scientists should be encouraged to engage in collaborative projects to maximize resources for research. ■

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AFRICA'S REGIONAL SCIENCE ACADEMY

FOR NEARLY 30 YEARS, THE AFRICAN ACADEMY OF SCIENCES (AAS) HAS SERVED AS ONE OF THE CONTINENT'S MOST VOCAL ADVOCATES FOR THE PROMOTION OF SCIENCE IN AFRICA. GIDEON B.A. OKELO, THE ACADEMY'S SECRETARY GENERAL, OUTLINES AAS'S FULL RANGE OF CURRENT ACTIVITIES AND HOPES FOR THE FUTURE.

When Thomas R. Odhiambo, one of Africa's most renowned scientists and the founding director of the Centre for Insect Physiology and Ecology (ICIPE), in Nairobi, Kenya, successfully led the effort to create the African Academy of Sciences (AAS) during the mid 1980s, his ultimate goal was to resurrect what he viewed as the continent's once-thriving scientific enterprise.

Indeed just a decade before the launch of AAS, Africa boasted some of the developing world's most eminent universities and research centres, such as the University of Ibadan in Nigeria and Makerere University in Uganda.

But political instability, often punctuated by violence and wanton neglect, had sapped the vitality of Africa's intellectual and scientific communities, rapidly transforming once-vibrant classrooms and laboratories into debased campuses of inferior education.

Today, AAS – with 125 members (120 'fellows' from Africa and 5 'foreign fellows') and an endowment fund boosted by a US$5 million grant from the government of Nigeria – is one of a number of organizations whose recent activities suggest that an African scientific renaissance could soon be at hand.

Odhiambo, who died last year at the age of 72, would be pleased by the budding indicators of progress. Yet, he would also be quick to note that Africa's sullied science enterprise will require a great deal more resources and attention – not just from the global scientific community but, even more importantly, from Africa's national governments and international donors – if science is to flourish across the continent. AAS stands ready to help in any way it can. In broad terms, AAS seeks to:

- Foster the growth of scientific communities in Africa and inspire scientific discovery and technological innovation as part of a larger effort to promote socio-economic development and regional integration.
- Nurture the capabilities of high-level scientific and technological personnel in Africa by identifying and

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recognizing talented individuals and encouraging their creativity.

- Stimulate, design and coordinate interdisciplinary scientific research and development and sponsor demonstration projects of regional interest and concern.
- Facilitate contacts among African scientists and assist in the dissemination of scientific information to the public.
- Plan, convene and coordinate science educational activities of crucial importance to Africa.

AAS pursues these goals through a series of programmatic initiatives focusing on:

- Capacity building in science and technology, including workshops on resource management, desertification and food security.
- Publication and distribution of scientific information. The Academy oversees both the publication of the peer-reviewed journal, *Discovery and Innovation*, and in collaboration with the Third World Academy of Sciences (TWAS), the operation of an in-house publisher – Academy Science Publishers (ASP) – that concentrates on producing and distributing books on science in Africa.
- Analytical studies and research reports on science-related economic development and broadly cast public policy issues. AAS publications include *Regional Integration in Africa: An Unfinished Agenda*; *The Greening of Africa*; *Africa in the Context of World Science; Thirty Years of Independence in Africa: The Lost Decades?;* and *Arms and Daggers in the Heart of Africa: Internal Conflicts*.
- Mobilization of the African scientific community through networking, the awarding of prizes for excellence in science and technology, and a host of other activities.

Currently, no African nation invests more than 1 percent of its GDP in science and technology.

AAS officials believe that the most important contribution it can make to the advancement of science in Africa is to provide authoritative information on the state of science in Africa (both in terms of research and policy) and to convince public officials of the need to make substantial and sustained investments in efforts that assist both scientists and scientific institutions.

Currently, not a single African nation invests more than 1 percent of its gross domestic product (GDP) in science and technology (S&T). Most, in fact, invest less than 0.5 percent of their GDP in S&T. Until governments decide to make adequate financial commitments to scientific research and science-based development, efforts to improve the state of S&T will remain seriously handicapped and any progress that is made will be at constant risk and often subject to reversal.

Over the past two decades, AAS has engaged in a broad range of programmatic initiatives that have been designed to advance the Academy's overall goals. Indeed, in many instances, AAS activities have sought to address issues and build skills that extend well beyond science. Academy officials have reasoned that science in Africa will not improve on a sustained basis unless shortfalls in policy and management are overcome.

The Academy's initiatives, therefore, have been broad-based and designed to address a wide range of issues. A major programme, for example, focuses on forestry and forest-related natural resource issues – most notably, water and soil management and efforts to promote sustainable forest management.

Over the past 20 years, AAS has awarded more than 100 grants – with a collective value of US$1 million – to foresters and resource specialists in 18 African nations. Specific programmes include the African Forestry Research Network (AFORNET), which offers modest grants – ranging from US$7,000 to US$8,000 – both to

scientists, in support of their research, and scientific institutions for the purchase of equipment. Under the programme, participating scientists have been encouraged to join one of three regional forestry networks: The Forestry Research Institute of Ghana for western Africa, the Kenya Forestry Research Institute for eastern Africa, and the Sokoine University of Agriculture in Tanzania for central and southern Africa. The centres are responsible for organizing regional meetings and workshops that examine critical forestry-related resource issues. In addition, they help to identify promising young scientists working in the field of forestry.

The National Forestry Programme, an AAS partnership programme organized jointly with 16 sub-Saharan nations, published two seminal reports on sustainable forestry management in Africa in 1999. One was prepared for the UN Food and Agriculture Organization's (FAO) Organizing Committee on Forests (COFO), based in Rome, and the other for the Intergovernmental Forum on Forests (IFF), based in Geneva.

Both reports provided a much needed African perspective on forestry-related management issues in sub-Saharan Africa, ultimately leading to the creation of the African Forestry Experts Group (AFEG), which has provided guidance not only to African scientists and scientific institutions but to international organizations seeking to promote sustainable forestry practices.

The AAS has also engaged in a series of programmes designed to improve soil and water management practices in Africa. The Young Scientists' Fellowships programme has awarded small grants to more than 20 promising young African scientists working in eight countries. The initiative is designed to encourage recipients to forge collaborations with colleagues in other institutions in ways that can broaden both their knowledge and resource base. To facilitate this goal, research issues were identified across the region, including soil run-off in Eritrea, irrigation management in Sudan, steep-slope farming in Tanzania, threats posed to bamboo wetlands in arid zones in Zimbabwe, and forest-related water conservation in Botswana.

In addition to its research and demonstration programmes, AAS also oversees several programmes to improve the management and administrative skills of scientists and scientific institutions in Africa. For example, the African Training for Leadership and Advanced Skills (ATLAS) initiative has provided a forum for scientists throughout Africa to adapt their knowledge and skills to meet the needs of scientific institutions and ministries within their own countries. ATLAS has sponsored regional workshops and conferences in nine African nations focusing on such critical concerns as democratic governance, environmental quality and educational reform, seeking to provide participants with a basic

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foundation in the principles of good management. Africa faces many challenges in science, not the least of which is how to manage scientific activities in a transparent and efficient manner.

The Academy has also sponsored awards programmes that include the AAS-Syngenta (formerly Ciba-Geigy and Novartis) Prize for agricultural biosciences in Africa. In addition, AAS has built a database consisting of the names and contact points for African scientists and scientific institutions that is available both in print and electronic form. And, in an effort to increase the number of articles by African scientists published in refereed international journals, AAS has launched an African Journals and Development Centre. Finally, it has played an instrumental role in the creation of the Network of African Science Academies (NASAC), a regional network of the continent's nine merit-based science academies that is seeking to build both the profile and capabilities of science academies, especially in their interactions with government. The InterAcademy Panel on International Issues (IAP), based at the TWAS secretariat in Trieste, Italy, has been instrumental in this effort, providing the seed money needed to get NASAC off the ground. NASAC is currently focusing on the HIV/AIDS pandemic in Africa and science education on the continent.

In Africa, a regional approach is the surest way to ensure that resources are efficiently invested.

CHALLENGES AHEAD

A limited budget – averaging less than US$20,000 a year during the Academy's first decade of existence – has often limited the scope of AAS. By focusing on capacity building initiatives (through research grants and funding for equipment) and pinpointing a number of critical issues (for example, forestry and soil and water management), the AAS has been able to make small but significant contributions to science and science-based development in Africa.

But the Academy is under no illusions concerning either its presence or impact. By many measures – including, the number of scientists living and working in Africa, the number of publications in international refereed journals authored by African scientists, and the number of patents issued to African technologists – the state of science in Africa, dismal to begin with, has actually worsened, not improved, since the Academy was created some 20 years ago at a meeting held at the TWAS secretariat in Trieste, Italy.

This much we do know: Science and science-based development rank among Africa's greatest challenges. Whether the issue is food security, access to safe drinking water, disease eradication or biodiversity conservation, science will play a key role in resolving the continent's most critical problems.

As a result, Africa's governments and international organizations must subscribe to policies that lead to substantial increases in funding. At the same time, to fulfil their part of the bargain, African scientists must agree to engage in mission-oriented research designed to address Africa's critical societal and resource concerns.

Yet, calling for more money from governments and donors and greater societal commitments from Africa's scientists represents only part of the challenge. Equally important, Africa must dedicated itself to a sustained effort in capacity building intended to create well-trained scientists who can find employment in scientific centres of regional, national and, yes, international excellence located within Africa. These centres must ultimately be part of an intricate matrix, or continent-wide network, focusing on a broad range of issues – biotechnology, information technology, water management and other concerns of critical importance to the future of Africa and its people.

To maximize the potential impact of this enterprise, the institutions that belong to this matrix should be regionally based yet remain open to scientists and scientific institutions located in other regions. In Africa, where development efforts in so many countries remain handicapped by too few qualified scientists and too many ill-equipped classrooms and laboratories, a regional approach is not only logical but essential. It's the surest way to avoid duplication of effort and to ensure that resources are efficiently invested.

Science academies have an essential responsibility to galvanize and strengthen the scientific community so that scientists can contribute more effectively to issues of relevance to the countries and regions in which they live and work. Science academies also have an important role to play in efforts to provide credible and independent scientific advice to policy makers.

Africa's science academies have been stymied both in their efforts to increase their capabilities and to influence decision makers for several reasons. First, merit-based science academies are few in number and therefore largely remain anomalies in policy circles. Indeed only nine of Africa's 53 countries have merit-based science academies. Second, they have been hamstrung by extremely limited budgets. Most of the academies have operated on budgets of less than US$10,000 a year. And, third, the absence of young scientists living and working Africa has meant that the academies' memberships often consists of older scientists. Youthful regeneration is a problem facing science academies around the globe but it is particularly troublesome for science academies in Africa.

Despite these obstacles, there are reasons for hope. Africa's new regional association of academies, NASAC, not only promises to serve as a platform that enables Africa's science academies to learn from one another, but it also promises to be a seedbed that can help germinate the creation of science academies where they do not currently exist. To date, Tanzania and Côte d'Ivoire – with NASAC's encouragement – have taken significant steps towards the creation of national merit-based science academies.

In addition, in 2002, the Nigerian government contributed US$5 million to help establish an endowment fund for AAS. During the first few years of its existence, AAS was never able to attract sufficient investments to serve as a credible source of programmatic funding. Now, drawing on the interest earned by the US$5 million plus endowment, AAS should be able to launch and sustain a series of capacity building programmes without jeopardizing the Academy's long-term financial well-being. Indeed the Academy hopes to use funds

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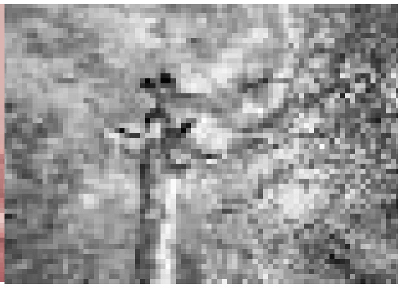

from the endowment to leverage funds from other sources, including international donors and foundations. AAS is soon to launch a campaign for additional contributions from African governments hoping to build on the nest egg provided by Nigeria.

Finally, the Bill and Melinda Gates Foundation has announced that it will provide a 10-year, US$20 million grant seeking to improve the ability of African science academies to advise their governments, especially on health-related matters. The grant, which will be administered by the U.S. National Academy of Sciences (NAS) in close cooperation with selected African science academies, will draw on NAS experience in serving as advisors to the US government to train African academy staff members to effectively advise their governments on critical health issues.

These encouraging developments, which bode well for the future of science in Africa, rest on three pillars of support that should prove essential for success as Africa seeks to build its scientific enterprise.

First, as embodied in NASAC, the continent's scientific challenges require regional responses to be effectively addressed. Second, as embodied in the Nigerian government's investment in the AAS endowment fund, government commitment to science and technology is critical and – indeed I would contend – is the one irreplaceable pillar for success. There is no substitute for national investment in scientific capacity building. And third there is a need for foundations and international donors, as embodied in the Bill and Melinda Gates Foundation grant for African science academies (and I might add the recent funding strategies of other international donors, including the Swedish International Development Agency, the Rockefeller Foundation and the World Bank), to concentrate on efforts that will provide a sustainable base for the promotion of science and science-based development in Africa, particularly sub-Saharan Africa. The key to these efforts is capacity building – that is, providing both the training and skills development necessary to help Africans help themselves.

It is an encouraging time for science in Africa – perhaps the most encouraging time in the past 30 years.

With these diverse groups addressing the issue of science capacity building and science-based development on a variety of fronts, it is an encouraging time for science in Africa – perhaps the most encouraging time in the past 30 years. After decades of neglect and decline, traces of a better future are on the horizon.

Thomas Odhiambo, unfortunately, won't be here to witness the full realization of his efforts. Nevertheless, one of the most significant outcomes of his life-long commitment to science in Africa – the AAS – is eager to move his agenda forward, not just in his name but, more importantly, in the name of a more peaceful and prosperous Africa. ■

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A PLACE APART, A PLACE BETWEEN

AFTER DECADES OF ISOLATION DUE TO APARTHEID, SOUTH AFRICA'S SCIENTIFIC COMMUNITY, WITH A GREAT DEAL OF HELP FROM THE NATION'S DEMOCRATICALLY ELECTED GOVERNMENT, HAS MADE IMPORTANT STRIDES IN BECOMING A LEADING VOICE FOR SCIENCE IN AFRICA.

South Africa is home to sub-Saharan Africa's strongest scientific community. The nation currently spends 0.75 percent of its gross domestic product (GDP) on research and development (R&D) – that's less than Brazil, China and India, but more than such countries as Argentina and Chile as well as virtually all other African nations. Moreover, South Africa's private sector accounts for more than 50 percent of the investment in R&D – a figure comparable to that of Europe, where overall R&D expenditures – from both the public and private sectors – average between 2 to 3 percent of GDP.

Indeed the figures on South Africa's R&D expenditures offer a shorthand view of South Africa's unique 'asymmetrical' position in the global scientific community.

When viewed from the perspective of Africa, South African science is advanced but not so advanced as to be a world apart; when viewed from the perspective of science in the North, South African science is weak but not so weak to prevent it from joining world-class universities and research institutes in the North on global research projects as true collaborators.

South African science is comparable to the level of science in Brazil, China and India. Each of these nations, in a sense, represent 'science in-betweeners' that are moving towards scientific proficiency but still have a long way to go. Each is scoping out dual roles for its scientific enterprise – on the one hand, seeking to gain international status in science and, on the other, serving as a role model and guardian for the development of science in the developing world. Each, in short, is exploring ways to help other, less scientifically proficient developing nations while advancing its own national agenda for science. In post-apartheid South Africa, the focus has been on partnerships with other African nations.

The strength of South Africa's scientific enterprise rests on three distinct yet interrelated pillars: universities, science councils and the National Research Foundation (NRF).

The university system is comprised of 26 research universities and 10 polytechnic universities (the curricula

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of five polytechnics have recently been incorporated into the curricula of existing universities as part of a larger reform effort in higher education). All told, the nation has six strong research universities, including Cape Town, Rhodes and Stellenbosch. Natural and health sciences historically have fared better than the social sciences and humanities, a deficiency in the nation's research system that is part of the legacy of apartheid and that the government is now trying to remedy.

The second pillar in South Africa's scientific enterprise is the science councils – publicly funded facilities that carry a mandate devoted exclusively to research. Councils cover a wide spectrum of fields that are addressed through the creation of individual facilities devoted to a particular field of study. For example, there are councils in agriculture, geoscience and medical research.

Historically, South Africa's ten research councils, with the exception of the Medical Research Council, have had little interaction with the nation's universities functioning much like the research councils in the former Soviet Union. Today the government is seeking to enhance the interaction between councils and universities as a way of developing greater synergy between the nation's researchers and forging stronger links between research and teaching.

The third pillar in South Africa's scientific enterprise is the National Research Foundation (NRF), the only national research foundation in Africa. The foundation has two inter-related responsibilities.

First, much like the US National Science Foundation or the National Natural Science Foundation of China, South Africa's NRF funds 'extramural' research – that is, research by scientists that is not funded by their home institutions because of limited resources and other priorities. Second, NRF also funds the construction of large, 'one-off' national and international research facilities – for example, an astronomical observatory, a nuclear science facility, a research centre for aquatic biodiversity and the national zoological gardens. Most recently, the NRF has become the lead agency in an international project to build to build the Southern African Large Telescope (SALT), which, at 11 metres in diameter, will be the largest in the Southern hemisphere when it becomes operational in 2005. The government of South Africa is taking the lead in the project, located on the Karoo plateau in the southern part of the country, by covering one-third of the cost. Other participating nations in the SALT project include Germany, New Zealand, Poland, the United Kingdom and the United States.

In addition to its international dimensions, the SALT telescope project reflects two other significant trends in science in South Africa. First, the government's growing interest in engaging the public in national efforts to advance science and technology and, second, the government's commitment to collaborating with other African nations.

The project, for example, will include a major public outreach effort. Not only will there be an a large interactive visitor centre but the government has also agreed to sponsor overnight visits to the facility by every secondary school mathematics and science teacher in the nation. This means that over the course of the next several years, hundreds of educators will have an opportunity to see this state-of-the-art telescope and learn first-hand about the experiments that are taking place there from the scientists who are conducting them. The goal is not only to share scientific information between university researchers and secondary school teachers but to help instil – or perhaps, more accurately, reinstil – a sense enthusiasm for science among teachers, who will then hopefully convey their excitement to their students.

At the same time, because South Africa is paying one-third of the costs for the facility and

because the facility is located in South Africa, one-third of the facility's operating time will be reserved for South African scientists.

The South African government has announced that its time at the facility will be made available to all African scientists. In another words, research proposals from Angola, Ghana and Senegal will compete equally with research proposals from South Africa in an effort to make the facility one that all Africans can benefit from. Similarly, the government of South Africa has announced that its National Laser Centre near Pretoria is joining laser facilities in Algeria, Ghana and Senegal to create a pan-African laser network that is designed to enhance the quality of laser research and scientific exchange throughout the continent. The participating nations hope to have the New Partnership for Africa's Development (NEPAD) designate the network as an integrated centre of scientific excellence.

The ultimate goal of all these efforts is to put South Africa's scientific expertise and infrastructure to work for the whole of Africa.

South Africa is particular strong in several different areas of science, including astronomy, anthropology, biodiversity and Southern oceans. These are research areas where South Africa's scientific community matches up well with scientific institutions in the North and they are the areas that largely account for South Africa's status as an observer in the Organization for Economic Cooperation and Development (OECD) Science Forum and its lead role in the European Union's Africa, Caribbean and Pacific (ACP) initiative.

On a bilateral basis, South Africa's scientific community has forged strong ties with the scientific community in France, Germany, the Netherlands, the United Kingdom and, to a lesser extent, the United States. Collaborative efforts with the North not only draw on South Africa's strengths in specific areas of science but increasingly focus on issues of particular concern both to South Africa and the global scientific community – for example, the development of research protocols and clinical trials for the study and treatment of HIV/AIDS.

The challenge in South Africa's relationship with scientific institutions in the developed world is to convince Northern partners that collaborative projects can be strengthened and expanded in the future only if the research component of projects is accompanied by strategies for capacity building that focus on the training of young, black and female scientists. That's because South Africa's historic strength in science resides with its minority white male population. Discrimination is a roadblock to progress and aging expertise an undeniable formula for decline.

South African science is comparable to the level of science in Brazil, China and India.

If South Africa's majority black and female populations are to be given an opportunity to join South Africa's scientific community – a goal that is not only a moral imperative but also essential for the well-being of the nation's scientific enterprise – adequate classroom and laboratory facilities and training must be made available for the next generation of South African scientists. Moreover, the pool from which these scientists are drawn must be as large and diverse as possible. That's why the UK Royal Society's capacity building programme for science and mathematics focusing on 'historically disadvantaged' – or 'black' – universities in South Africa, launched in 1996, has been such an important initiative.



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To date, scientists in a variety of disciplines, including biotechnology, ecology, nanotechnology and computational modelling, have received special training through a mentoring programme in which professors in the United Kingdom are teamed with professors in South Africa to teach promising young science students in four historically disadvantaged universities, Fort Hare, North, Western Cape and Zululand. The programme's success – by mid 2003 it had yielded some 125 research papers – has led to a three-year extension as well as discussions with the *Centre National de la Recherche Scientifique* (CNRS) in France and the National Institutes of Health (NIH) in the United States to establish similar mentoring schemes in other fields.

The government of South Africa is determined to make science more responsive to the critical needs of the people.

Apartheid in South Africa left the nation with a twisted and distorted scientific legacy. In 1994, just as the apartheid regime was crumbling under the weight of its own oppression, South Africa's investment in scientific research and development exceeded one percent of the nation's GDP – a more than respectable figure that was among the highest in the South. Yet this aggregate figure hid the enormous deficiencies in the nation's scientific enterprise that ultimately rendered it not only morally bankrupt but unsustainable.

Virtually all of the money was invested not only in white scientists and white-only institutions but was devoted to just a few areas of study – mainly, defence, energy (largely nuclear energy) and agriculture. In effect, the apartheid regime had created apartheid science and the strains that the government faced as an international pariah led it to concentrate its investments in science to just a few selected areas that served the short-term goals of the regime but failed to serve the long-term goals of the nation.

The few areas of science that were funded outside of those of direct concern to the regime focused primarily on basic – often abstract – questions and were usually far removed from application and therefore potential political controversies. Indeed one of the legacies of science from the period of apartheid remains one of the weaknesses of science in democratic South Africa today: that is, the scientific community's limited skills in turning science into technology so that the fruits of discovery find purpose and value in the wider society.

That's why the most recent comprehensive assessment of the nation's research and development strategies, published in 2003, emphasizes the need to build capacity in such areas as information technology, biotechnology, nanotechnology and mineral processing. The call for investments in such fields is designed to enable science to help drive economic and social progress.

South Africa's future scientific agenda has been very much shaped by its history and, more recently, by its place within the global scientific community. As it moves ahead, the government of South Africa is determined to make science more responsive to the critical needs of people both within the nation and beyond and to provide all South Africans with the opportunity to pursue rewarding careers in science; it is committed to establishing an agenda that fosters close collaboration with scientific communities throughout Africa; it will seek to partner with Northern scientific institutions in ways that not only advance the global scientific research agenda but help build the nation's scientific capacity building; and it will remain steadfast in pursuing strategies that improve the quality of life for all South Africans without burying its heads in the sand when it comes to basic research.

It is an ambitious agenda worthy of an ambitious and confident country. ■

AFRICA'S FIRST CENTRE OF EXCELLENCE

LAUNCHED IN 1970, THE INTERNATIONAL CENTRE OF INSECT PHYSIOLOGY AND ECOLOGY (ICIPE) IS AFRICA'S FIRST CENTRE OF SCIENTIFIC EXCELLENCE. THE TRIALS AND TRIBULATIONS THAT THE CENTRE HAS FACED OVER THE YEARS REFLECT THE FRAGILE YET RESILIENT NATURE OF SCIENCE IN AFRICA.

When Thomas Odhiambo (TWAS Founding Fellow) launched the International Centre of Insect Physiology and Ecology (ICIPE), in Nairobi, Kenya, in 1970, he was driven by a numbers game as stark as the figures themselves.

Eighty-five percent of the known animal species are insects. With more than one million known species, insects, in fact, represent the vast majority of the organisms on our planet, playing a vital role – for better or worse – in the well-being of all people and especially those living in rural areas like those that dominate Africa.

Put another way, insects are not just nuisances but are key components of the food chain and provide such valuable ecological services as pollination, nutrient recycling and even pest control through their predatory and parasitic behaviour.

Odhiambo's focus on insects, therefore, really amounted to a focus on a broad range of issues, including agricultural productivity, human and environmental health, rural economic development and sustainability.

For ICIPE, an autonomous, intergovernmental organization currently with a staff of 300 and an annual budget of US$11.5 million, the study of insects, or entomology, has always been a means towards an end – a way of addressing critical environmental, social and economic concerns in the world's poorest regions, particularly in eastern and southern Africa where its secretariat is located. As its staff like to say: "ICIPE is about much more than insects."

Now in its 34th year, ICIPE is seeking to express its long-standing mandate – "to conduct research, training and develop methods for managing pests and disease

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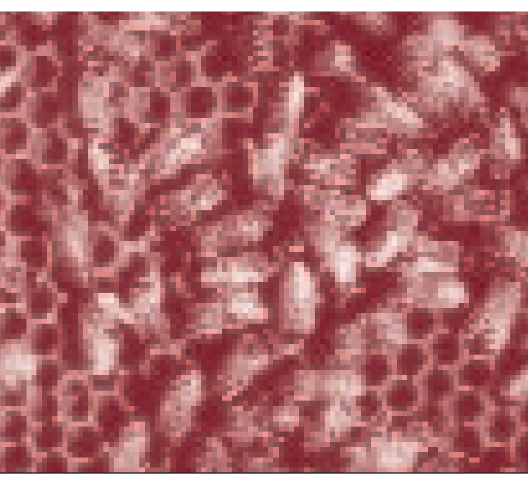
vectors in environmentally friendly ways and to enhance the useful effects of insects and other arthropods" – in a world that has changed enormously since the institute's inception.

Bees, butterflies, fruitflies and mosquitos may look the same as they did three decades ago – indeed three millennia ago, yet everything else in ICIPE's world – most notably the research and funding environment – has changed dramatically. Hans Rudolf Herren, who has served as ICIPE's chief executive officer and director general for the past 10 years, explains.

"ICIPE has always been at the forefront of seeking benign ways to address problems caused by insects and other pests with a minimal use of chemicals that can harm the environment," Herren says. "The tools we have relied on – integrated pest management, selective use of natural enemies, robust plants, crop rotations, habitat management and the like – remain as valid today as they did when Odhiambo first launched the organization. In fact, over the years, ICIPE has gained an international reputation in insect physiology, chemical ecology and integrated pest and disease vector management – research areas that remain at the core of our competencies."

At the same time, however, Herren acknowledges that scientists and farmers now have other tools in their research and development kit that may prove even more valuable in the endless campaign against insects – namely, the findings of molecular science, biotechnology and genetic engineering.



Herren recognizes that scientists in the developing world must become much more conversant in such cross-disciplinary fields as biochemistry, biophysics, bioinformatics and proteomics. He is quick to add, however, that these new scientific disciplines "should be developed in addition to, and not at the expense of, the 'classical' areas of entomology – for example, ecology, physiology, and taxonomy – that have driven ICIPE's research agenda since its inception.

"ICIPE," he says, "has taken steps to gain the necessary expertise in these emerging areas – both through the hiring of staff scientists and through partnerships with other scientific research organizations that have such expertise and are willing to work with us. Nevertheless, the explosive growth that biotechnology and genetic engineering have experienced over the past few decades means that research institutions like ours must focus ever-greater attention – and resources – on such cutting-edge endeavours if they are to remain relevant and effective."

ICIPE has gained an international reputation in insect physiology, chemical ecology and integrated pest management.



Insect science has changed dramatically over the past 34 years – and so too has the social and political environment in which ICIPE operates.

"When the institute was launched," notes Herren, "we were the only institution in Africa focusing exclusively on insect-related research. But that's no longer the case." Indeed several international research organizations are now addressing crop pest issues, all under the rubric of sustainability, but not in the holistic and integrated manner of ICIPE. Although the presence of these additional institutions has helped to advance the overall research agenda, ICIPE definitely has a head start when it comes to integration and taking a broader view of sustainable development. That's due to our interdisciplinary mandate and systems approach compared to other research institutions that tend to be more single crop- or discipline-based."

At the same time that ICIPE reaches out to other international organizations, it must also recognize that national scientific institutions and universities can also serve as important focal points of research on insect behaviour and environmentally friendly insect controls.

"ICIPE," adds Herren, "has a long history of capacity building for science." In fact, one of the institute's most successful programmes is the African Regional Postgraduate Programme in Insect Science (ARPPIS), established in 1983. To date, more than 270 scientists – with doctorate and masters' degrees from nearly 30 African universities from Casablanca to Cape Town – have received advanced training through ARPPIS in scientific fields that include molecular science, bioinformatics and behavioural and chemical ecology.

Many of these scientists have remained in Africa and now form the basis of a valuable insect research network. In the years ahead, ICIPE hopes to strengthen its ties with national research centres and universities – on the one hand, helping them to build their capacity and, on the other, partnering with them to help push the frontiers of insect-related research forward.

[CONTINUED PAGE 30]

Herren says that strengthening universities and creating a system of higher education free of political influence are keys to progress in Africa. “There is virtually no tradition of university research on the continent. As a result, it has been difficult, if not impossible, to nurture a culture of science. ICIPE’s postgraduate training programme represents a modest effort that we hope will help clear the way for universities that are both more effective and more involved in their societies.”

On another front of importance to ICIPE, funding organizations have also substantially altered their portfolios of grant projects over the past 34 years.

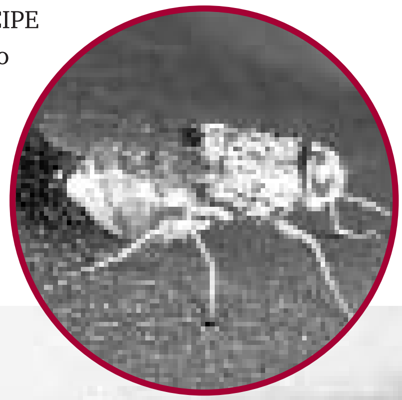
“When ICIPE was launched,” Herren notes, “funding organizations were much more willing to invest in basic science in general and agricultural science in particular. Today the time frames of funding organizations have become much shorter and they are placing greater emphasis on results on the ground. Agricultural research, meanwhile, has taken a backseat to other fields, such as information technology, which are viewed as an enabling technologies that can help poor countries in a variety of ways.”

While funding organizations and governments alike now realize that science-based development is a key to the future of well-being of developing countries both in sub-Saharan Africa and elsewhere, Herren says that “they have also become less willing to fund research initiatives that are driven largely by a quest for basic knowledge.”

All of these factors – dramatic advances in molecular science, biotechnology and genetic engineering, the growing strength of national and international research institutions, the increasing interest in building the capacity of Africa’s universities, and the emphasis that funding organizations now place on science that can have immediate impact on peoples’ lives – have conspired to push ICIPE in new directions.

“ICIPE,” says Herren, “is examining ways to build our scientific capacity in areas that are growing in prominence in the world of science but are not yet well established at the institute.”

“We have also sought ways to recalculate the balance between basic research and capacity building efforts (that is, human resource training) in ways that will not undermine our research capabilities, yet will enable us to be more responsive to funders’ expectations. As part of this effort, ICIPE is examining strategies to increase our visibility and strengthen our expertise in the social sciences. We are also working towards forging partnerships with other institutions that will allow us to extend our reach without over-extending our budget.”



The unexpected consequence of such a broad-ranging reconsideration of the institute’s purpose and agenda is that it has helped ICIPE, in some ways, to tailor its concerns ever-more tightly even as it has broadened its outlook.

First, while ICIPE was designed as an international research centre and the original signatories to ICIPE charter included such diverse countries as Brazil, Chile, Côte d'Ivoire, Kenya, Norway, Sweden, the Philippines, Sudan and Zambia, the institute's geographic niche thus far has remained in southern and eastern Africa. There has, however, been growing demand for ICIPE's research and capacity building capabilities from western and central Africa. As a result, in the years ahead, ICIPE's research and training agenda is likely to resonate across the entire continent. Over the long term, ICIPE hopes to be sanctioned as an African bioscience centre of excellence under the New Partnership for Africa's Development (NEPAD) and the African Union (AU).

> ***There has been growing demand for ICIPE's research and capacity building capabilities from western and central Africa.***

Second, ICIPE's focus on insect-related research remains the primary source of its recognition both within Africa and beyond. If ICIPE's expertise in insect research is compromised, all of its other endeavours – and, in fact, its credibility – will suffer.

ICIPE's recent initiatives have included programmes that involve research, development and marketing. These programmes range from initiatives to raise crop yields and reduce damage caused by insects to efforts to control disease vectors and improve the economic potential of such beneficial insects as bees and silkworms.

Here's a sampling of ICIPE's programmes, many of which are conducted jointly with other institutions:

Beans and okra. French beans and okra represent lucrative export markets for Kenyan farmers generating more than US$60 million a year in sales. However, that market is threatened by the frequent use of chemical pesticides, which are applied on average twelve times each year.

Such practices are not only expensive (accounting for nearly 15 percent of production costs) but pose a threat to farmers' health (some 20 percent of farm labourers enter health clinics each year with pesticide-related ailments). Moreover, extensive pesticide use also leaves chemical residues on plants that now exceed European Union import standards. As a result, pesticides present an economic threat as well.

To counteract these unwelcome trends, ICIPE has introduced an integrated pest management (IPM) system that reduces the annual number of pesticide applications from twelve to four. The system is based on extensive local knowledge of when the risks created by the pests are most acute. To date, nearly 350 farmers have been trained under an IPM programme operated in partnership with Kenya's Ministry of Agricultural and Horticultural Development Authority.

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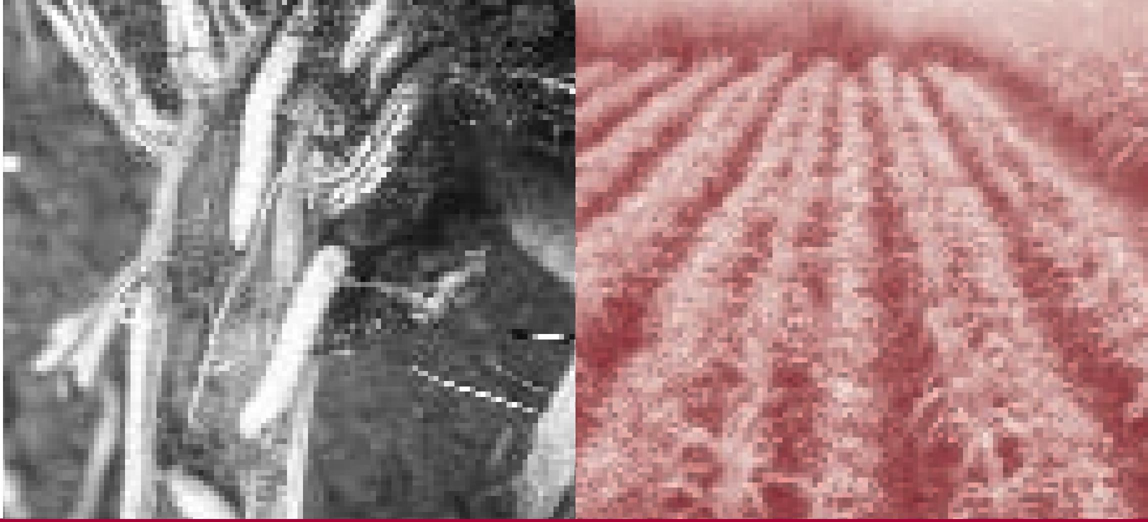


Push and pull. The voracious appetite of stemborers reduces maize yields in western Kenya by 20 to 40 percent – and, if the stemborers don't lay total waste to the crop then parasitic *Striga* weeds often take root on the exposed soil to finish the job.

To combat these deadly pests, ICIPE has developed a two-pronged 'push-pull' strategy. Stemborers are 'pushed' away from the maize crop through the cultivation of plants between the rows of maize that the stemborers detest: molasses grass and/or *Desmodium* (a fodder legume). At the same time, stemborers are 'pulled' towards the border of the cultivated fields by the planting of alluring Napier grass, which they savour. As added side-benefit, *Desmodium* suppresses the *Striga* that has caused major yield losses throughout Africa.

This push-pull technique, which is now used in several counties in east Africa, is expected to be adopted by 15,000 farmers by 2005 as sorghum and millet farmers join maize farmers in adopting this proven technique.

Silk and honey. Insects often get a bad rap. But many species are beneficial. Two of the best known examples are bees and silkworms.

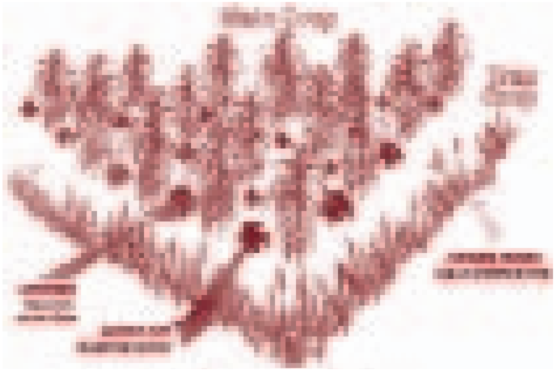
Beekeeping has been widely practiced in Africa but it has rarely yielded the quantity and quality of honey that are necessary to make it a reliable cash crop. And while silkmoth species are commonplace throughout Africa, silkworm farms have not been.

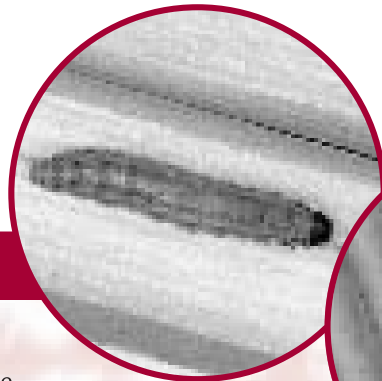
ICIPE decided to investigate both of these potential insect-based industries to determine if they could be transformed into a source of revenue for Africa's hard pressed rural residents. The first step was to assess the natural resource base – conduct surveys and genetic profiles (in east Africa as a test case) – to see if the region's ecology could sustain commercial beekeeping (apiculture) and silkworm farming (sericulture). The second step was to select the most appropriate races to ensure optimal production. For the production of honey, this meant the genetic selection and breeding of high-yielding queen bees; for the production of silk, this led to the selection of two silkmoth species domesticated in Asia and subsequently 'crossed' with carefully chosen African silkworm species to produce two ICIPE hybrids suitable for African conditions. The third step was to train African farmers in all aspects of the production cycle and to introduce them to effective marketing strategies.

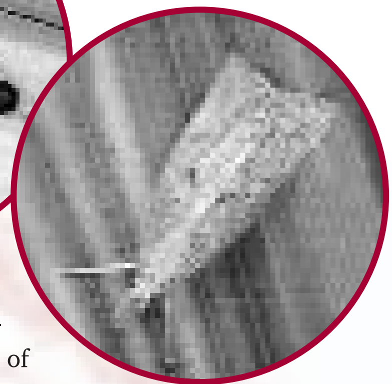
ICIPE has formulated its activities on the '4-H paradigm', dedicated to the 'health' of humans, animals, plants and the environment.

To date, with the help of Uganda's National Agricultural Research Organization and Kenya's Ministry of Agriculture, more than 10,000 farmers in 24 African countries have participated in this initiative, earning much-needed additional income.

Rice, cattle and malaria. In the central highlands of Kenya, nearly 25 percent of all children are infected with malaria parasites and nearly half of them ultimately display symptoms of the disease. Irrigated rice fields, which have spread across the region to improve







rice yields, have also spawned a 30- to 300-fold increase in mosquito populations in nearby villages. But to the surprise and delight of residents and public health officials alike, the rise in mosquito populations has not caused an increase in malaria cases. In fact, the incidence of malaria in these villages is actually lower – much lower – than in non-irrigated villages (0-9 percent compared to 17-54 percent).

Joint investigations by ICIPE and the University of Nairobi uncovered why this so. Mosquitos, it turns out, prefer to take their blood meal from cattle grazing on the land adjacent to the rice fields instead of humans working and living nearby. As a result, the introduction of irrigation has not only increased rice yields but decreased the incidence of malaria even as mosquito populations have risen dramatically.

ICIPE has launched programmes to introduce cattle alongside farm fields as an additional strategy for curbing malaria. Together with the maintenance of irrigation ditches so that the water continues to flow freely, and the use of natural and synthetic chemical repellents and larvicidal agents, ICIPE hopes to assemble a complete arsenal of tools to fight the scourge of malaria, which kills nearly one million Africans each year.

"ICIPE," notes Herren, "has formulated its complex cross-cutting activities on an intellectual framework that the centre refers to as the '4-H paradigm' dedicated to the 'health' of humans, animals, plants and the environment."

"Issues of food security and malnutrition, disease, poverty and environmental degradation, which are of acute concern to Africa," he explains, "cannot be adequately addressed without a full appreciation of the many integrated pest and vector management techniques that have been central to the work of ICIPE since its inception 34 years ago."

"The institute's integrated mandate – to create knowledge, build capacity and forge effective programmes and policies for sustained economic growth – has always been driven by one overarching goal: to improve the well-being of the world's most marginalized people."

"ICIPE," Herren continues, "believes that it has made – and will continue to make – a difference by focusing its efforts not just on the people themselves but on the planet's most numerous organisms: insects, which are both a blessing and a bane."

"This much we do know: We won't be able to meet future food demands, which are expected to rise 40 percent over the next 15 years, unless we learn how to manage insects. Bees, fruitflies, mosquitos, whiteflies, tsetse flies, silkworms, stemborers, termites... The list is endless and so too is the challenge." ■

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SCIENCE AT SEA IN TANZANIA

FOUNDED 25 YEARS AGO, THE UNIVERSITY OF DAR ES SALAAM'S INSTITUTE OF MARINE SCIENCES IS SLOWLY CARVING OUT AN INTERNATIONAL REPUTATION FOR ITSELF. IN 2002, IT WAS ONE OF SIX RESEARCH UNITS IN LEAST DEVELOPED COUNTRIES TO BENEFIT FROM THE AWARD OF A TWAS GRANT. AN OUTLINE OF THE INSTITUTE'S DEVELOPMENT AND RESEARCH PROGRAMMES FOLLOWS.

The coastline of mainland Tanzania measures more than 800 kilometres. Three islands lying 25 to 50 kilometres offshore, Unguja and Pemba (which together make up Zanzibar) and Mafia, add 600 kilometres to this total. The idyllic tropical setting, with long, sandy beaches shaded by coconut palms, is enhanced by a fringe of coral reefs, broken only where the rivers that flow across Tanzania's narrow coastal plain spill into the sea.

Zanzibar itself is an increasingly popular tourist destination, with people flocking to sample the delights of scuba diving among the coral reefs and to savour the flavour – literally – of the island's most famous exports, spices such as cinnamon, cloves and vanilla.

Against this backdrop, there are serious development issues that need to be addressed in an integrated and systematic manner if the patchwork of ecosystems – from sand dunes to seagrass beds and coral reefs to mangrove swamps – is to survive increasing pressure from a growing human population.

Some 8 million people now live in Tanzania's 15 to 25 kilometre-wide coastal plain, a population that could rise to 16 million by 2010. These people will be catching decreasing fish stocks for food, cutting down mangrove forests for fuelwood, mining beach sand for building materials, and farming the limited land available.

Imports and exports from the land-locked countries of Burundi, Malawi, Rwanda and Uganda must also arrive and depart from ports on the Tanzanian coast that is heavily used by oil tankers and other ships.

"There is a serious paucity of data on the ocean topography, coastal dynamics and other physico-chemical conditions of Tanzanian waters," says Alfred Muzuka of Tanzania's Institute of Marine Sciences. "Lack of information on the tides and currents of coastal waters and coastal geology, for instance, has been singled out as a major cause of the failed attempts to replant mangrove trees."

RESEARCH REQUIRED

Muzuka is a senior research fellow at the Institute of Marine Sciences (IMS), located on the island of Zanzibar. His research group is one of six that were awarded a TWAS Research Unit in Least Developed Countries grant in 2003. (For details of the others, see *TWAS Newsletter* Vol. 15, No. 4, pp. 9-13). Having put the first instalment of US$30,000 to good use, TWAS has just approved the award for a second year and allotted another US$30,000 to the institute.

"Tanzania's coastal waters are rich in marine resources and important ecosystems," continues Muzuka. "The relatiponship between these ecosystems and the productivity of the coastal waters is intrinsically linked to the physics of the coastal waters. It is therefore very important for the IMS to be given the necessary support to study and collect the information needed to understand the dominant physico-chemical processes in these waters."

IMS research now plays a major role in helping Tanzania identify and address issues related to the marine environment.

Unravelling these processes is a major priority of the IMS. Established in 1979 to strengthen marine science research, the IMS has three major objectives:

- Undertake research in all aspects of marine sciences.
- Provide undergraduate and postgraduate training to boost the nation's expertise in marine sciences.
- Offer advisory and consultancy services in marine affairs.

Based on these aims, IMS research now plays a major role in helping the country identify and address issues related to the marine environment. The expertise of the institute's scientists, many of whom have trained abroad but returned to their home nation, also enables Tanzania to contribute to national, regional and international programmes devoted to the study of the oceans and their resources. Through research, advice and direct intervention, IMS scientists also assist Tanzania's food security and poverty alleviation programmes.


Alfred Muzuka

The institution's research activities are divided into three sections:

- Living Resources and Ecology, which includes marine botany and fisheries research.
- Chemical and Environmental Marine Sciences, which includes chemical oceanography and marine pollution studies.
- Physical and Applied Marine Sciences, which includes physical oceanography, marine geology and ocean engineering.

Muzuka's research falls into this last section – the institute's largest – and it was this group that was awarded the TWAS grant. Specifically, the grant was given for: "The study of environmental changes in Tanzanian coastal waters for the sustainable utilization of marine resources and the conservation of coastal ecosystems," explains Muzuka.

"The grant enabled us to buy an automatic elemental analyser," he adds. "Now we can quickly and accurately determine the proportions of such elements as carbon, hydrogen, oxygen, nitrogen and sulphur that play important roles in biological processes in marine and other environments."

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PROTECTED ZONES

The University of Dar es Salaam's Institute of Marine Sciences (IMS) has been instrumental in the establishment of various marine parks and conservation areas. Among these are the Mafia Island Marine Park and Zanzibar's Menai Bay Conservation Area.

Mafia Island Marine Park was created in 1995 with assistance from the World Wildlife Fund (WWF), which continues to provide human and financial resources for its development and maintenance. Covering more than 800 square kilometres, the park is composed of mangrove and coastal forests, seagrass beds, coral reefs, intertidal reef flats and a lagoon.

These habitats are home to some 400 species of fish and many types of marine invertebrate, making the park one of the richest ecosystems on the east African coast. In addition, Mafia Island is also a nesting area for both green and hawksbill turtles. Since 2001, some 5,000 young turtles have successfully hatched from 200 protected nests.

Before the establishment of this park, dynamite fishing and coral mining caused substantial damage to the marine environment. Dynamite fishing has since been outlawed. Fisheries were also being harmed by the use of small-mesh beach-seine nets that removed juvenile fish and damaged coral reef and seagrass habitats. With WWF assistance, these fishing practices are being phased out and management plans are being put in place to help the 18,000 islanders develop more sustainable fishing methods and such alternative sources of income as seaweed farming and tourism.

IMS scientists have been directly involved in environmental impact assessments for the building of a park headquarters and a boathouse and boat-launching ramp. IMS officials continue to play an active role in both the Mafia Island Marine Park and the Menai Bay Conservation Area as members of their respective advisory committees. ■

Before this, whenever IMS scientists required data on such elements, they had to pay for the analysis to be carried out in laboratories abroad.

"This was both costly and took more time for the analyses to be completed," says Muzuka.

"With this year's grant money," continues Muzuka, "we plan to buy an atomic absorption spectrometer. All of this equipment will enhance the research capability and output of the institute."

Understanding the dynamics of marine sediments is important for many reasons. "Sedimentation in harbours and navigational channels is a constant headache, requiring continuous efforts to keep these transportation routes clear," says Muzuka. "In other areas, coastal erosion is a serious problem. Forest clearance on Maziwi Island, for example, greatly accelerated erosion and contributed to the island's eventual disappearance."

In addition, there has been a construction boom in Tanzania since the 1980s, the raw materials for which – sands and gravel – have been extracted from rivers and streams. "This deprives the beaches of the sand and silt they require to maintain their equilibrium," adds Muzuka.

One inter-disciplinary survey has already determined that coastal communities are aware that some of their activities contribute to the deterioration of local beaches. However, the survey also indicated that the people lack knowledge of how to mitigate these effects. To counter this, the IMS has produced videos and brochures explaining how communities should care for their beaches. The institute is also playing a key role in designing structures to protect against coastal erosion.

In other areas, landmass is increasing due to siltation. Muzuka's colleague in the Physical and Applied Marine Sciences section, Yohana Shagude, for example, has used Landsat satellite images taken in 1986, 1998, 1999 and 2000 to compare the outline of the Ruvu River delta.

The images show that, especially between 1986 and 1998, the landmass increased by about one square kilometre every three years. What is not known is whether this growth occurred gradually, or was the result of the extreme rain that fell – and the landslides it caused – during the 1997-98 El Niño Southern Oscillation event.

Such studies – related to the long-term effects of climate change – are another aspect of the work of the IMS.

"A change in the world's weather pattern will result in variations in the water discharge and sediment supply to the coastal zone," explains Muzuka. "One aim of the project for which TWAS provided the grant is to document past and present changes in the intensity and direction of monsoon winds and their impact on the productivity of the coastal waters. We will also try to determine the degree to which each coastal segment is at risk of inundation from storm surges and river flooding, and classify areas of the coastline according to their degree of vulnerability to erosion and flooding."

IMS aims to classify areas of the coastline according to their degree of vulnerability to erosion and flooding.

With the predicted increase in the human population of coastal Tanzania and the conflicts of interest of various land uses that will likely ensue, such studies will allow the Tanzanian government to decide, for example, which areas are important for water catchment, which areas should not be settled because they are at risk from flooding, and which areas are best suited to agricultural production.

LIFE SCIENCES

As human population increases, so does the pressure on the area's flora and fauna. The IMS Living Resources and Ecology Section is mandated to measure these impacts and design ways of reducing or eliminating them.

Critical pressures include the use of destructive fishing gear, pollution from untreated waste and agricultural run-off, and coral mining – a source of lime and cement for the construction industry.

Apart from assessing the fish catches in the waters around Zanzibar, and tracking population fluctuations of the major commercial species, scientists in the Living Resources and Ecology section have also initiated pilot projects for developing environmentally friendly aquaculture. Fish farming has great potential in Tanzania – not only as a source of protein for the growing population but as an opportunity for entrepreneurs to make money and provide jobs for local people.

Partners are also being sought to develop *Spirolina* farming. This single-celled blue-green alga, which grows in warm, brackish water, contains more than 60 percent protein (by comparison, beef contains only 22 percent protein) and many other essential nutrients such as vitamin B_{12}. In addition, the photosynthetic efficiency of *Spirulina* is two to three times greater than crops such as soybean.

Another marine-related industry has already proven itself to be environmentally friendly – seaweed cultivation. The practice, which was introduced into Zanzibar in 1989, now accounts for 20 percent of the island's annual export earnings. Moreover, throughout Tanzania, it provides employment for some 30,000

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people. Women, in particular, are involved in planting and harvesting the crops and many are becoming their families' main breadwinners. Tanzania now exports some 5,000 tonnes of dry seaweed each year, mainly for the extraction of carrageenan for the food and pharmaceutical industries.

IMS scientists have been instrumental in introducing seaweed farming into the Lindi and Mtwara areas of southern Tanzania. In addition, they have launched a research project aimed at increasing the genetic base of the cultivated species (*Kappaphycus alvarezii* and *Eucheuma denticulatum*) that will allow the seaweeds to withstand potential environmental changes and diseases. The institute has also put in place monitoring programmes to assess the environmental and economic impacts of seaweed production.

Tanzania exports some 5,000 tonnes of dry seaweed each year, mainly for the food and pharmaceutical industries.

INTERNATIONAL TIES

Like many institutions in the South, IMS is supported through a combination of government funds and donor contributions. The Swedish International Development Cooperation Agency - Department for Research Cooperation (Sida-SAREC), for example, supports the IMS through a bilateral programme. Some five PhD students come to IMS each year, mainly from Sweden, to carry out fieldwork using the institute's facilities. Likewise, the Canadian International Development Agency (CIDA) has been instrumental in the institution's long-term development. Muzuka himself also has strong links with Canada.


Alfonse Dubi

"I received my MSc degree in geochemistry from the Memorial University of Newfoundland and my PhD from the University of Quebec at Montreal," he says proudly. Thanks to this personal link, the Memorial University of Newfoundland has played a key role in supporting the institute's technical and human capacity building and research efforts.

The staff's international outlook has helped enhance the institute's reputation abroad. In a prime example of South-South collaboration, Alfonse Dubi, the institute's director has been invited to teach courses at the University of Mauritius and the University of Namibia. IMS also collabo-

rates with the School for International Training in Vermont, USA, part of the US-based World Learning organization, providing facilities and expertise for a 15-week summer study course.

Closer to home, IMS scientists helped establish the Western Indian Ocean Marine Science Association (WIOMSA) in 1992. This organization, which is a member of the Third World Network of Scientific Organizations (TWNSO), provides its members with research funds and travel grants to facilitate collaboration among institutions. One of Muzuka's research projects, for example, which is examining the distribution of heavy minerals along the west coasts of Unguja and Pemba Islands, is funded by WIOMSA. The information gathered will help Muzuka work out the geological history of the region and identify potential sources of heavy minerals on the two islands.

IMS is also involved with other regional programmes, particularly the marine-related projects of the Eastern African Action Plan, funded largely by the United Nations Environmental Programme (UNEP). In addition, coral reef research is funded by the World Bank and the Global Environment Facility (GEF), while other programmes are funded by the International Oceanographic Commission (IOC).

INTEGRATED MANAGEMENT

"The coastal zone of Tanzania is threatened by a combination of anthropogenic and climatic factors, but it also has the potential to provide a vast number of valuable resources. Therefore, proper management, based on good quality scientific data, is vital," says Muzuka. "Thanks to the work of IMS scientists, the importance of coastal zone management is now recognized at the highest political levels. Coastal zone management issues have been identified and projects initiated throughout the region."

These projects – many of which involve the IMS in either research or advisory roles – cover a wide spectrum of issues including not only the marine sciences but also environmental economics and socio-anthropological research on coastal zone resource use. For example, IMS is chairing the Science and Technical Working Group of the Tanzania Coastal Management Partnership (TCMP) focusing on such issues as the management of mangroves and fisheries.

"With its qualified staff and broad expertise, modern facilities and increasingly sophisticated laboratory equipment, and network of collaborating partners in both the North and the South, the IMS is well placed to integrate all this data into meaningful action," claims Muzuka.

Only through such integrated management plans can Tanzania – and other Third World countries – develop and utilize their natural resources in a sustainable manner.

Helping its host nation – and others in the region – in this way, as the IMS is doing, is surely a worthy aim for all scientific research institutes. ■

For additional information:
www.ims.udsm.ac.tz

ETHIOPIAN CONNECTIONS

ETHIOPIAN-BORN, EDEMARIAM TSEGA (TWAS FELLOW 1987) WORKED FOR 23 YEARS AS A MEDICAL DOCTOR IN HIS HOME COUNTRY BEFORE LEAVING TO LIVE IN CANADA. THE ICSU-TWAS-UNESCO VISITING PROFESSORSHIP PROGRAMME (RECENTLY RENAMED THE VISITING SCIENTIST PROGRAMME) HAS ALLOWED HIM TO RETURN TO HIS HOME COUNTRY ON FIVE OCCASIONS OVER THE PAST SIX YEARS TO HELP IMPROVE TEACHING PATIENT CARE AT A REGIONAL MEDICAL FACILITY.

Gondar, in northwest Ethiopia, was once the country's capital city. Founded in 1636 by the Ethiopian emperor Fasiladas, it became a centre for culture, trade and commerce. The city now boasts palaces, castles, churches and a library, all of which date back to the 17th century.

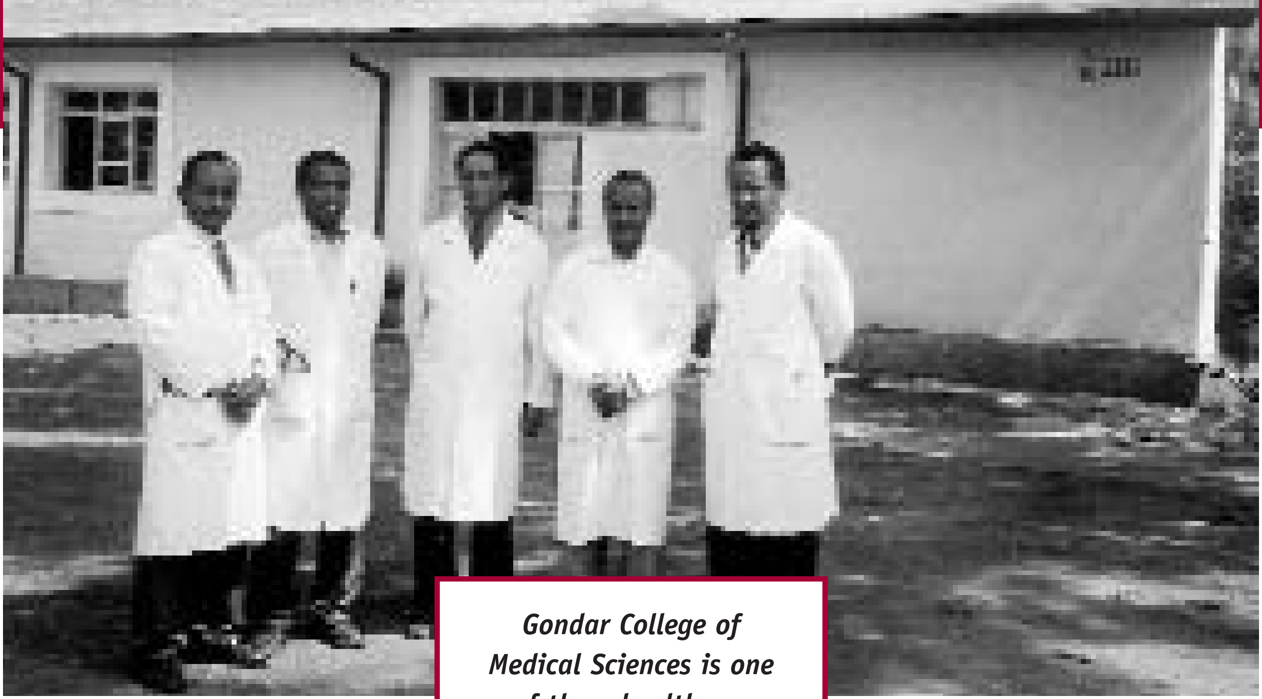
Edemariam Tsega

More recently, however, this once-flourishing city has been afflicted by a long period of stagnation and decline. Even its status of capital city was lost, first to Mekele, also in the north, and then, in 1892, to the present-day capital, Addis Ababa.

Gondar is now the fourth largest city in Ethiopia, with a population of some 140,000. It is also home to the Gondar College of Medical Sciences (GCMS), one of three healthcare training centres in Ethiopia.

Founded in 1954 with funds from the Ethiopian government and international donors, the centre initially trained public health officers and community nurses to work throughout rural Ethiopia. In 1978 it was upgraded to a medical faculty.

"At present, the college trains medical doctors, public health officers, clinical nurses, public health nurses, environmental health workers, midwives, pharmacists and laboratory technicians, with an annual enrolment of about 50 students in each programme," explains Edemariam Tsega (TWAS Fellow 1987). "While the number of programmes and students continues to increase, however, the number of teachers has declined as a result of the rural location of the college and the continuous brain drain. This is a serious, ongoing problem, especially as the college serves as a medical centre for the entire Gondar region, which has a population of 4.2 million."



Gondar College of Medical Sciences is one of three healthcare training centres in Ethiopia.

TWAS PROGRAMME

Tsega, who completed his elementary schooling in Gondar before moving to Addis Ababa to attend high school and college, is now professor of medicine at Henderson General Hospital, McMaster University, Ontario, Canada. An expert in liver and gastrointestinal diseases, he has returned to Gondar and GCMS no fewer than five times since 1999, assisted by a programme funded by TWAS, the International Council for Science (ICSU) and the United Nations Educational Scientific and Cultural Organization (UNESCO).

The scheme, initially called the Visiting Professorship Programme and now renamed the Visiting Scientist Programme, provides institutions and research groups in developing countries, especially least developed countries (LDCs) such as Ethiopia, with the opportunity to establish long term links with leading scientists to help build scientific capacity in their countries. Earlier this year, the United Nations University's Institute for Advanced Studies (UNU/IAS) joined the Visiting Scientist Programme as the fourth co-sponsoring organization.

"The visiting scientist is expected to deliver a series of updated lectures and seminars, as well as interact with members of the host institutions, with the aim of strengthening the existing research activities and/or assisting the establishment of new lines of research," adds Tsega.

During his five visits to Gondar, each of which lasted four to six weeks, Tsega has certainly achieved this – and more. His efforts have made a lasting difference to the coursework undertaken by medical students, the treatment of patients, and even the college's infrastructure.

TRAINING

Before travelling to Ethiopia, Tsega prepares a series of lectures designed to update the knowledge of medical personnel at GCMS – both staff and students – in topical subjects. Among the subjects he has focused on are the hepatitis viruses B and C, *Helicobacter pylori*, a bacterium that is thought to cause peptic ulcers, Crohn's disease, a poorly understood inflammation of the gastrointestinal tract that seems to have both genetic and environmental causes, and porphyria cutanea tarda, a liver disorder. All of these ailments are common in Ethiopia.

"The topics were discussed with the head of the Department of Internal Medicine at GCMS to make sure they were relevant to staff and medical students," says Tsega. "In addition, many of the lectures were based on evidence from clinical research in which I had been involved while working at Addis Ababa University."

Apart from these lectures, Tsega has been more directly involved in the day-to-day teaching of medical students. During his first and second visits in 1999 and 2000, for example, he taught a short course in physical diagnosis that included lectures in the morning and practical demonstrations on patients in the afternoons.

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He also acted as an external examiner for the final year qualifying examination.

"Because there was a shortage of clinical instructors," he adds, "my presence was more than welcomed."

Tsega's third visit, in 2001, was also timed to remedy a severe manpower constraint. "I spent most of my time with the final year medical students focusing on bedside teaching and management sessions," he notes. "At that time there were 24 students in the final year class but only four senior staff and two junior staff in the Department of Internal Medicine. In addition to teaching the final year students, the staff were involved in a number of other activities, including field work and teaching public health officers."

Thanks to Tsega's visits, increased attention is also being given to medical ethics at GCMS.

"During my first visit," he informs, "I proposed the formation of a medical ethics committee to clear research proposals. The problem was that proposals had to be sent to the University of Addis Ababa for approval, which obviously caused long delays and dissatisfaction. By the time of my second visit, I was happy to see that a committee consisting of GCMS faculty had been set up."

His lectures on medical ethics subsequently led to the creation of a medical ethics programme that has been incorporated into the medical school's curriculum.

Despite improvements to the curriculum and personal involvement with teaching, however, the brain drain problem remains stubbornly in place.

"In my view, a long-term and sustainable solution for the GCMS is the establishment of a postgraduate programme," noted Tsega after his first visit there. "Such a programme would provide a continuous supply of teachers. In turn, this would upgrade the standard of medical education, stimulate a higher level of clinical and allied research and geneally improve the level of the health service."

To initiate such a programme, Tsega envisaged obtaining the assistance of a foreign university for four to six years. "Experienced teachers will be needed," he explained, "each spending six to 12 months at GCMS. In addition, selected Ethiopian teachers would spend three to six months at the collaborating university to acquire specific skills and knowledge."

Five years on, a draft curriculum for such a postgraduate programme has been prepared and Tsega is

actively searching for volunteer expatriate and other qualified teachers to assist during the initial phase of the programme.

"So far my attempts have focused on Ethiopian physicians living in North America," he says. "Their responses have been encouraging."

PATIENT CARE

Improving the knowledge and skills of staff members and newly qualified doctors is one thing. Equipping them to carry out their vocation to the best of their ability is another.

During Tsega's first visit to GCMS, basic medical instruments were lacking not only at the college, but throughout the entire Gondar region. These instruments included various types of endoscopes – fibre-optic devices used for internal examinations of patients with liver and intestinal problems. An upper gastrointestinal endoscope, for example, can be used to diagnose such ailments as peptic ulcers, while a laparoscope can be inserted through an incision into the body cavity to view the liver and other organs.

"Initially, none of these expensive items were available and we had to buy an upper gastrointestinal endoscope from abroad," explains Tsega. "Just before the endoscopes's arrival, basic theoretical and practical instructions were given to two nurses and four senior staff from the departments of surgery and internal medicine by borrowing equipment from the University of Addis Ababa."

During his third and fourth visits to Gondar, eight additional staff received training and can now perform

upper gastrointestinal endoscopic procedures safely and independently in rooms designated for this purpose alone.

"Today there is a regular endoscopic service for patients coming from surrounding areas, thus avoiding referral to centres in Addis Ababa, which is about 720 kilometres from Gondar," says Tsega. "This is a remarkable contribution. The college now provides a service that was previously unavailable," he adds.

Tsega has also been active in soliciting donations of other medical equipment, including five anaesthesia machines, three pulse oximeters (used to measure the amount of oxygen in the blood), an echocardiogram, a ventilator and videocassettes designed to help teach physical diagnosis to medical students.

The college now provides a regular endoscopic service for patients that was previously unavailable.

BUILDINGS

Not content with reforming the institute's teaching curriculum and patient care practices, Tsega has also set about helping to improve the infrastructure of the teaching hospital.

"The hospital, situated within the premises of GCMS, has some 350 beds but the sprawling old bungalows have served their time and require renovation," explains Tsega. "In addition, the buildings are inconvenient for both teaching and patient care."

To remedy this situation, Tsega has mobilized expatriate Ethiopians living in North America, particularly members of the nongovernmental Gondar Development and Cooperation Organization (GDCO) based in the United States.

"I proposed that the GDCO raise funds to build a modern hospital on the GCMS campus," says Tsega. "There was an enthusiastic response and the GDCO has now accepted this as its most important project. Funds are already being raised from voluntary donors."

A site for the new building was also identified and plans were drawn up by another volunteer – a locally-born architect.

More than that, building has already commenced.

"I was given the honour, together with the local government representative, to lay the cornerstone of the new hospital in a ceremony attended by representatives of the GCMS and local chapters of the GDCO," says Tsega proudly.

These are not the only changes that Tsega has witnessed during his time as a TWAS visiting scientist. New student dormitories have been built, as have guest houses, meeting and lecture halls, laboratories and a library. Indeed, during his first visit to GCMS, Tsega proposed that all the institute's publications be compiled and catalogued. This task was almost completed by the time of his fourth visit in 2002 and will soon be available on the internet. In addition, there have been efforts to link researchers at GCMS with others working abroad, particularly in Canada and the United States.

"I have seen encouraging changes during the last three years," adds Tsega. "At present, for example, the new Gondar University is being built with World Bank funding, and GCMS has been integrated into the university, leading to the recent change of name to Gondar University College."

"Leaving a family behind to spend all my annual leave visiting and working abroad for five consecutive years has been a significant sacrifice," says Tsega. "But I have no regrets. All the contributions I have made in Gondar provide me with a great deal of personal and professional satisfaction. I strongly recommend that the ICSU-TWAS-UNESCO – and now UNU/IAS – programme continues." ■

POWER TO THE PEOPLE IN SENEGAL AND ZIMBABWE

IN OCTOBER 2002, SCIENTISTS FROM 12 COUNTRIES VISITED TRIESTE TO PRESENT CASE STUDIES ON THE APPLICATION OF RENEWABLE ENERGY TECHNOLGIES IN THEIR NATIONS. WE REVISIT TWO OF THESE CASE STUDIES, ONE IN SENEGAL, THE OTHER IN ZIMBABWE, TO ASSESS HOW THESE EFFORTS HAVE FARED OVER THE PAST TWO YEARS.

Since the days of the first European explorers, Africa has been known as the 'Dark Continent'. Today, thanks in part to satellite imagery, the continent is as well mapped as any other. Even so, satellites reveal that the 'dark' epithet remains an apt description. Images taken at night show how humankind has spread across the planet. Everywhere, the world's landmasses are dotted with bright lights, from China, Japan and Korea in the east, across India and Europe to Brazil and the United States in the west. Only the world's major deserts, forests and Arctic lands remain dark. And Africa.

In sub-Saharan Africa, an estimated 70 percent of the population live in rural areas and less than 10 percent of these have access to reliable sources of electricity. Conventional strategies for developing electricity grids are best suited for densely populated urban areas where large customer bases justify heavy capital expenditures. In much of the developing world, rural populations are just too dispersed and too isolated to benefit from such urban-based infrastructure. Small, decentralized systems based on renewable energy sources, on the other hand, can provide power to remote villages and even single households.

Against this background, in October 2002, the Third World Network of Scientific Organizations (TWNSO) held a workshop on renewable energy at which 14 case studies were presented. These were eventually published by the United Nations Development Programme's Special Unit for Technical Cooperation among Developing Coun-

tries (UNDP/TCDC), as volume 8 – *Examples of Successful Uses of Renewable Energy Sources in the South* – in the UNDP/TWAS/TWNSO series of *Sharing Innovative Experiences* (see *tcdc.undp.org/widenew/sharingsearch.html*).

Among the 14 case studies in the publication, four were based on African initiatives. Here we focus on two of these, from Senegal and Zimbabwe, reporting how the projects have developed over the past two years.

Comparisons between the experiences in the two countries are particularly revealing because both case studies featured projects aimed at bringing solar power to isolated rural communities and both relied on donor funds to provide the energy-producing solar panels and other hardware.

Specifically, the Energy Directorate, the implementing institution in Senegal, received funds and technical support from the Japanese International Cooperation Agency (JICA) and other Japanese organizations. The Energy Technology Institute (ETI) of the Scientific and Industrial Research and Development Centre (SIRDC) in Zimbabwe received funds from the Dutch embassy in Harare, Zimbabwe.

In 2001, a mere 300 of Senegal's 13,000 villages had access to a reliable source of electricity.

In the past, development projects that relied heavily on donor funding were typically successful in the short term, but the issue of 'sustainability' after the project ended was often not addressed. Clearly lessons have been learned from these past efforts, as both the Senegalese Energy Directorate and SIRDC in Zimbabwe have adapted their original case study projects and expanded the number of people benefiting from reliable sources of renewable energy.

MAR ISLAND, SENEGAL

Senegal has a population of more than 10 million, and more than half of these people live in rural areas. In 2001, 55 percent of urban households had access to electricity compared to only 7 percent of rural households. A mere 300 of Senegal's 13,000 villages had access to a reliable source of electricity, whether through a connection to the national grid or from a local electricity generating company.

Between 2000 and 2002, as reported in the original case study, the Energy Directorate implemented a JICA-sponsored project to bring solar power to Mar Island, a 30-minute boat ride from Ndagane, a village on the coast of Senegal that is 160 kilometres from the capital, Dakar. The site was chosen because there were no plans to connect the island to the national grid within the next 10 years.

With partners such as the Senegalese Agency for Rural Electrification (ASER), SENELEC, the national power company, and Matforce, a private company hired to maintain the solar power infrastructure, the Energy Directorate's project permitted the installation of solar home systems capable of supplying enough electricity to run up to seven lamps and either a television or radio in some 95 homes.

Users paid an initial sum of about US$80, plus a monthly fee of US$8. These payments are used by Matforce – which has been contracted for 20 years – to cover maintenance and replacement costs. The funds are also designed to ensure the sustainability of the project beyond the initial two-year period.

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With users reporting improved night-time working conditions and improved learning conditions for schoolchildren, as well as reduced petrol consumption because generators were no longer required, there was a waiting list of some 200 more homes by the time funding from JICA ceased in 2002.

The original case study also reported plans by ASER to take over the pilot project and continue increasing the supply of solar home systems to other rural areas of Senegal. So what has happened since?

For the first time, villagers can listen to weather forecasts, market conditions and agricultural and health advice.

UPDATE – SENEGAL

ASER did indeed carry on the rural electrification project, which has expanded dramatically since the case study was presented two years ago.

With funds from the Spanish government and the involvement of two Spanish companies with expertise in solar power, Atersa and Isofotón, a satellite orbiting over west Africa during the hours of darkness would detect a new bright spot off the coast of Senegal in the Saloum River delta, corresponding to Mar Island.

“With the Isofotón project, the demand for 200 additional photovoltaic systems, which had remained unsatisfied at the end of the JICA-funded project, has been met,” says Louis Seck, chief of the Solar Energy Division of Senegal’s Ministry of Energy and Mines, who was responsible for coordinating the original JICA project. “Better yet, a request was made for an additional 87 solar home systems. These were also supplied and installed.”

As with the pilot project, users paid an initial fee for the installation of the solar home system and continue to pay monthly fees based on the amount of electricity used. The price of the photovoltaic systems has been reviewed and set at about US$1 so that more people could afford to have them installed.

“With the Atersa project,” continues Seck, “some solar-powered street lamps were also installed on Mar Island.”

In addition to well-lit homes and streets, Mar Island – and other islands in the Saloum River delta – now boast hybrid photovoltaic/diesel power units, claimed to be the most technologically advanced in Africa, solar power stations, desalination systems for the provision of safe drinking water powered by photovoltaic cells, cold rooms for keeping food fresh, and solar-powered community buildings such as schools, clinics, youth hostel and religious centres, all of which help meet the energy needs of more than 10,000 people.

Not only that, but the pilot project has spurred the roll out of solar powered systems to other parts of Senegal. Together, Atersa and Isofotón are installing more than 2,500 street lamps, each powered by a 75 Watt photovoltaic module. In addition, more than 600 community centres in some 230 villages in Senegal will each be powered by a combination of four 85 Watt modules.

And the roll out is set to continue. A project being coordinated by ASER aims to gradually increase the number of Senegal’s 324 rural counties with access to electricity from fewer than 30 today to 50 by 2005, and to 200 by 2024. Each year, it is envisioned that 30 more villages will be ‘connected’.

“The reason we have decided to install electricity in community centres, including schools,” says Madické Niang, Senegal’s Minister of Mining and Energy, “is to

spread the use of new technologies in the rural environment and to promote literacy among the population."

With access to reliable sources of electricity, not only can school children and students continue studying during the hours of darkness, but radios and televisions are now providing access to educational programmes. For the first time, villagers can listen to weather forecasts, market conditions and agricultural and health advice – and take informed decisions about issues critical not only to their survival, but also to the development of their businesses and improvement of their livelihoods.

MUSINAMI CLINIC, ZIMBABWE

The Mhondoro solar photovoltaic charging station, located about 100 kilometres southwest of Harare, was the first of its kind in Zimbabwe.

Implemented by the Energy Technology Institute (ETI) of Zimbabwe's Scientific and Industrial Research and Development Centre (SIRDC), the project was based on the concept of reducing the initial costs of small-scale solar systems for home use. A solar home lighting system, for example, is based on four units, with the solar panel itself accounting for about half the cost – some US$20, which is beyond the reach of most people.

To sidestep this problem, 12 centrally located 83 Watt solar panels were installed – all using local labour – and a battery recharging service was set up. Customers pay a fee to charge their batteries from the solar panels and these batteries are then used to power home lighting in the 50 households that are participating in the programme.

The solar panels also provide power for Musinami Clinic, which serves some 250 households in 23 villages. Before the installation of the solar system, the clinic had no electricity and night time emergencies or births all had to be attended to by candle light or using kerosene lamps.

From the beginning, the project encouraged community involvement. Today local committees are responsible for maintaining the photovoltaic system and collecting fees from users. Other than tapping power to light homes and run radio and television sets, people are assessing other ways of using the power in small commercial enterprises.

"The success of the project has also had an effect on national policy makers and on their approach to disseminating renewable energy in rural areas," said G.B. Makokoro, senior research scientist at ETI.

UPDATE – ZIMBABWE

"I am pleased to report that another central charging station has been designed and installed in a clinic in Rusitu Valley in the eastern highlands, 300 kilometres southeast of Harare," says ETI director, Mosad Elmissiry. "The solar charging station in this project was designed to power a clinic and 12 nearby rural houses. Unlike the Mhondoro project, the station, its supporting frame and control and distribution boards were assembled at SIRDC rather than using local artisans. The installation and wiring were done on site with assistance from the local community, however," he adds.

In addition, clinic personnel have been trained to carry out simple maintenance procedures to keep the station running smoothly.

This latest project also differed from the Mhondoro scheme because it included the distribution of various types of energy efficient biomass stoves. As well as reducing the amount of smoke in houses – a factor that has been linked to poor health, mainly in women – more efficient stoves will also help women spend less time each day collecting fuelwood, hopefully providing them with more time for other activities while reducing the impact on the local environment. Women are also being asked to provide feedback on the different stove designs. Local artisans will be trained to make and market the most popular types.

Another commercial enterprise that is being developed now that the area has access to reliable electricity involves fruit processing.

"Solar-powered ovens used to dry fruit and vegetables are now empowering the local community economically. Farm produce is now dried and sold out of season, fetching higher prices," explains Elmissiry. A fruit canning project has also been initiated. The result is that farmers in the area now grow more fruit trees because they are assured of a market for their crops.

Once isolated from both the national power grid and distant markets, both the Mhondoro and Rusitu

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With reliable sources of power, local people are given the capacity to begin improving their own well-being.

Valley projects emphasize that, with reliable sources of power – and photovoltaic solar systems fall into that category – local people are given the capacity to begin improving their own well-being.

LESSONS LEARNED

The Senegal and Zimbabwe case studies, as published in *Sharing Innovative Experiences: Example of Successful Uses of Renewable Energy Sources in the South*, both included a section on 'Lessons Learned'. Both cited the fact that the respective projects were successful not only because local people and communities were involved from the early planning stages of the project but because mechanisms were put in place to charge consumers for the power they used and profits were ploughed back into the maintenance of the photovoltaic stations.

Two years on, what other lessons can be learned?

While both projects have been implemented on a wider scale, the extent to which each has developed could hardly be more different. Despite the excellence of the two lead institutions, Senegal's Energy Directorate and Zimbabwe's ETI, their abilities to attract funding from international donors are poles apart.

"The Rusitu Valley project was partially funded by the Global Environment Facility (GEF) and through a small grant from the United Nations Development Programme (UNDP)," explains Elmissiry. "Additional funds from international agencies that would be used to duplicate the project in other areas have so far failed to materialize, however, probably because of the unfavourable political situation Zimbabwe finds itself in at present."

"We hope that once we get back to normal, our chances of accessing donor funds to replicate the project will increase," adds Elmissiry. Despite the immediate outlook being somewhat bleak, Elmissiry can be content with having improved the lives of people in two once-isolated communities with a scheme that can easily and quickly be replicated elsewhere as soon as funds permit.

In contrast, the millions of dollars now being poured into Senegal's rapidly expanding electricity network (Spain has provided some €10 million) demonstrate that donor assistance linked to political will and institutional capacity can – in just a few short years – help improve the lives of millions. ■

SCIENCE IN NIGERIA

Turner T. Isoun, Nigeria's Federal Minister of Science and Technology speaks about the encouraging changes in science policy that have recently taken place in his country – changes that he believes have set Nigeria on the right course for science-based development.

How has science policy changed in Nigeria over the past decade? What accounts for these changes?

A great deal has changed over the past decade or so. In fact, the most recent changes in science policy in Nigeria date back to the mid 1980s when the national government deemed it necessary to revise the way in which it interacts with the nation's scientific enterprise. Until that time, when it came to science and technology, the role of Nigeria's national government was conducted largely through a coordinating agency. The national government sought to make sure that there was as little duplication of effort as possible. Beginning with the presidency of Olusegun Obasanjo, who assumed office in 1999, things began to change dramatically. The federal government not only continued to seek to coordinate Nigeria's overall research efforts but also acquired direct responsibility for overseeing frontline research initiatives – for example, in information technologies, energy, material science, space technology and biotechnology. The goal was not just to make the nation's scientific enterprise more efficient, which remains in place today, but to help build scientific capacity and to lay a strong foundation for science-based development. This transformation is based on the principle that science and technology capabilities are prerequisites for wealth creation and social and economic progress. While that may seem self-evident today, it was not so evident throughout much of the last half of the 20th century when African nations were emerging from decades of colonial rule and establishing themselves as independent countries. In the post-World War II period and indeed up to the end of the 20th century, most developing nations, especially those in Africa, believed that the clearest pathway to prosperity lay in tapping the 'advantages' of cheap labour and abundant natural resources (in Nigeria's case, oil and, to a lesser degree, solid minerals). Science and technology, the thinking went, were luxuries that could be purchased from abroad often with the revenues generated by industries that relied on cheap labour and natural resources. We were, moreover, encouraged to take this path by our trading partners and international donors.

Turner T. Isoun

What are the most significant signs of the dramatic change in Nigeria's science policies?

The clearest sign is found in the increase in the national government's budget for scientific research. In 1998, the budget stood at about 1.5 billion Nigerian Naira (NGN) or about US$11.5 million given today's exchange rate. In 2004, the annual budget stands at 5 billion NGN or over

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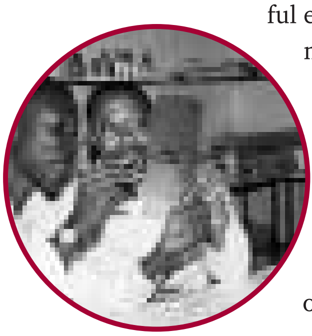
US$38 million. That's more than a three-fold increase. How the money is being spent is also an important indicator of the changes that have taken place. In September 2003, for example, Nigeria launched its first observational satellite used for remote sensing. The satellite has proved particularly effective in shedding light on such environmental issues as soil and water quality. The national government has also led the drive to build the nation's information technology infrastructure and has been particularly interested in wireless satellite technologies for telephone and internet use. Plans are now underway to launch a communications satellite in 2006 that will substantially increase access to electronic communications. The project should prove important not only for improving communication nationwide but for engendering a public-private investment strategy. Such partnerships have been rare in Nigeria and, as a result, the nation has often been denied an invaluable source of capital for building scientific and technological capacities. Finally, the national government's science and technology policies have focused on agricultural science where we are particularly keen to examine the potential of biotechnology. Take the case of cassava. Nigeria grows more cassava than any other country. We have tried to take advantage of this by creating higher-yielding, more pest resistant varieties – both through traditional plant breeding practices and biotechnology. The ultimate goal is not just to increase yields to enhance food security at home but to raise the income-generating potential of cassava in international markets. That explains recent efforts to develop an export market for cassava-based animal feed. And it also explains government efforts to promote the production and marketing of flour that is 90 percent wheat and 10 percent cassava. The government also believes that there are lucrative markets for Nigerian-grown pineapples and Nigerian-processed brown sugar.

What role should universities play in Nigeria's reform efforts?

Universities must play a critical role in Nigeria's science-based development efforts. That's why the government has launched a university-wide reform effort that is based on several factors it hopes will ultimately lead to success. First, we must be willing to pay our professors more money, and we have taken important steps to meet this goal. In fact, salaries for university lecturers have risen from about US$200 to US$1000 a month over the past three or four years. This increase is in addition to subsidies for housing and health care. University reforms, including further salary adjustments, will continue. We not only want to ensure that lecturers don't need to take second jobs but that we provide sufficient incentives to attract talented teachers and researchers. Second, we must guarantee that universities are free of political influence. Universities must be places where the free flow of ideas is encouraged. Such an atmosphere not only carries moral and ethical weight but it also helps to ensure that the nation's brightest minds are able to explore their ideas without restraint or fear. That will undoubtedly make the nation more productive and prosperous. Third, we must ensure that university classrooms and laboratories are well-equipped and inviting places to learn and explore. That requires sustained investment in university infrastructure – buildings, equipment, libraries and dormitories. And fourth, we must encourage researchers to examine topics that are of relevance to the society in which they live and work. Only then will universities justify the investment that their nation is making in them, and only then will the public fully appreciate what their universities can do for the nation. Nigeria is making progress on all of these fronts. You must bear in mind that the nation's university system collapsed under the oppressive weight of 15 years of military dictatorship in the 1980s and 1990s and that it will take time to recover from this period. I cannot, however, overstate how important the university reform effort is to Nigeria's future. The truth is that you cannot hope to build an advanced modern society without an advanced system of higher education.

Northern donors and aid agencies have recently focused a great deal of attention on promoting science in Africa. What do you make of these efforts? How are they different from previous assistance programmes?

Recent efforts to help Africa have taken place at an opportune time and the strategies that have been pursued are, in my estimation, right on track. There are several notable examples of Northern assistance for African science – the African Institute for Mathematical Sciences (AIMS), the Millennium Science Initiative (MSI), and the Gates Foundation National Academies programme, to name just three. But the reason these efforts seem so promising has as much to do with fundamental changes in Africa as it does with the strategic vision of the Northern benefactors. A number of African nations – for example, Ghana, my own nation of Nigeria, Senegal, South Africa, Tanzania, and Uganda – have launched a series of reforms that are transforming their societies in ways that are helping to promote sustained science-based economic development. Many of the reforms focus on strengthening political accountability and transparency; others concentrate on economic development and finance; and still others on education and training. The point is that effective reforms must begin from within and not be imposed from without, and that African nations must nurture an environment that enhances the effectiveness of outside assistance. In the past, the reform agenda was often set by the funders. Today, the most successful African nations are setting their own reform agendas and external sources of funding are being used to advance those agendas. As part of this effort, African nations are increasingly turning toward regional cooperation – fostering, if you will, pan-African cooperation in ways that take their cues from successful efforts at South-South cooperation. Such trends are reflected in the Nigerian government's decision to make a US$5 million contribution to the African Academy of Sciences endowment fund. It has also been reflected in the decision by the New Partnership for Africa's Development (NEPAD) to support the creation of regional centres of scientific excellence. Pan-African scientific cooperation makes sense for a host of reasons, not the least of which is that many individual nations are too small and too impoverished to have either the human or financial resources to establish vibrant research and development centres on their own. By working together, each of the partnering nations will benefit individually.



How can Nigeria assist in the advancement of science in Africa?

The first order of business is to make sure that Nigeria continues to pursue policies that help advance science within its own country. Such efforts not only inspire other nations but also help create potential opportunities for training and employment for African scientists from other parts of the continent. President Obasanjo's decision in 2002 to create the Presidential Advisory Council and Science and Technology, the first independent advisory council of its kind in Africa, illustrates how efforts to advance science in Nigeria can help efforts to advance science in the whole of Africa. The five-person council is chaired by Mohamed H.A. Hassan, president of the African Academy of Science and executive director of TWAS, and includes: Phillip Griffiths, former director of the Institute for Advanced Study, Princeton, USA; Balkumar Marthi, principal scientist with the Microbiology Laboratory, Hindustani Lever Research Centre, India; Lydia Makhubu, professor of chemistry at the University of Swaziland and president of the Third World Organization

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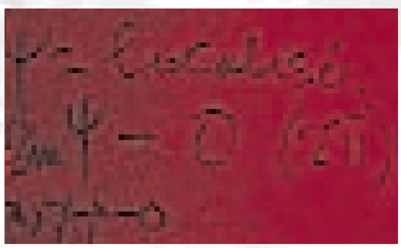
for Women in Science (TWOWS); Gabriel Ogunmola, president of the Nigerian Academy of Sciences; and Nigeria's minister of science and technology. The council has two inter-related mandates: first, to promote and encourage the development of science and technology in Nigeria and, second, to examine how science and technology can be used as an instrument for cooperation and integration in Africa. The council, which has met several times over the past two years, has made recommendations to President Obasanjo concerning Nigeria's potential leadership role in initiating and supporting regional programmes in such areas as space research, information and communication technology, biotechnology and the mathematical sciences – all areas of central importance to Nigeria's national policies for science and technology. In addition, the council's advice has helped shape the nation's strategies for the development of renewable energy sources, the creation of centres of scientific excellence, and efforts to foster innovation. The council welcomed the Nigerian government's decision to grant US$5 million to the African Academy of Sciences' endowment fund and expressed its support for regional programmes in scientific cooperation that the endowment is designed to promote. All in all, the advisory council has lent its considerable weight to the notion that initiatives designed to help science and technology in Nigeria and efforts to promote science in Africa through regional collaboration do not exist in separate domains but, in fact, are mutually reinforcing and beneficial.

Are you optimistic about Africa's future?

I am. I think there has been an imbalance between international press reports and what is going on in many places in Africa. Or, perhaps I should say that there has been too much reporting on Africa's problems and too little reporting on the good things that are happening here. Many of those good things, moreover, have to do with sustained investments in science that bode well for the continent's future. I don't mean to imply that Africa doesn't have problems – or even to downplay those problems. The AIDS pandemic affects more than 34 million Africans and, last year, killed an estimated 2.3 million people in sub-Saharan Africa. Life expectancy in some nations has fallen to less than 50 years of age. Political unrest and violence in Sudan and elsewhere indicate that we have a long way to go to fully stabilize the continent's political environment – a vital prerequisite for sustained economic growth. Africa also remains stymied by Northern tariffs that increase the price of agricultural commodities and textiles that are sold on the global market. That, in turn, limits the revenues that are available to invest in education and research. Despite these problems, there is reason for hope. The growth of democratic governments and the increasing commitment that these governments have made to science and technology; the rise of regional cooperation as reflected by NEPAD; broad-based educational reforms; and Northern investments in science that place a premium on long-term institutional excellence all bode well for the future. In the past, Africa seemed content to pursue short-term solutions to its long-term problems. That didn't work. Now more and more governments seem poised to pursue comprehensive policies designed to tackle the continent's long-standing problems. The sense of realism and commitment embodied in these policies is reason alone for optimism. And the efforts are beginning to bear fruit – the return on investment in Nigeria, for example, has been more than 40 percent over the past four years, a pace of growth that has encouraged some of the nation's talented professionals – scientists, scholars, entrepreneurs and financial and information-technology experts – who formed part of the 'diaspora' – to return home. All these trends provide reasons for hope and encourage us to continue the course for reform we have laid out. ■

STEPPING OUT IN CAMEROON

ON A CONTINENT WHERE DAILY POWER CUTS ARE COMMONPLACE, PAUL WOAFO FROM CAMEROON, WHO WAS RECENTY AWARDED A TWAS PRIZE FOR YOUNG SCIENTISTS, PROVES THAT GOOD SCIENTISTS CAN EMERGE – AND HIGH-QUALITY SCIENCE CAN BE PERFORMED – EVEN UNDER THE MOST DIFFICULT CONDITIONS.



Unless you have a very detailed map of West Africa – and of Cameroon in particular – the village Bancheghang would be hard to find. In fact, 25 years ago, the village, which today is home to 2,000 inhabitants, did not even boast a primary school.

This is where Paul Woafo – last year's winner of the TWAS Prize for Young Scientists awarded by the Cameroon Academy of Sciences – grew up. Bancheghang is some 300 kilometres northwest of the capital, Yaoundé, in the country's West Province.

"The primary school was 7 kilometres from our home," says Woafo, "so from the age of six, we got up at 6 o'clock every morning for the two-hour walk to school. Classes would last until 5 pm and then we would walk home again."

When he was 13, Woafo journeyed 25 kilometres from his village to lodge with a relative while attending secondary school. The following year he moved to Bokito, a larger town situated some 200 kilometres from home and 100 kilometres from Yaoundé. There he lived with a friend of his brother for several years.

Despite these difficult conditions, Woafo persevered with his studies. He excelled in many subjects, including physics, mathematics and languages, eventually gaining his *Brevet d'Etudes du Premier Cycle* that allowed him to transfer to a grammar school where he specialized in the sciences.

"After the fifth year there is another level of specialization where the best students of the scientific section are able to focus on their particular interests," explains Woafo. "I chose the chemistry, mathematics and physics sub-section. Then, in 1983, I entered class 7, the final class of the secondary education programme, and obtained my *Baccalauréat* a year later. This enabled me to apply to the University of Yaoundé, the only university in the country at that time."

In 1993, the university changed its name to the University of Yaoundé I, when five other universities were created in Cameroon – visible evidence of the Cameroon government's growing support for higher education.

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Woafo obtained his BSc in physics in 1987, and lost no time in advancing his education with a series of other qualifications and specializations. In 1988 he was awarded his *Maîtrise de Physique* with a focus on mechanics. This was followed by his *Doctorat Troisième Cycle* in 1992 and *Doctorat d'Etat* in 1997, with a focus on non-linear phenomena that included applications in solid state physics, surface physics and biological physics.

CAREER IN CHAOS

From these early days, Woafo's research has gone from strength to strength. After obtaining his *Doctorat d'Etat*, he was provided with his own laboratory. Three years later, in 2000, he was promoted to associate professor. He has also supervised more than 40 master's students and 12 PhD students, five of whom have already graduated. His research group now consists of four researchers, seven PhD students and four master's students, and he has published some 60 scientific papers, many of them in such high-impact factor journals as *Physics Letters* and *Solid State Communications*.

In 1994, Woafo visited the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy, where TWAS is headquartered, for the first time. A year later he became an ICTP Associate. He has visited Trieste five times since, most recently in 2004, to attend workshops and conferences and carry out his own research in the Centre's excellent facilities.

Given his scientific talents, Woafo's career is following a predictably linear path. A look at the titles of the workshops and conferences he has attended, however, suggest that his interests lie in more non-linear, chaotic systems. 'Noise in non-linear systems' and 'Spatiotemporal chaos' are just two examples of ICTP activities attended by Woafo.

Most non-physicists have an understanding of linear phenomena, where the result of an action is directly proportional to the size of that action. In electronics, for example, the current that flows across a resistor is directly proportional to the voltage across it, a relationship learned by every young science student as Ohm's law. Likewise, Newtonian mechanics teaches us that the acceleration of an object is proportional to the force applied to it.

A non-linear phenomenon, on the other hand, occurs when some complexity in the system means that this direct relationship doesn't hold true. In particular, very large responses can be achieved with very small perturbations to the system. The classic example is the weather – a butterfly flapping its wings in Yaoundé could, in theory, cause a storm in Trieste. A more mundane example in the world of electronics is the diode. Applying a small voltage in one direction allows a large current to flow, almost independent of the size of the voltage. When a voltage is applied in the other direction, however, practically no current flows until the voltage gets very large – a non-linear response.

Woafo describes chaotic systems in his own words:

"A chaotic system is a system with un-correlated behaviour. There is no relationship between its past, present and future states," he explains. "Knowing the present state of a chaotic system does not allow us to predict its future. Moreover, the history of a chaotic system depends greatly on the initial conditions, and a very slight difference between two sets of initial conditions induces large differences between the corresponding dynamical future states of the chaotic system."

Such chaotic systems have been found in many areas of science, including biology, physics and even the social sciences. In many cases, chaos could prove dangerous or destructive and is thus to be avoided. Scientists, therefore, have spent great efforts to determine conditions that help avoid chaos.

"In the early 1990s, however, it was shown that one can take advantage of the flexibility of chaotic systems to attain certain goals, particularly in engineering and medicine," adds Woafo, "driving the chaotic system to a desired and particular target."

Woafo's work in analysing and understanding chaotic systems is leading to practical applications in both medicine and high technology.

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APPLICATIONS

In developed countries, and increasingly in developing countries, cardiovascular diseases rank among the major causes of death. Woafo's work is focusing on two aspects of such diseases.

"Patients that require artificial pacemakers to control the rate at which the heart beats must wear a device bearing an electrical oscillator, or activator, linked to the heart by a conducting wire that passes through the skin," says Woafo. "This is not an ideal solution and there is a need to build a wireless system that would enable the connection between the internal part of the activator fixed on the heart and the external part on the device to take place via electromagnetic waves rather than a solid wire. This is a topic of intense research and forms the basis of some of our work on non-linear electromechanical devices."

Cardiovascular diseases can also cause lesions such as a stenosis (a stricture or narrowing of a blood vessel) and atherosclerosis (hardening of an artery), both of which can create local increases of blood pressure, the local coagulation of blood, or 'reflections of blood waves' or pulses. All these effects can put serious stress on the heart.

When these diseases are mild, drugs can help either cure the problem or at least reduce the intensity of the symptoms suffered by the patient. In severe cases, however, surgeons must remove the damaged part of the blood vessel. They then either suture the ends of the vessel together, or insert a prosthesis, a section of an artificial blood vessel.

In both cases, although the problem has been repaired, the inside of the operated blood vessel is still not as smooth as a healthy blood vessel and the flow of blood is affected. Despite the operation, the patient must continue to take anti-coagulating and other drugs.

"There is a need, therefore, to find characteristics for blood vessel prostheses which eliminate reflections of blood waves," explains Woafo. "We tackled this problem using the soliton theory to analyse the behaviour of blood waves in arteries with prostheses and stenoses."

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A soliton is a pulse-like wave that can exist in a non-linear system and does not disperse. The phenomenon was first described by a Scottish boat builder, John Scott Russell (1808-1882), who was testing a new boat design on a canal. Suddenly the boat, which was being pulled by two horses, stopped. However, whereas the waves left in the boat's wake quickly dissipated, an unusual wave, about 50 centimetres high, emerged from the bow of the boat and headed 'upstream'. Russell followed the wave on his horse, observing that it did not fully diminish for two or three kilometres.

What Russell called a 'wave of transition' has since been renamed a 'solitary wave' or 'soliton'. The physical principles behind such solitons now find applications in many areas of science, including non-linear optics, the study of tornadoes, elementary particle physics and hydrodynamics, or – in Woafo's case – the dynamics of blood flow.

"We derived what we termed the mechanical and geometrical characteristics of the ideal blood vessel prosthesis," continues Woafo. "This result was particularly well received by the scientific community. One paper, 'Dynamics of solitary blood waves in arteries with prostheses', originally published in *Physics Review E,* was selected by the American Physical Society as one of the most interesting research contributions in biological physics in 2003 and republished in the *Virtual Journal of Biological Physics*.

Almost all of Woafo's ground-breaking research has been carried out in Africa.

Another application of Woafo's work on chaos is in cryptography or, in Woafo's own words: "the high security masking of electrical and optical communications."

The process depends on the almost impossible ability to synchronize two chaotic systems in a master-slave arrangement.

"If, when a message is being sent, we add a chaotic master signal to the real message, the resulting masked message will be undecipherable during transmission," explains Woafo. "Where the message is being received," continues Woafo, "we use another chaotic system, the 'slave', whose behaviour is synchronized to that of the 'master'. We only need to subtract the slave chaotic signal from the incoming masked message to obtain the proper message transmitted with high security. Indeed, during transmission, 'pirates' cannot decipher the message unless they have yet another chaotic system synchronized to the master – a situation that is impossible since the pirates do not know the initial conditions of the master and the current conditions of any chaotic system depend on those original conditions and cannot be calculated in any other way."

Initially, it was not only difficult to define the coupling parameters required to synchronize chaotic systems, but sometimes such coupling also lead to unstable or catastrophic states. "Our contribution has provided one method of optimizing the synchronization process," says Woafo. "We then extended this to networks of chaotic oscillators and suggested additional applications in switching in chaos-secured communication networks."

TWAS AWARD

Developing such practical applications from what could be defined as 'theoretical' physics has brought Woafo's work to the notice of the Cameroon Academy of Sciences which, in 2003, awarded him a TWAS Prize for Young Scientists. The award was presented at a ceremony held on 8 July 2004 with both Zacharie Perevet, Cameroon's Minister of Science and Technology, and Maurice Tchuente (TWAS Fellow 1999), Minister of Higher Education, present. During the ceremony, which was also attended by Victor Anomah Ngu, president of the Cameroon Academy of Sciences, and Sammy Beban Chumbow, rector of the University of Yaoundé I, Woafo provided an overview of his research.

"I would like to dedicate this prize to the two forces behind me," says Woafo. "First to my wife, Philomene Solange, for her adaptation to my chaotic behaviours. Second, to my mentor, Kofane Timoleon Crepin, who, despite the constraints faced by scientists in Africa, has stood as firm as a soliton in his desire to build an internationally renowned research team. Such people, who agree to supervise scientific research under difficult conditions, need to be encouraged and recognized for their efforts."

This sentiment is derived from an unusual aspect of Woafo's career – almost all of his ground-breaking research has been carried out in Africa. "Apart from the times I visited ICTP," explains Woafo, "I have been abroad three times – to the Institute for Theoretical Physics in São Paulo, Brazil, and the Department of Physics at the Danish Technical University, Lyngby, both for one month in 2001, and to the Department of Physics at the University of Salerno, Italy, for one week in 2002."

"Although conditions are difficult here in Cameroon, my experience shows that scientists can carry out high quality research and achieve both national and international recognition for their work," adds Woafo. "Perhaps because I was awarded an ICTP fellowship early in my career, I have never been tempted to leave Africa and work abroad. I also stay because I think it is important to persuade other young Cameroonians that a career in science is both interesting and rewarding."

Woafo also believes that African scientists need to develop ways to work together through regional networks of three or four research groups that, collectively, can tackle critical issues.

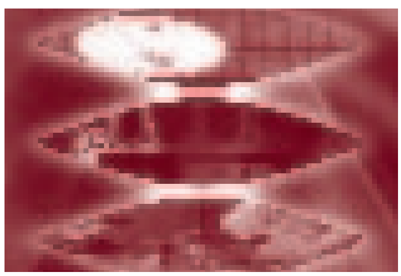
"We must focus on scientific problems that are of interest to the international scientific community," he explains, "but these problems must have implications for the development of our countries – as is the case with non-linear studies. This is certainly a difficult task, but African scientists must rise to the challenge." ■

FEATURE

INITIATIVE IN AFRICA

FOLLOWING THE SUCCESS OF ITS PROJECTS IN LATIN AMERICA, THE MILLENNIUM SCIENCE INITIATIVE (MSI) IS ABOUT TO LAUNCH A SERIES OF PROJECTS IN AFRICA DESIGNED TO BOOST THE CONTINENT'S CAPACITY IN THE BASIC SCIENCES. TWO MEMBERS OF THE MSI AFRICAN TASK FORCE EXPRESS GUARDED OPTIMISM FOR THE EFFORT.

African nations are emerging from decades of turmoil and brain drain that have weakened their institutions of higher education in general and science and technology in particular.



These nations now recognize the urgent need for stronger science and technology (S&T) capacity if they are to take their places among modern nations and harness the power of knowledge to reduce disease, enhance food security and stimulate their economies.

Mohamed Hassan, president of the African Academy of Sciences (AAS) and executive director of the Third World Academy of Sciences (TWAS), has stated the matter in blunt terms: "Science alone cannot save Africa, but Africa without science cannot be saved."

Members of a scientific task force associated with the Millennium Science Initiative (MSI) first met more than three years ago with the intent to design a new programme to strengthen African S&T. The goals of this initiative are to nurture Africa's long-neglected human resources, provide support to keep Africa's finest young scientists at home, and rebuild the effectiveness of the continent's universities and laboratories.

The African MSI is built on the initiative's successful scientific capacity building ventures in Latin America, which first took shape in 1999 when MSI began organizing programmes in Brazil, Chile and Mexico – efforts that were financed by the World Bank and national governments.

For Africa, an African MSI task force was organized jointly by TWAS and the Science Initiative Group (SIG), an independent, international nongovernmental organization that advises the MSI. The activities of SIG have been underwritten by the Packard Foundation.

Members of the MSI Africa task force, including leading African scientists and educators, selected three priority areas:

- Biology and Biotechnology – because of their essen-

tial role in combating disease, building food capacity, and developing new products with market potential.
- Mathematics – the bedrock and language of all the other sciences, which has been intolerably weakened by neglect and under-funding in recent decades.
- Instrumentation and Information Technology (IIT) – because of their essential role in strengthening weak S&T infrastructure and permitting scientists to obtain quick access to current technical knowledge and regain lost intellectual ground.

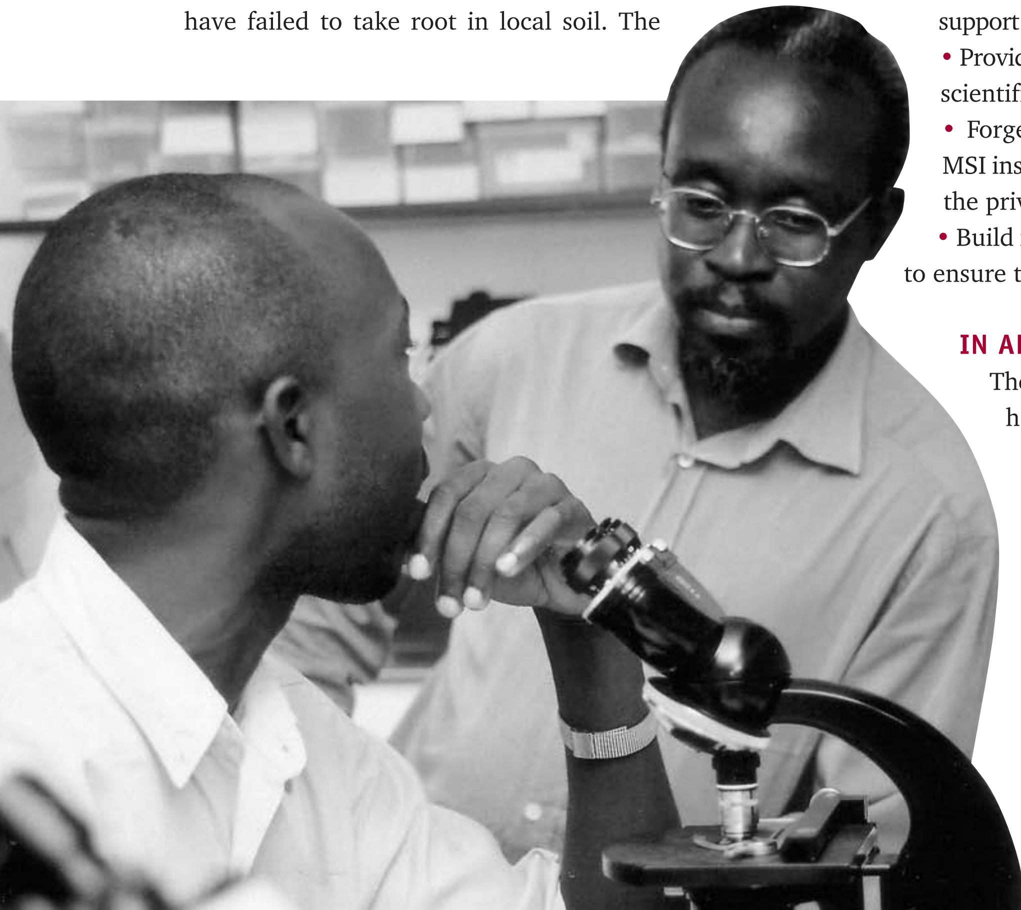
MSI's strategy involves strengthening and linking the work of local researchers, teachers and programmes to activities and institutions that are already in place. As a result, MSI is an international initiative that depends directly on local know-how and commitment for success.

African scientists are all too familiar with programmes that have been prompted by well-intended individuals from outside the continent but that have failed to take root in local soil. The current proposal follows a different approach: It is determined to strengthen local capacity in science and technology as a prerequisite to, instead of the endpoint of, development.

This approach rests on the understanding that local leaders best understand local needs and opportunities and have the best perspective on how to build Africa's scientific capacity over the long term. In this process, SIG acts as a catalyst, in collaboration with the World Bank, while the task force makes the substantive on-the-ground decisions.

MSI's strategy involves linking the work of local researchers, teachers and programmes to activities and institutions already in place.

Specifically, the purpose of the African MSI is to:
- Support small, flexible groups, 'MSI institutes', dedicated to scientific research and education.
- Work closely with government leaders to integrate scientific research into the country's development goals.
- Develop programmes of sufficient quality to support some of Africa's best scientists at home.
- Provide models of scientific education for the scientific leaders of tomorrow.
- Forge linkages and partnerships between MSI institutes, other research institutions and the private sector both in Africa and abroad.
- Build financial support for MSI programmes to ensure their long-term sustainability.



IN AFRICA

The three initial African MSI programmes have evolved from the recommendations and guidance provided by the original task force and are now being guided by independent groups of African scientists.

Biology/Biotechnology. The overriding mission of the biology/biotechnology programme is to advance African expertise in modern biology and its applications. The programme will seek to benefit from the synergies of four existing activities in

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WHAT IS MSI?

Launched in 1998 with financial assistance from the World Bank, the Millennium Science Initiative (MSI) strives to build capacity in modern science and technology in developing countries. Through its flagship MSI institutes – competitively chosen programmes of excellence in scientific research and training – MSI helps to nurture a cultural and material environment that allows scientists and engineers from developing countries to engage in world-class research and training in their home countries. MSI topics vary widely from biotechnology and complex engineering systems to public health and microelectronics. To date, MSI institutes have been established in Brazil, Chile and Mexico, and have reached the implementation stage in Africa. The mission of MSI will soon be reinforced by the creation of the Global Science Corps, which will send scientists from developed countries to work with colleagues in the developing world. For additional information, see www.msi-sig.org.

Botswana, Cameroon, Kenya and Uganda, directed by leading scientists in genomics, bioinformatics, chemistry and botany.

Principal programmatic goals, focusing on public health and food security, include strengthening genomic and post-genomic expertise to fight such endemic diseases as malaria, HIV/AIDS and tuberculosis at their genetic bases, and using the insights of biotechnology to increase crop production. In addition, the initiative hopes to develop strategies for screening and identifying plant products and develop marketable products.

MSI will help link these diverse components, leveraging their respective strengths and integrating them with regional programmes that traditionally work in isolation. Students will earn degrees with their home universities, study with invited experts, and spend periods at other MSI centres and institutions abroad.

The biotechnology effort is focused in Uganda and led by Thomas Egwang (TWAS Fellow 1997), director general of Med Biotech Laboratories in Kampala, Uganda, and co-author of this article. The biotechnology and bioinformatics effort is focused in Cameroon and led by Vincent Titanji, deputy vice-chancellor, University of Buea.

MSI efforts to help screen and identify plant products will be designed to fight disease, enhance health, and expand human food resources. In the longer term, the efforts will seek to develop products of commercial potential to stimulate local employment and increase exports. Screening of natural plant products will be led by Berhanu Abegaz (TWAS Fellow 1998) at the University of Botswana, where the emphasis will be on chemical analysis, and Keto Mshigeni (TWAS Fellow 1987) at the University of Namibia, where the emphasis will be on the identification and development of plant products with commercial potential.

We anticipate that the biology/biotechnology initiative will result in an increasing number of university graduates with the skills to work in the health, agriculture and service industries, particularly those that promote knowledge-based products and services. Specifically, we anticipate that the initiative will help build the skills necessary for scientists to pursue research and development agreements with industry that ultimately lead to new patents and products. The overall goal is to improve the quality of research and teaching and reduce or even reverse the brain drain.

Viewed through the lens of long-term economic development and efforts to promote social equity, all of the elements of the biology/biotechnology initiative have been designed to contribute toward better public health and greater food security that directly aid the poor.

The overall goal is to improve the quality of research and teaching and reduce or even reverse the brain drain.

Mathematics. The task force unanimously recommended an MSI mathematics programme for three reasons: (1) the weakened state of university mathematics in Africa; (2) the fact that in recent decades, all science-based fields have come to depend on mathematical knowledge and techniques, most notably computer modelling, statistics, and data processing; and (3) the growing consensus among both scientists and policy makers that the quantitative sciences are spreading to fields beyond the sciences, including finance, business, transportation, law and even entertainment. The simple truth is that Africa must respond to this growing demand for mathematical expertise if it is to acquire a sense of economic well-being and power in the world.

In 2003, a Writing Group for the African Mathematics MSI (AMMSI) completed a proposal for a multi-country initiative to address this challenge. Members of the planning group were drawn from Botswana, Cameroon, Kenya and Nigeria, and were assisted by mathematicians in South Africa, Sweden and the United States. This proposal was the subject of a broader workshop in Nairobi in June 2004, sponsored jointly by the African Academy of Sciences (AAS) and the International Mathematics Union (IMU), and supported by the Mellon Foundation and the Carnegie Corporation.

The significance of this workshop was illustrated by the stature of those in attendance, including the president of the African Academy of Sciences (AAS); current and past presidents of the African Mathematics Union (AMU); the secretary of the International Mathematics Union (IMU); and the general secretary of its Commission on Development and Exchanges (CDE), as well as leading mathematicians from the *Institut de Mathématiques et de Sciences Physiques*, Benin; National Mathematics Centre, Abuja, Nigeria; University of Botswana; University of Nairobi, Kenya; University of Western Cape and University of Stellenbosch, South Africa; and University of Yaoundé I, Cameroon.

Other organizations actively promoting mathematics in Africa were also represented, including TWAS; the *Centre International de Mathématique Pure et Appliqué,*

AND WHAT IS SIG?

The Science Initiative Group (SIG) provides support and guidance to the Millennium Science Initiative (MSI). SIG is governed by a seven-member board that includes C.N.R. Rao, president of TWAS; Jacob Palis, secretary general of TWAS; and Mohamed H.A. Hassan, president of the African Academy of Sciences (AAS) and executive director of TWAS. Other board members are Phillip A. Griffiths (chair), professor, Institute for Advanced Study (IAS), Princeton, New Jersey, USA; J. Thomas Hexner, venture capitalist, Cambridge, Massachusetts, USA; Chung W. Kim, president, Korea Institute for Advanced Study (KIAS); and Harold Varmus, president, Memorial Sloan-Kettering Cancer Center, New York City, USA. SIG is administered by a small staff based at the IAS. Much of SIG's work has been supported by grants from the Lucile and David Packard Foundation. For additional information, see www.msi-sig.org.

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France; the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy; the International Science Programme, Sweden; the United Nations Educational, Scientific and Cultural Organization (UNESCO); and the World Bank. The group not only brought broad experience and expertise in mathematics research and education but enthusiasm for revitalizing mathematics in Africa.

A pan-African partnership is the most effective instrument for building mathematics capacity on the continent.

In addition to the African Mathematics MSI, a second programme of pan-African scope was well represented at the workshop – the African Institute for Mathematical Sciences (AIMS), which opened in autumn 2003 (see "AIMS For Africa," pages 65-70).

AIMS is located in Cape Town, South Africa, where it trains students from all over Africa in a nine-month intensive postgraduate diploma course taught by outstanding African and international lecturers. Because the goals of AMMSI and AIMS are essentially the same, the two groups signed an agreement to collaborate in building African mathematics capacity. While AMMSI planning was initiated in sub-Saharan Africa, it envisions strong ties to North African partners as well.

Workshop participants also agreed that because of the diminished number of mathematics leaders on the continent, a pan-African partnership would be the most effective instrument for building mathematics capacity. Members of this partnership, it was agreed, would benefit from working together as a 'multi-centred' centre of excellence in teaching and research under the New Partnership for African Development (NEPAD). As a result, participants agreed to jointly approach NEPAD to request designation as a NEPAD centre of excellence. A response to this request is expected in the near future.

The organizations represented in Nairobi agreed to work together to build African mathematics in the following specific ways:

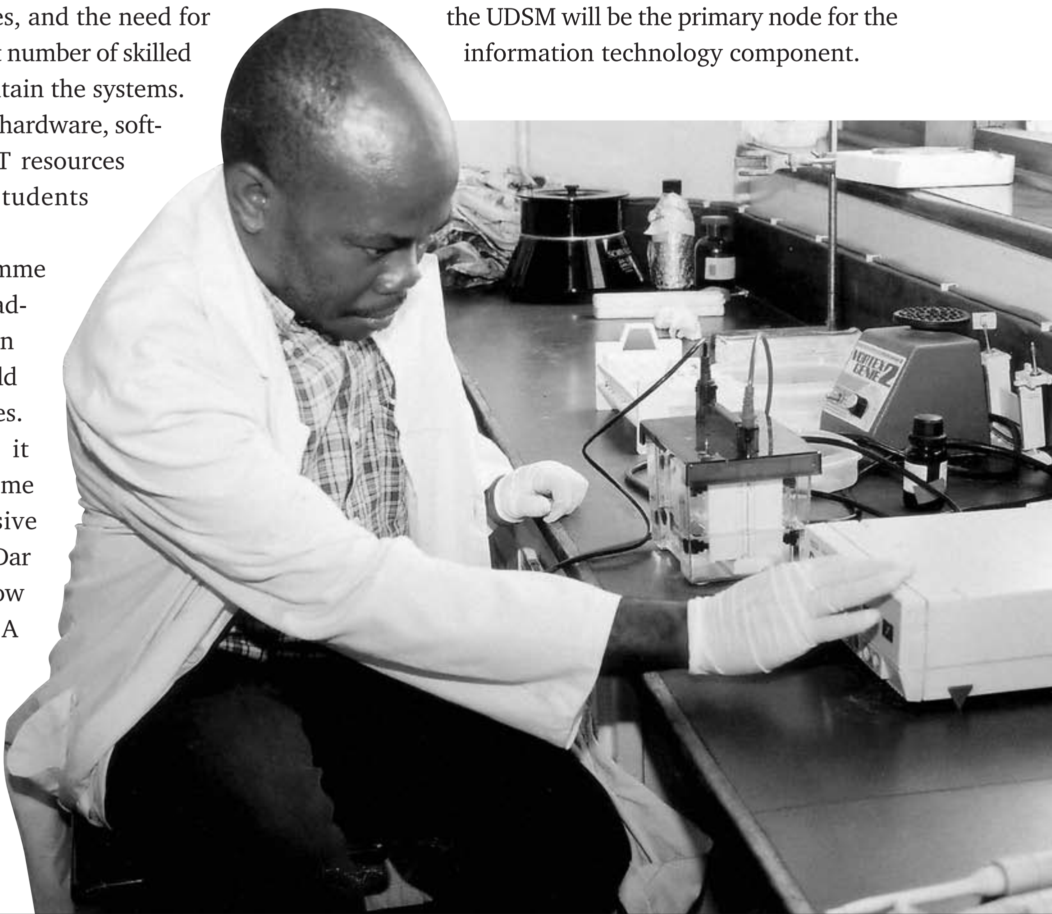
- Promoting education and research through the provision of funds for postgraduate and postdoctoral fellowships.
- Assisting young researchers in mathematics through the provision of funds for journals, books, computers, software and travel to professional meetings.
- Encouraging research through the award of prizes for young mathematicians.
- Providing links to colleagues and research groups both in Africa and throughout the world.
- Raising public awareness of the importance of mathematics to African nations.

Instrumentation and Information Technology (IIT). Stronger infrastructure in both advanced instrumentation and information technology have been priority areas for the African MSI since the earliest planning stages. Focus on these areas has been driven by two compelling factors: the need in most African universities for stronger technical infrastructures, and the need for training and retaining a sufficient number of skilled technicians to operate and maintain the systems. The effort is designed to provide hardware, software, training and access to IIT resources needed by scientists and students throughout Africa.

Initial interest in this programme was expressed by technology leaders in Tanzania. This interest, in turn, was discussed with the World Bank and government ministries. Following these discussions, it became clear that the programme must also solicit the extensive involvement of the University of Dar es Salaam (UDSM), which has now enthusiastically joined the effort. A meeting between SIG and university leaders in June 2004 and a larger stakeholders' meeting at the University of Dar es Salaam in July 2004 has led to a formal proposal for funding. The Tanzania Industrial Research and Development Organization (TIRDO) will be the primary 'node' for the instrumentation component, while the UDSM will be the primary node for the information technology component.

CHILE FIRST

The Centro de Estudios Científicos *(CECS, Centre for Scientific Studies) in Valdivia, Chile, was one of the first research institutes funded under the Millennium Science Initiative (MSI). Despite being located far from the Chilean capital, Santiago, CECS receives visits from students and scientists from all over the world interested in its specialist fields of biophysics and molecular physiology, theoretical physics, and glaciology and climate change. The institute, which also plays host to several international conferences each year, is headed by Claudio Teitelboim (TWAS Fellow 1991), a renowned expert in quantum black holes physics and the theory of gauge systems. For additional information, see www.mideplan.cl/milenio.htm.*



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The IIT initiative has five inter-related objectives:

- Expand the capacity for training and retaining technicians at institutions of higher learning;
- Educate more masters- and PhD-level students who would like to do research in IIT and educate others;
- Train scientists and engineers who would like to use advanced instrumentation;
- Provide access to advanced equipment for use by scientists and engineers from academia, government and industry;
- Offer consulting services and outreach in IIT to industry.

The over-arching goal of the IIT initiative is to nurture abilities that are marketable, competitive and usable both by educational institutions and by the private sector. To advance this goal, the programme will support undergraduate and graduate students in IIT fields through scholarships, internships and personnel exchanges. The College of Engineering at the UDSM, for example, describes an urgent need to support more graduate students pursuing the MSc degrees both in computer engineering and information technology. The faculty has few students in this area because students have to raise their own tuition. Tanzania, like many African nations, urgently needs more students trained in software engineering, network management and web-based education.

The goal of the initiative is to nurture abilities that are usable by both educational institutions and the private sector.

ROAD AHEAD

The time is right for an African MSI for several reasons.

First, it is clear that science and technology must be the capstone of a broad-based educational system if African nations are to take their place among modern nations.

Second, the political climate for investments in science and science-based development is more favourable today than it has been for several decades. As a result, governments have taken a direct hand in helping to shape science-based economic reforms and in providing funds and other policy incentives to make the reforms happen. For example, the government of Tanzania has recently repealed a surtax on all computer products and liberalized restrictive telecommunications laws. Such reforms have also included reassessments of the role of universities in society.

Third, international funding organizations have expressed a deep interest in helping to build scientific capacity in Africa. The World Bank, for example, has recently developed its own science and technology strategy to complement its emphasis on support for education.

We firmly believe that the ability of Africans to take hold of their own destiny must begin with a local knowledge revolution – and that this revolution must begin quickly.

By good fortune, new information and communication technologies can assist distance learning and provide the means for young Africans to gain access to the latest knowledge, even in remote areas. In short, thanks to the revolution in information and communication technologies, Africans now have the means to regain lost ground and retain more of their brightest young scientists and engineers to work at home.

Our vision today is for a strengthened and truly liberated Africa, led by a new generation of science-savvy young Africans who are equipped with the knowledge and tools they need to leapfrog into the 21st century. ■

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Howard Hughes International Fellow
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Both authors serve on the African MSI Task Force

AIMS FOR AFRICA

THE AFRICAN INSTITUTE FOR MATHEMATICAL SCIENCES (AIMS), A CENTRE DESIGNED TO RAISE THE LEVEL OF MATHEMATICS AND SCIENCE IN AFRICA, WAS RECENTLY LAUNCHED IN CAPE TOWN, SOUTH AFRICA.

From communications technology to finance, from environmental studies to epidemiological evaluations, from space research to oil and natural gas explorations, modern society is increasingly dependent on the knowledge and know-how of mathematical scientists.

It may not be a topic at the top of the development agenda but the truth is that the severe shortage of home-grown mathematicians poses a major obstacle to economic growth in many developing countries. That shortage is most acute in sub-Saharan Africa.

Just three years ago, institutions of higher education in the United Kingdom, France and South Africa – specifically, the universities of Cambridge and Oxford, the University of Paris-Sud-XI, and the universities of Cape Town, Stellenbosch, and the Western Cape – joined together to seek ways of reversing Africa's debilitating deficit in mathematics. The result was the creation of the African Institute for Mathematical Sciences (AIMS), which was officially launched in September 2003 at the AIMS headquarters in Muizenberg, a suburb of Cape Town, South Africa.

South Africa's Muizenberg Educational Trust donated an exquisite 1920s art-deco hotel to serve as AIMS' home. Nearby Stellenbosch University oversaw the refurbishing of the hotel, transforming its spacious living quarters into lecture and dining halls, a computer laboratory and library, classrooms, offices, and guestrooms for students and lecturers. Because everything is under one roof, *impromptu* tutorials and discussion groups often take place from early in the morning to late at night. Think of it as a 24 hour, 7 days a week think-shop for mathematics and science.

AIMS was inaugurated on 18 September 2003 in a ceremony attended by South Africa's ministers of education, Kader Asmal, and science and technology, Ben Ngubane; university vice chancellors Chris Brink, University of Stellenbosch, Njabulo Ndebele, University of Cape Town, and Brian O'Connell, University of Western Cape; and renowned figures in African and international science and mathematics, including Francis Allotey, Kumasi College of Technology, Ghana, and K.R. Sreenivasan, director of the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy. Noted speakers included Sir Michael Berry, University of Bristol, UK; James Gates Jr., University of Maryland, USA; Wayne Getz, University of California at Berkeley; and Sir Martin Rees, University of Cambridge, UK.

The goal of AIMS is to promote teaching and research in mathematical sciences across Africa. The primary means of advancing this goal is a nine-month post-graduate diploma course available – through open com-

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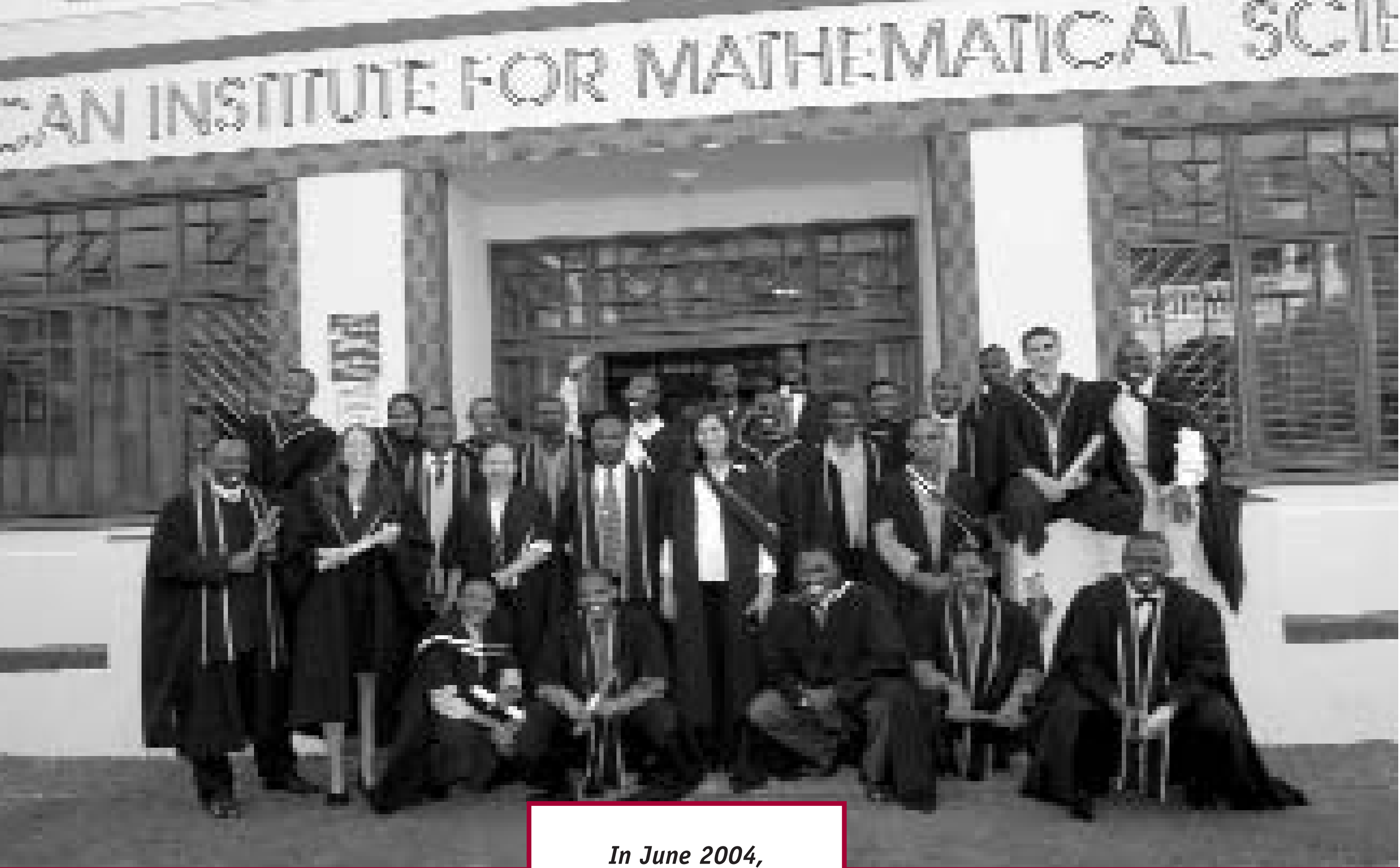

In June 2004, AIMS held its first graduation ceremony.

petition – to Africa's most promising young mathematicians and scientists.

Of course, goals are one thing and funding quite another. AIMS has been fortunate to have received financial support from a variety of sources. Start-up funds were given by PetroSA, South Africa's national oil company, and South Africa's Department of Science and Technology. Operational and programmatic funds have been received from the Gatsby Charitable Foundation, Vodafone Foundation, Andrew W. Mellon Foundation, Ford Foundation and Cambridge University Press.

In addition, AIMS was awarded a grant from the International Council for Science (ICSU), channelled through the Council's International Union of Theoretical and Applied Mechanics (IUTAM), that was used to fund a workshop on capacity building in mathematics, held in April 2004, and a two-week training course for secondary school teachers, held in July 2004 – both at the AIMS facility in Muizenberg.

The first group of 30 AIMS students, selected from more than 85 applicants, arrived at the institute in September 2003. In June 2004, AIMS held its first graduation ceremony.

The inaugural graduating class included students from 15 African countries, spanning the breadth of Africa from Algeria to Zimbabwe. While complete gender equality was beyond its reach, women comprised 20 percent of the class. About half the students were university lecturers who had taken a leave of absence from their faculty positions; others were part-time teaching assistants in institutions of higher education. Those who had shown an interest in teaching were encouraged to apply under the assumption that good teachers would help instil a sense of enthusiasm among students and thus have a multiplier effect that would increase the number of mathematicians in Africa over the long term.

For now, the vast majority of Africa's brightest young students go abroad for graduate and postgraduate studies. Few ever return. This trend persists in all disciplines but the situation is particularly acute in mathematics, where 90 percent of Africans earning PhDs in institutions outside Africa do not come back.

AIMS has been designed to counter Africa's chronic brain drain problem by instilling a spirit of long-term commitment to the continent and emphasizing the role that mathematics can play in Africa's development. A key aspect of this strategy is to bring together groups of talented African students who share a common interest in mathematics and who exchange not only their ideas but their personal hopes and fears at a critical juncture in their lives and careers.

If the response of students attending AIMS' first diploma course is any indication of what we can expect in the future, it is fair to say the programme has tapped deeply held sentiments that extend well beyond the students' shared interest in mathematics to a common desire to help Africa solve its critical economic and social problems. Many students, for example, expressed interest in the focus that the New Partnership for Africa's Development (NEPAD) has placed on devising African solutions to Africa's problems. The multicultural, yet pan-African, environment that is part of the AIMS experience provides a unique forum for exploring not just science for the sake of science but potential applications of science for addressing the continent's critical problems.

Upon successfully completing their nine months of training, AIMS students are encouraged to proceed to master's or doctoral degree programmes in African universities. On the one hand, this post-AIMS strategy is designed to provide a framework for keeping young African mathematicians at home. On the other hand, it is intended to strengthen AIMS' ties with Africa's academic community as part of a larger effort to ensure the long-term sustainability of the initiative.

AIMS' officials have also invited local researchers and executives in Africa's emerging private sector to visit the institute and for students to visit research institutions and private-sector companies in Africa. The goal here is to expose students to potential non-academic employment opportunities that will not only increase their job prospects but also broaden the role that mathematicians can play within their societies.

While the primary goal of AIMS is to build science and mathematics expertise in Africa, several first-round AIMS students have applied and been accepted for post-graduate studies outside of Africa – for example, in the

ADDING LONG-TERM VALUE TO CAREERS

My parents thought it was bad idea. My professors thought it was bad idea. But I did it anyway. I studied mathematics at the University of Kinshasa.

"A degree in mathematics will lead to few jobs apart from teaching," they told me. "You will die poor," they ominously warned.

My only retort was: "What do you know about mathematics?" – although I must confess I was concerned about my job prospects as well.

When I completed my studies, I was delightfully surprised by the number of job offers I received: for example, from such international organizations as the World Food Programme and from such private companies as Vodacom. My parents weren't just surprised. They were relieved.

Yet, instead of entering the world of work, I decided to enrol in AIMS' first diploma course – truly honoured to be one of 30 students chosen from a pool of 85 applicants. My friends and relatives thought I was crazy to turn down several excellent job opportunities to continue my studies in mathematics. "Do you think you will solve all (any?) of the world's problems with mathematics? Do you think your own career prospects will improve?"

Having proven them wrong before, I firmly believed I would prove them wrong again. In fact, I was confident that I would learn how to contribute to the development of Africa while enhancing my skills and employment prospects. That's why I decided to come to AIMS.

At AIMS I discovered applications of mathematics in such fields as epidemiology, information theory, fluid dynamics and mathematical finance. And I learned in ways unlike anything I'd experienced before.

At AIMS we were not given thick books to plough through. Instead we were taught the basics and then encouraged to discover how to assemble these building blocks into larger, more complex constructs. Instead of teachers writing theorems and proofs on blackboards and having us take down notes and commit them to memory, AIMS professors encouraged students to interact both with them and their fellow students. Classrooms were noisy, not silent places, as questions from lecturers and students alike filled the air. The goal was to nurture not just mathematical skills but mathematical intuition. During my university days, students learned to get good grades on their examination and usually would forget the material soon afterwards. At AIMS we learned because we wanted to learn

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and not just to pass examinations. Indeed the latter would be the consequence of the former and not an end in itself.

With the skills I acquired at AIMS, I am confident that I can meet the challenges set not only by mathematics but by other scientific disciplines as well. I will be pursuing a master's degree in computer science at the University of Stellenbosch in South Africa, specializing in network communication.

AIMS is a wonderful place for motivated and hard-working students. And, yes, mom and dad, the experience has truly brightened my job prospects both now and in the future.

Pierre Abraham Mulamba
AIMS Diploma Course 2003
Democratic Republic of Congo

University of Cambridge and University of London in the United Kingdom, and Syracuse University in the United States.

We fully appreciate a student's desire to maximize his or her career prospects and rather than seek to keep them in Africa we hope that AIMS, once proven successful, will encourage them to return to Africa after their studies abroad.

Indeed AIMS has already begun to act as a magnet, drawing African scientists back to the continent. For example, a grant from the Victor Rothschild Memorial Fund enabled four young African doctoral and post-doctoral research scientists, who had been studying abroad, to visit AIMS for two months to serve as guest lecturers for the diploma course.

AIMS novel diploma course consists of three sections: a skills section covering mathematical and computing research methods that include such fields as estimation and approximation, inference and information theory, and modelling and data analysis; an interdisciplinary review section covering such fields as biological systems, statistical physics, numerical analysis, astrophysics, quantum physics, geometry and topology, fluid dynamics and financial mathematics; and a section on science writing in which each student receives close supervision from a local academic in writing an essay on a scientific topic in which they are interested.

The structured learning environment consists of a series of lectures, often divided into themes, each of which lasts from three to four weeks. Visiting mathematicians and scientists from universities in Africa, Europe and the United States serve on the faculty. To date, more than 100 lecturers have volunteered to participate in the AIMS visiting lectureship programme. Because their services are often provided free-of-charge, we have been able to provide world-class instruction at a very low cost.

AIMS also organizes specialized shorter term courses. For example, in December 2003, the South African Centre for Epidemiological Modelling and Analysis partnered with AIMS to a hold a one-week course on epidemiological modelling.

AIMS has begun to act as a magnet, drawing African scientists back to the continent.

AIMS students tell us that they are "learning to think and to solve problems" for the first time in their lives and that the experience is exhilarating. For many students, rote learning for examinations rather than independent and creative thinking has been the norm. Lecturing in African universities tends to be formal and students are often discouraged from interacting with professors. AIMS seeks to provide a counterpoint to the impersonal learning environment that is so commonplace in African universities and research centres. Its self-contained learning environment, in fact, fosters far greater contact and teaching time than has been the case in conventional universities. AIMS also provides endless opportunities to adjust the curriculum to fit students' needs.

The goal is to have all students master the course material or, at minimum, to benefit from the course in some way. Because each lecturer is present only for a brief time, it is vital that students begin to work on problems from the first day of each course. Teaching at AIMS is demanding but lecturers tell us they find the experience rewarding. They report that AIMS students are among the most highly motivated they have encountered.

AIMS also emphasizes the use of new information technologies. All students and most lecturers, for example, have been recruited through email or the AIMS website. Information technologies not only boost the operational efficiency of institutions such as AIMS but, more importantly, give African scientists an opportunity to overcome obstacles that have long stood in the way of progress, including chronic isolation from others pursuing similar research and lack of access to such intellectual resources as journal articles and text books.

The internet allows rapid and cost-effective access to vast amounts of information. Indeed the electronic information revolution has not only increased the quantity of information readily available but has qualitatively transformed the way in which research is done. Much of modern scientific research involves analysing and modelling data. As a result, students trained to think and use computers creatively can enter a wide range of fields, including astronomy, bioinformatics and finance.

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The many huge data sets that are freely available on the internet allow African researchers engaged in such analytical work to integrate themselves quickly into the global scientific community.

We envision an important role for AIMS in selecting, training, teaching, and disseminating free software across Africa. Students and visitors are impressed with AIMS' efficient, user-friendly computer network. AIMS staff and students were able to catalogue and label the entire library of 3000 books in a single working night, at no cost, by tapping into the US Library of Congress catalogue system via the internet with software that AIMS had developed. This software will now be made freely available to African universities to facilitate the cataloguing of their library collections.

> ***AIMS' ultimate goal is nothing less than building a critical mass of expertise in the mathematical sciences in Africa.***

Because no comparable pan-African institute for postgraduate teaching or research in the mathematical sciences exists, such organizations as the International Mathematical Union (IMU) and the Millennium Science Initiative (MSI) have welcomed the creation of AIMS. So, too, have national and regional organizations dedicated to the promotion of mathematics and science in Africa.

AIMS is committed to working with like-minded organizations to build a strong network of centres of excellence for teaching and research in mathematics throughout Africa. In cooperation with South Africa's Department of Science and Technology, AIMS is currently developing a proposal to create a cyber-network of mathematical institutes in Africa dubbed the African Mathematical Institutes Network (AMI-net).

SUCCESSFUL START

Several factors account for AIMS' early success:

High demand. AIMS has received more than 170 applications to fill 45 places for its second diploma course scheduled to begin in September 2004. That's a doubling of applicants compared to the first year.

Good will. More than 100 professors from around the world have signed up for the AIMS' lecture programme. They provide their services free-of-charge.

Political commitment. South Africa, AIMS' host country, has strongly supported AIMS. NEPAD has also shown keen interest in the initiative, particularly in terms of the project's potential ties to universities and industry throughout Africa.

With the encouragement and support of so many organizations, proponents of AIMS remain guardedly optimistic about its future. AIMS' ultimate goal is ambitious: Nothing less than building a critical mass of expertise in the mathematical sciences in Africa. Yet the strategy AIMS has devised to advance this goal remains straightforward: To nurture an environment where critical thinking and the exchange of ideas can take place.

Maintaining the quality of the educational experience at AIMS, and thereby proving our value to the governments of Africa and other project supporters, is the best way to ensure that AIMS' efforts to build a bright future for the mathematical sciences in all of Africa remain on target. ■

Fritz Hahne
AIMS Muizenberg, Cape Town
Republic of South Africa

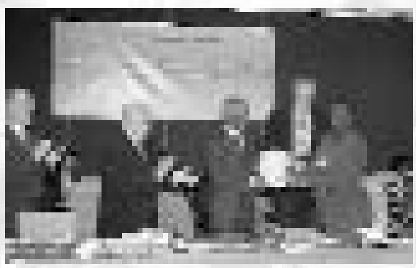
Keith Moffatt
Neil Turok
Centre for Mathematical Sciences
Cambridge, United Kingdom

For additional information about the African Institute for Mathematical Sciences (AIMS), see www.aimsforafrica.org or www.aims.ac.za.

AFRICA'S RAINBOW REVOLUTION

WILL AFRICA BE ABLE TO FEED ITSELF? THE ANSWER IS 'YES' – BUT ONLY IF IT ADOPTS A MULTIFACTED STRATEGY THAT RECOGNIZES THE CONTINENT'S UNIQUE ECOLOGY AND CULTURE. THAT'S THE CONCLUSION OF A RECENT REPORT BY THE INTERACADEMY COUNCIL (IAC).

Africa is rich in both natural and human resources. Yet nearly 200 million of its people are undernourished because of insufficient food supplies. Strategies must be adopted across the continent to harness the power of science and technology in ways that boost agricultural productivity, profitability, and sustainability – ultimately ensuring that all Africans have access to enough safe and nutritious food to meet their dietary needs. TWAS Founding Fellow M.S. Swaminathan, one of the co-chairs of the InterAcademy Council's (IAC) panel that prepared the recent report, Realizing the Promise and Potential of African Agriculture*, highlights the main elements of the action plan recommended to increase the productivity of African agriculture.*



There have been numerous studies, symposia and books on African agriculture in recent decades, each proposing strategies to ensure sustainable food security in Africa.

Several of these studies have shown that a 10 percent increase in crop yield would lead to a 6 to 10 percent increase in the annual survival rate of African women and men earning US$1 or less per day. Because more than 80 percent of Africa's population depends on crop and animal husbandry, fisheries, agro-forestry and agro-processing for its livelihood, enhancing farm productivity provides the best safety net against poverty and hunger.

Agriculture in Africa serves as the backbone of the food, livelihood and ecological security systems. What Africa needs is science and technology that helps to produce more food, more jobs and more income.

Building on the vast volume of data and information available and placing total confidence in the wisdom and innovativeness of African farm families and farm scientists, the InterAcademy Council's (IAC) panel report, *Realizing the Promise and Potential of African Agriculture*, calls for the launch of an ever-green revolution in African agriculture driven by the enhanced productivity, profitability, stability and sustainability of the major farming systems of this diverse and resource-rich continent.

The IAC report, however, refers to the productivity-based progress of African agriculture not as an ever-green

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revolution but as a 'rainbow revolution' because unlike Asia, where wheat and rice are the dominant food crops, Africa does not have a dominant farming system on which food security largely depends.

In recent decades, Africa's agricultural progress has been hampered by the spread of the HIV/AIDS pandemic; uncertain market access and fluctuating market prices associated with the trade and subsidy policies of industrialized countries; political instability; and ethnic conflicts. Nevertheless there have been several success stories on the continent that can serve as signposts for the road that lies ahead. These include:

- Soil health enhancement through nitrogen-fixing shrubs and rock-phosphate applications.
- Biological control of the cassava mealy bug.
- Cultivation of maize with improved protein quality.
- Development of tissue culture for the disease-free multiplication of banana.
- Development of New Rice for Africa (Nerica).

The steps that led to the conversion of unpromising 'hot spots' into appealing 'bright spots' were:

- Indigenous research by African scientists.
- Strategic partnerships with farm women and men, as well as with advanced research institutions, including institutions belonging to the network of the Consultative Group on International Agricultural Research (CGIAR).
- Farmer participatory research and knowledge management systems leading to the demystification of technologies.
- Location-specific technologies supported by such services as credit and seed inputs.
- End-to-end strategies involving all steps in the technology development, verification, adaptation and adoption process.
- Political support at the highest level that ensures access to remunerative markets and accords greater social prestige to agricultural scientists.
- Sustained funding for agricultural research, education and development.

Unlike Asia, Africa does not have a dominant farming system on which food security largely depends.

The formation of the Forum for Agricultural Research in Africa (FARA) and the New Partnership for Africa's Development (NEPAD) also constitute organizational 'bright spots' that can help accelerate the pace of agricultural progress.

ACTION

Let me highlight the principal components of the action plan devised by the IAC panel for leading Africa's agricultural future in the right direction.

Most African soils are both hungry and thirsty – that is, short of nutrients and water. Therefore an indispensable priority must be the nurturing of soil fertility and the development of measures for water harvesting, conservation and efficient use.

Rain-fed agriculture is dominant in Africa. That makes community water harvesting and watershed management as essential as the cultivation of high-value, low-water crops. Our panel has therefore placed considerable stress on the adoption of an ecological production approach in land and water use planning. Of the 17 distinct farming systems identified in different parts of Africa, we concluded that the following four systems offer immediate promise for increasing African food security:

- Maize-mixed system based primarily on maize, cotton, cattle, goats and poultry. The system recognizes the importance of off-farm work.
- Cereal-root crop mixed system based primarily on maize, sorghum, millet, cassava, yams, legumes and cattle.
- Irrigated farming system based primarily on rice, cotton, vegetables, cattle and poultry.
- Tree-crop-based system involving cocoa, coffee, oil palm, rubber, yams and maize. This system also recognizes the importance of off-farm work.

In addition, coastal areas hold promise for agroforestry systems involving aquaculture and such halophytic plant species as mangrove and saltbush. Ethiopia's highlands also hold promise for significant gains in productivity if the proper agricultural systems are put in place.

The IAC panel suggests methods for strengthening national agricultural research systems and establishing African Centres of Agricultural Research Excellence (ACARE) by building on the strengths of existing institutions. Because ecological agriculture is more knowledge-intensive than capital- or chemical-intensive, we

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STUDY PANEL

Responding to a request from the Secretary-General of the United Nations, in 2002, the InterAcademy Council (IAC) appointed a study panel on agricultural productivity in Africa. The panel was composed of co-chairs Speciosa Wandira Kazibwe, past vice-president of Uganda and former minister of agriculture, animal industry and fisheries; Rudy Rabbinge, dean, Wageningen Graduate School, and professor of sustainable development and systems innovation, Wageningen, Netherlands; and M.S. Swaminathan, chairman of the M.S. Swaminathan Research Foundation in Madras and father of India's green revolution in the 1960s. The panel also included 15 other distinguished members mostly from Africa. Jim Ryan of Australia, former director-general of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Hyderabad, India, served as the study director. The panel's mandate was to produce a consensus report for the UN that (1) addressed how science and technology could help improve agricultural production in Africa and (2) identified the larger economic, social and political conditions that are essential for effective use of science and technology in both the public and private sectors. The report was presented to the UN Secretary General in New York on 25 June 2004. The full text may be browsed at www.interacademycouncil.net.

SUCCESS WITH RICE

Such cultivated rice species as Oryza sativa*, which are indigenous to Asia, have been subjected to many cycles of selection and improvement by both farmers and scientists and, as a result, now yield up to 12 tonnes per hectare. In contrast, Africa's only native rice,* O. glaberrima*, despite having been domesticated centuries ago, yields only one tonne per hectare. It does, however, possess strong resistance to weeds and local pests – the reasons why Asian rice varieties are not widely grown in Africa. Until now, these two species of rice were genetically incompatible. Using a technique developed in the 1980s, known as 'embryo rescue', scientists have now combined the high-yielding traits of elite Asian rice with the pest-resistant properties of African rice. The product, labelled Nerica (New Rice for Africa), yields up to 2.5 tonnes per hectare and matures quickly, allowing farmers to grow a second crop – beans, for example, that fix nitrogen and help build soil fertility. Farmers throughout the upland rice growing regions of west Africa are currently cultivating Nerica varieties. Indeed Guinea saved some US$13 million in rice imports in 2003. Nerica rice is also being promoted in Uganda, where some 6,000 hectares have been planted. Thanks to Nerica, Africa is expected to be self-sufficient in rice by 2010.*

recommend the extensive application of modern information, education and communication technologies involving the integrated use of the internet, cable television, community radio and local press. And we call for the establishment of an African Virtual Academy for Agricultural Progress and Rural Prosperity to stimulate the spread of a rainbow revolution in rural areas.

Women play a key role in both the production and post-harvest phases of African agriculture. That's why our panel suggests that a 'women in agriculture programme' be initiated to promote both knowledge enhancement and skill empowerment of women farmers and women farm labourers. Programmes for bridging the 'digital divide' should also aim at narrowing the gender divide in technological capacity building. The panel also recommends that, rather than lamenting the brain drain, efforts should be made to support educated professionals who continue to live and work in their native countries. "Care for the brains at home" should be the motto.

Monetary compensation alone, although important, may not be able, on its own, to attract and retain creative scientists. Indeed such non-monetary benefits as well-equipped laboratories, a nurturing environment, academic freedom and efficient research management that encourage initiative and invention are just as important as high salaries in arresting the brain drain.

Finally, our panel recommends an African 'grid' of participatory science and technology pilot projects to introduce farm women and men to the opportunities offered by modern science and technology. The goal is to enhance agricultural productivity and income on an ecologically sustainable basis in a wide range of farming systems.

These pilot programmes should be set up where the production-processing-marketing-consumption chain can be assessed – and subsequently implemented – and should include:

- Indigenous technologies relevant to the improvement of productivity and food security.
- Market potentials and constraints for existing and prospective commodities in farming systems.
- New technologies to enhance productivity and food security, including:
  – Integrated nutrient and soil fertility enhancement.
  – Integrated pest management.
  – Small-scale water harvesting and use of micro-irrigation systems for delivery of water and nutrients.
  – Applications of improved genetic strains, biofertilizers and biopesticides.
  – Use of improved farm implements and appropriate mechanization for increasing labour productivity, reducing drudgery and ensuring timely farm operations.
  – Introduction of appropriate post-harvest processing, storage and marketing techniques.
  – Promotion of non-farm employment through introduction of technologies adding economic value to primary products and through agri-business.
  – Development of communication programmes to provide location-specific information related to meteorological, management and marketing factors and to

promote genetic and trade literacy among rural farm families.

– Establishment of farmer field schools for integrated pest, disease and weed management, integrated water and fertility management, and other aspects of production and post-harvest technologies based on the principle of learning-by-doing.

– Promotion of such institutional structures as co-operatives and self-help groups that can confer the power of scale to small landholders at the production and post-harvest phases of farm operations.

- For each pilot programme, the scope for other institutional innovations should also be explored, including:

– Promotion of a participatory knowledge coalition led by small landholders, who are encouraged to become involved with universities, national agricultural research institutions and extension agencies for the purposes of exploring new modes of partnership.

– Identification of candidates for ACARE centres to serve the interests of small landholders.

– Stimulation of public-private partnerships to address priority constraints that cannot be alleviated by independent activities and that are aimed at building convergence and synergies.

– Identification of the constraints that prevent the realization of the promise and potential of the pilot pro-

In African nations, as in other developing countries, if agriculture goes wrong, nothing else has the chance to go right.

SUCCESS WITH CASSAVA

More than 60 percent of the world's cassava is grown in sub-Saharan Africa. In the early 1970s, production of this root crop was threatened by the accidental introduction into west Africa of the cassava mealybug, Phenacoccus manihoti. *In the absence of natural enemies, the cassava mealybug spread at a pace of more than 300 kilometres per year. By the 1980s, it could be found throughout tropical Africa, endangering the food supply of 200 million people who relied on cassava as a subsistence crop. Among the several natural enemies introduced by scientists of the Nigeria-based International Institute for Tropical Agriculture (IITA) and collaborating agencies was a parasitoid wasp,* Apoanagyrus lopezi, *from Paraguay, the native home of the mealybug. Techniques were developed for mass-rearing the wasps, which were then distributed from aeroplanes. This large-scale strategy quickly led to the control of the pest over a wide area. The parasitoid wasp has now established itself in 26 African countries and continues to provide safe and effective control of the cassava mealybug throughout the region.*

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SUCCESS WITH BANANA

Banana is a major staple crop and source of income for more than 20 million people in east Africa, many of them resource-poor women farmers. Yet production is less than half the level it could be due to pests and diseases. The problem lies in the way bananas are traditionally propagated – simply by uprooting a sucker and transplanting it. Using this method transfers all the diseases that are infecting the ageing mother tree. Tissue culture propagation, on the other hand, can be used to produce thousands of tiny plantlets free of bacterial, fungal and viral diseases. Apart from being pest- and disease-free, tissue-cultured plantlets have several other advantages over traditional planting material. For example, trees reach maturity earlier and bear fruit bunches up to 50 percent heavier than traditionally raised trees. In addition, each tree produces double the number of suckers than traditionally propagated trees, which provides a rapid means of multiplying and disseminating improved planting material. A project launched in 1996 brought together the Kenya Agricultural Research Institute (KARI), the Institute of Tropical and Sub-Tropical Crops (ITSC) in South Africa and others to encourage the production, testing, dissemination and adoption of tissue-cultured banana plantlets. The private sector in South Africa is already producing more than 4 million banana plantlets each year, mainly for export, and private laboratories have also been set up in Kenya. An estimated 500,000 small-scale farmers in east Africa now grow bananas derived from tissue culture. In Kenya, as a result of farmers planting healthier banana plants, household income has reportedly increased from 700 Kenyan shillings (less than US$10) to 5,000 Kenyan shillings (US$60) per harvest.

grammes to improve agricultural productivity and food security at the local level.

– Introduction of a horizontal dimension to the different vertically structured programmes relating to the realization of the UN Millennium Development Goals.

The IAC panel suggests that interdisciplinary teams from national agricultural research systems, universities, extension services and farmers' organizations be constituted to prepare business plans and research agendas in each of the priority farming systems described above.

Nothing succeeds like success. Therefore the sites for the initial rainbow revolution pilot programmes should be developed where there is a socio-economic, political, scientific and ecological environment conducive to the achievement of the programmatic goals. For each pilot programme, a local farmers' advisory council, involving both men and women, should be constituted to assume ownership and undertake monitoring and evaluation.

In African nations, as in many other developing countries, if agriculture goes wrong, nothing else has the chance to go right. Bilateral and multilateral donors and national governments should lose not a minute more in implementing IAC's recommendations. Just as African societies take pride in rainbow coalitions at the political level, African agriculture can lead the world in demonstrating the power of a science-and-technology-based rainbow revolution in agriculture for eliminating poverty and hunger. ■

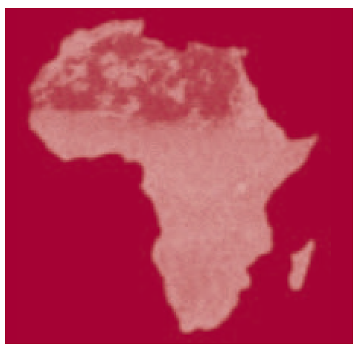
M.S. Swaminathan *(TWAS Founding Fellow)*
Chairman
National Commission on Farmers, India

Co-chair, InterAcademy Council's (IAC)
Panel for Harnessing Science and Technology to
Increase the Productivity of African Agriculture

For the full text of the IAC report, see
www.interacademycouncil.net

STATEMENT ON AIDS

TWAS AND THE AFRICAN ACADEMY OF SCIENCES (AAS) HAVE ISSUED A JOINT STATEMENT ON HIV/AIDS IN THE DEVELOPING WORLD, CALLING FOR GREATER INVOLVEMENT OF DEVELOPING WORLD SCIENTISTS IN RESEARCH INITIATIVES DESIGNED TO TREAT AND MITIGATE THE DISEASE. BOTH ORGANIZATIONS ARE PARTICULARLY KEEN TO ENLIST AFRICAN SCIENTISTS IN THIS CAMPAIGN.



On 8 July, just prior to AIDS 2004, the XV International AIDS Conference in Bangkok, Thailand, TWAS and the African Academy of Sciences (AAS) issued a Joint Statement on HIV/AIDS in the Developing World.

Specifically, TWAS and AAS believe that the discovery and development of new drugs and vaccines to combat HIV/AIDS should also be conducted through South-South collaboration, using the expertise present in the many centres of scientific excellence in the developing world.

"Such a programme of support would not only allow the enormous potential of developing countries' flora and fauna to be investigated for novel pharmaceutical products, but would also help stem the 'brain drain' – a major problem for the development of scientific capacity in the South, and especially in sub-Saharan Africa," says Gideon Okelo, TWAS Fellow 1989, professor of medicine at the University of Nairobi, Kenya, and AAS secretary general and executive director.

"It would also offer potential avenues of investigation that have yet to be explored because of the dominance of Northern scientists in the design and implementation of AIDS-related research," says Ahmed A. Azad, TWAS Fellow 2002 and director of research at the Faculty of Health Sciences, University of Cape Town, South Africa.

Azad and Okelo were the two lead authors of the TWAS/AAS joint statement. Once reviewed and approved by the TWAS Council and AAS Governing Council, the statement was released via two internet sites dedicated to serving science journalists on either side of the Atlantic, Alphagalileo (*www.alphagalileo.org*) in Europe and Eurekalert (*www.eurekalert.org*), managed by the American Association for the Advancement of Science (AAAS), in the United States.

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This statement is bound to increase the concerns of everyone about this global tragedy.

The statement was also posted on other science and healthcare-related websites, including the United Nations Educational, Scientific and Cultural Organization's (UNESCO) Natural Sciences portal (*www.unesco.org/science*), Biocompare (*www.biocompare.com*), which includes a dedicated life sciences news site, Medical News Today (*www.medicalnewstoday.com*), and on the webpages of the international AIDS charity, Avert (*www.avert.org*). In addition, the statement was posted on the websites of the InterAcademy Panel on International Issues (IAP) (*www.interacademies.net*) and the Brazilian Academy of Sciences (*www.abc.org.br/english/*).

The statement also received good visibility throughout Africa thanks to its posting on various websites. Among these were Panapress (*www.panapress.com*), dedicated to coverage of African news, and Countrywatch (*www.countrywatch.org*), which provides country-specific information for every country in the world. Indeed, the joint statement was featured on Panapress websites dedicated to several African countries, including Lesotho, Namibia and Senegal.

"One thing is certain," adds Okelo. "This statement is bound to increase the concerns of everyone about this global tragedy."

The full text of the statement follows. ■

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JOINT STATEMENT ON

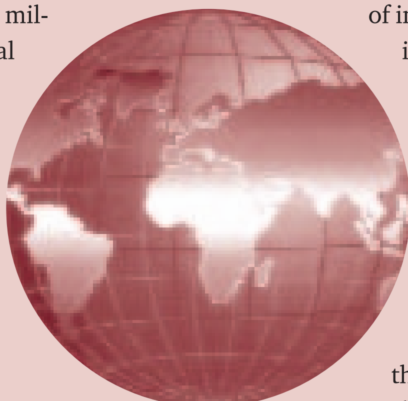
HIV/AIDS IN THE DEVELOPING WORLD

Third World Academy of Sciences (TWAS)
African Academy of Sciences (AAS)
Trieste, Italy / Nairobi, Kenya

During the past two decades HIV/AIDS has had a devastating impact on the health and social and economic well-being of populations in many parts of the developing world.

In 2003 alone, HIV/AIDS caused the death of more than three million people[1]. That made it the number one killer among all infectious diseases.

The vast majority of the 40 million people living with HIV/AIDS – indeed some 34 million or nearly 85 percent of the total number of people afflicted with the disease – live in Africa, Asia and Latin America, among countries that are least able to manage the epidemic or afford the costly combination of antiretroviral drugs which have dramatically reduced AIDS-related morbidity and mortality rates in developed countries.



Sub-Saharan Africa, on its own, accounts for about two-thirds of all HIV/AIDS-related deaths. The region also accounts for about two-thirds of the number of people living with HIV/AIDS.

The number of people afflicted with HIV/AIDS in Africa, particularly in sub-Saharan Africa, is truly daunting. More than 26.5 million Africans currently live with HIV/AIDS – 3.2 million of whom were infected in 2003. The HIV/AIDS-related yearly death toll in sub-Saharan Africa has reached 2.3 million in 2003. Experts expect that the total number of deaths due to the disease will reach 55 million by 2020 unless aggressive measures are taken to prevent and treat disease.

The HIV/AIDS epidemic, however, is by no means restricted to the African continent. South Africa has the highest number of HIV-infected people – some 5 million people or 20 percent of the population. But India has the second highest count in terms of absolute numbers (an estimated 2 to 5 million people) and the incidence of infection is also rising at an alarming rate in China. Failure to arrest the spread of the disease in the developing world, particularly in the world's two most populous countries that account for more than one-third of the world's population, could have disastrous consequences for the entire human race.

The enormous challenges posed by the HIV/AIDS epidemic has aroused a rising chorus of global concern for combating the disease. In September 2000, representatives at the Millennium Summit of the United Nations classified HIV/AIDS as one of the world's most pressing problems. In June 2001, the United Nations Special Session of the General Assembly cited the fight against HIV/AIDS as a global priority and issued a 'Declaration of Commitment' in which member states pledged to vigorously address the public health and social issues engendered by the epidemic. In April 2001, at the African Summit on HIV/AIDS, Tuberculosis and Other Related Infec-

[CONTINUED PAGE 80]

tious Diseases, held in Abuja, Nigeria, Kofi Annan, the Secretary General of the United Nations, issued a global call for action in the fight against HIV/AIDS in which he implored political and business leaders to respond to the challenge. The Secretary General's urgent request led to the creation of the Global Fund Against AIDS, Tuberculosis and Malaria in 2001.

The Third World Academy of Sciences (TWAS) and the African Academy of Sciences (AAS) acknowledge the enormity of the problems caused by HIV/AIDS in the developing world and recognize the pressing need to stem the spread of the epidemic through public awareness and education, universal access to both condoms and antiretroviral drugs, development of more effective, affordable and safer therapies, and the need for additional investment in the research and development of vaccines. In Africa, more than 4 million people would benefit from anti-retroviral drugs, but only 50,000 people are receiving such therapies.

Research should be conducted through collaboration with institutions in developed countries and South-South collaboration.

To help achieve these objectives, TWAS and AAS are eager to join UN agencies and government and non-government organizations in support of on-going research in the following areas:

1. Disease management and care of AIDS sufferers and HIV-infected individuals, including AIDS orphans.

2. Efforts to lower the cost of antiretroviral drugs and to make these drugs universally available to prevent mother-to-child transmission of HIV and to lower viral count in infected individuals.

3. Vaccine development through South-South and South-North research collaboration.

4. Public education and awareness of the disease process that would help reduce the incidence of HIV infection. Such campaigns should be intensified, together with efforts to increase universal access to condoms, as key preventative measures. Existing sources of indigenous knowledge, as well a in-depth assessments of prevailing cultural attitudes and beliefs concerning HIV/AIDS, should be identified as part of a larger effort to improve public awareness of the disease and its consequences.

5. Examination of the use of traditional herbal medicines in HIV/AIDS management and analyses of indigenous flora and fauna as potential sources of less expensive antiretroviral drugs. The role of traditional healers in preventing and treating HIV/AIDS should also be examined. The South is richly endowed with natural products that contain potential immune-boosting ingredients. Such products may prove particularly valuable in HIV/AIDS treatments, particularly for infants and for adults during early stages of infection.

TWAS and AAS are aware of the shortcomings of antiretroviral drugs currently in use and, therefore, recognize the need for additional research that could lead to the discovery and development of new drugs that are more effective, affordable and patient friendly.

The enormous potential of the flora and fauna present in the developing world, combined with the pooling

of expertise and resources within the South, could help promote the discovery and development of new antiretroviral and other drugs that prevent the destruction of the immune system or that boost existing immunity to arrest the progression of AIDS.

Vaccination is the cheapest and most effective way to prevent infection by HIV in the first place and to manage the disease over the long term. Despite two decades of intense international effort, no effective vaccine has been produced and none is likely to be discovered in the near future. The difficulty of producing effective vaccines is compounded by the enormous genetic diversity found among HIV strains. There is also an urgent need for therapeutic vaccines to arrest the progression of HIV in infected individuals. TWAS and AAS, therefore, encourage and support research leading to the development of cross-protective prophylactic vaccines to prevent new infections as well as therapeutic vaccines for the millions of individuals who have already contracted HIV.

TWAS and AAS believe that research, leading to the discovery and development of new drugs and vaccines to combat HIV/AIDS, should be conducted not only through collaboration with institutions in developed countries, but also through South-South collaboration, especially among centres of excellence in the developing world that possess complementary expertise. The latter efforts would not only help promote relevant and focused multidisciplinary research but would contribute to building scientific capacity in the developing world and thus serve to counter the 'brain drain' phenomenon. Such efforts could provide a unique opportunity for TWAS and AAS to become involved in efforts that have long-lasting benefits for people living in HIV/AIDS-affected areas both in sub-Saharan Africa and throughout the developing world.

Transfusion of unscreened blood that may be contaminated with HIV represents an insidious yet efficient method of HIV transmission. Although countries in the South are aware of this problem, the transfusion of unscreened blood is still a common occurrence in many developing countries. TWAS and AAS urge all governments in the South to ensure that only properly screened blood is used in blood transfusions and that all medical laboratories in the developing world have the necessary equipment and skilled personnel to perform safe and reliable transfusion procedures.

TWAS and AAS should involve the Network of African Science Academies (NASAC) to fully engage the entire scientific community in Africa in research on HIV/AIDS. AAS and TWAS should also work closely with national governments in Africa, the New Partnership for Africa's Development (NEPAD), the African Union (AU) and all relevant UN agencies – UNAIDS, the World Health Organization (WHO), the United Nations Development Programme (UNDP), and the United Nations Children's Fund (UNICEF) – in developing a pan-African strategy to combat an epidemic that now threatens the well-being not only of Africa but, increasingly, all other parts of the developing world. Similar organizations in Asia and Latin America should also be engaged.

TWAS and AAS should examine ongoing efforts in countries throughout the South for potential opportunities to collaborate as the basis of a larger effort to promote joint action to combat the HIV/AIDS epidemic in the South. ■

[1] All figures cited are based on UNAIDS, WHO and US Centers of Disease Control and prevention (CDC) data.

LAST WORD: SCIENCE PAYS

UGANDA'S PRESIDENT YOWERI MUSEVENI EXPLAINS WHY AFRICAN NATIONS SHOULD INVEST HEAVILY IN SCIENCE AND WHY SCIENTISTS SHOULD BE WELL PAID.

In the 1960s, Uganda's per capita income was equivalent to the per capita incomes of Singapore and South Korea. These two countries have since been very successful – Singapore's gross national per capita income now exceeds US$21,000 and South Korea is now ranked the 11th richest country in the world.

Uganda, however, like many countries in sub-Saharan Africa, is beset by problems, both internal and external, that have prevented it from progressing from a Third World country to a 'First World' country.

One of the most important factors that must be addressed to boost Uganda's development – and the development of other sub-Saharan African countries – is to build up our human resources.

Only in this way can we gradually shift production from such natural resources as coffee and cotton to production based on human intellect and ingenuity.

Japan, for example, has no natural resources: no oil, no diamonds, no other rich mineral deposits. Yet it has the world's second largest economy. Japan earns much more than such oil-rich countries as Saudi Arabia because its products are based on human intellect.

When it comes to earning foreign capital, products of the brain are much more valuable than natural products or stones in the ground. But you cannot achieve what Japan has achieved unless you educate your population.

We are lucky in Uganda. Our stones will remain in the ground until we have become better placed to develop the needed human resources to mine and profitably use them. We must, however, pay our scientists world-class wages so that we retain the true value of our stones rather than exporting them to the North.

I have been having a big problem with my administration here. I am

Yoweri Museveni

always having to fight. The civil service recently introduced the 'single spine' structure. This basically means the permanent secretary, because he is the senior administrator, earns the most and the structure runs down the hierarchy to the scientist who earns the least.

I have no problem with this structure but the scientist must be on top because he or she is the one who produces something. I intend to cause a revolution by generously supporting scientists. Scientists must be paid well to remain at home. I am

going to ensure this happens in Uganda. It is a big struggle but I have always fought such battles.

Ugandans living abroad collectively earn US$700 million. Some 100,000 Ugandans live in Canada and the United States alone. These emigrants are not peasants. They are doctors, engineers, scientists. They prefer to remain abroad because they are paid better there. Some of our people work for the US National Aeronautics and Space Administration (NASA), helping Americans go to the moon. Meanwhile, we in Uganda cannot even get to another town, never mind the moon. This is madness.

Scientists must be paid more than everybody else. They must be paid world-class wages in Africa. It does not matter if the president does not have the highest salary. Let the scientists earn the most even if I, as president, receive much less. The scientist will not get a 21-gun salute, but the president is a big man and will get it.

If you give scientists money, administrators, in time, will also get something. Once scientists have solved a number of problems for us, then administrators will ultimately be paid well too. If we kill the goose that lays the golden egg, however, how can we ever move forward? Let us start by supporting scientists. This is my struggle. ■

Yoweri Museveni
President
Uganda

Extracted from the opening speech of a conference for African ministers of finance, planning and economic development.
18 May 2004
Kampala, Uganda

WHAT'S TWAS?

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

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

The main objectives of TWAS are to:

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

TWAS was instrumental in the establishment in 1988 of the Third World Network of Scientific Organizations (TWNSO), a non-governmental alliance of 160 scientific organizations from Third World countries, whose goal is to assist in building political and scientific leadership for science-based economic development in the South and to promote sustainable development through broad-based partnerships in science and technology. ···> **www.twnso.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 2000 women scientists from 87 Third World 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 90 science academies worldwide established in 1993, whose primary goal is to help member academies work together to inform citizens and advise decision-makers on the scientific aspects of critical global issues. ···> **www.interacademies.net**

WANT TO KNOW MORE?

TWAS offers scientists in the Third World a variety of grants and fellowships. To find out more about these opportunities, check out the TWAS website:

www.twas.org

FELLOWSHIPS

Want to spend some time at a research institution in another developing country? Investigate the fellowships and associateships programmes.
www.twas.org/Exchange.html
TWOWS offers postgraduate fellowships to women from least developed countries (LDCs) and other countries in sub-Saharan Africa.
www.twows.org/postgrad.html

GRANTS

Are you a scientist seeking funding for your research project? Then take a look at the TWAS Research Grants scheme.
www.twas.org/mtm/RG_form.html
Is your institution seeking funds to collaborate with a research institute in another country in the South? Look to the TWNSO grants programme for support.
www.twnso.org/grants.html

EQUIPMENT

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

TRAVEL

Would you like to invite an eminent scholar to your institution, but need funding for his/her travel? Check out the Visiting Scientist Programme.
www.twas.org/hg/vis_sci.html

CONFERENCES

You are organizing a scientific conference and would like to involve young scientists from the region? You may find the help you need here.
www.twas.org/mtm/SM_form.html