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The Next 30 Years

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THE WORLD ACADEMY OF SCIENCES

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▲ Artificial fumarole at El Tatio geothermal field (Gerard Prins/Wikimedia Commons); Hong Kong from the Western District overlooking Kowloon. (Photo: Michael Janich/ Wikimedia Commons)

Cover: Marking the 30th anniversary of the Academy's first meeting, a special issue of the TWAS Newsletter looks at the next 30 years across a range of scientific fields.

▼ Women fetching water in Ethiopia. (Photo: © 2006 Kifle Abegaz/IFPRI)

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EDITORIAL

TWAS AND THE HORIZONS OF SCIENCE

▲ Bai Chunli

In July 1985, 250 delegates representing 50 science academies and councils from the developing world gathered in Trieste, Italy, for an occasion that would prove historic: the first meeting of TWAS. "Our major task is – first and foremost – the health of science itself in the South," Academy founder Abdus Salam told the delegates.

Today, in nations as diverse as India, Brazil, South Africa and China, science is flourishing in ways that could not have been imagined as TWAS was founded. The most recent Nobel Prizes included two remarkable scientists from the developing world: Chinese medical researcher Tu Youyou, whose discovery of anti-malarial drugs artemisinin and dihydroartemisinin has saved millions of lives; and Aziz Sancar, a Turkish-born chemist and TWAS Fellow, whose discoveries in gene-repair have illuminated mechanisms behind cancer and aging.

And yet, science in the developing world today must confront challenges that could scarcely be imagined three decades ago. Climate change, food and water security, health and biodiversity loss – these interconnected challenges are unprecedented.

In this special issue of the TWAS Newsletter, a corps of highly accomplished scientists looks hopefully across the next 30 years to these and other issues. They remind us that TWAS, too, must prepare for the next 30 years. Having learned much from my predecessors as TWAS president, and from the TWAS Council and other Fellows, I see eight critical goals for the Academy:

- **Increase the presence of women.** Even with recent progress, women still number just 10% of our Fellows. To be a global leader, TWAS must increase that ratio and bring more women onto our committees and Council.
- **Increase the number of younger scientists.** While many TWAS Fellows remain productive long past retirement age, younger Fellows can bring valuable new experience and perspective.
- **Expand our geographic presence.** TWAS Fellows represent 94 nations, but in many countries we have few or no members. Electing even one scientist in these countries is a seed for future growth.
- **Expand South-North cooperation.** Given our 2013 name-change to The World Academy of Sciences, we should attach more importance to productive partnerships with developed nations, extending the span of TWAS regional offices and centres of excellence.
- **Shift more responsibility to the five regional offices.** With detailed knowledge of issues, needs and opportunities in their areas, they should play a bigger role in running programmes and activities.
- **Address the gap between emerging and less-developed countries.** Our fellowships are critical. So is intensive training of the kind offered at the five CAS-TWAS Centres of Excellence.
- **Develop a "think-tank" capacity.** With the elite expertise of our Fellows and our experience and credibility at the highest levels, TWAS could expand its role as a global policy adviser.
- **Raise the funds needed to pursue these goals.** Use a creative, energetic approach to fundraising to seek new partners at foundations, in business and among philanthropic organizations.

These goals are certainly ambitious. But like science itself, TWAS must build on the work of leaders who came before us. To be of the greatest value to society, we must constantly grow and evolve. And we must have clear awareness that the priorities we pursue today will do much to determine our impact in the next 30 years.

Bai Chunli, *president, TWAS*

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LOOKING BACK: 1985

Thirty years ago, the Third World Academy of Sciences gathered for its first General Meeting in Trieste, Italy. The theme of the meeting, from 5-10 July, was "South-South and South-North Cooperation in Sciences". The occasion was auspicious, reflecting an awareness among global leaders that the Academy was embarking on a crucial mission.

Heads of state sent messages of support and encouragement, and top world leaders attended. Here are some highlights from their comments:

> We sincerely hope that the conference...at Trieste will produce positive and pragmatic results, and science will emerge as a factor to attain equality and solidarity and thus serve as a potent force for peace and understanding between peoples of the world.

Belisario Betancur
president of Colombia

> It is my hope that this conference will... address itself to the larger issue of the types of institutional structures and cooperative arrangements required for transforming research results into effective socioeconomic tools.

Jerry John Rawlings
head of state, Ghana

> The nations of the Third World...have the right to anticipate the best results from concentrating the efforts of their numerous young scientists in treating the nations' problems in order to attain their high hopes of progress and growth.

His Majesty King **Fahd Ben Abdel Aziz**,
Saudi Arabia

> India and other developing countries are only too aware of the crucial role played by science and technology in liberating people from the grip of want. In fact, science has an even larger role. It must free people all over the world from the grip of fear and suspicion and prejudice.

Rajiv Gandhi
prime minister of India

> I do believe that this conference will make valuable contributions to the development of the sciences in the Third World, foster unity and cooperation among the Third World countries, promote world peace and thus contribute to human progress.

Li Xiannian
chairman, People's Republic of China

> The development of agriculture and the conquest of avoidable disease are broadly known to be the priorities for most of the developing countries. However, it is only scientists who can define with clarity the relevance of the latest research and the gaps that still need to be filled. The judgements of social planners...will be sounder if they are arrived at after full discussions with scientists.

Javier Pérez de Cuéllar
United Nations secretary-general

> In recent times, in this adventure of discovery on the frontier, the South has not been able to play a commensurate role...principally because of lack of opportunity. This, however, is not a situation which young men and women from the Third World will accept. They enviously, and deservedly, long to participate in this exciting adventure of scientific creation on equal terms.

Abdus Salam
Nobel laureate and TWAS founder

CAN WE HEED ALARMS ON BIODIVERSITY?

After a half-century of warnings, the loss of species is accelerating. We must summon the will and accelerate efforts to save our life-support system.

by **Zakri Abdul Hamid**

Zakri Abdul Hamid, a 1996 TWAS fellow, is science adviser to the Prime Minister of Malaysia and a member of the UN Secretary-General's Scientific Advisory Board. He is the founding chair of the UN Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). He sits on the Global Leadership Council of the Sustainable Development Solutions Network and is the 2014 co-recipient of the Zayed International Prize for the Environment.

At the World Summit on Sustainable Development in 2002, the international community pledged to halt the loss of plant and animal diversity within eight years. That unmet target was replaced in 2010 with another, set in Aichi, Japan: to halt biodiversity loss by 2020. Will the goal be achieved this time? With just five years to go, optimism is difficult.

Around the planet, fish, animals, insects and even plants are moving out of their normal home ranges in an unprecedented response to changing climatic conditions and the loss of habitat because of human activities. Not all can move, or move fast enough. Species extinctions are occurring at a rate 100 times or even 1,000 times greater than the natural rate.

This problem directly threatens humanity's health, prosperity, food, fuel, clean water and air. Indeed, our very existence depends on the incredible diversity of other living things. We are destroying our life-support system.

Public awareness at both local and global levels is heightened, and modest progress has been achieved in several areas.

Most sorely needed are talent and expertise to help articulate the need for and how to halt biodiversity loss. Mobilising that expertise from disparate organisations – academies of science, scientific and non-governmental organisations, to name a few – while integrating indigenous and local knowledge needs to be concerted and focused. And a mechanism is needed to link that expertise with policymaking.

Such were the considerations behind the creation of the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES). It took years for governments to give the green light to IPBES and approve its first work programme in 2013, but we are now well into its implementation.

IPBES is mandated to build national capacity for biodiversity assessments, t o make use of indigenous and other forms of knowledge beyond Western science, and to catalyse information and knowledge to fill outstanding gaps.

These efforts of the scientific and academic communities, including those in the social sciences and humanities, have never been more urgently needed, especially in the developing world.

Environmentalists first sounded the alarm bells on the biodiversity issue 50 years ago. We have not reacted with appropriate urgency. Meaningful steps are now being taken, but we should all show support for accelerating protective efforts at every level – from the smallest communities to capitals of every nation. ◘

A CREATIVE WAY TO OFFSET BRAIN DRAIN

Brain drain has a deeply damaging effect on Caribbean countries. But is it possible that they could benefit by educating and training more scientists and sending them abroad?

by **Marvadeen Singh-Wilmot**

Marvadeen Singh-Wilmot was the first Caribbean scientist named a TWAS Young Affiliate (2010-2014). She is a chemistry lecturer at the University of the West Indies in Kingston, Jamaica, and has won honour both for teaching and research. Her research focuses on new materials for sensing and storage from lanthanide metals. Through teacher training workshops and kids' science programmes, she is working to popularize science in Jamaica.

Brain drain is one of the negative effects of migration which continue to retard growth in developing countries. Small island states and mainland countries in the Caribbean Basin are among the most seriously affected and have lost between 10% and 40% of their labour force due to emigration to countries such as the United States, Canada and the United Kingdom.

There is greater cause for concern when one considers that reduction in the labour force is larger in the higher education categories. The World Bank reports that Guyana loses 89% of its tertiary graduates, Jamaica 85%, Haiti and Suriname over 80%; the rest of the Caribbean countries have lost more than 50% of their labour force with university education.

Since the cost of education is largely government-subsidized in most Caribbean countries, this constitutes a major loss in return on investment in education, and it has been argued that funding of tertiary education in the Caribbean provides a direct subsidy to the economies of developed nations.

However, with weak infrastructure, high debt burden and low investments in key growth-drivers such as science, technology and innovation, it is very difficult for developing countries like those in the Caribbean to reverse this trend, stimulate growth and retain their brightest and best – or should I say retain their brightest and best and stimulate growth? Indeed one depends on the other so that highly skilled and educated people positively impact creativity and productivity in a country, but without the opportunities for them to work and grow they will certainly leave for greener pastures.

Photo: One Laptop per Child/flickr

The good news is that Caribbean people give back. The region is reported to be the world's largest recipient of remittances as a percentage of GDP. However, a 2006 International Monetary Fund Working Paper quantified the costs and benefits of migration in the Caribbean and concluded that the gains from remittances and other investments through diaspora engagement were much less than the loss from migration. If this position could be shifted so that returns from the Caribbean diaspora exceed the loss, an overall benefit could be realized.

Caribbean countries might therefore need to capitalize on the current global demand for highly educated knowledge workers by increasing access to and the quality of higher education. Large-scale training and export of highly skilled workers in a knowledge economy will lead to increased remittances and foreign direct investments through diaspora engagement. It could also reduce the augmented emigration loss as the pool of university-educated people will expand and international migration will have a smaller proportional impact on the labour force.

This can lead to increased productivity and competitiveness of the entire population and stimulate stagnated social and economic growth in many developing countries. ◘

THINK GLOBAL, WORK LOCAL

As the focus on climate change intensifies in years to come, understanding and response will depend on scientists with detailed local climate knowledge.

by **Filippo Giorgi**

Italian physicist Filippo Giorgi is the head of the Earth system physics section at the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy. His expertise lies in climate modeling, variability and change; chemistry-climate interactions; and land-atmosphere interactions. He worked at the National Center for Atmospheric Research (Boulder, Colorado, USA), from 1986-1998, and earned his PhD from the Georgia Institute of Technology (USA).

The Earth system, including the atmosphere, oceans, biosphere, cryosphere and anthroposphere, is one of the most complex and non-linear systems in science. Its study is based on extensive global observing networks and on increasingly comprehensive mathematical models which are integrated on the most powerful supercomputers and used to understand the history and future evolution of the Earth's climate. The evidence shows unequivocally that the climate is warming, mostly because of increasing emissions of carbon dioxide, methane and other greenhouse gases associated with the use of fossil fuels and with some agricultural practices.

As emissions increase, global warming will continue and possibly accelerate in future decades, leading to phenomena such as rising sea levels, melting glaciers and increased weather extremes. The impacts could be severe on natural ecosystems and human communities, threatening water resources, food security, health and even tourism.

Added to other environmental stresses, such as air and water pollution, soil degradation and loss of biodiversity, global warming can inhibit the sustainable development of societies. This is particularly the case for developing countries, which are most vulnerable to climate changes and lack the resources to implement suitable responses.

In fact, global warming research is an area where the divide between economically advanced and poor countries is especially marked. The large infrastructure needed to carry out climate projections with state-of-the-art global models simply is not available in most institutions of the developing world.

Yet climate information is needed at the regional-to-local scale in order to provide the basis for making decisions about climate change. The production of credible and robust regional- and local-scale climate projections is one of the great challenges in climate change research, since local climates are characterized by large variability and are affected by local conditions (e.g. topography, land use, aerosols) not captured at the coarse spatial resolution of global models.

Different techniques have been developed to overcome this problem, such as regional climate models and empirical-statistical approaches, which do not require massive infrastructure. These can enable researchers from developing countries to be more directly involved in the study of climate change problems specific to their regions.

EU Humanitarian Aid and Civil Protection

By offering the potential to employ critical know-how of local climate phenomena and related needs, regional climate research offers a tremendous and important opportunity for developing country scientists at the time of profound environmental stress. Not only can they provide invaluable scientific insights to an emerging field of research, but they can make influential contributions to the protection and sustainable development of their regions.

CRYSTALLIZING SOLUTIONS

The early challenges of crystal engineering should remind young scientists to see their dreams "with clarity, conscience, dedication and quality".

by **Gautam R. Desiraju**

Gautam Desiraju served as president of the International Union of Crystallography from 2011-14, and in that role helped organize the 2014 International Year of Crystallography. A structural chemist, he was elected a TWAS Fellow in 2002. He is a recipient of the Humboldt Forschungspreis and of the TWAS Prize in chemistry (2000). He sits on the editorial boards of the *Journal of the American Chemical Society*, *Angewandte Chemie* and *Chemical Communications*.

I returned to India to an independent position at the fledgling University of Hyderabad 35 years ago. My doctoral training in the United States had included some exposure to crystallography, but being essentially a chemist, I looked at the intersection of chemistry and crystallography. I began thinking about a new subject called crystal engineering, the design and synthesis of functional solids. The design tools in this engineering exercise are intermolecular interactions, the most prominent of them being the hydrogen bond.

My research in Hyderabad spanned three decades and I suppose my group made adequate contributions to crystal engineering, highlighting the role of the hydrogen bond and its wider ramifications in structural chemistry. A few colleagues in other far-flung locations across the world were also thinking on similar lines and the early work from our laboratories triggered much subsequent interest in the subject. Crystal engineering is in the scientific mainstream today with practitioners everywhere, including in the developing world —India of course, but also Brazil, China, Iran, Malaysia, Pakistan, South Africa and Vietnam.

It was not easy to do the best competitive science where I worked. The subsistence equipment of chemical crystallography is the single crystal X-ray diffractometer, but this facility remained a mirage in my university for ages. India, as Jawaharlal Nehru once famously said, is a rich country in which poor people live. Corruption is a multi-headed hydra in the developing world. Sycophancy and nepotism pervade in the making of appointments, in the giving of awards and fellowships, in showcasing a single institution or a single individual through extremely labyrinthine and skewed funding patterns, and the fate of the scientist who shuns this stultifying paradigm is the stuff of myth.

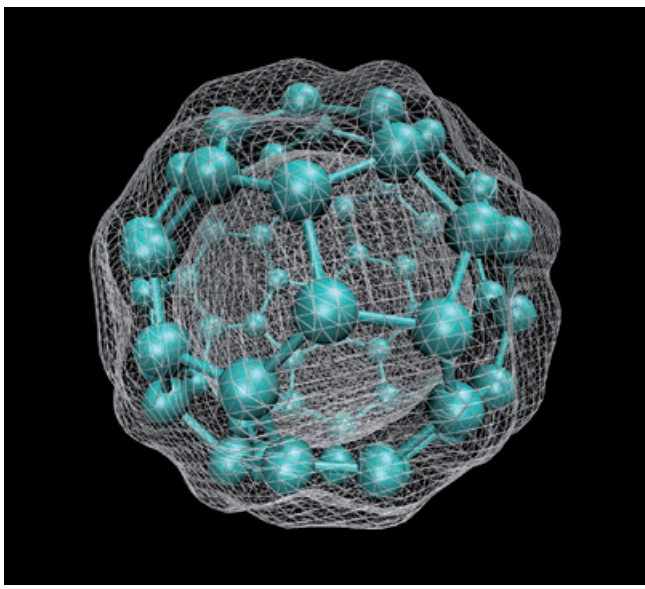


Photo courtesy: Isaac Tamblyn, University of Ontario, Canada

I can recount the past with some amusement now, but would mostly like to signify to young researchers across such nations that to see the dream with clarity, conscience, dedication and quality is to surmount all odds. As the mass of genuine work burgeons, there will fall into place a value system that is robust, because it is completely selfless and for the higher good. To establish this bedrock however, is the challenge at hand and this is where an organization like TWAS comes into play and assumes special significance. ◘

TO CUT DISASTER RISK, INVEST WISELY

Science and technology can reduce the risk of destruction and death caused by natural disasters. But first, policymakers must make it a priority.

by **B.N. Upreti**

Bishal Nath Upreti, a 2006 TWAS Fellow, is the chairman of the Disaster Preparedness Network Nepal. Formerly he served as dean of the institute of science and technology at Tribhuvan University in Kathmandu, Nepal. His research has focused on geology and tectonics of the Nepal Himalayas. He has been honoured with four national awards by the head of the state; three for academic and research excellence, and one for his rescue and relief operations during natural disasters.

Disasters today are affecting people and causing economic losses at rates that are unprecedented and increasing rapidly. By 2050, more than half of world's 9 billion people will live in large urban centres, most of them in developing countries. The enormity and frequency of disasters will bring further challenges that warrant visionary approaches.

The disaster impacts are unevenly distributed; Asia and Africa combined together take the brunt of nearly 68% of all people killed and 95% of those affected. From 2004 through 2013, disasters have killed 1 million people and affected 2 billion and economic losses from natural disasters now reach an average of US$250 billion to US$300 billion each year. Climate change will exacerbate the problem.

Photo: EU Humanitarian Aid and Civil Protection

The Disaster Risk Reduction (DRR) agenda is still on a low priority in most developing countries, despite enormous loss of lives and property in recent disasters – earthquakes in Nepal, Japan, Haiti, Pakistan, China, and Indonesia; typhoons in the Philippines; floods in Pakistan and many parts of Africa; and drought in East Africa. The recent Ebola epidemic in West Africa shows humanity's vulnerability to biological disasters. These disasters caused both deaths and erosion of hard-earned social and economic development gains.

The international initiatives on DRR such as the Sendai Framework for Disaster Risk Reduction (2015-2030) are welcome, and leaders and policymakers must aim to achieve these goals. The new mantra is to mainstream, not isolate, DRR in development.

Natural disasters cannot be controlled, but today science can help to monitor and forecast hazards and vulnerabilities, and to develop tools and methodologies for DRR. Current forecasting and tracking of cyclones (hurricanes and typhoons) is unprecedented and save countless lives each year, but more could be saved with better engineering, information and communication systems. Advanced weather and flood forecasting technology exists, but developing countries have yet to invest adequately. High-quality earthquake engineering and early-warning systems are installed in a few countries, but many more could benefit. Advances in medicine and epidemic response have helped curtail biological disasters, but best practices are far from universally implemented.

To achieve sustainable development, developing countries must invest in science, technology, education, and local capacity-building in DRR. Priorities should be in space technology, seismology, earthquake engineering, hydrology, meteorology, geology (including volcanology), epidemiology and behavioral science. Great opportunities exist for young professionals from a wide range of fields to contribute to DRR through cutting-edge research and innovation. The present challenge is how to motivate leaders and policymakers in developing countries to strongly integrate DRR along with other competing needs. ■

GLOBAL CONCERN, LOCAL SOLUTIONS

As nations develop, their need for energy will surge. To find solutions, scientists will have to leave their labs and go talk to policymakers, businesses and the public.

by **Carlos Meza-Benavides**

Carlos Meza-Benavides is a professor at the Costa Rica Institute of Technology, where he coordinates the Laboratory of Electronics Systems for the Sustainability (SESLab). For 11 years, he has focused on renewable energy research and policy, with projects related to renewable energy power generation in Central America and the Caribbean. From 2012-2015, he was a senior postdoctoral researcher at the Abdus Salam International Centre for Theoretical Physics (ICTP).

In 1985, the year of the first TWAS General Meeting, an average citizen from a high-income country used seven times more energy than someone living in the developing world. In that same year, developed countries were responsible for emitting 12.7 Gt of CO_2, more than double what developing countries were emitting. Today, things have changed dramatically. While high-income countries have increased their energy consumption by 9% over the past 30 years, developing countries have doubled their use of energy. Moreover, developing countries today emit 2.2 gigatonnes (Gt) of CO_2 more than high-income countries.

Energy and economic and social development are linked together. Abundant and affordable energy will most likely accelerate economic growth. Conversely, economic growth requires more energy. Therefore, it will continue to be a major necessity for developing nations to increase their energy production. It is a global interest that new energy sources tapped by developing countries are sustainable and clean.

If we really want to make this a reality, we need to see that a successful sustainable energy system will not come solely from a research laboratory. We will need people from governments, industry, universities and research centres. It is advisable that scientists sometimes hang up their lab coats, go out and talk with people from government and industry so that they can fully understand the local situation and contribute to the solution.

Photo: ColorCS/Wikimedia Commons

A sustainable energy system should make use of local energy resources and take care of local energy needs. A sustainable energy system cannot be imported; it has to be designed and engineered for the conditions of the place in which it will be implemented.

Leaving aside the fact that achieving a sustainable energy system requires an efficient multidisciplinary and multi-institutional working group – which is by itself a huge task – the major technical challenges are:

- Achieving an energy carrier for transportation which is clean, non-depletable, affordable, easy to store – and, ideally, one that can be introduced swiftly into current transportation technology.
- Developing efficient and reliable decentralized power systems that can balance locally intermittent energy sources (such as solar and wind energy) with variable power consumption.
- Achieving the technology and systems to deal with the abundant – but intrinsically variable – renewable energy resources such as wind, solar and ocean energy.

The aforementioned challenges are valid everywhere, but the way they are approached may change depending on the local conditions. This creates an enormous opportunity for scientists from developing countries to develop original and innovative technology and systems that have an important and positive impact on their countries. ◘

A VITAL LINK: FOOD, LAND AND GENDER

Within 30 years, we will have 2 billion new people to feed. To achieve food security, we must understand the role of women in food production and environmental protection.

by **Samira Omar Asem**

Samira Omar Asem is Arab Region vice president of the Organization for Women in Science for the Developing World (OWSD). A 2014 TWAS Fellow, she is principal research scientist at the Environment & Life Science Center at the Kuwait Institute for Scientific Research. She has directed mega-projects such as the Kuwait Environmental Research Program and the Soil Survey for the State of Kuwait. As a result of her work, Kuwait has put environmentally sensitive areas under protection.

Developing countries are facing problems related to food security and environmental degradation manifested by climate change phenomena, poor economic growth and political instability. The high population in these regions puts more pressure on natural resources in land and sea and more demand for food commodities.

Food security means access to enough food by all people at all times for an active and healthy life, contributing to more effective economic development. The World Bank and the UN Food and Agriculture Organization (FAO) suggest that about 800 million people in the developing world lack the food necessary for such a life. Asia and Africa show the highest numbers of undernourished people (525.6 million people in Asia and 226.7 million in Africa).

Availability and access to food are affected by population growth, demographic trends, economic development, government policies, income levels, health, nutrition, gender, environmental degradation, natural disasters, refugees, migration disease and concentrated resource ownership. These problems are beyond any national boundaries and extend throughout regions and around the world.

By 2045, we will have 9 billion people to feed, exerting more pressure on agricultural resources such as land and water. However, it is believed that the degradation in the environment and decline in quality and quantity of available resources, as well as ignorance of gender-related impacts, are the main causes for food insecurity.

It is only recently that the world realized the important role women play in food security in many developing countries. Studies have shown that environmental constraints, land scarcity, armed conflicts and migration of men to cities to look for better wages or jobs reduced male labor in rural areas. That increases the number of female-headed households. As a result, women are taking on new agricultural and income-earning responsibilities.

FAO studies showed that by neglecting women's role in agriculture, development opportunities in developing countries will be lost. Empowerment of women is, therefore a logical priority of agriculture programmes and policies that seek to promote agricultural development, poverty reduction and development of food security.

Hunger reduction requires an integrated approach, which includes: public and private investments to raise agricultural productivity; better access to inputs, land, services, technologies and markets and rural development, including strengthening their resilience to conflicts and natural disasters. Specific nutrition programmes targeting micronutrient deficiency in women and children need to be targeted for hunger reduction.

Poverty, food insecurity and environmental impact often coexist. Indeed, they are a self-reinforcing cycle. To improve food security, policymakers need to integrate agricultural development with environmental considerations and awareness of gender issues.

Photo: Jimmy Pittchar/ICIPE

A NEW STRATEGY FOR FOOD PRODUCTION

Developed nations are wealthy and well-nourished thanks to plants derived long ago from the less-affluent nations. It's time for the South to embrace a new plan.

by **Octavio Paredes-Lopez**

Octavio Paredes-Lopez is president of the Mexican Academy of Sciences and a founding member of the International Academy of Food Sciences and Technology. He is a professor and head of the laboratory of food biotechnology, Centre for Research and Advanced Studies, National Polytechnic Institute, Irapuato, Mexico, and the recipient of the 1998 TWAS-TWNSO award in agricultural sciences. He was elected a TWAS Fellow in 2005.

Most of the genetic resources used today by the developed world for food and health purposes arrived long ago from the developing world. Such resources were transferred without any official registration and clearly without any cash payment.

Agricultural strategies in previous centuries were employed in a world much different from today's. The developed world invested in knowledge for the development of agricultural technologies for their own diets and medical requirements. A high proportion of medicines in the previous centuries emerged from consumption of the plants themselves, and from plant extracts generated in different ways. The input of technology increased the quantities of target compounds in selected materials for nutritional, nutraceutical and medical purposes, and consequently the use of plants or their extracts has been modifed.

In many cases the evolution of technology, mostly in the affluent world, to produce the same natural or similar compounds by chemical and microbiological ways, has had strong commercial impacts, especially since the end of World War II. The free transfer of genetic

resources coming from the developing world has been accompanied in the developed world by an intensive generation of technology for the availability of new foods and medicines – and now the use of such technology in the wider world requires the payment of royalties!

The societies of the developing world have become highly dependent on the *savoire faire* of the countries which have become wealthy with such strategies. Fortunately, a few developing countries are capable of producing the key foods of their daily diets.

However, we have arrived with most of our population to a situation that is far from optimal. There is a general lack of food of whatever quality; the most nutritious foods, with high contents of nutraceuticals, are more expensive. People with much lower incomes are left to consume foods of lesser ingredients and low nutritional value, and consequently have higher rates of overweight people and obesity. This raises the incidence of diseases such as diabetes, which exert a damaging effect on life-quality for many people in the South.

Solutions will require a change of strategies. Fortunately, several of these regions have indigenous and almost-forgotten genetic materials of high nutritional and nutraceutical value that can grow and produce in low-quality agricultural areas. Additionally, we have outstanding examples of a few countries that have escaped the Third World designation in recent years. Their use of broad, high-quality education, adaptation of foreign technologies and internal generation of knowledge, plus high levels of self-esteem, have been the basic key to progress. ◘

MORE TRANSPARENCY, BETTER RESEARCH

To win back the public's trust, medical scientists must seek a new era of improved research ethics and transparency.

by **Jimmy Volmink**

Jimmy Volmink is dean of medicine and health sciences at Stellenbosch University and director of Cochrane South Africa at the South African Medical Research Council. He is an elected member of the Academy of Science of South Africa and an elected Fellow of the Royal College of Physicians of Edinburgh. He is also president of the Southern African Epidemiological Association and a member of the InterAcademy Medical Panel (IAMP) Executive Committee.

In recent years, instances of scientific fraud, errors in analysis, publication bias and failure to reproduce research results have been uncovered across a range of medical and scientific research disciplines. Greater transparency can help address these problems, improve accountability and restore the public's confidence in science.

In healthcare, clinical trials form the cornerstone of efforts to discover what works, and what does not work. People participate in such studies because they believe the research will improve future treatment for those with similar conditions. Unfortunately, trial findings are often not reported in full, and in many cases are not published at all, sometimes with dire consequences for patients.

This indefensible practice of non-disclosure is being met with an expanding global response. A decade ago the World Health Organization (WHO) and others called for clinical trials to be publically registered, at inception. More recently the WHO went further, calling for the public disclosure of key trial findings within 12 months of study completion. This latest recommendation follows the AllTrials campaign call for registration and reporting of results, which has already won the support of 86,000 patients, clinicians and researchers worldwide, plus 612 organisations representing millions of others.

Transparency in medical research is being promoted in other ways, no less important. Health research has been at the forefront of open access publishing, a movement calling for free access to research studies published in professional journals; in the past, such journals

allowed access only to those willing to pay substantial subscription fees.

Yet, access to a published study, even in a reputable journal, is no guarantee that the study's findings are valid and reliable. Various strategies to promote data-sharing have therefore been introduced to allow outside parties to check published research results for false conclusions and other problems.

Biased 'cherry-picking' of certain studies or relying on the results of studies that are too small or are methodologically flawed, can lead to poor decisions regarding the choice of healthcare or the need for future research. The Cochrane Collaboration, an independent organization operating in 130 countries, is addressing this challenge by producing systematic reviews of research to help people make more informed decisions.

All these initiatives provide a solid foundation for building a culture of transparency in health research. However, additional measures to minimise perverse incentives in the conduct of research, reporting bias and scientific fraud will be needed. ◘

LEARNING FROM BRICS AND ASIAN TIGERS

In coming years, Africa will need to educate and train more than 1 million new scientists and engineers. How to do it? The emerging economies offer good models.

by **Wole Soboyejo**

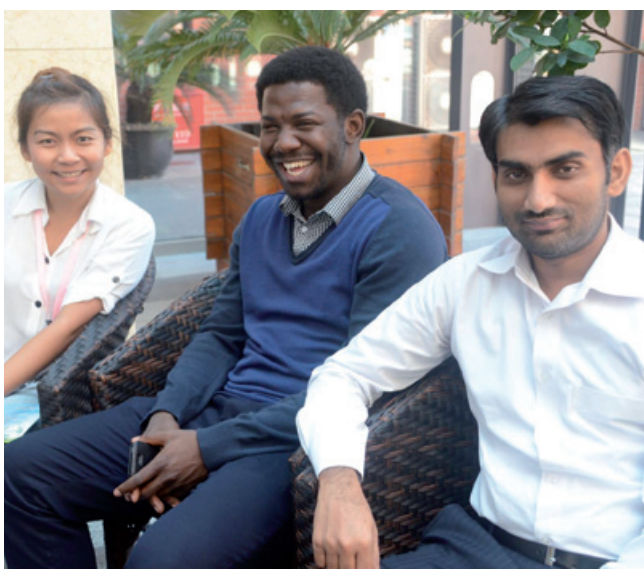
Wole Soboyejo is a member of the UN Secretary-General's Scientific Advisory Board and former president of the African University of Science and Technology in Nigeria. Now at Princeton University in the US, he is director of the U.S./Africa Materials Institute and a professor of mechanical and aerospace engineering. He is a Fellow of the Nigerian Academy of Science, the Materials Society of Nigeria and the American Society of Mechanical Engineers.

Over the past 30 years, the development of Brazil, India and China (BRIC countries) and the Asian Tigers has provided developing countries in Africa with examples of how to use science, technology and innovation as the engines of economic growth and inclusive development.

Like the Asian Tigers and BRIC countries, African countries must train a critical mass of scientists and engineers that have the skills and knowledge to address African challenges and opportunities. This means that Africa must train about 1 million scientists and engineers per billion people, in order to increase the ratio of scientists and engineers from 83 per million people to 1,000 per million people. This ratio, which is the threshold for science-driven industrial growth and economic prosperity, must be exceeded for Africa to have enough scientists and engineers to address its basic needs in food, health, water, energy and infrastructure.

Furthermore, for Africa to become self-reliant, she must evolve from a culture of aid towards a culture of self-reliance, which can be achieved by engaging in demand-driven research and education that addresses Africa's needs.

Africa should also become self-reliant in the extraction, processing and distribution of its natural resources. This requires integrated investments in primary, secondary and tertiary education. African human capacity development also requires a blend of academic and vocational education and the appropriate use of multimedia to train the next generation of Africans that can go from ideas to markets. Within this context, it is encouraging to note the emergence of new African institutions, such as the African University of Science and Technology and Redeemers University in Nigeria, Ashesi University in Ghana, 2iE in Burkina Faso and the Nelson Mandela African Institute of Science and Technology in Tanzania.



However, sustained investments are needed for Africa to achieve her full potential over the next 30 years. During this period, Africa should develop the knowledge to extract and process its natural resources, while adding value to its human resources. Like the BRIC countries and Asian Tigers, this will happen when African countries invest between 1% and 4% of their gross domestic product on science, technology and innovation. ◘

ACCESS WILL TRANSFORM THE WORLD

Information and communication technologies are driving development through innovation in education, health and banking. But to achieve the full benefit, we must seek universal access.

by **Houlin Zhou**

Houlin Zhao is Secretary-General of ITU, the United Nations specialized agency for information and communication technologies. From 1999 to 2006 he served as director of ITU's telecommunication standardization bureau, then he was appointed ITU's deputy secretary-general (2007-2014). He graduated from Nanjing University of Posts and Telecommunications, and holds an Master of Science in telematics from the University of Essex (UK).

Information and communication technologies (ICT) are at the forefront of innovation, delivering well-documented benefits for businesses and development: improving access to key services including education, government services and healthcare, and helping in the fight to mitigate and adapt to climate change. Their rapid proliferation – from 1985, when 600 million people around the world had access to a fixed telephone and the Internet was still in its infancy, to today, when there are 7.1 billion global mobile subscriptions and 3.2 billion Internet users worldwide – has transformed how we interact with the world.

ITU has long believed that all three pillars of sustainable development – economic development, social inclusion and environmental protection – are strengthened through ICT. The newly adopted Sustainable Development Goals (SDGs) note the catalytic role that they will play in achieving the ambitious targets: "The spread of information and communication technologies and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies."

The achievement of all 17 goals will be accelerated through ICT, and their ubiquity elevates the impact of development efforts. Smart cities help to reduce energy consumption

and greenhouse gas emissions. Disaster relief efforts are accelerated through life-saving technologies. And public services are easily accessed through e-government applications.

Yet there is a persistent divide that significantly impedes global development. Though mobile phone proliferation is high, with 97 subscriptions per 100 people, 4 billion people remain offline in the developing world. This mobile access gap impedes broader social and economic development in affected countries and, above all, it undermines the potential for local populations to seek innovative solutions to address their own development issues.

Innovation is happening across Africa in multiple sectors, from agriculture to education, to health and banking. Developed in Kenya, m-Pesa, a "mobile money" application, has given millions of people their first access to banking services. Today, over 18 million Kenyans have access through their mobile device. E-education platforms offer access to learning materials for the roughly 21 million African children who do not attend school. M-health innovations are revolutionizing access to healthcare in remote communities, preventing non-communicable diseases, tracking outbreaks such as Ebola, and improving maternal health.

Innovative ICT solutions have the power to transform the world by 2045, but only when we truly connect the world will we see the positive impact that they have in delivering services to those who need them most. Making ICT universally available will create new opportunities, help to protect the environment, and achieve the sustainable development that will transform our world. ◘

A MODEL FOR BATTLING FUTURE DISEASE

A pioneering campaign to control leprosy in Pakistan provides a powerful model for future science cooperation among nations, researchers and NGOs.

by **Rabia Hussain**

Rabia Hussain of Pakistan in 2014 was named by MuslimScience.com as one of the 20 most influential women scientists in the Muslim world. She has won honours for her work in immunology, with a focus on leprosy and tuberculosis. A 2003 TWAS Fellow, she serves as vice president for Central and South Asia. She is a Fellow of the Royal College of Pathologists and the Pakistan Academy of Sciences and distinguished national professor at the Central and Higher Education Commission, Pakistan.

One of the most challenging issues when dealing with control of communicable diseases is to obtain the right kind of support and trust from the people. To do so in a country wracked by terrorism and extremism is no less than a miracle.

Dr. Ruth Pfau, a German physician and nun, visited Karachi, Pakistan, 55 years ago and was affected by the plight leprosy patients, a totally marginalized group. She decided to stay and help. In 1963 this project was moved to a hospital in the heart of Karachi despite vehement opposition from both the medical community and civil society. This hospital became the nerve center of the control programme and was named Marie Adelaide Leprosy Center (MALC).

The plan to achieve leprosy control in Pakistan by 2000 was conceived in 1983, and launched in 1984. A network of field clinics and field technicians was developed covering more than 80% of the population. This programme extended into Azad Kashmir and Afghanistan, to be later handed over to local partners. This activity was to pay dividends when Afghan refugees flooded Pakistan, particularly Karachi, and were willing to trust Dr. Pfau, which allowed uninterrupted leprosy-control activities.

Control was achieved in 1996, making Pakistan the first country to achieve this target in the World Health Organization (WHO) Eastern Mediterranean region, four years ahead of the target date. However, control is not eradication of a disease, which requires every last patient to be treated and rehabilitated. This challenge is monumental as leprosy-causing bacteria

▶ Dr. Ruth Pfau examining a woman in Pakistan. (Photo: Marie Adelaide Leprosy Centre)

survive for more than 30 years in the body and can activate if the host immune system is compromised, thereby renewing the disease. Continued vigilance and training will therefore be required for several decades to come.

To keep this network viable, diversification of the programme was needed. Using the basic skills and experience already available, but keeping in mind the primary objective of moving towards leprosy eradication, a triple merger was conceived and implemented based on the needs of various provinces: Blindness control in Baluchistan and tuberculosis control in Sind was combined with the anti-leprosy project in Pakistan. Community-Based Rehabilitation was an essential part of the services for leprosy patients and now it is being extended to patients with non-leprosy deformities as well.

The future vision is to network with other non-governmental organizations carrying out similar activities so that separate campaigns against different diseases can benefit from each other's strengths while reducing inefficient duplication. ◘

CHANGING TOOLS, TIMELESS VALUES

In a time of dramatic evolution, amazing discovery and occasional controversy, science journalists are the vital conduit between researchers, policymakers and the public.

by **Pallava Bagla**

Pallava Bagla is an award-winning science communicator based in India. He is a correspondent for *Science* and science editor for India's leading network, New Delhi Television (NDTV). He also serves as president of the International Science Writers Association. His latest book, "Reaching for the Stars: India's Journey to Mars and Beyond", was published by Bloomsbury.

Science and science journalism are two sides of the same coin. Unless there is good science being done, science journalists would have little news to report about.

From the cradle to the grave, increasingly the advances of science and technology today drive the world. As we progress into the 21st century, the complexities are increasing. Scientific disciplines are highly specialized and the pace of development so fast that most scientists literally spend a lifetime immersed in unravelling the mysteries of their respective domains. Communicating results usually means writing complex scientific papers in a language understood only by the peer group. Consequently, the common person is seldom exposed to the excitement and joy of doing science. Indeed a pity.

It is here that science journalists with their curiosity and flair to take the message to the wider audience come face-to-face with the scientific community. Science journalists deconstruct complexities of research to tell a story that is understood by the layperson. A happy co-existence is the norm of the game. Though there is occasional sparring, as when we dig deep to expose sporadic instances of misconduct in the scientific community.

The tools used for communicating have changed dramatically, from a time when the printed word was king to today, when the Internet and the social media play a central role. Yet the fundamentals of science journalism – the who, what, when, where and why – have not changed in the last 30 years, nor are they likely to change in times to come.

Photo courtesy: Roberto Ferrari

Certainly a lot has changed in the world since the first meeting of TWAS in 1985. To give one example, the last 30 years have seen a sea change even in the world's largest democracy, India, thanks to effective deployment of science. Back then, when the Green Revolution was still unfolding, I used to line up for scarce food stocks in ration shops; today, my children queue up in food courts. Recently the "voice of the South" loudly reverberated when India made global history in reaching Mars in its very first attempt, opening a new era of low-cost inter-planetary exploration.

Change is omnipresent. Tomorrow's news may be highly personalized, tailor-made for each individual. In the not-so-distant future, the smart phones that journalists carry could become the equivalent of mobile television stations. Multimedia is the way forward and scientists who grasp and clinch this changing aspect of the communications technology are the ones who will be able to do better outreach.

There is no doubt that science has a bright future, and therefore, contrary to the gloomy scenario one sometimes hears, science journalism too has sunny prospects. Just embrace the change. ◘

MATHS ARE A MUST FOR PROBLEM-SOLVING

An aversion to mathematics among young people requires broad, creative efforts to encourage skills and raise awareness of its value to society.

by **Lilliam Alvarez Díaz**

Mathematician Liliam Alvarez Díaz is a member and executive secretary of the Cuban Academy of Sciences, where she also serves as head of the Group of the Promotion of Science. She is president of the Cuban chapter of the Organization for Women in Science for the Developing World (OWSD). She established the Sofia Kovalievskaia Award for young women in basic sciences. She is a 2008 TWAS Fellow and a member of the TWAS Advisory Panel for Gender Issues.

Basic sciences are the DNA of innovation. For every country, without exception, the capacity for creativity and innovation is strongly related with critical mass in physics and chemistry, engineering and mathematics. These sciences produce technologies, generating products with high added value, and in this way they demonstrate how science can drive economic and social development.

Mathematics is a must because it is the only discipline, besides language, that is taught in primary, secondary and tertiary education. Maths provides advantages for verbal reasoning, for learning skills for better student progression, increasing the self-esteem.

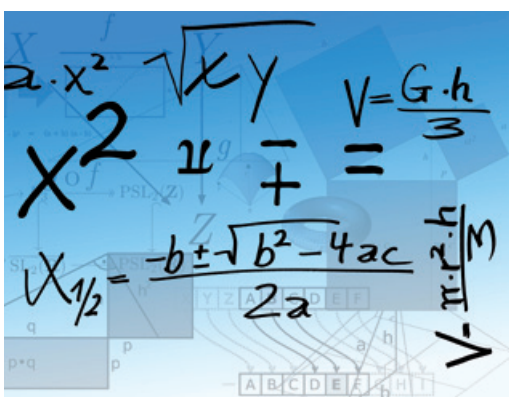
Mathematics provides models and tools to solve many problems in science and technology – and in society. But it also helps to develop the abstract thinking that is the root of reasoning and of understanding the world. The basic ability to divide big and complex problems into segments or into more simple problems – these skills prepare people for daily life in a world increasingly dependent on the use of knowledge and technology.

While maths skills are fundamentally important, recent studies in many regions have highlighted an alarming rejection of science and maths studies among young people – and there are few indications that this trend is improving. Further, girls are less interested in science education than boys. These gender differences are reflected in the numbers of women choosing academic studies in maths, science and technology. The risk is that science and the global research enterprise could be losing half of available talent.

Mathematics has been declared a priority by the International Council for Science (ICSU) office in Latin America and the Caribbean. Joint efforts by TWAS and national academies must focus urgently on improved education and training of maths teachers, with the input of mathematicians and researchers. Global Master programs especially designed for basic school teachers are needed.

Maths Olympiads are a popular way to promote maths skills, but in most of the world they are limited to students who have already shown special ability. And yet such competitions do not appear to have wide impact on maths education. We need more public and democratic contests, widening the scope and involving teachers, families, rural schools and even prisons. A long-term project in mathematics education should create a repository with open links to teaching resources and best practices in maths education. And we must consider how to re-shape education for new generations of "digital natives" born into the culture of information and communication technology.

The academies and national scientific unions must call attention to these needs in order to influence national policies and establish mathematics and maths education as priorities for sustainable development. ◘



DEVELOPMENT DEPENDS ON MENTAL HEALTH

We know that nutrition, education and disease-control help overcome poverty. Slowly, we're realizing the importance of mental health, too.

by **Abdallah Daar**

Abdallah Daar is member of the UN Secretary-General's Scientific Advisory Board and chairs the Grand Challenges Canada Scientific Advisory Board. He was born in Tanzania and worked for many years in Oman. In Canada, he is a professor of clinical public health and global health at the Dalla Lana School of Public Health and of surgery at the University of Toronto. He is a Fellow of the Royal Society of Canada and the Canadian Academy of Health Sciences. He was elected a Fellow of TWAS in 2007.

In 2001, the World Health Organization (WHO) focused its World Health Report on mental health, launching the optimistic, ambitious message, "new understanding, new hope". Fourteen years later, however, little has changed, and there's a continuing need for urgent action.

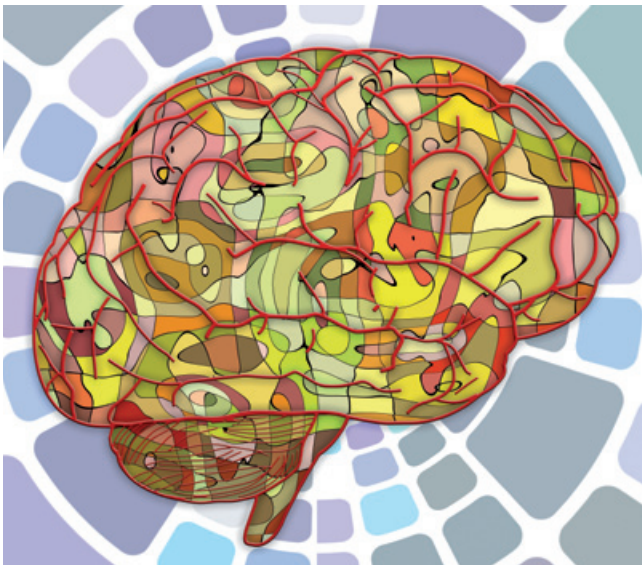
Still, things are moving. The global community is waking up to the cost of mental disorders, and medical science is more aware than ever that mental illnesses can be managed. Prevention is possible, and treatment doesn't cost that much; people can recover and get on with their lives. At the global level, WHO is providing superb leadership in this area.

But effective action must be based on clear knowledge of what mental health is – and what it is not. Mental health issues are made worse by poverty – by poor housing, malnutrition, a lack of services. All of those are more prevalent in developing countries.

There is a vicious cycle. On the one hand, poor mental health interferes with socio-economic development, and on the other hand the lack of development contributes to mental disorders. Nations that experience political instability face an increase in poverty and stress, and poor social services and medical care.

What we need is to convert good will into good practice, setting priorities and accepting that we cannot solve all the problems at once. In Africa, where in general less than 1% of the already small health budgets are spent on mental health care, more attention is given to such areas as physical health, education, food and national security.

Governments are primarily responsible for health, and they should be at the forefront of interventions because there is no health without mental health. Depression, epilepsy, severe anxiety states, schizophrenia are relatively common conditions. And substance abuse, which leads to violence – particularly against women – is right behind.



To achieve success, political leadership and national strategic plans are essential.

Many nations are now becoming aware of this need, and have already signed on WHO's comprehensive Mental Health Action Plan. The next thing to do is to elaborate a national strategic plan to support community-based prevention and care, plus empowerment of patient groups. There is also a desperate need to address the human rights of people suffering from mental health disorders.

Mental health is included in the new Sustainable Development Goals, with specific targets for 2030. We can do much to improve the situation, especially in developing countries. A year ago, Ebola was terrible epidemic; today it appears largely manageable. The same could happen with mental illness. ◘

THE WORLD'S MOST COMPLEX PUZZLE

Global brain research projects, supported by powerful new imaging technology, make neuroscience a promising field for young researchers.

by **Francisco J. Barrantes**

Francisco J. Barrantes, a 1991 TWAS Fellow, serves as vice president for the Academy's Latin America and the Caribbean region. He has pioneered studies on neurotransmitter receptors and the modulatory role of lipids on these molecules. He directs the laboratory of molecular neurobiology at the Institute of Biomedical Research, Pontifical Catholic University of Argentina-CONICET (National Scientific and Technical Research Council of Argentina).

Neuroscience will offer tremendous opportunities to new generations of scientists in the developing world. At the higher echelons of science and politics there is deep interest in understanding the most complex machine in nature, the brain. Billions of dollars are being invested to map brain connections, and while it is a daunting task, it can yield enormous benefits.

Modeling the brain, the goal of decade-long computational and neuroinformatics efforts – the Human Brain Project and the BRAIN Initiative, for example – constitutes a challenging exercise. This is an organ with an astronomical number of units (10^8) and beyond-imagination number of connections (10^{15}), some of which can change rapidly over time. A few hundred neurological conditions and neuropsychiatric diseases add layers of complexity.

Imaging technology is opening new horizons for the study of the brain and behavior. Two related magnetic resonance imaging (MRI) techniques, diffusion spectroscopy and functional MRI (fMRI), are being used to map the brain´s structural and functional connectivity, respectively. Their use as diagnostic tools and their increasingly intensive application to cognitive, mnemonic and other behavioral phenomena is allowing us to explore how the brain functions, even taking into account social context, ethical connotations, subtle cultural idiosyncrasies and other dimensions. Aversions, punishment, and a range of emotions are being interrogated. Advances on this front might be very informative in neurodegenerative diseases like Alzheimer´s and Parkinson´s or in neurodevelopmental diseases like the schizophrenias. These tools may also support advances in neuropharmacogenomics, the personalized tailoring of medicine to treat neurological diseases.

Theoretical and experimental research aimed at understanding higher brain functions are converging thanks to developments in artificial intelligence and neural theory and discoveries. The finest structures observable in the brain are the synapses and the tiny post-synaptic specializations called dendritic spines. Dynamic changes in these structures have been associated with synaptic plasticity, which is essential for the brain's most interesting assets, learning and intelligence. These areas of research are likely to be the most rapidly advancing ones in coming years.

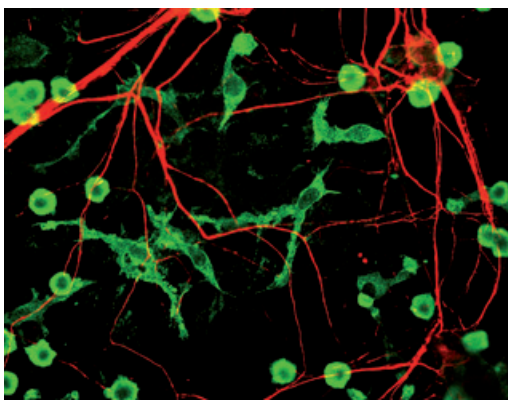


Photo: GerryShaw/Wikimedia Commons [CC BY-SA 3.0]

Another thought-provoking field uses neurogenetic data to examine historic forces that shaped the brain of *Homo sapiens* and related species. This work is highly interdisciplinary, involving neuroscientists, pharmacologists, ethnobiologists, population and mathematical biologists, physical and cultural anthropologists, historians, sociologists, physicians specialized in nutrition and genetic diseases and geographers specialized in human geography. Add questions about the future of the human brain, and philosophers can be added to that list. ◘

A 'WIN-WIN-WIN' PLAN FOR HEALTHY SEAS

A combination of natural and social sciences, and effective South-North partnerships, are helping to support fisheries in the developing world.

by **Jane Lubchenco**

Marine ecologist Jane Lubchenco was named by US President Barack Obama as the State Department's first Science Envoy for the Ocean. She also served in the Obama administration as undersecretary of commerce for oceans and atmosphere and administrator of the National Oceanic and Atmospheric Administration. She is distinguished university professor at Oregon State University, and a TWAS Fellow since 2004. She received the 2014 TWAS Medal.

The ocean is vital to the future of all people on Earth, but especially those in developing countries. If used properly and equitably, the ocean can provide food security, jobs, and revenue to support development and alleviate poverty. Recognizing the centrality of the ocean to sustainable development, the UN recently focused one of 17 Sustainable Development Goals on the ocean: "Conserve and sustainably use the oceans, seas and marine resources for sustainable development".

Sustainable fisheries are essential for achieving sustainable use of the ocean, but most small-scale fisheries that could deliver these essential benefits are in serious trouble and getting worse each year. A fisherman in the Philippines, for example, used to catch more than 40kg (88 pounds) of fish in the '40s, but now, with the same effort, is catching just 3kg (6.6 pounds). As fish become scarce, fishermen are forced to fish harder and harder, resulting in more overfishing. To make matters worse, illegal fishing and habitat destruction from some types of fishing gear also contribute significantly to the depletion and disruption of ocean ecosystems.

Many nations may be tempted to give up on fisheries as doomed, and pivot to aquaculture for seafood. However, recent scientific findings suggest that both sustainable aquaculture and sustainable fisheries will be needed for food security, and that it is possible to increase fish catches while also increasing biomass of fish in the ocean. Getting fishing right could mean more seafood on plates, more fish in the ocean and more profitable fisheries. This seemingly impossible win-win-win is, in fact, possible and is under way in a number of countries.

Guided by innovative efforts that combine natural and social sciences, such as the Fish Forever programme of Rare, the Environmental Defense Fund and the Sustainable Fisheries Group at the University of California at Santa Barbara, fishermen in the Philippines, Brazil, Belize and elsewhere are turning their fisheries around. Each situation is different, but the common elements of success include using rights-based approaches to fishery management, strong engagement of the entire community, scientifically determined catch levels, and use of fully protected marine reserves that provide conservation benefit and recharge adjacent fishing grounds.

Thus a powerful alternate trajectory to the present downward course is feasible and provides hope for the future. Solidly grounded in natural and social science, innovative efforts are showing how to fish smarter, not harder, how to use the ocean without using it up. ◘

POLICY FOR SCIENCE, POLICY FOR PEACE

In order for science to achieve its full potential for humanity, policy must support stronger bonds between researchers and governments.

by **Flavia Schlegel**

Photo: © UNESCO/P. Chiang-Joo

Flavia Schlegel is UNESCO's assistant director-general for natural sciences. Earlier, serving in Switzerland's State Secretariat for Education, Research and Innovation, Schlegel held high-level science/diplomatic positions in Washington, D.C., and in Shanghai, China. Having earned a medical doctorate in 1992 from the University of Zurich, she served in the Swiss Federal Office of Public Health as director of the AIDS Section and later as vice-director and member of the Executive Board.

Science and the results of research are public goods which should in principle be accessible to all people, regardless of creed, class, gender or country. In practice, however, this is difficult to realize, since the political economy of resources needed to access science is heavily skewed in favour of the developed nations, to the disadvantage of the developing world and notably the Least Developed Countries (LDCs).

Resources in this context include not only material wealth, but also cultural inputs such as higher education institutions; the training, salaries and mobility of researchers; and promoting STEM Education. Closing this gap and achieving a minimal level of scientific capacity through international cooperation are vital issues for LDCs.

Indeed the work of UNESCO provides a window on the historical advances made in this direction, as well as the various obstacles faced concerning what works and what does not.

Setting up bodies such CERN, SESAME and the International Union for Conservation of Nature (IUCN), and providing early support to the Abdus Salam International Centre for Theoretical Physics (ICTP) to become a UNESCO Category I center by 1996 – and to TWAS, joining the UNESCO programme family by 1991, reflect a key approach to further international cooperation. A critical partner or host of bodies as those mentioned above, UNESCO, will play a central role in the implementation of the 2030 Agenda and the 17 Sustainable Development Goals.

The interface between scientists and policymakers therefore is one that must be strengthened for science to provide more benefits to humanity. UNESCO is honoured to host the Secretariat of the UN Secretary-General's Scientific Advisory Board (SAB). Its main task is to improve the science-policy interface.

There are no two ways around it: The generation and use of science forms the bedrock of all economic and social development, and with this comes peace and security. ■

▶ UNESCO Headquarters, Paris. (Photo: © UNESCO/ Michel Ravassard)

TO REDUCE POVERTY, IMPROVE PARENTING

Research is needed to understand how parental practices in the developing world may be inhibiting the development of their children.

by **Linxiu Zhang**

Linxiu Zhang, a 2014 TWAS Fellow, is a professor and deputy director at the Center for Chinese Agricultural Policy, Chinese Academy of Sciences. Her research focuses on rural development in China, in particular on poverty alleviation and the economics of rural education and healthcare. She is the recipient of the TWAS-Celso Furtado Prize in Social Sciences (2013), and the Fudan Management Excellence Award (2014).

Exposure to risk factors during early childhood will compromise children's development and future human capital. It is estimated that over 200 million children under 5 years old are not fulfilling their development potential because they are exposed to multiple risks. The critical period before age 3 is considered to be a crucial window, during which interventions designed to improve language, cognitive, motor and social emotion development can have significant and lasting effects, even into adulthood. Moreover, investments in human capital accumulation during this period build a foundation for lifetime success.

The proven importance of this early development stage has induced researchers to delve more deeply into the underlying factors that may be associated with cognitive development during this period. As early as the 1990s, the literature had already extensively documented the link between poor nutrition and low levels of cognitive and motor skills among infants and toddlers. More recently, a number of studies have shown that the home learning environment that parents provide for their children is significantly linked with social and cognitive development. Reading, telling stories, and singing songs together have all been linked to early language acquisition and improved cognitive development.

However, almost all of the work has been done in developed countries, and little is known about the status of the home learning environment in developing nations. Given the absence of a large empirical literature on parenting practices in developing countries, studies to further our understanding of the home environment-based determinants of cognition growth would be useful for several reasons.

We know that the share of children with cognitive delays is higher in developing countries. Additional research could help us to understand what factors might be linked with these delays and the family attitudes or practices that are most in need of improvement. Research in these areas would help improve future interventions.

With the growing awareness of the importance of early childhood intervention for reaching development milestones, developing countries slowly start to take interventions but little is done beyond providing nutritional intervention. Thus, there are urgent needs for research to design and deliver parenting interventions together with nutritional intervention and to search for the best ways to reach a child's developmental potential.

▶ The author visits a family in rural China. (Photo courtesy: Linxiu Zhang)

Such efforts are believed to help break intergenerational poverty cycle by addressing the root causes of poverty. It also seems clear that, from a policy perspective, intervention during this time period is the most cost-effective. ◘

SCIENCE OFFERS A HOPEFUL NEW DIPLOMACY

When you bring together committed scientists who work in a region of conflict, borders dissolve and human issues come into focus.

by **Zafra Margolin Lerman**

Photo: Labeeba Hameed

Zafra Lerman is president of the Malta Conferences Foundation, which uses science for diplomacy and peace in the Middle East. She has received over 40 international awards, including the 2016 Andrei Sakharov Prize from the American Physical Society and the 2014 Science Diplomacy Prize from the American Association for the Advancement of Science. For 25 years she chaired the Committee on Scientific Freedom and Human Rights for the American Chemical Society.

The Malta Conferences Foundation brings together scientists from 16 countries in the Middle East and North Africa to collaborate on scientific issues of importance to the region and to the world. The biggest challenge for these scientists is the lack of a diplomatic relationship between their governments. Solving regional issues must be done through collaborations between nations.

Borders are only lines on a map. Nature and the environment don't recognize these borders, and therefore, issues of climate change, air pollution, water quality and diseases require collaborations among nations for their solutions – only science diplomacy will succeed in solving such issues.

A new way of thinking, teaching and learning science is also required. Science will play a major role in solving the challenges that face our planet and especially the developing world. We must have scientists who will be able to solve these problems. In order to have these types of scientists, we must have, in the pipeline, students who will become the scientists able to offer solutions to existing and new problems. This means developing a new curriculum and new methods of teaching science so that it can be accessible to all students in the developing world. The Malta Conferences are an example of a collaborative effort to establish an advanced science curriculum, which integrates ethics, new pedagogies and new technologies into the curriculum.

In addition to having a strong science curriculum, it is essential to incorporate a component on science diplomacy in the education of scientists. Science diplomacy can succeed in solving many of the problems in the developing world, but only when many scientists participate in the process.

▶ Delegates at a Malta Conference (Photo: Morton Hoffman)

The Malta Conferences are successful in working on regional problems like water because the scientists who participate set aside the traditional ideas of regional borders and eagerly work on the issues at hand. This is science diplomacy in action.

This model for collaborations and cooperation between scientists can be duplicated in many parts of the developing world to solve a wide range of issues. The Malta Conferences are a clear example that if scientists whose countries are at war can collaborate and build understanding, then science diplomacy truly prevails. ◘

URBANIZATION IS NOT THE PROBLEM

Critics warn of poverty and pollution in sprawling mega-cities. But cities are engines of innovation, and we must envision a new harmony between urban and rural areas.

by **Hans van Ginkel**

Hans van Ginkel was UN under secretary-general and rector of the United Nations University, Tokyo, from 1997 to 2007, and contributed to the development of the Millennium Development Goals. Earlier, he served as rector magnificus of Utrecht University in the Netherlands. His main fields of scholarship have been population, housing and urban development. He currently sits on the advisory board of the Bibliotheca Alexandrina in Egypt. He was elected a TWAS Fellow in 2005.

The cities in the less developed regions are facing a task of gigantic proportions. United Nations population projections indicate that from 2000 to 2050 their population will grow from about 2 billion people to 5 billion. This dash towards urbanization is inevitable.

Successful development generally begins with agriculture, but industry, trade, transport and education are essential, and all are centered in urban areas. No longer is urbanization just a matter of people coming to the cities. There is a growing integration between the urban and the rural. Increasingly, urban regions will consist of vast webs of interconnected people, functions and activities in different densities, of mixed landscapes, a spectrum from more rural to more urban. They are networked worldwide and smart, interacting with their hinterlands and beyond, in complex and kaleidoscopic patterns. These urban regions are the engines of economic growth and innovation. They have become true agents of change.

However, in too many cases big cities are also places of great poverty. Critics worry that in cities too many of the Earth's resources are being used, that skies and surface water are polluted, and solid waste is everywhere. Questions must be raised, however, whether the resources needed to feed and house people in cities will be much different from resources for the same number of people living in rural areas.

Urbanization is not the root problem, but rather the total number of people, their living standards and expectations of life, as well as energy and resource inefficiencies. To provide ten billion people with adequate and safe food, drinking water, shelter and more is a major challenge – a challenge for all science and technology, worldwide.

Image: NASA

Research has already shown that urbanization is the best solution for sustainability. The need for long-distance transport diminishes with higher densities. Wastewater treatment and solid-waste management will be easier and cheaper. This all helps to reduce the ecological footprint. However, the relation with locally available resources must also be considered. There is a logical limit to the size and density of urban agglomerations. In particular this is clear with regard to the availability of clean air and water and land suitable for construction.

We should try to address these issues by giving more space to the urban people, by bringing the rural to urban and the urban to the rural. We can no longer just make development plans for cities, without at the same time considering the surrounding rural areas. This requires not only knowledge of a region and its issues and goals, but also a capacity to look over the fences of different disciplines and territorial entities. It also requires a proactive approach and a capacity to pre-invest and to look beyond short-term self-interest. ◘

THE POWERFUL IMPACT OF BASIC SCIENCE

Step 1: Invest in research, especially in physics and the basic sciences. Step 2: Nurture a culture of science. The result: Innovation that drives development.

by **Fernando Quevedo**

Fernando Quevedo, a Guatemalan national, is director of The Abdus Salam International Centre for Theoretical Physics. He obtained his PhD from the University of Texas, Austin, in 1986. After research appointments at organizations such as CERN and the Los Alamos National Laboratory, he joined the University of Cambridge, UK, in 1998, where he is professor of theoretical physics and Fellow of Gonville and Caius College. He was elected a TWAS Fellow in 2010.

Theoretical physics and pure mathematics are often ignored in discussions about the importance of science for development and the well-being of society, and tend to suffer from a lack of funding. This is in spite of the fact that these fields claim some of history's top scientists, including Newton, Einstein, Feynmann and Hawking. Theoretical ideas sometimes lead to life-changing products, but the process often takes years and the end result is rarely predictable. That should not stop countries, rich or poor, from supporting basic sciences. History has shown that this is one of the best investments they can make.

Theoretical research has been the driving force behind some of the most important technological developments of the past century. Wireless communication, optics, lasers, integrated circuits, GPS, nanotechnology: the list of discoveries is impressive and ongoing. Yet few know of the theorists behind these modern conveniences. Bringing theory to reality takes a concerted effort between theorists, experimentalists and applied scientists, which is only achieved if there is a well-established culture of science.

The recognition of theoretical physics and its importance to development is particularly crucial to those countries that need development the most but can ill afford huge investments in science. ICTP founder Abdus Salam recognized this fact years ago when he set out to promote science in the developing world. By supporting the study of theoretical physics, a field that requires little more than a brain and appropriate working conditions, Salam managed to plant the seeds of science programmes throughout the developing world. Following Salam's vision has helped many developing countries to nurture a scientific culture in which a small, fragile, but usually active scientific community promotes research based on tools essential to scientific culture: analytical thinking and problem-solving. These are very much needed in developing countries.

The big challenges of the present and future – such as climate change, energy and health – affect developing countries disproportionately, and they need to have the background knowledge to tackle these problems. Establishing a culture of science is a crucial first step. It starts by having a critical mass of highly qualified individuals who, with the support of policymakers, should be able to address the challenges affecting their countries or regions.

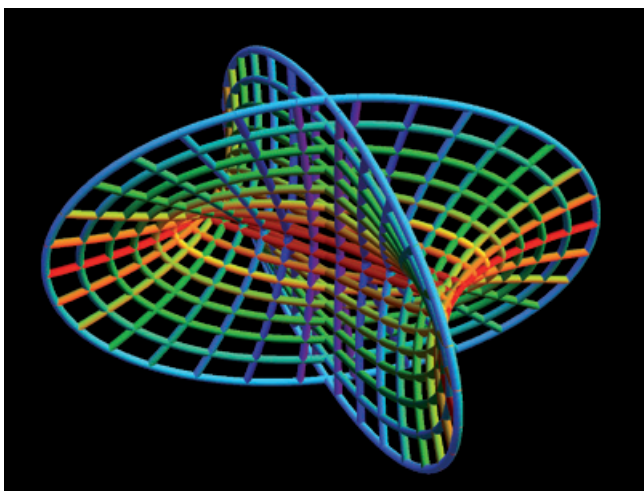


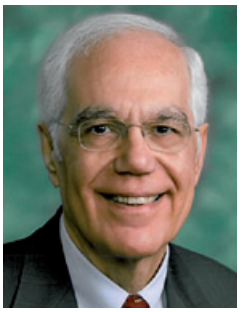
Image courtesy: Dr. Elizabeth Slavkovsky

Neglecting basic science would be unfair not only to those attracted to its intellectual appeal, but also to future generations. After profiting from the discoveries made in the past, we can leave a legacy of healthy support for basic science to our children's children that could guarantee better living standards in the future for all. ◘

WATER POLICY FOR AN ERA OF SCARCITY

The global water crisis is linked to increasing demand and degraded supplies. To assure future supplies, policy and pricing must support innovative strategies.

by **Mohamed El-Ashry**



Mohamed El-Ashry is a senior Fellow with the United Nations Foundation and a 1990 TWAS Fellow. He helped to establish the Global Environment Facility, where he served as CEO and chairman (1994-2003). He has served as chief environmental adviser to the president and director of the environment department at the World Bank, as senior vice president of the World Resources Institute, and as the director of Environmental Quality at the Tennessee Valley Authority (USA).

The way we think about water goes to the heart of the global concern about poverty, hunger, human health, the environment and sustainable development. Of all the natural resources needed for survival and economic development, water is the most crucial. At the beginning of the 21st century, we find ourselves facing formidable challenges: rapid population growth, increasing demands for water to satisfy people's needs both in agriculture and in expanding urban centers, failing water quality and associated health and environmental impacts, groundwater depletion, international conflict over shared water resources, and the uncertainties of climate change. Because of these challenges, the planet faces a 40% shortfall in water supplies by 2030, while climate change presents greater threats of floods and droughts.

Many developing countries are arid or semi-arid and are facing water scarcity. Their supplies are being stretched to their limits and water pollution from domestic and industrial waste as well as agricultural chemicals cause serious risks to human health.

The global water crisis is one of both quality and quantity and is closely linked to the degradation of critical ecosystems. It is a crisis of fragmented institutions, inadequate policies and legal systems, insufficient funding for water

supply and pollution control, and shortage of political will. These trends are not new – they are merely getting worse because of inaction. It is ironic that as the knowledge of the root causes of the water crisis becomes clearer, the political will for action becomes weaker.

Artificially low prices and heavy subsidies to water services are at the root of inefficiency, overuse, excessive pollution, and environmental degradation in many developing countries. Simply put, free water is wasted water. Water pricing is central to increased investment in water supply and management. Governments in many developing countries cannot meet the investment demands for water services now, let alone for the future.

The future can be brighter by adopting strategies for integrated water resource management, rationing water consumption, encouraging water reuse and protecting water supplies from pollution. Science and technology need to be effectively mobilized in support of policy and decision-making. Improving knowledge about groundwater resources, wetlands, lakes, and river basins is a necessary precondition for managing water in a sustainable manner. Various remote-sensing technologies and satellite observations can provide valuable information and better understanding of hydrology and water availability. Assessment studies would address how freshwater ecosystems are changing as a result of human activities and climate change. And research and development would advance new technologies for cheaper and more efficient pollution control and water treatment, for desalination using solar energy and for crop varieties that are drought and salinity tolerant. ◘

MORE WOMEN, BETTER SCIENCE

To develop an innovation culture, we need to bring more women into science and engineering. To do that, we must look at policy and culture in new ways.

by **Alice Abreu**

Alice Abreu is acting director of GenderInSITE, an international project hosted by TWAS to promote gender-awareness in science, innovation, technology and engineering. Abreu is professor emeritus in sociology at the Federal University of Rio de Janeiro. Previously she served as vice president, National Research Council of Brazil and director, OAS Office of Education, Science and Technology. She directed the International Council for Science Latin America office.

What will the world look like in 30 years? What are the challenges of developing countries to achieve sustainable and prosperous development? In 30 years' time, no country will have achieved sustainable development if it did not include science and technology in the equation.

Countries are slowly beginning to understand this and many invest in science, technology and innovation as a central element of their strategies for the future. However, no country will be able to fully develop its potential without including women – half of the population – in this process.

More women in science leads to better science. They bring diversity and different perspectives to the research effort, and therefore they contribute to the construction of more reliable and effective knowledge.

But to attain these advantages, we must also overcome challenges. We have to make sure women are well-represented in science, innovation, technology and engineering. We have to make sure they are given equal opportunities in the making of excellence. And we have to identify and remove any hidden obstacles to the highest positions of decision-making and policy development.

One also must have a gender lens when looking at sustainability, since men and women use and act upon our environment in very different ways. Not being able to identify how to better support and promote the different requirements of women and men will lead to ineffective solutions and to technologies that will not work to their full potential. Innovations, then, will not be able to have a wider impact.

To confront these challenges, we need reliable information and data. The systematic collection of sex-disaggregated data on science, innovation technology and engineering, and its analysis and dissemination, is central to inform policymakers and support future policy and programme formulation.

Facing these challenges will ensure the effective contribution of women in the knowledge economy and prove the huge economic potential of making a clear place for women in our vision of the future. ◘

Photo: George Joch/courtesy Argonne National Laboratory

BUILDING A SYSTEM TO SUPPORT SUCCESS

Many young scientists are among the brightest and most creative people in their generation. How can we free them to do their best work?

by **Sameh Soror**

Sameh Soror served as co-chair of the Global Young Academy from 2013-2015, and he is a co-founder of the Egyptian Young Academy of Sciences (EYAS). He is an associate professor of biochemistry and molecular biology at Helwan University, Cairo, Egypt, and founding director of Helwan Structural Biology Research, a centre for scientific excellence. He served as board member of the Global Council of the Science Education Program at IAP, the global network of science academies.

History tells us that many scientists have their greatest energy and creativity in the early years of their work. It follows that investment in science, and particularly in young scientists, is an investment in the future of any nation. This is especially true for the developing countries, where research and innovation are critically important for economic health and closing the gap between their home countries and the developed world.

The developing countries are facing grand challenges – water scarcity, food and energy security, infectious diseases and environmental threats. Young scientists are capable of contributing to solutions, but to achieve success, they need an environment that develops their full potential and allows them to do their best work.

"GloSYS", a recent study by the Global Young Academy (GYA), described the challenges that confront most young researchers in developing countries: The most obvious is a lack of resources and funding. But other obstacles also can impede their performance: They lack mentoring and support from superiors and training opportunities to develop professional skills. They are often overloaded with teaching and administrative tasks that leave little time for research. The process of hiring and promotion often lacks transparency.

To make an effective change, joint efforts are needed from governments, universities, research institutions, international organizations, foundations and young scientists themselves.

Science systems in developing countries should be refined to overcome these obstacles, and especially to support a reasonable balance between research and other duties. Universities and research institutes should work closely with international organizations interested in the developing countries to establish capacity building programs for young staff members to improve technical skills and leadership skills. A good example is the African Leadership Program for young researchers, run by the University of Pretoria in cooperation with GYA and the Bosch Foundation.

The movement to establish academies for excellent young researchers is spreading worldwide, and several developing countries have their own young academies. Networking should provide an ideal platform for these researchers to develop their creative ideas and, through cooperation, to unify their efforts to face local, regional and global challenges.

At the same time, we as young scientists should realize our responsibilities. We should employ our skills, creativity and enthusiasm to support the welfare of our communities. We should not work isolated from our societies. Our research should focus on our problems and challenges. We should express our ideas and needs, and engage in science policy dialogues to make the best use of our knowledge. We have to believe that we can shape the future of our nations. ◘

Photo courtesy: Carnegie Mellon University, Qatar

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The World Academy of Sciences for the advancement of science in developing countries – TWAS – works to advance sustainable prosperity through research, education, policy and diplomacy.

TWAS was founded in 1983 by a distinguished group of scientists from the developing world, under the leadership of Abdus Salam, the Pakistani physicist and Nobel Prize winner. Today, TWAS has nearly 1,150 elected Fellows from more than 90 countries; 16 of them are Nobel laureates. It is based in Trieste, Italy, on the campus of the **Abdus Salam International Centre for Theoretical Physics (ICTP)**.

Through more than three decades, TWAS's mission has remained consistent:

- Recognize, support and promote excellence in scientific research in the developing world;
- Respond to the needs of young scientists in countries that are lagging in science and technology;
- Promote South-South and South-North cooperation in science, technology and innovation;
- Encourage scientific and engineering research and sharing of experiences in solving major problems facing developing countries.

TWAS and its partners offer nearly 500 fellowships per year to scientists in the developing world for PhD studies and post-doctoral research. TWAS prizes and awards are among the most prestigious given for scientific work in the developing world. The Academy distributes USD1.9 million in research grants every year to individual scientists and research groups. It supports visiting scientists and provides funding for regional and international science meetings.

TWAS hosts and works in association with three allied organizations on the ICTP campus:

The Organization for Women in Science for the Developing World (OWSD). At its founding in 1989, OWSD was the first international forum uniting women scientists from the developing and developed worlds. Today, OWSD has more than 4,000 members. Their objective is to strengthen the role of women in the development process and promote their representation in scientific and technological leadership.

IAP, the global network of science academies. Established in 1993 as the 'InterAcademy Panel on international issues', IAP unites more than 100 science academies worldwide. It provides high-quality independent information and advice on science and development to policymakers and the public; supports programmes on scientific capacity-building, education and communication; and leads efforts to expand international science cooperation.

The InterAcademy Medical Panel (IAMP). IAMP is a network of the world's medical academies and medical sections of academies of science and engineering. It is committed to improving human health worldwide through the coordinated global action of its 73 members.

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