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TWAS newsletter

NEWSLETTER OF THE ACADEMY OF SCIENCES FOR THE DEVELOPING WORLD

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EDITORIAL

THE MISSION OF TWAS IS TO BUILD SCIENCE CAPACITY AND SCIENTIFIC EXCELLENCE IN THE DEVELOPING WORLD, MAINLY THROUGH PROGRAMMES AND ACTIVITIES WHICH WILL ENABLE RESEARCHERS TO REACH THEIR FULL POTENTIAL. INDEED, SCIENTIFIC KNOWLEDGE – BOTH DIRECTLY AND INDIRECTLY – HAS THE POWER TO ALLEVIATE MANY OF THE SOCIAL AND ECONOMIC CHALLENGES FACED BY COUNTRIES IN THE SOUTH.

Solid Foundations

Ultimately, this means ensuring that, in each developing country, there are enough researchers at all levels (PhD students, postdocs, professors) working on scientific and technological problems, as well as developments and innovations, and who can pass on that knowledge to others. It also means ensuring that there are enough science teachers, trainers and communicators at all levels (from primary to tertiary education, and in the media) to explain, disseminate and advocate science. This also means ensuring that there are appropriate mechanisms and networks for transferring scientific knowledge into the patents, products and services which in turn can provide the much needed resources and facilities (such as medicine and clean water, for example) – that will really make a difference.

KNOWLEDGE ACQUISITION

Excellent science can only be achieved through coherent education programmes and strategies. School teachers have the job of explaining what is already known to those people who don't yet know it – giving them the building blocks, the foundations in science. This involves making very important decisions at the policy level: what do we consider to be basic knowledge at the different growth phases in people's lives? Appropriate curricula need to be developed for every step of the education process – from primary, through secondary and on to higher education and vocational training.

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At TWAS, even though we do not focus on primary and secondary education (we see our mission as establishing science excellence at the research level so that this can filter down to teachers at all levels), we do recognize the very important contribution that researchers in science education and communication have to make. To this end, in 2007 we began to award TWAS Regional Prizes for such endeavours. You can read about one of last year's awardees in this Newsletter *on pages 30 to 37. As you will see, Jayashree Ramadas, living and working in Mumbai, India, has pondered for more than 36 years what kind of science should be taught in primary schools, and how to make the science curriculum directly relevant to young children in rural and urban areas throughout India.*

SOUTH-SOUTH

At the tertiary level, TWAS has a long-standing South-South Fellowships Programme, which provides students from developing countries with the opportunity to train for the three or four years of their PhD programmes in an 'emerging' country in the South (or opt for a 'sandwich' programme, undertaking their PhD at their home institute but spending up to one year in another institute in the South in order to benefit from specific knowledge and resources). In this Newsletter*, you can read how effective this South-South Fellowships Programme has been in ensuring there is a pool of trained researchers able to pass on their knowledge and so directly contribute to building science capacity in developing countries. Felix Akorli from Ghana, for example, was an early recipient of a TWAS South-South fellowship. He was sponsored to follow a four year PhD programme in Brazil. Seventeen years on, Akorli is a lecturer at the National University of Rwanda, developing and teaching a Master's programme in telecommunications, and passing on his acquired knowledge to help establish science, technology and communications in Rwanda (see pages 25 to 29). His story is an excellent and typical example of how TWAS's forward-thinking programmes have ensured (and continue to ensure) that knowledge, talent and scientific excellence are fostered throughout the South, and remain in the South. TWAS now administers the largest South-South fellowship programme in the world. We provide these opportunities in partnership with a number of emerging economies – including Brazil, China, India and Malaysia – and also by working together with a variety of agencies and institutions. This teamwork is fundamental to our success. There are more details*

about the effectiveness of these programmes in a special study of African fellowship holders who have pursued their research in China, on pages 13 to 21. You can also read about our long-standing and fruitful partnership with the Chinese Academy of Sciences, in an interview with Chunli Bai, TWAS vice president and generous host of this year's 12th TWAS General Conference and 23rd General Meeting which will take place in Tianjin, China, this September (see pages 6 to 12).

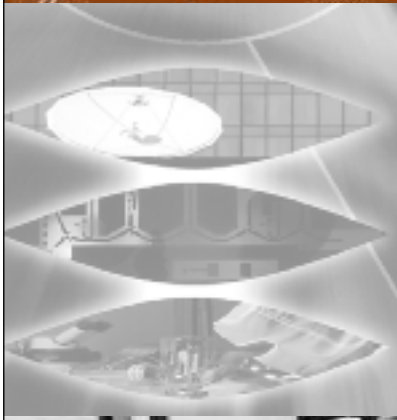
TWAS also provides much needed research support. We provide grants for scientists in the South to help them acquire the essential laboratory equipment and consumable supplies that they need for their research, which is especially useful for young scientists returning from studying abroad and who are starting to build up their own laboratory and research groups.

HUMAN CAPITAL MOBILITY

As well as our fellowship programmes, TWAS provides opportunities for scientific exchange with colleagues in technologically advanced countries, and with emerging developed countries, through exchange schemes such as the TWAS South-South Postdoctoral Fellowships; South to North visits from sub-Saharan Africa to Germany; TWAS Research Professors, Associateships and Visiting Scientist Programme; and support for scientific meetings. TWAS works in all these ways to facilitate the mobility of researchers around the world, ensuring that knowledge can be shared in the areas that most need it. A key way in which TWAS is able to do this effectively is through our five Regional Offices, which allow us to build on local knowledge and contacts, and to select candidates for our programmes and prizes.

KNOWLEDGE TRANSFER

Knowledge transfer is a further crucial step in ensuring that good ideas become actual marketable products, and thus contribute to economic growth and social improvement. TWAS, for this reason, is interested in sponsoring and supporting programmes that stimulate innovation and entrepreneurship in developing countries. On pages 43 to 46 of this Newsletter *you can read about one such 'Entrepreneurship Workshop', where selected physicists and engineers embarked on an intensive five day training programme to learn how to write a business plan, and how to pitch their products and services to potential investors.*



PURE SCIENCE TOO

At the same time, as a physicist myself, I know there is also a very strong case to be made for 'pure' science, and it is important that developing countries do not fall into the trap of funding only research that has pre-determined applications. To this end, I am especially interested in the article that Fernando Quevedo, director of the Abdus Salam International Centre for Theoretical Physics (ICTP), has contributed (pages 22 to 24) on the recent discovery of a Higgs boson-like particle. As an organization dedicated to promoting excellence in science in developing countries, TWAS celebrates the fact that Abdus Salam, founder of both ICTP and TWAS, born and raised in Pakistan, made an important early contribution to this eventual discovery – as indeed did Satyendra Nath Bose, from India, after whom the boson is named.

INNOVATION

Competition stimulates innovation – and a series of TWAS prizes reward and honour those scientists in the South who have made significant achievements in their field. Prize winners in targeted areas also serve as role models to encourage those who are generally under-represented in science to apply for training programmes. That is why I am particularly happy to announce the launch of an awards programme co-sponsored by TWAS, the Elsevier Foundation, and our partner organization, the Organization for Women in Science for the Developing World (OWSD), to recognize and reward talented early-career women scientists from Africa, the Middle East, Asia, Latin America and the Caribbean. You can read more about this important new award on the TWAS website (www.twas.org).

The challenges facing developing countries need solutions. Devising solutions requires an investment of money, but also of faith: there is a risk that experiments might come to nothing; that expensive equipment might not produce the desired results; or that the hours, weeks and years invested by dedicated researchers might not immediately yield the hoped-for return. Nevertheless, it is only through courageous strategic investments that innovation becomes possible. TWAS is committed to mobilizing talented young scientists who can exchange results and best practices, and generate the new ideas that can ultimately contribute to economic growth and social well-being. ■

PRIOR TO THE FORTHCOMING TWAS GENERAL CONFERENCE IN TIANJIN, CHINA, BAI CHUNLI, PRESIDENT OF THE CHINESE ACADEMY OF SCIENCES, TOOK THE TIME TO ANSWER SOME QUESTIONS POSED BY THE *TWAS NEWSLETTER* EDITOR.

First of all, can you give us an idea of what the Chinese Academy of Sciences does?
The Chinese Academy of Sciences (CAS) is the largest comprehensive national research and development institution in natural sciences and high technology development in China. It is an integrated institution that consists of a research and development system, a merit-based academic society and it also functions as an institute of higher education. Other roles include the promotion of sustainability and socio-economic development and ensuring that science and technology contribute to the overall competitiveness of China on the world stage.

THE CHINESE ACADEMY OF SCIENCES

The mission of CAS is to deliver quality science and technology, to foster talent and train high-calibre professionals, and to provide trusted advice to society. CAS consists of more than 100 research institutes engaged in almost all areas of science and technology and employs over 60,000 science professionals and staff. These research institutes are backed up by a dozen other supporting organizations, including a documentation and information centre (the China Science Library) and a computer network information centre.

CAS higher education is based around and supported by its two universities and the 100 plus research institutes. It currently has an enrolment of about 50,000 students, of which more than 35,000 are Master's or PhD candidates.

And of course, CAS is a merit-based academy with more than 700 eminent scientists as members and also a number of foreign members, selected every two years from Chinese universities, research institutions as well as other institutes under various ministries.

With regard to CAS research institutes, since early last year, they have been requested to further identify their development strategies based on their current research competencies, the global trends in science and technology, and an overall analysis of both the domestic and international situations they face. The idea is to make CAS institutes position themselves in the right niche in the scientific community compared with their counterpart institutes both at home and

abroad. Based on this analysis, our institutes are also requested to map out their mid- to long-term research objectives and resolve to make important discoveries and breakthroughs in those areas in which they enjoy a comparative advantage and thus have better potential for success.

How have CAS's strategic focal points changed over the past five years? And how will the agenda change over the next five years?

Over the past five years, the research priorities of CAS have focused on strengthening interdisciplinary and cross-institute cooperation through the implementation of CAS '1+10 S&T Innovation Clusters'. Initiated in 2006, the 'one' in the initiative stands for the common goal of enhancing fundamental research in major interdisciplinary frontier fields, while the 'ten' refers to the following key strategic fields:

- Information technology;
- Energy science and technology;
- Human health and medicine;
- Advanced sustainable agriculture;
- Marine resources and science;
- Space science and technology;
- Nanoscience, advanced manufacturing and new materials;
- Industrial biotechnology;
- Ecology and environmental studies; and
- 'Big science' facilities for comprehensive research.

Due to the construction of these clusters through the 1+10 initiative, interdisciplinary research and collaboration in these areas within CAS have been strengthened. In the coming five years and beyond, CAS will further develop its capacity and functions as:

- a scientific research base of international excellence;
- a base for training and developing high calibre research talents;
- a base for promoting and developing national hi-tech industries; and
- a national scientific think-tank.

To achieve our organizational goals and objectives, CAS has committed much effort to the attraction of talent. For example, we have a 'Package Plan for Talent Training and Recruitment'. The plan includes a whole range of programmes and initiatives such as a 'High-level Talent Recruitment Scheme', an 'Excellent Young Talent Training Scheme', a 'Technical and Administrative Talent Training Scheme', and an 'Overseas Brains Recruiting and Talent Training through International Exchanges Scheme'.

With the emphasis on innovative research and technology transfer, have there been any particular breakthroughs by Chinese scientists in the past few years, perhaps in your own

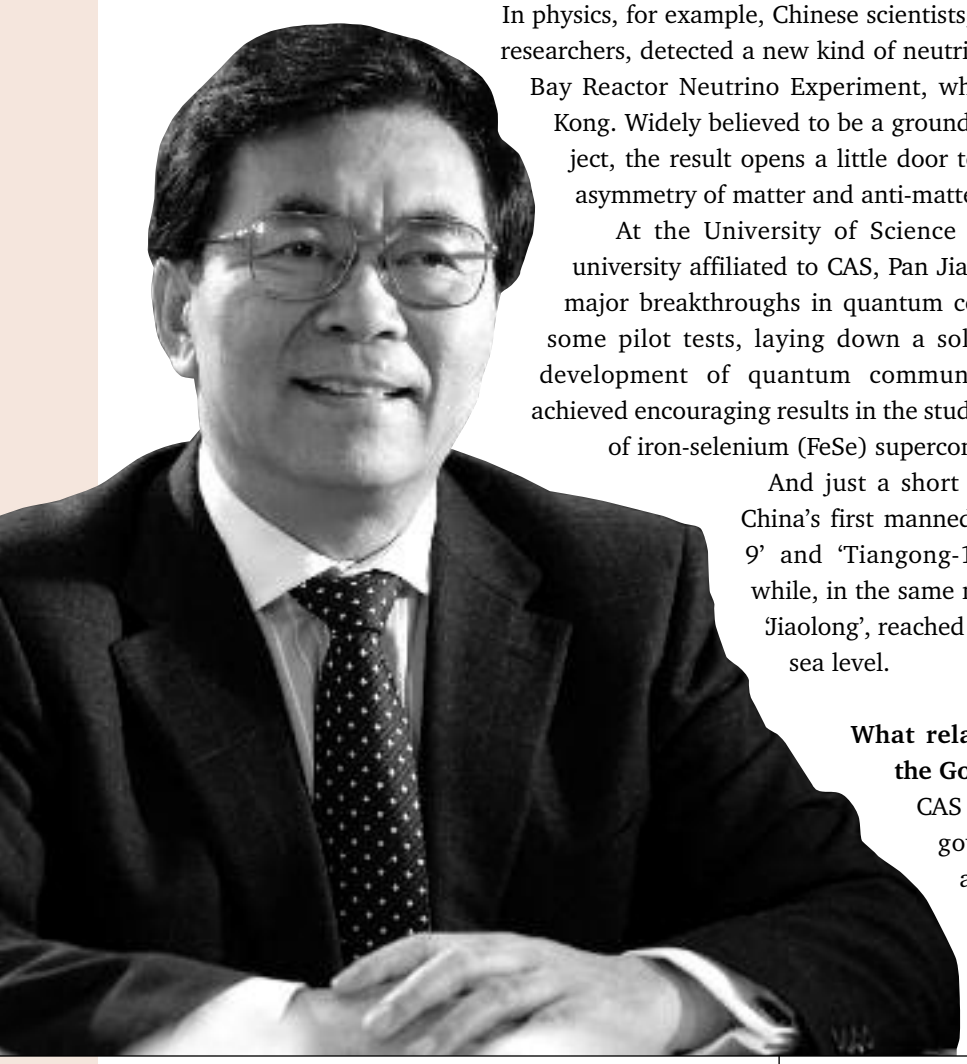
area of chemistry, that are having, or soon will have, a big impact?

Certainly! Let me provide a few examples.

In the area of nano-catalysis, Chinese scientists have invented a technique for producing ethylene glycol from coal. This technology will have a significant influence on the power generation and chemical manufacturing industries in China.

Chinese scientists also developed nano-green printing technologies based on the principle of a controllable wetness switch in micro- and nano-materials. This new invention is expected to become a mainstream technology of the future printing industry due to some significant advantages: low cost; no need for photo-plating; environmental friendliness; and the possibility of being highly automated. By employing this new technique, China stands a very good chance of regaining its historic place as a world leader in the printing industry.

In areas other than chemistry, we have also seen progress and significant breakthroughs.



In physics, for example, Chinese scientists, in partnership with American researchers, detected a new kind of neutrino transformation at the Daya Bay Reactor Neutrino Experiment, which is located north of Hong Kong. Widely believed to be a ground-breaking particle physics project, the result opens a little door to the further revelation of the asymmetry of matter and anti-matter in the universe.

At the University of Science and Technology of China, a university affiliated to CAS, Pan Jianwei and his team have made major breakthroughs in quantum communication and performed some pilot tests, laying down a solid foundation for the future development of quantum communication. Our scientists also achieved encouraging results in the study of electron pairing symmetry of iron-selenium (FeSe) superconductors.

And just a short while ago, in June this year, China's first manned space docking of 'Shenzhou-9' and 'Tiangong-1' was achieved successfully while, in the same month, a manned submersible, 'Jiaolong', reached a depth of 7,000 metres below sea level.

What relationship does CAS have to the Government of China?

CAS is a top advisory body to the government on major scientific and technological issues in China. Its academic divisions, composed of over 700 elected members, provide advice and

consultation to the government with the support of the whole of CAS, including the 100 plus research institutes. Whenever we receive a request, we follow up with a strategic study. CAS also has a channel of communication to the government, and we occasionally carry out strategic studies in consideration of national needs.

What is the nature of the relationship of CAS to universities in China?

Over the past decade, CAS has strengthened its research collaboration with universities in the following ways:

- CAS hosts more than 80% of the country's 'big science' facilities such as particle accelerators, synchrotron radiation facilities and telescopes. These are open to all universities and research institutions in China for scientific experiments. Based on these facilities, CAS has developed many joint research programmes and projects with universities to the mutual benefit of both;
- A large number of joint laboratories, research centres and engineering centres have been established between CAS institutes and universities and businesses in China. For example, CAS, in cooperation with Tsinghua University and Peking University, founded the National Centre for Nanoscience and Technology in 2003. I was the founding director of this centre;
- Some CAS institutes have also set up joint PhD and MSc programmes with universities, or have jointly appointed professors. At CAS, we understand that universities, especially the top-level universities, are the essential sources of graduate students and trained young scientists for our institutes.

What can other national science academies learn from China's experience, especially academies in emerging economies and developing countries?

I don't think the CAS experience in China is easily transferrable. Each academy has its own characteristics and actual national conditions. I believe each should develop in its own way according to its own circumstances. We can certainly learn from each other, however, and, most importantly, we can work together to understand how we can make our organizations better fit the needs of society.

How is CAS working with other scientific institutions outside of China, especially those in emerging economies and developing countries?

CAS gives great importance to international cooperation and exchanges. We have a full range of collaborations not only with developed countries, but also with developing countries, and with various key international scientific organizations as well.

In recent years, CAS's international cooperation has been growing rapidly in a number of areas, including personnel exchanges, data sharing and exchange, bilateral workshops, international conferences, project-based working visits, joint

laboratories, joint centres and partnership institutes. In all these cases, the idea has been to create an equal and mutually beneficial partnership. Such arrangements have varied from scientist-to-scientist cooperation to high-level strategic communication; from bilateral agreements between scientific institutions to multilateral research programmes; and from pure scientific research to partnerships with industries for translational research and technology transfer.

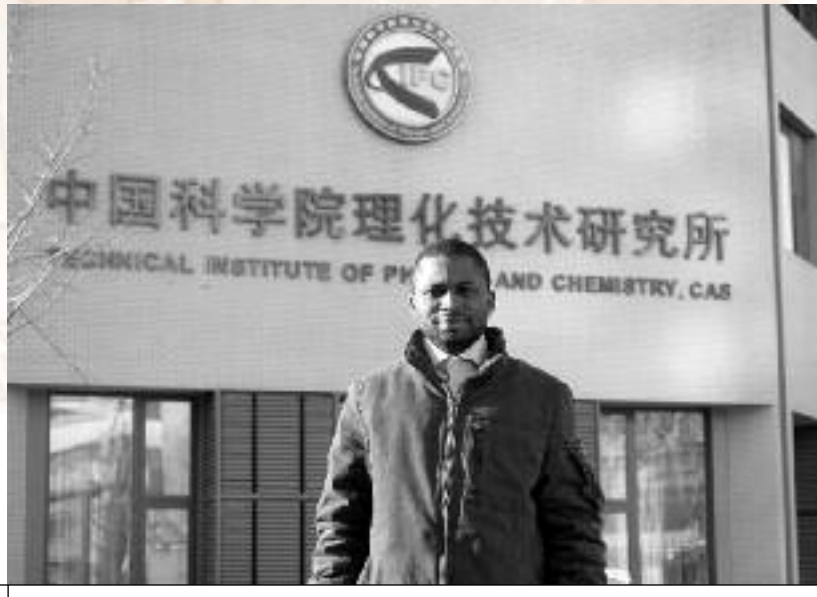
Let me share a few figures that serve to illustrate the range and extent of CAS's international cooperation:

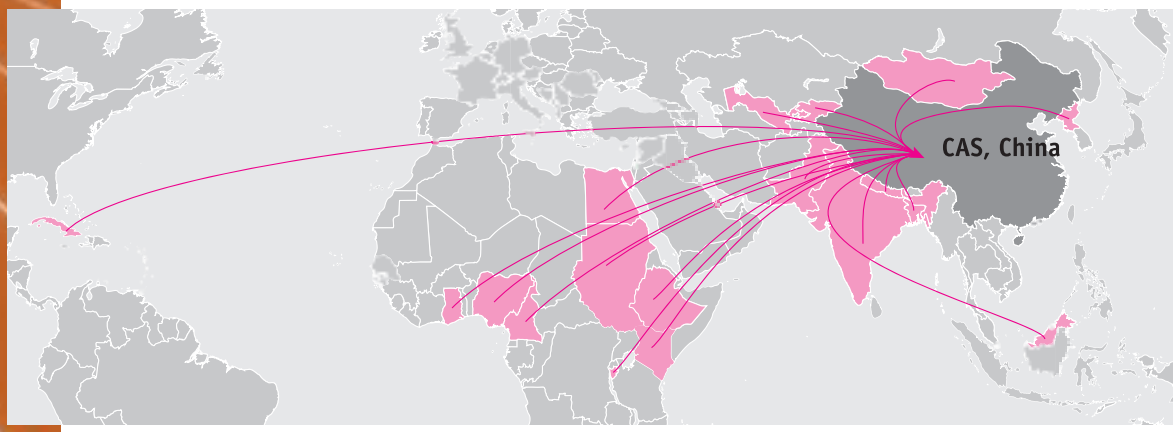
- Between 1998 and 2011 our international cooperation and exchange activities have tripled and now involve some 30,000 'person times' of exchanges and visits a year;
- At present, CAS has more than 200 cooperation agreements at the academy level and more than 1,000 agreements at institute level with various international partners;
- CAS institutes have jointly established more than 150 research centres, labs and partnerships with various foreign counterparts, including with multinational companies. For example, CAS-Max Planck Society (MPS) Partner Institute for Computational Biology; the *Institut Pasteur* of Shanghai, CAS; the Sino-French Laboratory in Computer Science, Automation and Applied Mathematics; the China-Australia Joint Centre for Phenomics Research; the Institute of Biophysics (IBP-CAS)-Queensland Brain Institute (QBI) Joint Laboratory of Neuroscience and Cognition; and the Qingdao Institute of Bioenergy and Bioprocess Technology (QIBEBT-CAS)-Boeing Joint Research Laboratory for Sustainable Aviation Biofuels, to name just a few.
- CAS organizes more than 350 international and bilateral conferences, workshops and symposia every year; and
- Each year, several hundred international cooperative research projects are conducted at the scientist-to-scientist level.

I would also like to emphasize that we are open to collaborating with any country, whether developed, 'emerging', or developing so long as the proposed collaboration and activities are mutual beneficial and fit within our interests.

What are the strengths of China's overall scientific enterprise? What areas require additional attention and improvement?

Because of our large population, China has a large research community. With government support, we have been making good progress in our scientific development. Over the past few years, for example, in terms of publications in peer-reviewed journals, Chinese scientists have ranked second in the world. Both from the perspectives of the volume of our output and of scientific excellence, China has built a good reputation in areas such as chemistry, nanotechnology, materials science, engineering sciences, mathematics and geo-eco-environmental sciences. However, China is still far behind developed countries in science and technology in terms of quality





and impact, as shown by the fact that many of our scientists are not so productive in the most cutting-edge areas of sciences. We must make more strenuous efforts to advance our research and go beyond our current level to achieve more significant results that will alter existing scientific paradigms. Of course, we also need to further improve our innovation culture and procedural mechanisms for transforming research into products.

To further develop China's scientific research capability, there are certain areas that require additional attention and improvement. First, we need to attract more top level scientists and engineers who are recognized by the international scientific community. Second, we should focus on developing our own advanced research facilities and equipment that can facilitate original discoveries and inventions instead of relying on purchased equipment. Third, we should create a better working environment that encourages fundamental and interdisciplinary frontier research. And last but not least, we need to develop an innovation-friendly culture that encourages pioneering work and tolerates failure in research.

How do you see the relationship of CAS and TWAS unfolding in the years ahead? How can both academies work together to achieve their common goals?

Over the years, CAS has built a strong partnership with TWAS. For example, the CAS-TWAS Fellowships Programme was launched in 2004. Since then we have hosted some 280 scientists from developing countries at CAS institutes in China, including 96 PhD students, 71 postdocs and 115 visiting scholars. These scientists have come from more than 30 developing countries, including Bangladesh, Egypt, India, Nigeria, Pakistan and Sudan. Once they return home, they become an important scientific force in and for their countries.

It is important to note that CAS also hosts the TWAS Regional Office for East and South-East Asia and the Pacific (TWAS-ROESEAP), through which regional collaboration has been significantly strengthened. In my personal opinion, it is vital that we continue to strengthen the connections of the regional nodes with the TWAS headquarters in Italy, especially in building regional scientific capacity.

Another notable programme is the series of CAS-TWAS-WMO (World Meteorological Organization) Forums (CTWF) on climate sciences, established in 2000. Each CTWF has provided a platform for scientists (mostly from developing countries) to communicate and to scale up cooperation between developing countries on climate-related issues. Since its establishment, CTWF has organized ten international workshop-style conferences on topical issues related to climate

science. In 2010, for example, the 9th CTWF focused on 'Climate and Environmental Change: Challenges for Developing Countries', while the 10th CTWF, held in 2011, focused on 'Regional Climate Change and its Impact Assessment'.

In the long term, I am sure the relationship between the two academies will be further enhanced. We are very much in favour of the values and vision that TWAS stands for and wish to make more contributions to the capacity-building and talent-training of the South through the TWAS platform. I am sure that both the Government of China and the Chinese scientific community, including CAS, will commit more resources to further advance the objectives and goals of TWAS. In fact, China is set to make a handsome contribution to TWAS to advance its capacity-building initiatives and their impact. We can also anticipate strengthened partnership and cooperation between CAS and TWAS for the benefit of all, especially in the developing world.

The next TWAS General Meeting, scheduled for September 2012, will be in China. What can we expect?

Together with the TWAS secretariat in Trieste, we are in the process of preparing for the next 12th TWAS General Conference and 23rd General Meeting, with the theme 'Science for Sustainability'. The conference will include a ministerial session on 'Science, Technology and Innovation for Economic Growth & Poverty', a forum on 'National Academies & Open Innovation' and a symposium on 'S&T Development in China'. This time, the conference will be held in Tianjin, the third largest city in China and also a key base for advanced industry and innovation. I know that our local organizing committee is doing a good job in preparing everything. I am sure that the logistical arrangements will run smoothly so that participants can relax and enjoy another successful meeting in China. TWAS is 29 years old and is at a critical stage for further development and growth. I wholeheartedly wish that the conference will lay a solid foundation for the continued flourishing of TWAS and the noble cause it stands for. In order to allow as many TWAS members from scientifically lagging countries as possible to come to China to share their wisdom for the future of TWAS and to see with their own eyes the dynamic changes and progress that have occurred in China in recent years, CAS has provided TWAS with significant funding to assist those who most need it.

I look forward with great anticipation to celebrating another successful and memorable TWAS conference with you and hope to see as many of you as possible in Tianjin. ■

AN AFRICAN PERSPECTIVE

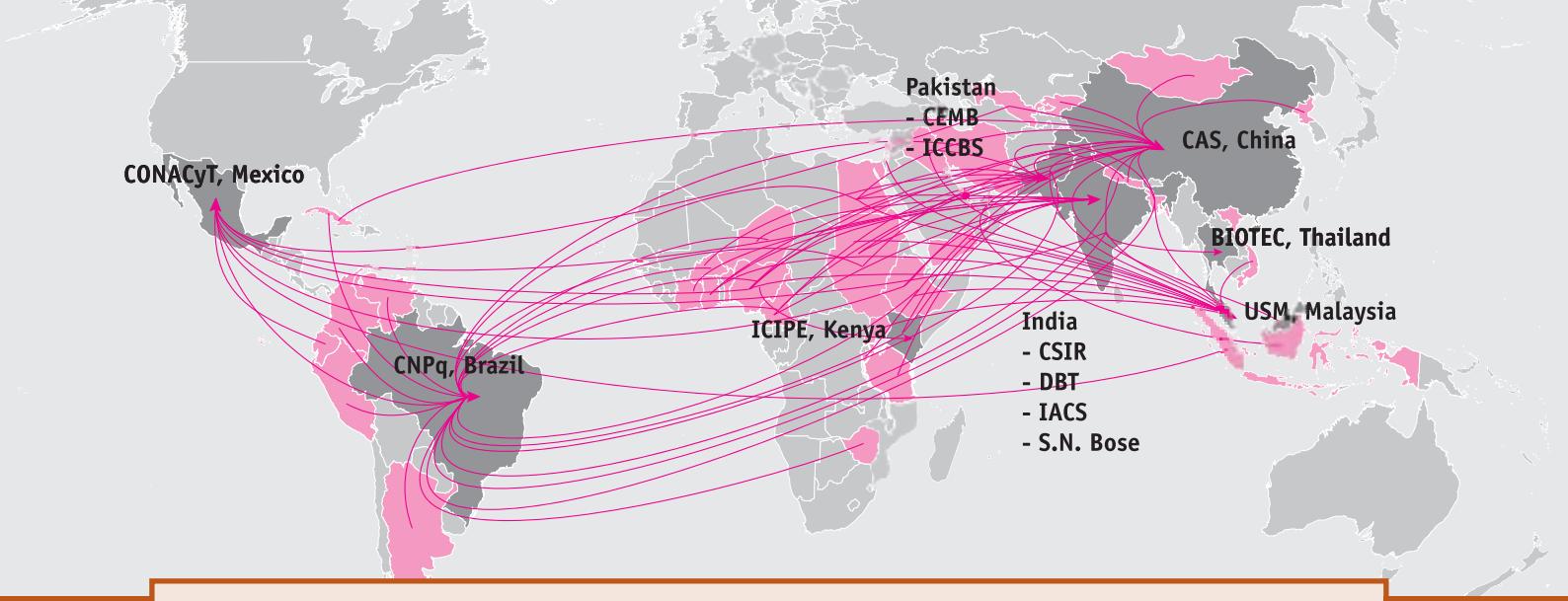
IN 2004, TWAS AND THE CHINESE ACADEMY OF SCIENCES (CAS) SIGNED AN AGREEMENT THAT ALLOWS UP TO 50 SCIENTISTS A YEAR TO SPEND TIME IN LABORATORIES IN CAS INSTITUTES. TO DATE, SOME 350 STUDENTS AND RESEARCHERS FROM DEVELOPING COUNTRIES HAVE BEEN AWARDED TWAS-CAS FELLOWSHIPS. HERE WE REVIEW SOME OF THE BENEFITS OF THE SCHEME, FOCUSING ON VISITORS TO CHINA FROM AFRICA.

Since the TWAS-CAS Fellowship Programme was launched in 2004, some 350 awards have been made to either postgraduate students, postdoctoral researchers or visiting scientists from developing countries. Under the agreement, postgraduate students may undertake the final year of the their PhD programme in a CAS institute; postdoctoral researchers can visit the chosen institute for 6 to 12 months to develop their research skills; and visiting scientists can hone their expertise and develop collaborative research projects during visits lasting from one to three months.

With all of CAS's 100 or so research institutions across China participating in the scheme and covering a wide range of subject areas, there are many opportunities for scientists from developing countries to benefit from the facilities available in these top-class centres – not only to learn new skills and carry out research, but also to take advantage of the library facilities for accessing recent publications and to build a network of international contacts.

Among the 350 students and scientists to have been awarded TWAS-CAS Fellowships, more than 150 (44%) come from Africa – perhaps the continent with the greatest need when it comes to providing opportunities for advanced training and developing human capacity in science.

As the first awardees under the programme started returning to their home countries in 2005, it is timely to review some of the successes of the programme and



TWAS SOUTH-SOUTH FELLOWSHIPS

Since the agreement was signed with CAS in 2004, the TWAS programme has expanded and is now considered to be the world's largest South-South fellowship programme. Currently TWAS provides more than 300 opportunities each year through agreements with 14 programme partners in nine developing countries, including:

- *Brazil – National Council for Scientific and Technological Development (CNPq);*
- *China – Chinese Academy of Sciences (CAS)*
- *India – Council of Scientific and Industrial Research (CSIR);*
- *India – Department of Biotechnology, Government of India (DBT);*
- *India – S.N. Bose National Centre for Basic Sciences;*
- *India – Indian Association for the Cultivation of Science (IACS);*
- *Iran – Iranian Research Organization for Science and Technology (IROST);*
- *Kenya – International Centre of Insect Physiology and Ecology (*icipe*);*
- *Malaysia –* Universiti Sains Malaysia *(USM);*
- *Mexico – National Council on Science and Technology (CONACYT);*
- *Pakistan – Centre of Excellence in Molecular Biology (CEMB);*
- *Pakistan – International Center for Chemical and Biological Sciences (ICCBS)*
- *Pakistan – National Centre for Physics (NCP); and*
- *Thailand – National Centre for Genetic Engineering and Biotechnology (BIOTEC).*

For full details, see: twas.ictp.it/prog/exchange/fells/fells-overview

its impact on the careers of a group of visitors from various African countries.

RENEWABLE ENERGY – BIOFUELS

China does not have a tradition of producing or consuming dairy products. Even so, some 9,000 tonnes of cheese were produced in 2006. With the hosting of the Olympic Games in Beijing in 2008, however, it seems the Chinese developed a taste for cheese, and some 15,000 tonnes were produced that year – a 75% increase.

Along with the production of cheese, however, comes whey – a watery byproduct containing a mixture of proteins and other organic components. Essentially, ten litres of milk give one kilogramme of cheese and nine litres of whey, which means that 135,000 tonnes of whey were produced in China in 2008 alone.



When Mervat Ibrahim Foda Aly travelled from her base at the Dairy Science Department, Food Industry and Nutrition Division, National Research Centre, Cairo, Egypt, to China with a TWAS-CAS Visiting Scholar Fellowship in 2009, she was expecting to work on the role of a small molecule, glutathione, in the biochemistry of cheese production. However, her host at the Institute of Microbiology, CAS, persuaded her to look into the possibility of using this waste whey for the production of biofuel.

Using different strains of *Clostridium* bacteria in a series of bioreactor/fermentation experiments, the new research partners were able to produce such biofuels as ethanol and butanol, as well as other useful products such as butyric acid. In addition to being used as an animal feed supplement, the foul-smelling butyric acid can be converted into molecules with more pleasant aromas that can be used in food and perfumes.

TWAS offers more than 300 fellowships each year.

Although Foda Aly's visit to China lasted little more than two months, a strong collaboration has developed, with a resulting paper published in an international journal, and a joint application submitted to a funding agency in China to help develop their research ideas. In addition, her Chinese host, Yin Li, organized an international workshop and invited her to give a lecture and to chair a session.

"The production of biofuels is currently a hot topic," confirms Foda Aly, "and we plan to continue our collaboration, perhaps through the exchange of PhD students and postdocs, to see where our research will lead."

RENEWABLE ENERGY – SOLAR

Teketel Yohannes Anshebo has a long history of participation in TWAS programmes. For example, he received two TWAS Research Grants, in 2002 and 2004, for individual young scientists for his studies on organic molecules in solar energy conversion devices.

Having helped him establish his laboratory at the Department of Chemistry, University of Addis Ababa, Ethiopia, TWAS also assisted Anshebo in developing his international contacts by awarding him a TWAS-CAS Visiting Scholar Fellowship in 2006. Thus, in October 2007, he travelled to the Institute of Chemistry, CAS, to join Xiaowei Zhan's Key Laboratory of Organic Solids.

"At present, the active part of the typical commercial modules in solar energy conversion devices is made of silicon. The thickness of the silicon layer in these devices makes the material costs per square metre a real bottleneck in competition with conventional electricity production from gas and coal," explains Anshebo. "Organic solar cells may provide a unique alternative to such inorganic systems", he adds. "Their advantages include a high absorption coefficient, low cost, light weight, ease of fabrication, and they can be used to coat large areas."

The goal, therefore, is to identify the best organic polymer for the job, which depends on measuring the electrochemical properties of the compounds – or, more specifically, their highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO).

"It is important to know the HOMO and LUMO level of the photoactive materials in the construction of solar energy conversion devices in order to select the proper combination of donor and acceptor materials for the construction of efficient devices," says Anshebo.

And it was exactly this kind of work that he undertook in the lab in Beijing. Basically, he carried out electrochemical studies on materials synthesized by graduate students in the research group, analysed the results to calculate the HOMO and LUMO of the compounds, and made recommendations concerning the best combinations of materials.

Anshebo has used this opportunity to develop his own research programme back in Addis Ababa. Between 2010 and today, for example, he has published more than ten articles in the area of solar energy in international and local journals. He has also maintained connections with Yongfang Li, a leading scientist in the area of organic solar energy conversion, who has made two trips to Addis Ababa and has acted as external examiner to one of Anshebo's PhD students. "On his second visit, he also brought with him some organic polymers that we may use to construct a solar energy device and to start a collaboration", adds Anshebo.

Anshebo continues to be active both at home and abroad. Not only did three PhD and five MSc students from his lab recently defend their thesis, he has just been promoted to director for research at Addis Aba-



ba University, he is a board member of the Africa Materials Research Society (AMRS), has helped establish the African Network for Solar Energy (ANSOLE), and is also actively involved in the activities of SPIE, the international society for optics and photonics.

CHINA-NIGERIA CONNECTIONS

As the most populous country in Africa, with some 170 million inhabitants, it is no surprise that 81 of the 154 African awardees to the TWAS-CAS Fellowships Programme (53%) are Nigerian. Here we briefly highlight the experiences of three:

- Emmanuel Iyayi Unuabonah was awarded his PhD by the University of Ibadan in 2007. He carried out part of his research towards his degree at the Institute of Soil Science, CAS, thanks to a 2005 TWAS-CAS Postgraduate Fellowship.
- Taofik Adewale Adedosu was awarded his PhD by the University of Ibadan in 2009. He carried out part of his research towards his degree at the Institute of Geology and Geophysics, CAS, thanks to a 2006 TWAS-CAS Postgraduate Fellowship.
- Armed with his PhD, Emeka Emmanuel Oguzie applied to the TWAS-CAS Postdoctoral Fellowship scheme in 2005 and subsequently spent 12 months at the Institute of Metals Research, CAS, from June 2006 to June 2007.

Unuabonah, currently at the Department of Chemical Sciences, Redeemers University, Mowe, Nigeria, studies the chemistry of locally-sourced kaolinite clays and their potential use in cleaning wastewater, adsorbing metal ions and organic compounds, and in other novel applications. As well as producing 25 publications between 2005 and 2011, he has been selected as a TWAS Young Affiliate (2009), was a winner of the 2011 AU-TWAS National Award for Young Scientists from Nigeria, has been elected president of the Nigerian Young Academy and is a member of the Global Young Academy. In 2011, he also won a TWAS Research Grant to study the removal of non-ionic organic contaminants and absorbable organic halides by novel organo-nano-clay adsorbents. There is no doubt that he has used the opportunities provided by TWAS and CAS to launch himself on a dynamic career in science.

China can act as a model in solving my country's problems.

Adedosu's chosen area of research could be considered as very specific to Nigeria: his thesis was entitled 'Aspects of organic geochemistry of Nigerian coal as a potential source-rock of petroleum' and his studies have focused on the interbedded shale of the Mamu rock formation of the Benue Trough in Nigeria. Was it a problem for him to work on a Nigerian problem in a Chinese environment?

"Actually, China is one of the countries in the world that has abundant coal deposits which serve as a source of petroleum and thus can act as a model in solving my country's problems," he says. "While in




China, I was able to do a biomarker characterization of the coal and its interbedded shale. I also analysed polycyclic aromatic hydrocarbons and the carbon isotopic composition of individual alkanes in the samples. This would not have been possible in Nigeria due to the unavailability or sometimes inaccessibility of geochemical analysis facilities to geochemists like myself. For these reasons, I applied for – and was awarded – a 2011 TWAS-CAS Postdoctoral Fellowship and will now return to China to improve my expertise in the field of organic geochemistry. The new fellowship will also assist in advancing my work in the search for commercial accumulations of hydrocarbons (oil and gas) in the Benue Trough."

Since his TWAS-CAS Postdoctoral Fellowship, which allowed him to advance his research into the chemistry of corrosion and, more specifically, how it can be inhibited, Oguzie has been promoted to the level of senior lecturer at the Federal University of Technology Owerri, where he has been since 1999.

"I consider that the TWAS-CAS Fellowship helped me 'internationalize' my career," he says. "It enabled me to produce work to a high standard that I have been proud to present at international conferences and have published in high impact factor journals. Thanks to the fellowship, I feel more competent, confident and self-assured in the work I do."

As someone selected as a TWAS Young Affiliate (2007), what advice would he give to other young scientists contemplating applying for a TWAS South-South Fellowship?

"It is important that a part of any research project should be achievable with the facilities available in our home institutions," replies Oguzie, adding that projects should be initiated at home and concluded at the host institution, with the idea of ultimately introducing innovations once the researcher returns home.

Like Unuabonah, Oguzie has also received a TWAS Research Grant, this time as principal investigator of a research unit, to study 'the development of non toxic corrosion inhibiting additives for iron and steel from natural products'.

MATHEMATICAL THINKING

Guy Degla, from the *Institut de Mathematiques et de Sciences Physiques*, Benin, travelled to the Institute of Mathematics of the Academy of Mathematics and Systems Sciences (AMSS), CAS, in October 2005, spending 12 months there under his TWAS-CAS Postdoctoral Fellowship.

"The Institute of Mathematics is integrated with other AMSS centres such as the Institute of Applied Mathematics, the Institute of Systems Science and the Institute of Computational Mathematics and Science/Engineering Computing. This means that

AMSS is a place where the motivations as well as the applications of mathematics are evident. This kind of framework does not exist in Benin," says Degla. "AMSS was also a place where I could not only hold discussions with distinguished Chinese mathematicians such as Yanheng Ding, my mentor, but also with other internationally eminent mathematicians who visited AMSS during my 12 months there."

While there, he submitted a paper to the *Journal of Mathematical Analysis and Applications* on his specialist field of functional analysis and its applications, which was published soon after his return to Benin. The following year, he had another paper published based on his work at AMSS, this time in the journal *Nonlinear Analysis*.

"I should also point out that I happened to go to AMSS at a time when most of the senior professors in Benin were retiring. There was also little research going on in mathematical analysis and the need for experts in our postgraduate schools was critical since these schools could not rely only on visiting professors," adds Degla. "In addition, my stay at AMSS helped me consolidate my postdoctoral research and allowed me to be hired directly by a postgraduate institute, the *Institut de Mathematiques et de Sciences Physiques,* through the Council of the Universities of Benin in 2007." Also in 2007, Degla was awarded a TWAS Prize for Young Scientists by the *Centre Béninois de Recherche Scientifique et Technique* (CBRST), which was presented to him by the then Minister of Scientific Research and Education, Vincincia Boko.

The TWAS-CAS Fellowship helped me internationalize my career.

At AMSS I could hold discussions with distinguished mathematicians from all over the world.

MEASURING WATER

As with the Nigerian Adedosu, Elzein Ahmed Elzein Mohammed went to China under his TWAS-CAS Postgraduate Fellowship to further his studies on the geology of his home country, in this case Sudan. In fact, he spent 12 months, from June 2005 to June 2006, at the Institute of Geology and Geophysics, CAS, advancing the research for his thesis on the 'Geoelectrical and hydrogeological characteristics of the groundwater aquifers in the Gezira area, central Sudan'. In China, Elzein Mohammed received training in controlled source audio-frequency magnetotellurics (CSAMT) field survey techniques, as well as in the use of specialized geophysics software for data processing and interpretation. Such research enables the mapping, for example, of the interfaces between saline and fresh groundwater – critical information that can help with the sustainable management of valuable natural resources, whether in China, Sudan or almost anywhere else on Earth.

As a result of his PhD research, which he submitted in 2007, Elzein Mohammed was awarded the Prize of the Sudanese Minister of Higher Education and Scientific Research in Earth Sciences (2007). Four years on, and Elzein Mohammed is now head of the Department of Geology and Applied Geophysics at the International University of Africa, Khartoum, Sudan.

Elzein Mohammed's achievements, and those of the other 'alumni' of the TWAS-CAS Fellowships Programme are typical. Several years on, after returning to their home countries – a condition of the fellowship – the young scientists are now assuming positions of responsibility in universities and research institutions.



ASSOCIATESHIP SCHEME

Ten years before the TWAS-CAS Fellowship Programme came into operation, TWAS was already collaborating with institutions in China through the TWAS-UNESCO Associateship Scheme. Under this programme, established in 1994, developing-country scientists are appointed for a three-year period, during which they carry out two visits of two to three months each to a centre of excellence selected from a roster of participating institutions.

Currently, TWAS has agreements with more than 100 host centres, 19 of which are CAS institutes and another three are also located in China.

Together, over the past ten years, these centres have hosted 18 TWAS-UNESCO associates from five different African countries.

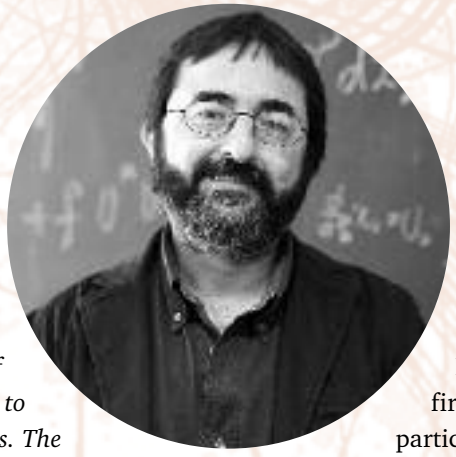
Among those benefiting from the programme are Daniel Lissouck and Evariste Wembe Tafo from the University of Douala in Cameroon, who both visited the Institute of Modern Physics, CAS, in Lanzhou, located some 1,200 kilometres west of Beijing. While there, they developed and worked on their collaborative research programmes: while Lissouck carried out research into condensed matter physics and the dynamics of magnetism, Tafo investigated micro-electronic circuits for use in particle detectors. In fact, both Lissouck and Wembe Tafo have been awarded second TWAS-UNESCO associateship appointments, allowing them to make third and fourth visits to their selected host institutes in China – and thus helping to forge long-term links between their home and host institutions.

Buoyed by their experience in China – by learning new skills and gaining confidence in their abilities to contribute and compete at an international level – these African scientists are now responsible for teaching and training the next wave of young African scientists, mentoring their MSc and PhD projects, and encouraging their participation in international meetings and networks.

Since the agreement between CAS and TWAS was signed in 2004, and taking into account all the other agreements TWAS has in place (see box, p. 14), we can consider that TWAS, through the South-South Fellowships Programme, has given a boost to a total of more than 800 scientists from 52 developing countries. With the multiplier effect of teaching, training and sharing experiences, that is a considerable contribution to building human capacity in the South – a contribution, because of the focus on young scientists, that will continue to provide spin-off dividends for decades to come. ■

THE HIGGS BOSON DISCOVERY

FERNANDO QUEVEDO (TWAS FELLOW 2010), DIRECTOR OF THE ABDUS SALAM INTERNATIONAL CENTRE OF THEORETICAL PHYSICS (ICTP) IN TRIESTE, ITALY, DESCRIBES THE IMPORTANCE OF THE RECENT DISCOVERY OF A HIGGS BOSON-LIKE PARTICLE AND THE EARLY ROLE PLAYED BY ABDUS SALAM, FOUNDER OF BOTH ICTP AND TWAS.

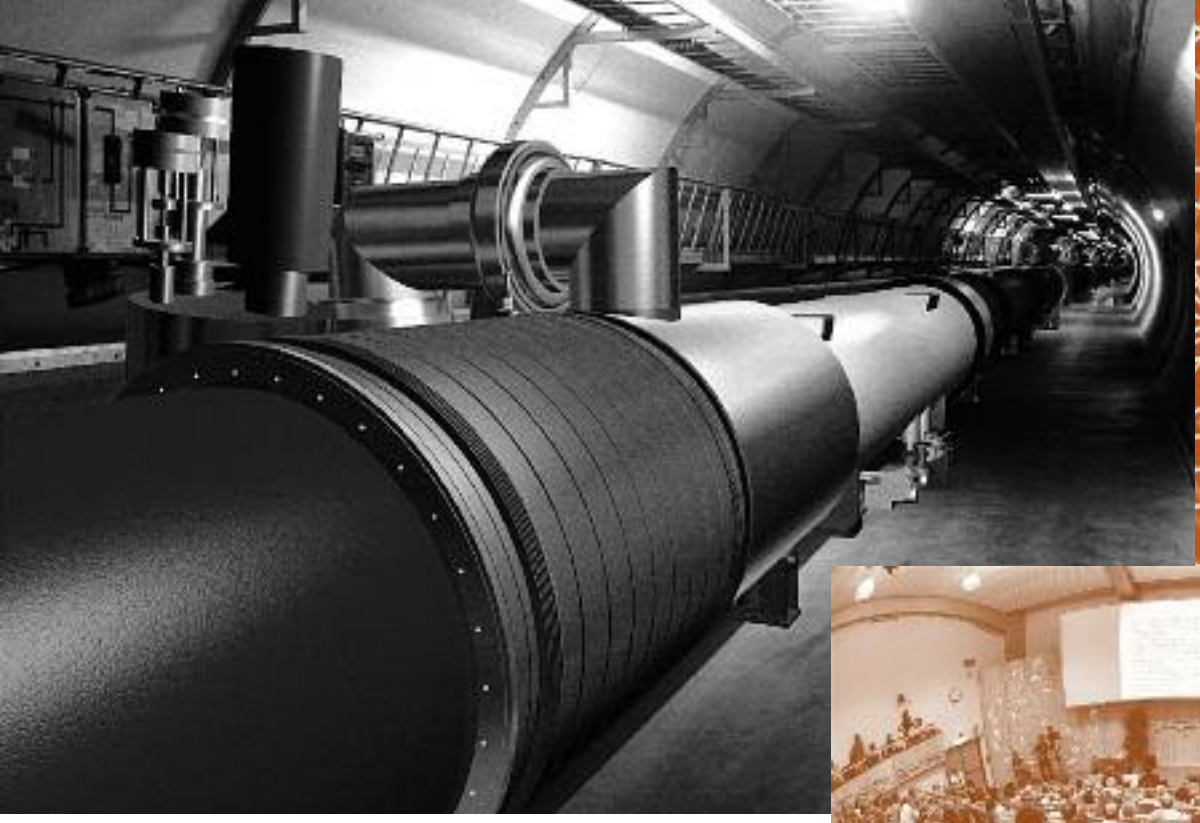


The announcement of the discovery of a new elementary particle with the properties of the long searched-for Higgs boson on 4 July 2012 at the European Organization for Nuclear Research (CERN), was one of the most important announcements to be made in physics in the past decades. The great excitement in the community of experimental and theoretical high-energy physicists is not easy to explain to non-experts.

Important steps towards this discovery were made by the founder of ICTP and TWAS, Abdus Salam. In fact, Salam, Sheldon Glashow and Steven Weinberg were awarded the 1979 Nobel Prize in Physics "for their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including, *inter alia*, the prediction of the weak neutral current."

Although Salam and Weinberg anticipated the existence of this particle, it is named after the British professor Peter Higgs, who first identified this general class of particles. Higgs and a handful of other theoretical physicists discovered the general mechanism for which the Higgs bosons are responsible for endowing other particles with mass. The particle just discovered seems to be the particular Higgs boson predicted by Salam and Weinberg, using the general mechanism of Higgs and others, in their model describing the electromagnetic and weak interactions.

There are very few elementary particles that compose all matter we know. These include electrons and quarks (components of all atoms) which have a prop-



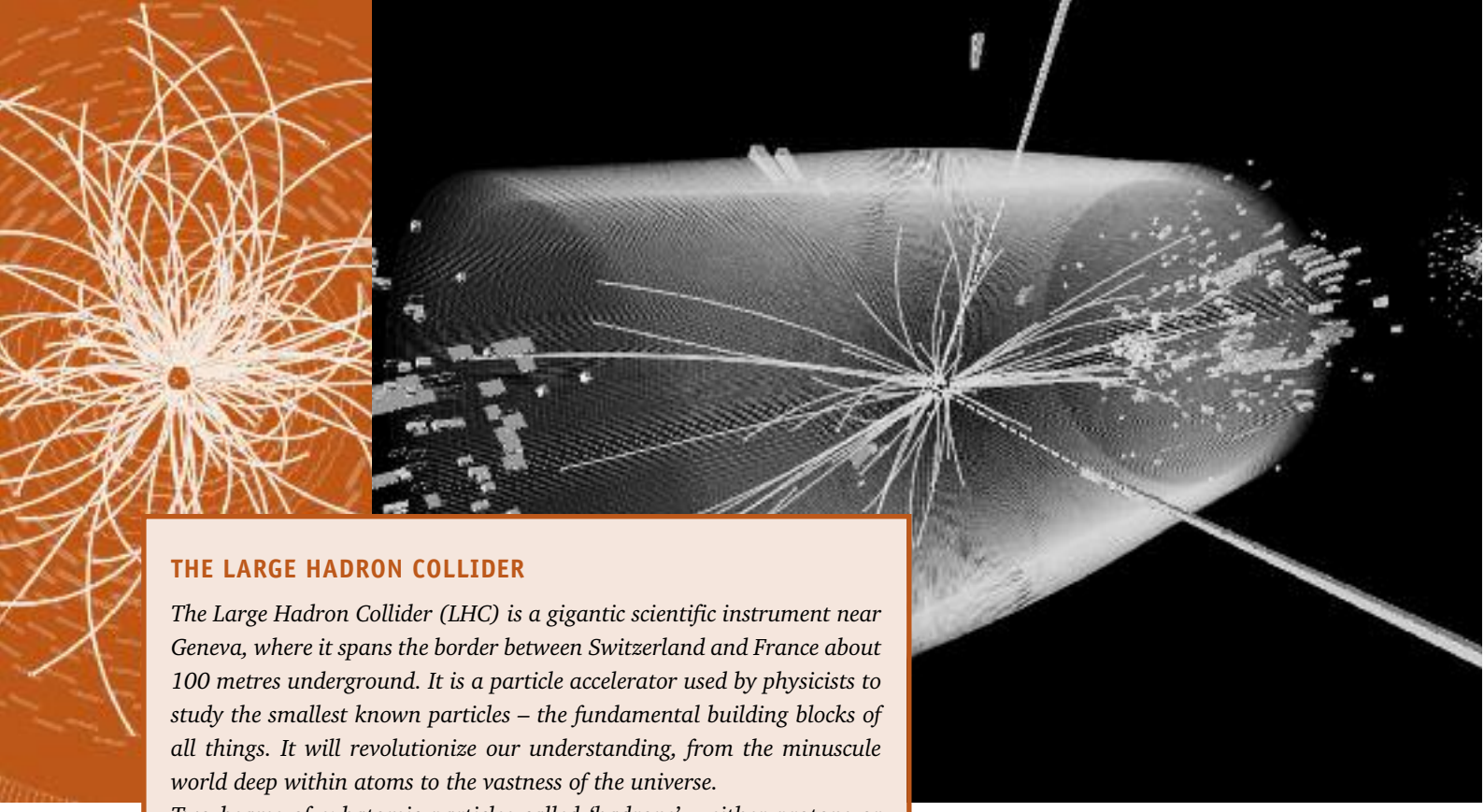
erty known as 'spin' which is exactly one half in appropriate units. Particles with such half integer spin are called 'fermions' (in honour of the great Italian physicist Enrico Fermi). Fermions behave in a particular way: any two of these particles cannot be in the same physical state, which explains the complicated structure of the periodic table of the elements.

But there is another class of particles called 'bosons' that have integer spin. Bosons were named after the great self-taught Indian mathematical-physicist Satyendra Nath Bose, who, together with Albert Einstein, described the behaviour of these particles. Indeed, this illustrates the fundamental contributions to physics made by scientists from developing countries – including Salam, from Pakistan, and Bose from India.

There are a few elementary bosons known that have spin equal to one. The best known is the particle of light, or photon. Bosons behave completely differently to fermions. Unlike fermions, many bosons can exist together in the same physical state: an example of this is the intensity of laser beams.

The simplest elementary bosons to describe mathematically are those that have no spin (or spin 0). But, until the announcement on July 4, that was just theory: no such bosons were known before. The Higgs boson would be the first elementary spin 0 boson to be discovered in the laboratory. It also has a uniquely important role in our understanding of nature, since its existence implies that nature has more underlying symmetries than can be observed. The field associated with a particle of spin 0, contrary to any other field, can take a non-vanishing average value that somehow hides the underlying symmetry. This value defines a scale in nature that, for the case of the Higgs boson, corresponds to the scale that determines the mass of *all* particles in nature. That is, if it is confirmed that this new particle is the Higgs boson, we can now claim that physicists finally understand the mechanism that gives a mass to all elementary particles.

The discovery of a Higgs boson-like particle is a major triumph in uncovering the basic laws of nature.



THE LARGE HADRON COLLIDER

The Large Hadron Collider (LHC) is a gigantic scientific instrument near Geneva, where it spans the border between Switzerland and France about 100 metres underground. It is a particle accelerator used by physicists to study the smallest known particles – the fundamental building blocks of all things. It will revolutionize our understanding, from the minuscule world deep within atoms to the vastness of the universe.

Two beams of subatomic particles called 'hadrons' – either protons or lead ions – travel in opposite directions inside the circular accelerator, gaining energy with every lap. Physicists use the LHC to recreate the conditions just after the Big Bang, by colliding the two beams head-on at very high energy. Teams of physicists from around the world then analyse the particles created in the collisions using special detectors in a number of experiments dedicated to the LHC.

There are many theories as to what will result from these collisions. For decades, the standard model of particle physics has served physicists well as a means of understanding the fundamental laws of nature, but it does not tell the whole story. Only experimental data using the high energies reached by the LHC can push knowledge forward, challenging those who seek confirmation of established knowledge, and those who dare to dream beyond the paradigm.

The above description is taken from the CERN website, with permission: http://public.web.cern.ch/public/en/lhc/lhc-en.html

The Higgs particle was the only missing particle needed to confirm the Glashow-Salam-Weinberg model of electromagnetic and weak interactions, one of the two cornerstones of the standard model of elementary particles. Its discovery marks a turning point between established physical knowledge and new physics. All new particles to be discovered from now on will indicate the existence of new physical principles.

I attended the seminar at CERN on 4 July, and the announcement was also broadcast live at ICTP. It was a once-in-a-lifetime privilege to be physically present and to share the excitement with the hundreds of other scientists who have been closely following the experiments at CERN. The discovery is, indeed, exciting for all of humanity. It represents the product of efforts by researchers, engineers and technicians from all continents working together for a common cause. It is also significant because it unites theory with experimentation.

The discovery of a Higgs boson-like particle is a major triumph in uncovering the basic laws of nature which, although it may not lead to direct short-term applications, increases our understanding of nature and the early universe. It highlights the pure value of scientific research and the great excitement in the community illustrates that this is the real reason most physicists dedicate their life to this noble endeavour. Let us hope this is only the beginning of a new era of discoveries led by the Large Hadron Collider experiments at CERN. ■

FROM GHANA TO BRAZIL TO RWANDA

TWAS HAS BEEN PROMOTING SOUTH-SOUTH COLLABORATION IN SCIENCE SINCE ITS INCEPTION IN 1983. FELIX KORBLA AKORLI, FROM GHANA, WAS AMONG THE FIRST AWARDEES OF A SOUTH-SOUTH FELLOWSHIP. IN 1995, HE TRAVELLED FROM GHANA TO RIO DE JANEIRO, BRAZIL, TO STUDY RADIO PROPAGATION. WHAT IMPACT HAS THE FELLLOWSHIP HAD ON HIS SUBSEQUENT CAREER?

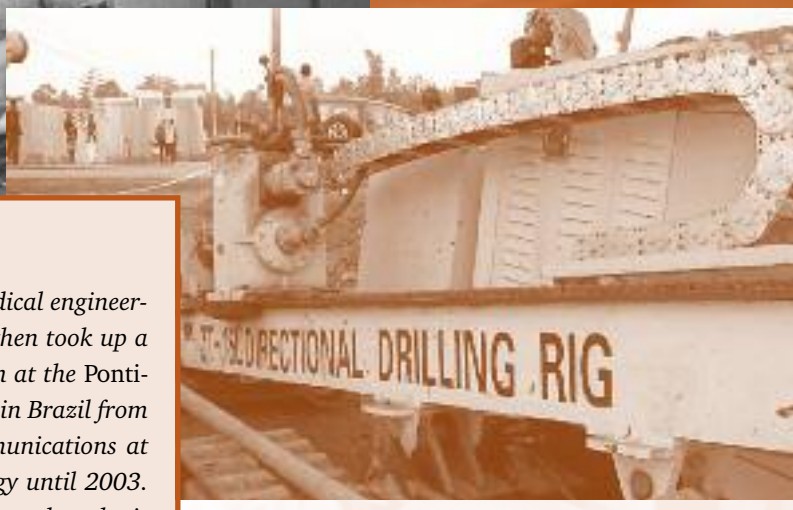
Felix Korbla Akorli, who is now coordinator of the Master's programme in information and communication technology (ICT) at the National University of Rwanda in Butare, was an early recipient of an award under the fledgeling TWAS South-South fellowship programme.

The programme has now become well established with 14 partners in nine countries, but at the time Akorli received the award in 1995, the programme was still in its early years.

Akorli was sponsored by the Brazilian National Council for Scientific and Technological Development (CNPq), which has since become one of TWAS's established programme partners.

Akorli's fellowship was for a full four-year PhD programme to study radio propagation at the *Pontifícia Universidade Católica do Rio de Janeiro* (PUC-Rio) in Brazil. "I was the only African doing a PhD at PUC at that time," he says proudly. "I had various options but, for me, Brazil was the obvious choice, because it is on the equator and so I could do research on radio propagation related to the tropical environment. I wanted to do research that I could apply back home."

Radio propagation describes the behaviour of radio waves when they are transmitted from one point on the Earth to another, or into various parts of the atmosphere. Telecommunications systems in general



ABOUT AKORLI

Felix Korbla Akorli was born in Ghana, did an MSc in medical engineering at the Technical University of Sofia in Bulgaria, and then took up a TWAS South-South Fellowship to study radio propagation at the Pontifícia Universidade Católica do Rio de Janeiro *(PUC-Rio) in Brazil from 1995 to 1999. He returned to Ghana to teach telecommunications at the Kwame Nkrumah University of Science and Technology until 2003. He was then invited to the National University of Rwanda, where he is currently coordinator of the MSc in information and communication technologies (ICT) programme.*

(including broadcast frequencies, mobile phone systems, radio navigation and radar systems) depend on radio propagation which itself is affected by such factors as the amount of water vapour in the troposphere and by ionization in the upper atmosphere caused by solar radiation.

Akorli was interested in studying how the tropical conditions of his native Ghana might affect radio propagation. This, in turn, would enable him to carry out further research in order to improve telecommunications in Ghana by designing reliable mobile telephone systems.

"Many countries in the developed world have already done research which has defined the parameters they use when designing telecommunications equipment. A lot of work has been done in Brazil for the tropical areas, for example, and by India and China because they extend into the equatorial region. But this research had not been done in Africa", explains Akorli.

"In Africa, we can only use extrapolated data from the International Telecommunications Union (ITU) and as a result our networks don't function as well as expected because they are based on data that is not entirely relevant."

FROM GHANA TO RWANDA

After completing his PhD, Akorli returned to his native Ghana to continue to research and to teach telecommunications at the Kwame Nkrumah University of Science and Technology (KNUST). Then, in 2003, he was released from his teaching position and sent to the National University of Rwanda (NUR) to support graduate students there.

"During the post-war, post-genocide period, my university in Ghana (KNUST) and the National University of Rwanda (NUR) signed a memorandum of understanding," he explains.

"In fact, Rwanda is a very young country. Everything had to start again after 1994. Policies were put in place that have been followed to the letter. In higher education everything is being done systematically. It is because of the education policy – that was in fact put in place by, among others, Romain Murenzi, who is now the executive director of TWAS – that they introduced the Master's programme in ICT at the National University of Rwanda. And apart from that, the policy of the government is to build on ICT so they have pushed the subject very hard."

The opportunities to develop ICT in Rwanda are very exciting.

In fact, the Rwandan government, under the leadership of President Paul Kagame, initiated a series of four five-year National Information and Communication Technology (ICT) Plans. The first plan, from 2001 to 2005, created policies intended to develop the framework and regulations for ICT. The second, from 2006 to 2010, focused on infrastructure, including laying fibre-optic cables throughout Rwanda. The third and current plan, which runs from 2011 to 2015, is focused on providing services that make use of the new technology.

Akorli was particularly involved in the first phase. "I was invited to NUR two or three times in 2002. They were starting up a Master's programme in ICT. From 2003, I was asked to stay on teaching and coordinating the programme – and that's where I've been for the last nine years."

Akorli explains that, while there is a great need for science capacity building in his native Ghana too, the opportunities to develop ICT in Rwanda are very exciting and there is a need for continuity to really establish a strong programme. "Some of my students who did the Master's programme will soon be completing their PhDs – and that's when I can go back to Ghana – when the programme is really established."

Akorli admits that there were challenges in setting up such a programme. "This was the first Master's programme in ICT in Rwanda. The students were pioneers. Of course they hesitated and wondered if they should go to the United States or India like their predecessors." When asked how he persuaded them to stay, Akorli is very clear. "Persuasion doesn't work. What you need is actual evidence that the programme is competitive. When the students started graduating and getting good positions in universities and businesses, that was the best form of persuasion. They have been selected for good positions among many high quality applicants. Mostly they have gone on to take up positions in Rwanda – so they are contributing very effectively to the economy."

Given the success of the programme, Akorli is clearly delighted to announce the next phase: "Now we are reviewing our content and syllabus and we are going to introduce an in-house PhD programme."

MOBILE PHONE TECHNOLOGY FOR AFRICA

Akorli is clear that the future of technology in Africa is in mobile phone technology. "I remember that the

companies that first came thought it would not be easy to sell mobile phones. But they were overwhelmed by demand, they were saturated – they had a lot of subscribers! The only problem we have is that most of the content and the applications are European. So the challenge for us is to develop content that is appropriate to our environment – and that people can understand."

The problem is not just that surfing the web on such a small screen is difficult – or that trying to key in information using only a phone 'keyboard' is fiddly and time-consuming. Texting and reading information from a screen require a level of literacy that many people in Africa don't have.

"Most people who use mobile phones in Africa communicate through voice. So we are trying to develop a platform especially for people in rural areas who don't have access to computers, where they can get the information they need just by using their voice or pushing a button.

"Villagers in Africa have a very strong memory – it's an oral culture. They have always had to store information in their heads and so they are good at it."

In 2009, Akorli was awarded an 'IBM X10 Innovation Faculty Award' worth USD20,000 to design, test and develop spoken-web applications, also known as the World Wide Telecom Web (wwtw). The spoken-web provides information and services through a voice driven channel over an ordinary phone call. The information that is available can be developed specially to suit different communities. "So some of my Master's students are developing a platform for that," says Akorli.

While the usefulness of such applications is clear, it is still difficult to imagine that mobile phones used in this way will ever be as effective as using a computer.

Almost every household in Rwanda has at least one mobile phone.

But Akorli believes that in time they could be. What is required, in fact, is a complete re-think of how information is supplied and retrieved on the web. Indeed, perhaps 'web' will no longer be an adequate word to describe this information retrieval process.

There are many immediate applications that Akorli and his department at NUR and other researchers in Rwanda are developing. "For example, farmers don't have access to information on how they could improve their produce but all this information is already on the net", explains Akorli. "Instead, if they have a problem with their tomato crop, for example, they need to find someone who can give them advice, and it can take time for the right person to visit, or to exchange information. But soon they will be able to use their phones to get the information they need about tomatoes – they can listen to it. Or, if they want to know the current market price

for their tomatoes, they can speak into their phones and listen to the answer."

Akorli's students are also developing a platform which can be used by doctors and nurses. "We have doctors who are based in district hospitals and then nurses who take care of healthcare in remote areas. So it can be a while before you get a visit from a doctor. But if there is an emergency in a village, say, at the push of a button someone can call the doctor in the operating theatre, for example, and they can leave a message. The system is set up for the doctor to call back as soon as possible, and to visit if necessary."

According to the Rwanda Utilities Regulatory Agency (RURA), one in every four Rwandans had a mobile phone in 2010, but the number of mobile phone owners is forecast to triple by 2015. Akorli claims that, in practice, mobile phones are already highly accessible. "Almost every household has at least one mobile phone. In the community, people can always find a phone to use."

Unlike the quite prohibitive costs of mobile phone contracts and call charges in Europe, using a mobile phone is relatively inexpensive in Rwanda, mainly thanks to using Voice over Internet Protocol (VoIP). As Akorli explains: "The telecom infrastructure is already there and we just use the internet to transmit the voice. Although there can be technical problems with this (sometimes there are delays, for example, or interference), it is much less expensive – and often free."

SOUTH-SOUTH BENEFITS

So would Akorli encourage students from developing countries to apply to the TWAS South-South fellowship programmes?

"The level of teaching at PUC in Rio de Janeiro when I attended in 1995 was as high and the facilities were as good as many institutes in the North I have visited since then. Most of the professors there were trained in the United States", he says.

"Apart from that," adds Akorli, "there are actually advantages of going South-South – you're looking at similar problems that you can then apply to your situation. Then you can make a difference. And there is less of a culture shock too.

"In fact, apart from the TWAS fellowship programmes, I should encourage some of my colleagues to consider applying to other exchange programmes offered by TWAS so they can top up their knowledge and expertise and return home stronger." ■

SMALL SCIENCE, BIG IMPACT

JAYASHREE RAMADAS, DIRECTOR OF THE HOMI BHABHA CENTRE FOR SCIENCE EDUCATION IN MUMBAI, INDIA, WAS THE RECIPIENT OF A 2011 TWAS REGIONAL PRIZE FOR HER PIONEERING WORK IN SCIENCE EDUCATION, AND ESPECIALLY FOR HER SERIES OF TEXT BOOKS, 'SMALL SCIENCE', DESIGNED FOR PRIMARY-AGE SCHOOL CHILDREN.

Jayashree Ramadas, winner of the 2011 TWAS-ROCASA Regional Prize for the development of scientific educational material, has authored and co-authored a series of innovative text books for primary schools. 'Small Science' covers the whole of the primary school science curriculum from class 1 (ages 5 to 6) to class 5 (ages 9 to 10). The curriculum is being carried forward into the middle school by one of the 'Small Science' authors at the Homi Bhabha Centre for Science Education (HBCSE) in Mumbai, India, where Ramadas is now director.

Ramadas estimates that so far the curriculum has reached over ten thousand students throughout India. Users of the books range from elite urban schools to schools for tribal communities and migrant workers, and from conventional mainstream to progressive alternative schools around the country. Their success can be gauged by the fact that the Indian National Curriculum Framework 2005 gave prominent place to the ideas suggested by the 'Small Science' curriculum, and that other Indian states have adapted and incorporated portions of the books into their own textbooks.

Coordinator of TWAS-ROCASA and member of the TWAS Regional Prize selection committee, V. Krishnan (TWAS Fellow 1996), reported that the committee "was particularly impressed with Ramadas' long-term commitment to science education, and the real impact her work has made on improving the ability of small children to understand fundamental concepts in science. The text books she has authored are especially relevant to the Indian context, with real-world examples the children can relate to."

The 'Small Science' books build on the solid foundations of research undertaken for over 36 years by

TWAS REGIONAL PRIZES

TWAS's Regional Offices play a key role in nominating and selecting candidates for TWAS's wide variety of activities, including prizes. They also administer a number of programmes themselves. One of these is the TWAS Regional Prize. Since 2007, each of the Academy's five Regional Offices (in Brazil, China, Egypt, India and Kenya) has awarded one prize each year, worth USD3,000. The prizes rotate among the following three areas:

(i) the popularization of science

(ii) the development of scientific educational material, and

(iii) building scientific institutions.

The prizes came about as a suggestion to the TWAS Council to highlight and honour the work of people in these important areas of building scientific capacity.

The selection process for these awards involves an open call for nominations, review by an expert committee composed mostly of TWAS Fellows, and then a second review of shortlisted candidates' achievements by all TWAS Fellows in the region.The prize winners are awarded their certificates and cheques at TWAS regional meetings or other major regional scientific events.

Ramadas on science education in general, and on the collective research and field studies on the science curriculum undertaken by her colleagues at the HBCSE. The centre is well known and esteemed in India, and indeed, though she became director of the centre only last year, Ramadas began her career in science education as a PhD student at HBCSE, evaluating the impact that changes in the science curriculum had on standards of teaching in the area.

The 'Small Science' books are the result of these many years of rigorous research and pilot studies, and are based on a philosophy of child-centred inquiry, aimed at encouraging and responding to the kinds of questions and curiosities children naturally have about the world around them.

"But," says Ramadas, "children can ask questions in a very naive way. The tools we give them are derived from the processes of science observation, tabulation, argumentation and analysis. The children are encouraged to draw connections. So we begin with concrete experiences and observations and then give them ways of enriching their experiences and finding patterns in these experiences." These tools, in fact, are the basis of a sound 'scientific method' and are far more useful to them in becoming scientists, Ramadas contends, than the rote answers to rehearsed questions common to many kinds of educational text books.

The topics covered begin with everyday experiences and immediate surroundings in the earlier years, moving gradually outwards: classes 1 and 2 focus on environmental studies; classes 3 to 5 are primarily concerned with science in general, though keeping in view social and cultural perspectives; while classes 4 and 5 make increasing use of measurement concepts.

Ramadas also co-authored the 'Teacher's Book' for classes 1 and 2 and explained why no text or workbooks were provided: "The cognitive skills of young children at this age (5-6 and 7-8 years old) are in advance of their literacy skills. If you limit them to understanding text books and workbooks you are in essence 'dumbing down' their skills and abilities. Much of the work we do in the classroom at this level is based on speaking and drawing, so they can express themselves and explore their thoughts and ideas without being restricted by reading and writing skills." The 'Teacher's Book' is a compilation of activities, games and ideas grouped around different themes directly relevant to the world the children have experience of (including 'my family', 'my body', 'plants and animals', 'food', 'people and places', 'time', 'things around us'). The aim of the unit on 'my body', for example, is "to get to know one's body while learning names of the parts of the body."

The cognitive skills of young children are in advance of their literacy skills.

The suggested questions and activities are:

- How many different actions can you do with your body while remaining in one place? Do them.
- Show how many different actions you can do with your body if you are allowed to move from one place to another.

Children go on to clap, to repeat rhythms and to learn songs, to create stick figures with pencils and attach labels to different parts of the figure. They discuss how to keep neat and clean, and they are asked questions about how they grow:

- Do your clothes fit you now? What do you do with your old clothes? Bring to class some of your old clothes which are now too small for you.
- Are there things you can do or any places you can reach, which you could not do when you were younger?

Drawings are central to all the books, and Ramadas explains that the content of the books evolved together with the specific artist she was working with at the

2011 TWAS REGIONAL PRIZE FOR THE 'DEVELOPMENT OF SCIENTIFIC EDUCATIONAL MATERIAL'

The 2011 prize was given in recognition of significant and innovative contributions to scientific educational material, especially the development of "creative programmes aimed at stimulating science education in school children" that have helped to advance the quality of science education in the region.

The 2011 winners were:

- *TWAS-ROESEAP (Regional Office for East and South-East Asia and the Pacific):*
  Liu Changming, China. *Liu has served as a national education inspector for the Ministry of Education, and as a coach at the Physics Olympiad School, in the Xicheng district of Beijing. Many of the students he has taught have won gold medals in international Physics Olympiad competitions.*
- *TWAS-ARO (Arab Regional Office):*
  Nadia Al Wardy, Sultanate of Oman. *Al Wardy was instrumental in setting up a medical education unit at the College of Medicine and Health Sciences, at Sultan Qaboos University, putting the College on a par with international and regional medical schools.*
- *TWAS-ROSSA (Regional Office for Sub-Saharan Africa):*
  Peet van Schalkwyk, South Africa*. Van Schalkwyk helped to establish the first science centre in South Africa at the University of Pretoria, and the Science Garden at North-West University, both of which have served as models for later science centres in South Africa.*
- *TWAS-ROLAC (Regional Office for Latin America and the Caribbean):*
  Patricio Felmer, Chile*. Felmer has made significant contributions to the formative training of school mathematics teachers and has been the director of a government initiative to define national standards in mathematics teaching.*
- *TWAS-ROCASA (Regional Office for Central and South Asia):*
  Jayashree Ramadas, India*. Ramadas has developed a series of innovative science text books for primary school children in India.*

time. "The designer of the class 1 book was a student. She developed it as a project, then she moved on. Then I was contacted by another designer, who was a teacher-educator who loved the books, and she, in turn, had a big influence on the design and content of the next books. So, in some ways, the books are developed in tandem with whichever artist I'm working with."

Ramadas clearly has a non-competitive temperament, speaking with delight of another researcher who contacted her, developed the class 5 books and is now preparing the series of books for middle schools. Ramadas is grateful and enthusiastic: "I have other projects to be getting on with, and the books have evolved with the right people at the right time." This is in line with her philosophy that teachers and authors are not, in fact, authorities. In other words, they should not dictate or instruct in a pre-conceived way. Rather, they, like their students, need to be responsive. For this reason, the 'Teacher's Book' is not an instruction manual, but a reader-friendly guide to possible approaches, including tips and suggestions, and full of personal accounts written by other teachers who tested out the materials. "Teachers are in a learning process themselves", stresses Ramadas.

A VIEW FROM THE CLASSROOM

'Teach for India' is a nationwide movement which recruits outstanding college graduates and young professionals to teach full time in low income schools for two years, with the aim that they will go on to advocate edcuational equality in their subsequent careers. Gunvant Jain, a 2010 'Teach For India' Fellow, used the 'Small Science' textbooks at the Shantabai Ladkat English Medium School, in Pune, India.

My classroom experience started with a conversation in Jayashree Ramadas's office when she encouraged me to try the 'Small Science' curriculum in my classroom. Thoroughly convinced, I managed to raise funds to provide the books for each of the 65 children in my grade 4 classroom.

The children just loved the books so much that for the first few weeks throughout the school these books were in their hands, irrespective of whatever was being taught. The pictures, experiments and activities just touched them.

During the year, the kids never felt that it was a 'subject', they in fact loved doing these activities and experiments at home. The curriculum empowered them to feel that every observation or curiosity has an answer and it is perfectly fine to have questions and ask them.

The children began to ask questions that ranged from the process of evolution to black holes to simple water falling in a bucket at different rates making different shapes of liquid inside it. Moreover, having workbooks allowed them to write their views and observations; suddenly there was nothing wrong or right – it was just their observations that mattered. This made them feel that it is acceptable to be wrong and make mistakes because you learn from them.

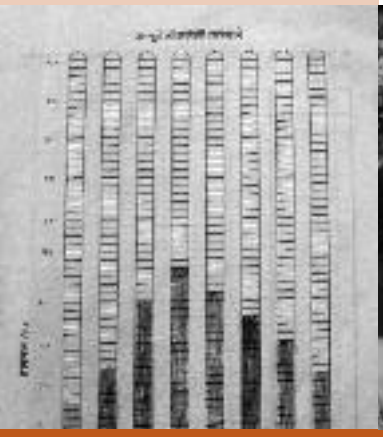
This year witnessed remarkable growth in every single child, in many aspects – including confidence, experimentation capabilities, observational skills, scientific temper, self reliance and cooperation, team building, sharing, criticizing, and a few of the children have even shown signs of hypothesizing.

This is an edited version of the description to be found on the 'View from the Classroom' pages of the 'Small Science' website at: http://tinyurl.com/bslsrht.

Classes 3 and 4 each have a teacher's book, text book and work book, and Ramadas is the sole author of them all. At this stage, language and expression take on increasing importance as key components in developing scientific skills and accurately communicating scientific observations and results: "Language is a tool that will help the students to conceptualize, to understand, and to express their thoughts. Throughout the curriculum, students apply their verbal and quantitative skills for more effective observations and inference. They also learn to communicate science knowledge."

There is attention to the sound and meaning of words, and to the development of narratives. Stories and poems figure in each chapter: "It bubbles, it blows / It creeps and it flows / It whistles, it sings / Lifts birds on their wings."

In the Indian context, this curricular approach aims to combine the strengths of the non-literate tradition (consisting of rich observations of the natural world),



and the literate culture (which contributes systematic analysis and articulation.) Students are encouraged to recount their experiences, ask questions and to engage in critical thinking, and to argue and debate. Students might be asked, for example, to both talk and write about the air they breathe every day.

"Is it clean or dirty? Why do you think so? What things make your air either dirty or clean? What can you do to get clean air?"

The curriculum is being produced in English, Hindi, Urdu and Marathi (Marathi is the official language of Maharashtra and is the 14th most-spoken language in the world). The content of the chapters, too, makes ample references to Indian reality. "In India, the monsoon season makes a big difference – everything changes after the rains", explains Ramadas. "After just one week of rain there is a large increase in the number of living things. So in the chapter on 'living things' we ask the students to observe and think about this phenomenon."

Students are encouraged to ask questions and engage in critical thinking, to argue and debate.

Summer and rains

- Choose a small patch of land near your home or school. Count how many different kinds of plants and animals you see there during the summer season. How many of these plants are trees?
- Look again after the rainy season has started. The old plants now look greener. But you also see many more, and many different kinds of small, baby plants. As the days go by they grow bigger.

You also see new animals. Look for frogs, earthworms, and different kinds of insects, like caterpillars, butterflies, beetles and flies.

Count how many different kinds of plants and animals you see in the rainy season.

Think! Think!

Where did all these new plants and animals come from? Where were they hiding in the summer?

Remember this…

We see many different kinds of living things around us. All these living things are either plants or animals. Plants stay fixed on the ground; animals move around. When it rains, we see new plants, and new animals.

Drawing and design are still seen as key to the later stages of the curriculum, as Ramadas explains in the 'Teacher's Book':

"For too many years, design and engineering have been a weak point in Indian education. Students must start to use skills of drawing and constructing spontaneously in learning concepts. They should develop an attitude of 'let's do it and see!' Learning comes out of a willingness to experiment, visual-spatial ability to design a situation, and manual dexterity to carry out

one's plans. The curriculum offers many opportunities for students to construct with their hands, to put down their observations in drawing, and to develop simple concepts of design."

Another feature of the 'Small Science' curriculum is that students are not assessed on the knowledge they have gained, but rather on the basic skills they have acquired, their ability to "learn how to learn". These skills include: observation; design, drawing and construction skills; measurement and quantitative thinking; and language development through science.

Ramadas also places great importance on a sensitivity to gender, culture and class. "Gender is a big issue – there is a lot of gender bias in educational text books. Boys are always shown in active roles, and the girl is usually watching."

Students are not assessed on the knowledge they have gained, but rather on the basic skills they have acquired.

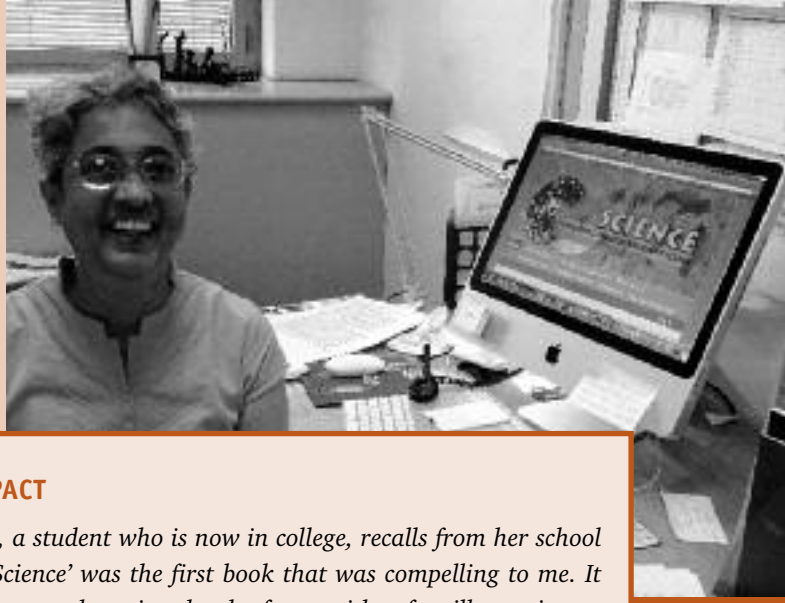
For this reason, many of the chapters include a story (invented by Ramadas) structured around a girl (Mini) and a boy (Apu), who appear throughout the books. The girl is active, coming up with questions and answers, and both of them take the initiative and do things." Such seemingly minor interventions into cultural mores can have a huge impact.

Ramadas also saw it as key that the books should be accessible to as many children as possible and so they have been designed in black and white so they can be printed at very low cost. In addition, extracts of the books are downloadable free of charge from the 'Small Science' website. The experiments, too, are very simple and the required materials are cheap and readily available.

LOCAL PUBLISHERS

'Small Science' has been published and distributed by Oxford University Press for the last five years, but HBCSE has recently signed a contract with a local Indian start-up company, InOpen Technologies, based at the Indian Institute of Technology (IIT) in Mumbai. Ramadas is very optimistic about this development, since it will ensure the publishers have a more hands-on approach to promoting the textbooks, and will allow the authors and practitioners to maintain contacts with the schools, receiving valuable feedback that they can then follow up on to help continually improve the series.

"By offering help and support to teachers, especially in the initial period of adoption, we hope that InOpen and HBCSE together will help to seed a community of practising teachers who interact and exchange ideas on academic issues. We hope that InOpen will document the implementation of 'Small Science' in schools and in that process create more support material for teachers. Over the last ten years some schools and teachers have been using 'Small Science' on their own initiative and enjoying the experience.



LASTING IMPACT

Ramya Mohan, a student who is now in college, recalls from her school days, "'Small Science' was the first book that was compelling to me. It didn't just have a to-the-point chunk of text with a few illustrations – instead, it had poetry, recipes, tips, amusing stories. All this was designed to engage and stir the curiosity of a child. It was a breath of fresh air. The books opened my eyes to a whole new way of learning – one I wish was implemented across all schools."

We hope that this group grows and flourishes with InOpen's help."

Ramadas is now particularly happy because a teacher who has successfully used the textbooks, Gunvant Jain, has recently joined InOpen. Ramadas is hopeful that, since Jain has had such a positive hands-on experience, he will be able to effectively and enthusiastically market the book to schools and teachers throughout India (see box, p. 34).

Rupesh Kumar Shah, founder and CEO of InOpen Technologies, shares Ramadas' optimism. "InOpen is currently in discussion with agencies to implement the use of 'Small Science' across schools in India", he confirms.

In fact, looking at the quality, thoughtfulness and immediate relevance of these beautifully presented books, it really would be a shame if they were not more widely adopted, not just throughout India, but as models of good practice in teaching science throughout the world. Let us hope that InOpen really do a good job promoting and distributing the books so that developing and developed countries alike can build on the solid but stimulating foundations Ramadas and her fellow educators at HBCSE have worked so hard to put down, and to supplement them with their own specific national, cultural and geographical examples. Ramadas' research, commitment and teachings go a very long way to ensuring there is an enquiring – and receptive – base of young minds on which to build science capacity in the South. ■

For more information on 'Small Science', visit: http://coglab.hbcse.tifr.res.in/

INTER-ACADEMY COOPERATION

BASED IN TRIESTE, ITALY, IAP – THE GLOBAL NETWORK OF SCIENCE ACADEMIES – UNITES ACADEMIES OF SCIENCE IN BOTH THE NORTH AND SOUTH, FOSTERING COLLABORATIVE PROGRAMMES AND DIALOGUE BETWEEN ACADEMIES, THE WIDER SCIENTIFIC COMMUNITY, POLICYMAKERS AND THE PUBLIC. HERE WE REVIEW SOME CURRENT IAP ACTIVITIES DESIGNED TO HAVE AN IMPACT ON THE WORLD'S 'GRAND CHALLENGES' FOR SUSTAINABLE DEVELOPMENT.

Rio+20, the recent United Nations Conference on Sustainable Development (20-22 June 2012), concluded with a statement entitled 'The Future We Want'.

The road to 'the future we want', however, is paved with so-called 'grand challenges': challenges relating to population, poverty, food, water, energy, disease, education and the environment.

Such challenges can be resolved through appropriately designed research, collaboration between scientists, and an integrated approach for transforming research into products and services – activities that are at the heart of the mission of IAP, the global network of science academies.

Indeed, the next IAP conference, to be hosted by the Brazilian Academy of Sciences (BAS) and scheduled for February 2013, will be held under the theme 'Grand Challenges and Integrated Innovations'. As well as marking IAP's 20th anniversary, the conference will build on the many activities conducted by IAP and its affiliated networks which address these challenges.

The term 'grand challenge' was first used by the German mathematician, David Hilbert (1862-1943). At the International Congress of Mathematicians in Paris in 1900, Hilbert produced a list of 23 unsolved mathematical problems. Although some of the challenges on Hilbert's list were solved in the ensuing years, others have still yet to be overcome.

Building on this concept, in 2003, the Bill & Melinda Gates Foundation identified 14 'Grand Challenges in Global Health' and, five years later, followed this

with a USD100 million initiative, 'Grand Challenges Explorations'.

The trend was now set, and some ten years later the international development community has developed a list of more than 50 'grand challenges', including those relating to chronic non-communicable diseases, development and engineering.

To suit this trend, a new definition was required. That devised by Grand Challenges Canada seems appropriate:

"A grand challenge is one or more specific critical barriers that, if removed, would help solve an important health problem in the developing world with a high likelihood of global impact through widespread implementation."

POPULATION AND CONSUMPTION

Two of the most critical challenges affecting human society today and increasingly so in the years ahead are population growth and unsustainable consumption.

To highlight this issue and emphasize its importance to decision-makers, on 14 June 2012 IAP released a statement on 'Population and Consumption'. The timing of the release of the statement was designed to coincide with the UN Rio+20 conference, as well as to mark the 18 years since the 1994 IAP Statement on 'Population Growth' and the 1994 UN International Conference on Population and Development.

Issued under the leadership of the Royal Society (UK), the new IAP Statement lists ten recommendations on which it urges international policy and decision-makers to act, including to:

- Ensure that population and consumption are considered

in all policies, including those related to poverty reduction and economic development, global governance, education, health, gender equality, biodiversity and the environment;

- Encourage modes of development that do not repeat mistakes made in the past by today's developed countries but which allow low-income countries to 'leap frog' to sustainable patterns of consumption; and
- Use existing knowledge more effectively and prioritize research in the natural and social sciences that will provide innovative solutions to the challenges of sustainability.

Speaking at the launch of the statement, IAP co-chairs Howard Alper and Mohamed Hassan said: "We are delighted that the world's science academies have chosen to come together to highlight two of the most profound challenges to humanity – population and consumption – and to call for urgent and coordinated international action to address them. For too long the dual issues of population and consumption have been left off the table due to political and ethical sensitivities. These are issues that affect us all, developed and developing nations alike, and we must take responsibility for them together." Alper and Hassan also encouraged policymakers meeting at the Rio+20 conference "to seize the initiative and choose to take the sound, evidence-based advice of their own academies of science as they make decisions that will affect the future of the planet."

Through IAP, academies from around the world, including countries as diverse as Bolivia, India, Japan, Latvia, New Zealand, Nicaragua, South Africa and the UK, have come together to call for action on population and consumption.

In the document, 'The Future We Want', adopted in

Rio, the heads of state and government, along with other high-level representatives and civil society organizations, renewed their commitment to and promotion of an environmentally sustainable future for our planet for present and future generations. IAP member academies are encouraged to disseminate the statement in the spirit of these commitments.

HEALTH CHALLENGES

Grand challenges in global health are addressed by the InterAcademy Medical Panel (IAMP).

Established in 2000, IAMP currently has 70 members, including medical academies and the medical sections of academies of science and engineering worldwide.

As well as its long involvement in issues relating to maternal and perinatal mortality, IAMP has been increasingly focusing on furthering our understanding of non-communicable diseases – a burden that is increasingly affecting people worldwide, as highlighted by the World Health Organization (WHO) and re-stressed in the Rio+20 'The Future We Want' report, which stated that better health is a "precondition for, an outcome of, and an indicator of sustainable development".

The distribution of non-communicable diseases has no correlation to economic status.

In this light, the IAMP Regional Workshop on Non-Communicable Diseases, hosted by the Brazilian Academy of Sciences and the Brazilian National Academy of Medicine and held in Rio de Janeiro, Brazil, on 3-5 May 2012, was an opportunity to share experiences concerning the prevention and control of cardiovascular diseases and cancer from an inter-American perspective. Expert participants were drawn exclusively from IAMP member academies in the Americas, including Argentina, Bolivia, Brazil, the Caribbean, Chile, Colombia, Cuba, Guatemala, Mexico, the USA and Venezuela.

Non-communicable diseases (NCDs) are a new frontier to be overcome in the fight to improve global health. Worldwide, such diseases are now responsible for more deaths than all other causes combined. Moreover, the distribution of NCDs has no correlation to the economic status of any country – North or South, rich or poor.

After two days of presentations and discussion, participants recommended that all countries should tackle NCDs as a top priority, and that a firm commitment to their prevention and control must be made by governments, the private sector, civil society, the United Nations and other international organizations.

IAMP is currently exploring opportunities to organize similar workshops in other regions to provide a global outlook, as also discussed in the IAMP meetings with representatives of the Chinese Academy of Medical Sciences (CAMS), Chinese Academy of Sciences (CAS) and the Chinese Academy of Engineering (CAE), and with Chen Zhu, China's Minister of Health and former IAP co-chair.

WATER CHALLENGES

The role of science academies in tackling water-related challenges in the developing world has also been addressed through the IAP Water Programme, including



the International Symposium on 'Enhancing Water Management Capacity in a Changing World', co-organized by the InterAmerican Network of Academies of Sciences (IANAS) and the Brazilian Academy of Sciences, held in São Paulo, Brazil, on 25-28 June 2012. The workshop brought together experts from 34 different countries (seven from Africa, 14 from the Americas, eight from Asia, and five from Europe) and representatives from various international water programmes, including the International Lake Environment Committee (ILEC), the International Hydrological Programme (IHP-UNESCO), the United Nations University Institute for Water, Environment & Health (UNU-INWEH), and the United Nations Environment Programme (UNEP).

The Association of Academies of Sciences in Asia (AASA) and the National Academy of Sciences of the Kyrgyz Republic (NAS KR) also held an IAP sponsored regional workshop on 'The Roles of Academies of Sciences in Water and Energy Problems in Central Asia and Ways for Their Solution', held on 30 June to 2 July 2011 in Bishkek, Kyrgyzstan.

The purpose of this regional workshop was to discuss and offer solutions to issues involving water resources and electrical power systems in Central Asia and to promote the social and economic development of the region. Responding to the question "*Why doesn't science have an effective impact on hydropower relations between Kyrgyzstan and neighbouring countries*?" were speakers from Armenia, Bangladesh, China, Georgia, Israel, Kazakhstan, Kyrgyzstan, Pakistan, Russia, South Korea, Tajikistan, Turkey and the USA. It was agreed that science should not be partisan but must impartially identify problems, understand the essence of these problems and propose solutions. Not only that, but science was seen as having a key role in providing solutions to the water and energy problems of the Central Asian region.

Science must impartially identify problems, understand their essence, and propose solutions.

These IAP and IAMP activities, and many others – supported financially by the Government of Italy and by in-kind contributions from academies of science worldwide – are always undertaken by adhering to the principles of research integrity. With this in mind, IAP is partnering with the InterAcademy Council (IAC) to develop the joint IAP/IAC 'Responsible Conduct in the Global Research Enterprise: A Policy Report'. IAP is also proud to foster a new generation of scientists addressing grand challenges and innovation, as highlighted by the 'Sandton Declaration on Sustainability' presented at the 2012 General Assembly of the Global Young Academy (GYA) held in Johannesburg, South Africa, on 20-24 May and submitted for inclusion in the Rio+20 deliberations. ■

For further information on IAP and IAMP activities, please see www.interacademies.net and www.iamp-online.org.

Lucilla Spini, IAP and IAMP coordinator
Joanna Lacey, IAP secretariat
Muthoni Kareithi, IAMP secretariat



PHYSICS, PRODUCTS AND PATENTS

IN APRIL THIS YEAR, TWAS CO-SPONSORED A FIVE-DAY 'WORKSHOP ON ENTREPRENEURSHIP FOR PHYSICISTS AND ENGINEERS FROM DEVELOPING COUNTRIES', ORGANIZED BY THE UK'S INSTITUTE OF PHYSICS AND HOSTED BY THE ABDUS SALAM INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS IN TRIESTE.

How does a research result become an idea for a new product or service? How can that idea actually be transformed into a product? And how can a research scientist take the first steps towards producing and marketing that product?

These were the issues discussed during a five-day 'Workshop on Entrepreneurship for Physicists and Engineers from Developing Countries' held in Trieste, Italy, on 23-27 April 2012.

During the workshop, a broad spectrum of topics were covered, ranging from the relationship between scientific research, inventions and products, to the concept of intellectual property and its significance in developing countries. More than 40 scientists from 20 developing countries attended and audience participation was guaranteed, since participants were required to work in small groups to produce a full business plan and to present their (imaginary-but-possible) products to a panel of judges.

Research scientists often have very little experience in business, and find it difficult to know how and where to start to translate their ideas and projects into marketable proposals. This is particularly true in developing countries, which have few training programmes or available resources in these areas. For this reason, TWAS was pleased to join the UK's Institute of Physics (IOP), the Abdus Salam International Centre for Theoretical Physics (ICTP) and the American Physics Society (APS) as sponsors of the workshop which gave engineers and physicists from developing countries valuable step-by-step advice on how to convert their good ideas into marketable products.

A PARTICIPANT'S PERSPECTIVE

David Cudjoe Adukpo, lecturer in physics at the University of Cape Coast in Ghana, attended the entrepreneurship workshop in Trieste. We asked him what gems of advice he would take back to his students.

How does research relate to entrepreneurship?

As researchers, we need to publish papers but often we don't look beyond that. Ideas, thoughts and creativity can also be marketing skills – getting our ideas across to stakeholders is always a problem. We need exposure to marketing techniques and to learn how to patent our research and our ideas. We are quite out of touch with the business world, actually.

What was the most important thing you got from the workshop?

The seminar by Beth Taylor, IOP's director of communications and external relations, on science communication was really helpful – the scenario she painted was quite intriguing. For me, the main question raised by her talk was about getting the message across: how do we communicate complicated research to the 'person in the street'? How do you go from the science lab, and make your research make sense, make it more relevant?

But Taylor also talked about the way we communicate our research to other scientists – why do we think our papers are rejected? She stressed that we need confidence. If you are not confident in your own ideas, you can't convince anyone. But you also have to be ready to listen, to understand what you need to say to convince them.

She also talked about making the decision – as a scientist – to become an entrepreneur and go into business. She made it clear that you must first and foremost be a good scientist, you need confidence to promote your research.

And she made another important point – even if we don't go into business, we still need to be 'business savvy', so we don't have to depend on others to make the right decisions for us. It's very important to have an understanding of business ethics, so we can protect ourselves. If a publisher comes round and offers to publish our work, we can ask "What about royalties?" Being informed also helps you to have a broader perspective.

Richard Brooks' business plan too was very helpful and can even be used as a model for planning in the lab, for example. I will certainly use his cash flow spreadsheet.

D. Cudjoe Adukpo

Did you make any good contacts during the workshop?

Just two weeks since the workshop has finished I have already exchanged emails with about 20 people from the workshop. An online forum is also operational – even today I read three messages already. One guy had this idea of developing a wrist-watch that could be used to detect malaria instead of having to collect blood samples to see if someone is infected. This watch would give you a malaria reading. We go back and forth with these ideas – we don't just validate something and say 'good idea', the forum allows us to discuss it, share our experiences and knowledge, and test out the idea among ourselves.

Any potential collaborations?

There is a woman participant from Cuba who is working in biomedical physics I would like to work with. We have an optics lab, and we could apply optics to the medical field – there are some interesting connections there.

The 40 physicists and engineers from 20 countries, including Algeria, Belarus, Cameroon, Indonesia, Nigeria, the Philippines and Togo, were selected from among 165 applicants to attend the workshop, which was the fourth edition to be held in Trieste since 2006.

"People think of physics as a basic discipline, made up of research and abstract calculations", commented Beth Taylor, director of Communications and External relations at IOP. "That is only true in part. Physics, in fact, lends itself very well to applications that can offer enor-

Physics lends itself very well to applications that benefit people and societies, especially in the developing world.

mous benefits to people and society, especially in the developing world. We like to call it 'Physics in Action'."

The five-day crash course in entrepreneurship not only looked at how to take science to market and work with industry, but also examined the timelines and processes necessary for turning an invention into a product.

"The workshop's programme was very ambitious, as we expected students to produce a full business plan by the end of the week", commented Joseph Niemela, head of ICTP's Applied Physics Group and local coordinator for the workshop.

To go about preparing this business plan, participants were divided into six groups, each assigned a tutor. "Choosing the tutors was a critical part of the whole workshop", confirmed Dipali Bhatt-Chauhan, international relations manager at IOP and co-organizer of the entrepreneurship programme. "We selected professionals with a sound background both in science and in business, to ensure that participants got the best advice from both sides."

Among the tutors were Surya Raghu, founder-president of Advanced Fluidics (USA) and also co-organizer of the workshop. Raghu holds a PhD in mechanical engineering from Yale University and has a strong background in aerospace, automotive and biotechnology applications. With 11 US patents already approved and another 10 pending, he was able to give the students invaluable feedback and suggestions.

Meanwhile, Richard Brooks, director of the London-based company FD Solutions, shared his long-standing experience in offering financial advice to small businesses. Likewise, Tony Bunn, director of the Innovative Centre of the South African Medical Research Council, offered his insights based on his involvement in five start-up companies.

The fifth – and last – day of the workshop was dedicated to ten-minute presentations of each group's product and business plan, to be judged by a panel made up of the six speakers and tutors who had been present throughout the five days. The panel had given very clear guidelines:

- What is your product or service, and why will it be commercially successful?
- What stage are you at, and how much cash will you need to get to the next stage?
- Who are your customers, and why will they buy your product or service?
- What return are you projecting for investors, and when?
- What is the market size and scalability for your product or service?

The standard of the participants' presentations was high, clearly demonstrating that the tutors and participants had worked together very effectively. Some of the presentations were utterly convincing (even though they were based on products that didn't actually exist yet). For example, Group B proposed a nanotechnology-based fire-resistant spray for wood that would be totally transparent, non-toxic and very economical to produce and buy. The spray would protect wooden houses from burning down, could be sprayed onto trees in vulnerable forest-fire regions, and also be

THE INSTITUTE OF PHYSICS: DEVELOPING ENTREPRENEURSHIP PROGRAMMES

Following an International Union for Pure and Applied Physics (IUPAP) conference on development in Durban in 2005, the UK-based Institute of Physics (IOP) was charged with taking the lead in one of the four priority areas identified by the conference – linking physics and economic development. To deliver on its commitment, IOP entered into a memorandum of understanding with ICTP to design, manage and deliver one workshop on entrepreneurship for physicists per year, located in alternate years in Trieste and in a developing country. TWAS, through its agreement to implement joint programmes with ICTP, joined the scheme in 2010.
Since the outset, IOP has developed and improved its programme, and has the resources and experienced staff to run at least two entrepreneurial workshops every year, promoting the role of physics and science in generating a knowledge-based economy for developing countries.

applied to antique furniture ("a very broad market", enthused the group-appointed CEO).

The winning invention, according to the panel, however, was a 'digital foetal stethoscope'. "Low-cost, accurate, easy-to-use, durable and patentable", said the group leader, convincingly. Usually reading a foetus's heartbeat accurately requires the presence of a trained expert who has to assess if the heartbeat is abnormal. If so, the mother is followed up at a clinic where she can receive preventive advice and the appropriate therapy to prevent a stillbirth. This small device, however, would allow even non-experts to check the heartbeat of a foetus and get an absolutely accurate reading. In the hands of midwives, for example, it could help save many lives, significantly reducing the high rates of infant mortality and childbirth-related deaths in developing countries.

The group's presenter was Chandana Gamage, senior lecturer in computer science and engineering at the University of Moratuwa in Sri Lanka. When asked if anything concrete might come out of his group's collaboration, he said, "Sure. The guys from Cuba and from Cameroon are working on the sensory aspects. I have the business experience. Richard Brookes, the tutor from FD Solutions, is interested. We're collaborators now. We're going to take this to market. Watch this space."

Since 2008, IOP has also organized the workshop directly in developing countries. So far, India (2008), Brazil (2009), South Africa (2009), Argentina (2010), Jordan (2011), the Philippines (2011) and Lebanon (2011) have hosted successful events.

TWAS is, in effect, the newest partner to come on board. Peter McGrath, TWAS programme officer, explained, "When we heard about the very successful workshop offered here in Trieste in 2010 we could see there was high demand among developing countries for such targeted advice – and when we saw first-hand how effective and well-delivered the workshop was, we wanted very much to be involved." TWAS went on to co-sponsor two editions of the workshop in 2011, in Jordan and in the Phillipines. In 2012, as well as the workshop in Trieste, TWAS is co-sponsoring a workshop on 'Entrepreneurship for Scientists and Engineers in East Africa' to be held in Addis Ababa, Ethiopia, on 5-9 November.


C. Gamage

"We are especially keen to be involved in this series of workshops," confirmed Romain Murenzi, TWAS executive director, "because this kind of transfer of knowledge from research to business is very much needed and will certainly contribute to building science capacity in the region." ■

For more information about IOP's entrepreneurship workshops, including the application process for organizers interested in hosting a workshop, see: http://www.iop.org/about/international/development/entrepreneurship

REVEALING SOILS

ECOLOGISTS AND GEOLOGISTS HAVE LONG KNOWN THAT THE SOIL CAN TELL STORIES: BY EXAMINING THE DIVERSITY AND RELATIVE ABUNDANCE OF ANIMALS, PLANTS AND MICROORGANISMS PRESENT IN EACH LAYER, THEY CAN DETERMINE THE IMPACT OF ENVIRONMENTAL CHANGES.

Under the TWAS Visiting Scientist programme, Stanislav Pen-Mouratov (senior researcher at the Soil Ecology Laboratory at Bar-Ilan University in Ramat Gan, Israel) visited the Institute of Geology and Geophysics, Academy of Sciences of Uzbekistan, in Tashkent, to examine the impact of pollution on soil ecosystems in Uzbekistan's Angren and Chadak industrial areas.

The city of Angren lies 115 kilometres east of Tashkent and is the centre of the Uzbekistan coal industry. It was created from mining settlements that grew up along a rich coal seam, providing the fuel for a string of industrial plants. Angren was a major industrial base during Soviet times but its importance has sharply declined since 1991, when, with the break-up of the Soviet Union, links between the different republics were disrupted and industrial production slumped. However, in April this year, Uzbek President Islam Karimov committed to creating a special industrial zone in Angren intended to create jobs and establish facilities to process mineral resources.

Soil microbiology and biogeochemistry investigations will play a very important role in assessing the ecological situation in this historically polluted post-Soviet area. Results from such studies will also be useful in developing new tools for bioindication and bioremediation of polluted sites, and in building the foundations for future ecologically benign industrial developments in this area of Uzbekistan.

Under the TWAS Visiting Scientist programme, Stanislav Pen-Mouratov travelled from Israel to work with scientists at the Institute of Geology and Geophysics (IGG) in Tashkent for two weeks in June 2011. His mission was to examine soil ecosystems in the Angren and Chadak industrial areas, working with his



long-term collaborator at the institute, Nosir Shukurov, senior scientist in the Laboratory of Geochemistry and Geotechnology at IGG.

These industrial areas are among the largest industrial complexes in Uzbekistan and include a metallurgical complex, a coal-fuelled power plant, and resin industries. Past studies have found that the soil in the surrounding area has been contaminated with high levels of lead, copper and zinc.

Collaborative work may well contribute to future policy decisions on minimizing the impact of industry on the environment.

Pen-Mouratov and Shukurov wanted to take a closer look at the soil around the industrial areas, to examine the effect of these heavy metals on biological activity, and in particular, on the the so-called soil free-living nematodes. Nematodes are microscopic non-segmented worms whose trophic structure, sex structure, and taxa composition are sensitive to changes in the soil quality. An incredible variety of nematodes function at several trophic levels of the soil food web. Destructive kinds feed on plants and algae, but those feeding on bacteria and fungi are known as soil free-living nematodes. These beneficial nematodes help control disease and cycle nutrients but are among the trophic groups most sensitive to disturbances in ecosystems, including the presence of heavy metals.

Pen-Mouratov and Shukurov's studies, which used

TWAS VISITING SCIENTIST PROGRAMME

The TWAS Visiting Scientist programme supports visits of internationally renowned scientists to institutions located in developing countries, especially those located in the Least Developed Countries (LDCs). The objective is to provide these institutions and research groups, especially those with limited outside contacts, with the opportunity to establish long-term links with world leaders in science and so help to build research capacity in their country.

Under the programme, prospective host institutions can invite internationally renowned experts to collaborate in research and training. The visiting scientist is expected to interact closely with the faculty and students of the host institution with the aim of strengthening the institution's existing activities and assisting in the establishment of new lines of research.

The initial visit has a minimum stay of two weeks at the host institution and further visits can be considered. While TWAS covers the cost of travel and a small honorarium, the host institution is expected to cover local expenses.

food consumption characteristics in order to understand the soil free-living nematode response to heavy metal pollution, indicate that plant parasites, followed by fungi-feeding nematodes, were the most dominant trophic groups at the pollution source, while, with distance, their dominance was replaced by bacteria-feeding and omnivore-predator nematodes.

To get these important measurements, the researchers and accompanying young scientists undertook field trips to the Angren and Chadak industrial areas to collect soil samples. Back in the laboratory, nematodes were extracted from the samples and observed under a new digital biological microsocope that Pen-Mouratov had helped to install and operate.

Pen-Mouratov also gave lectures for the local scientists and PhD students on soil free-living nemotodes as bioindicators of soil health, as well as outlining a methodology for developing skills in the quantitative and qualitative analysis of soil free-living nematodes.

Pen-Mouratov stresses that this visit was in fact a two-way exchange. The TWAS Visiting Scientist programme gave him "the opportunity to participate in scientific research under conditions of high industrial activity in a developing country. I also had the opportunity to share my own knowledge and experience with young Uzbekistan scientists. I am very much looking forward to future productive relations."

Shukurov agreed that "it was a very useful and productive visit. Stanislav Pen-Mouratov provided lectures which were immediately useful to my students' research investigations. We will certainly continue to collaborate."

Data and conclusions from their joint research on 'Soil biotic activity in coal-ash landfills of Central Asia' have been submitted to the international journal *Applied Soil Ecology* and their collaborative work may well contribute to future policy decisions on minimizing the impact of industry on the environment.

Indeed, it is amazing what tiny living creatures can reveal about the impact of our choices on the earth beneath our feet, and indeed, in consequence, their impact on the Earth itself. ■

QUEEN'S AWARD FOR VIJH

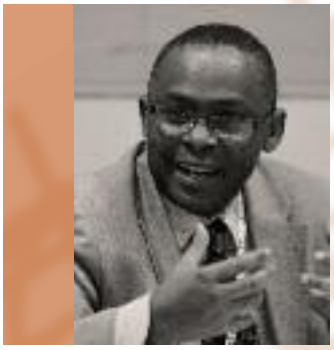
• **Ashok Vijh** (TWAS Associate Fellow 1987) has been awarded the Queen's Diamond Jubilee Medal for Canada. The commemorative medal, created to mark the celebrations of the 60th anniversary of Her Majesty Queen Elizabeth II's accession to the British throne, was awarded by His Excellency the Right Honourable David Johnston, Governor General of Canada, to 60,000 deserving Canadians. Vijh, who is *maître de recherche* at the Hydro Quebec Institute of Research (HQIR), is recognized for his outstanding contributions in the field of electrochemistry, his efforts towards the establishment of HQIR as a dynamic research organization, as well as his support for the promotion of fundamental scientific research in Canada.

Ashok Vijh

AAS NEW FELLOWS

Out of four new fellows elected to the **African Academy of Sciences (AAS)** in 2012, two were TWAS Fellows.

• **Romain Murenzi** (TWAS Fellow 2005), a physicist whose research has focused on applications of multidimensional continuous wavelet transforms to quantum mechanics, and image and video processing, was appointed minister of education, science, technology and scientific research for Rwanda in 2001. Murenzi



Romain Murenzi

contributed to the expansion and modernization of Rwanda's education system and the building of the country's scientific and technological capacity. In 2009, Murenzi left Rwanda to become a senior scholar at the American Association for the Advancement of Science (AAAS) in Washington, DC, USA. In July 2010, he was named director of the AAAS Center for Science, Technology and Sustainable Development, where he focused on issues related to science-based sustainable development, especially in the developing world. Appointed executive director of TWAS in April 2011, he continues to promote science and education throughout the developing world.

• The second TWAS Fellow to be elected to AAS this year is **Salim Abdool Karim** (TWAS Fellow 2009), pro vice-chancellor of the University of KwaZulu-Natal and director of CAPRISA (Centre for the AIDS Programme of Research in South Africa). Abdool Karim has had a profound impact on HIV prevention globally, and especially in Africa, through his landmark study demonstrating that tenofovir gel prevents both HIV and herpes simplex virus type 2 (HSV-2) infection. The finding has been heralded as one of the most significant scientific breakthroughs in the fight against AIDS by the World Health Organization (WHO), the Joint United Nations Programme on HIV/AIDS (UNAIDS), as well as several leading international research organizations. This path-breaking contribution to AIDS prevention emerged as a culmination of his epidemiological, clinical and basic research undertaken over more than two decades in Africa. He is also a pioneer in the use of microbicides for HIV and herpes prevention. In serving society, and particularly the women of Africa, he epitomizes the momentous contribution that innovative science and medical technology can make to disease prevention and global health.

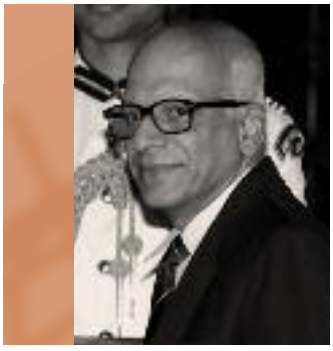
Salim Abdool Karim

2012 PADMA AWARDS

Four TWAS members were among the recipients of Padma awards, 2012, for distinguished service to India in the field of science and engineering. The awards were conferred on the occasion of Republic Day, 4 April, by the President of India at a function held at Rashtrapati Bhawan, the President's official residence in New Delhi.

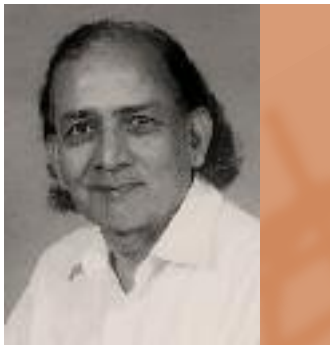
The *Padma Bhushan* award is India's third highest civilian award, given for distinguished service of a high order. This year it was awarded to M.S. Raghunathan (TWAS Fellow 1994) and S.M. Chitre (TWAS Fellow 1999).

• **M.S. Raghunathan**, head of the National Centre for Mathematics at the Indian Institute of Technology (IIT), Mumbai, was awarded the Padma Bhushan Award for his work in the field of mathematical sciences. Raghunathan, a mathematician whose areas of research are Lie groups and algebraic groups, has played a major role in the development of higher mathematics in India throughout his career. He was a founding member of the National Board for Higher Mathematics set up by the Government of India in 1983 to promote the development and growth of higher mathematics in institutions throughout India. As the head of the National Centre for Mathematics at IIT, an institution that he helped to found in 2010, he continues to support the promotion of mathematics education and research in India.



Madabusi Santanam Raghunathan

• **S.M. Chitre** was selected for the Padma Bhushan Award for his work in the fields of physics and astrophysics. Chitre, based at the University of Mumbai, is an Indian National Science Academy (INSA) Honorary Scientist and a distinguished faculty member at the Centre for Excellence in Basic Sciences and has a long record of contributions to stellar and solar physics, especially in the area of



Shashikumar Madhusudan Chitre

gravitational lensing, through making viable models of multiply imaged quasars. He has made seminal contributions to the understanding of solar oscillations in terms of the internal structure of the Sun and has related this work to the problem of solar neutrinos.

The *Padma Shri* award is India's fourth highest civilian award. TWAS Fellows Jagadish Shukla (1995) and Virander Singh Chauhan (2006) were among the recipients of the award this year.

• **Jagadish Shukla** was awarded the Padma Shri for his work in the field of climate dynamics. Shukla is currently professor and chair of the Climate Dynamics Program at George Mason University, and president of the Institute of Global Environment and Society, both in the USA. He has made fundamental contributions to the study of climate dynamics that have led to the development of a scientific basis for the prediction of climate beyond the limit of the predictability of daily weather. His work has led to the establishment of institutions such as the Center for Ocean-Land-Atmosphere Studies (COLA) in the US and the National Centre for Weather Forecasting in New Delhi, India, as well as weather and climate research groups at important institutions worldwide.

Jagadish Shukla

• **Virander Singh Chauhan**, director of the International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi, India, received the Padma Shri Award for his work in the field of biotechnology. Chauhan works on malaria drug and vaccine development. Experimental malaria vaccines developed by his group for clinical trials in India have contributed greatly to our understanding of how malaria drugs work. His research has also formed the basis for the development of drugs in the treatment against other diseases such as type-II diabetes.

Virander Singh Chauhan

WHAT'S TWAS?

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

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

The main objectives of TWAS are to:

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

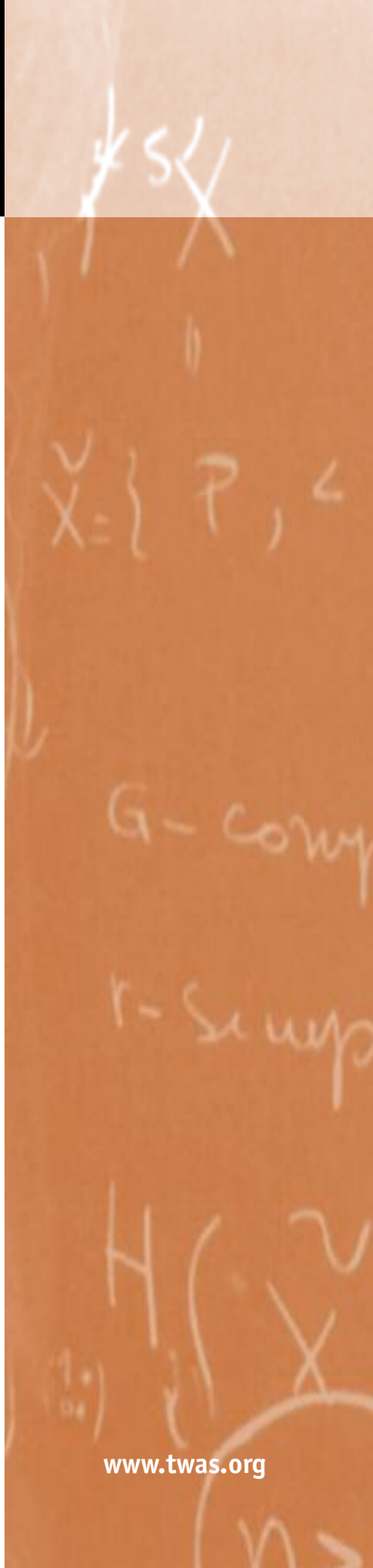
TWAS played a key role in the establishment, in 1993, of the Organization for Women in Science for the Developing World (OWSD, formerly the Third World Organization for Women in Science, TWOWS). Some 3,200 women scientists from more than 90 countries in the South are members of OWSD, making it the largest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

www.owsdw.org

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

www.interacademies.net

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



www.twas.org