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Science in a time of global transformation

Over the past 30 years, tremendous changes have swept across the international science landscape: developing countries have increased their investments in research and science education.

Since the beginning of the 21st century, they have more than doubled their expenditure on R&D[1]. The investments have paid off in growing numbers of researchers and publications, and in surging development and economic growth, especially in such countries as Brazil, India, and my own country, China. Other nations have seen this success and are following a similar path. Today, thanks to a great and continuing effort, the powers of innovation are being distributed across the globe. International scientific collaboration is flourishing.

TWAS can rightly claim some credit for this ongoing transformation. From the time of its birth in 1983, founder Abdus Salam, the 42 Founding Fellows and other Academy leaders advanced a central idea: through science, engineering and technology, developing nations can empower themselves to solve problems and build prosperity. In schools, laboratories and political capitals throughout the world, TWAS has built important programmes and networks. Just as important, it has helped to convey a sense of scientific confidence where confidence often had been absent.

This autumn, TWAS convenes its 24th General Meeting in the beautiful and dynamic city of Buenos Aires, Argentina. It is our 30th anniversary, and we are celebrating all of the important partners and friends who have shared our work and helped TWAS to grow. It is, as well, a celebration of science in Argentina and throughout Latin America.

Latin America has always been important to TWAS. Among the Founding Fellows, 10 were from the region. Brazilian chemist José I. Vargas, TWAS's president from 1996-2000, guided TWAS through a very important period after Salam's death. And my predecessor, Brazilian mathematician Jacob Palis, led TWAS to significant growth across a range of important programmes from 2006-2012.

CONTENTS

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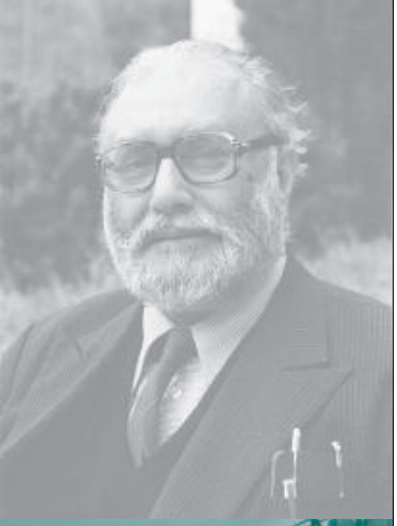


Argentina, with three Nobel science laureates, has long been admired by developing nations. In recent years, under the government of Argentinian president Cristina Fernández de Kirchner, Argentina has been working intently to leverage science and technology for economic strength. INVAP, a spin-off of the renowned Instituto Balseiro, provides satellites to NASA in the United States and to other nations; its nuclear research and energy facilities are in demand worldwide. Earlier this year, Argentina issued a plan that could increase R&D investment to 1.65% of GDP – more than double the current rate – by 2020.

Other nations in Latin America are following a course of similar ambition. According to SciDev.net, Brazil's science budget in 2002 was about USD575 million; for 2013, the investment has grown to USD5.6 billion, the nation's highest level ever. One estimate puts its 2013 R&D investment at 1.3% of GDP. Recognizing Brazil's skilled science workforce, a number of major international companies are creating research centres there. Mexico, meanwhile, is working to push investment up to 1% of GDP, and it is helping to educate and train science students from throughout the developing world through TWAS PhD and postdoctoral fellowship programmes. Chile is becoming the international capital of telescope astronomy.

Of course, Latin America's advances in science and engineering are happening in a global context. India's R&D investments amount to 10% of the total for all of Asia. Its science and engineering universities are among the continent's best, and its publications have been rising steadily. China is spending nearly 2% of its GDP on research and development. Its workforce of scientists and engineers was less than 800,000 at the turn of the century; by 2008 it was 1.6 million, and by the end of 2012 it had risen another 50% to 2.9 million. In materials science, it has emerged as the world leader in research publications.

You can look at other nations and see similar trends: South Africa and Rwanda, for example, or Malaysia and Bangladesh. In many nations of the Arab world, science enrollment in universities is surging. But the progress is uneven, and TWAS and others share a concern that many developing nations risk being left behind.

This creates a high priority for networking and cooperation among nations of the developing world. Again, we can point to many positive examples: universities and research centres across Latin America collaborating on physics, astronomy and social sciences, for example, or the nations of East Africa joining to increase internet bandwidth and access to information through a shared optical fibre network.

Over the past 30 years, helping to build science-based networks has been one of TWAS's most impor-

Top to bottom: TWAS founder Abdus Salam; construction of satellite at Argentina's leading technology company, INVAP; researchers on the Auger Project, based in Argentina, which is stydying ultra-high-energy cosmic rays; Argentinian president Cristina Fernández de Kirchner.

tant roles, and one of its greatest successes. Our PhD and postdoctoral research fellowships, to cite a key example, are based on the idea of building science in the developing world through South-South cooperation. We are now able to offer more than 500 fellowships per year, and we are aiming for at least 1,000 in years to come.

In China, the age of 30 is auspicious. In the Analects*, Confucius says: "At 30, I stood firm." This well describes TWAS as we celebrate our 30th anniversary. We are established and well-known; we have broad credibility in the world of science, both South and North. Still, TWAS faces a central challenge: Both our programmes and our vision must evolve to keep pace with a constantly changing global scientific landscape.*

Certainly it will be important for TWAS, in the years ahead, to focus energy on the least developed countries, and on programmes to support their scientific and technological development. TWAS also should seek to elect excellent scientists from countries where we currently have no members; a good goal is to expand our membership from the current 91 countries to 100 in coming years.

We may find one model in the five CAS-TWAS Centres of Excellence. The centres are focused on areas of critical importance and value for the developing world: water, biotechnology, green technology, climate and environment sciences, and space technology for disaster mitigation. The new investment of the Chinese Academy of Sciences (CAS) is focused on PhD programmes, joint research projects, workshops, training, and strategic study reports at CAS and the China-based centres.

The programmes will bring in top scholars from both the developed and the developing world. The programmes will be open to students from the developing world, and many will include support for women scientists. We envision the five TWAS regional offices playing an important role in supporting and advancing the centres of excellence.

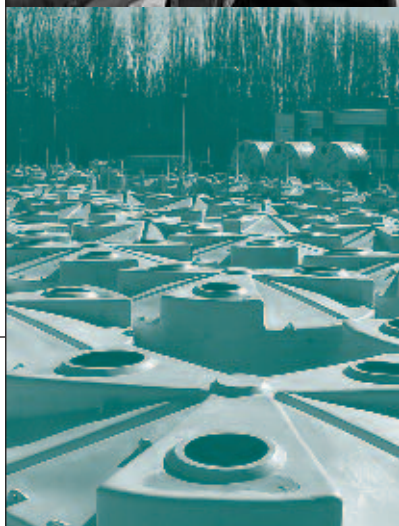
With this systematic approach, the centres will function as a powerful arm of TWAS in achieving some of its most important strategic missions, while fully employing its resources and building its networks.

TWAS attaches great importance to the nurturing of young scientific talents in developing countries. Bearing this in mind, TWAS and CAS initiated a new President's Fellowship Programme early this year; up to 140 students annually will be sponsored to travel to China for up to four years of PhD study and research. With this and many more other efforts, TWAS looks forward to the spreading of scientific awareness and strengthening of science capacity building in the developing countries.

The celebration of our 30th anniversary is an important time for us to acknowledge the hard work and transformative contributions of TWAS's founders and past leaders. As we reflect on their accomplishments in building the Academy, we must also commit ourselves to matching their ambition, their energy and their many years of innovation. ■

Bai Chunli *took office as TWAS president in January 2013. He also is president of the Chinese Academy of Sciences.*

[1] Based on the standard United Nations Statistics Division classification (composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings). *–Knowledge, Networks and Nations: Global scientific collaboration in the 21st century.* 28 March, 2011. -Royal Academy of Sciences



From top:
A radio telescope with the Atacama Large Millimeter Array project in the Atacama Desert in Chile (Photo: ESO).
Argentinian physicist José Antonio Balseiro, founder of the Balseiro Institute in Bariloche (Photo: Balseiro Institute).
A student in the KeV accelerator lab at the Balseiro Institute (Photo: Balseiro Institute).
Surface detector tanks staged for preparation at the Pierre Auger Observatory in Malargüe, Argentina (Photo: Pierre Auger Observatory).

At right:
"At 30, I stood firm."
***– Confucius,* Analects**
Calligraphy by TWAS president Bai Chunli offering the Academy good wishes for its 30th anniversary.

SCIENCE MINISTER LINO BARAÑAO DREAMS OF TRANSFORMING ARGENTINA INTO AN INTERNATIONAL CENTRE FOR RESEARCH. WHEN TWAS CONVENES IN BUENOS AIRES FOR THE ACADEMY'S 24TH GENERAL MEETING, MEMBERS WILL FIND THAT THE DREAM IS BECOMING REALITY.

ARGENTINA: A NATION FOR INNOVATION

Sometime later this year, Argentina will celebrate a milestone in its modern scientific development: After an epidemic of brain drain over the last 15 years, the 1,000th Argentinian scientist is expected to return home to resume work. It is a measure of the commitment to science made by Argentinian president Cristina Fernández de Kirchner and the nation's first minister of science, technology and productive innovation, Lino Barañao.

Barañao was appointed nearly six years ago, when the government upgraded the secretariat for science, technology and productive innovation into a ministry. He brought scientific vision and administrative skill to the job, and has maintained perspective by continuing to run his own cell biology laboratory.

Argentina has long had a sophisticated and accomplished science culture; it has had three Nobel laureates, more than any other Latin American nation. But for decades, many of its best researchers have left to work in Europe and the United States. This challenge is known well in many other nations of Latin America and the developing world, but for Argentina, the problem was compounded by a severe financial crisis in 2001–2003.

Under Kirchner, Latin America's second largest country is working to renew its research strength through targeted interventions in science and technology. It has increased investment in science, technology and innovation to 0.51% of its gross domestic product, up from 0.39% during the crisis. This has placed Argentina in third place among Latin American nations, after Brazil (1.11%) and Chile (0.68%). The country is now among the top performers in terms of number of scientists, with 5.68 for every 1,000 economically active people. It maintains partnerships with top research centres in Europe and the United States. Its universities are pulsing with new energy and resources, and its science-related companies are growing and succeeding in international markets.

However, Barañao aims high. He has a clear picture of where Argentina stands today, and of where it should be a decade from now. In advance of TWAS's 24th General Meeting, from 1 to 4 October in Buenos Aires, Cristina Serra from the Academy's Public Information Office interviewed him to get insight into Argentina's current work and future plans.

Your appointment as the first Argentinian minister of science, technology and productive innovation started in December 2007. What were the priorities in your agenda?

We identified two major goals. Formulate new science and technology policies, with the aid of a special secretary devoted to the elaboration of national plans; and draft guidelines aimed at obtaining governmental, private and international funds to carry out scientific projects. Such a big innovation differentiates the actual policy from the past. The strict coupling between medium- and long-term projects, with ad hoc funding to carry out these investigations, gave our recent strategic plan – *Argentina Innovadora 2020* – an unprecedented solidity, with important reflections also on our economy.

What is *Argentina Innovadora* and why is it so important for the economy?

Argentina Innovadora is the Argentinian plan for scientific and technological development that covers years 2012–2015. It acknowledges that the national development and the competitiveness of our economy are tightly linked. Science plays a key role in this, acting as in a domino

LINO BARAÑAO

A renowned scientist with strong expertise in cell biology, reproductive physiology and animal biotechnology, Lino Barañao is minister of science, technology and productive innovation in the government of Argentinian president Cristina Fernández de Kirchner.

Barañao graduated with honours in chemistry at the University of Buenos Aires in 1976, then earned his PhD in biological chemistry in 1980. The same year, he received the National Medical Academy's award for his investigations aimed at elucidating the role of hormones in diabetes. Moved by a passion for scientific research, he spent some time in the United States and Germany, and upon his return to Argentina, he was in the team that created the first genetically engineered calf, altered to produce 'fortified milk' containing human growth hormone (2002).

In 2003, he was the president of the National Agency for Science and Technology, and in 2007 was appointed Argentina's first minister of science, technology and productive innovation.

He is also president of the Federal Council for Science and Technology, a major advisory board to the ministry; president of the Science and Technology Cabinet; and member of the Management Council of the Argentinian Nanotechnology Foundation. He also remains a faculty member at the University of Buenos Aires.

effect: by fuelling our national scientific capacities, we give impulse to entrepreneurship and productive innovation. This, in turn, will boost the national workflow and ultimately improve the population's quality of life. The plan is a far-sighted document, as it was drafted by 300 experts from science, technology, production and social sectors, who identified strategic intervention areas worth developing such as targeted funding, technological innovation, availability of information (like in Argentina's Electronic Library of Science and Technology), outreach and science dissemination.

Argentinian science minister Lino Barañao with Argentinian president Cristina Fernández de Kirchner.

The economic crisis that struck Argentina in 2001–2003 caused massive stagnation. What did the government do to reboot the economy?

To compensate for the lack of imports, the government began to support some small local companies. A number of these then flourished, and now they are well consolidated. One such successful example refers to the milk industry. Instead of buying foreign supplies, the government helped a few dairy companies with incentives and tax concessions. As a consequence, the companies incorporated more professionals; they grew in size and competitiveness, and now they hold a firm position on the market. So, in some ways we exploited the crisis to promote local firms that in the past could not compete with foreign imports, and triggered local productive changes.

What happened to science during the crisis?

During last decade's crunch, the whole scientific community agonized. As a scientist (I still run a laboratory and follow my team personally), I recall that we suffered from the situation in terms of manpower, development of new ideas, wages. Generally speaking, salaries in Argentina were very low and many qualified colleagues fled the county looking for jobs at American or European universities, where facilities and funds were available.

How did these 'migrants of science' feel about leaving their country?

In most cases they knew that leaving was the right choice. However, they were strongly motivated to come back: they have an international brain, but their heart is Argentinian. Their roots were here. Families were here. They wanted to raise their children here. This is why, once given the chance, they were happy to return, to contribute to the prosperity of our society and to economic development.

As the newly appointed minister, what did you do to give science fresh energy and halt the brain drain?

From 2003, with the inception of the national agency for promotion of science, the government

tried to attract Argentinian scientists who were working aboard by launching a programme called R@ices (*raíces*, or roots). The idea was to repatriate skilled investigators and build a new scientific network with international links. They set up this programme under Nestor Kirchner's presidency, and we made it official with an *ad hoc* law under de Kirchner's mandate. From 2003 to July 2011, some 834 scientists came back, mainly from America (54%) and from Europe (44%). At the end of 2013, we expect to celebrate the 1,000th return. From the time of my appointment on, we also focused on creating better work conditions: by increasing the salaries, making new grants available and launching ambitious programmes to enhance scientific structures and facilities all over the country. Today, the budget allocated for science is tenfold the budget we had in 2003. And scientists have better equipment and wider spaces.

Were these scientists happy to come back?

We tried to ease their return by providing them with full-time contracts, special funds to establish laboratories and security for life. They were well-received, were interviewed on TV, explained what they were doing. Today I can say that we did the right thing: the productivity of these people is very high, their publications are excellent. Overall, Argentina's scientific production during the last seven to eight years has increased tenfold with respect to the past decade, showing that highly competitive scientists perform well, yet maintaining their collaborations with foreign countries. Which is an added value.

Other steps to boost science?

Making sure that we could develop both basic science and the private sector, we identified three platforms worth developing: nanotechnology, biotechnology and informatics. Argentina, for example, is particularly strong in biotechnology and in its intersection with health: we have identified some recombinant proteins – proteins engineered with laboratory techniques – that are now on the market.

In addition, we launched a call to boost proposals from public/private consortia, and we funded three consortia that produce recombinant proteins for medical use. With the initial grants we allotted, almost USD7 million, these consortia have covered the initial high-risk phase; then private actors followed, providing funds for further development and to up-scale the production and reach the market. This scheme is working well: partnerships between universities and companies widen the spectrum of opportunities, enhance human resources and provide a critical flow of knowledge, instrumental to getting transforming results.

Barañao at work in his laboratory.

Argentina was the first Latin American country to set up fruitful relationships with the European Union, through a cooperation agreement (1990). Since then, other articles were signed: what results stemmed from these science and tech agreements?

The first, in 1990, set the stage for bilateral cooperation and exportations. Then we signed other agreements on fisheries (1993), on the peaceful use of nuclear power

(1997) and on science and technology (1999). Our continuous participation in EU programmes is very important; this is why we set up a dedicated office that advises scientists on how to participate in the programmes. But we provide this service also to other Latin American countries that do not have such a facility. This is not an altruistic policy. We have an ambitious dream: to make Argentina first, and South America later, an international laboratory where scientists meet, exchange ideas and spot original solutions to common problems. This is why we keep close relationships with different European institutions, such as the Max Planck Institute in Germany; the CNRS in France; the International Centre for Genetic Engineering, in Trieste, a world-renowned centre for biotechnology. Cooperation with the EU is, in general, a top priority for us.

Regarding South America, this idea of an international laboratory calls for establishing fresh political connections based on common interests and more global views. How are the relationships between Argentina and the neighbouring countries?
I am deeply convinced that scientists share a common view of nature, common interests, that speak the same language and are able to tie countries that otherwise would remain isolated. Policy and economy work to maintain national identity for the benefit of national interests. Science and technology are international activities, not constrained by boundaries. In a sense, scientists are the *diplomacy arms* of governments. It is quite common to see scientists from Israel and Palestine or from Russia and China work together, bridging gaps that policy is unable to overcome.

This is why we are promoting international networks in Latin America: we participate in Mercosur, providing counseling in meetings on science and technology and we keep a high level of cooperation with Brazil.

Alongside Mercosur, there is another initiative called Biotechsur. Could you explain what it is?
Biotechsur is a biotechnology platform funded by the European Union. It aims at fostering innovation in food production through the promotion of biotechnology in the four Latin American members of Mercosur (Argentina, Brazil, Uruguay and Venezuela). Biotechsur is a far-sighted platform where policymakers formulate public policies based on these technologies, and it has already achieved some success. One example is a robot for the phenotypic evaluation of soybean plants that is speeding up the process of selecting proper varieties to increase the productivity of soils. In the pipeline, we also have some projects to identify vegetable genes that provide resistance to drought and abiotic stress. Some of these genes were already identified and patented in US companies and in Argentina's. Another study that will be published soon is on the genome of common

Barañao with his research team.

Left: Argentinian president Cristina Fernández de Kirchner and minister for science, technology and productive innovation Lino Barañao. Right: Scientists at work.

beans, carried out by a consortium of Latin American laboratories, which expects to find genes important in terms of productivity and nutritional values.

Let's try to imagine where Argentina will stand five to ten years from now…
I like to picture Argentina as *the* place for innovation, where scientists and entrepreneurs come with a problem, and from where they leave with a solution.

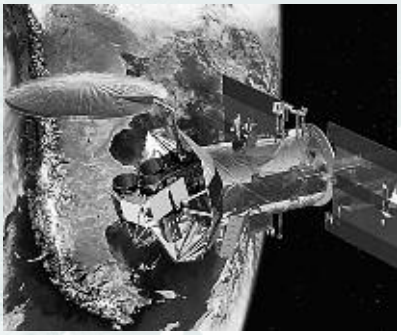
We want to develop and use our creativity and ingenuity, to provide innovation and show that we can compete as a country, not in terms of salaries, but in terms of creativeness. Latin America as a whole should recover a more dynamic role in innovation.

This autumn, Buenos Aires is hosting TWAS's 24th General Meeting, convening more than 300 scientists from all over the world. What are your expectations for this event? What could the major outputs be?
We will like to show what's going on in Argentina, what major technologies are, and I think it will be important for our country and for the other scientists to be here and have direct contact with our reality, to see our scientific products. It is also crucial for our politicians, as they need to show that Argentina is a very attractive country for scientists where science gets supported by an assisting policy. Our goal is to use this TWAS event to consolidate what we have been doing in the last ten years.

Do you think that science academies like TWAS have a role in modern societies and economies?
I think that Latin America, and Argentina in particular, owes much to TWAS, in terms of the formation of human resources. Many young scientists have received inspiration as well as important support from your Academy. In the long term we want to collaborate more closely with TWAS, sharing its mission to create new facilities in Buenos Aires and elsewhere, for training of scientists from all Latin America. We hope we can establish a new order based on scientific internationality. ■

ARGENTINA'S STAR IS RISING

THE COUNTRY'S COMMITMENT TO RESEARCH AND EDUCATION HAS MADE IT A LEADER OF SCIENTIFIC ADVANCEMENT IN THE SOUTH.



From a reputation in the biomedical sciences that grew from three Nobel prizes, to new prominence in the study of astroparticles, modern-day Argentina is an appealing place to be a scientist. By strongly supporting its public universities and institutions, the country has built a scientific framework for research in biomedicine, agrotechnology, physics, space sciences, climatology and Earth sciences. Now, the nation is a model for scientific growth in the developing world.

The central piece of Argentina's scientific framework is CONICET, the National Scientific and Technical Research Council, established in 1958, which supports thousands of scientists and their research. The Argentinian daily newspaper *La Nacion* said recently that CONICET financially supports 6,000 researchers, 2,500 technicians and 8,500 fellows at institutions and colleges. Further demonstrating the importance of science to its agenda, the Argentinian government appointed chemist Lino Barañao its first-ever minister of science, technology and productive innovation in 2007.

This autumn, for the first time ever, TWAS is bringing its General Meeting to Buenos Aires, the capital of Argentina. TWAS's annual event has been held in Latin America four times before: in Venezuela (1990), in Mexico (2008), and twice in Brazil (1997 and 2006). This year's meeting will run from 1 to 4 October, and those who come to Buenos Aires for the meeting will find a nation focused on science, engineering and technology. It can claim a range of significant scientific accomplishments in recent years, and it is confidently scaling up its ambitions for the future.

A LIVELY PLACE FOR LIFE SCIENCES

Argentina has a longstanding tradition in the biological sciences, including three Nobel Prize winners: Bernardo Houssay, Luis Federico Leloir and César Milstein (see boxes). Leloir's work allowed Argentina to set initiatives and found institutes on molecular biology in the early 1980s. Leloir and his fellow laureates' accomplishments served as an inspiration for Argentines everywhere, including for Alberto Kornblihtt, a molecular biologist with the University of Buenos Aires and CONICET. Kornblihtt is a 2011 TWAS Prize winner in the medical sciences and one of Argentina's

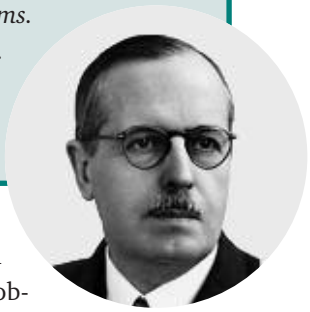
The Leloir Institute in Buenos Aires, Argentina, at night. The institute is a centre of biomedical research founded by Argentinian Nobel laureates Luis E. Leloir and Bernardo A. Houssay (Photo: Leloir Institute).

BERNARDO A. HOUSSAY, NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE, 1947

• **Houssay (1887–1971)** *won the Nobel prize for his discovery of how pituitary hormones regulate blood sugar while working for the Institute for Biology and Experimental Medicine in Buenos Aires.*

Houssay entered the School of Pharmacy of the University of Buenos Aires at the age of 14 and just three years later took a job with the Department of Physiology. By 1910, he became a physiology professor in the university's veterinary medicine school. He became a physiology professor in 1919 at the Medical School at Buenos Aires University.

He worked in almost every field of physiology, having a special interest in the endocrine glands. He worked on many other topics in physiology and pharmacology, including the physiology of circulation and respiration, the processes of immunity, the nervous system, digestion, and snake and spider venoms. He also had an active role promoting education and science research in his home country. Houssay was also the first-ever director of the National Scientific and Technical Research Council, the main Argentinian government agency that supports Argentinian science.



six foreign associates with the US National Academy of Sciences.

"Undoubtedly I am a product of the Leloir school", said Kornblihtt. "I did my PhD with Héctor Torres who had done his PhD with Leloir, who in turn had done his PhD with Houssay, and my postdoc with TWAS member Tito Baralle, who in turn had been formed in the Leloir school. In that school I learnt a love for experiments and the importance of commitment and rigorousness."

He credited Argentina's public education system for the country's strength in biochemistry and medical sciences. "Our university system is an open one", he said. "There are no fees for students; all throughout there is a principle that it's open to everybody." It also helps that Argentina has been a free society without intellectual repression for 30 years. "We've had democracy since the end of 1983", Kornblihtt noted.

CONICET has done landmark research on controlling human parasites.

There are several research teams working on important problems in biology at the moment, Kornblihtt noted. Hugo Daniel Luján's research team at Catholic University of Cordoba and CONICET has done landmark work on controlling human parasites, such as the single-celled *giardia* that wreaks havoc on the human digestive system. Andrea Gamarnik, an independent researcher for the Argentinian Council of Investigation, discovered a method the deadly Dengue virus uses to reproduce. Alejandro Schinder, at the Leloir Institute in Buenos Aires, is one of Argentina's leading neuroscientists, and demonstrated that neurons created in the adult brain function in a fundamentally different way from other neurons. Cancer researcher and 2010 TWAS Prize winner Gabriel Rabinovic has published important contributions on the biology of malignant

Left: A sunflower field in La Pampa, Argentina. Sunflowers are a major crop in Argentina (Photo: Wikimedia/Claudio Elias). Close right: A surface detector at the Pierre Auger Observatory in Argentina, 1.4 kilometres above sea level (Photo: Pierre Auger Observatory). Center right: A close-up view of a telescope mirror and camera in a Pierre Auger Observatory fluorescence detector (Photo: Pierre Auger Observatory). Far right: Argentina's National Atomic Energy Commission in Buenos Aires (Photo: Wikimedia/Pepe Robles).

LUIS F. LELOIR, NOBEL PRIZE IN CHEMISTRY, 1970

• **Leloir (1906–1987)** *won the Nobel prize for identifying and isolating specific sugar molecules with a role in building carbohydrates while working at the Institute for Biochemical Research in Buenos Aires, Argentina.*

His findings proved important for treating a genetic metabolic disorder called galactosemia. The disease interferes with the body's ability to use a sugar called galactose to make energy, and can lead to liver, brain, kidney and eye damage in infants.

Leloir received most of his education at the University of Buenos Aires, and started his scientific career working with Bernardo A. Houssay in 1932. His career flourished, and he did biochemical research in Cambridge before returning to Buenos Aires. He was a Founding Fellow of TWAS.

Houssay and Leloir founded a major biochemistry research centre known as the Leloir Institute. It is now connected to the University of Buenos Aires.

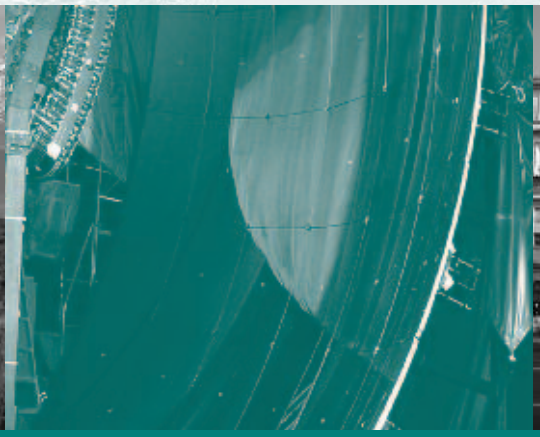
cells in *Nature Medicine*, *Nature Immunology* and *Cancer Cell*. Kornblihtt's lab at the University of Buenos Aires has been recognized for its work in gene expression and how a single gene can generate multiple proteins – the molecules that travel between genes and other biological structures, with papers in *Cell, Nature Structural and Molecular Biology* and *Molecular Cell*.

Argentinian scientists also have an important part in science institutions around the world.

"The Howard Hughes Medical Institute had grant programme many years ago for Canada and certain countries in Latin America, including Argentina", said Kornblihtt. "Those programmes were five-year grants – very competitive. For years, Argentina had almost as many resident scholars as Canada." Today Schinder and Kornblihtt are two of the 13 senior international scholars of the institute.

Argentina is in the running for the Cherenkov Telescope Array, the location for which will be decided by November 2013.

Some major findings in agricultural technology have also been made through Argentinian science. A study by biologist José Estévez of the University of Buenos Aires and CONICET on how sugars affect plant growth was published by *Science* in 2011. Also, Raquel Chan's team at the Agrobiotechnology Institute of the Universidad del Litoral last year was able to use genes from sunflowers, one of Argentina's major crops, to make a more resilient strain of corn. Argentina is also home to Instituto Nacional de Tecnología Agropecuaria (INTA), a government agency founded in 1956 that is dedicated to agricultural technology research, studying a range of plants from crops to forest trees. In an interview with the Argentinian journal *Revista de Investigaciones Agropecuarias,* Barañao called INTA "one of the pillars of scientific and technological activity in our


country" that carries out good basic research combined with "irreplaceable outreach activities".

REACHING FOR THE SKY

Argentina also holds a prominent place in the physical and space sciences. Argentina is part of the six-nation consortium behind the Gemini Project, which is building, installing, commissioning and operating two new 8.1 metre diametre optical and infrared telescopes, one in Hawaii, the other in Chile. Argentinian astronomers involved with Gemini receive 2.5% of the observation time available for their own studies, said Federico Sánchez of the Institute of Technology in Detection and Astroparticles (ITeDA).

But that's just a small element of the space science in Argentina – the country is also home to the Pierre Auger Observatory, the world's largest cosmic ray observatory, aiming to discover the origin of the most energetic particles in the universe so far observed from Earth.

Cosmic rays are mostly protons and more complex atomic nuclei that hail from deep space and largely originate either from supermassive black holes at the centres of distant galaxies or stars that died in huge explosions. They travel near the speed of light to the Earth and produce cascades of other particles when entering the atmosphere. One cosmic ray can produce millions of those other particles spanning several kilometres on the Earth's surface.

In 1992, American nuclear physicist James Cronin and British astrophysicist Alan Watson wanted to build the best cosmic ray observatory ever conceived, Sánchez said. The Southern Hemisphere happens to present the best view of the Galactic centre – the rotational centre of the Milky Way. The observatory's planners also needed enough space, over 3,000 square kilometres over a large flat area for cosmic ray detectors. Finally, they needed the sky above to contain few clouds and a quiet atmosphere. Several workshops later, there were three candidates for host countries, Australia, South Africa and Argentina – and an international panel selected Malargüe, Argentina.

Since then, the Pierre Auger Observatory has produced standout results in the study of cosmic rays. Today the Observatory has more than 490 scientists from all over the world and about 30 Argentinian scientists are members of the collaboration.

"The success of the Pierre Auger Observatory demonstrated that Argentina was a country trustable to host large scientific astrophysical projects", said Sánchez. "In this sense, it opened the door to other proposals to consider Argentina as a host country."

Some of these new projects, such as the European Space Agency's Deep Space Antenna, are already built and installed in Argentina. Argentina is also in the running for the Cherenkov Telescope Array, the location for which will be decided by November 2013.

The conditions for science in Argentina improved quite substantially over the decades, said Juan Pablo Paz, a quantum physicist with the University of Buenos Aires who won last year's TWAS Prize in physics for his work on the loss of quantum information into its envi-

Right: Headquarters of the Research Centre of the Sea and Atmosphere (CIMA) and the French-Argentinian Institute for Climate Studies and its Impacts (UMI-IFAECI) in Buenos Aires. Far right: (from left) CIMA and UMI-IFAECI director Carolina Vera talks with Virna Meccia and Fernanda Cabre, formerly PhD students at CIMA (Photos: CIMA).

ronment. "People are going abroad for postdocs and are returning back to work here. The number of students graduating increased substantially. There is zero unemployment in physics nowadays, and there is more money flowing into science."

Physics became a major field in Argentina in the 1950s, Paz said. At the time, the government had developed the National Atomic Energy Commission in a push to develop nuclear power. Now, there are more than 10 universities where people can get a degree in physics in Argentina, and most have a PhD programme. The largest universities are Buenos Aires, Cordoba, La Plata and the Balseiro Institute in Bariloche. In Buenos Aires, which has the largest physics department in Argentina, more than 20 PhD students graduate with a physics degree every year.

"There are about 1,500 physicists working at the moment in the country and they work at a number of institutions, mostly owned by the state", said Paz. "Research in private companies does exist but is not the main player here. Research in universities suffered a lot during military dictatorships as it was viewed as dangerous to mix scientists with students and politics. But that past seems to be over and, especially during the last 10 years, there are rather good conditions for science in universities."

Many physicists were involved in the development of the Argentinian company INVAP in the 1970s, noted Paz. INVAP recently designed and built a satellite called SAC-D that launched in 2011 and carried NASA equipment called Aquarius, which measures global ocean salinity. INVAP, Paz noted, also builds high-tech radars and exports nuclear reactors (see box on page 21.)

With more rainfall in some areas and warmer, drier weather in others, Argentina is focused on climate science.

DOWN TO EARTH SCIENCE

Earth scientists from Argentina have contributed in three major issues during recent decades, including leading research on the tectonic evolution of the Andes, which are still growing from the effects of the tectonic interaction along South America's west coast.

The Earth science field also has economic use, said Victor Alberto Ramos, a geologist with the University of Buenos Aires who studies Andes formation. "The study of the Andes fuels the finding and mining of giant copper and gold mines of Argentina and Chile, as well as the oil fields all along the Andean foothills from Colombia to Patagonia", said Ramos.

"The Earth Sciences, mainly geology, was one of the first disciplines taught in the School of Sciences of the Universidad de Buenos Aires, as early as 1865", said Ramos. There are 14 geology departments in Argentina, including large ones in Buenos Aires, La Plata, Córdoba, Salta and Tucumán. These departments, he said, have staffs of over 40 people.

Argentina also has a long history of natural hazards such as earthquakes and volcanoes and has developed

CÉSAR MILSTEIN, NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE, 1984

• **Milstein (1927–2002)** *won the Nobel prize for his work on the laboratory production of monoclonal antibodies, an extremely useful medical tool with applications ranging from drugs to diagnostics.*

In Les Prix Nobel*, a yearbook published by The Nobel Foundation, he credited his immigrant parents with the sacrifices that made his academic life possible. He had a prosperous career in the biochemistry of enzymes, but government persecution of scientists and intellectuals interfered with his work and forced him to leave Argentina in 1963 for Cambridge in the United Kingdom. There, Milstein's research interests shifted from enzymes to the immune system. At MRC Laboratory of Molecular Biology, he did landmark work in immunology, discovering a means to produce monoclonal antibodies.*

Milstein was an Associate Founding Fellow of TWAS. His work was characterized as "the most important immunological advance of the century" in a commentary by Abraham Karpas, the assistant director of research at Cambridge's Department of Haematology, for a 2002 edition of the British magazine Times Higher Education. *The work "opened numerous new and unforeseen avenues for research, many with medical implications", Karpas wrote.*

several institutes to monitor them. The recent 2011 Maule mega-earthquake shook and moved the city of Buenos Aires 3 to 4 centimetres in a few hours, Ramos noted. "Based on more than hundred years of experience, our scientists and technicians have developed networks of seismic detection as well as volcanological observatories to mitigate those natural disasters", he said.

Argentina is also keeping on top of atmospheric, oceanic, and climate sciences through Argentinian organizations, the Research Centre of the Sea and Atmosphere (CIMA) and the French-Argentinian Institute for Climate Studies and its Impacts (UMI-IFAECI).

"Climate-related investigations have remarkably grown worldwide and in particular in Argentina during the past decades", said Carolina Vera, an atmospheric scientist and director of both CIMA and UMI-IFAECI. "It is now possible for climate scientists to monitor, simulate and project global climate with unprecedented accuracy so that climate information can be used for decision-making."

CIMA researches how to numerically simulate and predict atmospheric and ocean processes. Since 2010, CIMA became a part of UMI-IFAECI, an international unit jointly sponsored by *Centre national de la recherché scientifique* (CNRS) of France, CONICET and the University of Buenos Aires. The French-Argentinian Institute works to simulate and predict climate variability and change, as well as their impacts in southern South America and surrounding oceans. It also fosters studies on how climate variability and change will impact population, biodiversity, production and vulnerability.

Argentina has good reason to have a stake in climate science, said Vera. More warm-season rainfall in the central lowlands of Argentina has partly led to agricultural regions shifting from grazing animals to farmland in the 20th century, and modern climate models are projecting those regions will have increasingly wetter summers, which will continue to influence agricultural trends. Meanwhile, in the southern-most region of Argentina, projections expect a warmer, drier climate, which could cause glaciers to further retreat in the region, affecting an important source of fresh water in the country.

The Institute's staff includes 47 researchers with positions. In the last four years, 14 postdocs performed research at the unit, 76 PhD students performed their thesis work, and 35 master-level students have also done their theses in climate science. Between 2010 and 2013, a total of 254 articles were published in refereed journals. UMI-IFAECI researchers also have leadership roles in international panels and programmes like International Panel on Climate Change. "UMI-IFAECI (is) a very powerful research pole not only of relevance in Argentina, but also at the international level," Vera said. ■

Sean Treacy

BALSEIRO: A 'SPECIAL PLACE' FOR GLOBAL SCIENCE

IN AN IDYLLIC SETTING, ARGENTINA'S INSTITUTO BALSEIRO HAS BECOME A CENTRE OF WORLD-CLASS SCIENCE. ITS CHARACTER AND CREATIVITY, HOWEVER, ARE DISTINCTLY LATIN AMERICAN.

In a garden outside the library at the *Instituto Balseiro,* there is an apple tree that is a direct descendant of the English tree that, nearly 350 years ago, gave Isaac Newton his flash of insight about gravity. It is not a grand monument, nor is it conspicuous, and yet it is a powerful reminder of the scientific and engineering aspirations on this campus in the Argentinian foothills of the Andes.

Far from Princeton and Berkeley, far from Stuttgart and Paris, Balseiro has become a centre of physics, nuclear engineering and other fields. Its students and researchers are admired throughout Latin America and in the world capitals of science, and with sustained support from the Argentinian government, they have helped the Institute achieve a deep impact throughout the nation's educational system, its government and its surging technology enterprises.

Manuel Cardona, one of the world's most influential physicists, calls it a "very special" place. What makes it special? "The strong selection of the entering students", he says. "The location in a beautiful, but strongly isolated place, almost 2,000 kilometres from the very large and restless capital of Buenos Aires. The connections with the developed world, which provide opportunities to its graduates and students. And the tradition – the awareness that many graduates have made it in the best institutions of the world and are worthy of emulation."

Argentina has a long history of excellence in science, but as TWAS convenes its 24th General Meeting in Buenos Aires, the nation's scientific work and energy are surging. And the accomplishments at *Instituto Balseiro* are an important source of strength and confidence.

The nation is building satellites for NASA and research nuclear reactors for nations around the world. It is a leading force in fields ranging from agriculture to biotechnology and nanotechnology. It is a global centre for the study of high-energy cosmic rays. And the *Instituto Balseiro* – the IB, for short – has a role in many of these accomplishments.

People who know Balseiro also see something almost intangible that sets it apart – a creative streak that shapes the culture of the place and the people who spend time there.

The Institute's website puts it simply: *"Estudiar en el IB es diferente."* Study at *Instituto Balseiro* is different.

TURBULENT TIMES, A PROTECTED PLACE

Cardona, a Spaniard by birth and now also German, is one of the most cited physicists of modern times, and he helped found the Max Planck Institute of Solid State Research in Stuttgart. He hosted a number of Balseiro graduates there and when he was on the faculty of Brown University in the United States. He also has written about the Institute's history.

He offers an unvarnished view of how it was born: In the years after World War II, an Austrian chemist persuaded Argentinian president Juan Perón that he had invented a way to produce energy at low cost through nuclear fusion. Perón's government made a significant investment in the Huemul Project, a complex of laboratories and research facilities in the small Patagonian city of Bariloche. But as Cardona tells it, "the fraud was discovered and attributed to the lack of [scientific] competency in the country."

Manuel Cardona

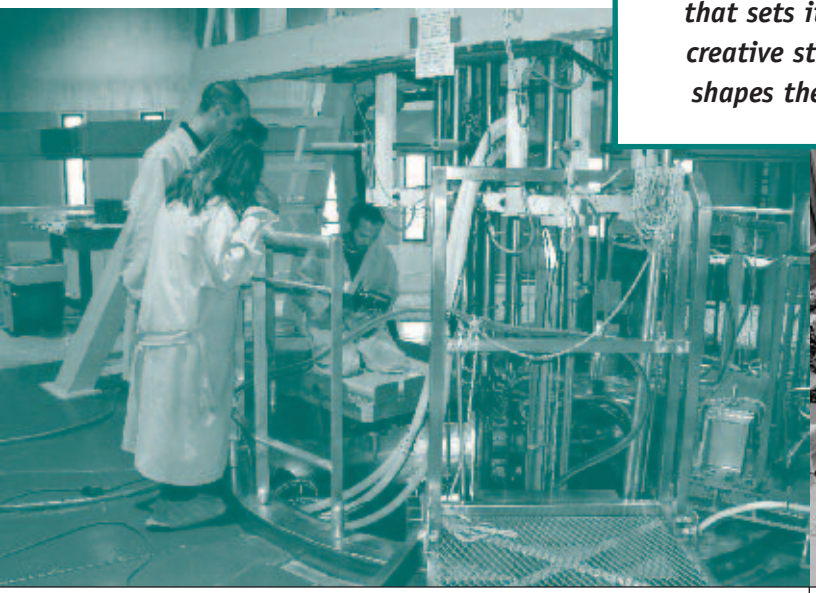
A group of researchers, including physicist José Antonio Balseiro, persuaded Peron that if Argentina wanted to prevent a repetition of the embarrassing chapter, it had to train scientists. Vacated real estate and labs were available and the recently created National Atomic Energy Commission *(Comisión Nacional de Energía Atómica, or CNEA)* allocated funds. In 1955, the new *Instituto de Física de Bariloche* was founded. Balseiro was appointed director; after his death in 1962, it was renamed *Instituto Balseiro*.

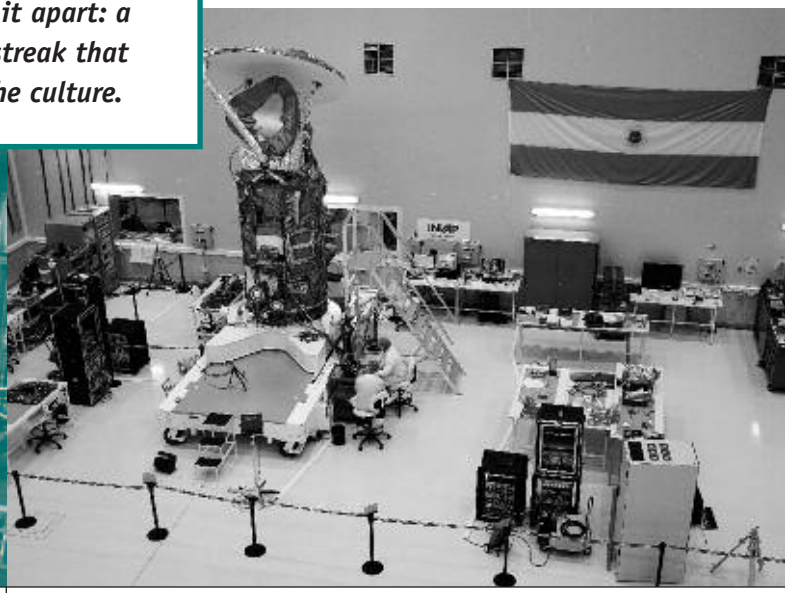
Today, CNEA operates the *Centro Atómico Bariloche*; the *Instituto* operates within the *Centro*. The National University at Cuyo provides Balseiro's academic framework.

Through the years, a long period of political repression and waves of economic crisis have driven many graduates and faculty to work in Brazil and Chile, or in the United States and Europe. At the same time, though, many Argentinian scientists and engineers found a refuge in Bariloche. The small city is sur-

People who know Balseiro see something that sets it apart: a creative streak that shapes the culture.

The SAC-D satellite under contruction at INVAP, a spin-off of the Balseiro Institute.





Alberto Rojo

rounded by Nahuel Huapi National Park. Among the founders and later faculty members, there was a great interest in music, literature and religion. The distance from Buenos Aires – at least 90 minutes by plane, and up to 20 hours by car – created a strong sense of community.

"Bariloche is geographically isolated from the rest of the world", says physicist Alberto Rojo, who earned his PhD at the Instituto in the late 1980s and early 1990s. "So far south, it was protected from the political oscillations of Argentina's Dirty War [in the 1970s]." Given these factors, Rojo said, students and faculty find "a sense of monastic enclosure, which makes it interesting as an incubator of creativity."

THE COMPONENTS OF SUCCESS

Over the course of almost 60 years, IB faculty and students have achieved remarkable accomplishments and individual influence.

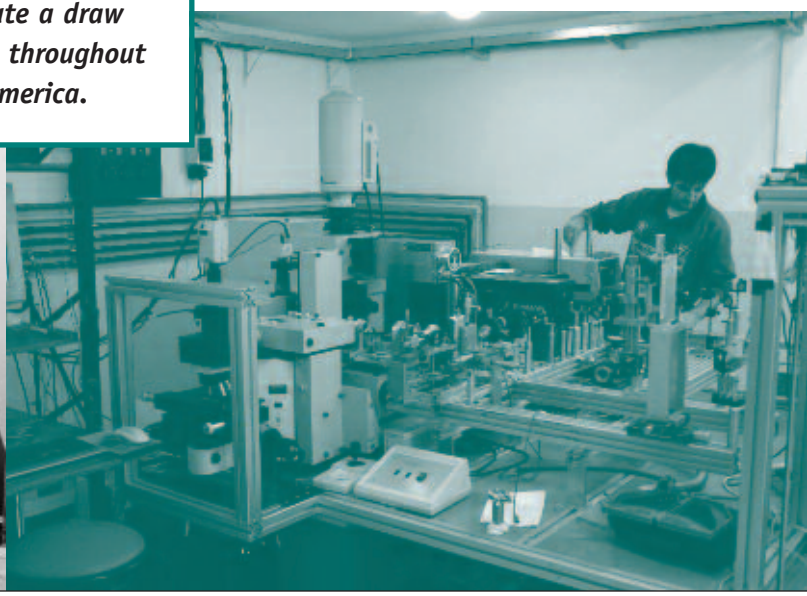
Leopoldo Falicov was in the first graduating class of physicists in 1958, and went on to a career of great influence and many honors as a theoretical physicist and teacher. For many years he was based at the University of California at Berkeley, but he was known for building expansive networks of scientists from throughout Latin America. He was known as well for his love of poetry, literature and music. Among many awards and prizes, he was elected to Argentina's *Academia Nacional de Ciencias Exactas, Fisicas y Naturales*; the US National Academy of Sciences; and TWAS.

Juan Martín Maldacena earned his undergraduate degree from Balseiro in 1991; his work on quantum gravity, string theory and related fields has made him one of the world's most influential theoretical physicists. He won a 'genius grant' from the MacArthur Foundation in the United States; he also has won the Sackler Prize and the Dirac Medal. Since 2001, he has been a professor at the Institute for Advanced Study in Princeton, New Jersey.

Rojo is not only an extensively published physicist, but also a premier guitarist who has recorded with top Latin American musical artists. He created and appeared in the Argentinian television series *Artistas de la ciencia* (Artists of science) and has written extensively on the intersection of science, music, literature and poetry. Now on the faculty of Oakland University in Michigan (United States), he also has conducted many public engagement events that feature both music and science.

Today, *Instituto Balseiro* has about 150 faculty members in engineering and 100 in physics. Among them are many with close ties to the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy, and winners of many of the most important science prizes in Argentina and the world.

Excellent facilities and top faculty make the institute a draw for students throughout Latin America.





INVAP: ARGENTINA'S GLOBAL SCIENCE ALL-STAR

It is difficult to get a firm measure of Instituto Balseiro*'s impact on Argentina's economy – no study has ever been done. But a private company spun off of the Institute in the 1970s is building satellites for NASA and nuclear research reactors for the international market, and it clearly is a powerful force for economic growth and innovation.*

The company – INVAP – traces its roots to the early 1970s, when Balseiro graduate Conrado F. Varotto retuned from a postdoc at Stanford University in California (United States). He persuaded leaders of Argentina's National Atomic Energy Commission (CNEA) to create a department, comprised mostly of other Balseiro graduates, to do research and development and provide services to industry. INVAP emerged from this department in 1976, owned by the Province of Rio Negro and Argentina's federal government, but with the authority to operate independently.

Among members of the founding team was Balseiro graduate Héctor E. Otheguy, now INVAP's general manager and chief executive officer. "The culture of excellence cultivated at the Institute was transferred to INVAP from the very beginning under Dr. Varotto's leadership", Otheguy said in an email interview.

INVAP today is working on projects that cross disciplines and applications: robotics, food freeze-drying, alternative energy and radiotherapy facilities for the treatment of cancer. But its most prominent work – and perhaps its signature accomplishments – are in nuclear engineering, satellite work and radar technology.

Otheguy reports that INVAP's annual revenues amount to USD200 million, up sixfold from USD35 million in 2003. It currently employs 1,100 scientists and technical personnel, up from 350 ten years ago. Another 500 are employed by companies subcontracted for various projects.

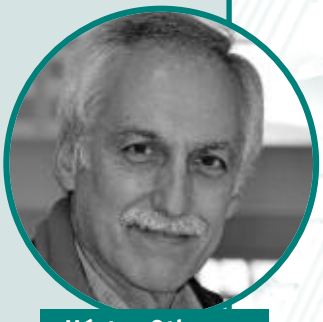
Nuclear projects were prominent almost from the start. A small research nuclear reactor designed and built by INVAP, called RA6, went online in 1982 for training nuclear engineers at Instituto Balseiro*. The next year, the company completed a uranium enrichment facility for CNEA, making Argentina one of few nations to have mastered that process. That was followed by a research nuclear reactor for Peru, and then by reactors for research and production of radioisotopes in Algeria in 1988, Egypt in 1998 and Australia in 2006. Currently, Otheguy said, INVAP is designing research reactors for Brazil and Argentina.*

Having gained experience and success in such areas, INVAP expanded into other fields, including aerospace, all in a framework of homegrown technology development.

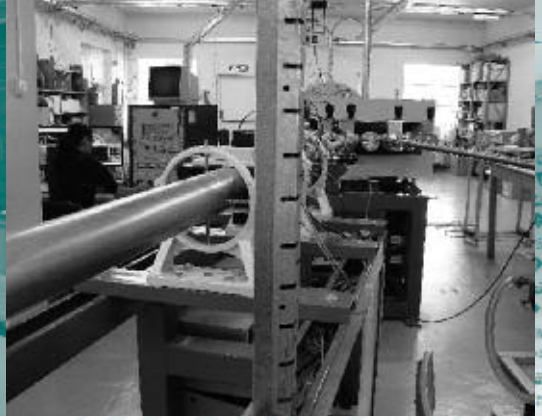
In the early 1990s, the company designed and built four satellites for Argentina's space agency, the Comisión Nacional de Actividades Espaciales (CONAE)*, within a joint CONAE-NASA agreement. In 2011, Argentina reached a milestone: The SAC-D satellite built by INVAP was launched into orbit carrying NASA's USD287 million Aquarius Earth-observation system, designed to measure ocean surface salinity for predicting future climate conditions.*

"Obviously the involvement of NASA in Argentina's satellite-building capacity is a source of pride for INVAP and CONAE", Otheguy said. "That NASA should place its trust in satellite platform SAC-D, designed and built by us is indeed a symbolic statement about the advance of science and technology in Argentina."

INVAP is currently engaged in a number of advanced projects, including geostationary communications satellites for Argentina, air traffic surveillance radars, state-of-the-art 3D radar for the nation's Defense Ministry and a full digital TV network for Venezuela.



Héctor Otheguy



Alex Fainstein

In part because the Instituto operates under Argentina's Atomic Centre at Bariloche, it offers the highly advanced equipment in both physics and nuclear science, including particle accelerators, a collection of advanced microscopes, a nanofabrication laboratory, cryogenic facilities for studying condensed matter at low temperatures, and the small RA6 research reactor.

That makes IB a draw for students from throughout Latin America and sometimes Europe. The competition is intense: After two years at an undergraduate institution, students take IB's rigorous entry exam. Alex Fainstein, deputy director for physics, said the process yields a class of 50–60 new undergraduates every year in physics, nuclear engineering, mechanical engineering and now telecommunications engineering. In addition, there are about 20 new master's degree students and 20 PhD students each year.

All of the students receive fellowships, which pay for education, housing and food, plus extensive related support. In Balseiro's close-knit community, they have access even to high-level faculty members and research opportunities. But the place demands hard work.

"Usually people who come here are very committed", said Fainstein. "There's a collective response...a kind of ambience that makes them work very hard. Everybody wants to get the most out of themselves."

PROJECTS AT THE FRONTIER OF GLOBAL SCIENCES

When the Institute was created and in ensuing years, says Fainstein, its main focus was on physics, engineering and related fields that "were critical for the implementation of the nuclear engineering sector" in the late 1970s. In the 1980s, interests increased to include high-temperature superconductivity and other fields.

Nuclear engineering currently remains central to Balseiro's mission, says former director and current faculty member José V. Lolich. As part of Argentina's nuclear infrastructure, staff at Balseiro and its spin-off company, INVAP, have been involved in building nuclear power projects in Argentina. They also have developed nuclear research reactors for Egypt, Algeria and Australia (see box on INVAP on page 21).

In the past decade, nanoscience has been prominent, and "recently very interesting applications in the medical field are emerging", said Ingo Allekotte, present head of the physics department. A radiotherapy and nuclear medicine centre now under construction is expected to provide a platform for research in medical diagnostics and the use of different types of radiation to treat cancer, brain diseases and other conditions.

Allekotte himself is deputy project manager of the Pierre Auger Observatory, an international facility established to detect and study ultra-high-energy cosmic rays. The project involves a new USD53 million centre and the work of more than 500 physicists from around the world; its detection technology is spread over 3,000 square kilometres in western Argentina.

"One wants to understand what produces these high-energy particles, how they propagate and so forth", he explained. "In the end, you get knowledge – why this phenomenon occurs and how it occurs. And it can lead you to develop new technologies."

THE POWER OF INTERNATIONAL NETWORKS

In spite of its isolation, the *Instituto Balseiro* is the hub of a vibrant global network. It's evident in the student body, where 10–15% of students are from other Latin American nations, and in dozens of alumni who teach and work worldwide. Longstanding ties connect IB with major science centres in France, Germany, Spain and the

United States, and also with Brazil, India, Japan and other nations. The United Nations-based International Atomic Energy Commission (IAEA) also is a close partner. Lolich, for example, serves on an IAEA panel that is studying security at nuclear research reactors. Raúl O. Barrachina, a former Balseiro director who currently serves on the faculty while holding posts with CNEA and Centro Atómico Bariloche, cites a 2010 IAEA meeting in Peru that created the Latin-American Network for Education in Nuclear Technology.

Indeed, the joint research projects with Latin American countries may be critically important for building research capacity in the developing region.

Argentina, Bolivia, Chile, Colombia, Guatemala, Mexico, Peru and Venezuela have joined in the Large Aperture Gamma Ray Observatory (LAGO), which studies gamma and cosmic rays captured at high-altitude sites in three Latin American nations. Allekotte cites the project's "very close ties" to Balseiro: Balseiro personnel are among the principal LAGO researchers. Student lab work has helped to refine the kind of detectors used in the LAGO project.

As another example, Barrachina noted Balseiro's master's degree in medical physics, where more than half of the graduates come from other countries in Latin America and the Caribbean Region.

Balseiro students often are pulled into the Argentinian job market before they get a PhD.

Fainstein explained that Argentina's commitment to Latin American networks reflects the nation's broad support of science and engineering. Balseiro is a microcosm for the new commitment.

"When I studied here", he recalled, "we were a small community trying to be the best graduates we could be, but it wasn't always clear what the graduates would do. Generally, people would go abroad. Now, the situation has changed." With a huge demand for engineers, Balseiro students often are pulled into the Argentinian job market – and onto big projects – before they get a PhD.

The campus, too, has been transformed. "We have doubled the built area – in the past five years, we have built as much as in the previous 53 years. We have so many new buildings: research buildings, a new library, two new buildings for student labs. Ten years ago, we did not have money to paint the walls. Now people come back here and they don't recognize it."

Fainstein would like to see the student body grow, too. But he cautions that growth must be carefully managed to maintain Balseiro's standards. "Yes, we are growing", he said. "The challenge is to do it well." ■

Edward W. Lempinen

MIXING SCIENCE INTO TRADITIONAL FLOUR

TO HELP GUATEMALANS CONSUME IMPORTANT NUTRIENTS, SCIENTISTS HAVE TO BE SENSITIVE TO LOCAL CULTURAL PRACTICES, SAY NUTRITION RESEARCHERS

On one of her first field missions working alone, nutrition scientist Mónica Orozco ran into a problem that forced her to improvise. She had planned to visit a rural, Maya village called Magdalena Milpas Atlas where she had contacts who would help organize local people to test just-developed condiments loaded with minerals and vitamins. The village is so remote it's only accessible by rocky, unpaved roads, so she arranged for someone with a pickup truck to drive her there from the nearby town of San Miguel Milpas Atlas. But when she arrived, the driver didn't show up.

Unable to get to the village in her sedan, she needed to find a different Maya population for the taste test. In San Miguel, a collection of cement buildings and adobe houses, the residents were Maya, but she had no local contacts to help her gather participants and set up her analysis work.

So Orozco approached women who were walking by and knocked on the doors of complete strangers until she had a small crowd of people by the road. Then she organized the condiments, some water, and documents for note-taking in her car trunk, converting it into a panel for the condiment taste test. "I had to do acceptability trials in the back of my car", she recalled, "with my participants testing the different samples standing on the side of the street." By the end, she had gathered the data she needed.

Such is the life of the researchers fighting Guatemala's deep-seated malnutrition problem, who sometimes must conduct scientific trials and even blood tests from the backs of vehicles, the tops of picnic tables, and peoples' back yards.

Last year, Orozco won the TWAS Prize for Young Scientists in Developing Countries for her nutrition

Mónica Orozco

Above: A scientist for the Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM) interviews a Guatemalan mother for a health survey (Photo courtesy of CeSSIAM). Right: Nutritionist Mónica Orozco (far right) won the TWAS Prize for research into ways to support the health of rural Guatemalans by fortifying traditional foods with micro-nutrients (Photo courtesy Mónica Orozco).

research work in Guatemala. Since 1986, TWAS has partnered with national organizations to recognize scientists under the age of 40 whose work is already making an impact. TWAS also provides prize money, up to USD2,000, while national organizations – in this case *Academia de Ciencias Médicas, Físicas y Naturales de Guatemala* – select the recipients. So far, 501 scientists have received the prize. Orozco, who is 38, is the 10th recipient from Guatemala, and the second recipient from The Centre for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM), a non-governmental, non-profit organization dedicated to nutrition research and education in Guatemala. Gabriela Montenegro Bethancourt was the first CeSSIAM scientist to win the prize in 2010.

Orozco said the recognition from the prize helped her receive a promotion to director of the Centre for the Studies of Lake Atitlán, an external campus of the Universidad del Valle de Guatemala, where she is a chemistry and nutrition professor. "The Prize came in at a crucial point because I was in great need of a change in my professional life", she said.

Guatemala has one of the highest chronic malnutrition rates in the world, and the worst nutrition ranking in all of Latin America, particularly for women and children. According to the US Global Health Initiative, the maternal death rates in rural Guatemala, where malnourished mothers rely on midwives to deliver their babies, are also high: up to five times higher in some areas than in Guatemala City.

One way to help fix the problem is by supplying food that is either fortified, with extra nutrients added directly into the recipe, or biofortified, using crops bred or engineered to increase their nutritional value. The Guatemalan government regularly delivers fortified foods to its people. Corn flour, for example, is used by rural populations for tortillas, and researchers can mix essential vitamins and minerals that are absent from local peoples' normal diets – iron, zinc, vitamin D, B vitamins – into corn flour. Fortified corn flour is a focal point of Orozco's current research.

Corn flour used for tortillas can serve as a way to administer missing nutrients to rural populations.

But studying malnutrition and whether efforts to control it are working can be exceptionally difficult. Many of the communities that scientists and aid workers want to help only have dirt roads, lack basic services such as sewers, and don't even have a local elementary school. Often the communities visited by nutrition scien-

tists even lack a clinic, and the only way they can get data is to set camp. "All you'll have is a family's backyard, and you have a picnic table, and you have to figure out how to get those blood samples", Orozco said.

"We're used to it and we know what to expect", said Orozco. "In the best cases, you'll find a house, a field, a yard, a health centre or a community auditorium to work in. But that doesn't always happen."

FOR WOMEN, BY WOMEN

Orozco started her biology career in a forensics lab, collecting and analysing evidence from crime scenes. But it was stressful to regularly see scenes of horrid violence. "It's very harsh because you see the most horrible things you can imagine."

She decided to pursue her master's degree and a research career instead. She began her nutrition work at CeSSIAM, working to create and test fortified foods such as condiments and corn flour. She grew passionate about it, she recalled, because in addition to lab work, she was able to interact with people in the rural villages of Guatemala.

CeSSIAM's focus hasn't always been nutrition. At its founding in 1985, the organization studied the biology of ageing in a developing country where few grow old. Its founders were largely drawn to Guatemala for the chance to conduct independent research, said CeSSIAM director and co-founder Noel Solomons.

CeSSIAM now only has female researchers on the staff, which is part of the "feminist objective". For a long time, women couldn't become doctors in Guatemala, Solomons recalled. But in the early 1980s, *Universidad Francisco Marroquín de Guatemala* became the first Guatemalan medical school to open its doors to women and graduated its first combined male and female class in 1985. Even still, no Guatemalan hospitals would hire women as resident physicians, he said. By sheer coincidence, CeSSIAM was founded that same year. "We harvested the best and the brightest of that first class and that's how we started off with some very upstanding women."

Among their early recruits were Carmen Castañeda Sceppa, now an exercise science professor at Northeastern University in the Boston, Mass., and Carolina Barillas-Mury, who now leads the Mosquito Immunity and Vector Competence Section at the US National Institutes of Health Laboratory of Malaria and Vector Research.

CeSSIAM currently focuses on the nutritional problems faced by women and children in Guatemala, not only because pregnant mothers need more nutrients, but because children battle for growth in first six months when they should be exclusively consuming their mother's milk. The situation is made worse because the patriarchal culture typically leads to men getting the most food at each family's dinner table.

"The women are usually at the bottom of the pyramid", Orozco said. So the researchers at CeSSIAM build relationships with community leaders the local women trust – typically midwives. "You can work with them directly."

FORTIFYING FOOD, EMPOWERING COMMUNITIES

The Central American food manufacturer, DEMAGUSA, approached Orozco and her colleagues in 2011 to design a fortified flour for indigenous populations in the Guatemalan highlands. But while the team had data on how much flour the indigenous populations ate, that didn't mean the rural people would willingly eat whatever fortified flour the researchers handed them.

> ***You can't go to a community and just impose your vision. You have to empower them to create their own solutions.***

"You can spend a lot of time designing the perfect formula, but if people don't actually eat it – because they don't like it, because it tastes funny, because when you make the tortilla it doesn't work well – it's useless", Orozco said. "You can't go to a community and just impose your vision and expect them to do whatever you tell them to. You have to empower them to create their own solutions."

CeSSIAM did interviews with 150 highland women to hear their opinions of the fortified flour they created. They learned that, not only did the women think the homegrown corn was more nutritious than the fortified flour, but that some of them even look down on those who use it.

"When you make tortillas from the raw corn, you have to grow the corn, cut it down, get the grains, put them to dry. Then you have to go to the mill, mill it to prepare the dough", Orozco said. "And *then* you make tortillas. That takes a lot of work. So there is a perception that women who use these flours are lazy and don't want to do all that work."

As it stands, Orozco is still planning to test the flour on a group of women breastfeeding their babies, to see how it affects the nutrients in the milk that help protect infants from diseases.

The other primary focus of Orozco's work is on tracing the effects of iron supplements, a frequent treatment for anemic populations. While about 35% of women in Guatemala are anemic, the government is giving iron supplements to everyone whether they have an iron deficiency or not, said Orozco. Her current work in CeSSIAM is investigating what happens to those who are taking the supplement but don't need it.

FOODS THAT FIT THE LOCAL CULTURE

What Orozco and her colleagues encounter in the field depends on how much aid the community has received in the past. While some communities are accustomed to food aid and already expect it, she said, many rural areas have never received food aid and are distrustful. The great challenge for nutritionists is to provide malnourished communities with the nutrients they need while convincing them they won't lose their traditional view of the world.

Guatemala contains 22 different ethnic groups, each with their own language and traditions, and sometimes their approach to food and health is based on beliefs that, while detached from science, dictate their lives.

For example, the people of some Maya communities believe that disease is caused by a temperature imbalance. When you get sick, it's because your body has slipped into being too 'hot' or 'cold.' They also believe different foods 'heat' or 'cool' the body, though that judgment has little to do with the literal temperature of the food. That criteria are instead passed down through the generations as folk wisdom: If you have a 'hot' disease like a fever, you cool down by eating 'cold' foods like black beans or fish. If you have a 'cold' disease like the chills, you might warm up with chili peppers.

The problem for nutritionists emerges when this ingrained view of how the world works disrupts the diets of people they're trying to help. But efforts to build a healthier Guatemala haven't always taken these worldviews into account. "If you want food security, you have to use their terms", Orozco said. "What works in Brazil or Venezuela isn't going to work here."

For example, Orozco noted, the Guatemalan earthquake in 1976 left 23,000 dead, thousands injured, and thousands more homeless. Several countries responded by sending food aid, including powdered milk, to the country's western highlands. Then people used it to paint their houses white. Years later, foreign aid workers tried to introduce soybeans to Maya communities, but the people there had never seen a soybean plant, didn't know how to prepare it, and didn't

Above: The Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM) focuses on helping women and children acquire the nutrients they need. Right: (from left) CeSSIAM scientist Mónica Orozco; Klaus Schümann, president, Hildegard Grunow Foundation for Nutrition Research; CeSSIAM scientist Liza Hernandez; CeSSIAM director Noel Solomons and CeSSIAM scientist Gabriela Montenegro-Bethancourt in 2009 (Photos: CeSSIAM).

care for the flavour. So they used the soybeans to feed their pigs and cows.

"The whole project was a failure", she said, "because it wasn't culturally acceptable."

URBAN PROBLEMS

Most of Guatemala's population is rural, setting the nation apart from most of Latin America. That distinction actually led to the urban populations of Guatemala being neglected by researchers and aid workers, Solomons recalled. "People had this notion of being like safari-helmeted anthropologists, so they jumped out into the countryside where the picturesque people were", he said, "and nobody had studied urban settings."

Urban life among low-income Guatemalans also presents a unique set of problems. Nutrition researcher Gabriela Montenegro Bethancourt, CeSSIAM's 2010 TWAS Young Scientist Prize winner and the 8th Guatemalan recipient, has studied the nutritional health of infants and their mothers in disadvantaged, urban settings in Guatemala.

Part of Montenegro's research has focused on encouraging breastfeeding by Guatemalan mothers. One study she conducted showed that while 85% of urban mothers breastfed their infants, they rarely ever breastfed them exclusively.

It is important to breastfeed newborns for their first six months to build their immune systems.

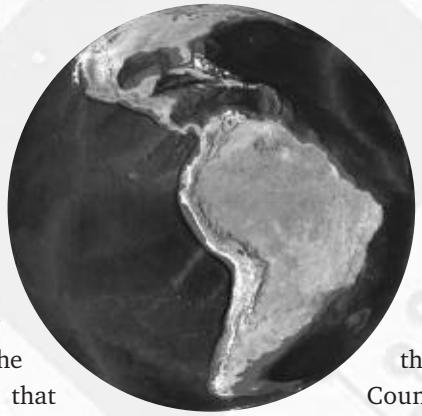
It is important to breastfeed newborns exclusively for their first six months because the practice can help shore up the child's immune system against diseases, which is especially important in regions where sanitation is lax, Montenegro said. Mothers who give their infants the local water expose them to diseases instead. "If it's not well-washed and disinfected," she explained, "the child gets infected and gets diarrhea."

She said doctors and health practitioners in Guatemala don't always reinforce the scientific guidelines about exclusive breastfeeding and adequate feeding practices, and that's part of the problem. The best they could do is try to reinforce their knowledge with public and person-to-person talks for mothers, Montenegro said. Guatemalan mothers in urban low-income communities also often start having children too young, and the only way to fix it is with educational programmes, said Montenegro. "The moms are interested in knowing. They ask you many things that you can answer. So I think it's important that you educate people." ■

Sean Treacy

CONNECTING TO LATIN AMERICAN SCIENCE NETWORKS

TWAS RESEARCH FELLOWS ARE FINDING THAT POSTS IN LATIN AMERICA, THOUGH SOMETIMES FAR FROM HOME, ARE ADVANCING THEIR WORK ON AGRICULTURE, HEALTH, POLLUTION AND OTHER FIELDS.



For young scientists at the early stages of their careers, access to a mentor with a lifetime of experience and knowledge is priceless. But, while such brilliant minds in every scientific field live and work throughout the developing world, promising young scientists don't always have the financial resources they need to tap that expertise.

Latin America is a region rich with expertise in many fields, where young scientists from all over the world can nurture their scientific knowledge, establish professional bonds and gain a challenging but irreplaceable new experience living and working in another country – even another continent. TWAS gives young scientists such opportunities through its postdoctoral and PhD fellowships. These programmes allow young scientists from one developing country to conduct research in another nation in the South with equipment and mentorship that would normally be unavailable to them.

The Academy awards these fellowships in partnership with numerous organizations globally, two of them in Latin America: the National Council for Scientific and Technological Development (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*, or CNPq), in Brazil, and the National Science at Technology Council (*Consejo Nacional de Ciencia y Tecnología, or CONACyT*) in Mexico. These councils provide living expenses and TWAS provides travel support and incidental local expenses.

Four postdoctoral scientists – from as far away as India and Egypt – show how TWAS research fellowships in Latin America are advancing science throughout the world.



FIGHTING FARM PESTS WITH THEIR OWN DISTANT KIN

An Egyptian mite taxonomist in Brazil

Bright-yellow, web-spinning creatures called two-spotted spider mites are an unwelcome visitor in many farms. They're found on undersides of leaves and feed on plants through needle-like mouthparts that pierce the plant's tissue and suck out its sap. If the mites grow out of control, the leaves fall off and the plants die. The mite is found in both fields and greenhouses, devouring everything from trees to fruit and vegetable crops.

How can farmers keep these pests under control? One answer is predatory mites, such as *Phytoseiulus persimilis*, a reddish little creature that pounces on spider mites and feasts on them. Farmers can buy small packets of the helpful mites and empty them on the leaves of plants infested with harmful mites. The more predatory mites researchers identify, the more weapons farmers have in the battle to save their crops.

Egyptian mite taxonomist Reham Ibrahim Ahmed Mohamed Abo-Shnaf looks for, studies and describes new species of predatory mites. Crop-eating mites are a problem for Egyptian farmers, and Egyptian scientists have historically been interested in predatory mites as a solution. Over 50 phytoseiid species have been reported from Egypt, as well as about 25 species of other mites. But Egyptian researchers who have been studying them for decades are either retired or about to retire, said Abo-Shnaf, so there is a need for younger researchers to fill those gaps.

Abo-Shnaf said she is particularly fond of taxonomy and happy to help resolve a problem in her home country. "In Egypt we have a lot of companies producing predatory mites for biological control", Abo-Shnaf said. "Also they can be exported abroad to different countries."

Abo-Shnaf is getting the experience she needs through her postdoctoral fellowship at the Universidade de São Paulo, Brazil. At the Brazilian lab, Abo-Shnaf uses a large library with detailed descriptions of species from all over the world. To identify new species of mites, she compares her specimens to the descriptions of all species of a related genus. If the mite is unique enough, she asks her supervisor to confirm her suspicions that it's a different species before labeling it such.

So far, she has discovered four species of predatory mites farmers can explore using as crop guardians: two from the Rhodacaridae family, which tend to live in soil and decaying organic matter, and two from the Phytoseiidae family, which especially love to eat spider mites. She has one paper submitted to the journal *Zootaxa*, describing the Rhodacaridae mites, and the second study on the new Phytoseiidae mites is still in progress. Her fellowship began in January and will last until the end of February 2014.

She said she has acquired invaluable knowledge from the fellowship, in particular from working with professor Gilberto José de Moraes, a world authority on mite control and taxonomy. "This fellowship is very useful for me because I have the opportunity to learn and know more about taxonomy under a famous professor", Abo-Shnaf said. She said the fellowship also provides her with a well-equipped laboratory, which includes microscopes connected to computers that can photograph the mites she's studying.

A FUNGUS TO TARGET DISEASE-CARRYING MOSQUITOES

An Indian entomologist in Brazil

Diseases such as malaria, dengue, and chikungunya fever have proven to be maddeningly stubborn foes for doctors and biologists, who are constantly seeking new ways to keep the mosquitoes that carry them under control.

One such possibility is a fungus called *Metarhizium anisopliae,* which has a devastating effect on the disease-carrying mosquitoes such as *Aedes aegypti* and *Anopheles stephensi*. The green-coloured fungus infects all mosquito stages. The insects cannot handle the fungus growing out of control in their bodies, and die.

Siva Kamalakannan is an entomologist from the Bharathiar University, Coimbatore, in India and specializes in pest control with botanical insecticides. Through a TWAS fellowship at *Instituto de Patologia Tropical e Saúde Pública* at the *Universidade Federal de Goiás in Goiâina*, Brazil, he researches ways to improve the fungus' ability to infect mosquitoes so that it can kill as many mosquito larvae as possible. This fungus infects over 200 insect species, including termites, locusts and – most critically – mosquitoes. "As early as 1879, fungi from this genus were being evaluated for control of wheat chafer beetles, *Anisoplia austriaca*, and sugar beet curculio, *Cleonus punctiventris*, in Ukraine", said Kamalakannan.

Kamalakannan and his colleagues in Brazil are working on formulations of *M. anisopliae* associated with insecticidal plants in order to develop effective weapons against mosquitoes that are inexpensive to produce.

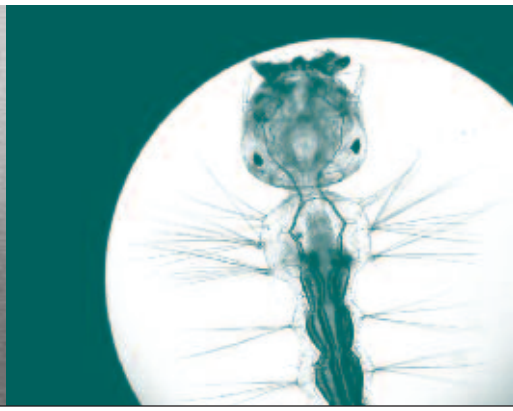
Anopheles stephensi, a major malaria carrier in India, and its larvae are commonly found in storage water and rain pools. *Aedes aegypti* transmits dengue fever and chikungunya, which are major problems in Kamalakannan's home country of India. Kamalakannan noted that there were more than 11,000 suspected cases of chikungunya in 2012 in India, and that the dengue virus has been on the rise in southern India since 2010.

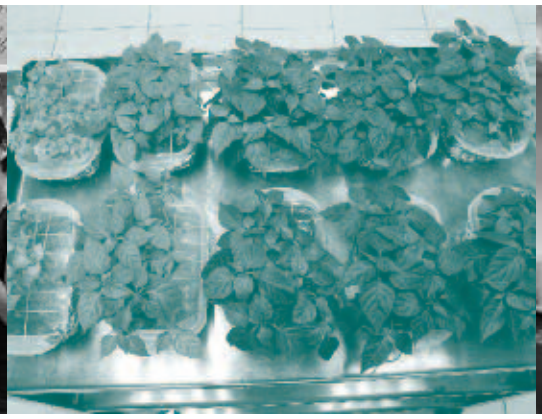
Kamalakannan's work focuses on combining the use of infective spores with plant products that also kill mosquito larvae. Specific plant compounds, such as azadiractin from the Neem tree that is native to much of South Asia, increase how vulnerable the larvae are to fungal infection, and these new formulations will be more effective against the larvae at breeding sites compared to conventional biological larvicides.

> ***Mosquito larvae cannot handle the fungus growing out of control in their bodies, and die.***

At *Universidade Federal de Goiás*, Kamalakannan has the opportunity to work under supervision of experienced scientists such as Wolf Christian Luz and Éverton Kort Kamp Fernandes. "This fungus kills eggs, kills larvae, and kills adults", said Luz. "The purpose of the formulation in Kamalakannan's studies is to increase the effectiveness and survival of the spores in the water, and their contact with aquatic larvae."

Kamalakannan also has access to high-quality equipment for specific formulation techniques, which is essential for the development of new, innovative larvicides. "People in Brazil are nice and it's an important experience", said Kamalakannan.




GETTING THE MOST OUT OF A POPULAR FERTILIZER

A Cuban agricultural biologist in Mexico

The habanero pepper is one of the most widespread crops in the Yucatán region, and researchers are looking for ways to yield more peppers. Through a TWAS fellowship, María de Lourdes Villalonga Santana of Cuba was able to go to the Yucatán and study the effects of this new approach to supplying habanero peppers with nutrients at *Centro de Investigación Científica de Yucatán* (CICY) in Merida, Mexico.

Villalonga and her colleagues are studying urea, an important fertilizer rich with nitrogen that plants need, and urease, an enzyme that prompts urea to decompose and release nutrients into the soil. The aim of her research is to create an agricultural tool that will increase the fertility of soils by increasing the concentration of urease, getting more urea to decompose and providing habanero plants with more nutrients.

Villalonga hopes her research will also help agriculture in her home country of Cuba.

One way to get a molecule like urease to do what you want it to do is to make it more stable, and one way to make it more stable is trap it in a little molecular cage. When contained in a tight area, the molecule is easier to control in conditions that would normally degrade it and make it less useful, such as high temperature.

So Villalonga and her colleagues drip urease and sodium alginate slowly into a calcium chloride solution, which then turns into calcium alginate capsules – small spheres about 5 millimetres wide – that catch the urease enzyme in the middle. "These capsules are soft to the touch but resistant, similar to small rubber balls", said Villalonga.

They studied the effects of immobilized urease on the pepper plant's growth in a lab, and found that the capsules improved the effectiveness of the urease. The next step, she said, would be to test the immobilized urease in the field.

Studying habanero peppers is a unique experience, she said, because scientists currently know little about how habanero pepper plants absorbs nutrients on the chemical level, and how those nutrients influence the growth of the plant. She hopes her research will also help agriculture in her home country of Cuba, and thinks a variety of legume and grass crops that are spread thin over a wide area agriculturally could serve as starting point. "With the experience gained at CICY, I can conduct similar research in agricultural crops of interest for my country", said Villalonga.

Villalonga said she enjoys working in Merida. "That city always fills me with satisfaction", she said. "The people there always make me feel at home."

"The stay of Dr. Villalonga in my work group was very successful", said Ileana Echevarría Machado at CICY. "She could learn methodologies that until then had not been made and also conveyed all her experience to the group, strongly supporting the training of master and doctoral students."

STRIPPING THE MYSTERY FROM A COMMON POLLUTANT

A Nigerian toxicologist in Brazil

What do rubber, carpets, glues, flame retardants, pesticides and plastics have in common? Factories that produce those items also produce 4-vinylcyclohexene, also known as VCH, which scientists suspect might cause infertility in women.

Factories directly release VCH into the air, soil and water through waste streams. It also slips into water supplies indirectly because it doesn't biodegrade quickly in soil. Once VCH gets in the water, it's consumed by fish, which are then eaten by people. Occupationally, workers may take in VCH through inhalation or contact with the skin at factories where it is generated as a byproduct.

When VCH comes in contact with living organisms, the living cells chemically convert them to related toxic molecules called VCM and VCD. Scientists have already shown that these compounds are toxic to ovarian follicles in female rats.

Biochemist Amos Abolaji from the Biochemistry Department of the University of Ibadan, Nigeria, has a TWAS postdoctoral fellowship that supports his research at the Federal University of Santa Maria in Brazil on the effects of these three chemicals, which are produced not just in Nigeria but in developed or developing countries throughout the world. "Ovarian follicles are the basic units of the ovary", he said. "They are made up of spherical aggregations of cells and they contain a single oocyte, or immature egg. Any agent that is toxic to the basic unit of the ovary, the follicles, will affect the egg."

Abolaji is testing those three chemicals on fruit flies. Fruit flies are a popular model organism because they have about 75% of the disease-causing genes that humans have, Abolaji said, and they're also easy to care for and reproduce rapidly. The goal is to understand just how these chemicals interact with ovaries. So he mixes the chemicals into the flies' food and watches what happens.

The research is ongoing. For now, they have found that VCH, VCM and VCD reduce the fruit flies' survival rate after as few as seven days of exposure. They also found that VCH reduced the fruit flies' levels of acetylcholinesterase, an enzyme that influences communication both between nerve cells in the brain and where nerves interact with muscles. "If the activity of this enzyme is inhibited by toxicants, the normal functioning of the brain will be altered", said Abolaji. That, in turn, could affect ovaries, which receives instructions from the brain to produce estrogen and progesterone, hormones needed for reproduction.

Working on this research topic entails the use of expensive substances that are difficult to obtain, and Abolaji said he was thankful for the opportunity through the fellowship. "Working at the Federal University of Santa Maria afforded me the opportunity to use facilities not available in Nigeria", he said. "I am also privileged to interact and learn from my supervisor, Professor João Batista Teixeira da Rocha and other seasoned academics at the Federal University of Santa Maria. They are all very open, accommodating and willing to assist."

Rocha, who is Abolaji's supervisor, praised his strong motivation, adding that it reflects past Nigerian students whose work was hosted by his lab. "We are also expecting to do a more stable collaboration with Dr. Abolaji after his return to Ibadan", Rocha said. ■

Sean Treacy

A HOME FOR STAR-GAZERS IN LATIN AMERICA

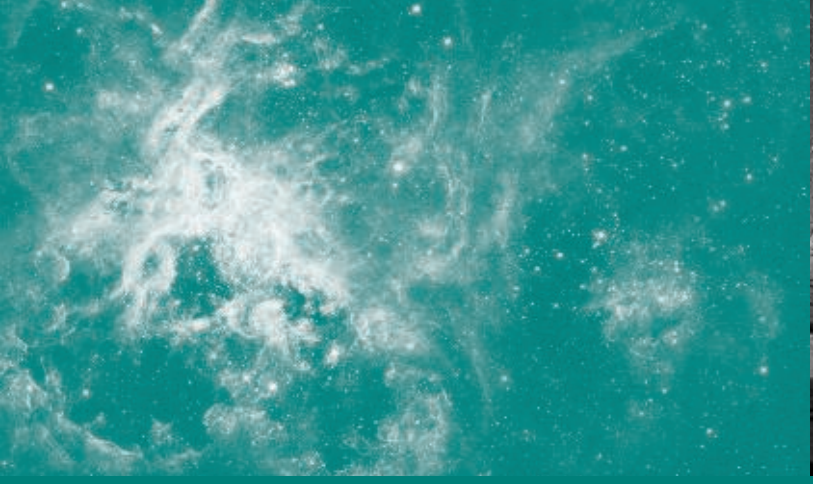
PERFECT SKIES MADE CHILE A GLOBAL CENTRE FOR TELESCOPE SCIENCE. NOW THE COUNTRY IS WORKING TO MAKE ASTRONOMY A PERMANENT PART OF ITS DEVELOPMENT STRATEGY

Northern Chile's clear skies and high altitudes have drawn high-tech telescopes from international astronomy agencies all over the world, but for a long time the country's role as a host has largely been a matter of its optimal view of the cosmos. Now Chile is actively trying to ride the wave of telescope technology and astronomy to enhance its scientific development.

Chile's expanding role as a host of international telescopes started with the US-managed Cerro Tololo Inter-American Observatory in 1965. Since then, consortiums of nations in the developed world and Latin America have built numerous state-of-the-art telescopes in the deserts and mountains of Chile. Europe's Very Large Telescope, located on Cerro Paranal, a mountain in Chile's Atacama Desert, is one of the most productive tools in all of astronomy. Chile also hosts the largest-ever international radio telescope project, the Atacama Large Millimetre Telescope (ALMA), built in a partnership with Europe, the United States, Canada and East Asia. ALMA has been fully operational since March.

Plans are underway for huge new projects such as the European Extremely Large Telescope (E-ELT), which represents an investment of roughly 1.5 billion euros and is scheduled to begin work in the early 2020s. Meanwhile, the United States, Australia and Korea hope to finish the Giant Magellan Telescope at about the same time. Also in operation is the Gemini project, an international agreement involving a consortium of the United States, United Kingdom, Canada, Argentina, Brazil, Australia and Chile. One of the telescopes for that project is located in Hawaii, the other in Chile.

By the beginning of the next decade, Chile will have as much as 70% of the surface area of the world's scientific telescopes, predicts Mónica Rubio, the astronomy



Left: A composite image of the Tarantula Nebula from Hubble Space Telescope and the European Southern Observatory in la Silla, Chile (Photo: NASA/ESA). Right: The Atacama Large Millimeter Array under the night sky in the Atacama Desert in Chile (Photo: ESO).

director of Chile's National Council of Science and Technology *(Comisión Nacional de Investigación Científica y Tecnológica, CONICYT)*. Since the 1960s, international astronomy agencies have shipped in telescope parts from across borders, said Rubio, and one of her objectives is to include more astronomers and engineers at Chilean universities in the planning and construction of telescope parts. One group at the University of Chile's Millimetre Wave Laboratory designed a prototype of a receiver – a sensitive instrument that detects radio waves – that could eventually be placed in each of the giant dishes that comprise ALMA. Another group at *Pontificia Universidad Católica de Chile* in Santiago is developing spectrometers for E-ELT.

The change began with the creation of the astronomy programme at CONICYT and the Chilean government's decision to make astronomy a strategic area for the country's development, Rubio said. CONICYT also prepared a 'Roadmap for the Fostering of Technology and Development and Innovation in the Field of Astronomy in Chile', a plan to bridge academic astronomy with industry in ways that could lead to economic growth.

CONICYT's astronomy programme focuses on increasing the number of astronomers in Chile, spreading awareness of the potential astronomy has for the development of new technology locally, and getting the funding to support those two goals. "It has been very successful", said Rubio. "We have been able for the first time to have a line in the national budget – USD1 million specifically for astronomy, created in 2012, and it was duplicated for 2013."

Furthermore, 10% of all telescope time in any telescope located in Chile is granted to Chilean astronomers, which is part of the negotiated agreements between Chile and the international organizations that run the telescopes. Chile has also reached out to other nations interested in taking advantage of its new leadership in the field. The University of Chile has had or currently has astronomy students from Colombia, Brazil, Argentina, Italy, France, Nepal and India.

Chile has also begun a new partnership with China, and signed an agreement last August with the Chinese Academy of Sciences to collaborate on a new Chinese-Chile joint astronomy centre, with headquarters in Beijing and Santiago, the capital of Chile. This way, China's budding astronomers will have the chance to learn from Chilean experts in the field. "China has decided to put USD2 million to 3 million per year to establish this centre. We're expecting we can co-fund the centre in 2014", Rubio said. "The Chinese astronomers have also expressed interest in building a telescope here in Chile some time in the future."

THE BIG BANG OF ASTRONOMY IN CHILE

In the 1960s, Rubio said, the first generation of Chilean astronomers received their PhDs abroad, and when they came back, began to develop astronomy departments at their universities. "Until 2000, the number of Chilean astronomers was about 30. Only two institutions had astronomy and they had masters programmes."

The astronomy field itself has grown rapidly within Chilean universities in recent years. When Patricio Rojo, the current president of Chile Astronomical Society,

Left: A rendering of the planned The European Extremely Large Telescope on Cerro Armazones in Chile's Atacama Desert (ESO/L. Calcada). Right: Globular star cluster 6362 captured by the MPG/ESO 2.2 metre telescope at La Silla Observatory in Chile (ESO).

was working on his master's degree in astronomy in 2000–2001 within a physics programme at the University of Chile, he was the only astronomy student there. "It was a very old programme, but the rate of students aware of astronomy was very low", he said. "It was not unusual to have a class of one or two students that meet at the professor's office."

But there was a boom in astronomy the year after, and the programmes filled with students when astronomy awareness in the country started changing. "Now it's just a more lively environment. There are more scientists, more talks. You can interact with people from all over."

That surge in local astronomers has led to even more astronomy science coming out of Chile, Rojo said, which in turn leads to even more public interest in astronomy. "I think it was all promotion, making colleagues and people aware that in Chile we are doing science and have the best telescopes in the world", said Rojo. "We cannot yet compare ourselves to first-rank universities from abroad, but we're going in that direction."

Rubio agreed with that sentiment. From 2005 on, she said, has been like "the Big Bang of astronomy in Chile". Now the country has about 150 astronomy PhDs, about 100 of them with faculty positions at 11 Chilean universities. They also host about 80 to 100 graduate students and 500 undergraduates in astronomy.

THE POWER OF PUBLIC SUPPORT FOR SCIENCE

The main way that astronomy drives scientific development is through its popular appeal, said Daniel Altschuler, who directed the National Astronomy and Ionosphere Centre's Arecibo Observatory in Puerto Rico for 12 years. Altschuler is also the author of *Children of the Stars: Our Origin, Evolution and Destiny* and an advocate for more engagement between scientists and the public.

There has been continuous excitement building about the growing number of telescopes in Latin America, he said. Chile can offer astronomers one of the best night skies in the Andes, and in return Chile and other Latin American countries can benefit from the spinoff growth of professional astronomy, astrophysics and the general public's awareness and understanding of science. But that spinoff is not the only benefit.

What is important is not so much the particular science but the scientific way of solving problems, said Altschuler. "It serves as an excellent means of recruiting not only future astronomers, but future scientists who might become interested in aspects of communications, data analysis and engineering, which are also an important part of astronomy."

Among the headline-grabbing discoveries in astronomy recently is the increasing number of discoveries of extrasolar planets, some of which have been found through Chilean telescopes. It's compelling not just because we're expanding humanity's knowledge of the universe, Altschuler said, but because of the philosophical implications of discovering other worlds that can support biology.

"We have hundreds of extrasolar planetary systems", he said. "Once you have the planet, the next question is: Is there anybody on those planets?" ■

Sean Treacy

FROM COLOMBIA, A LESSON IN RESILIENCE

A NEW BOOK FROM TWAS AND COMSATS PROFILES COLOMBIA'S *CENTRO INTERNACIONAL DE FÍSICA*, WHICH HAS ENDURED AS A MODEL OF EXCELLENCE DESPITE SHIFTING FINANCIAL AND POLITICAL CONDITIONS.

The story of the Centro Internacional de Física in Bogotá, Colombia, is a story of creative adaptation by a research organization, even when it is confronted with financial, social and political challenges. Despite conditions that were never easy, and often quite difficult, it has emerged as one of the leading research centres in Colombia and in Latin America. A new book in the TWAS 'Excellence in Science' series credits two broad factors for its success: Innovative research that adapts to a changing landscape, and the dedication and perseverance of its researchers.

The Centro – CIF, for short, and, in English, the International Centre for Physics – emerged from a humble and uncertain beginning to make an impact throughout science and engineering in Colombia. The evolution of this research centre reflects a recognition: to survive in a difficult environment, you sometimes have to follow opportunities wherever they take you – while assuring that your science is always strong.

Today, its work ranges from fundamental questions on pure physics to optical and material sciences, to agriculture, infectious disease and the effects of climate change. And it has had an important impact designing and producing devices for the industrial and energy sectors.

The new book is published with support from COMSATS, the Commission on Science and Technology for Sustainable Development in the South, an inter-

Left to right: Eduardo Posada, director of the Centro Internacional de Física (CIF) in Colombia; CIF has helped panela (brown sugar) producers improve their processes; a researcher in the CIF Environmental Biotechnology Group; a researcher at work in CIF's nursery.

governmental organization established in 1994 and headquartered in Islamabad, Pakistan. It is the 12th book in the 'Excellence in Science' series, which debuted in 2007. It is the second published with the support of COMSATS, which represents 21 member states and 18 centres of excellence; the organization works to promote South-South cooperation in the fields of science and technology that are most relevant to socio-economic development.

The new book and past volumes in the series are available both online as PDF files for download from http://tinyurl.com/twas-comsats-cif and as softbound paper edition (upon request to info@twas.org).

Why was CIF selected to be part of these series? Perhaps a quote in the book by CIF Director Eduardo Posada offers a clue: "Quality is the key", he said. "We have been able to have high-quality groups that do high-quality research."

CIF shows the world how research drives innovation and economic growth.

The book details a remarkable file of accomplishments by CIF and its faculty: 220 international and national research publications; 80 industrial products; 80 finished projects; 40 national cooperation agreements; and 140 trained scientists.

It was physicist Abdus Salam, the Pakistani Nobel laureate, who inspired Posada and two other CIF founders, pioneering Colombian physicist Humberto Rodríguez and Italian theoretical physicist Galileo Violini. Salam was the founder of the International Centre for Theoretical Physics and TWAS, both based in Trieste, Italy, and both organizations have maintained ties with CIF since its founding in 1985.

The new book covers the CIF's history, with a candid assessment of some obstacles that researchers and its director have overcome through the years, and it explores in detail it's varied lines of research and development.

In biophysics, CIF scientists work on leishmaniasis, a tropical disease which affects about a thousand people of Colombia every year, trying to understand how the parasite invades the host cell.

For almost a decade, a group of researchers studied cosmic background radiation by measuring it from a radio telescope located in Colombia. This lab was associated with the group led by Nobel Prize winner George Smoot at the University of California at Berkeley.

In the 1990s, CIF was the first in the country to produce holograms for the art and business sectors. The optical research focuses currently on sophisticated devices such as Lidar (Laser Interferometry Detection and Ranging). The materials science group produces and grows thin films which can be used in optics and engineering. Recently it has been working in the development of nanotechnology-based materials.

CIF researchers also work with Colombian farmers and ranchers, applying science to local practices for producing panela (brown sugar) and reducing pollution from palm oil production. A local farmer who worked with CIF raved about the collaboration: "Panela producers have now a better business, because we learned how to manage the whole system, from plagues and water to sowing sugar cane. We have now a better quality of life."

Aware of the consequences of climate change, scientists are helping cattle ranchers and coffee growers to develop strategies to adapt and protect water resources. As a result of biotechnology research, CIF got a patent for the development of a vaccine-like treatment for plants, based on the biochemical mechanisms used by flowers to resist pathogens.

CIF has pioneered industrial innovation as well. Several devices have been designed by its engineers and physicists, mainly for Colombia's electricity producers. For example, CIF scientists have worked to develop equipment for monitoring the quality of electrical energy. It has also worked with industry to develop monitors which check the levels of hazardous methane gas in coal mines, and on a system for collecting the methane for use as fuel.

CIF is the 'father' of some startups such as Teclaser, a firm based in Bogotá, founded in 1997, which began with an old but usable laser machine that made precise cuts to different type of materials. Teclaser was the first company that offered this service to Colombian metal-mechanic industries, as well as to business sectors ranging from plastics and wood to advertising and architecture.

Today, successful spin-offs provide a crucial part of CIF's revenue, along with funds from the public sector and industrial projects.

In Posada's view, three decades are just the beginning. TWAS Executive Director Romain Murenzi agreed. "Over the next 30 years, CIF, COMSATS and organizations like them will play a vital international role", Murenzi writes in the book's foreword. "They are models and guides for less developed nations, and they show all the world how research drives innovation and economic growth and improves human lives." ■

Lisbeth Fog

DISASTER PLAN: LOCAL KNOWLEDGE, THE LATEST SCIENCE

EARTHQUAKE, DROUGHT, CLIMATE CHANGE – IS THERE A BLUEPRINT FOR POLICYMAKERS TO FOLLOW BEFORE DISASTER STRIKES? THE CATALYST PROJECT HAS ANSWERS.

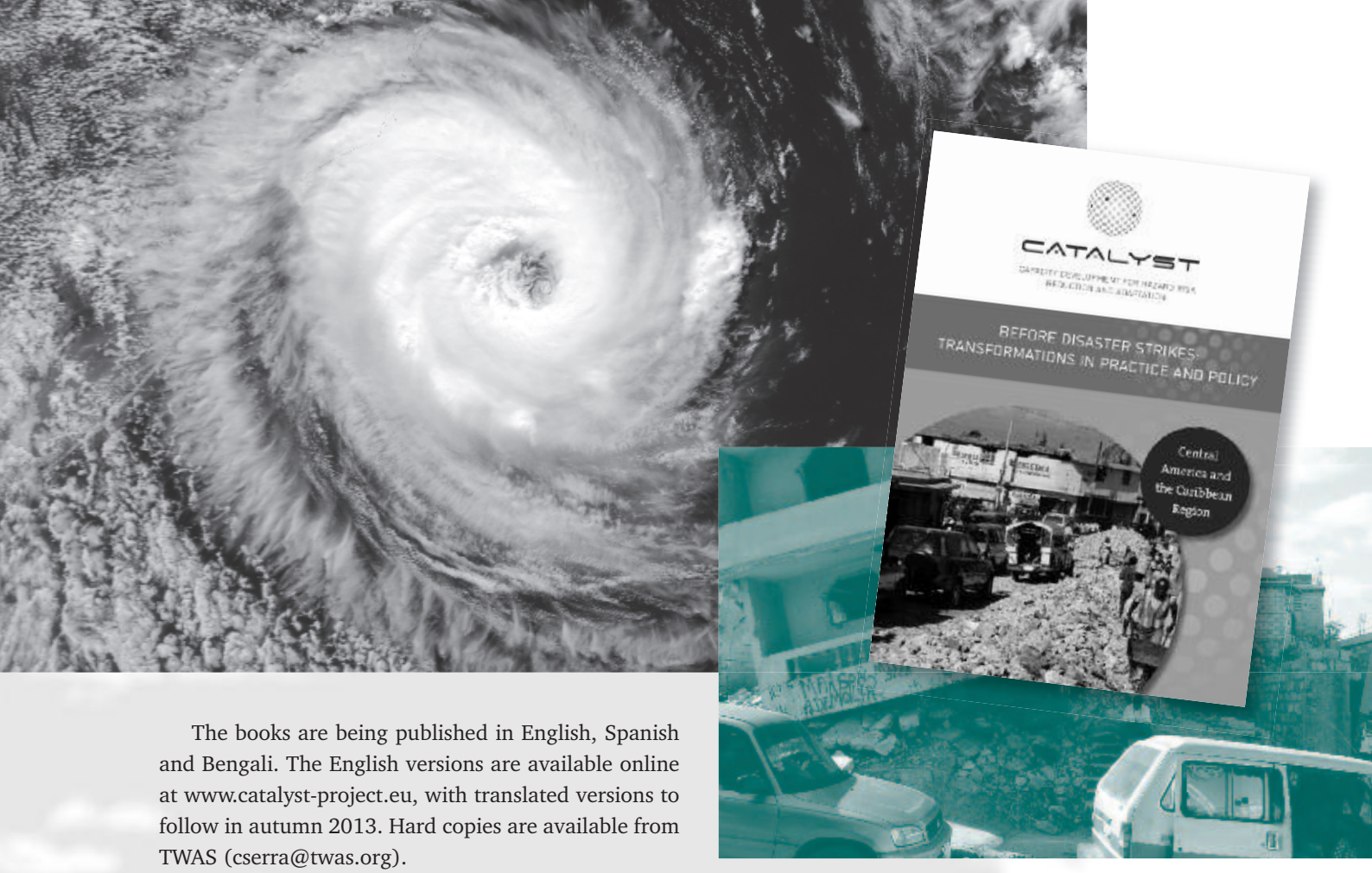
What to do with coconut husks? In many developing nations, the custom often is just to dump them, with little concern for the impact on the local environment.

The Central American nation of Guatemala, among the world's hot spots for biodiversity, shares this kind of problem with other Latin American countries. In addition, it faces food insecurity and has to cope with inadequate agricultural policies and environmental degradation.

But Guatemalan leaders have recently conceived a productive use for the husks that can actually strengthen the environment, while creating jobs and artisanal products. Its experience is cited in a new report from CATALYST, an international initiative funded by the European Commission Seventh Framework Programme (FP7) that identifies knowledge about best practices in capacity development for hazard risk reduction and adaptation.

As the culmination of a two-year effort, CATALYST has released best practice papers focused on four hazard-prone regions: Central America and the Caribbean; South and South-East Asia; East and West Africa; and the European Mediterranean region. A practical summary is also being prepared, with all communication work being coordinated by the TWAS Public Information Office.

The best practice papers conclude a project involving seven European partners, under which CATALYST collected and evaluated the most successful strategies for disaster risk reduction and climate change adaptation. The information is now being used to strengthen disaster preparation and response by local policymakers, educators and non-governmental organizations.



The books are being published in English, Spanish and Bengali. The English versions are available online at www.catalyst-project.eu, with translated versions to follow in autumn 2013. Hard copies are available from TWAS (cserra@twas.org).

The CATALYST project has followed a participatory framework, featuring input from scientists, local experts, business leaders and others, in an intensive, highly collaborative process. CATALYST is led by seven European partners: seeconsult from Germany; Alterra from The Netherlands; Fondazione Eni Enrico Mattei from Italy; the Geological Survey of Denmark and Greenland, from Denmark; Helmholtz Centre for Environmental Research (UFZ) and the United Nations University, both from Germany; and TWAS from Italy. The partners have worked closely with CATALYST's Think Tank members, a multi-regional group of 130 experts, to compile and analyse the best available knowledge.

Caroline van Bers from seeconsult, a company that supports participatory planning for the environment, coordinated the project with colleague Matt Hare. "CATALYST does not create new knowledge", van Bers said. "Instead, it is responding to the latest Intergovernmental Panel on Climate Change (IPCC) report by collecting and synthesizing the knowledge that already exists and packaging it so it can be of further use for practitioners, before disaster strikes."

GOOD PRACTICES TO BEST PRACTICES

Imagine a community accustomed to recurring disasters, and to responding with homemade strategies. Then imagine scientists who provide this community with state-of-the-art knowledge and technology; their aim is not to override local knowledge, but to complement it. The result could be a shift in the way communities and countries deal with hazards that can save lives and reduce damage and costs.

That's the idea that underpins CATALYST's best practice papers. The team first focused on Central America and the Caribbean region, and identified a few best practices that could be improved to provide more consistent results in managing natural disasters.

Guatemala is a land of mountains cloaked in lush forests and jungles, deserts, hilly valleys and beautiful coastlines. But this is also hurricane country, where the stress of repeated disasters is intertwined with pervasive social, economic and political problems.

In the southern part of the country, the Christian Communities of Support (*Comunidades Cristianas de Apoyo*) – part of the wider Network for the Manage-

ment of Risk and Climate Change Adaptation – is finding that coconut husks can be part of the solution to environmental degradation, poverty, and social stress.

Unemployed youngsters collect discarded coconut husks and then grind them to extract the fibers. Women from the community use these fibers to produce sandals and vases which can be sold in local and foreign markets (see the Terra Coco Facebook page at http://goo.gl/IdqSu5). They can also be put to another use: Braided into long, tough nets that are then employed to stabilize the slopes of the hills nearby. These land nets additionally help to reduce soil erosion and retain soil moisture and fertility, thus reducing the risk of landslides.

Healthy ecosystems are crucial for healthy cultures.

"This kind of intervention also reflects the cultural heritage of a region, which must be kept in mind when devising strategic interventions for disaster reduction", points out Elisa Calliari, researcher at Fondazione Eni Enrico Mattei in Venice, one of the CATALYST's partners.

The unique features of this small community, as well as their indigenous knowledge, serve to strengthen the livelihood of many, often marginalized, families, youth and unemployed people.

USING ECOSYSTEMS TO LOWER DISASTER RISKS

Imagine a green meadow with lush trees with abundant fruits. Now think of the same meadow turned into a dumping ground for garbage. Especially in developing countries, impoverished people often feel they can't afford to care much about the environment.

But healthy ecosystems are crucial for healthy cultures. They can be a sustainable source of food, medicine, fuel, building materials and tourism revenue. They can act as natural barriers that help protect people from storms, floods, and droughts. Unfortunately, the importance of natural ecosystems tends to be underestimated by policy- and decision-makers, who pay little attention to the gains they could derive from these ecosystems.

A number of CATALYST's Think Tank members have discussed the role of ecosystems in reducing the risks resulting from natural disasters. They have also tried to quantify the value of these natural resources, focusing on Small Islands Developing States (SIDS): small states with a small population and often weak economies that are dramatically affected when natural disaster strikes.

RiVAMP, the Risk and Vulnerability Assessment Methodology Development Project, is a good example of a cooperative effort aimed at acknowledging the importance of ecosystems. First pilot-tested in 2009 in Whitehall and Little Bay on the west coast of Jamaica, RiVAMP has developed an operational protocol to help local and national decision-makers to identify the best available options for the wise management of ecosystems in order to reduce disaster risk and cope with climate change. RiVAMP is a joint initiative of the United

Nations Environment Programme, the Caribbean Environment Programme and the UN Regional Office for Latin America and the Caribbean.

Jamaica lies in the hurricane belt of the Atlantic Ocean and is highly vulnerable to tropical cyclones and sea-level rise. Residents, however, do not rely heavily on natural environments when they seek protection during hurricanes or storms.

The RiVAMP process is based upon consultations with residents, local authorities, businesses and other local groups, who were asked to gather information on public perception of the ecosystems' role and to spot major threats to the environment. This information was then coupled with satellite imagery analysis and remote-sensing techniques to triangulate the available data and draw a precise picture of the region.

In doing so, analysts spotted some of the major threats to this area, including overfishing, destructive human practices and marine pollution; the analysis further highlighted the importance of coral reefs, mangroves and beach vegetation as natural barriers against the effects of hurricanes and storms. These rich ecosystems, if properly managed, offer protection not only to biodiversity, but also to the region's human inhabitants.

THE CUBAN MODEL

With three laws, 13 decrees, 21 ministerial resolutions and one directive on disaster risk mitigation, Cuba stands out among many Latin American countries for the effectiveness of its efforts in managing the potentially deadly natural events that periodically hit the island.

METEORO, a national simulation exercise that mobilizes local resources to mitigate risks and reduce dangers, is an example of Cuba's ability to prepare for the fury of storms. Every year in May, a simulation drill tests the island's preparedness. It takes place over a two-day training period, carried out at the national, county, municipal and community levels. Day one is devoted to providing practical information to the public on how prepare for an emergency, and to carrying out disaster response simulations. Day two is for practical preparatory activities, like checking reservoir walls, cutting tree branches, and identifying places where evacuated animals can be housed and protected.

All these activities are intended to prepare Defense Councils, company managers, local authorities and the population for sudden or violent hazard events such as earthquakes, tsunamis, high-intensity hurricanes and fires.

"The Cuban experience", points out Calliari, "demonstrates that effective disaster risk reduction is possible even in countries with limited financial resources, provided that the political will is strong enough to foresee policy priorities and mobilize resources and actions."

SEND IN THE DATA

A critical element that can make the difference, turning homemade strategies into good preparedness for natural hazard events, is the circulation of information and data, both historical and recent. As CATALYST found out, in some countries like Jamaica, the Cayman Islands and El Salvador, data sharing is quite challenging even among government organizations. Saint Lucia, a sovereign island country in the eastern Caribbean Sea on the boundary with the Atlantic Ocean, launched its first data sharing and management platform in 2012, with the support of the World Bank.

Called Saint Lucia Integrated National GeoNode, it provides a medium for agencies and institutions for sharing the spatial data they use through open-source software. National ministries and agencies are then able to add, catalogue, view and share data on the platform, and thus inform planning and decision-making on the basis of more complete information.

Following this example, other Caribbean countries like Belize, Grenada and Saint Vincent and the Grenadines are now using GeoNode to create, share and exchange geospatial data for land management and risk assessment in the region.

AND THE REST OF THE WORLD?

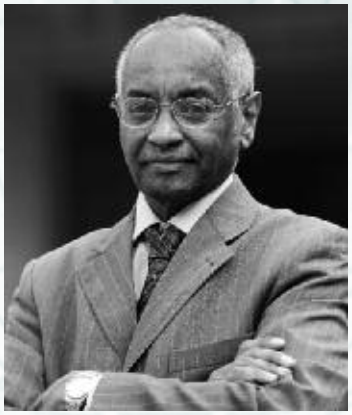
The best practice papers for the four CATALYST regions around the world have described approaches that can reduce significantly the impacts of natural hazards and climate change that governments and other stakeholders can adopt.

"Each year natural disasters affect the lives and livelihoods of millions people around the globe", says van Bers. "In 2010, for example, floods, droughts, tornadoes, tsunamis, earthquakes and landslides caused nearly 300,000 deaths and more than EUR70 billion in damages worldwide. The aim of CATALYST is to help reduce these numbers. Through a collective effort by all those currently involved and getting more organisations and communities involved, we know this is achievable." ■

Cristina Serra

A VOICE FOR SCIENCE IN THE SOUTH

THIRTY YEARS AGO, THE FOUNDING OF TWAS WAS MET WITH UNCERTAINTY AND, IN SOME QUARTERS, SKEPTICISM. BUT FOUNDER ABDUS SALAM HAD A DREAM THAT COULD NOT BE HELD BACK. REFLECTING ON THE ACADEMY'S BIRTH AND EARLY GROWTH, MOHAMED H.A. HASSAN, TWAS'S LONG-TIME EXECUTIVE DIRECTOR, EXPLORES KEY CHALLENGES – AND SUCCESSES – IN THOSE YEARS.



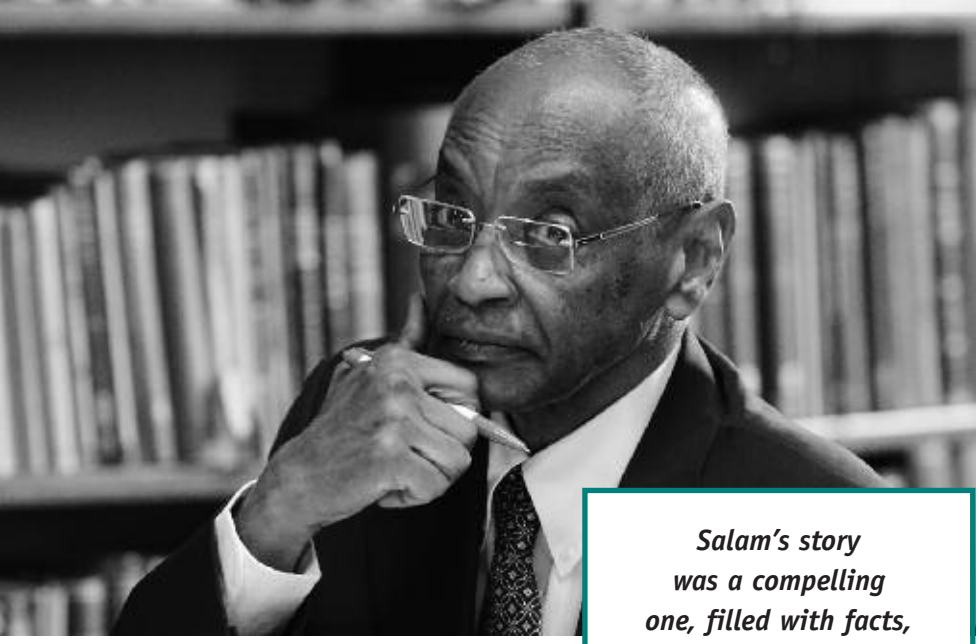
Working as a young mathematician at the University of Khartoum in Sudan in the early 1970s, I certainly knew about Abdus Salam. Virtually every physicist did. As a pre-eminent researcher and an untiring advocate for science, Salam was an iconic figure – the personification of what a scientist could and should be. He was not, however, someone whom I ever thought I would meet.

But that's exactly what happened in 1974, when during a trip to Europe, on behalf of my father, I travelled to Trieste, Italy, to visit the International Centre for Theoretical Physics (ICTP), the renowned physics research and training institute that Salam had created in the early 1960s.

I arrived at the ICTP at about 5:30 in the afternoon. The staff had left for the day. The campus was virtually empty. I entered the main building, took the staircase to the second floor and turned towards the director's office. The door was ajar. To my surprise, I saw Salam sitting at his desk. He looked up, said hello and motioned for me to come in.

At the time, I was a lecturer of mathematics at the University of Khartoum in Sudan. I had received a doctorate degree from Oxford University in the UK in 1973 and had returned home to begin what I hoped would be a rewarding career as a teacher and researcher. However, like many other young researchers in the developing world, I soon felt a discouraging sense of isolation.

Growing doubts about my future had prompted my trip to Europe. My father was a successful businessman



Mohamed H.A. Hassan in his current role as TWAS treasurer during the TWAS Steering Committee meeting in February 2013.

Salam's story was a compelling one, filled with facts, figures and, most importantly, people.

in Sudan. He had asked me to go to Europe to purchase machinery for his soap factory in Khartoum. I was fortunate because working with my father was always an option if I did not succeed as a university research professor. In my mind, discussions at the ICTP would likely be my best last hope to remain in science.

Salam and I spoke for more than an hour that afternoon. We continued our conversation the next morning. I was astonished by the amount of time that Salam gave me. Surely, I thought, he had more important things to do. I subsequently discovered that his deep concern for others was not only a reflection of the person he was but also one of his greatest attributes. He never forgot the difficulties that he had faced as a young researcher: The professional isolation he experienced in Pakistan, the loneliness he endured in the UK, and the need to choose between his dedication and love for his family and his dedication and love for science.

His ability to weave his own personal narrative – replicated in the experience of others – into a broad tapestry about trends in science in the developing world helps to explain why he was able to succeed on so many levels. His story was a compelling one, filled with facts, figures and, most importantly, people. Despite his enormous intellect, Salam spoke from the heart.

Drawing on his detailed knowledge of university conditions throughout the developing world, Salam said I had two options if I wanted to continue my career in science: I could change my field from plasma physics to high energy physics and transfer to the physics department at the University of Khartoum, which had retained an excellent reputation in high energy physics, or I could remain a member of the mathematics faculty.

Regardless of the path I chose, Salam strongly suggested that I should apply to be an ICTP Associate, which would enable me to visit the centre on a regular basis.

As an ICTP Associate, I traveled to Trieste several times over the next few years – breaking my isolation at home and introducing me to a larger network of scientists abroad. Salam's intervention at this critical juncture in my career steered me from my father's business ventures. To Salam's delight (and mine as well), I would not be lost to the business world.

In 1982, I joined several other faculty members in convincing the University of Khartoum to give Salam an honorary degree. This gave me another chance to see and speak with him. While day-to-day activities at the university remained dreary and difficult, my ties to the ICTP gave me a lifeline to the international research community.

It was during Salam's visit to Sudan that he told me about his plans to create an academy for scientists from the developing world. He mentioned that he had presented the idea at a lunchtime gathering of eminent scientists from the South at the Pontifical Academy of Sciences in Rome, Italy, which had taken place the year before.

Salam then surprised me by asking if I would be interested in helping him launch the academy. Without hesitation, I said yes. The truth is that I didn't have an inkling about what I was getting myself into. I barely knew what a science academy was.

A few weeks after Salam had returned to Trieste, he sent me a letter asking if I would come to ICTP for six months to help organize the 'foundation meeting' of the Third World Academy of Science (TWAS) and to begin drafting the organization's mission and statutes. Again, without hesitation, I said yes.

The first order of business was to learn about the mission, purpose and structure of other science academies so that their experience could be applied to our efforts at TWAS. During those early months I spent a great deal of time reading about academies, examining three academies in particular: the Pontifical Academy of Sciences, the UK's Royal Society and the Soviet Union Academy of Sciences.

Each sought to honour and reward scientific excellence. But each differed significantly in how it conducted its business.

Like the Pontifical Academy of Sciences, TWAS would assemble a broad international membership and engage in issues well beyond the conventional roster of in-country concerns that largely characterized national academies. Like the Royal Society, TWAS would be interested in issues related to global progress and would harbour ambitions to gain a presence on the world stage. And, while TWAS had neither the resources nor the intentions to be directly involved in the management of scientific facilities, like the Academy of Sciences of the USSR, it would be concerned about the administration of day-to-day scientific activities, seeking to draw strong links between scientific activities and economic policies.

During TWAS's first years, we all recognized that the future of the Academy depended on quickly growing its membership beyond the 42 eminent scientists who constituted its inaugural class. We soon discovered, however, that this would not be an easy task. Relatively few world-class scientists worked in the South and those who did were dispersed over an enormous area. Scientists, including those doing excellent work, were often not well-known within their own countries, let alone by scientists elsewhere. Communications in this pre-Internet age were difficult and slow. Interactions among scientists in the developing world were often scarce and sporadic.

Given these obstacles, we devised several interrelated strategies to build the Academy's membership. We asked the founding members to help us identify potential candidates. We reached out to visitors at ICTP who may have known scientists back home who were worthy of consideration. We contacted science academies across the globe, especially the largest and most active science academies in the developing world – in Argentina, Brazil, China and India – for suggestions about potential candidates. We identified eminent scientists in the North with ties to the South.

Our relentless efforts paid off. At the inaugural meeting of TWAS, held in Trieste in 1985, 39 scientists were elected as members, raising the total membership to 92.

TWAS's membership was rapidly increasing. Yet, to illustrate how difficult it was to fill the academy's ranks, it should be noted that, while the majority of the earliest members were born in the developing world, nearly half lived and worked in the North.

During its formative years, the Academy also encountered difficulties in gaining recognition from international organizations. Many advocates for inter-

Left: The ICTP Arab Friends Society presents a plaque to Abdus Salam in 1984; Mohamed Hassan is third from the left. Centre: Founding ceremony of TWAS in 1983 at the University of Trieste; from left: Mohamed Hassan, Antonino Zichichi, Paolo Budinich, Abdus Salam, Paolo Fusaroli. Right: Mohamed Hassan and Abdus Salam in conversation with participants in a workshop on biotechnology and industrial commodities in 1986.



national science did not see the need for an organization like TWAS. Their reasoning was that respected institutions were already in place to speak for international science. Confusion and duplication of effort, they contended, might follow if additional organizations, with largely the same mandates, were created. They also maintained that science was a global enterprise and dividing scientific interests into developed and developing world spheres could jeopardize the universality of the enterprise. And they expressed concerns that an institution dedicated to the interests of scientists in the developing world would have neither the expertise nor resources to abide by the scientific community's dedication to excellence.

Today, TWAS works closely with other international scientific organizations and is widely recognized as a key player in efforts to promote and advance both scientific capacity and scientific excellence in the developing world. However, during those early years, it was not clear – at least to circumspect observers – whether TWAS could shoulder any meaningful responsibilities in the arenas where it intended to operate, particularly responsibilities that were seemingly being shouldered by other organizations.

Looking back, it is clear that scientific issues of critical importance to the South were not being adequately addressed. The problem was not due to willful neglect. Instead it was the consequence of a lack of awareness. International scientific institutions simply did not have a sufficient number of scientists from the developing world among their membership to ensure that the voices of the South were being heard.

From the Academy's perspective, the issue was how to devise and implement a series of concrete programmes to address issues of critical importance to scientists in the developing world. Contrary to the view of wary critics, the Academy did not have to thread a needle within a dense fabric of competing and overlapping programmes. Instead, it had to envision a different pattern of support for a constituency that others had failed to acknowledge.

To advance this goal, TWAS organized international conferences that were meant, among other things, to promote South-South cooperation at a time when meetings and activities focusing exclusively on the concerns of scientists from the developing world rarely took place. The Academy also created an awards programme for scientific excellence in the South that was designed to recognize scientists who had received virtually no recognition for their accomplishments. And it sponsored research grants for scientists from the South, particularly young scientists, who were hard pressed to find funds.

Trifling support for science on the part of national governments and the absence of private foundations in the South left scientists in most developing countries desperate for money to sponsor their research. The TWAS research programme, supported with funds from the Italian government and later the Swedish International Development Cooperation Agency (sida), has been the

To mark its 30th anniversary, TWAS is assembling a series of oral histories from some of its most influential leaders and members. Their recollections will be published in a book next year.

Left: Abdus Salam and Mohamed H.A. Hassan in the early 1980s. Right: Abdus Salam with Chinese president Li Xiannian (left) at the opening ceremony of TWAS's Second General Conference in Beijing in 1987.

Abdus Salam welcomes UN secretary general Javier Pérez de Cuéllar to TWAS's inaugural conference on 'South-South and South-North Cooperation in Sciences' in Trieste, Italy, in 1985.

primary plank in the Academy's efforts to build scientific capacity. No other programme more clearly represents what Salam hoped to accomplish through TWAS and no other programme more clearly conveys the success it has achieved.

None of the Academy's early initiatives, which have come to define TWAS over time, could be found at other international scientific organizations. In this sense, TWAS was complementing the work of others by serving a constituency that had been largely ignored. In the process, the Academy was helping to build scientific capacity worldwide, a contribution to international science that the global scientific community came to quickly recognize and appreciate.

The Academy was also careful to complement, not duplicate, the work of ICTP, whose long-standing initiatives for scientific capacity provided the template for many TWAS programmes. For example, while ICTP focused its capacity-building efforts in physics, mathematics and related fields, the Academy encompassed the full spectrum of scientific disciplines, including biology, chemistry, environmental science and medical research. Later in its evolution, TWAS opened its membership to social scientists, too.

In a similar vein, ICTP's Training and Research in Italian Laboratories (TRIL) programme brought scientists from the developing world to research institutions in Italy – an effort that proved to be a sterling example of North-South cooperation in science. TWAS, in turn, grafted the TRIL concept onto a programme for South-South cooperation in science by partnering with pre-eminent research institutions in the developing world to sponsor research and training programmes for scientists from countries with lagging scientific capabilities.

Identifying centres of scientific excellence in the South during TWAS's early years posed enormous challenges. Convincing scientists from developing countries to travel to these institutions for training and collaborative research was even more difficult. In the 1980s, most scientists in the developing world desired to travel to the North for collaboration (a preference that persists to this day, but to a far lesser degree). They neither trusted the level of education and training they would receive in developing-world institutions nor believed that pursuing South-South collaboration in science would enhance their career prospects.

Today, South-South collaboration is a defining element in a new era of global science.

As a consequence, the Academy's initial efforts at South-South cooperation in the 1980s resulted in less than 30 participants annually. Today, the Academy, together with its partnering countries, offer more than 500 South-South research and training opportunities each year. In the 1980s, South-South cooperation was largely an abstraction – or, when viewed from Salam's perspective, a dream. Thirty years later, it is a reality and one of the defining elements of the new paradigm that is emerging in global science.

The progress that has taken place in science in the developing world over the past 30 years is cause for celebration. TWAS should be proud of the contributions it has made to this effort. Yet, as we all know, much remains to be done to ensure that all countries have the scientific capacity that they need to succeed and prosper.

Happy 30th anniversary TWAS, and many more. May the Academy continue its good work in the years ahead, both in service to the developing world and as a tribute to its founding president, Abdus Salam. ■

Mohamed H.A. Hassan, *as told to* **Daniel Schaffer**, *former TWAS public information officer*

ATTA-UR-RAHMAN HONOURED

• The Research Institute of Natural Products at Universiti Teknologi Mara, the largest Malaysian university, has been renamed the 'Professor Atta-ur-Rahman Institute' in recognition of Rahman's international accomplishments in science.

Atta-ur-Rahman, president of the Pakistan Academy of Sciences and a TWAS Fellow since 1985, is also an esteemed chemist, with more than 900 publications in organic chemistry, 25 patents and 116 books. He received this honour in particular for his scientific contributions in biological sciences and in the field of natural products.

During his career, Rahman has been honoured with a number of prestigious awards, including the UNESCO Science Prize (1999), the 'Grand Decoration of Honour in Gold with Sash' (2007), which is the highest civil award given by the Austrian government, and the TWAS Prize for Institution Building (2009).

Atta-ur-Rahman was also elected Honorary Life Fellow of Kings College, Cambridge University, United Kingdom, in 2007. Currently, he is the coordinator general of COMSTECH, the Ministerial Standing Committee on Scientific and Technological Cooperation, established by the Organization of Islamic Cooperation.

WORLD FOOD PRIZE

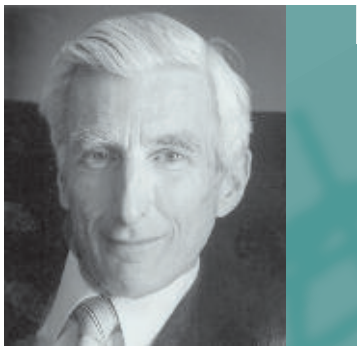
• **Marc van Montagu**, the founder and current director of the Institute of Plant Biotechnology Outreach in Ghent, Belgium, is the 2013 winner of the prestigious World Food Prize. Van Montagu, professor emeritus at Ghent University, gained global recognition for his groundbreaking discovery of the Ti plasmid. Ti plasmid is a circular DNA molecule that bacteria such as *Agrobacterium tumefaciens* host in their cell. This plasmid acts as a natural gene carrier that microbes use to insert genes into plants and create a favourable new environment to live in. As a side effect, it causes tumours called crown gall.

With his findings, obtained in collaboration with late colleague Jeff Schell, van Montagu paved the way to the modern technologies for plant gene transfer, pushing plant biotechnology into the limelight. Van Montagu himself used his technology to obtain transgenic rapeseed, tobacco and corn and he is now among the most passionate advocates of the usefulness of plant genetic engineering.

Van Montagu is president of the European Federation Biotechnology and the Public Research Regulation Initiative. He is also the founder of two biotech companies: Plant Genetic Systems, which is focused on insect-resistant and herbicide-tolerant crops, and Crop Design, focused on the genetic improvement of specific features of corn and rice seeds.

THE DIRAC MEDAL

• **Martin John Rees**, professor emeritus of cosmology and astrophysics at the University of Cambridge (UK), has been awarded the 2013 Dirac Medal and Prize, a prominent award named after theoretical physicist Paul Dirac.



Rees, who has been the director of Cambridge Institute of Astronomy and a Royal Society research professor from 1992 to 2003, is a prominent name in the field of cosmology and high-energy astrophysics. He has carried out innovative work on the origin of quasars and has predicted that the centre of galaxies could host a supermassive black hole.

Rees was educated at Trinity College and obtained his doctorate under the supervision of Dennis Sciama. In 2005, he was awarded the Crafoord Prize, an annual science prize established in 1980 by Holger Crafoord, a Swedish industrialist, and his wife Anna-Greta Crafoord. In December 2005 he was also elected president

of the Royal Academy and continued until 2010. He has been a TWAS associate fellow since 2007. In 2011, he received the Templeton Prize, an award that honours people who make meaningful contributions to affirming life's spiritual dimension, through insight, discovery or practical works.

Rees has authored more than 500 research papers, bringing important contributions to cosmological theories about galaxy formation and clustering, and about gamma-ray bursts. He is also a leading proponent of the idea that multiple universes may exist.

IN MEMORIAM

• **David Dickson**, long-time journalist and founder of the influential science development news website SciDev.net, passed away suddenly on 31 July 2013 after being stricken with a heart attack. Dickson last year received the 2012 Lifetime Achievement Award by the Association of British Science Writers.

Born in 1947, Dickson became a Washington correspondent and news editor for *Nature*, and had also reported on science policy issues for *Science* and *New Scientist*. In 2000–2001, he dedicated his work to the founding of SciDev.net, a unique website committed to covering science and policy issues in the developing world. Dickson had retired in 2012.

TWAS was an early, vocal supporter of his project, and the Academy remains an affiliate of the news organization. In late 2000, while SciDev.net was in the works, Dickson detailed the site's rationale in the TWAS Newsletter: "By creating an intelligent gateway to the world's scientific events, literature and debates, the aim is to empower both individuals and communities in

ways that will increase the impact of science and technology on sustainable development and the reduction of poverty."

"I was deeply saddened by the sudden and untimely death of David Dickson", said TWAS Treasurer Mohamed H.A. Hassan, who earlier served for more than a quarter-century as TWAS executive director. "David was a staunch supporter of promoting STI (science, technology and innovation) in developing countries and a great friend of TWAS. His brainchild, SciDev.net, will ever remain his legacy. He will be sorely missed by all of us."

Current TWAS Executive Director Romain Murenzi said he shared "a strong friendship" with Dickson. "This is indeed sad news", Murenzi said. "The developing world loses a champion for its socio-economic development through the use of science, technology and innovation."

• **Mustafa Shameel**, a renowned phytochemist and algae expert and a pioneer in the study and classification of marine benthic algae, passed away in May 2013.

Born in Rudauli, Uttar Pradesh (India), Shameel earned a botany degree (1962) at the University of Karachi, Pakistan, followed by a PhD in marine botany (1972) from the University of Kiel, Germany.

His natural curiosity led him to explore subjects as varied as homoeopathy and marine biology. He obtained the Gold Medal in Homoeopathy from the International Medical College Lahore, but never made this discipline his career. Instead, he became an expert in marine science and took on a post as assistant professor (1973–1978) first, and as associate professor later (1978–1979), at the Institute of Marine Biology, University of Karachi.

From 1994 to 1998 he was appointed the director of the Institute of Marine Science, and from 1999 to 2001 he was the director of the Centre of Excellence in Marine Biology, both in Karachi. He retired in 2001, but continued to nurture his passions and interests.

Shameel was the first to describe the effects of high pressure on the physiology of marine algae, found 24 new chemical compounds, and gave his name to 28 new groups of marine algae. After retiring, he used part of his pension to help found the *International Journal of Phycology and Phytochemistry*. A TWAS fellow since 2008, Shameel published more than 330 scientific articles and also 23 poems for children.

WHAT'S TWAS?

The World Academy of Sciences for the advancement of science in developing countries (TWAS) 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.

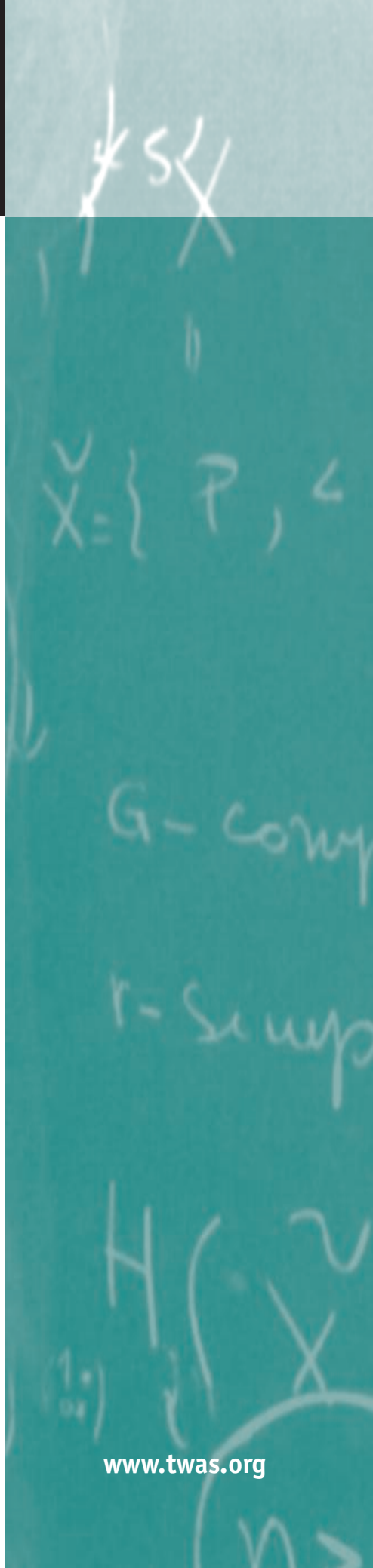
TWAS played a key role in the establishment, in 1993, of the Organization for Women in Science for the Developing World (OWSD, formerly the Third World Organization for Women in Science, TWOWS). More than 3,850 women scientists from 95 developing countries and 28 developed countries are members of OWSD, making it the largest organization of women scientists in the world. Membership also includes nearly 100 men from 31 developing countries and two developed countries. 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, 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 70 members. **www.iamp-online.org**



www.twas.org