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ADEL EL-BELTAGY (TWAS FELLOW 2005), CHAIR OF THE GLOBAL FORUM ON AGRICULTURAL RESEARCH (GFAR), OUTLINES WHAT NEEDS TO BE DONE TO ENSURE THAT AGRICULTURAL RESEARCH IN THE DEVELOPING WORLD PLAYS A MORE PROMINENT ROLE IN HELPING POOR COUNTRIES SOLVE ONE OF THE SOUTH'S MOST CRITICAL AND DISTRESSING PROBLEMS – HUNGER.

Food security for all

When it comes to food security, there is both good and bad news. The good news is that, as recent history shows, progress is possible. Between 1990 and 2005, the percentage of people worldwide going to bed hungry each night fell from 20 to 16 percent. The bad news is that hunger in poor countries remains stubbornly in place.

The progress that has been made in solving the hunger problem should be applauded. Yet, the number of people who continue to lead lives marked by chronic hunger and malnutrition remains shockingly high. Food experts estimate that the figure currently stands at more than 960 million people, including 300 million children. That is more than 16 percent of the global population. Even more ominously, over the past year, the percentage has been moving upwards due to rising food prices.

Even those who once suffered from hunger but who now have enough to eat often fear that their improved state of well-being can be reversed. Food security in poor countries can sometimes be effected by severe storms, extended droughts or other natural disasters. Food security can also be undermined by political conflict.

More often though, the fight against hunger has beeen compromised by mundane yet misguided policies. Take, for example, the recent flurry of global activity to convert millions of hectares of farmland from food to biofuels production. This global 'food-to-fuel' conversion, ignited by a spike in oil prices last summer that made biofuels production both desirable and profitable, ultimately left an additional 30 million poor people without the means to acquire sufficient quantities of food to lead healthy and productive lives. High food prices and declining food supplies sparked protests and social unrest in 38 poor countries.

The problem of hunger does not lend itself to easy solutions. If it did, it would have been solved long ago. Indeed the daunting challenges posed by hunger touches upon a full range of

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economic and political issues. It raises concerns involving unsustainable land use practices, adverse environmental impacts, limited access to credit and farm inputs (such as fertilizers and pesticides), and the inadequate marketing of agricultural commodities. It engages not just farmers, but workers employed in food processing plants, transportation and distribution, marketing, and as well as farmer and consumer advocacy groups, all of whom play key roles in the world's intricate food supply chains. It usually concentrates on local capabilities, yet directly involves international food aid organizations. It is a moral issue that can also undermine a nation's ability to successfully compete in today's global economy. It provokes serious, hard-headed debates about good governance (or more precisely the lack of good governance), while lending itself to some of the most heart-rending images of gaunt children with blank gazes begging for parcels of food. It arouses both anger and sympathy, and generates pangs of hope and hopelessness.

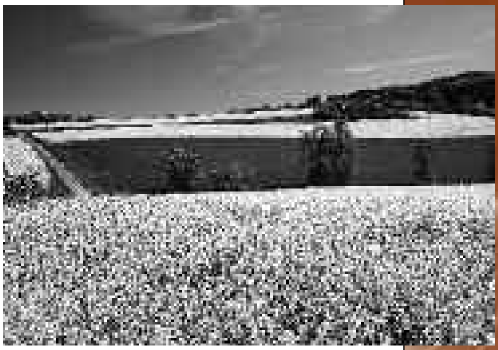
RE-ROOTING RESEARCH

When we think of problems of hunger, we tend to focus on those individuals without enough to eat. And that is how it should be. Yet, historically, successful campaigns to end hunger have depended on the work of a sufficient number of well-trained agricultural researchers and the presence of adequate numbers of agricultural laboratories and training centres to ensure that first-class research and development can take place.

Agricultural research – the cornerstone of successful agricultural policies in the developing world between the 1960s and 1980s – lost some of its standing following the success of the green revolution. The agricultural research community did not do anything wrong. In fact, there was a prevailing belief that researchers had done their job and that the remaining challenges posed by hunger and malnutrition were largely due to inadequacies in distribution and marketing.

FOOD VERSUS FUEL

As oil prices skyrocketed past US$140 a barrel last summer, the race to increase the output of first-generation biofuels – derived from cereals, sugarcane and vegetable oil crops – reached a fever pitch. Experts estimate that some 8 million hectares of corn, wheat, soy and other crops were planted not for food production but for fuel. The shift from food to fuel crops had an immediate and dramatic impact in many developing countries as food prices rose as much as 50 percent over the course of a few months. Some 36 developing countries, as a result, asked for emergency food aid. Thirty-five countries banned or restricted food exports to ensure that adequate food supplies remained for their own citizens. Meanwhile, 38 countries experienced food protests, among them Haiti where five people were killed and the government was forced to step down.



Only recently has agricultural research regained prominence as statistics showed a levelling-off of increases in crop yields in the 1990s. This has sparked growing concerns that the world will not have sufficient food stocks to feed its growing population, which is expected to reach 9 billion by 2050.

Emerging fields of research such as genomics and nanotechnology, which could have a dramatic impact on global agriculture, indicate that there will be ample opportunities to devise sustainable food production strategies capable of satisfying the needs of the world's growing population without placing undo stress on the environment and natural resources. Virtually all of the population growth between now and 2050 – indeed up to 99 percent, according to the Population Reference Bureau – will take place in the world's least developed countries (LDCs). That means a large portion of agricultural research must be directed towards the need of the poor.

The main challenge, then, lies in ensuring that the world's poorest countries have access to both conventional and cutting-edge agricultural technologies capable of increasing crop yields. It also requires farmers in the poorest countries to possess the requisite knowledge and skills to use these technologies effectively.

This is not just a moral issue. In fact, because nearly half of the developing world's population work in agriculture or agriculture-related industries, this is an economic issue of unquestionable significance as well.

TWO-FRONT CHALLENGE

Building such capacity requires a comprehensive campaign for reform that must be waged on two fronts.

On the first front, agricultural research communities in the developing world must work more closely with their governments to convince public officials of the enormous value and impact that agricultural research and development have on society.

Successful agricultural policy depends on broad scientific and technological knowledge, and the ability to transfer such knowledge to farmers working in the field. It also depends on putting the right policies in place to ensure that the needs of all stakeholders, and especially those of resource-poor agricultural communities, are incorporated in agricultural research and development programmes.

Historically, agriculture has been one of the prime areas of investment for research and development among governments in the developing world. That has certainly been the case in Egypt, which is home to some of the most respected agricultural research centres in the

developing world, including the Soil, Water, and Environment Institute and the Cotton Research Institute.

Yet, over the past decade investments have failed to keep pace with the challenge. Even more ominously, agricultural research institutes in the South have been lagging behind their counterparts in the North. Governments in the developing world, unfortunately but understandably, have focused more attention on other critical concerns – for example, access to safe drinking water and adequate sanitation – which they have come to believe posed a greater threat to their nation's well-being.

On the second front, agricultural research institutions in developed countries must work closely with their counterparts in developing countries. Initiatives should be enacted to facilitate the transfer of cutting-edge agricultural technologies from the North to the South. The goal should be to provide farmers in developing countries with the tools that they need to increase crop yields and to market their crops profitably. Who sets the agenda for the generation and transfer of new technologies and knowledge has been a constant issue in debates dealing with the sharing and transfer of new knowledge, skills and technologies between the North and the South. This is a debate worth having.

Yet, it is important to note that growing North-South gaps in agricultural research are delaying the adaptation of new technologies in the South. And that, in turn, is undermining potential increases in crop yields and placing even more stress on efforts to feed the poor.

With effective global policies in place, researchers in developing countries could serve as 'transponders' – that is, as knowledge brokers with the skills and resources that are necessary to convey emerging agricultural technologies and state-of-the-art agricultural practices to farmers in the field. Farmers could then apply the knowledge they acquire to expand their crop yields.

Experience has shown that agricultural researchers in developing countries are more likely to have a deeper understanding and appreciation of the challenges farmers in their countries face than agricultural researchers in the North. Equally important, they carry more credibility among local farmers and therefore can have a greater impact on what happens on the ground.

The problem is that, increasingly, researchers in developing countries do not have sufficient knowledge of the emerging technologies to convey that information to the farmers. That is where Northern researchers and agricultural institutions can come into play.

This new agricultural research paradigm is based on North-South-South collaboration – a process of information exchange that moves from researchers in developed countries to researchers in developing countries to farmers in developing countries.

Over time, of course, this research paradigm could shift to a South-South collaborative framework between the developing world's researchers and farmers. But for now agricultural researchers in the developing world need access to knowledge and technology that is

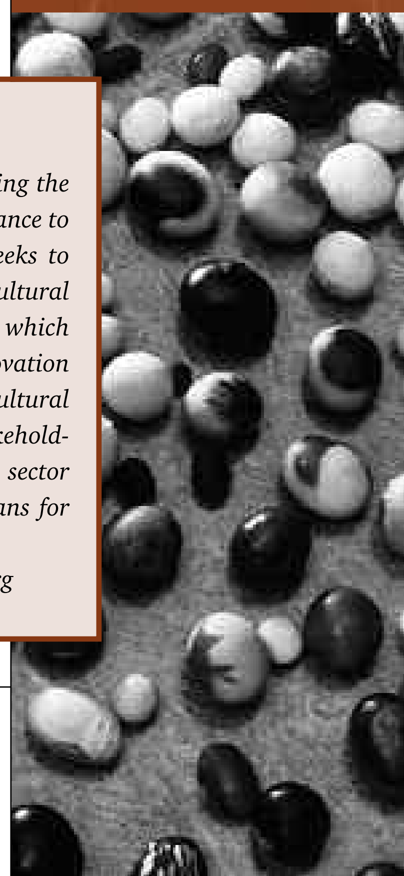
only available in the North. Experience also shows that building local capacities for innovation and promoting the spread of innovations locally is as important as promoting the transfer of technology and knowledge between researchers of the North and the South. North-South and South-South collaboration in agricultural research is not a zero-sum game. Both can take place at the same time without undermining either side of the equation.

BENEFITS NORTH

How might the North benefit from such a North-South agricultural research paradigm? First of all, in a time of financial crisis, global exchange and trade – in goods and services – are always welcome. For example, it is useful to note that between 2004 and 2008, Africa's gross domestic product (GDP) grew at an annual rate of 6 percent. As economists Paul Collier, of Oxford University, and Witney Schneidman, Director of Global Sullivan Principles, in Washington, DC and former US Assistant Secretary of State for African Affairs, recently noted, "Africa, usually the poorest performing region in the world economy, is now among the best performing regions".

One would think that Northern countries would be eager to collaborate and take part in the rising fortunes of Africa, which also has the highest percentage of people working in agriculture – some 70 percent of the population. The exchange of agricultural information not only makes moral sense (who would deny people information that would enable them to live healthier and more productive lives?), it also makes good economic sense. The reality is that ties with Africa will likely payoff in the future. Take, for example, the recent increase in trade between China and Africa. Between 2000 and 2008, China's trade with Africa rose four-fold from just over US$10 billion to US$40 billion in 2007.

Beyond the moral sensibilities and economic payoff that the exchange of agricultural research would invoke for the North, there is also the question of security. It has become a cliché but it is nevertheless true: hungry people are also desperate people who are more like-



A GLOBAL FORUM FOR AGRICULTURAL RESEARCH

Launched in 1998, the Global Forum on Agricultural Research (GFAR) is dedicated to improving the capacity of the agricultural research sector, especially in relationship to issues of critical importance to resource-poor, small landholders in farming communities in the developing world. GFAR seeks to advance its goals by facilitating and promoting dialogue on critical issues related to agricultural research, cost-effective partnerships and strategic alliances and by improving the ways in which knowledge is shared and communicated. Its primary aim is to create effective research and innovation systems that meet the complex economic, social and environmental needs of sustainable agricultural development. GFAR's signature event is a triennial conference that brings together diverse stakeholders from around the world – farmer associations, nongovernmental organizations, the private sector and government – to address current and emerging global issues and establish concerted plans for action. Meetings have been held in Dresden (2000), Dakar (2003) and New Delhi (2006).
For additional information about GFAR, see: www.egfar.org, or email: gfar-secretariat@fao.org

ly to engage in angry and even violent protest. That places the stability of governments in poor nations, where people suffer from hunger, at risk.

As recent events in Haiti show, governments that are unable to feed their people are governments that are likely to become unstable. Weak – or, even more ominously, failed – governments, in turn, are likely to harbour people who pose potential threats not only to their own countries but to the North as well. The price of doing nothing to improve the state of agricultural research and development in the developing world could be greater social instability across the South, especially among its poorest countries. That is a price no one can afford.

Solving the problems of hunger and malnutrition, of course, involves more than devising policies that enhance the capabilities of the developing world's agricultural research communities. For the South, it also means instituting political reforms that create more secure land rights, devising economic policies that provide greater access to capital, and advancing infrastructure programmes that bring farmers closer to markets, helping to raise their incomes.

For the North, it means not just scientific collaboration but also a reduction in farm subsidies, which last year amounted to US$280 billion a year (about equal to the GDP of all of Africa), and a reconsideration of national biofuel policies which, some experts estimate, could increase from a US$11billion industry today to a US$98 billion industry in 2011 if current levels of government support in the United States and Europe remain in place. A recent study by the International Institute for Applied Systems Analysis (IIASA), commissioned by the OPEC Fund for International Development, projects that if current biofuel targets are reached, an additional 30 million hectares of land would be converted to cereal production for fuels. That, in turn, would place an additional 140 million people at risk for hunger.

There are two gaps at work in agriculture in the developing world, and we must do all that we can to close both. First, there is the North-South gap in capacity in agricultural research and development. Second, there is the South-South gap between research and application.

We need to quickly narrow both gaps if we hope to achieve a more equitable and peaceful world: A world in which all people have access to sufficient quantities of nutritious food, and a world in which hunger is a thing of the past. ■

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THE ACADEMIES AND SOCIETY

IN PARTNERSHIP WITH THE INTERACADEMY PANEL (IAP), THE COUNCIL OF CANADIAN ACADEMIES RECENTLY ORGANIZED A WORKSHOP IN TRIESTE TO EXAMINE BEST PRACTICES IN ACADEMIES' ADVISORY ROLES AND MEMBERSHIP APPOINTMENTS. CONFERENCE PARTICIPANTS ALSO EXPLORED HOW ACADEMIES COULD BECOME MORE PROMINENT PLAYERS IN SCIENCE EDUCATION, POLICY DISCUSSIONS AND THE MEDIA.

Science academies must retain scientific merit as the primary criteria for membership. Yet, at the same time, academies need to continue efforts to attract underrepresented categories of membership, including young scientists, women and social science researchers, in order to achieve greater gender, ethnic and social diversity.

Academies must also be politically astute and use a variety of means to engage decision-makers. This means taking advantage of all opportunities, including 'quiet diplomacy', to ensure that science is an integral part of the decision-making process.

These are among the major conclusions of the participants at the InterAcademy Workshop on Best Practices in Advisory Roles and Fellowship Appointments, held on 12–13 February. The workshop, cosponsored by IAP and the Council of Canadian Academies, took place at the IAP secretariat in Trieste, Italy. More than 60 participants from 43 countries were in attendance.

There were representatives from the world's largest and oldest science academies, including Germany's Leopoldina and the Royal Society in the UK (founded in 1652 and 1660, respectively), as well as from small and emerging academies, including those of Sudan, Tajikistan and Zimbabwe, each founded within the past decade.

Topics of discussion focused on effective strategies for membership appointments, the role of academies in providing advice to governments, a review of best practices for conducting science assessments, the need to bolster academy-based programmes for public outreach and science education, and the importance of developing effective practices for enhancing media relations.

The workshop also offered an initial look at a comprehensive membership survey, the first to be taken in a decade. Fifty-nine of IAP's 100 members have responded, and additional members are expected to return the questionnaire in the near future.

The survey at once reflects and confirms the broad diversity of IAP's membership, ranging from the Kenya National Academy of Sciences, with fewer than 30 members, to the US National Academy of Science, which has 2,100 members and 350 foreign associates.

Workshop participants shared their own experiences in discussions of how science academies worldwide are seeking to address critical issues that will determine their impact on society, as well as their own success in the future.

For example, Jorge Allende, coordinator of IAP's Science Education Programme and professor of biomedical sciences and vice president of research at the University of Chile, spoke about a science education initiative, funded by the European Union, which began in Chile but has since expanded to include a growing number of countries in Central and South America. The programme, which promotes the adoption of 'inquiry-based' science education (featuring a 'hands-on', problem-solving approach to learning), has been dramatically transforming the way science is taught in schools. Shelley Peers, education and public awareness manager, Australian Academy of Sciences, described a similar effort by the Australian Academy of Science's Primary Connections programme to support inquiry-based science education. Both the Chilean and Australian experiences emphasized the need for academies to work together with government to improve science education.

Sergio Pastrana, foreign secretary of the Cuban Academy of Science, outlined the close relationship that exists between Cuba's scientific community and the government. These ties have both facilitated significant improvements in public health and world-class advances in medical research (particularly in vaccine development), allowing this small island nation to become a leader in these fields.

Hans Hilgenkamp, a member of the Young Academy of the Royal Netherlands Academy of Arts and Sciences, described the activities of the 'young academy', which was formed by the 'parent academy' in 2005 to recognize outstanding Dutch scientists who have received their doctorates within the past 10 years. The initiative has not only nurtured a welcome camaraderie among the nation's young scientists but has also helped build networks likely to assist these scientists throughout their careers.

A key theme of the workshop was how best to engage decision-makers. Tanveer Naim, consultant,

THE COUNCIL OF CANADIAN ACADEMIES

The Council of Canadian Academies supports independent expert assessments of science that are relevant to matters of public interest. A not-for-profit corporation, the Council's three founding member academies are the RSC: The Academies of Arts, Humanities and Sciences of Canada, the Canadian Academy of Health Sciences and the Canadian Academy of Engineering. The Council, operating since early 2006, has completed eight expert panel reports. It is independent of government but benefits from a $30 million founding grant, provided in 2005, for core operations through 2015. For additional information, see: www.scienceadvice.ca.




the Organization of Islamic Conference's (OIC) Committee on Scientific and Technological Cooperation (COMSTECH) in Islamabad, spoke about the results that can be achieved when senior decision-makers engage in a dialogue on science and technology and its economic and societal benefits. She described the dramatic increase in investments in science and technology that have taken place in Pakistan over the past decade and said that Pakistan's scientific community will continue to promote the vital role that science can play in the country's economic development efforts. More generally, Philippe Gailay, principal administrator at the European Commission's Research Directorate, discussed the diverse sources of advice and inputs that decision-makers receive, and the challenges academies face in getting their voices heard.

One of the guiding principles of IAP is that all science academies benefit from exchanging ideas and learning from one another. The truth of that principle was on full display at the workshop. While science academies may vary a great deal in size, funding and influence, they are bound by a shared belief in the value of science to society and the importance of excellence to the long-term well-being of a nation's scientific enterprise.

All academies occupy a unique place within their societies. On the one hand, academies are, in general, formally recognized and may be at least partially supported by their governments. On the other hand, in most cases they operate as self-organizing nongovernmental institutions with statutes, bylaws and programmes that are devised and endorsed by the members themselves.

An academy's association with government gives it access to the inner circles of political power. Its nongovernmental status gives it independence. It is up to the academies to use both their access and independence wisely.

Workshop participants pointed to several concrete steps that could be taken to advance their influence. Academies, for example, could publish peer-reviewed reports that examine critical societal issues

THE INTERACADEMY PANEL (IAP)

IAP is a global network of the world's science academies. Its primary goal is to help member academies work together to advise citizens and public officials on the scientific aspects of critical global issues. IAP is particularly interested in assisting young and small academies. Its secretariat, which is located in Trieste, Italy, operates under the administrative umbrella of TWAS. In 2004, the Italian parliament passed a permanent law to provide a secure funding base for IAP. Many of IAP's member academies contribute both financially and in kind to its programmatic activities. Member academies also sponsor events and actively participate in meetings. For additional information, see www.interacademies.net.

from a scientific perspective and present a series of options that governments may wish to pursue. Large, well-established academies such as the US National Academies and the UK's Royal Society have made this a significant part of their mandate. The InterAcademy Council (IAC), located in Amsterdam, has published a series of science policy reports designed for both national governments and international organizations on such topics as scientific capacity building, agriculture in Africa and global energy security. IAC has worked closely with IAP in putting together the teams of scientific experts that have been responsible for these reports.

As a number of workshop participants observed, other academies could learn from this experience, as well as that of the recently formed Council of Canadian Academies (see sidebar, p. 9), to develop their own scientific advisory programmes designed for decision-makers in their countries.

Academies seeking to advise policy-makers are not limited to producing reports, of course. They can – and, indeed, often do – speak directly to government officials about critical science-related issues for which their expertise gives them a unique status as well-informed advisors. For example, members of the RSC: The Academies of Arts, Humanities and Sciences of Canada, the Brazilian Academy of Sciences, the Chinese Academy of Sciences, the UK's Royal Society and many other academies speak regularly to government officials both on an informal and formal basis. A particularly successful example has been the RSC's 'Bacon & Eggheads' breakfasts in Canada, where scientists inform members of parliament about recent research developments.

Indeed, workshop participants concurred that an academy's strength lies in its ability to provide an evidence-based perspective on important issues – untarnished by politics or commercial interests. To this end, several workshop participants urged IAP to develop a 'toolbox' of proven strategies for academies seeking to gain direct access to policy-making circles.

As participants noted, an academy's influence should not be measured solely by the level of its interaction with government. There are several other avenues by which science academies can influence society: through promoting science education as part of a larger effort to create a more scientifically literate citizenry; engaging the media to broaden the scope of science-related information to which the public has access; and reaching out to other research communities – economists, social scientists and the humanities – to help forge a coalition of ideas that can best serve the interests of society.

The Trieste workshop, simply put, provided a valuable forum for academies to discuss how they could advance their broad goals without compromising their core principles. ■

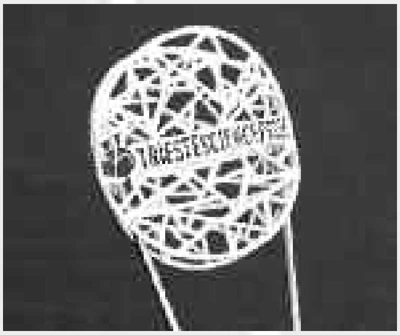
For additional information on the InterAcademy Workshop on Best Practices in Advisory Roles and Fellowship Appointments, contact iap@twas.org.

TRIESTE SCIENCE PRIZE WINNERS

AN INTERNATIONALLY RENOWNED INDIAN ENGINEER AND PHYSICIST, WHOSE WORK IN FLUID DYNAMICS HAS INCREASED OUR UNDERSTANDING OF TURBULENCE, AND AN EMINENT BRAZILIAN ASTROPHYSICIST, WHO HAS MADE A MAJOR CONTRIBUTION TO THE STUDY OF THE EVOLUTION OF THE CHEMICAL COMPOSITION OF STARS, HAVE BEEN AWARDED THE 2008 TRIESTE SCIENCE PRIZE. THE PRIZE, ADMINISTERED BY TWAS AND FUNDED BY ILLYCAFFÈ, PROVIDES INTERNATIONAL RECOGNITION TO OUTSTANDING SCIENTISTS LIVING AND WORKING IN THE DEVELOPING WORLD. WINNERS SHARE A US$100,000 CASH AWARD.

The fourth Trieste Science Prize recognizes the contributions of two outstanding scientists from the developing world: Beatriz Barbuy, from Brazil, and Roddam Narasimha, from India.

The prize winners work on opposite sides of the globe. Yet their research focuses on issues of fundamental importance and enduring fascination to everyone. From the way fluids such as water and air behave here on Earth and in the sky, to how our Galaxy evolved and the stars produced the chemical elements, their studies aim to make sense of the world around us, so we may better know where we came from and how to best adapt to where we are today.



HOW TO READ THE STARS

Beatriz Barbuy, professor at the Institute of Astronomy, Geophysics and Atmospheric Sciences of the University of São Paulo (IAG/USP), Brazil, and vice-president of the International Astronomical Union (IAU), was honoured for her seminal contributions to astrophysics, in particular to our understanding of the evolution of the chemical composition of stars.

Barbuy's research seeks to understand how our Galaxy was formed by studying its stars. Specifically, she seeks to determine what the stars in the various parts of the Galaxy are made of – that is, their chemical composition. This is done by examining the visible

TRIESTE SCIENCE PRIZE

The ***Trieste Science Prize****, now in its fourth year, is designed to bring recognition and distinction to the developing world's most eminent scientists who have not yet been honoured by other prominent international award schemes. Generously funded by Trieste-based premium coffee producer* ***illycaffè****, and awarded under the High Patronage of the Presidency of the Republic of Italy, the prize is named for Trieste, a city in northeast Italy that has made significant contributions to the promotion of science in the developing world. For additional information, please contact:* TWAS: Daniel Schaffer, +39-040-2240-327, +39-040-2240-538, schaffer@twas.org; illycaffè: Anna Adriani / Christine Pascolo, +39-040-3890111.

light emitted by the stars through a spectroscope, which breaks the light down into a spectrum (as a prism breaks a ray of sunlight into a rainbow).

You are here

A little perspective may be helpful. Our Galaxy, which we call the Milky Way (or the Galaxy, with a capital 'G'), contains, in addition to our Solar System, some 200 to 400 billion stars. The nearest star is 39,900,000,000,000 km (or 4.3 light years) away (in the Alpha Centauri system). The Milky Way, as the astronomer Carl Sagan was fond of saying, is but one of 'billions and billions' of galaxies in the observable Universe.

Astronomers categorize galaxies into three types. The Milky Way, with its pinwheel-like spiral arms, is called a 'spiral galaxy'. Like all spiral galaxies, it has three components: a flat *disc* (in which the spiral arms are located); a *bulge*, a tightly packed group of stars in the centre; and a spherical *halo*, a faint sphere surrounding the disc.

The bulge and halo contain the Galaxy's oldest stars, while the stars in the disc are mostly younger. Our Solar System is located in the outer regions of the Galaxy, within the disk (and one of the spiral arms), some 28,000 light years from the Galaxy's centre.

All stars, including our Sun, are huge nuclear processing plants. Through the process of nuclear fusion, they burn hydrogen and helium to produce the heavier chemical elements. Our Sun, for example, is composed of approximately 91% hydrogen and 9% helium (in terms of numbers of atoms), with only traces of the heavier elements.

By determining the composition of our Galaxy's stars, astronomers like Barbuy are able to learn two things: the relative age of a star, and how the Milky Way evolved. This is because only the lightest elements existed when the Universe began, with all other chemical elements being produced over time by the stars.

Barbuy's research seeks to understand how our Galaxy was formed.

Celestial factories

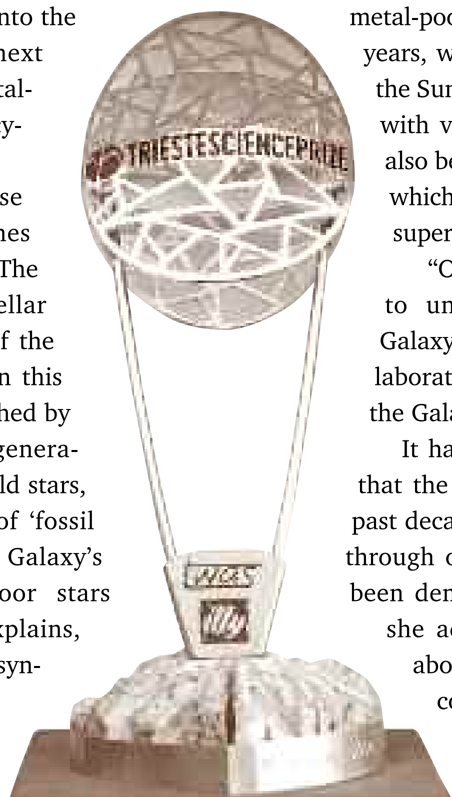
"For centuries," Barbuy says, "humankind puzzled over the formation of the elements. Alchemists, in particular, tried in vain to transform certain elements into others," for example, lead into gold. But it was not until the late 19th and early 20th centuries that the structure of the atom and the composition of matter began to become clear. In the late 1940s, she adds, "there was a scientific debate as to whether all elements were produced in the Big Bang or by stars."

It is now well established, Barbuy explains, that "the only chemical elements produced in abundance in the Big Bang were the light elements hydrogen, helium

and lithium." All the heavier elements that we are familiar with from the periodic table (and which astronomers call 'metals') were produced subsequently in the interior of stars, in the process of nuclear fusion that makes them shine. To put it another way, the gold in the ring you wear on your hand, or the silver in the spoon on your table – as well as the carbon and oxygen we ourselves are made of – all originated in those celestial factories, the stars.

The 'metallicity' of stars – the amount (or 'abundance') of heavier elements they contain – grows with each succeeding generation. This is because, at the end of each star's life, a portion of the heavier elements it has produced is ejected into the stellar medium, from which the next generation of stars (with greater metallicity) is born – a kind of cosmic recycling.

Stars are formed when a dense cloud of interstellar matter becomes unstable and collapses in on itself. The chemical make-up of the interstellar cloud determines the composition of the star that results from its collapse. In this way, each generation of stars is enriched by the metals produced by previous generations. Because metal-poor stars are old stars, their composition presents a sort of 'fossil record' of the early stages of our Galaxy's development. "The very metal-poor stars presently observable," Barbuy explains, "contain the signatures of the nucleosynthesis processes that took place within the first generation of stars."



How stars get their metals

It is this process of the evolution of the chemical composition of stars that Barbuy studies, in order to shed light on how our Galaxy was formed. "The study of the chemical composition of the oldest stars in the Galaxy," she says, "is particularly interesting for several reasons." To see how stars of different ages have different compositions, Barbuy explains, enables her "to trace the formation of the Galaxy, and its early chemical enrichment by the first supernovae."

"While the low-mass first generation of stars should still exist," Barbuy says, "no zero-metal stars have yet been detected." Yet, she continues, "extremely metal-poor stars have been found in recent years, with metallicities lower than that of the Sun by a factor of 100,000." Early stars with very high masses, she adds, "could also be detected from gamma-ray bursts," which were emitted at the time of their supernova explosion.

"Our studies," Barbuy explains, "aim to understand the formation of the Galaxy." For this reason, she and her collaborators "study its older components – the Galactic halo and bulge."

It has been known for several decades that the halo is old. "But it is only in the past decade," Barbuy continues, "and partly through our own work, that the bulge has been demonstrated to be old." Previously, she adds, there had been some doubt about this, because "the Galactic bulge contains mostly metal-rich stars."

Barbuy was the first to demon-

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strate very clearly that so-called 'metal-poor' stars in the Galactic halo have an overabundance of oxygen, relative to the heavier element iron. This, she explains, "indicates that, early in the life of our Galaxy, the halo was chemically 'enriched' by the explosion, as supernovae, of massive first-generation stars."

Seeing stars

Barbuy notes how, by using spectroscopy techniques, astronomers can separate the light coming from distant stars into wavelength spectra. "Spectroscopy is an extremely important tool in astronomy for studying the chemistry of stars." A spectrometer (connected to a telescope) spreads the starlight into its wavelengths, producing a spectrum.

When these spectra are magnified, small black lines can be seen over the colours. These 'absorption lines' indicate what frequencies of light have been absorbed by the chemicals on the surface of the star. Every atom and molecule absorbs certain wavelengths of light; thus each will have its own 'fingerprint' or pattern of spectral lines. From these lines, astronomers can determine the chemical composition of a star, as well as other information, such as its mass, temperature and motion.

Barbuy is unusual in being an expert at both observational astronomy and the analysis and interpretation of spectroscopic data. Using her skills in spectroscopy, Barbuy has also built up a large library of spectra, which has aided many other researchers in their investigations of our own and other galaxies. "After 20 years of gathering atomic and molecular data," she explains, "and improving a code to compute spectra for a large wavelength coverage, we have built an extensive grid of synthetic spectra."

Barbuy has also conducted important research on the Galactic bulge, working with a team on data obtained from the Hubble Space Telescope. The team's studies of globular clusters (gravitationally bound concentrations of up to a million stars) in the bulge helped show that these clusters and the bulge itself, though it contains mostly metal-rich stars, are very old. Controversial at the time, their finding has since been recognized as a breakthrough.

"The recognition that comes from winning the Trieste Science Prize is really significant."

Together with field (*i.e.*, individual) metal-poor stars, Barbuy says, "globular clusters are the oldest objects in the Galaxy." They are "particularly interesting because we can derive their ages by comparing their colour-magnitude diagrams with stellar evolution theory." For the past two decades, Barbuy and her collaborators have concentrated on globular clusters in the bulge, many of which, she adds, had never before been studied.

Common origin

"The recognition that comes from winning the Trieste Science Prize," Barbuy says, "is really significant" both for her and her colleagues. The prize is her first, she adds.

"It is very encouraging," she explains, "for all of us who have been devoting a lot of effort to do good work, and have been pushing to improve the infrastructure for research." She is hopeful the attention may help improve conditions for doing astronomy in Brazil. "We need better observing conditions," she admits. "But, nowadays, the way for countries like ours to obtain the expensive instruments is through consortia with other countries."

"I am fascinated by this work," Barbuy continues. "The field is evolving rapidly, and it enables us to better understand how the elements were formed." She adds that "I am interested in the origins of the elements not only because of what they tell us about our Universe, but also because they are our own origins as well."

ORDER IN CHAOS

Roddam Narasimha, Chairman of the Engineering Mechanics Unit at the Jawaharlal Nehru Centre for Advanced Scientific Research, in Bangalore, and Pratt & Whitney Professor of Science and Engineering at the University of Hyderabad, India, was honoured for his significant and lasting contributions to fluid dynamics, in particular the study of turbulent flow, or turbulence, and its role in both aerospace technology and atmospheric sciences.

He is best known for his work on the transitions between laminar and turbulent flow. 'Laminar flow' is the smooth movement of a fluid (such as air or water) in regular layers or paths (streamlines). In 'turbulent flow', the direction and magnitude of movement are chaotic. Here are two everyday examples: Turn your kitchen tap on low, and the water comes out smoothly. Open the tap all the way, and you have a chaotic flow (watch out that you don't get your clothes wet). Similarly, a plume of cigarette smoke rises smoothly at first, unfurling like a ribbon, but then becomes chaotic – opening up into clouds. "The world," says Narasimha, "is in fact full of turbulence."

Turbulence is of both scientific and practical concern. And Narasimha's contributions have extended to aircraft design, monsoon prediction and climate change problems, as well as the prospects of using wind energy in rural India.

Narasimha has been closely associated with the development of aerospace technology in India at both the technical and policy-making levels. As director, from 1984 to 1993, of the Indian National Aerospace Laboratories, he is credited with boosting the institution's effectiveness and international reputation. He is a member of the Scientific Advisory Committee to the Prime Minister of India and the Indian Space Commission, and previously served on the National Security Advisory Board and the Aeronautics Research and Development Board.

Turbulence is of both scientific and practical concern.

A search for hidden order in chaos is a fundamental motif of his research work. Whether investigating the possibility that there are "universalities in the transition zone between fully laminar and fully turbulent flow in the boundary layer", or exploring the structure and memory of fully turbulent flows, the nonlinear vibration of strings and the fluid dynamics of clouds, he has been a path-breaker.

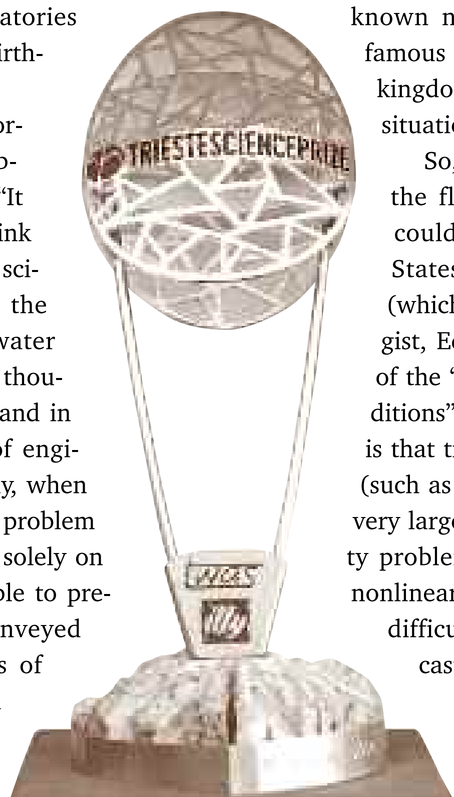
Poetry of flow

Like all scientists who excel in their fields, Narasimha is filled with enthusiasm for his subject. Fluid flows are

all around us, he says. "Trees sway in the breeze, clouds drift across the sky, waves lap or lash the beach: Nature is full of fluid dynamics – ranging from the gentle (rain drops sliding down a sagging wire) to the fierce (such as cyclones)." But, though we may not be aware of it, fluid flows also play an important role in everyday technology.

As a teacher, his ability to make connections to art, poetry and philosophy when explaining fluid dynamics has long made him a popular lecturer with both students and colleagues. In what has become a tradition of sorts, for many years now he has been invited to give a highly anticipated annual lecture at India's National Aerospace Laboratories (NAL) in commemoration of his birthday.

Despite their fundamental importance, many fluid dynamics problems remain unsolved as physics. "It comes as a shock to those who think of *all* technology as flowing from science," he says, "to learn that the ancient problem of conveying water from point A to point B – solved thousands of years ago by experience, and in the early 20th century in terms of engineering codes – remains to this day, when the flow is turbulent, an unsolved problem for science." That is to say, "based solely on first principles, it is still not possible to predict how much water can be conveyed through a pipe with a given loss of pressure." The answer is indeed known well enough for most applications, he explains, but not without use of test data. "So plumbers remain ahead of the scientists by several thousand years."

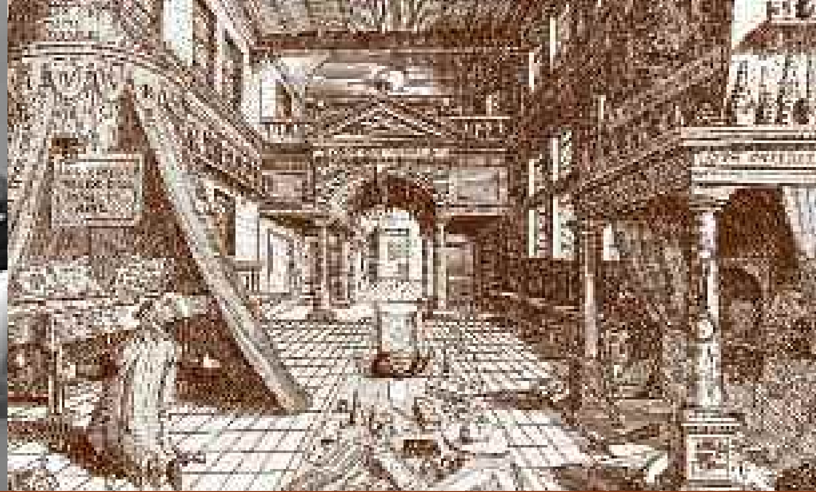


For want of a nail ... or spoon

The main reason such problems remain unsolved, Narasimha continues, is that the equations governing fluid flows are *nonlinear*. In mathematics, a nonlinear system is one in which effects are not proportional to causes. "In a *linear* system, output is proportional to input," he explains. "In nonlinear systems, on the other hand, small causes may lead to large effects (and vice versa)." As an example, he cites a well-known nursery rhyme and proverb: "That famous occasion when, 'for want of a nail, a kingdom was lost' was a highly nonlinear situation."

So, of course, is the popular notion that the flap of a butterfly's wings in Brazil could set off a tornado in the United States. The so-called 'butterfly effect' (which we owe to the late MIT meteorologist, Edward Lorenz) is a vivid illustration of the "sensitive dependence on initial conditions" explained in chaos theory. The idea is that tiny variations in a dynamical system (such as the atmosphere) can end up having very large consequences, making predictability problematic or even impossible. It is the nonlinearity of fluid dynamics that makes it difficult, for instance, to accurately forecast the weather.

Narasimha offers a more down-to-earth instance of the mysteries



of nonlinearity: "If you add a spoon of milk to your coffee, and stir it just a few times," he says, "it results in a remarkably homogenous mixture. This, at a molecular level, is a nonlinear phenomenon." But, he continues, "If you *did not* stir, the two fluids would still eventually mix, but by linear diffusion. And this, as we all know, will be an excruciatingly slow process indeed."

Because of their great complexity, "our understanding of even the simplest nonlinear systems," he says, "remains rudimentary." A striking feature of the nonlinear system of fluid flows is that its behaviour is, in general, chaotic. Yet, he adds, "there is reason to believe that hidden in this chaos is a considerable degree of order."

The nonlinearity of fluid dynamics makes it difficult, for instance, to accurately forecast the weather.

Flowing into order

Trained as an aeronautical engineer, Narasimha's first research examined aerodynamics. In particular, he looked at the ways in which the air flowing over an aircraft transitions from a smooth (or laminar) flow to a turbulent one. Anyone who has experienced 'turbulence' when flying knows what resistance the air can offer an aircraft. Narasimha discovered that there were certain universalities in the modes of this transition. This turned out to have important industrial applications, for example, in the design of aircraft gas turbine blades.

Most research in this field has focused on this transition to turbulent flow. Increasingly, however, Narasimha says, the importance of the reverse transition from turbulence to laminar flow – called 'relaminarization' – is being recognized. Once considered an academic curiosity, the phenomenon is now understood as having important practical implications.

Working with students and colleagues, Narasimha recently carried out a study for Boeing showing how relaminarization on airplane wings affects important aerodynamic characteristics such as the highest possible lift or lowest possible landing and take-off speeds. He is also investigating how wing designs can be improved for turbo-prop aircraft, which are making a come-back because of their fuel economy – an important goal at a time of volatile oil prices and concerns about global climate change induced by carbon dioxide emissions.

Head in the clouds

Narasimha's other major interest has been atmospheric fluid dynamics. Most recently, he has been looking at clouds, which were the subject of his talk at TWAS's 25th Anniversary meeting in Mexico City, last November. "We can look upon 'cloud flows' as a special class of turbulent shear flows," he explains.

"Clouds have long been the subject of poetry and song," he points out, citing as an example the long poem *Mēgha-dūta* (the Cloud Messenger), by "the 5th-century Sanskrit writer Kālidāsa". Cumulus clouds, in particular, with their "beautiful tower-like shapes", are at the centre of his most recent research. "They play a key role," he explains, "in tropical weather and climate".

The English amateur meteorologist Luke Howard was the first to classify clouds, in the early 19th century, giving us such familiar terms as *cumulus*, *cirrus*, and

BEATRIZ BARBUY WINS 2009 L'OREAL-UNESCO PRIZE

Shortly after being awarded the Trieste Science Prize, Beatriz Barbuy was named the 2009 Latin American Laureate of the prestigious L'ORÉAL-UNESCO Awards for Women in Science. She was honoured for her work on the life of stars from the birth of the Universe to the present time.

Each year, the L'ORÉAL-UNESCO prizes are awarded to five outstanding life science women scientists, one from each region of the world. The laureates were selected through nominations by a network of nearly 1,000 members of the international scientific community. Winners receive a US$100,000 cash prize. The awards ceremony for 2009 took place on 5 March at UNESCO headquarters in Paris.

Created in 1998, the L'ORÉAL-UNESCO Awards alternate each year between life sciences and physical sciences, recognizing work that makes major advances and addresses major challenges in modern science. The laureates serve as role models for future generations, encouraging young women around the world to follow in their footsteps.

stratus, and inspiring painters and poets. "But the dynamical significance of clouds," Narasimha explains, "was not really appreciated until the second half of the 20th century." Understanding the fluid dynamics of clouds, he explains, "is important for tropical meteorology (*e.g.*, for predicting the monsoons in India), as well as climate change."

Narasimha first began exploring cloud dynamics 20 years ago. What intrigued him was the discrepancy between fluid flow models in the laboratory and observations of real cumulus clouds. "The models were based on the prevalent dynamical theory of plumes," he says, "which assumed a kind of dynamical equilibrium in flow development." A 'plume', he explains, is a current of fluid that arises from a 'hot spot' on a surface. If the fluid is moist air, the plume becomes visible, as a cloud, when water vapour condenses.

Clouds in the laboratory

The problem concerned what is termed 'entrainment' – the way that ambient air is pulled into the plume of the cloud flow. "Aircraft measurements in clouds showed that some parcels of air rise undiluted all the way to the top of tall clouds – which is impossible according to classical theories," he explains. "The flow entrained from the ambient atmosphere does not keep pace with the flow velocity in the cloud air – that is, the flow equilibrium is broken."

In addition to doing numerical simulations, Narasimha approached the problem experimentally. Working with colleagues and students, he successfully reproduced cloud-like flows in the laboratory, using a water tank in which a plume issues out of a hole in the bottom.

These experiments have shown that the single most dominant mechanism in cloud flows is the release of latent heat on the condensation of water vapour. A dynamically equivalent amount of heat introduced into a vertical plume in a water tank will make it behave like a cloud in many ways. The studies, he says, "offer strong clues for understanding the long-puzzling entrainment characteristics of cumulus clouds." This experimental work has been followed up by numerical models and computer simulations supporting the theories.

Solutions awaiting discovery

"Turbulence," Narasimha says, citing the physicist Richard Feynman, "remains the greatest unsolved problem of classical physics." He explains: "We actually know a fair bit about turbulent flows, enough to design ships and aircraft, for example." Yet, he adds, "many fundamental problems remain, and we may not know what we are missing."

We may all take comfort in Narasimha's assertion that, often in Nature, "chaos masks an underlying order," which must be puzzled out. While some people think that "there is no new physics, in actual fact, the contrary is true." The "new physics", he explains, "is very much there in the nonlinearity of the equations, waiting to be discovered." ■

MAKING THE MOVE TO SUSTAINABLE ENERGY

DEVELOPING COUNTRIES FACE A TWO-FOLD ENERGY CHALLENGE IN THE 21ST CENTURY: MEETING THE NEEDS OF BILLIONS OF PEOPLE WHO LACK ACCESS TO ENERGY SERVICES, WHILE PARTICIPATING IN A GLOBAL TRANSITION TO CLEAN ENERGY TO ENSURE A BETTER FUTURE FOR ALL. SOLVING THESE TWIN PROBLEMS, SAY DILIP AHUJA AND MARIKA TATSUTANI, WILL BE THE KEY TO DEVELOPING A SUSTAINABLE ENERGY FOR THE FUTURE.

Since the Industrial Age, the ability to harness different forms of energy has transformed living conditions for billions of people, allowing them to enjoy a level of comfort and mobility unprecedented in human history and freeing them to perform ever more productive tasks. For most of the past 200 years, steady growth in energy consumption has been closely tied to rising levels of prosperity and economic opportunity in much of the world.

Now, however, humanity finds itself confronting an enormous energy challenge. This challenge has at least two critical dimensions. On the one hand, it has become clear that current patterns of energy use are environmentally unsustainable. Overwhelming reliance on fossil fuels, in particular, threatens to alter the Earth's climate to an extent that could have grave consequences. At the same time, access to energy continues to divide the 'haves' from the 'have-nots'. Globally, a large fraction of the world's population – more than two billion people, by some estimates – still lacks access to one or several types of basic energy services, including electricity, clean cooking fuels and adequate means of transportation.

In the latest TWAS Report, Sustainable Energy for Developing Countries, *authors Dilip Ahuja and Marika Tatsutani provide a comprehensive assessment of how developing countries can meet this two-fold energy challenge: how to expand access to energy while simultaneously participating in a global transition to clean, low-carbon energy systems. The following is an adapted*

excerpt from the Report, in which the authors discuss concrete policies and actions to assist developing countries in the move to sustainable energy.

FOUR STEPS

The energy challenges confronting developing countries today are significant and growing greater. It is clear that these countries will face potentially large adverse consequences without concerted policy interventions.

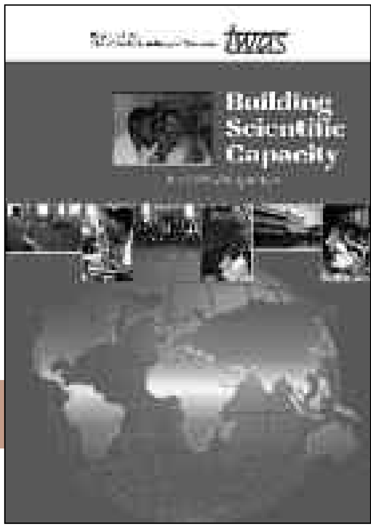
What follows is list of concrete actions that would help move developing countries to a more sustainable energy trajectory. None of these actions will be easy to implement. All will require the active engagement of all sectors of society, including individual consumers and local communities, non-governmental organizations, private businesses and industry, the science and technology research community, governments, intergovernmental institutions and donor organizations. Developing countries must take the lead in charting a new energy course for themselves, but developed countries must stand ready to provide support, recognizing that they have a vital stake in the outcome. These policy action include:

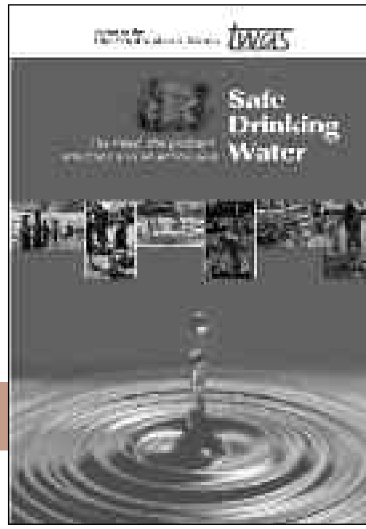
The energy challenges confronting developing countries today are significant and growing greater.

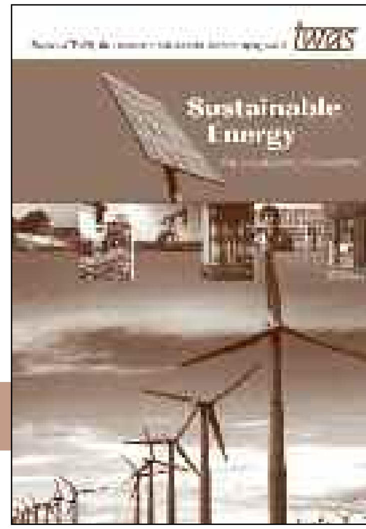
- Promote energy efficiency and adopt minimum efficiency standards for buildings, appliances and equipment, and vehicles.
- Reform and re-direct energy subsidies.
- Identify the most promising indigenous renewable energy resources and implement policies to promote their sustainable development.
- Seek developed-country support for the effective transfer of advanced energy technologies, while building the indigenous human and institutional capacity needed to support sustainable energy technologies.
- Accelerate the dissemination of clean, efficient, affordable cook stoves.

Two points concerning the need for harmonized policies and holistic approaches should be kept in mind. First, sustainable energy policies are more likely to succeed if they also contribute toward other societal and economic development objectives. Second, governments should look across policies to maximize positive synergies and to avoid conflicting incentives. Too often, governments – in responding to different pressure groups at different times – adopt policies that at least partially undermine each other. For example, government efforts to promote energy efficiency can be undercut by simultaneous subsidies that tend to promote increased energy consumption.

Harmonization will not always be possible for political and other reasons, and it may not be possible to pursue a comprehensive set of policies all at once. Nevertheless, governments should recognize that maximum benefits can be achieved through an approach that remains mindful of the interaction of different policies, leverages multiple opportunities wherever possible and responds to the specific needs and constraints of individual countries.







GREATER EFFICIENCY

Assessments of climate-change mitigation costs consistently find that energy efficiency improvements offer the largest and least costly emissions-reduction potential, while also providing important ancillary benefits such as energy cost savings, reductions in conventional pollutant emissions, less dependence on imported fuels and improved economic competitiveness. Energy efficiency can be especially important in rapidly industrializing countries as a way to manage demand growth, improve system reliability, ease supply constraints and allow energy production and distribution infrastructure to 'catch up.'

Historic trends show steady progress toward improved energy efficiency and reduced energy intensity (where intensity is measured by the amount of energy required to deliver a unit of goods or services).

China consumes nine times as much energy per dollar of GDP as does Japan.

This historic rate of improvement can be expected to continue. Yet, absent policy intervention, such improvement is unlikely to keep pace with continued growth in demand – especially in countries that are still in the early stages of industrialization. Moreover, experience shows that market forces often fail to capture all cost-effective opportunities to improve energy efficiency.

Countries like the United States have significant untapped energy efficiency potential. The US economy is only half as efficient as the Japanese economy (that is, the United States consumes twice as much energy per dollar of gross domestic product). But the opportunities are also large in some rapidly industrializing economies.

China, for example, consumes nine times as much energy per dollar of GDP as compared to Japan. Overall, a recent (2007) assessment of global efficiency opportunities by the McKinsey Global Institute found that the average annual rate of decline in global energy intensity could be boosted in a cost-effective way to 2.5 percent per year – essentially doubling the recent global rate of decline, which has been averaging approximately 1.25 percent per year. This is a significant finding. It confirms that even relatively small changes in year-to-year improvement can produce a wide divergence of outcomes over time.

At first blush, it might seem grossly insensitive to recommend energy conservation to countries that consume so little by global standards. But the historic record indicates that small, incremental and cumulative improvements in efficiency over long periods can deliver enormous benefits by making economies less wasteful, more productive and more competitive.

The potential benefits of such improvements are particularly large in countries with rapidly expanding demand for new infrastructure, buildings, appliances and equipment. It is typically much easier and more cost-effective to build in a high level of efficiency from

TWAS REPORT SERIES

Sustainable Energy for Developing Countries *is the third volume in TWAS's ongoing research report series, designed to examine critical science-related issues of importance both to the North and South. The previous volumes were* Building Scientific Capacity *and* Safe Drinking Water: The need, the problem, solutions and an action plan. *All three reports are available for downloading at http://www.twas.org/.*

the outset than to improve efficiency at a later point in time. Moreover, policies that ride the waves of grand transitions are less likely to encounter friction than those that run counter to them. In most situations and in all countries, programmes to promote more efficient use of energy are essential and represent a no-regret option for reducing demand for energy.

Governments have an important role to play in promoting energy efficiency and conservation. Efficiency standards for appliances, equipment and automobiles, for example, have proved extremely cost-effective in many developed countries and are often relatively easy to implement compared to other policies. Efficiency standards or codes for buildings are extremely important given the long life-span of most structures. To be effective, however, countries will need to educate architects and builders and develop the capacity to monitor and enforce compliance. By setting a floor or baseline for energy efficiency, minimum standards can deliver substantial energy savings in the future with a high degree of confidence.

SUBSIDY REFORM

Although energy subsidies have been declining in many parts of the world over the past decade, subsidies for fossil fuels still amount to several tens of billions of US dollars in developing countries. Cumulatively, these subsidies total less than overall taxes imposed on such fossil fuels as petrol. But they have several effects that undermine, rather than advance, sustainable energy objectives.

First, by artificially reducing the price of certain fuels, they distort the market and encourage inefficient levels of consumption. Second, fossil fuel subsidies make it more difficult for energy efficiency and cleaner sources of energy to compete.

The justification usually offered for subsidies is that they help the needy. In fact, many developing-country governments rely on subsidies largely because they lack other reliable mechanisms for making transfer payments to the poor. Even as a mechanism for poverty alleviation, however, subsidies are highly flawed. Because it is often difficult or impossible to restrict their use to the neediest households, the bulk of the benefits typically go to wealthier households that can afford higher levels of consumption.

Of course, fossil fuel subsidies are not peculiar to developing countries. They exist in many countries. They are also addictive and those who benefit from them are usually unwilling to give them up. Thus it is easy for analysts to write that subsidies should be eliminated or phased out. But this step is notoriously difficult to take for politicians who have to renew their mandates periodically.

Reforming and re-directing energy subsidies – if necessary, over time – may thus be a more realistic strategy for developing countries than attempting to abolish subsidies all at once. For example, a gradual

reduction in subsidies for conventional fossil fuels could be used to provide new subsidies for more sustainable forms of energy or more efficient technologies.

Where there is concern that poor households will not be able to access basic energy services if they have to pay the full market price, it might be feasible to provide subsidies only up to a certain level of consumption. Creative policy approaches are needed to navigate the tensions between expanding energy access and promoting sustainable energy outcomes. The research community and non-governmental organizations (NGOs) should take up this challenge and begin to explore possible solutions, including new mechanisms for transferring aid to poor households so that they can meet their basic needs.

In the longer run, energy prices for fossil fuels should not only *not* be subsidized, but also increased to reflect environmental and public health 'externalities' (*i.e.*, the unintended consequences of production) that are currently unrecognized by the marketplace. In principle, making sure that these positive and negative externalities are included in energy prices is an elegant way to address many issues of sustainability. Absent this step, the market will tend to over-allocate resources where there are negative externalities (such as pollution) and under-allocate resources where there are positive externalities (such as improved energy security).

The greatest obstacles to internalizing externalities are likely to be political. Raising energy prices is almost always deeply unpopular with business leaders and the public. Objections are likely to be voiced on the basis that higher energy prices could harm both consumers and the economy, with especially large effects on competitive industries and low-income households. As with reducing or removing subsidies, any effort to internalize externalities must navigate the apparent tension between raising prices for many conventional forms of energy and expanding access for the poor. (This applies whether government seeks to internalize externalities through a tax or through environmental regulation.)

Because of these parallels, some of the approaches noted in connection with subsidy reform may be helpful, including using a gradual approach and offsetting impacts on poor households through other forms of assistance. If the mechanism used to internalize externalities is an emissions tax, for example, the additional public revenues could be used to provide increased support for social services or other (non-energy) necessities or to subsidize other forms of consumption that primarily benefit the poor.

Many developing countries have abundant renewable energy potential.

INDIGENOUS RESOURCES

Many developing countries have abundant renewable energy potential and could benefit from the positive economic spill-overs generated by renewable energy development, especially in currently underserved rural areas where decentralized, small-scale renewable energy technologies are likely to be most cost-competitive with conventional alternatives.

CLEAN, EFFICIENT COOK STOVES

Immediate policy action is needed to accelerate the transition from traditional cooking methods to the use of clean, efficient cook stoves. Improved cook stoves are worth singling out because they offer enormous public health and welfare benefits at relatively low cost.

The World Health Organization (WHO) has estimated that, globally, exposure to indoor pollution from the use of fuels such as wood and dung for cooking and space heating causes as many as 1.6 million deaths annually, primarily among women and young children. In addition, the need to gather fuel can cause local environmental degradation and take up large amounts of time, for women and girls especially, that would otherwise be available for more productive activities.

A shift away from traditional fuels for cooking could marginally increase demand for commercial fuels like propane, natural gas or electricity. The change would be quite small in the context of overall energy requirements but more than justified from a social welfare perspective. Various programmes have been deployed to disseminate improved cook stoves among poor households in rural areas.

In most cases, however, government policies and public support will be necessary to capture these opportunities. The World Bank has concluded that incentives will usually be required to motivate the private sector to provide services to the remote and underdeveloped areas where the poor reside. In these areas, there is a case for providing intelligently designed incentives and/or subsidies for the development and use of appropriate technologies, preferably in ways that are targeted, simple, competitive and time-limited.

Incentives or subsidies by themselves will not always be adequate to overcome market barriers, especially for risky projects in less accessible areas of developing countries. In those cases, direct financial support from the government or outside groups or institutions may be necessary to implement renewable energy projects.

There is ample precedent for such interventions. International aid organizations and other entities have invested millions of dollars in sustainable energy projects in developing countries. The track record for such investments, however, is decidedly mixed. Many projects have failed as a result of inadequate attention to practical problems, local conditions and the need for ongoing maintenance and operational expertise.

Given the scale of the challenge in relation to the scale of available resources, it is vital that future efforts improve on the record of the past. This can partly be accomplished by taking greater care in the design and implementation of projects and by ensuring that the skills and financial resources needed to sustain new energy installations are in place. For its part, the research community should put greater emphasis on developing renewable energy technologies that are robust and well-adapted to the specific conditions found in developing countries. In addition, researchers and advocates alike must avoid the tendency to understate costs, or belittle potential problems with the technologies they bring forward.

Government support for sustainable energy technologies clearly has a role to play in the demonstration and initial deployment stages. But government involvement is even more crucial in the earlier stages of research and development (R&D).

Not surprisingly, developed countries have historically taken the lead in energy R&D spending because they have had the resources to do so. This is likely to continue to be the case. But it does not mean that there is no role for developing countries. Some of the larger developing countries have sufficient resources to make their own substantial technology investments. Others can participate by targeting investments and/or by working cooperatively with other countries or institutions to ensure that broader R&D efforts address the specific opportunities and constraints that apply in a developing country context. Investment in energy R&D can also be seen as a way to build indigenous human capital in science and engineering. Brazil, for example, has nurtured a viable domestic biofuels industry through all stages of technology development, deployment and commercialization.

Yet, according to the UNDP's 2004 *World Energy Assessment*, governmental support for energy R&D is declining in all countries. Given the challenges at hand, this trend will need to be reversed because only governments take a long enough view (on the order of decades) to support the long-term investments in energy R&D that are needed to fully commercialize new technologies.

TECHNOLOGY TRANSFER

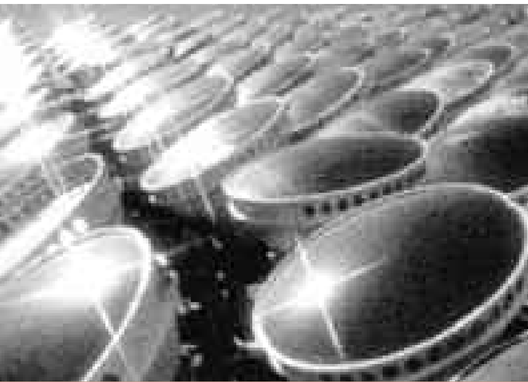
Substantial efforts to facilitate technology transfer from developed to developing countries are clearly essential to achieving global sustainability objectives. This need is widely acknowledged and was affirmed most recently at the December 2007 UN Conference on Climate Change in Bali, where developing-country negotiators called for language explicitly linking mitigation action by developing countries to "measurable, reportable and verifiable" support for technology, finance and capacity-building.

While the current situation clearly demands that more technology transfer be done, it also demands that technology transfer be done better. In the past, too many well-intended projects have failed to fulfill their promise. To ensure that rural areas of developing countries do not become graveyards for sustainable energy technologies, sustained attention must be paid – by host and donor nations alike – to the human and institutional capacities needed to support these technologies on a long-term basis.

Research shows that technology transfer is more successful and more likely to produce innovation when the host institution has requisite technical and managerial skills. As a result, there is an urgent need to develop skills to produce, market, install, operate and maintain sustainable energy technologies in developing countries. Ensuring that as much capacity-building as possible occurs in local communities and companies based in the host country could provide additional benefits, not only in terms of local job creation and

economic development, but also because project developers and operators are likely to be more effective when they have close ties to the population that will be using the technology.

One promising approach to capacity building involves the development of regional institutes that can provide training in basic technology skills to local organizations and individuals drawn from the local population. Such institutes could also help provide independent assessments of alternative technologies and policy choices, and explore strategies for overcoming real-world barriers to the expanded deployment of sustainable energy technologies. The Consultative Group on International Agricultural Research (CGIAR) has successfully used this approach to propagate technological and scientific advances in agriculture to developing countries. This may provide a promising model for the energy field.



In sum, successful technology transfer and a worldwide expansion of the human and institutional capacities needed to implement sustainable technologies are critical elements of an effective global response to the energy challenges we confront.

To meet these challenges, developed countries will need to follow through on current commitments and work closely with developing countries to make the most effective use of scarce resources. Developing countries, for their part, must not be passive bystanders in that process. They have everything to gain from leveraging future investments to build their indigenous human and institutional capacities and taking the lead in adapting and improving sustainable energy technologies to suit their particular needs.

The situation for developing countries is in many ways more difficult than for developed countries.

ENERGY OUTLOOK

The current energy outlook is challenging to say the least. The continuation of current energy trends would have many undesirable consequences, at best, and risk grave, global threats to human well-being, at worst.

The situation for developing countries is in many ways more difficult than for developed countries. Not only are there obvious resource constraints but access to basic energy services may be lacking for significant segments of their population.

Yet, developing countries also have some advantages: they can learn from past experience, avoid some of the policy missteps of the past half century, and may be able to 'leapfrog' directly to cleaner and more efficient technologies. Many elements of a sustainable energy transition can be expected to mesh well with other critical development objectives.

This does not mean that cleaner, more efficient technologies will usually be the first choice or that difficult trade-offs can always be avoided. In the near term, many sustainable energy technologies are likely to remain more expensive than their conventional counterparts. Changing incentives and overcoming barriers is for now more a question of political will and coordination than it is one of adequate resources.

Surveying the current landscape, ample justifications could be found for a profoundly pessimistic view – or an equally optimistic one. Which outlook proves more accurate will depend to a large extent on how quickly developed and developing countries not only recognize, but also begin to act upon, their shared stake in achieving positive outcomes that can be managed only by working together. ■

*···> **Dilip Ahuja**, ISRO professor of Science and Technology Policy at the National Institute of Advanced Studies (NIAS), Bangalore India, and **Marika Tatsutani**, independent consultant with more than 15 years experience in the field of energy and environmental policy*

···> To read the full report, see www.twas.org or contact info@twas.org

CAUTION: MEN AT WORK

THE SCIENTIFIC COMMUNITY HAS TOO MANY MEN AND, MORE OFTEN THAN NOT, THE MEN WHO DOMINATE SCIENCE ARE OLD, SAYS CIGDEM KAGITCIBASI (TWAS FELLOW 2006), PROFESSOR OF PSYCHOLOGY AT KOC UNIVERSITY IN ISTANBUL, TURKEY.

The following article is one of a series of more than 30 articles in A World of Science in the Developing World, *A TWAS Supplement to the Nature Publishing Group issued on the occasion of the 25th anniversary of TWAS. The Supplement provides a broad overview of the state of science and science policies in the developing world a quarter century after the Academy was launched. All of the articles can be freely accessed at www.nature.com/twas.*

In science, as in life, issues related to gender and age might not be that simple and, at times, they are beset by contradictions that might prove surprising and difficult to understand. Limited data, moreover, render any conclusions uncertain. Nevertheless, existing data show that there is tremendous diversity in gender and age balance among regions and cultures across the globe.

Statistics compiled by the United Nations Educational, Scientific and Cultural Organization (UNESCO), for example, shed revealing light on the place of women in the sciences and scholarship. In Latin America, 46 percent of researchers are women. That far exceeds the world average of 27 percent. By contrast, only 10 percent of researchers in India are women compared with an average of 15 percent in Asia. Yet, women scientists in such central Asian countries as Kyrgyzstan, Kazakhstan and Mongolia enjoy gender parity. That is true in only five European countries — Latvia, Lithuania, Macedonia, Bulgaria and Estonia — all in eastern Europe.

In southeast Asia, women comprise over 40 percent of the workforce in science. In the Philippines, it is 55 percent. In Myanmar, women represent 85 percent of all researchers, the highest proportion of any country in the world. Conversely, the percentage of women researchers in Japan is just 12 percent, the lowest in the region and comparable to the rates in Arab states. The relatively low percentage of women scientists in western Europe (27 percent) stands in sharp contrast to the high percentage in eastern Europe (42 percent).

These figures indicate that economic well-being, scientific capacity and even lofty political principles do not automatically translate into expanded opportunities for women in science. Other factors are also important, including a nation's educational policies, history and cultural norms.

WOMEN WORKING

The gender gap, of course, is not new. It existed in ancient times and has persisted in contemporary societies. It is often found in the most prestigious professions.

A study published by R. C. Blitz in the 1970s revealed a similar disparity. It determined that women in scientifically and technologically advanced countries averaged just 5.7 percent of the workforce in five elite professions (architecture, dentistry, engineering, law and medicine). The figure in middle-income nations and developing countries was 7.25 percent rising to 25 percent in Turkey and the Dominican Republic, the highest in the survey. Admittedly, the statistics used preceded the women's liberation movement in the West, particularly in the USA. Nevertheless, they are telling, and provide the background for the current global situation.

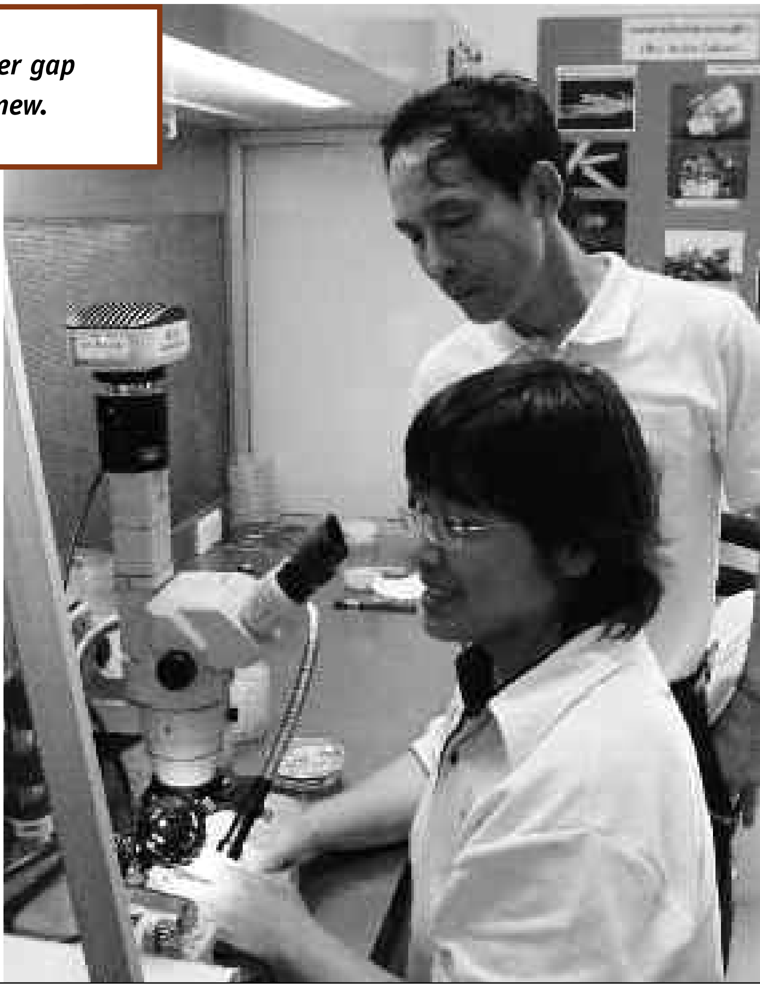
The gender gap is not new.

What accounts for these unexpected findings? Could it be that well-educated women in developing countries have enjoyed slightly better opportunities than their counterparts in developed countries? Rapid urbanization in developing countries has generated an increasing number of positions for well-educated citizens. Moreover, in developing countries such as Turkey, employers might prefer well-educated women living in nearby cities to less-educated men living in distant rural areas and small towns.

At the same time, elite professions and secure government jobs, which have rapidly increased in Turkey and other developing countries, are particularly attractive to middle-class women because of the high income and respectability that they bestow. In traditional societies where women have rarely worked, the distinction between 'appropriate' and 'inappropriate' work for women is often less of a factor. That is true in Turkey and many other developing countries, where it is as common for women to be engineers as teachers. Women in developing countries might, of course, find serious obstacles standing in the way of employment. Yet, once they breach these barriers, they do not face the prospects of being confined to 'female occupations'.

Put another way, the main distinction in many developing countries has been between 'working' and 'non-working' women. By contrast, social norms in countries like the USA, where women have been a prominent part of the workforce for over 50 years, traditionally defined teaching and nursing (with their emphasis on care-giving) as women's work, and engineering and scientific research (with their emphasis on competition and technical skills) as men's work. That is, at least until recently.

Again, before the women's liberation movement in the USA, researchers such as Matina Horner even detected a 'fear of success' among American women who, when considering careers in 'male' professions, worried that they would be ostracized for succeeding in a man's world. Such psychological sensibilities have



never been a critical factor among professional women in Turkey and many other developing countries.

Finally, the persistence of extended families and the greater availability of paid help in middle-class urban households in many developing countries have allowed women to depend on support from other women (such as mothers, sisters, cousins and maids) in pursuing their education and careers. Consequently, husbands have not had to assume what society sees as 'feminine' responsibilities, such as child care. With their traditional male gender roles intact, husbands have tended to be happier with their wives' pursuit of professional careers.

Turkey has more female full professors than any European Union country.

Women's liberation movements, especially in the USA but also in Europe, have helped to expand opportunities for women over the past three decades. Nevertheless, what we see so far is that the number of women in professional positions remains higher in many developing countries than in developed countries. Turkey, for example, has more female full professors (23 percent) than any other European Union (EU) country. In Germany the figure stands at 4 percent, in Denmark 6 percent, in Sweden 7 percent and in the UK 10 percent.

Despite the success of professional women, Turkey nevertheless has one of the continent's lowest participation rates of women in the labour force (just 23 percent compared with 41 percent in Germany and 40 percent in France). Women in Turkey also have one of the world's lowest literacy rates (78 percent), compared with 98 percent in Europe, according to the UNESCO Institute for Statistics (UIS).

Educated urban women in Turkey and in many other developing countries represent a privileged class. This points to one more gap: a female-to-female gap that is driven by distinctions in social class and urban versus rural lifestyles.

A WORLD OF SCIENCE

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The supplement's primary goal is to examine critical issues in science, technology and innovation and in science-based international development. The articles are written by prominent scientists. Many are from the developing world. All have devoted their careers either to scientific research or to science-policy issues in the South. Some have done both. All are either members of TWAS or scientists who have worked closely with the academy.

To browse the supplement, see www.nature.com/twas. All articles can be accessed and downloaded free of charge. A limited number of free-of-charge print copies are still available from the TWAS Secretariat; please contact gisela@twas.org.

Statistics, in fact, show that in developing countries, this 'in-gender' gap might be more prominent than the 'between-gender' gap. Whether this will continue remains an open question. Recent studies suggest the Westernization of urban societies in developing countries is generating the sort of gender distinctions seen in developed countries. In academia, for example, women are increasingly pursuing degrees in the arts, education and humanities, instead of engineering and the sciences.

On a global scale, only slightly more than one-quarter of the world's researchers are women. Two other characteristics mark the status of women in research worldwide. The first is that women are more likely than men to be employed in the public sector than in the private sector. The second is that women are less likely to hold administrative positions.

On the positive side, because some women are less burdened by administrative duties, they can devote more time and effort to teaching and research. On the negative side, of course, lies the question of power and influence. Women do not have much say in issues related to policies, budgeting, management and promotions.

Such workforce limitations, of course, are a global phenomenon and are not restricted to the developing world. Again, this might be driven by different factors, including a preference to devote more time to family and children, and a desire to focus on teaching and research instead of administration and management. Then again, the 'power gap' might be driven by gender bias. Whatever the causes, the result is that less power is in the hands of women.

For the first time in the history of the USA, women now serve as presidents in one-half of the Ivy League universities, including Harvard, and in a quarter of all colleges and universities, according to the American Council on Education. Yet, women in the USA still hold fewer than 20 percent of all full university professorships. Likewise, in many developing countries, women remain in the lowest academic positions and rarely become administrators, let alone presidents. That is particularly true in Africa and in the Arab region, although recently women have begun to enter mid-range management positions, mostly as deans and department chairpersons.

... in developing countries, the 'in-gender' gap might be more prominent than the 'between-gender' gap.

MIND YOUR AGE

Just like the gender gap, the age gap in the sciences and among researchers is a global concern that defies broad generalizations.

When it comes to science and academia, age truly does matter. The issue is this: how can age distribution be managed to provide opportunities for young researchers without undervaluing the benefits derived from the experience, knowledge and wisdom of older researchers and faculty?

If too many older scientists and scholars stand in the way of the younger generation's advancement, university students are likely to seek more lucrative fields in business, medicine and law. Personal goals for advancement must remain within reach if students are to pursue demanding and time-consuming careers in scientific and scholarly fields.

Yet, it also takes a great deal of time, effort and sacrifice to achieve distinction as a researcher or academic, and it would be unfortunate to see well-trained older individuals leave their positions while they remain enthusiastic and productive. Encouraging universities and research institutes to make full use of the human resources that are available benefits both science and society. That is especially true in developing countries, where intellectual resources are in short supply yet in high demand.

Statistics on age distribution in the scientific community are even more limited than those on gender distribution, and data are particularly sparse in the developing world.

GENERATION NEXT

As part of a larger demographic trend, the developed world is facing a future marked by ageing researchers and faculty. Improvements in medical care, combined with laws prohibiting mandatory retirement, have led a growing number of researchers and academics to continue working well beyond their sixties or even seventies. Statistics show that there was a threefold increase in the number of faculty over 70 years of age in US universities between 1995 and 2000. As Lawrence Summers, former president of Harvard University and currently director of the National Economic Council for US President Barack Obama, has noted: "It defies belief that the best way to advance creative thought, to educate the young, or to choose the next generation of faculty members is to have a tenured faculty with more people over 70 than under 40".

In India, by way of contrast, faculty must retire by the age of 60 years. As a result, the 'greying' of academia is not as much an issue there as it is in developed countries. India's slow promotion system, which at times is based more on personal contacts than merit, elicits much more concern and many more complaints.

While systems of promotion vary across the developing world, many still follow outdated methods of assessment drawn from the colonial period. However, many countries in the developing world have undergone a rapid expansion in higher education that has required them to hire a large number of young professors. In China, for example, 30 percent of the faculty are in their twenties and thirties, while only 3 percent are older than 60 years. There is, however, a 'faculty void' between the ages of 45 and 50 years, largely due to the assault on science and other intellectual pursuits that took place during the Cultural Revolution.

In 1990, an estimated 68 million students were attending universities worldwide. In 2004, the world's student population had nearly doubled to 132 million, and by 2025 it is projected to reach 150 million. Most of this growth is taking place in developing countries.

When it comes to science and academia, age truly does matter.

More students, of course, means more faculty will be needed. Yet, universities and publicly funded research institutes are not the only places where scientists and scholars can be found. There is also a rising number of research and development centres in the private sector, eagerly seeking to hire young graduates with good analytical skills. This is true in both the developed and the developing world.

In short, age is an issue in science and academia across the globe.

But the developing world's youthful population, combined with the unprecedented growth of universities and research centres, could mean that young scientists and academics will enjoy greater opportunities for advancement than their counterparts in the developed world. That will be true, however, only if procedures for hiring and advancement become less cumbersome and easier to implement. The young will be present in the developing world in large numbers, but whether they will be well-served will depend as much on administrative reforms as on demographics.

In China 30 percent of the faculty are in their twenties and thirties.

WHERE TO NOW?

As the discussion above indicates, issues related to gender and age are complex and multifaceted. Perceptions might differ from reality, and solutions might be less evident than they first appear.

This is particularly true in the case of gender distribution, where historical and societal forces have moulded cultural values that are not easily altered.

Attaining full gender equality, whether in science, academia or other sectors of society, will require a profound transformation in cultural values that will take generations to achieve. While waiting for a cultural revolution that might never arrive, nations could embark on specific reform measures to mitigate the problems inherent in the gender and age gaps. The measures that they might want to consider include educational programmes to increase awareness of the importance of gender equity both as a moral and economic issue. It could also mean enacting policies that encourage women to pursue education and employment in fields of science and scholarship.

Developing countries have a great deal to gain from the full participation of women in the knowledge economy. It is encouraging to note that many developing countries enjoy a head start in their efforts to advance this goal, largely due to the comparatively high percentage of professional women found in elite, high-paying fields. The challenges today lie in increasing opportunities for poorer, less-educated women in cities, small villages and rural areas, and in breaking through the 'glass ceiling' so that more women will hold management and leadership positions.

As for age imbalances, innovative policies must be devised to protect experienced knowledge workers without discouraging the next generation of students from entering science and other fields. For example, older professors could be allowed to remain on the faculty without remuneration and without administrative responsibilities – allowing them to pursue their own research agendas freely and to teach classes. This would allow older faculty to remain active and involved without blocking the career paths of younger researchers. It would also encourage an intergenerational exchange of ideas and research collaborations between young and old. It does, of course, depend on having reasonable pension systems in place, and a willingness to approve and enforce mandatory rules for retirement.

Achieving gender equality and constructing a balanced age profile in the developing world could prove to be as important as creating world-class laboratories and nurturing an environment that encourages creativity and innovation. ■

*→ **Çigdem Kagitcibasi** (TWAS Fellow 2006)*
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COMING HOME TO IRAQ

AFTER TWO DECADES OF WAR, INTERNATIONAL SANCTIONS AND DICTATORSHIP, IRAQ IS STARTING TO REBUILD ITS ONCE FORMIDABLE SCIENCE BASE. TWAS FELLOWSHIP RECIPIENT FOUAD MAJEED DESCRIBES WHAT IT'S LIKE TO RETURN HOME AFTER SPENDING NEARLY FOUR YEARS IN ITALY AND BRAZIL.

Fouad Majeed received his PhD in theoretical nuclear physics in June 2005 from Al-Nahrain University (formerly Saddam University), in Baghdad, completing his studies amid the turmoil of the war. Six days after graduating he was in Trieste, Italy, for a three-month research visit, thanks to a grant from the Abdus Salam International Centre for Theoretical Physics (ICTP). It was his first time abroad. During his short stay in Trieste, Majeed learned about TWAS and the opportunities offered by its postgraduate research grants.

Inspired by a rewarding experience at ICTP to pursue additional studies abroad, Majeed applied for a one-year TWAS-CNPq (Brazil's National Council of Technological and Scientific Development) Postdoctoral Fellowship to study nuclear reactions at the *Instituto de Fisica* of the Federal University of Rio de Janeiro (UFRJ). His application was accepted, and by the end of April 2006, Majeed was on his way to Brazil, a world away from home.

THE HEART OF MATTER

As a doctoral student in Baghdad, Majeed's research was restricted to nuclear structure – theoretical work focusing on the fundamental question of how the protons and neutrons are held together in the nucleus of an atom.

The TWAS-CNPq fellowship at UFRJ gave Majeed a chance to study nuclear reaction theory for the first time. Nuclear reactions – where two nuclei or nuclear particles collide, resulting in an alteration in the nucleus – can be induced and observed by experimental researchers to help them learn more about the properties of nuclei. Nuclear fusion (where two light nuclei 'fuse' to form a heavier one) and fission (where a heavy nucleus, having absorbed additional particles, splits into two lighter ones) are the best known of many types of possible nuclear reactions.

In Brazil, Majeed collaborated on research projects on "nuclear reactions with weakly bound nuclei." Such nuclei, Majeed explains, "are characterized by the low

energy that binds the nucleus" – that is, which holds the protons and neutrons together.

"Nuclear reaction experiments using beams of weakly bound nuclei," he continues, "have attracted considerable interest in the past decade." Such experiments involve bombarding a 'target' nucleus with 'projectile' beams of other nuclei. Upon collision, the target nucleus breaks up, emitting particles. Using such tools as gamma ray detectors, researchers can observe this process, signified by the changing levels of kinetic energies emitted by scattered particles, which, in turn, allows them to measure the various properties of a nucleus.

Reaction experiments with weakly bound nuclei are important for several reasons, including, as Majeed explains, "for the development of nuclear models, for a better understanding of nucleosynthesis and for the production of super-heavy elements."

"The TWAS fellowship made a big difference."

Theoretical nuclear researchers like Majeed and his Brazilian colleagues develop mathematical models to help explain the nuclear reactions that experimentalists observe. Such theoretical work is especially complicated (both to do and to explain) because it can involve both quantum and classical (or Newtonian) mechanics. While classical mechanics (the physics most of us learned in school) treats macroscopic objects, quantum mechanics describes matter at the atomic and subatomic scale. A fundamental insight of quantum mechanics is the dual nature of atomic particles – that is, they behave like both particles and waves.

This dual nature, as well as the extremely small scales involved, makes both measurement and calculation extremely difficult. Theorizing about what happens in experimental nuclear reactions depends upon such concepts of quantum mechanics as 'coupling' and 'tunnelling,' which are hard for the layman to grasp.

Quantum 'coupling' refers to a situation in which different quantum systems are 'bound' so that a change in one causes a simultaneous change in the others, revealing a kind of energy transfer that is not well understood but which suggests the wave properties of matter.

Quantum 'tunnelling' refers to how a nuclear particle, though faced with a barrier which (according to Newtonian mechanics) would require a higher energy to cross, nevertheless (according to quantum mechanics) materializes outside the barrier, as if it had 'tunneled' through.

"From the theoretical point of view," Majeed says, "nuclear reactions using weakly bound nuclei are very challenging." That's because "the break-up channel of the projectiles is in a continuum, and therefore an infinite number of channels must be taken into account." In other words, the many possible energy states occupied by the scattered particles are difficult to analyse because they overlap.

"Coupling occurs between the states in the continuum," Majeed says, "as well as the bound states of the

TWAS SOUTH-SOUTH FELLOWSHIPS

TWAS's South-South Fellowship Programme provides opportunities for young scientists from developing countries to conduct research at an approved institution in another developing country.
In 2007, the Academy awarded more than 100 of these fellowships, in cooperation with institutions in Brazil, China, India, Malaysia, Mexico and Pakistan. Since the programme's inception in 2003, TWAS and Brazil's National Council of Technological and Scientific Development (CNPq) have awarded 138 fellowships, 93 at the postgraduate level and 45 at the postdoctoral level.

projectile nuclei." So, the slightest adjustment in calculation for one quantum state will require an adjustment for all the states that are coupled.

"To handle this situation," he explains, "the continuum can be broken down into analysable segments, called 'energy bins,' by use of the continuum-discretized coupled channel method (CDCC)." This method is extremely complicated, he adds, and "requires considerable computer power," which was not available to Majeed in Iraq.

The wave-like behaviour of sub-atomic particles – allowing simultaneous interactions between separate states (coupling) and 'tunnelling' through barriers – makes calculating with any degree of accuracy (and at such microscopic scales) a formidable challenge. Complicating matters still further, Majeed and his colleagues at UFRJ rely on 'semiclassical models' – using quantum mechanics for some calculations and classical mechanics for others – to solve problems that could not be resolved using only one approach or the other.

GAINING TIME

Majeed's experience in Brazil was both rewarding and memorable. "I was fortunate to be able to study with such knowledgeable and friendly people," he says. "I am particularly grateful to my supervisors Luiz Felipe Canto and Raul Donangelo, who were so patient and helpful that I did not hesitate to ask even simple questions, and to M. S. Hussein, an Iraqi professor at the University of São Paulo, who assisted me in the early stages of my fellowship application."

"The TWAS fellowship," Majeed adds, "made a big difference. It allowed me to achieve significant progress in a short time. In addition to the physics, I also learned how to use computer programmes, such as FORTRAN, in nuclear reaction experiments."

Majeed's education was also cultural. In Brazil, he says, he "discovered an entire way of living that was markedly different than my own. The novelty of my surroundings, combined with the amicability of my hosts and the excitement of learning new things, really inspired me."

Despite his positive experience, Majeed's time in Brazil was overshadowed by the worsening situation in his home country. A brief lull in violence in the winter of 2004/05 had been quickly followed by a resurgence of death and mayhem. By the time of Majeed's departure from Iraq in June 2005, the situation there was rapidly deteriorating.

WAR'S CHAOS

Majeed had experienced the war first-hand, when his graduate studies were brought to an abrupt halt by the 2003 invasion. "I was in the second year of my studies, working on my thesis," he says. "My studies were interrupted for five months, from March to July 2003. I was forced to leave Baghdad for my family home in Babylon."

The US Marines used the campus of the then Saddam University as a base of operations. "The dormitory where we once lived," he says, "was badly damaged." Aside from the obvious physical dangers, the growing uncertainty prompted him and his fellow students to put everything on hold.

Yet, by September 2003, five months after the fall of the Saddam regime, he says, "the situation had begun to improve, which encouraged us to return to our studies. Although there were heavily armed forces everywhere, people were walking in the streets of Baghdad again, going to work and shopping." Before the year was out, however, the car bombings resumed. "Scenes of burning vehicles on the highway were a daily occurrence."

"In 2004, when the real chaos began, I was again living in Baghdad, having resumed my PhD thesis," Majeed continues. It was not long before "the situation became very dangerous, and we avoided moving in the streets, venturing out only if necessary, for example, to buy food. To reach my family in Babylon, I would have had to pass a very dangerous area – what came to be called the Triangle of Death."

"This chaos increased," he continues, "and, month after month, life became worse."

KILLING FIELDS

In addition to the mounting sectarian violence and terrorist attacks, a new menace began to surface – an organized campaign to assassinate Iraq's intellectual elite. With so much bad news coming out of the country, these assassinations went underreported. Conservative estimates, however, put the number of Iraqi scientists, academics and doctors who were killed at more than 300. Whoever was behind the assassinations, they understood only too well the importance of an academic community to a country's future.

"A few months before my departure for Trieste," Majeed says, "the attacks on academics and physicians began. It soon became clear that anyone known to have a university job was at great risk of being murdered." Just two months after leaving for Italy, he adds, "two engineers whom I knew were murdered in Baghdad."

"When people see such prominent people being killed," Majeed adds, "they feel they have no future, and they lose all hope." There were also the constant kidnappings.

While in Brazil, Majeed kept in close contact with family and friends back home, who urged him to remain abroad until the situation improved. So, when his TWAS fellowship came to a close, he returned to Trieste, applying successfully for humanitarian protection from the Italian government, hoping that conditions in his home country would soon get better. He was safe. But finding work in his field was another matter.

"When I came back to Trieste from Brazil in May 2007," he says, "I tried my best to find another post-doc or teaching position. Unfortunately, I found nothing." To support himself financially, he learned web design programming and worked as a freelance web designer.

Anyone known to have a university job was at great risk of being murdered.

HOMEWARD BOUND

But Majeed was eager to return home. He was also anxious to resume his research and to build on the knowledge he had acquired at the Federal University of Rio de Janeiro.

When, by late 2008, it had become clear that the situation in Iraq had finally stabilized, with violence levels having fallen dramatically (by 80 percent since early 2007, according to some reports), Majeed knew the time had come to go home.

On 15 November, after three and a half years, he returned at last to Iraq. "I decided to come home," he says, "because I felt that the security situation was finally under control. And I did not want to stay far from my family."

"Many streets were blocked and the army or police were everywhere." But security, he emphasizes, "has indeed improved."

Majeed quickly acquired a post teaching physics at Babylon University, near Hilla, in Babil province. "Getting a job like this," he says, "is not so difficult for well-qualified PhD-holders." He applied through a government programme encouraging qualified academics, who had left Iraq during the Saddam regime or after the 2003 invasion, to return to the country.

Though just 100 kilometres south of Baghdad, Babylon, says Majeed, "is more peaceful. Since I have been back, I haven't heard any explosions. I feel safe here."

One of the most renowned cities of antiquity, Babylon was home to the legendary ruler Nebuchadnezzar, who had the Hanging Gardens (one of the Seven Wonders of the World) built here in around 600 BCE. The provincial government recently opened a tourist park featuring the excavated ruins of the ancient city, near the river Euphrates, a small reminder of the long history of Iraqi civilization.

"The most recent official figures indicate that 250 PhDs have returned to Iraq since in 2008," he says. "This is up from 170 when I returned in November." Given that as many as 6,000 scientists, researchers and medical doctors are believed to have fled the country since the war, these numbers may not seem too encouraging.

Yet Majeed is optimistic that the tide has turned. "Of course, there are still many professors who left and are not yet ready to return," he says. After all, "even if things are much improved now, there are still incidents." And, he adds, "we are still rebuilding. It is always difficult to pass through the streets, for instance, with the traffic and the roadblocks."

Official figures indicate that 250 PhDs have returned to Iraq since in 2008.

Then too, many Iraqis have built a life elsewhere, and picking up and moving again is not so simple. "Perhaps they have married while abroad, or their financial situation does not allow it," he says.

MAKING DO

Majeed teaches in the physics department of the university's College of Education. He is, as he observes, "educating the country's future teachers." Babylon University has some 17,000 students. The academic staff numbers about 1,500, working in 12 colleges.

His students (120 third-year, and 80 fourth-year), Majeed says, "tend to be optimistic, and they are enthusiastic about their classes." Yet, he notes, "while the situation has improved, the country is still not completely safe, and the rebuilding of the infrastructure is a slow process." All this adversely affects the students' sense of the future. Consequently, many have little ambition to continue their studies.

Yet, he adds, "the academic staff are more positive about the future of the country." Most, he explains, "believe they now have a better chance to teach, do research and interact with researchers abroad – in other words, to lead a normal life as a university professor."

The war, of course, has left a seriously damaged infrastructure. Institutions in Babylon, thankfully, were largely spared the lootings experienced elsewhere. But students and professors must still make do with less than optimal facilities.

"The library is not very good," he admits. "Too few volumes survived the invasion, and most of the science and engineering books that remain are out of date. The university is just starting to work with international organizations, including UNESCO, to improve the situation."

Meanwhile, communication remains a challenge. "Landline telephones have bad service," he says, "and it is expensive to call within Iraq. Mobile phones are rapidly growing in popularity. But to get good reception, you have to be near the city centre."

"Internet access is also bad," he continues. "I need to go to the university's internet centre to use it, because I have no internet access in my office. So, if I want to check my emails, I have to take time to go over there. Access at home is too expensive, and the service is not good."

The greatest challenge for both students and professors, however, is overcoming what Majeed calls 'deteriorated' academic levels. "Higher education," he explains, "especially in the 1990s and the few years before the war, was in a state of decline due to the sanctions imposed on Iraq, which adversely affected the living conditions of Iraqi academics and researchers. The isolation of Iraq from the international community," he adds, "had an adverse impact as well."

But now, he says, "the improved security situation is encouraging academics to return to Iraq." As part of its measures to rebuild the country's science base, the

Iraqi government has raised academic salaries. University lecturers can now earn US$2,000 a month, compared to US$50 during Saddam's regime.

MAGIC NUMBERS

Majeed's return to academia has allowed him to resume his research, which he hopes will contribute to rebuilding Iraq's scientific base. His current research focuses on "nuclear structure, using shell model calculations and comparing these theoretical studies with the available experimental data."

The shell model is one of three mathematical models of the structure of the nucleus. Analogous to the atomic shell model, which describes electrons orbiting in 'shells' around the nucleus, the theory attempts to explain how the nucleus holds itself together without all the particles orbiting in that tiny space colliding with each other.

Lending support to the shell structure theory is the finding that nuclei with *even* numbers of protons and/or neutrons are more stable than those with *odd* numbers. Moreover, there are so-called 'magic numbers' (*e.g.*, 2, 8, 20, 28, 50, 82 and 126) of neutrons and protons that result in the greatest stability. The most stable nuclei have magic numbers of both protons and neutrons – and are referred to as 'doubly magic'.

Among its many complexities, the theory holds that nuclear particles do not collide with each other because they are 'fermions', which means that they obey the Pauli Exclusion Principle – that is, they avoid each other. Thus, when additional particles are added to the closed system of the nucleus, each occupies a different energy state, gradually filling up all the available states (from the lowest to the highest).

The goal of his research, Majeed explains, is "to develop more robust theoretical models to help guide the work of experimentalists."

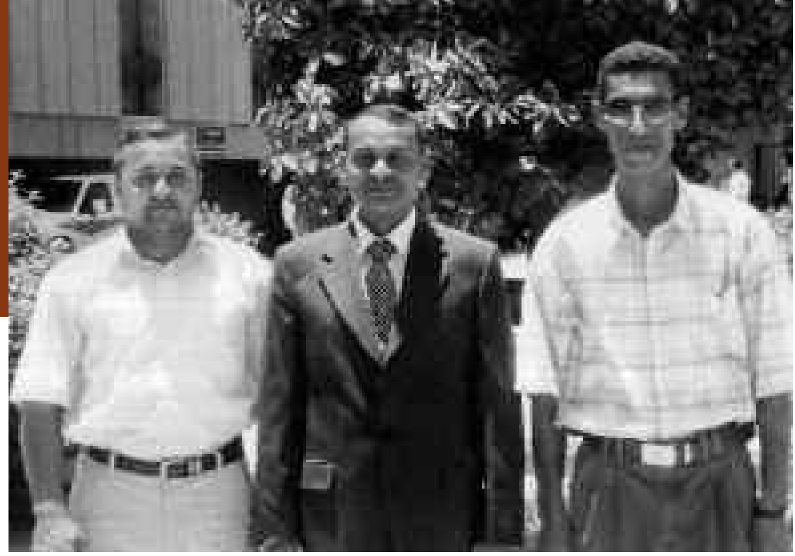
Though he says he has "two colleagues in the physics department" with whom he can discuss his work, Majeed is currently trying to find professors as well as promising students to form a study group to collaborate on complex research questions. "Hopefully, I will be able to do that soon," he adds.

WORLD OF OPPORTUNITY

In addition to helping his students learn physics, Majeed also tries to make them more aware of their opportunities. "They need to learn more about the outside world," he says, "and to aggressively seek out information about study programmes abroad."

Having successfully completed studies abroad, Majeed is a role model for how to take advantage of such opportunities. Moreover, he understands where his students are coming from and how such knowledge remains hard to come by. "They are like I was before I left," he says.

"Students may earn their PhD," he continues, "but then they don't know how to find ways to continue their research. It's partly a language problem: their English is lacking. Also, when they ask me 'what is my future?' they are usually thinking about tomorrow



or the day after tomorrow. They take a short-term view. I want them to think more long-term, to learn English, to find out about scientific opportunities abroad."

"The knowledge I gained in Brazil should prove helpful in my efforts to help raise the level of science in my home country. After so many years of destruction, we have begun to rebuild. I hope to be among those who will make a contribution to this effort, however modest it may be."

"Programmes like the TWAS fellowships provide an important avenue for scientists throughout the developing world and particularly for scientists in countries like Iraq. It provides opportunities for South-South scientific exchange that could serve as a source of future success for scientists whose careers have been put at risk because of the situation in which they find themselves."

For now Majeed is focused on his students. But in the not-too-distant future, he hopes to again be able to study abroad. "I have a dual passion for travel and learning," he says, "and I hope to be able to attend workshops outside of Iraq in the near future."

Despite the difficulties of the past six years, life has gone on for Iraqis.

REBUILDING, WITH THE GLOBAL COMMUNITY

Despite the difficulties of the past six years, Majeed says, life has gone on for Iraqis. "Even when the violence was so intolerable, people could not just hide away at home. They were afraid, yes, but they had to go to work, to school, to the market. You take care but you try to lead a normal life."

This resolve, he believes, will stand his compatriots in good stead as they face the daunting task of rebuilding their country following years of war.

Indeed, Majeed has high hopes for Iraq's scientific future: "I am confident that our universities will regain the level of excellence they once enjoyed," he says, "despite the great challenges that lie ahead." Today, he says, the country "is more open to the international community." This openness translates into "great opportunities for academics and researchers to interact with foreign researchers around the world."

"To strengthen the universities, the Iraqi ministry of higher education and scientific research has recently adopted a number of programmes," he adds. "These include scholarships for postgraduate studies and visiting programmes for academics." In 2008, the Iraqi government spent US$10 million to send 1,500 professors and students abroad. However, plans to provide 10,000 fellowships to study or do research abroad over the next four years have been put on hold in the wake of falling revenues due to the sharp decline in oil prices (from nearly $150 per barrel last summer to around $60 currently).

Nevertheless, he acknowledges that the Iraqi government cannot rebuild the scientific community all on its own. "Iraq will need more scientific and cultural exchange with both developed and developing countries," he says. "This collaboration with others from other cultures is crucial."

Majeed is looking forward to participating in this collaboration, doing his part to help rebuild his home country – from the fundamentals on up. ■

ONE AND THE SAME

BRAZIL IS A COUNTRY OF 180 MILLION PEOPLE. EACH BRAZILIAN, LIKE EACH ONE OF US, HAS A UNIQUE GENETIC MAKEUP THAT IS TRACEABLE TO A COMMON GENETIC LINEAGE WITH ROOTS THAT LIE IN AFRICA.

Sergio D.J. Pena (TWAS Fellow 2008), professor of biochemistry and immunology at the Universidade Federal de Minas Gerais in Brazil, explains what humankind's common genetic heritage means not only for Brazilians but for everyone, everywhere.

We are many. We are one. Or, as I sometimes prefer to observe in a much more mundane way: In appearance, we are all very much similar and we are all very much different.

At first glance, such a statement may sound like a contradiction or, even worse, incomprehensible. How can we be alike and different at the same time? Isn't that comparable to having sunshine and rain at the same time?

But think about it, sunshine and rain at the same time is possible. In fact, when a sun shower occurs, we are awestruck by the beauty that it creates and by the rainbow that often rises in the misty haze that follows the sunlit rain.

The truth is that each person has a unique genetic makeup, yet each shares a common genetic heritage. In fact, when it comes to our genome, we are all Africans. That's because we can all trace our genetic steps back to the first *Homo sapiens sapiens* (the only extant subspecies of *Homo sapiens*), who emerged from east Africa (present-day Ethiopia is the place most often cited by anthropologists) about 200,000 years ago.

Some 130,000 years later *Homo sapiens sapiens* began to leave their 'homeland', signalling the world's first – and most historically significant – wave of human globalization.

Scientists estimate that the earth is 4.5 billion years old. Since modern human evolution began some 200,000 years ago, it is fair to say that modern humans are indeed a young species, who has resided just a brief time on this planet. It is also fair to say that the first wave of human colonization, marked by *Homo sapiens sapiens* venturing from their east African homeland, is an even more recent phenomenon.

MEDICINE AND THE GENOME

There is a great deal of medical interest in the study of human genomic variation and its influence on health and individual drug responses. This has led researchers both to analyze and characterize the geographical distribution of human genetic diversity, usually by defining and dividing human populations by race, geography, culture, religion, physical appearance or other factors that seemingly distinguish one group from another. Yet, a growing body of evidence indicates that such divisions of humanity may not be the appropriate strategy for dealing with human variation. Treating people of African and European ancestry as separate entities for the purposes of genetic studies reinforces the perception that these two populations have different biological characteristics. The reality, however, is that Africans and Europeans have a deep and abiding genealogical relationship. Indeed the genetic heritage of Europeans is rooted in Africa and can be traced to ancestors who left their homeland some 200,000 years ago. This insight not only carries ethical importance but could also lead to a reassessment of how we conduct clinical trials and treat disease. That's because, given this knowledge, it makes no sense to speak about 'race-targeted' or 'ethnically targeted' drugs. Instead, we should focus on the unique genomes of each individual, which are structured as life-affirming-mosaics marked by diverse genealogical histories. Only after accepting this paradigm, based on individuals and not population groups, can we begin to fulfil the promise of personalized medicine.

The *Homo sapiens sapiens* who left east Africa some 70,000 years ago, in a sense, were the first human colonizers, replacing Neanderthals and other archaic *Homo sapiens* in their wake.

Many millennia later, between the 15th and 19th centuries, Africans were forcibly removed from their homelands and sent to the 'New World' as slaves by European colonizers (who themselves retained genetic markers of their African heritage).

This modern wave of human migration – deeply immoral and inhuman – nevertheless brought with it an amalgamation of values, perceptions and genes that forever changed the makeup of the Americas. No place was to experience more dramatic change than what ultimately became Brazil, where colonization and slavery of Africans and Native Americans led to a mixing of populations unparalleled anywhere else, not even in the United States.

SHAPE AND CIRCUMSTANCE

All humans are very much the same, yet very much different. We have a lot in common in our morphology: Our body structure, erect posture, thin skin and scarce body hair distinguish us from other primates. Yet we are vastly different too: in height, skin pigmentation, hair texture and facial features.

Although we share a great deal genetically, each individual remains easily identifiable. Relatives, friends and even passing acquaintances usually have no trouble picking out people they know in a crowd. Anthropologists call this 'morphological individuality' – the endless diversity in appearance that distinguishes one person from another within a population. Such individuality is intimately connected to personal identity – both for each individual person and for everyone else.

On the other hand, many individuals, despite their uniqueness, are part of a population group that has been defined historically by geography, ethnicity and religion. Anthropologists call this 'inter-population morphology'.

No one would mistake a person of Japanese lineage from one of Brazilian lineage. Indeed the 19th century German anthropologist Johann Friedrich Blumenbach notoriously divided all humans into five population groups. In the process, he created one of the standard 'intellectual' frameworks for separating humankind into 'races': Caucasians (light-skinned people of Europe, the Middle East, Central Asia, North Africa and India); Mongolians (East Asia); Ethiopians (dark-skinned people of Africa); Americans (Amerindians); and Malays (Oceania).

The division of humanity into different 'races', based on geography and appearance, persisted well into the 20th century as the prevailing paradigm for understanding human diversity, and it continues to shape a great deal of thinking about differences in global populations to this day. Yet, such a paradigm erroneously places greater emphasis on interracial diversity than on intraracial diversity.

All humans are very much the same, yet very much different.

Today, a growing body of scientific evidence convincingly shows that the genetic variability *within* 'races' far exceeds the genetic variability *between* 'races'.

Indeed, recent scientific research increasingly points to this fact: the genetic variability between population groups living on different continents is small and primarily due to morphological adaptations to the physical environment. For example, researchers now know that the type of melanin (a class of molecular compounds that protect us from the sun's rays) found in your skin determines your skin pigmentation, and that a mere four to six genes determine the type of melanin you have. Scientists, moreover, estimate that the human genome is comprised of 20,000 to 25,000 genes. Therefore the number of genes that determine skin colour is exceedingly small. The same is true for the shape of your nose, the thickness of your lips, and the colour and texture of your hair.

In other words, the continent on which you live, or the climate that you experience, determines what you look like in terms of population morphology. But why you look like you do is based on the unique characteristics and functions of very few genes.

Not surprisingly, then, the majority of genes that makeup your genome (some 90 percent) are the same

TWAS PRIZES

Sérgio D.J. Pena (TWAS Fellow 2008) received the 2007 TWAS Prize in the medical sciences. TWAS prizes are awarded to individual scientists in developing countries who have made outstanding contributions in research or in applications of science and technology in the following fields: agricultural sciences, biology, chemistry, earth sciences, engineering sciences, mathematics and the medical sciences. Prize winners receive US$15,000 and are invited to lecture at TWAS general meetings. For additional information, see prizes@twas.org genes found in other human beings. Many of these individuals (indeed most) live thousands of kilometres from where you live, often in places with vastly different climates, geography, ecosystems and cultural values.

As the famed US anthropologist John Relethford has shown, nearly 90 percent of the variation in skin pigmentation takes place between population groups living on different continents. Yet, nearly 90 percent of the variation in cranium size takes place among individuals living on the same continent. Put another, more colloquial, way, differences in appearance between population groups are just 'skin deep'.

IN BRAZIL

Brazil is home to one of the world's most heterogenous populations, comprised of Amerindians, Europeans and Africans. The native settlers of Brazil (the Amerindians) came from central Siberia – more specifically, Ketis and Altais near Lake Baikal – some 15,000 to 20,000 years ago. The 'native' population of Brazil, in turn, had previously undertaken a long journey from Africa to central Asia, where they had arrived some 40,000 years earlier and where they remained for 20,000 years before departing again.

Today, Brazil is home to some 720,000 Amerindians, much fewer than the estimated 2.5 million Ameridians who lived there before the arrival of the Europeans. The native population was drastically reduced by disease and conflict during the early decades of colonization. Moreover, the generations that followed those who had survived the devastation that accompanied colonization have been largely assimilated into the demographic 'melting pot' that characterizes modern Brazil.

The Portuguese, who first arrived in Brazil in 1500, soon brought enslaved Africans to work on sugarcane farms and later gold and diamond mines and coffee plantations. Indeed during the 300 years in which slavery was sanctioned by the government (it was abolished in 1888), it is estimated that 3.5 million Africans came to Brazil, compared to just 500,000 Portuguese.

Following the abolition of slavery, Brazil welcomed

GENERATIONAL MARKERS

DNA provides several different genetic markers. Autosomal markers are superb for providing individual markers since they are diploid and subject to recombination. They can also prove useful for ancestry marking provided that the allele frequency difference (a measure of genetic diversity) between ancestral populations is large. Singular parental maternal mitochondrial DNA and singular paternal chromosomes (non-recombined regions of the Y-chromosomes) are superb lineage markers because they are haploid (cells, such as sex cells in humans, that have half the chromosomes of normal cells – that is, 23 chromosomes instead of 46 chromosomes) and do not recombine. Consequently, such gene blocks are transmitted from one generation to the next until a mutation intervenes. Singular paternal chromosome markers are the tools-of-the-trade for genetic anthropologists. They are also playing an increasing role in our understanding of human health and the treatment of disease.

an increasing number of immigrants from around the world – from Italy, Spain and Germany in the 19th century, and Japan, Lebanon and Syria in the 20th century. All told, 500 years of migration to Brazil has led to this self-classified population profile, according to the 2000 census: 54 percent whites, 38.5 percent browns, and 6 percent blacks.

But it is not just Brazil's diverse demographics that make it a unique country. It is also the genetic makeup of its population. Unlike the United States, where barriers between races were strongly enforced (although without complete success), in Brazil contact (including sexual contact) between Europeans, blacks and the native Indian population was persistent and frequent. The result is that, genetically, virtually all Brazilians, regardless of whether they define themselves as white, brown, black, or native American, have a significant genetic mix of all three 'races'.

Brazil is home to one of the world's most heterogenous populations.

And that should be no surprise. After all, each population group can trace its ancestry to Africa (as stated above, the African origins of Amerindians also had a detour to central Asia, where their ancestors resided for 20,000 years). Moreover, offspring produced through unions between the population groups reinforced the tri-heritage background of the Brazilian population. Unlike North America, where European colonizers often brought their wives and families to farm the land and live in permanent settlements, 16th and 17th century Brazil was colonized largely by Portuguese adventurers determined to quickly exploit the land and enrich themselves. The result was widespread pillage and rape. Indeed it is not too much to say that much of Brazil's history during the colonial period was a time of sexual exploitation marked by European colonizers fathering children with black and Amerindian women.

Modern Brazilians might claim to be 'this' or 'that' colour. But the reality, confirmed by DNA studies, is that all Brazilians have genes from all three ancestral roots: Americas, Europe and Africa.

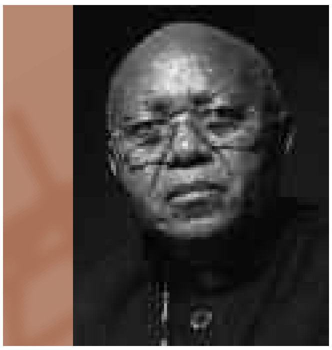
As a result, Brazil's rich genetic diversity lies not between distinct population groups but in the uniqueness of each individual – a rainbow within and not a rainbow between. Indeed, it makes no sense to speak of white and black Brazilians, or Afro- or Euro- or even Amerindian-Brazilians. Rather, the only sensible way to examine genetic diversity in Brazil is on a person-to-person basis – each one of whom is unique in his or her genome and unique in his or her history.

And what is true for Brazil is also true for the world. Recent studies indicate that up to 95 percent of human genetic diversity occurs within population groups and that only 5 to 15 percent of genetic variation takes place between population groups.

It is our (group) genetic homogeneity (which distinguishes us from all other species), combined with our (individual) distinctiveness, that largely defines who we are as human beings: a boundless collection of individuals who share so much, yet have the capacity to contribute even more as unique individuals who belong to one global family. This fact, more than any other, provides the most important and profound reason both to appreciate and celebrate the distinctive diversity of our individualism. ■

EDUCATION EXCELLENCE AWARD

• **Keto Mshigeni** (TWAS Fellow 1987) was awarded the African Higher Education Excellence Award by the Association of African Universities (AAU) in April. The honour recognizes his distinguished contributions to higher education and research in Africa. Mshigeni is vice-chancellor of the Hubert Kairuki Memorial University in Dar es Salaam, Tanzania. He has had a broad influence on higher education and research in Africa as pro-vice chancellor of the University of Namibia, professor of botany and director of postgraduate studies at the University of Dar es Salaam, UNESCO/UNU Africa chair of the Zero Emissions Research Initiative (ZERI) at the University of Namibia, and director of the UNDP Regional Project on Total Productivity and Zero Emissions Initiative in Africa. He is a fellow of the World Technology Network, African Academy of Sciences (AAS) and Tanzania Academy of Sciences, and has received the AAS CIBA/GEIGY Prize for Agricultural Biosciences and the Boutros Boutros Ghali Prize.



Keto Mshigeni

SPIE FELLOW

• **Zohra Ben Lakhdar** (TWAS Fellow 2006) was elected fellow of the International Society for Optical Engineering (SPIE) in February. The honour recognizes her achievements in applied atomic and molecular spectroscopy. Ben Lakhdar joins a group of 550 SPIE fellows who have made important contributions in the multidisciplinary fields of optics, photonics and imaging. She is director of the Laboratory of Atomic-Molecular Spectroscopy and Applications and professor of physics in the Faculty of Sciences, University of Tunis el Manar, and a senior associate at the Abdus Salam International Centre for Theoretical Physics (ICTP). She received the L'Oreal-UNESCO Award for Women in Sciences in 2005 as well as other numerous honours.

Zohra Ben Lakhdar

TYLER PRIZE

• **Veerabhadran Ramanathan** (TWAS Associate Fellow 2005) was named a co-recipient of the Tyler Prize for Environmental Achievement, along with glaciologist Richard Alley (Pennsylvania State University, University Park). They were honoured for their work on climate change. Among his many achievements, Ramanathan identified chlorofluorocarbons, stratospheric ozone and other pollutants as significant factors in the anthropogenic greenhouse effect. He is distinguished professor and director of the Center for Atmospheric Sciences, Scripps Institution of Oceanography, at the University of California, San Diego. Ramanathan will use the prize to help him organize a project in north India to demonstrate that more efficient stoves and cleaner fuels could thin the "brown cloud" that he documented eminating from India as a result of dung and wood fires and the burning of fossil fuels. He has also won the Rossby Award and the Volvo Prize.

Veerabhadran Ramanathan

MULTIPLE HONOURS

• **Padma Kant Shukla** (TWAS Associate Fellow 2007) has recieved three recent honours: The 22nd Kwarizmi International Award (KIA) by the Iranian Research Organization for Science and Technology (IROST) in January; a honorary doctorate degree from the Technical University of Lisbon in February; and selection as a corre-

Padma Kant Shukla

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sponding fellow of the Royal Society Edinburgh (RSE) in March. As a KIA laureate, he was recognized for his dedication and excellence as a researcher. The honorary doctorate was awarded for being an outstanding plasma physicist, who has published 1,000 papers and made several important advancements in plasma theory. The RSE recognized him for his excellent contributions in the discipline of plasma physics. Shukla is physics professor at Ruhr University Bochum in Germany. He also holds visiting/honorary professorships at five universities and institutes and has been honoured with the APS Nicholson Medal for Human Outreach, Gay-Lussac/Humboldt Prize by the French Ministry of Science and Education and an honorary doctorate from the Russian Academy of Sciences, Moscow.

IN MEMORIAM

• **Crodowaldo Pavan** (TWAS Founding Fellow) passed away on 2 April 2009 at the age of 89. At the time of his death, he was emeritus professor at the University of São Paulo, where he had received his DSc in 1944, and the University of Campinas, Brazil. He had served in a number of positions, including professor, University of São Paulo (1953-78); professor, University of Texas (1968-77); president, National Council for Scientific and Technological Development, Brazil (1986-90); and professor of genetics, State University of Campinas, Brazil (1978-89). For his work as an outstanding biologist and geneticist, he had been given several honours, including the Brazilian Great Cross, National Order of Scientific Merit, Prêmio Nacional de Genética, and Prêmio Moinho Santista (Biologia), Fundação Moinho Santista. He was

Crodowaldo Pavan

a member of a number of academies, including the Brazilian Academy of Sciences, Medical Academy of Sciences of São Paulo, Lisboa Academy of Sciences, Pontifical Academy of Sciences and the Chilean Academy of Sciences.

• **Tan Jiazhen** (C.C.) (TWAS Fellow 1985) died in November 2008 at age 99. He was honorary director of the Genetics Institute, Fudan University, Shanghai. He also served as professor of biology and dean of science, Chekiang University, and professor of genetics, Provost of the School of Life Sciences and vice president, Fudan University. For his contributions to the field of genetics, he received several honours, including the Distinguished Alumni Award from the California Institute of Technology; honorary doctorates from York University and the University of Maryland; and Medal of Merit from Konstanz University, Germany. He was named an honorary president of Ningbo University and was a member of the Chinese Academy of Sciences, the National Academy of Sciences, Accademia nazionale delle Scienze detta dei XL, Italy, and honorary life member of the New York Academy of Sciences, USA.

Tan Jiazhen

• **Jing Qicheng** (TWAS Fellow 1995) died in September 2008 at age 82. He was professor at the Institute of Psychology, Chinese Academy of Sciences (CAS). He also served as deputy chairman of the Department of Psychology at Beijing University, a Henry Luce fellow at the University of Chicago, USA, and fellow of the Center for Advanced Study in Behavioral Sciences, USA. For his contributions to the field of psychology, Jing received many honours, including three awards for the advancement of science and technology from CAS; a Lifelong Achievement Award from the Chinese Association of Science and Technology; and the Naitou International Prize for Care of Children. His was a member of the AAAS, New York Academy of Sciences, American Psychological Society and International Union of Psychological Science.

Jing Qicheng

WHAT'S TWAS?

TWAS, the academy of sciences for the developing world, is an autonomous international organization that promotes scientific capacity and excellence in the South. Founded as the Third World Academy of Sciences by a group of eminent scientists under the leadership of the late Nobel Laureate Abdus Salam of Pakistan in 1983, TWAS was officially launched in Trieste, Italy, in 1985, by the Secretary General of the United Nations.

TWAS has more than 900 members from 90 countries, 73 of which are developing countries. A 13-member Council is responsible for supervising all Academy affairs. It is assisted in the administration and coordination of programmes by a secretariat, headed by an Executive Director and located on the premises of the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. The United Nations Educational, Scientific and Cultural Organization (UNESCO) is responsible for the administration of TWAS funds and staff. A major portion of TWAS funding is provided by the Italian government.

The main objectives of TWAS are to:

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

In 1988, TWAS facilitated the establishment of the Third World Network of Scientific Organizations (TWNSO), a non-governmental alliance of some 150 scientific organizations in the South. In September 2006, the foreign ministers of the Group of 77 and China endorsed the transformation of TWNSO into the Consortium on Science, Technology and Innovation for the South (COSTIS). COSTIS's goals are to help build political and scientific leadership in the South and to promote sustainable development through broad-based South-South and South-North partnerships in science and technology. **costis.g77.org**

TWAS also played a key role in the establishment of the Third World Organization for Women in Science (TWOWS), which was officially launched in Cairo in 1993. TWOWS has a membership of more than 2,500 women scientists from 87 developing countries. Its main objectives are to promote research, provide training, and strengthen the role of women scientists in decision-making and development processes in the South. The secretariat of TWOWS is hosted and assisted by TWAS. **www.twows.org**

Since May 2000, TWAS has been providing the secretariat for the InterAcademy Panel on International Issues (IAP), a global network of 100 science academies worldwide established in 1993, whose primary goal is to help member academies work together to inform citizens and advise decision-makers on the scientific aspects of critical global issues. **www.interacademies.net/iap**

The secretariat of the InterAcademy Medical Panel (IAMP), a global network of 65 medical academies and medical divisions within science and engineering academies, relocated to Trieste in May 2004 from Washington, DC, USA. IAMP and its member academies are committed to improving health worldwide, especially in developing countries. **www.iamp-online.org**

www.twas.org