



SCIENCE IN THE DEVELOPING WORLD

THE FOLLOWING TEXT IS BASED ON A KEYNOTE ADDRESS GIVEN BY NOBEL LAUREATE AHMED H. ZEWAİL (TAS FELLOW) AT THE TAS 8TH GENERAL CONFERENCE IN NEW DELHI, INDIA, ON 22 OCTOBER 2002.

I am pleased to have this opportunity to share with you some personal reflections on current issues which I believe may well be at the core of world peace and stability. Science education and development through science are the subject of my presentation and I thought I would use my own journey through two cultures, one currently developing and the other developed, to address issues of concern and what should be done to achieve progress.

As someone who was born and educated in the developing world and who has lived and worked in the developed world, I have acquired both a personal experience and a professional perspective of what it takes to do science at the frontiers of knowledge – not just science for science's sake but science that enlightens the mind and helps our societies and our global community.



In light of the misunderstandings, tensions and violence that plague our world today, I would like to reflect on the critical role

that science can play by focusing on issues of concern to the “have nots” of the developing world. After all, they constitute 80 percent of the globe's population.

I was born in Egypt and educated in public schools there. As an undergraduate student at the University of Alexandria, where I earned bachelor's and master's degrees, I was not familiar with such advanced and frontier areas of research as lasers. Later lasers would play a key role in our work that led to the Nobel prize. I did not study advanced quantum mechanics, the language of the microscopic world. Later we would use this language to conduct research on time and matter at the atomic scale. I did not even know much about the Nobel Prize and, as a young boy, I did not spend a single minute dreaming that one day I might receive it.



However, the years that I spent in Egypt as a child and young adult blessed me with a solid foundation for life's journeys based upon these unwavering principles: strength comes from excellence in basic education, especially in science; strong family values are essential for success; and societal appreciation of scholarship motivates youngsters and adults alike.

When I came to the United States, I encountered both cultural and scientific barriers. My English was poor. (In restaurants, I would confusingly ask for "desert" instead of "dessert.") My knowledge of the latest science, especially cutting-edge science, was also poor or at best shaky. There were, moreover, misperceptions of people from my part of the world that often left me distressed. Many thought I rode camels all day long in Egypt. The truth is that I had never ridden a camel in Egypt. Many also imagined that most of my fellow Egyptians drilled for oil all day long. In reality, Egypt has limited oil resources.

Leaving aside these ill-informed views, what the United States gave me was the unique opportunity to develop my potential and a wondrous sense of appreciation for achievement to which I had never been exposed. While learning English and becoming acquainted with the culture, I earned a doctorate degree at the University of Pennsylvania and soon after was appointed a research fellow at the University of California, Berkeley.

My goal, at the time, was quite basic. I wanted to learn and acquire knowledge and then return home, but not before earning enough money to buy a big

fancy car – a Buick – to take back to Egypt where I had a permanent teaching position at the University of Alexandria. Through a series of circumstances, however, I eventually wound up as an assistant professor at the California Institute of Technology (Caltech). It was there that I would learn through personal experience the indispensable role that a vibrant culture of science plays in determining the future of young researchers.

There is a widespread misconception in the developing world that progress in science can be driven by buildings and slogans. That is simply not the case. As a youthful untenured professor at Caltech I was given an empty laboratory and some start-up funds. That was all, except for one other thing: enormous freedom to do what I wanted. I did not have a boss. Not even Caltech's president was my boss.

To be sure, after a judicious period of time, my work was assessed but in a thoughtful, yet vigorous, way. Caltech's faculty makes decisions on tenure. After 5 or 6 years, young professors usually know what the final decision is. If things are not going well faculty members shake young professors' hands and wish them good luck in their future endeavours which will take place at a place other than Caltech.

The freedom at Caltech proved special for one simple, yet compelling, reason: It made scholarship – and, more importantly, excellence in scholarship – the driving force on campus.

But the atmosphere was as intimidating as it was exhilarating. The first week after arriving on campus I came in contact with Richard Feynman, Murray Gell-

Mann and Max Delbrück – all Nobel Prize winners. Concluding there was no hope for me, I was ready to pack my bags and return to Egypt. But the scientific atmosphere and culture of science that found its way into every corner of the campus made it clear to me that, if I could develop to the best of my potential, I would likely earn tenure and be on my way to doing all kinds of exciting things in science.

And that is exactly what followed. I received tenure in less than two years. The university appreciated that my research group and I were opening new vistas that created real excitement among scientists around the world. We were not encumbered by bureaucracy. Tens of forms did not have to be signed; tens of seals did not have to be put on paper; and tens of personal status reports did not have to be completed. No push from high-up officials was invoked. A simple, well-defined, transparent system had been put in place – one with sufficient flexibility to ensure that achievement was rewarded fairly, efficiently and effectively.

Why did I earn tenure in less than two years? I headed a research team that came up with something original. Every chemist and physicist working with molecules is interested in their structures. I had a simple idea. I suggested that with lasers and other tools we might be able to look at structural dynamics – that is, structures changing over time and on the time scale of their atomic motions. This is of enormous importance to physical, chemical and biological transformations. If you look at the work of biologists today, they display a like-minded interest as they increasingly focus their research on the relationship between structure and function. Dynamics is at the heart of this junction.

The real challenge was that when scientists do experiments on molecules they look at billions – even trillions – of molecules. How, then, can we examine the intricate

dynamics of the sheer endless number of molecules (and the even more numerous individual atoms moving inside these molecules)? We turned to lasers trying to develop new techniques with new tools that would bring about the fastest camera for freezing atoms in motion – in a millionth of a billionth of a second.

Much of the conceptual progress, which brought physics and chemistry into confluence, took place at lunchtime in our faculty club, or late at night with my research group members. Each day, I could join informal roundtable discussions. Researchers – young and old, well-known and just starting out – would sit around the table discussing their work. Our research and discussions on many occasions lasted well into dawn. The excitement was everywhere!

The point is that I didn't come from Mars with a brilliant idea that would instantly win me a Nobel Prize. It didn't – and doesn't – work that way. The fanciest building is not responsible for producing breakthrough ideas. What you need is the right scientific atmosphere

and the right scientific support.

The work for which I won the Nobel Prize took place in 1987. That was just 10 years after I had arrived at Caltech. The freedom I enjoyed; the camaraderie I experienced; the give-and-take that sharpened my thinking; and the keen awareness I had that my achievements would be recognized and rewarded all helped move my research forward.

That didn't mean our work wasn't scrutinized carefully. Indeed many colleagues initially reacted to our research with scepticism. Critics thought the kind of resolution that we sought (10^{15} second) would be worthless due to the uncertainty principle that stipulates if you try to do measurements in very brief timeframes you lose information on energy, just as you lose information on the speed of an object, the more precisely you measure its position.

We nevertheless persevered in our work and eventually convinced our colleagues that the uncertainty principle actually operated in our favour. With proof in hand, the criticism was transformed into favourable recognition.

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I am convinced that the developing world – even with its limited resources – is capable of producing such an atmosphere. There are scientific centres in the South that have sufficient resources to conduct good research. It's not just a question of money. It's also a question of nurturing a scientific culture that encourages researchers to seek new knowledge and, in the process, challenges them to reach their full potential. Money counts but it must be invested in the right way and not spent on frivolous matters that ultimately have scant impact on the quality of science that is done.

In the past five years, the scientific community worldwide has published about 3.5 million research papers. Europe's share is 37 percent. The US share is 34 percent. The Asia/Pacific share is 22 percent. Other places – representing 70 to 80 percent of the world's population living largely in developing countries – have contributed less than 7 percent of these scientific articles.

What difference does this disparity in academic output make? Should only universities and research centres be concerned? Perhaps not. Consider this interesting correlation. The US contribution to the world's annual economic output is between 30 and 40 percent, comparable to its share of scientific output on a global scale. Europe's annual economic output registers a similar percentage and, like the USA, its economic output tracks its contribution to its output of scientific contributions. It's unlikely that this correlation is coincidental.

If we are aware of these trends and understand the problems that stand in the way of progress, why does the developing world have such difficulties building scientific capacity and putting science to work to improve its economic well-being?

A renaissance in thinking is needed. We need to pay more attention to education and we should invest more in science and technology. We need to lower the political barriers that stand in the way of success and to ensure that our laws do not allow political and fanatical principles to cast shadows over freedom of thought in ways that impede the use of our human resources. Women must participate as full partners in

our pursuit of knowledge. The developing world possesses very capable scientists and yet, unwittingly, continues to contribute outstanding scientists to the developed world as part of the brain-drain phenomenon. At Caltech, for instance, my own research group is more than 50 percent Asian.

The developing world, in brief, is rich in human resources. But to take advantage of this invaluable resource, we must develop strategies that nurture and reward the achievements of our scientists and scholars so that the best among them are encouraged to stay at home and pursue the work that their countries so desperately need. While politicians' knowledge of science may be limited (which is understandable; after all, their field is not science), politicians must promote science and its connection to development, and nurture its enormous capacity for interaction on an international scale.

The developed and developing world each shoulders responsibilities in efforts to improve the capacity of science in the South and to build better societies that will enable people to enjoy the fruits of science and technology.

First and foremost the developing world must get its house in order. We cannot just wait for the developed world to help us or accuse people there of conspiring against us. Yes, international politics play a role but people's will is a stronger force, provided the force is coherent and not dispersed by internal politics.

Specifically, the developing world must create new systems of education that emphasize rational thinking and that pursues hands-on approaches to the learning of science in ways that engage and excite young students. The objective is to build a new workforce equipped with 21st century tools of education and



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skills and with a belief in ethics and teamwork. Women must be included in the educational process not only because they deserve to be given an opportunity to succeed but because our societies cannot progress without them. Clearly, this may not be possible on a grand scale in a short time, but the foundation must be established properly and in a timely manner.

Developing countries, moreover, must implement a merit-based system that rewards excellence. Science in much of the developing world relies too much on seniority and puts too much decision-making into too few hands. Everything is centralized and everything needs approval. The result is a snail-paced environment in a fast-paced world.

Such long-standing problems must be addressed in an honest and clear way if we are to go forward. A merit-based system may be the only way to engage and excite young students and to convince them that what they're doing is worthwhile. In the developing world, countries must build their own centres of excellence in science and technology that are especially relevant both to their own country and the global community.

Despite its infrastructural problems, India, for example, has developed centres of excellence that have enabled its scientific community in several disciplines to become partners in international science, education, and a technology-driven economy. But no country can develop centres of excellence unless it creates the right atmosphere for researchers. That means identifying and investing in talent and putting in place

a system that minimizes bureaucracy and maximizes freedom and flexibility.

Besides all the obvious benefits of science and technology, the power of knowledge enhances national pride, limits the brain drain and leads the country into effective economical participation in globalization.

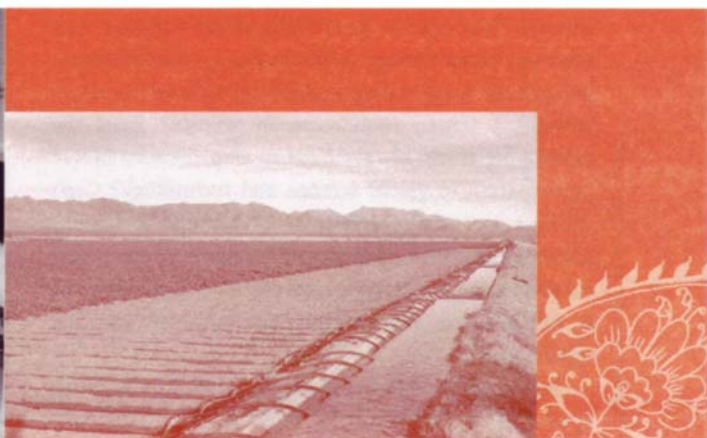
The developed world also carries important responsibilities in its efforts to promote scientific capacity and excellence in the developing world. First and foremost it must reform its international aid programmes, investing less money on military hardware and instruction and more on scientific training and partnerships. International aid programmes, moreover, must be drained of politics to ensure money is available for productive North-South initiatives that could help boost science and technology in the developing world.

What will rich countries receive in return for the help they give the "have-nots"?

First, there is the moral dimension. The psychological value derived from being a generous global neighbour should not be underestimated. Even on a personal level, most of us do try to help and all major religions encourage and legitimize efforts to help the needy. It is also difficult to ignore that the prosperity of the North is in part due to natural and human resources from the South and their markets.

Second, we should acknowledge the importance of reciprocation over time. Islamic civilization gave a great deal to Europe, especially during the dark ages. The Arab and Islamic civilizations, which at the time were the world's foremost economic and scientific

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powers, were major contributors to the European Renaissance. Today it is the Muslim world that needs help and there is nothing wrong with the United States and Europe (and other developed nations) lending a hand as a modest gesture to the changing fortunes of history.

Third, there is a more practical, self-centred consideration based on the time-tested importance of having an adequate insurance policy. In the United States, I pay a great deal for insurance to protect my family against the high cost of medical care, to protect our house against fire and theft, and to protect our cars against accidents. Similarly, the developed world needs to invest in an insurance policy to help it live in a safer and more secure world.

The choice for the “haves” is clear. They have to help in a genuine and sincere manner. The choice for the “have-nots” is also clear. They first have to get their house in order and build the confidence for a transition to a developed-world status.

In a meeting with Prime Minister Mahathir bin Mohamad on a recent visit to Malaysia, I learned of the critical role that the new education system has played in the nation’s rapid transition from a labour-intensive economy dependent on cheap labour to a knowledge-based economy on the doorstep of the developed world. This transition has been fuelled by the belief in building a proper base for science and technology. Malaysia has a majority Muslim population living in harmony with the Chinese and Indian population. Neither religion nor culture seems to hinder progress.

Cheap labour may have worked for developing countries in the past but it will not work in the 21st century. How can the developing world embrace such economy-transforming technologies as microcomputing, genetic engineering, and information technologies without a strong foundation in science? Does the developing world always have to wait decades before participating in global science and technology? Can’t we be a part of the modern world without losing our cultural and religious identities? Despite all the political and economic problems we currently face, progress is still possible. But change from within is the first ingredient.

For the sake of global peace and stability the developed and developing world must participate as part-



ners in a dialogue among civilizations and cultures. Such a dialogue should not be confused with slogans theorizing about conflicts between religions or cultures.

At its core, we should nurture a dialogue among the “haves” and “have nots.” What’s needed is visionary leadership, economic progress, and perspectives that rely on rational thinking. It is for this reason, as much as all the others, that we need global science. ■

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WHAT'S TWAS?

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

At present, TWAS has more than 660 members from 76 countries, 62 of which are developing countries. A Council of 14 members is responsible for supervising all Academy affairs. It is assisted in the administration and coordination of programmes by a small secretariat of 9 persons, headed by the Executive Director. The secretariat is located on the premises of the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. UNESCO is responsible for the administration of TWAS funds and staff. A major portion of TWAS funding is provided by the Ministry of Foreign Affairs of Italy.

The main objectives of TWAS are to:

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

TWAS was instrumental in the establishment in 1988 of the Third World Network of Scientific Organizations (TWNISO), a non-governmental alliance of more than 150 scientific organizations from Third World countries, whose goal is to assist in building political and scientific leadership for science-based economic development in the South and to promote sustainable development through broad-based partnerships in science and technology. → www.twniso.org

TWAS also played a key role in the establishment of the Third World Organization for Women in Science (TWOWS), which was officially launched in Cairo in 1993. TWOWS has a membership of more than 2000 women scientists from 87 Third World countries. Its main objectives are to promote research, provide training, and strengthen the role of women scientists in decision-making and development processes in the South. The secretariat of TWOWS is hosted and assisted by TWAS. → www.twows.org

Since May 2000, TWAS has been providing the secretariat for the InterAcademy Panel on International Issues (IAP), a global network of 85 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

WANT TO KNOW MORE?

TWAS offers scientists in the Third World a variety of grants and fellowships. To find out more about these opportunities, check out the TWAS web-pages! Our main page is at: www.twas.org

FELLOWSHIPS

Want to spend some time at a research institution in another developing country? Investigate the fellowships and associateships programmes: www.twas.org/Fellowships.html www.twas.org/AssocRules.html

GRANTS

Seeking funding for your research project? Take a look at the TWAS Research Grants: www.twas.org/RG_form.html TWNSO runs a similar scheme, for projects carried out in collaboration with institutions in other countries in the South: www.twngo.org/TWNSO_RG.html

EQUIPMENT

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

TRAVEL

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

CONFERENCES

You're organizing a scientific conference and would like to involve young scientists from the region? You may find what you are looking for here: www.twas.org/SM_form.html