Almost similar approach has been used by Lee *et al.*[3] for producing thermotolerant *Arabidopsis* plants. In this work, the authors showed that ATHSF1 is a HSF of *Arabidopsis* that is constitutively expressed but its activity for DNA binding, trimer formation and transcriptional activation of *hs* genes is repressed at normal temperatures. They were able to de-repress the HSF function by experimental means which led to constitutive expression of HSPs at normal temperatures. The level of basic thermotolerance of transgenic *Arabidopsis* plants, making constitutively higher level of HSPs was found to be significantly enhanced.

These two reports[2,3] present a new milestone as they show that by changing the expression of the transcription factor genes, it should be possible to alter levels of several target genes at the same time. This would definitely enhance the resistance levels compared to single gene manipulations. It is possible that the multigenic effect will not remain a bottleneck for engineering plants to abiotic stresses. For this approach to work further, one would have to isolate, clone and characterize more transcription factor genes as till date there is insufficient information on this aspect. Further research in this area is expected to open up vast possibilities in genetic engineering of crops for high level resistance against abiotic stresses.

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OPINION

Information technology: What it means for science communication in developing countries*

Subbiah Arunachalam

In an interview she gave to a British newspaper immediately after winning the Nobel Prize for literature, Princeton University professor Ms Toni Morrison said that it seemed as if writing about the life and sensibilities of the Blacks did not really count. It was not thought important enough to merit attention. It was peripheral.

It is the same with doing science (or working in any other area of scholarly pursuit) in the developing countries. One's work goes unnoticed. One who works under adverse conditions in the developing countries needs to achieve a lot more to win some recognition than those who work under much better conditions in the developed countries. Not surprising. After all, we live in an unequal world. Immediately following the Prague conference of biomedical editors (September 1997), *New Scientist* commented in an editorial (1 November 1997) that when it came to choosing manuscripts for publication, editors of reputed international journals would more likely select the one from Harvard in preference to the one from Hyderabad. Even though both manuscripts may be of comparable quality. Harvard any day is a safer bet than Hyderabad!

Technology tends to exacerbate this inequality and further marginalize scientists on the periphery. The Internet, or for that matter any technology, does not come without its attendant problems. History has repeatedly shown that technology inevitably enhances existing inequalities. Take for example, scientific research in India. It is very important for researchers to get to know what is happening around the world as well as to let others know what they are doing. Information is key to the growth of knowledge, and dissemination of information is crucial for the scientific enterprise. And information is disseminated through communication channels. In pre-Independent India, when scientists of the calibre of C. V. Raman, Meghnad Saha, J. C. Bose and S. N. Bose made their first-rate contributions to knowledge, the main vehicle for transmission of knowledge was the scholarly journal, and there were far fewer journals then than now. Scientists around the world were almost at the same level as far as accessing information was concerned. True that most journals were published in Europe and Raman and his Indian colleagues received the journal issues a few months later than their European colleagues – the time it took for the boat to cross the seas. Today there is tremendous proliferation of journals and many of them, especially those published by commercial firms, are out of reach for libraries even in the West what to talk of the poorer countries. (It is heartening to note that the Association of Research Libraries in the United States

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is taking steps to publish less expensive quality journals in collaboration with like-minded publishers such as the American Chemical Society to save scientists from being held to ransom by greedy private publishers.) The best academic science library in India, viz. the Indian Institute of Science library, receives only 1562 serials, including those they get on exchange and gratis. Thanks to the rising price of the dollar and pound sterling and the increase in the subscription prices of journals and databases, Indian libraries are cutting down on the number of journals and secondary services. The situation in Africa is even worse. A Nigerian professor once told Seun Ogunseitan, the dynamic journalist turned information provider: 'When you call some of us scientists, we laugh at ourselves. We know we can no longer make contributions to science. I do not know what my colleagues in Kenya or London have found, for example. So I cannot carry out an experiment and believe I am on the path to an original contribution to the sciences. If I have been giving generations of students the same notes for the last ten years, I should not call myself a scientist.' Says Ogunseitan, 'Many people in our universities are not sure what is the state of science. Scientists often have to rely on what they are told, for example, by newspapers, by friends or by *Time* magazine. How can such people ever become authoritative and confident scientists?' In the United States and possibly Europe, many university libraries subscribe to upwards of 50 thousand journal titles!

On top of it, today many primary journals and secondary services have gone electronic, and most physicists get to know of the latest developments from preprints circulated through the Los Alamos archive on the Internet. Current awareness services such as *Current Contents Connect*, abstracting services such as *SciFinder* of Chemical Abstracts Service and multidisciplinary citation indexes such as *Web of Science* are available on the web, at a fee that most university and research laboratory libraries in developing countries cannot afford, of course. Now even primary journals are accessible through password control on the web, such as under the *Science Direct* service of Elsevier. To access information in cyber space, one first needs access to the corresponding electronic technology. Often technology diffuses rather slowly and today most scientists and scholars in the developing countries do not have access to the new information technologies. As a result, one's performance can be (and is) affected, not necessarily because one is a poor physicist or chemist but because one has poorer access to electronic means – be it CD-ROM, online or the web – of getting the information needed. Accessing through CD-ROM offers capabilities that are not possible with the print form, and accessing through the web offers capabilities that are not possible with the CD-ROM form. As a recent editorial in *Science* (17 April 1998) pointed out: 'Digital publishing has much to recommend it over print publishing for practical if not for aesthetic reasons. Uncomfortable tradeoffs are involved, to be sure, but the gains include ease of access, rapid delivery over great distances, and hypertext links from indexing services and bibliographic citations to the full text of cited documents.' Hardly any laboratory in the developing world has web access to these databases. How can scientists working in these laboratories be equal partners in the worldwide enterprise of knowledge production? Thus the transition to electronic publishing from print will certainly widen the gap between the developed countries and the developing countries, and will further marginalize the already-marginalized scientists and scholars in the developing countries.

Most developing countries, especially those with large populations, do not have the necessary infrastructure (computer terminals, networks, communication channels, bandwidth, etc.) and will take a long time to have it in place to be able to take part as equal partners in the worldwide enterprise of knowledge production and dissemination. According to Bruce Girard, former director of Latin America's community radio Pulsar, 95% of all computers are in the developed nations; ten developed nations, accounting for only 20% of the world's population have three quarters of the world's telephone lines. Teledensity in India today is about 1.5 lines per 100 persons. Till 1994, it was less than one per 100 persons. And most of the telephones are concentrated in the metropolitan cities. Many scientists do not have telephones on their desks; those who have cannot make calls outside their towns/cities, let alone overseas calls. Many universities do not have E-mail or Internet facilities. Some have 1.2 or 2.4 kbps connections. With such low bandwidths and poor terrestrial telephone connections, one can at best send and receive E-mail messages but cannot surf the net or do online searches on the Internet. The simple truth is the information superhighway is not bringing the fruits of cyber space to all. There are far too many people in the developing world who have not been touched by the information and communication revolutions – the have-nots and the know-nots who risk being always behind.

A number of journals, especially in the STM area, are receiving manuscripts by E-mail, getting them reviewed by E-mail, and so on. Some journals are available only in the electronic form. Editors of such international journals will naturally be reluctant to use referees from developing countries, even if they are exceptionally competent in their fields, simply because it may be extremely difficult to reach them electronically. Nor for that matter, many developing country scientists will be able to publish their work in these electronic journals.

The United Nations is greatly concerned about the imbalance in access to communication facilities. The UN's Administrative Committee on Coordination issued a statement on Universal Access to Basic Communication and Information Services in April 1997 in which it comments:

'We are profoundly concerned at the deepening maldistribution of access, resources and opportunities in the information and communication field. The information technology gap and related inequities between industrialized and developing nations are widening: a new type of poverty – information poverty – looms. Most developing countries, especially the Least Developed Countries (LDCs) are not sharing in the communication revolution, since they lack:

- affordable access to core information resources, cutting-edge technology and to sophisticated telecommunication systems and infrastructure;
- the capacity to build, operate, manage, and service the technologies involved;
- policies that promote equitable public participation in the information society as both producers and consumers of information and knowledge; and
- a work force trained to develop, maintain and provide the value-added prod-

ucts and services required by the information economy.

We therefore commit the organizations of the United Nations system to assist developing countries in redressing the present alarming trends.'

While communication revolution is perceived as a liberating influence, what is most likely to happen is that in many developing countries (including India, I am afraid) scientists and scholars will be among the last to be reached by the revolution. Therefore, the relative disadvantage they suffer (in the matter of access to information and knowledge) will only increase. The number of institutions and individual scholars having access to E-mail and Internet in developing countries and the rate at which this access has grown over time will support this contention. The speedy transition to electronic publishing will make it much easier for scientists and scholars in the developed countries to interact with colleagues and members of their invisible colleges. My major worry is that the low level of information and communication technologies in the developing countries would lead to the progressive exclusion of a majority of scientists and scholars in these countries from the collective international discourse that is essential for making progress in new knowledge production. Even now, when much publishing takes place in print, participation by India and other developing countries in high impact journals (such as *Science, Cell, Journal of the American Chemical Society*) is very low. The already existing gulf in the levels of science and technology performed in the developed and the poorer countries will be widened further, and that could lead to increased levels of brain drain and dependence on foreign aid of a different kind (knowledge imperialism).

In an earlier era, the brilliant Indian mathematician, Srinivasa Ramanujan, who was a genius but who had not gone through a conventional training programme, was nurtured in the intellectually stimulating ambience of Cambridge University, thanks to the vision of G. H. Hardy. While such individual initiatives may still be welcome to overcome real and apparent handicaps, what we need to overcome the current crisis is a far more organized and systematic programme of action. Early introduction of satellite-based high bandwidth Internet access to tertiary educational institutions and research laboratories at low cost and differential pricing for information (journal subscriptions and access to databases) to developing countries are high on my agenda. On both fronts, I am not happy with what is happening. For example, India can easily afford to invest in Internet provision to the 100 or so cities and towns where most of the nation's research laboratories and universities are located. But this has not happened, although we go through the motions and give the impression of being serious. Within the last one year, there have been at least three initiatives. V. S. Arunachalam of Carnegie-Mellon University spent a few weeks in India, discussing with important people (such as the then Finance Minister Chidambaram, and the technology-savvy Chief Minister of Andhra Pradesh Chandrababu Naidu) a proposal for networking academic and research cities of India at a cost of a few tens of millions of dollars. He was even toying with the idea of getting the funds either as aid or as a soft loan from some international agency. The Scientific Advisory Committee to the Cabinet appointed a subcommittee under the chairmanship of Roddam Narasimha to prepare a report on the subject and the report was submitted to the then Prime Minister I. K. Gujral. Now, the Vajpayee government has appointed a committee under the chairmanship of Jaswant Singh, and the first draft of the committee's report is ready. Let us hope the nation is lucky this time round. But what is actually happening is disheartening. Different agencies in the telecom sector who have to implement and deliver ultimately are quarrelling with one another. Indeed, this is characteristic of the Third World: it often takes far too much time for things to happen or to translate something from the realm of the possible to reality. As for differential pricing, both publishers of primary journal and database producers are reluctant. In one rare exception, the Institute for Scientific Information, Philadelphia, offers its *Science Citation Index* at 50% discount to most developing country subscribers. Even then it is perceived as too costly!

I would not be surprised if very soon the gulf between the scientifically advanced nations and the others widens even further, leading to further reducing the role of the developing countries in the enterprise of knowledge production, dissemination and utilization. Do I sound pessimistic? So did Toni Morrison.

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COMMENTARY

Health care and medical research in India—A thumb nail sketch in *The Lancet*

T. Jacob John

Robin Fox, formerly editor of *The Lancet*, has helped the high profile medical journal put together a profile of India, in its 25 April issue[1]. During the Narasimha Rao–Manmohan Singh quinquennium, India had 'ended its long love affair with Soviet-style planning and embraced the free market'[1]. Fox, a veteran India visitor, returned to expose to the world what had been happening to health care and medical research through the thoughts and words of a well chosen panel of experts, several