PERIPHERALITY IN SCIENCE : WHAT SHOULD BE DONE TO HELP PERIPHERAL SCIENCE GET ASSIMILATED INTO MAINSTREAM SCIENCE

Subbiah ARUNACHALAM
Editor, Indian Journal of Technology
Publications & Information Directorate
Hillside Road, New Delhi 110 012, India

ABSTRACT

Science on the periphery is characterised by (i) absence of a viable scientific community, (ii) an insularity (resulting from inadequate access to relevant information and inadequate communication within the local scientific community and with the international invisible colleges), (iii) an unduly long phase lag before participants in these peripheral societies can take part in hot/emerging research fronts, (iv) weak institutional infrastructures (such as academies, research laboratories, and more importantly peer review systems), and (v) an excessive dependence on science done elsewhere. However, there are levels of peripherality and within a country there can be vast differences among different fields, for instance. And some researchers may be much better off than their colleagues in the same field. As the problems are so complex and multi-faceted, there can be no simple solution. Attempts to solve one problem or the other in isolation may not lead to an optimal solution. In my view, the key to science development in peripheral countries lies in improving access to information, better dissemination of whatever little is done in these countries, and facilitating the establishment of better peer evaluation procedures within the country and increased participation in international science. Problems and prospects in realising each of these steps are discussed.

RESUME

La science de la périphérie se caractérise par (i) l'absence d'une communauté scientifique viable, (ii) une insularité qui résulte d'un accès inadéquat à l' information pertinente et d'une mauvaise communication à l'intérieur de la communauté scientifique locale et avec les collèges invisibles internationaux, (iii) une mise à l'écart des fronts de la recherche, (iv) des infrastructures institutionnelles déficientes (telles qu'Académies, laboratoires de recherche, et plus important encore, les systèmes d'évaluation par les pairs), et (v) une dépendance excessive de la science produite ailleurs. Toutefois, il y a des niveaux de périphéricité et à l'intérieur d'un même pays on peut rencontrer des différences importantes entre différents domaines, par exemple. Ainsi, certains chercheurs peuvent être mieux lotis que leurs collègues dans le même domaine. La complexité des

problèmes appelle des solutions multiples: toute tentative pour résoudre un problème de façon isolée peut ne pas conduire à la solution idéale. A mon sens, la clef du développement de la science dans les pays de la périphérie réside dans une amélioration de l'accès à l'information, une meilleure dissémination des travaux locaux, la mise en place dans les pays mêmes de procédures d'évaluation par les pairs de meilleure qualité et une participation accrue à la science internationale.

INTRODUCTION

Mike Moravcsik was indeed a tall man. In a world where most scientists are happy to do their "normal" work of teaching, research and publishing papers, Mike decided to devote a considerable amount of his time and energy to promote science development in the Third World. He made a mark as a theoretical physicist, but his long and sustained work in the area of science development did not end with theorizing. He was always looking for practical solutions whose impact would be felt and could be tested quickly in the field. He had a great concern and genuine sympathy for the poorer countries of the world and he strongly believed that the introduction and development of science - as it is practiced in the advanced countries of the West today - in developing countries would not only change their status but it is a good thing per se for the world as a whole. He also believed that often voluntary efforts and individual initiatives could achieve a great deal more than government initiated programmes.

His books "Science Development" (Bloomington, Indiana, 1975) and "On the road to worldwide science" (World Scientific, Singapore, 1989), the large number of conferences he attended and spoke at, and the very large number of friends he made in the Third World are eloquent testimony to his keen interest in nurturing science in the developing countries. There is hardly any question or issue pertaining to Third World science on which Mike has not expressed his balanced views, often with supporting quantitative evidence. It should not, therefore, be surprising if what I say sounds familiar to those who have known Mike and who have read his copious writings! In fact, Mike played an important role in my own development as a keen student of scientometrics and science in the Third World. He was among the first to "spot" me working in virtual isolation in India and was responsible for my participation in more than one international conference. I feel greatly privileged to be one of those who will carry on with Mike's unfinished tasks.

I - PERIPHERAL SCIENCE.

Like everything else, science is not distributed uniformly among regions of the world or among different countries. In fact, the distribution of science - by which-ever means it is measured - is even more skewed than the distribution of wealth among nations. Just about a dozen countries account for close to four-fifths of the world's published journal literature! The differences are not restricted to the output of scientific research such as papers published, patens taken, processes developed, etc. But also cover a range of input indicators such as money invested in R&D, number ans size of laboratories, number of researchers and technicians, availability of equipment and instruments, etc. The recognition received by science done in different countries in terms of awards, medals, ans prizes won, the number of times work reported from a country's laboratories are cited in the literature, the number of people invited to speak at international conferences or to be on the editorial boards of journals, etc. Also vary widely.

Science is universal only to the extent that a large part of the cognitive content of science is context free. In the real world we live in, deviations to the "universalism" of science abound and affect both the practice of science and the dissemination of scientific knowledge.

Several hundred years after the emergence of modern Western science and the near-total eclipse of pre-Western scientific traditions and knowledge systems, today we live in a world where only a small minority is involved in both the generation of new scientific knowledge and its exploitation. Vast sections of humanity, living in the Third World, are mere bystanders, often not even able to realize the great consequences - not all of them benefitcal and some of them certainly detrimental to their interests - of such developments. Besides the loss of the vast human resources that remain untapped in scientific research, the benefits of research are largely confined to those countries that pursue science. Men like Moravcsik, Marcel Roche, Glen Seaborg and others like us who assemble in conferences such as this one believe that greater participation in science is inherently a good thing : good for science as it will enable science to draw upon talent from a larger pool and from a much more varied cultural milieu; and good for the people themselves as science could be a great liberating force.

I will not go inter a discussion of "alternative sciences". For the present, I will assume that science as it is known and practised today in the developed countries of the world, with its paradigmatic growth cycles and undisputed links to technology, has come to stay and that, despite reservations in some quarters, European science based on rational materialism, as pointed out by Ziman and Moravcsik in their classic paper in *Foreign Affairs*, "should become a dominant cultural force throughout the world", and proceed to look into the problems faced by science done in the peripheral countries in getting assimilated into mainstream science.

II - CHARACTERISTICS OF SCIENCE ON THE PERIPHERY.

What distinguishes a scientifically peripheral country from the mainstream countries ? The most obvious thing is the scale of operation, as pointed out in the previous section. But size per se need not prove to be an insurmountable obstacle : Israel is a case in point.

Absence of a "scientific community" - Science is not best done by individuals working in isolation. Although cognitive factors and an individual's "qualities of the mind" play a very important role, science is essentially a social activity. The creation of new knowledge, which in my opinion is the primary activity in science, does not take place in vacuum. A community of informed individuals and groups inter-acting with and augmenting one another's performance is a must. Such a scientific community either does not exist in most peripheral countries, or if one exists it is not mature. Even in a very large country like India which has a large number of publishing scientists, both sociologists of science and scientists - who unlike sociologists do not carry out scientific studies on India's scientific estate but have the benefit of insider's insight - believe that there is no viable scientific community in India. Both sociologists ans scientists of standing have categorically made this point - the sociologists have in fact published their findings, with ample evidence and sound logic, in refereed international journals. And no one, as far as I know, has refuted their assertion.

The problem of a weak (or non-existent) scientific community is often compounded further by a haste to raise the pace of scientific activity in peripheral countries. Many institutions - universities, higher institutes of science and technology, national laboratories, etc. - are created without much forethought. Often there may not be enough qualified people to man the various positions and therefore men who do not really deserve get appointed. Yet another factor could be adopting criteria which have nothing to do with a person's ability to perform scientific work competently in selecting candidates to man scientific positions.

As pointed out by sociologists Ramasubban and Singh, the organization of scientific research along bureaucratic lines stifles and distorts scientific activity in peripheral countries, leads to widespread frustration and dissatisfaction among researchers and gives scientists-administrators a higher status than that of working scientists.

One possible scenario is the division of the country's scientists into a small minority of better performers who have many of the attributes that go to make a good scientist and a vast majority of scientists who are in the profession but barely making their presence felt. A part of the scientifically more competent minority migrates to the West - the so-called brain drain. Those who stay back keep in touch with invisible colleges in the advanced countries, manage to attend international conferences, and contribute to better-run and better-cited journals published from the advanced countries. The other class of scientists usually make routine investigations of not much value, publish mostly in local journals of low impact, and do not normally belong to any invisible college or network. Often, despite the fact that scientists from one category know scientists from the other and they may even socialize, they may not influence one another's scientific work !

Weak institutional infrastructure - Often a peripheral country mimics the form without much care for the substance. National academies (sometimes more than one), professional societies/associations, etc. are established in much the same manner as in a developing country, but sooner than later these are allowed to deteriorate. The same goes for specialised institutes of higher education in science, engineering, medicine and agriculture. Then there are the ever proliferating number of scientific awards which distorts scientific perspectives altogether.

Here we would consider two institutions, viz. the peer review system is the linchpin of the scientific enterprise. Be it evaluating research proposals for funding or examining a research paper to see if it is worth publishing or choosing Fellows of an academy, one needs a very well working peer review system. In most Third World countries peer review system is not operating as well as it ought to. Let me give only one example from India. The late Professor Sambhu Nath De of Calcutta (1915-1985) made seminal contributions to our knowledge of cholera and related diarrhoeal diseases and indeed set the stage for the modern view of diseases caused by bacterial toxins. De's work constitutes a cornerstone of the edifice of cholera research and opened up the field of protein toxins. His work was not only highly relevant to India (after all Bengal was known as the home of cholera) but also set the highest standards of excellence in experimental design and execution. Undoubtedly it marked a high point of basic medical research in India. The full significance of De's work was brought out vividly in the 1983 book by van Heyningen and Seal Cholera : The American Scientific Experience (1947-1980). Prof. Joshua Lederberg, the American Nobel Laureate, nominated De for the Nobel Prize more than once. Gene Garfield paid rich tributes to Dr De in an essay he wrote in 1986 in his honour. And yet De died unhonoured and unsung in India. "That De received no major award in India during his lifetime and that our Academies did not see it fit to elect him to their. Fellowship must rank as one of the most glaring omissions of our time", said Prof. P. Balaram of the Indian Institute of Science in a special issue of *Current Science* (dated 25 july 1990) brought out to honour Dr De. A clear case of collective myopia, which fails to distinguish men of straw from scientists of substance. In contrast many of India's leading scientist (some of whom have turned administrators) are today more highly decorated than most generals of a victorious army after a successful war.

Although the neglect of Dr De by the Indian scientific community was brought home by Gene Garfield as early as 1986 (The 1983 book by van Heyningen and Seal is even now not easily available in India, and Garfield's tribute appeared in the much-circulated *Current Contents*), no regret was expressed in any quarters !

Well-run indigenous journals are essential components of a viable scientific community. True, many scientific journals are published from developing countries. But only about 40 of them are covered in *Science Citation Index*, the tool often used in studies on science indicators, evaluation of research performance, etc. Most developing country journals are of poor quality and the elite among the local scientists rarely publish their work in these journals. Because these journals publish a very large number of poor quality papers, they will find it difficult to attract good quality papers from both within the country and from abroad.

About three years ago, two professors from Madras - Prof. C N Krishnan of the Madras Institute of Technology and Prof. B Viswanathan of the Indian Institute of Technology - wrote a paper in a not-so-well-circulated journal called the *PPST Bulletin* and pleaded with Indian scientists to be more nationalistic in the matter of journals for publishing their research results. They thought that Indian should build journals of class as the Americans did in the early part of this century. And they found that it was the leaders of Indian science - fellows of the Academies and members of the editorial boards of journals who published most of their work in foreign journals. Although the Krishnan-Viswanathan paper was not the first to draw pointed attention to the quality of Indian journals, it had an unprecedented impact on India's scientific establishment. Prof. C N R Rao, one of India's most well known and highly regarded scientists, wrote to all Fellows of the Indian Academy of Sciences in December 1987 requesting them to consider publishing their better papers in the Academy journals. Prof. E S Raja Gopal, then editor of *Pramana,* India's best known physics journal, wrote on the declining support being received from leading Indian physicists and felt that it would indeed be sad if we had to close down our journals for want of adequate support from our scientists. *Physics News,* an organ of the Indian Physics Association, carried an editorial in early 1988 emphasising this point. Dr A P Mitra, Director General of India's Council of Scientific and Industrial Research, wrote to directors of all CSIR laboratories and members of the editorial boards of all CSIR journals seeking their suggestions on ways to make CSIR journals more attractive to Indian scientists.

However, the best that has happened since Krishnan and Viswanathan wrote their provocative paper was the appointment of Prof. S Ramaseshan, the man who founded *Pramana*, as the editor of *Current Science*, a fortnightly journal of more than 50 years standing. Within a year of his taking over the journal has shown remarkable improvement.

<u>Insularity</u> - Science in the Third World often suffers from insularity - lack of inadequate contact with international science. What is done in Third World laboratories and published in Third World journals is hardly ever noticed by scientists elsewhere. Many researchers, in particular Tibor Braun and colleagues at the Hungarian Academy of Sciences, have shown from publication and citation data the meagre - very nearly non-existent - impact Third World science has on world's mainstream science. Not only does most of peripheral science appear in low-impact and often non-SCI journals but il also has very low observed and relative citation rates. Added to this is the fact that most of the references quoted in peripheral science publications is pretty old and the work itself is of very low

current relevance. In fact, rarely do Third World scientists have opportunities to work in newly emerging research fronts. There is a considerable time lag before research on an area initiated in Western laboratories reaches developing country laboratories. There is another kind of insularity as well, viz. disciplinary insularity. Rarely do we see work done in a Third World laboratory that can be called interdisciplinary. A large part of the citations to peripheral country journals and to articles published by peripheral country scientists in foreign journals will be from scientists from the same country and researchers from the same field.

Among the several factors responsible for this state of affairs two appear to be of crucial importance. These concern inadequate access to relevant information and poor communication facilities. After all, the creation of new knowledge, the most essential activity in the enterprise of science as in other areas of scholarship, takes place in "information space" ; when one finds something new one has raised our understanding from the existing level of information to a new level. No wonder then researchers ought to be well informed. In this respect most Third World scientists are neither well up nor well served.

That improved access to worldwide information leads to better performance in science has been demonstrated time and again. For instance, India fares well in areas where access to information and the viability of the scientific community are better than in other areas : astronomy, high energy physics and biochemistry. I have talked about this extensively elsewhere.

Most developing countries have poor library facilities. And many Third World scientists are not in preprints/reprints circuit. Almost all the important current awareness services, abstracting and indexing services and leading journals are all produced either in North America or in Western Europe and they are frightfully highly priced. Thus not only for their essential equipment, instruments, chemicals and other material goods but also for access to information the Third World countries are abjectly dependent on the advanced countries. And almost always these services and goods have to paid for in scarce hard currency.

Most of what I have said thus far is well known. And if I have cited examples from India it is because that is the area I known well. However, I must add a caveat. India is not an ideal example of 'Paradisia'. In fact, in some respects India is as good as the advanced countries. For example, in high tech areas such as superconductivity, cold fusion, liquid crystals, radioastronomy, molecular biophysics etc. Indian researchers are tackling problems in emerging research fronts. The situation in most other Third World countries is considerably worse.

III - WHAT COULD BE DONE ?

Having described the general characteristics of peripheral countries, let me proceed to mention some of the possible approaches to bring in peripheral country research into mainstream science. There can be initiatives of different kinds : by individuals, voluntary groups, international organizations, governments, etc. There are many already in place. And others could be thought of. Improving the quality of science done on the periphery and making it easily assimilable in mainstream science is a complex task and it would be better to divide the problem into several component tasks. Each of these components can then be tackled by the most appropriate kind of initiative to be decided on the basis of feasibility, costs, etc. For example, raising the level of peer review in a country is essentially to be tackled internally. It is too sensitive an area to brook outsider interference !

However, it will not be wise to tackle one problem or the other in isolation ; that will not lead to an optimal solution. Two related problem, vis. improving access to information and better dissemination of research done in peripheral countries, will get top billing in my scheme of things. Related to these objectives is the task of increasing Third World scientists' participation in international and bilateral programmes.

The Third World Academy of Sciences, with its headquarters at Trieste, Italy, has a programme of gifting scientific journals and books to needy libraries. A voluntary group formed earlier this year in the USA, called Indian Descendent Engineers and Scientists (IDEAS) is willing to consider a similar scheme of donating books ans journals to needy Indian institutions, and to support Indian scientists visiting the USA and Canada to attend conferences. International organizations such as ICTP, Trieste, help a number of talented Third World scientists spend some time in the congenial surroundings of ICTP where they can work with talented scientists from other parts of the world including both advanced countries and other developing countries.

Bilateral programmes such as the Indo-US Subcommission on Science and Technology make it possible for several Indian laboratories to do collaborative work with US laboratories in a variety of fields. The flow is not always one-sided as might be imagined. In fact, the projects are chosen so carefully by the US team as to maximise their benefits ! About three years ago, the NSF carried out an elaborate exercise - including commissioned reports by experts, meetings of experts, a bibliometric study on the strengths and weaknesses of Indian science by an expert in scientometrics, and questionnaire surveys - decide on areas in which joint projects would be most beneficial.

Then there are projects such as the UNDP-sponsored "Transfer of Knowledge through Expatriate Nationals" which began in Turkey in 1977, and which is currently in operation in about 30 countries. TOKTEN provides a means for using the services of highly qualified and competent professionals abroad in S&T related fields in their home countries. It was initiated in India in 1980. In the first ten years of the programme, between 1980 and 1989, 257 expatriate Indians, mostly from the United States, visited India for periods ranging from 2 or 3 weeks to 12 weeks (average, a little over 4 weeks), at a cost to UNDP of about US $ 1.1 million. The Indian TOKTEN programme has been evaluated twice, first by a joint UNDP-Government of India team headed by Professor M C Madhavan of San Diego State University, USA (which covered the period 1980-

1987), and more recently by a purely Indian committee headed by Professor A K Sharma which evaluated the entire programme de novo covering the period 1980-1990 June. Both the Madhavan Committee and the Sharma Committee are unanimous in their verdict, viz. the TOKTEN project is well conceived, well implemented, and it should be continued and its scope expanded. The Tokten-India project has been perceived, without any exception, by all user organizations as very useful in many respects including transfer of technology, development of new processes, transfer of information and knowledge about emerging areas of research, introduction of novel approaches in ongoing research projects, etc. Every TOKTEN expert seems to have taken his assignment seriously and has indicated a definite willingness to participate in follow-up activities and to continue assistance to the host organizations. In many cases, collaborative research projects have been developed and regular contacts maintained with the experts. In a few cases, several Indian scientists visited the experts' laboratories in the USA to learn more about the new techniques or attend special training courses. A number of experts have also given rare chemicals/biochemicals, computer programmes and publications not easily available in India.

According to the report by the Sharma Committee, the contributions of TOKTEN consultants cover a wide spectrum of fields - physical, biological, and engineering sciences, medicine and technology. "The contributions are enormous, significant, and habe greatly benefited various national programmes geared towards development." There are two advantages to the TOKTEN programme. First, the cost is far less than any comparable 'consultancy' programme where visiting experts provide equivalent service. Second, and probably even more significant than the first, the transfer of knowledge and other benefits takes place under psychologically much more conducive atmosphere than when Western experts visit Third World countries. I do not have information on how other TOKTEN programmes - in countries like the People's Republic of China, Egypt, etc. - have been evaluated. But the Indian experience appears to be one of unqualified success. Such programmes should, therefore, be strengthened. In fact, India has launched other programmes, somewhat similar to TOKTEN but without the assistance of UNDP. One of them is TIES (Talented Indian Engineers and Scientists), aimed to tap the skills and goodwill of non-resident Indian experts.

Let us now turn our attention to initiatives calculated to improve information provision per se. In a paper published in Journal of Information Science in 1981, I have given several suggestions which I believe are valid even now. In short my proposals include : (1) creating an awareness among both researchers (users) and librarians and information officers of the central role played by information in R&D, (2) helping the users learn to search information more efficiently, (3) introducing new information technologies (on-line retrieval, off-line batch mode retrieval, use of CD-ROM databases, etc.). We will not go into the details for want of time.

The other problem of disseminating whatever is done in the developing countries is not all that straightforward. Often we hear Third World scientists complain that their own earlier work is not taken note of and subsequent work reported from some laboratory in the West is being cited in the literature. Sociologist Harriet Zuckermann and scientometricist Tibor Braun feel that no deliberate mischief or conspiracy is involved. Such things happen even when the work is published in highly circulated international journals.

Most journals published in Third World countries are poorly circulated and often what is published in them go unnoticed by researchers elsewhere. Unless these journals are covered by all the relevant secondary services there will be no chance of them being noticed by workers elsewhere. It is for this reason Mike Moravcsik assembled about 30 experts in Philadelphia in 1985 and tried his best to persuade ISI, Philadelphia, to cover many more Third World journals in SCI at least on a trial basis for a few years. Somehow, the plan did not work. We realize that philanthropy cannot always work ; in certain things hardheaded financial decisions are to be taken. Getting more Third World journals covered will cost money and we have got to find a source to fund the project.
However, we must realise that Third World scientific communities should ultimately have to become self-supporting. One cannot live on blood transfusion for ever. Any initiative which will make developing countries eternally dependent on outside support should, therefore, be eschewed.