Scenario of Research at Doctoral and Post-doctoral Level

– India vis-à-vis Developed Countries

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Introduction

Among developing countries, India holds a respectable position with regard to science and technology. In most developing countries, R & D manpower is low and much below the threshold required for sustainable scientific research. It is also a disappointing fact that in developing countries the fraction of S & T personnel (those holding at least a B.Sc. degree) actually engaged in research is much lower than in the industrialized countries. In India, although there are more than three million S & T personnel, only around one million are engaged in R & D activities. Most industrially advanced countries (such as USA, UK, FRG and Japan) have between three and five million such professionals. Among developing countries, only China comes close to this figure.

India is badly stricken by the problem of brain drain. The two fundamental axioms that guide the migration of professionals are: (1) "Brains go where the money is" and (2) "brains go where brains find encouragement". Other parameters that govern brain drain are discussed in this article along with steps taken by the Government of India to curb it.

Various factors that affect the productivity of S & T personnel in India as compared to those in the developed countries are discussed under the different subheadings.

Quality and Levels of Science and Technology Personnel

The quality of the manpower involved in a particular venture depends on how popular that venture is among people. Fortunately, in India, the profession of science and science-based technologies is reasonably respectable. This is not the case in many other developing countries and even in India not to the same degree as in the developed countries. Being a large country, ranking seventh in the world in area and second in population, India has numerous research institutions where research in almost all branches of science is carried out at various levels. The basic prerequisite to begin research is such that only those who have high aptitude for it get through. The National Eligibility Test (NET), the Graduate Aptitude Test in Engineering (GATE) and interviews are conducted at the national level to select Junior Research Fellows (JRFs) and Senior Research Fellows (SRFs) to carry out scientific work in different research projects. These tests are conducted by the University Grants Commission (UGC), the Council of Scientific and Industrial Research (SCIR) and the Ministry of Human Resource Development, and the fellows are paid a respectable monthly stipend for a period which may last up to five years. In addition to JRFs and SRFs, these bodies also recruit Research Associates (RAs), Research Scientists and Pool Officers who have considerable research experience (often from overseas laboratories) and who can coordinate work in the different directions of research projects.

In India as well as in the developed countries, the average age at which a student is awarded the Ph.D. degree in the science or engineering disciplines is 28 years, and like in the developed countries, the degree involves about five years of rigorous research work. Quite a good number of students receive Ph.D. degrees every year from different Indian universities in almost all disciplines in S & T. However, the area of imparting research training to medical graduates reveals a world of difference between India and the developed countries. In India the topmost brilliant layer of students, after passing very tough and highly competitive entrance exams, gain entrance into medicine. After graduating in medicine (at an average age of 23 years), most students join the post-graduate courses leading to the MD/MS degrees in clinical as well as non-clinical subjects. During the three-year post-graduation period, students submit a dissertation as partial fulfillment of the requirements for their degree. This training does not involve the rigorous skills needed for modern-day biomedical research which are imparted in the developed countries as part of post-graduate programs in the biomedical disciplines. Monetary and other reasons strongly dissuade the students from developing a taste for challenging biomedical research. As a result, medical graduates in India scarcely enter the Ph.D. program. Thus, the participation of medical graduates in research work in the biomedical disciplines in India is negligible. This is perhaps the main reason that India lags behind in the area of biomedical research. The Government of India is making all efforts to attract the medical graduates to attempting a career in biomedical research.

Another stark comparison between India and the developed countries can be made in personnel at the post-doctoral level. A post-doctoral scientist with his experience – and also because he does not have to work under stress to finish his Ph.D. – is very productive and can solve problems of contemporary interest. In developed countries, a research group on average has a 2:3 ratio of post-doctoral workers and graduate students. In India, a post-doctoral culture has not developed. After obtaining their Ph.D., most good students leave India for the West to gain post-doctoral experience, mainly because they receive better financial rewards and thrive in a competitive work atmosphere. It is very important that steps are taken to retain a good percentage of Indian students as post-doctoral fellows in India after completion of their Ph.D. This can be done through awarding much higher salaries. This will certainly improve the quality and pace of scientific work in India. Steps are being taken by different agencies in this direction. The UGC has initiated a scheme of appointing research scientists at the national level with higher stipends. This has made it possible to appoint research scientists in research projects. By doing so, we have been able to obtain better and more useful results in our ENRECA research project (see below).

Motivation and Future Security

Certain physiological functions occur without motivation, but nearly all conscious-driven behavior requires motivation and so does doing research. In the Indian context, researchers are motivated mainly to satisfy their security and esteem needs.

If the ways and means to achieve these are very cumbersome and difficult (particularly so in India) then frustration sets in the mind of the individual. This is probably more responsible than anything for the brain drain among Indian scientists and their relative inefficiency and decreased output while working in India.

Quantum of Work Put In

Almost certainly, the productivity or the output of researchers in India is not consistent with the work input in the field of scientific research. The reasons for this have their roots in motivation, planning, the quality of the available research facilities, the lack of the required research environment and the socio-economic conditions of the country in question.

On average, researchers put in an appreciable amount of work and try to extract as much as possible from the prevailing infrastructure. In our laboratory, research scholars spend nearly ten hours a day six days a week on research-related work, and we are satisfied by the output in the existing infrastructure. However, we strongly believe that if the classical conventional methods we routinely exercise were replaced by modern and less cumbersome procedures, and if modern, sophisticated equipment were available at our disposal, our efficiency and output would rise manifold.

Research Infrastructure and Variety of Research Projects Executed

Only a few developed countries equal India in its varied research programs, but India is hardly equal to the developed countries in terms of the availability of the rich infrastructures and environments required to carry out research programs of current interest. By and large, people can carry out research at Indian universities in any area of S & T in which they have expertise and aptitude, although arranging funds to perform them may be a problem.

Many Indian scientists receive training abroad in a newly developing field. When they come back and get a suitable independent position at an institution, they attempt to develop an infrastructure to continue research along similar lines. On the whole, India does have the research infrastructure, even if it is not developed for all kinds of research. Various funding agencies, such as the Department of Science and Technology (DST), the Department of Biotechnology (DBT), The Council for Scientific and Industrial Research (CSIR), the Department of Atomic Energy (DAE), the University Grants Commission (UGC), the Indian Council of Agricultural Research (ICAR), the Indian Council of Medical Research (ICMR), the Defense Research and Development Organization (DRDO), etc. call for relevant projects from potential scientists, assess their utility and support them financially with periodic assessment of their progress. However, this kind of support is not easily obtainable for every willing and capable scientist due to scarce resources.

In all countries, the pressure on scarce resources is so intense and expectations so urgent that people are often unsympathetic to long-term basic research. In this regard, India is particularly fortunate. We have a long tradition of scholarship, a heritage of pioneering scientific research and full political support at the highest level.

Planning

Freedom to carry out scientific research of choice sounds good, but it does have serious drawbacks with regard to the interests of the country. Researchers tend to choose a newly developing field where – with relatively little work – one can flourish easily and show high productivity in terms of publications or otherwise.

India – being a developing country – needs to develop many things on its own and hence expects its manpower to work along those lines. So much funding goes into salaries and fellowships to researchers and to finance various research projects – how nice it would be if the research work carried out with these funds were directed towards developing the indigenous technologies which the country needs so badly. This would not only develop India's position and reduce its expenditure on imports, but also generate more money for research. Most small-scale industries in India are starving for the appropriate technology. Because these industries can not compensate qualified manpower to develop technology for them in monetary terms, they are compelled to use the old, cumbersome and inefficient technology and hence do not flourish.

This may be true on the international level also, as peer reviewers of grant applications look for the number of publications as a strong criteria for assessing the potential of the applicant to execute a proposed research project. However, due to meager resources, it is more critical for India that efforts and proposals to develop technologies directly useful at the common-man level are encouraged and funded, rather than proposals from applicants with an impressive-looking publication track record alone. In this context, it can be mentioned (see below for details) that we are conducting a project on the examination of Indian plants for biologically active phytochemicals, a traditional and still useful area of investigation in the chemical sciences. We have obtained preliminary results which may find applications in agriculture and health.

Quality of Available Research Facilities

The non-availability of the state-of-the-art equipment required to do world class research at most Indian institutions obstructs the pace of productivity and to some extent the quality of work. Even if the equipment is available, it is not available in sufficient numbers, and trained technicians are not there to install, maintain and repair it. The techno-administrative condition is such that if a piece of equipment fails, it takes an average of six months to get it repaired – and this is often done by inviting foreign technicians. This becomes quite expensive and time-consuming, particularly since inviting technicians from abroad requires a number of different clearances from different government agencies. In the developed countries, all this is a matter of a phone call, a fax or an E-mail message.

Because equipment is very limited, the rush and load on it is enormous (which may also be a cause of the frequent equipment breakdowns), and work consequently proceeds quite slowly.

Laboratories where research in the chemical sciences and related areas goes on often face difficulties in producing the chemicals which are not indigenously manufactured. The time needed to place orders for these chemicals, their shipment and delivery, all take so much time – particularly for hazardous chemicals – that urgent needs can not be met.

As a major research activity, we have been working actively for the past five years on the isolation, characterization and biological activity evaluation of natural products and their analogues in collaboration with two Danish universities under a project funded by DANIDA through its ENRECA program. For this task, we need a high resolution NMR spectrometer, among other sophisticated equipment. We do not have access to this instrument, and as we isolate on average ten compounds (also in impure form) from a plant extract, our pace and productivity are slow. When a post-graduate fellow from our laboratory works at Odense University in Denmark, his efficiency increases manifold. Making use of the required research facilities and equipment available at his disposal, he isolates as many as 35 structurally interesting compounds from one plant extract – and many of these turn out to be novel compounds. Our endeavor in the isolation of novel natural products has led to the isolation of nearly six hundred compounds from different natural sources belonging to the classes of polyphenolics, alkaloids, lignans, terpenoids, steroids and neolignans. Quite many of our compounds have shown interesting and useful biological activities – i.e. insecticidal, cancer preventive, antibacterial, antifungal and antiviral.

Library facilities pertaining to research studies also count for a lot. Owing to rather small allocations and increasing inflation, libraries keep reducing the number of journals and research study material subscribed. This is a serious limitation for Indian researchers, who are compelled to remain dependent on abstracts when the often detailed information needed on a particular subject is not easily available. Libraries at the universities and institutions of developed countries are connected through computer networks and make all kinds of literature available to their research scholars.

Interactions and Collaborations among Scientists at the International Level

Interactions with the international scientific community builds a sound research atmosphere, affording us to meet the leaders in our field. Owing to the resource crunch, international symposia and conferences are not as frequently held in India as they are in the developed countries. For the same reason, Indian scientists are not able to go abroad to participate in meetings, and our young scientists can not go abroad for advanced training.

No invention or discovery is complete until its full utilization is exploited. This is only possible if scientists work in collaboration. By and large, India lacks this culture, which prevails in the industrialized countries and has an appreciable share in their development. The Government of India has made provisions for collaborative programs with developed countries in thrust areas of S & T through various schemes. We have successful ongoing collaborations between a few Indian research teams and research groups in the following developed countries; USA, UK, Belgium, Italy and Denmark.

Socio-Economic Conditions

While both industrialized and developing countries spend roughly the same percentage of the GNP on S & T, the order of magnitude is lower for the latter group of countries. R & D investments in India have been progressively increasing – from around 0.2% of the GNP in 1958 to 1.13 in 1990, a factor of more than five.

Of the investments made in S & T development, the largest share comes from the government, while very little comes from industry. In India, this percentage ratio is 80:20, while in developed countries it is close to 40:60. Researchers who command funding from outside (from foreign or national agencies) are better off, devoting more time and zeal to their research than the researchers who can not obtain outside funding.

Migration of Trained Manpower

Flight of the skilled manpower from one country to another is mainly caused by economic conditions. Other reasons, such as bureaucratic and administrative control, lack of high quality facilities, absence of peer appraisal and societal aspects also play important roles. Some developed countries have created a demand for engineers, scientists and other highly skilled manpower which they are not able to meet from within their countries. Absorption of highly educated and skilled Indian personnel by the developed countries has caused concern in India, which happens to be one of the principal donating countries. A considerable part of the meager resources available in India is spent on setting up institutions of higher learning to meet the needs for technical manpower for higher education, research for industrialization, and R & D and Health programs. However, these goals are not met, as most of the talented and well-trained scientists who turn out from these institutions travel abroad and settle there. The US Census data of the last few decades indicate that on average, 35,200 professionals, 8,500 technicians and 10,100 managerial personnel – totaling 53,800 skilled personnel – have migrated to the USA from India over a ten year period. However, the Indian National Statistical (INS) data shows this number to be even larger: 163,100 persons migrate to the USA during a ten year period, while an almost equal number of Indians emigrate to other countries, such as UK, Canada, Germany, Australia, etc.

In the 50s, India had set up a mechanism making provision for foreign-trained scientists, engineers and doctors to be placed temporarily in a pool which guaranteed them a stipend for a period of 2-3 years, so that returning personnel had ample time to look for a respectable job in India. However, as the stipend was not attractive and the working environment in India unappealing to the returnees, many of them left again.

Another effort which has succeeded in India is worth mentioning. Some 40 years ago, an award called the "Bhatnagar Award" was introduced, to be given to scientists below the age of 45 in six different areas of S & T for the most outstanding scientific and technological work carried out in India. This is the most prestigious award given to scientists and technologists in India. Of approximately 290 such awards given over the past 39 years, only about half a dozed awardees have settled outside of India. Thus, nearly all of the awardees preferred to remain in India and create schools of research of outstanding international level in different fields.

Conclusion

Blessed with highly motivated and talented S & T manpower and equipped with a workable infrastructure for research, India is bound to do better in the years to come. The economy of the country is improving, and the liberalization policy adopted by the government is in favor of a scientific and technological revolution in India. With the advent of multinational companies in India, the S & T people have gained more importance and their efforts are now likely to produce results of applicable nature.

The change in the scenario can easily be visualized. Up to about ten years ago, the contributions from Indian laboratories in esteemed international journals was less than 2%. Currently, the figure is close to 10%. Many Indian scientists have gained name and fame in the international scientific arena in different areas.

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