The role of postdoctoral training for careers in research and higher education

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The importance of well-trained workforce of postdoctoral scientists to science, technology and for other sectors of the society has been recognized world over. While many developed countries have implemented well-structured postdoctoral training programmes to maintain excellence in science and engineering, in the Indian context they are rare. The training programmes are especially important in light of increasing global competition for the best students and scholars. The DBT-postdoctoral training programme in biotechnology and life sciences has become an effective programme and has succeeded in retaining a significant number of trained postdoctoral fellows in India. It is possible that the elements of this successful programme may be transferable to other areas of science and engineering in India.

Keywords: Careers in research, higher education, post-doctoral training.

TRADITIONALLY, three cadres of personnel form the backbone of scientific enterprise in the university, non-university research institutes and government laboratories: trained research assistants/technicians, postdoctoral fellows and Ph D students, not necessarily in that order. In the Indian context, the available data fail to portray this traditional model. Graduate students contribute the most, if not all, to our research output in many disciplines. During a student's tenure, basically the emphasis is on training rather than research productivity. Prior to the sixties, the Ph D degree was normally sufficient for appointments to permanent positions. Those were the good times! However, with increasing competition for positions and diminishing career prospects, it became inevitable that a Ph D degree was not enough and postdoctoral research experience was thought necessary to prepare Ph D degree holders for independent academic and research positions. During postdoctoral studies, normally the fellows learn the essential skills required for an independent career in their respective fields under the supervision of an established mentor. In India, with no postdoctoral experience, appointments are normally made to the rank of Lecturer or equivalent grade. Until recently, five plus years of postdoctoral experience (there have been exceptions, however!) was essential to be eligible for appointments at the level of Assistant Professor/Reader in the universities, non-university research institutes or equivalent in government laboratories. It now appears that job applicants tend to have one or more postdoctoral positions of longer durations invariably in foreign countries. Similarly, recent global surveys suggest that it is common for postdoctoral researchers to spend five plus years before getting a job. In a select group of countries, the postdoctoral training programmes have proven successful in many respects, and have become pipelines to produce future generation of academics, scientists and engineers. It must be noted that the availability of skilled research personnel is equally important to the industry as well.

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Impact of postdoctoral research on the research landscape

Progress in modern science, technology and engineering increasingly depends upon postdoctoral researchers, who occupy an important place in the academic research landscape. Postdoctoral researchers use the period during training to broaden their research interests, learn new techniques and skills such as grant writing and laboratory management, hone critical thinking and communication, and become acquainted with new scientific perspectives and approaches. All these skills are important for success in academic or non-academic careers. Freshly graduated Ph Ds bring enormous energy, creativity and originality to the system. In many a cases, the period of postdoctoral training is perhaps the most valuable and productive, as demonstrated by important publications and other accomplishments. On the other hand some, although a minority, might believe that postdoctoral training is a bit detrimental to their self-esteem!

Historically, the roots of postdoctoral research can be traced to Europe during the early part of the 20th century. However, expansion and strengthening of postdoctoral research training programmes occurred in universities and at NIH in the United States after the World War II. Currently, the universities, government laboratories, private research institutes and industry provide exciting training

opportunities for postdoctoral researchers. Overall, the postdoctoral training programmes in select countries are structured, well-managed and adequately funded by the government funding agencies as well as innumerable philanthropic organizations. The research community and science administrators have recognized the impact of postdoctoral research. The universities, non-university academic and government research institutes provide state-of-the-art infrastructure, stimulating and rewarding scientific environment in a broad range of areas. Motivated by these factors, postdoctoral researchers tend to get attracted to the Western countries and conduct a large part of their research work. Apparently, the annual research output in the United States depends very substantially on immigrant postdoctoral researchers who had training from all over the world and in particular from India, China and the former Communist bloc. With Ph D students, one prefers to take up research projects that have a high degree of success because of several limitations. Postdoctoral researchers are often willing to pursue long-range, high-risk research questions without distraction from course work, mid-term exams and comprehensive or qualifying exams. In ideal situations, high-calibre postdoctoral researchers change the landscape of science. For example, James Watson co-discovered the structure of DNA during his postdoctoral studies at MRC, Cambridge. Because of the immense success of the postdoctoral research programmes, the United States has maintained a clear leadership in all fields of science, technology and engineering since World War II.

The career paths for the postdoctoral researchers have changed in recent years. Although near the end of postdoctoral training, the ambition of many is to get an academic position, it might not be possible in all cases. The traditional government jobs include basic research, applied research and administrative positions. There are many a valued careers in industry, teaching, media, patent work through law firms, business and other alternate professions.

State of postdoctoral education and research in India

A number of studies have emphasized that higher education in basic sciences and engineering is currently facing great challenges in India. For many years now, C. N. R. Rao has been relentlessly focusing the attention of the government and associated agencies to India's faltering higher education system and worrying trends in research output. Lately, there have been numerous newspaper columns, TV interviews and internet blogs on this issue. Applications to post-graduate courses in basic sciences have declined in recent years. The status of pure sciences is so adversely affected that even legislators have begun to take notice of it. As policy makers debate on the state of Indian science, the academic community needs to introspect the possible reasons for the current state of higher education and research output in India. Apparently, there are many reasons for this alarming decline. Certainly, one of the reasons among many is the massive expansion of IT and business management education at all levels. Second, we have counted too heavily on the Ph D training itself. In fact, the infrastructure, the quality of training, and opportunities available for doctoral and postdoctoral researchers are rather poor in many academic institutes and universities. Therefore, it is understandable that almost all Ph Ds produced by 'premier' research institutes and universities head Westward, thus converting our graduate programmes into Ph D-producing centres for laboratories in foreign countries. A small number of Ph Ds from the less endowed universities and research institutes join some select laboratories for postdoctoral research. Unsurprisingly, many use the skills acquired during their postdoctoral studies in India as a launching pad for the Westward journey. Consequently, the science administrators and academics should do serious soul-searching to minimize these factors.

With regard to teaching at the Bachelor's and Master's degree levels, the IITs and IIMs are considered to be the powerhouses of world-class higher education, but not the same when it comes to producing research papers. Intriguingly, in many different fields of engineering where advances have been made, the central apparatus in these studies is a computer rather than a laboratory experiment. The principal consequence of neglecting higher education in experimental science and engineering seems clear. There is a growing scarcity of qualified people to fill in the existing positions in universities, non-university institutes and government laboratories, and this will have several further consequences. It is also becoming increasingly difficult to recruit qualified people to fill in the existing positions even in the centres of excellence. Without remedial action, this trend might continue in the immediate future. Increasing the postdoctoral research community in science, especially in biomedicine, together with training students for the Ph D degree, is a daunting challenge in higher education. There is a need to link research and postdoctoral training to changing needs of academia, industry and society. The issue is more critical than ever before, because research in biomedicine and drug discovery is growing increasingly and becoming inter-dependent. Qualified researchers are scarce in these emerging areas. Thus, fostering the next generation of academics and scientists through training should be the 'mantra' for future development. The concept of postdoctoral fellowship programme has been successful in the Western countries. I believe we should adopt this concept in India as well.

Some thoughts on the Indian higher education system

I am relying upon my own personal experience as Coordinator of the National Postdoctoral Programme in Biotechnology

and Life Sciences, and also on my thoughts as to how we can collectively improve the Indian research landscape in basic sciences and engineering. The thread that runs through the career paths for most Ph D degree holders in India goes like this: Ph D degree, overseas postdoctoral training and exploring careers. This traditional path has not changed during the past 60 years. One cannot think about advances in science and engineering without strengthening research training programmes and retention of the well-trained personnel. These are important prerequisites for the success of the entire research system. If India aspires to be a global leader in higher education in science and engineering, it has to set the international standards, especially in providing young researchers infrastructure and opportunities to work successfully at the cutting edge of research. Various indicators suggest that a significant number of our talented students are joining some universities in European countries that do not even match up to some of the institutes in India. There is also a broader concern: although it is clear that appropriately qualified human resources are the primary key to the nation's strength in science and technology, we have not paid adequate attention to the high degree of variability of standards in Ph D training programmes. In effect, human resources have been taken for granted as a by-product of our policies for the extra-mural support of research. We do not have a broader vision of the future for training in higher education. The naive assumption – both inside and outside the academic community – has been that the function of Ph D programmes is to produce the next generation of academic researchers. It is time for a fuller recognition, by academics and science administrators alike, of the contribution of postdoctoral researchers to science, engineering and technology. However, the foregoing concerns should not undermine the fact that a number of serious efforts have been made in recent years to improve higher education in India.

The government funding agencies should introspect on how much of their overall budget is spent on the HRD programmes. In regard to the support for HRD programmes in higher education, the funding agencies, except DBT and CSIR to a certain extent, allocate relatively a low percentage of their total budgets to the training programmes. To my knowledge, apart from the Lady Tata Memorial Trust, no other philanthropic organization awards doctoral or postdoctoral fellowships to pursue research in India. However, the funding agencies should be aware that HRD programmes do not generally produce short-term results, and they require stable, long-term investments. A centralized department should administer the postdoctoral programmes in science and engineering analogous to the NRSA in the US, JSPS in Japan, British Academy fellowships, ARC and NHMRC in Australia, etc. In recent years, few institutes have started postdoctoral training programmes of their own. In India, the government funding agencies, universities and academic institutes indeed contain complex bureaucracies. Each institute or university has its own unique administrative structure and finding the right administrators who have responsibility for postdoctoral training/research can sometimes be a challenge. Therefore, by creating a dedicated department, the level of bureaucracy, duplication of work and wasteful expenditure can be minimized. Nurturing the postdoctoral researchers in science, engineering and technology requires different types of support. At the basic stage, promising postdoctoral fellows need to be brought together, offered career guidance and intellectual environment. I believe that giving attention to postdoctoral training and education in all areas of basic sciences and engineering can significantly change the Indian research landscape, and might help retain our freshly graduated Ph Ds in our system. Without a strong postdoctoral research community, we would still be debating as to what is wrong with our higher education system for the years to come. In his editorial entitled 'Footsoldiers of science' P. Balaram[1] had briefly discussed the importance of postdoctoral training programmes and their impact on Indian science.

DBT postdoctoral programme in biotechnology and life sciences

An instructive example of a structured training programme is the National DBT Postdoctoral Programme in Biotechnology and Life Sciences. I wish to mention that as the Founding Coordinator of the programme, the views expressed in this discussion are my own. DBT, New Delhi out-sourced this programme to Indian Institute of Science (IISc), Bangalore which has been responsible for co-ordinating essentially all aspects of this programme. The goal of the programme is to train postdoctoral fellows in all areas of life sciences, with emphasis on biotechnology. The programme been implemented since 2001. The basic budget comes exclusively from DBT. The postdoctoral fellowship is for a period of three years, contingent on satisfactory performance, expandable up to five years.

Here, I review the results of the five-year old programme, which suggest that structured postdoctoral training programmes might not be a mere pipedream in the Indian context. The programme receives about 500 applications each year from Ph D degree holders in all branches of science, engineering as well as MD/MS degree in medicine. The postdoctoral programme, as a rule, is open to investigators at all universities, non-university institutes and private and public R&D organizations. The programme has a significant presence of Indians who have recently obtained Ph D degrees from foreign universities. About 90 fellowships are awarded each year. During the past five years, 324 postdoctoral students have been trained in the program; 17 of them had MD/MS degree in medicine. As expected, >72% of applications were from

students who had their Ph D degrees from universities. Figure 1 illustrates the origin of postdoctoral researchers from various universities, including agriculture, veterinary and medical sciences and non-university research institutes. The programme also attracts a smaller pool of recently graduated Ph Ds from IITs, IISc and CSIR and DBT institutes as well as medical colleges.

In broad terms, the programme has been able to attract a large numbers of women scientists, including those who had discontinued academics due to family commitments, to pursue postdoctoral research. In addition, it also draws a number of applications from in-service academics and scientists. Analysis of gender-wise distribution for men and women shows that the former fared better (52% versus 48%), although the differences are small. An important role that the members of the selection committee have been playing is to identify potential institutes, laboratories and mentors for selected postdoctoral fellows. The state-wise origin of Ph D students is shown in Figure 2, which indicates that the programme is reaching almost all parts of India. A comparison between different States with regard to universities/institutes awarding Ph D or MD/MS degrees, indicates that about 14% each was from the universities and research institutes located in Tamil Nadu, Karnataka and Uttar Pradesh. This was followed by West Bengal, Andhra Pradesh and Maharashtra. However, the most important feature of this analysis is that more than 60% of postdoctoral fellows pursued training in various research institutes and universities in the tri-State hub comprising Karnataka, Andhra Pradesh and Maharashtra, thus reflecting on the existing opportunities and facilities for research in modern biology in these States. The sponsoring institutions for training of postdoctoral researchers has included academic research institutes, universities and private and public R&D organizations located in almost all the States (Figure 3). The fellows were not only trained in life sciences departments in the universities and research institutes, but also in IITs and medical colleges. Major government research institutes under CSIR, DBT,

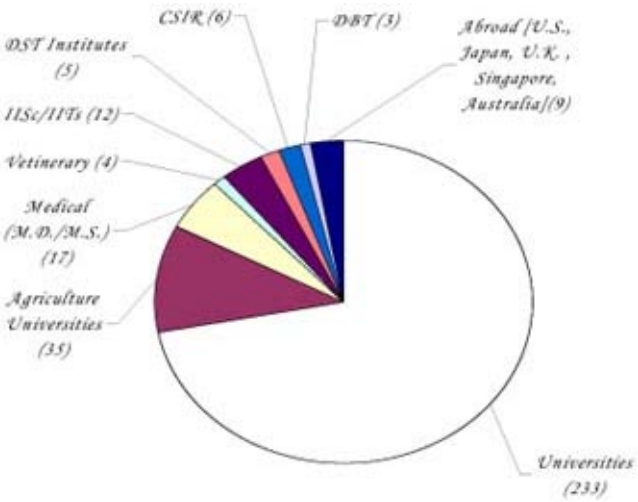

Figure 1. Origin of postdoctoral fellows from institutions/ universities.

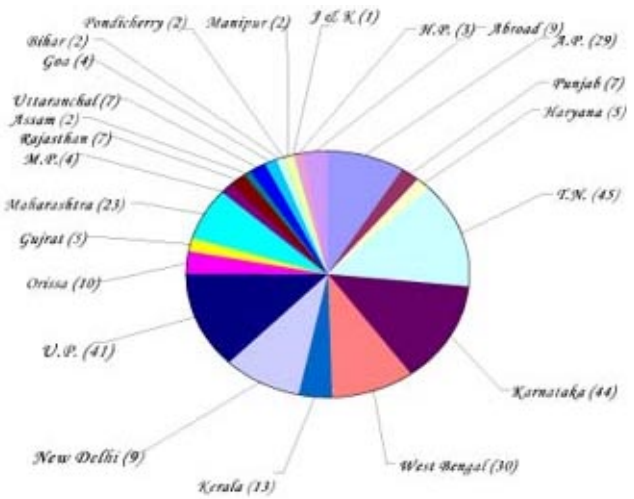

Figure 2. Geographic origin of postdoctoral fellows.

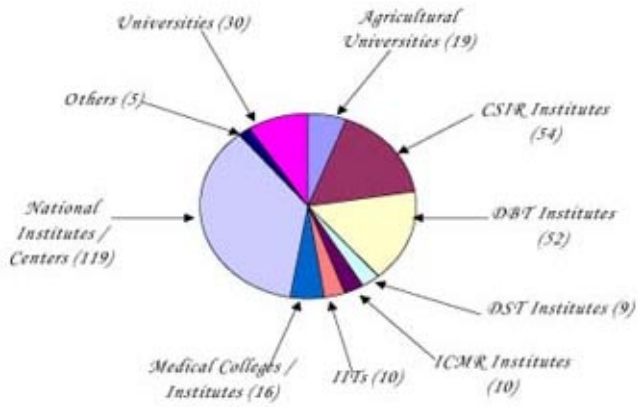

Figure 3. Where are they trained?

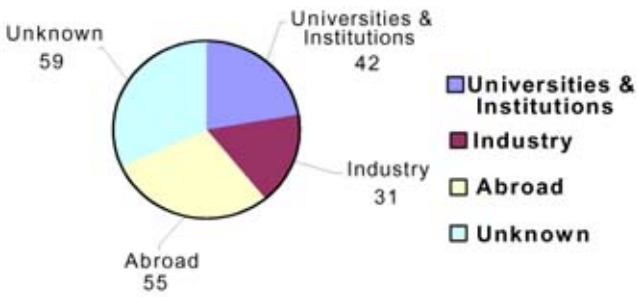

Figure 4. Placement profile.

DAE and DST participated in training postdoctoral researchers under the DBT programme.

The training received by postdoctoral researchers has helped them to find suitable positions in academia and industry. Papers co-authored by the postdoctoral researchers during the tenure of their training in the programme have appeared in top scientific journals and some have co-authored 3–4 papers, and this trend continues. Figure 4 shows the placement profile for 187 postdoctoral fellows who have completed their training under this programme. As of July 2006, 38% secured jobs in the academia, government laboratories or industry in India and about 30% went Westward to continue their research careers. It seems that postdoctoral researchers trained under this programme are able to find opportunities not only in academia, but also in biotech and pharmacological industry.

Finally, the intent of this article is to suggest that it is worthwhile to consider structured training programmes for postdoctoral researches in all branches of science, enginering and technology. In this context, there should be a measurable change of attitudes toward postdoctoral researchers trained in India. This change in attitude must be accompanied by changes in the appointment practices of academic departments, research institutes and government laboratories together with changes in the policies of academic administrators and funding agencies.

1. Balaram, P., *Curr. Sci.*, 1999, **77**, 1225–1226.

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