BARC and nuclear science in India – reflections of a nuclear scientist†

I started my research career as a young trainee in the Bhabha Atomic Research Centre (BARC) (then Atomic Energy Establishment, Trombay (AEET)) Training School exactly 50 years ago. For nearly 25 years, BARC nurtured me and enabled me to carry out research in several areas of nuclear science. Of course, we were all very proud to be a part of the Department of Atomic Energy (DAE) family. But I must confess that I really recognized the unique strengths of BARC and the DAE family only after I moved out of DAE.

BARC is a truly multidisciplinary organization of many scientific disciplines – physics, chemistry, biology, engineering, technology, manufacturing, even agriculture. One would joke, if you have a problem in your work, walk along the corridors of Modular Laboratory at BARC, you will find someone who has the answers or knows someone who can help. We normally take this for granted. I did not realize how difficult it is to build a multidisciplinary organization till I went to Delhi as Secretary, Department of Science and Technology. Practically, every department in every institution or university functioned in silos with very little interaction. For example, we wanted to build indigenously a superconducting NMR system. One institution in Delhi had the expertise to build superconducting magnets. Another had the wherewithal to design and build the control system. A third institute knew the operation and use of the system for cutting-edge research. But the scientists from the three institutions met rarely, except in DST organized meetings. We still import NMR systems. I know that BARC still has some commercialization problems, but the interdisciplinary atmosphere of the Centre cannot be missed.

Resource constraints have always been a characteristic feature of the Indian S&T system and BARC is no exception. We used to find our own novel cost-cutting methods. I believe that the technology denial regime, post-1974, in fact brought out the true strength of BARC. We used to say if anyone could do it anywhere in the world, we could also do it. Sometimes I wonder, if there had been no technology denials, whether BARC would have achieved whatever it has so far.

While discussing the unique strengths of BARC, it is also necessary to point out two challenges that the Centre faces; in fact the entire nuclear community. We all remember the hectic drama that preceded the commissioning of the Koodankulam nuclear power station. Unacceptable public risks as perceived by a section of the population were quoted as the reason for the agitations. I was wondering whether the long-term interests of the country were being compromised. The anti-nuclear lobby is not new to us. In the early years, it was the non-proliferation issues that used to power the anti-nuclear lobby. Subsequently, some of the pending technical issues like the management of long-lived radioactive waste, operational safety, etc. used to power them. It was for the first time that public risk perceptions were in the forefront, driven by the Fukushima disaster and a proactive media. I was indeed surprised that repeated assurances by the specialists did not seem to be cutting the ice with the agitators. As a trained scientist, I was indeed surprised and pained.

Of course, the nuclear sector was not the only one to suffer. You may recall the drama that preceded the national moratorium on *Bt* brinjal. One might argue 'after all, we are a democracy. Let the public decide'. But the question is whether 'Is the public is informed enough, particularly on issues that are highly technical and especially when there is no consensus. How do we protect the system from vested interests? This is indeed a challenge to all democracies.

The only way to handle large-scale public misconception is to engage the public extensively. This can only be done by the scientific community, of course, with the help of science journalists and science communicators. I am aware of the excellent work being done by the Indian Nuclear Society in this direction, but we need to do more considering the vastness of our country, the language diversity and the multiplicity of the media. A focused effort to understand the public perceptions and manage them through effective communications is clearly the challenge of the day. Every one of us has a responsibility in this.

The second challenge faced by the nuclear community is management of the human resource and knowledge management pipeline. As you are aware, the nuclear industry is in a plateau in many of the developed countries. Some countries like Germany are taking an anti-nuclear stand. It is only countries like India, China and a few other developing countries which are on an aspirational economic growth trajectory that are interested in the growth path of nuclear electricity. Unfortunately, the financial muscle of these countries is limited, as well as the research intensities.

The turbulence, including the slowing down of the nuclear sector in some developed countries during the last few decades has seriously disrupted the human resource pipeline and the knowledge management strategies across the world. Being a mature industry with more than five decades of existence, the nuclear sector certainly lacks among the young students the glamour of some of the emerging sectors such as information technology, biotechnology or nanotechnology-based industries. The sector also lacks the entrepreneurial opportunities which some of the emerging technologies offer. The decreasing job opportunities and the constant battering by the anti-nuclear lobby, only add to this negative image of the sector. An unfortunate consequence of a declining student intake in the academic institutions is the declining faculty strength in nuclear science and engineering disciplines. A number of nuclear facilities in educational institutions have also been closed during this time. Overall, there is a clear decline in nuclear research in the academic institutions with an unmistakable impact on new nuclear knowledge generation and nuclear knowledge management. At the plant level, the onset of retirements of the first-generation technologists is threatening to disrupt knowledge management, since the human resource pipeline has been seriously disrupted, that too at a time when we are striving hard to improve safety levels of plant operation, to cope up with the unavoidable post-life time management of the first-generation plants and long-term management of radioactive waste.

†Based on BARC Foundation Day lecture delivered on 13 October 2014.

Before I conclude, I will like to draw your attention to yet another thought of mine relating to BARC. As you are aware, the Indian nuclear energy programme is more than 60 years old. Thanks to the foresight of Homi Bhabha, today we have a scientific and technological competence in this area comparable to that of many developed countries. We are perhaps the only developing country having full control over the entire fuel cycle. We can take pride in our capabilities in the fast reactor domain. Keeping everything in mind, some of my friends ask me whether the research mandate of BARC is as relevant today as it was in the early years of the programme. I am of the view that it is still relevant today. As you are well aware, the whole world is looking for nuclear reactor designs that have a level of safety far more than those in operation today. I keep hearing about the Gen-IV reactors and I am sure that BARC leads the exercise in India. There are several unresolved issues in the management of spent fuels that warrant intense research in the coming years. There could also be new technologies round the corner waiting to displace the conventional nuclear fission reactors. For example, fusion systems for power generation have been on the drawing board for several decades. Accelerator-driven sub-critical systems for power generation offer inherently safe nuclear power. Are these likely to become standard work horses of nuclear electricity in the coming decades? We do not know. But without a vibrant research programme and a human resource to support it, none of these can be realized. I am therefore of the view that the research mandate of BARC will continue for a long time to come.

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Second Swadeshi Science Nobel Prize – a mirage?

A recent report on why IITs have failed to produce Nobel laureates has reignited debate on the topic[1]. Such a debate appears transiently every year around the months of October and December when the Nobel Prizes are announced and awarded. I would like to extrapolate the question to include premier institutions like the Indian Institute of Science, Jawaharlal Nehru Centre for Advanced Scientific Research, National Centre for Biological Sciences, International Centre for Theoretical Sciences, Tata Institute of Fundamental Research, Institutes under the Council of Scientific and Industrial Research, University of Hyderabad and University of Delhi, which have state-of-the-art infrastructure and get prime attention in funding. These institutions have quality faculty and do attract the best graduate students. The moot question is why these and other premier institutions did not produce a single Nobel laureate during the last 85 years after the only Nobel Prize in science was awarded to C. V. Raman in 1930. To answer this question we must understand what constitutes 'Nobel science', the cultural ethos and academic ambience of the institutions which have been winning Nobel Prizes at regular intervals[2–4].

(i) The institutions winning Nobel Prizes at regular intervals[4] have stalwarts working in frontline areas with original ideas and well-defined objectives for a breakthrough. We know brilliance breeds brilliance. They are either Nobel laureates or belong to the 'Nobel class'[2,5] and attract graduate students and postdocs with a passion for high-end research and earning global recognition.

(ii) Could Har Gobind Khorana, Subrahmanyan Chandrasekhar and Venkatraman Ramakrishnan have won the Nobel Prize had they continued in one of the institutions in India? Perhaps not. In addition to individual brilliance, academic milieu and ambience of the institutions play a pivotal role in fostering creativity[6]. The greatest challenge is to make our institutions and laboratories attractive for the most brilliant and competitive, who often leave the country after graduation.

During the last decade or more, China has recognized and appreciated the above points and set a target for creating institutes of global significance. Our premier institutions do have a large pool of brilliant researchers of international repute, but remain short of winning the coveted 'Prize'. This implies that there are issues which hold us back. A disinterested view of the scenario in our country reveals that we are progressing too slow and too late to make a tangible impact. This is evident from the data in Nature Impact 2014 (ref. 7) and Nature Impact Asia-Pacific 2015 (ref. 8). There is no rigorous mechanism for a reality check of the institutes for quality parameters. Similarly, a fresh look at the cultural ethos of the institutes for novelty and innovation is highly desirable. It is high time to do soul-searching for our global status notwithstanding our achievements in space, atomic energy and agriculture. The recent miracle in science education and research is China rushing to overtake USA[7,8]. The obvious question is why we cannot do what China has done? A pragmatic recipe for a turn around and pathway to meritocracy in Indian science has been given by Yamuna Krishnan[9]: 'To catapult India into the top five scientific nations, the country needs enabling policies that money can't buy. India has huge positives but it is hamstrung by socio-cultural issues, two of which I address here: a herd mentality and a paucity of early-stage mentorship. My ideas, stem from my 15 years as a graduate student and young research-group leader in India.'

After taking a holistic view of the global scene in science education, research and cultural ethos of high-ranking institutions the following points emerge for urgent consideration of the planners for science education and management:

- Mission statements of the institutions should clearly enunciate a time-bound goal for innovation, achieving global high ranking and winning international recognition, including a Nobel Prize.
- Faculty hiring criteria should be rigorous with a long-term perspective[10]. To quote Ian Gibson, British politician: