INDIA'S STRENGTH IN BASIC SCIENCES – AN ASSESSMENT

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In India, from about the middle of the last century, the introduction of modern technology began significantly to affect the character of Indian society. Industrialization and the consequent rise of entrepreneurial and working classes began to make the first dents on the caste system by the beginning of this century. The essential link between the introduction of science and the development of a rational and critical spirit began to be grasped from an early stage. Raja Ram Mohan Roy, campaigner against sati, religious reformer and defender of the freedom of the press was also a pioneer in the promotion of modern science education. Science and technology and their impact on society were seriously debated during the freedom struggle. The Indian Science Congress provided a serious forum where the political leadership of the freedom struggle could meet the leading figures of science and technology in India.

Around the time UNESCO was established in 1946, India was also on the verge of being an independent nation. Thanks to the rich and ancient cultural heritage of India, it had a scholarly tradition in several fundamental areas of scientific activities. India's base for scientific knowledge goes back to more than a thousand years as is evident from the India's contributions in the field of astronomy, mathematics, architecture and town planning, metallurgy as well as in the fields of medicine and surgery. Even during the colonial era, particularly through the work of distinguished scientists like C.V. Raman, J.C. Bose, M.N. Saha, S.N. Bose and many others, India's science flourished considerably - no doubt mainly due to the effort of these individuals. Scientific academies and even research institutes were established for the pursuit of basic science. In order to provide a data base for natural resources in India, the British established organizations like Botanical, Zoological, and Geological Surveys of India which provide excellent base for data collection and storage -- the essentials of an information system for science and technology. What did not happen in a major way during the colonial period was the capacity building for the utilization of scientific knowledge through well drawn out programmes of applied science, the

occurrence of which would have brought benefits to the society. As a developing country, India could not reap the fruits of scientific knowledge for its economic development, India missed the industrial revolution which had made a tremendous difference to the western societies.

Soon after independence in 1947, under the leadership of its first Prime Minister, Jawaharlal Nehru, the process of capacity building for science was started. Apart from the purely material and economic benefits of science and technology for the people, science was seen as a positive agent for social transformation. Recalling in 1962 the origins of his deep interest in science, Nehru wrote: ``*In later years ... I arrived again at science, when I realised that science was of the very texture of life ...Politics led me to economics, and this led me inevitably to science and the scientific approach to all our problems and to life itself. It is science alone that could solve these problems of hunger and poverty"* (Nehru quoted in Jaggi, 1984, p. 190).

Again in the Science Policy Resolution of 1958, drafted by Nehru and adopted by Parliament, independent India's first Prime Minister characterised the contribution of science thus: ``*Science ...has not only radically altered man's material environment, but what is of still deeper significance, it has provided new tools of thought and has extended man's mental horizon. It has thus influenced even the basic values of life, and has given to civilisation a new vitality and a new dynamism"* (Nehru quoted in Jaggi, 1984, p. 191).

NEW FRONTIERS

A renaissance was witnessed in the first half of the 20th century. The Science & Technology infrastructure has grown up from about Rs. 10 million at the time of independence in 1947 to Rs. 30 billion. Significant achievements have been made in the areas of nuclear and space science, electronics and defence. The government is committed to making Science & Technology an integral part of the socio-economic development of the country.

India has the third largest scientific and technical manpower in the world; Nearly 200 universities award 4,000 doctorates and 35,000 post-graduate degrees and the Council of Scientific and Industrial Research runs 40 research laboratories which have made some significant achievements.

In the field of missile launch technology, India is among the five top nations of the world.

Science and technology, however, is used as an effective instrument of growth and change. It is being brought into the mainstream of economic planning in the sectors of agriculture, industry and services. The country's resources are used to derive the maximum output for the benefit of society and improvement in the quality of life. About 85 per cent of the funds for Science & Technology come directly or indirectly from the Government. The Science & Technology infrastructure in the country accounts for more than one per cent of the GNP. Science & Technology in India is entering a new frontier.

Atomic Energy

The prime objective of India's nuclear energy programme is the development and use of nuclear energy for peaceful purposes such as power generation, applications in agriculture, medicine, industry, research and other areas.

India is today recognised as one of the countries most advanced in nuclear technology including production of source materials. The country is self-reliant and has mastered the expertise covering the complete nuclear cycle - from exploration and mining to power generation and waste management. Accelerators and research and power reactors are now designed and built indigenously. The sophisticated variable energy cyclotron at Calcutta and a medium energy heavy ion accelerator 'pelletron' set up recently at Mumbai are national research facilities in the frontier areas of science.

As part of its program of peaceful uses of atomic energy, India has also embarked on a program of nuclear power generation. Currently eight nuclear stations are producing 8 billion kilowatt of electricity. Four more nuclear power stations are planned. The new nuclear reactors are designed in India. The peaceful nuclear program also includes producing radioisotopes for use in agriculture, medicine, industry and research.

The Indian Department of Atomic Energy founded the laboratory, recently rededicated as Raja Ramanna Centre for Advanced Technology (RRCAT) which was earlier called the Centre for Advanced Technology, as India's entry in laser and accelerator physics in 1979. Now, the lab's facilities are internationally competitive, including a newly upgraded synchrotron light source called Indus-II, and its products are benefiting India's society. And what could pass as a quiet, small town near Indore, is a critical element in a science-and-technology revolution that is transforming this massive country, home to more than a billion people.

Space

The Indian Space Research Organization (ISRO), under the Department of Space (DOS), is responsible for research, development and operationalisation of space systems in the areas of satellite communications, remote sensing for resource survey, environmental monitoring, meteorological services etc. DOS is also the nodal agency for the Physical Research Laboratory which conducts research in the areas of space science, and the National Remote Sensing Agency which deploys modern remote sensing techniques for natural resource surveys and provides operational services to user agencies. India is the only third world country to develop its own remote sensing satellite.

India joined a select group of six nations on October 15, 1994, when the Polar Satellite Launch Vehicle (PSLV) successfully accomplished its mission of placing the 800-Kg remote sensing satellite, IRS-P2, in the intended orbit. Earlier in May, the fourth developmental flight of the Augmented Satellite Launch Vehicle (ASLV) achieved its mission by placing the 113 Kg SROSS-C2 scientific satellite in a near-earth orbit. India is well on its way to developing a Geosynchronous Satellite Launch Vehicle (GSLV) capable of putting 2000 Kg satellites into space. The Indian Space Research Organization (ISRO) is currently trying to develop an indigenous cryogenic engine GSLV. A GSLV model has already been tested in wind tunnel.

The INSAT series of satellite launched earlier are performing well and provide vital services for telecommunications, television, meteorology, disaster warning and distress detection. The latest INSAT series will include new features like Ku-band transponders and mobile satellite services transponders. The remote-sensing satellites, launched in 1988 and 1991, have already become the mainstay of the natural resource management system of the country. The projected launch of advanced remote sensing satellite will not only enhances the scope of their application, but will also offer commercial service to other countries.

The Indian achievement in the application of space-based remote sensing technology has led a US company to enter into an agreement for marketing the data from Indian satellites globally.

India's progress in space technology has attracted worldwide attention and demand, with leasing agreements for marketing of IRS data and supply of space hardware and services. India also believes in cooperation in space with agencies all over the world. A high-level UN team selected India for setting up a UN Center for Space Science and Technology Education. India is on the threshold of achieving self-reliance in the launch capability

The emphasis on indigenisation of research and building infrastructure has permitted India to build monumental research facilities on par with those found anywhere in the world.

High technology facilities like the Giant Meterwave Radio Telescope, the INDUS 2 synchrotron facilities are some of the most recent examples of this. These capabilities are most conspicuous in the fields of space sciences and nuclear power.

Future plans, such as the projects of pure scientific pursuit like ASTROSAT and more applied fields like fast breeder reactors optimised for Indian conditions are examples of how this investment in scientific research and development has infused a new sense of confidence amongst Indians.

Electronics

The Department of Electronics plays the promotional role for the development and use of electronics for socio-economic development. Many initiatives have been taken for a balanced growth of the electronics industry. The basic thrust has been towards a general rationalization of the licensing policy with an emphasis on promotion rather than regulation, besides achieving economy of scale with up to date technology. A multi-pronged approach has been evolved for result-oriented R&D with special emphasis on micro- electronics, telematics, and high performance computing and software development.

Application of electronics in areas such as agriculture, health and service sectors has also been receiving special attention. For upgrading the quality of indigenously manufactured products, a series of test and development centers and regional laboratories have been set up. These centers for electronic design and technology help small and medium electronics units. A number of R&D projects have been initiated to meet the growing requirements of the industry.

Oceanography

India has a coastline of more than 7,600km and 1,250 islands, with its Exclusive Economic Zone covering over 2 million sq. km and continental shelf extending up to 350 nautical miles. The Department of Ocean Development was established in 1981 to ensure optimum utilization of living resources, exploitation of non-living resources such as hydrocarbons and minerals, and to harness ocean energy. Two research vessels, ORV Sagar Kanya and FROV Sagar Sampada, are assessing and evaluating the resource potential.

Survey and exploration efforts have been directed to assess seabed topography, and concentration and quality of mineral nodules. In August 1987, India was allotted a mine site of 150,000 sq. km in the central Indian Ocean for further exploration and development of resources. India is the only developing country to have qualified for Pioneer Status by the UN Conference on the Law of the Sea in 1982, and it is the first country in the world to have secured registration of a mine site.

India has sent 13 scientific research expeditions to Antarctica since 1981, and has established a permanently manned base, Dakshin Gangotri. A second permanent station, an entirely indigenous effort, was completed by the eighth expedition. The objective is to study the ozone layer and other important constituents, optical aurora, geomagnetic pulsation and related phenomena. By virtue of its scientific research activities, India acquired Consultative Membership of the Antarctic Treaty in 1983 and acceded to the Convention on the Conservation of Antarctic Marine Living Resources in July 1985. India is also a member of the Scientific Committee on Antarctic Research, and has played a significant role in adopting a Minerals Regime for Antarctica in June 1988. A National Institute of Ocean Technology was set up for the development of ocean -related technologies. It is also responsible for harnessing resources of the coastal belts and islands.

Biotechnology

India has been the forerunner among the developing countries in promoting multi-disciplinary activities in this area, recognizing the practically unlimited possibility of their applications in increasing agricultural and industrial production, and in improving human and animal life. The nucleus of research in this area is the National Biotechnology Board, constituted in 1982. A Department of Biotechnology was created in 1986.

Recently, the Biotechnology Consortium India Lt. was set up. It will play the role of a catalyst in bridging the gap between Research and Development, Industrial and Financial Institutions. Some of the new initiatives taken include developing techniques for gene mapping, conservation of biodiversity and bioindicators research, special biotechnology programs for the benefit of the scheduled castes and scheduled tribes and activities in the area of plantation crops.

The areas, which have been receiving attention, are cattle herd improvement through embryo transfer technology, in vitro propagation of disease resistant

plant varieties for obtaining higher yields, and development of vaccines for various diseases.

Council of Scientific and Industrial Research (CSIR)

CSIR was established in 1942, and is today the premier institution for scientific and industrial research. It has a network of 40 laboratories, two cooperative industrial research institutions and more than 100 extension and field centers. The Council's research programs are directed towards effective utilization of the country's natural resources and development of new processes and products for economic progress. It is now playing a leading role in the fulfillment of the technology missions evolved by the Government.

INDIAN SCIENCE BUDGET 2006-07

The budget allocation for various science and research related activities has increased by 17% for the financial year 2006-07 to £2.3 billion.

Sectors set to gain from the budget include **biotechnology, nanotechnology and pharmaceutical research.**

Funding of biotechnology research has increased by 25% over the previous year. Status of an autonomous National Institute has been accorded to Rajiv Gandhi Centre for Biotechnology, Kerala to boost more research work including training more young scientists. The budget includes £22.5 million for a national nanotechnology research programme.

In continuation with the efforts by Indian government to create '**Institutions of Excellence**', three more universities (Universities of Calcutta, Mumbai and Madras) have been allotted a special research grant of £6 million each to be given at the conclusion of the year. All these universities have entered their 150th year. Last year Indian Institute of Science had got a grant of £12.5 million. Punjab Agricultural University, Ludhiana has received a grant of £12.5 million in acknowledgement of its pioneering contribution to the green revolution. Its research on high yielding crop varieties helped boost food production in 1960s.

National Agricultural Innovation Project for research at frontiers of agricultural science will be launched in July 2006.

Funding has been provided to **National S&T Entrepreneurship Board** to set-up Technology Business Incubators, enabling concessions to be provided to incubate entrepreneurs. These incubatees could be universities, R&D institutes and engineering colleges.

The allocations to various S&T departments/ ministries are as follows:

Department	2005-06 (£ million)	2006-07 (£ million)	% increase
Space	334	451	26
Science & Technology	181	218	17
Atomic Energy	338.5	396	14.5
Ocean Development	38	59.5	36
Medical education, training and research (Health)	164	180	9
Scientific & Industrial Research	188	219	14
Biotechnology	50	67	25
Defence research	350	376	7
Agricultural research	237	270	12
Ministry of non conventional energy resources	44.5	75.5	41

AREAS OF CONCERN

This is not the place for a critical examination of the achievements and problems of science and technology in India. But it is worth noting some major weaknesses which are relevant to our discussion. The weakening over time of the drive for self-reliance has resulted in a gradual downgrading of research and a dissipation of enthusiasm, especially in technology. Another factor retarding the growth of science has been the sheer mass of illiteracy in our society; present trends virtually guarantee that India will begin the twenty-first century with half the world's population of illiterates. The inadequacies of the education system include its weak emphasis on creativity and originality, its failure to promote a critical spirit, and its overemphasis on scholasticism and bookish knowledge to the detriment of purposeful experimentation. Obscurantism, superstition and prejudice mar the functioning of scientific agencies. While the current state of science and technology in the country provides us a base for further progress, the structure is still quite fragile. To make matters worse at this juncture, the overall funding for research and universities is being cut savagely.

In most of the premier research institutes of India and elsewhere, one of the major complaints relates to the depletion of good students' influx for higher studies in science subjects. One of the main reasons for this trend has been the job market; nowadays everyone wants applications of basic science subjects or

degrees in applied sciences. In this scenario, it is becoming difficult for science teachers in schools to lure their pupils to study a science subject as major subject. The craze to study medicine, engineering, business management, or information technology reduces the chances of good students entering the science stream of education. In this regard there have been various attempts to emphasise importance of science education. Conferences such as Indian Science Congress, National Science Day and National Symposia in various science disciplines, winter or summer schools, and efforts by individual scientists/groups of scientists to organise seminars, lectures, workshops, demonstrations, etc. have been the means of arousing interest in science.

In this regard, the National Talent Search Examinations (N.T.S.E) and the International Science Olympiads serve as a medium for young children to get interested in science. The International Science Olympiads are efforts in this direction and are competitions in which students from secondary schools take part while working on theoretical and experimental tasks from different fields of science. They also serve the purpose of forming personal relationships between budding natural scientists from different countries. In India, the Homi Bhabha Centre for Science Education (HBCSE) is the nodal agency for implementing the Olympiad program in mathematics, physics, chemistry, biology and astronomy. Historically, the science Olympiads started first with International Mathematics Olympiad (IMO) followed by Physics, Chemistry, and more recently by Biology. The newest subject in which the science Olympiad is conducted is Astronomy. The first International Mathematics Olympiad was held in Romania in 1959. India, however, started participating in this event fairly late (1989).

The participants of International Science Olympiads in Mathematics, Physics, Chemistry, and Biology automatically qualify for the well-known Kishore Vaigyanik Protsahan Yojana (KVPY) Fellowship of DST, provided they continue to study science. The Physics and Chemistry Olympiads' participants are offered direct admission to Bhabha Atomic Research Centre training school provided they pursue under/postgraduate careers in science. **However, past statistics show that many medalists actually chose professional courses after their school education, although most of them maintain a strong interest in pure sciences and have a desire to turn to them sometime after their basic professional degree.**

Table 1. International Science Olympiad results for Indian teams in 2004

Subject	Medal tally	Rank*	No. of participating countries
Mathematics (6 participants)	4 Silver 2 Bronze	14	85
Physics (5 participants)	1 Gold 2 Silver 2 Bronze	11	71
Chemistry (4 participants)	1 Gold 1 Silver 2 Bronze	11	60
Biology (4 participants)	3 Silver 1 Bronze	10	40
Astronomy (5 participants)	4 Gold 1 Bronze	1	75

*The ranking is based on aggregate team score; all national ranks are unofficial as the Olympiads are individual events.

DECLINE

The over emphasis on the professional courses has resulted in a serious set back to interest in basic sciences.

India has a major educational problem as it is neither able to provide education for all nor is it able to provide quality education for the few, says Roddam Narasimha of the Jawaharalal Nehru Centre for Advanced Scientific Research in Bangalore. "We are neither able to provide equity of education nor excellence in education." Most distressing was that the quality of students appearing for scientific programmes was well below the standards. This was especially true with regard to pure sciences where the quality of students was "distressingly low" and the number of students appearing for the programmes is very few, Prof. Narasimha said.

In the recent Common Entrance Test, he said five per cent of the students who took the test scored zero in Physics and 50 per cent of them scored less than five out of 60 marks.

Prof. Narasimha said that in terms of scientific research also India was well behind some other countries. Chinese and South Korean research works were also more often cited by other researchers than those by Indians.

The stagnation of the standard of education in pure sciences was partly because of the growth in information technology and partly because the stream was not financially lucrative. "Students with a basic engineering degree or some body working at a call centre can earn much more than a Ph.D. student," he said.

What is of immediate concern is the status of education and research in Indian universities. They are riddled with mediocrity and excessive bureaucratic stranglehold. Unwarranted political interference and endemic corruption in the system are other serious problems. Another glaring lapse has been the large number of faculty positions that have been vacant in its universities for many years. Although there are no official figures for the number of vacancies in science faculties, Arun Nigavekar, Chairman of the University Grants Commission stated recently that across all disciplines, an average of 25 per cent of faculty positions in India are lying vacant.

Today, a student with the ability and desire to pursue a career in research has to assume that if he pursues PhD in a good institution, he will have no job security till the age of 28. Moreover, with salaries of school teachers in richer schools exceeding those of very senior research scientists, the salary structure designed in the pre-liberalisation days need to be seriously revised. There is also a lack of appreciation of research as a career amongst the young.

Take a look at the following statements:

- Between 1980 to 2000, the number of scientific papers from India, indexed in the Science Citation Index, fell from 14,987 to 12,127. China's grew from 924 to 22,061.
- A recent much accepted top 500 ranking of world universities features only three Indian universities - one in the 251 to 300 rank slot and the other two in the 451 to 500 slot.
- Among the 149 top countries in science and technology, India ranks 119 when it comes to number of citations per scientific paper.

While a debate has raged in scientific circles over the past few years on India's scientific prowess - vis-a-vis the rest of the world, there is now an almost universal acceptance that a rot has set in. In terms of interest in science, investment, institutes, number of scientists, scientific papers and their quality, Indian science is on the decline, say experts.

"There is very little doubt now that science in India has not kept pace with its competition. While countries like China and Brazil are galloping ahead we are far behind," says the Director of the Indian Institute of Science, Bangalore, Prof Goverdhan Mehta.

China forges ahead, India lags behind

"The fact, however bitter, is that India's contribution to science has come down enormously. We are not comparing ourselves to the US or Japan anymore, but to China and South Korea," says eminent scientist Prof C N R Rao. Areas like physics, chemistry are seeing hardly two hundred papers emerging from India per annum, he says.

"Take my area of chemistry, China used to contribute 3 per cent of chemistry papers a few years ago. Today, it contributes 10 per cent. India used to contribute 8-10 per cent, but today it contributes only 2.5 per cent," Prof Rao points out.

"A grossly sub-critical effort is responsible for our under achievement as seen in our share of global research and development output, which is only 1.58 per cent," says scientist-in-charge of the Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Dr Gangan Prathap. While funding for research has increased marginally in recent times, the decline in the university system – with research shifting to specialised agencies, and the lack of support systems to match the changing face of science, are obvious reasons for decline, says Prof Mehta.

Incidentally, the `academic ranking of world universities 2003 is among the most recent indicators of the health of Indian research.

Academic ranking of top 500 world universities				
Country	University in top 500	Highest	Rank	Asia/Pacific Rank
USA	161	Harvard	1	NA
UK	42	Oxford	9	Na
Japan	36	Tokyo	19	1
China	18	Natnl Taiwan Univ	152-200	18-22
Australia	12	Australian Natnl Univ	50	3
India	3	IISc	251-300	27-36

IISc is the only one in the list

The Indian Institute of Science figures as India's highest representative in the ranking at 251 to 300, while IIT, Delhi and Kharagpur figure between 451 to 500. *"There should be at least 100 world class universities in India itself,"* says Prof C N R Rao.

The root cause for all this to happen is to do with our education and social perception of it. I do not agree that the quality of education has come down but I do agree that the direction of education has changed. Earlier, education was a hallowed profession for gaining knowledge. Today, it is an investment for future prosperous living. The craze of the students for joining professional courses should be seen in this light. It does not mean that most of them have a great love for these courses but they perceive them to be a passport for lucrative jobs. Money seems to be calling the shots.

Changing icons

Most of us in today's world feel that the society is becoming more materialistic and values are being pushed into the background. There is nothing unusual about it. Each era of human existence throws up a role model and the whole society tries to emulate this model during that time. To make the idea clearer, let us consider the Vedic times. Who was the role model for the society? It was a wise man or a *Rishi*. He was an icon. Even the kings and the princes came down to his hermitage, sat at his feet to get knowledge. He was held in highest esteem. Even a mighty king like Dasharatha could not decline the request made by the sage Vishwamithra, who asked the king to send his dearest sons to the forest with him. The icon of a *rishi* was so strong that a warrior like Kaushika did severe penance and became Sage Vishwamithra. It was the time when wisdom and knowledge were respected. Let us proceed in history and take a look into the period of Mahabharata. By then the role models had changed. Who were the heroes of Mahabharata? The heroes of this era are undoubtedly the mighty warriors such as Bhishma, Drona, Karna, Arjuna etc. The Brahmin Dronacharya was teaching the princes warfare instead of philosophy and scriptures. Even the God incarnate, Parashurama was running a specialised institution of warfare. It was the time when every one wanted to be a great warrior. That is why a tribal boy like Ekalavya wanted to be like Arjuna and not Vedavyasa. The icon had shifted from 'wisdom' to 'bravery'.

Why go so back in history? Let us consider the pre independence period. Before the independence of India, our role models were Gandhi, Patel, Nehru, Azad, Bhagat Singh, Rajguru and other freedom fighters. It was the dream of every youngster to be a freedom fighter and every school in the country was a training ground for freedom fighting. All school campuses reverberated with the chanting sounds of *vande mataram*. The icon was 'patriotism'. After independence, unfortunately, the icon of the society has been a rich man or 'money'. Every one in the society is aspiring to become rich. They want to be as much rich as possible and as quickly as possible and at any cost. Getting rich at

any cost has been the motto. Invariably this process of getting rich instantly is at the cost of values.

It is true that money can provide the facilities for bodily comforts and can also provide for necessities in future. The irony of life is that you will understand the futility of anything only when you possess it. Let us consider an example to clarify this concept. Who gave the call "*Ahimsa paramo dharma*"? Lord Krishna, Lord Rama, all the Teerthankara's and Buddha gave this call for non – violence. Remember, they were all kshatriyas – warriors. They were all born with weapons and they were trained to play with them and get drenched in blood. They have the right to plead for non – violence. When did King Askoka craved for non – violence? Only after he destroyed Kalinga, he sat in the ruins and longed for non – violence. Only a person who goes through the thick of violence realises the futility of violence. This is true with respect to all the possessions including money. To satisfy the physiological and security needs, man runs behind money assuming that it would give him happiness. Only when you acquire money, you would realise that it is futile. Money can buy you a bungalow but cannot make it a home; it can give you the best car but cannot make you comfortable; it can give you the softest bed but cannot guarantee sleep. Money makes one believe that happiness can be found in materials outside us. Only when one acquires more money, he realises that the happiness that he was looking for was inside him and not in the material comforts outside.

The situation would not remain like this forever. No icon in the past has remained for a long time. If you care to see the writing on the wall, the icon of 'money' is slowly giving way for something else. These icons like everything else in life are cyclical. There are enough indications that our country would awaken once again to those eternal values for which this land has stood for many centuries.

Does it mean that we have to wait till this natural process continues and then people would realise the worth of basic sciences and turn towards it? No. Efforts should be multiplied to arrest this lop sided growth and to educate our children about the charm of sciences. We should catch the imagination of a child today to produce a Nobel laureate of tomorrow. We should make teaching of science in the schools truly exciting and enjoyable. That is a worthwhile investment for the secure future of this glorious country.

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APPENDIX

Dr. A.P.J. ABDUL KALAM
President of India

ADDRESS AT THE INAUGURATION OF THE SEMINAR ON 'ATTRACTING YOUNG PEOPLE TO CAREERS IN SCIENCE' Indian Physics Association IIT, New Delhi

31-03-2005 : NEW DELHI

Challenge to Science: Attracting the Youth

I am indeed delighted to inaugurate the seminar on "Attracting Young people to Careers in Science" organized by the Indian Physics Association on the occasion of the International Year of Physics - 2005. I greet the organizers, scientists, engineers, distinguished guests and the other participants in the seminar. Keeping in mind the main theme of the seminar, I would like to discuss with you about: "**Challenge to science: Attracting the youth**".

Great things - how do we achieve in science?

I would like to narrate an incident which happened during a programme for honouring Prof. Norman E Borlaug with Dr. M S Swaminathan award, at Vigyan Bhavan, New Delhi on the 15th of March 2005. Prof. Norman E Borlaug, at the age of 91 was in the midst of all the praise showered on him from everybody. First, he talked about India's advancement in the agricultural science and agricultural production and the present status of agricultural science in India. He turned to the dais; he talked about Dr. M S Swaminathan and a political visionary late Shri C. Subramaniam who were the prime architects of First Green Revolution in India. He also recalled about Dr. V. Kurien who was the father of White Revolution in India. Then he turned to the audience and started identifying scientists such as Dr. Raja Ram, a wheat specialist, Dr S K Vasal, a maize specialist, Dr. B. R. Barwale, a seed specialist who was contributing in the agricultural advancement in India and abroad. Dr. Borlaug introduced them to the audience by asking them to stand and ensured that the audience cheered and greeted them with great enthusiasm. Here, I noticed a unique way of a 91 year old Nobel Laureate, who remembered and recognized all the key contributors to the agriculture mission irrespective of their

position. This lesson, I would like the Indian scientific community to observe and follow, while dealing with all young scientists.

Let me tell you about another incident. Recently, my friend Dr. Vasant Gowariker sent me an executive summary of The Fertilizer Encyclopedia prepared by him and his team. The comment by Dr. Norman E. Borlaug on this document is noteworthy. I quote: Asian farmers in particular must now judiciously increase their per hectare use of fertilizer, looking for greater efficiency in use and also in dealing with deficiencies of secondary and minor elements of the soil? Unquote. This is how he sets the targets and provides encouragement for pursuing science across the world.

Another unique personality whom I remember, when I talk about science is Prof. C.N.R. Rao. I have visited his laboratory. He is a pioneer and an example of leading from the front. His research started from structure of molecules and that opened newer frontiers in surface sciences and more recently in nano particles and nano materials. He is one of the highly decorated Indian scientists. He is a motivator par excellence and pursues science with passion. Among the many awards he has received for his contribution in science, I would like to particularly mention the prestigious 'Dan David Prize' given to him by Dan David Prize Foundation headquartered at Tel Aviv University for his contribution towards the future time dimension in the filed of material science. In addition, he is the first recipient of 'India Science Award' announced on 28 Feb 2005.

Another important scientist in the field of medicine, I would like recall is Dr. P. Venugopal, Director, All India Institute of Medical Sciences, New Delhi. In his laboratory, he pioneered stem cell research in the field of cardiology. One of the cardiac diseases, where conventional medical and surgical treatment were ineffective because of the affliction of the heart muscle, stem cells implantation into the diseased heart muscles had been applied in order to improve the function of heart muscle. This kind of application of this procedure is the latest and very few cases have been done in the world, the first time in India. This is expected to open new frontiers in the treatment of patients for regeneration of heart muscles, thereby giving new hope for the patients suffering end stage heart disease. The commitment of Dr. P. Venugopal for research ultimately results in saving hundreds of lives.

I have mentioned these names only to assure ourselves that the Indian science has great future.

Empowering the Young Scientists

I remember an incident with Prof. Vikram Sarabhai during the 1960’s. There were a few scientists and technologists, whom Dr. Sarabhai nurtured. I would like to share with you how he nurtured them. Whenever he comes to Trivandrum, I used to discuss with him the proposal for the development of Composite Products. At that time I was in the initial stages of my career as rocket engineer, with less than 2 years of experience in ISRO.

Similarly, there was Dr. SC Gupta, a specialist in guidance and Dr. Amba Rao a specialist in Aerospace structures. In spite of our being just introduced into the organisation with few years of experience, noticing our interest in development of certain materials and systems Dr. Sarabhai funded for the creation of laboratories. He created fibre composite laboratory based on my proposal, which later became Reinforced Plastic Centre. He created Gyro laboratory centered on the expertise of Dr. Gupta, which later became Guidance Laboratory and space structures laboratory centered around Dr. Amba Rao, which later become advanced dynamics group. These centres became the centres of excellence and incubated many advanced technology missions that fed critical inputs to space programme. Once the potential of the young scientist is understood, the heads of the organisation must invest on them boldly irrespective of the positions of the scientists and their age considerations. If this philosophy is pursued with sincerity the research would flourish and youth would be encouraged to embrace science.

Great Indian Scientists

In India, science and technology took a two-phase progress with the momentum created in 1930s, by the great scientists of international repute. They gave the country the confidence. We may remember the pioneering contributions to science made by Chandrasekhar Subramaniam for his Chandrasekhar limit and black hole, Sir CV Raman for his discovery of the "Raman effect", Srinivasa Ramanujan for his contributions towards number theory, JC Bose in the area of microwaves, Meghnad Saha for "Thermo-Ionization Equation". This phase, I consider the glorious phase of Indian science. This scientific foundation laid by them always triggered the later generations also. The unique similarities of all these scientists are the one that they had dedicated their entire life for the cause of scientific research and the spirit of inquiry for the fields that they have chosen amidst all the hurdles and problems in their life as well as their career. Science always gives life time missions to the scientists, and then only success comes. They have not deviated towards the other worldly prospects or towards their own career advancements. This quality helped them to make singular contributions for the benefit of science and the world. It is a question of dedication, commitment and understanding and also the environment for research in science, which gives birth to the scientists for the nation. They inspired many later generation scientists including GN Ramachandran, the originator of triple-helix.

Let me now discuss on how India has attracted large number of scientist and engineers towards drawing the road map for achieving self-reliance in critical technologies in defence, space and atomic energy.

The post-independence phase of Indian science and technology

All of you know, in history, any country reposes its confidence initially among a few stout and earnest knowledge giants. Particularly I took interest to study the lives of three scientists, as I was interested in their scientific technological leadership qualities that focused the relationship of S&T and development of the nation. In the history of India, there may be many but I was very close to these three great personalities for one reason or the other. They are founders of three great institutions. I worked in two of the institutions directly and one in partnership. Dr DS Kothari, a Professor in Delhi University was an outstanding Physicist with special interest in Astrophysics. He is well known for ionization of matter by pressure in cold compact objects like planets. This theory is complementary to epoch making theory of thermal ionization of his guru Dr Meghnad Saha. Dr DS Kothari set a scientific tradition in Indian defence tasks when he became Scientific Adviser to Defence Minister in 1948. The first thing he did was to establish the Defence Science Centre to do research in electronic material, nuclear medicine and ballistic science. He is considered as the architect of defence science in India. His race continued and followed up with a momentum working and contributing in the areas of strategic systems, electronic warfare systems, armaments and life sciences.

Now, let me discuss about Homi Jehangir Bhabha. He did research in theoretical physics in Cambridge University. During 1930-1939, Homi Bhabha carried out research relating to cosmic radiation. In 1939, he joined Sir CV Raman in IISc Bangalore. Later, he was asked to start Tata Institute of Fundamental Research with focus on nuclear science and mathematical science. He subsequently established Indian Atomic Energy Commission in 1948. Multi centers were born with his vision in nuclear science to nuclear technology, nuclear power, nuclear devices and nuclear medicine. These science institutions established multi technological centers, but basic science was the vital component.

The youngest of the three was Prof Vikram Sarabhai and he worked with Sri CV Raman in experimental cosmic ray. Prof Sarabhai established Physical Research Laboratory in Ahmedabad with Space research as focus. In later years he became the Director of Space S&T Centre. The SSTC (1963) started with the launching of sounding rockets for space atmospheric research. His vision transformed Indian Space Research Organisation (ISRO) into multiple space technology centers. These centers are responsible for development and leading to launch of PSLV in the sun synchronous orbit. And we have also witnessed a launching of GSLV in the geo-synchronous orbit with communication satellite.

I have talked about the three personalities, Dr. D.S. Kothari, Dr. Homi Baba and Dr. Vikram Sarabhai. All the three of them were physicists, who went on to build huge S&T institutions that became the home of more than 20,000 young scientists and engineers and also the kindler of their innovativeness. I believe strongly that if the three scientists had gone on to concentrate only on science, at least one of them would have got the Nobel Prize, but India would not have had the advantage of having the atomic energy, space and defence research establishments in the country with this magnitude. We must take the message and the mission of successful scientists such as Raman, Chandrasekar,

Kothari, Homi Bhaba and Sarabhai to the youth so that they will understand the various ways by which one could contribute to the growth of the nation, if they take science as a career. This would surely attract many young people towards science.

Importance of science in the present context

As soon as we became independent, the country was infested with problems to bring in urgently needed technologies for steel, civil structures, hydro dams and thermal power stations. Our concentration was directed towards solving burning problems like feeding the population, providing water, shelter and health care. The political visionaries at that time, in spite of our having a very weak economy, decided to wisely setup what ultimately has become the science base of our country such as Atomic Energy, Space, CSIR, DRDO, DST etc., The country also setup the powerful educational base including the creation of IITs and many universities, which had a unique blend of science and technology.

Today the country has become one of the strongest in the world in terms of scientific manpower in capability and maturity. Our economy has also become strong. Hence, we are in a position not only to understand the technologies that we may have to borrow, but also to create our own technologies with extensive scientific inputs of indigenous origin. This, in fact, would do a value addition. In many areas such as Pharma, we are delivering to the world, products which are backed by large amount of R&D. Basically we have come a long way since our independence, from mere buyers of technology to those of who have made science and technology as an important contributor for national development and societal transformation. In a world where the powers are determined by their share of the world's knowledge, reflected by patents, papers and so on, the WTO starts to play a crucial role in the economic development. It is important for India to put all her acts together to become a continuous innovator and creator of science and technology intensive products. The science that we do today must have the innovativeness and the foresight and the vision for it to be the centre of the technology that we develop tomorrow for the competitive world.

Scientific challenges for the future

In the last three decades, we have witnessed an unstinted growth in miniaturization of IT products in the world. Central to this is the silicon technology. The feature size of the transistors has been decreasing relentlessly. It is predicted that the miniaturization using silicon – micro electronics will find its plateau and its limit will be reached within the next decade. The world is on the lookout for an alternative to silicon. The transformation from microelectronics to the nano science and nano technology is knocking at our doors. The endless alternatives include molecular transistors, quantum computing, nano electronics and so on. India has the good science base needed for being a pioneer in making this breakthrough a reality.

In addition to the above, the challenges facing Indian scientists in the coming decades will be the development of anti vaccine for HIV/AIDS and development of seeds for agricultural products which requires minimum water and can provide high yield per hectare to compensate the reduced availability of land. Apart from this, there is a need to work on thorium based nuclear power plants, integrated mission for stem cell research, launching of hypersonic reusable launch vehicle and take discoveries and innovations to provide better quality of life to the differently challenged people. These are some of the challenges facing the scientific community in the coming decades.

Conclusion

I would like to make the following suggestions for attracting the young people to careers in Science.

1. It is essential to have an assured career in science for a certain number of high quality committed scientists with aptitude towards research. There should be a minimum annual intake of about 300 M.Sc and 100 Ph.D. scientists with proper emoluments and assured career growth in the organisations such as ISRO, DRDO, Atomic Energy, CSIR, DST and the Universities. The private and government funded universities must be encouraged to appoint M.Sc and Ph.D who have been selected through a nationally coordinated competitive selection process. This will be a great motivator for the science students and also their parents for pursuing advanced courses in science. This is the first and foremost need for attracting young people to career in science – an assurance to the youth and the parents that the future is secure, once they take science as a career.

2. The experienced scientists and policy makers of the organisations must recognize the talents available in the organisation irrespective of the position and empower the young scientists to create state-of-the art laboratories once they have concrete thoughts and vision. Prof Vikram Sarabhai in the initial stages of ISRO brought in a culture of management which encouraged and satisfied the vision of the young scientists which collectively succeeded in making the mission of the organisation a reality.

3. Universities and Research and Development institutions must encourage and facilitate the young scientists to write quality research papers in frontier areas and in prestigious journals. They should also facilitate the youth to present the papers in national and international seminars and symposiums which will enable them to assess their standard against international benchmarks. Encouraging youth to be lead authors while publishing the joint research would be a very good gesture that the youngsters would cherish for many years.

4. Based on my experience during my interaction with the 600,000 students, I realize that they are looking for role models, whom they would like to follow after their 10+2 career. Approximately 7 million students appear for plus two examinations every year. Out of which 3 million students are from the science stream. To attract this youth towards a career in science, we need many novel ideas. The youth must be made to understand the beauty of doing science, the pleasure of doing science and the

ultimate bliss when the results of science make you understand the nature, master it, control it and finally make things that improve the quality of life of the human kind. Every one of us, scientists must pledge that we will at least spend sometime visiting the schools to ignite the young minds by recounting our own experiences.

My best wishes to the organizers of this conference for fruitful discussions and generation of ideas for attracting young people with passion and aptitude for a life of science and in science.

May God bless you.

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