Science Education and Attraction of Talent for Excellence in Research

Presidential Address

by

T. Ramasami
General President,
Indian Science Congress Association

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Secretary
Department of Science and Technology,
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96th
Session of the Indian Science Congress
North Eastern Hill University
Shillong Meghalaya

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Preamble

Hon'ble Prime Minister of India, His Excellency the Governor of Meghalaya, Hon'ble Minister of Science and Technology and Earth Sciences, Hon'ble Chief Minister of Meghalaya, Chancellor of the University, the Chairman of the Scientific Advisory Council to the Prime Minister, my Esteemed Colleagues on the dais, our Guests from Abroad, Distinguished Delegates, Guests, Representatives of the Media, Students, Distinguished Ladies and Gentlemen,

Let me add my own words of welcome to all of you to the 96th Session of the Indian Science Congress. This is a historical moment. We are meeting for the first time for the Indian Science Congress in the North Eastern Region. Many of you have weathered the weather and many challenges to join this session today. Let me begin this address with a sincere thanks to all of you for your participation.

Special Responsibility on Account of Dual Roles

I am charged with a dual responsibility on this occasion. In my capacity as the General President of the Indian Science Congress Association, I bear a responsibility to address some major issues concerning the Indian science community and promote an active dialogue among the

stakeholders. I am expected to draw the attention of the Government of India to the pressing needs of the country in the Science and Technology sector.

While doubling as a Secretary to the Government of India in the Department of Science and Technology, I bear also a responsibility to proactively develop and implement solutions to the pressing challenges of the Indian science community. Let me try and do my best for the dual roles expected of me.

Changing Roles of Science

Science, Technology and Innovations have emerged as main mantras of the modern world and knowledge economies. During the beginning of the last century, the driving factor in the pursuit of science was mainly personal passion. When, the pursuit of science was driven by personal passions of individuals, Indian scientists of the calibre and class of Sir C. V. Raman excelled and matched or outshone some of the very best scientists in the world. They are proud sons of India.

As the human population increased manifold and life styles changed in favor of high consumption, the challenges to the mankind have multiplies manifold in relation to those of our ancestors. There are far too many social problems awaiting innovative solutions flowing from the scientific community. Applications of *"solution science" for* solving many social problems have gained high importance. During the last quarter of the twentieth century, technology and innovations have gained the center stage of global Research & Development sector.

Investments into Research and Development have started assuming an important benchmark for calibrating the National preparedness for meeting

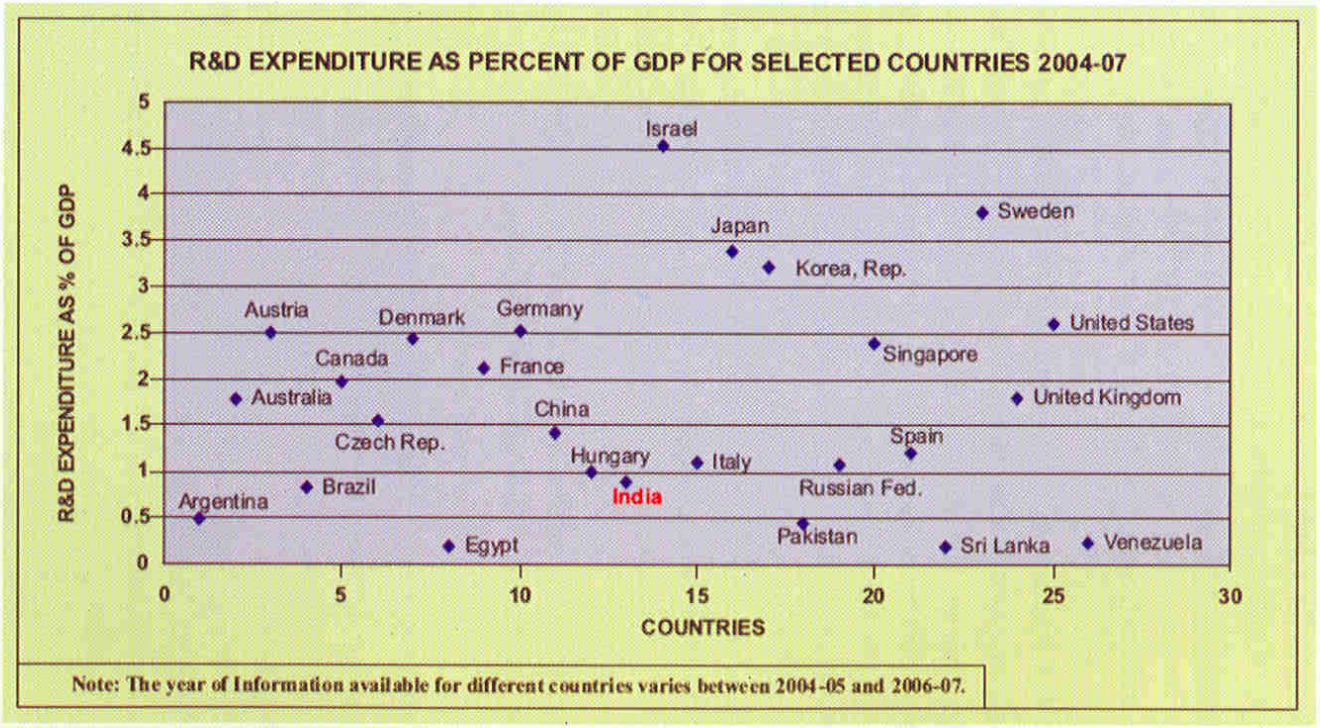

Figure 1: *Inter-comparison of India with International Investments into R&D as percentage of GDP with other countries (source: Research and Development Statistics at a Glance 2007-08, Department of Science & Technology, page 12)*

the emerging challenges of the global knowledge economies. Typically, investments of different nations into Research and Development as a percentage of Gross Domestic Product (GDP) are compared in *Figure 1*. Many Nations have started linking their Gross Expenditure on Research and Development with their planned economic growth.

Role of S&T Systems in the Growth of Gross Domestic Product

Most emerging economies are rapidly ramping up their Gross Expenditure on Research and Development. They are expanding their Research and Development base. Most developed economies invest about 2-5% of GDP in research and development. Our Pradhan Mantri Ji announced that the Government will invest about 2% of GDP into Research and Development. With our GDP growing at 7-9% per year since the last decade, gross investments into research & development are growing steeply. Such planned investments into Science and Technology should deliver some tangible results for the people of the Nation and promote favorable outcome. Significant outlays for research and development from the public funds should be justified by way of matching public goods. The percentage share of technology-led manufacturing in our GDP growth should become significant.

Right-Sizing the Research and Development Base of India

While we plan to optimize our Gross Expenditure on Research and Development, we need to review and right-size the Science and Technology machinery as well. A correlation of publications in Science Citation Indexed Journals with Gross Expenditure on Research and Development (GERD) has been made in *Figures 2a and 2b.*

a) Correlation of publications in SCI journals with Gross Expenditure of R&D and b) With Full Time Equivalent S&T professionals/ million populations

GERD Vs SCI papers correlations in World of Science

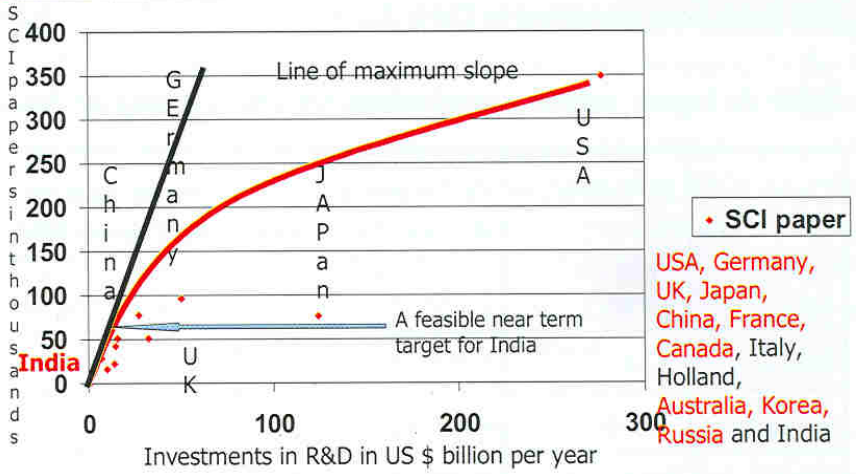

Figure 2(a)

Scientific productivity of nations in terms of R&D people/ million population

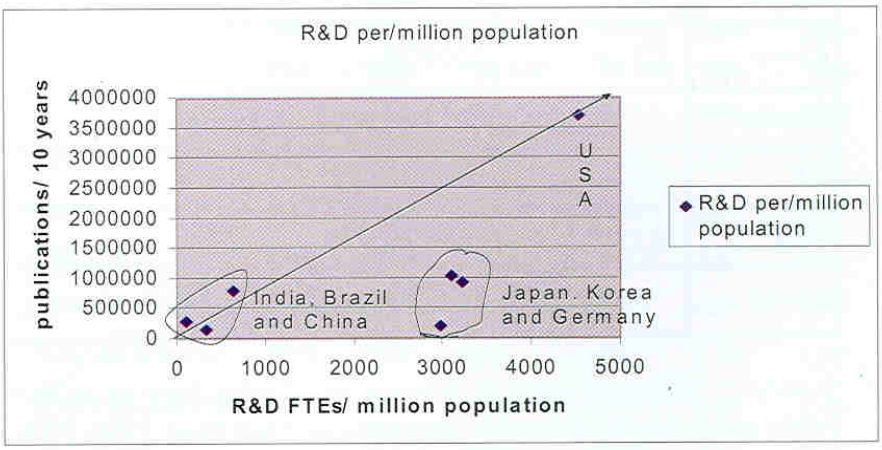

Figure 2(b)

There is a direct correlation between investments into R&D and outputs in the form of patents and PhD students trained in global R&D system. Input-output correlations for the S&T sector for a select group of countries have been presented in *Table 1*.

Table 1: Input- output correlations for select group of Nations

Country	*FTE/Million*	*SCI publications during 1996-2006*[a]	*Growth rate in publications 1996-06*[a]
Australia	*3446*	*314233*	*6.1*
Brazil	*324*	*172410*	*20*
Canada	*3487*	*499600*	*4.1*
China	*633*	*817737*	*20.7*
France	*3134*	*667908*	*2.9*
Germany	*3222*	*926552*	*3.5*
India	*110*	*297850*	*7.0*
Japan	*3085*	*1037476*	*2.1*
Korea	*2979*	*226958*	*5.4*
Russia	*3415*	*354168*	*-0.14*
UK	*2691*	*1039024*	*3.4*
USA	*4526*	*3699272*	*0.8*
World		*14570278*	*4.1*

Source: [a:] Status of India in Science and Technology as reflected in Publication output in Scopus International Data base, 1996-2006, BM Gupta, SM Dhawan, NISTADS, CSIR 2008.

Qualitatively correlations presented in Figures 2a and 2b as well Table 1 reveal that the return on dollar invested into Indian R&D system is relatively high. However, on absolute terms, Indian competitiveness as a Nation in the world of science is low. The relatively weaker competitiveness of India in S&T output indicators can be traced to the subcritically smaller size of the R&D base. The size of our S&T machinery will need to match the future requirements of a Nation as large as ours and an economy growing as fast of that of India. The S&T sector of the country is mismatched to our future needs, especially when the changing paradigm of the global knowledge economy links economic growth to technology and innovation led processes. Our R&D base may need to be at least trebled within the next five years.

Data on scientific publications from India for 10 year periods between 1996-2006 and 1998-2008 have been compared for various disciplines in *Table 2*.

Table 2: Comparisons of Indian publications in SCI Journals in different fields (From ISI Web of Knowledge data base)

Field	Papers 1998-2008	Papers 1996-2006	Citation 1998-2008	Citation 1996-2006	Citation/ paper 1998-2008	Citation/ paper 1996-2006
Agriculture	9437	9241	20400	16429	2.16	1.78
Biology	11925	11005	71655	59099	6.01	5.37
Chemistry	53501	48776	281481	231331	5.28	4.74
Clinical Medicine	20661	18350	99447	82883	4.81	4.47
Computer Science	3616	3374	7695	6352	2.13	1.88
Economics & Business	829	766	2059	1841	2.48	2.40
Engineering	21066	19374	55276	44686	2.62	2.31

Environment/Ecology	5704	5171	23632	18046	4.14	3.49
Geosciences	7490	7006	28640	24164	3.82	3.45
Immunology	1415	1251	9707	8634	**6.86**	**6.90**
Materials Science	17313	15411	66939	52520	3.87	3.41
Mathematics	**4267**	**4306**	**7143**	**6602**	**1.67**	**1.53**
Microbiology	3010	2747	19521	15987	6.49	5.82
Molecular Genetics	2994	2696	23048	19632	7.70	7.28
Multi-disciplinary	2116	1980	2748	2302	1.30	1.16
Neurosciences	2427	2364	12957	10432	5.34	4.41
Pharmacology	5280	4475	29570	20584	5.60	4.60
Physics	28374	27192	160387	144836	5.65	5.33
Plant and Animal Science	18049	17919	41589	35453	2.30	1.98
Psychiatry	612	558	3775	2925	6.10	5.24
Social Sciences	2146	2039	4380	3455	2.04	1.69
Space Sciences	2820	2730	18582	17276	6.59	6.33
	224855	208911	990631	825469	4.40	3.95

Data on S&T output indicators reveal a) 8% increase in the number of publications, 20% in citations and 11% in citations per paper and b) the essentiality of planned interventions for promotion of education and research in areas like mathematics, computer science and social sciences. A concerted effort to couple natural and social sciences is also called for.

Comparison of global data on S&T professionals, per million populations reveals a grossly mismatched size of our R&D base. With a ratio of FTE/million populations well below 150, India does not compare favorably with the corresponding other competing economies with ratios of 800-4500. The realization of our Vision 2020 calls for a planned

expansion of the National R&D base as well as the development of a new educational and research system. This would call for a) attraction of talent to study science and careers with research, b) review and revisit systems of science education, c) expansion of the R&D base through both policy interventions and programme initiatives, and d) a more active engagement of Public-Private Partnerships in Research and Development Sector. The Government has initiated several enabling and proactive measures during the last four years. Some of important 23 initiatives are listed in *Table 3.*

Table 3: Major proactive Steps taken by the Government of India for promotion of Research and Development during 2004- 08

No	Major proactive measure/ scheme/programme
1.	*Formation of Science and Engineering Research Board*
2.	*Protection and Utilization of Public Intellectual Property (IP) Bill*
3.	*Evolving National Biotechnology Strategy*
4.	*Formation of new Ministry of Earth sciences*
5.	*Modernization of Indian Metrological Department*
6.	*Launching of Innovation in Science Pursuit for Inspired Research (INSPIRE)*
7.	*Establishment of Indian Institutes of Science Education and Research and new Indian Institutes of Technology*
8.	*Enhancement of Junior and Senior Research fellowships and research Associate ships*
9.	*Formation of new Department of Health Research*
10.	*Launching of Welcome Fellowships*
11.	*Mounting of Nano mission*

12. *Establishment of Institutes for Nano Science and Technology, National Agro Biotechnology Institute, Translational Research Institute and proposals for setting up five other major research institutes*
13. *Institution of JC Bose Fellowships, Ramanujan Fellowships, Raja Ramanna and Ramalingaswamy fellowships*
14. *Performance Related Incentive systems (commencing with monthly honoraria for SSB award winners instituted by CSIR)*
15. *Scheme Small Business Innovative Research Initiative (SBIRI)*
16. *Building Stem Cell Research Infrastructure*
17. *New Biotechnology Initiatives in North Eastern Region*
18. *Special package for Science Education and Research in North Eastern Region*
19. *Establishment National Spatial Data Infrastructure*
20. *Science Express as a motivator for excitements of youth*
21. *Stepping International S&T cooperation at an annual growth rate of 20%*
22. *Promotion of University Research and Scientific Excellence (PURSE)*
23. *Enlargement of Drug & Pharma Research Programme including Grant-in-aid for R&D on neglected diseases.*

Some tangible improvements in S&T output indicators are registered as evidenced from growth trends in publications and patents from India as presented in Figure 3.

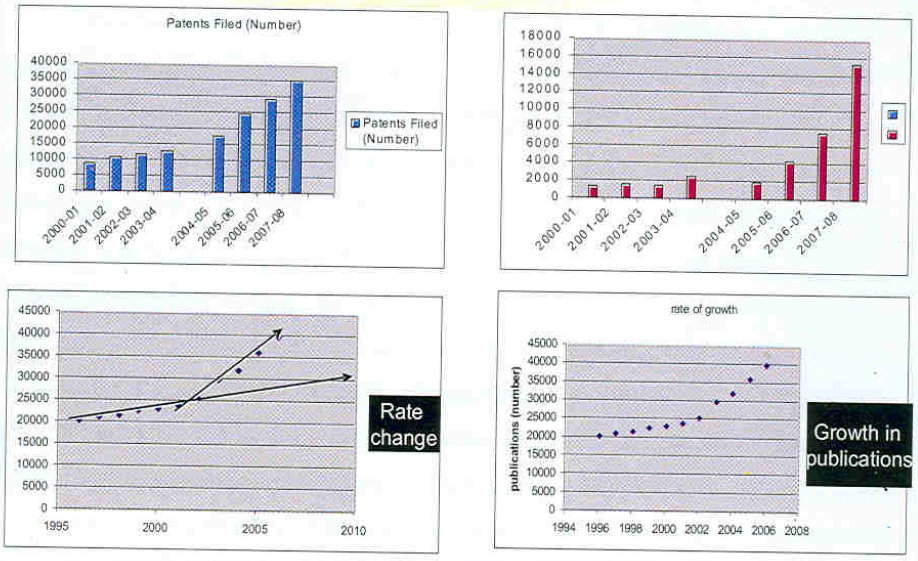

Figure 3: ***Growth trends in publications and patents from India***

In order to stimulate excellence in research, on a long term, a major initiative for management of supply chain of talent has been mounted.

Innovation in Science Pursuit for Inspired Research (INSPIRE)

Hon'ble Pradhan Mantri Ji launched on 13th December, 2008 a new Scheme, "Innovation in Science Pursuit for Inspired Research" called INSPIRE. It is a proactive initiative for attracting talent to study science through a long-term programme. The Ministry of Science and Technology is implementing the scheme through the Department of Science and Technology. Talented youth seeks satisfaction, emotional gratification and thrill of success in their endeavors. It may be necessary to build into INSPIRE such contents that provide psychic delight and thrill

of learning and excitement. Let us hope that the programme would deliver the desired and much expected results for the country. We have begun and let us hope that the best will come.

Science Education: To Meet the Challenges of the Future

Methodologies and systems designed for imparting education in science are undergoing sweeping changes in the world. Most developed countries are constantly reviewing their systems for imparting science education and reformat them to suit changing needs. Education of science was until recently built around the understanding of the ways of Nature and natural phenomena. The focus of science education has been in building of scholarship. In modern world, the definitions of science have enlarged and include also technology and innovations. Both technology and innovation are market linked and driven by considerations of economic benefits. In other words, science education in most thriving economies is more closely connected to real world issues and practical applications.

I have been interacting closely with both students and teachers from various schools recently. There seems to be a general feeling among the students as well as educators that there is disconnect between science education and the real world in our system. Students express lack of excitement in our science education. They seem to feel overburdened with heavy course contents and syllabus. Different approaches to "teaching science" for promotion of excellence in research may well be required in comparison to building scientific approaches to learning as a whole. A careful review of approaches to teaching science and mentoring for research may be beneficial.

Inadequate demand for admission into degree science courses is often being reported by our colleges. Similar trends are observed in other

countries as well. Scientific awareness and approaches to profession and applications of science in every walk of life would need one type of education system whereas science education for creating new knowledge and innovations would call for another. Our Academies are suggesting some pilot experiments in science education for promoting excellence in research. It may be a good proposition to establish a wider debate on the implementation of the proposals of our scientific academies for restructuring the systems in science education.

There are some apprehensions amongst students that the focus of science education is distanced from the ground realities of life. Inadequate practical experience in learning fundamental principles is considered a limitation by the youth. In many other parts of the world, education includes problem solving skills and expertise. Project based learning is a component of science education in schools. Higher levels of engagement of our industrial houses in imparting problem solving skills and attitude are necessary. While our education system trains our youth to answer questions, questioning answers is the most fundamental step to ensure excellence in research. In order to inculcate a questioning mindset and awaken inquisitiveness in our youths, the education system may lay more emphasis on analytical strength rather than on the quantum of the content and recital of known information.

Through interactions with teachers engaged in science education, I learn that the information overload might impair the inspirational component of science education. Inspiring youth in learning to learn and learning to create appears to be a main challenge ahead of our educational system.

Expansion of Research and Development Base and Rejuvenation of Research in the University Sector

Rejuvenation of research in Universities is a critical step for accelerating

the development of the S&T systems. We need to strengthen the coupling between science education and excellence in research in the University sector through planned interventions. A recent study has shown that 35 institutions have contributed to about 47% of publications from India during 1996-2006. From amongst them, 14 are universities. The Ministry of Science and Technology has mounted a special scheme for Promotion of University Research and Scientific Excellence (PURSE) that has been recently launched by our Pradhan Mantri Ji. The Scheme provides incentive grants to Universities based on research performance. There is a critical requirement for planned expansion of R&D base of the country and promotion of R&D in both public and private sectors. This calls for policy interventions as well as programme initiatives.

Public Private Partnerships in Science Education for Innovations and Excellence in Research

Our private sector needs to play a more proactive role rather than being a beneficiary of the education system. They will have to play the role of a partner in educating the youth of the Nation for meeting future challenges. Recently, the Ministry of Science and Technology has mounted special Fellowship Schemes for promoting doctoral research in computer sciences and medical electronics in association with NASSCOM and medical electronics industrial sector, respectively. India may need more such initiatives under Public Private Partnerships. Active Public Private Partnerships in science education and research are also likely to promote a culture of innovations and solving of problems. The long term sustainability of our knowledge based industries demands a many fold increase in the engagement of the private sector in research and development. Policy interventions are required to scale up successful examples of Public Private Partnerships for creating innovations and technology leaderships.

Creating an Innovation Ecology through Scientific Excellence

Knowledge economies depend on the strength of Research and Technology systems. Innovations, as first application of concepts, form differentiating strength in competitive world. Ability to innovate and access innovations with commercial advantages will determine the future growth potentials of Nations. The world has selected a technocratic-push model for promoting innovation systems. The process of innovation seems the most focused priority in the global competition. India could differentiate from others by focusing on purpose of innovations and in cost optimization of innovative applications. The current research models for creating innovations lead to products and processes, which require the backing of huge capital. Such innovations remain inaccessible to a vast majority of global population. Innovation for inclusive development is an area where our science, technology and innovation system could excel.

Some Important Recommendations

Attraction of talent to study of science and careers with research for promoting excellence in research is a current global concern. The Indian Government has started addressing the issues proactively based on the recommendations of our scientific fraternity. On behalf of the Indian Science Congress Association, in my capacity as the General President, I venture to make some recommendations for consideration of the community.

1. Formation of an Advisory Council for designing science education curriculum at the school and college levels for creating excitement in learning science
2. Revision of the syllabi and content in early stages of science education

for two parallel streams, one with general science for scientific awareness and approach to learning and the other with composite science that leads students for careers in science research and development

3. Implementation of selected recommendations of a Report on Science Education by the Inter-Academy panel in some selected centers of excellence after a wider debate
4. Constitution of an Expert Panel of teachers for revising science education curricula for balancing between scholarship and problem solving alignments in learning based on global best practices
5. Formulation of policies to promote more active engagement of private sector in education as well as research funding and partnering
6. Development of an evidence based budgeting and policy building approaches for research and development
7. Right sizing and expansion of R&D base in both public and private sector establishments through new induction within the next five years
8. Increased career opportunities in S&T sector for the youth and
9. Establishment of Performance Related Incentive System for the S&T professionals.

Concluding Remarks

The Annual session of the Indian Science Congress has been convened in the salubrious location of Shillong, for the first time in the North Eastern Region. The occasion is made special by the people who made this Congress possible at this Venue. While I thank them for all the cooperation, I seek your forbearance for the challenges you may have faced, if any, in reaching the venue. We have showcased high levels of cooperation in the organization of this Science Congress. Quality science

education and attraction of talent to careers with research are critical requirements for promoting excellence in research. Let me hope that our actions of today will enable India meeting the challenges and gaining from the opportunities of knowledge economy of the world.

Acknowledgement

Although the majority of views expressed in this address are personal, my thinking has been influenced extensively by discussions with leaders in Science and Technology. High level Scientific Councils and Committees have made several important recommendations. Some executive decisions of the Ministry of Science and Technology (MST) as well as Ministry of Human Resource Development (MHRD) based on such advice have started impacting the Science and Technology Sector.

I thank all the senior scientists and my colleagues in both the Government and Indian Science Congress Association for the inspiration and advice. I owe my contributions to my teachers and mentors. I thank them all on this special occasion.

Jai Hind.