

## India 2020 – A Vision for the New Millennium\*

B V Sreekantan

National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore 560 012

I would like to discuss "The Vision for the New Millennium" under two headings:

- (i) Mundane and practical aspects of taking the nation to a higher level of prosperity and make it equivalent to a developed country in terms of scientific, technological, economic, commercial and social aspects.
- (ii) Esoteric aspects – which deal with higher values of life – pure science – driven by the motto "knowledge for the sake of knowledge", Art, Philosophy and Culture.

These may be elaborated as follows:

### A Vision for the New Millennium

<i>Mundane Aspects</i>	<i>Esoteric Aspects</i>
<i>Focus on becoming a Developed Nation from a Developing nation</i>	
<ul style="list-style-type: none"> <li>❖ Technological Strong nation</li> <li>❖ Economic Prosperity</li> <li>❖ National Security</li> <li>❖ Rightful place in the World</li> <li>❖ People to live above the poverty line</li> <li>❖ High level of Education, Health and Security</li> <li>❖ Capacity to produce Quality goods and Export</li> </ul>	<ul style="list-style-type: none"> <li>❖ Science as a contributor to Fundamental Knowledge</li> <li>❖ To understand the Universe and its Processes</li> <li>❖ Origins of Space, Time, Matter</li> <li>❖ Life, Death, Consciousness</li> <li>❖ Moral Values</li> <li>❖ Cultural Values</li> <li>❖ Art, Literature, Music</li> </ul>

\* National Seminar for Research Scholars on Philosophy, Science and Culture: Visions and Tasks for Future, Gauhati University, Guwahati, Assam, 16-18 March 2005

The book entitled "INDIA 2020, a vision for the New Millennium" by APJ Abdul Kalam with Y S Rajan, which appeared in 1998 as a Penguin Book, has been read by Millions of Indians with great interest, and has provided very authentic information on where India stands with respect to many of the issues facing the country, based on a scientific analysis of the information gathered by TIFAC, Technology Information, Forecasting and Assessment Council that was set up in 1988, and projected a realistic Action Plan to transform India from a Developing country to a Developed Country in a time scale of about 25 years – by about 2020.

Several task forces and panels had been set up by TIFAC with the objectives

- ❖ Provide directions for national initiatives in science and technology to realize a vision for India upto 2020.
- ❖ Provide strong basis for policy framework and investment for R&D in the government and private sector and
- ❖ Contribute to the development of an integrated S&T policy both at the state and the national level.

The task forces and the panels addressed themselves to the questions listed in **Table 1**. The Chinese vision document for roughly the same period is given in **Table 2**, which as is to be expected runs very similar to the Indian objectives. Japan is a country which has pioneered in the actualizing long term vision into reality in a short span of time moving from a technologically backward country in the 60's to a very forward one by 90's. The way trade deficit has been changed in the period 1975 to 1995 to Trade surplus as shown in **Figure 1**. By 1994 the payment towards imports were 39.17 billion yen and receipts from exports 56.21 billion yen (see **Figure 2**).

**Table 1.** The task forces and panels set up by TIFAC addressed the following questions

- |  |
|--|
| <ul style="list-style-type: none"><li>❖ Are there areas where India has a strong technology base?</li><li>❖ What are the technologies which can dramatically change Indian social or economic conditions or which have specific advantages?</li><li>❖ What are the spin-offs from the technologies developed?</li><li>❖ What is the focus on in-house and indigenous technological development?</li><li>❖ What should be the actions, strategies and policies, competitive advantage in the world market?</li><li>❖ Which are the technologies that would come into the future in a big way by 2010, 2015, 2020 and 2025 respectively?</li><li>❖ Which are the technologies that would become obsolete or disappear by 2000, 2005, 2010 and 2015 respectively?</li></ul> |
|--|

In the 1960's South Korea was considered to be a poor country that had not recovered from the damage caused by the Japanese invasion during the Second World War. However, it has shown a remarkable development and to day its per capita income is US \$10,000. The Koreans concentrated their efforts on few industries like Shipbuilding, Automobiles and Electronics. Israel is another country, which has moved very fast, despite being in a desert and faced with shortage of food and water. The **Figure 3** shows the milk yield of cattle of different countries. While an Indian cow on the average yields ~0.3 tons of milk per year the Israeli cow yields ~9-5 tons – more than a factor of 30 in its yields. A clear demonstration of what a well planned initiative can do.

**Table 2.** Some glimpses of the Chinese vision document:

- ❖ Open all avenues for new sources of food and develop new protein resources and mixed animal feeds. Develop diversified food production and plant resources for the purpose of improving the diet of urban and rural residents.
- ❖ Take full advantage of hybrid and genetic engineering techniques to screen and breed new high-yield, fine quality, adversity-free animal and plant varieties.
- ❖ Strengthen research and development of various elements to drastically increase the quality and yield of agricultural products.
- ❖ Equip agricultural and township enterprises with modern industrial technologies, develop technologies for storage, transport, processing, packaging, and comprehensive utilization of agricultural products.
- ❖ Guide the diversion of surplus rural labour to the development of a rural commodity economy.
- ❖ Accelerate research and development of core technologies for heavy-duty rail transport and rapid passenger transit lines over 200 km/hour.
- ❖ Strengthen the technological and industrial capabilities for electronic equipment and machine tools.
- ❖ Increase rate of innovation in the field of mechatronics.
- ❖ Increase science and technology inputs to the consumer goods industry. Improve the technical levels of village and township housing construction, design and management.
- ❖ Upgrade the technical level of social and public facilities and service industry.
- ❖ Micro-electronics and computer technologies: accelerate the development of micron and sub-micron silicon integrated circuits design, manufacturing, and testing centers and opto-electronic integration technologies; super high-performance parallel computers and commercial software engineering; new generation computers; artificial intelligence; robotics technology.
- ❖ Use of biotechnology as a powerful means of addressing food, health, resources, environmental, and other major problems.
- ❖ Advanced materials technology to make breakthroughs and to bring about fundamental changes.
- ❖ Aerospace technology: manned space flight and maintaining an international position in the field.
- ❖ Develop a network of gas pipelines to meet growing energy demand.
- ❖ Source energy supplies overseas.

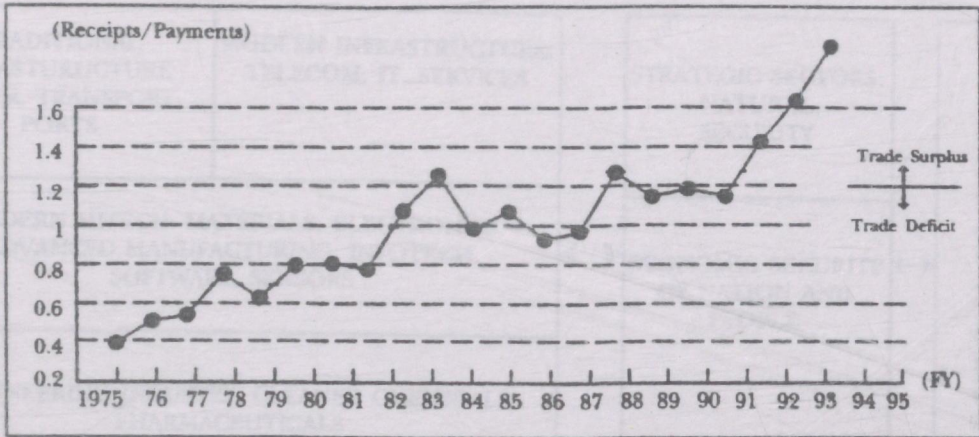


Figure 1. Technology Balance of Japan (Ratio of Receipts and Payments)

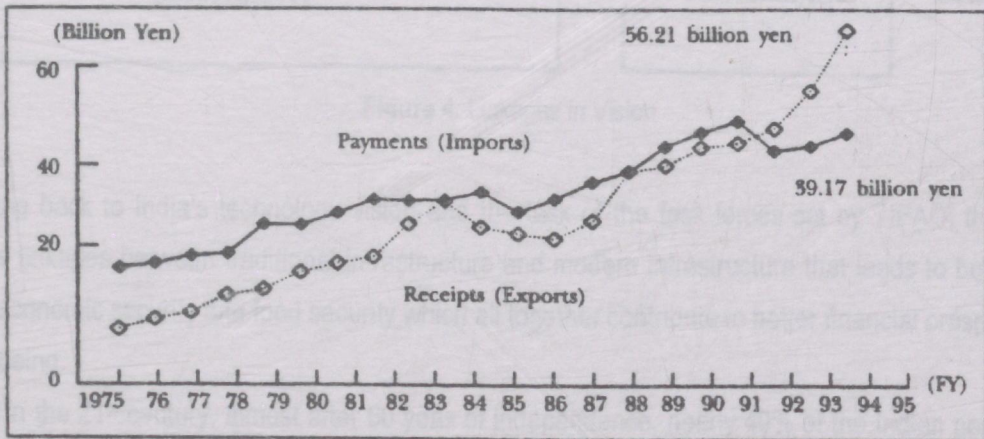


Figure 2. Technology Trade of Japan (Payments and Receipts)

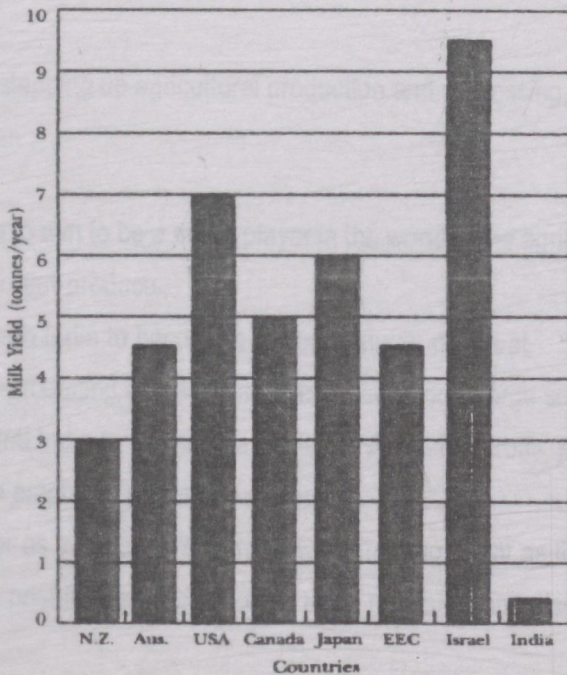
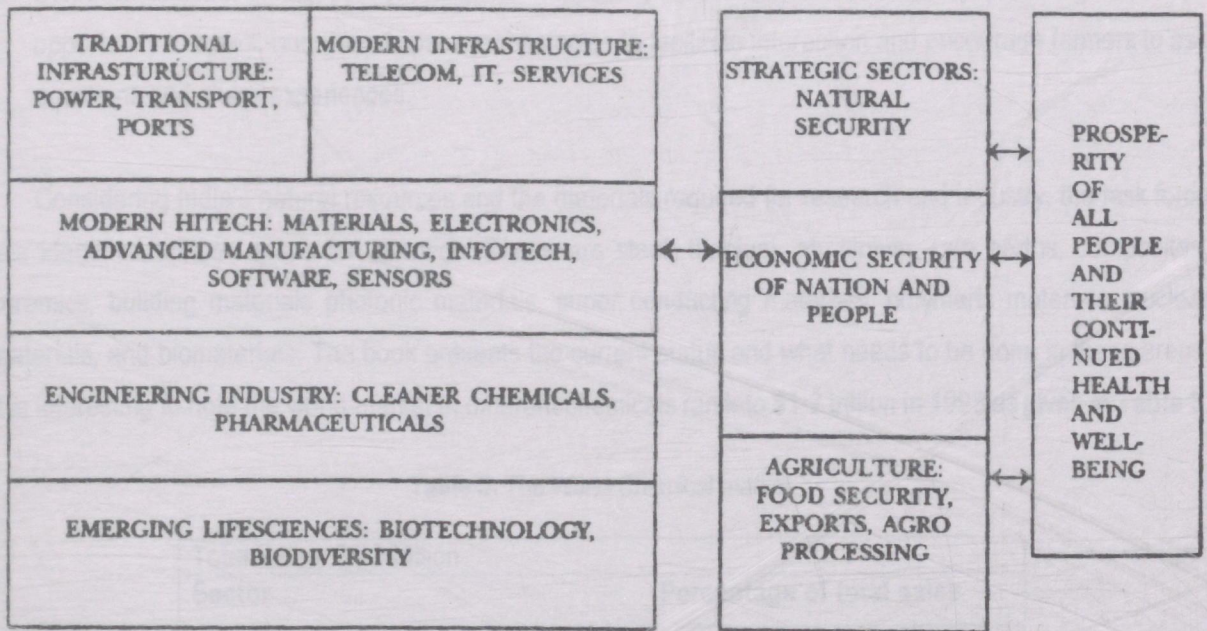


Figure 3. Milk yield for Major Countries per Head of Cattle Per year



Coming back to India's technology vision and the task of the task forces set by TIFAC, the **Figure 4**, shows the linkages between traditional infrastructure and modern infrastructure that leads to better national security, economic security and food security which all together contribute to better financial prosperity, health and well-being.

Even in the 21<sup>st</sup> century, almost after 60 years of independence, nearly 40% of the Indian population live below the poverty line – no money, no food, no housing and no medicine and so on. The only saving grace is that the country as a whole has had no series of famines after independence, which used to be the case before.

For stepping up agricultural production and processing, the following steps have been proposed by Kalam and Rajan

- ❖ India to aim to be a major player in the world in the agricultural sector and a leading exporter of grains and other agri-products.
- ❖ Eastern India to become a major producer of wheat.
- ❖ Rice-producing areas to use hybrid seeds on a large scale.
- ❖ Central India to be made a center of vegetable, fruits, pulses and coarse grains.
- ❖ More emphasis on tuberous crops.
- ❖ Water as a national resource—water management as the key to agricultural prosperity.
- ❖ Core post-harvest technologies to be mastered and disseminated.

- ❖ Steps to educate farmers about what is happening elsewhere, if need be by providing them the opportunity to travel, and use of space technologies to facilitate interaction and encourage farmers to ask questions and share experiences.

Considering India's natural resources and the materials required for research and industry, the task force has identified thirteen areas for attention. These are steel, titanium, aluminium, rare earths, composites, ceramics, building materials photonic materials, super conducting materials, polymeric materials, nuclear materials, and biomaterials. The book presents the current status and what needs to be done in these areas. It is interesting to note the world market in different chemicals ran into \$1.2 trillion in 1998 as given in **Table 3**.

**Table 3.** The World Chemical marker

Total Sales: \$1.2 trillion	
Sector	Percentage of total sales
Petrochemicals	39.0 per cent
Pharmaceutical chemicals	16.4 per cent
Performance chemicals	16.0 per cent
Agrochemicals	11.0 per cent
Textiles	9.9 per cent
Inorganic chemicals	6.7 per cent
Other fine chemicals	1.0 per cent

Source: TIFAC, *Chemical Process Industries: Technology Vision 2020*

A significant development in the chemical and pharmaceutical industries has been the recognition of the environmental hazards that result in production, and the side effects following the consumption of the drugs. In this context, there is increased effort at re-visiting the traditional systems of medicine, which have deep roots in India for hundreds of years. In this context an interesting episode that is narrated by Kalam and Rajan is that of an officer in Andhra Pradesh who was in charge of tribal development finding a tribal wood and gum material when put in turbid water, makes the water absolutely clear. Later it was found by some scientists that the same tribal material absorbs heavy minerals also. Though this lead was not followed in our country, some foreign laboratories showed interest in following it up.

India is rich in medicinal plants particularly in the Himalayas. The history of medicinal plants in India goes back to the Vedic Period. The Atharva Vada has detailed information of more than 2000 species and their use. The Charaka and Sustratha Samtitas speak of 700 drugs for all kinds of diseases. The Age of Herbal medicine is dawning in many countries, in recent decades.

The Ancient Indian skills in medicine, metallurgy, construction (bridges, temples and monuments), textiles, hydraulics and shipbuilding are fairly well known. What about new materials?

At present one of the leading manufacturing activities of India is computer software, which is likely to swell further in the coming years. The other projected areas are machine tools - computer and numerically controlled, textile, electrical and transport equipment using the advanced computer controlled technologies.

The economy of many countries is increasingly controlled by its Service Sector. Some of the important service sectors in the TIFAC report are:

- ❖ Financial services
- ❖ Marketing communication services (i.e. advertising, media, consultancy and infotainment)
- ❖ Marketing logistics, trading and distribution
- ❖ Trade promotion services
- ❖ Human resources development
- ❖ Technical and management consultancy
- ❖ Testing, certification and calibration services
- ❖ Government administration
- ❖ Security services

There are also other important activities. To name a few

- ❖ Repair and maintenance
- ❖ Tourism and hotels
- ❖ Leisure and sports resorts
- ❖ Cultural activities
- ❖ Old age care services
- ❖ Preventive health care services

If we have to achieve the stated goals by 2020, then it is extremely important that sufficient attention is paid to Human Resource Development. There are multifarious aspects to this problem, which may be short listed as follows.

- (i) Upgradation of education at all levels – Primary, Secondary and Higher education
- (ii) Removing the Gender Inequalities in power sharing in all sectors – private and public enterprises
- (iii) Higher investment in Science and Technology
- (iv) Greater support for Entrepreneurial Skills
- (v) Improving the efficiency of governmental personnel – transforming their attitudes
- (vi) Higher mechanization in all sectors, ensuring no job reduction in terms of personnel, which may call for redistribution after suitable training.

The TIFAC has also emphasized the role of management consultancy in a variety of the related issues: Redeployment, Business Process Re-engineering, Diversification, Encouragement of Joint Ventures, Outsourcing, Franchising, Providing access to Data Bases, Modeling and Simulation, International Business, R&D Management. Agrobusiness, Biotech Applicators, Infrastructure Improvements – power, telecom, roads, transportations, park, etc. and IT strategies.

The strategies proposed include:

1. Radical administrative changes in government
2. Removal of controls and curbs. Instead introduce regulation and promotional role.
3. Greater transparency in government functioning
4. Involvement of experts in decision making and planning
5. Effective integration of Indian Economy with the global one
6. Closer connection to be established in decision making between Federal, State and Grassroots operators
7. Problems connected with Human Rights to be attended to
8. Priority for Infrastructure development.
9. Training and retraining of Personnel

The following statement by Former Prime Minister I.K. Gujral during his address to the 1998, Science Congress at Hyderabad is a vary revealing one on the state of our basic amenities. 'I see before me the bottled water kept for the dignitaries on the dais. It reminds me of three classes of Indians: one who can afford bottled water; others who manage to get some water in their taps or in a nearby tap or a pump irrespective of its quality or regularity of supply; the third set of Indians are those for whom drinking water is a daily problem and who will be ready to drink any polluted water'. For such a situation to persist after fifty years of independence was a national shame, he added. Unfortunately, if we do not do enough on this front, and the related one of health care, ten years down the road we might still be saying the same thing.

In the final chapter of the book, which they have called "Realizing the Vision", they have restated the vision in the following words:

- ❖ India should emerge as a global leader in the services sector with its vast and skilled human resources base being its core strength. The services will range from the simple to the most sophisticated ones using the emerging digital and communication revolution. The services sector is not only to be a money-spinner but will also employ a good proportion of our people, often in self-employment, with abilities ranging from simple skills to super skills.

- ❖ While India needs to pay most attention to economic areas and employment generation, both crucial to making her a developed country, attention should also be to the strategic sectors. The confluence of civilian and defence technologies are basically 'dual use' in nature. A carbon-composite material can go into making a tennis racquet or a FRO-caliper device for polio-affected patients and also for a missile system. A computer can do simulations for a civilian product, for rapid prototyping or the suitability of market conditions for a future product; it can also simulate performance of a fighter aircraft or weapon performance. These 'dual technologies' are closely guarded by the developed countries under the premise of non-proliferation of nuclear weapons or missiles. But they are the basis for their market dominance as well! Therefore countries like India should master technologies relating to space, atomic energy or defence and even many complex machine tools or electronics. These will lead to domestic and foreign business orders for Indian companies even when they are not necessarily for the use of ISRO, DRDO or the Atomic Energy Department. The value additions would be very high. To continue as an economic power, therefore, India has to master the strategic technologies as well, though in the short run they may appear to be high-cost technologies. Fortunately, Indian laboratories and industries have an excellent base in these technologies and have assumed a leading position globally in a number of areas of materials, electronics, propulsion, and simulation, among others. India needs to further strengthen these areas with concrete missions focused on dual use capabilities. That is, to develop a generic technology common to defence while simultaneously developing multiple civilian applications on a commercial scale. Therefore it is necessary to draw Indian industry, especially the private sector, into these high-tech areas not merely for fabrication but for design, development, production, marketing and post-sale services. India should also emerge as a major exporter of products and services resulting from its capabilities in high-tech areas.
- ❖ The health of all our people is vital even while we are pursuing the all-round rapid growth of the economy and technological prowess. People's health leads to better economic and social progress. Many recent technological inventions are making it possible to reach health services to all. Sensors and information technologies in particular, are making it possible for access of specialist attention to even remote areas—popularly called 'telemedicine'. India should attend to short-term rapid action and emerge as a nation with excellent health service cover, which would be an example to the world.
- ❖ In order to achieve the vision, several crucial actions need to be taken to ensure speedier growth of infrastructure: energy, quality electric power in particular, roads, waterways, airways, telecommunication, ports, etc. Several short-term measures and some unconventional steps need to be taken. The long-term action should be aimed at providing world-class facilities for all parts of India. Rural connectivity is crucial even in the short run if the boom in agriculture and agro-food sector is to be utilized fully. In addition, the progress in information technologies is leading to the possibility of very advanced world-class industries

and businesses being established in a village. Highly creative projects in software, information technology, design and other creative work can in fact be better done in a rural environment, which has good facilities and good connectivity. The persons who live there should have access to the latest information available globally if they have to be creative and current. Such connectivity can be provided by electronic means even today. Thus, there is a true possibility of many of our well-connected rural areas becoming world-class centers of excellence and also making for a lot of value-added exports or vigorous domestic business, besides giving us food and other products, which normally come from rural areas. There are also excellent possibilities that such well-connected rural areas may be host to a number of biotechnology factories, which will produce value-added natural products for sale globally. But all these are possible only with an excellent rural connectivity which means good roads, telecommunications and, of course, quality electric power.

- ❖ Given the devolution of power to the panchayats, they can also play a major role, with competition as well as cooperation between the village panchayat enhancing performance.

The next problem they discuss is how to initiate the necessary action. They recognize that all action cannot take place simultaneously. In this Kalam and Rajan emphasize the role of the three categories of people: The Panchayats, the Panchayathikaris and Panchayatanets, as also the other golden triangle of Industry, Government and R&D institutions. Under Industry the role of large, small, Mini industries, Public sector undertakings by the Central Government and State Government, and the role of Multi National Companies and also of the Media in carrying out the Mission oriented and time bound execution of the various projects envisaged has been dealt with in detail. The emerging role of the IT Sector is highlighted. They look forward with optimism the integration of five mega missions Agriculture, Electric Power, Education and Health, Information Technology and National Security and feel that these implemented with a national focus will take India into the ranks of the Developed Countries of the world.

### **Esoteric Aspects of Vision India 2020**

So far we have dealt with science and technology vision concerning the mundane aspects – ensuring the essential requirements of food, water, shelter, security, transportation, industrial development etc which is the sine qua non of the developed world. While there is no question that these have to be given top priority in the planning of any country for the future, it has to be recognized particularly in the context of the present seminar that every human being is endowed from birth with a sense of curiosity and quest for knowledge not so much for practical utilization, but for understanding the way nature operates and how the emotions that manifest within himself come about. *Man does not live by bread alone. When Professor R R Wilson – the*

scientists who constructed the Fermi Accelerator at Chicago, was asked by a senator, whether his project which involved billions of dollars, would help in the defence of his nation, the answer he gave was "I do not know whether it will help the defence of the country, but it will certainly make the country worth defending". Science has a much bigger role in human life than providing a certain level of comfortable living. It may be appropriate to quote here the Nobel Laureate Professor Charles Townes: "Science is the attempt to understand the structure of the universe and how it works including ourselves" and Religion is the attempt to understand the purpose and meaning of the universe including our own lives"

India is a country with a rich tradition in philosophy, culture, and ancient sciences of – mathematics, astronomy, medicine, chemistry, metallurgy and architecture, and also of music and art. But Modern Science per se, which itself is only 400 years old, came to India only a 150 years ago. In India religion has played and is continuing to play a major role in the lives of a large section of the people. In planning the vision for 2020, it is imperative that these aspects are also taken into account. I am happy to see some of the related topics are already included in the presentations of other scholars at this seminar. I will concentrate on those aspects of science – Pure Sciences – which are carried out in the spirit "knowledge for the sake of knowledge". It is well known in the history of science that most of applied science and technology has emerged from the reservoir of such pristine knowledge. This is illustrated in the **Table 4** where the technologies that emerged in the 20<sup>th</sup> century are given on the right hand side and the particular discoveries responsible for these technologies are in the left hand side.

**Table 4.** Interaction between Science and Technology in the 20<sup>th</sup> Century

Discoveries in Physical sciences	Technologies Development
❖ Electron, proton	❖ Electronics, Valves, Solid state devices
❖ Electromagnetic waves	❖ Radio, TV, Radar, ... VCR
❖ X-rays	❖ X-ray Machines
❖ Radioactivity	❖ Particle Accelerators
❖ Relativity $E=mc^2$	❖ Atom Bomb, Hydrogen Bomb
❖ Quantum Mechanics	❖ Refrigeration
❖ Electron, Positron – Anti particles	❖ Super conducting Magnets
❖ Photo-electric effect	❖ Computers
❖ Nucleus, Neutron	❖ Lasers
❖ Fundamental particles	❖ Tomography
❖ Maser, Laser	❖ Space Technology
❖ Low Temperatures	❖ Radio Telescope
❖ Superconductivity	❖ Space Telescope (Hubble)
❖ Transistor	
❖ Nuclear Magnetic Resonance	

The main emphasis in Pure Sciences continues to be on discerning:

- (i) The Large Scale constituents of the universe
- (ii) The ultimate constituents of matter and radiation and the forces responsible for all the phenomenon observed in nature
- (iii) The origins of matter, radiation, life and consciousness

While these fundamental problems have remained for several millennia, the developments in science and technology (**Table 4**) have enabled the acquisition of a large body of detailed knowledge that has brought lot of new insights, but at the same no final solution is in sight to any one of them. As the famous physicist John Wheeler has said, "*As the island of knowledge grows so does the shore of our ignorance*". Nevertheless it is extremely important to note that the expansion of knowledge is by no means trivial, and the following new disciplines have come into the fore:

- (i) Structure of Matter – High Energy Physics, Elementary Particles – the Basic Forces – Strong, Weak, Electromagnetic and Gravitation – Quantum Mechanics and Special Theory of Relativity
- (ii) Structure of Space and Time – the General Theory of Relativity.
- (iii) The structure of the universe as revealed by the new astronomies, Radio, Optical, IR, UV, X-ray, Gamma-ray, Neutrinos – and the existence of queer object like the Quasars, Neutron Stars, Black Holes and the expanding and accelerating aspects of the universe as a whole
- (iv) The phenomena of high temperature superconductivity – nano-sciences.
- (v) Chaos Theories, String Theories leading to new connection between physics and mathematics.
- (vi) Physico-chemical processes in the brain and the associated neuronal circuits using the newly developed tomographic instruments.

What is exciting from the point of view of India is that Indian scientists in the various research laboratories in India (TIFR, NCBS, IISc, JNCAR, IIA, PRL, CCMB, ISAC, IUCAA, ISRO) are engaging themselves at internationally high competitive levels both in theoretical and experimental investigations in these frontier areas. The laboratories are flush with the state of the art instruments. The Large Radio Telescope at Pune is the largest aperture telescope in the meter wave length region in the world. The 2m optical telescope at Hanle in the Himalayas, named the Chandra Telescope is an optical and IR telescope and it is the highest altitude (15,500 ft) telescope in the World. It is designed such that it is routinely operated from Hosakote near Bangalore via a satellite communication system. JNCASR is equipped with the best of instruments for research in Nano-Physics. The ISRO is putting into orbit by 2007 a comprehensive Satellite borne astronomical telescope called the ASTROSAT. Research in Elementary Particle Physics is being carried

as collaborative projects with the accelerator laboratories at Fermilab in the US and CERN at Geneva. Theoretical work on string theories are in progress at TIFR, Harischandra Institute, Institute for Mathematical Sciences and at several other places. Neuronal Studies are in progress at the Brain Research Institute, NCBS and TIFR. I have given only a few representative fields of research and a few representative institutions where work is in progress in these new areas of science. There are many more areas and places where equally important front ranking work is being carried out. There is also the area of pure mathematics in which India has earned a unique place of honour.

While one feels happy that a large number of young students are getting into these areas in recent years, there is need for much larger numbers. One always feels that for a country of the size of India, the scientific effort has to be orders of magnitude higher. It is only then we can really make a dent in the field of front ranking fundamental research and take an appropriate place in the world scenario.

### **Acknowledgements**

The first part of this talk is essentially a summary of what is contained in the book of Abdul Kalam and Rajan which I would recommended every one interested in the future of India to read. It is a treasure house of information, ideas and plans of action. I would like to thank Prof. D P Chattopadhyaya and Prof. Kireet Joshi for giving me this opportunity to participate in this exciting, refreshing seminar, and have the opportunity of interacting with young minds from different parts of the country.

collaborative projects with the accelerator laboratories at Fermilab in the US and CERN at Geneva. Theoretical work on string theories are in progress at TIFR, Varkanas Institute, Institute for Mathematical Sciences and at several other places. Higgs boson studies are in progress at the Centre for High Energy Physics, Mumbai and TIFR. I have given only a few representative fields of research and a few representative institutions where work is in progress in these new areas of science. There are many more areas and places where equally important front working work is being carried out. There is also the area of pure mathematics in which India has earned a unique place of honour.

While one feels happy that a large number of young students are getting into these areas in recent years, there is need for much larger numbers. One always feels that for a country of the size of India, the scientific effort has to be of order of magnitude higher. It is only then we can really make a dent in the field of front working fundamental research and take an appropriate place in the world scenario.

#### Acknowledgements

The first part of this talk is essentially a summary of what is contained in the book of Abdul Kalam and Rajan which I would recommend every one interested in the future of India to read. It is a treasure house of information, ideas and plans of action. I would like to thank Prof. D. P. Chakrabarti and Prof. K. Suresh Joshi for giving me the opportunity to participate in this exciting, refreshing seminar, and have the opportunity of interacting with young minds from different parts of the country.