Chapter 29

SCIENCE AND TECHNOLOGY

Introduction

The major objectives and thrust in Science & Technology (S&T) sector during the Ninth Five Year Plan, inter alia, has been on (a) optimum harnessing of S&T for societal benefits, (b) developing R&D programmes on mission mode, (c) nurturing of outstanding scientists by offering them facilities comparable with international standards, (d) attracting young scientists for taking science as a career, (e) establishing linkages between the industry and research institutions/ laboratories for development and market technology, (f) developing clean and eco friendly technologies, (g) generating maximum resources for R&D from production and service sector, and (h) creating awareness on technology marketing and intellectual property rights issues. Emphasis has also been laid on science, technology and education including promotion of basic research and excellence, S&T communication and popularisation of science, promotion of international science and technology cooperation.

2. In relation to the Ninth Plan thrust outlined above, there has been significant progress in various areas. Efforts have been continued to maintain a strong science base and develop technological competence. In order to strengthen technological capabilities of the Indian industries, both for meeting the national needs and for proving global competitiveness, a number of new initiatives have been launched through *Programme Aimed at Technology Self Reliance (PATSER)*, Technology Development Board (TDB) and Home Grown Technologies. Individual innovators are also being supported under new Technopreneur Promotion Programme (TePP). Efforts have been made for: strengthening R&D activities through creation of new research facilities, introduction of the concept of basic research missions; attracting young scientists by awarding fellowships; strengthening S&T infrastructure in universities and academic institutions; promotion of indigenous technology using Science and Technolgy Advisory Committee (STAC) of the various socio-economic sectors and Inter-Sectoral Science and Technology Advisory Committee (IS-STAC) mechanism of the Department of Science and Technology (DST). A number of science and society-related programmes have been implemented to demonstrate the application of S&T for improving the quality of life by creating productive jobs, reducing drudgery, improving health and environment in the areas of black-smithy, carp breed hatchery, low cost preservation and processing of horticulture products, food irradiation, application of radio isotope and laser for the diagnosis and treatment of various diseases, use of PFZ maps for fishing activities. Jai Vigyan Mission Mode S&T Projects have been launched in the areas of plant genetic resource conservation, development of new generation vaccines, biotechnological approaches towards herbal product development, genomic research, development of light transport aircraft and ocean thermal energy conservation. Significant achievements have

been made in the area of space, nuclear, biotechnology, ocean sciences and scientific and industrial research.

3. Concerted efforts have been made to promote frontier areas of science and technology and also strengthen various infrastructure facilities through well defined programmes in various disciplines of S&T. Efforts have been made to ensure greater inter action among the scientific community and establishment of linkages among national laboratories, academic institutions and industries.

4. In order to attract young scientists, several incentives have been introduced which include launching of Swarnajyanti Fellowship under which research support is provided to outstanding young scientists ; Kishore Vigyanik Protsahan Yojana under which 50 students of 10+ standard selected through all India competition are provided financial support for taking up specific projects in various discipline of science ; CSIR Programme for Youth Leadership in Science (CPYLS) in which top 50 students at 10^{th} class level of each State Education Board would be invited at CSIR (Council of Scientific & Industrial Research) expense to visit its laboratories to experience the excitement in R&D . Also, young scientists are encouraged to take up science as a career through the on-going programme Better Opportunities for Young Scientists in Chosen Area of Science and Technology(BOYSCAST) Fellowship for working in laboratories abroad. In the area of biotechnology, Special National Bioscience Awards for career development of scientists and Outstanding Women Bio-scientist Awards have been instituted.

Major thrust and objectives are on :

- Optimum harnessing of S&T for societal benefits.
- R&D programmmes on mission mode.
- Nurturing of outstanding scientists by offering them facilities comparable with international standard.
- To attract young scientists for taking science as a career.
- Establish linkages between the industry and research institutions/ laboratories for development and market technology.
- Development of clean and eco friendly technologies.
- Generation of maximum resources for R&D from the production and service sector.
- Creation of awareness on technology marketing and intellectural property rights issues.

5. A major programme Fund for Improvement of S&T Infrastructure in universities and related institutions (FIST) has been initiated to augment and strengthen the infrastructure facilities for post graduation education and research.

6. To achieve the objective of integration of science and technology in the socio economic sector and promote S&T activities for the societal benefit, 24 socio economic ministries have set up Science and Technology Advisory Committees (STAC) for supporting science and technology programmes in the respective sector. An Inter-Sector S&T Advisory Committee (IS-STAC) functioning under the Science & Technology is

actively promoting multi-partnership effort in close collaboration with the STACs and several technology transfer and technology fall-outs have taken place. In the areas of Technology Development Programmes, efforts are continued to develop joint R&D projects with industry and other user agencies in the areas of instrument development, various areas of home grown technologies and Programme Aimed at Technological Self Reliance (PATSER) of Department of Scientific and Industrial Research (DSIR). These are in addition to efforts made by Technology Development & Application Board for promoting indigenous technology to the level of commercialisation through participation of industries. A new golden jubilee initiative called "Technopreneur Promotion Programme (TePP)" has been initiated to tap the best potential of Indian innovators. Several technology mission mode programmes have been pursued in the areas of sugar technologies, advance composites, fly ash utilization, bio-fertiliser, bio-pesticides , aqua-culture etc. In addition, the launching of Jai Vigyan Mission Mode S&T Projects in various disciplines is another step towards implementation of time bound technology development programmes.

7. Several science and society related programmes were evolved and implemented for improving the quality of life by creating productive jobs, reducing drudgery, improving health and environment. These include programmes on artisan blacksmithy; common carp breeding hatchery; low cost processing and preservation of horticulture product; cultivation and processing of high value medicinal plants, floriculture and mushroom culture, setting up of women technology parks for dissemination and generation of technology relevant to women, core support to S&T field group for demonstration of S&T at the field level, radiation processing of food technology, application of radio isotope for disease control, industrial and medical laser, generation of action plan of various districts using space technology under Integrated Mission for Sustainable Development, application of remote sensing for management of natural resources, satellite based inter active network for rural development, use of Potential Fishing Zone (PFZ) maps for fishing activities, shore to vessel communication facilities etc. Proven biotechnologies have been used to improve living conditions of the rural population with particular focus on SC/ST population and women.

8. A massive programme on creation of awareness on intellectual property rights (IPR) and diverse aspects of patents have been initiated through the Patent Facilitating Cell set up by the Department of Biotechnology and Department of Science & Technology to provide support for patent search services, generation of data base in CD ROMs and also establishment of seven patent information centres in different States to create patent awareness and provide patent information and facilitating filing of patent applications. Greater thrust has been made on manipulation and management of Intellectual Property Rights (IPR) for corporate advantage.

9. Internationally, India has S&T cooperation with 50 countries in select areas of mutual interest to facilitate interaction in scientific research, develop advance technologies and take mutual advantage of complementary scientific and technological capabilities among participating countries.

10. The funding of the S&T programmes remains mainly through the budgetary support by the Scientific Departments/Agencies of the Central Government. The financial contribution of the industry sector in R&D is about 28% of total R&D expenditure

11. Review and appraisal of the progress made by some of the major sectoral agencies towards achieving the objectives and thrust of the Ninth Five Year Plan are briefly indicated below :

Space Science & Technology

12. The thrust of Space Science & Technology programmes has been on the development of satellite-based communication for various applications, satellite- based resources survey and management and environmental monitoring, meteorological applications, development and operationalisation of indigenous satellite, launch vehicle and associated ground segment for providing these space- based services.

13. Major achievements include the successful launching of : first operational flight of PSLV-C1 carrying IRS-1D satellite into orbit ; PSLV-C2, the first commercial flight of PSLV, carrying IRS-P4 into orbit in addition to two auxillary foreign satellites, TUBSAT(Germany) and KITSAT (Republic of Korea); and INSAT-2E. The Geosynchronous Satellite Launch Vehicle(GSLV) project has successfully completed the development phase and

Several initiatives have been taken to achieve the S&T's objective and thrust. These include :

- Strenthining of R&D activities through creation of new research facilities, introduction of concept of basic research missions, enhancement of fellowships etc.
- Attracting young Scientist by awarding Swarnajayanti Fellowship for research, BOYSCAST Fellowships, Kishore Vigyanik Protsahan Yojana, National Bioresource Awards and Promote Youth Leadership in Science for school students.
- Strengtening S&T infrastructure in the universities & academic institutions through FIST programme.
- Promotion of indigenous technology using STAC and IS-STAC machanism and also through the programmes of PATSER, TDB, Homegrown Technologies etc. Individual innovators are also being supported under newly instituted TePP programme.
- Number of science and Society related programmes were implemented to demonstrate application of S&T for improving quality of life by creating productive jobs, reducing drudgery, improving health and environment in the areas of blacksmithy, carp breed hatchery, low cost preservation and processing of horticulture products, food irradiation, application of radio-isotope and laser for the diagnosis and treatment of various diseases, use of PFZ maps for fishing activities etc.
- Creation of awareness on intellectual property rights and diverse aspects of patents.

entered the flight hardware realization phase. Significant progress has been achieved in the indigenous development of Cryogenic Upper Stage Project (CUSP) with the establishment of test facilities and fabrication of engine. The construction of Second Launch Pad at Sriharikota has also started. The IRS-1D was successfully launched in September, 1997 carrying payloads identical to those of IRS-1C. The IRS-1C/1D data have been operationally used in crop area/yield estimates, wasteland mapping, ground water potential, command area management, integrated resource survey, urban management etc. IRS-P4 (OCEANSAT), launched in May 1999 has been used in recording ocean biological parameters and also to estimate a number of geophysical parameters.

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14. The INSAT-2E , launched in April 1999, has been carrying both communication and meteorological payloads. Under an agreement with International Telecommunication Satellite Organisation (INTELSAT), 11 C-band transponders on INSAT –2E have been leased to INTELSAT with a lease fee of $10 million per year. There are about 83 transponders in the INSAT system (including the capacity leased to INTELSAT) as on December, 1999 and the number is expected to increase to 119 by the end of Ninth plan against the targeted 135.

15. Under the space application oriented programmes, the Jhabua Development Communication Project (JDCP), a satellite based interactive network for rural development, has been successfully completed and the scheme has been expanded/extended in scope to neighbouring districts. For the distance education and training network system, Training and Development Communication Channel (TDCC) has been extensively used by several agencies and industries and State Governments. The Integrated Mission for Sustainable Development (IMSD) initiated in 175 districts has been extended to 800 watersheds of Orissa. As a part of National Drinking Water Mission, a major project has been taken up for preparation of satellite based hydrogeomorphological mapping for identification of prospective

Milestones achieved in the Space S&T :

- Successful launch of first operational flight of PSLV-C1 carrying IRS-1D satellite & PSLV-C2 carrying IRS-P4 along with two auxillary foreign satellites viz. TUBSAT(Germany) and KITSAT (Republic of Korea);
- Launch of INSAT-2E and its 11 C-band transponders leased to INTELSAT with a lease fee of $10 million per year
- Jhabua Development Communication Project, successfully completed and the scheme extended to neighbouring districts.
- Integrated Mission for Sustainable Development (IMSD), initiated in 175 districts for generating local specific developmental action plan, extended to 800 watersheds of Koraput-Bolangir-Kalahandi areas of Orissa.
- Network of international ground stations receiving the IRS data expanded to 10 ground stations around the globe and the market share of IRS in global satellite data has gone up to 20 per cent.

zones for ground water exploration. A comprehensive integrated project for forecasting agricultural output using space, agrometeorology and land based observations has been initiated in coordination with Department of Agriculture and Cooperaiton. Projects have also been taken up to map wastelands in about 192 districts, biodiversity characterization at landscape level in the Himalayan region, Western Ghats and Andaman Nicobar Islands for bioprospecting of biological wealth. A pilot project on Disaster Management System (DMS) has been implemented in flood prone districts of Assam. A network of 10 international ground stations in USA, Germany, Spain, Dubai, Saudi Arabia, Korea, Japan, Thailand, Alaska and Ecuador have been receiving the IRS data.

16. The INSAT programme has entered the operational phase and providing regular communication services. There is a need to segregate the INSAT progamme from the S&T sector of DOS, and this may be included under the development sector like Communication. Space services should be provided to the users on cost basis so that the INSAT system could be made self sustaining both in terms of fabrication of the satellite and launch services. In the areas of remote sensing, large volume of data information and imageries are being produced and the Department has already initiated several remote sensing application programmes on a pilot basis. While the social relevance of Space technology is well established, there should be greater application of the remote sensing data/information by the development departments for designing, implementing and monitoring various developmental programmes.

Atomic Energy (R&D Sector)

17. The major R&D thrusts of the Department of Atomic Energy have been on life extension of Pressurized Heavy Water Reactors, design and development of fast breeder reactor; enhancement of thorium utilisation; engineering development of thorium-based advanced heavy water reactor and matching developments in the fuel cycle area; accelerator-based systems and fusion power; technology missions in radiation applications in health, agriculture and food, specially on food preservation, desalination and isotope hydrology; strategic technologies in the areas of special materials, laser, particle accelerators, parallel computers, robotics, cryogenics and special instrumentation; safety and environmental protection; and technology spin-offs to industry.

18. One of the important achievements has been conducting Nuclear tests at the Pokhran range on May 11-13, 1998. The major activities of BARC include: design and development of AHWR; attainment of full power level of 30 KWt by neutron source Kamini reactor; design and construction of 6300 cubic metre per day nuclear desalination plant utilizing both thermal and membrane processes; transfer of technology for radiation processing of food; development of radiation source of treatment of eye cancer; export of high density thoria buttons for monitoring of cooling gas in electric generator; upgradation of technologies for production of uranium compounds, rare earths, nuclear grade thorium; setting up of Lithium Metal Pilot Plant; and technology demonstration of low temperature niobium-titanium multifilament super conducting cables.

19. The Fast Breeder Test Reactor (FBTR) at Indira Gandhi Centre for Atomic Research (IGCAR) was operated successfully. A programme relating to R&D and engineering development of a 500 MWe Prototype Fast Breeder Reactor (PFBR) has been taken up. The Centre for Advanced Technology (CAT), Indore, has set up a Synchrotron Radiation Source (SRS) facility, Indus-I. Other significant achievements include: design and development of beam line instrumentation for using Indus-I, insertion devices, plasma chamber and magnet coils for microwave ion source, development and supply of surgical model of carbon dioxide laser, nitrogen laser for treatment of tuberculosis etc. The Variable Energy Cyclotron Centre (VECC) at Calcutta delivers beams of nuclear particles for research in nuclear physics and nuclear chemistry and produces radioisotopes for various applications. The setting up of super conducting cyclotron made significant progress which includes completion of major steel forging for main magnet frame, ordering of main liquid helium plant, fabrication of a 300 ampere power supply as a prototype etc,. besides initiation of activities on radioactive ion beam facility and advanced computational facility.

Major achievements in Atomic Energy (R&D) :

- Nuclear tests that were conducted at the Pokhran range on May 11-13, 1998.
- Initiation of design and development of AHWR.
- The neutron source Kamini reactor attained full power level,
- Technology spin-offs include design and construction of 6300 cubic metre per day nuclear desalination plant.
- Transfer of technology of radiation processing of food, development of a radiation source for treatment of eye cancer; export of high density thoria buttons to General Electric Company, USA for monitoring of cooling gas in electric generator etc.
- Successful operation of the Fast Breeder Test Reactor (FBTR) .
- Setting up a Synchrotron Radiation Source (SRS) facility.

20. The research institution under DAE provides R&D back- up for the first stage of nuclear power programme based on Pressurised Heavy Water Reactors particularly design and manufacturing of complex equipment, repair and refurbishment techniques, harnessing the latest advances in information technology for further improvement of control and monetary systems, in–service inspection, fuel development etc. Use of irradiation technology for improving the shelf life of agriculture produce and also application of radioisotopes and lasers in the diagnosis and treatment of various diseases need to be further strengthened for improving the quality of life.

Science and Technology

21. The thrust has been on building and sustaining a strong Science and Technology base in the country, developing centres of excellence in frontline areas of science and

technology and modernising infrastructure of its autonomous research institutions. The overall approach has been to promote basic research around outstanding scientific groups and to a large extent in the academic sector by way of research funding, development of manpower and capabilities, creation of infrastructure facilities, implementation of societal programmes, international S&T cooperation and scientific services in the areas of meteorology and mapping.

22. The important technologies developed include: superconducting technology based ore separator and power generator, fish freshness bio- sensor, lactate and cholesterol bio-sensor, multi model imaging and image identification of cancer related diseases, expert systems for diagnosis and monitoring of leprosy, optical fibre based immuno sensor for Kala-zar, etc. A new Golden Jubilee initiative called 'Technopreneur Promotion Programme (TePP) has been initiated to tap the vast potential of Indian innovators.

23. The Patent Facilitating Cell (PFC), set up by the Department to provide support to scientists on all aspects of patenting has facilitated filing of 79 patent applications including nine in foreign countries. PFC has conducted 34 workshops besides publication of IPR bulletin, providing patent search services, generation of data base in CD ROMs and also establishment of 7 Patent Information Centres in various States to create patent awareness and provide patent information and facilitate filing of patent applications. Two women technology parks (for dissemination and generation of technologies relevant to women), in the mountain region and West Coast have been supported besides long term core support to two S&T field groups in the North Eastern Region A rural technology park is also being set up at Sikkim. With a view to promoting S&T entrepreneurship development, two new S&T Entrepreneurship Parks were set up at Thapar Institute of Engineering and Technology, Patiala, and PSG College of Technology, Coimbatore.

Some of the important achievements :

- 800 research projects including 200 projects for young scientists supported by SERC.
- BOYSCAST fellowships, Swaranjayanti Fellowship and Kishore Vigyanik Protashan Yojana initiated to encourage young scientists.
- National Accreditation Board for Testing and Calibration Laboratories (NABL) set up for providing accreditation to testing and calibration laboratories in the country.
- Important technologies developed include: superconducting technology- based ore separator and power generator, fish freshness bio- sensor, lactate and cholesterol bio-sensor, multi model imaging and image identification of cancer related diseases, expert systems for diagnosis and monitoring of leprosy and optical fibre based immuno sensor for Kala-zar.
- PFC facilitated filing of 38 patent applications including nine in foreign countries and sensitised large number of scientists and technologists on IPR related issues.

24. The India Meteorological Department continued to make systematic efforts to modernise its facility and improve the quality of meteorological services. To achieve this objective, sophisticated Doppler Radars are being introduced in the cyclone detection network for effective cyclone forecasting. Ozone spectro- photometers have been deployed at Antarctica to enhance the quality of meteorological data and study of ozone and upper air.

25. There is a need for S&T sector to lay greater emphasis on technology development programmes. A large number of sophisticated research facilities have been created in the country. These facilities should increasingly be utilized not only for research purposes but also for providing services to the industry. Science and society related programmes need to be more closely tied up with development sectors so that programmes relating to poverty alleviation, employment generation etc. could be strengthened with S&T inputs and large scale application of the new technologies is possible.

Scientific and Industrial Research

26. CSIR's major initiatives as the main agency for scientific and industrial research were related to: (a) re-engineering of the organisational structure to enable it to be more customer and market responsive; (b) linking R&D to market place through alliances, networking and leveraging; (c) stimulating intellectual property management in the CSIR; (d) selectively investing in high quality science that would be the harbinger of future technologies; and (e) refurbishing the ageing human capital.

27. As a result of various initiatives taken by CSIR, the total external cash flow for 1997-99 from contract R&D and services from CSIR laboratories reached Rs.440 crore, up from Rs 393 crore during the corresponding period in 1995-97. The Indian patents filing during the year 1997-99 at 575 was lower than the 900 targeted but foreign patent filing at 206 exceeded the target of 175. Similarly, although there was no significant increase in the number of scientific papers contributed, the impact factor per paper has shown an increase from 1.26 in 1996 to 1.51 in 1998. The industrial production based on CSIR knowledge base has touched the figure around Rs.4,200 crore in 1998-99, which was about 10 per cent above the 1996-97 figure.

28. Significant achievements include: (a) design and development of Light Transport Aircraft (LTA) and development of Light Combat Aircraft (LCA); (b) obtaining of provisional certification of the two-seater trainer aircraft, HANSA-3 for commercial production; (c) release of a high yielding menthol mint variety Himalaya for commercial cultivation,; (d) development of energy efficient conversion technology of natural gas to lower olefines, conversion of methane to syngas and ethane to ethylene; (e) initiation of a major coordinated programme on development and commercialisation of bio-active molecules and introduction of a new anti-malarial plant based drug; (f) launching of human trial of a non-toxic cholera vaccine; (g) development of diagnostic probe for leishmaniasis; (h) development of non-hazardous process for anti-AIDS drug;

(i) standardisation of hepatoprotective formulations; (j) conducting of exhaustive studies on pollution emission behaviour of different types of brick kilns; (k) development of a pollution control device for brick kiln; (l) development of a fluorescence based prototype kit rapidly to detect adulteration of argemone in mustard oil.

29. Important achievements of Department of Scientific and Industrial research (DSIR) include: (a) recognition of new in-house R&D Units in industry and non commercial Scientific & Industrial Organisations (SIROs) under the scheme R&D by Industry; (b) recognisation of 133 in-house R&D units and 48 SIROS ; (c) organisation of annual national conferences on in-house R&D in industry; (d) completion of 17 technology development and demonstration projects involving over 13 industrial units under PATSER scheme, resulting in commercialisation of products and processes such as SPV Traffic Signalling System, automatic transmission control for dump trucks, detonating card for exploration; (e) supporting of 16 projects under the Technopreneur Promotion Programme (TePP) jointly by DSIR under its PATSER scheme and DST under its Home Grown Technology Scheme; (f) continuation of National Research Development Corporation (NRDC) effort on development and transfer of indigenous technology through Invention Promotion Programme; and (g) completion by the Central Electronics Ltd. (CEL) of projects like design and development of Solar Photo Voltaic (SPV) Systems and SPV Monitoring Systems.

Important Achievements:

- Major initiatives on re-engineering of the organisational structure, linking R&D to market place, networking and leveraging; stimulating intellectual property management, selectively investing in high quality science & refurbishing the ageing human capital.
- Launching CSIR Programme for Youth Leadership in Science (CPYLS) scheme to attract youth to science.
- External cash flow for the period 1997-99 from contract R&D and services reached Rs.440 crore.
- The Indian patents filing during the year 1997-99 at 575 & the foreign patent filing at 206 exceeded the targets.
- The industrial production based on CSIR knowledge base touched the figure around Rs.4200 crore in 1998-99,
- A satellite based CSIRNET is being set up connecting CSIR headquarters and laboratories to have a fast real time access to one another as also to internet.
- Achievement made in technology development include : design & development of LTA, release of high yielding mint variety for commercial cultivation, new anti-malarial plant based drug, diagnostic probe for leishmaniasis, non-hazadous process for anti-AIDS drug, prototype kit for rapid detection of mustard oil etc.

30. Concerted efforts are needed for taking up R&D programmes with more interface with industry. Emphasis is to be given on undertaking projects sponsored by the industries so that R&D funding could be enhanced with reduced dependence on budgetary support. Although CSIR is laying emphasis on IPR- related issues and is doing pioneering work in patenting its research findings, it is necessary to devote greater effort to identify critical area where research result leads to value added processes and product development, and have potential for patenting.

Biotechnology

31. The main thrust of biotechnology programme aims at bio-industrial development of the country; ensuring judicious utilisation and conservation of biological resources using the biotechnological tools; research and development for products, processes and technology generation for achieving academic excellence of the highest national and international standards and for societal benefit.

32. Significant achievements are : (a) development of pest- resistant transgenic cotton, markers for high quality in wheat, hybrid mustard seeds, transgenic viral- resistant tobacco plants; (b) transferring of technology to industry for producing myccorhizal biofertiliser besides development of an anti-fungal formulation for control of root- rot diseases; (c) transferring of three protocols for Eucalyptus, Sugarcane, and Populus to the industry for large scale production of these plants; (d) functioning of two tissue culture pilot plants at National Chemical Laboratory (NCL), Pune, and TERI, New Delhi, as micro-propagation technology parks; (e) standardization of embryo transfer technique in camel and development of a new protocol for camel super ovulation; (f) development and transferring of three diagnostic kits for detection of HIV-I & II, a therapeutic vaccine for leprosy, (Leprovac) and a drug delivery system for systemic fungal infections transferred to industry; (g) setting up of a biotechnology facility in the North East for popularisation of tissue culture technology and producing sufficient quantity of planting material for the region; (h) setting up of Golden Jubilee Biotechnology Park for women at Chennai and Bio-Village in Gujarat for economic development; (i) developing of four low cost nutrient food supplements through biotechnological approaches; (j) developing of the process know-how and making it available to the industry for maintenance of culture and production of spawns, commercial production and dehydration of Oyster Mushroom; (k) completion of Phase-III clinical trials on patients having systemic fungal diseases and Phase-II clinical trials on patients having leishmaniasis and transferring it to industry for commercialization.

33. The autonomous institutions like National Institute of Immunology (NII), New Delhi, National Centre for Cell Science (NCCS), Pune, and Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad, have been contributing through basic research and several leads have been obtained resulting in publications, patents and technology transfers which include transfer of technology for anti-leprosy vaccine and HIV detection tests, large scale expansion of human skin in culture for the treatment of burns, etc.. Two new autonomous institutions were also established, namely, National Centre for Plant Genome Research and National Brain Research Centre at New Delhi. Four Jai Vigyan S&T mission projects have been initiated in areas of herbal product development, genomic database, coffee improvement and new vaccine development for important communicable diseases.

Salient achievements :

- Development of pest resistant transgenic cotton, marker for high quality wheat, hybrid mustard seed.
- Technology transfer for producing myccorhizal biofertiliser & tissue culture protocols for eucalyptus, sugarcane & populus.
- Diagnostic kits for detection of HIV-I & II, a therapeutic vaccine for leprosy (Leprovac) and a drug delivery system for systemic fungal infections transferred to industry.
- Standardisation of ETT technique in camel;
- Biotechnology parks set up in the North East for popularising tissue culture.
- Golden Jubilee biotechnology park for women at Chennai and a bio-village in Gujarat for economic development.

34. Many agencies like ICAR (Indian Council of Agriculture Research), CSIR and ICMR (Indian Council of Medical Research) are supporting bio-technology R&D programmes in addition to Department of Bio-Technology (DBT). There is already collaboration between DBT and these agencies through inter departmental expert task forces. It is nevertheless very necessary to identify specific thrust / programmes with clear identification of activities/areas among various departments/agencies for optimum utilization of scarce resources. Though the programme for biotech product development are being strengthened, the programmes relating to vaccines, diagnostics, biofertilisers, biopesticides need further strengthening. Efforts have been made for consolidation of the research results, validation, pilot level production, technology transfer and commercialisation. Greater emphasis is needed on the critical tasks of consolidation of research results for technology development and transfer and taking up R&D programmes which have potential for market oriented technology development so that benefits of these efforts are fully realized.

Ocean Development

35. The programmes of the Department of Ocean Development (DOD) are basically grouped as : basic research, strategic fields, technology development/scientific services

and societal programmes. Major activities are in the areas of (a) polar sciences, ((b) marine living and non-living resources, (c) marine environment and coastal zone management, (d) ocean observation and information services, (e) marine research and manpower development. Under basic research, projects have been implemented in collaboration with national laboratories, universities and educational institutions for development of potential drugs and chemicals from the marine organisms.

36. Antarctic Research and Polymetallic Nodules are two long-term programmes of DOD. So far, 19 scientific expeditions to Antarctica have been launched with strengthened logistics support from Maitri Station. A brewer Spectro-photometer was installed at Maitri Station to measure the ozone and trace gas contents. The activities of the Polymetallic Nodules Programme include : survey and exploration of Polymetallic Nodules in the Central Indian Ocean Basin, Environmental Impact Assessment Study, Technology Development for Mining of Nodules and Technology Development for Extraction of Metals. Spot sampling at a closer grid of 5 km was initiated in the identified blocks. A Remotely Operated Vehicle (ROV) capable of operating up to a 250- meter depth was designed, fabricated and field- tested. A pilot plant of metal extractive technology of 500 kg per day was designed and developed. Basic engineering and specifications of a mining complex module capable of operating at 6000 meter depth with a mining capacity of 25,000 tonnes of nodules per year is in progress.

37. Data products in the form of sea surface temperature, potential fishing zones maps and other ocean features like waves, upwelling zones, oceanic eddy information, chlorophyll and suspended sediment loads etc. have been generated and disseminated to potential users. Twelve Data Buoys for data collection on meteorological oceanography and environment have been deployed at select locations in the coastal/deep waters in Indian Ocean. Integrated Coastal and Marine Area Management (ICMAM) capacity building programme has initiated activities on development of GIS- based information system, determination of waste load allocation based on waste assimilation characteristics of select estuaries, development of model ICMAM plans for Chennai, Goa and the Gulf of Kutch.

38. A multi-disciplinary and multi-institutional programme for making an assessment of marine living resources beyond 70 metre depth within the Indian EEZ was initiated. Two hundred new marine flora and fauna have been collected and identified for chemical extraction and bio-evaluation; and bio-evaluation of 6 organisms possessing anti-viral, anti-diabetic, anti-cholesterol, anti-anxiolytic, wound healing and larvicidal activities completed. India ratified the UN Convention of the Law of the Seas in 1995 and the claim for extending the outer limits of India's continental shelf beyond 200 nautical miles of EEZ has to be made before the year 2005. Ocean Science and Technology Cells (OSTC) were set up in eight selected Universities located in the coastal states in the field of marine coastal ecology, marine geology and geophysics, marine micro-biology and marine culture systems.

39. Ocean Observation and Information Services programme being implemented for generation and dissemination of potential fishing zone maps should be based on the

demand/requirement of the user community. Benefits accruing from the programme therefore need to be quantified. The Ocean Science and Technology Cells being set up in various universities for generation of skilled manpower in specific field of ocean science need to be demand-driven, i.e. closely tied up with the demand of ocean scientists. The two long term programme viz.Antarctic Research and Polymetallic Nodules (PMN) programmes need to be critically examined in the light of experience and results obtained so far, and necessary mid-course corrections initiated accordingly.

Major achievements :

- 17th and 18th Scientific Expeditions to Antarctica launched.
- Spot sampling at a closer grit of 5 km initiated and 30 per cent pioneer area relinquished to the International Sea Bed Authority.
- 1MW gross and 600KW net Ocean Thermal Energy Conversion (OTEC plant) under construction
- A pilot plant of metal extractive technology of 500 kg per day is being established.
- The data products in the form of sea surface temperature, potential fishing zones maps and other ocean features like waves, upwelling zones, oceanic eddy information, chlorophyll and suspended sediment loads etc. generated and disseminated to the potential users.
- 12 Data Buoys for data collection on meteorological oceanography and environment have been deployed at selected locations in the coastal/deep waters in Indian Ocean.
- 200 new marine flora and collected and identified for chemical extraction for development of drugs of which bio-evaluation of 6 organisms possessing anti-viral, anti-diabetic, anti-cholesterol, anti-anxiolytic, wound healing and larvicidal activities completed.
- Ocean Science and Technology Cells (OSTC) set up in eight selected Universities located in the coastal states in the field of marine coastal ecology, marine geology and geophysics, marine micro-biology, marine culture systems, marine biology , marine benthos, placer deposits and under water engineering and robotics

Generic Issues Relating to S&T Sector : An Assessment

Policy Guidance Mechanisms

40. A three tier National Apex level S&T mechanism comprising Cabinet Committee on S&T (CCST), Science Advisory Committee to the Cabinet (SACC) and Committee of Secretaries for S&T (COS S&T) were in existence to provide policy directives, introduce the process of planning the programmes/ projects, setting priorities among the various S&T sectors and restructuring the S&T system to suit the changing needs. These mechanisms were non functional. Recently, National Apex level S&T mechanism has

been reconstituted and efforts are being made to evolve policy directives and implementation mechanism on various S&T matters including Technology Vision 2020. This mechanism needs to play a critical role so that institutionalized policy and implementation guidance could be evolved for harnessing Science and Technology for development of the various sectors of economy.

Applied Research & Technology Development

41. There is no doubt that significant achievements have been made over the years in various disciplines of science and technology. Primarily the efforts have been on promotion of basic research and scientific excellence by creating sophisticated infrastructural facilities in research and academic institutions. The technology development programmes appear to be significantly low. Although several technology spin-offs have taken place, final commercialisation and large scale use of the technology are yet to attain the desired level. Most of the research programmes irrespective of discipline require to be demand driven recognising importance of market mechanism so that the sophisticated research facilities and vast scientific and technological expertise could be utilised optimally for improving the quality and productivity of the goods and services.

S&T For Socio-Economic Development

42. For integrating S&T with the socio-economic development, Science and Technology Advisory Committees (STACs) were set up in as many as 24 ministries/ department besides an Inter-sectoral Science and Technology Advisory Committee to co-ordinate the S&T activities in the various development departments through STAC mechanism. Some of the STACs are very effective and functional while others are ineffective and non-functional. STACs need to be encouraged to take up an active role in providing the technology and inputs necessary for the concerned sector. Greater initiative is needed in dovetailing new and innovative S&T in major sectors of development. The role of vast S&T infrastructure and scientific and technical manpower of the country need to be defined on the basis of the S&T-based programmes for creative employment, quality of life, improved environment and health.

Integration/Linkages Of Research Initiatives

43. The research programmes mainly in basic sciences are being supported by several departments without any integrated approach. There is need to evolve thrust area programmes in various disciplines of science for implementation by different agencies. This would ensure the focussed approach and avoid duplication. This mechanism may also ensure the follow-up of various research programmes toward development of technology by involving national research laboratories and industries. Greater involvement and linkages are required to promote basic research in universities and academic institutions, specially around outstanding scientists, with a focus on strengthening of infrastructural facilities.

Areas of attention :

- Reconstituted National Apex level S&T mechanism need to play a critical role in policy making and implementation guidance for S&T programmes.
- Research programmes should be demand driven recognizing the importance of market mechanism with greater participation and involvement of industries in R&D..
- Integration of S&T with Socio-Economic Ministries using STAC mechanism for harnessing S&T for development of various sectors. Successful S&T demonstration programmes needs to be tied up with the ongoing development programmes for better performance and higher returns.
- Active involvement and effective linkages of universities and academic institutions for basic sciences.
- Reorientation of research programmes with greater thrust on patenting besides creating awareness of IPR related issues.
- S&T manpower development needs immediate attention to deal with new and emerging technologies as well as to fill the gap in availability of specialised trained manpower.
- Research laboratories should be encouraged to seek certification under ISO/peer group standards for acquiring competitive edge.
- The S&T thrust in response to WTO needs to be focused on conformance to global standards particularly for IPR, quality assurance system and enabling the Indian industry to cope with the problems arising from fundamental and radical technological and trade changes.

Demonstration of Pilot Projects

44. Several science and society related demonstration and pilot projects are being pursued and there are success stories. But these are so insignificant that the impact is nearly invisible. A major bottleneck is the lack of tie-up of this type of programme with development sectors from the beginning. The science department must interface its science and society related programme with major development programmes like IRDP, (Integrated Rural Development Programme) TRYSEM (Training of Rural Youth for Self Employment) etc. so that innovative S&T based programme could be enmeshed for better performance and higher return.

Industry Funding Of R&D

45. So far as funding of the S&T programmes is concerned, it is primarily through budgetary support of the Government. At present, the industry is contributing only about 28% to the R&D expenditure and remaining 72% is being funded by the Government. However, it has been emphasised that S&T funding should be significantly increased through greater participation of the industry. In order to attract greater industry funding, national R&D institutions and laboratories should orient themselves in a greater measure

to address the needs of the industries and take up industry- specific problem- solving programmes.

Patents & IPR

46. In the areas of patent and protection of intellectual property rights, efforts have been made to create awareness among the country's scientists and technologists. The Patent Facilitating Centre (PFC) has been providing assistance in patenting inventions emanating from university-funded and government-funded programmes. PFC has set up seven Patent Information Centres in different States under the aegis of State S&T Councils. While efforts have helped create an overall awareness, a fire fighting approach seems to be prevailing to prevent others from securing intellectual property rights on manifestly Indian products. More needs to be done proactively to encourage patenting. India with its large S&T capabilities and facilities does not have any brand name in the market or any technology that is being exploited on a large scale at the international market. .

Manpower Development

47. Concerted efforts have been made over the years to promote various disciplines of science and technology and wide- ranging S&T infrastructure and capability have been developed. However, two of the most challenging areas namely manpower development and large scale applications/integration of S&T in various sectors of development should be the critical areas of focus. There is a large scale migration of students from India to other countries or from one career option to another resulting in non-availability of specialised and trained manpower in the field of S&T. A policy direction on manpower development to suit national requirements require urgent attention.

Strategic Concerns

48. There are also some strategic concerns particularly relating to restrictions on supply of technologies by the developed countries. While the resources are limited, there exists a need to continuously evaluate strategies of optimal utilisation and conservation of resources to deal with likely shortages in future. New technologies relating to materials and processing need to be continuously addressed. There also exists a need to assess requirements of equipment, products and services which fall under the category of strategic needs particularly technologies for the extraction of new energy sources and raw materials from diverse sources including the sea-bed.

Response To WTO Issues

49. On the S&T response to World Trade Organisation (WTO), two issues need immediate attention namely conformance to global standards particularly for IPR and quality assurance system and enabling the Indian industry to cope with the problems arising from fundamental and radical technological and trade changes. In order to deal

with the challenges posed by WTO, the S&T thrust need to be focused on (a) strengthening of Intellectual Property awareness, information, generation and exploitation mechanisms; (b) aligning of Quality Assurance Systems for S&T to international norms; (c) widening the innovation base through supporting non-formal and grass-root level innovation; (d) intensifying the funding of knowledge/ innovation- based industries; (e) exploring and initiating the export of S&T based services; and (f) deepening and strengthening linkages among and between different players in the innovation chain.

50. As against the total Ninth Five Year Plan Outlay of Rs. 12,022.17 crore under the Central sector for six scientific departments viz DAE (R&D), DST, DBT, DOD, DSIR/CSIR and DOS, the total anticipated expenditure during first three years of the Plan would be of the order of Rs. 6,550.56 crore at current prices and Rs. 5,771.26 crore at constant (1996-97) prices i.e nearly 48% of the Plan outlay. It is therefore highly unlikely that the total outlay would be utilized during the Plan period.

Progress of outlays/expenditure is given at Annexure 13 A.

Conclusion

51. The major thrust has been on harnessing of S&T for societal benefits, R&D programmes on mission mode, nurturing of outstanding scientists, establishing linkages between industry and research institutions/laboratories for the development of market technology , development of clean and eco-friendly technologies, awareness on technology marketing and IPR issues. . Concerted efforts have been made on strengthening R&D activities, S&T infrastructure in universities and academic institutions and promoting indigenous technology using STAC and IS-STAC mechanism. National Apex level S&T mechanism needs to play a critical role to provide policy directives and implementation guidance. The technology development programme should be demand-driven recognizing importance of market mechanism so that sophisticated research facilities and vast S&T expertise could be utilized optimally. There is need to evolve thrust area programmes in various disciplines of Science for implementation by different agencies to ensure focused approach and avoid duplication. The S&T funding needs to be significantly increased through greater participation of the industry. Although efforts have been made to promote various disciplines of S&T , the manpower development and large scale applications / integration of S&T in various sectors of development are areas of critical focus in the domain of S&T . The S&T thrust in response to WTO needs is to be focused on conformance to global standards particularly for IPR awareness, information, generation and exploitation mechanism and quality assurance system.

CENTRAL S&T DEPARTMENTS/AGENCIES

PROGRESS OF PLAN OUTLAY/EXPENDITURE

Annexure -A

(Rs.In crores)

Sr. No.	DEPARTMENTS	Ninth Plan Outlay 1997-02	Annual Plan (1997-98)				Annual Plan (1998-99)				Annual Plan (99-2000)				(97-2000)				2000-02 Balance	
			BE		ACT		BE		ACT		BE		AE		BE		AE			
			Current Price	Const. Price	Current Price	Const. Price	Current Price	Const. Price	Current Price @	Const. Price	Current Price	Const. Price	Current Price @	Const. Price	Current Price	Const. Price	Current Price	Const. Price	Current Price	Const. Price
1.	Department of Atomic Energy (R&D)	1500.00	225.00	212.99	173.93	164.64	300.00	265.89	243.08	215.44	325.00	271.74	370.21	309.54	850.00	750.61	787.22	689.62	712.78	810.38
2.	Department of Ocean Development	510.62	88.10	83.40	83.96	79.48	88.00	77.99	88.00	77.99	90.00	75.25	90.00	75.25	266.10	236.64	261.96	232.72	248.66	277.90
3.	Department of Science & Technology	1497.35	280.00	265.05	276.79	262.01	305.00	270.32	227.36	201.51	310.00	259.20	310.00	259.20	895.00	794.57	814.15	722.72	683.20	774.63
4.	Department of Biotechnology	675.00	107.00	101.29	85.23	80.68	107.00	94.83	100.81 *	89.35 *	110.00	91.97	110.00	91.97	324.00	288.09	296.04	262.00	378.96	413.00
5.	Department of Sci. & Indus. Research (Including CSIR)	1327.48	230.00	217.72	220.52	208.75	230.00	203.85	225.94	200.25	289.00	241.64	306.00	255.85	749.00	663.21	752.46	664.85	575.02	662.63
6.	Department of Space	6511.72	990.00	937.15	838.73	793.95	1381.00	1223.97	1281.00 *	1135.34 *	1519.00	1270.07	1519.00	1270.07	3890.00	3431.18	3638.73	3199.35	2872.99	3312.37
	Total S&T	12022.17	1920.10	1817.60	1679.16	1589.51	2411.00	2136.85	2166.19	1919.88	2643.00	2209.87	2705.21	2261.88	6974.10	6164.30	6550.56	5771.26	5471.61	6250.91

@' indicate figs. from plan proposal of Mid-term Appraisal of Ninth Plan.

*** indicate RE Fig.**