CHAPTER -10

SCIENCE AND TECHNOLOGY

10.1 Science and technology (S&T) is widely recognised as an important tool for fostering and strengthening the economic and social development of the country. India has made significant progress in various spheres of science and technology over the years and can now take pride in having a strong network of S&T institutions, trained manpower and an innovative knowledge base. Given the rapid pace of globalisation, fast-depleting material resources, increasing competition among nations and the growing need to protect intellectual property, the importance of strengthening the knowledge base is an important issue that needs to be recognised during the Tenth Plan. Recognising the global economic order, the focus of the Tenth Plan in the science and technology sector would be to: strengthen application-oriented research and development (R&D) for technology generation; promote human resource development, especially in terms of encouraging bright students to take up science as a career; encourage research in and application of S&T for forecasting, prevention and mitigation of natural hazards; integrate the developments in science and technology with all spheres of national activities; and harness S&T for improving livelihood, employment generation; environment protection and ecological security.

APPROACH AND THRUST

10.2 Recognising that in the globally integrated knowledge-based world, the comparative advantage is shifting to those with the capability of absorbing, assimilating and adopting the spectacular developments in S&T for national development, the Tenth Plan will give a special thrust to the sector by leveraging the strong institutional framework built up in post-independent India.

10.3 The approach in the Tenth Plan would be to lay greater emphasis on the development of indigenous technologies and focus on latest technologies available elsewhere. Significant efforts will be made in those areas where India has a competitive edge globally and where the benefits of S&T can percolate to people who have been denied these benefits so far. This will require emphasis on the development of innovative technologies to meet the country's needs and to preserve, protect and add value to indigenous resources and biodiversity and protect and preserve the country's rich traditional knowledge. Harnessing of the full range of technologies (traditional, conventional and modern) would go a long way in national development.

10.4 Indian exports today derive their competitive advantage on the basis of cheap labour and abundance of natural resources. The Indian export basket does not have a significant amount of technologically-intensive products. This situation needs to change. Therefore, emphasis would be on the export of high-tech products and export of technology.

10.5 The Tenth Plan will give high priority to technologies that are oriented towards human welfare. These include technologies that provide creative and cost-effective solutions in health services, population management, mitigating the effects of natural hazards, conservation of land, water and energy resources and their integrated management for sustainable development.

10.6 Human resource development in science and technology is an area of concern today. The declining popularity of science and the unwillingness among the youth to take up science as a career will jeopardise India's future. Imaginative and innovative programmes would need to be undertaken to attract the students to science and technology and enhance the number of young scientists.

10.7 Science is an endless frontier, a unique human activity without limits. During the Tenth Plan, massive support would be provided to basic research, especially in universities, so that India can contribute significantly towards advancing that frontier.

10.8 While building on the comparative advantage that India possess in the emerging areas of information technology (IT) and biotechnology, special attention would be given to agriculture and agro-based industries and infrastructure sectors like energy, transportation, communication and housing. S&T concerns will be integrated into various policies and programmes covering the economic, energy, environmental and other socio-economic sectors. This integration will be reflected in the identification of technological choices, the investments and the S&T interventions in the individual sectors. The approach will be to make S&T an essential component in the Plans and programmes of development sectors.

10.9 The following would be important focus areas during the Tenth Plan:

Interface Between Industry, R&D Institutions and Academia

10.10 S&T has enormous significance for economic growth at the macro level and for building business competitiveness at the micro level. Globalisation and liberalisation have thrown up immense opportunities and some challenges for S&T. In an increasingly competitive world, Indian industry needs the support of indigenous S&T in a big way. Over the past few years, it has been increasingly recognised that greater coordination and cooperation between industry on the one hand and the R&D/academic institutions on the other is necessary for facing these challenges and taking advantage of the opportunities offered.

10.11. At the macro level, S&T management should focus on meeting the needs of the nation (including industry), and encompass a wide spectrum of activities, namely basic research, applied research, technology transfer, design, development, fabrication, tests and trials, manufacturing, marketing, maintenance and product support during the life cycle. At the micro level, R&D institutions and the academia must move from R&D to R&D and Engineering so that the indigenous technology can meet the specific requirements of the Indian industry.

10.12 In the present liberalised, competitive environment, industry should pay much more attention to the external sources of technology and upgrade its technology through quantum leaps in technological inputs. It should anticipate and take advantage of technological changes to develop new products. Customers' experiences and preferences may project new demands, which will stimulate the development of newer technologies. Technology management for industry can, thus, be viewed as a continuous process.

10.13 In order to strengthen the interface between industry–R&D–academia and to enhance the level of industry participation, appropriate steps need to be taken at various levels by all concerned — Government, industry associations, R&D institutions and universities. The awareness of mutual strengths and requirements would require measures like: joint workshops/seminars and exhibitions; promotion of sandwich programmes involving attachment of students to an industry during their academic stints; establishment of sustained one-to-one linkages between R&D/ academic institutions and the industries located in a particular region; and setting up of accurate, up-to-date, reliable, realistic and user-friendly database on indigenous technological expertise/ infrastructure, S&T personnel, R&D programmes, technological breakthroughs and innovations etc. Encouraging the mobility of S&T personnel between industry and R&D/academic institutions would also be a thrust area. Academic institutions and R&D laboratories also need to organise appropriate training programmes for industry personnel in order to cater to the specific requirement of industry. Policy, procedures and systems should be reformed to encourage the academic faculty to accept contract/collaborative research for industry.

10.14 Technology transfer to industry would be another thrust area. R&D/academic institutions should give appropriate importance to design and product engineering aspects, the application and constant upgrading of the technology to be transferred. Interaction with the industry should not

end with technology transfer but the agency providing the technology must constantly interact with the user industry for problem solving, technology absorption, and improvement/ upgradation of the technology. Government and industry associations should work together for the establishment of independent test facilities for reliable quality-checks, calibration and also for technology validation. Establishment of Industry S&T Interface Institutions (ISTI), with technology management centres manned by qualified personnel, could also be considered, besides the establishment of S&T entrepreneurship parks, Technology Business Incubators, upgrading R&D infrastructure of the industry through consortiums of industry associations. Incentive/support measures would also need to be introduced for promoting the purchase of products developed through indigenous technologies.

Application of Science & Technology for the Society

10.15 There is an urgent need to make all-out efforts to ensure that appropriate research outputs, which can be put to use for the benefit of society, are generated and reach the people. It is, therefore, essential to evolve a mechanism and identify programmes for application of S&T for improving the quality of life of the people, particularly the weaker sections and women, for the development of rural areas to reduce regional imbalances and for inculcating scientific awareness among the masses. During the Tenth Plan, a mechanism would need to be instituted through which the scientific institutions/departments take stock each year of the industrial products developed and the impact of these on improvement in the quality of life in the rural areas, in terms of health and nutritional status, purchasing power potential and increasing knowledge and empowerment.

10.16 The S&T interventions must aim at providing simple, affordable scientific solutions, which help the individual save time and energy and augment income. The kind of technologies to be provided should be what people want rather than what someone else wants them to adopt. This approach would not only ensure acceptability of the technological innovations but would also help in inculcating a scientific temper amongst the masses. Technologies that aim at value addition in the products of cottage/small scale industry can play a vital role in improving their competitiveness. Broadly speaking, S&T can play important role in reaching IT to the remotest parts of the country by emphasising on computer literacy, making it accessible even to those not having formal education. The 'problem population' can thus be converted into a valuable 'human resource' through activity-oriented training and skill improvement, helping to develop entrepreneurship and facilitating self-employment by using new technologies. For this, it is important to involve people by working on scientific and research-based solutions for their long-term problems like drought, epidemics, drinking water shortage, nutrition, sanitation, health, housing etc. and other day to day problems including shift towards non-conventional energy sources and product packaging.

10.17 It is also important to find ways of making people cultivate the habit of using natural resources like wood, bamboo, medicinal plants etc. more judiciously through application of environmentally-clean technologies. In order to measure the success of these endeavours, the Research Audit Cells (RACs) may be set up not only to judge the merit of the R&D endeavors but also to weigh the claims of the developing agency. In order to optimise the impact of R&D efforts, there is a need to introduce a network approach amongst the various agencies involved in R&D. Information dissemination on useful technologies needs to be strengthened and the concept of Common Facility Centres needs to be introduced for motivating people to use various technologies for their benefit and to provide necessary assistance to the user groups on new technologies. These centres, which may be located close to the user groups as permanent service institutions, are expected to maintain both forward and backward linkages and provide a link between the user and the S&T agency.

10.18 Special emphasis would be given to identifying, promoting and supporting grass root innovations, adding value to them and disseminating them to ensure that the impact of such innovations is reflected in improved prospects of livelihood of a large number of people. Efforts would be made to scout for advanced time and energy-saving tools/ machineries and equipment available in other countries, their adaptation, motivation of

entrepreneurs to take up their manufacture and also encourage the innovators of advanced tools and equipments.

International Cooperation in S&T

10.19 International cooperation in science and technology is essentially a mechanism to enable interaction between scientific researchers to update and refine the knowledge base, develop advanced technology and to take mutual advantage of complementary scientific and technological capabilities. This helps in the creation of national science and technology assets through optimum utilisation of available resources. The aim is on building capability in terms of upgrading skills, modernisation of facilities and exchange of information. The thrust during the Tenth Plan would be on: participation in major international programmes; establishment of centres of excellence/international quality facilities by wooing non-resident Indian as well as foreign scientists to work in these institutions; intensification of cooperation with developing countries by offering fellowships to science and technology personnel from those countries to work and be trained in India; programmes for attracting talented young Indian researchers working abroad to work in Indian institutions or Swarnajayanti Fellowship, initiated in 1997; and also inviting foreign scientists to undertake research in Indian institutions and utilise international class facilities like the Giant Meter Radio Telescope in Pune, telescope facilities in Hanley in Ladakh etc. The Tenth Plan would also emphasise catalyzing technology development by establishing joint R&D centres for pre-commercial technology development; showcasing Indian expertise/technologies through exhibitions; integration of the S&T International Cooperation Programme with major national programmes like natural disaster mitigation, AIDS/cancer research, alternate energy sources, clean technologies; protection of intellectual property rights arising from joint research/cooperative projects; coordination of international S&T cooperation and management of the database/information system, enhancing S&T representation in Indian missions abroad etc. Some of the science and technology areas identified for international cooperation include: basic sciences, high performance ceramics, high performance polymers, nano-materials, nano-technology and nano-electronics, sensors, manufacturing technology, bionics, development of coupled atmosphere-ocean models for extended range prediction/climate prediction, global networking for natural disaster management, functional genomics and proteomics, diagnostics and vaccine research, plant and agricultural biotechnology, technologies for exploration and exploitation of ocean resources, training of scientists/technologists from developing countries in coastal zone studies, research in the ocean atmosphere coupled models with advanced countries, science popularisation/communication (like the establishment of a Chair) etc.

Human Resource Development in Science and Technology

10.20 Although there has been a phenomenal growth in the number of universities and colleges imparting science education, there has been a consistent decline in the percentage of school students opting for science after passing the higher secondary examinations, from 32 per cent in 1950 to 15 per cent now. There has also been a marked change in the profile of students taking up the science stream. Today, high school students opting for science are often those with low scores while in the past, those with high scores would opt for science. Even the majority of the meritorious 150 students selected for the mathematics, physics, chemistry and biology Olympiads do not opt for careers in the sciences. The drop-out rate among the research fellows qualifying the National Entrance Test (NET) is also a fairly high 35 per cent.

10.21 Human resource/manpower development assumes a special significance in the process of developing technological innovations as well as implementation of new technologies and finding solutions to problems arising during the process of modernisation. It is also a measure of the strength of the country as it contributes to socio-economic development. Development of S&T manpower depends on the quality of higher education in science and technology. Considerable strengthening of the scientific and technical manpower will be needed with the liberalisation of the economy and the thrust on science and technology programmes. This would be done by selectively nurturing excellence in S&T education; identifying talented students and motivating them

to take up science and technology as a career; providing avenues and opportunities for those engaged in the science and technology field to update and enhance their knowledge and skills; devising strategies to retain the best talents in active scientific work and involve the corporate sector in science education and R&D. All this will be achieved through setting up of specialised science institutes as centres of excellence on par with the Indian Institutes of Technology (IITs) and Indian Institutes of Management (IIMs); adoption of at least one school and one undergraduate college by each national laboratory; attracting talented students to R&D through an assured career opportunity scheme; and upgrading the knowledge base of teachers through the concept of floating academics on a regional basis in new emerging areas like genomics, bio-informatics, conducting polymers etc. Other measures will include: liberalisation of travel grants for attending conferences/seminars abroad, co-joint appointments with universities abroad; getting the corporate sector to sponsor chairs in specialised institutes and to adopt a school or college; providing graduate-level and postgraduate-level merit scholarships/fellowships from a central fund for netting young talented scientists etc.

ACHIEVEMENTS DURING NINTH FIVE YEAR PLAN

10.22 Some of the significant achievements made by the Central S&T departments/ agencies during the Ninth Plan are:

Department of Space

10.23 The major thrust of the space programme during the Ninth Plan has been towards strengthening the space-based services for the country's socio-economic development. One of the major targets set for the Ninth Plan in the launch vehicle area was the development of the Geosynchronous Satellite Launch Vehicle (GSLV) towards achieving self-reliance in launching the Indian National Satellite System (INSAT) satellites. The activities in earth observation systems were oriented towards building state-of-the-art satellite systems configured for applications related to the management of land and ocean resources, addressing both emerging national needs as well as global service requirements. In the area of satellite communication and meteorology, the efforts were directed towards augmenting the INSAT system with additional capacity and newer services through the development and launch of third generation INSAT satellites, based on demands voiced by the users. A number of studies and experiments were also planned in the areas of space science and environment. Besides, significant progress was made in the participation of industry, policy initiatives, international co-operation, commercialisation of space capabilities and human resource development.

10.24 The major milestones in the Indian Polar Satellite Launch Vehicle (PSLV) programme were the successful flight of PSLV-C1 on 29 September, 1997 carrying the Indian Remote Sensing Satellite (IRS), IRS-1D, into orbit, PSLV-C2 on 26 May, 1999 placing three satellites — Indian IRS-P4 (Oceansat) and two auxiliary foreign satellites TUBSAT (German) and KITSAT (Republic of Korea) — and PSLV-C3 on 22 October, 2001 carrying the Technology Experiment Satellite (TES) in addition to two foreign piggyback satellites like BIRD of Germany and PROBA of Belgium. All this strengthened India's capability to tap the vast global potential that exists in this field. The TES demonstrated advanced technologies for future high resolution imaging systems. The launch of IRS-P4 (Oceansat) has opened up new vistas for ocean development and coastal studies. The PSLV C2 and C3, apart from being commercial ventures, have established the multiple satellite and the multiple orbit launching capability of PSLV. The production of PSLV has now been taken up with substantial industry participation. Another major landmark in the Indian space programme was the successful launch of the first development flight, GSLV D1, carrying the Geo-stationary Satellite (GSAT) on 18 April, 2001. The GSLV project, with complex developments involving cryogenics, was a major step towards achieving self-reliance in launching the 2T INSAT type of satellite.

10.25 The launch of INSAT-2E, India's most advanced communication satellite, started in April 1999, INSAT-3B, the first in the third generation INSAT satellites, in March 2000 and the INSAT-3C in January, 2002 enhanced the capacity of INSAT's space segment for developmental and other applications like mobile communication

services. It also strengthened India's capability to successfully fabricate and operate the INSAT class of satellites.

10.26 The remote sensing applications have grown over the years to cover diverse themes as a part of the National Natural Resources Management System (NNRMS) for which the Department of Space is the nodal agency. The data from IRS satellites has played a vital role in implementing several national missions in key areas of social development. The network of international ground stations receiving the IRS data has been expanded with the addition of seven ground stations. Important applications of IRS data are in wasteland development; generation of developmental action plans for sustainable development for 175 problem districts; characterisation of the bio-diversity at landscape level in the bio-rich areas of the North Eastern Himalayas, Western Himalayas, Western Ghats and the Andaman and Nicobar Islands. Other applications include: landslide risk zoning using satellite maps along important tourist and pilgrim routes in Uttaranchal and Himachal Pradesh; national mission on drinking water; seasonal snowmelt runoff estimation; operationalisation of satellite remote sensing-based crop acreage and production estimation (CAPE). In addition, IRS data was also used in Coastal Regulation Zone (CRZ) mapping, environment impact analysis, wetland mapping, grassland mapping; disaster management support; forest cover mapping; drought monitoring; and flood monitoring, land use/land cover mapping; mineral targeting etc.

10.27 The INSAT, established in 1983 with the launch of INSAT-1B, is providing operational space services in the areas of telecommunication, television broadcasting and meteorology. INSAT-2E heralded new capabilities such as global beams and capacity lease to the international telecommunication organisation (INTELSAT). INSAT-2E is the most advanced satellite in INSAT-2 series and is a forerunner of the forthcoming INSAT-3 series. The INSAT-3B and INSAT-3C have augmented the private VSAT (very small aperture terminal) networks and the NICNET services. INSAT-3B provides fixed satellite services in extended C-band and Ku-bands and mobile satellite services in S-band. One of the transponders is also used for setting up the Education and Training Network in Andhra Pradesh. Work on INSAT 3A, 3E and 3D are also in progress. With the growth in the INSAT system, the application services have also been expanded to include additional Doordarshan channels/regional services and news gathering services, expansion of the VSAT networks for remote rural communication and business communications and educational channels. The application services also cover communication services in strategic applications, developmental communication networks in different states, mobile satellite services, internet services, search and rescue services, VSAT services using C band and extended-C band, meteorological services and a host of other services. One of the important applications of the INSAT system has been the satellite-based interactive network for rural development. Towards this end, a pilot project to demonstrate the developmental communications and training for rural development in the Jhabua district of Madhya Pradesh, has been successfully completed. Other services introduced in the INSAT system relate to tele-medicine for remote and rural areas and flood forecasting through 100 real time hydro-meteorological data collection platforms.

10.28 Another important initiative of the Ninth Plan was the setting up of a North-Eastern Space Applications Centre (NE-SAC) at Shillong as an autonomous body under the Department of Space to provide access to high technology space infrastructure for focussed development activities of the north-eastern states.

10.29 In the area of international co-operation, the Department of Space has acquired a significant role as a result of the recognition by other countries of India's achievements in the areas of satellite technology, space applications and the operational capability to launch satellites. A significant event was India playing host to the second ministerial conference on space applications for sustainable development on behalf of the United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP) in 1999. The conference adopted a Delhi Declaration which launched the second phase of ESCAP's regional space applications programme identifying common denominator projects under a minimum common programme of the region. At the initiative of UN, India has also established a Centre for Space

Science and Technology Education for Asia and the Pacific (CSSTE-AP) with a view to provide capacity- building opportunities in space science and technology for the countries in the region.

10.30 There has been significant progress in marketing of the space capabilities developed through the space programme. Two important achievements in this direction are the leasing of eleven 36MHz transponders on board INSAT-2E to INTELSAT and launching of four foreign satellites of Belgium, South Korea and Germany on board PSLV-C2/C3. Several other export contracts for providing space services and supply of space hardware have also been executed during the Plan period.

10.31 The Department of Space has also taken several policy initiatives. A policy framework for satellite communication in India including provisions for the use of INSAT capacity by the non-government sector and also provisions for the private sector to establish satellite systems has been approved by the Cabinet. A remote sensing data policy, taking cognizance of the issues relating to the availability of high resolution data for development purposes has also been drawn up. The Department is also working on the adoption of a map information policy with reference to the usage and digitisation of Survey of India toposheets. A National Spatial Data Infrastructure is also being conceptualised to provide access for the country's map information in computerised digital geographic information system (GIS) format to facilitate developmental planning and decision-making.

Department of Atomic Energy (R&D Sector)

10.32 The projects being pursued under the R&D sector of the Department of Atomic Energy (DAE) envisage comprehensive research in several areas related to nuclear energy and its applications. The programmes are being pursued by several constituent units and aided institutions. This sector provides much-needed research support to the peaceful applications of nuclear energy.

10.33 The nuclear power programme involves a long-term strategy for exploiting the indigenous nuclear fuel resources in the country. It consists of setting up of Pressurised Heavy Water Reactors (PHWRs) in the first stage, Fast Breeder Reactors (FBRs) in the second stage and Thorium-Based Reactors in the third stage. The first stage is already in the commercial domain and has demonstrated excellence in performance standards. However, sustained R&D support to continually upgrade technology for safe operation at high capacity factors, life extension and further improvement of economic viability will be an ongoing programme. Investments made in R&D in this area have resulted in India mastering all aspects of this difficult technology and the power reactors and fuel cycle facilities are operating satisfactorily.

10.34 All the technology objectives of the Fast Breeder Test Reactor have been realised and the reactor is operating satisfactorily with its advanced plutonium-uranium carbide fuel, far exceeding its originally stipulated performance standards. The design of the 500 MWe Prototype Fast Breeder Reactor (PFBR) is progressing well.

10.35 The Bhabha Atomic Research Centre (BARC), Mumbai, has made good progress in the design and development of the Advanced Heavy Water Reactor (AHWR), which aims to utilise the country's vast thorium reserves. The design of this reactor incorporates advanced safety features. Various activities are being pursued to ensure the completion of the detailed project design report. As a part of setting up of a critical facility for AHWR and 500 MWe PHWRs, detailed design of various systems has been completed and preliminary safety analysis report has been prepared. Process design and detailed engineering for the Advanced Reactor Experimental Facility have been completed.

10.36 BARC has contributed significantly towards the development of several control and instrumentation systems for the nuclear power plants being set up by Nuclear Power Corporation of India Limited (NPCIL). Systems developed by BARC include programmable digital comparator system, dual processor hot stand-by process control system, dual processor hot stand-by reactor regulating system, channel temperature monitoring system, on-power fuelling control system, and supervisory control and data acquisition system (SCADA). BARC has handed over three channel inspection systems (BARCIS) to NPCIL for their field use and operators from the sites have been trained

to operate the system. The ANUPUM Supercomputer developed by BARC is being continuously upgraded.

10.37 In the area of technology development for recycling of nuclear waste, a facility for the separation of Uranium-233 from thoria and thorium targets irradiated in the Dhruva and Cirus reactors has been completed and is undergoing commissioning trials. A waste immobilisation plant at Trombay for the treatment and immobilisation of high level waste from the reprocessing plant at Trombay has been commissioned. Revamping and refurbishing of waste management facilities at Trombay, Tarapur and Kalpakkam has made significant progress.

10.38 Indigenous efforts for the design and development of turbo-expanders, helium compressor, cryo-heat-exchangers and simulation rigs, which are critical equipment for decontamination and upgrading of heavy water, are in various stages of progress. Construction of a desalination plant at Kalpakkam to demonstrate the feasibility of coupling a desalination plant with a nuclear reactor is progressing well.

10.39 The radiation technology applications include health-care, agriculture, food preservation, industry and research. Important programmes under health care include: setting up of a Radiation Medicine Centre (RMC) at BARC, which has become the nucleus for the growth of nuclear medicine in the country; comprehensive treatment for cancer and allied diseases at the Tata Memorial Centre, Mumbai; a Regional Radiation Medicine Centre at Kolkata as a part of the Variable Energy Cyclotron Centre (VECC); radiation detection interface and software to estimate the percentage of labeling of radio-pharmaceuticals at RMC; besides upgrading/modernisation of major equipments like magnetic resonance imaging (MRI), X-ray machines, mammography, orthopatograph and ultrasonography machines.

10.40 Application of radiation to agriculture has resulted in the release of 22 improved varieties of seeds. Of these, black gram (urad) accounts for 95 per cent of the cultivation of pulses in Maharashtra. Applications of radiation technology for industry span a wide range including radiography, water hydrology, gamma scanning of process equipment, use of tracers to study sediment transport at ports and harbours, flow measurements etc. To enhance the analytical capabilities of the isotope hydrology laboratory, sophisticated instruments like computer-aided tomography facilities for advanced industrial non-destructive testing applications, isotope-processing facilities and shielded lead cell set up for development of radio-pharmaceuticals have been procured.

10.41 The areas that are receiving attention under technology development are lasers and accelerators. Besides the Synchrotron Radiation Source (SRS) Indus-1 at Centre for Advanced Technology (CAT), Indore, the second SRS, 2.2 GeV Indus-2, is being operationalised. In addition, few other accelerators are under development at CAT, which can be used for radiation processing of paper pulp, surface modifications, paint and resin curing and other industrial applications; and accelerators for radiation processing of agricultural products and sterilisation of the medical products. An Electron Beam (EB) Centre at Kharghar, Navi Mumbai is being set up in collaboration with the Society for Applied Microwave Electronic Engineering and Research (SAMEER) for further enhancement of facilities for the commercial application of EB irradiation. The heavy ion accelerator programme and the radioactive ion beam programme is also progressing well at VECC. The Laser Programme which has industrial and medical applications developed a surgical CO_2 laser system and a dozen of them have been supplied to various hospitals.

10.42 Important technologies transferred to other agencies include: development of finite element-based software package specially tailored to rotor dynamic analysis of turbo-pumps required for indigenous development of cryo-engines and Nickel-Titanium shape memory sleeves for the lightening insulator assembly for LCA; constricted arc plasma generator for testing strategic thermal protection systems for rocket motors and re-entry simulator devices; development of a pipe inspection gauge for monitoring the health of cross-country oil pipelines for Indian Oil Corporation etc.

Department of Biotechnology

10.43 The main thrust of the biotechnology programmes was on short-term and long-term research support for excellence, new products or processes, large-scale demonstrations, validation of R&D leads, involvement of user agencies and industries, technology development and transfer, innovations for patenting purposes and high quality research publications. Emphasis was also laid on establishing new centres of excellence, facilities, programme support in priority areas, expansion of bio-informatics network and human resource development. Efforts were made to ensure that biotechnology tools are utilised to harness the biological wealth for societal and economic benefit of the country on an environmentally sound basis. Some of the new initiatives in bio-technology research include: setting up of a national facility for virus diagnosis and quality control of plants raised by tissue culture; programme on genomics; bioprospecting of biological wealth; setting up of a Women's Biotechnology Park at Chennai; setting up of a Biovillage at Mocha at Porbandar in Gujarat; and setting up of a patent facilitating cell.

10.44 A major thrust has been given to product and process-oriented biotechnological R&D for application in agriculture, health sector and industry. Basic research was supported through R&D projects to develop expertise and understand basic biological processes for further applications in protein engineering, drug and molecular design, identified potential molecules for development of vaccines and diagnostics for infectious diseases. Some of the achievements in plant biotechnology are: the International Rice Genome Sequencing Programme; development of markers for high quality protein content; development of molecular methods for hybrid seed mustard; production of transgenic plants of tobacco with viral resistance etc.

10.45 Under the biofertilisers programme, technologies were transferred to four industries producing mycorrhizal and rhizobial biofertilisers for mass multiplication and distribution. Biopesticide formulation technologies have been transferred to the industry under the Integrated Pest Management programme.

10.46 In animal sciences, the embryo transfer technique in camels was standardised and a new protocol for camel superovulation was developed for the first time. Seven different types of transgenic mice carrying antibiotic markers, Hepatitis-B antigens, interleukin genes and other markers have been developed and a new rabies vaccine for animals has been produced and is being tested for technology transfer.

10.47 Considerable progress was made in the areas of bio-prospecting and molecular taxonomy, seri biotechnology, medicinal and aromatic plants, biodiversity conservation, medical and food biotechnology. Fourteen genetic clinics were established for providing molecular diagnosis and counselling for the common genetic disorders prevalent in the country. Powerful computational capability for handling large-scale human genome sequence data for functional genomics programme, robotic methodologies for genotyping and Polymerase Chain Reaction (PCR) based diagnostics for common genetic disorders have also been developed.

10.48 Four Jai Vigyan National S&T Missions in the areas of development of new generation vaccines, biotechnology for herbal product development, coffee improvement and establishment of mirror sites for genomics were launched. About 25 technologies have been transferred to different industries. These include, diagnostic kits for HIV, hepatitis, dengue, assessment of reproductive hormones, Japanese encephalitis, vaccines for leprosy, drug formulation for septic shock, plant tissue culture protocols, formulation of biofertilisers, high protein gene from *Amaranthus* and bioremediation technology for mine spoiled dumps and crude oil spillage.

10.49 Fifty five centres set up under the Bio-informatics Biotechnology Information System (BTIS) net and six interactive computer graphic facilities have continued to disseminate information to the researchers under the bioinformatics programme. The main focus of human resource development has been to generate highly trained scientists/students in large numbers through consolidation of 38 post-graduate, post-doctoral and one-year diploma courses and 19 additional courses including one-time support for strengthening post-graduate programmes.

10.50 Some significant contributions were made by the autonomous institutes in basic R&D of new products and technologies. At the National Institute of Immunology (NII), New Delhi, one Australian, two American and one Canadian patents were granted and a biosafety level-3 facility has been established. A number of studies conducted at National Centre for Cell Sciences (NCSS), Pune, on cell culture, tissue banking and engineering have resulted in the development of biocompatible synthetic matrices suitable for controlled drug release and immuno-isolation of islets and dermal equivalents for transplantation for burn patients. The Centre for DNA Finger-printing and Diagnostics (CDFD), Hyderabad, started a new born screening programme for diagnosing in born errors of metabolism. The National Brain Research Centre (NBRC), New Delhi, was established in 1999 with the main aim to undertake, aid, promote, guide and coordinate research in basic and clinical neuroscience. At the National Centre for Plant Genome Research (NCPGR), New Delhi, which started functioning from 1 April 1998, a novel gene has been used for generating transgenic plants of agronomic importance. The relevant technology has been transferred to Cadila Pharmaceuticals for industrial production of animal feed supplement.

10.51 During the Ninth Plan, the National Bioresource Development Board (NBDB) was set up under the chairmanship of the Minister of Science and Technology with the main objective of developing a policy framework for the effective application of biotechnological and related scientific approaches for R&D and sustainable utilisation of bioresources, especially for the development of new products and processes.

Department of Science and Technology

10.52 The activities of the Department of Science and Technology are primarily focussed towards scientific research, technology development, socio-economic development, scientific services, international cooperation and supporting autonomous S&T institutions.

10.53 Some of the major R&D programmes supported by the Department include: sub-Himalayan cenozoic sediment studies; macromolecular crystallography; bio-organic chemistry; Raman spectroscopy study on strongly correlated systems; laser application in high resolution molecular spectroscopy; non-accelerated particle physics; etc. A programme on drug development was initiated for promoting collaborative R&D in drugs and pharmaceuticals involving national laboratories, industry and academic institutions. Thirty research projects relating to new chemical entities/formulations to treat diseases like cancer, arthiritis, diarrhoea, gastritis, pancreatitis, tuberculosis, Hepatitis-B, rabies etc. were funded. Four national facilities for identification of the immuno-modulating potential of herbal products and extracts of natural origin, pharmacological testing, characterisation of crystals and medium throughput screening in different national laboratories were established.

10.54 Several major research facilities/centres of excellence and programmes were established during the Ninth Plan. These were: the National Centre for Computational Fluid Dynamics at IIT-Chennai; Technical Acoustics facility at the Indian Institute of Science (IISc), Bangalore; Laser Scanning Confocal Microscope Facility at the Banaras Hindu University (BHU), Varanasi; X-ray facility for Structural Biology at the IISc (along with DBT); National Single Crystal X-Ray Diffractometer Facility at the University of Hyderabad; cross flow turbine technology for microhydel application etc.

10.55 The Swarnajayanti Fellowships and the Kishore Vaigyanik Prothsahan Yojana were launched, with support from the IISc, IIT-Mumbai and the All India Institute of Medical Sciences, New Delhi. These programmes were aimed at encouraging young scientists, besides providing sophisticated analytical instruments such as ICP, WMR, EPR Mass Spectrometer XRD, TEM, SEM etc to the scientists from academic and research institutes and users from industries.

10.56 Technology development programmes have been pursued through the Technology Development Board, Technology Information Forecasting Assessment Council (TIFAC), New Delhi, and Advanced Research Centre, Hyderabad. The Technology Vision 2020 Reports published by TIFAC have, for the first time, documented new areas of S&T covering various science disciplines. Besides, it also released 31 reports on frontier

technologies like transgenic seeds, recombinant DNA products, bio-degradable plastics etc. TIFAC also facilitated networking of seven engineering/ research institutions with high performance computing facilities for taking up selected technology demonstration projects.

10.57 Keeping in view the importance of protection of intellectual property rights in the globalised world, a Patent Facilitating Centre (PFC) was set up in 1995 which has helped in generating patent awareness. Under the Technopreneur Promotion Programme (TePP) started jointly by the DST, Department of Scientific and Industrial Research (DSIR), and TIFAC, several projects relating to zeolite-based catalytic converter, next generation membrane oxygenerator etc. were supported.

10.58 Through the IS-STAC mechanism, 12 joint technology projects have been taken up in the areas of column flotation technology for ore benefaction and pilot plant for enrichment of helium from hydrothermal sources etc. As a means of promoting S&T for socio-economic development, Rural Technology Parks have been set up in the northeastern region. A number of need-based S&T projects were supported in several places including hilly regions in the farm and non-farm sector. These covered areas like: inland aquaculture, sustainable agriculture, solar/bio-mass-based energy devices/ systems, post harvest technologies, land-based activities, women's health, rural engineering etc. Three women's technology parks were also set up at Dehradun, Manipal and Barmer. A major breakthrough was achieved with the launching of a project on food security by installing a fish aggregation device in Andaman Island for the primitive tribal group.

10.59 Project-mode support to tackle state-specific problems was provided to the State S&T Councils. These projects related to: the problem of high mortality of broiler birds at Namakkal, Tamil Nadu; drying of large cardamom in Sikkim; documentation of medicinal plants in the Thar region of Rajasthan and in Madhya Pradesh; documentation of traditional fishing crafts and gears in Manipur; cultivation of ginseng by tissue culture technique in Manipur; use of hydrams for irrigation purpose in Himachal Pradesh; demonstration plants for cupola furnace in Bihar and solar passive housing technology in Manipur.

10.60 Under the S&T Communication and Popularisation Programme, four National Children's Science Congress (NCSC) were organised. A television serial *Kudratnama* on science and technology was also telecast and video programmes on different scientific topics exhibited. Under the NRDMS programmes, 15 GIS database centres were set up, Planning Atlas for some districts of Gujarat was prepared and coordinated programmes for ground water modeling, coastal zone management and conservation, and bio-geo database and ecological modeling were taken up.

10.61 Since the DST is a nodal department for international S&T cooperation, several programmes were undertaken in this area. These include: setting up of an Indo-US S&T Forum; launching of the Department of Science and Technology-National Science Foundation (DST-NSF) programme from 1999; supporting technology-oriented projects on surface engineering of components; steel for automobiles; special plastics processing and pharmaceuticals development under an Indo-German programme; and DST-DAAD project-based Personnel exchange Programme. In addition, several joint projects in the fields of advanced materials and manufacturing technologies, information technology etc. were taken up. Agreements were also concluded with the Third World Academy of Sciences (TWAS) and International Centre for Theoretical Physics (ICTP).

10.62 Scientific services in the areas of meteorology, survey and mapping have been provided to the user agencies through the Indian Meteorological Department (IMD), Survey of India (SOI), Dehradun, National Atlas and Thematic Mapping Organisation (NATMO), Kolkata and the National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi. Significant achievements of the IMD are: commissioning of two Doppler Radars at Chennai and Kolkata; installation of 10 High Wind Speed Recorders; Cyclone Warning Dissemination Systems; Current Weather Instrument System at the Ahmedabad and Guwahati airports; new instrument for measuring Runway Visual Range at the New Delhi and Kolkata airports; upgrading of the seismological network

through the establishment of a National Seismological Data Centre at New Delhi, which is connected online to the Global Seismological Network. In view of modern technologies and multi-disciplinary approach being adopted in the planning process, the SOI introduced digital cartography techniques in its circles and units to create Digital Cartographic Data Bases (DCDBs) from the topographical maps.

10.63 Thirteen DST-aided autonomous institutions continued their research activities and transfer of technologies to industries. Significant achievement of these institutions include: development of a folion spray beneficial to crop yield; development of laboratory-scale process for microbial detoxification of cyanide and metal-cyanide complexes; nano-structured semiconductor and CMR materials and devices; and establishment of the world's highest observatory for optical astronomy in the Himalayas. Professional science academies continued their efforts in promoting scientific activities such as publication and communication programmes in S&T and promotion of engineering education and research.

Department of Scientific and Industrial Research (DSIR) including Council of Scientific and Industrial Research (CSIR)

10.64 The DSIR has been providing project-based support to industries under the Programme Aimed at Technological Self Reliance (PATSER) for the development and demonstration of indigenous technologies. Thirty-five technology development and demonstration projects were completed in the Ninth Plan in the areas of digested organic supplement from agriculture waste, earth moving machinery, cold rolling mill, ginger oil-based on green ginger, upgradation of technology for solar photovoltaic cells, interactive voice response system, nuclear-based moisture and density gauge etc. These resulted in the commercialisation of products and processes and led to the filing of 20 patents. Thirty projects were taken up jointly with the DST under the TePP. In addition, recognition was given to 249 newly announced R&D units in industry and 104 non-commercial Scientific and Industrial Research Organisations (SIROs). Other activities of the DSIR included: publication of 50 quarterly newsletters and organising the annual national conference on in-house R&D in industry. The National Research Development Corporation (NRDC), New Delhi, continued its efforts on development and transfer of indigenous technology through invention and promotion programmes, particularly in the areas of biodegradable plastics, rice husk particle board, glucose bio-sensor, spirulina algae, glycol- based anti-freeze coolant, manufacture of shrimp food, etc. Central Electronics Ltd. (CEL), Sahibabad, was engaged in the development of technologies in the areas of solar photovoltaics, high throughput aluminium metallisation of Ultra High Efficiency (UHE) solar cells, switched mode power plant, new ferrite technology etc. The National Information System for Science & Technology (NISSAT) was further strengthened through sectoral information centres on food, drugs and pharmaceuticals, chemicals and textiles; setting up of the Value Added Patent Information System (VAPIS), and launching of 100 short-term courses on information science and technology.

Council of Scientific & Industrial Research (CSIR)

10.65 As a premier national R&D organisation, CSIR continued to provide through its 40 laboratories and 80 field centres, valuable scientific and industrial R&D not only for India's sustained development but also for meeting its strategic needs. Implementation of various programmes in the CSIR was done in accordance with a white paper on Vision 2001 and CSIR's mission statement that seeks to provide scientific industrial R&D to maximise economic, environmental and societal benefits. The important organisational reforms envisaged by CSIR are: organisational restructuring to enable CSIR to be more responsive to the customer and the market; linking R&D to the market place through alliances and networking; stimulating intellectual property management, both within the CSIR and outside; investing in select high quality science; and refurbishing the ageing human capital.

10.66 The broad achievements of CSIR include: the total external cash-flow for the 1997-2001 period crossed Rs. 1,000 crore and this catalysed industrial production to the tune of over Rs. 17,000 crore; filing of nearly 1,400 Indian patents and 650 foreign

patents and increasing the impact factor per research paper from 1.26 to 1.552.

10.67 The Ninth Plan programmes/activities of the CSIR were implemented in 16 broad sectors. These were: aerospace; biology and biotechnology; chemicals; drugs and pharmaceuticals; earth resources and natural hazards mitigation; ecology and environment; electronics and instrumentation; energy; food and food processing; housing and construction; information products; leather; machinery and equipment; minerals, metals and materials; rural development; and exports of R&D and services. Some of the significant achievements of CSIR in these sectors are: design fabrication and air worthiness testing of a 9-14 seater light transport aircraft; certification of the two-seater trainer aircraft – HANSA-3 designed and built by National Aerospace Laboratory (NAL), Bangalore, and commencement of commercial production. Other programmes were: development of several new products and processes like a versatile universal polymer support; a promising genotype of *Mentha arvensis* through cross-pollination of Gomti and Kalka varieties and its release for commercial cultivation; a new strain of Withania (Ashwagandha), yielding about 14 quintals of dry roots/hectare; catalyst-free esterification and transesterification of vegetable oils for the preparation of lubricants; mini refineries with capacities varying from 0.5 to 2.0 million tonnes per annum (MTPA) and self-contained, skid mounted, low cost and low maintenance units congenial for installation in any location. Other achievements were: a new anti-malarial drug (EMAL) and a new drug, Ablaquin for treatment of recurring malaria, now being manufactured and marketed by Nicholas Piramal India Ltd., Mumbai; Chamber Ventillation Technique using injection of high-pressure, highly stable nitrogen foam for the control of fires in the long wall panels in mines which was successfully used in putting out the fires in Jharia, Bihar; cokeless cupola, replacing coke by natural gas fuel in foundries and reducing the emissions of polluting gases; process for treatment of paper mill effluent water to separate the lignin; fluorescence-based prototype kit for detection of adulteration of mustard oil; a high quality synthesis system useful for the visually handicapped persons as a 'reading' machine as well as for information retrieval in railways/airlines/tourism industry and toys with voice synthesis; a technology for the display of vital flight parameters at about the pilot's eye level; an eco-friendly mining method known as wide stall mining without stowing, for optimal recovery of coal; a simple retrofit technology for conversion of two-stroke engines of petrol/diesel run three-wheelers to CNG-operable engines; pre-harvest and post-harvest technologies for export of mango, litchi, strawberry, guava and grapes; controlled/modified atmosphere storage of fruits and vegetables; process for extraction of ginger oil from fresh ginger; alternate building materials which utilise wastes and economise on energy and are eco-friendly; an Interlocking Concrete Block (ICB) pavement technique for special locations such as bus or container terminals, industrial roads, snow-bound regions as well as for rehabilitation of old concrete surfacing; powder x-ray diffractometer; an environment-friendly process for manufacture of synthetic rutile; a high homogeneity superconducting magnet with superconducting shims for radial and axial field corrections suitable for NMR spectrometer application; and a low cost online water purification system. A centralised unit for R&D on information products was also set up to convert the dispersed and non-digital databases of CSIR to merchandisable information products. In addition, a major coordinated drugs and pharmaceutical programme was mounted for the development and commercialisation of bioactive molecules that which will help to put in place state-of-art expertise and facilities for new drug design.

10.68 One of the important activities undertaken by the CSIR was the modernisation of various national laboratories by introducing some state-of-the-art instrumentation facilities. An important contribution made by CSIR under the S&T-HRD scheme was to foster, sustain and upgrade the stock of the highly specialised scientists, engineers and technologists required for R&D. The scheme has provided support to the academic community for research schemes, award of fellowships/ scholarships and scientists' pool placement.

Department of Ocean Development

10.69 The programmes and activities undertaken by the Department of Ocean Development during the Ninth Plan relate to sustainable and environment-friendly exploration and utilisation of

marine resources, both living and non-living. With a view to promoting polar science and as a treaty obligation, scientific expeditions to the Antarctica were undertaken on an annual basis. The activities undertaken during these expeditions included: commissioning of three component seismometer that recorded 360 seismic events; trial test of fuel cells and wind energy audit for application studies; mapping of seasonal variation of geomagnetic field and total magnetic field intensity; installation of two remote Automatic Weather Stations which recorded various surface energy flux; establishment of a permanent Global Positioning System (GPS) station; and a permanent environmental lab at Maitri.

10.70 Under the Drugs from Sea programme, six organisms possessing anti-diabetic, anti-diarrhoeal, anti-hyperlipidaemic, anti-anxiety, anti-cholesterol, anti-bacterial and larvicidal properties were identified and 84 compounds having interesting biological activity and novel chemical structure were isolated. The activities under marine living resources programme include: acquisition of benchmark data on marine benthos in the shelf waters of India to undertake studies on the impact of bottom trawling on marine benthos. Systematic collection of environment and productivity data of the exclusive economic zone for summer, winter and inter-monsoon periods was also undertaken for possible correlations with fluctuations in the availability and distribution of living resources.

10.71 Survey and exploration in the Central Indian Ocean Basin (CIOB) mine site was continued for re-validation of relative concentration and quality characteristics of polymetallic nodules in different pre-determined blocks. As a part of its obligation as a pioneer investor, the Department relinquished 30 per cent of the allocated 1,50,000 sq. km. area to the International Sea Bed Authority (ISBA). An environmental impact assessment study was carried out at CIOB and the impact of disturbance in the test and reference site is being monitored periodically to ascertain the recolonisation effect of the benthic organism on the basis of the benthic disturbance.

10.72 As part of technology development for mining, demonstration of shallow bed mining technology at a depth of 420 m in open sea off Tuticorin was conducted in March 2000 in which slurry was pumped. An improved Remotely Operated Vehicle (ROV) system is also ready for test in waters upto 250 meters depth. The ROV is capable of inspecting underwater structures, pipelines, sampling etc. As a part of technology development for extractive metallurgy, a demonstration pilot plant was set up with a capacity of 500 kg/day. In order to revalidate the laboratory scale process package, demonstration campaigns were carried out at Regional Research Laboratory (RRL), Bhubneshwar and BARC.

10.73 Processing of data from the National Marine Data Centre on marine pollution at the Mumbai regional centre of the National Institute of Oceanography, Goa, was undertaken under the coastal and marine area management programme and the information was disseminated to the Pollution Control Boards whenever necessary. Under the Integrated Coastal and Marine Area Management (ICMAM) programme, GIS-based critical habitat information system was developed for the Pichavaram mangroves, Gulf of Mannar, and Kadamat, Malvan and Gahirmata (Lakshadweep) and environment impact assessment guidelines were formulated for major coastal developmental activities and processes like construction of ports and harbours. In addition, assimilative capacity was determined for the Tapi estuary in Gujarat and Ennore creek near Chennai in Tamil Nadu.

10.74 Ocean Observation and Information Services were carried out by deploying the moored buoys, drifting buoys, current meter arrays for undertaking studies on oceanographic processes and validation of satellite data. An autonomous centre, the Indian National Centre for Ocean Information Services (INCOIS), was established at Hyderabad to cater to the need for generating and disseminating quality data and data products. Fifty units of Integrated Fish Finder cum Navigation Guidance System (IFFNGS) were distributed in West Bengal, Orissa, Maharashtra, Pondicherry, Andaman and Nicobar Islands, Gujarat and Lakshadweep under the Coastal Community Programmes (Societal Programmes). These programmes were taken up by the Department of Ocean Development for locating fishing shoals and the position of fishing vessels in the sea. The Potential Fishing Zone (PFZ) advisories were also

generated regularly and disseminated on a bi-weekly basis. The Department has also been assisting various institutions and universities to create infrastructure facilities, taking up research and building up a skilled human resource base in marine sciences.

10.75 The National Institute of Ocean Technology (NIOT), Chennai, completed the testing of a OTEC pilot plant of a capacity of 1 MW, undertook the work on design and manufacture of an underwater thruster of 800 W power rating and 140 mm diameter for operations at 1,000 metre depth and an underwater connector suitable for operations at 1,000 metre depth in coastal and environmental engineering. It also took up indigenous development of instruments/hardware for marine and oceanographic use. To create ocean awareness among the public, the Department participated in a number of fairs/exhibitions and funded various seminars, conferences, workshops etc.

10.76 Several activities were undertaken to promote international cooperation and fulfill international obligation. India participated in meetings of the International Seabed Authority and the Antarctic Treaty Consultative Committee. It also participated in the programmes of the Commission on Conservation of Antarctic Marine Living Resources, Scientific Committee on Antarctic Research, International Oceanographic Commission, Regional Seas and Independent World Commission on Oceans. In additon, it signed MoUs with a number of bilateral organisations for undertaking joint ocean-related programmes. The Department's efforts lead to the International Seabed Authority finally approving India's application for work for the exploration of polymetallic nodules in the pioneer area.

TENTH FIVE YEAR PLAN PROGRAMMES

10.77 In order to achieve the goals envisaged for the Tenth Plan, efforts would be made to build upon the strengths of the country's S&T system and address its weaknesses. While the S&T system is robust and has a graded organisational structure, lack of linkages with industry has resulted in R&D being largely academic in nature, with very few applications and very little commercialisation and patenting. Although the S&T infrastructure facilities in strategic areas as well as areas of basic sciences have been strengthened significantly over the years, it is not robust enough to take on the national challenges in some of the key areas. There is also the problem of obsolescence in a large number of our research laboratories and academic institutions, since the scientific instruments are changing at a very fast pace and have a much shorter shelf life. India has also demonstrated its strength in several areas of R&D which has led to the country achieving self-sufficiency in food grain production; eradication of communicable diseases like small pox and plague, substantial decrease in the infant mortality rate and increase in life expectancy; and the development of indigenous technologies and their commercialisation particularly in health, engineering, drugs, agriculture, electrical systems; etc. In the strategic sectors, India has demonstrated its capability to build and operate nuclear reactors, including FBRs, build and launch satellites including cryogenic technology for GSLV, and application of space technology for resource management, meteorological services etc. India has also emerged as a significant basic research power, with world-class scientists in almost all areas of basic research, a fact that is reflected in the quality and number of publications. Our scientists have built world-class facilities like Giant Metre Wave Radio Telescope (GMRT), Variable Energy Cyclotron, Synchrotron Radiation Sources etc. and are also in the process of building superconducting cyclotron and a superconducting steady state Tokamak. At the international level, India is now participating as an equal partner in several front-ranking experiments like the compact mono solenoid (CMS) experiment and a large ion collider experiment (ALICE) experiment at European Organisation for Nuclear research, CERN, Geneva, experiments at Fermilab in the United States and RIKEN and KEK in Japan etc. However, India's strength in R&D has not translated into commensurate benefits for society due to lack of a sufficient number of competent scientists working in the areas of technological innovation and commercialisation. Barring some landmarks like GMRT and developments in the strategic sectors, the instrumentation activities, particularly machineries and equipment, have been declining. India's failure to compete technologically with the developed world has resulted in outright

import of machineries and equipment. Further, the Government has so far been the main source of funding S&T activities in the country. This needs to be significantly supplemented by the industry. Therefore, the focus during the Tenth Plan would be on important areas of basic research, technology development, demonstration and dissemination including strengthening and creation of infrastructural facilities, development of skilled and trained manpower and providing technology for societal benefits in the fields of space sciences, nuclear sciences, ocean sciences, biotechnology, scientific and industrial research and science and technology. The Salient features of the thrust of the Tenth Plan and related programmes in each of these sectors are:

Space Science

10.78 The primary objective of the space programme has been to establish operational space services in a self-reliant manner in the areas of satellite communications; satellite-based information for the management of natural resources and meteorological applications through indigenous development of satellites, launch vehicles and associated ground segment. The thrust will be on the development of space technology and large-scale applications of this technology in priority areas to act as a catalyst for economic development, a tool for enhancing the quality of human resources and to strengthen national security. Technology advancement, which is essential to maintain competitive relevance, will be an important thrust area for future space endeavours. Considering the expected multi-fold increases in the demand for space services in the years to come, concerted efforts will be planned to identify and develop industries to meet the production capacity requirements. Suitable policy initiatives would be taken to promote industry participation in the space programme. The focus will be to substantially enhance the participation of industries from a mere fabrication/production function to assembly and testing at system/ subsystem level with the overall goal of realising the 'produced, tested and accepted' space systems and services from industry in a 'ready-to-use' condition. The remote sensing applications have grown to cover diverse themes as a part of the NNRMS and the data from IRS satellites have played a vital role in implementing several national missions in key areas of social development.

10.79 With the broad vision of developing India as a leader in space technologies, the overall direction of the Space Programme, formulated within the framework of a Ten Year Profile (2001-2010), will be to consolidate the gains and build upon the achievements of the Ninth Plan. The major goals set by the Department of Space for the Tenth Plan are: to acquire new capabilities for space communications by positioning indian satellite systems – GRAMSAT and INSAT networks – for operational services; to maintain leadership in earth observations by positioning earth observation infrastructure to meet the national imaging demands and supporting the NNRMS and Disaster Management Support (DMS). The other areas of action will be developmental activities and improved weather and ocean state forecasting; major thrust for space transportation by regular production of PSLV, operationalising GSLV, upgrading launch capabilities and undertaking major R&D leading to future generation vehicles; to encourage space science enterprise by mobilising high quality scientific groups for advanced space science endeavours; to encourage spin-offs in human resource development and with industry and international partnerships.

10.80 The major objective of the satellite communications programme would be to develop a self-sustaining satellite-based communication network : GRAMSAT programme - for developmental communications, e-governance, tele-medicine, tele-education and rural development with the involvement of state governments and non-government organisations (NGOs). The INSAT system has five satellites — INSAT-2C, 2DT, 2E, 3B and 3C. With INSAT-2C and 2DT reaching the end of their life in 2002, INSAT- 3A and 3E are planned for launch in 2002-03. Thus, by the first year of the Tenth plan (2002-03), it is expected that INSAT-2E, INSAT-3B, 3C, 3A and 3E will be in service and remain operational throughout the Plan period. Together, they will provide a total capacity of 116 transponders. The fourth generation INSAT-4 satellite series, with a total capacity of 142 transponders, has been planned to meet the capacity and service requirements projected for the Tenth Plan. One of the primary considerations in

configuring the INSAT-4 has been the planned availability of GSLV Mk II with a lift-off capability of 2T satellite by 2003-04.

10.81 The meteorological services provided by the INSAT system are planned to be substantially enhanced with improved/new payloads as well as through establishment of dedicated meteorological satellites, METSATs. To provide backup for the crucial meteorological segment of INSAT, the first satellite, METSAT-1, carrying a Very High Resolution Radiometer (VHRR) and Data Relay Transponder (DRT) is planned for launch on board PSLV. The METSAT-2 satellite, carrying VHRR and DRT, is planned for launch on PSLV during 2004-05. This will also eventually be a replacement for METSAT-1. The other communication satellites that are scheduled to be launched during the Tenth Plan are: GSAT-3, GSAT-4 and Advanced Communication Satellite.

10.82 Within the framework of the long-term vision, the Indian Earth Observation Programme will continue to serve as the mainstay of the NNRMS. A disaster management support programme drawn up by the Indian Space Research Organisation (ISRO)/Department of Space will be implemented during the Tenth Plan. The programme, with special focus on the northeastern region involves: mapping and monitoring support; creation of thematic and cartographic information database for flood-prone and cyclone-prone areas and ortho-photomaps of earthquake-prone areas; demonstration of the applicability of GIS-based decision support system for disaster management; infrastructure, including networking facilities; R&D support etc.

10.83 Based on the launch vehicle requirement scenario and the long-term vision of the space transportation system, programmatic targets have been set. PSLV would remain the workhorse vehicle for earth observation and space science and meteorology satellites. The development flights and operationalisation of GSLV (Mk I and II) with indigenous cryo stage and the establishment of second launch pad at Sriharikota Range (SHAR) will be completed .The development of GSLV Mk III will be an important thrust area. It is also proposed to develop the critical technology base related to the Recoverable Launch Vehicle (RLV) and realisation of the proto unit of RLV technology demonstrator.

10.84 While bilateral and multilateral efforts to pursue international cooperation will continue, the major thrust will be on: space mission operations, meteorology, environment and humanitarian services such as Megha Tropiques; a cooperative satellite mission with Synthetic Aperture Radar; international charter on Space Disaster Management Support, Global Observing Strategy, Global Precipitation Mission etc.

10.85 Another thrust area would be organisational development and human resources. These would relate to: consolidation of core competences and enhanced outsourcing; reorientation of administrative systems and efficiency improvement; motivation, improving morale and maintaining organisational health; succession planning through induction and retention of talent; learning and knowledge management etc.

10.86 The major identified mission mode programmes would include: operationalisation of NNRMS, technology development for future generation launch vehicle, development of all-weather remote sensing technology, and application of space technology in education and health.

Nuclear Science

10.87 Nuclear science involves a chain of activities viz. research, development, demonstration and deployment of technologies, which has been a crucial factor in building a self-reliant capability in all aspects of the nuclear fuel cycle. Concerted efforts have been made in the field of nuclear science to carry forward the developments in advanced technologies in order to insulate the country from technology denial regimes. Since energy security is important for economic as well as strategic reasons, thorium-based nuclear energy systems will have to be a major component of the Indian energy mix in the longterm. Realising that India has to be in the lead in the development and deployment of thorium utilisation technologies, the future policy of the Department of Atomic Energy will be to build a strong indigenous R&D infrastructure as well as to marshal the trained scientific and engineering manpower in their future programmes.

10.88 India is pursuing a three-stage nuclear power programme which has been formulated to provide long-term energy security based on indigenous nuclear fuel resources. The programme envisages a closed fuel cycle involving reprocessing of the spent fuel to separate the fissile fuel for recycling. The focus would be on R&D to ensure that the technology does not become obsolete, the safety and economic competitiveness of nuclear power is continually improved, and capacity utilisation is maximised. Technology for the fuel cycle needs to be pursued along with the nuclear reactor technology with the objectives of: improvement in the existing technology for the enhancement in process performance; development of cross-cut technologies to merge nuclear reprocessing and waste management; development of new process and technologies to cater to the programmes involving FBR and AHWR fuel cycles etc. In addition, health, safety and environment programmes form an integral component of the entire spectrum of activities in the nuclear fuel cycle.

10.89 The Tenth Plan objectives in the field of nuclear sciences include: utilisation of thorium as fuel on a commercial scale; large-scale deployment of nuclear power; improving cost-efficiency as compared to alternate options for energy generation; attaining higher levels of safety through utilisation of inherent and passive safety features; utilising the proliferation resistant potential of the thorium fuel cycle to the fullest extent. It will also attempt to provide for adaptability to non-electrical applications, particularly desalination and high temperature processing applications, including those for generation of non-fossil fluid fuels.. Emphasis would also be laid on basic research in nuclear sciences and allied areas. This would cover frontier areas in physics (condensed matter physics, nuclear physics, plasma physics, astrophysics, accelerator and laser physics); in chemistry (radiation and photo-chemistry, laser chemistry, interfacial chemistry and chemical dynamics); in biology (molecular biology, radiation biology, genetics, cancer research); in agricultural sciences and food technology; and in mathematical and computer sciences. The radiation technology applications programme will continue to develop research reactors, accelerators and lasers and other advanced technologies. Important mission mode programmes would be identified in some of these areas. Recognising the long-term strategic necessity of ensuring the availability of adequate and quality human resource , emphasis would be laid on research-education linkages and evolving a mechanism to facilitate large-scale deployment of applications, especially in agriculture.

10.90 The first stage of the nuclear power programme started with the indigenous development of nuclear power plants based on uranium cycle in PHWRs. In the case of operating plants, continuing R&D will be deployed in some areas like ageing management, life extension, in-service-inspection, repair technologies which can carry all jobs remotely with minimum man-rem consumption and also in other programmes like progressive introduction of MOX fuel in the reactors at Tarapur. Technology for the front end and the back-end of the fuel cycle also will be pursued hand in hand with the nuclear reactor technology.

10.91 The second stage started with the FBR Programme at Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam utilising plutonium-based fuel. Improvements and upgradation in the technology will be an important part of the programme in the coming years. For irradiation of fuel and structural materials to be used in the fast reactors, various projects are to be pursued in the areas of physics and shielding, chemistry, materials, thermal hydraulics, structural mechanics, component development, fuel development, in-service-inspection, instrumentation and control and fuel cycle.

10.92 The third stage pertains to designing and developing advanced nuclear power systems that will utilise the plutonium resources in an optimum way to maximise conversion of thorium to ^{233}U, extract power in-situ from the thorium fuel, and recycle the bred ^{233}U in future reactors.

10.93 Keeping the objectives and the current international trends in nuclear technology in view, a roadmap has been drawn up for the third stage of the nuclear power programme. This involves four steps viz., development of AHWR for utilising thorium for commercial power generation; design and development of high temperature reactor-based power packs, mainly for process heat and non grid-

based electricity generation applications; Accelerator Driven Sub-critical Systems (ADS) to produce several times more electrical energy than that required to run the accelerator; and accelerator-driven system with a fast reactor sub-critical core, together with a mainly thorium-fuelled thermal core somewhat similar to that present in the AHWR.

10.94 Under the radiation technology application programme, one of the major activities to be initiated is the setting up of a research reactor for isotope production and associated isotope processing facilities at a new campus to be set up for BARC. Development of technologies for desalination will be given further impetus. Efforts to develop technologies for the production of strategic materials in the country will be intensified. The DAE will also initiate projects around all its installations for the deployment of technologies. Some examples are: farming for the production of breeder seeds using mutants developed by BARC; setting up of laboratory facilities for the production of saplings by tissue culture techniques for distribution to farmers in the area; any other technology which could provide improved means of livelihood to the people. For this purpose, land around nuclear installations will be utilised with the farmers and the DAE scientists working together.

10.95 The important mission mode programmes would be relating to the development of technology for utilisation of thorium, water desalination, nuclear medicine, and application of irradiation technology for farm products.

Ocean Science

10.96 The ocean science programmes in the Tenth Plan would be in the areas of exploratory survey, assessment and sustainable utilisation/ harnessing of the ocean resources (living and non-living) and renewable sources of ocean energy and technological advances geared towards the protection and preservation of the marine environment. Other programmes would cover development of technology relating to instrumentation, diving systems, position fixing, materials development, oceanic data collection devices, submersibles, etc.; developmental activities related to integrated coastal and marine area management, coastal community development, etc.; establishment of an ocean-related information system; international co-operation in ocean science and technology; development of technologies relating to seabed mining, extractive metallurgy and conducting environmental impact assessment studies. In addition, strengthening of front-ranking research in polar sciences through Antarctica expeditions; basic and applied research in ocean science and technology; human resource management; creation of centres of excellence in academic institutions; and public awareness on the potential uses of ocean would also be taken up. Drugs from the sea programme would be directed towards product development, commercialisation of the products and confirmation and optimisation of new leads already developed. Thrust would also be given to survey and exploration, mining and allied technology development and metallurgy of polymetallic nodules, and monitoring the health of coastal waters; management of the marine environment through capacity building using GIS for management of critical habitats; and development of a model for critical habitat information system and zonation of coastal waters etc. Indian National Centre for Ocean Information Service (INCOIS), Hyderabad will continue to process and disseminate data relating to ocean information to the user community involved in areas like fisheries, weather forecasting, climate, ports, shipping, etc. It will also take up development and issue of Ocean State Forecast. Emphasis would also be given on research in the areas of biological productivity, weather and climate studies, sea level variability, air-sea interaction, deep and bottom ocean circulation, bio-geochemical studies, technology development for energy and fresh water from sea, deep sea technologies including mining, technologies for coastal and off-shore applications, technology for data buoy and marine instrumentation system etc.

10.97 Several new initiatives are proposed to be undertaken in the Tenth Plan. These include: setting up of a second permanent station in the Antarctica; research programmes in Southern Ocean Oceanography and in Polar Environment and Ecology; biotechnological studies of Antarctica microbes and biodegradation of organic wastes by employing psychrophilic bacteria; bioluminescence and its significance in the Eastern Arabian Sea,

survey of marine mammals of Indian EEZ; Climate and Marine Fisheries, Assessment of tuna resources of the Indian exclusive economic zone (EEZ). Other activities will relate to: basic research on marine living resources; comprehensive systematic EEZ topographic surveys; marine biogeochemical studies; monitoring of harmful algal blooms (HAB) by setting up a regional centre for monitoring and surveillance of HAB in the Indian Ocean sector etc. A new multipurpose vessel for technology services and demonstration is proposed to be procured. Mission mode programme in the areas of technology development and demonstration of drugs from the sea, technology development of gas hydrates and large-scale technology demonstration of Ocean Thermal Energy Conversion (OTEC) plant would be initiated.

10.98 Under the Polymetallic Nodules Programme, survey and exploration, environment impact assessment, mining and allied technology development, and metallurgy will be continued. Bay of Bengal Fan (BENFAN) programme will also be taken up with emphasis on long coring of the sediments at selected locations. Comprehensive systematic EEZ topographic surveys using state-of-the-art multi-beam systems will be initiated to identifying areas for future detailed surveys for the non-living resources exploration. A strategy would then be evolved for comprehensive assessment of resource potential of the Indian EEZ including gas hydrates, cobalt crust, etc.

10.99 The existing stations for collection of near-shore samples identified under the Coastal Ocean Monitoring and Prediction System (COMAPS) programme will be more carefully planned to reflect the pollution load occurring close to the shore. The activities under Integrated Coastal and Marine Area Management (ICMAM) capacity building programmes funded by the World Bank, training to coastal states on the use of GIS and on critical habitat information system using GIS, and zoning of coastal waters will continue. As a pre-requisite for the preparation of ICMAM plans in selected areas, eco-system modelling studies which can be used for management of the shoreline land, particularly to control erosion and accretion, will be conducted. Other R&D activities in this area include: decision support system for management of small to large habitats, migratory patterns of turtles, long-term monitoring of pollutants, development of online pollutant detection system using sensors for hotspot areas etc.

10.100 Under the Ocean Observation Systems, the number of moored buoys would be increased to 40 with indigenisation of its prototypes. The number of drifting buoys would be increased to about 150, tide gauges to 34, besides 150 Array of Real Time Geostrophic Oceanography (ARGO) floats. Extended Bathy Thermograph (XBT) line would also be added. Development of algorithms, models etc. will continue to make full use of the newly planned Indian and foreign satellite missions such as Megha Tropiques, Oceansat-II etc. Consolidation of the ongoing efforts under the Indian Ocean Modeling and Dynamics (INDOMOD) for operational applications will be continued on a priority basis.

10.101 Under the ocean energy programme, modification of the 1 MW OTEC plant to function as a land-based or shelf-mounted plant for islands would be taken up. Deep sea technology activities include development of technologies for direct applications to shallow and deepwater mining and technology base for deepwater applications. The technology and necessary expertise for the exploration and recovery of gas hydrates will also be developed. National Institute of Ocean Technology (NIOT), Chennai would endeavor to have institutional cooperation/collaboration for technology development with reputed national and international research laboratories, academic institutions, international organisations and private R&D institutions. New initiatives include: development of wave-powered data buoys for offshore applications and establishment of a marine meteorology cell, and marine instrumentation and sensors calibration cell.

10.102 Under the Marine Research and Capacity Building and Ocean Awareness programme, Ocean Science and Technology Centres (OSTCs) will be further strengthened. Some of the new initiatives include training programmes for foreign students in India and taking ocean sciences to schools and to the common man.

10.103 The Department of Ocean Development would continue to participate in the meetings of the Law of the Sea, International Sea Bed Authority,

Antarctic Treaty System, Inter-governmental Oceanographic Commission and the Regional Seas Programme. It will also initiate bilateral scientific cooperation. Under the Southern Ocean Marine Living Resources programme, two cruises will be conducted for assessment of krill and tuna fish in the Indian Ocean sector of the Antarctic waters in collaboration with South Africa, Poland and Russia.

10.104 Two research vessels ORV Sagar Kanya and FORV Sagar Sampada, which are on the verge of becoming obsolete, would be upgraded/ renovated. In addition, it is also proposed to acquire/ construct a new multipurpose vessel for technology services and demonstration to serve as a platform for the programmes and as a utility science vessel, which will augment the capacity needed for the living and non-living marine resources programmes.

10.105 Since developments in the ocean sector have national, regional and global implications and the management of diversified programmes involving the Central and State Governments and their agencies is a complex task, an apex body – the Ocean Commission – on the lines of the Space Commission and Atomic Energy Commission is proposed to be set up.

10.106 Some of the mission mode programmes identified for the Tenth Plan include: (i) large scale technology demonstration of OTEC plant (ii) studies on exploration and technology development of gas hydrates (iii) ocean information service aimed at generation, analysis, modeling, product development and dissemination of ocean data and data products to users, and (iv) technology development and demonstration of drugs from the sea.

Biotechnology

10.107 India is well poised to embark upon biotechnology-based national development. The underlying assumption of the policy framework is that the developments in the field of biotechnology will have the greatest impact on food, nutrition, health, environment and livelihood security. The recent advances in many areas of biological research, notably genomics, cell biology, structural biology and molecular approaches to biological function hold great promise for future developments in biotechnology. Long-term support would be provided for basic biology research in areas related to infectious diseases, metabolic engineering, biomaterials, stem cell research, chemical ecology etc. by providing the necessary infrastructure and instrumentation facilities. Some important areas for research would be food and nutritional security; optimal utilisation of biological resources through biotechnological interventions; genomics; cost-effective, easy-to-administer and affordable healthcare regime, especially molecular medicine; biotechnological solutions for environmental issues like biodiversity conservation, and waste recycling and pollution abatement. Conversion of indigenous research leads into biotech products and processes would continue to be a major endeavour. This will be facilitated by instituting new academia-industry and private-public partnerships. Human resources needed for biology research and biotech development would be generated through specific programmes. The Department of Biotechnology's mission is to develop biotechnology as an intellectual enterprise, to provide the impetus to help utilise this knowledge for the benefit of mankind and to launch well-directed efforts for harnessing biotechnological tools for generation of products, processes and technologies that will enhance the efficiency and productivity of agriculture and forestry improve nutritional security, development of molecular medicine and environmentally safe technologies for pollution abatement, biodiversity conservation and bio-industrial development and creation of a strong infrastructure both for research and commercialisation of bio-products, bioprocesses and biotechnologies.

10.108 Concerted and long-term support would have to be provided to basic research in the new areas of modern biology and biotechnology and mechanisms to identify creative talents among the youth need to be established. Commercialisation of the knowledge base should be facilitated through simplification of some procedures and policies. These include: single window clearance mechanism for the biotech industry, especially based on recombinant DNA technology; venture capital funding to encourage large-scale production of biotech products, incubators or pilot plants through the joint efforts of the public and private sectors and tax holidays to publicly supported indigenous R&D. Bioscience enterprises will be identified and

encouraged in three major areas: agriculture, health-care and the environment. The commercialisation of bio-products will be encouraged by developing innovative policies in conjunction with other government departments and agencies. Besides the ongoing programmes on genetic counseling, emphasis would also be placed on genomics of humans, animals, plants and microbes, human genome diversity studies, molecular epidemiology; setting up of network facilities in at least four to five centres for high throughput screening, functional genomics, microarray and structural genomics, etc. The major funding for this would come from industry, with the Government providing only a nominal support. Major mission mode programmes would be initiated in the areas of genomics, new drugs and molecules from important medicinal plants, bio-resources characterisation, bio-fuels, new generation vaccines, food and nutritional security.

10.109 In the field of agriculture, biotechnology research will be used mainly in crop improvements for high export-value products through genetic modification of other crops or through in-vitro techniques. Other approaches in this field are: fine mapping of genome regions harbouring useful genes; developing transgenic biofertilisers; creating an awareness among farmers on the benefits of bio-pesticides and integrated pest management (IPM) technologies etc.

10.110 Research on plant biotechnology would be directed towards molecular and genetic phenomena associated with the process of infection, progression of disease (infectious and systemic) and the underlying pathology; metabolic engineering using recombinant DNA technology; characterisation of enzymes involved in carbon and nitrogen assimilation; plant tissue culture; bio-prospecting of wild plants; generation of a network programme on bioengineering of crops for Bio-fuels and Bio-energy; development of medicinal and aromatic plant crops with value addition in terms of proteins, minerals, vitamins and bio-molecules of therapeutic value and industrial use, genomics of selected medicinal and aromatic plants etc. In animal biotechnology, the focus will be on large animals and employment of newer techniques like cloning and stem cell derived animals (transformed and non-transformed).

10.111 In the area of aquaculture and marine biotechnology, a Marine Biotechnology Centre would be set up for research on novel enzymes, bio-remediation, extremophilic organisms, bio-medicals, genomics and proteomics of various marine organisms. The areas of focus for medical biotechnology research are: tuberculosis, HIV, malaria, cholera, Japanese encephalitis, edible vaccines, helicobactor pylori, rabies, cancer and drug delivery systems. The programmes will be prioritised taking into consideration criteria like disease burden, cost effectiveness of technologies and the potential utility of these technologies for community needs.

10.112 Broad areas of activity identified for genomics (human, animal, plant and microbial) are: computational genomics and genome-sequence data analysis, micro-array technology, structural genomics of humans and microbes, single-nucleotide polymorphism (SNP) analysis and pharmaco-genomics.

10.113 In the field of environment and biodiversity, the projects to be initiated relate to: collection, conservation and sustainable use of bio-diversity; bio-remediation, waste recycling and wasteland reclamation; development of biosensors, bio-indicators; phyto-remediation; and engineering of microbes for pesticide degradation, production of industrial and specialty chemicals, resource recovery and waste recycling etc.

10.114 Major new initiatives are also planned in the expanding area of bioinformatics. These include: dedicated high speed network for the BTIS net to achieve near-instantaneous access to the biological databases; setting up of teraflop supercomputer facilities for bioinformatics; establishment of a National Bioinformatics Institute for carrying out various activities like policy making; establishment of a Centre for Genome Informatics for carrying out research related to genomics and proteomics that include database mining, computational gene discovery, sequence similarity searching, gene expression analysis, etc.

10.115 Besides continuing the existing biotech facilities and repositories at various places, the new facilities to be set up pertain to: high field nuclear magnetic resonance (NMR) imaging facility, mass

spectrometry and microarray facilities at two to three centres; pilot plant facilities and biotech incubators for diagnostics; good manufacturing practices (GMP), facilities in collaboration with private industry participation etc. Biotechnology parks and biotechnology incubators will be set up in a few states in collaboration with the concerned State Governments. A few centres of excellence will also be set up in emerging areas such as: marine biology, high altitude biology, medical molecular biology, molecular ecology, invertebrate neurobiology and computational biology. To address biotechnology-related intellectual property rights (IPR) issues in a holistic manner, a Biotechnology–IPR Centre will be set up as an autonomous society under the DBT for organising training programmes and setting up of a Patent Information Networking System.

10.116 In the area of human resource development, support would be provided to 20 additional institutions and between 100 and 150 fellowships, besides instituting distinguished biotechnology professorships, biotechnology chairs and national bio-sciences career awards. Popularisation of biotechnology will be intensified through the mass media and co-curricular programmes. In order to attract a large number of small and medium scale biotech entrepreneurs, a Biotech Venture Capital Fund will be initiated in collaboration with organisations like the Small Industries Development Board (SIDBI), Industrial Development Bank of India (IDBI) etc.

10.117 While the existing programmes of international collaborations will continue, the focus for the initiatives will be on basic research in new biology for understanding molecular and genetic phenomena of pathogenesis in plants, animals and human beings; plant molecular biology; biosensor development; metabolic and tissue engineering; and product and process-oriented research involving scale up/ field trials and validations through technology transfer of both techniques and materials.

10.118 The autonomous institutes under the jurisdiction of DBT — NII, NCCS, CDFD, NBRC, NCPGR and the Institute for Bioresources and Sustainable Development (IBSD) — will continue to conduct research within the framework of the policy guidelines laid down for the Tenth Plan. Each of institutes will implement one or more Mission Mode programmes.

10.119 Mission Mode Programmes would be launched in the areas of genomics, development of new drugs and molecules from important medicinal plants with special emphasis on validation and standardisation of the active constituents already identified and bioresource characterisation and inventorisation and documentation of the endangered eco-system. They would also cover production, demonstration and testing of biofuels, development of new generation vaccines, and food and nutritional security through enhancement of crop productivity, value-addition and genetic engineering for enhanced nutritional status.

Scientific and Industrial Research

10.120 The plans and programmes relating to scientific and industrial research are implemented by the DSIR and CSIR. The DSIR is concerned with the promotion of industrial R&D, development of new technologies and processes, acquisition, management and export of technology and development of consultancy capabilities. The objectives/activities of the various programmes of DSIR covers financial support for SIROs, fellowship, traineeship and international R&D collaborations; support to new technology development projects; support to grass roots decentralised projects; support for technology innovations and resource centres and chairs in technology and innovation management; support for technology trade facilitation centres, technology counselors in developing countries and product design centres.

10.121 During the Tenth Plan, various programmes of DSIR relating to technology and R&D promotion in industries would be converged under one umbrella programme. In addition, support to the programmes of the NRDC and CEL would continue.

10.122 Important activities under the programme on technology and R&D promotion in industries include: recognition of new in-house R&D centres and SIROs; organising annual national conferences for presenting R&D awards to industries; approval of commercial R&D companies and in-house R&D centres u/s 35(2AB) of the Income Tax Act;

financial support to recognised SIROs; award of fellowships to selected meritorious research workers who opt to work in recognised R&D centres; assistance to small and large industrial units for international R&D collaborations; support to technology development projects in various areas; TePP; technology evaluation studies in important sectors/areas and marketing of technologies; workshops and seminars. In addition, technology development studies, studies on technology and innovation management and preparation of directories of foreign collaborations would also be supported.

10.123 The NRDC will continue to undertake the projects under two programmes — Invention Promotion Programme (IPP) and Technology Promotion Programme (TPP). In addition to awards, assistance to investors, publications etc, some new programmes have been proposed for IPP like organisation of Inventors' Clubs and exhibitions and revamping their publications to cater to the needs of the small-scale industry. Under the TPP, for the development and promotion of rural technologies, a demonstration-cum-operating centre will be set up near Delhi for demonstration of rural and household technologies. In order to promote the export of technologies, the NRDC will participate in international exhibitions/seminars/trade fairs and prepare multimedia compact disc presentations of technologies. Other measures under the TPP relate to: setting up a technology information-related portal covering information on indigenous and foreign technologies, IPR, R&D institutes and awards, training programmes etc.; interactive multimedia package on IPR; funding of technology development programmes in the areas of gene delivery systems, digital fountain clock, slow release spray of pesticides etc.; and providing loan/equity/convertible loan/grant to licensees of NRDC technologies, etc. CEL will continue to work on technologies relating to 250 micron thick silicon wafers for manufacturing solar cells, and manufacture of 125 mm and 150 mm pseudosquare multicrystalline solar cells. CEL would also initiate R&D work on thin film solar cells; photovoltaic products for use as building materials; strategic electronic equipments and systems so as to make this area of operation contribute to about 20 per cent to 30 per cent of the turnover; digital axle counter and other signalling and safety systems for Indian Railways and export; and hybrid remotely-operated PV systems for microwave repeater stations, and applications of piezo electric elements for defence and automobiles.

Council Of Scientific And Industrial Research (CSIR)

10.124 CSIR seeks to foster the values of excellence in science; global competitiveness in technology based on high science; local relevance in tune with socio-cultural and economic ethos of the people and innovation in all the spheres of activities ranging from science to technology management to financing. These principles, coupled with the results of a SWOT analysis carried out in CSIR laboratories, were taken into consideration in drawing up the opportunities for CSIR technologies in the market place. Accordingly, CSIR will seek to form strategic partnerships with Indian industry for innovative research; application and development of technology; commercialisation of technology; technology transfer, especially to SMEs and helping certain weak industrial sectors to regain their growth rates and become competitive globally.

10.125 Other factors which influenced the formulation of CSIR programmes for the Tenth Plan are: responsibilities arising out of the international IPR arena; continuous training and retraining of CSIR staff; advancement of knowledge through enlarging the scope of fellowships to trans-disciplinary areas and supporting basic research; and extension of S&T to the masses by involving the NGOs.

10.126 The focus of the CSIR would be to provide scientific industrial research and development that maximises the economic, environmental and societal benefits. The major thrust of the programmes would be on needs of and the opportunities in the market place; partnerships with industry for innovative R&D; development, application and technology transfer in areas that promote global competitiveness; technology based on high science and finding holistic and optimal solutions to the pressing problems of the nation. The core programmes include: high science and technology for national aerospace programmes; medicinal plant chemotypes for enhanced marker and value-added compounds; globally competitive chemical processes and products; development of speciality polymers; industrial waste minimisation and clean up; coal

preparation for quality enhancement; biomolecules; infectious diseases handling; design analysis and health assessment of special structures etc. The activities in the area of leather processing technology, leather product technology, leather environment technology, biotechnology in leather would be strengthened. Mission mode programmes would be launched in the areas of leather technology, carcass utilisation technology, design and development of civil aircraft, documentation of traditional knowledge, exploration and exploitation of the nation's microbial wealth, molecular biology of selected pathogen, evolving pollution monitoring system/devices for air /water /solid waste, microwave tube technology and rural technology.

10.127 The Tenth Plan programmes of the national laboratories have been formulated under 14 heads. These are: aerospace, biology and biotechnology, chemicals, earth resources and natural hazards mitigation, ecology and environment; electronics and instrumentation, energy, food and food processing, health-care and drugs and pharmaceuticals; housing and construction, information dissemination and products like leather, materials, minerals and metals and manufacturing.

10.128 Under the S&T human resource development programme, support to the CSIR Programme for Youth Leadership in Science scheme and Shyama Prasad Mukherjee fellowship scheme will continue. In addition, a 'training and motivation' programme will be initiated for selected science teachers. In order to attract youth to science and to promote interest, excitement and excellence in science education at the school and undergraduate levels, each CSIR laboratory will adopt at least one school and one college in its area. It will not only offer its facilities for project work and experimentation but also carry out student guidance and motivational programmes. Fellowships will be offered to researchers in trans-disciplinary areas and a spirit of entrepreneurship will be inculcated among research scholars through appropriate motivation, skills development and venture financing so they may establish their own R&D enterprises.

10.129 The IPR regime is presently in a state of flux and there are major unresolved issues with respect to 'traditional knowledge', 'genomic sequences', 'copyright on the Net' etc. National Institute of Science, Technology and Development Studies (NISTADS), New Delhi in CSIR has been mandated to coordinate this activity through enhancing the portfolio of foreign patents from 500 to 2,500 by the end of the Tenth Plan; identifying potential threats to and opportunities in the IPR regime; creating electronic/digital database on CSIR's intellectual property and knowledge- base holdings; developing educational programmes on intellectual property and technology management, etc.

10.130 During the Tenth Plan, CSIR has envisaged the establishment of an organisational Human Resources Development Centre at Ghaziabad as a follow up to the recommendations of the CSIR Review Committee in 1986. The Centre is expected to train around 600 senior personnel annually. Other activities under R&D management support include: partnerships that could add value to R&D activities in the national laboratories; popularisation of CSIR activities among masses through various media; and continuing support to the Unit for R&D in Information Products to catalyse and mobilise packaging of information products based on CSIR databases in order to make it self-sustaining.

10.131 The objective of the New Millenium India Technology Leadership Initiative (NMITLI) scheme, initiated in February 2000, is to help India capture the global leadership position in a few selected technology areas. In the first year of its operation, CSIR initiated nine 'proof of concept projects'. On completion, five of these projects will qualify for the next stage of specific product/process/application/ development and upscaling. Around 20 per cent of the funding for these projects will come from external sources. This scheme will enable India to acquire global leadership/monopoly position in at least three niche technology domains.

10.132 Programmes under infrastructure renovation and refurbishment include: internet connectivity to all laboratories through a national level Internet service provider (ISP) including Virtual Private Network (VPN) solutions to establish a CUG (Closed User Group) and refurbishing of the antiquated physical infrastructure which was built

or acquired more than thirty years ago. Some of the laboratories like the Central Drug Research Institute (CDRI), Lucknow, Central Food Technology Research Institute (CFTRI) Mysore, Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar etc. are housed in centuries-old palaces which were converted into laboratories by carrying out minor renovations. Most of the CSIR laboratories are not suited for modern day R&D especially in terms of good laboratory practices (GLP), International Standards Organisation (ISO), National Accreditation Board for Testing Laboratories (NABL) requirements for accreditation and certification. Also many buildings are dilapidated and unsafe and need renovation.

10.133 Mission mode programmes have also been identified in the design and development of civil aircraft like Stretched SARAS and HANSA; exploration and exploitation of the country's microbial wealth for novel compounds and bio-transformation processes; molecular biology of selected pathogens for drug targeting; study of mesozoic sediments for hydrocarbon exploration in coordination with the Department of Ocean Development; pollution control and monitoring system/devices for air, water and solid waste; development of microwave electron tube technologies for ultra high frequency communication for large-scale applications; development of technology for control of asthma resulting from pollution; standardisation, validation and introduction of newer scientific herbal preparations; setting up of a Traditional Knowledge Digital Library (TKDL) for tracking and storing comprehensive information and document on traditional knowledge; and environment-friendly leather processing technology, including carcass utilisation.

Science & Technology

10.134 It is widely recognised that long-term technological competence and international competitiveness can only come from a strong foundation of high quality basic research. While encouraging research in basic sciences, there is need to ensure that such research must be relevant to national priorities and goals. Above all, it should be geared towards stimulating economic growth. The broad strategy in this area would be according priority to synergy among science and technology, public policy and organisation in order to achieve the national goals; focussing on knowledge capital as a tool for faster economic development; reorganising the technology transfer systems to make them client-controlled and user-driven so that technology dissemination losses could be minimised; making efforts to fulfil the S&T vision in a socially relevant and participatory mode. Other elements of the strategy would be to raise the country's capability and excellence in science and technology relevant to long-term strategy for overall development; orient efforts towards finding solutions to poverty eradication, employment, environment and other related issues on a priority basis; evolve an integrated science plan focusing as much on population, education, gender, nutrition and environment as on production, sustainable growth and trade; enhance government and private investments in research over the next five years; accelerate national, regional and international collaboration for technology generation, assessment and transfer through information and communication technologies, while safeguarding against the attendant risks of globalisation. In order to get the maximum gains of science to society and the economy, it is necessary that a proper atmosphere be created for original and basic research and financial support provided for it. The decline of Indian contribution to this field has been a matter of deep concern. It is necessary to remember that there can be no high technology without high science and vice versa. Indeed, science provides new insights and approaches for technology development. It is, therefore, of utmost importance to create a strong edifice of basic research on which future aspirations of Indian S&T can be built.

10.135 India, with its rich intellectual capability, can be a leader in basic research, if proper strategic thinking, adequate funding and facilitating mechanisms are provided. If the problem of the dwindling number of young students opting for science and scientific R&D is not effectively addressed in the near future, India will cease to be a storehouse of quality technical manpower. Our national laboratories, universities and higher educational institutions have an aging faculty profile requiring infusion of quality young manpower. Secondly, adequate infrastructure for contemporary R&D is lacking even in national laboratories and is

almost absent in higher educational institutions. Systematic efforts need to be made to refurbish the R&D infrastructure for basic research, especially in the higher educational sector. Given its scope for generating sustainable livelihood and reducing pressure on timber resources, a comprehensive programme in the bamboo sector would be initiated to boost the usage of bamboo, promote specialised product development for commercialisation etc. The programme will identify the technology-oriented business opportunities for processing raw bamboo into value-added products and expedite their economic and marketing feasibilities. The areas identified for mission mode programmes would include: technology for bamboo products, drugs and pharmaceutical research, instrument development including development of machinery and equipments, seismology, nano science and technology business incubators.

10.136 The thrust of the Tenth Plan programmes of the DST would be on basic research, technology development, S&T manpower development, providing scientific services to the community and to undertake programmes relevant to societal needs. Within the framework of the broad strategy, some new initiatives will be taken. These will include: restructuring of Science & Engineering Research Council (SERC) into a National Science and Engineering Board (NSEB) as an autonomous body to provide directions to basic research; building strengths in a few chosen emerging S&T areas like system/integrative biology, nano-technology, synchrotron facility, 6 to 8 M optical telescope, molecular electronics; evolving a tripartite arrangement for the involvement of scientific agencies, national laboratories/IITs and universities to prepare an Integrated Manpower Development Programme; providing industrial research fellowships to promote interaction between industry and academic institutions; formulating a separate scheme for women scientists with either excellent scholastic record or good publications to their credit; promotion of India's capability to set up centres of excellence jointly with other countries through its bilateral S&T programmes; encouraging talented young Indian researchers working abroad to return by offering competitive career awards to work in Indian institutions of their choice in nationally important programmes; encouraging higher value addition activities and preservation of natural resources through the development and application of high technologies such as biotechnology, new materials, computers, telecommunications and information techniques and systems, micro-electronics, etc.

10.137 The SERC mechanism is a major programme under the R&D schemes. Though it has gained reputation among the scientists, it was felt that it requires a new system of governance, which ensures a greater freedom for choice of research areas, faster utilisation of funds and quicker disbursement to investigators. That is the reasoning for restructuring SERC into the NSEB. Several new national facilities will be set up, namely, Radioactive Ion Beam Facility, Crystal Growth Facility, Low Temperature and High Magnetic Fields Facilities, Biomedical Imaging and Spectroscopy Facilities, XRD and TEM facility, etc. Research centres will also be set up in the areas of non-linear and integrated optics, molecular manufacturing, bio-engineering, tissue engineering, etc. The scheme on Fund for Improvement of S&T Infrastructure in Academic and Related Institutions (FIST) will be continued and about 1,000 departments will receive support during the Tenth Plan. Another continuing scheme is the Young Scientists Programme which includes the Kishore Vaigyanik Protsahan Yojana, Schemes for Young Scientists, Boyscast, Swarnajayanti Fellowship for Basic Research and the Fast Track proposals for the Young Scientists (FAST TRACK). All these programmes will be brought under NSEB.

10.138 The other new initiatives of DST include: Patent facilitation scheme to create an awareness about the latest information on patents; creation of an NSEB Chair and providing emeritus scientist position to superannuated scientists etc. Flexibility in manpower deployment and enhancement of research fellowships will be introduced to attract more candidates to Junior Research Fellowships, Senior Research Fellowships, Post-Doctoral Fellowships (JRF/SRF/PDF). Other programmes relate to selective support to professional bodies for quality based activities; encouragement to the senior and young scientists in scientific events/ seminars by providing internal/international travel support; refurbishment of the Regional Scientific Instrumentation Centres (RSICs) to minimise obsolescence; expanding the scope of the National

S&T Management Information System (NSTMIS) to undertake activities relating to development of national level databases in selected S&T areas like R&D outputs leading to commercialisation, outcomes of extramural sponsored research projects, scientific manpower, scientific equipments & instruments, etc; national level study on commercialisation of patents; preparation of a national manual on the measurement of S&T activities; development of S&T indicators in the new knowledge economy etc. Some new initiatives will be taken under the seismicity programme in the light of the earthquakes disasters at Latur, Jabalpur and Bhuj.

10.139 The Technology Development Programme will be given a boost by undertaking activities relating to development of new and innovative technologies through national as well as international programmes and funding of multi-disciplinary, multi-institutional technology programmes in high, traditional and socially relevant areas and mega projects on infra-red detector, image processing, etc. A more interactive approach would be evolved by creation of a DST-IS-STAC Forum with the development departments/Ministries and creating an independent website covering the various STACs, their R&D efforts and S&T related policy issues, besides, replication and extending the existing activities of the Patent Facilitating Cell to more centres.

10.140 Under the drugs and pharmaceuticals research programme, several new projects relating to nutritional deficiency and related diseases —iron and protein deficiency, herbal drugs, new drug delivery systems etc. — would be initiated. Efforts will also be made to set up new national facilities for screening of anti-viral activity, combinatorial synthesis, high throughput screening, regulatory toxicology, clinical pharmacology, etc.

10.141 The ongoing activities of TIFAC like preparation of TIFAC reports, Technology Vision 2020 reports, homegrown technology programme etc. will continue.

10.142 In view of rapid globalisation and the growing need to protect intellectual property rights, the DST will give a new thrust to international S&T cooperation by encouraging participation of Indian scientists and the laboratories in the setting up of major facilities abroad, establishment of international class facilities within the country, intensification of cooperation with developing countries by offering fellowships etc., encouraging young Indian researchers working abroad to return, showcasing Indian expertise/technologies through exhibitions and ensuring linkages of international collaborations with large programmes like natural disaster mitigation, AIDS/cancer research, superconductivity, technology missions etc. In addition, R&D programmes would be initiated in a few focused national priority areas like high performance ceramics, nano materials, photonics, sensors, bionics, process engineering, exploitation of ocean resources etc.

10.143 The science and society programmes comprise need-based individual projects for technology development/modulation and demonstration where people's need for technology component and services will be given adequate attention. They will focus on the farm and non-farm sector, horticulture and processing techniques, inland aquaculture, modern nursery, solar/biomass-based energy devices/systems etc. Bamboo farming will be undertaken in the form of a technology mission. The programmes will be implemented at selected locations through networking of people and S&T-based field groups by linking them with S&T institutions.

10.144 The scheme on S&T for Women is aimed at empowerment of women through the introduction of S&T in the areas relating to technological needs of women. The focus of this scheme will be on increasing incomes and creating employment based on local resource; capacity building; inter-linkages with R&D institutions for promoting and sourcing technology for women; non-traditional occupations; etc. Some successful technology packages will be replicated in other locations as coordinated programmes through networking of local women, S&T-based field groups and S&T institutions, besides initiating a few multi-sectoral programmes for biomass utilisation, income generation and health issues of women and disaster management in these remote areas. Women Technology Parks will be set up in all the agro climatic zones of the country.

10.145 Efforts under the tribal sub-plan will be continued to undertake research, development and

demonstration in the traditional vocations for socio-economic upliftment and improving the quality of life of scheduled tribes. Some of the areas for research under the special component plan meant for the development of scheduled castes include coordinated programme on waste re-cycling and management; animal husbandry with reference to smaller animals; quality product from bio-mass; etc.

10.146 The NRDMS network will be expanded by setting up at least one district NRDMS centre in all states to expose the respective state governments to the methodology of NRDMS and train the administration in the adoption of the data-based approach for district level planning. Developments in the field of communication technology will be exploited to reach out to different groups with need-based science and technology.

10.147 Under the National Science and Technology Development Board (NSTEDB), the scope and contents of the newly-initiated scheme for the establishment of Technology Business Incubators (TBIs) will be enlarged to help in the development of knowledge intensive enterprises, new product development and innovative ideas. Special training programmes as well as awareness programmes will be organised in the fields of quality control, pollution and environmental control and IPRs, Besides adopting a cluster approach for modernisation through technology and design inputs and the possibility of setting up new enterprises would also be explored.

10.148 The National Centre for Medium Range Weather Forecasting (NCMRWF) will be further strengthened and encouraged to meet the ever-growing demands of weather forecasting through appropriate communication infrastructure for reaching out to the user community. The IMD will continue to emphasise on the major areas of Space Meteorology, Telecommunications, Cyclone Warning, aviation services, seismology and observational organisations by inducting the latest technologies, particularly by providing cutting-edge S&T in high value sectors. New programmes proposed to be undertaken by IMD pertain to: starting a commercial cell; establishment of a satellite based network of 1,000 stations for automatic collection of meteorological data for assimilation in numerical models in near-real-time and pursuance of scientific work to develop improved climate prediction models. Some of the important initiatives of the SOI include: introduction of dual series of topographical maps; upgradation of photogrammetric potential; establishment of National Geo-spatial Digital Infrastructure Centre; Airborne Laser Terrain Mapping Technology etc. NATMO's ongoing schemes like District Planning Maps; Economic Science and Technology Atlas and revision of the Forest Atlas of India, etc. will continue during the Tenth Plan.

10.149 The autonomous institutions under the DST will continue to pursue fundamental and applied research in various related areas; produce high quality manpower in unique and frontline areas of science and engineering and initiate work on upgradation of facilities. They will be modernised to undertake research at par with developed countries. The network of State S&T Councils will be further strengthened by continuing support with focus on S&T manpower, suitable career advancement of scientists working in S&T secretariats; identification, formulation and implementation of location-specific and multi-sectoral programmes in the states; etc.

THE PATH AHEAD

10.150 It is recognised that technology plays a pivotal role in national development. A three-pronged development strategy is called for covering societal transformation, wealth generation and knowledge/resource protection. For societal transformation, the focus should be on education, health-care, agriculture and governance. These will eventually lead to employment generation, higher industrial growth, higher national efficiency and productivity, empowerment of women, and rural prosperity. The important areas in relation to wealth generation include information technology and communication, biotechnology, space technology, materials technology, and oceanography. The service-driven areas include weather forecasting, disaster mitigation, tele-medicine, tele-education, infotainment, conventional and non-conventional energy, environment and ecology etc. In order to benefit from the potential of these areas, attention should also be given to the informal sector. This would not only accelerate the growth of gross domestic product (GDP) but would also help improve the quality of employment and increase incomes of workers in the informal sector.

Growth of knowledge society requires the development of capabilities for protecting the knowledge/resource and, therefore, involves areas like strengthening of intellectual property rights, protection of biological and microbial resources, protection of native knowledge and culture, protection of network and information generators from all kinds of electronic attacks.

10.151 The developmental strategy with technological-orientation should focus on meeting the needs of the nation, including industry, and encompass a wide spectrum of activities, namely basic research, applied research, technology transfer, design, development, fabrication, tests and trials, manufacturing, marketing, maintenance and product support during the life cycle. In the present liberalised environment, industry should pay much more attention to external sources and upgrade its technology through radical technology jumps. It should anticipate and take advantage of technological changes , acquire appropriate new technology depending on its business strategy and commercially exploit it to develop and produce new products for the competitive markets.

Tenth Plan Outlays for Science and Technology

10.152 The Plan outlays for the Central S&T Departments/Agencies and for the S&T in States and Union Territories under State Plan for the Tenth Plan are given in Annexure 10.1 and 10.2 respectively. Schemewise breakup of Tenth Plan outlays for the Central S&T Departments/Agencies is given at Appendix.

R&D IN INFORMATION TECHNOLOGY

10.153 Out of the total of 1,180 R&D units presently registered with the DSIR, there are about 300 units in electronics & IT. Some good institutions like the Central Electronics Engineering Research Institute (CEERI) Pilani, Electronic Research and Development Centres (ER&DCs), Centre for Development of Advanced Computing (C-DAC), SAMEER, IITs/ IISc, Optel, National Physical Laboratory (NPL), Electronics Corporation of India Ltd (ECIL) etc., have significant innovations in the field of electronics and IT to their credit. However, the present investment in R&D within the country is not on par with rest of the world.

10.154 Besides the public and private investment in R&D, a number of Central/State Government agencies like the Department of Information Technology, the DAE, DBT-, Department of Ocean Development, DST, CSIR, DRDO, Indian Council of Agricultural Research, Indian Council of Medical Research, ISRO, University Grants Commission (UGC) and others provide financial support for R&D at academic institutions, R&D laboratories and in the industry. These agencies play a catalytic role in scientific innovations for accelerating the pace of development and creating infrastructure to enhance the country's production capabilities.

Ninth Plan Review

10.155 Besides the Department of Space, DAE and DRDO, which have their own R&D programmes, other government agencies invested about Rs.200 crore on R&D programmes in electronics and IT annually during the Ninth Plan. These programmes have been able to help India establish a technological base besides generating specific products.

10.156 During the Ninth Plan, over 200 R&D projects were initiated at a number of institutions. Some of the areas where significant success has been achieved through sponsored R&D projects are:

- Future Air Navigation System (FANS) programme led to the development of GPS and Differential Global Positioning System (DGPS) and other airport modernisation equipment.
- Design and development of 'PARAM' series of Supercomputers by C-DAC.
- Design and development of meteorological instruments like Cyclone Warning Radar and MST Radar which was the third of its kind in the world.
- Development of diagnostic and therapeutic instruments for cancer therapy.
- Fibre optics systems such as fibre optic node controller, fibre optic railway signaling system, fibre optic remote terminal unit, etc. were developed.

- Development of technologies relating to e-commerce, IT security and e-governance. A Versatile Online Information System (VOICE) for the needs of citizen, civic administration and municipal corporations, etc., has been implemented in Andhra Pradesh.

- Prototyping of digital mobile radio for secure and reliable mobile communication with full duplex voice and option for encryption. Other major communication and broadcasting equipment developed are ultra high frequency (UHF) wireless data modems for high speed data communication and spread spectrum radio modem for various networking applications.

- Thirteen resource centres for Indian Language Technology Solutions covering all the languages listed in the Constitution were set up. Various information processing tools to facilitate human-machine interaction in Indian languages were developed.

- Retrofit automation for various manufacturing and process industries including computerised energy management, were developed and implemented.

- An indigenously developed 200 KV, 200 MW national high voltage direct current (HVDC) project was successfully implemented. A state-of-the-art digital SCADA system was implemented at the 1500 MW Singrauli-Rihand-Delhi HVDC project.

- Advanced software in the areas of intelligent computing, visual computing, internet technology, on-line education, etc., were developed.

- Application Specific Integrated Circuits (ASICs) for various applications were developed under the Microelectronics Development Programme.

- Various simple to operate agro-instruments like fertiliser testing kit, soil and grain moisture indicating instruments, soil nutrient measuring instruments, rice polish measurement have been developed.

Issues and Concerns

10.157 The IT industry is a highly knowledge and skill-intensive one and requires R&D on a regular basis. Most of the leading international players, especially those in Very Large Scale Integrated (VLSI) chip design, have set up their design and R&D centres in India. Some Indian companies have also made successful entry into global R&D services for developing world-class products. However, even though the software sector has done so well, the following concerns need to be addressed in the Tenth Plan:

- The software export industry has been mainly concentrating on the services sector. Here, the overall productivity, which is much lower than in the developed countries, needs to be increased.

- The IT services sector has been able to provide sustained growth over the last decade. In order to continue this, Indian industry needs to take immediate steps to move up the value chain.

- Though Indian professionals and the Indian software industry have contributed to the development of intellectual property, the Indian industry owns very few patents.

- The performance of the hardware industry has been below expectations.

10.158 For India to become an IT superpower, it is necessary that an integrated approach that boosts the hardware and software sectors, strengthens manufacturing and lays emphasis on education, R&D and generation of IPR is evolved and implemented.

Major Objectives and Initiatives- Tenth Plan

10.159 In line with the commitments required under the World Trade Organisation's Information

Technology Agreement (WTO-ITA), the IT sector would be brought to a zero duty regime by 2005. Therefore, it has become imperative for India to develop technologies, products and services of international cost and quality and become a global leader at least in some selected fields. Pursuing purposeful R&D is the only way to meet this challenge. However, we have to be careful not to fritter away our scarce financial and human resources by trying to tackle all the areas. The following classification and strategy is envisaged for R&D in IT:

- In the long-term R&D, the focus should be on key emerging subjects of basic research like nano-technologies, bio-informatics, etc., which are expected to be all pervasive and have far-reaching impact. Research in such technologies should be taken up in universities and reputed R&D laboratories.

- In the medium-term R&D, the focus should be on current technologies like high-end computing, wireless technologies, microelectronics, GPS hardware, Photonics, Microelectronic Mechanical Systems (MEMs), next generation internet, blue-tooth technology, high-end computing cyber security, robotics etc., which have mass deployment potential and would create necessary infrastructure for achieving accelerated growth. This would also enable us to apply these technologies for the development of new applications and upgrade existing products and services at a lower cost as compared to imported technologies. Medium-term R&D can be pursued at technical institutions / R&D centres and industries.

- In the short term R&D, the focus should be on improving products and reducing costs. Thrust areas identified for R&D in this category may be in technologies related to low cost personal computers, capital goods, GIS software, e-commerce, e-governance, e-learning, transport and safety, large database, multimedia, smart card, etc.

10.160 Apart from these, a number of R&D initiatives are proposed to be taken up in Tenth Plan. These include: Media Lab Asia, telemedicine, e-commerce and cyber security, IT application for visually handicapped, Internet-based distance education, IT for watershed development, IT for the masses etc. A few centres of excellence are proposed to be set up at the existing reputed institutions in the areas of nanoscale technologies, communications system and networking, multimedia, signal and image processing, speech recognition and synthesis for Indian languages.

Financial Resources

10.161 The Working Group on Information Technology for the Tenth Five Year Plan has observed that the IT industry needs to spend a minimum of 5 per cent of their revenue earnings on R&D to remain competitive. The Working Group has estimated a total R&D investment to the tune of Rs.3,400 crore per year to be shared by industry and Government in the ratio of 80:20. The R&D models can be designed based on the strategic value, gestation period, technology risk and commercial potential of the technologies. A few options for R&D funding are:

- The benefits of long-term R&D are uncertain and the gestation period could be more than 10 years. Such technologies may be unattractive for private sector funding and therefore, long term R&D will have to be funded by the government.

- The gestation period of the medium-term R&D could be three to six years. Development of such technologies should be funded by private sector enterprises with partial funds from the Government, if need be.

- The gestation period of short-term R&D projects is normally one to three years. Since these technologies have immediate commercial potential and, therefore, should be funded to a large extent by industry with minimum support from the government funds.

- The small and medium enterprises (SMEs) are neither able to set up their own R&D infrastructure nor retain high quality research professionals. The industry associations like Manufacturer's Association of Information Technology (MAIT), Confederation of Indian Industry (CII), National Association of Software and Services Companies (NASSCOM) etc., should come forward for creating proper linkages to share R&D between SMEs and large manufacturing industries with a view to enhance hardware production.

- International R&D cooperation needs to be utilised more effectively, especially in the areas of long-term and medium-terms research programmes. India should seek international cooperation in these areas, based on the strength of cooperating countries, institutions, research labs or industries.

Annexure-10.1

Central Scientific Department
Progress of Plan Expenditure

(Rupees in Crore)

S. No.	S&T Departments /Agencies	Ninth Plan 1997-02 Outlay	Annual Plan 1997-98		Annual Plan 1998-99		Annual Plan 1999-2000		Annual Plan 2000-01		Annual Plan 2001-02		Ninth Plan 1997-02 A.E.	Tenth Plan 2002-07 Outlay
			Outlay	Actuals	Outlay	Actuals	Outlay	Actuals	Outlay	Actuals	Outlay	RE		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Department of Atomic Energy (R&D Sector)	1,500.00	225.00	173.93	300.00	243.08	325.00	320.99	420.00	367.89	459.00	417.86	1523.75	3,443.00
2	Deptt. of Ocean Development	510.62	88.10	83.85	88.00	86.03	90.00	83.16	135.00	79.89	142.00	120.00	452.93	1,125.00
3	Deptt. of Science and Technology*	1,497.35	280.00	276.79	305.00	228.02	310.00	272.37	362.00	340.22	410.00	398.00	1515.40	3,400.00
4	Deptt. Of Bio-technology	675.00	107.00	85.23	107.00	104.46	110.00	116.46	125.00	140.90	175.00	175.00	622.05	1,450.00
5	Scientific & Industrial Research	1,327.48	230.00	220.53	230.00	222.50	289.00	270.98	355.00	314.84	360.00	340.42	1369.27	2,575.00
6	Department of Space	6,511.72	990.00	838.73	1,381.00	1,165.85	1519.00	1,424.24	1,700.00	1,593.98	1,710.00	1600.00	6622.80	1,3250.00
	Grand Total	**12,022.17**	**1,920.10**	**1,679.06**	**2,411.00**	**2,049.94**	**2,643.00**	**2,488.20**	**3,097.00**	**2,837.72**	**3,256.00**	**3051.28**	**12106.20**	**25,243.00**

*** :** Actual Expenditure & RE in respect of Department of Science and Technology is excluding Capital Works Component.

Annexure 10.2

S&T Plan Outlay/Expenditure for Ninth Plan (1997-2002) and Tenth Plan (2002-07) under State Plan

(Rs.in lakh)

S. No.	States/UTs	9th Plan (1997-2002) Outlay	1997-98 B.E.	1997-98 Actual	1998-99 B.E.	1998-99 Actual	99-2000 B.E.	99-2000 RE	2000-01 B.E.	2000-01 RE	2001-02 B.E.	2001-02 R.E.	Ninth Plan Anti. Expdr.	Tenth Plan Outlay
1	Andhra Pradesh	937.00	125.00	24.00	325.00	312.00	300.00	300.00	56.22	98.00*	20.00	96.00	830.00	500.00
2	Arunachal Pradesh	105.00	23.00	20.00	17.00	16.00	20.00	22.00	223.07	222.00	123.56!	124.00	404.80	420.00
3	Assam	1350.00	158.00	17.00	188.00	64.00	185.00	185.00	60.00	60.00	163.00	163.00	489.00	750.00
4	Bihar	2154.00@	2700.00	135.00	578.00	172.00	350.00	350.00	300.00	0.00	79.55	30.00	687.00	0.00
5	Chattisgarh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.00	47.00	300.00
6	Goa	308.00	40.00	28.00	30.00	28.00	30.00	50.00	65.00	56.00	25.00	25.00	187.00	175.00
7	Gujarat	3125.00	437.00	546.00	437.00	546.00	811.00$	811.00$	675.00$	272.00$	620.00$	6500.00$	8675.00	29835.00
8	Haryana	642.00	135.00	72.00	217.00	81.00	180.00	80.00	150.00	149.00	150.00	150.00	532.00	565.00
9	Himachal Pradesh	600.00	90.00	110.00	150.00*	141.00	148.00	103.00	146.00	146.00	N.A.	0.00	500.00	592.00
10	Jammu &Kashmir	320.00	64.00	30.00	81.00	40.00	604.15*	76.80	74.37	63.00	76.87	614.00	823.80	3619.00*
11	Jharkhand	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33000.00*
12	Karnataka	2500.00	249.00	272.00	238.00	232.00	234.00	252.49	170.00	167.00	156.00	156.00	1079.49	1293.00
13	Kerala	7500.00*	1400.00*	1203.00*	1700.00*	1710.00*	1780.00*	1780.00*	1885.00*	1900.00*	1750.00*	1750.00*	8343.00	12000.00**
14	Madhya.Pradesh	935.00	200.00	100.00	200.00	79.00	200.00	180.00	162.00	134.00	170.00	170.00	663.00	858.00
15	Maharashtra	885.00	157.00	64.00	397.00	367.00	362.00	362.00	181.30	347.00	200.00	145.00	1285.00	4325.00
16	Manipur	720.00	80.00	60.00	74.00	57.00	85.00	85.00	75.00	44.00	N.A.	223.00	469.00	1227.00
17	Maghalaya	450.00	70.00	49.00	70.00	59.00	93.00	155.00	93.00	88.00	93.00	93.00	444.00	515.00
18	Mizoram	291.00	65.00	54.00	74.00	42.00	90.00	90.00	90.00	90.00	110.00	110.00	386.00	513.00
19	Nagaland	400.00	29.00	18.00	25.00	19.00	225.00	221.00	17.00	45.00	32.00	32.00	335.00	350.00
20	Orissa	1655.00	283.00	201.00	300.00	768.00	526.00	404.48	215.68	1034.00	167.47	539.00	2946.48	2281.00@@
21	Punjab	3619.00	150.00	25.00	303.00	43.00	306.00	310.19	138.70	46.00	131.10	56.00	480.19	3303.00
22	Rajasthan	1051.00	250.00	130.00	235.00	188.00	185.00	105.00	100.00	96.00	60.00	60.00	579.00	753.00
23	Sikkim	800.00	50.00	50.00	58.00	58.00	87.00	78.00	70.00	80.00	N.A.	70.00	336.00	600.00
24	Tamil Nadu	2010.00	156.00	232.00	194.00	264.00	177.00	216.93	219.23	219.00	337.44	337.00	1268.93	4735.00
25	Tripura	222.00	40.00	43.00	37.00	38.00	43.00	43.61	27.81	29.00	100.00	42.00	195.61	904.00
26	Uttar Pradesh	3080.00	715.00	329.00	831.00	874.00	1051.00	205.00	462.00	400.00	462.00	462.00	2270.00	5950.00
27	Uttranchal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.00	0.00	60.00	87.00	304.00
28	West Bengal	988.01	221.00	124.00	265.00	218.00	270.00	170.00	155.00$	723.00$	329.30$	3753.00$	4988.00	13831.00
	Total States	**36647.01**	**7887.00**	**3936.00**	**7024.00**	**6416.00**	**8342.15**	**6636.50**	**5811.38**	**6535.00**	**5356.29**	**15807.00**	**39330.50**	**123498.00**

Annexure 10.2

S&T Plan Outlay/Expenditure for Ninth Plan (1997-2002) and Tenth Plan (2002-07) under State Plan

(Rs.in lakh)

S. No.	States/UTs	9th Plan (1997-2002) Outlay	1997-98 B.E.	1997-98 Actual	1998-99 B.E.	1998-99 Actual	99-2000 B.E.	99-2000 RE	2000-01 B.E.	2000-01 RE	2001-02 B.E.	2001-02 R.E.	Ninth Plan Anti. Expdr.	Tenth Plan Outlay
U.Ts.														
1	A&N Islands	199.85	28.26	22.93	66.00	25.19	60.00	14.00	20.00	22.44	20.00	20.00	104.56	212.00
2	Chandigarh	37.00	13.00	3.75	7.95	5.72	28.00	28.00	18.00	16.50	32.00	32.00	85.97	60.00
3	D & N Haveli	30.00	6.00	4.75	7.00	6.94	7.00	7.00	6.00	7.50	6.00	6.00	32.19	35.00
4	Delhi	15.00	1.00	6.07	3.00	13.63	5.00	5.00	4.00	50.00	5.00	385.00	459.70	700.00
5	Daman & Diu	47.00	14.00	8.45	15.00	8.17	9.00	9.00	22.00	9.81	10.00	10.00	45.43	80.00
6	Lakshadweep	643.81	83.05*	27.73	82.00*	28.22	35.56	35.56	35.57	39.33	41.00	37.24	168.08	307.64
7	Pondicherry	60.00	10.00	5.25	35.00	19.87	35.00	35.00	35.00	25.53	35.00	35.00	120.65	140.00
	Total UTs.	**1032.66**	**155.31**	**78.93**	**215.95**	**107.74**	**179.56**	**133.56**	**140.57**	**171.11**	**149.00**	**525.24**	**1116.58**	**1534.64**
	Grand Total	**37679.67**	**8042.31**	**4014.93**	**7239.95**	**6523.74**	**8521.71**	**6770.06**	**5951.95**	**6706.11**	**5505.29**	**16332.24**	**40347.08**	**125032.64**

* Including Ecology and Environment
@ excluding Technical Education
! Including earmarked outlay for TFC
$ excluding Information Technology.
N.A. Not Available
** Includes Information Technology
@@ Proposed Outlay