SCIENCE AND TECHNOLOGY

2.3.1 Science and technology is a vital tool for stimulating and strengthening the economic and social development of the country. During the Tenth Five-Year Plan, the science and technology (S&T) sector has focused on generating relevant innovative technologies; preserving, protecting and adding value to indigenous resources; adopting an appropriate mix of traditional, conventional and modern technologies; developing and nurturing human resource; strengthening basic research in areas of frontline science and; promoting S&T interventions in major socio-economic ministries and states so as to make them real stakeholders of S&T.

Financial Progress

2.3.2 The Tenth Plan outlay for the Central S&T departments/agencies is 6.2 per cent of the total Central sector budgetary support of the Plan. The progress of outlays/expenditure is given in Table 2.3.1. In terms of expenditure, progress in the first four years is broadly in line with the Plan.

2.3.3 The progress made by some of the major sectoral agencies towards achieving the Tenth Plan objectives and thrust, as well as the way forward required during the remaining Plan period, are briefly indicated below:

Nuclear Science

2.3.4 Efforts are being continued under the power sector programmes of the Department of Atomic Energy (DAE) for large-scale deployment of nuclear power in the country. The first stage of Indian nuclear power programme using pressurised heavy water reactor (PHWR) technology has already reached a mature state. The Bhabha Atomic Research Centre (BARC) is committed to providing R&D support to the nuclear power programme in terms of repair and life extension technologies, reactor control and regulating systems, etc. Improved project management techniques have helped to reduce the gestation period for PHWRs. From 8-10 years in the early 1990s, it now takes five years from the first pour of concrete to commercial operation. This has brought down the interest component during the construction period. The present

Table 2.3.1
Progress of Plan outlays/expenditure of Central S&T departments/ agencies during the Tenth Five-Year Plan

(Rs crore at 2001-02 prices)

S. No.	S&T departments/ agencies	Ninth Five-Year Plan 1997-2002		Tenth Plan outlay (2002-07)	2002-03 (Actual Exp.)	2003-04 (Actual Exp.)	2004-05 (RE)	2005-06 (BE)	Total of four years in Tenth Plan	% age of Col.(10) to Col.(5)
		Outlay	Realisation							
1	2	3	4	5	6	7	8	9	10	11
1	Department of Atomic Energy (R&D sector)	1935.73	1631.17	3443.00	391.09	383.20	520.43	732.96	2027.68	58.89
2	Deptt. of Ocean Development	658.95	489.97	1125.00	134.60	137.76	176.37	285.55	734.28	65.27
3	Deptt. of Science and Technology	1932.31	1622.88	3400.00	517.91	563.07	851.94	1049.80	2982.72	87.73
4	Deptt. of Biotechnology	871.08	666.96	1450.00	197.47	232.59	282.19	373.73	1085.98	74.89
5	Deptt. of Scientific & Industrial Research	1713.10	1463.01	2575.00	342.46	411.90	529.10	710.51	1993.97	77.44
6	Department of Space	8403.30	7107.36	13250.00	1782.91	1816.15	1940.04	2351.56	7890.66	59.55
	Grand Total	**15514.47**	**12981.35**	**25243.00**	**3366.44**	**3544.67**	**4300.07**	**5504.11**	**16715.29**	**66.22**

time taken for completion of a 540-MWe PHWR nuclear power plant is comparable with international standards. In addition, the 540-MWe unit design has been up-scaled to 700 MWe, which would lead to about 20 per cent reduction in the capital cost per MWe. Construction of the first commercial 500-MWe fast breeder reactor (FBR) under the second stage of the nuclear power programme is in progress at Kalpakkam.

2.3.5 Significant developments have taken place for utilisation of thorium on a commercial scale, particularly in view of the proliferation-resistant potential of the thorium fuel cycle. These include: Completion of engineering development for various systems of the advanced heavy water reactor (AHWR), which derives much of its power from thorium; setting up a critical facility for experimentation and validating reactor physics aspects of AHWR design and; completion of structured peer review of project report of AHWR. Pre-licensing design safety appraisal by the Atomic Energy Regulatory Board (AERB) is being initiated. Site selection and pre-project activities for the first commercial reactor – AHWR – utilizing thorium, including the detailed engineering and design validation, would be completed by the end of the Tenth Plan. Construction is likely to start in the Eleventh Five-Year Plan. Construction of the first demonstration AHWR utilising thorium as fuel under the third stage of the nuclear power programme will commence in the Eleventh Plan. During construction of the fast breeder reactor (FBR), project management concepts similar to those used for the construction of PHWRs are being deployed to reduce the gestation period.

2.3.6 Several experiments have been initiated for developing AHWR to attain higher levels of safety through utilisation of inherent and passive safety features. These include tests on advanced accumulator and passive containment coolers and establishment of two-phase natural circulation related characteristics under high pressure and high temperature. Several advanced safety features of AHWR arise out of passive components and systems. The design of a passive valve which will automatically divert

Box 2.3.1
Major achievements in nuclear science

R&D units of the Department of Atomic Energy (DAE) are committed to providing R&D support to the nuclear power programme for peaceful applications of nuclear energy and societal applications in the country. Some of the significant achievements during the during the Tenth Plan period are:

- Engineering development of various systems of advanced heavy water reactor, which derives much of its power from thorium.
- Up-scaling the 540-MWe unit design to 700 MWe, which would lead to about 20 per cent reduction in capital cost per MWe.
- Setting up of an 1800-cubic metre/day capacity reverse osmosis (RO) water desalination plant at Kalpakkam.
- Setting up of Positron Emission Tomography (PET)-CT Fusion machine at Tata Memorial Hospital.
- Development of Hydrogel for burn injuries and wounds.
- Development of cobalt-60 tele-therapy machine at half the cost of equivalent imported machine for cancer treatment.
- Development of a digital medical imaging system to replace conventional X-ray machines.
- Completion of phase I of tele-medicine link for cancer, connecting Tata Memorial Hospital to Dr. B. Barooah Cancer Institute (BBCI), Guwahati and Walawalkar Hospital, Dervan, Maharashtra.
- Setting up of a high-dose irradiation-plant for spices at Vashi and a low-dose irradiation plant for onion processing at Lasalgaon (KRUSHAK).

steam to isolation condenser following a reactor trip has been completed. A number of instruments with associated software were also developed to measure void fraction in a two-phase flow. Besides the AHWR technology for using thorium for power generation, accelerator-driven system technology is being pursued in stages and is expected to meet the Tenth Plan targets.

2.3.7 'High-temperature reactor' is the core technology for adapting nuclear power to non-electrical applications particularly, desalination and high temperature applications, including those for generating non-fossil fluid fuels. The compact high-temperature reactor being developed at BARC would be designed to operate at a temperature of about 1000°C. Development of fuel and structural materials suitable for operating at such high temperatures will be of primary concern for this work. Design of a test set-up for a passive power regulation system has been completed and the engineering R&D for high-temperature reactor systems will be completed during the Tenth Plan.

2.3.8 Significant progress has also been made in respect of the Mission Mode programmes. During the Tenth Plan period, several new water desalination technologies have been taken up for development and demonstration. A reverse osmosis (RO) water desalination plant with 1800 cubic metres per day (cmpd) capacity is operational at Kalpakkam. It generates potable water at a running cost of 5-6 paisa per litre. A multi-stage flash distillation water desalination plant with a capacity of 4500 cmpd, which uses nuclear heat, is currently under construction and is likely to be completed and commissioned during the Tenth Plan period. A desalination plant based on the low-temperature vacuum evaporation process has been integrated with the CIRUS reactor to demonstrate utilisation of low temperature waste heat for desalination of sea water. Development of a barge-mounted RO plant for deployment in remote areas is also in progress.

2.3.9 Some of the major developments in nuclear medicine include: setting up of the Positron Emission Tomography (PET)-CT Fusion machine at the Tata Memorial Hospital (TMH), Mumbai; Advanced Centre for Treatment, Research and Education in Cancer (ACTREC), Navi Mumbai; medical cyclotron to produce isotopes for PET applications at the Variable Energy Cyclotron Centre (VECC), Kolkata; development of Hydrogel for burn injuries and wounds by BARC; cobalt-60 tele-therapy machine at half the cost of an equivalent imported machine for cancer treatment by BARC and; a digital medical imaging system to replace conventional X-ray machines by the BARC hospital.

2.3.10 In addition, a country-wide service in cancer through telemedicine is planned to network 19 regional cancer centres (RCCs) with TMH through satellite-based tele-medicine links in three phases. Phase I, which involves connecting TMH to Dr. B. Barooah Cancer Institute (BBCI), Guwahati, and Walawalkar Hospital, Dervan, Maharashtra, has been completed. Phase II will link TMH to the centres in Nagpur, Ahmedabad, Gwalior and Hyderabad and all the remaining RCCs will be linked in phase III in a four-year time frame.

2.3.11 A new variety of oilseed viz. TG37A (groundnut) has been released under the Mission Mode programme on application of irradiation technology for farm products. Work on developing pest- resistant and saline-resistant varieties of crops is also under way. A high-dose irradiation plant for spices at Vashi and a low-dose irradiation plant for onion processing at Lasalgaon (KRUSHAK) are functioning. Thirteen entrepreneurs have signed MoUs for setting up irradiation plants for both food and medical use. One of the plants, set up by a private company, OGFL, Kolkata, is already operational and two plants are in an advanced stage of construction. The remaining plants are at various stages of planning/construction. An accelerator-based food processing unit is also being set up at the Centre for Advanced Technology (CAT), Indore.

Space Science and Technology

2.3.12 The first three years of the Tenth Plan have witnessed significant progress in the Indian

space programme. With a view to acquiring new capabilities for space communications, the INSAT system capability was augmented with the launch of INSAT-3A, 3E, GSAT-2 and GSAT-3 (EDUSAT) satellites during the first three years of the Tenth Plan. The INSAT system now has 140 transponders on board, being used extensively for telecommunications, broadcasting, developmental communications, tele-health, tele-education and mobile satellite services. INSAT-4A, carrying high-power transponders capable of enabling direct-to-home (DTH) services, is in the final stages of testing and would be launched in May/June 2005. The GRAMSAT developmental communication network was established and operationalised in several states, including remote/tribal areas of Madhya Pradesh, Orissa and the North-East. The INSAT system would be further augmented with the launch of INSAT-4B, 4C and 4D in the next two years, thereby increasing the number of transponders in the INSAT system to more than 200, exceeding the Tenth Plan target of 175 transponders.

2.3.13 The Department of Space has continued to maintain its leadership position in the field of earth observation infrastructure and has been satisfactorily meeting the national imaging demands for supporting the National Natural Resources Management System (NNRMS). It is also providing the necessary disaster management support. The launch and operationalisation of remote sensing satellite Resourcesat-1 (IRS-P6) onboard India's PSLV C5 on 17th October 2003 has been an important achievement in enhancing the earth observation infrastructure of the country. The data from RESOURCESAT-1 and other IRS satellites in orbit have been extensively used for natural resource management applications in the country by various user ministries/departments and other agencies; monitoring the formation of the artificial lake in the Tibetan region; planning relief and rehabilitation activities in the Andaman and Nicobar Islands, severely affected by tsunami. To further consolidate leadership in this field, advanced high-resolution satellites – CARTOSAT-1 and 2 – for cartographic applications would be launched during the remaining Tenth Plan period.

Box 2.3.2
Major achievements in space science and technology

The space programme during the Tenth Plan period has attempted to strengthen the space infrastructure of the country in a self-reliant manner towards meeting the national requirements in the areas of satellite communications, meteorology and natural resource management information. Some of the significant milestones achieved in the first three years of the Tenth Plan are as under:

- Successful launch of INSAT-3A, 3E, GSAT-2 and GSAT-3 (EDUSAT) satellites.
- The number of transponders in INSAT system will be more than 200 by the end of Tenth Plan, exceeding the Plan target of 175 transponders.
- Launch and operationalisation of remote sensing satellite Resourcesat-1 (IRS-P6) on board India's PSLV C5 for enhancing the Earth Observation Infrastructure of the country.
- Launch of METSAT-1 (redesignated as Kalpana-1) for providing improved weather forecasting.
- Operationalisation of the geosynchronous launch vehicle (GSLV), with the first operational flight of GSLV-F01 placing EDUSAT satellite in orbit.
- Establishment of a satellite-based educational network connecting 100 engineering colleges in Karnataka as a demonstration project.
- Establishment of a tele-health network connecting 89 hospitals on a pilot level with 24 super-specialty hospitals serving 65 district/rural area hospitals.
- Setting up of four village resource centres (VRCs) jointly with the M.S. Swaminathan Research Foundation, Chennai, to provide space-enabled services.

2.3.14 The launch of METSAT-1 (redesignated as Kalpana-1) on 12th September 2002 and INSAT-3A on 10th April 2003 carrying very high resolution radiometer (VHRR) and charge coupled detector (CCD)-based cameras have helped provide significantly improved data for weather forecasting. Advanced meteorological instruments such as imager and sounder are being developed to further improve capability in this field. These instruments would be placed on board the INSAT-3D satellite, slated for launch towards the end of the Tenth Plan period. The Government is processing the proposal for the OCEANSAT-2 satellite, equipped with payloads for oceanographic studies including ocean state forecasting, and payload development has begun. METSAT-2, earlier planned for the Tenth Plan period, has been rescheduled to the Eleventh Plan in view of the extended life of METSAT-1.

2.3.15 As envisaged in the Tenth Plan, the polar satellite launch vehicle (PSLV) has been put into regular production after undergoing seven successive successful flights. Indian companies are producing more than 60 per cent of the hardware for PSLV. The PSLV-C6 launch is planned for March/April 2005 to launch CARTOSAT-1 satellite from the recently commissioned second launch pad. The geosynchronous launch vehicle (GSLV) has also been operationalised after completing two successful development flights in 2001 and 2003. The first operational flight of GSLV-F01 took place on 20 September 2004, placing into orbit the EDUSAT satellite, weighing 1950 kg. The launch capabilities of both PSLV and GSLV have been progressively upgraded [PSLV – from 850 kg to 1400 kg for sun synchronous orbit; GSLV – from 1560 kg to 1950 kg for geosynchronous transfer orbit (GTO)]. An advanced launch vehicle, GSLV Mk III, capable of launching 4T INSAT type of satellites into GTO, is also being developed for further upgrading launch capabilities.

2.3.16 With a view to encouraging space science enterprise in the country, the Department of Space has taken up an important planetary mission, Chandrayaan-1, which would be launched in 2007 on board India's PSLV. The main scientific objectives of the planetary mission is to undertake high-resolution remote sensing of the moon in visible, near infrared, low-energy X-rays and high-energy X-ray regions. This will include preparing a three-dimensional atlas of regions of scientific interest on the moon and chemical mapping of the entire lunar surface. In addition, a multi-wavelength dedicated X-ray astronomy satellite ASTROSAT is also under development and is planned for launch in 2007. Both these missions would provide valuable scientific data and a challenging opportunity for space science research in the country involving several scientific institutions of national and international repute.

2.3.17 The Mission Mode programmes of the Department of Space are being implemented as per the targets set out in the Tenth Plan. Several application projects of national importance, such as the Natural Resource Census, natural resource database and large-scale mapping, have been initiated towards operationalisation of the NNRMS. IRS data has also been extensively used for several developmental application projects such as the National Drinking Water Mission, wasteland mapping, bio-diversity characterisation of bio-rich areas of the country and state watershed development/planning. In the area of future-generation launch vehicles, a Space Capsule Recovery Experiment Mission is planned in 2005-06 to validate the re-entry technologies of relevance for future generation re-usable launch vehicles. Further, a technology demonstration initiative on future reusable launch vehicle (RLV) has been taken up. Relevant technologies, such as air breathing propulsion for RLV, are also being developed.

2.3.18 Development of a radar imaging satellite (RISAT) to provide all-weather remote sensing capability for critical applications in the areas of disaster management support, agriculture and other areas, has been initiated and the launch of the satellite is expected in 2007-08. EDUSAT was successfully launched on 20th September 2004 on board India's GSLV F01. A satellite-based educational network connecting 100 engineering colleges has been operationalised in Karnataka. Establishment of a network connecting 880 primary schools in

predominantly tribal districts of Karnataka is in an advanced stage of completion. A tele-health network has also been operationalised in the country using INSAT satellites. On a pilot level, 89 hospitals have been connected in the network with 24 super-speciality hospitals serving 65 district/rural area hospitals. Four village resource centres (VRCs) were set up jointly with the M.S. Swaminathan Research Foundation, Chennai, to provide integrated space-enabled services such as tele-education, tele-health, natural resource data, disaster management support, agricultural advisories and other allied services at the village level.

Biotechnology

2.3.19 The activities and programmes of the Department of Biotechnology (DBT) are being pursued through the national laboratories and academic institutions to fulfil the Tenth Plan targets. Biotechnological interventions, primarily by DBT and also other government agencies such as Department of Science and technology (DST), Council for Scientific and Industrial Research (CSIR), Indian Council for Agricultural Research (ICAR) and Indian Council for Medical Research (ICMR), have helped in promoting growth of this sector. During 2003-04, the biotech industry recorded a growth of 39 per cent with a market share of US $ 705 million. However, it still contributes very little to the global industry. The major impact of the technology so far has been felt mainly through public sector-supported research efforts. To further promote innovation and knowledge commercialisation, effective public-private linkages are being fostered. The impact of this promising technology has been felt at the grassroot level as well, with low-cost, affordable technologies/products being made available in the agriculture, environment and health sectors.

2.3.20 Keeping in view the main thrust areas of the Tenth Plan, biotechnological tools have been effectively used for agriculture improvement. Genetically engineered *Brassica* (mustard) expressing transgenes has been developed for high-yielding hybrids by the University of Delhi South Campus (UDSC), Indian Agricultural Research Institute (IARI), New Delhi, and the National Research Centre for Weed Science (NRCWS), Jabalpur with the support of DBT. Transformation studies have also been taken up in other important crops like, cotton, pigeonpea, chickpea and sorghum. Transgenic cotton having insect and viral resistance, fibre strength and heterosis-breeding traits has been developed jointly by UDSC, Delhi, the Central Institute for Cotton Research (CICR), Nagpur, and the University of Agricultural Sciences (UAS), Dharwad. In addition, the National Centre for Plant Genomics Research (NCPGR), New Delhi, has successfully transferred a novel gene to potato for improving nutritional security. Field trials have shown enhanced protein content. Studies are now being undertaken to transfer this gene to rice, cassava and sweet potato.

2.3.21 The Government, through the Genetic Engineering Approval Committee (GEAC), had cleared for commercial cultivation in March 2002 three hybrids of transgenic Bt. Cotton protected against American bollworm, developed jointly by Monsanto (United States) and Mahyco, and commercialised by Mahyco-Monsanto Board, Jalna, as well as a hybrid by Rasi Seeds, Attur, Tamil Nadu in March 2004 for central and south India. These four hybrids have today been planted over 1.3 million acres. In addition, six more hybrids (two each from Rasi Seeds, Ankur Seeds and Mahyco) have been cleared by GEAC in March 2005 for commercial plantation in north India. A programme on bio-fortification of staple crops – rice, wheat and maize – is also being initiated. In the forestry sector, characterisation of genetic diversity is being done for important species. Genetically superior material has been identified in eucalyptus, teak, populus and casuarina. Studies on transformation for desirable traits related to improved productivity have also been undertaken.

2.3.22 Several infrastructure facilities have been set up in public funded R&D laboratories and academic institutions and a number of R&D projects have been taken up for development of molecular medicine and expand stem cell research in the country. Haematopoietic stem cells (HSCs) have been characterised and, for the first time in the

country, haploidentical stem cell transplantation has been carried out on 2nd April 2003 for treatment of cancer. It is proposed to establish stem cell city clusters at six locations in the country. Focused and targeted programmes are being considered for human stem cell research with the involvement of clinicians such as plastic surgeons, cardiologists, neurosurgeons, orthopaedicians and others.

2.3.23 Programmes have also been developed on clinical proteomics. Significant progress has also been made towards the development of environmentally safe technologies for pollution abatement and biodiversity conservation as a result of the financial support provided by DBT. These include the oil zapper technology for crude oil spill treatment and petroleum sludge degradation (The Energy Research Institute – TERI) and microbial desulphurisation of fossil fuels and biogas (National Environmental Engineering Research Institute (NEERI), Nagpur). Eco-restoration technologies for restoration of freshwater bodies are being standardised and attempts are being made to transfer to user industries the technologies for detection of pathogens in drinking water, removal of odour from industrial emissions and eco-restoration of mine spoil dumps and degraded ecosystems.

2.3.24 In the area of bio-industrial development, new vaccines/constructs have been developed indigenously and are

Box 2.3.3
Major achievements in biotechnology

The field of biotechnology the world over, as well as in India, has moved with spectacular speed towards developing a better understanding and insight into life processes and addressing many problems concerning mankind. Its impact in the health, agriculture, environment and industrial sectors has given a new dimension to the development process. During the Tenth Plan, there has been a paradigm shift in basic research in modern biology and technology development. Significant developments include:

- Development of genetically engineered *Brassica* expressing transgenes for high-yielding hybrids.
- Successful transfer of a new gene to potato for increasing protein content and improving nutritional security.
- Characterisation of haematopoietic stem cells (HSCs) for the first time in the country, and transplantation of haploidentical stem cell for treatment of cancer.
- Development of environmentally safe technologies for pollution abatement and biodiversity conservation, viz. oil zapper technology for crude oil spill treatment and petroleum sludge degradation and technology for microbial desulphurisation of fossil fuels and biogas.
- Development of new vaccines/constructs for cholera, anthrax, rabies and childhood diarrhoea.
- Development of a diagnostic test for Japanese encephalitis and licensing to Xycton, Bangalore.
- Establishment of human skeleton muscle culture technique (HSMCs).
- Whole genome sequencing of a typical Indian isolate *Mycobacterium* and clinical trial of this strain as leprosy immunotherapeutic.
- Completion of biodiversity characterisation at landscape level through remote sensing tools for the two hotspots in the North-East and Western Ghats and also Western Himalaya and Andaman & Nicobar Islands.
- Development of an efficient procedure for transesterification of *jatropha* oil to produce methyl esters.

undergoing trials. These include rotaviral vaccine for childhood diarrhoea (by the All India Institute of Medical Sciences (AIIMS), New Delhi), the Centre for Disease Control and Prevention (CDC), Atlanta, United States, and Bharat Biotech International Ltd., Hyderabad, along with financial assistance from the Bill-Melinda Gates Foundation); vaccines for cholera (by AIIMS, New Delhi and Indian Institute of Science (IISc), Bangalore); anthrax (by Jawaharlal Nehru University (JNU), New Delhi and Panacea Biotech Ltd., New Delhi) and; rabies (by IISc, Bangalore, and Indian Immunologicals Ltd (IIL), Hyderabad). A diagnostic test for Japanese encephalitis was also developed and commercialised. This technology has been licensed to Xycton, Bangalore, and the kits are being marketed under the brand name 'JEV-CHEX'. Vaccines and diagnostics for animal and marine health have also been successfully developed and commercialised and are being marketed by Mangalore Biotech Laboratories, Cochin. In addition, technologies in the areas of biofertilisers, biopesticides and plant tissue culture have also been commercialised, which include Bioprahar and Ecorrhiza.

2.3.25 In order to further promote bio-industrial development in the country, the Department of Biotechnology has proposed a Biotechnology Innovation Fund to develop and commercialise bioprocesses and products by promoting entrepreneurship through development of partnership with innovators from universities, national R&D institutions, academic institutions and industry. This will be operationalised during the remaining period of the Tenth Plan through public-private partnership.

2.3.26 Simplification of regulatory assessment of biotech products has been achieved through two committees, namely, the Task Force on Applications of Agricultural Biotechnology and the Pharmaceutical Research and Development Committee. The new regimen will be introduced from April 2005. In addition, a proposal for a National Biotechnology Regulatory Authority is being developed under the auspices of an inter-ministerial group. A single-window clearance committee is also being proposed in consultation with the Ministry of Environment and Forests and other administrative ministries/departments to deal with applications related to various clearances required for commercialising recombinant products.

2.3.27 Mission mode programmes in the areas of genomics, new drugs and molecules from important medicinal plants, bioresource characterisation and inventorisation and documentation of endangered eco-system, biofuels, vaccines, and food and nutritional security have been progressing well. Under the genomics programme, polymorphism in genes has been genotyped for identification of genes that cause or predispose Type 2 diabetes. A human skeleton muscle culture (HSMC) technique has been established. Whole genome sequencing of a typical Indian isolate *Mycobacterium* has also been implemented. This strain has been used as a leprosy immunotherapeutic and clinical trial has been carried out using this strain.

2.3.28 Under the programme for development of new drugs and molecules from important medicinal plants, several lead molecules – including 12 anti-cancerous, three anti-diabetic and 15 having immunomodulatory properties – have been identified. Biodiversity characterisation at landscape level through remote sensing tools has been completed for the two hotspots in the North-East, Western Ghats and also Western Himalaya and Andaman & Nicobar Islands. The first phase of four inventories on medicinal, other economically important plant, microbial and marine have been completed. As a part of the Mission Mode programme on biofuels, bioenergy plantations have been set up in five different locations and cultivation and demonstration of quality planting material of *jatropha* has been initiated at 12 different locations covering a total area of 500 hectare. An efficient procedure for transesterification of *jatropha* oil has been developed to produce methyl esters.

2.3.29 Vaccines for rotaviral diseases, rabies, HIV/AIDS, cholera and tuberculosis are in

advanced stages of development. In the area of food and nutritional security, the thrust is on development of low-cost nutrient food supplements, health food/nutraceuticals, food additives, biofunctional foods and value-added products from agricultural residues. An important area is development of zinc as an immunomodulator for prevention of diarrhoea and pneumonia in children. Technology for stable, low-cost dispensable zinc formulation is being transferred to ORS manufacturing companies in partnership with the World Health Organisation.

2.3.30 Under capacity-building, human resource development has been strengthened and M.Sc. (biotechnology) was supported in nearly 60 universities with an annual intake of approximately 900 students. Ph.D. and post-doctoral fellowships have been instituted in addition to overseas associateships for in-service scientists. An effective bioinformatics network has also been established across the country with five centres of excellence, 10 distributed information centres (DICs) and 49 sub-DICs. Ph.D, M.Tech. and post-graduate diploma courses in bioinformatics have also been started.

2.3.31 The societal development programme has had a good impact on the Scheduled Castes/ Scheduled Tribes (SC/ST), rural and women target groups. Nearly 65,000 person including 12,000 women have been benefited through application of proven biotechnologies in the area of medicinal plant, vermicompost, biofertiliser, biopesticide, etc.

Science and Technology

2.3.32 The Department of Science and Technology (DST) has been playing a pivotal role in the promotion of S&T in the country. Support to basic research, cutting across disciplines and institutions, by DST has enabled Indian scientists to perform at a globally competitive level in several areas of science and engineering and contribute to technology development of interest to Indian industries. A large number of publications in internationally and nationally referred journals and IPR in the form of Patent Cooperative Treaty (PCT) filings through the Patent Facilitating Cell have resulted from these efforts. However, as the intellectual property protection plays a key role in gaining an advantageous position in the competitive technological game for achieving economic growth, there is a need to generate greater awareness among scientists.

2.3.33 A number of Indian scientists have received international recognition by being elected to international academies such as the Third World Academy of Sciences. A large number of scientists, including young scientists, were encouraged to participate in international S&T conferences abroad to enable them to interact with the global scientific community.

2.3.34 In line with the objectives/targets laid down in the Tenth Plan, DST is preparing a proposal for establishing National Science and Engineering Board/Foundation. In order to build strengths in areas like nanotechnologies, nine centres have been established in the country for carrying out R&D in the area of nanoscience and technology. A proposal to launch a mission on nanoscience and technology has been prepared and is under consideration for approval by the appropriate authorities. Some of the facilities for building strengths in molecular electronics have also been established. The department is actively considering proposals for establishing a synchrotron facility and a six-eight-metre optical telescope. Advance materials and composites, information and communication technology and microelectronics are being tried for higher value addition in various products, including agriculture and agro-food processing.

2.3.35 The department has been able to sustain a steady flow of competent scientists to carry out the research programmes through innovative programmes like establishment of core groups/centres of excellence in technical educational institutions, creation of specialised research facilities in universities and other R&D institutions and systematic manpower development schemes. Considering that a large number of young students today opt for careers other than scientific research in a highly competitive environment, these programmes

have a major significance in maintaining national S&T competence. A comprehensive scheme for training scientific manpower working in the Central scientific departments has also been initiated.

2.3.36 The Women Scientists Scheme of DST provides new opportunities to S&T-trained women who wish to contribute to research or engage in other S&T-based employment including self-employment. About 300 women scientists have so far benefited through this scheme. Active participation of industry and academic institutions has been ensured under drugs and pharmaceuticals research and in various other technology development and demonstration programmes of the Technology Information, Forecasting and Assessment Council (TIFAC). The department is also taking various initiatives with Indian diaspora to attract scientists and technologists of Indian origin (STIOs) to share their expertise and involve them in Indian S&T initiatives.

2.3.37 Inter-disciplinary studies involving multi-disciplinary capabilities in research, instrument design and manufacture has led to several first-of-its-kind programmes in the country. The Squid-based MEG system for human brain studies, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam; establishment of a linear accelerator with conformal radiotherapy and intensity modulation radiotherapy at the Sanjay Gandhi Post-Graduate Institute of Medical Science (SGPGIMS), Lucknow; the high-resolution NMR facility for biomedical research at the Advanced Centre for Biomedical Research (ACBR), Delhi, are unique examples of high S&T expertise being mobilised to address basic health problems of the population. It has also been possible to deploy cutting edge science in a number of frontline areas including nanotechnology, materials technology and biotechnology. These relate to new properties of carbon nano tubes, structural biology of plant lectins, plasma enhanced chemical vapour

Box 2.3.4
Science and technology for women

The S&T programme for women, being implemented by DST and DBT is aimed at empowerment of women through application of S&T. Under this programme, support is provided to projects aimed at identifying gap areas relating to technological needs of women, development and adaptation of technology or transferring the available ones for the benefit of women. Some of the major initiatives taken up during the Tenth Plan include:

- Fellowships to women scientists to pursue research in frontier areas of science and engineering, societal problems requiring S&T intervention and for undergoing S&T-based internship leading to self-employment
- Establishment of women technology parks at Assam and Maharashtra and a women biotechnology park at Chennai.
- Training complexes established for women in the field of seritechnology (Mysore), for aquaculture practices (Mangalore), cultivation and processing of jute with pisciculture (West Bengal) and bioinformatics in organic cultivation of traditional and non-traditional crops (Uttaranchal).
- Demonstration and transfer of proven technology packages for skill upgradation and income and employment-generation activities relating to value-added products from bioresources, aquaculture, floriculture, vermi-composting, poultry, medicinal and aromatic plants, mushroom cultivation and sericulture.
- Coordinated programmes on fodder management, development of prevention and intervention strategies for nutrition-related non-communicable disorders among women, vector control with community participation, post-harvest utilisation technology of seaweed, diversified products from lac, pottery and ceramics.

Box 2.3.5
Major achievements of the Department of Science and Technology

The Department of Science & Technology (DST) has been playing a pivotal role in the promotion of science & technology in the country. Support to basic research cutting across disciplines and institutions has enabled Indian scientists to perform at a globally competitive level in several areas of science and engineering and contribute to technology development of interest to Indian industries. Some of the important initiatives taken up by DST during the first three years of the Tenth Plan are:

- Establishment of a Centre for Soft Computing Research at the Indian Statistical Institute (ISI), Kolkata.
- Creation of major research facilities in R&D institutions for mobilisation of high science and technology expertise to address basic health problems of the population and also national facilities in the areas of nano-materials science and technology.
- Launch of National Mission for Bamboo Application (NMBA), which seeks to develop and promote environment-friendly, value-added, bamboo-based products, practices, technology and processes, including wood substitutes.
- Cutting edge science in frontline areas relating to carbon nano tubes, structural biology of plant lectins, plasma enhanced chemical vapour deposition (PECVD) for photonic devices and specific drug development.
- Launch of a Seismology Mission for setting up of multi-parametric geophysical observatories and upgradation of a strong national motion instrumentation network.

deposition (PECVD) for photonic devices and specific drug development. Through the Fund for Infrastructure in Science & Technology Instituiuons (FIST) initiative, a systematic strengthening of research infrastructure in a large number of university departments has taken place, that not only raises the level of research but also contributes to attracting fresh young talent to the Indian research sector.

2.3.38 Among the various Mission Mode programmes identified during the Tenth Plan, the National Mission for Bamboo Application (NMBA) has been launched. It is multi-disciplinary and multi-dimensional in its approach and seeks to develop and promote environment-friendly, value-added bamboo-based products, practices, technology and processes, including wood substitutes. A corpus of Rs.150 crore has also been created to pursue drugs and pharmaceuticals research programmes in the country. The seismology mission has been launched with a view to setting up multi-parametric geophysical observatories and upgradation of national strong motion instrumentation network. A "National Nanotechnology Mission" is also under consideration of the Government, keeping in view the tremendous applications of this technology in the areas of drug delivery, surface coatings/engineering, sensor devices, nano electronics, etc. In addition, the department is according high priority to the instrument development programme and technology business incubator (TBI) programme and 12 TBIs have already been established.

Ocean Sciences

2.3.39 The Department of Ocean Development is actively engaged in exploratory surveys for assessment of living and non-living ocean resources through a series of dedicated cruises of the fisheries and oceanographic research vessel (FORV) during summer monsoons, winter monsoons and inter-monsoons. Dedicated cruises were also undertaken for summer monsoon and winter monsoon coverage of the Bay of Bengal. The Andaman Sea was also surveyed through five dedicated cruises. A centralised FORV Data and Referral Centre has been set up at the

Centre for Marine Living Resources and Ecology, Kochi. Survey and exploration for polymetallic nodules (PMN) is also being carried out in 92 blocks (316 stations) out of about 500 retained blocks at a closer grid interval of 6.25 km, to refine resource estimation further and to identify first-generation mine sites. Sampling of 120 stations has already been completed and the balance stations would be sampled within the Tenth Plan period.

2.3.40 With a view to protecting and preserving marine environment, the quality of coastal waters is being assessed continuously at 82 locations along the coastline of the country including areas of concern like Mumbai, Kochi, Veraval, Veli, Tuticorin, Cuddalore, Chennai, Kakinada and Visakhapatnam. The results have indicated that the pollution levels have remained constant over the years. No decrease of pollution has been found in the waters off Mumbai except at Versova. Technology development activities have led to indigenous development of moored data buoys with INSAT communications at almost one-third of the cost of imported data buoys. Tide gauges have also been indigenously produced and the American patent on tide gauge has been received. Integrated coastal and marine area management plans developed for Chennai, Goa and Gulf of Kachchh demonstrated the use of GIS, remote sensing and mathematical modelling in developing integrated management solutions.

2.3.41 To establish ocean-related information system, a dynamic website and ocean portal was commissioned at the Indian National Centre for Ocean Information System (INCOIS) for ocean data mining and warehousing of a variety of ocean-related collection through various national and international efforts. The INCOIS website (www.incois.gov.in) matured as a prime vehicle for delivery of ocean data, information and advisories. A set of 10 information kiosks, one each in the coastal states of India, was installed in fishing harbours for dissemination of potential fishing zone (PFZ) information. The Ocean State Forecast Services was also launched on an experimental basis for safe operations and travel at sea. In addition, India has established a regional alliance in the Indian Ocean on Global Ocean Information and Observation System (IO-GOOS) at the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, with 21 organisations from different countries. As a part of the commitment for deployment of 150 Argo floats in the Indian Ocean under GOOS and to improve the delivery of ocean information, 60 Argo floats have been deployed for real-time data acquisition in respect of conductivity and temperature profiles around the place of deployment. In addition, three-current meter array moorings have been deployed in the equatorial region.

2.3.42 As a part of technology development for exploitation of nodules from deeper depth in phases, a shallow bed-mining system has been thoroughly refurbished. Design and development of crusher and collector for nodules for greater depth is in progress and is expected to be developed as envisaged by the year 2007. In addition, the design of the unmanned submersible has been taken up by the National Institute of Ocean Technology (NIOT), Chennai. Demonstration of the system is scheduled during the year 2005. A semi-commercial pilot plant of 500 kg/day capacity was commissioned at Hindustan Zinc Limited (HZL), Udaipur, for exploitation of nodules, and a shallow bed mining system at a depth of 500 metres would be demonstrated in 2005.

2.3.43 In addition to the yearly scientific expeditions to Antarctica, the National Centre for Antarctic and Ocean Research (NCAOR), Goa, has set up an ice core laboratory equipped with state-of-the-art storage and processing facilities maintained at -20^0 C and -15^0 C for strengthening front-ranking research in polar sciences. A team of five scientists was specially deputed for conducting scientific experiments during the total solar eclipse that occurred on the midnight of 23/24 November 2003, near Maitri Station in Antarctica. A site has also been identified for a new station at Antarctica in the central part of Larsenmann Hill on the basis of a reconnaissance survey. The department has also decided to set up a Centre of Excellence in Ocean Science & Technology

Box 2.3.6
Major achievements in ocean sciences

The programmes/activities of the Department of Ocean Development have long-term technological implications and are aimed at development of technologies for exploration and sustainable exploitation of vast marine resources both living and non-living and management of the marine eco-system. Some of the important achievements during the Tenth Plan include:

- Setting up of a centralised FORV Data and Referral Centre at the Centre for Marine Living Resources and Ecology, Kochi.
- Completion of sampling for survey and exploration for polymetallic nodules (PMN) in 120 stations at a closer grid interval of 6.25 km to refine resource estimation further and to identify first-generation mine sites.
- Continuous assessment of the quality of coastal waters at 82 locations along the coastline of the country with a view to protecting and preserving the marine environment.
- Indigenous development of moored data buoys with INSAT communication at almost one-third of the cost of imported data buoys and deployment of a 20-buoy network in the Indian Ocean.
- Indigenous development of tide gauges and patenting in the United States.
- Development of integrated coastal and marine area management plans for Chennai, Goa and the Gulf of Kachchh.
- Commissioning of a dynamic website and ocean portal at INCOIS for Ocean Data Mining and Warehousing.
- Establishment of a regional alliance in the Indian Ocean on Global Ocean Information and Observation System (IO-GOOS).
- Deployment of 60 Argo floats for real-time data acquisition in respect of conductivity and temperature profiles.

at the Ocean Science & Technology Cell in Marine Biology, Annamalai University, Tamil Nadu.

2.3.44 In the wake of the recent Indian Ocean tsunami, which is considered to be one of the strongest in the world in the past 40 years, resulting in extensive loss of life and property in several coastal areas of the Indian Ocean, the Department of Ocean Development has been given with the responsibility of putting in place a early warning system for tsunami and storm surge in the Indian Ocean region with an ultimate objective of saving lives and property. The total cost of this system has been estimated at Rs.125 crore and is expected to be operationalised within a period of 30 months.

2.3.45 The Mission Mode programme on development of drugs from sea has been initiated by the Department in phases. As a part of the programme, systematic collection of identification of leads has been accomplished and the focus is now on product development in seven major areas viz. anti-diabetic/anti-diarrhoeal; anti-hyperlipidaemic; anti-anxiety; anti-hyperglycaemic; anti-bacterial/anti-fungal; anti-tumour/anti-cancer and; larvicidal. Clinical trial of anti-diabetic compound has been commissioned in two hospitals. Two patents have been filed to protect the IPR. The department has also undertaken an initiative for large-scale technology demonstration of an ocean thermal energy conversion (OTEC) plant (one MW capacity). Due to the logistic constraints of deployment and rough sea conditions along with other unforeseen factors that developed during the two deployment attempts made so far, the full deployment of the plant has not been achieved so far. Under the technology development programme for gas hydrates, NIOT, Chennai, has already completed the design of the submersible and specifications for sensors required for gas hydrate studies and the same would be ready by May/June, 2005, for demonstration and sample collection. An Indo-Russian Centre for Gas Hydrate studies has been set up at NIOT to carry out various studies related to gas hydrates.

Scientific and Industrial Research

2.3.46 The Department of Scientific and Industrial Research (DSIR) has been primarily engaged in promotion of industrial R&D; development of new technologies and processes; acquisition, management and export of technologies; and development of consultancy capabilities, under the Technology Promotion, Development and Utilisation (TPDU) Programme. This has resulted in establishment of strong linkages between industries and national research organisations. Thirty-seven technology development and demonstration projects involving over 32 industrial units have been completed, resulting in commercialisation of a number of products and processes.

2.3.47 Significant developments have taken place in the CSIR during the period. The development of R&D projects and their implementation have undergone a sea change. CSIR developed synergistically linked large network projects spanning across the organisation. At the same time, through the New Millennium Indian Technology Leadership Initiative (NMITLI), it has evolved large projects in the public-private partnership (PPP) mode with external organisations, including industry. The effort under network projects is to organically link the vast competencies developed across laboratories and to draw upon the cumulative strength of CSIR. This paved the way for it to move away from laboratory-centric projects to large, impact-making, organisation-centric projects.

2.3.48 During the period, CSIR developed and put in place 55-networked projects covering several S&T areas. Some of these projects are: Spearheading small civilian aircraft design development and manufacture; molecular biology of selected pathogens for developing drug targets; scientifically validated herbal preparations for global positioning; traditional knowledge digital documentation and library; environment-friendly leather processing technologies; exploration, assessment and management of ground water; globally competitive chemical processes and products; cell and tissue engineering; developing green processes for organic chemicals, etc. In the process, it has also established a strategic partnership with Indian industries for carrying out innovative R&D. Some of the major industries which partnered with CSIR are Reliance, Atul, Chatterjee group companies, Tata group of companies, BHEL, Lupin, Cipla, Dabur, Nicholas Piramal, Hindustan Aeronautics, etc.

2.3.49 CSIR has achieved a commendable feat by designing and developing a 14-seater light transport aircraft – SARAS – particularly useful for the difficult terrains of north-eastern states and small towns across the country. Based on the results of several test flights of SARAS, certain structural modifications are being made, including weight optimisation. Indian Air Force has shown interest in buying six aircraft for training programme. A traditional knowledge-based digital library (TKDL) has resulted in creation of a Traditional Knowledge (TK) - Ayurveda database containing 36,000 formulations in five international languages. Several environment-friendly leather-processing technologies have been standardised, which include: Less salt curing methodologies, enzyme assisted de-hairing of goat skins, closed-loop pickle-tanning system, pickle-less tanning, and water-saving methodologies. The other important application-oriented technologies developed by CSIR are: Disease-resistant rice variety, biodiesel from *jatropha*, 'Asmon' polyherbal medication that provides relief and succour in bronchial asthma, anti hypertensive drug s-amlodipine, biorefining of rice bran oil, new rare earth based glass and glass-ceramic phosphors developed for compact fluorescent lamps and cathode ray tube display screens; brackish water desalination plant for rural population, ceramic membrane-based technology for removal of arsenic and iron from contaminated ground water, etc.

2.3.50 The technology transfer to industry has also kept the desired pace and as many as 85 new knowhow/technologies have been licensed to various industries during the period under review. These include, naphtha and natural gas to liquified petroleum gas (LPG) and high-octane gasoline, a 1500-tonnes per annum (tpa) plant for conversion of starch to D-gluconates, Sonalika tractor, etc. Continuing

with its commitment to provide technological support for basic human needs through research and development, CSIR developed RO plants to enhance the potability of water. These plants of diverse capacities were installed at various places, including tsunami-affected areas. CSIR has also developed an RO plant with a capacity of one million litres a day for generating processed water from sewage water at the Chennai Petroleum Corporation Limited (CPCL), Chennai. Two full-scale demonstration common effluent treatment plants at Dindigul and Erode have been designed based on an integrated approach of in-plant control and end-of-pipe treatment solution.

2.3.51 Significant scientific achievements have also been made in respect of other programmes viz. gene silencing for a possible therapy for cancer and other related diseases; exploration and exploitation of the country's microbial wealth for novel compounds and bio-transformation processes; novel therapeutic strategies to tackle leishmaniasis; synthetic peptide-based nanotubes useful for DNA material for gene therapy and also for making biochemical sensors; a smart biosensor based on ion-sensitive field effect transistor (ISFET); biodegradable polymers from sugarcane bagasse; study of mesozoic sediments for hydrocarbon exploration; pollution control and monitoring devices for air, water and solid

Box 2.3.7
Technological developments at CSIR

During the Tenth Plan, significant developments have taken place in CSIR. On the one hand, CSIR has developed synergistically linked large network projects spanning across the organisations and on the other, it has evolved large projects in the public-private partnership (PPP) mode with external organisations including industry, through the New Millennium Indian Technology Leadership Initiative (NMITLI). CSIR has also established strategic partnership with Indian companies for carrying out innovative research and development. Some of the major industries which partnered with CSIR are Reliance, Atul, Chatterjee group companies, Tata group companies, BHEL, Lupin, Cipla, Dabur, Nicholas Piramal, Hindustan Aeronautics, etc. During the first half of the Tenth Plan, it has filed 827 patents in India and 1223 patents abroad, resulting in grant of 384 US patents. The number of US patents granted in this period surpasses the cumulative figure of previous years, a remarkable achievement indeed. Its contribution to basic research over the years has also been increasing, and its average impact factor per paper (AVIF) has gone up to 1.75 in 2003 from 1.55 in 2000. Some of the significant technological developments include:

- Design & development of a 14-seater light transport aircraft-SARAS.
- Creation of a traditional knowledge (Ayurveda) database containing 36,000 formulations in five international languages.
- Environment-friendly leather processing technologies.
- Application-oriented technologies like disease resistant rice variety, biodiesel from jatropha, 'Asmon'- polyherbal medication, an anti-hypertensive drug, biorefining of rice bran oil, new rare earth-based glass and glass-ceramic phosphors for compact fluorescent lamps and cathode ray tube display screens, brackish water desalination plant for rural population, ceramic membrane-based technology for removal of arsenic and iron from contaminated ground water, etc.
- A comprehensive, portable and versatile software package - 'BioSuite' - for bio-informatics.
- A new therapeutic molecule for tuberculosis.
- An oral herbal formulation for the treatment of psoriasis.
- A novel catalyst for deep desulphurisation of diesel to reduce sulphur content to less than 50 ppm.

waste; development of microwave electron tube technology, etc.

2.3.52 The NMITLI has emerged as India's largest and best managed public-private partnership scheme. Its basic objective is to catalyse innovation-centred scientific and technological developments as a vehicle to attain for Indian industry a global leadership position in select niche areas in a true 'Team India' spirit by synergising the best competencies of publicly funded R&D institutions, academia and private industry. It has catalysed 33 projects involving 220 partners – 55 of them from the private sector – in setting new technological paradigms in diverse S&T areas such as liquid crystals, nano materials, fuel cells, industrial chemicals, catalysts, bio-informatics, drugs and pharmaceuticals, biotechnology, etc. The initial successes under the scheme cover development of a comprehensive, portable and versatile software package – 'BioSuite' – for bio-informatics that was launched in the United States and India, discovery of a new therapeutic molecule for TB and filing of an investigational new drug (IND) application, an oral herbal formulation for the treatment of psoriasis and filing of IND, a novel catalyst for deep desulphurisation of diesel to reduce sulphur content to less than 50 ppm, systematic scientific validation of different chemotypes of ashwagandha, development of new varieties of mentha, etc.

2.3.53 CSIR continued its efforts in innovation-driven R&D pursuits to nurture and develop patentable new ideas and concepts. During the first half of the Tenth Plan, it has filed 827 patents in India and 1223 patents abroad, resulting in grant of 384 US patents. The number of US patents granted in this period surpasses the cumulative figure of previous years, a remarkable achievement indeed. Further, CSIR not only stayed ahead as filer of the highest number of international patents from India but also achieved the distinction of occupying the first position in filing of Patent Cooperation Treaty (PCT) applications among developing nations in 2002.

2.3.54 The steady emphasis on excellence in research in frontier areas has enabled CSIR to publish research papers in high-impact factor journals. Its average impact factor (AVIF) per paper has gone up to 1.75 in 2003 from 1.55 in 2000. CSIR continued to be one of the significant contributors of research papers emanating from India. During this period, CSIR has also trained a large number of researchers and thus contributed to the human resource development effort of the nation.

Generic Issues Relating to the S&T Sector: An Assessment

2.3.55 The Indian S&T system has progressed well in several sectors during the last few years and has established global competitiveness. Significant progress has also been made in the implementation of various S&T programmes/activities and a number of technologies have been developed and transferred to the users. There has also been significant improvement in establishing linkages between the industry and research institutions/laboratories for the development and marketing of technologies. A number of S&T programmes are being implemented in mission mode, not only for knowledge generation but also for improving the quality of life of the common man. However, several areas of concern have also emerged. For the country to derive full benefit from its S&T capabilities, it would be necessary to take appropriate steps to strengthen the S&T system for overall economic and social development. This may require additional allocation of resources and revamping of the system. Some of the major issues are discussed in the following paragraphs.

Apex Level Policy Guidelines Mechanism

2.3.56 With the constitution of Science Advisory Council to the Prime Minister (SAC-PM), the existing S&T mechanisms like the Cabinet Committee on Science and Technology (CCST), the Science Advisory Committee to the Cabinet (SAC-C) and the Consultative Group of Government Departments/Agencies on Science and Technology (CGDST) need to be activated for providing policy directives, defining priorities and reorienting the S&T system to suit changing needs. Effective programme implementation will become key to making rapid progress.

Giving Impetus to Basic Research

2.3.57 There is need for setting up a National Level mechanism on the lines similar to those of National Science Foundation (NSF) of USA with necessary administrative and financial powers to act as an apex body for evolving an overall policy framework and for promoting and supporting basic research, building strengths in chosen emerging areas of S&T, coordinating with various scientific departments/ agencies to evolve a focused approach that avoids overlapping in areas of research and funding and ensures a greater degree of integration and focus to national level priorities. The proposed mechanism could be in the form of 'Indian Science Foundation (ISF)' and tasked with supporting all fields of fundamental science and engineering, identifying relevant new initiatives and the leading Indian scientists in the field and providing necessary guidance and for enabling them to excel. In addition to funding basic research in the traditional areas, the proposed ISF may identify and support "high risk, high pay off" ideas.

Encourage Investments by Industry in R&D

2.3.58 Experience across the world has shown that a strong linkage between R&D laboratories and the industry and an enabling environment to commercialize laboratory knowledge are necessary to exploit the Science and Technology capabilities for economic development. In India, this linkage has traditionally been weak. Since 1990s there has been increasing awareness among industries that a knowledge portfolio is a necessity for attaining competitiveness in the marketplace. As a result, sizable investment in R&D has taken place in sectors such as, pharmaceutical research, biotechnology and more recently in manufacturing (Automobile) sector. However, this is yet to percolate into other sectors in a big way. Consequently, while the Government has been trying to increase investments in R&D per capita over the last several years, the contribution of industry is still less than 30 per cent of the total R&D investments. Considering that in most of industrially advanced countries, the non-governmental contribution exceeds 70 to 80 per cent , there is need for more concerted efforts to attract investments by industry in R&D. One way of doing this could be through creation of a fund from R&D cess on sales turn over, which could be used by the industry itself for undertaking R&D in its areas of operation. Several initiatives taken by Science Departments like the Department of Science and Technology (DST), Council of Scientific and Industrial Research (CSIR) in building public-private partnership in R&D also need to be strengthened and expanded.

Strengthening of University Research

2.3.59 The Universities are the cradles of basic research. However, over the years, there has been significant decline in the R&D activities being undertaken by universities due to erosion of the research base. It is therefore necessary to remedy this situation by strengthening of research infrastructure in the university system. This would require a policy framework that incentivises those among the faculty that undertake research. Faculty positions in the Universities and colleges will also need augmentation so that teachers can devote sufficient time to research. Additionally, the concept of research project as a part of the degree requirement may be introduced in Post Graduate courses.

Greater Autonomy and Flexibility

2.3.60 A stagnation of scientific output in India, in terms of number of scientific publications and citations, has been a major concern. Increasing bureaucratization of the scientific establishments and weakening of the university system has likely contributed to this stagnation. Experience across the world has shown that, to increase the knowledge portfolio of a country, it is necessary to increase investment per scientist for research and also increase the number of scientists per unit population. There is reason to believe that we may be slipping in relative terms. While the number of scientists per unit population in China has grown ten fold in last one decade, in India it has stagnated and the value is much below the corresponding number for industrially advanced nations. Further, bracketing scientists as yet another category of Government employees has brought in several distortions in the system. Research in futuristic areas involves a great deal of risk taking. Funding decisions for research

cannot, therefore, be subjected to the same set of audit guidelines as other routine Government activities and this practice has weakened the decision making process in the scientific system. Keeping this in view, the S&T Departments, especially the autonomous scientific institutions, need much greater autonomy and flexibility in their operations and removal of all hurdles in the recruitment of scientists i.e. greater financial powers, freedom in appointment and placement of scientists and technologists without the usual government ban on recruitments, assuring career prospects for young scientists etc.

Ensuring S&T inputs in all major programme of Development Departments

2.3.61 Among the thrust areas of S&T during the Tenth Five Year Plan is the identification of technological choices, investment decisions and the S&T interventions necessary for the individual sectors, so as to make all socio-economic ministries and states the real stakeholders of S&T. Science and Technology Advisory Committees (STACs) have been set up in 24 development departments/socio-economic ministries like Agriculture & Cooperation, Animal Husbandry & Dairying, Chemicals & Petrochemicals, Civil Aviation, Commerce, Fertilizers, Heavy Industry, Information & Broadcasting, Labour, Power, Railways, Telecommunication, Shipping & Water Transport, Steel, Coal, Petroleum and Natural Gas, Water Resources etc. for providing S&T inputs in the implementation of various developmental programmes. Majority of these STACs have become non-functional. There is a need to activate the Science and Technology Advisory Committees (STACs) and the Inter-Sectoral-STAC mechanism of DST for ensuring specific S&T component in their developmental programmes to improve effectiveness.

Support for Technology Development and Demonstration Programmes

2.3.62 It would be prudent to evolve a technology development and demonstration mechanism at the National level, which would ensure that only relevant technology development programmes are pursued with participation from user agencies and industries. In addition, it is necessary to strengthen the Industry-academia interface for smooth transfer of technology and protection of intellectual property rights, addressing not only the issue of filing of patents but also their commercial exploitation for resource generation. The Tenth Five Year Plan envisaged establishment of Industry S&T Interface Institutions (ISTI), with technology management centers manned by qualified personnel. This would need to be pursued expeditiously.

Promoting Human Resource development and Excellence in Science

2.3.63 The world today is witnessing, not only globalization of trade and commerce but also globalization of education and employment. Consequently, the job market for skilled hands and knowledge workers has also been globalised. This has resulted in a large number of Indian students migrating to other countries and also into careers other than scientific research. While migration of bright students to other countries might some times reverse and lead to brain circulation and benefit the country in the long run. Migration of bright students to non-science career options is irreversible and permanently weakens the science streams. The problem is further complicated because of the weakening of University and other educational system where quantity overtake quality. The number of scientists and engineers in R&D per thousand population in India is about 0.10 as compared to 3 to 5 in the developed countries. There is need for pro-active steps to strengthen the educational system, particularly the higher education, where the future scientists are trained. The present policy of many universities on freezing faculty appointments and State Governments not having adequate funds for supporting the activities of the universities are resulting in untold damage to the educational system. This situation need to be remedied and the education system, in particular higher education needs to address this problem. The existing HRD programmes pursued by various departments/ agencies also need to be strengthened. We need to launch special initiatives of creating world class R&D facilities and providing competitive compensation to scientists to arrest flight of human capital.

Bright young students need to be picked up at 10+ stage itself and groomed, assuring them reasonable assured career opportunities by creating positions at different levels including supernumerary positions.

Energizing the State S&T Councils and making them effective vehicle for dissemination and transfer of technology

2.3.64 With a view to using Science and Technology as an effective tool for economic development and to utilize the vast scientific and technological potential existing in the States and Union Territories, an apex level body (The State Science and Technology Council) has been set up in almost every State. However, most of these State S&T Councils have become dormant and the activities are getting restricted to science popularization. In order to provide new dynamism to the application of S&T for development, the State S&T Councils needs to be activated so that they can serve as effective vehicles for dissemination and transfer of technology at the State/UT level.

THE WAY FORWARD

- Activate all the existing apex-level S&T mechanisms for providing policy directives, defining priorities and reorienting the S&T system to suit changing needs as well as for effective programme implementation.
- Set up a national-level mechanism — viz. an Indian Science Foundation — similar to the National Science Foundation (NSF) of the United States for supporting basic research in all fields of science and engineering.
- Make concerted efforts to attract investments in R&D from industry through a mechanism such as the creation of a fund from R&D cess on sales turnover.
- Strengthen research in universities significantly by adopting a multi-pronged approach. Provide incentives to faculty for undertaking research, augment faculty positions so that teachers can devote sufficient time to research and introduce the concept of research projects at the post-graduate level.
- Provide S&T departments and institutions with greater autonomy and flexibility in their operations, especially greater financial powers, freedom in appointment and placement of scientists and technologists without the usual government ban on recruitments, assuring career prospects for young scientists, etc.
- Activate the science and technology advisory committees (STACs) of various development departments and the inter-sectoral STAC mechanism of DST in order to ensure specific S&T components in terms of technological inputs to improve the effectivness of various developmental programmes.
- Strengthen the industry-academia interface for smooth transfer of technology and protection of intellectual property rights. Pursue the proposed establishment of industry-S&T interface institutions with technology management centres.
- Strengthen the existing HRD programmes pursued by various departments/agencies. Launch initiatives for creating world-class R&D facilities and providing competitive compensation to the scientists to arrest flight of human capital. Identify and groom bright young students at the 10+ stage itself, ensuring them reasonable, assured career opportunities by creating positions at different levels including supernumerary positions.
- Activate the states' S&T councils so that they can act as an effective vehicle for dissemination and transfer of technology at the state/Union Territory level. This will provide a new dynamism to the application of S&T for development.

Annexure 2.1.1

Review of financial progress in the Tenth Plan

(Rs Crore)

S. No	Name of the Sector	Tenth Plan (2002-2007) Approved Outlay	Annual Plan 2002-03 Actual Expdr.	Annual Plan 2003-04 Actual Expdr.	Annual Plan 2004-05 Revised Outlay
A	**Department of Elementary Education & Literacy**				
1.	Elementary Education	28750.00	4259.29	5203.40	*8982.00
2.	Adult Education	1250.00	216.33	232.50	250.00
	Total A	**30000.00**	**4475.62**	**5435.90**	**9232.00**
B	**Department of Secondary & Higher Education**				
1.	Secondary Education	4325.00	578.14	639.08	693.00
2	University & Higher Edn.	4176.50	619.14	560.44	640.00
3	Language Development	434.00	103.57	104.11	121.29
4	Scholarships	52.00	0.28	0.16	7.00
5	Book Promotion	67.00	6.26	6.53	6.71
6	Planning & Administration	70.50	4.40	4.65	7.00
7	Technical Education	4700.00	600.47	626.34	750.00
	Total B	**13825.00**	**1912.26**	**1941.31**	**2225.00**
	Total A + B	**43825.00**	**6387.88**	**7377.21**	**11457.00**
C	**Ministry of Youth Affairs and Sports**	**1825.00**	**275.92**	**302.82**	**375.00**
D	**Ministry of Culture**	**1720.00**	**254.07**	**243.25**	**336.00**

* Includes additional allocation of Rs 1232 Cr in the State sector for Mid Day Meal Scheme and Rs 2000 Cr for Sarva Shiksha Abhiyan

ANNEXURES ON HEALTH SECTOR

Annexure 2.2.1

Millennium Development Goals

Premature mortality and chronic morbidity on a huge scale across the developing world became a matter of serious concern and prompted the international community to put health firmly at the centre of the Millennium Development Goals (MDGs) at the Millennium Summit in September 2000. India is a signatory to the United Nations Millennium Development Goals. Among the eight Millennium Development Goals at least six goals and targets, refer directly to health care and one (rural sanitation) is a "non-health determinant" of health care.

India is not on track on many of the health related parameters. Efforts towards realising these goals clearly need to be accelerated.

Table on MDGs
Progress towards achieving the MDGs in India

Indicator	Year	Value	Year	Value	On track value*	Linearly projected 2015 value	MDG target value	Status
Proportion of population below poverty line (%)	1990	37.5	1999-2000	26.1	30	9	18.75	On track
Undernourished people as % of total population	1990	62.2	1999-2000	53	49.8	39.2	31.1	Off track
Proportion of under-nourished children	1990	54.8	1998	47	46.1	29.6	27.4	Off track
Literacy rate of 15-24 year olds	1990	64.3	2001	73.3	N.A.	84.7	None	N.A.
Ratio of girls to boys in primary education	1990	0-71	2000	0.77	0.83	.86	1	Off track
Ratio of girls to boys in secondary education	1991	0.64	2001	0.68	.79	.73	1	Off track
Under five mortality rate (per 1000 live births)	1990	123	2001	93	.87	54.8	41	Off track
Infant Mortality rate (per 1000 live births)	1990	80	2001	66	56.7	48.1	27	Off track
Maternal mortality ratio (per 100,000 live births)	1991	437	1998	407	332	405	109	Off track
Population with sustainable access to an improved water source, rural (%)	1990	61	2000	79	69	100	80.5	On track
Population with sustainable access to an improved water source, urban (%)	1990	88	2000	95	90	100	94	On track
Population with access to sanitation urban (%)	1990	44	2000	61	55	86.5	72	On track
Population with access to sanitation rural (%)	1991	9.46	2001	21.91	39.3	55	72	Off track
Deaths due to malaria per 100,000	1994	0.13	2003	0.10	-	-	-	
Deaths due to TB per 100,000	1998	0.75	2001	1.50	-	—	-	
Deaths due to HIV/AIDS	2000	471	2004	1114	-	-	-	

* The on track value is a linear projection that reflects where the country should have been, for the last year of available data, in order to meet the MDG target value.

Source: Human Development Report, 2003; World Development Indicators, 2003; Economic Survey of India, 2002-03; The World Bank 2004, IIM Ahemdabad (did a previous version in collaboration with the Millennium Project Secretariat, UNDP)

Annexure 2.2.2

Comparison of Central Plan Outlays and Expenditure Under Major Sectors/Heads of Development During Ninth and Tenth Five Year Plans Periods

(Rs in crore at 2001-02 prices)

Sectors / Heads of Department	Ninth Plan (1997-2002)		Tenth Plan Outlay (2002-07)	2002-03 (Actual Expenditure)	2003-04 (Actual Expenditure)	2004-05 (RE)	2005-06 (BE)	Total of four years in Tenth Plan	%age of Col. (9) to Col. (4)
1	2	3	4	5	6	7	8	9	10
	Plan Outlay	Realization							
Health	5118.19	3912.61	10252.00	1311.31	1239.30	1733.87	2442.26	6726.74	65.61
Family Welfare	15120.00	11386.99	26126.00	3776.89	4121.58	4673.72	5395.15	17967.34	68.77
AYUSH	266.35	229.69	775.00	86.58	125.23	176.37	293.94	682.12	88.02
Total	**20504.54**	**15529.30**	**37153.00**	**5174.77**	**5486.11**	**6583.96**	**8131.35**	**25376.19**	**68.30**

Annexure-2.2.3

Comparison of Plan Outlays and Expenditure Under Health Sector During Ninth and Tenth Plan Periods in States/UT Plans

Rs in crore at 2001-02 prices

State/UT	Ninth Plan (1997-2002)		Tenth Plan Outlay (2002-07)	2002-03 (Actual Exp.)	2003-04 (RE)	2004-05 (BE)	Total of 3 years of Tenth Plan	%age of Col.(8) to Col.(4)
	Plan Outlay	Realisation (Expenditure)						
1	2	3	4	5	6	7	8	9
Andhra Pradesh	630.52	1124.97	1330.24	212.23	360.96	361.51	1552.32	116.69
Arunachal Pradesh	335.02	98.65	231.29	21.03	20.57	24.53	107.74	46.58
Assam	384.10	450.11	570.69	79.02	73.68	57.57	365.47	64.04
Bihar	832.00	380.82	1079.20	103.48	102.76	125.06	591.50	54.81
Chattisgarh		49.36	434.18	53.52	75.56	132.95	404.45	93.15
Goa	81.22	69.29	131.35	18.21	24.53	31.05	121.75	92.69
Gujarat	832.25	993.17	1166.16	146.50	207.71	223.05	1019.26	87.40
Haryana	351.34	236.67	960.62	21.54	55.15	62.82	272.98	28.42
Himachal Pradesh	317.65	557.81	787.72	124.45	188.79	161.34	786.36	99.83
J & K	1100.29	549.44	796.66	124.02	146.72	144.01	679.05	85.24
Jharkhand		64.98	650.00	62.66	70.11	123.81	458.87	70.60
Karnataka	1100.00	1230.65	1530.52	170.83	157.83	158.83	803.72	52.51
Kerala	309.40	320.15	408.40	76.34	79.31	89.33	404.91	99.15
Madhya Pradesh	567.87	614.14	715.33	140.03	122.34	179.00	745.76	104.25
Maharashtra	918.23	953.50	1106.66	208.61	580.16	179.00	2075.11	187.51
Manipur	36.00	40.70	81.73	2.93	21.31	16.90	76.10	93.11
Meghalaya	140.00	146.54	180.00	31.05	35.52	35.64	164.52	91.40
Mizoram	112.01	116.73	123.70	26.29	38.38	26.46	146.51	118.44
Nagaland	106.31	105.56	79.65	15.06	22.28	19.46	94.01	118.02
Orissa	416.06	424.97	521.39	70.23	125.72	103.52	625.47	119.96
Punjab	511.59	467.29	530.81	62.52	113.97	66.22	430.05	81.02
Rajasthan	770.60	605.10	568.92	38.90	69.72	95.34	404.17	71.04
Sikkim	80.00	66.20	80.00	13.58	15.20	19.49	78.71	98.38
Tamil Nadu	780.52	637.01	700.00	137.76	151.10	171.08	713.11	101.87
Tripura	85.59	79.53	250.72	13.57	29.90	22.36	98.92	39.45
Uttar Pradesh	1185.00	770.35	2405.43	250.24	211.25	299.18	1346.14	55.96
Uttaranchal		48.12	387.67	55.63	68.78	77.24	311.77	80.42
West Bengal	978.64	754.18	1036.18	136.33	249.73	209.35	1062.54	102.54
A & N Islands	77.41	109.53	114.00	20.44	20.19	21.08	101.57	89.10
Chandigarh	170.65	192.92	224.26	38.04	29.08	30.66	163.54	72.93
D & N Haveli	5.14	11.40	12.25	2.60	2.49	3.02	12.89	105.24
Daman & Diu	8.87	9.74	17.50	2.10	2.12	2.56	10.78	61.61
Delhi	1101.40	1095.22	2381.50	318.64	394.28	474.21	1961.99	82.38
Lakshadweep	8.17	13.76	9.01	2.24	2.20	1.98	11.20	124.23
Pondicherry	100.00	131.87	163.60	28.93	30.51	36.68	157.64	96.36
Total	**14433.85**	**13520.41**	**21767.34**	**2829.57**	**3899.90**	**3786.28**	**18360.87**	**84.35**

1 Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, Jharkhand, Uttaranchal, and Chhattisgarh and Orissa