Science and Technology

10.1 The importance of developing S and T in a major way has been recognised since independence. The whole-hearted support provided to science and technology since then, has resulted in many accomplishments in a wide variety of disciplines. Moreover, these activities have played a dominant role in the socio-economic development of the country. At the time of independence, the scientific and the technological base of the country was very small. But, today it consists of a wide spectrum of infrastructure in terms of laboratories, R and D institutions, in-house R and D establishments' etc. covering several disciplines. There has been a significant growth in the capabilities and achievements in several high technology areas, namely nuclear and space sciences, electronics, defence etc. In addition to the growth in these and other strategic vital sectors, determined by sectoral needs, there have been spin-offs and technology transfers to other sectors, especially the broader production sectors, having large societal implications. Efforts have been mounted for developing the newly emerging areas viz. microelectronics; informatics/ telematics; biotechnology; new materials; renewable energy sources; ocean sciences; and several areas of basic research. Indian scientists and technologists have risen to the occasion to fulfil the national needs, whenever needed. Nevertheless, there is still much more to be done in the years ahead by evolving alternative strategies utilising the infrastructure and technical manpower created over the years to emerge as a global technical power. Science and technology efforts have to under-pin the growth of agriculture, industry, infrastructure and services so that the per capita incomes rise across the board and the economy becomes globally competitive.

10.2 India has been moving in a balanced manner leading to an economy which, while working towards fulfilling the expectations of its large population, is also globally relevant. The S and T policy and the approach that should be adopted for the Ninth Plan must, therefore, reflect the reality of the present day world in which nations progress along their own chosen paths but in a much more closely interconnected and interdependent manner.

10.3 In the context of exploring new horizons and new vistas of economic prosperity, S and T has to remain the main focal point and meet the economic, industrial, trade and societal challenges. The technology policy must go beyond technology import, absorption, adaptation and assimilation. More importantly, the benefits emerging from S and T must reach all sections of the community, including the weakest section of the society. While many of the earlier S and T inputs have been very useful for building up a viable S and T infrastructure, the new challenges require considerable modifications in the existing policies, especially with regard to the mechanisms of implementation.

10.4 It must be borne in mind that scientific explorations and widening the frontiers of knowledge are important activities of all civilised societies. India has had its own treasure house of traditional sciences. India has produced many giants in a variety of disciplines of science during the twentieth century. It must be ensured that creativity and excellence are nurtured amongst the younger generation and India contributes to future discoveries and inventions on a scale that is appropriate for its size and history.

S and T Policy and Approach during the Ninth Plan

- Need for mounting efforts to control population and improve the levels of food security, economic growth, literacy, health and so on, apart from realising the technological strengths in the emerging global industrial/economic environment by optimal utilisation of the S and T Systems in India.
- Scientists with exceptional capabilities should be nurtured and supported fully by offering them, with in the country facilities comparable with international standards.
- To be in the forefront in some of the chosen fields, the research programmes should be taken up on a mission mode through appropriate re-structuring and re-orientation.

10.5 India has made a substantial progress in a number of areas related to the economy viz. food security, average life expectancy, literacy and higher education. But, one cannot be complacent about these achievements, as growth towards excellence is a continuous process and there is need to mount efforts to control population and improve the levels of food security, economic growth, literacy, health and so on, apart from realising the technological strengths in the emerging global industrial/ economic environment by optimal utilisation of the S and T system in the country, which provides immense opportunities and offers great challenges. There is need to sensitise the policy makers in the government about the significance of Science and Technology especially in tackling these national priorities. Since a strong science base is a prerequisite for achieving technological competence, efforts will be continued to build and maintain the same. In this endeavour, scientists with exceptional capabilities should be nurtured and supported fully by offering them, within the country, facilities comparable with international standards; by creating

more Centres of Excellence in institutions of higher learning for supply of future S and T manpower; and by utilising the existing infrastructure in terms of facilities and manpower for planning and development of S and T programmes.

10.6 To be in the forefront in some of the chosen fields of agriculture, exports and industry, the research programmes should be taken up on a mission mode through appropriate restructuring and reorientation of many of the scientific institutions and laboratories.

10.7 In order to minimise the hierarchical bureaucracy in the R and D institutions, there is a need for radical change in the mindset of our science administrators. Efforts should be made to create a conducive environment through measures such as professionalisation of science auditing with the concepts of time accountability on decision makers and administrators as well as evaluation of achievement of goals/targets; decentralisation of decision making powers and authority for implementation; introduction of participative decision making processes in the S and T institution; etc. The Science and practitioners science need to be made central to all our planning and operations. The ultimate aim is to ensure that, by and large, the activities pertaining to scientific management, promotion and development are performed by scientists and technologists. For Indian Science to flourish, the administrators and government officials should act as facilitators of science and not masters of scientists. They should create conditions that encourage young scientists.

10.8 For the development and marketing of technology, there is a need, not only to upgrade, modernise and expand the existing S and T infrastructure but also to establish linkages between the industry and the research institutions/ laboratories and encourage venture capital funds for this purpose. In the process, the industry should emerge as the prime investor. While making any new investment, efforts must be made to avoid needless duplication and new centres/institutions should be set up on the basis of careful selection, preferably around academic institutions/research scientists with a high degree of freedom and flexibility. The major focus of the S and T programmes should be to encourage and strengthen interaction among R and D institutions and the users.

10.9 For the evaluation of S and T proposals, the criteria could be: the outputs/results, quality and timeliness (instead of quantities in terms of number of projects, expenditure incurred etc); ability to face global competition and to meet national needs; and ability to attract services or funds from the industry and the financial institutions.

- The science and practitioners of science should be made central to all our planning and operations.
- For Indian science to flourish, the administrators and government officials should act as facilitators of science and not masters of scientists.
- There is need to establish linkages between the industry and research institutions/labs and encourage venture capital funds for development and marketing of technology.
- There is need to develop core strengths and concentrate on areas where competitive strength can be built so that technological capabilities can be converted into commercial strengths.

10.10 One of the key elements in the modern global interaction is to have core technological strengths not only in strategic areas but in most of the key sectors of economy and trade as well. But, with limited resources, all-round excellence in all facets of technologies cannot be aimed at. Therefore, there is a need to develop the core strengths and concentrate on areas where competitive strengths can be built so that the technological capabilities can be converted into commercial strengths. In this context, various government departments could prepare long-term S and T profiles, keeping in view the Technology Vision 2020 document, prepared by the Technology Information Forecasting and Assessment Council (TIFAC) with the ultimate objective of integrating their plans with the productivity and effciency factors envisaged within the concerned socio-economic departments vis-a-vis improving the existing infrastructure in them (including facilities for evaluation and certification of new products and processes). This would help accelerate the economic growth and derive maximum societal benefits. For this purpose, it is essential to promote and strengthen the interaction between the S and T system and the socio-economic ministries. To achieve this, there is a need in each ministry to set aside a specified percentage of its total budget for S and T promotion in such a way that no diversion of funds, earmarked for the S and T programmes, takes place. In consonance with the principles of Agenda-21, adopted by member countries at the United Nations Conference on Environment and Development (UNCED), held in Rio de Janerio in June, 1992, there should be greater emphasis on clean and eco-friendly technologies with zero toxicity and zero environmental impact for sustainable development. Focus should be on the concept that one industry's pollutant is another industry's raw material and systematic efforts must be made to establish this nexus so that the industries could be developed in a sustainable manner without damaging the environment. For such a technology development process to take place, various organisations must set their machinery and management techniques appropriately.

- There should be greater emphasis on clean and eco-friendly technologies and focus should be on the concept that one industry's pollutant is another industry's raw material.

- There is need to create conducive environment in our educational institutions for developing creative skills and innovative capabilities with greater emphasis on modern management techniques, technology marketing and IPR related issues.
- Intensive efforts should be made to generate maximum resources for R and D from the production and service sectors.

10.11 For a qualitative growth, as distinct from the quantitative, human resource development and motivation must be regarded as key issues. This calls for several measures. The scientific and technical education needs to be oriented towards developing creative skills and innovative capabilities by creating conducive environment in our educational institutions, with greater emphasis on training of scientists in modern management techniques, including technology marketing and Intellectual Property Rights (IPR) related issues. In addition, creativity should also be encouraged in industry by a constant quest for productivity and quality so that the human resource could be tapped effectively, irrespective of their level. The S and T manpower must be given greater responsibilities to develop new energy efficient and environment-friendly processes based on automation and artificial intelligence, in addition to those concerning fiscal and material resources. Mobility of the S and T personnel among various R and D organisations, academic institutions and industries needs to be encouraged. Young scientists should be attracted through appropriate incentives to the scientific and technological research careers.

10.12 Science and technology activities in the States and Union Territories should be geared up to take up location-specific R and D programmes for providing S and T inputs in the key sectors of socio-economic development by increasing the demands from State Governments for the S and T inputs, through promotion of joint innovative programmes with industry, NGOs etc.

10.13 The process of planning the programmes/projects in various S and T sectors involves giving policy directions from time to time, setting priorities among the various S and T sectors and restructuring the S and T system to suit the changing needs. In all these aspects, efforts should be made to utilise the 3-tier national apex level S and T mechanism comprising of Cabinet Committee on S and T (CCST), Science Advisory Committee to the Cabinet (SACC) and the Committee of Secretaries for S and T (COS S and T).

10.14 While the role of the Government in supporting basic research, technology development and its application as well as the promotion of S and T infrastructure would continue at an accelerated scale, intensive efforts should be made to generate maximum resources for R and D from the production and service sectors.

PRIORITISATION IN S and T AND THRUST AREAS

(A) Prioritisation

- Strategic sectors such as Atomic Energy and Space should continue to receive increasing investments.
- Injection of technology in the fields of agriculture and related products can make a significant impact on production.
- The Department of Biotechnology and other Scientific Departments should make a mark in the light of the international control regimes pertaining to IPR and TRIPS for protecting the interest of the country.

10.15 India is one of the top ranking countries in the field of basic research and her success in technology development has been very significant. India's capability in building nuclear reactors, communication and remote sensing satellites and guided missiles, just to mention a few, has been clearly demonstrated. The industries also handle a wide range of technologies. With these capabilities, Indian S and T has come to be regarded as one of the powerful instruments of growth and development, specially in the emerging scenario of globalisation and competitive economy. In the wake of recent developments and the new demands that are being placed on the S and T system, it is charged with significantly new responsibilites and has a major role to play in the country's development. The IPR system has to be in tune with the rest of the world for providing the requisite framework for India to emerge as global R and D platform.

10.16 During the earlier Plan periods, support to basic research has been receiving a rather high priority. Though this may continue to a considerable extent, a proper balance should be maintained between fundamental research and applied research in scientific fields. Recent developments have brought home the need to accord high priority to technology related areas, particularly the process technologies, which may be characterised as core technologies, which need to be strengthened with particular emphasis on ensuring partnership with the concerned socio-economic activities and industry wherever possible. In this process, the Indian industry and the users of technology have a

crucial role to play. They should be made aware that industrial R and D requires not merely continuous upgradation but generation of technology as well, which would be able to sustain a competitive technological edge. Funding of R and D by industry and formation of consortia for technology development will be essential in the new scenario. The industry initiatives ought to constitute the driving force not only for generating innovative industrial technologies which should be built on a wide and strong S and T base created so far, but also for bringing the same into rapid and wide-spread use through up-scaling at pilot level, market surveys and bench marking. In this context, it is necessary that, during the 9th Plan, emphasis is placed on clearly defined criteria for prioritisation and identification of thrust areas.

10.17 To determine science and technology priorities at any point of time for a country's development is a daunting task. Several demands compete with each other and the resources invariably limited. Evolving an optimal programme of action calls for a detailed analysis of the past developments, available strengths and visions of the future. The criteria for prioritisation in the S and T sector can be based on several aspects such as academic excellence, strength in a particular activity, strong domestic market base, trends in world trade and world production, industry orientation, economic benefits, employment opportunities, commercially relevant technologies, strategically (security-related as well as industry-related) significant technologies, capability to address national needs and national competence vis-a-vis global status. In addition, the following considerations have to be kept in mind:

i. Strategic sectors such as Atomic Energy and Space should continue to receive increasing investments. This is inevitable in the context of several export control regimes which appear to target particularly India.
ii. Injection of technology in the fields of agriculture and related products can make a significant impact on production.
iii. The trends observed in the 8th Plan in linking institutional S and T capability to domestic needs (e.g. water) and economic requirements (e.g. energy, materials, information and communication) should gain in range and in depth.

- The challenge posed by the new global regime has been compounded by unilateral and arbitrary restrictions being placed by the industrial countries on transfer of technology on the suspicious ground of preventing proliferation of "dual use". This situation will have to be faced in a concerted manner both at the national and international levels.
- Exploration and exploitation of the vast living and non-living resources of the oceans for sustained socio-economic development of the society and judicious management and conservation programme of the marine environment should be pursued
- Joint R and D ventures between Indian institutions and those abroad should multiply in mutually beneficial technology areas

iv. The commendable self-reliance achieved by the country in the field of Nuclear Science and Space Sciences should be encouraged and further strengthened.
v. The new areas of biotechnology and environmentally significant technologies are rapidly growing world-wide. The developed countries have been putting greater and greater emphasis on patenting of living organisms in the light of the international control regimes pertaining to IPR and TRIPS. The Department of Biotechnology and other Scientific Departments should also make a mark in this endeavour for protecting the interests of the country. There is also a need to create much greater awareness amongst the scientists and technologists regarding the patents and IPR-related issues.
vi. The global regime represented by TRIPs severely restricts national autonomy. By enhancing the protection of intellectual property rights across-the- board, this regime has tilted the balance between the public interest, on the one hand, and the private interest of the inventor, on the other, excessively in favour of the latter. The challenge posed by the new global regime has been compounded by unilateral and arbitrary restrictions being placed by industrial countries on transfer of technology on the suspicious ground of preventing proliferation of "dual use". This situation will have to be faced in concerted manner both at the national and international levels. National laws will have to be suitably strengthened to withstand such unilateral restrictions. Gaps and ambiguities in the international regime will have to be availed of creatively to seek more favourable interpretations of its provisions. At the international level, a new initiative will have to be launched in consultation with developing countries to mitigate the rigour of the international regime and to secure a more favourable deal at the impending review of the TRIPs Agreement in the WTO.
vii. The oceans are known to be the last frontier of natural resources. Exploration and exploitation of the vast living and non-living resources of the oceans for sustained socio-economic development of the society and judicious management and conservation programme of the marine environment should be pursued.

viii. The investment in R and D from private industry should be stimulated to grow.
ix. Joint R and D ventures between Indian institutions and those abroad should multiply in mutually beneficial technology areas.
x. Attracting creative scientific talent to the frontier areas of research and basic sciences should continue.

(B) Thrust Areas for Technology Promotion

10.18 Determination of the thrust areas for technology promotion requires far wider consultation. The TIFAC has recently gone through an innovative exercise with the help of several task forces to identify the thrust areas in various sectors of economy, as part of Vision 2020 programme. This should guide the efforts in selecting the areas of thrust. For effective identification of the priorities and the thrust areas, it is also essential to restructure the present S and T systems with a focus on greater autonomy in S and T with flexibility and accountability; strong monitoring and peer review system; support to basic research on a long-term basis; human resource development in specialised areas; spin-offs from high-tech/strategic S and T fields (Atomic Energy, Space, Defence) for use in civilian sectors and bringing in professionals to the S and T system/services through the creation of a pool of science and technology managers for efficient management and administration of scientific activities.

SCIENCE, TECHNOLOGY AND EDUCATION INCLUDING PROMOTION OF BASIC RESEARCH AND EXCELLENCE

10.19 Starting from the early 1970's, there has been a significant increase in the Government support for science and technology. India today has a wide base of infrastructure for R and D. There are 200 universities, about 400 national laboratories and 1300 in-house R and D units of industries. As a result of this and other endowments, India has become internationally competitive in a number of areas. This progress must be maintained and improved upon through appropriate training of manpower in the emerging technologies with infrastructural development as the basic input and earmarking of funds for higher education by the scientific departments in the form of direct support to identified Centres in the universities.

10.20 The problems in bringing about improvements in S and T education pertain to the unavoidable socio-political influences on education, besides inadequacy of laboratory facilities in universities for research and teaching work at the M.Sc. and Ph.D levels. The academic community should try and isolate higher education from the negative external influences and build up the infrastructure and, where necessary, gradually motivate the faculty to do research by giving them a sense of empowerment and autonomy of functioning within the university system and through the revival of the teacher training programmes of the 1960's.

- The academic community should gradually motivate the faculty to do research by giving them a sense of empowerment and autonomy of functioning with in the university system.
- The inter-university centres, which are providing very valuable services to the university research community should be encouraged by earmarked support through the UGC.
- The operation of research funds both at the level of the individual research worker and at the institutional level, needs to be reviewed so that sub-critical support is avoided.

10.21 The Inter-University Centres, which are providing very valuable services to the university research community, should be encouraged by earmarked support through the UGC for running the existing Centres and for establishing new ones in other areas after appropriate assessment by a national body. The possibility of supporting these Centres from scientific departments and socio-economic ministries should also be explored. With a view to promoting a coordinated approach in the utilisation of instruments and equipment facilities, the possibility of establishing Regional Sophisticated Instrumentation Centres (RSIC) in the universities and setting up advanced research Centres/ Groups in certain specialised fields such as optical materials, condensed matter physics, low energy accelerator research, molecular electronics, laser instrumentation, colloides and surfactants, astronomy, astrophysics, plasma physics etc. may be explored.

10.22 The operation of research funds both at the level of the individual research worker and the institutional level needs to be reviewed so that subcritical support is avoided. At the level of individual scientific worker, the research support should be based on the proven track record with maximum flexibility and autonomy in controlling the research funds. In this regard, the funding agencies may evolve common guidelines. At the institutional level, there should be greater provision for long-range programmes and infrastructural support, involving, wherever necessary, several related departments. Efforts should also be made to set up Centres of Excellence around outstanding scientists or group of scientists following a peer review system.

- The extra-mural research funding should be enhanced by carefully building up rigorous, objective, constructive and credible peer review system.
- Efforts would also be made to provide financial support to the universities and related institutions for improving S and T infrastructure.
- Establishment of some regional science and engineering research libraries in chosen institutions with net-working facilities

10.23 One of the mechanisms for funding basic research is through the Extra Mural Research (EMR) budgets of several scientific agencies like DAE, DOS, DST, CSIR, DBT etc. and of the socio-economic departments such as DOE, DNES, DARE etc. The EMR funding should be enhanced by carefully building up rigorous, objective, constructive and credible peer review systems. There is also a need to provide autonomy in the use of such funds. In building up such a system of scrutiny, guidance can be taken from the All India Council for Technical Education (AICTE), which has taken steps to strengthen technical education and support the R and D in engineering and technical institutions in the country.

10.24 Another source of guidance is the Science and Engineering Research Council (SERC) which is the major EMR funding source for basic research in all areas of science and engineering and across all institutions. During the 9th Plan, the possibility of upgrading the SERC mechanism to a significantly higher level with greater autonomy can be explored for the formulation of broad R and D policies and providing direction regarding the setting up of national facilities, coordinated R and D programmes etc.

10.25 In order to improve the facilities for basic research in the universities and research institutions, comparable to those in the developed countries, several measures are called for. These, inter-alia, include revival of the UGC programme of the Committee for Strengthening Infrastructure in S and T (COSIST) as an independent programme. In addition, strengthening of programmes relating to Centres for Advanced Studies (CAS) and Special Assistance Programmes (SAP)/Department Special Assistance (DSA) programme should be taken up to make them much more responsive and stricter in their assessment and evaluation aspects. Efforts would also be made to provide financial support to universities and related institutions for improving S and T infrastructure. The efforts of the National Board for Higher Mathematics (NBHM) of the DAE, in supporting selected libraries to serve as regional resource centres in mathematics, may be expanded by establishing some regional science and engineering research libraries in chosen institutions with networking facilities.

10.26 Communication facilities are needed for the vast majority of our research and teaching community to escape from intellectual isolation. Information technology needs to be deployed appropriately to ensure greater dissemination of knowledge in various fields of industrial and agricultural development. This can be achieved through full Internet connectivity with broad-band channels for multi media facility, networking of libraries, computers etc. This will be a major information resource not only for basic research in science and engineering, but in all academic fields including health, medicine and humanities. It must be done in a well coordinated manner.

10.27 Another important area where the creation of infrastructure is called for, relates to the accelerator based research facilities in the academic institutions/ universities in collaboration with UGC/Department of Education. It will play a major role in keeping the country in the forefront of modern technology. Various institutions are having plans to have different types of accelerators and to develop experimental facilities such as detector arrays. There is a need to pool the technical and financial resources and build national facilities in this area. A national committee needs to be set up for defining the priorities and drawing up national plans so that the available funds are most optimally deployed and duplication is avoided.

- Need for building up national facilities in the area of accelerators by pooling of technical and financial resources.
- Need for revival of the National Science Talent Scheme in its original form and introduction of some high quality under graduate science programmes at selected institutions.
- In order to raise the national R and D expenditure to the desired level of 2% of GNP, the industry should be made to come forward in a big way by putting in demands on the existing R and D infrastructure and by supporting innovative programmes of technology development and refinement

10.28 A major problem today is to find ways and means to attract the most talented youngsters to basic science at a young age. For this obviously, both the image of a career in science and the available educational opportunities must be attractive enough as compared to other more lucrative options. This calls for a multi-pronged approach like revival of the National Science Talent (NST) Scheme in its original form, meant exclusively for science students; giving

awards to outstanding science students after the 12th standard by the scientific agencies and socio-economic departments similar to the DBT's programme; introduction of some high quality undergraduate science programmes at selected institutions in addition to the ongoing programmes to attract the talented students to the science streams; introduction of scholarship schemes for M.Sc level students and providing support to specialised courses at the universities by science agencies like DAE, DRDO, DOS etc. similar to the manpower development programme of DBT/DOD; increased financial support at the doctoral/post doctoral level; revision of the recruitment and staffing patterns in the scientific institutions by offering specialised posts to Ph.Ds as in the developed countries etc. With these and similar such measures, the science education and careers in science can be made more attractive and even internationally competitive.

10.29 The industry can also play an active role in the process of promoting S and T education and basic research. There are some good quality research centres run by the industry in some areas like pharmaceuticals. At the faculty level, greater intellectual exchange between the industry and the academic institutions can be brought about with possibilities of adjunct appointments, sabbatical programmes, etc.

10.30 At the national level in high technology programmes, scientific agencies, universities and industry naturally come together, as in the case of Technology Development Missions. Since the industry, like the scientific agencies, need and use trained manpower, sooner they enter the training process, the better. The industry can sponsor students with scholarships in special disciplines, co-sponsor research programmes, provide assistance for laboratory work at the postgraduate and doctoral levels etc. These steps would naturally lead to greater synergy between industrial R and D and research activity in academic institutions.

10.31 There is no denying the fact that for the basic sciences sustained support has to come from the Government sources. While providing such support an academic group should, as far as possible, be identified for organising joint collaboration development programmes in a time-bound manner. Applied research should be supported by the industry in a major way, as the industry will be the direct beneficiary of this. In the new economic scenario, the technological levels of many industries in India need significant upgradation. Compared to developed countries, the contribution of Indian industry to the total R and D expenditure, at about 23%, is much less than desired. Therefore, in order to raise the national R and D expenditure to the desired level of 2% of GNP, the industry should be made to come forward in a big way by putting in demands on the existing R and D infrastructure and supporting innovative programmes of technology development and refinement. The in-house R and D set up should also be suitably strengthened as this will strengthen the competetiveness of the industry.

10.32 Thus, while formulating the 9th Five Year Plan, the goals in the sphere of basic research and associated higher education have to be determined not only by the infrastructure available for R and D, but also by several other major considerations. These include: fierce technological competition during the transition to a liberalised economic environment; strengthening of the range and depth of scientific and technological capabilities which can be achieved through high quality basic research and responsive education system; sound scientific and technological base to fulfill societal needs and the need for recognition of the interconnection of research in basic sciences with applied work, technology, engineering and production vis-a-vis national development.

MECHANISMS FOR HARNESSING S and T FOR NATIONAL DEVELOPMENT

- There is need to strengthen further the mechanism of transfer of technology to industry during the Ninth Plan.
- Technology export is an important channel for enhancing the exports
- In order to improve the technological competitiveness in the global market and enhance the technology export potential, attention has to be focussed on areas such as university-corporate R and D spending, lab to industry conversion, indigenous innovation, IPR protection etc.
- A novel experiment for harnessing S and T has been the consortia approach' in which one of the laboratories acting as a nodal institution, forms a consortium with the industry or other departments.

10.33 For harnessing S and T for national development, the Government has been adopting several methods. Technology transfer to industry is one of them. Under this, the S and T capability is being transferred to the open market in the form of products of acceptable quality in a cost-effective manner. Several national laboratories have been doing this, either directly or through the National Research and Development Corporation (NRDC), which is a government agency for `transfer and commercialisation of technology'. The Department of Space (DOS) has been doing so directly until the "Antrix Corporation", was set up for this purpose. The Department of Atomic Energy (DAE) has also been doing so for quite some time. There is a need to strengthen further this mechanism of transfer of technology to industry during the Ninth Plan.

10.34 Technology export is an important channel for enhancing the exports. The industrial experience gained in the process of technology acquisition, absorption and adaptation and the strong capabilities built in R and D and academic institutions can be shared with other countries for mutual benefits. In order to improve the technological competitiveness in the global market and enhance the technology export potential, attention has to be focussed on areas such as university-corporate R and D spending, lab to industry conversion, indigenous innovation, IPR protection etc. There is also a need to create institutional mechanism to promote technology exports and sensitise the export promotion agencies like the Export Promotion Councils (EPCs) about the role of technology exports in catalysing overall exports. The Transfer and Trading in Technology (TATT) scheme of DSIR could be further strengthened to promote export of technologies, projects and services. NRDC can also play an important role by undertaking activities like pre-feasibility studies, market potential studies, awareness building among the Indian companies about technology transfer negotiations, organising seminars on matters such as those relating to WTO, providing assistance in filing foreign patents etc.

10.35 A novel experiment for harnessing S and T has been the `consortia approach' in which one of the laboratories acting as a nodal institution, forms a consortium with the industry or other departments. The Non-ferrous Materials Technology Development Centre (NFTDC) is an example of this consortium approach with the Defence Metallurgical Research Laboratory (DMRL) acting as a nodal laboratory and four leading public sector enterprises, namely, National Aluminium Co. (NALCO), Bharat Aluminium Co. (BALCO), Hindustan Zinc Ltd. (HZL) and Hindustan Copper Ltd. (HCL), functioning as industry members of the consortium. While the nodal laboratory, DMRL, provides extensive facilities and R and D support, the industry members contribute by way of corpus fund, deputation of industry personnel and, most importantly, defining the market-oriented product development. Other examples of such a consortium approach are: the Composite Product Development Centre, (COMPROC) of the Defence Research and Development Laboratory; the Society for Biomedical Technology (SBMT) for the promotion of bio-medical devices, a joint effort of DRDO and DST and supported by the Ministry of Welfare as well as the Ministry of Rural Areas and Employment; the Centre for Laser Processing of Materials (CLPM), recently set up jointly by DRDO, the Department of Mines and the DST in Hyderabad, in association with the industry, for the purpose of developing and demonstrating the capability in a new technology area.

- A network of testing and evaluation facilities. The National Accreditation Board for Laboratories (NABL), set up in this direction, needs to be nurtured.
- While creating the mechanisms for harnessing S and T, it is necessary to ensure that the investment in technology development programmes is governed by national needs.

10.36 Another mechanism, being adopted, has been through a kind of `Government-Industry Interface' under the Programme Aimed At Technological Self Reliance (PATSER), in which assistance is provided to the industry, in the public as well as the private sectors in the area of technology development and its transfer. A number of multi-institutional projects have been recently developed, involving several departments and socio-economic ministries in the fields of building materials, wood substitutes; mini-micro hydel power; CFC substitutes; high energy magnets; and laser processing of materials. More such projects need to be taken up and a method may be evolved to ensure that the industrial links already established are further strengthened.

10.37 Still another mechanism to harness S and T, which has proved to be successful, is the "Technology " or the "Mission Mode Projects". This approach envisages new management structures with much closer linkages and better interaction and coordination among many departments/agencies for deriving large-scale, time-bound tangible applications of S and T. A number of mission mode programmes can be formulated, based on Technology Vision 2020 programme, with inputs from a wide cross-section of economic ministries and in line with the criteria laid down for prioritisation. In this context, the special requirements in the emerging global scenario have to be kept in mind. Such programmes can be of two types. The first is the Missions of Technological Significance in the areas such as energy, lasers, optics, drugs etc. The second is the Missions of Societal Significance. These can be in the areas of female health care, medical systems, AIDS education, transport systems etc.

10.38 The success of these mechanisms for harnessing S and T depends to a large extent on the allied infrastructure support. For example, in the light of the experience with the implementation of certain technology programmes, it was felt desirable to set up an Engineering Research Centre (ERC) in an educational institution or a forward looking research laboratory with respect to each of the technology areas, selected to be built up, Such a Centre can function on a three-way partnership basis involving the academia, the industry and the Government Laboratory and/or agency. The fundamental aim of such centre will be to bring together engineering and scientific disciplines to address R and D issues, crucial to technology advances from an engineering system perspective. This will also help educate the new generation of engineering students in cross disciplinary systems of problem solving. The possible areas where ERCs can be established are: advanced manufacturing technology, technical accoustics and vibration control, advanced combustion engineering, experimental robotics, opto-electronics/ microelectronics, materials processing etc. While the management structures for a programme of this nature are to be carefully planned, such a programme

would require participation and long-term commitments from the industry, the user organisations and the government agencies. An excellent outcome of such a cooperative endeavour is the receiver-based telephone answering chip developed jointly by the Indian Institute of Technology, Chennai (an academic institution), the BPL (an Indian company) and the Analog Devices (an MNC).

10.39 Another infrastructural necessity is a network of testing and evaluation facilities. While there have been exceedingly good facilities for doing both basic and applied research, one needs high quality and standard testing and evaluation facilities for upscaling the technology development. Further, it is essential that such facilities in the long run get accreditation with the aim to provide to the nation a network of testing, evaluation and calibration facilities in accordance with international standards. The National Accreditation Board for Laboratories (NABL), set up in this direction, needs to be nurtured. Some of the areas of S and T where such testing and evaluation facilities have already been set up are: wind tunnel facilities, building materials and characterisation facilities, geo technical centrifuge facilities, aeronautic material test facilities etc. The scope of this initiative needs to be widened in such a way that it can cater to the needs of the small scale sector as well.

10.40 While creating the mechanisms for harnessing S and T, it is necessary to ensure that the investment in technology development programmes is governed by national needs. Depending on the emphasis on utilising technology for the improvement of the economy, the pattern of investment would require readjustments in various socio-economic sectors. Science and Technology should be harnessed not to deepen the problem of unemployment but to make the quality of the products more competitive. There should be innovation of appropriate technology that will accelerate the process of decentralised development. With regard to the financing of technology development efforts, it should be ensured that all possible partners - the Government, the industry and the academia - are fully involved in their respective financial commitments and that other sources of funds like the Technology Development Board (TDB), the ICICI, the financial institutions etc. are tapped. The investments from these sources should not, however, be used for building infrastructure which may prove costly, unproductive and redundant. During these endeavours, it is essential to make the monitoring and evaluation mechanisms perfect and institutionalised.

APPLICATION OF S and T FOR SOCIETAL DEVELOPMENT

- Efforts should be made for the development and application of appropriate technology packages for rural areas with active participation of voluntary agencies; development of rural enterprises through science and technology intervention and complementary development of rural infrastructure through application of science and technology.

10.41 Recognising that S and T can contribute significantly to poverty alleviation and improvement in the quality of life, in recent years and particularly in the 8th Plan scientific departments/agencies like DST, DBT, DOD, CAPART, ICAR, DOS, CSIR etc. have initiated several structured schemes with a focus on disadvantaged sections of society including the weaker sections, women, rural poor, tribals etc. They have made attempts to carry the fruits of science to rural areas. For example, the use of biomass as a source of energy through briquetting, gasifiers, biomass plants etc. has become very popular. New experiments on wind, hydro and solar energy have also been tried and demonstrated. Other technologies relevant to societal development are in the areas of low-cost housing, safe drinking water, sanitation, organic agricultural practices and biotechnology etc. These attempts apart, programmes such as Integrated Mission for Sustainable Development (IMSD) of the DOS, have carried the fruits of scientific research to several areas of the country. With issues such as global warming and bio-diversity becoming extremely important, the sectors of ecology and environment have been given due importance and special attention. There have been a large number of programmes on organic agriculture which have been implemented with a focus on natural ecology and sustainable development. Important studies have also been carried out to evaluate the social impact in the area of health with particular reference to tuberculosis, diahorreal diseases, psycho-social research in family planning, AIDS, nutrition etc.

10.42 A careful scrutiny of the important areas and the interests of the scientific departments, the research institutions and the implementing agencies, particularly in the non-government sector, indicates that the major sectors for taking up intervention programmes are: agriculture, rural artisanal industry, energy, housing and habitat, drinking water, sanitation and health, ecology and environment. During the 9th Plan, efforts should be made by the S and T departments both in the States and the Centre, for the development and application of appropriate technology packages for rural areas with active participation of voluntary agencies; development of rural enterprises through science and technology intervention and complementary development of rural infrastructure through application of science and technology. This calls for a well planned implementation strategy.

10.43 In formulating such a strategy, the first consideration is the unit of operations at the grossroot level. As the village or a Panchayat is too small to undertake a project, the Block has emerged as a viable and stable administrative unit catering to the development needs of about 1,00,000 people. Originally, the development

emphasis in a Block was on the welfare and on the provision of minimum social infrastructure. At the second stage, the focus shifted to area development. At present, the concern is towards poverty alleviation. Since the S and T inputs so far in all these stages have been only marginal, in the next stage, the focus must be on technology.

- Voluntary organisations, which have a strong science and technology base and high level of professionalism, have to play a very important role in implementing development projects with S and T inputs
- For replication of successful models, measures like granting sabbatical leave or attractive deputation terms to the scientists working on the project may be necessary.
- Special emphasis will be given to the promotion of research and development and adaptation of technologies for improving the life, working conditions and opportunities for gainful employment of women, especially in the rural areas.

10.44 In this task, one of the challenges before the S and T establishments is to build the local capability to identify local priorities, plan for solutions and participate as partners. In this, the voluntary organisations, which have a strong science and technology base and high level of professionalism, have to play a very important role in implementing development projects with S and T inputs. Their role would be to help local Governments/Panchayats in ensuring S and T inputs in the development plans being finalised by the District Planning Committees. As the number of such voluntary organisations is very limited at present, there is a need to have more such S and T field groups. The necessary technical back-up for the development activity can be ensured by formulating collaborative programmes with the involvement of S and T institutions, working scientists, technologists and the State S and T Councils. In the formulation of a project, the implementation mechanism and the enterprise characteristics should be so built into it that it becomes financially viable. The success of the Integrated Mission for Sustainable Development (IMSD) initiated by the DOS to generate and implement locale-specific developmental plans at watershed level with the help of Central/State agencies, academic institutions, NGOs and voluntary agencies in certain districts, is an excellent example in this regard.

10.45 Once a S and T department, either in the State or at the Centre, has successfully generated/demonstrated a model and proven its replicability, preferably through an assessment involving the other line departments and the financial institutions, a suitable inter-departmental structure/ mechanism may be set up for replication. Organisations like the National Small Industries Corporation (NSIC), the Small Industries Development Bank of India (SIDBI) etc. should be involved in the replication of the models in several diverse socio-economic/geographic contexts. To make this process a success, measures like granting sabbatical leave or attractive deputation terms to the scientists working on the project may be necessary. This will enable them to devote their time fully to their new assignments.

10.46 Another aspect that should be taken care of, under S and T application for societal development, is the improvement of traditional technologies which have the potential of employment generation and upgradation of the quality of life of the common man. Special emphasis will be given to the promotion of research and development and adaptation of technologies for improving the life, working conditions and opportunities for gainful employment of women, especially in the rural areas. The present state of inventories of traditional technologies in various sectors is weak. An initiative has been taken by the National Informatics Centre (NIC) to document these, through Geographical Information System Network (GISTNIC) at various district centres. This needs to be integrated/linked with the TIFAC's activities. During the 9th Plan, efforts should be made to have a complete documentation of traditioanl knowledge, specially in the areas like health care, medicinal plants, nutrition, agriculture, water harvesting, building technologies, metallurgical practices, non-farm occupations, etc. Regional centres for promoting research and documentation in traditional sciences and technologies may be set up in the existing institutions around eminent experts/scientists to study documentation, validation, upgradation and diffusion of traditional knowledge**.**

SCIENCE and TECHNOLOGY IN THE STATES AND UNION TERRITORIES

- The State level S and T machinery has to take the role of a major "prime mover", while the Centre can play a catalytic and advisory role in encouraging this initiative.
- The focus should be on programmatic support through strengthening the linkages/interaction between the State S and T Councils and the Central S and T agencies by suitably dovetailing each others' programmes.

10.47 With a view to planning and coordinating the activities of science and technology in the States, conscious efforts are being made over the years to set up at the State level a suitable organisational structure in the form of State Council of Science and Technology and Department of Science and Technology to provide necessary planning and organisational inputs for pursuing science and technology activities relevant to the development of the concerned State. The State level S and T machinery has to take the role of a major "prime mover", while the Centre

can play a catalytic and advisory role in encouraging this initiative of the State Government through decentralised planning approach. Today, all the States and Union Territories have set up State Councils/Departments of Science and Technology and the S and T activities are slowly gaining momentum.

10.48 During the Ninth Five Year Plan, the State Governments should be activated much more to bring about a rapid socio-economic development through the application of science and technology. The focus should be on programmatic support through strengthening the linkages/interaction between the State S and T Councils and the Central S and T agencies by suitably dovetailing each others' programmes. Such efforts would go a long way in bringing about a rapid socio-economic development in the States. For this purpose, certain measures need to be taken both by the State Governments and the Central S and T departments.

10.49 The State Government should (i) ensure adequate linkages between the State S and T departments and the development departments for identification of the S and T components of the State' development sectors to improve the productivity of the concerned sectors; (ii) formulate specific S and T projects which can be included in the State's annual and the Five Year Plans in such a way that they would contribute to the development of the State; (iii) identify the specific role that S and T can play in helping the programmes of poverty alleviation and improvement in the quality of life of the people of the State; and (iv) earmark an outlay for, and encourage expenditure on, the S and T activities which would be of direct relevance to the States/UTs, particularly in improving the operational efficiency and productivity.

10.50 The Central S and T departments/agencies should : (i) help in undertaking or initiating studies /surveys which are of special interest to the States/UTs on location-specific research and technology development, field trials of technologies developed by various Central S and T agencies /States for technology transfer; (ii) share mutually their experiences and the experiences of the States for initiation of regional development programmes through various interactive mechanisms; (iii) make the S and T personnel working in various State Councils aware of the areas, such as management of S and T, patents, laboratory accreditation etc. (iv) dovetail their programme with the programmes of State S and T Councils in the areas of patents, laboratory accreditation, science and society; popularisation of science; entrepreneurship development; National Resource Data Management System (NRDMS); biotechnology; remote sensing and information technology etc; (v) evolve suitable mechanisms for dissemination of information of successful developmental projects taken up by some of the State S and T Councils/departments for horizontal transfer of information/ know-how through the medium of State S and T newsletters etc. and by the networking of State S and T Councils and Central S and T agencies/departments using the NICNET facility.

SCIENCE and TECHNOLOGY INTERFACE WITH INDUSTRY

- In the emerging competitive environment, cooperation and coordination between Indian enterprises and R and D institutions is not a matter of choice but rather of compulsion derived from competitive pressures.
- The initial emphasis and endeavour should be on developing synergies and alliances to enhance Indian industry's competitive advantage and on gaining a greater share of global markets

10.51 The domestic R and D system and the industrial enterprises are the two main players in the S and T-industry interface which had been functioning so long in distinct and distant compartments without much interaction, as the former is generally in the strategic and non-competitive areas of R and D whereas industrial R and D, which was concerned more with investigating incremental production problems, was not geared to new process/ product development and was having little interaction with the national and international S and T community. But now the move towards a market economy is compelling both to establish a dialogue and work together for mutual advantage. This change is evident from the fact that the publicly funded R and D programmes are more market driven now than earlier; performance criteria are linked to economic, societal and environmental issues; there has been increasing awareness about the IPR and confidentiality issues and conscious efforts are being made to forge alliances and consortia for more comprehensive technology/service packages. Even on the part of the in-house R and D units, there has been an appreciation of the need for innovative technology development, deployment of larger investments in R and D and recognition of technology as one of the effective instruments of corporate strategy. While these attitudinal changes are desirable, cooperative efforts are also needed.

10.52 The increasing complexity of technology makes it difficult for the individual enterprises, especially the small and medium enterprises (SMEs), to engage themselves in the competitive R and D and technological development efforts due to high financial risks. In the emerging competitive environment, cooperation and coordination between Indian enterprises and R and D institutions is not a matter of choice but rather of compulsion derived from competitive pressures. The need for cooperation is to bring about value addition to the products through endogenous resources/skills; environmentally clean and economically viable processes; closely held technologies that are commercially denied to Indian industry; strategic/dual-use technologies; technology packages as available from commercially operating units; process/product upgradation and incremental productive improvements; and strategic

alliances with partners abroad for gaining market/technology advantage/dominance.

10.53 The initial emphasis and endeavour should be on developing synergies and alliances to enhance Indian industry's competitive advantage and on gaining a greater share of global markets in such areas like speciality chemicals, drugs and pharmaceuticals, footwear and leather products, automotive and light engineering components, customised software, textiles and garments, gems and jewellery, agro-based products etc. This is alread visible in the drugs and pharmaceuticals sector. Several Indian pharmaceutical companies have already forged strategic alliances with the domestic R and D institutions. The Drugs and Pharmaceuticals Research Scheme of the DST, the Home Grown Technologies of the TIFAC and the PATSER scheme of the DSIR are some examples of successful Government intervention in shaping the cooperative endeavours. The specific roles to be played by the Government, the publicly funded R and D system, the industrial enterprises and the financial institutions in this process are elaborated in the following paras.

- The Government will have to provide an economic environment favourable not only for the conduct of different kinds of business but also to catalyse the arrangements and the institutional mechanisms that would facilitate synergistic technological development, its absorption and upgradation.
- The efficiency and effectiveness of the R and D institutions can be significantly enhanced by providing them adequate flexibility and freedom to function in a market economy.
- The increased participation and involvement of the industry in the decision making bodies of R and D institutions will make their programmes not only more attractive to industry but also to the financial institutions offering venture/risk capital.

10.54 The Government will have to provide an economic environment favourable not only for the conduct of different kinds of business but also to catalyse the arrangements and the institutional mechanisms that would facilitate synergistic technological development, its absorption and upgradation. As a measure of enhancing R and D/technology demand, industry may be encouraged to establish its own R and D units by according tax incentives for investments on R and D; allowing accelerated depreciation for product development costs; cost-sharing of R and D projects of even private enterprises; etc. For improving the efficacy of R and D/technology supply, a single window system for R and D funding may be introduced. The R and D/ technology support facilities are required to be enlarged through the development of S and T information networks; the strengthening of standardisation, quality control and assurance systems; enhancement of the capacity of local consulting firms to translate R and D outputs to economic value products; support to technology marketing efforts of R and D institutions and promotion of peer-groups through more active industry/ professional associations.

10.55 On the part of the publicly funded R and D system, the avoidance of a purely bureaucratic approach is a necessity. The efficiency and effectiveness of the R and D institutions can be significantly enhanced by providing them adequate flexibility and freedom to function in a market economy. They should, in turn, devise strategic R and D/business plans aligned with the national priorities and tuned to the market needs by utilising multifunctional inputs in the project formulation with clear definition of project objectives and outputs, by introducing operational flexibility at the bench level and by undertaking effective publicity and marketing of R and D outputs. With a view to increasing the commercial attractiveness of R and D outputs, the industry may be helped to identify and articulate its R and D needs, followed by prioritisation of programmes to be taken up for R and D and by avoiding subcritical funding. The increased participation and involvement of the industry in the decision making bodies of R and D institutions will make their programmes not only more attractive to industry but also to the financial institutions offering venture/risk capital. Strategic alliances can be forged, if the technology is offered with performance guarantees, and more so, if offered as a technology-cum-financial package or as a turn-key project. This can be achieved by a consortium approach, where the R and D institutions, design and consultancy organisations, and financing institutions/venture capital firms will share the stakes in the technology package. The other steps which the R and D institutions should take relate to providing the enterprises access to technical information on several aspects like technological trends, technology sources, technology choices, technology assessment, sources of raw materials and equipment, financing possibilities; meeting the needs of industry for specialised training/skill development and facilitating mutual visits/short term placement of one's experts into the others' system/ environment.

- The industry should adopt a cooperative approach in identifying its R and D needs, inviting scientists/ technologists to serve on the Boards of companies and, finally, in financing in a major way the projects of their concern.
- Commercially operated venture capital financing has the potential to promote the synergising of competencies of the publicly funded R and D system and industry.
- The DFIs and the venture capital funds may also introduce a scheme for technology insurance to under-write

the risk of using the domestically developed new technology.

10.56 Parallely, there are several aspects in which industry has to extend its cooperation. For example, in the high risk and high cost R and D areas, the industry need to cooperate in supporting the programmes for the development of generic technology with publicly funded R and D. Some Indian examples are: CFC substitutes, Vitamin A, Cobalt-based chemicals, high energy rare earth magnets, Flosolver, Cobalt recovery, Carbon fibre for braiding applications, Membrane cell process for chlor alkali production, Titanium scrap recycling etc. These need to be proliferated to enable the Indian industry gain a competitive advantage in the market place. Promotion of long-term R and D alliances between the in-house R and D units and the publicly funded R and D institutions is another method through which one can optimise on the time and costs of technology development and its application. This role apart, the industry should adopt a cooperative approach in identifying its R and D needs, inviting scientists/ technologists to serve on the Boards of companies and, finally, in financing in a major way the projects of their concern.

10.57 The financial institutions like SIDBI, banks and ICICI have a role to play in this game. In the Indian context, it has been found difficult to raise funds for technology development and proving the technology either by the industry or the research institutions on their own or sometimes even jointly by both of them. While the newly established Technology Development Fund should cater to the bigger needs, the commercially operated venture capital financing has the potential to promote the synergising of competencies of the publicly funded R and D system and industry in several ways.

10.58 For technology demonstration/ proving, it is difficult for small and medium enterprises (SMEs) to raise funds from public capital markets due to the smallness of size, the early stage of development and the limited potential for leverage. The venture capital funds do provide finance for this activity, but their coverage has been small. Therefore, this activity needs to be taken up by the other Development Financial Institutions (DFIs) especially by the SIDBI which deals with SMEs. The DFIs and the venture capital funds may also introduce a scheme for `technology insurance' to under-write the risk in using the domestically developed new technology. Finally, a pragmatic action plan for a meaningful orchestration of Government-Industry-R and D system should be formulated.

10.59 Various steps are involved in the formulation of such an action plan. To start with, each publicly funded R and D institution may prepare, with professional assistance, atleast a five year business plan and the funding by Government should be based on that business plan, with gradual reduction in the percentage of Government funding over a period of time. The next step should be networking and forging alliances with other R and D institutions and in-house R and D units to identify various facilities and services available with them which are required for their business plans. On the basis of this, the small and medium enterprises can be assisted to meet their R and D/S and T needs. The R and D in industry should, on the other hand, move towards more innovative product and process development through several measures viz. networking with publicly funded R and D institutions, finding appropriate placements for the scientists to work in industry, giving representation to scientists on the Board of Directors of companies and by approaching the R and D institutions for relevant aspects of their R and D/S and T requirements/ plans, in confidence. The Government intervention can be in terms of providing tax incentives linked to direct benefits derived by the economy and creating an environment of freedom and flexibility commensurate with the regulations of a market economy. The financial institutions and the Chambers of Commerce should formulate appropriate rules and guidelines to facilitate the funding of technology development and demonstration activities of the R and D institutions or the industry and to evolve and implement a technology insurance scheme to underwrite the risk of using domestically developed technology.

S and T COMMUNICATION, POPULARISATION AND BUILDING OF SCIENTIFIC TEMPER

10.60 With the setting up of the National Council for Science and Technology Communication (NCSTC), considerable emphasis has been laid over the years on the popularisation of science and the development of scientific temper. A whole range of programmes involving a large number of voluntary agencies as well as official agencies are being undertaken in this direction. Some of the encouraging programmes are: training of science communicators; development/production/ dissemination of software for different media; support to popular science magazines in different languages; compilation of computerised science communication databases; activity-based field projects involving people in large numbers, like celebration of National Science Day, organisation of Bharat Jan Gyan Vigyan Jatha and National Children's Science Congress etc. Besides these activities, the National Council of Science Museums has established a chain of Science Centres and Science Museums in the country under a common coordinating umbrella, with free exchange of personnel, exhibits and training facilities.

- Greater efforts should be made for instilling the scientific spirit especially among the youth with a view to overcoming the barriers of sectarianism and social prejudices.

10.61 Notwithstanding the participation of members from professional academies, academic institutions and other scientific agencies/research institutions in science communication activities, there has been only a limited improvement in the pattern of institutional participation/ involvement in science popularisation activities/ programmes. In the States, for example, even though science popularisation is a specific priority and a thrust programme of the State S and T Councils, there is a need to catalyse all the possible science communication activities through the active involvement of interested voluntary organisations. In addition, the National Council for Educational Research and Training (NCERT), New Delhi has been encouraging students and science teachers in creative activities designed to stimulate scientific temper by improving the science text books, production of several books on popular science etc.

10.62 The experience gained in organising the science popularisation programmes should become the basis for undertaking new activities during the Ninth Plan, which could increasingly include encouragement to the publication of the popular science books, institution of incentives like prizes, awards and honours for outstanding science communicators; translation of outstanding popular science books published in foreign langauges; efficient distribution mechanism to make these accessible to the target readers through various communication media like radio, TV etc. To bring about change of attitudes and practices of primary school children and their teachers, efforts like children's science congress, `joy of learning' children's projects, exhibitions, activity camps etc. by schools, voluntary organisations and dedicated science communicators may be encouraged. Greater efforts should be made for instilling the scientific spirit especially among the youth with a view to overcoming the barriers of sectarianism and social prejudices. Further, the existing network of Adult Education Centres, Krishi Vigyan Kendras, District Industries Centres, Health Centres, Jan Shikshan Nilayams, State Science and Technology Councils etc. should be systematically involved in science popularisation activities. Research in science communication is another important area which needs encouragement. Some obvious areas of research are: the levels of science awareness in different communities; the effectiveness of different communication media; the impact of scientific literacy etc. Concerned agencies should support the creation of facilities for research in science communication and education in the existing academic/research institutions. Other promising measures for popularisation of science are: the formulation of enabling mechanisms for the cooperative functioning of S and T personnel and teachers with capable voluntary organisations; the augmentation of the existing infrastructure in terms of science museums, exhibitions, planetaria etc. the development of locally relevant community science programmes; the setting up of a network of nodal centres in selected blocks and villages; and establishment of accessibility both to the nodes of several electronic networks as well as to the stand alone systems, which will become important retrieval and referral systems of information.

S and T MANPOWER DEVELOPMENT AND EMPLOYMENT

10.63 When one is concerned with aspects such as technological innovations, implementation of newly developed technologies and finding solutions to problems of modernising and developing a society, especially in the context of the process of liberalisation, the S and T manpower assumes a special significance and will be required in considerable strength. Moreover, it is an indirect measure of the strength of the country because of the contribution of S and T activities to socio-economic development. But there have been a number of hurdles in the process of S and T manpower development. The major problems inhibiting the growth of S and T manpower are unemployment and under-employment of S and T personnel. The country is facing on the one hand a shortage of S and T manpower in some encouraging areas and on the other a surplus in some conventional areas. In this context, the matters of concern are the lack of accurate estimation of demand and supply of S and T personnel in general and of those in the specialised areas, in particular, especially an assessment of training requirements. The aspects that need consideration in such an estimation process pertain to the outturn and stock of S and T personnel and their training needs.

- Besides improvement in quality, what is crucial is the management of S and T manpower.
- Establishment of a National Science Manpower Information System (NSMIS) is required to make available information on scientific manpower in all possible data forms at a single point.

10.64 As regards the outturn, it is noted that there has been a significant growth in the infrastructure for higher education and consequently there has been a steady increase in the number of graduates, postgraduates and doctorates in the science and engineering streams. Presently, the estimation of the stock of S and T personnel has been attempted by various organisations like the CSIR, the IAMR etc. and discipline-wise projections have been made. Taking clues from these estimates/ projections, indepth studies need to be undertaken to estimate the demand and supply of S and T personnel as well as their training needs.

10.65 While looking at the technical manpower, it is not the number alone that should be considered important but the quality as well, especially when the aim is to harness optimally the available resources. But the high quality depends on the education and training facilities available. Moreover, since the requirements of manpower depends on the needs of the society from time to time, the system of education must change accordingly and adapt itself to

the changing demands of modern technology. This calls for modernisation of the syllabi in various scientific disciplines as a continuing activity.

10.66 Besides improvement in quality, what is crucial is the management of S and T manpower. For this purpose, specific measures are needed. These include organisation of all -India level selections based upon competitive examinations, akin to the other major service sectors in the country; networking of R and D institutions, universities and industry with necessary cost sharing mechanism; creation of new courses in the thrust areas involving academic sector and utilising the facilities of specialised institutions; involvement of NRI experts in the upgradation of knowledge and skills in the scientific and technological institutions; continuous training to the S and T employees in the subjects of their respective specialisation or in the allied areas in which their professional background/exposure can be gainfully deployed; special training in accessing the information super highways; mobility of scientists/ engineers among the sectors of industry/R and D/planning institutions, academia; active involvement of S and T personnel in the decision making process; establishing linkages among the academic programmes, research work and the users; etc.

10.67 Apart from these, the establishment of a National Science Manpower Information System (NSMIS) is required to make available information on the scientific manpower in all possible data forms at a single point so that it can provide answers to manpower-related querries covering all the important aspects like characteristics of scientific institutions, inventory of inplant training facilities, enrolment and outturn of science postgraduates, utilisation of S and T manpower, unemployment etc. To look into various S and T manpower-related functions, suitable mechanism at the national level is called for.

INTERNATIONAL SCIENCE and TECHNOLOGY COOPERATION

10.68 International cooperation in S and T is essentially a mechanism to (a) facilitate interaction among scientific researchers of various countries to update and refine their knowledge base for accelerating the pace of investigation as also to fill up any gaps in the available information, (b) develop advanced technologies, high tech equipment and new materials required for the economic growth of the participating countries and (c) take mutual advantage of complementary scientific and technological capabilities amongst the participating countries' teams. The existing mechanisms of cooperation under various programmes include exchange of technical information as well as scientists and research workers; and joint research, training and R and D programmes. On the Indian side, S and T collaboration agreements, on a general basis, have involved the DST, the CSIR and the Indian National Science Academy (INSA), while separate specific sectoral agreements have been concluded by the DAE, the DOS, the DBT, the DOD, the DOE, the DNES and the DOE and F besides the Ministries of Agriculture, Health etc.

For strengthening the international S and T cooperation, the formulation of S and T programmes should take into consideration the prevailing national scenario as well as conditions and trends in other parts of the world.

10.69 India has entered into inter-governmental S and T agreements with 46 countries. During the last 3-4 years a large number of new agreements were concluded. Of these, the countries with which specific programmes of cooperation are being actively followed are China, Hungary, Israel, Italy, Poland, Russian Federation and Ukraine. In addition, a few bilateral programmes are at an advanced stage of implementation including an Indo-French Centre for the Promotion of Advanced Research (IFCPAR) and an Indo-Uzbek Centre for the Promotion of Scientific and Technological Cooperation. Under multilateral cooperation, a Centre for Science and Technology of the Non-Aligned and other Developing Countries (NAM S and T Centre) and an International Centre for Genetic Engineering and Biotechnology (ICGEB) were set up in New Delhi. Besides, the UN Centre for Space Science and Technology Education for Asia-Pacific Region was established in Dehradun.

10.70 During the past five years joint bilateral collaborative work undertaken with CIS, USA, France, Ukraine, European Community, Poland, Hungary, Germany, Japan, Netherlands, Sweden and Mauritius, includes 300 projects, visits of about 800 Indian S and T personnel, publication of 650 joint research papers, visits of about 100 foreign S and T personnel to India, 241 postdoctoral level fellowships, 73 joint workshops etc. Some examples of multilateral collaboration are : UNESCO - Nehru Science Chair at Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore and S and T projects with UNDP assistance sponsored by the DST in the areas of Natural Resource Data Management System, Meteorological Application to Agriculture and improving technology transfer through networking.

10.71 For strengthening further the international S and T cooperation, the formulation of S and T programmes should take into consideration the prevailing national scenario as well as the conditions and trends in other parts of the world. Besides mutuality of interest, the investments on international S and T programmes should enhance self-reliance, yield social, economic and scientific returns to the participating countries on equal terms and complement the ongoing national efforts. An international programme should emerge as a follow-up of the identification of the technological gaps in certain areas. Even with regard to funding, the internal sources should be tapped first and then the collaborative activities with other countries should be undertaken to supplement it, based on the mutual interest

of the concerned parties. In order to coordinate the international S and T collaborative programmes, an advisory mechanism needs to be set up to formulate an overall policy, to evaluate the needs and suggest an approach for the future, including participation in major international experiments on a cost-sharing basis; visits of foreign specialists; acquisition of the cutting-edge technologies; imparting training to S and T personnel in IPR issues etc.

REVIEW OF THE EIGHTH FIVE YEAR PLAN PROGRAMMES

- A three tier national level S and T structure:
- Cabinet Committee on Science and Technology (CCST)
- Science Advisory Committee to the Cabinet (SACC)
- Committee of Secretaries on S and T (COS S and T)

10.72 During the Eighth Five Year Plan, concerted efforts were made to implement well-defined, time-bound programmes in various disciplines of science and technology. Science and Technology Advisory Committees were set up in most of the socio-economic sectors for the identification, formulation and implementation of the S and T programmes in the concerned sectors. In order to promote science and technology activities at the grass-root level, State Science and Technology Councils/ departments were strengthened and their interaction with various scientific institutions and development departments was ensured for effective implementation of location-specific projects/ programmes. To take an overall view of the scientific efforts and policy guidelines for the development of S and T in the country, a three-tier national level S and T structure, viz. Cabinet Committee on Science and Technology (CCST), Science Advisory Committee to the Cabinet (SACC) and a Committee of Secretaries on Science and Technology (COS S and T) has been established.

10.73 There had been a number of significant events during the Eighth Plan period in the science and technology sector. The successful launch of the indigenously built INSAT 2A, 2B and 2C resulted in the provision of several facilities like video conferencing, expansion of TV services to more areas. The PSLV-D2 and D3 were successfully launched and remote sensing satellites (IRS P2 and P3) placed in orbit. The IRS-1C, the best civilian remote sensing satellite, presently orbiting the earth, was launched. A programme entitled "Integrated Mission for Sustainable Development (IMSD)" was launched in several districts for the formulation of location-specific development plans. The National Institute of Ocean Technology (NIOT) was set up at IIT, Chennai with the objective of undertaking research in the fields of ocean energy, marine instrumentation, ocean engineering systems etc. Some of the useful contributions of atomic energy research pertain to the consolidation of pressurised heavy water reactor technology, demonstration of fast breeder technology, the development of mixed oxide fuel assemblies for power reactor, the initial commissioning of fuel reprocessing plant and U-233 fuelled KAMINI research reactor. A significant development during the Eighth Plan period was the launching of technology mission mode projects in the areas of sugar production technologies, advanced composites, fly ash disposal and utilisation, aquaculture, biological pest control, biofertilizers and leather technologies, for the validation and demonstration of technologies having great promise to the country. Some of the significant achievements vis-a-vis special features in respect of the major S and T departments/agencies are briefly indicated below :

(A) SCIENTIFIC AGENCIES AND DEPARTMENTS

Department of Atomic Energy (DAE) - R and D Sector

Important achievements of DAE (R and D Sector) :

- BARCIS system for in-service inspection of coolant channels in operating Heavy Water Reactors.
- Conceptual design of the Prototype Fast Breeder Reactor and related R and D studies.
- Release of high yielding and disease resistant varieties of moong and groundnut.
- Food irradiation process for preservation of onions and potatoes.
- Desalination plants on Multi Stage flash (MSF), Reverse Osmosis (RO) and Low Temperature Vacuum Evaporation (LTVE) process.
- Assembly of 450 MeV Synchrotron Radiation Source.
- 64-node parallel processor.
- Giant Meter wave Radio Telescope (GMRT).

10.74 The R and D programmes of the DAE continued to focus on producing safe and economic nuclear power exploiting the natural resources of uranium and thorium in the country and made significant contributions in various

sectors like energy, industry, food, health and water. During the Eighth Plan, the DAE registered a significant progress and crossed several milestones in many areas covering peaceful application of nuclear energy. While laying greater emphasis on basic research, the DAE continued to be a nodal organisation for launching some of the technologies having applications in defence, space and other strategic sectors. Some of the milestones achieved in various areas of atomic energy research are listed below :

10.75 The achievements under reactor technology include introduction of MOX fuel in Tarapur reactors, use of thorium in PHWRs, BARCIS system for in-service inspection of coolant channels in operating pressurised Heavy Water Reactors, technology for decontamination of operating reactors, repair technologies and modernisation of control systems based on computers. The development of computerised distributed control and monitoring systems for nuclear power projects was completed. The Fast Breeder Test Reactor (FBTR) was operated at a power level of 10.5MWt corresponding to maximum fuel rating with indigenously developed carbide fuel. The conceptual design of the Prototype Fast Breeder Reactor (PFBR) and related R and D studies and the experimental phase for the development of technology for the fabrication of critical reactor components, modelling studies relating to equipment and instrumentation were completed. Under the thorium utilisation programme, indigenously designed mini reactor, KAMINI utilising Uranium-233 was constructed at Kalpakkam. The design for advanced heavy water reactor in BARC was completed.

10.76 In the area of prospecting for atomic minerals, with the proving of the resources of Uranium in Meghalaya, Bihar and Andhra Pradesh, the resource base of uranium in the country has been enlarged. The initial commissioning of Kalpakkam reprocessing plant and commissioning of radiochemical hot cell facility for the examination of irradiated fuel were the other achievements in this area.

10.77 In the areas of safety and environmental protection related to atomic energy activities, many studies were completed and a number of environmental monitoring and communication systems developed in BARC. Research in the non power related areas contributed significantly to socially relevant sectors such as health and food. In the field of applications of radio isotopes in health, radiation sterilisation of medical products and contributions to diagnostics and therapy, yearly six lakh patient investigations and 1.5 to 2 million radiation treatment cases were handled using radioisotopes. A 10 Mev microtron developed at Indore was in the process of commissioning for radio-therapy work. The Regional Radiation Medicine Centre (RRMC), Calcutta installed a 4 Mev Linear Accelerator (LINAC), indigenously developed by SAMEER, Bombay and CSIO, Chandigarh enabling it to treat about 600 patients per month.

10.78 In the area of agriculture and food, the achievements include the release of high-yielding and disease resistant varieties of moong and groundnut; food irradiation process for preservation of spices, potatoes and onions; improvements and multiplication of crop plants, developing technologies for the processing and maintenance of quality of fruits like mangoes. In the area of water management, desalination plants on multi-stage flash (MSF) evaporation, reverse osmosis (RO) and low temperature vacuum evaporation (LTVE) processes were set up in the rural areas for purification of brackish water.

10.79 In the area of accelerators, CAT, Indore assembled India's first 450 MeV Synchrotron Radiation Source Indus-1 storage ring and three beamlines were also ready. The other achievements in this area include: commissioning of high resolution beam line at VECC, the Electron Cyclotron Resonance (ECR) Ion Source; and Superconducting booster LINAC and a booster synchrotron etc. The 500 KeV industrial electron accelerator was in an advanced stage of fabrication for application in the plastics industry. In the area of cryogenic technology, a closed cycle cryo-refrigerator was developed and a helium liquifier was under development at CAT. A laboratory was set up to carry out helium gas collection from the hot springs of Bakreshwar and Tantloi.

10.80 The achievements in the areas of robotics, computer technology, material characterisation etc. include the development of a tele-operated manipulator for re-tubing operation of nuclear reactors, installation of antenna control system for GMRT at Pune, development of several robotic devices for integrated automatic sampling and analysis system for reprocessing operation; installation and use of several high speed super computer facilities like 64-node parallel processors, artificial intelligence- based graphics and speech-based user interfaces for nuclear facilities. In addition a National Centre for Compositional Characterisation of Pure Materials was set up.

10.81 The DAE's R and D efforts have resulted not only in the saving of large amount of foreign exchange but also in providing a number of state-of-the-art technologies to Indian industries including specialised consulancy services in areas such as computers, advanced instrumentation, power electronics, technology relating to materials, chemical and bio-chemical processes and associated equipment, robotics and non-destructive testing.

10.82 Apart from technology development and services, the DAE provided continued support to promote R and D in the frontier areas of science through its aided institutions covering a wide spectrum of subjects such as physics, mathematics, chemistry, biology, material science, condensed matter physics, accelerator-based research, gamma ray astronomy, astrophysics and seismology for creating knowledge base as well as development of strategic

technologies. A major achievement of the DAE was the setting up of the Giant Meterwave Radio Telescope (GMRT), which was near completion at Khodad, near Pune. In the area of life sciences, a new gene which controls the ability of organism to grow at low temperatures was identified and the base sequence of its DNA determined along with its expression under different conditions.

10.83 Some of the measures taken for enlarging the scope of the DAE-university interactions include Inter-University Consortium for the Department of Atomic Energy Facilities (IUC-DAEF) at Indore, the DHRUVA national facility and Global Environmental Radiation Monitoring (GERMON) programme for monitoring radiation exposure and radioactivity levels around the globe, installation of prototype 10 MeV compact microtron at Mangalore University, supply of various lasers to universities by CAT for pursuing research work and setting up of a neutron-generator in the Calcutta University by the Saha Institute of Nuclear Physics, besides funding mission oriented R and D activities in some advanced areas of science and technology by BRNS. Several national research programmes/facilities were also implemented like the National Centre for Compositional Characterisation of Pure Materials; the national facility for neutron beam research by BARC; the Centre for Research in Biological Sciences; Homi Bhabha Centre for Science Education by TIFR and National Programme on Lasers by CAT. In addition, an international collaborative research programme involving the utilisation of the international facility namely the Large Hadron Collider (LHC) at CERN, Geneva was implemented by CAT, BARC, VECC and other aided institutions like SINP and IOP.

Department of Space (DOS)

Indian Space programme has established a number of capabilities in building world class satellites for communication and remote sensing and launching remote sensing satellites with indigenously developed launch vehicle.

Various milestones achieved:

- INSAT-2A and 2B launched in July 1992 and July 1993 respectively
- INSAT-2C launched in December 1995.
- IRS-P2 and IRS-P3 launched in 1994 and 1996 respectively.
- IRS-1C launched in December 1995.

10.84 Over the last three decades, the Indian space programme has established a number of capabilities in the country, e.g building world-class satellites for communications and remote sensing; launching remote sensing satellites from India with indigenously developed launch vehicle and reaching the benefits of space technology to improve the quality of life at the grass-root level, essentially through the two national space systems based on INSAT and IRS.

10.85 The INSAT-2A and the INSAT-2B, launched in July 1992 and July 1993 respectively have enhanced the INSAT space segment capacity, facilitating introduction of metro channel in Doordarshan, rural networks, search and rescue service and additional regional channels. The INSAT-2C, launched in December 1995, has been providing additional capability for business communication, services and extended coverage to enable TV programme outreach beyond Indian boundaries catering to the population from South East Asia to the Middle East. The domestic mobile satellite services, being introduced with the INSAT-2C and to be augmented further using the INSAT-2D, will enable communications from any part of India and the sea areas of interest with small portable terminals and ship-mounted terminals. The INSAT-based Meteorological Data Collection System and the Disaster Warning System (DWS) are two invaluable contributions by the DOS for providing meteorological forecasts and cyclone warning services. A developmental communication project, started in Jhabua District of Madhya Pradesh has been providing training and awareness among the rural masses on better agricultural practices, land and water resources management, family planning, health care and hygiene. This project is expected to provide valuable inputs for planning and establishing such networks on a wider scale in the country.

10.86 The Earth Observation Systems, consisting of a series of remote sensing satellites, have been providing a wide variety of data useful for natural resources management of the country. The IRS-P2 and the IRS-P3 satellites, which were successfully launched and operationalised in 1994 and 1996 respectively, have been complementing the data requirements of the user community. The IRS-1C, which is another sophisticated satellite, was launched in December 1995. The data from the IRS satellites, being used on operational basis for a wide range of applications covering agricultural crop acreage and production estimation, forestry, wasteland management, mineral prospecting, ground water targetting, snow melt run-off prediction, environmental monitoring, environmental impact analysis etc. has helped in several aspects of decision making process. This data has also enabled the DOS to take up a major developmental project, viz., Integrated Mission for Sustainable Development (IMSD) to formulate locale-specific developmental plans for sustainable development of land and water resources by synthesising thematic information derived from remotely sensed data with other collateral information. This project is now being executed in 174

selected districts of the country. A more significant development is that the IRS satellite constellation has become an international system recently, with a US company, EOSAT, entering into commercial agreement with India for reception and marketing of the IRS data worldwide.

10.87 Under the launch vehicle programme, the ASLV-D3 mission of May 20,1992 facilitated validation of a number of technologies useful for larger vehicles of operational class. On this basis, the development of the PSLV and the GSLV was initiated. With the two continuous successful missions, the PSLV was declared operational. The next one, i.e.,PSLV-C1, will carry the operational IRS-1D satellite in 1997. However, in respect of the Geo-Synchronous Satellite Launch Vehicle (GSLV) whose first developmental flight was initially targetted towards the end of the Eighth Plan, is now scheduled during the Ninth Plan.

10.88 Among the other programmes, the MST Radar facility is being extensively used by the scientific community, including university students for advanced research in the area of atmospheric sciences. The infrared telescope was commissioned and scientific validation with trial observations completed. Through the medium of the RESPOND programme, aimed at establishing a large S and T infrastructure base at the academic institutions in the country for carrying out space research projects/programmes, the DOS-academic interface has been strengthened. Over the past 25 years, the DOS has supported as many as 100 universities and research institutions in carrying out about 200 research projects in the areas of space science and technology. In recognition of India's role in sharing her experience in the development and application of space technology for societal benefits, the UN Asia-Pacific Regional Centre for Space Education was set up in India. Due to the strong DOS-industry interface, so far, about 225 technologies developed by ISRO/DOS, have been transferred to the industry for commercialisation. For handling technology marketing and providing consultancy services to the industry, ANTRIX Corporation was set up as a corporate unit within the DOS.

Department of Science and Technology (DST)

- **Major achievements:**
- National facilities and core groups were set up for promoting research in frontier areas of S and T.
- Experimental demonstration on simultaneous manifestation of light as a particle and a wave.
- New series of compounds exhibiting novel liquid crystalline phase.
- International Advanced Research Centre for Powder Metallurgy and New Materials.
- Treatment of tuberculosis and other diseases using lasers.
- Demonstration-cum sale of PARAM super computer.
- Integration of seismographs for use by IMD.
- Mission Mode projects undertaken in the areas of:
- Sugar Production Technologies.
- Advanced Composites.
- Fly Ash disposal and utilisation.

10.89 The DST has been making increasing efforts to promote basic research. The financial support to basic research in the Eighth Plan was double that in the Seventh Plan. The number of R and D programmes supported under basic research so far was more than 1236, involving a total cost of about Rs 125 crore and 544 institutions. About 70% of this funding was received by the academic sector and more than 500 R and D programmes costing Rs. 8 crore were sanctioned for young scientists. National facilities and core groups were set up for promoting research in the frontier areas of S and T which include superconductivity, lasers, carbon and nano materials, neurosciences, x-ray crystallography, robotics, laser processing of materials, nutritional studies etc. About 3000 original research papers were published by 13 DST supported autonomous institutions. Some of the outstanding works of these institutions were in the areas of blood oxygenator, hydrocephalus, amorphous silicon solar cells, BOD Sensors, Plasma Nitriding Process etc. besides experimental demonstration on simultaneous manifestation of light as a particle and a wave; and new series of compounds exhibiting novel liquid crystalline phase. Several of these technologies were transferred to the industry.

10.90 Under the international R and D co-operation, efforts were made to expand and accelerate the pace of collaborative research with a number of countries abroad. Some of the significant outcomes were: the setting up of International Advanced Research Centre for Powder Metallurgy and New Materials, treatment of tuberculosis and other diseases using lasers, demonstration-cum-sale of PARAM supercomputers, integration of seismographs for use by IMD etc.

10.91 Through the S and T Advisory Committees (STACs) set up in 22 Ministries to promote and coordinate the technology development programmes, the DST undertook several joint R and D projects with other Government

departments and the industry in a number of areas such as building materials, wood substitutes, orthopaedic devices, mini-micro hydel power, robotics, CFC substitutes, air pollution control catalysts, laser processing materials etc. A few mission mode projects that were undertaken, and the significant results that were demonstrated, relate to sugar production technologies, advanced composites, fly ash disposal and its utilisation etc. Several society-related programmes were undertaken by the DST with an emphasis on development of technologies for poverty alleviation, employment generation, enhancement of income and improvement in quality of life of rural and urban poor, women, scheduled castes and tribal populations and weaker sections. More than 364 projects involving 250 NGOs in the area of rural and tribal development were implemented benefitting about 170,000 people. Under the S and T Entrepreneurship Development Programme, more than 35000 job opportunities were created and more than 1000 industrial units were set up by trained entrepreneurs, providing additional employment to about 4000 people. Some of the science popularisation efforts being organised by the National Council for Science and Technology Communication (NCSTC) included Bharat Jan Gyan Vigyan Jatha (BJGVJ)-1992, 144 episodes of radio serial titled `Manav Ka Vikas' - the longest science serial ever produced and broadcast simultaneously in 18 languages; two National Childrens' Science Congress in which thousands of children participated; production and telecast of TV serials on different themes of S and T etc. Under the programme of National Resources Data Management System (NRDMS), 22 Data Base Centres were established in the country in different geo-environmental settings for developmental planning. The other important activities of the DST pertain to the development of an operational medium range weather forecasting model suited to indigenous needs using Super Computer and the strengthening of the State S and T Councils for the development and promotion of State level S and T activities, particularly locale-specific programmes.

Important programmes undertaken by IMD

- Modernisation of radar data network for improving the accuracy in the forecasting of upper winds and severe storms.
- Modernisation of upper air network with 401 MHz radio-theodolites.
- Installation of CYBER-2000 computer to make forecasting network more efficient.
- Commissioning of instruments like ceilographs/ skopographs at National Airports.
- World Bank Aided projects to upgrade the seismological instrumentation in peninsular India and hydrological networks.

10.92 The India Meteorological Department (IMD) continued to engage itself in the dual role of conducting research in the areas such as ozone in tropics, agricultural meteorology, use of monsoon teleconnections etc. and providing specialised services in terms of meteorological forecasts to meet a variety of demands from different types of users through a network of 5 Regional and 13 State Centres. The important programmes undertaken during the Eighth Plan pertain to the modernisation of radar data networking by replacing 6 wind finding radars and 4 storm detection radars for improving the accuracy in the forecasting of upper winds, severe storms etc.; modernisation of the upper air network by replacing 6 old and obsolete Metox radio-theodolites by new 401 MHz radio-theodolites; installation of a CYBER 2000U Computer at Delhi to make the forecasting network more efficient; and commissioning of the instruments like ceilographs/ skopographs at the national airports etc.

10.93 The other major programmes and services rendered by the IMD relate to meteorological telecommunication; agromet-advisory services; establishment of the INSAT Meteorological Data Processing System at New Delhi to receive, process and disseminate INSAT data; replacement of the computer at National Data Centre (NDC), Pune for improving the management and storage of meteorological data for research and study; etc. Besides these, two World Bank Projects were also launched to upgrade the seismological instrumentation in peninsular India and hydrological networks. The execution of the 8th Plan projects in the IMD led to a visible improvement in the quality and scope of various meterological forecasting services.

Department of Scientific and Industrial Research (DSIR)

Major achievements of DSIR

- PATSER resulted in commercialisation of products and processes for:
- CNC tools and Cutter Grinder
- Fuel efficient diesel LCV engines
- 25 KW solar photo voltaic power plant
- NRDC programmes resulted in licensing of technologies related to:
- Heart Valve
- Cyclosporin-A

- Rice Husk Particle Board
- Calcium Gluconate
- Fly Ash bricks
- Carbon fibre for braiding applications
- Glycol based automobile coolant
- Special blister packaging machines

10.94 The DSIR has been undertaking schemes relating to Technology Promotion, Development and Utilisation (TPDU); the National Information System on Science and Technology (NISSAT); two public sector undertakings, viz. National Research Development Corporation (NRDC) and the Central Electronics Limited (CEL) and the programmes of the Council of Scientific and Industrial Research (CSIR). The programmes under the TPDU scheme are of 3 types viz., Research and Development by Industry (RDI), Programme Aimed at Technological Self Reliance (PATSER); and Scheme to Enhance the Efficacy of Transfer of Technology (SEETOT).

10.95 Under the RDI scheme, 5 National Conferences on In-house R and D in industry were organised; 88 National Awards for outstanding In-house R and D achievements were presented; recoginition was accorded to about 350 new In-house R and D units and about 150 new Small Industries Research organisations (SIROs), and financial support was provided to several R and D projects. Under the PATSER scheme, about 50 technology development projects were completed, resulting in the commercialisation of products and processes such as CNC tool and Cutter Grinder, fuel efficient diesel engines for tractors, improvement of fuel efficiency and emission reduction in LCV engines and 25 KW solar photovoltaic power plant etc. The support under the PATSER programme to the tune of about Rs.16.0 crore for technology development has generated projects costing Rs.40 crore. These not only resulted in significant technological and commercial returns but also helped in building up the R and D capabilities of the concerned units. The other activities under PATSER scheme resulted in bringing out Technology Evaluation and Norms reports in 50 sectors/areas; 6 reports on assessment of capital goods requirement in various sectors and 20 pre-feasibility reports to attract investment from Talented Indian Engineers and Scientists (TIES). The main activities under SEETOT included compilation and analysis of foreign collaborations, analytical studies relating to technology transfer, preparation of reports on more than 80 technology status studies, international trends, gaps in technology etc. A total of 31 studies, projects and other activities were completed. In the area of consultancy development, 28 studies on sectoral/State level consultancy capabilities were completed and the Consultancy Development Centre (CDC) was supported for undertaking training programmes, information services etc.

10.96 The activities of the National Information System on Science and Technology (NISSAT) included the maintenance of 11 Information Centres already set up in the areas of leather, food etc. and promotion of resource sharing among libraries and the Information Centres by setting up library networks at Calcutta, Delhi, Mumbai, Pune, Ahemdabad and Mysore; completion of software development for automation and networking of S and T libraries and organisation of about 60 training courses on various subjects of information science and technology.

10.97 The NRDC completed technology upscaling of the projects relating to rice husk particle board, spirulina algae and heart valve etc. resulting in the licensing of the technologies relating to heart valve, cyclosporin A, rice husk particle board, calcium gluconate, fly ash bricks, carbon fibre for braiding applications, resorcinol, glycol based automobile coolant, spice oleoresins, special blister packaging machines etc. Cash prizes were awarded to 55 inventions and financial and technical assistance was provided for filing around 130 patents in India and 55 abroad. Export of projects and services through NRDC led to foreign exchange earning of around Rs. 3 crore.

CEL R and D activities resulted in:

- Improvement of solar cell efficiency from 10.4% to 13.5%
- Establishment of pilot plant for Ultra High Efficiency Solar Cells of 17% efficiency
- New SPV surface centrifugal pumps
- High Efficiency invertor
- SPV educational kits
- High efficiency ferrites.

10.98 At CEL, the R and D schemes undertaken were: Solar Cell Process Development (SCPD); Ultra High Efficiency Single Crystalline Solar Cells (UHEC); New SPV Systems (NSS); Bench Scale Process Development of High Permeability Ferrites (HPF); Advanced Ceramics and Ceramic Paste (ACCP); and Railway Electronics. The projects on SCPD, UHEC and HPF were completed. The efficiency of the solar cells was improved from 10.4% to 13.5% and a pilot plant for making Ultra High Efficiency (UHE) Solar Cells of 17% efficiency was established. Under

the New SPV Systems, some of the technology developments include new SPV pumps using surface centrifugal pumps, high efficiency invertor, SPV educational kits, high efficiency ferrites etc. SPV systems were exported to Bhutan, Cuba and Oman and an SPV module and systems plant was established in Syria. The CEL earned Rs.15 crore from Railway Electronics business and Rs. 9.5 crore on microwave components. About 60000 piezo ceramic electric systems were also supplied for defence communication.

10.99 The Council of Scientific and Industrial Research (CSIR) has built up over the years a network of 40 specialised national laboratories with 80 field extension centres having expertise and knowledge-base in diverse scientific disciplines and serving practically all the socio-economic sectors. During the Eighth Plan, the CSIR reoriented its actitives to operate in an environment of international competition and to strive towards self sustaining growth. For this, policy changes were brought about in the management structures and the mode of functioning so that the CSIR system became more user responsive and market-driven. Efforts were also made to develop closer links with the user agencies and to forge strategic alliances through increased industry representation on the apex decision making bodies of CSIR such as Governing Body, Technical Advisory Body etc. and by providing technical know-how on turn-key basis.

Important achievements of the CSIR laboratories:

- Design and fabrication of all composite aircraft.
- New catalysts for refineries, petrochemical and chemical industry.
- New drugs for anti-fertility, bio-enhancer and memory enhancer.
- Novel cost-effective processes for 30 drugs and four drug intermediates licensed.
- Long wall and wide stall methods of mining.
- Oil palm processing technologies.
- Mechanised pulse mill of 100Kg/Hr capacity.
- Hand operated daal mill of 40-50 Kg/Hr. capacity.

10.100 There were several scientific and technological achievements by the CSIR laboratories. The country's first all-composite aircraft was designed and fabricated. New catalysts were developed for refineries, petrochemical and chemical industry. A cost-effective novel process for NMP (a solvent used in refinery processes) was developed. New drugs for antifertility, bioenhancer and memory enhancer were developed and novel cost-effective processes for over 30 drugs and four drug intermediates were licensed as anti-AIDS, anti-viral, anti-cancer, anti-bacterials, anti-malarial, analgesics, anti-inflammatory and anti-allergic. In the Energy Sector appropriate techniques/ technologies were developed for long-wall mining and wide stall method of mining, beneficiation of coking and non-coking coal for reduction of ash content, coal carbonisation, solvent refining, conversion of synthetic gas/coal to middle distillates etc. The R and D in Food and Food Processing Sector led to the development of oil palm processing technologies including a screw press of 5 tonnes FFB/hr capacity; mechanised pulse mill of 100 kg/hr capacity and hand-operated daal mill of 40-50 kg/hr capacity. The CSIR's wide-ranging, multi-disciplinary expertise and capabilities were gainfully utilised by several clients in the developed countries like USA (Abbot Laboratories, Parke-Davis, Smith-Kline Beecham, FMC, GE, Du Pont etc.), UK, Switzerland, Canada, Finland, as well as in the developing countries like China, Brazil, Indonesia and Oman.

Performance indicators of CSIR

- Industrial production based on CSIR know how increased to Rs. 10,000 crore.
- 250 New technologies made available for licensing.
- 800 Technology license agreements signed.
- 920 patents filed in India.
- 120 patents filed in other countries.
- Rs. 700 crore External Cash Flow generated through contract R and D work and consultancy.

10.101 During the Eighth Plan, the industrial production based on CSIR know-how increased to Rs. 10,000 crore, with a productivity saving worth Rs. 800 crore. In addition, 250 new technologies were made available for licensing and 800 technology licence agreements were executed. A total of 920 patents were filed in India and another 120 patents abroad. Technical assistance was rendered to about 4000 entrepreneurs and an external cashflow to the tune of around Rs. 700 crore was generated through contract R and D work and consultancy. These achievements apart, the CSIR has been able to create and nurture R and D manpower at all levels, over a wide spectrum of disciplines. This is realised through awards, Fellowships/ Associateships to scientists, sponsoring extramural

research (EMR) schemes to Universities/ R and D organisations etc. During the Eighth Plan period, a total of around 5000 JRF, 6000 SRF, 1000 RA and 2000 Pool Officers were supported.

Department of Biotechnology (DBT)

Major achievements:

- Diagnostic Kits for tuberculosis, hepatitis A and C, Amoebiasis, Pregnancy, Streptococcal infection in children and HIV-I and II.
- High frequency reproducible regeneration of wheat plants.
- Transfer of technology for monoclonal M-13 bacteriophage.
- Marketing of Diagnostic kit for Leishmaniasis.
- Cloning of gene coding and expression in E.coli.
- Mission mode projects initiated in the field of:
- Biofertilisers
- Biological control of pests
- Aquaculture.
- Establishment of Centre for DNA Fingerprinting and Diagnostics (CDFD) at Hyderabad.

10.102 There were several breakthroughs in the field of biotechnology, particularly in the areas of molecular biology, plant and animal cell culture and in the development of immunology covering agriculture and allied areas, medical research, environment including biodiversity conservation with biotechnological tools etc. Major advances have taken place in basic research in modern biology, leading to the emergence of many techniques, tools and products to usher in a biotechnology revolution in the country. New leads for vaccines and drugs were made available through basic research. Cloning of gene, structural studies using X-ray crystallography and genome mapping have also provided clues for further work in the area of medical biotechnology. The development of diagnostic kits for infectious diseases has received very high priority. The development of kits for tuberculosis, hepatitis A and C, amoebiasis, pregnancy, streptococcal infection in children and HIV-I and II infections are in very advanced stages and negotiations on technology transfer to industry are in progress. There was a significant breakthrough in wheat, where high frequency reproducable regeneration of plants has been achieved and a large number of plants have been transferred to the field. Tissue culture raised cardamom plant gave 37% higher yield. Through continued support to the States and socio-economic ministries for research and development programmes, demonstration activities, technology transfer, patenting of inventions and conservation of natural resources, especially of genetic diversity, using biotechnological tools, efforts were made to formulate and implement joint proposals for promoting research in various areas of biotechnology. During the Eighth Plan, about 700 projects were recommended for financial support, ten patent applications were filed and 15 were under process. Atleast 10 technologies have been perfected and negotiations are in progress through BCIL and NRDC for their transfer to the industry. Some of the scientific services provided by the DBT were: infrastructural facilities in the areas of animal house, cell cultures, genetic engineering, germplasm collection etc. The facilities for fundamental research in structural biology, bioinformatics network etc. are being utilised extensively by a large number of scientists and students in the country.

10.103 The other significant contributions of the DBT were transfer of the technology for monoclonal M-13 bacteriophage to M/s Pharmacia Inc., USA., marketing of a diagnostic kit for leishmaniasis developed at the CDRI Lucknow; the cloning of the gene coding and expression in E. coli at IMTECH, Chandigarh; `Alphanso' variety of mango through somatic embryogenesis; multiplication of a few endangered species of orchids and tea, cocoa, pepper and coffee; solvent extraction and chemical fractionation of six plants at NII leading to the identification of two active fractions with distinct antibacterial activity etc.

10.104 During the Eighth Plan period, three mission mode projects on biofertilizers, biological control of pests and aquaculture were under implementation. The first two were successful while there was a slippage in the case of the aquaculture project. Under the first one, there has been an increase in the grain yield with the use of biofertilizers. Under the second, eight candidate biopesticides were developed and perfected. Under the aquaculture project only demonstration of freshwater prawn culture could be initiated in the States of Orissa, Madhya Pradesh and Tamil Nadu. Due to the special efforts made by the DBT, about 5000 persons belonging to SC/ST and weaker sections benefitted in terms of employment opportunities, better nutrition and health care systems. In the earthquake-affected areas of Latur and Osmanabad, 13000 families were benefitted through eight demonstration projects.

10.105 In the area of Human Resource Development, postgraduate teaching and postdoctoral research and training programmes are being conducted at 33 select universities and institutions; a number of short-term training courses are being supported and a number of national and overseas Associateships awarded. Under international

cooperation, the significant programmes include the setting up of a Centre of Excellence with the help of SIDA; establishment of gene banks for medicinal and aromatic plants and a sub-programme on Asian Biotechnology and Biodiversity supported by UNDP/FAO. The significant research efforts at the two autonomous institutes, viz., the National Institute of Immunology, New Delhi and the National Centre for Cell Science (NCCS), Pune pertain to immunisation, diagnostic tests based on synthetic peptides of the various antigens of HIV; leprosy vaccine as immunotherapeutic and immunoprophylactic; a non-isotopic modality of PCR-based DNA probe for tuberculosis; research on primary cultures of human foreskin fibroblast etc. The third centre, viz., International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi became functional from its new building. The significant areas of research work of this Centre relate to hepatitis vaccine, technology for production of gamma interferon, diagnostic kits for AIDS etc. A new Centre for DNA Fingerprinting and Diagnostics has also been set up with DBT support at Hyderabad during the Eighth Plan.

DEPARTMENT OF OCEAN DEVELOPMENT (DOD)

10.106 The programmes of the Department of Ocean Development were broadly grouped as : Basic Research, Strategic Fields, Technology Development / Scientific Services and Societal Programmes. Under basic research, 42 projects were implemented in colla-boration with a large number of national laboratories, universities and educational institutions. They provided interesting and useful results on the history of the sedimentation process and provided clues for the development of potential drugs and chemicals from the marine organisms. They also facilitated identification of the areas of heavy metal pollution; characterisation of the toxic components of various pollutants specifically in some estuaries and coastal areas and standardisation of technologies for extraction of iodine from selected seaweeds.

Major achievements:

- Six expeditions to Antarctica.
- Survey of entire pioneer area of 1,50,000 sq. Km. For Polymetallic Nodules using hydrosweep.
- Prototype of remotely operated collector unit operating up to 200 meter depth.
- Bucket-in-pipe lifting system for transporting nodules from the collector system.
- Three process routes for recovery of metals from nodules.
- Identification of 17 potential organisms having several medicinal properties.
- Established National Institute of Ocean Technology (NIOT) at Chennai.
- Potential fishing zone advisories disseminated to 174 fish landing centres.
- Communication facilities created at nine places in four southern states for enhancing the safety of fishermen.

10.107 The activities in strategic fields included polar exploration, Polymetallic Nodules Programme and international cooperation. During the Eighth Plan, six expeditions to Antarctica were conducted and polar research was carried out on various aspects of global climatic phenomena, ozone depletion, ice-core samples, etc. In one of these expeditions, the distribution and abundance of krill, cephalopods and Antarctic fish were studied and the feasibility of commercial exploitation of these resources was established. In the Polymetallic Nodules programme, the survey of the entire pioneer area of 1,50,000 sq. Km. allotted to India in the Central Indian Ocean Basin has been completed using the hydrosweep. A prototype of a remotely operated collector unit operating upto 200 metre depth and a bucket-in-pipe lifting system for transporting nodules from the collector system was designed and fabricated and three process routes for the recovery of metals from nodules were identified. As per the international agreement, out of 50% of the area to be relinquished in the Central Indian Ocean, 20% has already been relinquished to the International Seabed Authority.

10.108 The most important among the technology development projects relates to the development of potential drugs from the ocean leading to the identification of 17 potential organisms having several properties like anti-fertility, anti-microbial, anti-viral, anti-diabetic, anti-malarial, anti-hypertensive and anti-inflammatory. Out of these, five organisms, which showed potent activity as anti-diabetic, anti-viral, anti-amoebic, anti-anxiety and larvicidal agents, have been identified for development of atleast two herbal drugs in the next few years. The National Institute of Ocean Technology (NIOT), set up in IIT, Chennai initiated projects in the areas of Ocean Energy, Deep Sea Technology and Ocean Mining, Coastal Zone and Marine Instrumentation. These have enhanced the capabilities for generating energy from the ocean; venturing into shallow bed mining; identification of new sites for ports and harbours, etc. The major societal programmes initiated were: Coastal Ocean Monitoring and Prediction System (COMAPS); National Ocean Information System (NOIS) and Marine Satellite Information Service (MARSIS). The data on various pollutants collected under the COMAPS programme, helped in drawing a long-term plan for keeping our coastal zone clean. The data collected through the NOIS, set up in 14 National Marine Data Centres, is being used for planning, development, management of specific fields of ocean science and technology and exchange of data with national and international institutions. Under the MARSIS programme, potential fishing zone advisories

were disseminated to 174 fish landing centres on a regular basis. This helped the fishermen in getting better fish catches and reducing the time spent on reaching the fishing grounds which in turn reduced the overall operational cost and improved their incomes and living conditions. The communication facilities created at nine places in the four southern States and South Goa have benefited over 850 fishermen families and demonstrated the usefulness of the communication system for enhancing the safety of fishermen.

(B) SOCIO-ECONOMIC SECTORS

Joint R and D projects identified through IS-STAC mechanism:

- Column floatation technology for industrial applications (Ministry of Mines)
- Development and Testing of STATCON Dynamic Voltage Restorer (DVR) (Ministry of Power)
- Industrial application of vorsyl separator (Ministry of Coal)
- Super Clean Coal development for metallurgical industry (Ministry of Coal)
- Introduction of short wall mining (Ministry of Coal)
- Energy efficient materials for mining industry (Ministry of Mines)

10.109 The integration of S and T component with the concerned socio-economic sectors was continued through the Science and Technology Advisory Committees (STACs) set up in 22 ministries with the objective of identifying and formulating specific S and T Plans and promoting S and T programmes relevant to the concerned sector. The guidelines for STACs were formulated and assistance was provided to various socio-economic sectors in terms of identification of experts, thrust areas, linkages with national laboratories/ universities. Efforts were made to make the STACs more active in the overall S and T development and planning of the concerned sectors. An Inter-Sectoral Science and Technology Advisory Committee (IS-STAC) continued to function in the DST with a view to coordinating the STAC activities and providing a forum to share their expertise and experiences. This process served the dual purpose of making the STACs, which were already functional, more active and in activating those which till then had not yet become functional.

10.110 With the active cooperation of the STACs, several technology mission mode projects were initiated in the areas of sugar production technologies, development of advanced composites, fly ash utilisation, biofertilizers, biopesticides and aquaculture and a number of important R and D projects which have relevance to the concerned sectors identified and funded. An important initiative taken through the IS-STAC mechanism led to the identification of some joint research projects/programmes and schemes in consultation with the concerned ministries/departments. Some examples of such joint projects are: development of indigenous column floatation technology for industrial applications (Ministry of Mines); development and testing of STATCON Dynamic Voltage Restorer (DVR) (Ministry of Power); industrial applications of vorsyl separator (Ministry of Coal); super clean coal development for metallurgical industry (Ministry of Coal); introduction of shortwall mining (Ministry of Coal); energy efficient materials for mining industry (Ministry of Mines) etc. The other measures of the IS-STAC, which have an impact on the S and T inputs in the socio-economic sectors are: publication of a newsletter, `STAC Scan', covering information regarding technology needs of the socio-economic ministries and organisation of awareness workshops on, Control Technologies for Greenhouse Gas Emissions, Pre-combustion Clean Coal Technologies and R and D in Energy and Energy Efficiency.

NINTH FIVE YEAR PLAN PROGRAMMES

(A) Scientific Agencies/Departments

DEPARTMENT OF ATOMIC ENERGY (DAE) - R and D sector :

10.111 The thrust during the Ninth Plan in R and D sector will be on design and development of fast breeder reactor; enhancement of thorium utilisation; engineering development of thorium-based advanced heavy water reactor and matching developments in the fuel cycle area; accelerator-based systems and fusion power; technology missions in radiation applications in health, agriculture and food, specially on food preservation, desalination and isotope hydrology; strategic technologies in the areas of special materials, lasers, particle accelerators, computers, robotics, cryogenics and special instrumentation; safety and environmental protection; and technology spinoff to industry.

Thrust of DAE (R and D) during the Ninth Plan:

- Design and development of fast breeder reactor.
- Enhancement of Thorium utilisation.

- Engineering development of Thorium based advanced heavy water reactor.
- Accelerator based systems and fusion power.
- Technology missions in radiation application in health, agriculture and food.
- Safety and environmental protection.
- Technology spin-offs to industry.

10.112 On the power reactor front, the existing PHWR programme aims at more efficient utilisation of uranium and eventually of thorium, development of specific reactor systems, such as high temperature reactors, source-driven reactors which use spallation or fusion neutrons and accelerators as non-fission neutron sources in application areas such as desalination and compact power packs for use in remote areas etc. The programme of advanced heavy water reactors is aimed at getting a large fraction of energy output from thorium. The Fast Breeder Technology Development Programme, pursued in IGCAR, will focus on schemes relating to R and D in engineering and technology development for Fast Breeder Reactors (FBRs). Under Nuclear Fuel Development, the efforts will be on modernisation of fabrication and assembly facilities incorporating advanced automation systems and updating of hot laboratory facilities. In addition, metallurgy and materials development programme for FBRs will be pursued for carrying out R and D work. The work on reprocessing of thermal reactor fuels will concentrate on upgrading the technology to the state-of-the-art by process innovations, equipment development, incorporation of remote maintenance by robots, advanced techniques etc.

10.113 The activities relating to safety will be directed towards understanding safety-related phenomena, surveillance, monitoring and life prediction of components through related experimental studies. Under the radiological safety programme, a Regional Radioactivity Laboratory will be set up for continuous monitoring of very low levels of short/long-lived radionuclides in a variety of environmental matrices. The Atomic Energy Regulatory Board (AERB) will take up research related to nuclear industrial and radiation safety with specific emphasis on regulatory aspects covering development of computer codes and their validation, studies connected with serious accidents, safety evaluation methodologies etc. The programme under radiation and radioisotope technology envisages improved infrastructure and state-of-the-art instrumentation in hydrology, industry and medicine, covering the upgradation of isotope technology laboratory; the setting up of Electron Beam Irradiation Centre; the development of prototype accelerator for various applications like food irradiation, medical product sterilisation and theraputics etc. The research work on the application of nuclear energy for societal benefit will relate to research in nuclear agriculture, plant bio-technology, plant molecular biology, with application of radiation-induced mutations and plant breeding techniques; plant tissue culture techniques for various applications; large-scale production of biopesticides and integrated pest management for maintaining high yields in crops etc. The R and D programme relating to the application of radiation and radioisotope technology to health care will be intensified by establishing medical cyclotron with Positron Emission Tomography (PET) facility for metabolic imaging for diagnosis, including development of new radiopharmaceuticals at site. A few mobile rural Cancer Centres will also be set up for early detection of cancer in the rural population.

10.114 Some of the essential facilities that will be upgraded/set up include: animal house facillities at BARC and TMC; installation of a high frequency NMR machine; augmentation of low temperature facilities; completion of the ongoing scheme relating to Advanced Centre for Training, Research and Education in Cancer (ACTREC) by Tata Memorial Centre (TMC); establishment of linear accelerator; augementation of equipment at TMC; augmentation of space and infrastructure at Tata Memorial Hospital (TMH); augmentation of equipment at Cancer Research Institute (CRI); replacement of megatron linac system with dual energy linear accelerator etc.

10.115 Thrust will also be on the R and D programmes on accelerators. Besides the ongoing programme on Superconducting Cyclotron, the Variable Energy Cyclotron Centre (VECC) would take up schemes relating to heavy ion accelerator with Variable Energy Cyclotron, setting up of radio active ion beam facility, radiation medicine and application, material science research using accelerator, recovery and analysis of helium from hot springs, heavy ion experimental facilities etc. The Centre for Advanced Technology (CAT) will take up new projects for utilisation of INDUS-II, Protron Synchrotron, Accelerator Technology and Application and DAE-CERN collaboration for Large Hadron Collider (LHC). The laser programme will focus on demonstration of laser-based processes for nuclear programme, spinoff techniques for use of lasers in various applications, such as diagnostics, therapy in medical field, instrumentation and Non Destructive Testing and Evaluation (NDTE) applications. The thrust will be on the expansion of infrastructure facilities at CAT besides new activities relating to advanced laser technology and applications, special materials etc.

10.116 The programmes under basic research, which will receive priority relate to X-ray-based condensed matter research using INDUS-I and II; collaborative research programme by using the upcoming international high energy facilities such as RHIC, Brookhaven and LHC, CERN and Spring8-Japan; frontier areas of mathematical physics, condensed matter physics, astroparticle physics, Bose-Einstein condensation, quantum computation and communication and complexity theory, chemical physics etc. at TIFR; condensed matter physics and surface studies,

ultrafast parallel processing, setting up of research facilities for high temperature superconductors, composites, intermetallics and alloys, thin film, low temperature measurement etc. at Saha Institute of Nuclear Physics (SINP); pelletron-based experimental programme, theoretical astrophysics and setting up experimental facilities in biophysics at Institute of Physics (IOP); and strengthening of research in mathematical science at Institute of Mathematical Science (IMS) and Mehta Research Institute (MRI). Under plasma research, the scheme relating to advanced plasma research for steady state superconducting TOKAMAK will be continued and ADITYA will be upgraded to increase plasma purity in addition to augmentation of diagnostics at IPR.

10.117 Under the technology development and transfer programme, the facilities to be set up include development of electron beam melter, electron beam welder and electron beam evaporation unit; development of plasma melter, plasma gas heater, RF plasma reactor and microwave and low pressure plasma reactors; development of RF excited carbon laser, pulsed excimer laser and photo chemical reactor, facility for fabrication of ultra high precision components along with balancing equipment for the accelerator programme, employing super conducting cavity and beamline equipment etc. The Centre for Product Engineering and Technology Transfer would be engaged in technology transfer.

10.118 The new national programmes proposed to be taken up include: neutron beam research, facilities for macromolecular crystallography and superconductivity and cryogenics, international programmes relating to nuclear physics research with high energy accelerators by BARC; international collaboration programme for the study of quark-gluon plasma at heavy ion colliders at VECC and SINP; and the setting up of centres for radioastrophysics, applied mathematics and accelerator physics. In addition, facilities for high current isotope separation ion implantation; multi-element gamma and Heavy-ion and neutron array detectors will be set up at SINP besides strengthening of Homi Bhabha Centre for science education and the National Centre for Biological Science.

10.119 As in the past, HRD will be accorded due priority in accordance with the requirements of manpower arising out of the global science and will maintain interaction with various science Departments of the Government and other premier scientific agencies in the country during the execution of its programmes.

DEPARTMENT OF SPACE (DOS)

10.120 While the basic vision for the space programme will continue to be the same as was enunciated at its inception, it will be adapted to respond effectively to the dynamic and complex scenario of the coming years and unstinted efforts will be made towards developing and harnessing advanced space technologies to provide additional and newer services in a self-reliant manner for the socio-economic development of the country.

Important missions planned for Ninth Plan:

- **Satellites:**
- INSAT-2D and INSAT-2E
- INSAT-3A, 3B, 3C and 3D
- INSAT-3E as ground spare.
- GSAT satellite
- IRS-1D
- IRS-P4 (Oceansat-1)
- IRS-P5 (Cartosat-1)
- IRS-P6 (Resourcesat)

Launch Vehicles:

- PSLV will be the workhorse vehicle for all IRS satellites.
- Enhancement of payload capability and reliability of PSLV
- Operationalisation of GSLV enabling indigenous launch from INSAT-3C onwards.
- Development of Cryogenic Upper Stage (C20) and Solid Booster (S250).

10.121 Under the INSAT series, the INSAT-2D and 2E are planned to be launched followed by four satellites of the INSAT-3 series (INSAT-3A, 3B, 3C, 3D) during the Ninth Plan. The INSAT-3E is planned to be a ground spare, with flexibility in configuration. The GRAMSAT network is planned to be established in the coming decade, integrating the potentials of satellite communication and satellite remote sensing for a wide range of applications for rural development, including tele-education and tele-health. The ongoing Jhabua Development Communication Project will be completed and large-scale replications of the same in several districts will be carried out. The new communication

services proposed to be rendered include: Digital Audio and Data Processing, expansion of mobile communication services etc. The GSAT satellite is planned to be launched during the Ninth Plan to meet these requirements. In the area of earth observations, the major objective will be to emerge as a front ranking leader globally in high quality data, wide range of application services etc.

10.122 While continuing to utilise the remote sensing technology for widening the scope of the IMSD and the establishment of NNRMS, efforts will be directed towards a better understanding of the geosphere-biosphere interaction, enviornmental protection of the earth, establishment of a National Disaster Warning and Management System etc. To achieve these objectives, the IRS-1D, identical to the IRS-1C and three more remote sensing satellites, viz., the IRS-P4 (Oceansat-1), the IRS-P5 (Cartosat-1) and the IRS-P6 (Resourcesat) are planned to be launched during the 9th plan. Significant developmental efforts are also planned during the 9th Plan towards realisation of the follow-on remote sensing satellites required to be launched during the 10th Plan such as the IRS-2A, the IRS-2B and the IRS-2C satellites, meteorological satellite and the microwave remote sensing satellite, which will ensure continuity of services in an enhanced manner and enable capitalising on the technology edge established in the global market. A National Disaster Warning and Management System using the potentials of communication and remote sensing satellite, will be established.

10.123 In the area of launch vehicle systems, interlocking the satellite requirements with the launch vehicle capability will be the prime objective. The Polar Satellite Launch Vehicle (PSLV) will continue to be the workhorse vehicle for launching all the IRS satellites. The major targets for the Ninth Plan are: enhancement of the payload capability and reliability of PSLV; operationalisation of Geosynchronous Satellite Launch Vehicle (GSLV) towards achievement of self-reliance in launching communication satellites enabling indigenous launch from the INSAT-3C onwards, progressively enhancing the payload capability of GSLV to meet the requirements of the state-of-art communication satellites; and the development of Cryogenic Upper Stage (C20) and the Solid Booster (S250).

10.124 The Indian industry and academia will have an enhanced role, as partners in the national space effort. The Regional and State Remote Sensing Centres will play a major role as delivery systems for space application services at the grass-root level. In the international space scene, strategic alliances will be forged with international agencies to service the commercial global space market. Research and development as well as technology development will continue to be the mainstay of the space programme. Research programme in the area of astronomy/ aeronomy missions, inter-planetary studies and microgravity experiments will be initiated. Human resource development will receive the maximum possible attention in the coming years. Even though the missions and tasks to be accomplished in the 9th Plan will be double that in the 8th Plan, there will not be any significant addition to the existing manpower, except in technologically complex and new initiatives. In all, 16 satellite missions and 11 indigenous launch vehicle missions are envisaged during the 9th Plan, as compared to 9 satellite missions and 5 indigenous launch vehicle missions in the 8th Plan.

DEPARTMENT OF SCIENCE AND TECHNOLOGY (DST)

Important initiatives under SERC:

- Promotion of research in less endowed universities.
- Setting up Engineering Research Centres in the area of Concurrent Engineering, Bio-Engineering, Technical Acoustics etc.
- Providing industrial research fellowships to work in industry.
- Encouraging frontier areas like biodiversity, plasma chemistry, micro-robotics, chemical engineering, modern classical optics, boundary layer modelling etc.

Major facilities planned under IRPHA

- Electron Spray Mass Spectrometer
- Radioactive Ion Beam
- Multi GeV Hadron Heavy Ion Accelerator
- Low energy accelerator
- Confocal Microscopy facility

10.125 The thrust of the DST during the 9th Plan will be on building and sustaining a strong science and technology base in the country, developing centres of excellence in the frontline areas of science and technology and modernising the infrastructure of its autonomous research institutions. Under the SERC programme, new initiatives will be launched to further strengthen the S and T base in the country in selected areas of technological importance.

The overall approach will be to promote basic research around outstanding scientific groups and to a large extent in the academic sector. The SERC will be provided more autonomy and flexibility for better management of R and D schemes and their proper monitoring and evaluation. Some of the important initiatives under the SERC will include promotion of research in less endowed universities; setting up Engineering Research Centres in the areas of Concurrent Engineering, Bio-Engineering, Technical Acoustics etc; providing industrial research fellowships to work in the industry; encouraging some of the frontier areas like biodiversity, noise control, plasma chemistry, micro robotics, chemical engineering sciences, modern classical optics, stress biology and immunology, boundary layer modelling, study of atmospheric chemistry etc. The research areas for the engineering sciences, will be in the disciplines like Chemical Engineering; Materials, Mining and Mineral Engineering; Robotics; Computer Engineering; etc. Under the programme of Intensification of Research in High Priority Areas (IRHPA), the focus will be on setting up a few major sophisticated facilities and Centres in the country to pursue frontline R and D, such as electron spray mass spectrometer, radioactive ion beam, multi-GeV Hadron heavy ion accelerator, low energy accelerator, confocal microscopy facility etc.

10.126 The National Accreditation Board for Testing and Calibration Laboratories (NABL) will be strengthened to meet the demands which are likely to go upto about 1500. Along with it, the assessors training programme and the laboratory awareness programme will be intensified. The NABL will be enrolled as a member of the International Laboratory Accreditation Cooperation as well as the Asia Pacific Laboratory Accreditation Cooperation for achieving the Mutual Recognition Agreement.

Technology Development programmes:

- A more holistic and user friendly approach towards making the high technologies and products available to the society.
- Drug development based on traditional systems of medicine.
- Technology mission mode projects in the areas of:
    - Agro food
    - Food processing
    - Waterways
    - Road Transportation
    - Electric Power
    - Telecommunication
    - Aviation
    - Sensors

10.127 As a part of the National Science and Technology Manpower Information System (NSTMIS), a new initiative on the setting up of a National Science Manpower Information System, will be taken up and it will be integrated with the ongoing National Technical Manpower Information System of the Ministry of Human Resource Development. An on-line access to international databases on S and T statistics will also be established. In the area of technology development, a more holistic and user-friendly approach will be adopted towards making the high technologies and products available to the society. The thrust will be on technology missions, technology promotion and special technology projects through critical technology promotion, high technology intervention in selected export areas and promotion of NGO/society/ organisation. In respect of the Instrument Development Programme, it is proposed to support new projects for the development of instruments in some new areas like energy monitoring and management, sensors etc. besides conducting training programmes and transfer of know-how of instruments to industries. The new initiatives under drugs and pharmaceutical research will include: drug development based on traditional systems of medicine like Ayurveda, Unani, and Sidha besides Homeopathy and support to joint projects leading to drug development for infectious diseases. For undertaking technology projects on a mission mode, the new areas will be agro food processing, waterways, road transportation, electric power, telecommunication, aviation, sensors, IPR and future technology forecast for India for 2020. The thrust of the S and T Entrepreneurship Development activities will be on strengthening and expansion of the entrepreneurship development cells and the S and T Entrepreneurship Parks. Efforts will be made to initiate rural enterprise development through innovative S and T-based micro-enterprises in rural areas.

10.128 The science communication and popularisation programme will be expanded to cover more beneficiaries. The activities proposed include training in S and T communication through short-term courses for voluntary organisations, teachers; support to popular science magazines in regional languages; production and screening of science films on Doordarshan; development of low-cost toys, dissemination of software for S and T communication/popularisation etc. The National Resources Data Management System (NRDMS) will concentrate on

building specialised problem-oriented data bases and operationalising them for real-life planning and administrative decision making. The activites of the State S and T Councils/Departments will be intensified so that the States will be able to take up major projects and a visible impact can be seen during the Ninth Plan. Under the international S and T co-operation programme, efforts will be made to strengthen bilateral and multi-lateral joint venture programmes and to expand and accelerate the pace of S and T co-operation with research institutions in a number of countries. The 12 autonomous research institutions being supported by the DST, will be upgraded with state-of-the-art research facilities in a phased manner. In addition, funds would be provided for improvement of S and T infrastructure in universities and related institutions.

10.129 The India Meterological Department (IMD) will further intensify its high technology efforts which have already resulted in improving the accuracy of predicting severe weather, its timely warning and dissemination of its long range predictions of the monsoon. The major activities proposed during the Ninth Plan include: modernisation of the observational and telecommunication systems, use of contemporary radar and satellite technology for better understanding of weather systems, satellite-based dissemination of timely warning of tropical cyclones, monitoring of seismic activities, exploitation of remote sensing data for agro-meteorological advisories, etc.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH (DSIR)

Important programmes of DSIR

- Creation of awareness of Intellectual Property Rights (IPR)
- Development of Export Promotion mechanism
- Establishment of Indian Internet server and a facility to promote and support public and private institutions on database development.
- NRDC would promote:
    - Design and engineering consultancy companies
    - Equity investments in R and D companies
    - Promotion of small and medium industries in NE states

R and D Activities planned by CEL

- Process upgradation for larger size cells.
- New/alternate SPV technology.
- New SPV systems.
- Electronics systems for Railways, Telecommunication and Power.
- New ferrite materials.
- Surge arrestors
- Beam switching array
- Antenna elements

10.130 The efforts initiated by the DSIR in the areas of Technology Promotion, Development and Utilisation (TPDU) under the three schemes viz., Research and Development by Industry (RDI), Programme Aimed at Technological Self reliance (PATSER) and Scheme to Enhance the Efficacy of Transfer of Technology (SEETOT) will be continued. The programmes proposed to be taken up include: creation of awareness of Intellectual Property Rights (IPR) through training and education and development of export promotion mechanism to make the companies aware of the processes involved in the acquisition of technologies from abroad and their export. Some of the activities/projects which NISSAT will initiate are: establishment of Indian Internet Server and a facility to promote and support public and private institutions on database development, information resource development and services generation; development of information referral system; establishment of a regular mechanism to study international trends in information and information technology etc. The activities proposed by the NRDC include promotion of design and engineering consultancy companies; equity investments in R and D companies; regional technology transfer centres etc. besides promotion of small and medium industries in the North Eastern States to develop entrepreneurship. The specific R and D programmes and projects identified by the Central Electronics Limited (CEL) pertain to process upgradation for larger size cells; new/alternate SPV technology; new SPV systems; electronics systems for railways, telecommunications and power; electronics component development for coils/transformers; new ferrite materials; surge arrestors; beam switching array; antenna elements etc. Under the manufacturing sector, the CEL's efforts will be directed towards plant capacity expansion from 2 MW to 3.5 MW; upgradation of production facility for electronic systems; power control unit for SPV power plants; manufacture of solar batteries; production of Electronic Ballast, coils/ transformers; development of new PZT Components and Microwave components; production of phased arrays;

capacity upscaling for PCM production etc.

Goals set by CSIR:

- Generation of an Annual Cash flow of over Rs. 700 crore from external sources.
- Development of at least ten exclusive and globally competitive technologies in niche areas.
- Creation of a Patent Bank of 500 foreign patents.
- Realisation of 10% of operational expenditure from Intellectual Property licensing
- Deriving annual earning of $ 40 million from overseas R and D work and services.

10.131 The programmes of CSIR will be guided by the White Paper, `CSIR 2001: Vision and Strategy', with the Mission statement: "To provide scientific and industrial research and development that maximises the economic, environmental and societal benefit for the people of India". Accordingly, the CSIR has set for itself certain goals and targets to be achieved by the terminal year of the Ninth Plan i.e. 2001-02, which include generation of an annual cash flow of over Rs.700 crore from external sources (as against Rs. 225 crore envisaged in 1996-97) with at least 50% from industrial customers; development of at least ten exclusive and globally competitive technologies in niche areas; creation of a Patent Bank of 500 foreign patents as against less than 50 at present; realisation of 10% of operational expenditure from intellectual property licensing compared to less than 1% at present; and deriving annual earnings of $ 40 million from overseas R and D work and services, compared to less than $ 2 million now. In order to achieve these targets, efforts will be made to re-engineer the organisational structure; link and relate R and D to market place; stimulate intellectual property orientation; and invest in high quality science for generation of future technologies. Depending on the R and D needs, priorities and the societal requirements, the national laboratories will undertake new programmes in various socio-economic sectors like health, food, energy, environment, housing and construction, rural development, industrial development besides exports of R and D and services, basic research etc.

10.132 The CSIR has a significant potential to market its R and D knowledgebase and services to the international clientele both in the developed and the developing countries and it is proposed to develop business opportunities wherever possible. Since there has been a long-felt need in the CSIR system for the modernisation of obsolete equipment and facilities, which have adversely affected the productivity and competitiveness of the CSIR laboratories, the CSIR's endeavour will be to modernise and upgrade its facilities during the Ninth Plan in a phased manner. In the area of Human Resource Development Programme, besides the ongoing activities, the CSIR will take special measures to formulate a structured scheme to bring together the working of researchers from academia, national laboratories and in-house R and D units in industry. To meet the needs of the CSIR Headquarters which has multifarious activities and responsibilities in the new context of greater market orientation, self sufficiency and global competitiveness of the laboratories, advanced level training programme will be organised. In addition, a well designed and workable Management Information System (MIS) linking the HQ and laboratories will be set up in order to optimise business opportunities, synergise the core competencies and the resource base and to bring in a sense of transparency and empowerment. The proposed MIS will encompass customer and market information, project management, financial management, human resource management, investment management and intellectual property and technology management.

10.133 In respect of residential buildings and other amenitites, the endeavour will be to bring the housing satisfaction up to an average level of 60% (70% in remote locations, 60% in towns and 50% in metropolitan cities) by the end of the Ninth Plan, as compared to 40% now. In order to achieve this target, a long-term plan has been evolved, seeking construction of additional staff quarters in selected places (2500 quarters); leasing of accommodation for some categories of staff; and transit accommodation and hostel accommodation for research fellows. Further, in view of CSIR's objective of expanding its business development activity several fold in the Ninth Plan period, a few Business Centers - self contained modern offices - with tele-conferencing facilities through advanced communication systems will be set up initially at four places viz., Mumbai, Hyderabad, Delhi and Calcutta.

DEPARTMENT OF BIOTECHNOLOGY (DBT)

10.134 For providing the basic minimum requirements of the population, including food, economic, ecological and livelihood security, since biotechnology is likely to become a lead technology in future, one of the objectives of the Ninth Plan programmes will be to realise the full potential of biotechnology for national development. Accordingly, appropriate biotechnological inputs will be provided for enhancing the productivity and efficiency of the concerned areas such as: health care system; soil fertility and environmental conservation and protection, aiming at sustainable development, particularly for rural areas. The projects/programmes in this sector will aim at meeting the livelihood and economic and ecological security of the people through research and development, demonstration and application of biotechnology covering all important sectors.

Thrust of Biotechnology programmes:

- Bioindustrial development of the country.
- Judicious utilisation and conservation of biological resources using biotechnological tools.
- Research and Development for product, processes and technology generation.
- Long term support for basic research in sectors like:
    - Structural biology
    - Drug development and design
    - Genome mapping and sequencing
    - Host parasite interaction

- Priority to programmes of:
    - Genetic enhancement
    - Micropropagation parks
    - Centres of excellence in areas of brain research, molecular medicine etc.

10.135 The main thrust of biotechnology programmes during the Ninth Plan will be on bioindustrial development of the country, ensuring judicious utilisation and conservation of biological resources using the biotechnological tools; research and development for products, processes and technology generation for achieving academic excellence of the highest national and international standards and for societal benefit; mission mode programmes in identified areas; biotechnology based programmes for weaker sections, SC/ST and rural areas; technology transfer activities with the help of the Biotechnology Consortium India Limited (BCIL), the NRDC, financial institutions and industry; support to product development activities in some identified areas in collaboration with industry and financial institutions; human resource development at required levels; strengthening, expansion and operationalisation of a country-wide network in bioinformatics; and the setting up of new infrastructure facilities and Centres of Excellence in the areas of relevance to the country.

10.136 A major effort will also be to provide long-term support for basic research in a few strategic sectors such as structural biology, drug development and design, genome mapping and sequencing, host parasite interaction etc. From the viewpoint of both the societal needs and industrial development, some of the areas like basic molecular biology, crop biotechnology, medical research, industrial and environmental programmes will be accorded priority. Various aspects of research on transgenic plants and animals, immune system diagnostic development, prospecting of useful genes and biomolecules from the biodiversity, Indian genome initative etc. will be studied. To ensure that the research leads are converted into commercial ventures and to evolve appropriate biosafety guidelines and regulatory procedures, programmes on product development, especially for diagnostics, biologicals and biomolecules would be taken up. Human resource development covering all aspects of biotechnology will also be pursued including technicians' training and popularisation of biotechnology in the country. Priority will be accorded to the programmes of genetic enhancement, micropropagation parks and centres of excellence in areas such as brain research, molecular medicine etc. besides training programmes for the scientists, legal experts and industries on patenting in biotechnology areas.

DEPARTMENT OF OCEAN DEVELOPMENT (DOD)

10.137 The importance and uses of ocean are well known and the developments towards ocean science and technology are directed towards exploring and exploiting the vast resources of the ocean on a sustained basis for the socio-economic benefit of the human society with integrated approach towards environment and development.

Important activities planned under Ocean Sciences:

- Five Antarctic expeditions.
- Antarctic Study Centre at Goa as a first Polar Research Laboratory with facility of sub-zero temperature research.
- Developing mining device with a crawler, collector and riser system along with technology for collection of nodules at a depth of 6000 meters.
- Commissioning of 500 Kg./day capacity pilot plant for metallurgy.
- Designing of remotely operated vehicle capable of operating at 6000 meters depth.
- Undertake studies on Ocean Thermal Energy Conversion (OTEC).
- Delineation of continental shelf under the UN convention on the law of the sea.

10.138 During the 9th Plan, five Antarctic expeditions will be undertaken, one each year and multi disciplinary research carried out in the areas of atmospheric sciences, earth sciences, human physiology, biological oceanography and environmental sciences. An Antarctic Study Centre will be established at Goa as a first polar research laboratory with a facility for sub-zero temperature research on ice cores retrieved from both Antarctica and the Himalayas. It will also function as a nodal point for the Antarctic scientific and logistic activities. The major activities under the Polymetallic Nodule (PMN) programme include: sampling work of the Survey and Exploration in 40 selected blocks of 25 km. x 25 km. at 5 km. grid covering 800 stations; Environmental Impact Assessment (EIA) study for monitoring the impact on the re-colonisation and restoration of the original benthic organisms at Chavara and Manavalakuruchi areas; developing a mining device with a crawler, collector and riser system along with a technology for collection of the nodules at a depth of 6000 meters; commissioning of 500 Kg/day capacity pilot plant for metallurgy; development of an upgraded remotely operated vehicle at a depth of about 200 metres and designing of remotely operated vehicle capable of operating at 6000 metres depth.

10.139 The three ongoing programmes - Marine Satellite Information Service (MARSIS), Sea Level Modelling and Monitoring (SELMAM) and Data Buoy will be integrated under one scheme viz. Ocean Observation and Information Services and will be operated under four components viz. (a) ocean observation services (b) ocean information services (c) satellite oceanography and ocean modelling and (d) ocean dynamics. For the monitoring of Marine Pollution (COMAPS), a Geographical Information System (GIS) will be developed to keep track of the various sources of pollutants and two indigenously built coastal research vessels, Sagar Paschimi and Sagar Purvi will be utilised to monitor the health of coastal waters of India. Under the ongoing Marine Research and Manpower Development Scheme, research projects in the emerging and frontline areas of ocean sciences will be funded and assistance provided to selected universities to undertake specialised courses in marine sciences. The construction of an oceanarium in Goa, which was started by a foreign firm in the 8th Plan on Build, Own, Operate and Maintain (BOOM) basis, will continue. The NIOT will undertake studies on Ocean Thermal Energy Conversion (OTEC) and test new designs of turbine, generators and caissons for various other applications of the wave energy plant at Vizhingam. It will also work on the technologies relating to deep sea mining and the sub-systems used in deep sea applications. Under the ongoing project on Drugs from the Sea, efforts are on to develop two drugs and license them for marketing as traditional medicine and to file 2 to 3 international patents.

10.140 For promoting sustainable marine development, two new schemes viz., (i) Integrated Coastal Marine Area Management and (ii) Marine Biodiversity are proposed to be taken up. The objective of the first is to ensure sustainable development through proper management of the ocean resources and enforcement of rules and regulations for ocean-related activities in the economic ocean zone and to make Indian oceans clean and productive. The second is intended to preserve, conserve and protect the marine flora and fauna and to promote sustainable development through proper use of biological resources. Another important new scheme relating to `Delineation of Outer Limits of Continental Shelf' will be initiated. The objective of this is to obtain the data through bathymetric and seismic surveys of India's coastline for collection of relevant biological, geodetic and hydrographic data and preparation of required charts and maps for submission to the Commission on the Delineation of the Continental Shelf under the UN Convention on the Law of the Sea (UNCLOS) by the year 2005. For this purpose, a ship equipped with sophisticated scientific instruments for the collection of data will be chartered. Delineation of the continental margin will give an additional area of about 1.5 million Sq. km. outside the exclusive economic zone.

(B) S and T in Socio-Economic Sectors

10.141 The efforts made in the Eighth Plan to integrate S and T component with the concerned socio-economic sectors will be pursued more vigorously during the Ninth Plan. While the stress generally will be on identification of technology priorities in various sectors and on undertaking R and D for technology absorption/upgradation and support to Research, Development and Demonstration (RD and D) projects, priority will be given to energy research and technology development projects. The efforts will be to evolve a few joint technology development programmes in priority areas involving the user ministries, the industries and the acadamic institutions. The attempt will be to evolve new mechanisms for identifying and catalysing multi-partnership sectoral projects in this fast changing technology scenario in association with the organisations involved in forecasting and assessment. The areas of common interest to more than one ministry such as clean coal technologies, telecommunications, alternate fuels, bio-reactor technology etc. will also be taken up.

FINANCIAL ASPECTS

10.142 The total Plan outlay for the S and T sector has increased from Rs.4086 crore in the Seventh Plan to Rs.9393 crore in the Eighth Plan (an increase of 130%). The actual expenditure during the Seventh Plan was Rs.5106 crore and in the Eighth Plan it is estimated to be of the order of Rs. 11561 crore (an increase of about 126%). This increase is in absolute terms. But if the growth of S and T as measured by the ratio of S and T expenditure to Gross National Product (GNP) is considered as an indicator, it is not very encouraging. It is only 0.81% of the GNP in 1994-95. This is very small as compared to that in developed countries like USA, UK, Japan, France, Germany etc. which spend

about 2% to 3% of their GNP on S and T. The experience of the developed world shows that increase in R and D expenditure can be achieved by substantially increasing the industrial R and D expenditure which is only about 0.60% of the sales turnover in India in 1994-95. In terms of the share of the industrial sector's R and D to the total R and D expenditure, there was a slight decrease from 27% in 1992-93 to 26.5% in 1994-95. These figures show that the level of expenditure made on R and D by the industry is very low (only about 27%) as compared to about 60 to 70% in the developed countries like USA, FRG and Japan. This calls for an appropriate policy for bringing about substantial increases both in Government and industrial R and D expenditures.

10.143 While the Government's role in supporting basic research, technology development and application as well as S and T infrastructure should continue and also be considerably enhanced, experience of other countries indicates that a substantial part of S and T expenditure has to come from users and industries. With regard to the Central S and T Agencies/Departments there will be increases in their allocations depending on their projections. In respect of the socio-economic sectors, it is necessary that the S and T allocation should have a relationship with the overall investment in that sector. This is possible, if all the socio-economic ministries allocate not less than a fixed percentage of their respective total budget to S and T activities. This will go a long way in promoting S and T for sectoral development.

10.144 The second strategy will be to ensure that the industry, both in the public and the private sectors, invest substantially in the S and T areas. For this, incentives by themselves are not enough. The industry itself should take the challenge and initiate R and D programmes. While there is a need for the industry to substantially increase its R and D expenditure as a percentage to its sales turn over, the S and T agencies should utilise sources like the Technology Development Fund, SIDBI and other financial institutions. It is only then that the desired increase in R and D expenditure can be brought about.

10.145 Annexures 10.1, 10.2 and 10.3 summarise the financial outlays/expenditure in the Seventh and Eighth Plans in respect of each of the S and T Departments/agencies, various socio-economic ministries and the States/UTs.

Click here for Annexures