Chapter 19:
SCIENCE AND TECHNOLOGY

The crucial role of science and technology as an instrument of social and economic change has been appreciated and the rapid development of science and technology and of its application, accepted as a major objective of planning. This trust in science is embodied in the historic Scientific Policy Resolution of the Government o'f India adopted in 1958. In the last thirty years or so, 119 universities, affiliating about 1050 colleges, 5 institutes of technology, 150 engineering colleges and about 100 medical colleges and 35U polytechnics have been established; about 150,000 qualified scientific and technical personnel are produced every year. The total stock of scientific and technically qualified manpower is estimated at 2.5 million, ranking India as the third largest complement of such manpower in the world, occupying a unique position among developing countries. Simultaneously, about 130 specialised research laboratories and mstiiutes have been established under the aegis of Indian Council of Agricultural Research (1CAR), Council of Scientific and Industrial Research (CSIR), the Indian Council of Medical Research (ICMR), the Departments of Atomic Energy, Science and Technology, Space, and the Defence Research and Development Organisation, etc. In recent years, public and private sector organisations and undertakings, assisted by fiscal incentives, have established over 600 in-house research and development laboratories largely to meet their internal technological requirements. A relatively new but important development in the last fifteen years is the rapid growth of engineering consultancy 'organisations to provide design and consultancy services and act as the bridge between research institutions and industry. There are now over 150 such firms of varying size and capability employing over 20,000 technologists. The total expenditure on science and technology is now close to 0.6 per cent of the GNP.

19.2 Political independence has thus been matched by increasing technological independence in many areas. A range of industries, from the small to the most sophisticated, has been established covering wide areas of utilities, services and goods, and a large number of technologists are now familiar with their operations. There is now a reservoir of expertise well acquainted with the most modern advances in basic and applied areas, and equipped to make choices between available technologies, readily absorb new technologies and provide a framework for future national development. Scientists and technologists have distinguished themselves not only in class rooms and laboratories but also in factories and fields, in conceptual planning and formulation of strategies and in their implementation. Indian scientists and technologists have demonstrated on many fronts that given clearcut objectives and tasks and necessary support, they can fulfil national expectations. The relevance of a large part of the effort in Indian Science and Technology to, and its correlation with, national development can be well established.

APPROACH

The present position and the perspective for the future

19.3 Over the past few decades, the growth ol science and technology in the advanced countries of the world has been phenomenal. The frontiers of knowledge have been moved forward in unbelievable fashion and new areas have emerged with clearly great potential for the benefit of mankind. These strides have taken place in the developed countries. The reason for this is that 97 per cent of the world R and D is confined to the advanced countries and the developing countries, with their share of 3 per cent, have not been able to contribute as they should have.

19.4 While the total stock of scientific and technical manpower in India appears large at first sight, as a proportion of the total population it does not compare favourably with that m the advanced countries or even some other developing countries. The fact is that the science and technology content of. Indian society as it is today (as borne out by the total national investment in this sector, the number of technically qualified personnel, facilities for science and technology education, size of teclmical services, etc.) as well as its involvement in R and D is low in comparison to the size and population of the country. A large part of the total stock of S and T manpower is not actually engaged in activities that can be construed as scientific or technical. Even more significantly, the quality of these personnel varies widely; there will be need for a considerable reorientation and upgrading of a large proportion of this stock of manpower through appropriate training programmes. In large areas of economic activity, relatively obsolete cost in-effective technology continues to be applied, the pace of scientific and technological innovation remains unimpressive and the adoption of the available scientific and technological knowledge is tardy. There are many gaps

in new important fields and in the ranks of leadership and in excellence. While in the early years after Independence, there was a rapid expansion in university education, an increase in the number and size of facilities and in the formation of new institutions, all of which created a new plan, few new institutions have been started recently. In universities and several other institutions, the support provided has not kept pace, with the increased need for better facilities. In a large number of areas, our capabilities are almost twenty years behind those in the advanced nations and also behind those established recently in some developing countries. The competitive capability, in international terms, of our scientific community has been impaired and this has prejudiced the provision of experience of modern science backed up by modern technology and instrumentation to the large majority of graduate and post-graduate students, thereby affecting their level of appreciation of new science and their capabilities for research. There is a lack of coordination between manpower requirements (in terms of areas and levels of training and numbers) and the actual training of personnel which has led to serious shortage of qualified and trained manpower in many areas. In sum, while significant advances have taken place on the science and technology Iront in India over the past three decades, the gap between what obtains in the country and in other advanced countries in terms of infrastructure and capabilities has significantly widened due to the much faster rate of progress in those countries. There is, therefore, no room for complacency on the basis of our past accomplishments.

19.5 In the area of application of science, success lias been achieved in several fields in agriculture and in specific mission-oriented specialised agencies for atomic energy and space. The need to conserve foreign exchange and consideration of national security induced the application of domestic science and technology in the substitution of imports. With the increasing emphasis on cost effectiveness in establishing domestic production and exports, a new chal-lenae is nosed to the use of domestic scientific and technological talent. There is a serious danger that this new emphasis could lead to greater insistencs on provenness and aversion to risk: this is particularly true if suitable mechanisms (both administrative and financial) are not developed to adopt and force technological development to a point of satisfactory performance and demonstration and also the acceptance of risk. Calculated risk taking and the development of risk reduction through systematic scientific effort is vet to be promoted adequately. A detailed strategy for major technological break-through appropriate to our resources and changing national environment has therefore to be properly formulated.

19 6 While linkages and mechanisms for the effective application of science are deficient in most fields, this lack is specially serious in the optimal use of natural resources and in areas such as energy, health and medicine, population control, ecology and environment and integrated industrial and rural ieve-lopment. This has also led to an insufficient use of science generated in universities and national laboratories, giving rise to the often expressed feeling that the fruits of science and technology have not reached the bulk of the population and have not contributed to planned economic and social growth. Consequently, these deficiencies are tending to reduce the impact of science and technology in dealing more effectively with the economic and social problems of the country. While there are exceptions to this, it is clear that the major investment areas in our plans require a much more deliberate and sustained application or science and technology than hitherto. This requires not only financial support for S and T activities but linkages between the various sectors (educational, R and D establishments, industry and Governmental machinery) and policies conducive to the use of endogeneous efforts. Instruments for policy formulation and task implementation in this regard are lacking at present. When we consider the magnitude and dimensions of India's problems of economic and social development, associated with the vast and increasing population and immense poverty, especially rural poverty, it becomes clear that massive application of science and technology has to be an essential component for their solution. Science and technolo-sv must now be considered a vital input in all investments on par with capital and trained manpower although it has a longer gestation period: the latter implies advance planning beyond the normal five vear framework. Science can and must establish new heights for achievement and endeavour, which are bie enough to provide the challenge and excitement for the country's best talent. This will generate pride and self-confidence, as well as new innovative ideas and solutions which go beyond mere import substitution. With the much lower costs at which S and T activities can be carried out in India, compared to that in other countries, science and technology is the one resource, which more than any other, provides the greatest advantage and it is, therefore, only logical for us to base our strategy for economic and social growth on this important resource.

19.7 Some well-planned measures are called for to see that the best and well trained among our postgraduate students of science and technology are provided adequate incentives to take up research as a career and that areas are defined and supported that best serve national interests and priorities towards which such talent can be directed or encouraged to work on. On the one hand, we have pockets of excellence In terms or sophisticated manpower in some areas with no exploitative base, on the other, vi'a1 areas are crying out for expertise. Such mismatch needs to be avoided. Our R and O institutions have had a tendency to work on a large number of programmes that have been going on for years with a fair proportion of obsolete equipment and manpower. There is need to modernise them and provide them the challenges that will stretch them to the full.

19.8 Science and technology must help to speedily improve production through better efficiency and fuller utilisation of capabilities already created in the various sectors of the economy. Technology has to be oriented to improving productivity. It has to help in the creation of more employment opportunities and in the reduction of drudgery

especially of the weaker sections of the community. It should strengthen the nation and reduce vulnerability. Hence, self-reliance must be at the very heart of S and T Planning and there can be no other strategy for a country of India's size and endowments. The achievement of our development goals has often been impaired due to several national disasters like floods, droughts and communicable diseases; S and T has an important role to play in eliminating or controlling them, if instead of short term ad-hoc approaches, long term strategies are worked out. Problems of extreme poverty, sought to be mitigated through the minimum needs programme, are also well known. Science and technology has an important role to play in finding rational and long term solutions for such disasters and national problems.

19.9 Science is both an outlook and a value system. Despite the tremendous growth of science, very few scientists have taken upon themselves the responsibility of creating a scientific ethos. The task of creating a scientific temper is a vital necessity for the grow'h of science and its utilisation in the development process. There is need to create a scientific climate and involve the people in discussions on various issues of science and technology which affect their lives. There has to be dissemination of knowledge about natural phenomena and technological innovations, through popular science journals and other media. There is also need for promoting public debate on major Issues of science and technology. The full potential of science has to be utilised for eradication of irrational attitudes, which tend to hold back the na^on from the path of progress.

19.10 The total role assigned to science and technology must, therefore, be to develop on a long term basis a sound base in science, in competence and in skills. Shorter term plans must harmonise with this ultimate objective which may have a gestation period extending well over one five year plan. The aim must be to:

- attract (and retain) the very best and young talent to contribute to science and technology and achieve originality and excellence in international terms;
- improve and transform the existing structure of science and technology for this purpose (e.g. support for exciting areas of scientific activity, greater involvement of scientists in defining the tasks that they are expected to perform, better career prospects and amenities for scientists and technologists. improving the mobility of scientists within the country etc.); establish much more effective linkages in organisational form and policy framework and an effective utilisation of science and technology to meet economic and social objectives; and
- identify major new areas of science and technology of special significance to the country and in some of these areas invest in an optimal manner so as to achieve technological breakthrough in the shortest possible time.

S and T and Education

19.11 The first priority must be to nurture talent by a substantial improvement in the general science and technology facilities in universities and research institutions. The University science system has been allowed to run down through lack of support in the recent past, a trend which, if allowed to continue, may result in an irretrievable situation. The current pressure to which 'he universities are subjected in terms of the enormous intake of science students needs to be reduced. The ten-plus-two-system of higher secondary education has to be effectively brought to use uniformly in all regions, taking note of the opportunities that it provides for filteration at successive levels of 10 to 12 years of school level education. This filteration will only succeed if the alternative channels for vocational training and, later, opportunities for gainful employment, are taken care of.

19.12 The higher education institutions with their research facilities are a unique base for the training of competent scientists and technologists. But with the rapid expansion of the number of institutions and students, without the corresponding inputs by way of facilities, the role of universities as advanced centres of teaching and research has been eroded, leading not only to the weakening of science teaching and research but also adversely affecting the climate so essential for higher learning. The need today is therefore to restore to the universities their proper image as centres of higher learning. Although it would be unrealistic to expect all the members of the academic community to take up research hi addition to teaching, there is an urgent need to revive the concept of integrating of teaching and research so that in 10 to 15 years from now, our universities present a different image and are restored to their recognised position.

19.13 Facilities available in universities are not adequate. That thev should be increased cannot be overemphasised. It is in the general interest of not only the universities, but also scien^fic agencies such as CSTR, DAE. ISRO. public enterprises and technical departments in the Centre and the States, that the resources in the educa^on sector are considerably augmented, since the manpower that they need comes from the University sector. Moreover, as the benefits of these researches will extend to several sectors of "The economy. State Governments and industries should also share in funding research in universities.

19.14 Linkages between academic institutions on the one hand nnd national scientific agencies, laboratories and

public sector enterprises on the other, have to be strengthened. This can be done in several ways such as through increased mobility of scientific personnel between education and research organisations, joint research projects, and insistence on a miamium percentage of the R and D budget of government scientific agencies and public sector enterprises being spent in the academic sector. Universities and colleges should also be encouraged to under-take applied research, useful for several regions of the country. Since the problems of a particular region are unique and intrinsic the best way that the S and T thrust could be made in finding out solutions to those regional problems would be to make use of the local resources—people, the scientists and community at large.

Basic Research

19.15 Basic research is important not only for its own sake, but also because of the solid foundation it provides for applied research and development. By definition, basic research has to be carried out at the frontiers of human knowledge and can only be carried out by those with originality and innovativeness of a high order. Successful accomplishment of basic research automatically results in the creation of manpower imbued with great intellectual quality, self-confidence and the ability to find new and innovative solutions to problems. There are many areas of basic research today that are very expensive in terms of resources, both financial and manpower. Therefore, one has to be selective in the areas chosen to ensure that real progress is made. With the continuing emergence of inter-disciplinary areas, it is important to support the newly developing broad spectrum ac^vities where many of the classical disciplines such as physics, mathematics and chemistry are brought to bear rather than attempt to build isolated peaks on a narrow basis. With our preoccupation to foster research programmes of a highly applied nature, much attention has not been paid to these advancing frontiers of science. While we strengthen the universities for carrying out advanced research in the frontiers of science, there may be a need to set up a few new research institutes in some important areas such as plasma physics, immunology and applied microbiology. The new institutions must have a strong mandate for theoretical and pure research. A beginning of this kind must be made immediately if the gap is not to widen.

Policy Formulation and Implementation

19.16 It is important to create on an urgent basis appropriate instruments relating to policy formula^on for science and technology and for S and T planning. At the apex level, there will be a Cabinet Committee on Science and Technology which will consider all impo -tant issues, related to science and technology. The Cabinet Committee will be supported by the Scientific Advisory Committee to \bs Cabinet. This Committee will critically assess the progress of S and T policies in relation to the aspirations of the people and in relation to the achievement of advanced nations and make appropriate recommendations to the Government.

19.17 The Department of Science and Technology will have the overall responsibility for the implementation .of science and technology policy, administering special research institutions especially in their nascent stages and promoting scientific research in frontier areas. The Department will also play the role of drawing on the expertise available in the agencies, Ministries/Departments and universities.

19.18 There is need to have in the economic Ministries, particularly those concerned with large investments, properly structured Information Planning and Analysis Groups staffed with professional scientists and technologists and headed by senior scientists] technologists, who will function as Scientific Advisers ij the Ministers; it has to be ensured that their views are given appropriate consideration. What is important is to ensure that in all areas of priority in the Plan, where large investments are to be made, the S and T component is clearly identified and broken down into tasks that can be assigned to institutions capable or working on them (whether coming under the concerned Ministry or otherwise) and where necessary, new capabilities built up. It has, been past e\-perience that there is very little correlation betwefcu R and D decisions and activities on the one hand and investment and production decisions on the other; or between R and D scientists and decisions relating to import of know-how.

19.19 The Planning Commission's role is with regard to the optimal allocation and utilisation of resources to fulfill national aspirations and goals. S and T has an important role to play in specifying the manner in which these aspirations can be met in the shortest possible time at minimal cost. The plan programmes of the economic ministries and State Governments in various sectors of the economy hav? to be appropriately analysed in the Planning Commission with a view to integrating the S and T plans and proerammes as a part of the investment plans. This would call for clear delineation of the S and T information for planning purposes, analysis of the capabilities and content of the S and T programmes and advice on priorities for investments in S and T. Programmes emerging from bilateral and multilateral foreign assistance agreements would need to be harmonised with the national science and technology plans and policies. The Planning Commission would need to be supported by an aporopriate structure for S and T advice, staffed with professional scientists and technologists and headed by a senior scientist as Scientific Adviser.

19.20 It is only in recent years that a number of enterprises and a few departments of the Government have set up in-house R and D organisations. Their efforts have been mostly confined to providing assistance in establishing

process and product standards, substituting imported raw materials and intermediaiis and towards bringing about product improvemepts based on feed back from the market or users. \ maior initiative in the Plan would be to induce the public and orivate enterprises to enlarge their nascent R and D caoabi'ities to srow rapidly with a ifew to engaging them in the task of promoting technological innovations. These would also need to be facilitated through appropriate institutional mechanism to enable the managements of such enterprises to have R and D advice in the pursuit of technologij'al innovations as a part of corporate planning.

19.21 Financial institutions and development banks could play a useful role in evaluation of technology, preinvestment studies, choice of technology, risk taking in the use of indigenous technology, facilitating horizontal transfer of technology etc.

19.22 The activities of the National Research and Development Corporation (NRDC) need to be radically modified so that apart from licensing indigenous technologies, it vigorously promotes research and development. It should also concern itself with evolving mechanisms for dissemination and transfer of technology within the country, export of Indian technologies and mutual transfer of technology between developing countries.

19.23 There has to be a National Register of foreign collaboration. The prime contractor of any project must invariably be Indian; there must also be a commitment to associate appropriate Indian R and D activities with all import of know-how, and thereafter a commitment to ensure a scale of investment in R and D lor the absorption of the import of know-how and subsequently for its adaptation, improvement and conversion to new technologies.

19.24 The import of technology should be preceded by advice tendered by competent groups in the larger interest of the country. The imports should be so planned as to result in their internal dissemination and lurther development as far as possible.

19.25 A strong information base is a prerequisite for a S and T plan with self-reliance as one of,its principal objectives. Since information is utilised not only for the understanding of current status but also for anticipating the shape of things to come, a strong base for the pursuit of intellectual efforts in the direction of technological forecasting, information analysis, R and D management etc. has to be created. Computerised net-works for handling of information would have to be institutionalised to meet the requirements of policies trends of research, monitoring on a global level, resources availability, industrial, technological and market intelligence.

19.26 Steps will have to be taken to bring scientists and society together through appropriate feed back mechanisms. Science through proper cofli-munication should be made a powerful force to eradicate old irrational attitudes. A science information bureau would be established for this purpose.

19.27 A serious lacuna in the research system is the inadequacy of testing, calibration, standard and quality control facilities : these significantly affect the optimal use of national resources and health. environment and safety aspects while in use. The Sixth Plan would endeavour to promote a comprehensive programme which will establish a national centre of standards and expand ihe existing laboratories, test houses and certification centres so that in due course these can cover a large range of activities throughout the country.

Science and Technology and Rural Development

19.28 It is necessary to emphasise that application of existing knowledge to the solution of neglected problms of development, especially in mter-dis-ciplmary areas with an additional socio-political dimension, often demands highly creative and innovative efforts and an application of a systems analysis capability of a high order, which is typical of any S and T endeavours.

19.29 Rural technology should not be taken to mean primitive technology or technology of yesterday. A determined effort is needed to take modern science and technology to the rural areas so that it is brought well within the material, financial and skill resources of rural people. Therefore, while searching for and improving upon such technologies which increase employment opportunities for our people, it will be simplistic and dangerous to confine indigenous efforts to relatively simple technology for rural neefls and depend on import of technology in ihe high technology areas, We have also to ensure an appropriate mix of small, medium and large sc^e technologies, in a manner consistent with our loae-t(,rm interests.

19.30 A national rural resources corps of young orofessionals would be organised to cover, in the t>eginning, the tribal, drought and flood prone and hill .was. A similar corps of professionals trained in managerial skills would be developed for helping the small and marginal farmers. The first group could be of great assistance in providing the needed support for implementing effectively the employment generation, agricultural and industrial programmes, the minimum needs programme and programmes of energy supply, housing ,and urban development, nutrition, elementary and adult education. The second group has the potential to make a signficant contribution to the processes of transfer of new agricultural technology to millions of small and marginal farmers who have continued to

lag behind. These farmers need management support in the form of agro-services of various kinds in our villages, blocks and districts, which can be provided through a large number of young professionals trained in modern management techniques.

Science and Technology and Hitman Resource Development

19.31 S and T can obviously play a significant role in the promotion of human welfare. In the coming years. the benefits of science must percolate more effectively to the vulnerable sections of the community and backward areas of the country. The manner in which this is sought to be achieved is briefly set out in the paragraphs which follow.

19.32 S and T for weaker sections: In promoting the applications of science and technology for the benefit of the weaker sections, special programmes would be devised in the Sixth Plan. A more coordinated and vigorous effort than in the past is needed to equip suitable persons from socially backward groups and weaker sections of the society to play a purposeful role in the S and T area. Consortia of S and T institutions could be formed in each district to provide the needed technical training and back up for the implementation of special programmes for Scheduled Castes and Scheduled Tribes and the weaker section of the society. In order to ensure appropriate technological back-up for this programme, it is proposed to initiate an all-India coordinated research project for technologies for landless labour families to be jointly undertaken by major scientific agencies. State universities, colleges and technical institutions and to mobilise professionally qualified young persons for service in rural areas.

19.33 It will be the endeavour of major S and T institutions to follow an integrated strategy which will aim at increasing production and productivity in agriculture and allied sectors based on the better use of irrigation and improved technology. Programmes in the areas of agriculture, animal husbanday, village and small industries will receive special emphasis. In the hill areas, afforestation, soil conservation and water shed management will receive priority. Alternative land management systems may have to be introduced to make shifting cultivation unnecessary. There is also need for introducing high-value, low-volume crops backed by processing and marketing to include horticulture, tea, coffee, spices etc. particularly in the north-eastern region. New technologies based on local raw-materials to minimise transportation cost and on the locational advantage of cool climates will also have to be developed.

19.34 A desert development programme will be implemented both in the hot and cold arid zones of the country. The emphasis will be on arresting desertification through activities which restore the ecological balance, stabilize sand dunes and facilitate soil and wa er conservation. Plantation of shelter belts, adoption of water harvesting techniques - and developing pastures to sustain the livestock economy will have to be vigorously pursued. S and T programmes for improved agricultural and animal husbandry practices would be intensified in cold and arid zones.

19.35 S and T for Women: The question of developmental activities related to women vis-a-vis science and technology has two aspects. First, there is the contribution by women to the development of science and technology. Secondly, one has to consider as to how science and technology can contribute to improvement in the life and status of women generally. As regards greater involvement of women in science and technology, it is felt that the following areas deserve special attention:

a. science teaching in girls' schools and colleges:
b. Greater enrolment of women in engineering. agricultural, veterinary, fisheries and forestry colleges;
c. better personnel policies to enable them u look after their families as well as continue in employment; and
d. their involvement in the decision making process including opportunities for placement at higher levels of decision making.

The educational programmes should be so conceived as to pay greater attention to training both boys and girls to share responsibilities at home. Restructuring of courses in womens' colleges and training institutions, imparting of new skills to rural women and training in cooperative marketing for women are some of the other programmes that need be taken up.

19.36 Application of science and technology to the improvement of the life and status of women will depend upon the development of home technologies, suitable agricultural technologies and technologies for improvement of productivity. Forestry, sericulture, handloom and crafts like pottery could be considered potential segments of women's work where application of simple technology can go a long way in improving their productivity and give them enough time to participate in programmes for their educational and other development.

19.37 There is greater need to develop appropriate technologies for those working in the small and unorganised sector. This is particularly applicable to women facing serious occupational hazards jn several professions leading to avoidable health problems. There is also a need for a coordinated research project to find out methods to improve the production efficiency and reduction of drudgery in the occupations of women. In the field of information

disseminatiun, mass media could play a useful role in spreading information on technologies relevant to home needs such as care and maintenance of household gadgets, electrically operated utensils etc.

19.38 Special cells for promotion of S and T for women could be set up in the University Grants Commission, CSIR, ICAR, ICMR, Departments of Atomic Energy, Space, Electronics Science and Technology and Defence Research and Development Organisation. Specific programmes relating to technologies for rural women and warding off of occupational hazards, have lo be structured. There is also need to look into the personnel policies for promoting greater involvement of women in S and T. The coordinating role in this regard Has been entrusted to the Department of Science and Technology.

19.39 Involvement of the Scientific Community :The large S and T manpower available in the country has to be mobilised towards the objective of accelerating the pace of economic growth of the country. Measures will have to be taken to give a sense of involvement to the scientists, to energise the different segments of the scientific community and to utilise purposerally the scientific academies and professional societies. These are highlighted in the following paragraphs.

19.40 Young Scientists: The involvement has to be at the following three levels:

a. development of the programmes of the institutions and organisations where the scientists are working;
b. interaction with the State Councils of Science and Technology; and
c. at the national level, there Is a need for a proper mechanism for a continuous involvement of young scientists in the formulation and implementation of policies for science.

19. 41 Scientific academies and professional societies:In planning of S and T, a sense of perspective and a futuristic outlook are essential. Gaps in S and T between what exists in our country and that in the advanced countries have to be identified, particularly because S and T is to be used as an important instrument of our frture development. Current trends in research have to be studied, state of art reports have to be prepared and forecasting has to be resorted to in several areas. The expertise available with the science academies and professional societies could be fruitfully employed for these activities. These academies and societies could interact with educational and training institutions in the matter of curriculum development, retraining and refresher course for the older groups in the profession and intensive training for special categories of professional scientists. They could organise seminars and workshops where the society comes face to face with the decision makers, the scientific community and those concerned with implementation 'it grass-root levels. The academies and societies should work in close collaboration with State S and T Councils and State Planning Boards. Financial allocation for stimulating such activities has been made in the Plan under Department of Science and Technology.

Facilities and Amenities for Scientists

19.42 The Indian scientists are a part of the society for whose development they are deeply committed, The socio-economic problems faced by the scientists are not different from those of other citizens. Many of the younger scientists in their creative years have to devote too much of their time to problems of every day living while they would like to devote their time to thinking ai'd researching. Attention will have to be given to the problem of salary structure, housing, educational facilities and other incentive if research ins^t'rtions are to be made more creative and greater returns are expected from research.

S and T in plates

19.43 The State Councils of Science and Techno logv are being activised under the new plan. One of the specific ways by which the State Councils could foster S and T in their own region could be to associate the national laboratories, university science departments, research scientists and professional societies in the States, in the identification of problem areas and application of S and T for their solution. The State Councils could also organise public discussion and debate on S and T policies, plans and programmes being followed or proposed to be followed by the various Central and State S and T institutions situated in the State. Dissemination of science and fostering of scientific temper should be the guiding principle for the working of these State Councils. This could be achieved by the publication of special journals in local languages, programmes for the children in schools and science melas organised in research institutions in which a large number of people participate. The Councils could also commission mobile science museums for purposes of exhibition in rural areas.

Technical Cooperation in S and T

19.44 Collaborative efforts through multilateral programmes such as those of the various agencies of the UN system or bilateral technical assistance programmes have emerged as significant vehicles for inter-country cooperation in S and T. It is, however, important that such programmes of technical cooperation are enmeshed with the indigenous S

and T capability and linked to the S and T plan. In devising programmes of technical cooperation with other countries, aid as such should not be the primary objective. Since the basic infrastructure of S and T is strong enough in the country, it would be advantageous to look for programmes which call for collaborative effort between our scientists and those of the advanced countries. It should be the endeavour of R and D institutions to see that, as far as possible, the emphasis in the collaboration is on exchange of specialised knowledge on both sides and procurement of specialised equipment from advanced coun-triet, Certain specific areas in which we have advantage could be considered for offer of training facilities for the scientists of other developing countries. In this regard, the Centre for S and T for non-aligned countries and Regional Centre for Transfer of Technology (under ESCAP auspices) will be supported and developed. It may also be possible to offer proven technologies to neighbouring countries faced with development problems similar to. ours.

PROGRAMMES

19.45 As explained in the sections which follow, the Plan investment on science and technology in the Sixth Five-year Plan will be significantly higher than in the earlier plans. While the realignment of the scientific effort in the country fully in line with the foregoing approach will take some time, the programme content in the new Plan marks a step in this direction.

Indicative thrust areas for S and T

19.46 In order to utilise our existing manpower resources and strengthen the infrastructure of our institutions, so as to leapfrog into advanced areas of science and technology, it will be necessary to concentrate on we)l selected areas of science and technology and provide the requisite amount of resources so that major breaks through may be achieved in the selected thrust areas; these must be chosen such that even limited resources can make an impact. I he identification of these thrust areas and assignment of appropriate priorities is a continuous process involving interaction amongst different groups of scientists and technologists from educational and research institutions as well as from the industry. Many of these thrust areas need inter-disciplinary work encompassing different traditional disciplines such as physics, chemistry, biology and engineering. Another feature relates to the setting up of appropriate institutional mechanisms to ensure that these new interdisciplinary areas are pursued by scientists of high calibre, particularly young scientists from different parts of the country around whom suitable core groups or units may have to be built up, providing them with the necessary facilities including appropriate training programmes, specialised courses, career award schemes etc. Some of the indicative thrust areas identified so far and the corresponding Departments/Ministries and agencies which might take the lead in implementation are indicated in Annexure 19.1.

19.47 The programmes on Science and Technology are described in the various sectoral plans. For an integrated picture, the salient features of the S and T plan programmes are indicated in the following paragraphs:

Agriculture, Animal Husbandry, Fisheries and Food

19.48 Agricultural research in India has many achievements to its credit. The production of food-grains touched a record level of 131.4 million ton-nes in 1978-79 as compared to 45.6 million tonnes in 1947. This improvement in foodgrains production has been made possible by the development of high-yielding crop varieties and improved production technology through sustained research effort. Similarly, the research advances made in commercial crops, horticultural crops, plantation crops etc. have added to the production potential of these crops. The technology has also been developed for reclamation of saline, alkaline and desert soils into productive lands and for improvement of live-stock and their disease control. Cross-breeding programmes in live-stock and sheep have been introduced for increasing the milk yield and wool and meat production. Relevant technology for improvement of both inland and marine fish production is being developed. Research for improvement of goats, poultry, pigs etc. is also under way. Extension programmes for transfer of technology have been undertaken through national demonstrations, whole village operational research projects, Krishi Vigyan Kendras and Lab-to-Land programmes.

19.49 During the last three decades, the maior objective of agricultural research and development was to achieve self-sufficiency in food. During the eighties, the goal wo"ld not only be to further improve productivity and stabilise and diversify production,but also to conserve it and to generate rural employment and enhance consumption by increasing the purchasing power of the people. High-yield-cum-stability production system, in both ten-ertrial and aquatic farming will be developed, ensuring maximum utilization of available resources in soil, water and sun light. Identification of constraints responsible for the gap between the potential and actual farm yields and causes of slow technology transfer would continue to be of prime concern. 'Research effort will be oriented to conservation of plant, animal, soil and water resources, evaluation and stabilisation of production trends in unirrigated areas, evolving technology to suit marginal and small farmers' holdings, improvement of animal and fisheries resources and development of integrated farming systems. Measures for effective transfer of technology to the field and providing research support to the farming community will receive special consideration.

19.50 The S and T programmes under the Department of Food pertain to Indian Grain Storage Institute and its field stations and the National Sugarcane Institute. Promotion of research effort and popularisation of improved techniques for foodgrains storage and pest control at farm level are important facets of the Grain Storage Research and Training Centre. The Centre also undertakes training for Government personnel deployed for procurement and buffer stock maintenance and for pest control in Government go-downs. The development of designs of metal and non-metal storage structures, appropriate insect and rodent control techniques for adoption in the village and identification of field problems in various post harvest operations are some of the programmes in the Plan. The National Sugar Institute will continue its programme of research on problems pertaining to sugar technology, sugar and sugarcane chemistry and sugar engineering, render technical advice and assistance to sugar factories with a view to improve efficiency and provide specialised technical education.

Forestry

19.51 The S and T component ia the forestry sector is built around the programmes of the Forest Research Institute. These will be concerned with developing technologies to increase, maximise and stabilise wood production per unit area under different management and exploitation methods, improvement in utilisatioa and generation of employment without endangering ecological security, particular attention will be paid to the extensive cultivation of legumenous shrubs and trees which can provide fodder, feed, fuel and fertiliser (through fixation of atmospheric nitrogen).

Environment and Ecology

19.52 A new Department of Environment has been set up. The activities in this important area will pertain to:

i. support for R and D programmes, developing an information system, monitoring network, field action and demonstration schemes, and matters relevant to planning and coordination on environment aad ecology at the national and State levels;
ii. operational programmes such as establishment of biosphere reserves and centres of excellence for environment education and managements, and Eco-developnaent force and Eco-development camp
iii. programmes pertaining to pollution control measures (water, air, noise etc.).

Irrigation

19.53 The focus of the research activities will be on evolving improved and economical designs, use of locally available materials, adoption of better construction practices and development of indigenous technology for new instruments and materials, identification of activities required for the optimum development of water resources by remote sensing techniques and promotion of studies in pure and applied hydrology.

Meteorology

19.54 The S and T programmes in meteorology aie undertaken by the establishments of the Indian Meteorological Department, Indian Institute of Tropical Meteorology, Indian Institute of Geomagnetism and Indian Institute of Astrophysics. The programmes pertain to strengthening the infrastructure capabilities and competence to provide weather forecasts, warn against severe weather phenomena (like cyclones, heavy rains, snow, heat and cold waves), and for detection and location of earth-quakes and evaluation of seismic risks. New programmes proposed relate (o integrated weather service for agricultural opera-lion and planning, application of remote sensing technique to agricultural meteorology, extension of soil moisture observational network, reconnaissance of cyclonic storms and development of instruments.

Health

19.55 Over the years, the aim of Indian Council of Medical Research has been to strengthen indigenous capabilities and develop a broad-based and balanced cadre of research personnel able to cope with the present and new problems affecting the health of the nation. In the Plan, the activities of Indian Council of Medical Research would be oriented to operational research for improving health conditions in major problem areas like fertility regulation, control of communicable diseases, improving the nutritional status, particularly of mothers and children and alternative strategy of delivery of health care. The effort would be to strengthen and develop capabilities in new areas such as immunology, genetics including molecular biology and genetic engineering for control of intractable communicable diseases, viz. malaria, leprosy, filarisis and kala-azar. An important step towards implementation of the programmes will be the adoption of the task force approach, viz. to set up inter-discipllnaryyinter-institutional task forces for specific problem areas like child health; nutrition, cancer, communicable diseases and endocrinology, in which the R and D tasks would be identified and programmed for achievement in a time bound manner. In addition, the Indian Council- of Medical Research have prooosed to set up a national cancer registry with four regional centres, three

advanced cenlres in areas of hematology, neurophysiology and neurobiochemistry and five regional centres to promote regional biomedi-cal research during the Plan period. Among other major S and T objectives in the Health sector will be development of indigenous capabilities for the manufacture of bulk drugs and utilisation of medicinal plants.

Education

19.56 The basic approach will be to provide selective support for high calibre but broad-based scientific research and thereby to improve the quality of the educational system.

19.57 The University Grants Commission has provided assistance to Universities to set up computer faculties, instrumentation centres, and centres for advanced study in science. Support is also provided by UGC to selected university science departments to develop accessory and infrastructure faculties for undertaking group research in selected subjects, strengthen and consolidate their teaching and research programmes and to identify an area of specialisation in which they would ultimately strive to achieve excellence. With UGC support, specific time bound research projects are also undertaken by university faculty members and junior teachers in colleges and universities. These activities will continue in the Sixth Plan.

19.58 In the area of technical education, besides strengthening R and D in Indian fastiutes of Technology, it is envisaged to take up programmes relating to expansion of facilities in areas where gaps have already been identified, such as instrumentation, computer science, electronics, bio-sciences, and development of emerging areas li'

Housing, Urban Development and Construction

19.59. The S and T programmes in the area of housing and construction materials will concentrate on applied research and development covering building materials, soil engineering, building processes, rural housing. construction equipment and techniques and nd structural designs, marine structures, construction management and solar energy in buildings. The implementing organisations include Central Water Commission, Central Board of Irrigation and Power, Indian Road Congress, Defence Research and Development Orgapi-sation, National Building Organisation, Central Building Research Institute, Indian Institutes of Technology and other laboratories.

Energy

19.60 The thrust of the research effort in the energy sector will be on improving the efficiency of production, distribution and utilisation of all forms of energy, improvement of energy efficiency in processes and equipment, recycling of waste for augmenting energy supply and development of new and renewable energy technologies. As the ensrgy problem has emerged as the most critical problem which the world has to face in the coming decades and as investments on this sector are growing increasingly massive, the S and T effort in the energy sector is being intensified over the entire range from atomic energy at one end to animal energy at the other.

19.61 Apart from the potential role of new and renewable energy sources in meeting the country's energy demands, the development of solar, wind and bio-mass sources of energy are of particular interest fcr supplying the energy needs of the decentralised and rural sectors, as well as several potential industrial uses. In order to have institutional arrangements for a well-coordinated approach in this area, a Commission for alternative energy sources is being established. This Commission will be similar in structure and powers to the Atomic Energy Commission. It will be responsible for formulating policies and pro-grammes for development of non-conventional and renewable sources of energy, for coordinating and stepping up the research and development activities in this area and for ensuring implementation of Government's policies in regatd to matters concerning such sources of energy.

19.62 The highlights of the S and T programmes relating to energy are set out in the sections which follow.

19.63 Petroleum: R and D effort in the petroleum sector is undertaken by three institutes of ONGC viz. institute of Petroleum Exploration (IPE). Institute of Reservoir Studies (IRS) and Institute of Drilling Technology (IDT) as well as by the Indian Institute of Petroleum (IIP), Engineers India Limited (EIL), Indian Oil Corporation (IOC)—R and D Centre, and Indian Petrochemicals Corporation Limited (IPCL) R and D Centre.

19.64 IPE will be undertaking studies on basic issues connected with petroleum genesis and accumulation, by adopting an integrated and multidisciplinary approach. IRS will be concentrating on programmes for developing enhanced recovery techniques for different oil fields. IDT will initially concentrate on solutions for problems of drilling deep wells. The deveopmental activities of the three institutes include import substitution and indigenisation of equipment. In tlie field of oil refining, IIP will be the prime organisation to conduct R and D programmes, it will the supplemented by IOC (R and D Centre), EIL and others. The main areas of research would be thermal and fluid catalytic cracking, catalytic reforming, solvent dewaxmg and deoiling, hydro-treatment and sweetening of various petroleum products. The Plan programmes envisage setting up a semi-commercial pilot plant next to the Koyali

Refinery. Concentrated efforts will also be made to develop catalysts required for various refining processes.

19.65 The R and D projects undertaken by EIL are in the areas of chemical engineering, petroleum refining, petrochemicals, slurry transport, equipment development, environmental engineering,' non-ferrous metallurgy and ocean engineering. The R and D schemes of IPCL and IOC pertain to product development and process improvements relevant to their corporate objectives.

19.66 Coal: The Coal R and D projects are coordinated and monitored by the Central Mines Planning and Designs Institute, Ranchi. Under the Department of Coal, an inter-ministerial Standing Committee on Science and Technology has been formed. The programmes include those of the Central Fuel Research Institute, the coal companies and research sponsored in academic institutions like Indian School of Mines, Central Mining Research Station and Indian Institute of Technology and Banaras Hindu University. In the Sixth Plan two new techniques of mining, viz. shield mining and hydraulic mining will be tried on an experimental basis. Other S and T schemes include the introduction of geophysical methods for the estimation of river sands, monitoring of environmental conditions, underground communications and technologies for Coal benefication, conversion, agglomeration etc.

19.67 Power: The first stage expansion of Central Power Research Institute (CPRI) has been completed; during 1980-85, the programmes include setting up of an experimental line for research on UHV/ HVDC transmission, contactor and transformer testing facility at Switchgear Testing and Development Station, Bhopal and setting up of a 2500 MVA short circuit testing facility. Additional regional laboratories are also proposed to be set up by OPRI for routine testing of various power apparatus. In .addition, CPRI proposes to undertake research projects on problems of thermal power station operation such as failure of boiler tubes, water chemistry in thermal stations, corrosion of ID fans and corrosion of coal conduits.

19.68 The Central Board of Irrigation and Power. which sponsores problem-oriented research activities, specially among the State Electricity Boards, will intensify its activities in the next five years. Geother-mal field investigations in progress in the Parbati Valley in Himachal Pradesh and in the Puga Valley in J and K are expected to be completed by 1982-83 and 1983-84 respectively. These will be followed by schemes to explore the feasibility of harnessing the energy. Investigations and studies have been proposed regarding development of tidal power in the Gulf of Kutch.

19.69 Renewable Energy Sources: The Department of Science and Technology has an ambitious programme for research and development in new energy sources. As explained in the Chapter on "Energy", it covers development of technologies and devices for utilising new^purces of energy such as Solar, biomass and wind. "Research activity is also to be initiated on energy conservation and energy efficiency in industries. .agriculture and transport, and for developing integrated energy systems for the decentralised sector. The establishment "of a 5 MW (thermal) Magneto-Hydro Dynamics (MHD) experimental facility will be completed in the Plan period.

Atomic Energy (R and D}

19.70 The R and D effort is oriented to achieving self-sufriciency in the exploitation of the potential for nuclear power generation and applications for national development and is accordingly directed to the development of power reactor systems and applications of radioisotopes in industry, agriculture and medicine. The reactor technology development programmes, have hitherto concentrated on thermal reactor development; several types of experimental reactors have been built and project engineering^ capacities developed. As a spin off, special expertise has become available in areas like special materials, electronics, and exploration and exploitation of atomic minerals. At the Bhabha Atomic Research Centre, the 100 MW thermal research reactor is expected to be commissioned in 1983.

19.71 Some of the new programmes envisaged at the Bhabha Atomic Research Centre are the development of a Medium Energy Heavy Ion accelerator, studies in laser induced fusion and related high temperature high density plasmas, and development of a 500 MW thermal reactor. At the Reactor Research Centre at Kalpakkam, the Fast Breeder Test Reactor is expected to attain criticality in 1982. The R and D programmes of the Centre relate to sodium technology, reprocessing engineering and special materials research. At the Variable Energy Cyclotron project at Calcutta, which is the national facility for advanced work in nuclear physics and for the controlled direct irradiation of biological and agricultural products, research facilities are being set up for biological, biomedical and chemical studies of charged particle and induced radio isotopes. The Atomic Minerals Division will carry out a reconnaissance survey of an additional 50,000 sq. kms and detailed surveys in 1200 sq. kms.

19.72 New research efforts envisaged in the Plan at the Tata Institute of Fundamental Research are in the areas of molecular biology, radio'-astromomy, chemical physics and computer sciences. The research programmes of the Saha Institute of Nuclear Physics in the areas of bio-physics, cyclic accelerators, molecular biology, plasma and laser physics will continue. Grant-in-aid support to universities for basic research would be further augmented with a view to help strengthen the infrastructure capability of the university system and develop a national base for expertise in areas of interest to atomic energy development programmes.

Rural Development

19.73 Science and technology programmes relevant for rural reconstruction would be designed to generate exper ise and skills for using local resources and manpower, establishing structural Dnkages between national laboratories, institutions of higher education and state development agencies and programmes through a consortium approach, developing a corps of young professionals and stimulating action-oriented research for development and transfer of appropriate technologies. In this regard, special attention will be paid to 'he betterment of landless labour, marg'nal farmers, village artisans and rural women. The S and T programmes would be oriented to the plan programmes which are specially geared for rural development, such as the minimum need .programme, village and cottage industries development, integrated rural development, national rural employment programme and special programmes for hill areas, deseris and tnoal areas. Specific measures envisaged are the starting of an all India coordinated research project for technologies for landless labour, developing a corps of young professionals, promotion of S and T for weaker sections and women, and involvement of younger scientists for solutions of local specific problems.

19.74 These new initiatives will be in addition to the on-going S and T programmes such as those undertaken by the Khadi" and Village Industries Commission, the National Institute of Rural Development, Centres for application of S and T to rural development and sponsored R and D in other institutions. S and T programmes which relate to improvement and development of implements and machinery needed, for village industries, reduction of drudgery and increasing Uie earning capacity of the workers, will continue.

Large and Medium Industries

19.75 Heavy Industries: The principal objectives in this sector would be the development of energy efficiency, increasing productivity, improving the process design and deevlopment of capabilities for the design and fabrication of equipment and plants for the manufacture of fertilizers, petrochemicals, cement, paper, sieel, non-ferrous metals, etc. As far as machine tools are concerned, development of the capacity of the 'industry to design and manufacture newer and more sophisticated tools and development of supporting technologies would be the principal goal. Specific areas where major effort would be required aie automobiles, agricultural equipment and machinery, mechanical and electrical equipment and printing technology.

19.76 The RD programmes will be carried out by the public sector units such as Bharat Heavy Electri-cals, Hindustan Machine Tools, Bharat Heavy Plate and Vessels, Bharat Pumps and Compressors, Heavy Engineering Corporation, Mining and Allied Machinery Corporation, and institutions such as Welding Research Institute, Central Machine Tool Institute and Automotive Research Association Institute. The main objective of in-house R and D units will be to develop competence to provide engineering services, bring about improvement in product design and efficiency, import substitution and technology absorption, as also for a steady flow ot new products, processes and services.

19.77 In the case of textiles, the R and D programmes will bs looked after by industrial research associations for jute, cotton textiles, silk, man-made fibres and wool. The R and D programmes identified in the Plan cover jute—fibres, jute re-inforced plastics, energy and water conservation in textile mills, improvement in technologies of yam and fabric preparation in the decentralised sector, open end spinning technology, machinery development and instrumentation.

19.78 Mining and Minerals: The S and T projects are implemented through five Central public sector units (Bharat Gold Mines, Hindustan Copper, Hindustan Zinc, Bharat Aluminium and Mineral Exploration Corporation), the Indian Bureau of Mines and Gujarat Mineral Development Corporation; grant-in-aid support is also given to research schemes of Indian School of Mines and other academic institutions. The programme will be oriented to the development of new and efficient methods of exploration and exploitation of mineral deposits, improvement of efficiencies in mines and plants, recovery of precious .and minor (but valuable) metals present in base metal ores, applied research for pollution control and protection of environment in the process of mining and production of non-ferrous metals.

19.79 Chemical Industries: It is proposed to set up facilities for in-house R and D under Indian Drugs and Pharmaceuticals and Hindustan Antibiotics for carrying out development work and improving productivity in the field of drugs and pharmaceutical^. Hindustan Organic Chemicals intend to establish multi-purpose pilot plant facilities. A central complex for R and D in the field oi' insecticides is planned by Hindustan Insecticides.

19.80 A National Insti:ute of Fertilizer technology under the administrative control of the Department of Chemicals and Fertilizers is proposed to be set up during the Sixlh Plan. Some of the R and D areas identified for special attention in the field of. fertilizers are fuller exploitation of pyrites resources; recovery Of sulphur from gypsum, production of nitro-phos-phate w'ith use of nitric acid to reduce dependence on sulphur, methods of making tailor made nutrient mixture for specific requirements, miniaturisation of ammonia plants and simplification of process routes to encourage decentralised production units and hio-fixation of nitrogen. The thrust in R and D on drugs will be on the development of processes for drugs like anti-leukae'mic, anticonvulsant, antifertility, anti-malaria, anti-tumor and anti-turberculosis drugs. Work on development of technology for drugs from indi-geneous plants would be continued. A coordinated programme is envisaged on development of fermentation technology covering drugs, pharmaceuticals, food and industrial raw material particularly aimed at replacing petro-chemicals.

19.81 Steel: The Research and Development Centre for Iron and Steel under Steel Authority of India is engaged in undertaking in-house R and D projects of the steel plants. The Sixth Plan programmes will cover areas such as raw materials for producing iron, direct reduction steel making, rolling mills, refractories, instrumenta'ion control etc. Amongst the important projects, mention may be made of the partial briquetting of coal charge which aims at utilisation of about 20 per cent non-coking coal in the existing coke !oven batteries, installation of coal dust injection facility at Bhilai Steel Plant, development of alternate routes for production of iron and steel using non-coking co;'.l by rotary kiln sponge iron pilot plant, improvement in the LD lining life, pilot plant at Durgapur for development of bottom blow oxygen steel n.rikina process, development of technology for removing alumina from iron ore on a commercial scale and commercial scale production of cold bonded pellets utilising steel plant wastes. An Information and Documentation Centre is being set up at Ranchi.

Council of Scientific and Industrial Research

19.82 The national laboratories under CSIR have undertaken turn-key projects and provided basic designs for processes to various industries. Upto 1979-80, more than 1200 processes have been released; to industry of which over 500 have gone inCo commercial production. Design and consultancy capabilities have been developed in several specialised area e.g. optics, electronics, instrumentation, geophysical surveys, pollution control, chemicals, food processing, leaiher, glass, civil engineering structures etc. For taking science to the grass roofs level. CSIR has also pioneered a programme of adoption of districts.

19.83 The R and D programmes are implemented through a net-work of national laboratories and institutes, regional field stations, extension centres and polytechnological clinics. The S and T programmes of CSIR are reviewed, monitored and managed through a multi-tier system involving the governing body, the exec'Jliv'? committees of the laboratories and coordination councils of Direc:ors of laboratories. The CSIR also supports extra-mural research in universities, IITs etc.

19.84 Attention in the Sixth Plan period would be directed towards projectisation and making an impact through close coordination on an inter-institu-tional, inter-agency and multi-disciplinary basis, with full u:ilisation of existing facilities and infrastructure. Programme? in some of the major areas are:

i. Materials Development including polymers, corrosion and catalysis Development of special alloys steel, aluminium alloys, magnets, cryogenic materials, infra-red materials, industrial ceramics, special glasses, speciality paper products; rheology, processing and reaction engiiicerin" of polymers; simulation, chemical engineering and process design of industrial catalysts;evaluation and prevention of metallic corrosion in structure".
ii. Cliemicals : Biological evaluation of pesticides and agro chemicals; process technology for drugs; special surface coatings and paints; fuel cells, phosphors, ion-selective electrodes; biological active 'principle from marine flora and fauna, marine chemicals as by-products; and desalination technologies.
iii. Biotechnologies : Tissue culture application for medicinal and economic planis; fermentation technology and enzyme engineerina for chemicals, antibiotics and other medicinal products development; agricultural and forest residues and slaughter house wastes utilisation; emerging areas like genetic engineering and molecular biology,
iv. Oceanography : Geo-physical, geological and biological surveys in the ocean areas; dynamics of ocean environment; sea farming technology; marine instrumentation; collection, collation and analysis of data for ocean engineering.
v. Environmental Research : Studies on environmental pollution, marine pollution, biological monitoring techniques, rural sanitation, industrial pollution and protective measures.
vi. Mining and Metallurgy : New mining methods, mine modelling techniques, ground movement investigations, mine safety problems, productivity improvement in mining techniques, development of extractive technologies hydro-electro-metallurgical techniques, metal working techniques for clad metal, and material conservation.
vii. Electronics : Semi-conductor materials and devices, industrial control system, silicon and other electronics materials, micro-processors and instrumentation.
viii. Natural Products : Survey and screening of medicinal aromatic and other economic plants; identification of active principles and application of tissue culture, chemical engineering, agricultural engineering, bio-chemical engineering and technology for extraction and application.
ix. Energy : Coal utilisation inclusive of gasification; development of other non-conventional energy sources, e.g. solar energy and biomass, geothermal studies, wind power, energy storage and battery systems.
x. Aeronautics : Turbo-machinery and combustion studies, fatigue study, design studies on aircrafts structure; active flight control technology; development of other materials and composites for structures; rigs and tools development.

19.85 While acquiring new equipment for modernisation of facilities, the needs of the maior thrust areas and projects of national priority would receive special consideration. The linkages of the CSIR laboiT.lories with the user Ministries/Departments under the Central and State Governments, Universities, IITs and industries would be further strengthened.

Department of Science and Technology

19:86 The Department of Science and Technology is concerned with promotional efforts in new areas of science and technology as also coordination of S and T activities in the-area's in which a number of institutions and other Departments have interest and capabilities. The Department also provides support to some scientific establishments, science academies and societies and deals with matters concerned with international scientific collaboration programmes. The Department has established appropriate mechanisms to operationalise S and T schemes such as advisory Committees and steering Committees, which bring together various institutions, expertise and capabilities to help in implementing schemes and monitoring them in a coordinated manner.

19.87 In the Sixth Five Year Plan, the infrastructure facilities for the promotion of scientific and technological effort in oceanography and sophisticated instrumentation will be strengthened. The Ocean Science and Technology Agency would be acquiring oceanographic research vessels for undertaking scientific surveys and research for both mineral and biological resources; a marine research and development fund to intensify R and D work is envisaged. The four Regional Sophisticated Instrumentation Centres already set up would be strengthened by adding new equipment; a few more centres to serve the instrumentation needs of scientists in other regions are envisaged.

19.88 The Department has another set of Plan schemes which pertain to industrial promotion. The programmes under instruments development pertain to design and fabrication of optical, opto-mechanical and opto-electrical instruments, which would include process control, pollution control and electro-medical instruments. Another programme relates to the development of new fibres and composites: the development of resin systems would be undertaken and the earlier technology efforts would be operationa-lised through pilot plants for glass fibres, carbon fibres and fabrication of end products. The NRDC would be reoriented to promote diffusion of technology. Suitable mechanisms would be evolved and implemen ed for screening of proposals for analytical testing facilities and accredition of quality of testing.

19.89 A major effort would be made in the Plan for supporting basic research, multi-disciplinary research and initiating efforts in the emerging areas of science. In the exploratory phase, more than thousand scientists were involved in undertaking inter-disciplinary research work on 200 projects through the Science and Engineering Research Council. Thirty thrust area research programmes are envisaged in the second phase. Intensification of scientific research in some newly emerging areas by providing financial support to viable groups of scientists and technologists e.g. immunology, vaccine development, plasma physics etc. are envisaged: a national consultation and consensus process will be evolved for this purpose.

19.90 Four sectoral scientific information, centres (drugs, leather, food and machine tools) were set up as a first step for developing a National Information Sys'em for Science and Technology (NISSAT). The plan envisages settins up four more such centres, as also training in information acquisition,storage and retrieval and bringing about linkage towards developing the' national system. Support for seminars and symposia in selected areas would continue.

19.91 Promotion of scientific interest would be an important Plan effort of the Department. The schemes under this category envisage promotion of awareness of science and technology, fuller and purposeful utilisation of the capabilities of scientific academies and professional bodies, younger scientists and women scientists. Promotional efforts for catalysing the State Councils for Science and Technology would be undertaken for application of S and T for local and regional problems. Appropriate programmes to involve young scientists would be developed to help in promoting self-employment schemes i'n the areas of sericulture, animal husbandry, social forestry, fisheries, small industries etc.

19.92 Under international science collaboration, the support for the Regional centre for Technology Transfer in collaboration with ESCAP would continue. The setting up of a Centre for Science and Technology for non-aligned countries is envisaged, as also coordination of programmes under Technical Cooperation among Developing Countries (TCDC).

Testing and Analytical Facilities

19.93 The National Test House (NTH) renders analytical and testing services to Government and non-Government agencies and industries. The ongoing scheme of strengthening of testing facilities at Calcutta a'nd Bombay and setting up of regional test houses at Madras and Delhi would be completed. The facilities are proposed to be modernised and updated in the areas of chemical, physico-mechanical, electrical and electronic disciplines so that the NTH can work on quality control, standardization, calibration of testing equipment and also provide services bf consultancy and training to other testing laboratories.

Electronics

19.94 The S and T programmes in electronics are funded through the Technology Development Council ,and National Radar Council sponsored by the Electronics Commission. These institutional mechanisms are responsible for identifying,'financing and monitoring R and D efforts in this sector. The projects are selected through national

consultative processes and on the basis of a comprehensive definition linking all the elements such as technology gaps, technology competence, in-house R and D needs of industry, import of know-how, manpower needs, creation of facilities, appropriate applications etc. in order to ensure the establishment of a viable technology base for electronics development in the country. The development on micro-electronics on a major scale and its applications for microprocessors and compu-•ter systems, development of efficient and reliable Systems needed for tele-communication, satellite technology, process control etc. will receive special attention in the Sixth Plan. Several schemes are also envisaged relating to spin-offs from space research, atomic energy research and defence research, which would cover video -technology, telemetry and telecontrol, navigational systems, UHF/micrpwave communication systems, tethered ballon technology, infrared and mm wave technology. Some of the application areas will be thyristor controlled industrial devices, digital switching, opto-electronics and control systems and systems engineering, production of electronic materials, components and equipment.

Space, Science and Technology

19.95 The principal objective of the space programme in India has been to develop indigenous compe:ence in designing and building sophisticated hardware involved in space technology, including rockets and satellites for scientific research and practical applications, the use of the systems for providing point to point communications and the application of satellites for meteorolgy and for remote sensing of earth resources. During the last decade, substantial progress has been made in establishing a firm indigenous base for the development of space science and technology. More than a thousand rockets have been launched from Thumba and Sriharikota ranges for scientific, 'technological and meteorological studies. The technology for development and fabrication of satellite launchers, complete with solid propellants, rocket motor propulsion systems, control and inertial systems and electronics has been successfully established. The building up of the capability to construct satellites indigenously has also registered a good advance. The successful launch and operation of the satellite Aryabhatta was followed by the launching in 1979 of Bhaskara, both with the cooperation of the Soviet Union. In the area of applications, two major experiments were completed. The Satellite instructional television Experiment, which was conceived to test the feasibility of utilising satellite T.V. broadcasting for rural audiences, has led to the establishment of technical and organisational capabilities within the country for organising a large scale satellite based rural T.V. system. Under the other experiment, the Satellite Telecommunication Experiment Project, the applicability of space technology for remote area communication and emergency communication, was investigated.

19.96 A milestone in the development of space science and technology in our country was the success-full launching of SLV-3, India's first satellite launch vehicle, m August, 1980. The fabrication of an experimental three-axis stabilised communications satellite APPLE, which is a preparatory step to building future operational communications satellites, has been completed and is to be launched in 1981 in a developmental flight of the European launcher Ariane. Also scheduled for launch in 1981 from USSR is a satellite SEO-II, which wiil be a further step in the development of remote sensing satellite systems.

19.97 During the decade 1980—90, there will be three major missions in the space programme. The first is to develop and launch an Indian remote sensing satellite in 1984-85 for effective utilisation of remote sensing technology and the promotion of a national natural resources survey and management system. The second major objective will be to develop by 1986-87 a launch vehicle capable of launching satellites of the class 500—600 KGs in the equatorial orbit and more importantly in the polar orbit. As an intermediate step, launch vehicles capable of placing 140—150 Kg. satellites in near circular orbits will be developed by modifying the SLV-3 system. The third major programme is geared to the comissioning, in the early years of the Seventh Plan period, of the proto type of a multi-purpose satellite so that the country could eventually utilise indigenous satellites to meet its needs of space communication. Subserving these three major objectives, launch vehicle development facilities, satellite development facilities, {racking, telemetry and command net work will be augmented and R and D programmes in the area of advanced communication techniques, geodesy etc. intensified.

19.98 The National Remote Sensing Agency, now under the Department of Space, has acquired facilities for aeromagnetic surveys and for data collection from satellites and in'erpretation. The use of microwaves in remote sensing and the development of expertise for modelling in areas like agricultural yield prediction and hydoology would be experimented.

Telecommunications and Broadcasting

19.99 The Telecommunications Research Centre will take up R and D schemes in the switching and transmission areas and creation of support facilities e.g. telephone instruments, digital telephones, key telephones, micro-wave and line systems, UHF/VHF and environmental laboratory facilities. The major areas in the plan of Indian Telephone Industries relate to digital and rural communication hardware e.g. Telephone subscriber apparatus and instrumentation, telemetry. R,Ts and powerline carrier communication systems and integrated communication systems. Hindus'.an Teleprinters propose to set up functional laboratories and facilities such as pilot production shop, prototype machine shop, PCB facilities, technical library -etc. The programmes of Wireless Monitoring Organisation pertain to formulation of interference criteria, simultatioii studies, channelisation plans in VHF and UHF bands etc.

19.100 In the Information and Broadcasting sector, S and T programmes have been taken up by the Research Department of All India Radio. Studies and projects catering to immediate needs of AIR and Doordarshan in the areas of VHF/UHF, TV studio equipment, TV translator, multi-lingual attachments, scale model measurements of antenna and colour TV systems have been taken up. New programmes will include MF/ HF propagation, stereophonic broadcasting, TV transmitting and receiving aerials, TV transmitting equipment, digital TV, audio and accoustic engineering studies, development of MF/HF equipment and FM transmitting equipment.

Shipping and Transport

19.101 The focus in this sector would be on optimisation of the operational efficiency and quality of the existing Systems, energy savings and efforts related to materials, structures. The projects in the road sector pertain to highway training design studies, highway materials and construction, bridges and highway structures, Research programmes have been initiated for development and design of various modes of road transport like motorised cycle-rickshaws, mini buses and bullock-carts. The projects relating to ports pertain to siltation in artificially developed ship channels, coastal erosion and protection, floating break waters, marine structures, port layouts, designs for light beacons, etc. Ideal designs for mechanised country craft, improvement in ferry craft and development of low horse power engines are some of the R and D programme relevant to inland water transport systems. As regards ship building, research Schemes in the areas of ship design and production control systems would be taken up.

OUTLAYS FOR S and T

19.102 The plan outlay for science and technology is broadly categorised under two groups. Under the. first category are the outlays pertaining to the R and D programmes in the S and T Sector of the plan of the. five S and T agencies, viz., Department of Atomic Energy, Department of Space, Department of Science and Technology, Department of Environment and Council of Scientific and Industrial Research and of the National Test House (Deplt. of Supply). The aggregate of the outlays of these Departments constitutes the S and T sectoral outlay as shown in the Plan. In the second category are the outlays for S and T programmes in other Ministries/Departments, which form a part of the sectoral outlays in the respective sectors. In addition to the Plan outlays, expenditure is also incurred on S and T efforts under 'non-plan' by various agencies and Ministries/Departments. The deployment of internal resources by the public sector undertakings for S and T is also being categorised as "non-Plan'.

19.103 During the Sixth Plan, the approach would be to fund the programmes under S and T agencies undertaking research, development and design upto the stage of competence building and data collection and to a more limited extent in terms of pilot plants or product and process demonstration units; the latter will be in areas where the application is clear and likely. The further requirements for application orient-ed efforts in terms of up-scaling of technology, extension and field trials etc. would be funded by the concerned ministries and departments. In addition, certain areas of work in S and T agencies such as CSIR, particularly those calling for large S and T expenditure, will be taken up only on the basis of a clear-cut indication of their need or priority in the concerned economic sector; fne S and T agency will then take up its part of the programme on the basis of funding provided from the S and T allocation of the concerned economic ministry or department. This would ensure both the rationale for the programmes and their need and also utilization of the technology developed. Suitable mechanism is being evolved for such complementary funding of programmes in the agencies or research institutions.

19.104 A total picture of the S and T outlay (both plan and non-plan) under the S and T agencies and Ministries for the period 197-1—80 is presented in Annexure 19.2. The plan outlays for S and T during 1980-85 and estimates of the likely non-plan expenditure on S and T programmes during the same period are indicated in Annexure 19.3 .

Annexure 19.1 **Indicative Areas of Thrust - Minlstrles/Departmentt/Agencies Concerned with implementation**

Sl	No. Thrust Areas	Ministries/Departments/Agsncies concerned with implementation (indicative and not comprehensive)
(0)	(1)	(2)
A.	LIFE SCIENCES	
1	Basic Life Sciences :	
	1 Molecular biophysics and theoretical biology. 2 Molecular and Cellular Biology 3 Dsvilopmental biology of milti-cellular systems. 4 Nsurobiology and mschanims of Behaviour. 5 Animil behaviour. Ecology and Evolution.) 6 Biology of reproduction. |	Ministry of Health/ICMR Ministry of Agriculture/ICAR, Deptt. of Science and Technology/CSIR Ministry of Education/UGC, National Institutions like TIPR, Deptt. of Environment.
2.	Medical Sciences :	
	1-1 Immunological control of Tropical and communicable diseases and ") modernisation of vaccine production technology. 2- 2 Virology as related to Hepatitis, Japanese	Ministry of Health/ICMR DST/CSIR DAE/TIPR DAE/TIPR Min. of Education/UOC

	Encephalitis etc. 2- 3 Hmmn Neurobiology in relation to mental health. 1 2-4 Fertility Control '	
3	Applied Biological Sciences :	
	3-1 Genetic Engineering. 3- 2 Microbial Productivity. 3-3 Biomass as a source of energy. 3- 4 Physiology and biochemistry of plants 3-5 Protiction of endangered species and presirvation of genetic diversity of living organisms. 3-6 Ecological balance for sustainabis utilisation of biological resources forests, grazing lands and fisheries.	Ministry ofHsalth/ICMR ICMR DST/CSIR DST/CSIR Ministry of Edusation/UGC Department of Environment.
B.	CHEMICAL SCIENCES	
1	Molecular Structure and Dynamics	
	1-1 Recent development in spectroscopy such as two dimensional F1NMR ,1 Multi-nuclear solid state i HRNMR, FTIR spectrospoy and photoacoustic spectroscopy. 1 . 2 Laser chemistry and laser spectroscopy) • 3 Fast (nano—and pico-second) kinetics involving relaxation and other .methods. 1-4 Gas phase kinetics including molecular Lsams and plasma chemistry	DAE/TIFR Min. of Education/UOC DST/CSIR IISC/IITs
2	Solids. Surfaces and Catalysiss	
	2-1 Ultra-micro structure of sol ids. 1 2-2 Solid state organic chemistry. I 2 3 Solid State electro-chemistry, Energy copersion and storage. 2- 4 Synthesis and properties of novel rniterials. I 2- 5 Newe; techniques of surface characiwisation such as electron energy loss spectroscopy photo-electron spectroscopy, SIMS, Auger Spee-troscopy, LEEDS, etc. 2-6 Heterogeneous and homogenous, "catalysis including eatdlyst development and characterisationd phase transfer. 2' 7 Micelles, Membranes, Reverse esmosis.	DST/CSIR Min. of Education/UOC Min. of Petroleum Min. of Chemicals and Fertilizers DAE.
3	Formtiers of Organic Chemistry:	
	3. 1 Synthesis of organic molecules utilising new and innovative synthetic schemes and teconiques. 3.2 Newer reactions and reagents. 3.3 Mechanisms of organic reactions. 3.4 Polymer synthesis and mechensm of polymerisation. 3.5 Total synthenis of complex natural products and other exotic molecules 3.6 Structure of scarce and complex natural products.	DST/CSIR Min. of Education/UOC Min, of Petroleum Min. of Chemicals and Fertilizers Department of Space DAE
4	Coordination Chemistry and Organo metallic Chemistry:	
	4-1 Electron transfer reaction and mechanistic coordination chemistry 1 4- 2 Structure spectroscopy and Photochemistry. | 4-3 Activation of molecules and catalytic synthesis including reactions of }• carbon monoixde. i 4.4 Novel orgfir.ometallics and their applications in organic synthesis J	DST/CSIR Min. of Education/UGC Min. of Petroleum Min. of Chemicals and Fertilizers.
5	New Interfaces of Chemical Sciences with Biology	
	5-1 Biomimetic Chem'stry '1 5- 2 Chemistry of Biopolymers and their constituents [5.3 Membran5 and Model Systems 5- 4 Metal ion interactions with biomolecules)	DST/CSIR Min. of Education/UGC Min. of Petroleum Min. of Chemicals and Fertilizers Min. of Health/ICMR
c. HYSICAL SCIENCES r		
i.	Energy :	
	l-I New Energy Sources	
	(a) Solar energy through thermal and photovoltaic routes;) (b) Biological route (e.g.) energy plantations, petro-crops), biomass pro- duction and biocon version, biogas; | (c) Wind energy development (materials, devices and systems); 1 (d) Energy conservation and efficiency in industry, buildings trans- | portation etc.; (e) Electrical vehicles development; (f) Energy from waste; (g) Ocean; (h) Magnetohydrodynamics(MHD); and (i) Geothennal.	DST/CSIR/Deptt. of Environment Min. ofEducation/UGC/IITs DAE KVIC ICAR Deptt. of Power Min. of Industry/ BHEL
	1-2 Coot:	
	(i) Gasification and Liquefaction "1 '(ii) Beneficiation y (nil Slurry and other	DST/CSIR Department of

transportation of systems J	Coil M-'n. of Industries/EIL/BHEL.
1.3 Qil	
(i) Exploration and production capabilities, particularly offshore (ii) Conservation } (iii) Improving efficiencies in consumer sectors J	Min. of Petrol eum/ONGC Min. of Energy Min. of Industries DST/CSIR
1.4 Power i	
(i) Efficiency Improvement in power system materials and devices T	Min. of Energy Min. of Iflndustries/BHEL IITs
1 . 5 Nuclear Energy	
(i) Improving thermal power reactors, *1 (ii) Development of fast breeder power reactors, leading to ultimate Y thorium utilisation, r (iii) Development of capability to move into fusion technology, J	DAE
2. EartH Sciences :	
1' 1 Survey and mapping of the country, 2-2 Mineral resources for copper, chromium, iron, "manganese, tungsten, zinc, lead, nickel, phosphorite and magnesite. 2- 3 Energy resources including fossil fuels, geothermal and gas, 2- 4 Improvement in mining extraction technologies 2" 5 Remote sensing technologies, 1- 6 Hydrological Resources survey techniques and studies on hy-drological cycle. 2-7 Improving the efficiency of water utilisation and studies on recycling of the same. 2- 8 Studies on prediction of natural disaster:	DST/CSIR; Department of Mines; Deptt. of Environment Mm. of Edcation/UGC Min. of Agriculture and Irrigation/UCAR Department of Space IMD
3. Ocean Sciences :	
Development of Ocean Science Technology for the survey of living and non-living resources—Enhancement of facilities such as Research Vessels etc. jt	DST/CSIR/M/o Agriculture CAR/DOS/PRL M/0 Education/UGC/IITSSM/0 Defence
4 Atmospheric Sciences:	
4-1 Meteorology and National Disaster Warning Techniques. 1 (i) Computer modelling techniques, forecasting etc. i (ii) Space meteorology I 4-2 Cloud Seeding. 4-3 Monsoon Systems. I	fmd Min. of Communication Dsott. of Fosi and Agriculture DST/CSfR Deptt. of Space
5 Space Sciences : J	
5-1 Basic studies in Astrophysics, Plasma Physics etc. 5-2 Satellite Telecommunication' 5- 3 Satellite Mass Communication Education to Rural Communities (TV etc.) ; 5-4 Remote Sensing-Optical, infrared and microwave technique. \ 5-5 Satellite launching and training capabilities.	Dsptt. of Space D'ptt. of Electronic! Min. ofC3nmunication DST/NRSA'CSIR Min. of I and B Dsptt. of Agriculture
6 Nuclear Sciences:	
6-1 HighEnergy Accelerators , 6-2 Nuclear Radiation Research in Life Sciences and Agriculture. 6-3 Nuclear Medicine. 1	Deptt. of Atomic En'srgy Dsptt. of Agriculture/ICAR Deptt. of Halth/'NJO
7. Electronics:	
7-1 Equipment, Instruments and Systems—Quality Control, Medical 1 Electronics, mining Electronics, Industrial Electronics, etc. 1 7- 2 Components and Devices—LSI, VLSI, etc. 1 7- 3 Communication—Fibre optics. Digital techniques, etc. 7-4 Telecommunication— 1 —Communication network. Switching Systems, 1 —4 GHz, 6 GHz Microwave systems, etc. I 7- 5 Microprocessors, computers and softwares. 7-6 Information Systems: Computer networks, and other systems. 1 7- 7 Laser Research, f	Dsptt. of Electronics Deptt. of Industry Deptt. of Defence Deptt of.Tinniei DST/CSIR DAE/ECILAll Sectors
8. Materials Sciences—Nature of thrust areas to be identified—	
D. I ENGINEERING SCIENCES:	
1. Aeronautics : 1-1 Aerodynamics. 1 1 . 2 Propulsion studies. 1'3 Systems dwelopment, control and systems cn^ine;rins- J	DST/CSIR Deptt. of Defense Dsptt. of Space Deptt. of Electronics
2. Heavy Engineering :	
2-1 Building up of indigenous capibilities in plants and equipment for the following (i) Fertilizers (ii) Petroleum refining	D;ptt. orinlustry Feriilizers/petohiiTi/Sfeel/Dere ics/ CSIR./DST

	and petrochemicals (iii) Steel and metallurgy (iv) Mining and ore beneficiation (v) Port and harbour (vi) Sugar (vii) Cement (viii) Paper (ix) Heavy machine tools (x) fclectric equipment (xi) Printing (xii) Packaging (xiii) Manufacture of fabrics (xiv) Heavy Pressure Vessels (xv) Heat exchangers.	
	2-2 Aluminium	Deptt.ofInlnslry/CSIR
3.	Stee[1] and Metciturfy :	
	3' 1 Direct reduction of iron ores with solid reductants. 1 3-2 Small Steel Plants. J 3'3 Removal of ash from coking coal, development of formed coke.) 3-4 Development of high grade steel alloys and super alloys. J 3-5 Process improvement in the metallurgical industry to effect . saving in energy (for example 1NRED process). 3- 6 Development of basic oxygen process for making high alloy steels. 3' 7 Development of alloy powders and their products. 3-8 Development of anti-corrosion products to suit Indian climate.	Min. of/Steel/InJustry DST/CSIR Dapet.ofCoal Min. of Defenc.:
4	Machine Too Is:	
	4-1 Achievement of self-reliance in tools, equipment and machinery parti-l cularly in the following areas : (i) Laser Technology (ii) Plant and equipment for processing industry (iii) Chemical processing (iv) Agricultural equipment and machinery (v) Mechanical engineering industry (vi) Electrical and electronics industry (vii) Printing machinery and accessories	Min. of Industry Min. of Agriculture/ICAR DST/CSIR Deptt. of Electronics
	4- 2 Development of tools, equipment and machinery for the small-scale }-and unorganised sectors.	DST/CSIR
5.	Light Engineering :	
	5' 1 Improvement of the quality of products, by developing quality control through the use of sophisticated instruments, j 5- 2 Production techniques and equipment	Min. of Industry
6	Housing and Construction Technology :	
	6' 1 Low cost materials 1 6- 2 Building materials from agro-wastes and community wastes 1 6' 3 Building materials for energy conservation y 6-4 Offshore structures to exploit marine resources (6-5 Urbanisation studies)	Min. of Works and Housing DST/CSIR Min. of Petroleum Min. of Education/tITs
Transport :		
	1 Modernisation of various modes of transport	
	(a) Railways : (i) Electronics for signalling communication etc. |	Min. of Shipping and Transport Mm. of Railways DST/CSIR Deptt. of Electronics
	(ii) Electrification of Railways | (b) Inland Transport : J (i) Mechanisation of boats.	
	(e) Road Transport :	
	(i) Development of weather proof light transport	Deptt. of Defence Research and Development.
	(ii) Battery operated, light-weight vehicles	
	2 Improvement in the quality of engines to save energy and to increase speeds.	
S.	Instrumentation--(Thrust Areas to be identified)	Y DST/CSIR
E.	THER SCIENCES	
1.	Agriculture and ' Food :	
	(i) Creation of higher potentials for yield in pulses and oilseeds i (ii) Operational research for closing the yield gaps in cereals (iii) Cropping systems (iv) Water managemsnt and water use efficiency (v) Agro-energy rsssarch including biomass and bio-con version (vi) Transition from non-renewable industrial inputs to ranewable biological inputs through nitrogen fixation and microbiological applications (vii) Soil management and fertility (viii) Post-bar vest technology (ix) Mod.a-nisation of horticulture for protective food? (x) Energy crops for fuel, fodder and feed (xi) Agricultural management and marketing (xii) Molecular biology and agriculture 11 xiii) Upgrading and conservation of animal resources J [xiv) Scientiflcally and socially relevant mechanisation	Min. of Agriculture /ICAR/CSIR/DST/Deptt of Environment
2.	Forestry :	
	(i) Social and Rural Forestry 1 (ii) Energy plantation }. (iii) Plant-soil-air-water	Min. of

relationship J (iv) Intensification of wood science and technology	Agriculture/ICAR/DST/CSIR/Diptt. of Environment.
3. Environment and Ecosystem t	
(i) Rural and Urban Sanitation "I (ii) Air and Water pollution Control (iii) Man and Biosphere Research J	Min. of Works and Housing . CSIR Deptt. of Environment
4. Policy Sciences	
(i) S and T Information Systems I (ii) S and t Planning. Monitoring and Evaluation Systems (iii) International Relations in S and T J (iv) Technological Forecasting and Technology Assessment	DST/CS1R DOE All other related agencies.

Annexure 19.2 **Expenditure on Science and Technology 1974—80**
(Rs. In crores)

Agency/Department/ Ministry	1974-75			1975-76			1976-77			1977-78		
	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
A. S and T Agencies												
1 Atomic Energy (R and D)	18-24	23-64	41-88	27-18	28-49	55-67	31-02	30-00	61-02	28-91	32-21	61-12
2 Space	17-26	13-47	30-73	22-48	14-67	37-15	23-80	15-42	39-22	22-75	15-64	38-39
3 DST	3-83	15-10	18-93	8-15	18-63	26-78	13-20	21-02	34-22	15-94	24-45	40-39
4 CSIR	9-76	22-60	32-36	11-90	25-21	37-11	14-02	27-44	41-46	18-49	29-60	48-09
5 NTH	0-02	0-58	0-60	0-14	0-60	0-74	0-14	0-62	0-76	0-20	0-63	0-83
total 'A'	49-11	75-39	124-50	69-85	87-60	157-45	82-18	94-50	176-68	86-29	102-53	188-82
B. S and T Component under Ministries/Departments												
6 Heavy Industry	0-39	0-50	0-89	1-73	0-50	2-23	2-95	0-50	3-45	7-65	5-06	12-71
7 Industrial Development	0-06	0-22	0-28	0-84	0-12	0-96	1-72	0-43	2-15	2-75	0-56	3-31
8 Commerce												
9 Steel	0-22		0-22	0-61		0-61	0-71		0-71	0-97		0-97
10 Mines				0-02		0-02	0-54		0-54	0-48		0.48
11 Power	0-40	0-29	0-69	0-47	0-38	0-85	0-84	0-40	1-24	0-70	0-64	1-34
12 Coal							1-25		125	1-25		1-25
13 Petroleum	1-24	0-58	1-82	1-80	0-75	2-55	1-64	1-71	3-35	1-86	1-72	3-58
14 Chemicals and Fertilisers				0-07		0-07	0-19	0-25	0.44	0-51	0-26	0-77
15 Electronics	0-74	2-95	3-69	1-29	1-09	2-38	3-27	0-96	4-23	3-80	1-37	5-17
16 Communications	1-78	1-33	3-11	3-09	2-31	5-40	4-17	3-35	7-52	4-93	4-37	9-30
17 Information and Broadcasting .		0-18	0-18	0-19		0-19	0-06	0-24	0-30	0-06	0-25	0-31
18 Shipping and Transport							0-30		0-30	0-64		0.64
19 TCA-IMD and Instts. .	2-05	7-44	9.49	3-98	8-33	11-30	2-23	9-53	11-76	5-76	9-81	15-57
20 Works and Housing												
21 Labour												
22 Education	2-40		2-40	5-36		5-36	5-62		5-62	5-87		5-87
23 Health-ICMR	2-55		2-55	3-20		3-20	4-26		4-26	4.49		4-49
24 Social Welfare												
25 Rural Reconstruction												
26 Agri-ICAR	14-	14-15	28-7	522-8	16-21	3 39-	29-07	17-30	46-	39-	19-98	59-18

	60					05			37	20		
Agri-FRI	0-21		0-21	0-29		0-29	0-37		0-37	0-61		0-61
27 Food	0-19	0-32	0-51	0-59	0-37	0-96	0-45	0-43	0-88	0-49	0-38	0-87
28 Irrigation	0-27		0-27	0-30		0-30	0-22		0-22	0-38		0-38
29 Railways (RDSO)		3-78	3-78		4-60	4-60		4-41	4-41		4-47	4-47
total 'B'	27-10	31-74	58-84	45-49	34-83	80-32	59-86	39-51	99-37	82-40	48-87	131-27
grand total (A+B)	76-21	107-13	183-34	115-34	122-43	237-77	142-04	134-01	276-05	168-69	151-40	320-09

	Agenoy/Department/Ministry	1978-79			1979-80 (RE)		
		Plan	Ion-Plan	Total	Plan N	on-Plan	Total
A	S and T Agencies						
1	Atomic Energy (R and D)	30-74	34-60	65-34	28-38	41-68	70-06
2	Space	29-09	16-71	45-80	23-38	25-11	48-49
3	DST	17-95	25-94	43-89	16-18	32-04	48-22
4	CSIR	19-14	30-89	50-03	21.79	32-49	54-28
5	NTH	0-16	0-62	0-78	0-19	0-61	0-80
	Total 'A'	97-08	108-76	205-84	89-92	131-93	221-85
B.	'S and T Component under Ministries! Departments						
6	Heavy Industry	7-08	8-91	15-99	9-72	16-12	25-84
7	Industrial Development	2-68	1-15	3-83	1-49	2-65	4-14
8	Commerce*						
9	Steel	1-97		1-97	4-67		4-67
10	Mines	1-84	0-06	1-90	1-15	0-32	1-47
11	Power	0-87	0-73	1-60	1-22	0-96	2-18
12	Coal	1-35	1-62	2-97	2-11	2-37	4-48
13	Petroleum	2-17	2-82	4.99	4-60	3-40	8-00
14	Chemicals and Fertilizers	0-97	0-10	1-07	3-16	0-27	3-43
15	Electronics	5-31	0-81	6-12	8-19	0-77	8-96
16	Communications	5-02	5-07	10-09	5-60	4-72	10-32
17	Information and Broadcasting	0-06	0-25	0-31	0-22	0-30	0-52
18	Shipping and Transport	1-04	0-72	1-76	1-78	0-77	2-55
19	TCA-IMD and Instts	6-10	9-74	15-84	9-17	11-55	20-72
20	Works and Housing	0-21	0-67	0-88	0-20	0-71	0-91
21	Labour				0-10		0-10
22	Education	5-17	0-83	6-00	4-70	1-97	6-67
23	Health—ICMR	1-49	3-81	5-30	2-10	4-05	6-15
24	Social Welfare						
25	Rural Reconstruction	0-73		0-73	0-88		0-88
26	Agri—ICAR	47-65	20-26	67-91	53-07	32-85	85-92
	Agri—FRI	0-90		0-90	1 1-25		1-25
27	Food	0-47	0-45	0-9	2 0-91	0-49	1-40
28	Irrigation	0-72		0-7	2 1-00		1-00
29	Railways (RDSO)		5-75	5-75		6-36	6-36
	Total 'B'	93-80	63-75	157-55	117-52	90-40	207-92
	Grand total	190-88	172-51	363-39	207-44	222-33	429-77

Note: For 1979-80, data in respect of Part 'A' relates to Actuals and for Part 'B' it relates to R.E. For Department of Textiles, included under department of Industrial Development upto 1979-80.

Annexure 19.3 **Sixth Plan Outlays Science and Technology**
(Rs. crores)

Sl.No.	Agency/Deptt./Ministry	1980—85 (Plan Outlay)	1980—85 (Estimated non-Plan Outlay)*
(0)	(1)	(2)	(3)
A.	S and T Sector—Agencies		
I	Atomic Energy (R and D) .	248.98	284.59
2	Space (S and T)	245.80	146.92
3	DST	134.87	189.55
4	Environment	40.00	13.12
5	CSIR	170.00	218.24
6	NTH (Supply)	8.50	3.56
	sub -total 'A'	848.15	855.98
B. 0	other Sectors—S and T Component under Ministriesl Deptts.		
7	Heavy Industry	57.51	100.00
8	Industrial Dev.		
	(i) Large and Medium Industries.	8.411	10.00
	(ii) Small Scale Industries	9.291	
9	Commerce		
	(i) Textiles Research Associations	6.50	8.40
	(ii) Other Programmes	25.00	
10	Steel	41.70	
11	Mines	16 16	
12	Power	53.10	5.00
13	Coal	25.00	15.00
14	Petroleum		
	(i) Petroleum	39.08	30.00
	(ii) Petro-Chemicals	5.58	
15	Chemicals and Fertilizers	26.03	3.50
16	Electronics	32.34	3.00
17	Communications	62.15	33.00
18	Information and Broadcasting	2.50	2.00
19	Shipping and Transport	12.75	5.00
20	TCA		
	(i) IMD and Institutes	45.00	73.00
	(ii)R and DDte.C.A.	1.50	0.80
21	Works and Housing —CBRI	2.00	3.80
22	Labour	1.06	
23	Education	112.00	30.00
24	Health—ICMR	40.00	26.00
25	Social Welfare	2.00	
26	Rural Reconstruction	10.05	
27	Agriculture		
	(i) ICAR	340.00	190.00
	(ii) PRI	12.00	
28	Food	8.10	3.30
29	Irrigation	20.45	14.00
30	D.S.T.	54.00@	
31	Railways (RDSO)		36.00
	Sub-total-b	1071.26	591.80
	Grand total (A+B)	1919-41	1447.78

**Tentative Estimates. @Rs. 50 crores under energy Sector and Rs. 4 crores under Housing and Urban Development Sector.*