

C H A P T E R 4

Consolidation and Rapid Growth of Scientific
Establishments during 1941 - 1988

We continue our survey of the growth of science in India, focussing now on the period 1941 - 1988. This will then be used to relate the growth to the progress of scientific journals during that period.

If J.C.Bose, Raman, P.C.Ray, S.N.Bose and Saha dominated the Indian science scene till the 1940's, it was scientists like Bhabha, Bhatnagar, Mahalanobis and Vikram Sarabhai who organized Indian science just before and after Independence. The deep interest and concern Jawaharlal Nehru, India's first prime minister had for science was a very important factor. This support of the Government for the development of science and technology in the country was very much continued during the prime ministership of Indira Gandhi also. Senior scientists like Krishnan, Saha, Bhagavantam and Raman continued to contribute in the post-Independent phase in different ways to Indian science.

The academies like the Indian Academy of Sciences pursued their objectives of **publication** of journals. The Indian National Science Academy (which was known as the National Institute of Sciences of India **till** 1970) became the official representative of the country in various international organizations.

The dominant feature of the post independence period is the huge expansion of Science and Technology activity through the creation of several departments like the Department of Atomic Energy, Department of Electronics, Department of Energy, Department of **Bio**-technology, Department of Ocean Development, Department of Nonconventional Energy Sources and the Councils for Scientific and Industrial Research, Medical Research and Agricultural Research. Table 6 gives some data on these organizations. To complement these, research **institu**-tions for specific subjects like Astronomy, **Atomic** and Nuclear Science and their **allied** fields, Space research and Applied research were **established**. For higher technical education, Institutions like the five Indian Institutes of Technology were started. The University Grants Commission was set up to support and supervise the various activities of the universities and help the University education. The founding of some of the

TABLE 6

Data on some Science & Technology Organisations

	No. of institutions#/ laboratories	Manpower	Budget
Department of Space	12	10,400	3481 million (1988-89)
Department of Science & Technology	18*	3,500	1989.7million (1988-89)
Department of Electronics	13	23,00,000 [⊙]	1200 million (1988-89)
Department of Atomic Energy	19		1658 million (1986-87)
D R D O	45	1,82,000	5850 million (1986-87) (Investment)
C S I R	42	24,500	1996.1million Planned Exp. (1985-88)
I C A R	41		2272 million Planned Exp. (1985-88)
I C M R	28		895.1million Planned Exp. (1985-88)

The number of institutions are either directly under the organisation or connected with it in some way or the other.

* Some of these institutions are autonomous bodies but funded by the organisation.

⊙ This number indicates the total manpower in this field taking into account various small scale industries.

important departments and the Institutions related to the fields of Physics and Astronomy are discussed below.

Department of Atomic Energy:

An important scientific and technical endeavour initiated in the country was the programme relating to Nuclear Power. The main architect of the Nuclear Programme was Homi Bhabha who started it way back in 1944. As a result of his vision, initiative, and drive, the Tata Institute of Fundamental Research was founded in 1945. The Atomic Energy Commission was established in 1948 and the Department of Atomic Energy in 1954. The starting of the Atomic Energy Establishment at Trombay in 1957 was mainly due to the efforts of Bhabha. This was renamed the Bhabha Atomic Research Centre in 1967 after his death. The Nuclear Power Board (now called the Nuclear Power Corporation of India Ltd.) established under the Department of Atomic Energy, is responsible for construction and operation of the Nuclear power stations in the country. About twenty organizations are administered by this Department. Apart from the Bhabha Atomic Research Centre and its divisions in different parts of the country, a few other important organizations under this department are, Atomic Minerals Division, Nuclear Fuel Complex, Uranium

Corporation of India Ltd., Electronics Corporation of India Ltd., and Indian Rare Earths Ltd.; and research institutions like the Tata Institute of Fundamental Research, Bombay, the Saha Institute of Nuclear Physics, Calcutta, the Institute of Physics, **Bhuvaneshwar** and the Institute of Mathematical Sciences, Madras. The Science and Technology programme in the field of Atomic Energy is promoted by the Board of Research in Nuclear Sciences which advises the Department of Atomic Energy on the Scientific and Technical activities.

Department of Space:

Soon after the launching of "Sputnik", the first space satellite, by the Russians in 1957 there was widespread interest in space research all over the world. In India, Homi Bhabha was interested in studying Physics related to Space. He suggested to Vikram Sarabhai ~~the~~ initiation of such studies in the country. After some discussions on the matter, a proposal was put up by Bhabha and Sarabhai to the Government for support to Space Science and Technology for possible application to Indian problems. This proposal was readily approved by Nehru, the then Prime Minister (Dhawan, 1985). The

"Space Programme" in the country started formally with the founding of Indian National Committee on Space Research (INCOSPAR) in 1962 under the Department of Atomic Energy, and the establishment of the Thumba Equatorial Rocket Launching Station, the same year. However, studies related to space sciences were already going on at the Physical Research Laboratory started by Vikram Sarabhai at Ahmedabad in 1957. The Indian Space Research Organization (ISRO) established in the year 1969 (the trained manpower that was formed at laboratories which were involved in the INCOSPAR project became a part of ISRO. Rajan, 1988) became the Research and Development Agency of the Department of Space founded in 1972 under the chairmanship of Satish Dhawan. Several organizations specifically related to space technology were started by this Department. Some of them were, the Space Application Centre at Ahmedabad, Vikram Sarabhai Space Centre at Trivandrum and ISRO satellite Centre at Bangalore. Activities of the National Remote Sensing Agency and the Physical Research Laboratory are supported by the Department of Space. The launching of rockets and satellites by the country during the past decade is an outcome of the research and development programmes of this Department. Apart from the building and launching of rockets and satellites, the space programme opened up new research fields related to

physics and allied subjects. Over ten thousand scientific and technical personnel are working in the various programmes of this department. Its expenditure during 1984-87 was Rs.7,049 million and an outlay of Rs.3,481 million was provided for the year 1988-89. (Publications and Information Directorate, 1988a)

Department of Science and Technology:

To support the activities of the various Scientific and technical institutions in the country, the Department of Science and Technology (D S T) was established in 1971. The main function of this Department is Policy and Guidelines Formulation for Science and Technology, promotion of S & T activities and International S & T Cooperation. It functions through a dozen Divisions, each taking care of a particular aspect of Science & Technology. DST funds not only the activities of several research institutions (about 18 in number) but also specific research projects of science departments in the Universities. This Department's estimated budget for 1988-89 was nearly Rs.1,990 million (Publications and Information Directorate, 1988b).

Department of Electronics:

This Department established in **'1970** is the executive wing of the Electronics Commission. **It** coordinates the research and development activities in the field of Electronics. **It** is the main body for sponsoring electronics development projects of the various civil and defence research organizations in the country. The Directorate of Standardization, Testing and Quality Control, Centre for Electronics Design and Technology, the Computer Maintenance Corporation, the Semiconductor Complex Ltd., are some of the organizations coming under the purview of this department. Autonomous societies like the National Centre for Software Technology, Centre for Development of Advanced Computing Technology are associated with this department. The Department had an outlay of Rs. **1,200** million for the year **1988-89**. **Thirteen** organizations are either directly under this Department or associated with **it** in connection with their projects.

Department of Biotechnology:

This Department was established in **1986** to give a boost to biotechnology in the country. The main activities of the department are in the areas of development

of effective vaccines and indigenous production of vaccine; creation of infra-structural facilities in the field of biotechnology, and developing trained manpower for all its programmes. It has established an International Centre for Genetic Engineering and Biotechnology at New Delhi with a unit at Trieste, Italy. The Department conducts short term courses.

Defence Research and Development Organization:

This organization under the Ministry of Defence, was started in 1958 and it oversees the S & T activities related to Defence. With a network of forty five institutions and organizations engaged in research and development activities relating to machines and equipment required by the Armed Forces, this organization serves as the centre for all technical matters pertaining to the defence departments of the country. Its activities encompass fields like aeronautics, electronics, numerical research, combat vehicles, food technology and material science. It also sponsors defence oriented research projects and regular academic courses at Masters level in some universities. It has a man power resource of about 35,000 people, and its budget during 1986-87 was Rs.5,850 million in

1986-87.

In addition to the above departments, the Department of Ocean Development, the Department of Scientific and Industrial Research, the Department of Telecommunication, the Department of Power and the Department of Nonconventional Energy Sources were some of the other establishments created to promote activities related to the concerned fields.

The Council of Scientific and Industrial Research:

The Council of Scientific and Industrial Research, (CSIR) one of the largest scientific organizations in the country today was established in 1941 as a part of the Department of Supplies and Industries for aiding the war effort. It (CSIR) was transferred to the Department of Planning when the latter was set up in 1944. One of the responsibilities assigned to the Council was the collection and the dissemination of scientific information relating to not only research but also industrial matters generally, and publication of scientific papers and a journal of industrial research and development. Since its establishment in 1941, its subject area of activity has very much widened. As of 1988, it had 44 National Laboratories and

institutions under its wing covering the Physical, Earth, Chemical and Biological Sciences besides Industrial Research. In addition to the National Laboratories, the CSIR has 101 Extension Centres and 9 Poly-technology Transfer Centres (Publication and Information directorate, 1988c). Though the scope of CSIR was applied research to start with, it has been concerned with fundamental sciences also. Apart from direct research activities, it is also involved in other science-related activities like information transfer, funding scientific research and maintaining a national register of Scientific and Technical Personnel in the country. There are nearly 24,500 people (out of whom 5,400 are scientists and 10,500 are technical staff) working in the various organizations under its purview. It had an estimated Plan expenditure of Rs.1996.1 millions for 1985-88. CSIR releases the processes developed by its laboratories to entrepreneurs for commercial utilization. Its planning division and technology utilization division interact with various other governmental and non-governmental organizations in the country. An important laboratory related to the field of Physics under this Council is the National Physical Laboratory. This was set up in 1948 at New Delhi under the directorship of K.S.Krishnan. The main

objective of this laboratory is to develop, maintain and update the national standards of physical measurements. It is also involved in research in basic and applied physics.

The work of **S.S.Bhatnagar** in the organization of the CSIR and its various laboratories was very much recognised by Nehru who paid a tribute to him at the Baroda Science Congress in 1955. He said :

" I would like to pay a tribute to Bhatnagar who I think has done, this I say with due respects to others, more than anyone else for scientific development in India. I can truly say that but for Dr. Bhatnagar you could not have seen today the chain of National Laboratories in India " (Nehru, 1955).

Indian Council of Agricultural Research:

Established in 1929, this Council's activities have spread to a great extent after Independence. It is concerned with agriculture and animal husbandry research in the country. A large number (41) of research and educational Institutions come under its purview. In addition it has connections with 26 Agriculture universities in the country. It has also started Krishi Vigyan Kendras which provide training to farmers. Its estimated plan expenditure for the period

1985-88 was Rs.227 crores (Publications and Information Directorate, 1988d).

Indian Council of Medical Research:

This is the Apex body in the country for Medical Research. Established in 1911, it promotes research activities of institutions set up by it as well as those departments related to this subject which are under the universities and other non ICMR Institutions. Its programmes include promotion of goal oriented projects, research activity on health problems specific to particular regions and fostering research capabilities in this field in different parts of the country. It has 28 institutions under its wing and had a plan expenditure of Rs.89.5 crores during the period 1985-88. In addition to this, there are 35 other institutions and laboratories doing research in the medical and allied subjects. These are attached to the Ministry of Health and Family Welfare.

Research Institutions:

Research activity was promoted in the country by either establishing or supporting different types of

institutions. Some organizations which were mainly concerned with applied research pursued basic research also. These were organizations like Bhabha Atomic Research Centre, Indira Qandhi Centre for Atomic Research at Kalpakkam, Variable Energy Cyclotron Centre at Calcutta, Space Application Centre at Ahmedabad, Vikram Sarabhai Space Centre at Trivandrum, National Aeronautical Laboratory at Bangalore and the National Physical Laboratory, New Delhi; there were centres which were basically pure research institutes like Saha Institute of Nuclear Physics, Calcutta, Institute for Mathematical Sciences, Madras, Tata Institute of Fundamental Research, Bombay, Institute of Physics, Bhubaneshwar; and Advanced Centres in Universities like that at Madras, Indian Institute of Science, Osmania and Poona universities. Activities of some of these organisations are summarized below:

Tata Institute of Fundamental Research:

At the Tata Institute of Fundamental Research (T I F R) started under the directorship of Homi Bhabha in 1945, Cosmic Ray studies was one of the early areas of research. Bhabha was involved in this work even while at the Indian Institute of Science, Bangalore. Heeding the advice of Paul Dirac, that a School of Physics could

not grow without a School of Mathematics, Bhabha started a Mathematics school at TIFR (Anderson, 1975). He persuaded a leading mathematician then working in the United States of America to head this group. This school is one of the strongest in the country today. But the interaction between the two schools (i.e. of mathematics and physics) was not very strong (Mukunda, 1990). With Bhabha's close contacts with Nehru, both at the personal level and the official level, the Institute got full support for research. Theoretical Physics, Electronics and Nuclear Physics were pursued, with Bhabha himself taking part in the theoretical physics programmes. After the establishment of the Atomic Energy Establishment at Trombay, the activities of TIFR centred around basic research. It was one of the few institutions which had autonomy (mainly due to the efforts and insistence of Bhabha) and functioned in a different style from most other research schools. The Institute attracted many scientists working abroad to come and work here. New schools in different subjects - Radio Astronomy, Molecular Biology, Chemical Physics, Computer Science were started. These schools set high standards in research, and today form an elite group of scientists in the country. With the number of subjects increasing, there was a growth in the organization.

The Radio Astronomy Group built a Radio Telescope at Ooty and is involved in research in that subject. It is presently in the process of building one of the largest Radio Telescopes in the world (Giant Metre Wave Radio Telescope) near Poona. TIFR has a mathematics centre at Bangalore and field stations at Kolar Gold Fields and Gauribidanur near Bangalore.

Bhabha Atomic Research Centre:

The Atomic Energy Commission established in 1948 by the Government of India started the Atomic Energy Establishment at Trombay (AEET) in 1954 with the objective of providing research and development facility needed to fulfill the nuclear power programme. Homi Bhabha was instrumental in starting this centre. Scientists already working at TIFR in related fields became a part of this organization. In 1967 AEET was renamed as Bhabha Atomic Research Centre (BARC). The activities of this centre, though mainly related to nuclear science, have been multi-disciplinary in nature. Planning and building reactors, production and research programmes in radio isotopes, material science, nuclear and radio chemistry, biochemistry, biology, food irradiation and processing, electronics and instrumentation, robotics and basic research in some frontier areas of nuclear and

condensed matter physics are all being pursued. It has set up reactors at different parts of the country and research wings at some centres like Calcutta, Indore and Kalpakkam. One of the important activities of this centre is its training programme. A training school was started in 1957 to train scientists and engineers in different disciplines related to the nuclear programme. The trainees coming out of this Institute formed the back bone of the S & T groups of this organisation.

Saha Institute of Nuclear Physics:

In 1945, Saha made a move to establish an Institute of Nuclear Physics at Calcutta. Saha felt nuclear physics and nuclear sciences would dominate in the post war years, and he did not want India to lag behind. He succeeded in starting the institute of his dreams by getting grants from different sources including the Atomic Energy Commission whose establishment he had initially opposed. Saha was the Honorary Director of this Institute established in 1950. Research work related to building a Cyclotron was one of the initial activities at the Institute. Later on work in Biophysics was started. Its present activities include research in particle physics, nuclear science, atomic and

molecular physics, condensed matter physics, plasma physics and biosciences.

Raman Research Institute:

After his retirement from the Indian Institute of Science, **Raman** started his own Institute at Bangalore in 1948. Unlike at the Indian Institute of Science, here he had only a small group of students. As could be expected, physics was the main branch of study in the initial period. But after the **1950's**, he worked all by himself, on other topics like physiology of vision and perception of colours. After his demise in 1970, the Institute was **reorganised** with a number of scientists (physicists and astronomers) joining **it**. Today, its research activities are centred around liquid crystals, theoretical astrophysics and radio astronomy. A ten metre radio telescope working at millimetre wave length has been fabricated here and is being used for astronomical observations. In a joint programme with the Indian Institute of Astrophysics, **it**, has built a decametre wave length telescope at Gauribidanur.

Indian Institute of Astrophysics:

This Institute was established as a separate organ-

ization in 1971. Earlier it was functioning at the Kodaikanal Observatory under the Department of Meteorology. Vainu Bappu was the architect of this Institute and was instrumental in starting the construction of an Optical Telescope (93 inches) at Kavalur which is now a national facility. As already mentioned it has joint programmes with the Raman Research Institute at Gauribidanur.

Prior to the establishment of the Indian Institute of Astrophysics, as a follow up of the recommendations of a committee headed by Saha in early 1950's, the Astronomical Observatory at Kodaikanal was improved in 1957. A new observatory was also built at Naini Tal in 1953 under the leadership of Bappu. Very recently (1987) an Inter University Centre for Astronomy and Astrophysics was started at Poona. This is a collaborative effort of the Poona University and the University Grants Commission. It is planned that this centre will act as an apex body for astronomy research in the Universities, and also as an advanced centre for research in this field, similar to the International Centre for Theoretical Physics at Trieste, Italy. In another collaborative activity, a Joint Astronomy Programme has been started at the Indian Institute of

Science in which five astronomical institutes are participating along with the Indian Institute of Science in teaching and training students for a career in Astronomy. This subject is also being taught in some universities.

The Universities:

Along with the growth of specialized institutions like the ones mentioned above, a large number of universities were started in the country during this period. Where there were four universities in the previous century, there were **148** universities in the country in **1988**. In addition to this, there were 22 Institutions deemed as universities (U G C, **1988**). Figure 5 shows the growth of the Institutions deemed to be universities during the period **1979–1988**. To oversee university education and to support the activities of the various university centres, the University Grants Commission (U G C) was established in **1953**. In addition to the various universities run by the state governments there are **13** centres in different parts of the country designated as Central Universities. These are administered by the U.G.C. A few other centres have been identified as Centres for Advanced Studies in different subjects. One such Centre is for

Growth of Institutions deemed to be Universities (1979-80 to 1987-88)

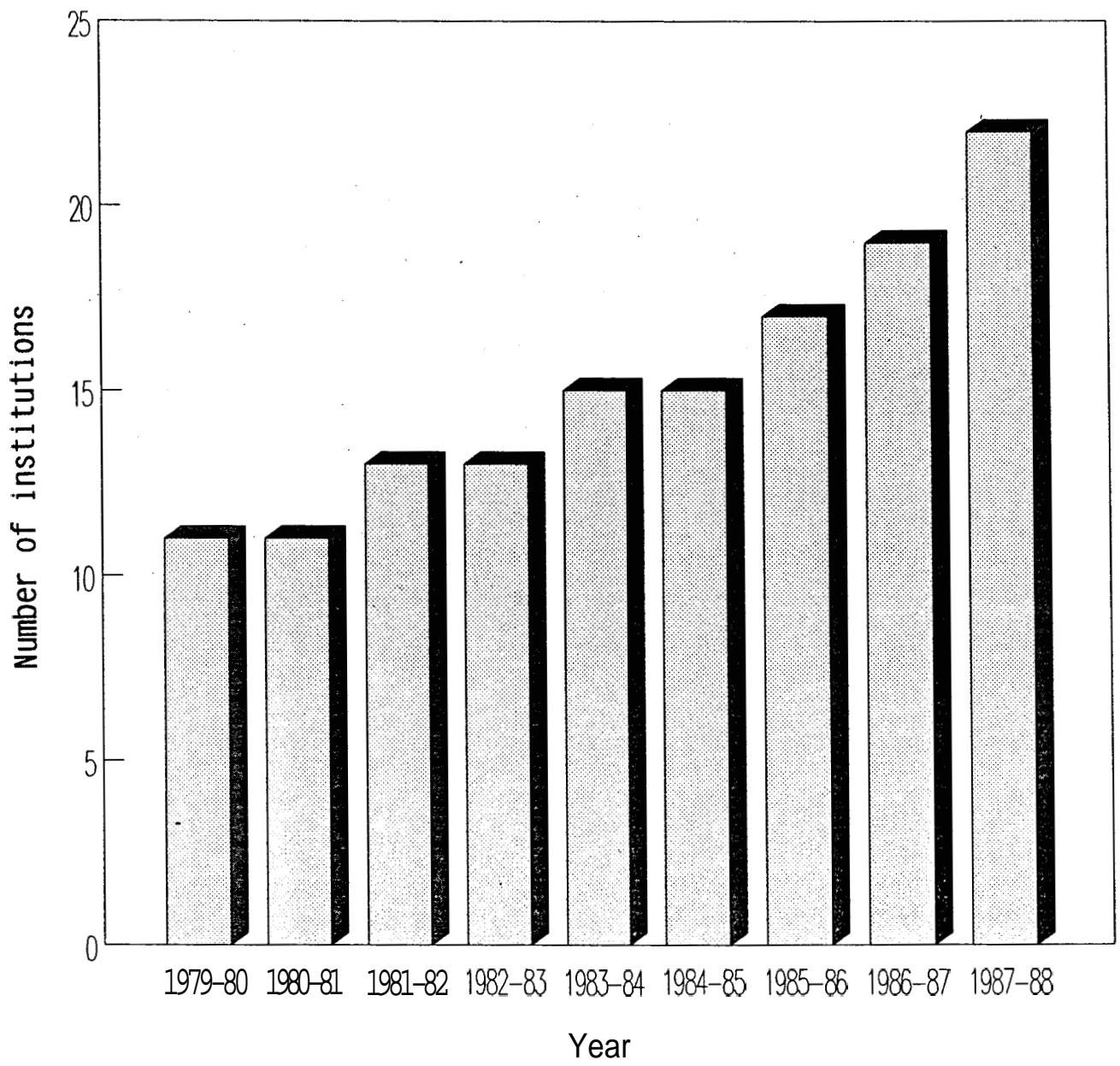


Figure 5

Astronomy at the Osmania University, Hyderabad. Faculty members working in **universities/colleges** and teachers who have retired receive funds from UGC for projects approved by **it**. UGC also offers fellowships (both Junior and Senior) for research work. **It** has also established a National Science Information Centre at Bangalore to help scientists working in universities and research institutions to have access to nascent information in their fields.

The Indian Institutes of Technology:

Apart from the technical colleges established by various state governments and private organisations, five Institutes of Technology were established after 1950's for higher education in Engineering. At some of these institutes, in addition to engineering subjects, Physics is also pursued as a discipline.

Academies and Societies:

It is observed that when a subject grows sufficiently, **it** is normally followed by the starting of a society in that discipline. Such a thing happened in the country in physics and astronomy. With the growth

in the number of research organisations in these fields (as seen earlier) the number of people involved in research activities also increased. Consequently new societies were started. The Indian Physics Association was founded in 1970 to promote active interaction among those interested in achieving advancement, dissemination and application of the knowledge of Physics. (Physics News, 1988). It has nearly 3,200 members (but only 300 to 400 ^{are} active members (RAO, 1990) and has chapters in different cities. There are also societies like the Vacuum Society of India, Acoustical Society of India for sub specialities. The Astronomical Society of India started in 1973 has objectives similar to the Indian Physics Association, viz. to promote Astronomy in the country. Both these organisations bring out their publications, Physics News and the Bulletin of the Astronomical Society of India.

As scientific conferences are extremely important for the exchange of nascent developments in a field, a number of national and international conferences are organized in different parts of the country. Various agencies have been supporting the running of summer/winter schools in different disciplines. The TIFR Schools in Panchagani (Particle physics), the Solid State Symposia of BARC and the Astronomy summer

schools are fairly regular features. Recently the Department of Science and Technology has initiated a scheme called the Theoretical Physics Seminar Circuit wherein it supports individuals who have done important work in India to lecture at certain centres for short periods. Physics research in the country has not stopped just at the study of the physical phenomena but has had impact on derived fields like biophysics, chemistry, geophysics, meteorology, engineering and electronics. Similarly, astronomy research is not confined merely to observations using an optical or radio telescope, but has become more refined and has led to the use of computers, CCD Cameras, infrared and x-ray detectors, all of which demand high precision work.

Apart from the research activities at the various Scientific and Research establishments funded partly or fully by the Government, the Research and Development activities in the private sector also increased to a great extent. Though we are yet to have something like the Bell Labs of USA, the industries are slowly waking up. There were about 75 Private In House R & D Centres which incurred Rs.7.5 millions expenditure on R & D activities during 1987-88. The expenditure of these centres on R & D raised steadily from Rs. 1.50

million in 1958 - 59 to Rs.3817.30 million in 1987-88
!(Publications and Information Directorate 1988e)

Thus it is seen that around and after the 1970's, not only did the Science and Technology activity in the country greatly increase but it was also spread over a number of disciplines. These coupled with the national facilities created like the Cyclotron, Large Telescope and Reactors resulted in an increased number of scientific and technical personnel pursuing research careers. Table 7 gives a general idea about the magnitude of the S & T activities in the country. (The figures shown are all indicative and not exact) It becomes clear from the developments seen during the last two decades that pursuit of scientific research took firm roots during this time. To quote Venkataraman :

" Within a few fleeting years, science became a vast, nationally organized activity and there were people working on a71 sorts of subjects ranging from astrophysics to antibiotics, from computers to catalysts, from mesons to the monsoon, from number theory to nuclear physics, from pulsars to polymers, from quarks to earthquakes, from reactors to remote sensing, from semiconductors to sewage treatment, from turbulence to tuberculosis ,....." (Venkataraman, 1988).

If awards and recognitions from outside the country mean anything, there were quite a few of them for Indian Scientists. Several Indians have been elected to

TABLE 7

Data relating to Science & Technology activities
in the country (1986-87)

Research institutions including specialized laboratories	1300
Private research associations/institutions/foundations/centres	530
In-house R & D units (public and private sector)	1015
Universities	160
Learned societies/academies	> 73
Total estimated Science & Technology personnel (in million)	0.24
Research papers published per year	> 22,000
Patents filed (1985 - 86)	359

From : Status Report on Science & Technology in India, New Delhi, 1988 : Publication and Information Directorate, Page 138

important international bodies like the International Astronomical Union, International Union of Pure and Applied Physics, International Union of Pure and Applied Chemistry, the Royal Society, London. It has often been pointed out that India has the third highest Scientific manpower. If one goes by degrees awarded, this may be correct. But if one takes into account how many of these people are pursuing a career in science, this picture does not hold good. Nevertheless, even after making allowance for this, there is still a sufficiently large number working in the scientific and technical fields. One should therefore expect a sizable scientific output and therefore also a healthy impact on our journals. The actual state of affairs is discussed in later chapters.

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