New institutions in India

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In India, about 3000 public and private institutions are engaged in fundamental and applied research work in various fields of Science and Technology (S&T). Today, the country stands tall in its attempt to achieve and provide quality education for all, according to the Constitutional resolve. In the field of education, constantly in flux and in keeping with the requirements of the day, new institutions are being born. For viewing this ascent (of new institutions) from a historical perspective, glimpses of the foundations laid are of interest.

INDIA'S S&T achievements date back to ancient times. Indian civilization contributed to the art of town-planning, copper and iron smelting, alloy-making as evidenced from bronze artifacts, pottery and brick-making, and also excellence in engineering and metallurgical processes (Iron Pillar at Delhi). Ancient mathematicians helped in the development of algebra, geometry and astronomy. India contributed significantly to the knowledge of medicine and the human body, surgical procedures, food technology and preparation of drugs. Also, sound sanitary practices were incorporated into building design. Medieval India saw techniques in agriculture such as grafting, irrigation, introduction of new crops, growth in textile technology, architecture, building material and construction techniques.

With the framework for a scientific temper already well-constructed, the seeds of modern-day S&T took root with the foundation of the Asiatic Society in Kolkata (1784), which published scientific papers. This was followed by the formation of the Agricultural Society of India (1821). During the pre-independence era, several activities that related to survey of the flora, fauna and mineral wealth of India, culminated in the establishment of the Geological Survey of India (1851), Botanical Survey of India (1890), Indian Mathematical Society (1911), Zoological Survey of India (1916), to name a few. These institutions mostly carried out surveys, systematic studies and research, peppered with publications and the launch of various scientific journals.

Medical research in India in the 19th century was supported by the formation of a chain of institutes. The Bacteriological Laboratory at Agra (1892), the Plague Research Laboratory (1899) that later became Haffkine Institute, Mumbai, Pasteur Institute at Kasauli (1900), King's Institute at Chennai (1903) and the School of Tropical Medicine in Kolkata (1910) are some examples.

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In agriculture, the Indian Agricultural Research Institute was set up in 1905 at Pusa, North Bihar, as an autonomous body. Later it was renamed for a short period as Imperial Agricultural Research Institute in 1919 and then finally shifted to its present location in Delhi as the Indian Agricultural Research Institute (IARI). It is popularly referred to as the 'Pusa Institute'. It conducts basic and applied research in different branches of agricultural sciences, extending on-farm techniques for integrated rural development and building of human resources at a national level.

Born from a need to foster scientific and industrial research and to promote applications generated from research for national development, the Council of Scientific and Industrial Research (CSIR) was founded as an autonomous body in 1942. It presently comprises 40 R&D laboratories and 80 field stations.

However, India's pride for research in the pre-independence era was the formation of two prestigious institutes. One being the Indian Association for the Cultivation of Science (IACS), Kolkata, founded in 1876, that provided the right environment for C. V. Raman to discover the 'Raman effect'. Raman was awarded the Nobel Prize in 1930. The second, the Indian Institute of Science (IISc), Bangalore, founded in 1909, is an institute of national importance. It continues to pursue excellence in various fields of science and engineering and has more than 40 academic departments.

After India gained independence in 1947, her development in the field of higher education and research in S&T has gone from strength to strength. The higher education system has seen a twelve-fold increase in the number of universities and twenty-two-fold increase in the number of colleges. According to the information provided by the Student Information Service Division of the Association of Indian Universities, there are currently 268 universities, 50 deemed to be universities and 12 institutions of national importance and about 11,100 colleges established through Central and State legislation. Of the 268 universities, 17 are Central Universities and the rest State Universities. Together they

provide a major impetus to the training of S&T workforce and for conducting research. The University Grants Commission, while providing financial assistance, also advises both Central and State governments on improvement of university education.

Among other institutions of importance are the Bhabha Atomic Research Centre (BARC), Mumbai and the Tata Institute of Fundamental Research (TIFR), also at Mumbai. BARC, formerly known as the Atomic Energy Establishment, Trombay was given its present name in 1967. Its aim is to provide self-reliant R&D support needed for development and sustenance of the Indian nuclear power programme. TIFR, established in 1945, is an autonomous body conducting fundamental research in frontier fields of mathematics and physics.

Of the Government funding agencies in India for research and development in S&T, the major agencies are the Council for Scientific and Industrial Research (CSIR), Defence Research and Development Organization (DRDO), Department of Atomic Energy (DAE), Department of Biotechnology (DBT), Department of Ocean Development (DOD), Department of Science and Technology (DST), Department of Scientific and Industrial Research (DSIR), Indian Council of Agricultural Research (ICAR), Indian Council of Medical Research (ICMR), Indian Space Research Organization (ISRO) and the University Grants Commission (UGC). Among the several institutes, etc. funded by these agencies, some are the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, the Saha Institute of Nuclear Physics and the S. N. Bose National Centre for Basic Sciences, both of these located at Kolkata, the National Geophysical Research Institute (NGRI), Hyderabad, The Institute of Mathematical Sciences, Chennai and a host of DRDO and ISRO laboratories spread right across the country.

Among well-known institutions catering to medical research is the All India Institute of Medical Sciences (AIIMS), New Delhi, set up in 1956. AIIMS has undergraduate and post-graduate instruction, conducts research and awards Ph D degrees. It also has a noted hospital. The Post-Graduate Institute of Medical Education and Research (PGIMR), Chandigarh has evolved both as a teaching and research institution with extensive medical facilities. The Sree Chitra Tirunal Medical Centre was established at Tiruvananthapuram in 1973. It was renamed in 1981 as the Sree Chitra Tirunal Institute for Medical Sciences and Technology. In 1980, it was accorded the status of an institute of national importance. The centre devotes itself to promoting biomedical engineering and technology, with high standards of patient care and advanced medical facilities. Among others, the Tata Memorial Hospital and the Tata Memorial Centre in Mumbai are carrying out work in all facets of cancer research.

Other noteworthy institutes in medical and related fields are the National Institute of Nutrition (NIN), Hyderabad, founded in 1919; Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Pondicherry, founded in 1956; the National Institute of Communicable Diseases (NICD), Delhi, established in 1963, and the National Institute of Mental Health and Neurosciences (NIMHANS), Bangalore established in 1974. In addition to several medical colleges, there are institutes devoted to Indian systems of medicine and homeopathy spread all over the country. The Indian Council of Medical Research (ICMR) is an autonomous body set up in 1911 (initially called as Indian Research Fund Association) that sponsors and co-ordinates medical research in the country.

In engineering, there are the well-known Indian Institutes of Technology (IITs) at Chennai, Mumbai, Delhi, Kanpur, Kharagpur and Guwahati with Roorkee recently added to this list. They impart a broad-based education and training to make quality engineering professionals. In addition, research is carried out in a variety of fields in areas of fundamental sciences, technology, humanities and social sciences. There are a large number of Regional Engineering Colleges and other colleges dotted right across the country educating and training students to be future engineers.

The Centre for Advanced Technology (CAT), Indore (founded in 1987 under the Ministry of Science and Technology, Department of Atomic Energy) has been developing and commissioning synchrotron radiation facilities, which include a 20 MeV microtron and a 450 MeV synchrotron radiation source constituting INDUS-1 and the INDUS-2 not yet commissioned. The establishment of the Inter-University Consortium for Department of Atomic Energy Facilities (IUC-DAEF), with centralized facilities in several cities in the country serves to further the research efforts of University faculty.

Research in plasma sciences with emphasis on the physics of magnetically confined plasmas and some aspects of nonlinear phenomena is carried out at the Institute of Plasma Research (IPR), Gandhinagar. Founded in 1986, the IPR has successfully commissioned the first indigenously built tokamak device 'ADITYA' for basic plasma studies. Among the various research programmes, the institute has also initiated experiments in the field of free electron lasers (FEL). The institute runs a Ph D programme in the field of plasma physics.

The Indian Institute of Astrophysics (IIA), Bangalore caters to research in physics, astronomy and astrophysics. The institute has recently set up a modern astronomical observatory at an altitude of 4500 m in Hanle, Ladakh. The observatory is ideally located for the study of celestial objects through a wide range of the electromagnetic spectrum. Housed here is the new 2-m optical-

The 2-m telescope at the Indian Astronomical Observatory, Hanle, Ladakh. (Photocredit: Indian Institute of Astrophysics, Bangalore.)

infra-red telescope, primarily for enabling studies of various stars and stellar systems. The observatory also conducts studies in geodynamics, geomagnetism, upper-atmospheric, ionospheric and stratospheric research.

Since independence, the development of existing institutions and the creation of newer ones have gained momentum. The wide network is expanding. In fact, the preceding two decades have seen up and running institutions in the area of modern biology, biotechnology and plant molecular biology. The National Institute of Immunology (NII), New Delhi, founded in 1981, promotes research in basic and applied immunology, research and development (R&D) of new vaccines and immunological reagents for communicable diseases and research into regulation of human reproduction. The Centre for Cellular and Molecular Biology (CCMB), Hyderabad, established in 1977, has major R&D programmes in biomedicine and biotechnology, genetics and evolution, cell and developmental biology, molecular biology, biochemistry and biophysics. In plant molecular biology, the National Centre for Plant Genome Research (NCPGR), New Delhi has broad research areas in plant genomics and transgenics, while recently initiating new research projects in chickpea genomics. The National Bureau of Plant Genetic Resources, New Delhi explores and collects crop plant germplasm, including wild relatives of agri-horticultural crops and has facilities for cryopreservation.

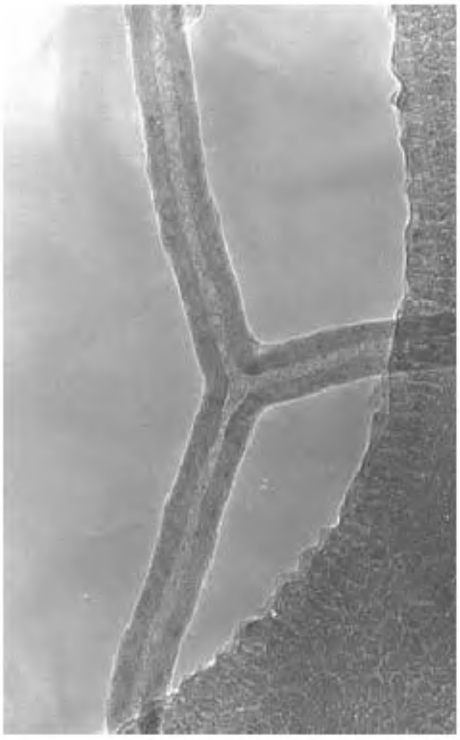
The International Centre for Genetic Engineering and Biotechnology (ICGEB) with its Directorate in Trieste (Italy) has two component laboratories, one at Trieste, Italy and the other at New Delhi. ICGEB was founded in 1987 as a special project of UNIDO. Since 1994, ICGEB has played a role as an independent intergovernmental organization with a network of 43 member states. ICGEB undertakes to transfer the fruits of research on common themes of interest to its members, to developing countries. The New Delhi-wing of the ICGEB, carries out research in broadly two areas, mammalian biology and plant biology. In mammalian biology, specific research priorities are virology, e.g. hepatitis viruses, immunology and vaccine preparation. The malaria research programme is of particular interest to developing countries. In plant biology, research is carried out on the application of genetic manipulation techniques to agriculturally important plants and development of new plant varieties having insect resistance.

Institutions set up during the last few years have demonstrated a vitality for scientific research, supported in this goal by other scientific institutions in the country. These are, for example, the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore (in frontier areas of science and engineering); National Centre for Biological Sciences (NCBS) also at Bangalore (in modern biology); National Brain Research Centre (NBRC), New Delhi (in neurosciences) and the National Institute of Pharmaceutical Education and Research (NIPER), Chandigarh (in pharmaceutical sciences). The dynamism shown by these four national laboratories by their choice of research areas and academic activities are detailed below.

Jawaharlal Nehru Centre for Advanced Scientific Research

JNCASR was founded in 1989 to commemorate the birth centenary of Pandit Jawaharlal Nehru. It is an autonomous institution funded by the Department of S&T, Government of India. C. N. R. Rao had held the office of the President of the Centre from its inception until 1999. The current President is V. Krishnan. Rao's own laboratory, the 'Advanced Materials Research Laboratory' was added in 1999 and is considered to be one of the best in the area of Materials Science and Solid State Chemistry. The laboratory has been undertaking research in the area of Perovskite manganates,

Jawaharlal Nehru Centre for Advanced Scientific Research, Advanced Materials Laboratory in Bangalore (Photocredit: JNCASR, Bangalore).



Y-junction carbon nanotube synthesized for the first time. (Photocredit: JNCASR, Bangalore) (Deepak, F. L., Govindaraj, A. and Rao, C. N. R., *Chem. Phys. Lett.*, 2001, **345**, 5–10).

metal nanoparticles and their assemblies, novel materials, materials design and synthetic strategies, e.g. nanotubes and nanowires. Materials science is also the focus of the 'Chemistry and Physics of Materials Unit' at JNCASR where research interests lie in molecular electronics, new forms of carbon, nanomaterials and clusters, Brillouin scattering, surface science, thin films and ceramic materials.

The other units at JNCASR are:

Evolutionary and organismal biology unit

This unit has four constituent laboratories. These are in the areas of chronobiology, behavioural ecology and sociobiology, evolutionary genetics, population ecology and biodiversity. It also maintains a Biodiversity Documentation Centre. The research facilities include computerized insect activity recording systems, full-fledged *Drosophila* laboratory, chronocubicle complexes for work on insects and mammals, etc.

Fluid dynamics unit

This unit has thrust areas in flow instability and transition, direct numerical simulation of turbulent flows, atmospheric boundary layers, mixing and vortex dynamics and insect flight dynamics.

Geodynamics unit

This unit pursues studies that are mainly field-based. These are tectonic movements and neotectonic studies into the mechanism of recent earth movements, both in the South Indian Shield and the Central Himalaya in the north.

Molecular biology and genetics unit

This unit has six laboratories. The Genetics Laboratory is working on the molecular basis of neurological and psychiatric human diseases such as juvenile myoclonic epilepsy and schizophrenia, in addition to work on fruit flies. The Molecular Parasitology and Protein Engineering Laboratory has interests in *in vitro* protein evolution using a directed molecular evolution approach to understand the substrate specificity of the enzyme hypoxanthine guanine phosphoribosyltransferase (HGPRT). The molecular parasitology group's interests are in the area of many human and veterinary pathogens such as plasmodium (malaria), toxoplasma (infection associated with AIDS) and eimeria. A 'Biosafety-level 2 plus' Laboratory, under preparation would focus on characterizing type-C of HIV-1, the sub-type prevalent in India. Lastly, the Vascular Biology Laboratory studies blood vessel formation during mouse development and the Disease and Transcription Laboratory, chromatin-mediated transcription regulation in humans, with special reference to diseases.

Theoretical sciences unit

This unit is studying *ab initio* calculations for solid surfaces, supercooled liquids and random matrix models.

Two other units, the Chemical Biology Unit (CBU) and the Condensed Matter Theory Unit (CMTU) are both located on the Indian Institute of Science (IISc) campus in Bangalore. The CBU has several multidisciplinary research areas comprising supramolecular chemistry, molecular design surfactants, structural and modification studies on DNA, stereochemical studies of peptides, mechanism of action of hepatotoxins and protein folding dynamics. The CMTU is engaged in theoretical research on topics in the general area of physics and chemistry of condensed matter systems.

Several extension programmes of JNCASR have been 'highly successful', according to C. N. R. Rao. One of these has been the Summer Research Fellowships offered to undergraduate and graduate students. JNCASR has been the first to initiate such a programme. From about a few thousand applications each year, the best are picked and placed with scientists in India for a period of two summer months. Interestingly, it must be

noted that in spite of this short work duration, at least 14 commendable reports from the various project guides of these students state that the work would result in a research publication. Secondly, the Centre offers Visiting Fellowships, where scientists can avail of an opportunity to work either in JNCASR or with faculty of the centre elsewhere in the country. This is for short periods of 2–3 months. Another, is the JNCASR-COSTED International Fellowship. This is an extension programme available to scientists from developing countries in Asia, Africa and Latin America. It is given for the duration of three months. The ICTP–IISc–JNCASR Associateship Programme is also for scientists from the developing countries. A three-month placement is possible in the JNCASR–DST Coordinated Programme with National Academy of Sciences, Kazakhistan and Uzbekistan. Regular discussion meetings are held in specific areas, with a forthcoming one on nanomaterials. Three-day short-term courses attracting participation from teachers and research scholars are conducted with the help of a few select faculty.

The Education Technology Unit functioning since 1996, designs and develops economically viable kits for science education at the school and college level. Multimedia packages for interactive education brought out by the Unit are 'Our Earth in the Sky', 'Understanding Chemistry' (based on the book by the same title), etc. Several such projects are underway.

In a short period, JNCASR has made significant strides in pursuing its goals in frontier areas of S&T.

National Centre for Biological Sciences

NCBS founded in 1992 is a centre of the TIFR, housed in a modern building having about 80,000 sq ft of space, located on the campus of the University of Agricultural Sciences, Bangalore.

The four areas of research at NCBS are structural and cell biology, biology of disease, neurogenetics, and molecular and systems neuroscience.

Structural and cell biology has five groups: mechanisms of protein folding, ion transport through membranes, mechanisms of endocytosis, microtubule motor proteins and subcellular motility, and computational approaches to protein science.

Biology of disease has two groups: pathogenesis of pappillomaviruses, and lymphocyte death and immune homeostasis.

Neurogenetics has three groups: genetic analysis of chemosensory perception, nerve and muscle development in *Drosophila*, and molecular analysis of olfaction in *Drosophila*.

Molecular and systems neuroscience has three groups: molecular neurobiology, computational neuroscience and cellular neurophysiology.

National Centre for Biological Sciences building in Bangalore. (Photocredit: NCBS, Bangalore.)

Since 1997, NCBS has organized a series of research-oriented and teaching workshops in diverse areas pertaining to the research interests of its faculty. These are plant development, infectious diseases, protein structural bioinformatics and genomics, emerging trends in neurophysiology, etc.

Its academic activities include a Ph D programme and an integrated Ph D programme. There is a Summer Training Programme for pre-doctoral students for 6–8 weeks, giving them an insight as to what research in modern biology is about. An active Teacher Training programme facilitates college and university teachers to pursue research leading to a Ph D degree. Post-doctoral fellowships are also available.

NCBS has several inter-institutional links. These are with the Manipal Academy of Higher Education, Mangalore; IISc, Bangalore; University of Agricultural Sciences (UAS), Bangalore; National Institute of Mental Health and Neurosciences (NIMHANS), Bangalore; IIT, Delhi, and the newly formed National Brain Research Centre (NBRC), New Delhi. NCBS has also several international collaborations and visits by scientists from outside the country.

NCBS has a very positive approach to scientific research that is echoed by its Director, K. VijayRaghavan who says 'a small biology laboratory like ours can be a part of world science only if people and activities flow across regularly. We also strongly encourage our faculty to collaborate widely – in India and abroad – and these collaborations have often resulted in new directions' (as stated in the Annual Report).

National Brain Research Centre

NBRC was set up by the Department of Biotechnology in 1999 as an autonomous society. NBRC recently moved to its new premises at Manesar, Gurgaon District, Haryana (40 km from New Delhi). P. N. Tandon, a neuroscientist, is the President of the NBRC Society and Vijayalakshmi Ravindranath is its Director. NBRC

has been set up 'not only to provide state-of-the-art facilities for a coordinated multidisciplinary team of scientists to work in the frontier areas of neuroscience, but also to support and network the existing groups in the country and provide comprehensive training and teaching of neuroscience', the main objective being 'to undertake frontline research to understand brain function in health and disease'. The intramural activities include investigating basic function of the normal brain. This would help to further understand the disease process itself.

The following are the research areas of interest at NBRC:

Neural stem cell research

Neural stem cell can be isolated and maintained in culture and used to generate neural tissue applicable in molecular therapies and for cell replacement. Scientists at NBRC hope to understand the factors responsible for the regulation of *in vivo* neurogenesis.

Systems and cognitive neuroscience

Neural connectivity, i.e. the intricate network of connections among neurons gives rise to the complex information processing which the brain performs. Little is known on how the brain function is related to its structure in areas of function such as sensory processing, memory, language, decision-making and planning. The techniques to be employed are brain lesion, quantitative electrophysiology, pharmocology and neuroanatomical techniques.

Research on brain-related disorders

Diseases such as Alzheimer's, Parkinson's and motor neuron would be researched from their molecular genetics and role of environment on such diseases. Childhood-related disorders, e.g. autism, attention-deficit hyperactivity syndrome and dyslexia would be of research interest. The consequences of HIV infection on the nervous system (neuro-AIDS) would also be a subject of research. The possibility of validating existing traditional knowledge of Ayurveda to treat brain disorders with respect to dementia, aging and mental illnesses could lead to the potential discovery of drugs based on traditional medicine.

Computational neuroscience and neuroinformatics

This would involve the development of computational simulations of neural information processing for understanding brain function.

Consciousness and brain–mind relationship

A multidisciplinary approach to understanding the neurobiological correlates of conscious states and as to which of these correlates are actually responsible for the production of consciousness.

Extramural activities include networking of the existing neuroscience groups and promoting multidisciplinary research in neuroscience. Networking is hoped to be achieved in three different ways: (a) information sharing through electronic network; (b) identifying 'collaborating' centres for mutual interaction; and (c) establishing satellite centres in different parts of the country. Having been planned as a frontier institute for neuroscience research, NBRC is developing centralized facilities that would be made available to scientists throughout the country.

NBRC would also play a major role in human resource development by promoting neuroscience courses at the M Sc level, such as the one already initiated at the TIFR, Mumbai. Further information can be obtained at the website: www.nbrcindia.org.

All this is part of NBRC's vision to catalyse the growth of neuroscience as a discipline in the country.

National Institute of Pharmaceutical Education and Research

NIPER is an autonomous body under the aegis of the Ministry of Chemicals and Fertilizers (Department of Chemicals and Petrochemicals), Government of India. The institute is located at Mohali, about 10 km from Chandigarh. Being the first national level institute in pharmaceutical sciences and related areas in the country, its mandate is 'to create human resource of a very high calibre to serve Indian pharmaceutical industry, undertake cutting-edge research and development in the area of drugs and pharmaceuticals and to help the pharmaceutical industry to achieve its goal to become a global player'. C. L. Kaul is the Director of NIPER.

NIPER admits students for the M Pharm, M Tech (Pharm), M S (Pharm) and Ph D programmes in the various departments. The first batch of Masters students qualified in December 1999. A total of ten departments have been envisaged for the institute, of which seven have become functional and the others will become functional in due course.

These seven departments are as follows:

Medicinal chemistry

This department is engaged in the areas of research such as identification and validation of novel target sites for various therapeutic areas, asymmetric synthesis, combinatorial chemistry, eco-friendly processes and computer-aided drug design.

National Institute of Pharmaceutical Education and Research building in Chandigarh. (Photocredit: NIPER, Chandigarh.)

Natural products

Research includes chemical and biological evaluation of the leads obtained from traditional medicines in some areas such as immunomodulation, antidiabetics, gynaecological disorders, etc. Other fields of interest are database generation of herbal medicines through chemoprofiling, etc., selection of high active content-bearing plants with their propagation through biotechnological techniques and development of chemical process technology for important natural products.

Pharmacology and toxicology

The department enters into collaborations for regulatory toxicological testing. Projects such as cause and effect relationship of opiod tolerance and dependence, development of animal models for cerebral ischaemia, etc. have been undertaken.

Pharmaceutics

Research is in the area of conventional and novel drug delivery systems, formulation development and stability testing. Biopharmaceutical and pharmacokinetic studies like bioavailability and bioequivalence studies are also carried out. NIPER has been accredited by World Health Organization (WHO), for bioavailability studies of fixed dose combination (FDC) formulations of antitubercular drugs. Several of these bioequivalence studies have been completed for various pharmaceutical companies.

Pharmaceutical analysis

This department has several industrial research projects. Its major activities are: method development and validation of analytical methods, degradation chemistry and stability studies, impurity profiling, identification and determination of individual and total impurities and their isolation and characterization.

Biotechnology

Full-fledged laboratories are working in the areas of cell biology, biochemistry, immunology, molecular biology, microbiology, parasitology, cell and tissue culture, fermentation technology, biotransformation and membrane drug interaction.

Pharmaceutical technology

The special feature of this department is to directly interact with the industry. It will have a pilot plant useful for pilot-scale processing of bulk drugs, pharmaceutical formulations and natural products. It is engaged in process development of bulk pharmaceutical chemicals and employs chemical or chemoenzymatic routes. It also undertakes the development of ecofriendly technologies and process development of conventional and novel formulations.

'NIPER has selected thrust areas in drug discovery with proper biological targets. These areas have relevance to the needs of the country and include malaria, tuberculosis, leishmaniasis and diabetes. The institute has been conducting short- and medium-term continuing education programmes for the benefit of other academic institutes, industry and regulatory bodies from India and other developing countries', according to C. L. Kaul, Director, NIPER, in the Annual Report of NIPER 1999–2000.

Information in this article is partly obtained from the Annual Reports of the concerned institutes, the Directory of Scientific Research Institutes, published by the Indian National Scientific Documentation Centre, New Delhi and the Internet.