

Biotechnology research in India

Introduction:

Biotechnology has clearly emerged as a field which targets all segments of society. The unique feature is that the blend of the new and conventional technologies has paved the way for an overall socio-economic development of the nation. The field of biotechnology offers enormous opportunities for research and development to generate excellence and products and processes of relevance for human kind. The developments in biotechnology, particularly with the basic understanding of genetics, immunology, biochemistry, biochemical engineering and molecular biology have give the way for major biotechnological products and process. The development of the field in molecular biology, plant and animal cell culture, immunology and related areas are being correlated with the progress of industrial development in the world. Recognizing the importance and potential of biotechnology, the Government of India set up the National Biotechnology Board in 1982 which became a full-fledged department (called as Department of Biotechnology, DBT) in 1986 under the Ministry of Science and Technology.

Technology Transferred:

During the last fifteen years, since this Department of Biotechnology has come into being, a strong infrastructure for biotechnological research and services. The Department creates national laboratories and academic institutions across the country. An integrated human recourse development pogramme along with basic and applied product oriented research was the prime goal of this department. Both from the view point of attaining excellence and for product and process development has resulted in very good research publications and 58 technologies have also been developed and transferred to the industry. There was also little report of commercialization of those biotech products till 2005 (Table 1 & 2).

Table1: Technology Transferred to industry till 2000-2005

S.No	Technologies	Developed by	Transferred to
2000-2001			
1	Pregnancy slide test	National Institute of Immunology, New Delhi	Ranbaxy Laboratories, New Delhi
2	Latex agglutination	National Institute of Immunology, New Delhi	Ranbaxy Laboratories, New Delhi
3	Pregnancy DOT-ELISA	National Institute of Immunology, New Delhi	Ranbaxy Laboratories, New Delhi
4	Typhoid fever detection kit	National Institute of Immunology, New Delhi	Lupin Laboratories, Bombay
5	Typhoid fever detection kit	All India Institute of Medical Sciences, New Delhi	Ranbaxy Laboratories, New Delhi
6	Amoebic liver abscess	National Institute of Immunology, New Delhi	Cadila Laboratories, Ahemadabad
7	Polypeptide P form bitter gourd	University of Rajasthan, Rajasthan	Lupin Laboratories, Bombay
8	Bamboo by tissue culture	University of Delhi, Delhi	Tata Energy Research Institute, New Delhi
9	Animal birth control injection (Talsur)	National Institute of Immunology, New Delhi	Karnataka Antibiotics and Pharmaceutical Ltd., Bangalore
10	Osmotolerant and high alcohol tolerant yeast strain	Institute of Microbial Technology, Chandigarh and Vittal Malaya Scientific Research Foundation, Bangalore	United Breweries, Bangalore.
11	Blood grouping monoclonals	National Institute of Immunology, New Delhi	Cadila Laboratories, Ahemadabad
12	Microbial convention on	Central Drug Research Institute,	Atlus Laboratories, Ambala

	benzaldehyde into L-phenylacetylcarbinol	Lucknow	
13	F-MOC derivatives of 12 amino acids	Center for Biochemical Technology	Atual Products, Bulsar
14	Hepatitis B detection kit	National Institute of Immunology, New Delhi	M/s. Lupin Labs Ltd. Bhopal
15	Leprosy immunomodulator	National Institute of Immunology, New Delhi	Cadila Laboratories, Ahemadabad
16	Leishmaniasis detection kit	Central Drug Research Institute, Lucknow	Span Diagnostics Ltd, Surat
17	Monoclonal to M 13 phage proteins III and VIII	University of Delhi, Delhi	Pharmacia Inc. USA
18	Liposomal amphotericin B	Seth G.C. Medical College and Hospital, Bombay	ACE Diagnostics, New Delhi.
19	Western blot test for HIV and II	Cancer Research Institute, Bombay	M/s J. Mithra and Co, New Delhi
20	Development of a drug formulation for prevention of septic shock in patients	National Institute of Immunology, New Delhi	Gufic Health Care Ltd, Mumbai.
21	Process know-how manual for infectious bovine rhinotracheitis (IBR) vaccine as developed by BAIF Foundation, Pune	BAIF Foundation, Pune	Hoechst Roussel Vet India Ltd.(HRV)
22	Agglutination based detection of HIV-I/II antibodies in human blood	University of Delhi, South Campus	Cadila Pharmaceuticals, Ltd. Ahmedabad
23	Plant tissue culture	TERI, New Delhi	Cadila Pharmaceuticals, Ltd. Ahmedabad
24	Plant tissue culture	NCL, Pune	Cadila Pharmaceuticals, Ltd. Ahmedabad
25	Mass production of mycorrhiza	TERI, New Delhi	Cadila Pharmaceuticals, Ltd. Ahmedabad
26	Lipase for food industry	UDSC, New Delhi	Techno EMO, New Delhi
27	Mass production of rhizobial fertilizer	RRL, Jammu	M/S Prathisth Industries Ltd, Secundrabad, M/S Javeri Agro industries and Investment Co Ltd, Amravati
28	Mass production of bio-pesticide - Trichoderma	RRL, Jammu	M/S Prathisth Industries Ltd, Secundrabad, M/S Javeri Agro industries and Investment Co Ltd, Amravati, M/S bee Zed Biotech., Gurgaon
29	Mass production of biopesticides-Trichogramma, Heliothis NPV	TNAU, Coimbatore	Crop Health Products Ltd, Ghaziabad
30	Mass production of biopesticides-Trichoderma	TNAU, Coimbatore	Crop Health Products Ltd, Ghaziabad, Hoechst AgrEvo, Bombay maharashtra Cooperative Oil seed Federation, Jalgaon
31	Mass production of biopesticides – Aspergillus niger	IARI, New Delhi	Cadila Pharmaceuticals, Ltd. Ahmedabad
32	Amaranthus protein gene for nutritionally enriched animal feed	NCPGR, New Delhi	Cadila Pharmaceuticals Ltd. Ahmedabad
33	The IgM Mac ELISA for the detection of dengue	National Institute of Virology, Pune	Zydus cadila Health Care Ahmedabad
34	The IgM mac ELISA for the detection of Japanese encephalitis	National Institute of Virology, Pune	Zydus cadila Health Care Ahmedabad
35	The IgM mac ELISA for the detection of West Nile fever	National Institute of Virology, Pune	Zydus cadila Health Care Ahmedabad
36	ELISA system to measure alpha fetoprotein levels in pregnant women	Indian Institute of Chemical biology, Kolkata	Santha biotech, Ltd Hyderabad
37	An IgM based assay for the detection of hepatitis A virus using monoclonal/polyclonal antibodies	National Institute of Virology, Pune	Bharat Biotech Ltd, Hyderabad
38	Urine based system (ELISA) for the detection of four reproductive hormones	Institute for research in reproduction, Mumbai	Zydus cadila Health Care Ahmedabad

39	Western blot for detection of HIV-1 and -2	Cancer research institute Mumbai	J. Mitra and co New Delhi
40	Agglutination test for HIV-1 and -2 using recombinant reagents	Universit of Delhi, South Campus	Cadila Pharmaceuticals, Ahmedabad
41	A technology utilising Yarrowia lipolytica expressing hepatitis B surface and pre-S genes (Yielding high level of proteins/single step purification)	University of Baroda, Baroda	Biological Evans Ltd, Hyderabad
42	A technology for expressing hCG using Ppichia patoris system	Indian institute of Sciences, Bangalore	Cadila Pharmaceuticals, Ahmedabad
43	Oil Zapper technology for oil spill treatments	TERI, New Delhi	Sriram Biotech Ltd. Hyderabad BPCL, Mumbai
44	Recombinant protective antigen (rPA) agaist anthrax	Centre for Biotechnology, JNU, new delhi	Panacea Biotech Ltd, New Delhi
45	Diagnostic test for pestedes ruminants virus	Madras Veterinary College, Tanuvas, chennai	Indian immunologicals, Hyderabad
46	Production of xanthan gum	Birla institute of Scientific Research, Jaipur	M/S Shriram Biotech Ltd, Hyderabad
2002-2003			
48	Simultaneous detection of white-spot shrimp virus (WSSV) and monodon baculo virus (MBV) for aquaculture industry	College of Fisheries, Mangalore	Mangalore Biotech Laboratory, Mangalore
49	Process for targeted and site specific gene/drug delivery system	University of Delhi, South Campus, New Delhi	M/s Panacea Biotech Ltd. New Delhi
50	Development of nutraceuticals	Anna University, Chennai	M/s Parry Nutraceuticals Ltd. Chennai
51	Polyherbal formulation (BHU-x) for artherosclerosis	Institute of Medical Sciences, Banaras Hindu University, Varanasi	M/s Surya Pharmaceuticals, Varanasi
52	Elite lines of <i>Mucuna pruriens</i> with improved yield and high L-dopa content	Zandu Foundation for Healthcare, Valsar, Gujarat	M/s Zandu Pharmaceutical Works Ltd., Mumbai
2004-2005			
53	Mycorrhiza biofertilizer mass production	TERI, New Delhi	M/s SHEEL Bio-tech, technology New Delhi
54	Technology for production of high protein biscuits	CFTRI, Mysore	
55	A polyclonal antibody-based immunodiagnostic assay for the detection of white spot syndrome virus - a simple diagnostic test kit Melvishram	1. Centre for Biotechnology, Anna University, Chennai and - 2. C. Abdul Hakeem College,	Poseidon Biotech, an aquaculture-based company.
56	The technology for biological deodorization of gaseous effluents has been demonstrated at pilot plant level	NEERI, Nagpur	The pilot plant commissioned at Jubilant Organosys Ltd., Gajraula.
57	DNA/MVA based HIV-I Subtype 'C' candidate vaccine	AIIMS, New Delhi	Under negotiation for transfer to M/s. PanaceaBiotec Ltd., New Delhi
58	Farmer level monoclonal antibody based kit for the detection of white spot shrimp virus	College of Fisheries, UAS,	Being transferred to Genex Biotech, Goa for commercialization.
Source: Annual report, DBT, 2000 to 2005			

Table 2: Commercial launch of technology

2002-2003			
Sl No	Title of the technology	Institute where developed	Technology commercialized by
1	Shantest-AFP (Alphafeto protein)	National Instt. Of Chemical Biology, Kolkatta	Shantha Biotechnics Pvt. Ltd., Hyderabad
2	Oil Zapper	TERI, New Delhi	Sriram Biotech Ltd. Hyderabad
3	Simultaneous detection of white-spot shrimp virus (WSSV) and monodon baculo virus (MBV) for aquaculture industry	College of Fisheries, Mangalore	Mangalore Biotech Laboratory, Mangalore
2004-2005			
1	JEV chex- a rapid detection kit for CSF and serum	AIIMS, New Delhi	XCyton Diagnostics the Japanese Encephalitis in human Limited, Bangalore
<i>Source: Annual report, DBT, 2003 to 2005</i>			

A unique feature of this Department has been the strong interaction with scientist and institution cross the country to promote biotechnology R & D efforts for commercialization and also to benefit the rural people for their socio-economic development. Another important feature has been the interaction at the state Government level to promote biotechnology to meet the needs of the various regions. The investment in the area of biotechnology has increased from from Rs. 750 million in 1092-1993 to 2250 million in 2002-2003.

Transgenic Research:

India has evolved from a net importer of food grains with a domestic production of about 50 mt in 1950-1951 to a position of self sufficiency of food grains. The country has achieved record food grain production of 206 mt in 1999-2000. The intensive area development pogramme (IADP), high yielding variety programmes and to some extent multiple river valley projects is duly responsible for Indian food security.

The department of Biotechnology has made a concerted effort to support various programmes in the area of plant biotechnology. Three major types of activities are being supported: research and development projects in identified priority crops (rice, wheat, chickpea and mustard); multi-institutional projects on development of transgenic for stress resistance and quality traits and plant molecular biology pogrammes in centers of excellence. In addition to the public funded research there is a major interest being shown by the private groups also.

Table 3 Developments in Transgenic research in India

Institute	Crops used for transformation	Transgenes inserted	Aim	Current Status
Central Tobacco research institute	Tobacco	Bt Toxine genes	Resistance to tobacco caterpillar (<i>Spodoptera litura</i>)	One season of caontained field trail completed, further evaluation under progress
Central Potato	Potato	Bt toxin gene	Resistance to	Ready to under take glasshouse

Research Institute, Shimla			potato tuber moth (<i>Phthorimaea opurculella</i>)	trials
Indian Agriculture research institute (IARI), New Delhi	Bringal	Bt toxin gene	Resistance to shoot and fruit borer (<i>Leucinodes arbonailis</i>)	Two season of field trials over; further evaluation in progress
IAIR, New Delhi	Rice	Bt toxin gene	Resistance to yellow stem borer (<i>Scirpophage incertula</i>)	Ready for green house trail
IARI, New Delhi	Tomato	Bt toxin gene	Resistance to diamond back (<i>Helicoverpa armigera</i>)	One season field trail over, evaluation in progress
IARI, New Delhi	Cabbage	Bt toxin gene	Resistance to d	Ready for green house trail
IARI, New Delhi	Tomato	ACC synthase gene	Delayed fruit ripening	Ready for green house trail
IARI, New Delhi	Brassica Juncea	Ammexin gene from Arabidopsis	Tolerance to moisture stress	Field trail in progress
IARI, New Delhi	Potato	Osmotin	Tolerance to moisture stress	Field trail in progress
Directorate of Rice Research (DRR), Hyderabad	Rice	Bt toxin gene	Resistance to yellow stem borer	Ready for green house trail
DRR, Hyderabad	Rice	Chitinase gene	Resistance to sheath blight disease	Ready for green house trail
Bose Institute, Calcutta	Rice	Bt toxin gene	Resistance to yellow stem borer	Green house trail in progress
Delhi Univ, South Campus, Delhi	Mustard/Rapessed	Barnase and Barstar	Pollination control for hybrid development	Ready for field trails
Jawaharlal Nehru University, New Delhi	Potato	Ama-1 gene from Amaranthus	To improve nutritional quality	Transgenic lines under evaluation under containment conditions
Central Institute of Cotton research, Nagpur MKU, Madurai	Cotton	Bt toxin gene	Resistance to <i>lepidopteran</i> insect pest	Greenhouse trials in progress
ICAR, Research Complex, Shillong	Rice	P5cs gene	Resistance against abiotic stresses	Transgenics ready for field trials
Rallies India Ltd, Bangalore	Rice	Snow drop Lectin gene	Resistance against <i>lepidopteran</i> , <i>coleopteran</i> in pests	Transformation being carried out
M/s Proagro PGS India Ltd, New Delhi	Mustard/Ra pesees	Barnase and Barstar	Pollination control for hybrid development	Contained field trails in more than in more than 15 locations over; open-field research trials in progress
M/s Proagro PGS India Ltd, New Delhi	Tomato	Bt toxin gene	Resistance against <i>lepidoptern</i> , <i>coleopteran</i> in pest	One season contained field trial over, further trials in progress
M/s Proagro PGS India Ltd, New	Brinjal	Bt toxin gene	Resistance to <i>lepidopteran</i> insect	Glasshouse experiments in progress

Delhi			pests	
M/s Proagro PGS India Ltd, New Delhi	Cauliflower	Barnase and Barstar	Pollination control for hybrid development	Glasshouse experiments in progress
M/s Proagro PGS India Ltd, New Delhi	Cauliflower	Bt toxin gene	Resistance to insect pests	Glass house experiments in progress
M/s Proagro PGS India Ltd, New Delhi	Cabbage	Bt toxin gene	Resistance to insect pests	Glass house experiments in progress
M/s Proagro PGS India Ltd, New Delhi	Cotton	Bt toxin gene	Resistance to <i>lepidopteran</i> insect pests	Field trails in over 40 locations completed; Now large scale field trials and seed production underway

Human resource development for biotechnology R & D:

Recognizing the need for developing adequate human resource in the multidisciplinary field of biotechnology and for training personnel for research and industrial activities, the department of Biotechnology has been implementing a programme on human resource development. The main focus of this programme has been to generate large no of highly trained scientists/students. Under this programme nearly 60 universities have been covered in almost all regions of the country and great deal of interest has been generated in many state universities also. Post graduate programmes include specialized biotechnology courses in area of agriculture and industrial biotechnology and neurosciences. There has been a major thrust in the area of biochemical engineering and biotechnology and this initiative was launched in the 1970s by IIT Delhi. With gradually built up facilities and excellent students. There are also five year integrated M Tech course on biochemical engineering and biotechnology.

To acquire competence in these and related areas the training must impart quantitative knowledge in both new biology and chemical engineering science. The products of such a training will be engineers capable of solving difficult problems in process biotechnology. Selection of students must also rigorous. Because of the lack of growth of science based biotechnology industry in India such as model was not a in demand until early 1960s. Though mutual discussion between microbiologist (without engineering) and chemical engineers (without biology), management of fermentation processes (very few in in number) could be done, because products were few and well defined and competition was even less. In addition PG diploma and post MD/MSc training courses are supported on a regular basis (Table 4)

Table 4 Institution offering DBT supported post-graduate teaching programmes in biotechnology.

	Name of University/Institution(Year of Start)
M.Sc Biotechnology (2 years courses)	
1	Jawaharlal Neheru University, New Delhi (1985-1986)
2	Madurai Kamaraj University, Madurai (1985-1986)
3	MS University, Baroda (1985-1986)
4	Univrsty of Poona, Pune (1985-1986)
5	Banaras Hindu University, Varanasi (1985-1986)
6	Indian Institute of Technology, Mumbai (1987-1988)
7	Roorkee University, Roorkee (1991-1992)
8	Aligarh Muslim University, Aligarh (1991-1992)
9	Guru Nanak Deb University, Amristsar (1991-1992)
10	Devi Ahilya Viswavidyalaya, Indore (1991-1992)
11	University of Hyderabad, Hyderabad (1991-1992)
12	Himachal Pradesh University, Shimla (1994-1995)
13	University of Calicut, Kerala (1994-1995)
14	Banasthali Vidyapeeth, Banasthli, rajathan (1994-1995) for only girls

15	Tezpur University, Tezpur (Assam) (1998-1999)
16	Gubarga University, Gulbarga (Karnataka) (1998-1999)
17	Jammu University, Jammu (1999-2000)
18	Gujrat University, Ahmedabad (1999-2000)
19	Mysore University, Mysore (1999-2000)
20	University of Allahabad (1999-2000)
21	Guru Jambheshwar University, Hisar (2000-2001)
22	University of Kashmir, Srinagar (2000-2001)
23	Kumaun University, Nainital (2000-2001)
24	University of North Bengal, Siliguri (2001-2002)
25	Lucknow University, Lucknow (2002-2003)
26	Utkal University, Bhubneshwar (2002-2003)
27	Pondicherry University, Pondicherry (2002-2003)
28	Sri. Padmavathi Mahila Visvavidyalayam, Thirupathi (2003-04)
29	Nagpur University, Nagpur (2003-2004)
30	Nagpur University, Nagpur (2003-2004)
31	Visva- Bharathi, Shantiniketan (WB) (2003-04)
Master in Agriculture biotechnology (two years)	
1. Assam Agricultural University, Jorhat (1988-89)	
2. Tamil Nadu Agricultural University, Coimbatore (1988-89)	
3. GB Pant University of Agriculture and Technology, Pantnagar (1988-89)	
4. Indira Gandhi Agricultural Univ. Raipur (2000-2001)	
5. Orissa University of Agriculture & Technology, Bhubneshwar (2002-2003)	
5	Himachal Pradesh Krishi Viswavidyalaya, Palampur, (HP), (1999-2000)
6	Indira Gandhi Agricultural University, Raipur (2000-2001)
7	Marathwada Agricultural University, Parbhani (2000-2001)
Master in Medical biotechnology (two years)	
1	All India Institute of Medical Sciences, New Delhi (1986-87)
M.Sc in Marine biotechnology (two years)	
1	Goa University, Goa (1988-89)
MSc in Neuro Sciences (3 years)	
1	Tata Institute of Fundamental research , Mumbai, (2000-2001)
MTech/ M.Sc (Tech) biochemical engineering and biotechnology	
1	Indian Institute of Technology, New Delhi, (1969-1970)
2	Indian Institute of Technology, Kharagpur (1986-1987)
3	Anna university Chennai, (1991-1992)
4	University department of Chemical technology, Mumbai(1993-1994)
Post MD/MS Certificate course in Medical biotechnology, (1 year)	
1	All India Institute of Medical Science , New Delhi
2	Post Graduate institute of Medical Education and research, Chandigarh
3	Sanjay Gandhi Post Graduate Institute of medical Sciences, Lucknow, (2000-2001)
M.Sc. Industrial Biotechnology	
Sardar Patel University, Vallabh Vidhyanagar (2003-04)	
M. Tech Biochemical Engineering & Biotechnology (5 years integrated 4semesters/2 years course)	
Indian Institute of Technology, Kharagpur (1986-87)	
Indian Institute of Technology, New Delhi (1986-87) Dual degree (degree (5 year integrated as well as 4 semester courses) since 1993-94	
Anna University, Chennai (1991-92)	
University Institute of Chemical Technology, Mumbai (formerly UDCT, Mumbai) (1993-94)	
West Bengal University of Technology, Kolkata (2002-2003)	
Indian Instt. of Technology, Kanpur (2002-2003)	

All over India total 74 universities are now offer postgraduate courses in which total 935 people are being groomed as promising biotechnologist or biochemical engineer in every year (Table 5).

Table 5: Number of institutes running DBT supported PG Programmes (Area Wise)

Number of Universities	No of Universities	Annual intake of students
General Biotechnology	41	530
Agriculture Biotechnology	09	110
Medical Biotechnology	01	010
Marine Biotechnology	02	030
Neurosciences	03	025
Industrial Biotechnology	01	010
M. Tech. Biotechnology	09	140
M.V. Sc	02	015
Post MD/MS Certificate	02	009
PG Diploma	04	056
Total	74	935
<i>Source: DBT, Govt of India, 2005</i>		

Human resource development has been recognized as an important area in bioinformatics. Towards meeting the needs for trained bioinformatics professionals, long-term courses are being run as part of this network in four reputed universities. More than 20 short term courses are conducted every year to train the researcher and scholars in bioinformatics. Several major international databases for application to genomics and proteomics have been established in the form of mirror sites as part of the bioinformatics programme. These databases are being linked through high-speed and large bandwidth as VNP to promote a faster sharing of information. Biotechnology Information Centre (BTIC). Four institution namely Bose Institute, Indian Institute of Science, Jawaharlal Nehru University, Madurai Kamraj University and University of Pune involve research work on Molecular Modelling & Genetic Engineering, Structural Biology & Bioinformatics, Computational Genomics, Genetic Engineering & Structural Bioinformatics and Computational Biology & Genomics respectively.

Centers of excellence

The Department of Biotechnology has been supporting a large number of centers of excellence, facilities and repositories to promote research and development, demonstration, product development and technology transfer activities (Table 6). The Centres of Excellence would be established through financial support from the Department of Biotechnology. Interaction and linkages with industries and international organisations would be encouraged. A special committee would be constituted in the DBT to monitor the progress of the COEs. It is also proposed to enter into an MOU with the host institutions to clearly delineate the duties and responsibilities of DBT and the host Institution.

Table 6: Biotech facilities established/ supported by the Department of iotechnology at various research institutions and universities

A. National Facilities/repositories
1. National facility on Microbial type Culture Collection, IMTECH, Chandigarh
2. National facility on Blue green Algal collection, IARI, New Delhi
3. National facility on Plant Tissue Culture Repository, NBPGR, New Delhi
4. National Animal House facility, CDRI, Lucknow
5. National Animal House facility, NIN, Hyderabad
6. National Facility on Biochemical Engineering Research and Process Development, IMTECH, Chandigarh.
7. National Facility on Oligonucleotide Synthesis, CBT, Delhi

8. National Facility for enzymes and biochemicals, CBT, Delhi
9. Three Genetic Engineering Units at JNU, New Delhi, BHU, Varanashi and IISc, Bangalore
10. Computational facility for Oligonucleotides, CBT, Delhi
11. center for reproductive biology, and Molecular endocrinology, IISc, Bangalore,
12. Carbohydrate Cell Surface and cellular Transport facility, IISc, Bangalore,
13. Protein-Peptide Sequencing Facility, IISc, Bangalore,
14. NATIONAL nmr Facility, AIIMS, New Delhi,
15. national facility for Marine cyanobacteria, BharTHIDASAN University, Tiruchirappalli
16. Antibiotic Development Consortium, HAL, Pune
17. repository on Filarial Parasites and reagents, MGIMS, Sevagram
18. Repository of Firal Parasites and reagents, MGIMS, Sevagram
19. repository of Medicinal and Aromatic Plant Materials, CIMAP, Lucknow
20. National Gene bank for Medicinal and Aromatic plants, NBGPR, New Delhi
21. National Gene bank for Medicinal and Aromatic plants, TBGRI, Thiruvananthpuram
22. National Gene bank for Medicinal and Aromatic plants
23. MMicropopagation Technology Park, TERI, New Delhi.
24. Micropopagation technology Park, NCL, Pune
25. Centre for genetic Engineering and Strain Manipulation, MKU, Madurai,
26. Automated DNA sequencing facility, IISc, Bangalore,
27. Automated DNA Sequencing Facility, UDSC, New delhi.
28. MALDI-TOF mass Spectrometer Facility, ICT, Hyderabad
29. national Facility for X-ray Crystallography, IISc, Bangalore
30. National facility for transgenic containment and Quarantine, NBPGR, New Delhi
31. National Facility for Virus diagnosis and Quality control in Tissue Culture raised Planting materials, IARI, N. Delhi with five satrlite centers at NCL, Pune, TERI, N. Delhi, IHBT, Palampur, IIHR, Bangalore and SPIC, Chennai
32. Gene Bank on Medicinal Plants, IHBT, Palampur
33. Functional Genomics Facility, CBT, New Delhi
34. National Facility for Stable Isotope Discrimination and Molecular Marker for WUE at USA, Bangalore
35. Drosophila repository and research Facility, IIT, Kanpur
36. International repository and Research facility, IIT, Kanpur
37. FACS Facility, CCMB, Hyderabad
B. Hardening Units
1. Jai Narayan Vyas University, Jodhpur
2. Haryana State Council, Hisar
3. G.B. Pant Institute of Himalyan environment and development, Almora
4. West Bengal Council of Science and Technology, Kolkata
5. Regional Research Laboratory, jammu
6. Tata Energy Research Institute, Guwahati
C. Micropropagation Technology Parks
1. TERI, New Delhi
2. NCL, Pune
<i>Sources: DBT, 2001</i>

Biotechnology is one of the most important scientific and technological revolutions of that last century and has greatly benefited various aspects of human life. Department of biotechnology Govt. of India, has focused to promote research activities on several areas like healthcare, agriculture, biofertilizer, animal husbandry, biofuells, biological conservation and bioprospecting etc. A large no of research institute /universities and organizations across the country had been developed. These human resources developmental activities help to acquire integrated knowledge regarding both fields of life science and engineering.