

BIOTECHNOLOGY & BIOINFORMATICS

Q. What is Biotechnology?

Biotechnology is an interdisciplinary science including not only biology, but also subjects like mathematics, physics, chemistry and engineering. It is a blend of various technologies applied together to living cells for production of a particular product or for improving upon it. Its use and application ranges from fields like agriculture to industry (food, pharmaceutical, chemical, bio-products, textiles etc.), medicine, nutrition, environmental conservation, animal sciences etc. making it one of the fastest growing fields. The work is generally carried out in the laboratories, as it is a scientific research oriented field.

The nature of work of biotechnologists, being interdisciplinary, requires working together of people from different fields such as biology, chemistry, biochemistry, microbiology, molecular biology, immunology, genetics, engineering, food science, agriculture etc. Some of the fields where biotechnology studies are applicable are as follows.

1. **MEDICINE AND HEALTH CARE:** Biotechnology's application in this area has helped in the development of various medicines, vaccines and diagnostics. The remarkable development work carried out by biotechnologists in this field has led to improvement in the methods of diagnosis, medicines and vaccinations for diseases which once thought were incurable are no more a cause of worry, which has been a blessing for humankind.
2. **INDUSTRIAL RESEARCH AND DEVELOPMENT:** Both the government and the private sector employ biotechnologists. They conduct research and development work, for increasing productivity, improving energy production and conservation, minimizing pollution and industrial waste etc. Biotechnologists also find opportunities at places involving activities like chemical processes, genetic engineering, textile development, cosmetic development etc..
3. **AGRICULTURE AND ANIMAL HUSBANDRY:** Indian economy is very much dependent on agriculture and biotechnologists have made major advancements in this area. Over the years, the agricultural output has been improving, owing to the

improvements in the quality of seeds, insecticides and fertilizers. The latest technologies like micro propagation and tissue culture has further helped agriculturists to overcome problems like soil imbalances, genetic breeding and crop diseases. Biotechnologists are also encouraging a shift from chemically prepared fertilizers and insecticides to biochemicals and bioinsecticides.

Biotechnology's intervention in the area of animal husbandry has improved animal breeding. Numerous kinds of genetically engineered, high yielding animal breeds have come up which has increased the output of dairy products as well as the meat products. India has in fact, become the largest milk producer in the world

4. ENVIRONMENT: Environmental biotechnology has become another area of extensive work due to the dangers brought about by increasing levels of environmental pollution. A lot of hard work is being done to protect our environment. In this field, the job of a biotechnologist spans from checking industrial air pollution levels, treatment of industrial waste to recycling of sewage sludge..

As the work is largely related to scientific research. It becomes quite important to have a good academic background in science. Hard work and high level of intelligence with a scientific bent of mind, determination, perseverance, imagination, innovative attitude, ability to work for long hours, originality, team spirit are some important essentials for becoming a successful biotechnologist.

Q. What are the courses available in Biotechnology?

After (10+2) in science stream a student can opt for a course in B.Tech in Biotechnology or B.Sc. in Biotechnology. Also student can opt for any other graduation course in Bio-science or engineering course and then opt for Biotechnology at P.G. level. The P.G. courses are:

- M.Sc. Biotechnology
- M.Sc. (Agriculture) Biotechnology
- M.V.Sc. (Animal) Biotechnology
- M.Tech. Biotechnology, M.Sc./M.V.Sc. Veterinary Biotechnology

- M.Sc. (Marine) Biotechnology
- Medical Biotechnology
- M.Tech. in Biomedical Engineering/Biotechnology.

Depending upon the aptitude and necessity, more advanced courses such Ph.D. and Post-Doctoral Research in Biotechnology can also be pursued.

Q. What is Agricultural Biotechnology?

With increase in population and concern about the quality of food, the bio-agriculture has gained focus in the recent past in India. The farmers in India are looking at the GM (Genetically Modified) seeds, bio-fertilizers, bio-pesticides from which they can expect more return on their investments and also increase productivity. The farmers are now getting a premium for the organic produce. With this now they are able to export their produce at much higher price. Lot of research initiatives are also being undertaken in the field to explore new technologies and new tie ups and joint ventures are being set up and are getting approvals from government for exploiting the technologies for the betterment of farmers and obtaining decent returns

GM Seeds

The challenge of producing more food grains to feed the ever increasing population of India that has already crossed one billion mark with less resources has bought companies like Mahyco, Monsanto, Syngenta, ProAgro, Advanta to invest in GM crops. It was in 2002 a joint venture between Mahyco and Monsanto called Mahyco- Monsanto Biotech Ltd got the green signal from the Government of India for the commercial production and sale of Bt cotton (Bollgard) in six southern states of India.

A lot of awareness campaigns have to be conducted to reach out to the farmers to brief them about the benefits of using seeds that are resistant to pests, diseases, herbicides, and crops which are tolerant to drought, cold, salinity and other harsh environments. This will bring in confidence among the farmers as well as the industry people.

Bio-fertilizers, bio-pesticides

In addition to GM seeds, the farmers are also looking at bio-fertilizers, bio-pesticides to get more benefits. Now the farmers are using formulations based on Bt, viruses like NPV, and GV, as well as neem-based pesticides. To meet the increasing demand, the industry has to scale up investments in bio-fertilizers and bio-pesticides. Conservative estimate shows that the 10 percent

saving through the use of bio-fertilizers will result in an annual saving of 1.094 million tons of nitrogenous fertilizers costing around Rs 550 crore.

Bio-fuel

Looking at the opportunity in bio-fuel sector, the central government has taken an initiative to promote this sector in a big way. The total consumption of ethanol-blended petrol is expected to be 4.6 million tons per year. This sector not only helps sugarcane farmers, as cane is used as raw material for production of ethanol, but also helps in building up the oil security apart from benefiting the environment. It can save foreign exchange to the tune of Rs 80,000 crore, as India imports about 70 percent of its requirement of crude oil.

Q. What is Green Biotechnology?

Green biotechnology which is more commonly known as Plant Biotechnology is a rapidly expanding field within Modern biotechnology. It basically involves the introduction of foreign genes into economically important plant species, resulting in crop improvement and the production of novel products in plants. Use of environment friendly and cost effective alternatives to industrial chemicals such as bio fuels, bio fertilizers and bio pesticides are not only resulting in enhanced crop output, improvement in health and safety standards, these new products are also leading to less environment pollution and use of green technology. The ever increasing demand of agricultural produce has given new impetus to research in the field and has resulted in great benefits for farmers and users alike. Today plant biotechnology encompasses the following main areas of research and application:

Plant tissue culture: A technique that allows whole plants to be produced from minute amounts of plant parts like the roots, leaves or stems or even just a single plant cell under laboratory conditions. An advantage of tissue culture is rapid production of clean planting materials. Examples of tissue culture products in Kenya include banana, cassava, Irish potato, pyrethrum and citrus.

Plant genetic engineering: The selective, deliberate transfer of beneficial gene(s) from one organism to another to create new improved crops, animals or materials. Examples of genetically engineered crops include cotton, maize, sweet potato, soy beans etc.

Plant molecular marker assisted breeding: A technique that uses molecular markers to select for a particular trait of interest such as yield. A molecular marker is a short sequence of DNA

that is tightly linked to the desirable trait (such as disease resistance) that selection for its presence ends up selecting for the desirable trait. E.g. maize that is tolerant to drought and maize streak virus.

Bio fertilizers and bio pesticides: Increasingly farmers are using bio fertilizers and bio pesticides to reap more benefits and avoid the chemical pesticides having pollutants and ill effects for crops. As per Conservative estimate in India, a 10 percent saving through the use of bio-fertilizers will result in an annual saving of 1.094 million tons of nitrogenous fertilizers costing around Rs 550 crore.

Hybridization: Increasingly plant scientists exploit the characteristic feature of better yielding 'hybrids' in plants. Hybrid vigor, or heterosis as it is scientifically known, exploits the fact that some offspring from the progeny of a cross between two known parents would be better than the parents themselves. Many hybrid varieties of several crop species are being grown all over the world today. An example of this is the hybrid tomatoes that we eat commonly.

Q. What is White Biotechnology?

White or more commonly known as industrial biotechnology is used to produce all kinds of products used in daily life – ranging from bread and cheese to biodiesel to microbial strains and bio catalysts. It also involves fermentation and enzymatic processes that are fast becoming better financial and ecological alternatives to chemical-physical and mechanical processes and applications by virtue of being cost effective and more environment friendly. White biotechnology is a prime example of interdisciplinary cooperation. Its technology pool is generated from as diverse areas as chemistry, molecular biology, genetics, microbiology, chemical engineering, agriculture science, informatics, computer engineering and process engineering. New insights, in particular in genome research and systems biology, are currently giving great impetus to white biotechnology revolutionizing the whole industrial application and processes and thereby resulting in greater economies. Use of bio technology in industrial application is also leading to introduction of environmentally-friendly methods and processes in various industries such as the food, textile, mining, cosmetics and paper industries. Currently only 5% of chemical products are produced using biotechnological methods. McKinsey report titled “Uptake of white biotechnology by the chemical industry”) has stated that an increase of 10 to 20 percent in 2010 is expected – with

further future growth tendency. This is expected to give good sound bytes to green peace volunteers.

There exist more than 3,000 different known enzymes of which only 150 to 170 are used commercially. There is therefore a huge research potential waiting to be exploited. Other challenges include the optimization of methods and the enzymes involved. Washing agents are probably the best-known example of the biotechnological use of enzymes. Using biotechnology has a significant effect on cost: washing without enzymes requires nearly twice the energy as compared to when enzymes are used. Enzymes also render the entire production flow more competitive and environmentally-friendly. A good example is its effect on the textile industry: the use of enzymes in washing processes in textile purification leads to a reduction of energy and water consumption of up to 50 percent. White biotechnology is also used in water purification involving bacteria and the application of renewable materials. Products such as bio fuels like biodiesel, bio-plastics etc. have a promising future and have opened great research opportunities for mutual benefits of research institutions and industrial houses. Greater research into the field of white biotechnology acts as a three pronged strategy. It gives a boost to the research initiatives, leads to greater industrial output and enhanced commercial and financial gains and at the same time leads to use of technology which are more environment friendly and less polluting. Needless to say that more and more funds will continue to flow into this arena as the gains are enormous and mutual for all those involved in the process.

Q. What is Red Biotechnology?

Red Biotechnology is working for human health and improving life style by using advancements in technology and innovation. In medicine, biotechnology has become an integral part in diagnostics, gene therapy, clinical and contract research and trials, bioactive therapeutic, stem cell research, genetic engineering and in the development and production of new drugs for treating various life threatening diseases. Increased use of combination vaccines, such as DPT with Hepatitis B, Hepatitis A and injectable polio vaccine, besides several veterinary and poultry vaccines are examples of biotechnology application in medicinal arena. Tissue engineering, which deals with tissue implantation following the cultivation of cells on bio-compatible and bio-degradable materials is the new field offering great application for human development and alleviating of human sufferings. Besides the production of artificial skin, tissue-engineering

products predominantly service the orthopedics markets through the supply of cartilage, bone and spinal disc replacements. Increased application of biotechnology in the areas of cancer research and in the treatment of Parkinson's disease by discovering mutations and amplifications of a particular gene which induces Parkinson's disease is a revolution for opening new frontiers in finding better and more effective treatment for the diseases. Biochips are also developing as important tools in the further development of individualized medicine. Biochips are miniaturized analytical tools that are used in diagnostics. They enable the rapid analysis of a patient's individual genetic make-up. They accelerate the development of new drugs, enable the early diagnosis of diseases, the adaptation of drug dosage to the patients' individual requirements and hence the reduction of the number of unwanted side effects. It is also known that certain substances are only effective in some patients because of their particular genetic disposition. Scientific studies have shown that a particular anti-cancer drug is only effective in about 10 percent of all cancer patients. It is possible to genetically determine whether a particular patient belongs to the group of patients for whom the drug is effective. Another study has shown that patients react differently to dosages of anti-depression drugs and beta blockers for keeping hypertension in check depending upon their metabolism level and genetic disposition. Molecular genetics has shown that it is possible to determine the best possible drug dose or to clarify whether a particular drug is actually effective. It is, of course, also possible to design drugs according to the specific genetic requirements of specific groups of patients. All this leads to tremendous research potential and industrial application for a market which is ever growing. Needless to say that red biotechnology has great application not only for the growth of the industry but is also useful for a more philanthropic purpose- to use the technology to alleviate human sufferings and enhance the quality of life.

Q. What is blue biotechnology?

Blue biotechnology is concerned with the application of molecular biological methods to marine and freshwater organisms. It involves the use of these organisms, and their derivatives, for purposes such as increasing seafood supply and safety, controlling the proliferation of noxious water-borne organisms, and developing new drugs.

Q. What is the prospect of Biotechnology in India?

Biotechnology is the sunrise industry and perhaps one of the fastest emerging sectors in the new generation Indian economy, resulting in tremendous growth in research initiatives and jobs creation. The vast base of intellectual prowess and well developed skill sets, R&D facilities and cost advantage all tend to make India as one of the most promising markets in the world and offer great opportunities to business and industry for making investments and reaping the benefits thereof. The government is also trying hard to frame and modify the policy framework so as to make India a vibrant hub of bio technology research and infrastructure development centre.

Biotechnology in India can be divided into three broad areas – Medicinal sector relating to improved human and animal health care and drug research, agricultural sector leading to introduction of new crops and improved plant produce and industrial arena leading to establishment of new economy companies and industries.

The core competence of Indian biotech industry exists in the following areas and sectors:

- Growth of fermentation-based products.
- Use of plant and animal parts for extracting value added products of high purity.
- Use of cell and microbial culture techniques.
- Plant breeding techniques and animal breeding technology based on molecular methodology.
- Plant cell/tissue culture, etc.
- DNA technology of plants and animals
- Isolation of plants and animal products.
- Bioprocess engineering
- Gene manipulation of microbes and animal cells;

According to a NASSCOM-KPMG Study, the biotech industry's R&D and services will reach a turnover of US\$3 billion by 2010 and the bioinformatics market will touch US\$ 2 billion. Indian companies have become providers of biotech information to clients around the world.

Sequencing genes and delivering genomic information for big pharmaceuticals companies is the next boom industry. India has the potential to become one of the prime forces in the development and manufacture of genomic drugs with right climate and well directed research efforts and initiatives. At present, there are about 190 biotech companies in India. The Indian Biotech Scenario

India comprises a large market for biotech based products. However most of these products are

not developed here but are imported by domestic and foreign firms. As per the analysis done by capitalmarket.com, the Indian biotech industry is expected to reach Rs. 4,40,000 Crores in 2020. The current demand for Biotech Products in India according to the Technology Information Forecasting and Assessment Council (TIFAC) report include: - Fermentation based products in vaccines.

- DMA products and antibiotics among healthcare products.

- Alcohol, organic acids, enzymes, amino acids, baker's yeast and other industrial products.

There were about 400 firms in India with biotechnology-related activities in 1995. This number has risen to around 850. India's biotech-industry is small compared to its pharmaceutical industry (about 16,000 small and large drug manufacturers). Biotech in India began during the mid-1980s and was concentrated within the large domestic or multinational drug firms. In 1986, the Government of India established the Department of Biotechnology (DBT) within the Ministry of Science and Technology. Several small biotech companies have been established since then.

Q. What is Biological Engineering or Bioengineering?

Biological engineering, biotechnological engineering or bioengineering is the application of concepts and methods of physics, chemistry, mathematics, and computer science to solve problems in life sciences, using engineering's own analytical and synthetic methodologies and also its traditional sensitivity to the cost and practicality of the solution(s) arrived at. In this context, while traditional engineering applies physical and mathematical sciences to analyze, design and manufacture inanimate tools, structures and processes, biological engineering uses the same sciences, as well as the rapidly-developing body of knowledge known as molecular biology, to study many aspects of living organisms.

Biological Engineers or bioengineers are engineers who use the principles of biology and the tools of engineering to create usable, tangible, economically viable products. Biological Engineering employs knowledge and expertise from a number of pure and applied sciences, such as mass and heat transfer, kinetics, biocatalysts, biomechanics, bioinformatics, separation and purification processes, bioreactor design, surface science, fluid mechanics, thermodynamics, and polymer science. It is used in the design of medical devices, diagnostic equipment, biocompatible materials, renewable bio-energy, ecological engineering, and other areas that improve the living standards of societies. In general, biological engineers attempt to either mimic

biological systems to create products or modify and control biological systems so that they can replace, augment, or sustain chemical and mechanical processes. Bioengineers can apply their expertise to other applications of engineering and biotechnology, including genetic modification of plants and microorganisms, bioprocess engineering, and bio-catalysis.

The Main Fields of Bioengineering may be categorized as:

- **Bioprocess Engineering:** Bioprocess Design, Biocatalysis, Bioseparation, Bioinformatics, Bioenergy
- **Genetic Engineering:** Synthetic Biology, Horizontal gene transfer.
- **Cellular Engineering:** Cell Engineering, Tissue Culture Engineering, Metabolic engineering.
- **Biomedical Engineering:** Biomedical technology, Biomedical Diagnostics, Biomedical Therapy, Biomechanics, Biomaterials.
- **Biomimetics:** The use of knowledge gained from evolved living systems to solve difficult design problems in artificial systems.

What is bioinformatics?

Bioinformatics is the application of computer technology to the management of biological information. Computers are used to gather, store, analyze and integrate biological and genetic information which can then be applied to gene-based drug discovery and development. The need for Bioinformatics capabilities has been precipitated by the explosion of publicly available genomic information resulting from the Human Genome Project. The science of Bioinformatics, which is the melding of molecular biology with computer science, is essential to the use of genomic information in understanding human diseases and in the identification of new molecular targets for drug discovery. In recognition of this, many universities, government institutions and pharmaceutical firms have formed bioinformatics groups, consisting of computational biologists and bioinformatics computer scientists. Such groups will be key to unraveling the mass of information generated by large scale sequencing efforts underway in laboratories around the world.

The terms bioinformatics and computational biology are often used interchangeably. However bioinformatics more properly refers to the creation and advancement of algorithms, computational and statistical techniques, and theory to solve formal and practical problems posed by or inspired from the management and analysis of biological data. Computational biology, on

the other hand, refers to hypothesis-driven investigation of a specific biological problem using computers, carried out with experimental and simulated data, with the primary goal of discovery and the advancement of biological knowledge. In the last few decades, advances in molecular biology and the equipment available for research in this field have allowed the increasingly rapid sequencing of large portions of the genes. This deluge of information has necessitated the careful storage, organization and indexing of sequence information. Information science has been applied to biology to produce the field called Bioinformatics. The simplest tasks used in bioinformatics concern the creation and maintenance of databases of biological information. Nucleic acid sequences (and the protein sequences derived from them) comprise the majority of such databases. While the storage and or organization of millions of nucleotides is far from trivial, designing a database and developing an interface whereby researchers can both access existing information and submit new entries is only the beginning.

Q. What are the employment opportunities in the field of Biotechnology?

Biotechnology is ranked second as a growth sector after multimedia industry with a tremendous employment potential. Most biotechnologists are employed in research and development, departments of institutions and industries involved in biotechnological work. From the production of antimicrobial agents, reagents and consumables to the marketing of instruments used in biotechnological applications and research the opportunities for biotechnologists are on the increase. Biotechnologists work extensively in the production departments of these industries. Generally Biotechnology students from engineering stream are given preference for production jobs.

Biotechnologists work in industries producing food, chemicals, bio-processed products etc. They are involved in research in genetics, biochemistry and biochemical engineering and all areas where these processes are implied. Industrial R&D covers areas such as chemical processes, increase in productivity, waste and pollution management. Some industries employ biotechnologists in their marketing department to develop business in the sector where their product would be most required. They also help to identify biotechnological development opportunities for the industry in India and abroad. A steep rise in employment is envisaged in environmental biotechnology. Spending to the tune of \$ 600 billion by the turn of the century

will open up vast avenues in this sector, as biotechnologists are expected to resolve crisis related to marine life, depletion of the atmosphere etc. In the area of drugs and pharmaceutical there are new ventures both in the government and private sectors coming up to provide for the latest R&D facilities as the sector envisages a global market share of almost Rs35,000 crores. Pharmaceutical industries are offering lucrative pay packets to biotechnologists, microbiologists, molecular biologists and biochemists. Government labs such as CDRI in Lucknow are constantly employing research workers/scientists. The private sector placements are in both technical and managerial positions. The management levels match those of a business firm and the task relates to industrial, production and marketing management. In academics biotechnologists (Doctorates) are working in departments of marine biotech, biomedicine, earth sciences biomedical engineering, agricultural and environmental biotechnology etc.

Industries employing biotechnologists : Hindustan Lever, Thapar group, Indo American Hybrid Seeds, Bincon India Limited, Bivcol, IDPL, Indian Vaccines Corporation, Hindustan Antibiotics, Sun Pharma, Cadila etc.

Laboratories and Institutes employing Biotechnologists : These include the Centre for Cellular and Molecular Biology, National Botanical Institute, National chemical laboratory, Tata Energy Research Institute, Central Aromatic, Plants Institute, Indian Institute of Science, Agricultural Research Institute, CSIR, National Environment Research Institute-Nagpur, National Institute of Immunology-New Delhi, CDRI- Lucknow, IIT-Mumbai, Delhi.

Q. Where and how can I take a Master Degree course in Biotechnology?

Jawaharlal Nehru University (JNU), New Delhi was one of the first six Universities in India to initiate a Postgraduate teaching and research programme in the field of Biotechnology in 1985. Since 1985, it was running as the Special Centre for Biotechnology (CBT) under the joint sponsorship of the University Grants Commission (UGC) and the Department of Biotechnology (DBT), Ministry of Science & Technology, Govt. of India. To begin with, it was started to initiate Biotechnology education programme with an impetus to generate a workforce that could turn into a substantially trained pool to meet the country's demands. Considering the growth of Biotechnology at an international level, its applications in general spheres of life and the

significant contributions made by the faculty of the Centre for Biotechnology, the Executive Council of JNU resolved to elevate the status of the Special Centre for Biotechnology to that of a School of Biotechnology (SBT) in 2006. Over the years, Biotechnology programme at JNU has established itself as a leading academic programme both from the teaching and research point of view. The faculty of the School is internationally recognized for their contribution to basic and applied aspects of Biotechnology research.

Jawaharlal Nehru University conducts a Combined Entrance Examination for admission to 2-Year M.Sc. Programme in Biotechnology on behalf of following participating Universities. The Entrance Examination is held during the month of May at enters all over the country.

1. University of Allahabad, Allahabad
2. Annamalai University, Tamil Nadu
3. Banaras Hindu University, Varanasi
4. University of Burdwan, Burdwan
5. University of Calicut, Kerala
6. Devi Ahilya Vishwavidyalaya, Indore
7. Goa University, Goa
8. Gulbarga University, Gulbarga
9. Guru Jambheshwar University of Science & Technology, Hisar
10. Guru Nanak Dev University, Amritsar
11. Himachal Pradesh University, Shimla
12. HNB Garhwal University, Garhwal
13. University of Hyderabad, Hyderabad
14. University of Jammu, Jammu
15. Jawaharlal Nehru University, New Delhi
16. Kumaun University, Nainital
17. University of Lucknow, Lucknow
18. Madurai Kamaraj University, Madurai
19. M.S. University of Baroda, Vadodara
20. University of Mysore, Mysore
21. University of North Bengal, Siliguri
22. Pondicherry University, Pondicherry

23. University of Pune, Pune
24. R.T.M. Nagpur University, Nagpur
25. Sardar Patel University, Gujarat
26. Tezpur University, Tezpur (Assam)
27. T.M. Bhagalpur University, Bhagalpur
28. Utkal University, Bhubaneswar
29. Veer Bahadur Singh Purvanchal University, Jaunpur
30. Visva-Bharati University, Santiniketan

Q. What is DBT?

The setting up of a separate Department of Biotechnology (DBT-www.dbtindia.nic.in), under the Ministry of Science and Technology in 1986 gave a new impetus to the development of the field of modern biology and biotechnology in India. In more than a decade of its existence, the department has promoted and accelerated the pace of development of biotechnology in the country. Through several R&D projects, demonstrations and creation of infrastructural facilities a clear visible impact of this field has been seen. The department has made significant achievements in the growth and application of biotechnology in the broad areas of agriculture, health care, animal sciences, environment, and industry.

The impact of the biotechnology related developments in agriculture, health care, environment and industry, has already been visible and the efforts are now culminating into products and processes. More than 5000 research publications, 4000 post-doctoral students, several technologies transferred to industries and patents filed including US patents, can be considered as a modest beginning. Department of Biotechnology (DBT) has been interacting with more than 5,000 scientists per year in order to utilise the existing expertise of the universities and other national laboratories. A very strong peer reviewing and monitoring mechanism has been developed. There has been close interaction with the State Governments particularly through State S & T Councils for developing biotechnology application projects, demonstration of proven technologies, and training of human resource in States and Union Territories. Programmes with the states of Gujarat, Rajasthan, Madhya Pradesh, Orissa, West Bengal, Haryana, Punjab, Jammu & Kashmir, Mizoram, Andhra Pradesh and Uttar Pradesh have been

evolved. Biotechnology Application Centres in Madhya Pradesh and West Bengal have already been started. A unique feature of the department has been the deep involvement of the scientific community of the country through a number of technical task forces, advisory committees and individual experts in identification, formulation, implementation and monitoring of various programmes and activities.

In India, more than a decade of concerted effort in research and development in identified areas of modern biology and biotechnology have given rich dividends. The proven technologies at the laboratory level have been scaled up and demonstrated in field. Patenting of innovations, technology transfer to industries and close interaction with them have given a new direction to biotechnology research. Initiatives have been taken to promote transgenic research in plants with emphasis on pest and disease resistance, nutritional quality, silk-worm genome analysis, molecular biology of human genetic disorders, brain research, plant genome research, development, validation and commercialisation of diagnostic kits and vaccines for communicable diseases, food biotechnology, biodiversity conservation and bioprospecting, setting up of micropropagation parks and biotechnology based development for SC/ST, rural areas, women and for different States. Necessary guidelines for transgenic plants, recombinant vaccines and drugs have also been evolved. A strong base of indigenous capabilities has been created. The field of biotechnology both for new innovations and applications would form a major research and commercial endeavor for socio-economic development in the next millennium.

Q. What is BITS?

Biotechnology Information System (BTIS) is a National Bioinformatics Network.

Implementation of Biogrid of India: Research in biotechnology, which is highly knowledge and capital intensive, has generated a deluge of information in this decade. To make use of this information effectively there is a need for high speed and large bandwidth network. Towards this end, the Department has successfully established a high-speed and high-bandwidth network in the form of Virtual Public Network (VPN) named as BIOGRID INDIA. Eleven nodes have been established in the first phase, which are actively pursuing bioinformatics activities such as human resource development and R&D in bioinformatics besides,

dissemination of biotechnology information to researchers in the country. The nodes are interconnected through 2mbps dedicated leased circuit line at each location and 4Mbps Internet bandwidth shared from the central server by all the nodes. The BIOGRID allows exchange of database & softwares which have been created/acquired by the individual centers/nodes of BTIS. This resource sharing helps in enhancing the value and usefulness of the BTIS, the only true resource sharing network in India. The Department of Biotechnology, Government of India is also supporting long-term teaching programs on bioinformatics and BIOGRID will be useful in sharing teaching materials, to deliver lectures through video conferencing-virtual classrooms besides synergizing research in biotechnology and bioinformatics. In the second and third phase the remaining centres and DBT institutions are envisaged to be covered under the faster network. The mirror sites of internationally recognized genomic databases such as GDB, Protein Data Bank (PDB), Plant Genome Data Banks, Databases of European Bioinformatics institute (EBI) and public domain bioinformatics software packages are also available on the BIOGRID. The advantage of mirroring these databases in India is to provide unhindered mining of high quality data from well established primary and secondary information sources. Commercial softwares essential to carry out research & training in bioinformatics will also be made available through biogrid. The network will act as a knowledge pathway for discoveries in biotechnology and bioinformatics.

Development of databases/resource directories: More than 100 subject specific databases are currently available on the BTISnet. Each centre is responsible for developing a database in the identified thrust areas. Some of these efforts have received international recognition. For example, a major database on animal viruses developed by the center at University of Pune has been recognized by the Microbial Strain Data Network, CODATA, a Committee of International Council of Sciences on Data for science & technology and other international bodies.

Strengthening of biocomputing facilities: A national facility has been established at IIT Delhi towards the development of In-silico drug development by using bioinformatics applications. The Facility was dedicated to the nation by the Hon'ble Minister for S&T Prof. Murli Manohar Joshi. During this occasion, software of gene to drug developed by IIT Delhi

was released by Hon'ble MOS (S&T) Shri Bachi Singh Rawat. The facility is being networked through Biogrid India so as to use the compute power & softwares at IIT Delhi by the Biogrid nodes remotely.

R&D Activities: The Bioinformatics Centres are being extensively used for intensive research by the hosts and neighboring institutions. The acknowledgements to BTIS centers in more than 500 research articles published in high quality peer reviewed journals points out the usefulness of this activity. In addition scientists at bioinformatics centres have carried out research in gene analysis, protein structure prediction & engineering, modeling, macromolecular assembly, evolutionary biology developing tools for peptide vaccine, metabolic pathways engineering, new tools for data mining etc.

International Cooperation: Cooperation with India has been sought by several countries in this emerging field of Bioinformatics in view of the progress made and expertise developed. Under a UNDP/FAO/UNIDO sponsored initiative, a referral centre has been set up as part of the Apex Bioinformatics centre in DBT to maintain regional information on various aspects of the FARM programme, viz. Farming systems, Watershed Management, Agroforestry, Integrated Pest Management, Safe Pesticides, Biotechnology & Biodiversity and People's Participation. Through the initiatives of DBT, network connectivity had been established at national focal points in China, India, Indonesia, Philippines, Thailand and Vietnam. DBT also coordinated a meeting of the SAARC countries in India to develop mechanisms for exchange of scientific information in biotechnology amongst the SAARC member-countries. Another international cooperation with Weizmann institute of science (WIS), Israel has been initiated as part of international cooperation in Bioinformatics sponsored by UNESCO. Under this programme, India will host a regional node in Bioinformatics along with other regional nodes proposed in China, Poland and Turkey. The Central node had been set up at the WIS, Israel; India has been recognized to host the regional node in bioinformatics with particular emphasis to extend the regional cooperation to the SAARC countries. Cooperation on bioinformatics with Govt. of Malaysia has recently been approved and with Maldives is under active consideration.

Training/Workshops/Long term courses in Bioinformatics: A number of workshops and

training programmes were conducted on the use of computers and databanks in modern biology and biotechnology. Considering the importance of the subject, some institutions and university Departments have introduced the Bioinformatics course in their existing post – graduate programmes in Biotechnology. DBT has introduced a long-term academic course in Bioinformatics leading to the award of an advanced diploma in Bioinformatics in five Universities viz. Madurai Kamaraj University, Madurai, University of Pune, Pune, JNU, New Delhi, Calcutta University, Kolkata and Pondicherry University, Pondicherry. There had been a sudden increase in the demand of such professionals by small size gene-hunting companies. Many of the larger pharmaceutical companies are now seeing real value in gene mapping and sequence data and have started attracting experts from academia. In light of these developments, the efforts started by DBT are likely to be rewarding towards generation of employment opportunities.

Q. Where can I study B.E./B.Tech in Biotechnology?

Some of the institutions offering B.E./B.Tech in Biotechnology in India are:

01. Anna University, Chennai
02. Acharya Institute of Technology, Solladevanahalli, Chikkabanawara Post, Bangalore North, PIN: 560090
03. Alfa College of Engineering & Technology Allgadda, Kurnool Dist Ph : 08519 – 221357
04. Anil Neeruknoda Institute of Science & Technology Sangivalasa, Bheemunipatnam, Visakhapatnam Dist.(AP) Ph : 08933 - 226395, 225084
05. Al-Ameer College of Engineering & Technology Gudilova, Anandapuram (M), Visakhapatnam (AP). Ph : 0891 - 2523419, 2523421
06. Audhishankara College of Engg. & Tech. Vindhur, Gudur, Nellore Dist.(AP) Ph : 08624 - 272042, 221942.
07. Bapuji Institute of Engg. & Technology, Shamnur Road, Davangere-577004
08. Bellary Engg. College, Kolagal Village, Ballery Hospet Road, Ballery-583104
09. Bapatla Engineering College G.B.C Road, Bapatla, Guntur Dist (AP) Ph : 08643 - 224244
10. CMR Institute of Technology, 132 Kundalahalli, IT Park Road, AECS Layout Bangalore-560037

11. C.M.R. College of Engineering & Technology Kandla Koya, Medchal, R.R. Dist.(AP) Ph: 08418 – 225199 / 224988
12. DVR & Dr. Himasekhar MIC College of Technology, Kanchikacharla, Krishna Dist.(AP) Ph: 08678 - 273535
13. GM Institute of Technology, Karur Village, Kasaba Hobli, Davangere-5770066
14. Guru Gobind Singh Indraprastha University, Kashmere gate, Delhi-110006
15. Godavari Institute of Engineering & Technology Chaitanya Nagar, NH-5, Rajahmundry.(AP) Ph: 0883-2484828
16. Gandhi Institute of Technology & Management (GITAM) Gandhi Nagar, Rushikonda, Visakhapatnam. (AP) Ph: 0891- 2790202
17. Gokaraju RangaRaju College of Engg. & Tech. Bachupally, Miyapur, R.R. Dist.(AP) Ph : 040 - 23045448, 23042666
18. Indian Institute of Technology, Kharagpur
19. Joginpally B.R. Engineering College Yenkapally, Moinabad, R.R. Dist.(AP) Ph : 927 - 252136, 923 – 235752
20. KLES'S College of Engg. & Technology, Udyambag, Belgum-590008
21. Koneru Laxmaiah College of Engineering Vaddeswaram, KC Works (Post) Guntur Dist.(AP) Ph: 08645 - 246948
22. MITS, 85 New Colony, Rayagada-765001, Orissa
23. MS Ramaiah Institute of Technology, MSR Nagar, Bangalore-560054
24. MVJ College of Engineering, Near Whitefield Bangalore-560067
25. Madanapally Institute of Technology & Science Angallu, Madanapally, Chittoor Dist.(AP) Ph: 08571- 226166.
26. Mallareddy Engineering College Gundla Pochampally, Medchal, R.R. Dist.(AP) Ph: 928- 232466, 040- 55347356
27. Nagarjuna College of Engg. & Technology Hosahalli Village, Vijayapura, Hobli Bangalore-562110
28. New Horizon College of Engg. Varthur, Hobli, Bangalore-560087
29. NMAM Institute of Technology, NITTE, Udupi Dist., Karkala-574110
30. PA College of Engineering, Banktval Taluk, Mangalore-574153
31. PES Institute of Technology, Ring Road, BSK III Stage, Bangalore-560085

32. RV College of Engineering, Mysore Road, Bangalore-560059
33. Sapthagiri College of Engg., Hesaraghatta Main Road, Bangalore-560057
34. Shri BVV Sangha's Basaveshwar Engg. College, Nijalingappa Road, Bagalkot-587102
35. Shri Devi Institute of Engineering. & Technology, Maralenahally, Sira Road, Tumkur-572106
36. Sri Jayachamarajendra College of Engg., Manasagangothri, Mysore-570006
37. Sri Indu College of Engg. & Tech. Ibrahimpatnam, R.R. Dist.(AP) Ph: 924- 224155, 224166
38. St. Martins Engineering College Dhoolapally, via Hakimpet, Secunderabad. (AP) Ph :08418 - 232111.
39. Srinidhi Institute of Science & Technology Yamnampet, Ghatkesar, R.R. Dist.(AP) Ph : 08415 - 223001, 002
40. Sri Vidya Niketan College of Engineering Sree Sai Nagar, Rangampet, Tirupathi, Chittoor Dist.(AP) Ph :08574 - 276718
41. The Oxford College of Engg., Hosur Road, Bangalore-560068
42. T.K.R. College of Engineering & Technology Medbowli, Meerpet, Hyderabad Ph : 040 - 55587536, 55347536
43. Vagdevi College of Engineering Bollikunta, Warangal. Ph : 0870 - 2865182, 183
44. Vellore Institute of Technology, Vellore-632014(Tamil Nadu)
45. University Institute Of Engineering & Technology, Sector-14, Punjab University, Chandigarh
46. Govt. Engineering College, Raipur Chhattisgarh - 492 010
47. Raipur Institute Of Tech, S. South Avenue, Choubey Colony, Raipur, Chhattisgarh - 492 001
48. Delhi College Of Engineering, Shahbad-Daulatpur, Bawana Road, Delhi-110042
49. Netaji Subash Institute Of Technology, Ajad Hind Fauj Marg, Sector-3, Dwarka, New Delhi-110045
50. Vyavsaik Vidya Prathisthan's Sanch. College Of Engg, Vajdi,Virda, Kalawad Road, Rajkot-360 005, Gujrat
51. Ambala College Of Engineering & Applied Research, Devsthali, Ambala-Jagadhari Highway, Po-Sambhalkha, Ambala, Haryana-133101

52. Career Institute Of Technology & Management, Sector-43, Aravalli Hills, Surajkund-Bhadkal Road, Faridabad, Haryana-121001
53. C.R.State College Of Engineering, Murthal, Sonapat, Haryana-131039
54. N.C. College Of Engineering, Balana, Israna, Distt. Panipat, Haryana-132107
55. Birla Institute Of Technology, Mesra, Ranchi-835 215
56. Met's School Of Engineering Kuruvillassery P.O., Mala, Thrissur Dist. – 680735, Kerela
57. Mohandas College Of Engineering & Technology, Anad Village, Nedumangad, Thrivananapuram, Kerela– 695003
58. Sahrdaya College Of Engineering & Technology, Kodakara, PB No.17, Thrissur – 680684, Kerela
59. Sree Buddha College Of Engineering, Pattoor P.O., Padanilam, Noornad,, Alappuzha Dist. – 690529, Kerela
60. Sree Chitra Thirunal College Of Engineering, Pappanamcode, Thiruvananthapuram - 695 018
61. Madhav Instt. Of Tech. & Science, Gola Ka Mandir,P.O. Residency, Gwalior, M.P. - 474 005
62. Shri Rawatpura Sarkar Institute Of Technology, Peeli Kothi, Bhawani Vilas, Thandi Sadak, Datia - 475 661, Madhya Pradesh
63. Kolhapur Instt.Of Tech's Col Of Engg, Gokulshirgaon,Tal Karvil,Kolhapur-416 234
64. Shri Warna Vibhag S.M's Taty Saheb Kore Inst. Of Engg. & Tech., Warananagar, Tal. Panhala, Dist. Kolhapur-416 113
65. Thadomal Shahni Engineering College, 32nd Road, T.P.S.-Iii., Bandra, Mumbai – 50
66. Gandhi Institute Of Engg. & Tech., Kharling Post, Gobriguda, Gunupur- 765022, Rayagada
67. Majhighariani Institute Of Tech. & Science (MITS), Bhujabal, Kolnara-765001, Dist. - Rayagada, Orissa – 765001
68. Shri Rajiv Gandhi Institute Of Tech, R.S. No. 25,26&27, Pondy - Cuddalore East Coast Road, Kirumambakkam, Pondicherry, Pin - 605 102
69. Shaheed Udham Singh College Of Engineering & Technology, Tangori, Mohali
70. Thapar Institute Of Engineering & Technology, Bhadson Road, Patiala

71. Jaipur Engineering College And Research Centre, Sri Ram Ki Nangal, Via Vatika, Sukhpuria, Rajasthan-303905
72. Maharishi Arvind Institute Of Engineering & Tech., Sector-7, Madhyam Marg,, Mansrovar, Rajasthan
73. Seedling Academy Of Design Technology And Mgt.' Main Campus, Khore, Bariyan, Tehsil-Sangarner, Jagartpura, Rajasthan-302017
74. Seedling Academy Of Design Technology And Mgt., Main Campus, Khore, Bariyan, Tehsil-Sangarner, Jagartpura, Rajasthan-302017
75. Sobhasaria Engineering College, Gram-Gokulpura,, Sikar, Rajasthan-332001
76. A.R.J. College Of Engineering &Tech., Thiruma Kottai Main Road, Edayanatham Village, Mannargudi Taluk, Tiruvarur Dist., Tamilnadu
77. Adhiyamaan College Of Engineering, Dr. Mgr Nagar, Hosur, Pin - 635 125, Dharmapuri Dist., Tamilnadu
78. Arulmigu Kalasalingam College Of Engg., Anand Nagar, Krishnankoil, Pin - 626 190, Virudhunagar Dist., Tamilnadu
79. Arunai Engineering College, Mathur, Tiruvannamalai, Pin - 606 603, Tiruvannamalai Dist., Tamilnadu
80. Bannari Amman Institute Of Tech., Alathukombai, M. Komarapalayam (Post), Sathyamangalam, Pin - 638 401, Coimbatore Dist., Tamilnadu
81. Bharathidasan Institute Of Engg. & Tech., Bharathidasan University, Tiruchirapalli Dist., Tamilnadu
82. G.G.R. College Of Engg., Perumugai, Chennai-Bangalore High Way, Vellore, Pin - 632 004, Tamilnadu
83. Jeppiar Engineering College, Jeppiaar Nagar, Old Mammallapuram Road, Chennai, Pin - 600 119
84. K.S. Rangaswamy College Of Tech., K.S.R. Kalvi Nagar, Thokkavadi, Tiruchengode, Pin - 637 209, Tamilnadu
85. Kamaraj College Of Engineering & Tech., S.P.G. Chidambara Nagar, C.Nagammal Campus S.P.G.C. Nagar, Virudhunagar, Pin - 626 011, Madurai Dist., Tamilnadu
86. Karpaga Vinayaga College Of Engg. & Tech., Karpaga Vinayaga Nagar, Palayanoor Post, Maduranthakam, Pin - 603 308, Kancheepuram Dist., Tamilnadu

87. Kumaraguru College Of Technology, Chinnavedampatti., Coimbatore, Pin - 641 006, Tamilnadu
88. Madha Engineering College, Somamangalam Road, Kunrathur, Chennai, Pin - 600 069, Tamilnadu
89. Mepco Schlenk Engineering College, Amathur Post, Sivakasi, Pin - 626 005, Tamilnadu
90. National Institute Of Technology, Tiruchirapalli, Pin - 620 015, Tamilnadu
91. P.S.G. College Of Technology, Peelamedu, Coimbatore, Pin - 641 004, Tamilnadu
92. P.S.R. Engineering College, Appayanaickenpatty, Sevalpatty, Sivakasi, Pin - 626 140, Tamilnadu
93. Periyar Maniammai College Of Tech. For Women, Periyar Nagar, Vallam, Thanjavur, Pin - 613 403, Tamilnadu
94. Prathyusha Engineering College, Aranavayal, Pin - 602 025, Thiruvallur Dist., Tamilnadu
95. Rajalakshmi Engineering College, Rajalakshmi Nagar, Thandalam, Chennai, Pin - 602105, Tamilnadu
96. Shri Andal Alagar College Of Engg., No.6, Namandur Village, Gst Road, Madhuranthakam, Kancheepuram Dist. Tamilnadu
97. Sree Sastha Institute Of Engg. & Tech., Chembarambakkam, Pin - 602 103, Thiruvallur Dist., Tamilnadu
98. Sri Nandanam College Of Engg. & Tech., Molagarampatti, Tirupattur, Pin - 635 601, Vellore Dist. Tamilnadu
99. Sri Venkateswara College Of Engg., P.B.No.3, Pennalur, Sriperumbudur, Pin - 602 105 Kancheepuram Dist., Tamilnadu
100. St. Joseph's College Of Engineering, Jeppiaar Nagar, Old Mamallapuram Road, Chennai- 600 096, Tamilnadu
101. St. Michael College Of Engg. & Tech., Somanthamangalam Group, Kalaiyarkoil, Pin - 630 551, Sivagangai Dist., Tamilnadu
102. St. Peter's Engineering College, Avadi, Chennai - 600 054, Thiruvallur Dist., Tamilnadu
103. Udaya School Of Engineering, Udaya Nagar, Vellamadi Junction, Kanyakumari, Pin - 629 204, Tamilnadu

104. Vellore Institute Of Tech., (Deemed Univ.), Katpadi-Tiruvalam Road, Vellore - 632 014, Vellore Dist., Tamilnadu
105. Vivekananda College Of Engg. For Women, Elayampalayam, Tiruchengodu, Pin - 637 205, Namakkal Dist., Tamilnadu
106. College Of Engineering Technology, Lodhipur Rajput, Delhi Road, Moradabad - 244 001.
107. College Of Engg. & Technology, Iilm Academy For Higher Iilm Academy For Higher Learning, Plot No. 17 & 18, Knowledge Park, Phase II, Greater Noida, Distt. Gautam Budhnagar.
108. Faculty Of Engineering & Technology, Raja Balwant Singh College, Bichpuri, Agra - 283 105.
109. Ims Engineering College, Nh-24, Delhi-Hapur Bypass Road, Adhyatmik Nagar, Ghaziabad - 201 009.
110. Motilal Nehru National Instt. Of Technology, Teilarganj, Allahabad - 211 004.
111. Meerut Institute Of Engg. & Technology, Baghpat Road Bypass Crossing, P.O.: Malyana, Meerut - 250 002.
112. S.D. College Of Engg. & Technology, Sahawali, Jansath Road, Muzaffarnagar - 251 001.
113. Saroj Institute Of Technology, Ahmamau, Arjunganj, Sultanpur Road, Lucknow - 226 006.
114. Haldia Institute Of Technology, P.O. Hatiberia, Haldia, Pin 721657
115. Heritage Institute Of Tech., Chowbaga Road, Anandpur, P.O: East Kolkata Township, Kolkata- 700107
116. Institute Of Technology & Marine Engg, Vill-Jingha, P.O—Amira, P.S.Diamond Harbour, Dist Sought Pargana, West Bengal

Q. Where can I study Biotechnology course in Delhi?

Degree / Course	College / Institute	Eligibility
BSc. Biochemistry	University of Delhi, Delhi – 11007	Class XII with Physics, Chemistry and Biology
BSc. Biochemistry	Shivaji College, University of Delhi, Delhi	Class XII with Physics, Chemistry and Biology
BSc. Biochemistry	Deshbandu College, University of Delhi, Delhi	Class XII with Physics, Chemistry and Biology
BSc. Biochemistry	Venkateshwara College, University of Delhi, Delhi	Class XII with Physics, Chemistry and Biology

BSc. Biochemistry	Daulat Ram College, University of Delhi, Delhi	Class XII with Physics, Chemistry and Biology
BSc. Biochemistry	Amity Institute of Biotechnology, RBEF, E-27, Defence colony, New Delhi – 110024	Class XII (50%) or equivalent with Biology as a subject
BSc. Biochemistry	Gargi College, University of Delhi	Class XII with Physics, Chemistry and Biology
BSc. Biochemistry	Institute of Home Economics, University of Delhi	Class XII with Physics, Chemistry and Biology
BSc. Biochemistry	Ram Lal Anand College, University of Delhi	Class XII with Physics, Chemistry and Biology
BSc. Biochemistry	Swami shradhanand College, University of Delhi	Class XII with Physics, Chemistry and Biology
BTech. Biotechnology	All India Institute of Medical Sciences, New Delhi	Class XII with Physics, Chemistry and Biology
MSc. Bioinformatics	Amity Institute of Biotechnology, RBEF, E-27, Defence Colony, New Delhi – 110024	BSc.
MSc. Biochemistry	University of Delhi, Delhi 110007	BSc.
MSc. Microbiology	University of Delhi, Delhi 110007	BSc.
MSc. Genetics	University of Delhi, Delhi 110007	BSc.
MSc. Biophysics	University of Delhi, Delhi 110007	BSc.
MSc. Plant Molecular Biology	University of Delhi, Delhi 110007	BSc.
MSc. Biotechnology	Jawaharlal Nehru University, New Mehrauli Road, New Delhi	BSc. in Physics/Biology/Agriculture/Pharmacy/Veterinary Science/ BE
MSc. Agricultural Biotechnology	Jawaharlal Nehru University, New Mehrauli Road, New Delhi	BSc. in Physics/Biology/Agriculture/Pharmacy/Veterinary Science/BE
MVSc. Animal Biotechnology	Jawaharlal Nehru University, New Mehrauli Road, New Delhi	BSc. in Physics/Biology/Agriculture/Pharmacy/Veterinary Science/BE
MTech.		

BioTechnology	Jawaharlal Nehru University, New Mehrauli Road, New Delhi	BSc. in Physics/Biology/Agriculture/Pharmacy/Veterinary Science/BE
MSc. Biotech Industrial Training	Jamia Hamdard University, Hamdard Nagar, New Delhi	BSc./BTech., MSc./Mtech. in Biotechnology
MSc. Biotech Industrial Training	Biotech Consortium India Ltd. G-6, NDSE Part-I, New Delhi	BSc./BTech., MSc./Mtech. in Biotechnology
MTech. Biotechnology	All India Institute of Medical Sciences, New Delhi	BSc./BTech.
MTech. (Integrated) Biotechnology	Indian Institute of Technology (IIT), New Delhi	Class XII with Physics, Chemistry and Mathematics
MTech. (Integrated) Biotechnology	Guru Gobind Singh Indraprastha University, New Delhi	Class XII with Science
PG Diploma in Bioinformatics	Jawaharlal Nehru University, New Mehrauli Road, New Delhi	BSc./BTech.
Ph.D. Biotechnology	Jawaharlal Nehru University, New Mehrauli Road, New Delhi	Bachelor's in Veterinary and Fisheries Sciences
Post-Doctoral Research	Department of Biotechnology, Ministry of Science and Technology, New Delhi	MSc./MTech./Ph.D.
Research (Ph.D.)	All India Institute of Medical Sciences, New Delhi	MSc./MTech.