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Origin, Scope and Importance of Biotechnology

The origin of biotechnology can be traced back to prehistoric times, when micro-organisms were already used for processes like fermentation.

In 1920's Chaim Weizmann used Clostridium acetobutylicum for converting starch into butanol and acetone later, was an essential component of explosives during world war I. This also hopes fore commercial production of useful chemicals through biological processes, and may be the considered as the first rediscovery of biotechnology.

Similarly during world war II, the production of Penicillin as an antibiotic discovered by Alexander Fleming on a large scale marked the second rediscovery of biotechnology.

The third rediscovery of biotechnology is its recent reincarnation in the form of recombinant-DNA technology, which lead to the development of a variety of gene technologies, and is thus considered to be the greatest scientific revolution of this century. (1970's & 1980's)

Biotechnology, as word indicates, is the product of interaction between the science of biology and technology.

This relationship between science and technology has been observed to be complex, so that not only science has influenced technology, but the technology has also influenced science.

Because of this complex relationship and its major impact on human welfare, it is believed that biotechnology in future may became a major force for human existence.

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Already the products of biotechnology including diagnosis prevention and cure of diseases eg. Pharmaceutical drugs, and the new food sources; devices for environment protection and energy conservation etc. are playing a very important role in employment productivity, trade and quality of human life in all world.

It has been recognised that a complete definition of biotechnology is difficult due to wide range of its usage.

Following are some of the definitions of biotechnology:

(a) Biotechnology is the application of biological organisms system or processes of manufacturing and service industries (According to British Biotechnologist).

(b) Biotechnology is the integrated use of biochemistry, microbiology, and engineering sciences in order to achieve technological application of the capabilities of micro-organisms, cultured tissue cells and parts thereof. (According to European Biotechnologists).

(c) Biotechnology is a technology using biological phenomena for copying and manufacturing various kinds of useful substances (Japanese Biotechnologists)

(d) Biotechnology is the controlled use of biological agents such as micro-organisms or cellular components for beneficial use (U.S. National Science Foundation)

The last definition is brief and comprehensive and may be used by any person or students.

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Scope and Importance of Biotechnology:

Biotechnology ~~was explained~~ has its newest roots in the science of molecular biology and microbiology. Advances in these two areas have been exploited in a variety of ways both for production of industrially important biochemicals (including enzymes) and for basic studies in molecular biology.

Tissue culture techniques in biotechnology:-

An important aspect of all biotechnology processes is the culture of either the micro-organisms or plant and animal cells or protoplasts in case of plants or tissues and organs.

While microbes in culture are used in recombinant DNA technology and in a variety of industrial processes, Plant cells and tissues are used for a variety of genetic manipulations. For ep- anther culture is used for haploid breeding. Gametic and somatic cell/tissue cultures are used for tapping gametoclonal and somatoclonal variation or for production of artificial seeds. Transformation of Protoplasts in culture leads to the production of useful transgenic plants. Embryo culture technique has also helped in extending the range of distant hybridization for Plant breeding purposes.

Similarly animal cells (ep. egg cells) are used for multiplication of superior livestock using a variety of techniques like cloning of superior embryonic cells, transformation of cultured cells leading to the production of transgenic animals, and in vitro fertilization and transfer of embryos to surrogate mothers.

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Gene technology as a tool for biotechnology:

Most biotechnology companies make use of gene technology or genetic engineering, which involves recombinant DNA and gene cloning.

More recently, extensive use of newly discovered Polymerase chain reaction (PCR) has also been made for gene technology.

This gene technology has became a major thrust area of present day researches and some of the developed countries are encouraging researches in this field as a matter of national priority.

Biotechnology in Medicine:

In the field of medicine, Insulin and interferon synthesized by bacteria have already been released. A large no. of vaccines for immunization against dreadly diseases, DNA Probes and monoclonal antibodies (including ELISA tests) for diagnosis of various diseases and human growth hormone and other Pharmaceutical drugs for treatment are being released or are in the process of being released. During 1990-92, patients suffering with some lethal diseases were subjected to gene therapy. These patients are doing well.

→ DNA fingerprinting and autoantibody fingerprinting techniques are also proving a great boon in forensic medicine for identification of criminals like murderers and rapists through the study of DNA or antibodies from blood and semen stains, urine, tears, saliva, perspiration or hair roots.

Immunotoxins are being produced from gene fusions so that the toxic drugs meant for killing tumour cells may be carried to the target sites with the help of specific antibodies.

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Biotechnology and Protein (or Enzyme) engineering:

Another very important area of biotechnology is protein engineering that will lead to the production of superior enzymes and storage proteins. In this area a protein engineer first prepares a computer aided protein model for a specific function and then prepares a synthetic gene that will produce this desired protein in a predictable manner.

Biotechnology has also provided us with a remarkable technique in the form of immobilized enzyme systems which allowed the production of a variety of substances eg. high fructose, glucose isomerase which helps in Industries.

Biotechnology and metabolic engineering:

One of the major objectives of biotechnology research is the use of living systems for the production of metabolites at the industrial scale. However, cells metabolic networks, that evolved in nature, are not optimized for industrial production of these metabolites. In such cases, performance of metabolic pathway are being manipulated, so that the metabolites are over produced.

The opportunity to introduce heterologous genes and regulatory elements made metabolic Engineering, a very fascinating area of research. However, there is a variety of limitations in metabolic engineering that need to be overcome.

For instance, when alterations are made (by genetic manipulations) for flux distributions at key branch points (called nodes) of a metabolic pathway

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Biotechnology in agriculture:

Biotechnology has also revolutionized research activities in the area of agriculture which includes the following:

(i) Plant cell, tissue and organ culture
(ii) Genetic engineering leading to transformation followed by regeneration of plants to give transgenic plants carrying desirable traits like disease resistance, insect resistance and herbicide resistance eventually this may also be used for increasing photosynthetic efficiency, nitrogen fixing ability, improved storage proteins, hybrid crops, crops for food processing, etc.
(iii) Somatic hybrids between sexually incompatible species, permitting transfer of desirable traits from wild or unrelated crop species to our crop plants
(iv) Transgenic animals produced in mice, pigs, goats, chicken, cows etc.

It is suggested that some of these will eventually be used as bioreactors to produce drugs through their milk, blood or urine (as molecular farming).

Biotechnology and Industrial microbiology:

Industrial microbiology is yet another area receiving major attention of biotechnologists. A number of Pharmaceutical drugs and chemicals are being produced, or will be produced in future utilizing techniques of biotechnology (including genetic engineering) to increase substantially both the quality and quantity of these drugs and chemicals.

Biotechnology and environment:

Biotechnology is also being used for dealing with environmental problems. Fears are also

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expressed about the complication of advances in biotechnology in terms of release of harmful organisms developed through recombinant DNA technology. In view of this, rules & laws have been framed from time to time to safeguard against the risks which the recombinant DNA technology poses to the clean and friendly environment.

Biotechnological methods have been devised for some environmental problems like the following
(i) Pollution control
(ii) Depletion of natural resources for non renewable energy
(iii) restoration of degraded lands
(iv) biodiversity conservation.

for instance, microbes are being developed to be used as bio-pesticides, biofertilizers, biosensors etc.

They are also used for biomonitoring in industries where employees are exposed to a variety of risks.

Biomass is being produced and used as a renewable source of energy, by capturing solar energy.

Tissue culture and genetic engineering microbi (VAM Fungi) root nodulation are also used for reclamation of degarded lands.

Bioinformatics:

In the area of bioinformatics, nine distributed information centres (DICs) and 14 user centres were established in various institutions in the country. The nine DIC's are located at the following institutions:

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(i) Indian Institute of Science (IISc), Bangalore
(ii) Madurai Kamraj University (MKU) - Madurai
(iii) Bose Institute Calcutta
(iv) Jawahar lal Nehru University (JNU)
(v) Poona University; Pune
(vi) Indian Agricultural Research Institute (IARI) New Delhi
(vii) Centre for Cellular and Molecular biology (CCMB) Hyderabad
(viii) Institute of microbial technology (IMTECH) Chandigarh.
(ix) National Institute of Immunology (NII) - New Delhi

These DICs are linked with each other and with the central Information Network at DBT in New Delhi which has access to international databases in biotechnology.

To give the desired boost programmes of Crop improvement through biotechnology, Key Centres for plant molecular biology were established by DBT at the following institutions.
(i) MKU - Madurai
(ii) JNU - New Delhi
(iii) TNAU - Coimbatore
(iv) Osmania University - Hyderabad
(v) Bose Institute - Calcutta
(vi) NBRI - Lucknow.

Infrastructural facilities:

DBT has set up service oriented infrastructural facilities in the following areas:
(a) Germ plasma banks for plants, animals, algae and microbes
(b) Animal houses
(c) Oligonucleotide synthesis (DNA-synthesizers)
(d) Production, import and distribution of enzymes reagents and radio-labelled compounds.

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(e) BioProcess Optimization and Pilot Plants.
(f) Genetic engineering R&D Units
(g) Centre for reproductive biology & molecular endocrinology
(h) Carbohydrate Cell Surface & Cellular transfer
(i) Protein and Peptide sequencing
(j) NMR facility
(k) Marine cyanobacterial germplasm Collection
(l) Antibody development consortium.

The above achievements in biotechnology led to the preparation of an action plan by DBT so that the benefit may meet the needs of rural developments. Following eight Programmes are listed in this "action plan"

(i) Vaccines (eg- oral Polio vaccine)
(ii) Oil Palm demonstration project
(iii) Increased production of biomass.
(iv) Immunodiagnostics
(v) Aquaculture (Increase production of Prawns & Carp)
(vi) Embryo transfer technology.
(vii) Biofertilizers
(viii) Sericulture.

The above is a brief account of the facilities developed and achievements made in India in the field of biotechnology. The fruits of the efforts made are becoming visible now and it is hoped that in 21st century India should make significant contribution and may also became a leader in Asia at least in some areas of biotechnology research.