Chapter - 14
Biotechnology – General Introduction

Human has had knowledge about some simple but important applications of biotechnology since ancient period. Almost ten thousand year ago, our ancestors had produced wine, beer, vinegar, bread etc. by fermentation that is done by the activities of unicellular organism. In fact, biotechnology was used by our ancestors to fulfill their requirement, identify the plants suitable for agriculture and developing them for agriculture and domesticate the animals to utilize their products for daily use. Making curd and other products by fermenting milk, develop advanced varieties by hybridisation between various varieties of plants, getting antibiotics from microbes etc. are examples of biotechnology.

The term biotechnology was first of all used by agriculture engineer Karl Erecky from hungary in 1919. In next chapters we will study in detail about techniques of biotechnology, their important products and the processes through which we obtain important products.

Definition : Biotechnology word is derived from word Bio (living) and Technology (Techniques). In general, using living organism mainly micro organisms like Bacteria, unicellular animals, plants, their cells, their component and exploiting their metabolism, for producing useful products and services is called biotechnology. According to European Federation of Biotechnology "Integrated application of biochemistry, microbiology, engineering etc. to achieve the technological applications of the capabilities of micro organism, culture, tissue, cells and their organs, is biotechnology".

Brief History of Biotechnology

As we know that biotechnology has been used for the fulfillment of human requirement since ancient times. Important discoveries and achievements related to this field of ancient and modern time, are given in following table 14.1.

Table 14.1 : Major Historical Dates Related to Biotechnology

Year	Important Discoveries and their Discoverer
Before 6000 BC	Use of yeast in production of wine and beer.
Before 4000 BC	Making Leavened bread and Alcoholic beverages from fruit juice by fermentation.
Before 2000 BC	Production of cheese in Ancient Greece.
1150 AD	Production of Ethanol.
1663-1675 AD	The discovery of cell (dead) by Robert Hooke and discovery of protozoa and Bacterial cell (living cell) by Antonie Von leeuwenhoek
1799-1802	First time the term biology had been individually used by K. F. Burdach(1799), G.R. Treviranus (1800), and Jean Baptiste Lamarck (1802).

1885	*Escherichia coli* bacteria was discovered by Theoder Escherich.
1888	W. Waldeyer discovered chromosomes
1897	- Eduard Buchner described the cell free fermentation process in which the sugar is converted into the alcohol by enzymes. He also discovered the enzyme complex zymase from yeast extract.
1915	- Bacteriophage/Phage/Bacterial virus was discovered by Frederick W. Twort.
1919	- The term biotechnology was first used by Karl Ereky.
1928	- The penicillin a ntibiotic was discovered by Alexender Fleming.
1941	- The word "Genetic Engineering" was first used by Jack Williamson in his novel "Dragon's Island".
1953	- The double helix structure of DNA was elucidated by James Watson and Francis Crick.
1970	- Hamilton D. Smith, Thomas Kelly and Kent Wilcox. discovered the restriction endonuclease enzyme
1972	- First time synthesis of complete gene (yeast t RNA gene) was done by Hargovind Khurana and et. al.
1973	- Stanley Cohen and Herbert B oyer first of all performed experiment related to recombinant DNA.
1975	- Production of monoclonal antibodies by the hybridoma technology was represented by George Kohler and Cesar Milstein.
1981	- Development of first gene synthesizing machine
1982	- Approval of use of insulin produce by the genetic engineered micro – organism in the USA and UK.
1983	- Polymerase Chain Reaction (PCR), was discovered by Kary B. Mullis. He got Nobel prize in 1993 for chemistry. In 1983, first artificial chromosome was synthesized.
1985 – 90	- Use of monoclonal antibodies in diagnosis of disease - Human genome project started - Use of genetic engineered growth hormone in the treatment of dwarfism.
1997	- Development of cloned sheep Dolly by Ian Wilmut and coworkers. Sequencing of yeast genome completed.
2000	- Cloning of human embryo by advanced cell technology company, America. - Genome sequencing of *Arabidopsis* plant complete.
2001	- First genomic map of rice complete.
2003	- Human genome sequence complete.
2010	- Researchers of J. Craig Venter Institute-Synthesized first artificial cell.
2010	- First Clinical trial of stem cell obtained from human embryo in treatment o f spinal cord injury. - Death of Hargovind Khurana.
2015	- First time gene therapy was used in treatment of leukemia disease successfully (Brehus and Kasim)
2016	- Clinical trial of vaccine of zika virus was approved by Food and Drug Administration (FDA).

Techniques of Biotechnology

Plant tissue culture

Animal tissue culture

Plant genetic engineering

Animal genetic engineering

Production of mono clonal antibodies

Recombinant DNA technology

Embryo transfer in animals

DNA nanotechnology

Besides the above mentioned technology,

biotechnology is also used in following areas.

At present, two terms "Traditional Biotechnology" and "Modern Biotechnology" are popular in the field of biotechnology. The Areas of biological control and food fermentation technology comes under traditional biotechnology category. While the study of recombinant DNA technology, Monoclonal antibodies technology, genetic engineering are part of modern biotechnology. These technologies are complicated and relatively expensive.

Major techniques of modern Biotechnology are as follows –

Biosensor

Biosensors are bio-derived products (such as tissues, microbes, cell, organelles, cell receptors, enzymes, antibodies, nucleic acids etc.) which interact with analytics. It means biosensors are complexes of bio-substances which turns chemical and olfactory sensation into electrical signals. with the help of transducer device.

The common example of commercial biosensor is blood sugar biosensor, which breaks or degrade the blood sugar by glucose oxidase enzymes.

There are many applications of biosensors. Some of them are as follows :

1. Glucose monitoring in diabetic patients and other medicinal uses.
2. In the field of environment like-detection of pesticides and water pollutant in river water.
3. In preventing the bio-terrorism activities by remote sensing of aerobic bacteria.
4. In the field of protein engineering.
5. In identification of pathogen.

Many types of bio sensor are found on the basis of function and nature such as – fluorescent glucose biosensor, DNA biosensor, ozone biosensor, microbiology biosensor, nano biosensor, metastatic cancer cell biosensor etc.

Biochips

Biochips are also known as DNA chip or DNA microarray. Biochip is a collection of small DNA molecules which are immobilized on a solid base. This technique is used by scientists to measure the multiple gene expression levels at a time.

Stephen P.A. Fodor and collegues in 1991 developed the first DNA gene chip.

Substrate of biochip is made of silica quartz, soda glass, plastic etc. They are being chosen according to the requirement of experiments on the basis of their chemical structures and physical properties.

Gene chips – It is a micro chip on which probe DNA (Complementary DNA) spots are stabilized which derived from double stranded DNA and which are able to identify the samples used for analysis.

Micro array is of following types-

(A) DNA microarray – Its size is even smaller than stamp. Approximately 4 lakh cells are spotted on glass substrate; in each cell a small spot of DNA is found. In each micro spot-single stranded DNA sequences of various genes are present.

(B) Protein Microarray – It is a technique based on microorgan engagement measurement. which depends on the products formed by the target. molecules and stable molecules in the solution.

This technique is used in study of nucleic acid protein, protein-protein, attached receptor, medicine-protein target and enzyme – layer interactions.

The common example of micro array is the antibody micro array.

Biofilm

Biofilm is a combination of microbial cell that are attached and grow on the surface. This combination is covered by matrix of poly saccharides. These biofilms are made up of microbial cells and Extra Cellular Polymer Substances (EPS), and their formation can be observed in natural and modified environment. It can act as fundamental unit in processes as waste water treatment, sudden change in quality of water etc.

Biotechnology in India

Research works on biotechnology are in progress many National and International level institutes and universities of our country. Considering the importance of the applications of biotechnology and their roles in the field of human welfare, the National BioTechnology Board (NBTB) was established by the Government of India in 1982. Initially, it was under control of department of science and technology, Government of India but in 1986 an independent Department of BioTechnology – (DBT) was established looking at importance of biotechnology. Main motive of this department is to develop basic facilities at national and international level institutions, universities working in the field of biotechnology, research in national and international institutes and universities and providing grant in aid for their development.

The following are the special centers established in the field of biotechnology in India.

1. Indian Institute of Science, Bengaluru– Genetic Engineering
2. Madurai Kamraj University, Madurai
3. Bose Institute, Kolkata
4. Jawahar Lal Nehru University, New Delhi
5. Delhi University, Delhi
6. Puna University, Puna (Animal cell culture and virology)
7. National Chemical Laboratory, Pune (Plant tissue culture)
8. Indian Agricultural Research Institute, New Delhi (Plant tissue culture, photosynthesis, plant molecular biology and Agricultural information science)
9. Centre for Cellular and Molecular Biology, Hyderabad (Oncogene, cell transformation, nucleic acid and protein structure)
10. National Immunological Institute, New Delhi (Research on immunology)
11. Microbiological Institute – Enzyme Engineering

Department of Biotechnology has established eleven Distributed Information Centre and fifty sub distributed information centre in various institutes and universities. The main objective of these centres is to provide help and support to institutions, groups and scientists. At present these centres and sub centres are providing training related to information technology by conducting workshops.

Biotechnology Department of India started many projects for germ plasm collection, conservation and reestablishment of germ plasm.

(i) National Bureau of Plant Genetic Resources – (NBPGR), New Delhi National facility for plant tissue culture repository for germ plasm conservation of cloned crops.

(ii) Central Institute of Medicinal and Aromatic Plants (CIMAP) Lucknow - For conservation of germ plasm of medicinal and aromatic plants.

(iii) Tropical Botanical Gardens and Research Institute (TBGRI) Trivandrum-Gene bank established.

(iv) National Bureau of Plant Genetic Resources (NBPGR) New Delhi-Gene bank established.

At these centres, besides seed and field banks some facilities like plant tissue culture, repository and cryo-preservation are also available. The universities, research centres and institutes which are funded, supported and established by Department of Biotechnology include those carrying research work in field of medical biotechnology, bio resources and environment, aquatic biotechnology, aquaculture and marine biotechnology.

Looking into importance of biotechnology, Rajiv Gandhi Biotechnology Centre was established in Thiruvananthapurum, Kerala and International Centre of Genetic Engineering and Biotechnology – (ICGEB), New Delhi was established by United Nations Industrial Development Organisation – (UNIDO) of United Nations Organisation (UNO) in the year 1983.

Biotechnology Parks

To provide information and counselling to

those people who want to establish biotechnology based industries, 19 biotechnology parks have been established in our country.

Looking into significance of biotechnology field establishment of more than 15 biotechnology parks is in planning phase.

Some of the established biotechnology parks are as follows :-

(i) Biotechnology Park, Lucknow (Uttar Pradesh)

(ii) Hyderabad Biotechnology Park, Hyderabad (Andhra Pradesh)

(iii) Golden Jubilee Biotech Park (Biotechnology Park) for women siruseri, Kanchipuram (Tamil Nadu)

(iv) Guwahati Biotechnology Park, Assam

(v) Biofarma – IT Park Andharua, Bhubneshwar

(vi) TICL – International Biotechnology Park, Hinjewadi, Pune

(vii) KINFRA – Biotechnology Park, Kerala etc.

Scope and Importance of Biotechnology

All aspects of human life are influenced by biotechnology, directly or indirectly. Hence, we can say that the field of biotechnology spreads from micro-organism to environment and human welfare. Important areas of biotechnology related to human welfare and environment conservation includes :

1. In the field of Medicine – Biotechnology is very important in the field of medicine at present. Various efforts and applications in the field of biotechnology are given below.

S. No.	Production	Importance
1.	Important medicines such as humulin, human growth hormone obtained from modified bacteria which is produced by genetic engineering .	Easy availability of medicine to treat related disease.
2.	Vaccine obtained from genetically engineered bacteria .	More secure and cheap than normal vaccine .
3.	Production of DNA probe from genetically modified bacteria .	In diagnosis of disease .
4.	Production of monoclonal antibodies by hybridoma technology .	To make immune system effective.
5.	Technique of gene treatment .	In treatment of genetic disease
6.	Development of food vaccine/ edible vaccine .	Safety from disease .

2. In the field of plant biotechnology – Various methods have been developed in biotechnology which are useful in multiplication of plants conservation, crop improvement and production of desirable metabolites.

Some of the important methods and their uses are given in following table –

S. No.	Methods	Uses
1.	Micro propagation.	Used in development of desired plant clones, conservation of rare plant species and in multiplication at large scale of commercially important plant.
2.	Production of somatic embryo.	Mentioned as above.
3.	Somatic clones	In production of secondary metabolites
4.	Haploid plant culture .	Develop a pure line for crop improvement.
5.	Shoot apex culture .	Development of virus free plants .
6.	Artificial seed production .	Development of capsulear round the somatic embryo.

3. In the field of animal biotechnology – Ian Wilmut and his co-workers from Rosalin Institute, Scotland on July 5, 1996 got success in developing the first clone of mammals by fusion of a nucleus obtained from breast cell of 6 year old dorset sheep with a egg cell (without nucleus) of scottish blackface sheep.

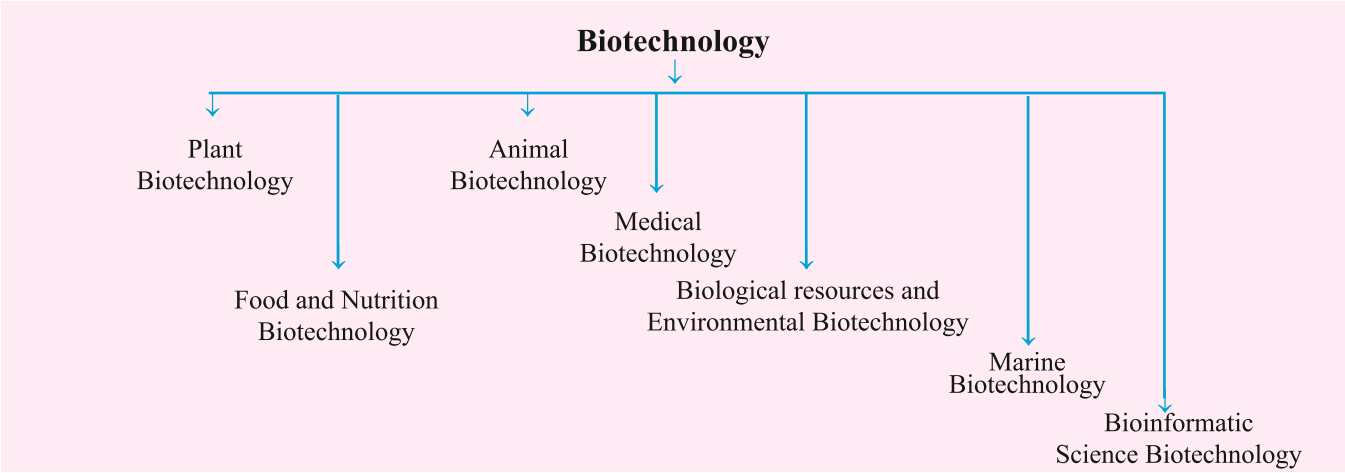
Wilmut and et. al. publilsh it in February 22, 1997 and the cloned sheep was named Dolly. This success of Ian Wilmut and his co-workers lead to many new possibilities in the field of animal cloning. Up to now more than 20 clones with desired features of useful animals have been developed.

4. In the production of commercial products– Various type of commercial product such as alcohol, acetone, glycerol, different type of organic acids, vitamins, enzymes, antibodies obtained by single cell culture, biogas etc. are produced by cell and tissue culture technology. Less useful products can be converted into more useful product with the help of biotransformation technique of cell culure.

5. In the field of environment conservation – Selected bacteria and their modified strains are being used in sewage treatment, detoxification of toxic material of industrial waste and degradation of mineral oil. Anand Mohan Chakraborty developed the strain of *Pseudomonas putida* bacteria called super bug which can control nearly three fourth of oil pollution.

Branches of Biotechnology

Different branches of biotechnology are shown in the following chart –



Important Points

1. The production of useful products for human welfare by using micro- organism, animals, plants and their biological process, is called biotechnology.
2. Biotechnology is used since ancient period for fulfillment of human needs such as use of yeast in production of bear and alcohol.

   Biotechnology is classified in two categories

   (i) Traditional Biotechnology (ii) Modern Biotechnology
3. Plant tissue culture, Animal tissue culture, Plant and animal biotechnology, DNA nano technology etc. are studied under modern biotechnology while biological control and biological processes related to fermentation of edible food are studied under traditional biotechnology.
4. A device which is made up of biological substance that change chemical and olfactory sensation into electrical signals is called biosensor.
5. P.A. Foder made first DNA gene chip.
6. Biofilm is aggregation of microbial cells which is adhesive on the water surface.
7. Government of India established "National Biotechnology Board – NBTB in the year 1982 for all works related to biotechnology.

Practice Questions

Multiple choice Questions-

1. Which of the following is not an example of traditional biotechnology.
   (A) formation of curd and cheese from milk
   (B) formation of vinegar from sugarcane juice
   (C) medicine production by recombinant DNA technology
   (D) Production of beer from sugar
2. Who used the word "Biotechnology" for the first time?
   (A) Alexander Fleming
   (B) Karl Ereky
   (C) Haberlandt
   (D) Shipra Guha Mukhrjee
3. In which year National Biotechnology Board was established by the Government of India.
   (A) 1982 (B) 1978
   (C) 1986 (D) 1990
4. Where is the Cellular and Molecular Biology centre situated in India.?
   (A) In New Delhi (B) In Hyderabad
   (C) In Pune (D) In Chandigarh
5. ICGEB is associated with which organization.
   (A) NBTB (B) UNIDO
   (C) IARI (D) ICFRE
6. Name of first clone of sheep which was developed by Ian Wilmut.
   (A) Molly (B) Dolly
   (C) Polly (D) Jolly
7. Who discovered the Bacteriophage Virus?
   (A) Theodor Ischrich
   (B) Antonie Von Leeuwenhock
   (C) K.F. Budarch
   (D) Frederich W. Wort

Very Short Answer Questions

1. Define biotechnology.
2. What do you understand by traditional biotechnology?
3. What are the differences between traditional and modern biotechnology?
4. Define biotransformation.
5. What do you understand by biotechnology park?
6. What is gene chip?

Short Answer Questions

1. Comment on –
   A. International Genetic Engineering and Bio-techonolgy centre. (ICGEB)
   B. Biochips
   C. Biosensor
   D. Biofilm
   E. Microarray
   F. Biotechnology department
   G. Biotechnology parks
   H. Biotechnology institutes in India
   I. Application of biotechnology in the field of medicines
   J. Important biotechnology parks in India
   K. Important schemes of biotechnology department
2. Mention the names of various branches of biotechnology.

Essay Type Questions

1. Write a note on development of biotechnology in India.
2. Write about various application devices of biotechnology.
3. Write a short note on biotechnology institutes and their functions.
4. Describe the different working areas and their importance of biotechnology.

Answer Key-

1. (C) 2. (B) 3. (A) 4. (B)
5. (B) 6. (B) 7. (D)