

Biotechnology: Scope and importance

A- What is Biotechnology?

The term biotechnology was coined in 1917 by a Hungarian Engineer, Karl Ereky, to describe a process for large scale production of pigs. According to him all types of work are biotechnology by which products are produced from raw materials using living organisms.

- Biotechnology is defined by different organization in different ways. It has been broadly defined as "the development and utilization of biological processes" forms and systems for obtaining maximum benefits to man and other forms of life.



- Biotechnology is the science of applied biological process (1981) .
 - * The application of biochemistry, biology, microbiology and chemical engineering to industrial process and products and on environment. (International Union of Pure and Applied Chemistry (IUPAC, 1981).
 - * Biotechnology is "the controlled use of biological agents such as microorganisms or cellular components for beneficial use (U.S. National Science Federation).

B-History of Biotechnology:

If we trace the origin of biotechnology, it is as human civilization. Development of biotechnology can be studied considering its growth that occurred in two phases:

- 1- The traditional (old) biotechnology

2- The new (modern) biotechnology.

1-THE TRADITIONAL BIOTECHNOLOGY

The traditional biotechnology is really the kitchen technology developed by using the fermenting bacteria.

Kitchen technology is as old as human civilization. During period (5000-7000 B.C), Sumerians and Babylonians were drinking the beer.

The traditional biotechnology refers to the conventional technology which have been used for many centuries. Beer, wine, cheese and many foods have been produced using traditional biotechnology which are based on the natural capabilities of microorganisms.

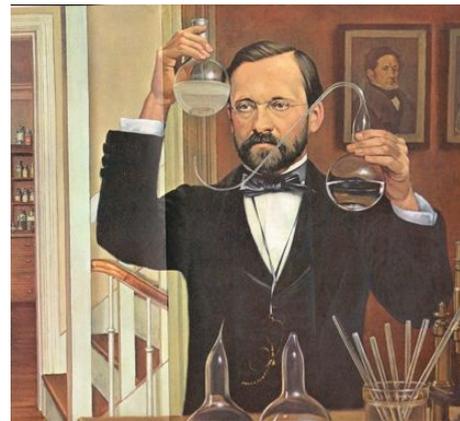
In Egypt and Palestine (about 1500 B.C.) , the art of production of wine from crushed grapes.



Role of Microorganisms in Fermentation.

The causes of fermentation could be discovered after observing microorganisms using a microscope by Antony van Leeuwenhoek (1673-1723, Holland).

- The study of microbiology was started since the first report of Louis Pasteur (1857) on lactic acid fermentation from sugar.
- Pasteur suggested that high percentage of microbial population is killed by heating the juice at 62.8 °C (145 °F) which is now called as Pasteurization.
- Robert Koch (1881) gave the method for established relationship of a pathogen with a disease using the pathogenicity test, following this technique he proved that the anthrax disease is caused by *Bacillus anthracis*.



- Edward Buchner (1897) was the first to demonstrate enzymatically-mediated fermentation reaction; he showed that cell free yeast extract mixed with concentrated sugar solution produced the carbon dioxide (CO₂) and ethyl alcohol.
- Discovery of viruses and their role in disease was possible at 1884 by Charles Chamber land.
- Emil Von Behring (1890) injected the inactivated toxin into rabbit that induced to produce antitoxin in the blood. The antitoxin inactivated the toxin and protected against the disease.

2- MODERN BIOTECHNOLOGY :

The major feature of technology differentiates the modern biotechnology from the classical biotechnology is the capability of science to change the genetic material for getting new products for specific requirement through recombinant DNA technology.

- During world war I fermentation processes were developed which produced the acetone from starch.
- During world war II the antibiotic penicillin was discovered.
- After the discovery of double helix DNA by Watson and Crick (1953), Werner Arber (1971) discovered special enzyme in bacteria which he called the Restriction enzymes. These enzymes can cut the DNA strand and generate fragments.
- In 1973, S. Cohen and H. Boyer removed a specific gene from a bacterium and inserted into another bacterium using restriction enzymes. This discovery marked the start of recombinant DNA technology or genetic engineering.
- In 1978, a U.S company "Genetech" used genetic engineering technique to produce human insulin in *E.coli* (*Escherichia coli*)

- In 1996, the first clone lamb "Dolly" was borne successfully by Scotland scientists.
- In 2001, the sequence of the Human Genome was published in Nature and science. Human Genome Project was completed by March 2003.
- Many biochemical companies such as Genetech Co. (USA) and Biogen (Switzerland) are producing of growth hormones, insulin, vaccines, immunogenic proteins, gene therapy , biofertilizers, Enzymes, antibiotics, acid and fuels.



Dolly - the first mammalian Clone

The key difference between biology and biotechnology is their scale of operation. Usually the biologist works in the range of nanograms to milligrams but biotechnologists working on the production of vaccine may be satisfied with milligram –kilogram or tones (Smith 1996).

This led the evolution of biotechnology which is an outcome of integrated effort of biology with technology, the root of which lies in biological science (fig-1).

Following are some of the areas where biotechnology has done the best. (table – 1).

1- Health care:

Biotechnology derived proteins and polypeptides (such as insulin) from the new class of potential drugs.

Since 1982, human insulin (Humulin) has been produced by microorganisms in fermenters, similarly hepatitis B vaccines are genetically engineered vaccines produced biotechnologically.

Some of the important products produced through genetically modified organisms are given in the table – 2.

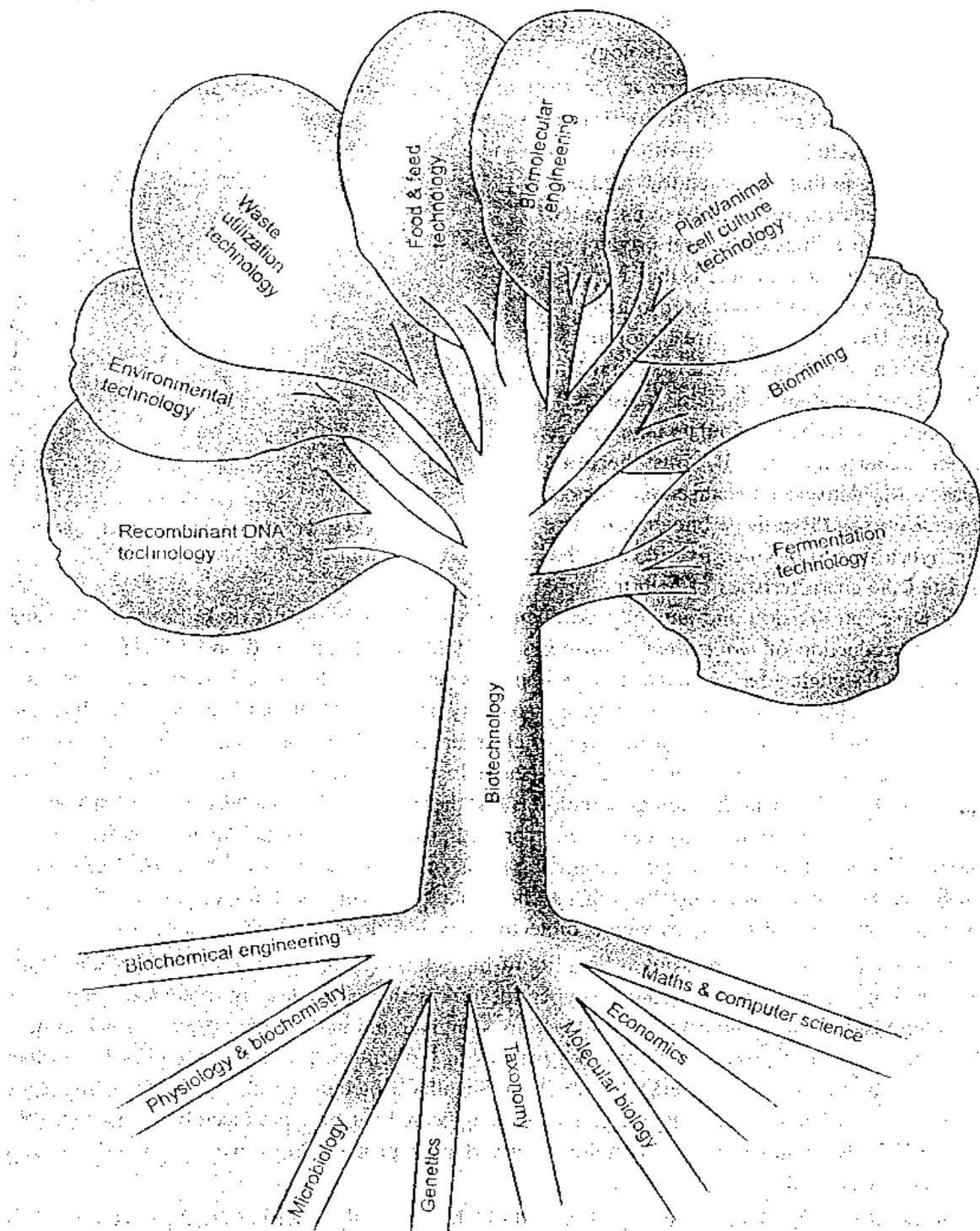


Fig. 1. A Biotechnology tree.

Table – 1 Area of biotechnology.

Area of interest	Products
1. Recombinant DNA technology (genetic engineering)	Fine chemicals, enzymes, vaccines, growth hormones, antibiotics, interferon.
2. Treatment and utilization of bio-materials (biomass)	Single cell protein, mycoprotein, alcohol and biofuels.
3. Plant and animal cell culture	Fine chemicals (alkaloids, essential oils, dyes, steroids), somatic embryos, encapsulated seeds, interferon, monoclonal. antibody
4. Nitrogen fixation	Microbial inoculants (biofertilizers)
5. Biofuels (bioenergy)	Hydrogen (via photolysis;), alcohols (from biomass), methane (biogas produced from wastes and aquatic weeds).
6. Enzymes (biocatalysts) chemotherapy	Fine chemicals, food processing, biosensor
7. Fermentation	Acids, enzymes, alcohols, antibiotics, fine chemicals, vitamins, toxins (biopesticides).
8. Process engineering	Effluent, water recycling, product extraction, novel reactor' harvesting.

Table – 2 :Example of some therapeutic products produced through recombinant DNA Technology

Products	Application
Interferon	Cancer and Viral infection
Human urokinase (tPA)	Plasminogen activator used in vascular disorder
Insulin	Treatment of diabetes
Human factor IV	Clotting factor for hemophilia
Lympholines	Auto-immune functioning
Serum albumin	In surgery
Attenuated pseudorabies virus antigen	Vaccine against rabies
Tissue plasminogen activator	In treatment of heart attack
Somatosatin	Treatment of Human growth disorder

2- Agriculture :

Biotechnology is making new ground in the food agriculture area.

Bovine somatotropin, BST (a hormone administered to cows to increase milk production) is an example of biotechnology product.

- The Flavrsarv[™] tomato (produced by transgenic plants engineered to preserve flavor and quality).
- A transgenic "Golden rice" has been produced by introducing three genes for the production of vitamin A.
- Several insect resistant transgenic Bt plant have been produced by Bt gene of *Bacillus thuringiensis*.

3- **Human Genome project (HGP):** Almost the whole human genome has been sequenced and chromosome map has been developed in laboratories. Human chromosome mapping was completed by March 2003. There are about 33,000 functional genes in human. More than 97% genes are non-functional (that do not encoded for any polypeptide chain.)

4- **Environment:** The natural biodegradability of pollutants present in environment has increased with use of biotechnology.

Bioremediation: Is the use of microorganisms (such as *Bacillus*, *Candida* and *Trichoderma*) to detoxify pollutants present in soil or water.

5- Genomics and proteomics:

Genomic: computer-based study and designing of genome.

Proteomic: Study of proteins present on genome of organism using computer.

6- **Bioinformatics:** It is a new field of biotechnology linked with information technology.

Bioinformatics: may be defined as application of information sciences (mathematics, statistics and computer sciences) to increase the understanding of biology, biochemistry and biological data.