BIOTECHNOLOGY& GENETIC ENGINEERING

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What Is Biotechnology and What Does It Mean to You?

• **Biotechnology** – using living organisms, or the products of living organisms, for human benefit to make a product or solve a problem(for commercial purposes).

• **Historical Examples:**

– Fermentation

– Selective breeding

– Use of antibiotics

A narrower and more specific definition of **biotechnology** is "the commercial application of living organisms or their products, which involves the deliberate manipulation of their DNA molecules "

"**Any technological application that uses biological systems, living organisms, or derivatives, to make or modify products or processes for specific use '**

Plant, animal and microbes have been used by humans for nutrition and development of products for consumption such as beer or bread. Technological development has also allowed exploiting plant, animal and microbial to provide products of commercial or pharmaceutical importance. All these activities (research and development) fall under the big umbrella of biotechnology.

In simpler word, **Biotechnology** is the summation of activities involving technological tools and living organism in such a way that it will enhance the efficiency of the production. The final goal of this field is to improve the product yield from living organism either by employing principles of bio-engineering/bioprocess technology or by genetically modifying the organisms. For example, production of bread or other bakery items from wheat flour after adding yeast as fermenting organism, we note the increase in volume of the dough after fermentation and formation of pores in cross section of bread .

Yeast mixed in dough utilizes sugar present in it and produces CO_2 through fermentation; exit of gas causes formation of pores and is responsible for sponginess of bread .

• **Modern Examples**

– Gene cloning

– Genetic engineering

– Recombinant DNA technology

– Human Genome Project

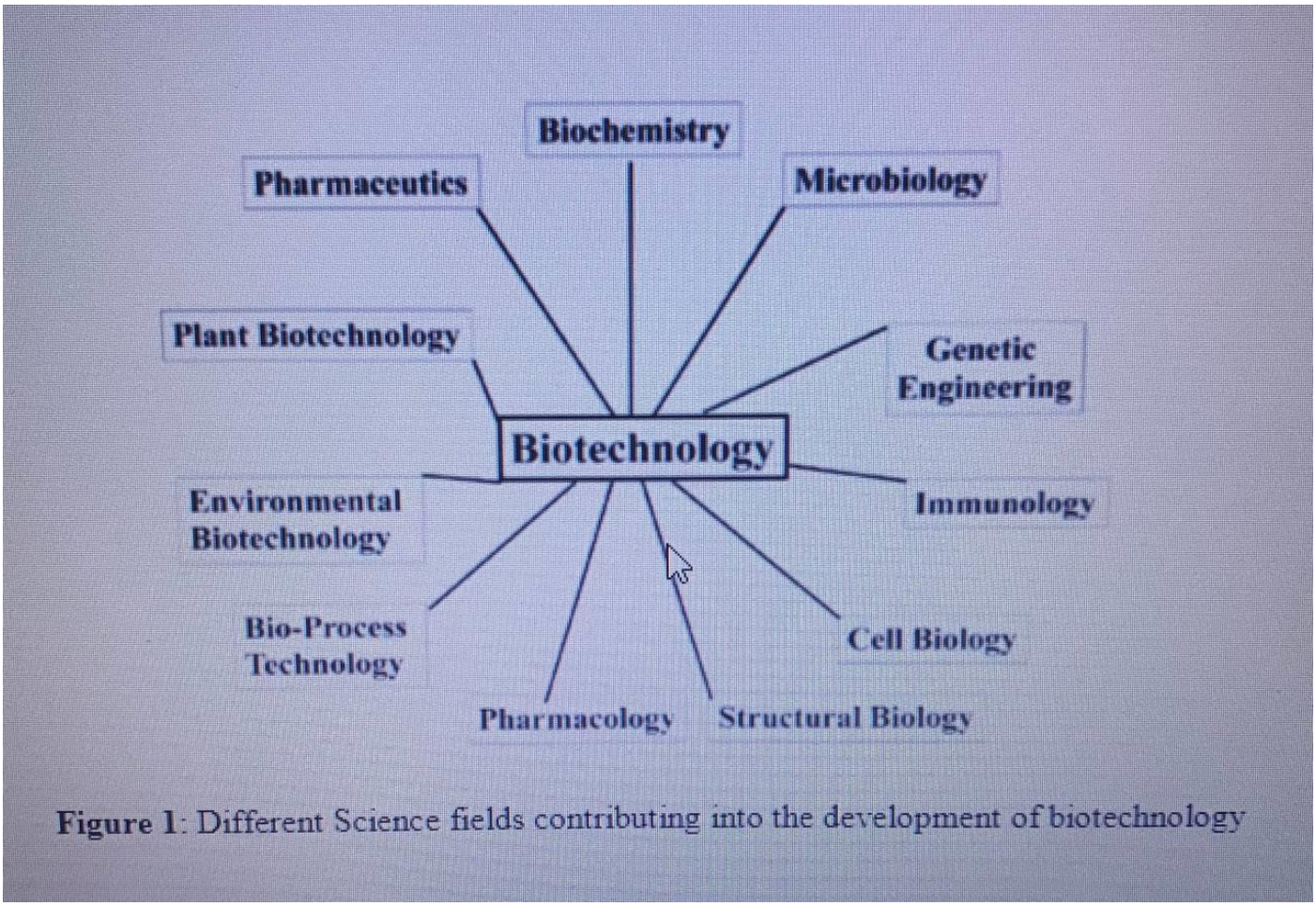

Figure 1: Different Science fields contributing into the development of biotechnology

Types of Biotechnology

- Microbial Biotechnology
- Agricultural Biotechnology
- Animal Biotechnology
- Forensic Biotechnology
- Bioremediation
- Aquatic Biotechnology
- Medical Biotechnology
- Regulatory Biotechnology

Historical Advancement of Biotechnology

Biotechnology related activities depend on two parameters: technological advancement and knowledge of available biota .

Biotechnology starts as early as human have realized the importance of organism (animal/plants or microbes) to improve their life-style. The earliest biotechnology related activities are selection and cross breeding of high yielding animals, cross breeding of plants to acquire specific phenotype and preserving the seeds of high yielding crop plant for next sowing season .

These were few initial scientific experiments and based on the results, human have made significant modification in available biota. In last century, the systematic and scientific study of living objects with advanced technology has given immense potential to human imagination to either genetically manipulate living organism with desired phenotype or the same metabolic reactions in an invitro system (either in test tube or in cells) to produce molecules with therapeutic importance. Such as "Humulin" is the insulin being produced in bacterial expression system and it is now been making life of millions of diabetic patients easier.

Similarly during this era, drought, pest or abiotic resistant plants, high milk yielding animals, transgenic bacteria to produce biofuel, degrade environmental hazard or chelation of heavy metal have been developed.

Table 1: A systematic chronological description of biotechnological advancement over the course of different time periods

7000 BC-100CE	- Discovery of fermentation . - Crop rotation as a mechanism to improve soil fertility. - Animal and plant products as a source of fertilizer and insecticide respectively .
Pre-20th Century	- Identification of living cell and bacteria - Discovery of small pox vaccine, rabies vaccine. -Process development to separate cream from milk, - Discovery of artificial sweetners, "invertase". - Discovery of DNA and chromosome responsible for genetic traits.
20th Century	-Discovery of Penicillin. - 3-D Structure of DNA. - Production of human insulin in bacteria "Humulin". - Discovery of PCR. -Gene therapy. -Procedure for artificial insemination and test-tube baby. - Cloning of first mammal "Dolly"
21st Century	-Vertebrate, invertebrate and bacterial genome sequences. - Completion of Human Genome sequence. - Sequencing of Rice genome. -Discovery of Nano radio.

Advantages and disadvantages of biotechnology

Advantages

1- Transgenic organisms with high yield and high level products.
2- Production of genes and specific DNA probes for diagnosis.
3- Production of human genes, proteins, enzymes for treatment human difficult diseases.
4- Production of hybrid antibiotics, monoclonal antibiotics and bio-receptor.
5- Establishment of bank for recombinant DNA, nucleic acid and proteins.
6- Development new technologies such as nonotechnology and nanoparticals, smart antibiotics and drugs .

In addition to these big advantages of modern biotechnology, there are other advantages in related to the same process of biotechnology .

1- Production: - processes occurred under fair condition PH, temperature, and pressure; it means low coast manufacture conditions comparing with chemical processes which occurred under high coast conditions.
2- Bio-catalystic enzymes: - in biotechnology are very specific, most of raw materials were consumed, little intermediated toxic products and simple removed at the end of process. Whereas chemo-catalysts are less specific, expensive, many toxic intermediated products and difficult to remove from the end product.
3- Cheap available raw materials used in biotechnology and mostly low cost agricultural, food, industrial and public service wastes. While in chemotechnology expensive and pure chemicals must be used.
4- Usually the low cost and non dangerous water used as solvent in biotechnology, while expensive and dangerous organic solvents used in chemotechnology.
5- Preparations, and equipments and processing steps in biotechnology are simple with in short time, while chemical process depends on difficult steps and time-consumption methods.

On the other hand, there are **two main disadvantages** may be faceted with them when we dealing with biotechnology process :

1- Process and product may be exposed to the contamination and we will lost whole batch. So it's so necessary biotechnology process should be occurred under very strict sterile condition.
2- Biotechnology, particularly genetic engineering biotechnology need high efficient staff and high level laboratories and high grade instruments for strain improvement, purification and safety assessment etc. In our under- development countries it is so difficult to provide such requirement if not impossible. **In other words**: it needs very high quality technicians and laboratories to apply such dangerous and high quality technology.

Definitions

- **Agrobacterium**: - A natural bacterium that can be used to transfer DNA genes into broadleaf plants, such as tobacco, tomato, or soybean.
- **Chromosome**: - A cellular structure comprised of a long, folded DNA molecule and protein.
- **DNA**: - deoxyribonucleic acid, the substance within cells that carries the "recipe" for the organism and is inherited by offspring from parents.
- **DNA fingerprinting**: - cutting a DNA chromosome with restriction enzymes and separating the pieces by electrophoresis to generate a unique pattern, the "fingerprint" for each species, breed, hybrid, or individual, depending on which enzymes and probes are used.
- **Electrophoresis**: - a lab technique for determining DNA fragment sizes by separating them in a gel placed in an electric field.
- **Gene:** - is the linear DNA sequence required to produce a functional RNA molecule, or a single transcriptional unit.
- **Genetic code**: - the information contained in DNA molecules that scientists describe on the basis of a 4-letter alphabet (A, C, G, and T).
- **Genetic engineering**: - the process of transferring DNA from one organism into another that results in a genetic modification; the production of a transgenic organism.
- **Genetic map**: - the locations of specific genes along a chromosome marked with probes.
- **Genome**: - the entire DNA "recipe" for an organism, found in every cell of that organism.
- **Mutation**:- a change of one of the "letters" in the DNA "recipe" caused by chemicals, ultraviolet light, X-rays, or natural processes.
- **Plasmid**: - a small, circular DNA that is used to transfer genes from one organism into another.
- **Probe**: - a very short piece of DNA used to find a specific sequence of "letters" in a very long piece of DNA from a chromosome or genome.
- Recombinant DNA: - DNA formed by joining pieces of DNA from two or more organisms.
- **Sequence**: - the order of "letters" in the DNA "recipe." The DNA sequence is the chemical structure that contains information.
- Transformation: - a procedure to transfer DNA into the cells of an organism.
- **Transgenic**: - an organism that has been modified by genetic engineering to contain DNA from an external source.
- **Vector**: - any DNA structure that is used to transfer DNA into an organism; most commonly used are plasmid DNA vectors or viruses.