

## Learn the key concepts of Science topic - Biotechnology

Today we will be discussing about biotechnology and see how it can have various uses of organisms to produce useful products. Then, we'll take a closer look at applications of it. So let's start.

Biotechnology is a multidisciplinary field which has a major impact on humankind. This technology has been known since time immemorial. It is concerned with the working of cells or cell- originated molecules for various applications. The term "biotechnology" which is often referred to as "biotech," was first used by Hungarian engineer Karl Ereky in 1919. It means the production of products from raw materials with the aid of living organisms. He was also known as the father of biotechnology. The European Federation of Biotechnology has given the definition of biotechnology as follows: "Biotechnology is the integration of natural science and organisms, cells, parts thereof, and molecular analogues for products and services."

## History of biotechnology

Biotechnology has existed for thousands of years from an era when humans first learned to produce bread, beer, and wine using the natural process of fermentation. For many past years, the principles of biotechnology were restricted to agriculture, such as harvesting better crops and increasing yields by using good seeds and breeding livestock. Some of the important spotlights are mentioned below:

### Principles of Biotechnology:

Today modern biotechnology is based on two major techniques that are namely:

**(i) Genetic engineering:** Genetic engineering is the manipulation of an organism's gene by the utility of biotechnology that is used to alter the genetic framework of the cell. The combination of technologies are used for the genetic framework of the cells that includes the transfer of genes in the species limits for the fabrication of improved organisms called clones resulting in gene cloning.

**(ii) Maintenance of a sterile environment in chemical engineering:** It aids in the growth of only those microorganisms that are needed and this procedure helps in the development of vaccines, antibiotics, drugs, etc.

**Basic Principles of Biotechnology:** Genetic engineering consists of the isolation and introduction of only those genes into an organism that are desired and eliminates the undesirable genes. The steps included in genetic engineering are as:

1. Development of recombinant DNA (rDNA).
2. Cloning of the desired gene.
3. Transfer of the cloned gene into the suitable organism.

## Tools for genetic engineering

**Origin of replication (ori):** It is a section of DNA sequence which is acknowledged by a cell's DNA replication proteins that allows initiation of new DNA synthesis. The foreign DNA that is inserted into the Host organism requires to be connected to the origin of relocation and this results in the development of multiple copies of the DNA while if the foreign gene is not attached to the origin of replication then it may not result in the multiplication of DNA.

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**Antibiotic resistance gene:** In the case of some specific microbes, there are several genes that have the ability to grow in the presence of specific antibiotics while the genes give resistance against them. These genes are generally located on the plasmids and are used in the cloning and transformation process.

**Restriction Enzymes:** The restriction enzymes are responsible for the cutting of DNA Fragments at specific sites. They are also known as “molecular scissors”. These enzymes chop the DNA at a particular site which is specific for each restriction enzyme. They aid in the process of cutting the tranquilized gene which is then inserted into the specific sites of the host. These enzymes cut DNA fragments at their particular Recognition sequences.

**Recognition sequences:** This sequence is the bases of the DNA sequence that are specific for each restriction enzyme and act as the site for restriction or cutting resulting in the formation of the palindromic sequences.

There are two types of restriction enzymes- Endonucleases and Exonucleases.

**Endonucleases:** are responsible for the cutting of DNA from the middle. Examples of restriction endonucleases are ECoR1, Hind III, etc. Each endonuclease characterized the restriction site by a specific recognition sequence. Restriction endonucleases are responsible for identification of the specific palindromic nucleotide sequence in the DNA.

**Vectors:** A vector is any vehicle like virus or plasmid that is used to transport a desired DNA sequence into a host cell as part of a molecular cloning process. The four main types of vectors are plasmids, viral vectors, cosmids, and artificial chromosomes. Out of these, the most commonly used vectors are plasmids.

**Host organism:** where the recombinant DNA is introduced. The host organism is the ultimate tool of recombinant DNA technology that takes in the vector engineered with the desired DNA with the help of the enzymes. There are various ways in which these recombinant DNAs are inserted into the host namely microinjection, biolistics or gene gun, alternate cooling and heating, use of calcium ions, etc..

## Applications of biotechnology

Biotechnology is a technology that uses biological systems, living organisms or parts to develop or create useful products. Biotechnology deals with industrial scale construction of biopharmaceuticals and biologicals using genetically modified Microorganisms, fungi, plants and animals. The applications of biotechnology consist of therapeutics, diagnostics, and genetically modified crops for agriculture, processed food, bioremediation, waste treatment, and energy production.

**Genetically Modified Organisms (GMO):** Plants, bacteria, fungi and animals whose genes have been altered are called Genetically Modified Organisms (GMO). GM plants have a variety of uses. The Genetic modification has advantages such as:

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- Crops made are more tolerant to abiotic stresses (cold, drought, salt, heat).
- Decreased reliance on chemical pesticides (pest-resistant crops).
- Aided to decrease post-harvest losses.

**Genetically modified bio-pesticide:** Bt toxin is produced by a bacterium known as *Bacillus thuringiensis* (Bt for short).

**Pest resistant plants:** Various nematodes parasite a wide variety of plants and animals including human beings.

A nematode *Meloidogyne incognita* infects the roots of tobacco plants and causes a great loss in yield. A brilliant strategy was adopted to prevent this infestation based on the process of RNA interference (RNAi). RNAi takes place in all eukaryotic organisms as a technique of cellular defense. This technique includes silencing of a specific mRNA due to a complementary dsRNA molecule that binds to and prevents translation of the mRNA (silencing).

**Medicine:** The recombinant DNA technology processes have made a deep impact in the area of healthcare. It aids in mass production of safe and more effective therapeutic drugs. The recombinant therapeutics do not induce undesired immunological responses.

**Genetically Engineered Insulin:** Management of adult-onset diabetes is attained by taking insulin regularly. Insulin consists of 2 short polypeptide chains: chain A and chain B which are linked together by disulphide bridges. In mammals including humans, insulin is manufactured as a prohormone. The pro-hormone also requires to be processed before it becomes a fully mature and functional 93 hormone which consists of an extra stretch known as the C peptide.

**Diagnosis of HIV:** PCR is an important technique to identify many dangerous genetic disorders. Polymerase Chain Reaction (PCR) is presently regularly used to detect HIV in suspected AIDS patients. It is being used to check on the mutations in genes in suspected cancer patients also.

**ELISA** is based on the principle of antigen-antibody interaction. Infection caused by pathogens can be detected by the presence of antigens like proteins, glycoproteins, etc. or by detecting the antibodies developed against the pathogen.

**CRISPR Technology:** CRISPR technology is a simple and vital tool for editing genomes. This tool permits scientists to easily alter DNA sequences and modify gene function. CRISPR-Cas9 was developed from a naturally occurring genome editing system in bacteria. The bacteria seize fragments of DNA from invading viruses and utilize them to create DNA segments known as CRISPR arrays. The CRISPR arrays permit the bacteria to remember the viruses. If the viruses attack again, the bacteria produce RNA fragments from the CRISPR arrays that target the viruses' DNA. CRISPR technology is used on a wide variety of diseases, including single-gene disorders such as cystic fibrosis, hemophilia, and sickle cell disease.

**Transgenic Animals:** Transgenic animals are those animals whose DNA is manipulated to possess and express an extra foreign gene. Transgenic rats, rabbits, pigs, sheep, cows and fish have been created.

**Normal physiology and development:** Transgenic animals are designed to help in the study of how genes are regulated, and how they affect the functions of the body and its development. For example, study of complex factors involved in growth such as insulin-like growth factors.



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## Biotechnology in India

The Department of Biotechnology under the Ministry of Science and Technology controls most of the programmes of the biotechnology sector in India. The main goals of this section are:

1. To deliver services in the areas of research, infrastructure, generation of human resource, popularization of biotechnology, promotion of industries etc.
2. Implementation of biosafety guidelines for genetically modified organisms, recombinant DNA products and biotechnology-based programs for societal profits.
3. To build an information network for the Bioinformatics mission of India in the scientific community, nationally as well as internationally.

**Genetic Engineering Appraisal Committee:** The Genetic Engineering Appraisal Committee is apex biotechnology regulatory body in India. The GEAC works under the Ministry of Environment, Forest and Climate Change (MoEF&CC). This committee is responsible for the appraisal of activities that include large-scale use of dangerous microbes and recombinants in research and industrial production from the environmental angle. The committee is also responsible for the appraisal of proposals connecting to the release of genetically engineered organisms and products into the environment which contains experimental field trials.

Application of biotechnology is a major tool for development all over the world. Intertwined with culture and socio-ethical values, biotechnology could be useful in solving future problems like food and water insecurity that obstruct national development and threaten peace in the developing world. This was all about biotechnology and its applications. Hoping all your doubts are clear. Stay tuned.