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Introduction:

The term '**biotechnology**' was used before the twentieth century for traditional activities such as making dairy products such as cheese and curd, as well as bread, wine, beer, etc. But none of these could be considered biotechnology in the modern sense. Genetic alteration of organisms through selective breeding, plant cloning by grafting, etc. do not fall under biotechnology. The process of fermentation for the preparation and manufacturing of products such as alcohol, beer, wine, dairy products, various types of organic acids such as

vinegar, citric acid, amino acids, and vitamins can be called **classical biotechnology** or traditional biotechnology. **Fermentation** is the process by which living organisms such as yeast or bacteria are employed to produce useful compounds or products.

Modern biotechnology is similar to classical biotechnology in utilizing living organisms. So what makes modern biotechnology modern? It is not modern in the sense of using various living organisms, but in the **techniques for doing so**. The introduction of a large number of new techniques has changed the face of classical biotechnology forever. These modern techniques, applied mainly to cells and molecules, make it possible to take advantage of the biological process in a very precise way. **For example**, genetic engineering has allowed us to transfer the property of a single gene from one organism to another. But before going into

the details of biotechnology and the techniques that make it possible, let us first define biotechnology.

Definition of Biotechnology:-

There are several definitions for biotechnology. One simple definition is that it is the commercialization of cell and molecular biology. According to United States National Science Academy, biotechnology is the **"controlled use of biological agents like cells or cellular components for beneficial use"**. It covers both classical as well as modern biotechnology. More generally, biotechnology can be defined as **"the use of living organisms, cells or cellular components for the production of compounds or precise genetic improvement of living things for the benefit of human"**. Or **"the use of living organisms to process foods**

and make other products that are useful to humans is what we generally refer to as "biotechnology." Even though biotechnology has been in practice for thousands of years, the technological explosion of the twentieth century, in the various branches of sciences physics, chemistry, engineering, computer application, and information technology revolutionized the development of life sciences, which ultimately resulted in the

evolution of modern biotechnology.

Supported by an array of biochemical, biophysical, and molecular techniques besides engineering and information technology, life scientists were able to develop new drugs, diagnostics, vaccines, food products, cosmetics, and industrially useful chemicals. Genetically-altered crop plants, which can resist the stress of pests, diseases, and environmental extremes were developed.

Why Needs of Biotechnology:-

Naturally occurring animal, plant or microbial strains have few limitations for them to be utilized for desired products due to following reasons-

1. Purity of the living stock

2. Production of undesired products

3. Secretion of toxic metabolic by-products

4. Inability to withstand harsh biochemical processes/treatments.

5. Higher production cost

6. Susceptible to disease and other environmental conditions.

The existing technology today enables us to engineer plants and animals making them suitable for maximum production. Living organism has a complex cellular structure, metabolic pathways, genetic make-up, and behavior in the synthetic growth media and understanding these processes can help us to modulate specific process/environmental condition or metabolic pathways to achieve the goal of biotechnology.

Few of the selected science research areas contributing into the development of biotechnology are given in the Figure 1.2. The foundation of biotechnology relies on the research & development activities in different areas of science and interaction of interdisciplinary areas. The research in the field of plant biotechnology allowed us to produce plants through micro-propagation but with the evident advancement of genetic engineering, it is now possible to produce plant with predefined characteristics imprinted at genetic level through genetic engineering. The similar relationship may also exist for many other overlapping areas and as a result biotechnological operation output is amplified several folds.

HISTORICAL PERSPECTIVES:

Biotechnology as a science is very new (about 200 years old) but as a technology it is very old. The word biotechnology, first used in 1917, refers to a large-scale fermentation process for the production of various types of industrial chemicals.

But the roots of biotechnology can be traced back to pre-historical civilizations, such as Egyptian and Indus valley civilizations, when man learned to practice agriculture and animal domestication. Even before knowing about the existence of microorganisms, they had learned to practice biotechnology.

The History of Biotechnology

5000 BC Indus and Indo-Aryan civilizations practiced biotechnology to produce fermented foods and medicines and to keep the environment clean. **4000 BC** Egyptians used yeasts to make wine and bread.

1750 BC The Sumerians brewed beer.

250 BC The Greeks used crop rotation to maximize crop fertility.

1500 AD The Aztecs made cake from spirulina.

1663 Robert Hook first described cells.

1675 Microbes were first described by Anton Van Leeuwenhock.

1859 Darwin published his theory of evolution in *'The Origin of Species.'*

1866 Gregor John Mendel published the basic laws of genetics.

1869 DNA was isolated by Friederich Miescher.

1910 Genes were discovered to be present in chromosomes.

1917 The term 'biotechnology' was used to describe fermentation technology.

1928 The first antibiotic, penicillin, was discovered by Alexander Flemming.

1941 The term 'genetic engineering' was first used.

1944 Hereditary material was identified as DNA.

1953 Watson and Crick proposed the double helix structure of DNA.

1961 Deciphering of genetic code by M.Nirenberg and H.G. Khorana.

1969 The first gene was isolated.

1973 The first genetic engineering experiment was carried out by Walter Gilbert.

1975 Creation of the first hybridomas.

1976 The first biotech company.

1978 World's first 'test-tube baby,' Louise Brown, was born through *in vitro* fertilization.

1981 The first gene was synthesized. The first DNA synthesizer was developed.

1982 The first genetically engineered drug, human insulin, produced by bacteria, was manufactured and marketed by a U.S. company. Production of the first monoclonal antibodies for diagnostics.

1983 The first transgenic plant was created—a petunia plant was genetically engineered to be resistant to kanamycin, an antibiotic.

1983 The chromosomal location of the gene responsible for the genetic disorder, Huntington's disease, was discovered leading to the development of genetic screening test.

1985 DNA fingerprinting was first used in a criminal investigation.

1986 The first field tests of genetically-engineered plants (tobacco) were conducted.

1990 Chymosin, an enzyme used in cheese making, became the first product of genetic engineering to be introduced into the food supply.

1990 Human genome project was launched.

1990 The first human gene therapy trial was performed on a four-year-old girl with an immune disorder.

1991 The gene implicated in the inherited form of breast cancer was discovered.

1992 Techniques for testing embryos for inherited diseases were developed.

1994 First commercial approval for transgenic plant by the U.S. government.

1995 First successful xenotransplantation trial was conducted, transplanting a heart from a geneticallyengineered pig into a baboon.

1996 First commercial introduction of a 'gene chip' designed to rapidly detect variances in the HIV virus and select the best drug treatment for patients.

1996 Dolly, the sheep was cloned from a cell of an adult sheep.

1998 Embryonic stem cells were grown successfully, opening new doors to cell- or tissue-based therapies.

1999 A U.S. company announced the successful cloning of human embryonic cells from an adult skin cell.

1999 Chinese scientists cloned a giant panda embryo.

1999 Indian scientists and companies started producing recombinant vaccines, hormones, and other drugs.

2002 The draft of human genome sequence was published.

APPLICATION AND IMPORTANCE OF BIOTECHNOLOGY:

In the past, biotechnology concentrated on the production of food and medicine. It also tried to solve environmental problems. In the nineteenth century, industries linked to the fermentation technology had grown tremendously because of the high demand for various chemicals such as ethanol, butanol, glycerin, acetone, etc.

The advancement in fermentation process by its interaction with chemical engineering has given rise to a new area—the bioprocess technology.

Large-scale production of proteins and enzymes can be carried out by applying bioprocess technology in fermentation. Applying the principles of biology, chemistry, and engineering sciences, processes are developed to create large quantities of chemicals, antibiotics, proteins, and enzymes in an economical manner.

Bioprocess technology includes media and buffer preparation, upstream processing and downstream processing.

Upstream processing provides the microorganism the media, substrate, and the correct chemical environment to carry out the required biochemical reactions to produce the

product. Downstream processing is the separation method to harvest the pure product from the fermentation medium. Thus, fermentation technology changed into biotechnology, now known as classical biotechnology. Now if we look at biotechnology, we find its application in various fields such as food, agriculture, medicine, and in solving environmental problems.

This has led to the division of biotechnology into different areas such as agricultural biotechnology, medical or pharmaceutical biotechnology, industrial biotechnology, and environmental biotechnology.

Modern biotechnology is mainly based on recombinant DNA (rDNA) and hybridoma technology in addition to bioprocess technology. rDNA technology is the main tool used to not only produce genetically-modified organisms, including plants, animals, and microbes, but also to address the fundamental questions in life sciences.

In fact, modern biotechnology began when recombinant human insulin was produced and marketed in the United States in 1982. The effort leading up to this landmark event began in the early 1970s when research scientists developed protocols to construct vectors by cutting out and pasting pieces of DNA together to create a new piece of DNA (recombinant DNA) that could be inserted into the bacterium, *e. coli* (transformation). If one of the pieces of the new DNA includes a gene for insulin or any other therapeutic protein or enzyme, the bacterium would be able to produce that protein or enzyme in large quantities by

applying bioprocess technology.

Another way of preparing human therapeutic proteins, vaccines, and diagnostic proteins is by hybridoma technology.

The first hybridoma experiments were carried out in 1975. In hybridoma technology, a Blymphocyte secreting antibody against a specific antigen is fused with a myeloma cell. The resulting (a-cancerous B-lymphocyte) cell, if injected into a mouse's abdomen or if cultured in a bioreactor by applying bioprocess technology, will grow and divide indefinitely, producing large quantities of the antibody, which can then be harvested. The resulting proteins are called monoclonal antibodies (MAb) and are most often used in diagnostic kits. The most famous MAb-containing diagnostic kit is the pregnancy test.

In agriculture, rDNA technology can be used to produce new varieties of crop plants with improved agricultural and nutritive qualities. Transgenic plants, which are resistant to biotic and abiotic stresses such as salinity, drought, and disease, have been produced.

FIGURE an overview of modern bioprocessing.

Impact of Biotechnology on different fields and human life