You should be able to understand in this chapter

- General introduction of Biotechnology
- History of Biotechnology
- General and advanced definitions of Biotechnology
- Scope of Biotechnology
- Importance of Biotechnology
- Ethical issues related to Biotechnology

Introduction

Technology is the main driving force for major events in human history. Improved awareness of agriculture and metal brought human out of the Stone Age. In the 19th century the industrial revolution occurs and as the result of its machine era started together with the increase in a number of larger cities. The 20th century was the age of industrial activities like petrochemicals, pharmaceuticals, fertilizers, atomic energy, transmitters, the laser, and microchips. Understanding of the fundamentals of life processes achieved in the latter part of the 20th century has ensured that the 21st century will be having dominance of biology and the technologies associated with biology. According to the trends, the change in society is the driving force for the development of new technology. The impact of new technology in biological science is not only on scientists but on the general public as well. If the general public accepts the new technologies this is a natural booster to the scientists. The consequences of accepting or rejecting the new technical innovations are the driving force for the development of new techniques. That is the reason, how the biotechnology scientists are developing new therapies and cures for many plants, human and animal diseases.

Biotechnology: A view

In our daily life, we prepare food items such as curd, bread, cake, idli and dosa by the action of microorganisms, the bacteria and fungi. We have been using the biological processes of microorganisms from ancient times to make useful food products and to preserve dairy products. Yeast (fungus) is used to make beer and also antibiotics like penicillin are obtained from certain fungi. Nowadays, biological processes like fermentation by microorganisms is being used in industry on a commercial scale for making food, drinks, medicines and industrial chemicals.Figure 1.1 shows the different science fields contributing to the advancement of biotechnology.

The term ‘Biotechnology’ appears the latest term but it is nearly as old as civilization itself. It has been used to signify activities relating to biological process and technologies. The aim was to understand the mechanisms for improving every activity from farming to food processing. Early farmers selected particular plants to grow crops and saved their seeds for the following season. Over the years, they bred the varieties of seeds they found best and learned how to grow them more efficiently through techniques of irrigation and weed control. The process of

choosing certain seeds for their expressed characteristics and learning how to irrigate and rotate the crops was the outcome of earlier days of biotechnology. In the 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 ultimate goal of this field is to improve the product yield from living organism either by employing principles of bioprocess technology or by genetically modifying the organisms.

The new era of biotechnology started in the 1970s after the development of genetic engineering and in India, Department of Biotechnology established in 1986 under Ministry of Science and Technology. The genetic engineering allowed scientists to modify the genetic material of living cells and it is the manipulation of DNA molecules to produce modified plants, animals, or microorganisms. The genetic information of an animal or plant is controlled by DNA and is contained in individual units or sections of DNA called genes. These genes are passed from parent to offspring to determine the traits. Biotechnology scientists are now able to isolate the gene or genes for the traits they want in one animal or plant and move them into another. This artificial transfer of a gene from one organism to another is called recombinant DNA technology.

The population of the world is growing, but its surface area is not. Compounding the effects of population growth is the fact that most of the earth's ideal farming land is already being utilized. To avoid damaging environmentally sensitive areas, such as rainforests, we need to increase crop yields for land currently in use. By the increase of crop yields, through the use of biotechnology, the constant need to require more land for growing food is reduced. It is a situation of dilemma that how to continue feeding a growing population for countries in Asia and Africa. Biotechnology holds the key to increase the yield of crops by allowing farmers to gather bigger harvests from currently cultivated land while preserving the land's ability to support continued farming. Malnutrition in underdeveloped countries is also being combated with biotechnology. The Rockefeller Foundation is sponsoring research on "golden rice", a crop designed to improve nutrition in the developing world. Biotechnology is being used by Rice breeders to build Vitamin A into the rice because Vitamin A deficiency is a common problem in developing countries. Golden rice will offer dramatic improvements in nutrition and health for millions of people, with little additional costs to consumers. The initiatives like this are aimed at making crops more productive by reducing their dependence on pesticides, fertilizers, and irrigation, or by increasing their resistance to plant diseases. Increased crop yield, greater flexibility in growing environments, less use of chemical pesticides and improved nutritional content make agricultural biotechnology, quite literally, the future of the world's food supply.

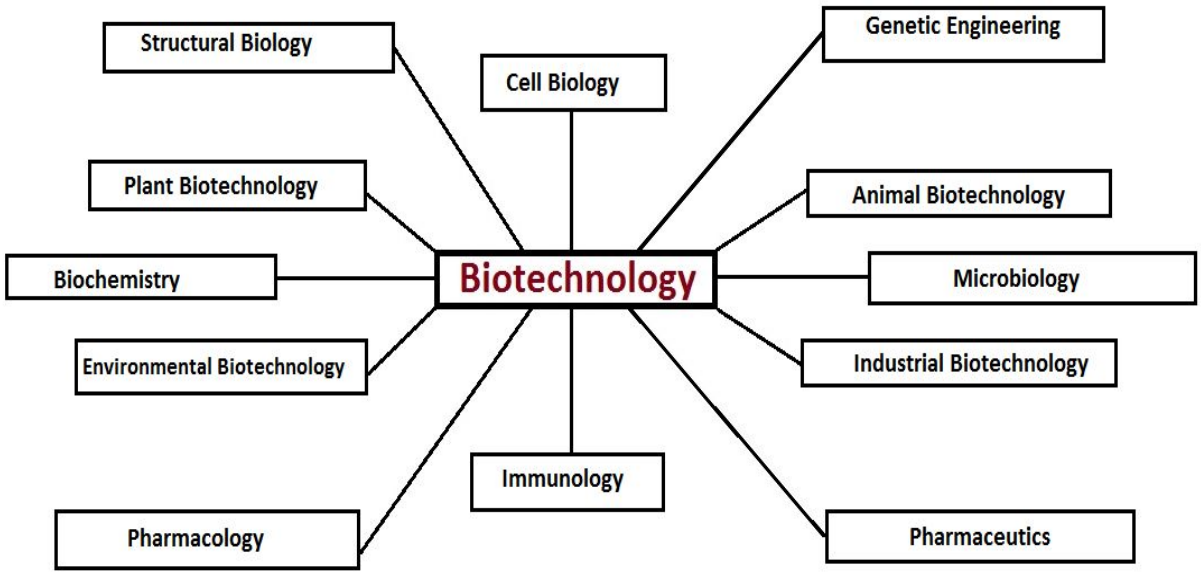

Figure 1.1 Different Science fields contributing into the advancement of biotechnology

Definitions of Biotechnology

The word biotechnology has come from two words namely bio means biological sciences and technology means technological applications. Thus biotechnology is defined as the industrial application of living organisms and their biological processes such as biochemistry, microbiology, genetic engineering, etc. in order to make the best use of the microorganisms for the benefit of mankind. Biotechnology is applied in many areas to produce foods and medicines, in the development of new diagnostic tools, gene therapy, DNA fingerprinting for forensic purposes etc.

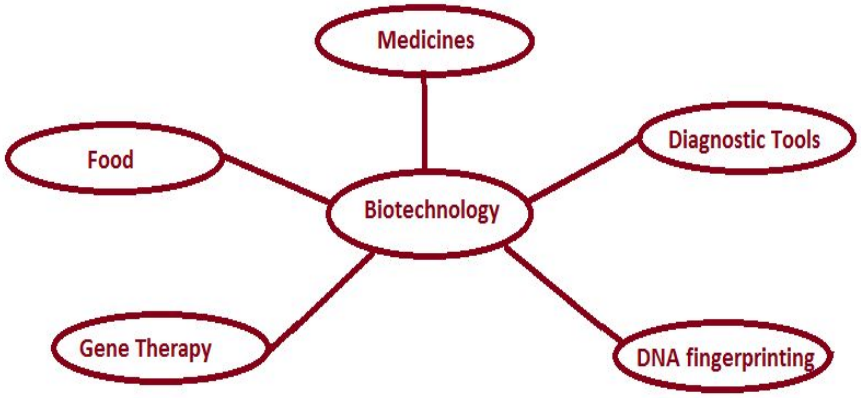

Figure 1.2:-Biotechnology is applied in the areas

The simplest definition of 'biotechnology' is the commercialization of biology". Biotechnology is a term that covers various techniques for usingthe properties of living organisms to make products or provide services.

The Convention on Biological Diversity defines biotechnology as: "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products for specific use." This definition includes medical and industrial applications as well as many of the tools and techniques that are common in agriculture and food production.

According to the definition of the Codex Alimentarius Commission (CAC) as the application of in vitro nucleic acid techniques, including recombinant DNA and the direct injection of nucleic acid into cells or organelles or fusion of cells beyond the taxonomic family, that overcomes natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection. This definition appears to be rather complicated; however, a much simpler definition was laid down by the Organisation for Economic Co-operation and Development (OECD). The OECD developed a single definition for the term biotechnology in 2002. The OECD defines biotechnology as: "the application of science and technology to living organisms as well as parts, products, and models thereof, to alter living or non-living materials for the production of knowledge, goods, and services."

Another definition given by the Food and Agricultural Organisation (FAO) is as follows. The major uses of biological processes or organisms are for the production of materials and services of benefit to humankind. Biotechnology includes the use of techniques for the improvement of the characteristics of economically important plants and animals and for the development of micro-organisms to act on the environment.

A chronological history of biotechnology

Year	Event
1919	term"biotechnology"
1938	Commercial production of a bio pesticide as *Bacillus thuringinesis* begins in France
1953	The DNA was described as a double helical structure by James Watson and Francis Crick's.
1964	The International Rice Research Institute in the Philippines starts the Green Revolution
1965	Harris and Watkins successfully fuse mouse and human cells
1969	An enzyme is synthesized in vitro for the first time.
1972	First recombinant DNA molecule and NIH(National Institutes of Health) guidelines for rDNA
1975	A first commercial company founded to develop genetically engineered products
1981	A mouse first transgenic animal was created
1978	Recombinant insulin synthesis

1982	the first biotech drug, human insulin produced in genetically modified bacteria, is approved by FDA
1983	The polymerase chain reaction (PCR) technique
1986	The first field tests of transgenic plants (tobacco) are conducted
1987	The first approval for a field test of modified food plants: virus resistant tomatoes
1988	Human Genome Project to map the human genetic code.
1990	First insect-protected corn: Bt corn.
1993	The creation of the Biotechnology Industry Organization (BIO).
1995	The gene therapy becomes a tool against cancer.
1997	First animal cloned from an adult cell: a sheep named Dolly in Scotland
2000	Har Gobind Khorana synthesized DNA in a test tube First biotech crop field-tested in Kenya: virus-resistant sweet potato.
2001	The first complete map of the genome of rice.
2002	A draft version of the complete map of the human genome is published
2003	Celera and the NIH successfully finished the sequencing of the human genome Dolly, the first cloned sheep is euthanized after developing progressive long disease. Japanese researchers develop a biotech coffee bean that is naturally decaffeinated.
2004	Institute of Medicine (IOM) considers biotech crops as the traditional, concerning safety and risks.
2006	The FDA sanctioned a recombinant vaccine against human *papillomavirus*
2007	Use of human skin cells to produce embryonic stem cells.
2008	Venter replicated a bacterium's genetic structure completely from laboratory chemicals Japanese chemists developed the first DNA molecule made nearly entirely of artificial parts. The finding could be used in areas of gene therapy.
2009	Three new genes connected with Alzheimer's disease, paving the way for possible new diagnostics and therapeutics. The first FDA approved clinical trial by means of embryonic stem cells.
2010	The FDA sanctioned a modified prostate cancer medicine that improves a patient's immune cells Craig Venter showed that a synthetic genome could duplicate alone.
2011	A trachea developed from stem cells were transplanted into a human recipient.
2012	The FDA issued draft regulations for biosimilar drugs
2013	Human embryonic stem cells developed by somatic cell nuclear transfer

Scope of biotechnology

Biotechnology is one of the technological field in which it is most complex to expect good results. Biotech is mainly characterized by two output parameters: profits and people. The first parameter can be assessed through economic and financial tools but the assessment of people's parameter is not possible. The main opportunity for biotechnology is to develop new

products and services for a never demanding society. Everyone in the world wants to live in a better society so there is a basis but there is also a big pressure from this society. They want to have new treatment methods, medicines, better quality food, etc., as fast as possible. Moreover, biotech opens a new door to fight against poverty with a better value and much better resistance against plant diseases to provide food to the world.

Since biotechnology is proficiently working as integration with allied fields such as biochemistry, molecular biology, and microbiology to facilitate the technological application of biological agents. With the development of modern biotechnology will provide enormous potential for human welfare in areas ranging from food processing to human health and environmental protection. The scientific manipulation of living organisms, especially at the molecular genetic level, to produce new products, such as hormones, vaccines or monoclonal antibodies.A set of biological techniques developed through basic research and now applied to research and product development. The scope of Biotechnology is roughly divided into three main parts green biotechnology, red biotechnology, and white biotechnology.

Green Biotechnology is a very important field of modern biotechnology. The foundation of green biotech is the crop improvement and production of new products in plants, which is achieved by implanting foreign genes to plant species that are economically important. There is three main areas to facilitate: plant tissue culture, plant genetic engineering, and plant molecular marker-assisted breeding. Plant tissue culture consists of producing a whole plant from a part of it or even a single plant cell in the laboratory conditions. Plant genetic engineering is the field of green biotechnology that provides a pool of techniques allowing advantageous genes to be implanted from one organism to another. This creates improved crops, materials or even animals. Plant molecular marker-assisted breeding is an area involves the use of molecular markers, selected a short sequence of DNA, which is responsible for the desired trait. In this way, better varieties, such as disease resistance, can be attained.

Red biotechnology uses own tools and weapons of the human body to fight diseases. Red biotechnology is used in traditional drug discovery and in creating new possibilities for treatment, prevention, and diagnosis tools. Biotechnology medicines account for about 20% of all market medicines. The continuous growth of knowledge, new discoveries, and investments in this field will give results in the fact that the opportunities for curing will increase. Through cell therapy, damaged joint cartilage can be regenerated in the body repaired by growing patient's own cartilage cells. Stem cells Research may result in treating serious diseases, like Parkinson's disease. Gene therapy is the most conditioning factor in many forms of cancer, and that is why identifying the gene responsible for such a disease and redirecting it can result in new opportunities to face the disease. Improvements in diagnosis Biotechnology offers many new tools for better diagnosis and testing. This is more comfortable for patients, but also it is better for doctors, providing extensive information. Over a thousand human hereditary diseases can be identified by detecting mutations in a single gene by using genetic testing.

In White Biotechnology the industrial and environmental processes are included. This field of biotechnology is connected with the industry. White biotechnology uses molds, yeasts, bacteria, and enzymes to produce goods and services. A wide range of bio-products like detergents, vitamins, antibiotics etc. are offered by white biotechnology. Most of the white biotechnology processes result in the saving of water, energy, chemicals and in the reduction of waste compared to traditional methods. Eco-efficient enzymes speed up some processes in certain chemical processes like transforming one substance into another, with consuming less water, raw materials and energy than the traditional methods. This is a better solution for industry, with the environmental impact minimized, a better product and lower costs.

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In blue biotechnology the aquatic and marine organisms process through biotechnology because the oceans make up about 70 per cent of the surface of our planet and over 99 per cent of the biosphere and they represent the greatest extremes of temperature, light, and pressure encountered by life. Biotechnological applications related to drug discovery, environmental remediation, increasing seafood supply and safety, and developing new resources and industrial processes are required for adaptation to these harsh environments has led to rich marine biodiversity and genetic diversity with potential.

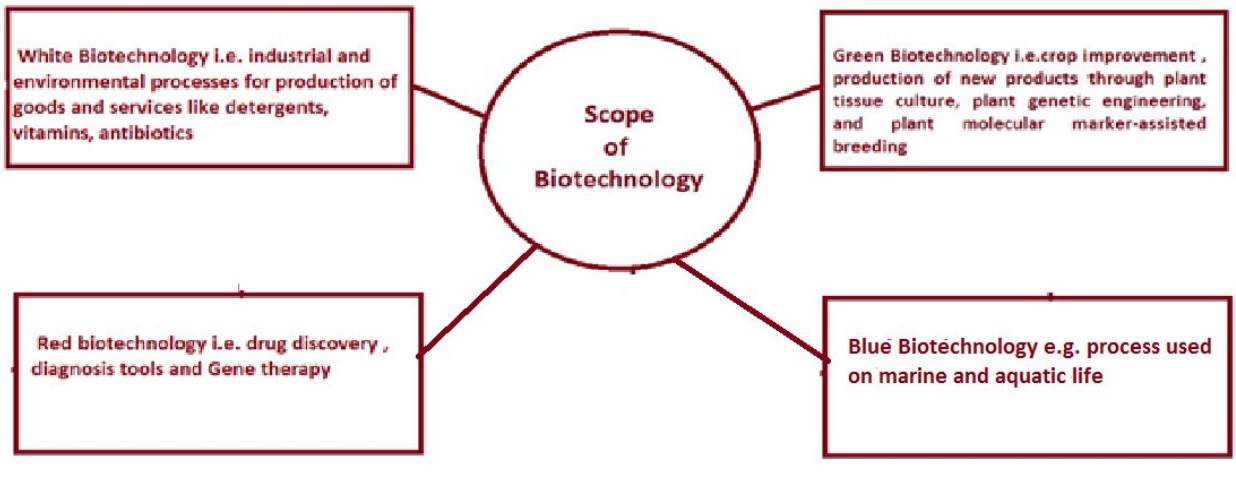


Figure 1.3: An Overview on scopes of Biotechnology

Advantages of biotech

For last 35 years, the biotechnology sector has been experiencing an important growth because it is a very dynamic business, with a lot of challenges in the development of new products to improve the health quality of people. There are two most important fields of research for biotechnology is DNA and genomics. Every branch of biotechnology can profit from the results of the research in DNA and genomics, so every branch can continue its development for a long time. The biotechnology is a worldwide cross-cultural sector and it is not bound by a single country. The main advantage of this is that development is unlimited and can go on. When a country forbids applying new innovations like cloning or the use of GMO's; the research will always go on in another country. Some advantages of biotech are:

- Reduce pollution and waste
- Decrease the use of energy, raw materials, and water
- Lead to better quality food products
- Create new materials and biofuels from waste
- Provide an alternative to some chemical processes.

Biotechnological Applications for Human

Fight against infectious diseases: Biotechnology is used extensively in the study of infectious diseases such as SARS (Severe Acute Respiratory Syndrome), influenza, etc. As a result, more effective pharmaceuticals have been developed.

Development of vaccines and antibiotics: Using biotechnology, microorganisms are used to develop antibiotics and vaccines to cure diseases. For example, bacteria like *Bacillus polymysea*

is used to produce polymyxin B antibiotic that is used to cure urinary tract infections, fungus-like *Penicillium notatum* is used to produce penicillin that is used to cure fever, pneumonia, etc.

Treating genetic disorders: Disease can occur due to genes when they are defective due to mutations. It is possible to use gene therapy to replace an abnormal or faulty gene with a normal copy of the same gene. It may be used to treat disease such as heart disease, inherited diseases such as SCID, Thalassemia.

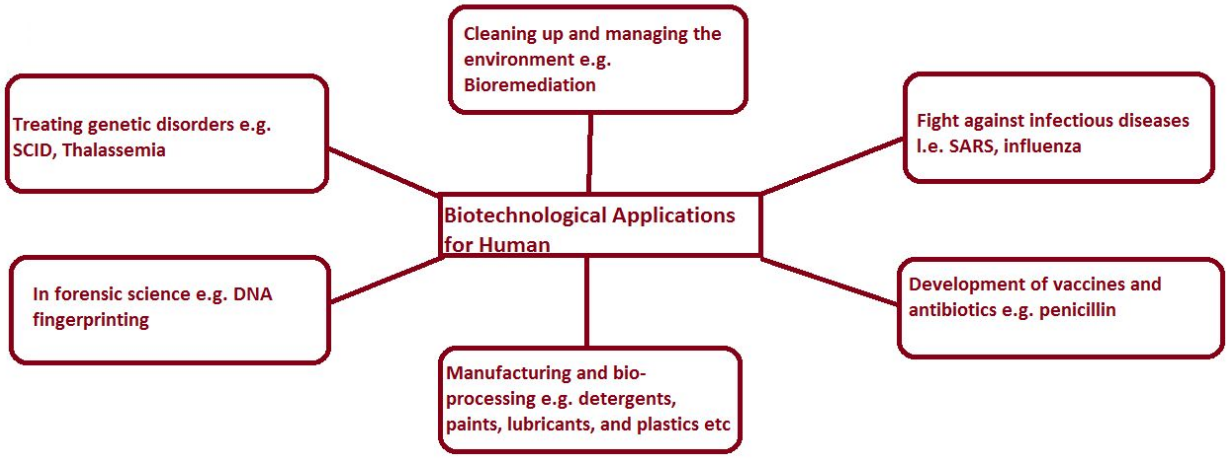
In forensic science: it has now become easy to identify criminals with the help of new techniques such as DNA fingerprinting.

Cleaning up and managing the environment: Bioremediation is the cleaning up the environment using living organisms. Naturally occurring, as well as genetically modified microorganisms, such as bacteria and fungi, and enzymes are used to break down toxic substances present in the environment.

Control of pests: The control of insect pestsis an application of biotechnology. The genetic make-up of the pest is modified by causing some mutations and then pests become sterile and cannot produce the next generation.

Manufacturing and bio-processing: It has become possible to grow on a large scale, the plants that produce compounds for use in detergents, paints, lubricants, and plastics etc. with the help of new biological techniques

Food and drinks: It has now become easy to process foods and their productswith the help of biotechnology.For laterconsumption, preservation and storing of food have become easy and cheap with the help of biotechnology. Seedless fruits like grapes and citrus have been developed using biotechnology. A lot of microorganisms are used in the mass production of items such as cheese, yogurt, alcohol, etc.



Ethical issues

Controversy is also attached with biotechnology as every subject and it has to deal with its own ethical issues. Like stem cells research, the aim is to understand the mechanism of cell differentiation and to produce specific cells from stem cell lines and cure various diseases like cancer, diabetes, etc. The main problem is that only embryonic stem cells can be turned into any cell type. An embryo can be used as a cell producer. People doubt that an embryo is already a person. Embryonic stem cells are derived from frozen, fertilized eggs produced through in vitro fertilization that have not been implanted can be used for these researches.

Cloning is the process of replication of genes, cells or organisms in a laboratory, from a single original entity. There are two types of cloning can be distinguished therapeutic cloning and reproductive cloning. The therapeutic cloning is used to develop new tissues that could replace damaged tissues that cure diseases like diabetes, Parkinson's, Alzheimer's and various types of cancer and heart diseases. With the use of therapeutic cloning techniques would result in the modification of tissues and organs genetically identical to the patient's and, therefore, with no rejection from the body. Reproductive cloning is used to create copies of an existing organism and that will lead to the hypothetical reproduction of people, born as a transplantable organ bearer. The problem is that if therapeutic cloning is allowed, some researcher will risk making reproductive cloning and that would lead to a psychological and physical problem for the clone and could create a black market of usable organs.

Agricultural biotechnology is used to modify plants and animals to import better properties to them, but the consequences are yet not known. Species have been crossed to produce new varieties with better properties for centuries and are it like the genetic crossing of species. It will be a hard endeavor to distinguish genetically modified plants from the natural ones.

A lot of products are tested on animals before being tested on man. Human lives are saved by these tests permitted to develop hundreds of products but on the other hand, are it acceptable animal suffering for new products. There is no authority who decides about the necessity of tests on animals. Ecological organizations are fighting against big companies that rely on the excessive use of animals in their research.

Glossary

To be attached in subsequent chapters