Biotechnology:
It is the branch of science that deals with maximum utilization of living organisms for the benefit of mankind. It is a new discipline of science in which latest technology has been applied to biological organisms for the welfare of society.

Branches of Biotechnology:

1. **Tissue culture:** It is also known as plant tissue culture. It is a technique of growing plant cells, tissues or organs in an artificially prepared nutrient medium under aseptic condition. It has following benefits:
   i. rapid multiplication of economically important plants in huge quantities.
   ii. produce pathogen free plants.
   iii. wide range of hybridization.
   iv. increase plant productivity.
   v. improvement of varieties.
2. **Protoplast culture:** It is the technique of growing plant by culturing protoplast. It has following benefits:
   i. produce germ free plants.
   ii. injection of foreign genes.
3. **Gene transfer:** Gene is a part of DNA segment of particular character. In this technique, a foreign gene of required character can be inserted into other plants by direct transfer or through various agents.
4. **Hybridoma technology:** It is a technique used to fuse normal antibody-producing lymphocytes with myeloma cells (a kind of tumor cell) produce a hybridoma.
   * This tumor cell grows indefinitely to supply of an antibody of choice.
5. **Genetic engineering:** In this technique, a piece of foreign DNA is inserted into DNA of a vector. The resulting recombinant is multiplied by introducing the vector into a bacterium.

Application of Biotechnoloty:

1. **Medical applications:**
   a. Antibodies produced by hybridoma technology are used for detection of animal and plant disease.
   b. Vaccines against human and animal diseases such as rabies, polio, tetanus are used to prevent and cure respective diseases.
   c. Diagnosis of diseases such as AIDS, cancer, foot and mouth disease, tuberculosis is done through biotechnological tools like ELISA (Enzyme Linked Immuno-sorbant Assay) test, PCR based technique.
   d. Hormones, enzymes, vitamins and chemicals for pharmaceutical use have been produced with the help of biotechnology. Eg: Insulin.

e. Antibiotics have been produced from genetic engineering. Various antibiotics have been developed and are being used to prevent and cure bacterial disease.
f. Gene therapy can be used for treating or even curing, genetic and acquired disease like cancer and AIDS by using normal genes to supplement or replace defective genes or to bolster a normal function such as immunity.
g. Genetic testing includes techniques in molecular biology to detect genetic diseases.

2. Agricultural Applications:

a. Small sized propagules are prepared in laboratory for production of large number of plants under aseptic condition.
b. Apical meristem is cultured to produce a callus which can further divided into large number of individual plants.
c. The plants having required characteristics are produced.
d. Organic fertilizer is again prepared by the activity of different types of bacteria and fungi.

3. Fermentation Applications:

a. Bacteria and fungi are used in dairy industries to prepare milk products such as curd, cheese etc.
b. Yeast and other fungi are used to prepare bread, alcoholic beverage, solvents etc.
c. Micro-organisms such as Acetobacter, Lactobacillus helps to produce acetic acid, lactic acid, citric acid etc.
d. Enzymes such as lignolytic and cellulolytic enzymes have been produced by biotechnology to breakdown cellulose and lignin.
e. Vitamins can be synthesized by biological means. Riboflavin and vit. B12 are synthesized from fungus.

Bio-fertilizer:

The living organism that grows along with crop and adds nutrients to soil due to the biological activity is called bio-fertilizer. They are again of different types.

i. **Bacteria as bio-fertilizer:** Several symbiotic and non-symbiotic bacteria add nitrogen in the soil by various processes. Eg: *Rhizobium* (symbiotic), *Azotobacter*, *Azospirillum* (non-symbiotic) and bacillus, *Thiobacillus* (phosphate solublizing bacteria).
ii. **Blue green algae as bio-fertilizer:** Some of blue green algae trap atmospheric nitrogen symbiotically where as some of asymbiotically. Mixture of two or more blue green alga produces nitrogenase in heterocysts and makes atmospheric nitrogen available to plants. Eg: *Anabaena*, Azolla etc.
iii. **Fungi as bio-fertilizer:** Some fungi symbiotically associate with the root of higher plants. They help in absorption of mineral and water for plants. They also help to convert non-available phosphorus into available form that help in increase of plant and protect against soil pathogens. Eg: Mycorrhiza.

Advantages of Bio-fertilizer

1. They are cheap and sustainable.
2. They lead to soil enrichment.
3. They do not harm to soil, water, air as well as human health.
4. They help in high quality product.
5. They can be cultivated by using local technology.

Limitations

1. They do not show quick response.
2. The nutrient supplied by them is not adequate to meet the total need of crop.

Genetic Engineering:

It is a manipulation of DNA of an organism towards a desired end in a directed and predetermined way. By this process, we obtain permanent and heritable changes in plants and animals for the benefit of mankind. It is also known as recombinant DNA technology or gene cloning.

It provides different varieties of crops with better nutritional status, resistance to insects, pests and herbicides, resistance to fungal, bacterial and viral diseases and resistance to environmental stresses.

Cloning of DNA:

It is the manipulation of DNA of any organism which is completed in three different steps.

1. The DNA of an organism containing the gene of interest is cut into smaller pieces. This gene is called target gene or foreign DNA.
2. The target DNA is joined to a second piece of DNA that can replicate itself and attach any target DNA. The second DNA is called vector. The result of the joining is a hybrid molecule, a hybrid or recombinant DNA.
3. The joined target and vector is then introduced into a living cell. The cell serves as a biological copying machine, making many exact copies of recombinant molecule.

Application of Genetic Engineering

1. Human insulin: Deficiency of insulin hormone causes disease, diabetes mellitus where blood sugar levels become raised with harmful consequences.
   To control the sugar level, insulin is taken externally. For this large quantity of insulin produced within limited time. It is only possible with the introduction of genetic engineering. The gene for human insulin is inserted into a bacterium and the bacterium is grown in a fermentor to make large quantities of the insulin.
2. Human growth hormone: Low levels of growth hormone in childhood results in the dwarfism. To treat dwarfism, growth hormone extracted from the pituitary gland of dead human is applied.
   Human growth hormone produced by genetic engineering with the help of bacteria. It contains the human gene for the hormone.
3. Interferons: These are the member of large group of proteins which protects from viral infections, intracellular parasites etc. They affect a wide range of target cells and tissues by binding to specific receptors present on the surface of their target cells. They are also produced by genetic engineering.

4. Antibiotics: Antibiotics are compound produced by one micro organism which inhibits the growth of other micro organism. It is also produced by genetic engineering.
5. Recombinant vaccines: Vaccine is a preparation which contains an antigen composed of whole disease causing organisms or parts of such organisms. They are used to confer immunity against antigens.
   These vaccines are produced using recombinant DNA technology. The immunogenic proteins from pathogen identified and isolated. Then are expressed in suitable host for mass production.

Possible danger in genetic engineering

1. New allergens in the food supply: Transgenic crops could bring new allergens into foods that sensitive individuals would not know to avoid.
2. Antibiotic resistance: Genetic engineering often uses genes for antibiotic resistance. Such genes will give rise to antibiotic resistant pathogens.
3. Production of new toxin: In some cases, plants contain inactive pathways leading to toxic substances. Addition of new genetic material through genetic engineering could reactivate these inactive pathways or otherwise increase the levels of toxic substances within the plants.
4. Concentration of toxic metals: Some of the new genes being added to crops can remove heavy metals like mercury from the soil and concentrate them in the plant tissue.
5. Enhancement of the environment for toxic fungi: Genetic engineering is used to remove undesirable secondary metabolites such as alkaloids from plant products may cause the growth of toxic fungi on the plant product.
6. Unknown harms to health: As with any new technology, the full set of risks associated with genetic engineering have almost certainly not been identified.
7. Gene transfer to wild varieties: Novel genes placed in crops will not necessarily stay in agricultural fields. If relatives of the altered crops are growing near the field, the new genes can easily move through pollen into those plants.
8. Change in herbicide use patterns: Crops genetically engineered to be resistant to chemical herbicides are tightly linked to the use of particular chemical pesticides. Adoption of these crops could therefore lead to change in the mix of chemical herbicides used across the country.