BIOTECHNOLOGY AND ITS APPLICATIONS

1. Biotechnology

It deals with the production of biopharma ceuticals and other biological products using microbes, plants, animals and their metabolic machinery. This became possible due to Recombinant DNA Technology (RDT), in which valuable and useful manipulation of genes in various living species is done to obtain desirable products at a large scale. The critical research areas of biotechnology are

(i) To provide the best catalyst in the form of improved organisms, usually a microbe or a pure enzyme.

(ii) To create optimal conditions through engineering for a catalyst to act.

(iii) Downstream processing technologies to purify the organic compounds.

2. Biotechnological Applications in Agriculture

Green revolution succeeded in increasing the food supply however, it was not sufficient to feed the increasing population of the world. It managed to enhance our food production with the help of improved crop varieties, agrochemicals and better techniques.

However, most of the agrochemicals are harmful to the environment and organic farming is expensive for farmers. The best solution to overcome these issues is to develop **Genetically Modified** (GM) foods or crops. The plants, bacteria, fungi and animals whose genes have been altered by manipulation are called **Genetically Modified Organisms** (GMO). These are also called transgenic organisms, as they contain and express one or more foreign genes called transgenes. A cell which contains and expresses a transgene is known as **transgenic cell**.

GM plants have developed various changes as given below

(i) More tolerant to various abiotic conditions.

(ii) Use of chemical pesticides and fertilisers has been reduced.

(iii) Reduces post-harvest losses.

(iv) Enhances nutritional value of food.

Some examples of GM crops are

I. **Bt Crops** Such type of crops are being produced by biotechnological methods. These plant species are pest resistant. Bt is a type of antitoxin which is produced by Bacillus thuringiensis or Bt bacteria. It is a soil bacterium, which was discovered by Japanese scientist **Ishiwata** in 1902.

Gene of Bt toxin is transferred into plants by extracting it from the bacterium. The plants so produced are pest resistant. Bacillus thuringiensis forms protein crystals (Cry) during a particular phase of their growth. These crystals contain a toxic **insecticidal protein**.

This leads to the formation of antitoxin in the plants (crops) and pesticides are no longer required. Such types of crops are called Bt crops

A. **Bt Cotton** Bt toxin gene is isolated from the bacteria and is transferred to the cotton/crops. In this way, Bt cotton plants are formed, Bt cotton being resistant from bollworms increases its production. The gene forming. Bt toxin is called cry gene. It is of various types

(i) cry IAc and cry IIAb control cotton bollworms.

(ii) cry IAb controls corn borer.

B. **Bt Brinjal** In this brinjal, cry gene present in soil bacterium Bacillus thuringiensis is inserted. Protein synthesised by this gene, prevents Fruit and Shoot Borer (FSB) insect attacking on brinjal.

II. **Pest Resistant Plants** A nematode Meloidogyne incognita infects the roots of tobacco plants which reduces the production of tobacco.

The strategy adopted to prevent this infection is based on the process of **RNA interference** (RNAi), which occurs in all eukaryotic organisms as a method of cellular defence.

This method involves silencing of specific mRNA due to complementary dsRNA that binds and prevents the process of mRNA translation.

III. Nutrition Rich Crops

(i) Golden Rice is a transgenic variety of rice which contains good quantities of β-carotene (provitamin-A inactive state of vitamin-A.

(ii) Flavr Savr In tomato, enzyme polygalacturonase is responsible for softening of fruit by degrading pectin of cell wall. In the transgenic tomato variety ‘Flavr savr’, production of polygalacturonase is blocked. Hence, fruits remain fresh for long time.

3.**Biotechnological Applications in Medicines** The recombinant DNA technological processes have made immense impact in the area of healthcare by enabling the mass production of safe and more effective therapeutic drugs. Some examples are given below

(i) Genetically Engineered Insulin This has lead to the sufficient availability of insulin for the management of adult onset of diabetes.

Human insulin is not easily available and animal insulin if used in human, can cause allergic reactions. In humans, insulin synthesised needs to be processed by removal of c-peptide, which is an extra stretch of polypeptide present in inactive insulin.

Eli Lilly, an American company, prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of E. coli to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulphide bonds to form human insulin, i.e. **humulin**.

(ii) **Production of Vaccines through Genetic Engineering**Such vaccines are called recombinant vaccines. These are also called as 'subunit vaccines' or 'second generation vaccines, e.g. vaccines for hepatitis-B, vaccine for polio virus.

(iii) **Gene therapy** is the replacement of a defective or faulty gene with normal healthy ones to correct a genetic disorder. It is used to correct ADA (Adenosine Deaminase) deficiency as follows

- Lymphocytes are isolated from the blood or bone marrow of the patient and grown in a culture outside the body.
- A normal ADA gene is isolated from normal cells.
- This normal functional ADA gene is then introduced into the cultured lymphocytes, which are subsequently returned to the patient.
- These cells have a limited life, so the patient requires repeated infusion of such genetically engineered lymphocytes.
- Gene therapy is also used to prevent cystic fibrosis, haemophilia, etc.

(iv) Stem cell technology is known to be the most rapidly developing field that combines the efforts of cell biologists and geneticists for treatment of malignant and non-malignant cells by using stem cells. The potential applications of stem cell include organ and tissue regeneration, bone marrow transplantation, brain disease treatment, etc.

(v) Molecular Diagnosis For effective treatment of diseases, early diagnosis and understanding their pathophysiology is very important.

● By using conventional methods of diagnosis (serum and urine analysis), early detection of diseases is not possible.

● Recombinant DNA technology, PCR (Polymerase Chain Reaction) and Enzyme-Linked Immuno-Sorbent Assay (ELISA) are some of the techniques that serve the purpose of early diagnosis.

4. Transgenic Animals

Those animals whose genome have been modified by genes obtained from other species are called transgenic animals or Genetically Modified (GM) animals.

Benefits of Transgenic Animals

(i) Study of normal physiology and development. (ii) Study of diseases like cancer, cystic fibrosis, etc.

(iii) To obtain biologically improved products, e.g. α-1-antitrypsin used to treat emphysema, **Rosie**, the first transgenic cow to produce protein (lactalbumin) enriched milk.

(iv) To ensure vaccine safety.

(v) For chemical safety testing. Mice are the most commonly used organisms for transgenic experiments.

5. Ethical Issues in Applications of Biotechnology

■ Genetic modification of organisms can have unpredictable results when such organisms are introduced into an ecosystem.

■ The GM crops may lead to the change in the evolutionary patterns.

■Accidentally, new infectious agents can be formed.

■ In order to control the issues related with ethical concerns, validity of GM research, safety issues patents, etc., the Indian government has setup organisations such as Genetic Engineering Approval Committee (GEAC).

6.Biopatent

■A patent is the right granted by a government to an inventor to prevent others from making commercial use of his/her invention.

■The patents granted for biological entities and products derived from them are called as biopatents.

■The modification/usage of living organisms for public services, e.g. food (medicine) has also created problems with patents granted for the same.

7. Biopiracy

It refers to the use of bioresources by multinational companies and other organisations without proper authorisation from the countries and people concerned, without compensatory payment. Some nations are developing laws to prevent such unauthorised exploitation of their bioresources and traditional knowledge.