

Chapter - 12

Biotechnology and its applications.

- Biotechnology essentially deals with industrial scale production of biopharmaceuticals, and biologicals using genetically modified microbes, fungi, plants and animals.

Three critical research areas of biotechnology are -

- i) providing the best catalyst in the form of improved organisms usually a microbe or pure enzyme.
- ii) Creating optimal conditions through engineering for a catalyst to act.
- iii) Downstream processing technologies to purify the protein / organic compound.

Biotechnological applications in agriculture:

options that can be thought for food production.

- i) Agrochemical based agriculture.
- ii) Organic agriculture
- iii) Genetically engineered crop based agriculture.

- Green revolution succeeded in tripling of food supply but yet it was not enough to feed the growing human population.

Use of agrochemicals, better management, improved crop varieties increases yield.

Genetically modified organisms (GMO) -

plant, bacteria, fungi, and animals whose genes have been altered by manipulations. Genetic modification has -

- i) made crop more tolerant to abiotic stress (cold, drought, salt, heat)
- ii) reduce reliance on chemical pesticides (pest resistant crops)
- iii) helps to reduce post harvest losses.
- iv) increased efficiency in mineral usage by plants.

v) Enhanced nutritional value of food e.g: Golden rice vitamin A rich.

- Bt toxin is produced by bacterium *Bacillus thuringiensis*. Bt toxin gene has been cloned from the bacteria and been expressed in plants to provide resistance to insects without the need for insecticides, in effect created bio-pesticide. e.g: Bt cotton, Bt corn, rice, tomato, potato and soyabean.

Bt cotton:

Bacillus thuringiensis forms protein crystals during a particular phase of their growth. This crystals contains a toxic insecticidal protein. it exists as inactive protoxins but once insect ingest the inactive toxin, it converted into an active form of toxin due to alkaline pH of the gut which solubilises the crystals, activated toxin binds to surface of midgut epithelial cells and create pores that cause cell swelling and lysis & eventually cause death of insects.

- toxin is coded by a gene *cryIAC* named *cry*. protein is encoded by *cryIAC*, *cryIAb* control the cotton bollworm. that of *cryIAb* control corn borers.

pest resistant plants:

- A nematode *Meloidogyne incognita* infects the root of tobacco plants and causes a great reduction in yield.
- ① Novel strategy to prevent infection - RNA interference (RNAi)
- RNAi provide cellular defense in all Eukaryotes. Strategy - silencing of specific mRNA due to a complementary dsRNA molecule that binds to and prevents translation of the mRNA.
- ② Using *Agrobacterium* vector, nematode specific genes were introduced into the host plant. Introduce DNA produce both sense

and antisense RNA in the host cell. Two RNA form dsRNA that initiated RNAi & thus silenced the specific mRNA of nematode. Consequence was that the parasite could not survive in a transgenic host expressing specific interference RNA.

→ Biotechnological applications in medicines:

* Genetically engineered insulin -

- earlier insulin was extracted from pancreas of slaughtered cattle and pigs. but it developed allergy in some patients.

• Insulin - consist of two polypeptide chain chain A and chain B that are linked together by disulfide linkage.

• In mammals insulin is synthesized as a pro-hormone which contain an extra stretch called C peptide. It is removed during maturation of insulin.

• In 1983 Eli Lilly an American company prepared insulin two DNA sequences corresponding to A and B chain of human insulin & introduced them in plasmid of E. coli to produce insulin chain.

- Chain A and B were produced separately, extracted & combined by creating disulfide bond to form human insulin.

→ Gene therapy

- Gene therapy is a collection of methods that allows correction of a gene defect that has been diagnosed in child/ embryo.

- Here genes are inserted into a person's cells and tissues to treat a disease.

• Correction of a genetic defect involves delivery of a normal gene into the individual or embryo to take over the functions of and compensate for the non-functional gene.

- first gene therapy - in 1990 - to 4 year old girl with adenosine deaminase deficiency. (ADA)
- ADA - crucial for immune function.
- Lymphocytes from patients blood grown in culture outside body then functional ADA introduced in lymphocytes. which are subsequently returned to patient. Here patient require periodic infusion of such genetically engineered lymphocytes.
- However if the gene isolated from bone marrow cells producing ADA is introduced into cells at early embryonic stage, it could be a permanent cure.

* Molecular diagnosis -

- Recombinant DNA technology, polymerase chain reaction (PCR), and Enzyme Linked Immuno-Sorbent Assay (ELISA) are some of the techniques that serve the purpose of early diagnosis.
- 1) Very low concentration of bacteria or virus can be detected by amplification of their nucleic acid by PCR.
 - 2) A single stranded DNA or RNA, tagged with a radioactive molecule (probe) is allowed to hybridize to its complementary DNA in a clone of cells followed by detection using autoradiography. The clone having the mutated gene will hence not appear on the photographic film, because the probe will not have complementarity with the mutated gene.
 - 3) ELISA - antigen-antibody interaction, pathogen can be detected by the presence of antigens or by detecting the antibodies synthesized against pathogen.

Transgenic animals:

Animals that have had their DNA manipulated to possess and express an extra (foreign) gene, are known as transgenic animals.

- Transgenic rats, sheep, rabbits, pigs, cow and fish are produced. (95% produced are mice),

reasons why this animals are produced & their benefits:

1) Normal physiology and development -

Transgenic animals are specifically designed to allow the study of how genes are regulated and how they affect the normal function of the body, and its development.

e.g. for studying the effect of genes.

2) Study of disease:

Transgenic animals are designed to introduce increase understanding of how genes contribute to the development of disease. Today transgenic model exist for many human disease such as cancer, cystic fibrosis, rheumatoid arthritis, Alzheimer's.

3) Biological products:

- Transgenic animals that produce useful biological products can be created by introduction of the portion of DNA which codes for a particular product such as Human protein (α-1-anti-trypsin) used to treat emphysema.

- First transgenic cow, Rosie produced human protein enriched milk (2.4 gm/litre)

4) Vaccine safety:

Transgenic mice are developed for use in testing the safety of vaccines before they are used on humans.

e.g. to test safety of polio vaccine.

5) chemical safety testing:

Transgenic animals are made to carry genes which make them more sensitive to toxic substance than non transgenic

mice. They are then exposed to toxic substances and the effects studied.

Ethical Issues :

- Genetic modification of an organism can have unpredictable results when such organisms are introduced into the ecosystem.
- Genetic Engineering Approval Committee - make decision regarding the validity of GM research.
- Basmati rice - distinct for its unique aroma and flavour, and 27 documented varieties of basmati documented in India. An American company got a patent in 1977 & right on Basmati rice but the new variety of basmati rice was actually derived from Indian farmers.
- Several attempts have been made to patent uses, products and processes based on Indian traditional herbal medicine.
eg: turmeric neem.

Biopiracy:

used to refer to the use of bioresources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment.

Indian parliament has recently cleared the 2nd amendment of the Indian patents bill that takes many issues into consideration including patent terms emergency provisions and research and development initiatives.