12. BIOTECHNOLOGY AND ITS APPLICATIONS

APPLICATIONS IN AGRICULTURE

Uses of Genetically Modified Organisms (GMO):

- It makes crops more tolerant to abiotic stresses.
- Pest-resistant crops reduce the use of chemical pesticides.
- It increases efficiency of mineral usage by plants.
- It enhances nutritional value of food. E.g. Golden rice (Vitamin A enriched rice).
- To create tailor-made plants to supply alternative resources (starches, fuels, pharmaceuticals etc.) to industries.

Pest Resistant Plants

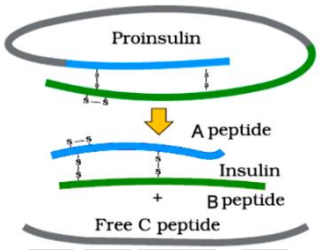
Bt Cotton:

- Some strains of *Bacillus thuringiensis* have proteins that kill insects like coleopterans, lepidopterans & dipterans.
- *B. thuringiensis* forms an insecticidal protein **(Bt toxin)** crystal during a phase of their growth. It does not kill the *Bacillus* as it exists as inactive *protoxins.*
- When an insect ingests the toxin, it becomes active due to alkaline pH of the gut which solubilise the crystals. Toxin binds to surface of mid-gut epithelial cells creating pores. It causes cell swelling and lysis and death of the insect.
- **Bt toxin genes** were isolated from *B. thuringiensis* and incorporated into crop plants such as cotton.
- Most Bt toxins are insect-group specific. They are coded by **cry genes**. E.g. proteins encoded by *cryIAc* & *cryIIAb* genes control cotton bollworms. Protein of *cryIAb* gene controls corn borer.

APPLICATIONS IN MEDICINE

1. Genetically Engineered Insulin

- Insulin is used to manage adult-onset diabetes.
- Insulin from the pancreas of animals (cattle & pigs) causes allergy or other types of reactions to the foreign protein.
- Insulin consists of two short **polypeptide chains (chain A & chain B)** that are linked by disulphide bridges.



- In mammals, insulin is synthesized as a **pro-hormone (pro-insulin).** It is processed to become mature and functional hormone.
- The pro-hormone contains an extra stretch called **C peptide**. This is removed during maturation into insulin.
- In 1983, **Eli Lilly** (an American company) prepared two DNA sequences corresponding to A & B chains of human insulin and introduced them in plasmids of *E. coli* to produce insulin chains. Chains A & B were combined by creating disulfide bonds to form human insulin ***(Humulin).***

2. Gene Therapy

- It is a method to correct a gene defect in a child/embryo.
- Here, genes are inserted into a person's cells and tissues to treat a hereditary disease. It compensates for the non-functional gene.
- First clinical gene therapy (1990) was given to a 4-year old girl with **adenosine deaminase (ADA) deficiency.**
- This is caused due to the deletion of a gene of ***adenosine deaminase*** (an enzyme for the functioning of immune system). It can be cured by **bone marrow transplantation** or by **enzyme replacement therapy** (injection of ADA). But these are not completely curative.
- **Gene therapy for ADA deficiency:** Collect **lymphocytes** from the patient's blood and grow in a culture → Introduce a functional **ADA cDNA** into lymphocytes (using a retroviral vector) → They are returned to the patient. This should be periodically repeated as lymphocytes are not immortal.
- If the **ADA gene** from marrow cells is introduced into cells at early embryonic stages, it could be a permanent cure.