Biotechnology and Its Application

- **Biotechnology:** Deals with industrial scale production of biopharmaceuticals and biologicals using GM microbes, fungi, plants and animals.
- Applications of biotechnology include:
- Therapeutics processed food
- Diagnostics bioremediation
- Genetically modified organisms
- Crops for agriculture
- Waste treatment
- Energy production

BIOTECHNOLOGICAL APPLICATIONS IN AGRICULTURE

- Made crops more tolerant to abiotic stresses (cold, drought, salt, heat).
- Reduced reliance on chemical pesticides (pest-resistant crops).
- Helped to reduce post harvest losses.
- Increased efficiency of mineral usage by plants (prevents early exhaustion of fertility of soil).
- Enhanced nutritional value of food, e.g., golden rice, i.e., Vitamin ' *A* ' enriched rice.
- Insect resistant plants-Bt Cotton
- Pest resistant plants-Tobacco plant (By RNAi)

INSECT RESISTANT PLANT- BT COTTON:

- *Bacillus thuringiensis* produces certain proteins that can kill insects such as lepidopterans, coleopterans, and dipterans.
- They produce insecticidal protein, which when entering the body of the insect will become active.
- This toxin then binds to the midgut and causes cells to swell and eventually the death of the insect.
- These Bt genes are isolated and inserted into cotton plants. Such cotton is known as Bt cotton.
- The gene that codes for an insecticidal protein is known as cryIAc and cryptic.
- The proteins encoded by the genes cryIAc and cryIIAb control the cotton bollworms, that of cryIAb controls corn borer.

PEST RESISTANT PLANTS

- A nematode Meloidogyne incognita infects the roots of tobacco plants and causes a decrease in the yield of the plant.
- To prevent this, RNA interference technology was used.
- This method involves silencing a specific mRNA due to a complementary dsRNA molecule.
- This inhibits the translation of the mRNA

BIOTECHNOLOGICAL APPLICATIONS IN MEDICINE

30 recombinant therapeutics have been approved for human use the world over. In India, 12 of these are presently being marketed.

- Insulin consists of two short polypeptide chains: chain A and chain B, that are linked together by disulphide bridges. In mammals, including humans, insulin is synthesised as a prohormone (like a pro-enzyme, the

pro-hormone also needs to be processed before it becomes a fully mature and functional hormone) which contains an extra stretch called the C peptide.

- This C peptide is not present in the mature insulin and is removed during maturation into insulin. In 1983, 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 disulfide bonds to form human insulin.
- Genetically Engineered Human Insulin (humulin) → manufactured by Eli Lilly, an American company in 1983
- Gene Therapy → First clinical gene therapy was conducted in 1990 in a 4 year old girl to treat adenosine deaminase (ADA) deficiency.

MOLECULAR DIAGNOSIS METHODS

Parameters	Conventional	Modern
Early detection	Not possible	Possible
Examples	Serum and urine analysis	RDT, PCR, ELISA

- ELISA (enzyme-linked immunosorbent assay) is based on antigen and antibody reactions to detect different diseases.
- PCR (polymerase chain reaction) is a technique to amplify specific DNA segments. This technique helps in detecting HIV in AIDS patients

TRANSGENIC ANIMALS

- Possess manipulated DNA and express foreign gene
- Transgenic rats, rabbits, pigs, sheep, cows
- 95% of transgenic animals are mice.

USES OF TRANSGENIC ANIMALS

- Transgenic models exist for study of diseases like cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's
- Biological products
  - α –1 antitrypsin - Treat emphysema
  - Similar attempts are made for treatment of PKU (Phenylketonuria) and cystic fibrosis.
  - First transgenic cow: Rosie developed in 1997 producing human protein enriched milk (2.4 grams per litre)
- Vaccine Safety

  Transgenic mice are being used to test the safety of the polio vaccine to replace the use of monkeys.
- Chemical safety testing

  Transgenic animals are made more sensitive to toxic substances to obtain results in less time.

ETHICAL ISSUES

- GEAC (Genetic Engineering Approval Committee): Makes decisions regarding the validity of introducing GMO for public services.
- Biopiracy refers to the use of bio-resources by multinational companies and other organisations without proper authorization from the countries and people concerned without compensatory payment.
- The Indian Parliament has recently cleared the second amendment of the Indian Patents Bill.

CONTROVERSIES REGARDING PATENTS AND BIOPIRACY

- **Basmati rice:**
  - 2,00,000 varieties of rice in India, 27 documented varieties of Basmati rice in India.
  - In 1997, an American company got patent rights on Basmati rice through the US patent Trademark office.
- **Turmeric and Neem**
  - Though Indians were using turmeric for hundreds of years, in 1995, the patent for the use of turmeric in wound healing was given to the University of Mississippi medical centre.
  - Several traditionally herbal based medicinal products made up of turmeric and neem were also patented.