FREE NOTES · NCERT + NEET LEVEL

Biotechnology & its Applications

Applications in agriculture (GM crops, Bt cotton, pest-resistant plants, RNAi), medicine (genetically engineered insulin, gene therapy, molecular diagnosis), transgenic animals, ethical issues and biopiracy.

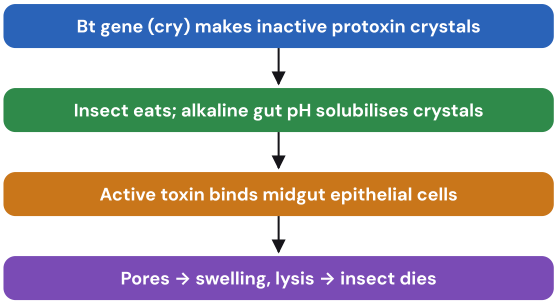
01 Biotechnology in agriculture
02 Bt cotton
03 Pest-resistant plants: RNAi
04 Biotechnology in medicine
05 Molecular diagnosis and transgenic animals
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01 Biotechnology in agriculture

- Options to increase food: agrochemical-based agriculture, organic agriculture, genetically engineered crop-based agriculture.
- **GMOs** (genetically modified organisms): genes altered by manipulation. Benefits: tolerance to abiotic stresses (cold, drought, salt, heat); less reliance on chemical pesticides (pest-resistant crops); reduced post-harvest losses; better mineral use (prevents early soil exhaustion); enhanced nutritional value, e.g. **Golden rice** (vitamin A enriched).
- Creation of tailor-made plants to supply alternative resources (starch, fuels, pharmaceuticals) to industries.

02 Bt cotton

- *Bacillus thuringiensis* makes proteins that kill insects: lepidopterans (tobacco budworm, armyworm), coleopterans (beetles), dipterans (flies, mosquitoes).
- Bt toxin exists as inactive **protoxin**; activated by alkaline pH of insect gut. Bacterium is not killed by its own toxin (inactive form).
- Genes **cry IAc** and **cry IIAb** control cotton bollworms; **cry IAb** controls corn borer.



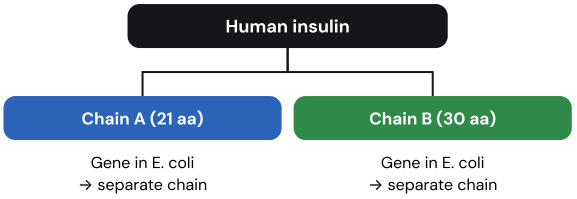
How Bt toxin kills insects

03 Pest-resistant plants: RNAi

- Nematode *Meloidogyne incognita* infects roots of tobacco, reduces yield.
- **RNA interference (RNAi)**: silencing of specific mRNA by complementary dsRNA that binds and prevents translation. Natural cellular defence (dsRNA from RNA viruses or transposons).
- Using *Agrobacterium* vectors, nematode-specific genes introduced into host; produce sense and anti-sense RNA ⇒ dsRNA ⇒ silences nematode mRNA ⇒ parasite cannot survive in transgenic host.

04 Biotechnology in medicine

- ~30 recombinant therapeutics approved worldwide; 12 marketed in India. Safe, no unwanted immunological response.
- **Insulin**: earlier from pancreas of cattle and pigs (allergy). Human insulin: chains A and B linked by disulphide bridges; made as **pro-insulin** with extra **C peptide** (removed). **Eli Lilly** (1983) prepared A and B DNA sequences, introduced in plasmids of *E. coli*, combined chains by disulphide bonds.
- **Gene therapy**: first in 1990 on a 4-year-old girl with **ADA deficiency** (adenosine deaminase; immune system). Lymphocytes grown, functional ADA cDNA inserted using retroviral vector, returned; periodic infusion needed. Permanent cure: ADA gene into cells at early embryonic stage (from bone marrow cells).



Making human insulin (Eli Lilly)

05 Molecular diagnosis and transgenic animals

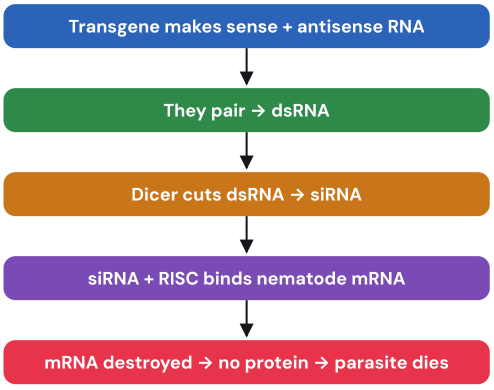
- Early diagnosis needs very low pathogen concentration detection: **PCR** (HIV in suspected AIDS patients, mutations in suspected cancer, genetic disorders), **ELISA** (antigen–antibody interaction), single-stranded DNA/RNA **probe** with radioactive tag detected by autoradiography (mutated gene does not appear on film).
- Transgenic animals (rats, rabbits, pigs, sheep, cows, fish; >95% mice) for: normal physiology and development (insulin-like growth factor), study of disease (cancer, cystic fibrosis, rheumatoid arthritis, Alzheimer's), biological products (α-1-antitrypsin for emphysema; first transgenic cow **Rosie** (1997): human protein-enriched milk, 2.4 g/L, with human α-lactalbumin), vaccine safety (polio vaccine tested on transgenic mice), chemical safety (toxicity testing).

06 Ethical issues and biopiracy

- Indian Government set up **GEAC** (Genetic Engineering Appraisal Committee): decides validity of GM research and safety of introducing GM organisms for public services.
- **Patents**: e.g. US company got patent on **Basmati rice** (1997) through USPTO; India has 27 documented varieties of Basmati. Patents also on turmeric, neem.
- **Biopiracy**: use of bio-resources by multinational companies without proper authorisation or compensation from the countries/people concerned. Industrialised nations rich financially but poor in biodiversity.
- Indian Parliament cleared second amendment of the Indian Patents Bill to address such issues (patent terms, emergency provisions, R&D).

07 Extra + tricks

- **Flavr Savr tomato**: polygalacturonase (softening enzyme) blocked by antisense RNA ⇒ longer shelf life.
- **Hirudin** (anticoagulant from leech) produced in *Brassica napus* seeds.
- **Tracy** (transgenic sheep): milk with α-1-antitrypsin for emphysema.
- Golden rice: β-carotene (pro-vitamin A) genes; developed by Ingo Potrykus and Peter Beyer.
- Biosafety: GEAC (India); patents vs biopiracy (neem, turmeric, basmati).



RNA interference against nematodes

08 Important Q&A

Q1. Why does Bt toxin not kill the bacterium?

It exists as an inactive protoxin; it becomes active only in alkaline gut of insect.

Q2. What is the C-peptide and why is it removed?

Extra stretch in pro-insulin joining chains A and B; it is removed during maturation into active insulin.

Q3. Name the first transgenic cow and its product.

Rosie (1997); milk with human α-lactalbumin (2.4 g/L), more nutritionally balanced for babies.

09 Common mistakes

- Saying Bt toxin is active inside bacterium.
- Writing that gene therapy for ADA is a permanent cure (lymphocyte method is not).
- Mixing cry IAb (corn borer) with cry IAc (bollworm).
- Thinking RNAi adds a new protein (it silences mRNA).

10 Practice (NEET style)

1. Nematode controlled by RNAi in tobacco?
2. Company that made human insulin (1983)?
3. Enzyme deficient in first gene therapy?
4. Indian body for GM approval?
5. Vitamin in Golden rice?

ANSWERS

1) *Meloidogyne incognita* · 2) Eli Lilly · 3) Adenosine deaminase · 4) GEAC · 5) Vitamin A

11 Quick revision: 5 minutes before the exam

AGRICULTURE

- GMO benefits
- Golden rice vit A
- Bt cotton cry genes

BT AND RNAI

- Protoxin → alkaline gut
- cry IAc bollworm, IAb corn borer
- RNAi vs Meloidogyne

MEDICINE

- Insulin A + B, C-peptide removed
- ADA gene therapy 1990
- PCR, ELISA diagnosis

ANIMALS/ETHICS

- Rosie: α-lactalbumin
- GEAC
- Basmati biopiracy

Have a doubt? Ask the AI Doubt Solver at padhaiadda.netlify.app, or take the mock test on this chapter.