CHAPTER 12

# BIOTECHNOLOGY AND ITS APPLICATIONS

## POINTS TO REMEMBER

**Biopesticides :** Biological agents that are used to control weeds, insects and other pests.

***Cry* Gene :** The Bt toxins are coded by a gene named Cry.

***Cry* Protein :** The insecticidal protein which is produced by *Bacillus thuringiensis.*

**Green Revolution :** Substantial increase in crop yields due to use of high yielding varieties, use of fertilisers and pesticides, imrpoved agricultural practices etc.

**Genetically Modified Organisms (GMO) :** The organisms which have altered genes in them. These are also known as transgenic organisms.

**Molecular Diagnosis :** Refers to early detection of diseases using recombinant DNA molecules and techniques like PCR and autoradiography.

**RNA Interference (RNAi) :** Process used to develop pest resistant plants. It involves silencing of a specific mRNA due to complementary double stranded RNA.

**Sustainable Agriculture :** It involves organic farming and other integrated management practices which maintain soil fertility while increasing crop productivity.

**Uses of GM Plants :** Tolerant to abiotic stress, Reduced dependence on chemical pesticides, less post harvest-loss, Efficient use of minerals, enhanced nutritional value.

**Uses of Transgenic Animals :** To study normal physiology and development, to study diseases, to get biological products, to test vaccine and chemical safety testing.

**Gene Therapy :** It is a technique of inserting genes into the cells and tissue of an individual to treat a hereditary disease.

- The first clinical gene therapy was given in 1990 to a four year old girl with adenosine deaminase (ADA) deficiency. ADA enzyme is required for proper functionng at immune system.
- This disorder is caused due to the deletion of the gene for adenosine deaminase enzyme.
- In some children ADA deficiency can be cured by bone marrow plantation. Lymphocytes from the blood of patient are grown in a culture. A functional ADA cDNA is then introduced into these lymphocytes using retroviral vector. The lymphocytes are transferred into the body of patients.
- As these cells are not immortal, the patient required periodic infusion of such genetically engineered lymphocytes.
- If a functional gene is introduced into a bone marrow cells at early embryonic stage, It could be a permanent cure of ADA deficiency.

**Bt. Cotton :** The soil bacterium *Bacillus thuringiensis* produced crystal protein called *cry* protein that kills certain insects larvae such as tobacco budworm, armyworm, beettles and flies.

- Bt toxin protein exists as inactive protoxins, but once an insect ingest this inactive toxin, it is converted into active form of toxin due to the alkaline pH of the gut which solubilise the crystal. This causes swelling and lysis of epithelial cells of midgut leading to death of insect larvae.
- Bt toxin genes were isolated from *Bacillus thuringiensis* and incorporated into the several crop plants such as cotton.
- The proteins encoded by the genes :

  crylAc and cryllAb control the cotton bollworms and *crylAb* control corn borer.

  **Pest Resistant Plants :** A nematode *Meloidegyne incognitia* infects tobacco plants and reduces their yield.
- Nematode specific genes were introduced into the host plant using *Agrobacterium* as a vector.
- The introduction of DNA was such that it produced both sense and anti-sense RNA in the host cells.
- These two RNAs being complementary to each other formed a double stranded RNA (dsRNA) making it inactive.
- This dsRNA molecule binds to and prevents translation of mRNA (silencing) of the nucleotide by the process called RNA interference (RNAi).

- ❑ The result was that the parasite could not survive in the transgenic host and the transgenic plant got protected for the parasite.

**Three Critical Research Areas of Biotechnology**

(i) Providing best catalyst in the form of improved organism usually a microbe.

(ii) Creating optimal conditions for a catalyst to act.

(iii) Downstreaming processing technologies to purify the desirable product.

## QUESTIONS

### VSA (1 MARK)

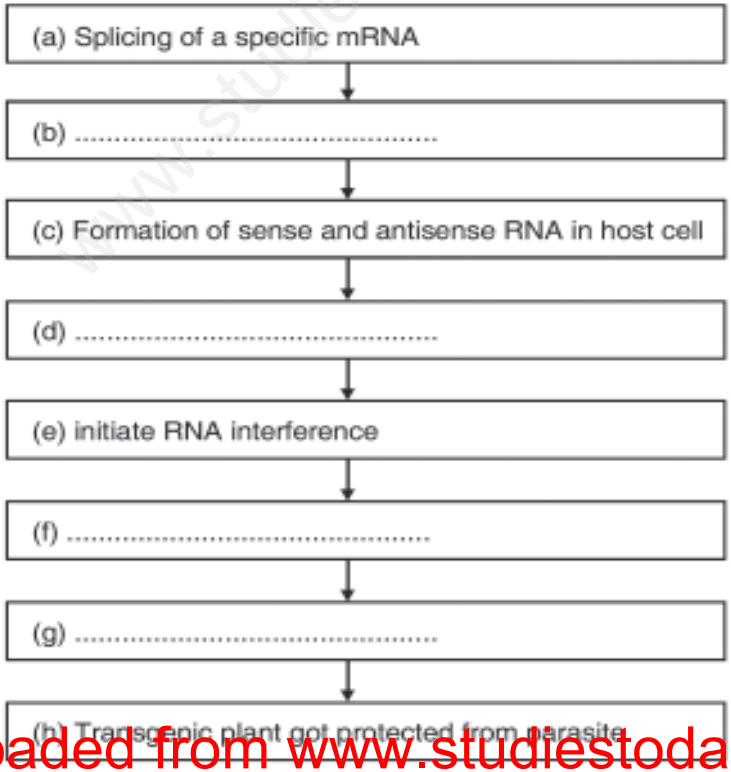
1. Name the technique based on the principle of antigen-antibody interaction used in detection of a virus (HIV).
2. Development of a transgenic food crop may help in solving the problem of night blindness in the developing countries, name this crop plant.
3. Which nematode infects the roots of tobacco plant and causes a great reduction in yield?
4. The first transgenic cow, produced human protein – enriched milk. Name the cow and the protein found in milk.
5. The insulin produced using recombinant DNA technology is more advantageous than the insulin extracted from pancreas of slaughtered cattle and pigs. How?
6. Name two pest resistant plants produced by using recombinant DNA technology.

### SA-II (2 MARKS)

7. What are the two methods for correcting ADA deficiency in a child?
8. Some crop plants are modified genetically by manipulating their genes. How are they made beneficial?
9. GEAC is one of the organisation set up by Indian Government. Write its full form. Give its two objectives.
10. "Industrialised nations are exploiting the bioresources of under industrialised nations". Justify the statement with a suitable example.

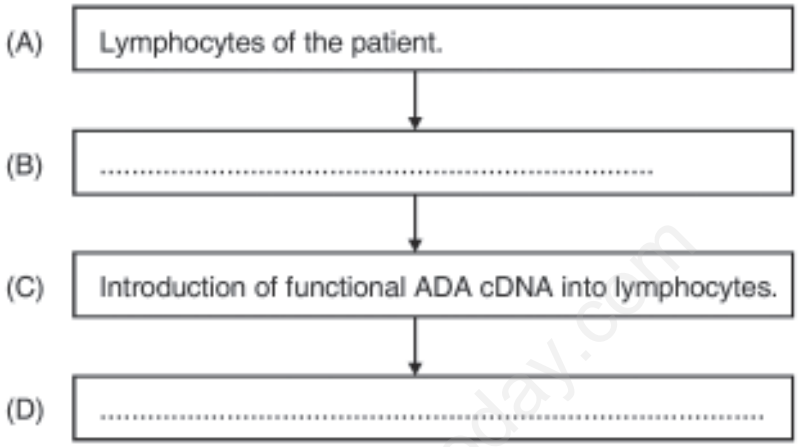
## SA-I (3 MARKS)

11. Some multinational companies and other organisations are using bioresources for commercial benefits, without proper authentication and compensation to concerned authorities.
    (a) Give the term for this unauthorised act.
    (b) Suggest any two ways to get rid of this.
12. A bacterium *Bacillus thuringiensis* produces a toxic protein named '*cry* protein' that is lethal to certain insects but not to bacterium
    (a) Why this toxin does not kill the bacteria?
    (b) What type of changes occur in the gut of insects on consuming this protein?
    (c) How man has exploited this protein for his benefit?
13. Given below is an incomplete flow chart showing the process of production of nematode resistant tobacco plants based on RNAi technique.
    (i) Write the missing steps in proper sequence
    (ii) At which level RNAi silences the gene?



## LA (5 MARKS)

14. The clinical gene therapy is given to a 4 years old patient for an enzyme which is crucial for the immune system to function.




Observe the therapeutical flow chart and give the answer of the following:

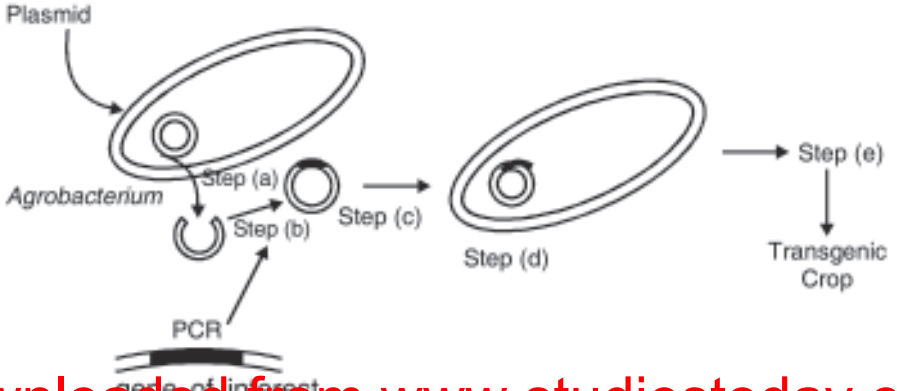
(a) Complete the missing steps (B) and (D)

(b) Identify the disease to be cured.

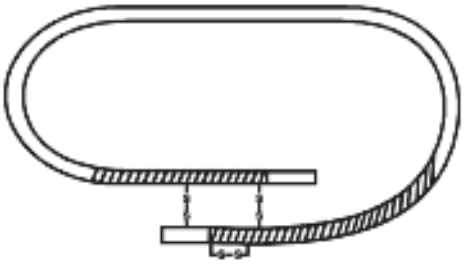
(c) Why the above method is not a complete solution to the problem?

(d) Scientists have developed a method to cure this disease permanently. How?

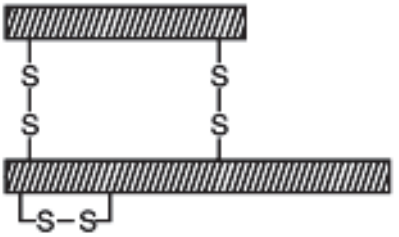
15. In the given figure, *Agrobacterium* is utilized for the production of a transgenic crop. Explain the steps a, b, c, d and e shown in the figure.



16. In the given figure, Form (A) and Form (B) represents different forms of a proteinaceous hormone secreted by pancreas in mammals.



Form 'A'




Form 'B'

(a) What type of bonding is present between chains of this hormone?

(b) What are these form (A) and form (B). How these forms differ from each other?

(c) Explain how was this hormone produced by Eli Lilly, an American company, using rDNA technology.

## ANSWERS

### VAS (1 MARK)

1. ELISA (Enzyme linked immuno - sorbent Assay)
2. Golden Rice
3. *Meloidegyne incognitia.*
4. Rosie, alpha-lactalbumin
5. Insulin obtained from animal source causes allergy.
6. Bt Cotton, Bt Corn, Bt Brinjal.

### SA-II (2 MARKS)

7. Bone marrow transplantation having functional ADA enzyme and Enzyme replacement therapy.
8. More tolerant to abiotic stresses; pest resistant; reduction in post harvest losses; increased nutritional value of food.
9. GEAC – Genetic Engineering approval committee. Objectives of GEAC are
   (i) To make decisions regarding validity of GM research.
   (ii) Safety of introducing GMO for public use.

10. ❑ Industrialised nations are collecting and patenting the genetic resources of under industrialised country like India. An American Company got patent rights on Basmati rice.

    ❑ Valuable biomolecules obtained from bioresources are patented and used for commercial purposes.

## SA-I (3 MARKS)

11. (a) Biopiracy

    (b) (i) Benefits of bioresources should be shared between developed and developing nations

    (ii) Laws should be developed to prevent unauthorsied exploitation of them bioresources.

12. (a) Produced in inactive form as Prototoxins.

    (b) Prototoxin becomes active toxin in alkaline pH of gut of insects. Toxins bind to surface of midgut and cause perforation, swelling, lysis of cells ultimately leading to death.

    (c) Specific Bt toxin genes isolated from *Bacillus thuringiensis* and incorporated into several crop plants such as cotton and corn which become pest resistant against certain insects.

13. (i) (b) Using *Agrobacterium* as a vector, introduced into tobacco

    (d) dsRNA (double stranded RNA)

    (f) Silenced specific mRNA of the nematode

    (g) Parasite could not survive.

    (ii) RNAi silences the gene at translation level

## LA (5 MARKS)

14. (a) Step (B) : Lymphocytes are grown in culture medium.

    Step (D) : Infusion of genetically engineered lymphocytes into patients.

    (b) Adenosine deaminase (ADA) deficiency.

    (c) As genetically engineered lymphocytes are not immortal, the patient requires periodic infusion of cells.

    (d) If the gene isolated from bone marrow cells producing ADA is introduced into cells at early embryonic stages, it could be a permanent cure.

15. **Step (a)** Plasmid is removed and cut open with restriction endonuclease.

    **Step (b)** Gene of interest is isolated from another organism and amplified using PCR

    **Step (c)** New gene is inserted into plasmid

    **Step (d)** Plasmid is put back into *Agrobacterium*

    **Step (e)** *Agrobacterium* based transformation.

16. (a) Disulphide bonds

    (b) Form (A) – Proinsulin

    Form (B) – Mature insulin.

    Proinsulin contains an extra stretch called C – peptide which is absent in mature insulin.

    (c) Eli Lilly company prepared two DNA sequences corresponding to A and B peptide chains of human insulin and introduced them in plasmid *E. coli* to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulphide bonds to form insulin.