Chapter 12

Biotechnology and its Applications

1. Mention the source organism of the gene cryIAc and its target pest.
   Ans. Source organism — Bacillus thuringiensis Target pest — Cotton bollworms
2. Name the specific type of gene that is incorporated in a cotton plant to protect the plant against cotton boll worm infestation.
   Ans. Cry IAc/Cry IIAb genes are incorporated in a cotton plant.
3. State a method of cellular defence which works in all eukaryotic organisms.
   Ans. RNA interference.
4. State the role of transposons in silencing of mRNA in eukaryotic cells.
   Ans. Transposons or mobile genetic elements in viruses are the sources of the complementary dsRNA, which in turn bind to specific mRNA and cause RNA interference of the parasite.
5. PCR requires very high temperature conditions where most of the enzymes get denatured. How was this problem resolved in a PCR?
   Ans. This problem was resolved by the use of a thermostable DNA polymerase, Taq polymerase derived from Thermus aquaticus which remains active during the high temperature and induces denaturation of double stranded DNA.
6. Name a molecular diagnostic technique to detect the presence of a pathogen in its early stage of infection.
   Ans. ELISA (Enzyme Linked Immunosorbent Assay)
7. Name any two techniques that serve the purpose of early diagnosis of some bacterial/viral human diseases.
   Ans. Enzyme linked immuno sorbent (ELISA) and Polymerase Chain Reaction (PCR) serve the purpose of early diagnosis of human diseases.
8. Why do children cured by enzyme-replacement therapy for adenosine deaminase deficiency need periodic treatment?
   Ans. As enzyme replacement therapy does not cure the disease completely, it requires periodic treatment.
9. What are transgenic animals? Give an example.
   Ans. Animals that have had their DNA manipulated, to possess and express an extra (foreign) gene are known as transgenic animals. Example, Rosie is a transgenic cow.
10. What is biopiracy?
    Ans. Biopiracy is the use of bioresources by multinational companies and other organisations without proper authorization or compensation payment to the concerned country or organisation.
11. State the purpose for which the Indian Government has set up GEAC. OR Mention two objectives of setting up GEAC by our government.
    Ans. GEAC was set up to make decisions regarding the validity of GM research and the safety of introducing GM-organisms for public services.

12. Highlight any four advantages of genetically modified organisms (GMOs). OR Describe any three potential applications of genetically modified plants.
Ans. Advantages of GMOs: (i) Tolerance against abiotic stresses (cold, drought, salt, heat). (ii) Reduce reliance on chemical pesticides. (iii) Reduce post-harvest losses. (iv) Increase efficiency of mineral usage by plants.
13. cryIAb is introduced in a plant to control infestation by corn borer. (a) Name the resultant plant after successful insertion of the gene desired. (b) Summarise the action of the gene introduced.
Ans. (a) Bt corn (b) CryIAb/Bt toxin gene codes for crystal protein; the Bt toxin protein exists as an inactive protein, but once an insect ingests it, it gets converted into an active form due to the alkaline pH of the gut which solubilises the crystal. The activated toxin binds to the surface of mid gut and creates pores that cause swelling, lysis and eventually death of the insect.
14. Name a genus of baculovirus. Why are they considered good biocontrol agents?
Ans. Nucleopolyhedrovirus is a genus of baculovirus. They are species-specific, have narrow-spectrum insecticidal application and no negative impact on non-target organisms, hence they are considered good biocontrol agents.
15. Why do the toxic insecticidal proteins secreted by Bacillus thuringiensis kill the insect and not the bacteria itself
Ans. The Bt toxin protein exists as inactive protoxins but once an insect ingests the inactive toxin, it is converted into an active form of toxin due to the alkaline pH of the gut which solubilise the crystals. Therefore, it does not kill the bacteria.
16. Name the genes responsible for making Bt cotton plants resistant to bollworm attack. How do such plants attain resistance against bollworm attacks? Explain.
Ans. Bt cotton has cryIAc/cryIIAb genes. These genes produce crystals of protoxin. When bollworm bites the cotton fruits, it consumes the toxic insecticidal protein. The alkaline pH in its gut activates the toxin. The activated toxin binds to mid-gut epithelial cells resulting in the lysis of cells leading to the death of the insect.
17. (a) State the role of DNA ligase in biotechnology. (b) What happens when Meloidogyne incognita consumes cells with RNAi gene?
Ans. (a) DNA ligase joins the DNA fragments with same sticky ends. It also links Okazaki fragments or discontinuously synthesised fragments. DNA ligase is used to link desired gene with plasmid to form recombinant DNA. (Any one) (b) The specific mRNA of the nematode is silenced and the parasite dies.
18. Why does the Bt toxin not kill the bacterium that produces it but kills the insect that ingests it?
Ans. Bt toxin exist as inactive protoxin in the bacterium. It becomes active only when it enters the gut of insect due to the alkaline pH of the gut which solubilise the crystals.
19. A corn farmer has perennial problem of corn-borer infestation in his crop. Being environmentally conscious he does not want to spray insecticides. Suggest solution based on your knowledge of biotechnology. Write the steps to be carried out to achieve it.

Ans. The following steps should be followed: (i) Isolation of Bt toxin genes from Bacillus thuringiensis. (ii) Incorporation of gene into corn. (iii) Toxin coded by gene cryIAb in corn, kills the pests and the pest dies.

20. Explain the process of RNA interference.
Ans. RNA interference takes place in all eukaryotic organisms as a method of cellular defence. It involves silencing of a specific mRNA due to complementary dsRNA molecule that binds to and prevents translation of the mRNA.

21. How did an American Company, Eli Lilly use the knowledge of rDNA technology to produce human insulin?
Ans. Two chains of DNA sequence corresponding to A and B chains of human insulin were prepared. They introduced them into plasmids of E. coli to produce separate A and B chains. The A and B chains extracted were then combined by creating disulphide bonds and form human insulin.

22. Write the functions of adenosine deaminase enzyme. State the cause of ADA deficiency in humans. Mention a possible permanent cure for a ADA deficiency patient.
Ans. Adenosine deaminase enzyme is responsible for the proper functioning of the immune system. ADA deficiency is caused by deletion of gene for adenosine deaminase. A possible permanent cure would be gene therapy, if it is detected at early embryonic stage.

23. How has recombinant technology helped in large scale production of vaccines? Explain giving one example.
Ans. Production of insulin by rDNA techniques was achieved by an American company, Eli Lilly, in 1983. It prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of E. coli for production. The A and B chains produced were separated, extracted and combined by creating disulfide bonds to form human insulin.

24. How is 'Rosie' considered different from a normal cow? Explain.
Ans. Rosie is a transgenic cow. Rosie produces human protein-enriched milk containing human a -lactalbumin.

25. What is gene therapy? Name the first clinical case where it was used.
Ans. Gene therapy is a collection of methods that allows correction of a gene defect that has been diagnosed in a child/embryo. Genes are inserted into an individual's cells and tissues to treat disease. The first clinical case where it was used was for caring Adenosine deaminase (ADA) deficiency.

26. Why is the introduction of genetically engineered lymphocytes into an ADA deficiency patient not a permanent cure? Suggest a possible permanent cure.
Ans. Introduction of genetically engineered lymphocytes into an ADA deficiency patient is not a permanent cure because these cells are not immortal and the patient requires periodic infusion of such genetically engineered lymphocytes. A possible permanent cure can be isolating the gene producing adenosine deaminase (ADA) from bone marrow cells and introducing it into cells at early embryonic stages.

27. Biopiracy should be prevented. State why and how.

Ans. Biopiracy is unauthorised exploitation of bioresources of developing or under-developed countries. Hence, it should be prevented. It can be prevented by developing laws to obtain proper authorisation and by paying compensatory benefits.

28. Mention some transgenic plants and their potential applications.

S. No.	Transgenic plants	Useful applications
(*i*)	Flavr Savr tomato	Better nutrient quality.
(*ii*)	*Brassica napus*	Contains hirudin (a protein) that prevents blood clotting. Hirudin is synthesised chemically and it is transferred into *Brassica napus*.
(*iii*)	Bt cotton	It has resistance to bollworm infestation, tolerance to herbicide, high yielding.
(*iv*)	Wheat	Resistant against herbicide PPT (Commercial name "Basta"—26 per cent PPT).
(*v*)	Potato	Content of starch increased by about 20–40 per cent.
(*vi*)	Corn, brinjal	Insect resistance.
(*vii*)	Maize, soyabean	Herbicide resistance.
(*viii*)	Golden rice	Rich in vitamin-A.

29. Name the process involved in the production of nematode-resistant tobacco plants, using genetic engineering. Explain the strategy adopted to develop such plants.

Ans. The process involved in the production of nematode-resistant plants is RNA interference or RNAi. Using Agrobacterium vectors, nematode-specific genes were introduced into the host plant. The introduction of DNA was such that it produced both sense and antisense RNA in the host cells. These two RNA's being complementary to each other formed a double stranded RNA (dsRNA) that initiated RNAi and thus, silenced the specific mRNA of the nematode. The consequence was that the parasite could not survive in a transgenic host expressing specific interfering RNA. The transgenic plant, therefore, got itself protected from the parasite.

30. How have biotechnologists effectively used Agrobacterium tumefaciens in plants and retroviruses in animals? Explain.

Ans. In plants the tumor inducing (Ti) plasmid of Agrobacterium tumefaciens has been modified into a cloning vector, which is no more pathogenic to the plants, but is still able to use the mechanisms to deliver genes of our interest into a variety of plants. In animals retroviruses have been disarmed and are used to deliver desirable genes into animal cells. Once a gene or a DNA fragment has been ligated into a suitable vector it is transferred into a bacterial/plant or animal host (where it multiples).

31. Why do lepidopterans die when they feed on Bt cotton plant? Explain how does it happen.

Ans. Bt cotton contains inactive toxin protein or protoxin. These are insecticidal proteins in the form of crystal protein. Once the insect ingests its, the inactive protoxin is converted into active form due to alkaline pH in the gut, which solubilise the crystals. The activated toxins bind to the surface of midgut epithelial cells, thus creating pores which causes cell swelling and lysis, eventually leading to the death of the insect pest.

32. Name the pest that destroys the cotton bolls. Explain the role of Bacillus thuringiensis in protecting the cotton crop against the pest to increase the yield.

Ans. Cotton bollworms destroy the cotton bolls. Bacillus thuringienesis has Bt toxin genes. These genes produce toxic proteins that kill the pests. Bt toxins are initially inactive protoxins but after ingestion by the insect their inactive toxin becomes active due to the alkaline pH of the gut. The activated toxin binds to the surface of midgut epithelial cells thus killing the insects. Specific Bt toxins were isolated from Bacillus thuringienesis and incorporated into the cotton plants to make them pest resistant.

33. How did the process of RNA interference help to control the nematode from infecting roots of tobacco plants? Explain.
Ans. Using Agrobacterium vectors, nematode specific genes are introduced into host plant. The introduction of DNA produced both sense and anti sense RNA in host cells. These two RNA's being complementary formed a double stranded RNA (dsRNA) that initiated RNAi and silenced the specific mRNA of the nematode. As a result, the parasite could not survive in the transgenic host expressing specific interfering RNA.

34. How has the use of Agrobacterium as vectors helped in controlling Meloidogyne incognitia infestation in tobacco plants? Explain in correct sequence.
Ans. By using Agrobacterium vectors, nematode-specific genes were introduced into the host plants which produce both sense and anti-sense RNA in the host cells. These two RNAs are complementary to each other and form a double-stranded RNA (dsRNA) that initiates RNAi and hence silence the specific mRNA of the nematode. The parasite cannot survive in the transgenic host, so protects the plants from pests.

35. (a) Name the deficiency for which first clinical gene therapy was given. (b) Mention the causes of and one cure for this deficiency.
Ans. (a) Adenosine deaminase deficiency (ADA). (b) Cause: Deletion of ADA gene. Cure: Bone marrow transplantation/enzyme replacement therapy/giving functional ADA to patient by injection/infusion of genetically engineered lymphocytes/introducing gene isolated from marrow cells producing ADA into cells at early embryonic stages.

36. (a) Why are transgenic animals so called? (b) Explain the role of transgenic animals in (i) Vaccine safety and (ii) Biological products with the help of an example each.
Ans. (a) Transgenic animals are so called because these animals have their DNA manipulated. (b) (i) Vaccine safety: Transgenic mice are developed to test safety of polio vaccine before being used on humans. (ii) Human protein (α-1-antitrypsin) is used to treat emphysema.

37. (a) Why is Bacillus thuringiensis considered suitable for developing GM plants? (b) Explain how it has been used to develop GM crops.
Ans. (a) Some strains of Bacillus thuringiensis produce proteins that kill some insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes). Bt toxins are initially inactive protoxins but after ingestion by the insect their inactive toxin becomes active due to the alkaline pH of the gut which solublise the crystals. The activated toxin binds to the surface of midgut epithelial cells thus creating pores which causes cell swelling and lysis,

further leading to death of the insects. (b) Bacillus thuringiensis produces Cry protein. Cry protein producing gene is transferred to the plant to provide resistance against insect larvae. Man has developed several transgenic crops by introducing these genes from bacteria to crop plants such as Bt cotton, Bt corn, etc.

38. (a) Name the source from which insulin was extracted earlier. Why is this insulin no more in use by diabetic people? (b) Explain the process of synthesis of insulin by Eli Lilly Company. Name the technique used by the company. (c) How is the insulin produced by human body different from the insulin produced by the above mentioned company?

Ans. (a) Earlier, insulin was extracted from pancreas of slaughtered cattle and pig. This insulin is not in use as some patients developed allergic reaction to this foreign protein. (b) Eli Lilly used the following procedure for insulin synthesis: (i) Two DNA sequences corresponding to A and B chains of insulin were prepared. (ii) These sequences were then introduced in plasmids of E. coli. (iii) The two insulin chains are produced separately. (iv) The two chains are extracted and combined by creating disulphide bonds to form the assembled mature molecule of insulin. (c) The pro-hormone produced in the human body has an extra stretch of C-peptide.

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