Very Short Answer Questions (PYQ)

[1 Mark]

Q.1. Mention the source organism of the gene *cryIAc* and its target pest.

Ans. Source organism — *Bacillus thuringiensis*
Target pest — Cotton bollworms

Q.2. What are *cry* genes? In which organism are they present?

Ans. The genes which code for Bt toxin, which is toxic protein. They are present in *Bacillus thuringiensis*.

Q.3. 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.

Q.4. Bt-toxins are released as inactive crystals in the bacterial body. What happens to it in the cotton bollworm body that it kills the bollworm?

Ans. The inactive Bt-toxins are converted into an active protein due to alkaline pH of the gut of the bollworm. The toxin binds to midgut cells and create pores on the surface. This causes cell swelling and lysis that kills the bollworm.

Q.5. List the type of cry genes that provide resistance to corn plants and cotton plants respectively against lepidopterans.

Ans. *Cry IAb* provides resistance to corn plants and *Cry IAc* and *Cry IIAb* provide resistance to cotton plants.

Q.6. How are two short polypeptide chains of insulin linked together?

Ans. Two short polypeptide chains of insulin are linked together by disulphide bridges.

Q.7. State the role of C peptide in human insulin.

Ans. C-peptide (extra stretch of polypeptide) makes the insulin inactive.

Q.8. State the role of transposons in silencing of *m*RNA in eukaryotic cells.

Ans. Transposons or mobile genetic elements in viruses are the sources of the complementary *ds*RNA, which in turn bind to specific *m*RNA and cause RNA interference of the parasite.

Q.9. Name a molecular diagnostic technique to detect the presence of a pathogen in its early stage of infection.

Ans. ELISA (Enzyme Linked Immunosorbent Assay)

Q.10. Name any two techniques that serve the purpose of early diagnosis of some bacterial/viral human diseases.

Ans. ELISA and PCR serve the purpose of early diagnosis of human diseases.

Q.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.

Q.12. What is the significance of the process of RNA interference (RNAi) in eukaryotic organisms?

Ans. RNA interference in all eukaryotic organisms is a method of cellular defence.

Q.13. State the cause of adenosine deaminase enzyme deficiency.

Ans. Deletion of gene for adenosine deaminase.

Q.14. Suggest any two possible treatments that can be given to a patient exhibiting adenosine deaminase deficiency.

Ans.

i. Enzymes replacement therapy (in which functional ADA is injected)
ii. Bone marrow transplantation
iii. Gene therapy/Culturing the lymphocytes followed by introduction of functional ADA *c*DNA into it and returning it into the patient's body. (*Any two*)

Q.15. A boy has been diagnosed with ADA deficiency. Suggest any one possible treatment.

Ans. Bone marrow transplant/enzyme replacement therapy/gene therapy.

Q.16. 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.

Q.17. Suggest any two techniques which can help in early detection of bacterial and viral infections much before the symptoms appear in the body.

Ans. Enzyme Linked Immunosorbent Assay (ELISA), Polymerase Chain Reaction (PCR).

Q.18. What are transgenic animals? Given 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.

Q.19. 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.

Q.20. A multinational company outside India tried to sell new varieties of turmeric without proper rights. What is such an act referred to?

Ans. Biopiracy

Very Short Answer Questions (OIQ)

[1 Mark]

Q.1. Why is the gene encoding for 'Cry' protein inserted into a crop plant?

Ans. Cry protein producing gene is transferred to the plant to provide resistance against insect larvae.

Q.2. Give the name of HGH (Human Growth Hormones), developed during recombinant DNA technology and used for treating hypopituitary dwarfism in human.

Ans. Somatotropin.

Q.3. State a method of cellular defence which works in all eukaryotic organisms.

Ans. RNA interference

Q.4. Give the full form of SCID.

Ans. Severe Combined Immuno Deficiency.

Q.5. How many amino acids are arranged in the two chains of insulin?

Ans. A molecule of insulin consists of two short polypeptide chains A and B. The chain A has 21 amino acids and chain B has 30 amino acids.

Q.6. What is Bt cotton?

Ans. It is a transgenic variety of cotton which contains a foreign gene obtained from bacterium *Bacillus thuringiensis*.

Q.7. What is "Flavr Savr"?

Ans. It is a transgenic tomato variety which has blocked production of polygalacturonase.

Q.8. In insulin molecule, which bond joins chains A and B together?

Ans. Disulfide bond joins chains A and B of insulin.

Q.9. How many polypeptide chains are present in a molecule of insulin?

Ans. Two.

Q.10. A boy has been diagnosed with ADA deficiency. Suggest any one possible treatment.

Ans. Bone marrow transplant or enzyme replacement therapy or gene therapy.

Q.11. Name two genetically modified hormones.

Ans. Insulin and human growth hormones.

Q.12. Write the two uses of PCR technique in diagnosis.

Ans. Two uses of PCR technique:

i. It is used to detect HIV in suspected AIDS patients.
ii. It is used to detect mutations in gene, in suspected cancer patients.

Q.13. 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, *Thermus aquaticus* which remain active during the high temperature and induce denaturation of double stranded DNA.

Q.14. How transgenic animals, that produce useful products, can be created?

Ans. Transgenic animals that produce useful biological products can be created by introduction of the portion of DNA (for genes) which codes for a desired product.

Q.15. Name the first transgenic cow.

Ans. Rosie was the first transgenic cow

Q.16. What was the speciality of the milk produced by the transgenic cow Rosie?

Ans. The first transgenic cow, Rosie, produced milk with human alpha-lactalbumin which was nutritionally, more balanced product for human babies than natural cow milk.

Q.17. What is chimeric DNA?

Ans. Chimeric DNA molecules are produced by inserting a foreign segment of DNA into the DNA molecule of a vector.

Q.18. Which gene was introduced in the first transgenic cow?

Ans. Gene for human alpha lactalbumin was introduced in the gene of first transgenic cow, which made the milk nutritionally richer.

Q.19. How is patent given?

Ans. Patent is given for producing new products or inventions or for modified and improved earlier inventions.

Q.20. A multinational company outside India tried to sell new varieties of turmeric without proper rights. What is such an act referred to?

Ans. Biopiracy.

Q.21. What is Chakravarthy bug? Give its scientific name and its application?

Ans. Chakravarthy bug is a super bug of *Pseudomonas* with multiple plasmids. They are helpful in removing oil spills.

Q.22. Name a recombinant vaccine that is currently being used in vaccination program?

Ans. Hepatitis B recombinant vaccine, Engerix-B, is used for vaccination of hepatitis virus.

Q.23. For which variety of Indian rice, patent was filed by a USA Company?

Ans. Indian Basmati was crossed with semi-dwarf variety and was claimed as a new variety for which the patent was filed by a USA company.

Q.24. Name any genetically modified crop.

Ans. Bt cotton.

Q.25. State a method of cellular defense which works in all eukaryotic organisms.

Ans. RNA interference.

Short Answer Questions-I (PYQ)

[2 Marks]

Q.1. Name the source and the types of *cry* genes isolated from it for incorporation into crops by biotechnologists. Explain how have these genes brought beneficial changes in the genetically modified crops.

Ans. Source of *cry* gene is *Bacillus thuringiensis*.

The following type of cry genes are isolated from it: *cry*IAc, *cry*IIAb, *cry*IAb.
The introduction of *cry* gene acts as biopesticide. The *cry* gene produce crystals of toxic insecticidal protein. The activated toxin causes death of the insect.

Q.2. 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.

Q.3.

a. **How does *cry*IAc gene express itself in its host?**
b. **State the role of this gene in controlling the infestation of bollworm.**

Ans.

a. *cry*IAc gene codes for a toxic insecticidal protein that controls the cotton bollworms.
b. This gene codes for a toxin that becomes active when ingested by the insect. The activated toxin binds to the surface of mid-gut epithelial cells thus creating pores which causes cell swelling and lysis, further leading to death of the insects.

Q.4. Name the insect pest that is killed by the products of *cry*IAc gene. Explain how the gene makes the plant resistant to the insect pest.

Ans.

a. cryIAc gene codes for a toxic insecticidal protein that controls the cotton bollworms.
b. This gene codes for a toxin that becomes active when ingested by the insect. The activated toxin binds to the surface of mid-gut epithelial cells thus creating pores which causes cell swelling and lysis, further leading to death of the insects.

Q.5. 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 *m*RNA due to complementary *ds*RNA molecule that binds to and prevents translation of the *m*RNA.

Q.6. Explain how a hereditary disease can be corrected. Give an example of first successful attempt made towards correction of such diseases.

Ans. A hereditary disease can be corrected by gene therapy. In this method, genes are inserted into a person's cells and tissues to treat a disease.
The first successful attempt for gene therapy was done for adenosine deaminase (ADA) **deficiency.**

Q.7. Name the first transgenic cow developed and explain the improvement in the quality of the product produced by it.

Ans. Rosie was the first transgenic cow. It produced human protein-enriched milk (2.4 gram per litre).

Q.8. What is GEAC and what are its objectives?

OR

Describe the responsibility of GEAC, set up by the Indian Government.

Ans. GEAC (Genetic Engineering Approval Committee) is an Indian government organisation. Its objective are to:

a. examine the validity of GM (Genetic modification of organism) research.
b. inspect the safety of introducing GM for public services and for their large scale use.

Q.9. 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. reduces reliance on chemical pesticides.
iii. reduces post-harvest losses.
iv. increase efficiency of mineral usage by plants.

Q.10. How has recombinant technology helped in large scale production of vaccines? Explain giving one example.

Ans. Production of insulin by *r*DNA 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.

Q.11. 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.

Q.12. 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 *crylAc/crylIAb* 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 cell leading to the death of the insect.

Q.13. Nematode-specific genes are introduced into the tobacco plants using Agrobacterium vectors to develop resistance in tobacco plants against nematodes. Explain the events that occur in tobacco plant to develop resistance.

OR

How has RNA*i* technique helped to prevent the infestation of roots in tobacco plants by a nematode *Meloidegyne incognitia*?

Ans.

- A nematode Meloidegyne incognitia infects the roots of tobacco plants which reduces the production of tobacco.
- It can be prevented by using RNA interference (RNAi) process which is checked by silencing of specific mRNA due to a complementary dsRNA.
- dsRNA binds and prevents translation of the mRNA (silencing).
- 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.

Q.14.

a. **Tobacco plants are damaged severely when infested with *Meloidegyne incognitia*. Name and explain the strategy that is adopted to stop this infestation.**

b. Name the vector used for introducing the nematode specific gene in tobacco plant.

Ans.

a. Gene expression can be controlled by using RNA molecule and this technology is called RNA interference or RNAi or gene silencing. During this process nematode specific gene is introduced into host plant (using *Agrobacterium*) which produces *ds*RNA. This silences specific *m*RNA of the nematode and parasite dies.
b. *Agrobacterium tumifaciens*.

Q.15. 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.

Q.16. How is 'Rosie' considered different from a normal cow? Explain.

Ans. Rosie is a transgenic cow.
Rosie produced human protein-enriched milk containing human alpha-lactalbumin.

Q.17. How did an American Company, Eli Lilly use the knowledge of *r*-DNA technology to produce human insulin?

OR

Explain how Eli Lilly, an American Company, produced insulin by Recombinant DNA technology.

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.

Q.18.

a. Mention the cause and the body system affected by ADA deficiency in humans.
b. Name the vector used for transferring ADA-DNA into the recipient cells in humans. Name the recipient cells.

Ans.

a. The cause is the defective gene not producing ADA. The immune system is affected.
b. A retroviral vector is used, recipient cells are lymphocytes.

Q.19. 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.

Q.20. Why is the functional insulin thus produced considered better than the ones used earlier by diabetic patients?

Ans. The insulin prepared by *r*DNA technology does not produce sensitive allergic reactions and immunological reactions whereas those used earlier produced allergic reactions and other complications to the foreign protein as earlier they were extracted from pancreas of slaughtered cattle or pigs.

Q.21. 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 a 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.

Q.22. 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.

Q.23. How have transgenic animals proved to be beneficial in:

Q. Production of biological products?

Ans. Rosie–the transgenic cow, produced human proteins containing human α-lactalbumin. Transgenic animals have been made to produce 2- 1-antitrypsin used to treat emphysema.

Q. Chemical safety testing?

Ans. Toxicity testing – Transgenic animals are more sensitive to toxic substances, so the results are obtained in less time.

Q.24. What is gene therapy? Name the first clinical case where it was used.

Ans. Give 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 for Adenosine deaminase (ADA) deficiency.

Q.25. What is Biopiracy? State the initiative taken by the Indian Parliament towards it.

Ans. Biopiracy is the use of bioresources by organisations without proper authorisation from the countries and people concerned without compensatory payment.
The government has cleared patent terms, emergency provisions and research and development initiative.

- Some nations are developing laws, to prevent such unauthorised exploitation of their bioresources and traditional knowledge.
- To check these problems, Indian Parliament has recently cleared the second amendment of the **Indian Patents Bill**, that takes such issues into consideration.

Q.26. How has the bacterium Bacillus thuringiensis helped us in controlling caterpillars of insect pests?

Ans. *Bacillus thuringiensis* products are endotoxin which when ingested and released in the gut of the larvae of insect pest, disrupts the insect gut lining thereby killing them.

Q.27. Answer the following questions:

Q. State the role of DNA ligase in biotechnology.

Ans. DNA ligase joins the DNA fragments with same sticky ends./Link Okazaki fragments or discontinuously synthesised fragments./Link desired gene with plasmid to form recombinant DNA. (*Any one*)

Q. What happens when Meloidegyne incognitia consumes cells with RNAi gene?

Ans. The specific *m*RNA of the nematode is silenced and the parasite dies.

Short Answer Questions-I (OIQ)

[2 Mark]

Q.1. Name any four transgenic animals commonly produced. Which animal constitutes a major proportion among transgenic animals?

Ans. Four commonly produced transgenic animals are mice, pigs, cows and sheep. 25 per cent of the transgenic animals are mice.

Q.2. Name the biological products made in transgenic animal to treat emphysema. Explain.

Ans. Human protein *α*-1-antitrypsin is produced to treat emphysema. The gene for this protein is isolated and introduced into a mouse. The transgenic mouse produces the protein, which is to be isolated, purified and used on human beings after further clinical trials.

Q.3. What are the conditions for which patent is given?

Ans. Patent is given for:

i. producing new products or inventions.
ii. modification and improvement of earlier inventions.
iii. technical know-how.
iv. designing of new concepts.

Q.4.

a. Given below is a single stranded DNA molecule. Frame and label its sense and antisense RNA molecule.
5' ATGGGGCTC 3'
b. How the RNA molecules made from above DNA strand help in silencing of the specific RNA molecules?

Ans.

a. 5' ATGGGGCTC 3' sense
3' TACCCCGAG 5' antisense
5'AUGGGGCUC 3' sense
3'UACCCCGAG 5' antisense
b. The two strands of RNA (*i.e.*, sense and antisense) being complementary will bind with each other and form double stranded RNA as a result its translation and protein expression would be inhibited.

Q.5. Differentiate between gene therapy and gene cloning.

Ans.

Gene therapy	Gene cloning
The process of replacing defective gene responsible for hereditary disease by the normal gene is called gene therapy.	The technique to produce identical copies of a particular segment of DNA or a gene.

Q.6. How is a mature, functional insulin hormone different from its pro-hormone form?

Ans. Mature functional insulin is obtained by processing of pro-hormone which contains extra peptide called C-peptide. This C-peptide is removed during maturation of pro-insulin to insulin.

Q.7. Expand GMO. How is it different from a hybrid?

Ans. GMO stands for genetically modified organism. It differs from a hybrid because in a hybrid, cross is done between total genomes of two species or strains, whereas in a GMO, foreign genes are introduced in the organism and is usually maintained as extra-chromosomal entity or is integrated into the genome of the organism and their is change in only one phenotype.

Q.8. Mention the problems when we consume GM food.

Ans. When we consume GM food, following problems arise:

i. GM food may cause toxicity.
ii. The bacteria present in the alimentary canal of human could take up the antibiotic resistant gene which is present in GM food, that will cause problem.

Q.9. How is PCR used to detect gene mutation in case of suspected cancer patient?

Ans. A single stranded small DNA or RNA is tagged with radioactive molecule to be used as a probe. The probe is hybridised with DNA in cancer cells, to be followed by autoradiography. The clone with mutated gene will not appear in the autoradiography, because the probe will not have the complementary sequence with mutated gene.

Q.10. What is legally wrong in the US patent law? Mention the common items of biopiracy.

Ans. US patent law does not recognise technologies and methods in use to other countries as ‘prior past’. The common items of biopiracy are soil micro-organisms, plant, animals and their genetic materials.

Q.11. Why are yeasts used extensively for functional expression of eukaryotic genes?

Ans. Yeasts are simplest unicellular eukaryotic organisms and like bacteria they are genetically well characterised, easy to grow and manipulate. They can be readily cultured in small culture vessels as well as in large-scale bioreactors.

Q.12. Bt cotton is resistant to pest, such as lepidopteran, dipterans and coleopterans. Is Bt cotton resistant to other pests as well?

Ans. Bt cotton is made resistant to only certain specific taxa of pests. It is quite likely that in future, some other pests may infest the Bt cotton plants. It is similar to

immunisation against small-pox which does not provide immunity against other pathogens like those that cause cholera, typhoid, etc.

Q.13. ELISA technique is based on the principles of antigen and antibody interaction. Can this technique be used in the molecular diagnosis of a genetic disorder, such as phenylketonuria?

Ans. Yes. One can use antibody against the enzyme (that is responsible for the metabolism of phenylalanine) to develop ELISA-based diagnostic technique. The patient in which the enzyme protein is absent would give negative result in ELISA when compared to normal individual.

Q.14. Gene therapy is an attempt to correct a genetic defect by providing a normal gene into the individual. By this the normal function can be restored. Alternate method would be to provide the gene product (protein/enzyme) known as enzyme replacement therapy, which would also restore the function. Which in your opinion is a better option? Give reason for your answer.

Ans. Gene therapy would be a better option because it has the potential to completely cure the patient. It is because the correct gene once introduced in the patient, can continue to produce the correct protein enzyme. Enzyme therapy does not offer permanent cure as it needs to be given to the patient on regular basis. It is also more expensive.

Q.15. A person is born with a hereditary disease, suggest the possible corrective method for it. Illustrate by giving a specific example.

Ans. The possible corrective method is gene therapy.
For example, ADA (Adenosine deaminase) deficiency has been treated through gene therapy. Lymphocytes from the blood of the patient are grown in a culture. A functional ADA *c*DNA is introduced into these lymphocytes, which are subsequently returned to the patient. The permanent cure is done by introducing ADA *c*DNA into cells at early embryonic stages.

Q.16. How has the bacterium *Bacillus thuringiensis* helped us in controlling caterpillars of insect pests?

Ans. *Bacillus thuringiensis* products are endotoxin which when ingested and released in the gut of the larvae of insect pest disrupts the insect gut lining thereby killing them.

Q.17. *cry*IAb 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. *Cry*IAb/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.

Short Answer Questions-II (PYQ)

[3 Marks]

Q.1. What is GMO? List any five possible advantages of a GMO to a farmer.

Ans. Genetically modified organisms (GMOs) are plants, bacteria, fungi and animals whose genes have been altered by manipulation.

Genetic modification of crops have resulted in

a. increased tolerance against abiotic stresses (cold, drought, salt, heat).
b. reduced reliance on chemical pesticides (pest-resistant crops).
c. reduced post-harvest losses.
d. increased efficiency of minerals used by plants (this prevents early exhaustion of fertility of soil).
e. enhanced nutritional value of food, e.g., vitamin 'A' enriched rice (golden rice).
f. creation of tailor-made plants to supply alternative resources such as starches, fuels and pharmaceuticals to industries.

Q.2. 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 (*ds*RNA) that initiated RNAi and thus, silenced the specific *m*RNA 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.

Q.3. Explain the synthesis of genetically engineered human insulin.

Ans. Genetically engineered insulin

- Insulin contains two short polypeptide chains—chain A and chain B linked by disulphide bridges.
- In mammals, insulin is synthesised as a pro-hormone (that needs to be processed to become mature and functional hormone). It contains an extra stretch called C peptide.
- C peptide is absent in mature insulin and is removed during maturation into insulin.
- Earlier, insulin was extracted from pancreas of slaughtered cattle and pigs but some patients began developing allergies.
- Production of insulin by *r*DNA 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.

Q.4. Describe the various stages involved in gene transfer for the commercial production of human insulin by Eli Lilly.

Ans.

a. Eli Lilly prepared two DNA sequences corresponding to the A and B chains of human insulin.
b. Sticky ends were produced in the *Escherichia coli* plasmid and the insulin gene by treating them both with the same restriction endonucleases.
c. These two are then joined together by the enzyme DNA ligase.
d. The bacteria are then grown in sterilised bioreactors in the appropriate growth medium.
e. The chains A and B are produced separately, extracted and purified.
f. These two chains are then combined by creating disulfide bonds to form human insulin.

Q.5.

a. What is gene therapy?
b. Describe the procedure of such a therapy that could be a permanent cure for a disease. Name the disease.

Ans.

- Gene therapy is a collection of methods that allows correction of gene defects, diagnosed in a child or embryo.
- By insertion of normal genes, the defective mutant allele of the genes are replaced and non-functional gene is compensated.
- ADA is caused due to deletion of gene for adenosine deaminase.
- Lymphocytes from patient's blood were grown in a culture and functional ADA, cDNA was introduced in these lymphocytes using a retroviral vector.
- The lymphocytes were transferred into the patient's body. Periodic infusion of such genetically engineered lymphocytes is done because these cells are mortal.

Q.6. Expand the name of the enzyme ADA. Why is this enzyme essential in the human body? Suggest a gene therapy for its deficiency.

Ans. ADA–Adenosine deaminase.

This enzyme is essential for immune system to function. ADA deficiency can be cured by gene therapy. Lymphocytes from the blood of the patients are extracted and cultured outside the body. A functional ADA *c*DNA (using a retroviral vector) is introduced into these lymphocytes and these lymphocytes are then returned to the patient's body.

However, as these cells are not immortal, the patient requires periodic infusion of such genetically engineered lymphocytes.

Q.7.

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. (*Any one*)

Q.8. Describe the gene therapy procedure for an ADA-deficient patient.

Ans. Gene therapy is a method which corrects or replaces the defective genes. In 1900, first clinical gene therapy was given to a 4-year old girl with adenosine deaminase (ADA) deficiency. This enzyme plays an important role in functioning of immune system. This disorder is caused due to the deletion of the gene for adenosine deaminase. In gene therapy, lymphocytes from the blood of the patient are grown in a culture outside the body. A functional ADA *c*DNA (using a retroviral vector) is then introduced into these lymphocytes, which are returned to the patients. However, as these cells are not immortal, the patient requires periodic infusion of such genetically engineered lymphocytes.

Q.9. Explain enzyme-replacement therapy to treat adenosine deaminase deficiency. Mention two disadvantages of this procedure.

Ans. Functional adenosine deaminase is given to the patient by injection.

i. Lymphocytes from the blood of the patient are grown on culture outside the body.
ii. A functional ADA, cDNA is then introduced into these lymphocytes using a retroviral vector.
iii. The genetically engineered lymphocyte are returned to the blood of patient.

Disadvantages: Therapy is not completely curative as cells do not remain alive and periodic infusion of lymphocytes is required.

Q.10.

a. **How do organic farmers control pests? Give two examples.**
b. **State the difference in their approach from that of conventional pest control methods.**

Ans.

a. By natural predation or biological control. **Examples:** Lady bird used to kill aphids, dragon flies used to kill mosquitoes, *Bacillus thuringiensis* used to kill cotton bollworm.
b.

Conventional pest control	Organic farming based pest control
1. Use of chemical insecticides and pesticides.	1. No chemical used.
2. Harmful to non-target organisms.	2. Not harmful to non-target organisms.
3. Cause environmental pollution.	3. No adverse impact on environment.

Q.11.

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 had 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.

Q.12. Name the host plant and the part that *Meloidegyne incognitia* infects. Explain the role of *Agrobacterium* in production of *ds*RNA in host plant.

Ans. *Meloidegyne incognitia* infects the roots of tobacco plant.

- 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 (*ds*RNA) that initiates RNAi and hence silence the specific *m*RNA of the nematode.
- The parasite cannot survive in the transgenic host, so protects the plants from pests.

Q.13. 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 protein in the form of crystal protein. Once the insect ingests its the inactive protoxins 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.

Q.14. 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.

Q.15. How did Eli Lilly synthesise the human insulin? Mention one difference between this insulin and the one produced by the human pancreas.

OR

How did Eli Lilly Company go about preparing the human insulin? How is the insulin thus produced different from that produced by the functional human insulin gene?

Ans. Eli Lilly 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. Insulin in human pancreas is synthesised as a pro-hormone containing the C peptide, which is removed to form mature hormone. The synthesised insulin did not contain C peptide and was directly prepared in mature form.

Q.16. List the three molecular diagnostic techniques that help detect pathogens from suspected patients. Mention one advantage of these techniques over conventional methods.

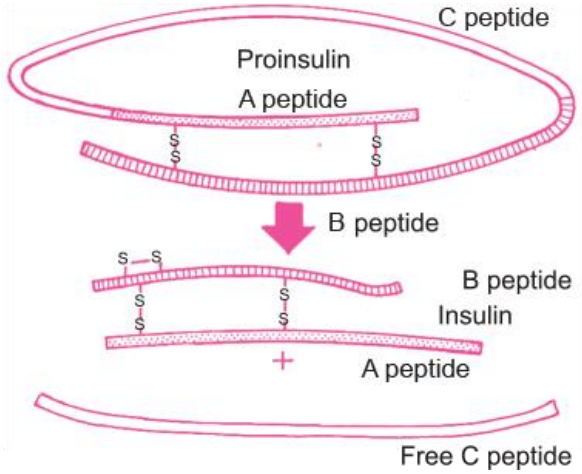
Ans. The three molecular diagnostic techniques that help to detect pathogens from suspected patients are:

a. Recombinant DNA technology
b. Polymerase chain reaction (PCR)
c. Enzyme-linked immunosorbent assay (ELISA)

These techniques are better than the conventional methods because they help in early diagnosis of the disease even when the bacteria or virus concentration is very low.

Q.17. Recombinant DNA-technology is of great importance in the field of medicine. With the help of a flow chart, show how this technology has been used in preparing genetically engineered human insulin.

Ans.



Maturation of proinsulin into insulin after removal of C-peptide

Q.18. Why is proinsulin so called? How is insulin different from it?

Ans. Proinsulin is called so because it is an inactive form of insulin.

S.No.	Insulin	Proinsulin
(*i*)	It is made up of two short polypeptide chains A and B linked by disulphide bridges.	Along with the two polypeptide chains in insulin. It contains an extra stretch called C peptide.
(*ii*)	It is functional.	It is non-functional.

Q.19. Plasmid is a boon to biotechnology. Justify this statement quoting the production of human insulin as an example.

Ans. Plasmids are extra-chromosomal, self-replicating, usually circular, double-stranded DNA molecules found naturally in many bacteria.

In 1983, Eli Lilly an American company, first 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. These chains A and B were produced separately, extracted and combined by creating disulfide bonds to form functional human insulin (humulin).

Q.20. 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 (*ds*RNA) that initiated RNAi and silenced the specific *m*RNA of the nematode. As a result, the parasite could not survive in the transgenic host expressing specific interfering RNA.

Q.21. Answer the following questions:

Q. List any four beneficial effects of GM plants.

Ans.

i. Increased tolerance against abiotic stresses (cold, drought, salt, heat).
ii. Reduced reliance on chemical pesticides (pest-resistant crops).
iii. Reduced post-harvest losses.
iv. Increased efficiency of minerals used by plants (this prevents early exhaustion of fertility of soil).
v. Enhanced nutritional value of food, *e.g*., vitamin 'A' enriched rice (golden rice).

Q. Explain how has Bacillus thuringiensis contributed in developing resistance to cotton bollworms in cotton plants.

Ans. Bt cotton

- Some strains of Bacillus thuringiensis produce proteins that kill some insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes).
- *B. thuringiensis* forms protein crystals which contain a toxic insecticidal protein.
- The toxin is coded by a gene called *cry* which is of various types. For example, proteins encoded by the genes *cryIAc* and *cryIIAb* control the cotton bollworms and that of *cryIAb* control corn borer.

Short Answer Questions-II (OIQ)

[3 Marks]

Q.1. What are genetically modified organisms? Name two factors on which their behaviour depends.

Ans. Plants , fungi, bacteria and animals that have had their DNA manipulated to possess and express an extra (foreign) gene are known as genetically modified organisms. The two factors on which the behaviour of such organisms depend are:

i. nature of gene transferred.
ii. nature of the host cell.

Q.2. Mention some transgenic plants and their potential applications.

Ans. Some transgenic plants and their potential applications are given below:

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.

Q.3. Biotechnology has helped farmers to get pest resistant cotton crops. Explain the technique adopted along with its mode of action. (Mention six points)

Ans. The technique involves the use of a popularly known biopesticide Bt toxin produced by bacteria *Bacillus thuriengiensis*. Bt toxin protein when ingested by the insect gets converted to its active form due to alkaline pH of the gut. The activated toxin binds to the surface of midgut epithelial cells. It creates pores in these cells that cause swelling and lysis and eventually kills the insect. The genes (cry genes) encoding this protein are isolated from the bacterium and incorporated into crop plants like cotton. The proteins encoded by these cry genes control the pest.
Specifically, *cryIAc* and *cryIIAb* control cotton bollworm (*Helicoverpa armigera*), an insect belonging to Lepidoptera which earlier used to destroy the whole crop.

Q.4.

i. **Give the scientific name of the soil bacterium which produces crystal (Cry) proteins.**
ii. **How are these proteins useful in agriculture?**
iii. **What do the differently written terms 'Cry' and '*cry*' represent respectively?**

Ans.

i. *Bacillus thuringiensis*.
ii. These Cry proteins are toxic to certain larvae of insects and thus provide resistance against them. The gene encoding Cry proteins are used in several crop plants (Bt toxin). Such a crop plant is resistant to the particular insect pest.
iii. Cry represents crystal protein while *cry* refers to the gene encoding the Cry protein.

Q.5. How does a transgenic organism differ from the rest of its population? Give any two examples of such organism for human advantage.

Ans. A transgenic organism contains foreign gene, hence it differs from the rest of the population in having one or more extra genes apart from the gene pool of that population showing an additional phenotype.

Example,

i. Transgenic *E.coli*, with gene for human insulin.
ii. Transgenic mouse with gene for human growth hormone.

Q.6. Explain the steps involved in the production of genetically engineered insulin. Name the source from which insulin was extracted earlier. Why is this insulin no more in use by diabetic people?

Ans. Genetically engineered insulin

- Insulin contains two short polypeptide chains—chain A and chain B linked by disulphide bridges.
- In mammals, insulin is synthesised as a pro-hormone (that needs to be processed to become mature and functional hormone). It contains an extra stretch called C peptide.
- C peptide is absent in mature insulin and is removed during maturation into insulin.
- Earlier, insulin was extracted from pancreas of slaughtered cattle and pigs but some patients began developing allergies.
- 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.

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.

Q.7. What do you understand by the term biopesticide? Name and explain the mode of action of a popular biopesticide. Biopesticides are methods of controlling pests that rely on natural predation rather than introduced chemicals/or living organisms used to kill pests.

Ans. Biopesticide is a pesticide which is:

a. not chemical in nature.
b. more specific in action against the pest.
c. safer for environment than chemical pesticides.

A popularly known biopesticide is Bt toxin, which is produced by a bacterium called *Bacillus thuringiensis*. Bt toxin gene has been cloned from this bacterium and

expressed in plants. Bt toxin protein when ingested by the insect, gets converted to its active form due to the alkaline pH of the gut. The activated toxin binds to the surface of midgut epithelial cells and create pores that cause cell swelling and lysis and eventually kills the insect.

Q.8. Gene expression can be controlled with the help of RNA molecule. Explain the method with an example.

Ans. Gene expression can be controlled by using RNA molecule and this technology is called RNA interference or RNAi. It is used to block the expression of certain genes and also referred to as gene silencing. During this process a complementary RNA to the *m*RNA being produced by the gene is introduced into the cell. This RNA binds to the *m*RNA making it double stranded and therefore stops translation. Resistance to nematode *Meloidegyne incognita* in tomato has been achieved by this method.

Q.9. List the disadvantages of insulin obtained from the pancreas of slaughtered cow and pigs.

Ans.

i. Insulin being a hormone is produced in very little amounts in the body. Hence, a large number of animals need to be sacrificed for obtaining small quantities of insulin. This makes the cost of insulin very high, demand being manyfold higher than supply.
ii. Slaughtering of animal is also not ethical.
iii. There is potential of immune response in humans against the administered insulin which is derived from animals.
iv. There is possibility of slaughtered animals being infested with some infectious micro organism which may contaminate insulin.

Q.10. You have identified a useful gene in a bacteria. Make a flow chart of the steps that you would follow to transfer this gene to a plant.

Ans. After identifying a useful genein bacteria, following steps should be undertaken:

Isolation of useful gene using restriction endonuclease.

↓

Transferring the gene to a suitable vector to create a recombinant DNA molecule.

↓

Transfer of these recombinant DNA molecules to the target cells.

↓

Screening of cell for transformation.

↓

Selection of transformed cells.

↓

Regeneration of plants from the transformed cells to get transgenic plants.

Q.11. Answer the following questions:

Q. What is plasmid?

Ans. Plasmid is a circular extra-chromosomal DNA molecule present in a bacterial cell, which replicates autonomously independent of bacterial chromosomal DNA.

Q. What is meant by ADA deficiency? How is gene therapy a solution to this problem? Why is it not a permanent cure?

Ans. Gene therapy

- ADA is caused due to deletion of gene for adenosine deaminase.
- Lymphocytes from patient's blood were grown in a culture and functional ADA, *c*DNA was introduced in these lymphocytes using a retroviral vector.
- The lymphocytes were transferred into the patient's body. Periodic infusion of such genetically engineered lymphocytes is done because these cells are mortal.
- For permanent cure, gene isolated from the bone marrow cells producing ADA, at early embryonic stage can be a possible cure.

Long Answer Questions (PYQ)

[5 Marks]

Q.1.

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.

Q.2. What are transgenic animals? Explain any four ways in which such animals can be beneficial to humans.

OR

Define transgenic animals. Explain in detail any four areas where they can be utilised.

Ans. Transgenic Animals

- Animals whose DNA is manipulated to possess and express an extra (foreign) gene are known as transgenic animals. Transgenic rats, rabbits, pigs, sheep and cows have been produced.
- Following are the common reasons for developing transgenic animals:

(i) Study of normal physiology and development

- Useful to study gene regulation, their effect on the normal functions of the body and its development.

- For example, study of complex growth factors like insulin-like growth factor.

(ii) Study of disease

- Study of genes which are responsible for diseases in human and their treatment.
- Transgenic models have been developed for many human diseases like cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's disease.

(iii) Biological products

- Useful biological products can be produced by introducing, into transgenic animals, the portion of DNA (or genes) which codes for a particular product.
- For example, human protein (α-1-antitrypsin) is used to treat emphysema.
- In 1997, the first transgenic cow, Rosie, produced human protein-enriched milk (2.4 g/L).
- The milk contained the human alpha-lactalbumin and was more nutritionally balanced for human babies than natural cow milk.

(iv) Vaccine safety

- Transgenic mice are developed to test safety of vaccines, before being used on humans.
- For example, polio vaccine.

(v) Chemical safety testing

- Transgenic animals are made to carry genes, which make them more sensitive to the toxic substances than non-transgenic animals.
- On exposing to the toxic substances, their effects are studied in less time.

Q.3.

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.

Q.4. One of the main objectives of biotechnology is to minimise the use of insecticides on cultivated crops. Explain with the help of a suitable example how insect resistant crops have been developed using techniques of biotechnology.

Ans. Bt cotton

- Some strains of *Bacillus thuringiensis* produce proteins that kill some insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes).
- B. *thuringiensis* forms protein crystals which contain a toxic insecticidal protein.
- 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 solublises 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.
- Specific Bt toxin genes obtained from *Bacillus thuringiensis* are used in several crop plants like cotton.
- The toxin is coded by a gene called *cry* which is of various types. For example, proteins encoded by the genes *cryIAc* and *cryIIAb* control the cotton bollworms and that of *cryIAb* control corn borer.
- Bt tobacco was first cultured to kill hornworm (*Manduca sexta*).

Q.5.

a. Name the nematode that infests and damages tobacco roots.
b. How are transgenic tobacco plants produced to solve this problem?

OR

How is a transgenic tobacco plant protected against *Meloidegyne incognitia*? Explain the procedure.

Ans.

a. Nematode *Meloidegyne incognitia* infects the roots of tobacco plant.
b. **Pest resistant plants**

- A nematode *Meloidegyne incognitia* infects the roots of tobacco plants which reduces the production of tobacco.
- It can be prevented by using RNA interference (RNAi) process which is checked by silencing of specific *m*RNA due to a complementary *ds*RNA.
- *ds*RNA binds and prevents translation of the *m*RNA (**silencing**).

- 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 (*ds*RNA) that initiates RNAi and hence silence the specific *m*RNA of the nematode.
- The parasite cannot survive in the transgenic host, so protects the plants from pests.

Long Answer Questions (OIQ)

[5 Marks]

Q.1. Explain the different uses of biotechnology in medical field.

Ans.

i. The recombinant DNA technology is used for production of therapeutic drugs which are safe and effective.
ii. About thirty recombinant therapeutics have been approved from human use in the world including India.
iii. The genetically engineered insulin helps in maintaining the glucose–glycogen balance in the body.
iv. Gene therapy treatment is used in the defective heredity by introduction of normal healthy and functional genes.
v. It is used in the treatment of diseases like cystic fibrosis, haemophilia, AIDS, cancer, Parkinson's, etc.
vi. Due to advancement in the field of biotechnology, it is now possible to develop recombinant vaccines with specific actions and less side effects.
vii. Also, monoclonal antibodies are produced with high specificity for specific antigens and are ideal for diagnosis of specific diseases. One of the major role of these monoclonal antibodies is immune suppression for kidney transplantation.

Q.2. How have pest-resistant plants been produced using biotechnology? Explain.

Ans. Pest resistant plants

- A nematode *Meloidegyne incognitia* infects the roots of tobacco plants which reduces the production of tobacco.
- It can be prevented by using RNA interference (RNAi) process which is checked by silencing of specific *m*RNA due to a complementary *ds*RNA.
- *ds*RNA binds and prevents translation of the *m*RNA (**silencing**).
- 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 (*ds*RNA) that initiates RNAi and hence silence the specific *m*RNA of the nematode.
- The parasite cannot survive in the transgenic host, so protects the plants from pests.