10 Biotechnology and Its Applications

Fastrack Revision

- **Biotechnology** deals with industrial scale production of biopharmaceuticals and biologicals using genetically modified microbes, fungi, plants and animals.
- Applications of biotechnology include therapeutics, diagnostics, and genetically modified crops for agriculture, processed food, bioremediation, waste treatment, and energy production.
- Human beings have used biotechnology to improve the quality of human life especially in the field of food production and health.
- **Biotechnological Applications in Agriculture**
  - Methods opted for increasing food production are:
    - Agro-chemical based agriculture
    - Organic agriculture
    - Genetically engineered crop-based agriculture
    - Plants, bacteria, fungi and animals whose genes have been altered by manipulation are called Genetically Modified Organisms (GMO).
  - Genetic modification has become useful to plants in many ways:
    - Made crops more tolerant to abiotic stresses.
    - Reduced reliance on chemical pesticides.
    - Helped to reduce post-harvest losses.
    - Increased efficiency of mineral usage by plants.
    - Enhanced nutritional value of food, *e.g.*, vitamin 'A' enriched rice.
  - To produce vitamin 'A' enriched rice, two genes from flower Daffodil and one from the bacterium *Erwinia uredovora* were inserted in the rice genome and these three genes produce the enzymes necessary to produce provitamin-A. When golden rice is ingested, the human body splits the provitamin-A to make vitamin A.
  - The production of pest resistant plants such as *Bt* cotton and tobacco plants decreased the amount of pesticide used.
- ***Bt* Cotton**
  - Some strains of *Bacillus thuringiensis* produce protein crystals during a particular phase of their growth.
  - The crystals contain a toxic insecticidal protein that kills certain insects such as lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes).
  - The toxin does not kill the *Bacillus* because the *Bt* toxin protein exists as inactive protoxins but once the 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.
  - The activated toxin binds to the surface of midgut epithelial cells and creates pores that cause cell swelling and lysis and cause death of the insect.

Knowledge BOOSTER

First introduced transgenic crop in India is Bt Cotton.

  - The toxin is coded by a gene named cry.
  - There are a number of genes acting against the insects, for example, the proteins encoded by the genes *cryI*Ac and *cryII*Ab control the cotton bollworms, that of *cryI*Ab controls corn borer.
  - Specific *Bt* toxin genes were isolated from *Bacillus thuringiensis* based on the crop and the targeted pest which is then incorporated into the several crop plants.
- **Tobacco Plants**
  - A nematode *Meloidegyne incognitia* infects the roots of tobacco plants.
  - The process of RNA interference was adopted to prevent the infection of tobacco plants.

Knowledge BOOSTER

First transgenic plant was tobacco that contains resistant gene against weedicide glyph orate.

  - The process of RNA interference (RNAi) involves silencing of a specific *m*RNA due to a complementary *ds*RNA (double stranded RNA) molecule that binds to and prevents translation of the *m*RNA, also referred as RNA silencing.
  - The source of this complementary RNA could be from an infection by viruses having RNA genomes or transposons which are mobile genetic elements that replicate *via* an RNA intermediate.
  - Using *Agrobacterium* vectors, nematode-specific genes were introduced into the host plant such that it produced both sense and anti-sense RNA in the host cells.
  - 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.
- **Applications of Biotechnology in Medicine**
  - The recombinant DNA technological processes have made immense impact in the area of healthcare by enabling mass production of genetically engineered medicines such as insulin, by creating methods like gene therapy, recombinant DNA technology, Polymerase Chain Reaction (PCR) and Enzyme-Linked Immunosorbent Assay (ELISA).
  - About 30 recombinant therapeutics have been approved for human-use over the world.

- **Genetically Engineered Insulin**
  - Insulin used for diabetes was earlier extracted from pancreas of slaughtered cattle and pigs which caused some patients to develop allergy.
  - Insulin consists of two short polypeptide chains: chain A and chain B that are linked together by disulfide bridges.
  - In mammals, including humans, insulin is synthesised as a prohormone which contains an extra stretch called the **C peptide** and the C peptide is not present in the mature insulin but is removed during maturation into insulin.
  - Two DNA sequences were prepared 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, which were extracted and combined by creating disulfide bonds to form human insulin.
- **Gene Therapy**
  - Gene therapy is a collection of methods that allow correction of a faulty gene by a healthy and functional gene.
  - Correction of a genetic defect involves delivery of a normal gene into the cells or tissues to take over the function of and compensate for the non-functional gene.
  - The first clinical gene therapy was given in 1990 to a 4 year old girl with Adenosine Deaminase (ADA) deficiency which is caused due to the deletion of the gene for adenosine deaminase.
  - ADA enzyme is crucial for the immune system to function.
  - Lymphocytes from the blood of the patient are grown in a culture outside the body and a functional ADA cDNA (using a retroviral vector) is then introduced into these lymphocytes using a retroviral vector which are returned to the patient.
  - In some children, ADA deficiency can be cured by bone marrow transplantation or by enzyme replacement therapy in which functional ADA is given to the patient by injection.
- **Stem Cell Technology**
  - Stem cells are body cells that not only have the ability to renew themselves by mitotic division but also differentiate into various types of specialised cells, tissues and organs.
  - Stem cell technology was established in 1960 by Earnest McCulloch and James Till.
  - Research on stem cells is going on, and it is believed that stem cell therapies can cure ailments like paralysis and alzheimer's as well.
  - Stem cells are of four different types *i.e.*, embryonic stem cells, adult stem cells, induced pluripotent stem cells and mesenchymal stem cells.
- **Molecular Diagnosis**
  - Recombinant DNA technology, Polymerase Chain Reaction (PCR) and Enzyme-linked Immuno-sorbent Assay (ELISA) are some of the molecular diagnosis that serves the purpose of early diagnosis to understand the pathophysiology of the disease.
  - **PCR** is used to detect HIV in suspected AIDS patients and to detect mutations in genes in suspected cancer patients too.
  - Very low concentration of a bacteria or virus can be detected by amplification of their nucleic acid by PCR.
  - A single stranded DNA or RNA, tagged with a radioactive molecule (probe) is allowed to hybridise to its complementary DNA in a clone of cells followed by detection using autoradiography where the clone having the mutated gene will hence not appear on the photographic film, because the probe will not have complementarity with the mutated gene.
  - **ELISA** is performed based on the principle of antigen-antibody interaction. Infection by pathogen can be detected by the presence of antigens or by detecting the antibodies synthesised against the pathogen.
- **Transgenic Animals**
  - Animals that have had their DNA manipulated to possess and express a foreign gene are known as transgenic animals. Examples: Transgenic rats, rabbits, pigs, sheep etc.
  - Transgenic animals are created due to the following reasons.
    - **Normal Physiology and Development:** To study how genes are regulated, and how they affect the normal functions of the body and its development. Example: Study of complex factors involved in growth such as insulin-like growth factor.
    - **Study of Disease:** To study how genes contribute to the development of disease.
    - **Biological Products:** To produce biological products such as human protein (α-alfa-1-antitrypsin) used to treat emphysema, proteins to treat phenylketonuria and cystic fibrosis, human alpha-lactalbumin enriched milk. For example, the first transgenic cow, Rosie, produced human protein-enriched milk of 2.4 grams per litre.
    - **Vaccine Safety:** For testing the safety of vaccines before they are used on humans. For example, Transgenic mice are being used to test the safety of the polio vaccine.
    - **Chemical Safety Testing:** For testing toxicity of drugs. Toxicity testing in transgenic animals allows to obtain results in less time.
- **Ethical Issues**
  - Genetic modification of organisms can have unpredictable results when such organisms are introduced into the ecosystem. Hence, the Indian Government has set up organisations such as GEAC (Genetic Engineering Approval Committee), to make decisions regarding the validity of GM research and the safety of introducing GM-organisms for public service.
  - The modification/usage of living organisms for public services has also created problems with patents granted for the same.
  - Patent is the right granted by the Government to a producer to prevent others from using his product.
  - An American company got patent rights on Basmati rice but the variety of Basmati had actually been derived from Indian farmer's varieties.
  - Several attempts have also been made to patent uses, products and processes based on Indian traditional herbal medicines. *e.g.*, turmeric, neem.
  - Bio-piracy is the term used to refer to the use of bio-resources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment.
  - Some nations are developing laws to prevent such unauthorised exploitation of their bio-resources and traditional knowledge.

Practice Exercise

Multiple Choice Questions

Q 1. In which of the following industrial area biotechnology is applicable?
a. Healthcare b. Environment
c. Agriculture d. All of these

Q 2. Food supply has increased during green revolution due to:
a. use of chemicals b. use of biochemicals
c. use of photochemicals d. use of agrochemicals

Q 3. The method during which genetic characteristics of animals are improved by mating of selected breeds is known as:
a. Improved breeding b. Selective breeding
c. Mating d. Breeding

Q 4. In which therapy, vectors are used to introduce desired gene into the body of patients?
a. *In vivo* gene therapy b. Germ line therapy
c. *Ex vivo* gene therapy d. Foreign gene therapy

Q 5. The phenomenon of introduction of exogenous DNA into the genome of animals is:
a. *in vivo* gene therapy b. foreign gene therapy
c. *ex vivo* gene therapy d. transgenesis

Q 6. Which one of the following is not the product of transgenic experiments? *(CBSE 2020)*
a. Pest-resistant crop variety
b. High nutritional value in grains
c. Production of insulin by rDNA technique
d. Drought-resistant crops

Q 7. The animals whose genome is altered by introduction of transgene is known as:
a. Modified animals b. Hybrid animals
c. Cross breed animals d. Transgenic animal

Q 8. Transgene introduced in the first transgenic cow was responsible for the production of:
a. albumin enriched milk
b. protein enriched milk
c. human protein enriched milk
d. vitamins enriched milk

Q 9. What was the amount of Alpha-lactalbumin in the milk of transgenic cow?
a. 4.2 grams per litre b. 2.4 grams per litre
c. 3.4 grams per litre d. 4.2 grams per litre

Q 10. The main objective of production of pest resistant GM crops is to: *(CBSE SQP 2023-24)*
a. encourage eco-friendly pesticides.
b. reduce pesticide accumulation in food chain.
c. eliminate pests from the field without the use of manual labour.
d. retain maximum nutritional content in the crop that would be otherwise consumed by pest.

Q 11. Earlier which animals were used to test the safety of Polio Vaccine?
a. Transgenic rat b. Transgenic pigs
c. Transgenic mice d. Transgenic sheep

Q 12. The right granted by government to prevent others from the commercial use of resources invention is:
a. Government grant b. Patent
c. Official document d. Bio patent

Q 13. Exploitation of Patent of biological resources of other nations is called as:
a. Biosafety b. Biopiracy
c. Biowar d. Bioabuse

Q 14. Organisms which can be used to gain commercial benefits are called:
a. Beneficial resources b. Bio resources
c. Financial resources d. Biological resources

Q 15. The plant *Peritadiplandra brazzeana* belongs to which country?
a. China b. West Africa
c. Pakistan d. America

Assertion & Reason Type Questions

Directions (Q.Nos. 16-23): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Select the correct answer to these questions from the codes a, b, c and d as given below.*
a. Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
b. Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
c. Assertion is true but Reason is false.
d. Assertion is false but Reason is true.

Q 16. Assertion (A): Molecular probes are available for diagnosing genetic disorders, *e.g.*, Duchenne muscular dystrophy, cystic fibrosis, Tay-sach's disease.
Reason (R): The molecular probes are usually double stranded pieces of DNAs, labelled with radio isotopes such as 32p.

Q 17. Assertion (A): In gene therapy, new gene is introduced only into the somatic cells.
Reason (R): Genetic modification is done to replace faulty genes by normal functional gene.

Q 18. Assertion (A): Mouse is the most preferred mammal for studies on gene transfers.
Reason (R): Mouse possesses features like short oestrous cycle and gestation period, relatively short generation time, production of several offspring per pregnancy, etc.

Q 19. Assertion (A): Transgenic food may cause toxicity or produce allergy.
Reason (R): Transgenic plants have high nutrient content.

Q 20. **Assertion (A): Genetically modified microbes help in crop protection.**

Reason (R): Transgenic bacteria control insects by producing endotoxins.

Q 21. **Assertion (A): Organs of pig such as heart, pancreas, etc., for human use can be grown through transgenic animals.**

Reason (R): Transgenic pigs show improved growth and meat production.

Q 22. **Assertion (A): PCR is routinely used for early diagnosis of HIV in suspected AIDS patients.**

Reason (R): PCR can detect low amounts of DNA.

Q 23. **Assertion (A): Bio patents are awarded for biological entities and all products derived from them.**

Reason (R): Patent on use of turmeric in wound healing was cancelled in 2008.

Answers

1. (d) All of these
2. (d) use of agrochemicals
   Increases yield have mainly been due to the use of:
   (i) Agrochemicals (fertilisers and pestisides).
   (ii) Better management practices.
   (iii) Improved crop varieties.
3. (b) Selective breeding
   Selective breeding is the process by which humans use animal breeding and plant breeding to selectively develop particular phenotypic traits by choosing which typically animal or plant males and females will sexually reproduce and have offspring together.
4. (a) *In vivo* gene therapy
5. (d) transgenesis
   The phenomenon of introducing exogenous DNA or DNA from another organism into the genome of plant or animal is called transgenesis. The foreign DNA introduced in this process is called a transgene and the animal in which it is introduced is called a transgenic animals.
6. (c) Production of insulin by rDNA technique
7. (d) Transgenic animal
   A transgenic animal is one whose genome has been altered by the transfer of a gene or genes from another species or breed.
8. (c) human protein enriched milk
9. (b) 2.4 grams per litre
   One of the major protein components in milk is alpha-lactalbumin. Since it is one of the intermediates that can facilitate the process of lactose synthesis, it plays an essential role in milk. Transgenic cows are produced with the human alpha-lactalbumin gene introduced in the cow. The first transgenic cow named Rosie was produced in 1997. The amount of human alpha-lactalbumin present in the milk of a transgenic cow is about 2.4 grams/litre.
10. (b) reduce pesticide accumulation in food chain
11. (c) Transgenic mice
12. (b) Patent
    A patent is a type of intellectual property that gives its owner the legal right to exclude others from making, using or selling an invention for a limited period of time in exchange for publishing an enabling disclosure of the invention.
13. (b) Biopiracy
14. (b) Bio resources
    Bio resources are natural renewable sources like organic wastes and naturally formed or formable raw materials from human and animal activities. In large quantities they are generated by industries or mills in the agriculture, forestry, marine and municipal sectors.
15. (b) West Africa
16. (c) Assertion is true, but Reason is false.
    DNA probes are stretches of single-stranded DNA used to detect presence of complementry nucleic acid sequence (target sequences) by hybridisation. They are usually labelled with radioisotopes, to enable their direction.
17. (b) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
18. (a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
19. (b) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
20. (b) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
21. (b) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
22. (b) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
23. (c) Assertion is true, but Reason is false.

Case Study Based Questions

Case Study 1

Crown Gall

Crown gall is a neoplastic disease of most dicotyledonous plants and is caused by the soil bacterium Agrobacterium tumefaciens. A large extra chromosomal plasmid in these bacteria was found to be responsible for this disease. The plasmid is known as Ti-plasmid. Bacteria free crown gall cells can be cultured in the absence of phytohormones. Ti-plasmid is widely used in genetic engineering to deliver the desirable genes. The part of Ti-plasmid transferred into plant cell DNA is called T-DNA. T-DNA with desired DNA segment is inserted into the chromosome of the host plant where it produces copies of itself.

Q 1. Which of the following is the full form of T-DNA?
a. Transfer DNA b. Tumor Inducing DNA
c. Transgenic DNA d. None of these

Q 2. Ti-plasmid cannot infect and develop crown gall in:
a. tomato b. maize c. soyabean d. sunflower

Q 3. While making transgenic plant, T-DNA is inserted into the host cell, it then:
a. is integrated into the target host genome.
b. lies independent of the host genome.
c. ruptures the host cell wall.
d. produces oncogenic factors in the host.

Q 4. *Agrobacterium* mediated gene transfer in plants:
a. allows relatively large segment of DNA.
b. transfer of DNA with defined ends and minimal rearrangement.
c. high quality and fertility in transgenic plants.
d. All of the above

Q 5. Assertion (A): In *Agrobacterium* mediated gene transfer in plants, transgenic plants do not develop tumors.
Reason (R): In T-DNA, tumor producing genes are deleted during the process of gene transfer.
a. Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.
b. Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
c. Assertion is true, but Reason is false.
d. Assertion is false but Reason is true.

Answers

1. (a) 2. (b) 3. (a) 4. (d) 5. (b)

Case Study 2

β-Carotene

Golden rice was engineered from normal rice by Potrykus and Beyer in the 1990s. The typical golden colour is due to the production of β-carotene, a precursor of vitamin A. Golden rice differs from its parental strain by the addition of three β-carotene genes. These included two genes from daffodil plant and third from a bacterium. The incorporation of these genes allows the rice plant to modify certain metabolic pathways in its cells to produce β-carotene.

Q 1. Due to genetic modification, golden rice plants produce and store β-carotene in:
a. stem b. seed c. leaves d. All of these

Q 2. Transfer of genes to produce golden rice is achieved by:
a. *Agrobacterium* b. *pBR322*
c. 2-phage d. gene gun

Q 3. In golden rice, two genes were taken from:
a. *Narcissus sp.* b. *Erwinia*
c. *Coryza sativa* d. None of these

Q 4. Golden rice is helpful to fight against disease caused by the deficiency of:
a. Vitamin B_{12} b. Vitamin C
c. Vitamin A d. Vitamin D

Q 5. Golden rice was genetically engineered by:
a. Fire and Mello b. Potrykus and Beyer
c. Banting and Best d. Kohler and Milstein

Answers

1. (b) 2. (a) 3. (a) 4. (c) 5. (b)

Case Study 3

Transgenic Animals

Transgenic animals can serve as factories that in some cases, may produce large amount of proteins more efficiently. Transgenic mice have been engineered to express human antibodies by introducing large segment of human DNA encoding human immunoglobulin genes. In transgenic large animals such as cow or sheep, proteins of pharmaceutical value can be produced in large quantities in milk which is later purified. Transgenesis can be used to alter many phenotypic properties including growth rate, fat composition, milk production, hair texture, etc.

Q 1. The production of transgenic animals includes:
a. identification and separation of desired gene.
b. combining the desired gene with appropriate vector.
c. introduction of vector in cells, tissues or embryos.
d. All of the above

Q 2. In transgenic animals, *i.e.*, cow and sheep proteins of pharmaceutical value are produced in large quantities in the:
a. blood b. accumulated fat
c. mammary glands d. None of these

Q 3. Mouse is mostly preferred animal for studies on gene transfer because of:
A. short oestrous cycle
B. long gestation period
C. short generation time
D. production of one or two offspring per pregnancy
a. Both A and C b. Both A and B
c. Only D d. Both C and D

Q 4. Transgenic genes alter many phenotypic properties including:
a. growth rate b. fat composition
c. milk production d. All of these

Q 5. Assertion (A): Transgenic mice have been engineered to express human antibodies.
Reason (R): Large segment of human DNA encoding human immunoglobulin have been transferred to mice.
a. Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.
b. Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
c. Assertion is true but Reason is false.
d. Assertion is false but Reason is true.

Answers

1. (d) 2. (c) 3. (a) 4. (d) 5. (a)

Case Study 4

Bt Cotton

Plants having foreign genes in their genome through genetic engineering are called transgenic plants. Genes can be incorporated either through a vector or through direct introduction of DNA. *Bt* cotton is a genetically modified organism which is pest resistant. It contains gene *cryI*Ac and *cryII*Ab of *Bacillus thuringiensis*. It is used to control lepidopterans, coleopterans and dipterans. *Bt* cotton can resist cotton bollworm and produce higher yields. Cry gene produces cry protein or *Bt* toxin. It is an endotoxin which remains as protoxin in plants and converted to active toxin after getting ingested by the insects. Alkaline pH of the insect gut solubilises the protein crystals, the activated toxin creates pores to the midgut wall of the insects which cause them to death.

Read the given passage carefully and give the answers of the following questions:

Q 1. Define transgenic plants.
Ans. Plants having foreign genes in their genome through genetic engineering are called transgenic plants.

Q 2. What type of crop is Bt cotton?
Ans. *Bt* cotton plant is genetically modified with the *Bt* gene to protect the plants from bollworm which is a major pest of cotton.

OR

Which was the first *Bt* crop in India?
Ans. *Bt* brinjal is the first transgenic crop commercially available in India.

Q 3. Name an organism that produces cry protein.
Ans. *Bacillus thuringiensis* bacteria synthesise this protein.

Very Short Answer Type Questions

Q 1. Mention the chemical change that proinsulin undergoes, to be able to act as mature insulin. *(CBSE 2018)*
Ans. The proinsulin is cleaved to remove extra stretch called the C-peptide to form mature insulin having only α-chain and β-chain joined by disulphide bond.

Q. 2. What are Cry genes? In which organism are they present? *(CBSE 2017)*
Ans. Cry genes code for a toxin which is poisonous to some insects thus giving resistance to the plants. They are present in bacterium *Bacillus thuringiensis*.

Q 3. Name the technique based on the principle of antigen-antibody interaction used in detection of a virus (HIV). *(CBSE 2015)*
Ans. ELISA (Enzyme-Linked Immunosorbent Assay).

Q 4. What is the difference between 'Cry' and 'CRY'?
Ans. Cry is the gene which codes for *Bt*-toxin which is an insecticidal protein while CRY is the protein coded by cry genes.

TiP
There is no difference in spelling. The only difference is lower and upper case. Gene name abbreviation has to be written in running way with first letter in upper case then in lower case while protein abbreviation must be written in upper case.

Q 5. The insulin produced using recombinant DNA technology is more advantageous than the insulin extracted from pancreas of slaughtered cattle and pigs. How?
Ans. Insulin obtained from animal source causes allergy and produces disease.

Q 6. Name the genetically engineered human insulin.
Ans. Humulin is the genetically engineered human insulin.

Q 7. Expand GEAC.
Ans. Genetic Engineering Approval Committee.

Q 8. A boy has been diagnosed with ADA deficiency. Suggest any one possible treatment.
Ans. Bone marrow transplant/enzyme replacement therapy/gene therapy.

Q 9. Name any one disease for which gene therapy has been proved effective.
Ans. Adenosine Deaminase (ADA) deficiency is the disease for which gene therapy has been proved effective.

Q 10. Which nematode infects the roots of tobacco plant and causes a great reduction in yield?

OR

Write the scientific name of nematode that attacks the root of tobacco plant?
Ans. *Meloidogyne incognita.* is the nematode that infects the roots of tobacco plant and causes a great reduction in yield.

TiP
Students are advised to learn proper spelling by writing them repeated number of times.

Q 11. Development of a transgenic food crop may help in solving the problem of night blindness in the developing countries. Name this crop plant.
Ans. Golden Rice is a transgenic food crop that may help in solving the problem of night blindness in developing countries.

Q 12. The first transgenic cow produced human protein enriched milk. Name the cow and the protein found in milk.
Ans. Rosie is the first transgenic cow and. alpha-lactalbumin is the protein found in milk.

Q 13. Name two pest resistant plants produced by using recombinant DNA technology.
Ans. *Bt* Cotton and *Bt* Corn are produced by using recombinant DNA technology.

Q 14. Name the first transgenic sheep.

Ans. Dolly is the first transgenic sheep.

Q 15. Name the bacterium which is used to produce insect-resistant plants by genetic engineering.

Ans. *Bacillus thuringiensis* is used to produce insect resistant plants by genetic engineering.

Q 16. What is 'Flavr Savr'?

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

Q 17. Name the first transgenic cow.

Ans. Rosie was the first transgenic cow.

Q 18. 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 19. 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 20. Name the technique which is used to detect HIV in suspected AIDS patient.

Ans. PCR (Polymerase Chain Reaction) is used to detect HIV in suspected AIDS patient.

Q 21. Name any two diseases for which transgenic mice are used as model organisms.

Ans. Rheumatoid Arthritis and Cystic fibrosis.

Q 22. Name any disease against which vaccine is developed by Recombinant DNA Technology.

Ans. Hepatitis B vaccine is developed by Recombinant DNA technology.

Q 23. Which vaccine was being tested on mice?

Ans. Polio vaccine was being tested on mice.

Q 24. Define a patent.

Ans. Patent is the government protection to the inventor of biological material, securing to him for a specific time the exclusive right of manufacturing, exploiting, using and selling an invention.

Q 25. How is patent given?

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

Short Answer Type Questions

Q 1. What are the three critical research areas in the field of Biotechnology?

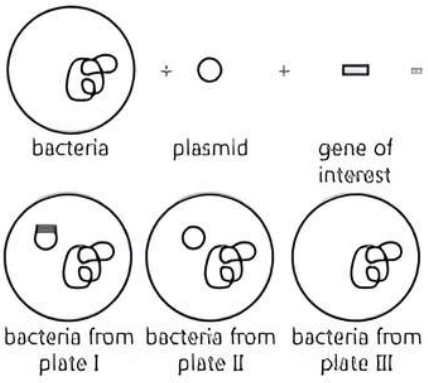
Ans. The critical research areas in the field of biotechnology are:

(i) Providing best catalyst in the form of improved organism usually in the form of microbe or pure enzyme.

(ii) Creating optimal conditions through engineering for a catalyst function.

(iii) Downstream processing to purify the protein/ organic compound.

Q 2. The image below shows the result of plating bacteria in chromogenic medium after incorporating the gene of interest in plasmid. Some plates had blue colonies; some plates had white colonies. A single bacterium extracted from Plate I,II,III is shown below:



On the basis of your observations:

(i) Identify the plate(s) which is/are white. Give a reason.

(ii) Identify the plate(s) which is/are blue. Give a reason. *(CBSE SQP 2023-24)*

Ans. (i) Plate I, b-galactosidase enzyme is responsible for blue colour. Gene is inserted in the b-galactosidase site of the plasmid thereby causing insertional inactivation of the enzyme, so no blue colour is made.

(ii) Plate II-Gene of interest not inserted in the plasmid

Plate III - No plasmid.

Q 3. Mention any four applications of Biotechnology in the field of Agriculture.

Ans. The four applications of biotechnology are:

(i) To make crops tolerant to abiotic stresses *e.g.* cold, Drought, salt, heat.

(ii) To reduce reliance on chemical pesticide by producing pest-resistant crops.

(iii) Increased efficiency of mineral usage by plants.

(iv) Enhanced nutritional value of food *e.g.* Vitamin-A rich golden rice.

Q 4. A patient admitted in ICU was diagnosed to have suffered from myocardial infarction. The condition of coronary artery is depicted in the image below. Name two bioactive agents and their mode of action that can improve this condition.

(CBSE SQP 2022, Term-2)

Ans. Streptokinase (produced by the bacterium *Streptococcus*) is used as a 'clot buster' for removing clots from the blood vessels of patients who have undergone myocardial infarction.
Statins (produced by the yeast *Monascus purpureus*) act as blood-cholesterol lowering agents.

Q 5. Why is recombinant insulin produced by genetic engineering need to be processed?

Ans. Recombinant insulin produced by Genetic engineering need to be processed because insulin which is produced as proinsulin contains an additional C-peptide apart from α - and β- chain of insulin. So, to make an active insulin vaccine, a peptidase enzyme is added to proinsulin to cleave C peptide and rejoining of β-chain to form active insulin.

Q 6. How is autoradiography used to detect a mutated gene?

Ans. A single stranded DNA or RNA tagged with radioactive molecule is allowed to hybridise to its complements DNA in a clone of cells followed by detection using autoradiography. The clone having the mutated gene will hence not appear on photographic film because probe will not have complementarity with mutated gene.

Q 7. Why did Bacterial toxin does not kill the bacteria but only the insects?

Ans. Bacterial toxin does not kill the *Bacillus* because *Bt* toxic protein exists as inactive protoxin but once an insect ingest the inactive protoxin, it is converted into active form of toxin due to alkaline pH of gut which solubilise the crystal. The activated toxin binds to surface of midgut epithelial cells and create pores that cause cell swelling and lysis.

TiP

Question can be asked in such a way that what will happen if inactive protein is treated in acidic environment and alkaline environment separately.

Q 8. What are the two methods for correcting ADA deficiency in a child? *(CBSE 2015)*

Ans. Bone marrow transplantation having functional ADA enzyme and Enzyme replacement therapy are the two methods for correcting ADA deficiency in a child.

Q 9. What are transgenic bacteria? Illustrate using any one example.

Ans. The bacteria in which genes of interest (i.e., foreign DNA fragment) have been introduced are called transgenic bacteria *e.g., E.coli.*
When two DNA sequences A and B chains of Insulin are introduced into plasmid of this bacteria, then it is called transgenic bacteria and start to produce insulin chain.

Q 10. Give any two examples of products, how transgenic animals can be used to produce biological compounds?

Ans. The two examples are:
(i) Alpha-1-antitrypsin—a protein that is used to treat emphysema.
(ii) Alpha—lactalbumin—protein—rich milk that is more nutritionally balanced product for human babies.

Q 11. (i) Name (a) a GM cereal crop having enhanced nutritional value, (b) the nutrient it is rich in.
(ii) State any two benefits of genetically modified crops.

Ans. (i) (a) Golden rice is a transgenic variety of rice which contains a gene which codes for Vitamin A precursor.
(b) These varieties have green yellow coloured grains and are rich in Vitamin A and thus nutritionally very advantageous.
(ii) Benefits of Genetically Modified (GM) crops are as below:
(a) They have enhanced nutritional content.
(b) These crops are less dependent on pesticides and insecticides as they are genetically resistant to pests.

Q 12. GEAC is one of the organisation set up by Indian Government. Write its full form. Give its two objectives.

Ans. GEAC- Genetic Engineering Approval Committee.
Objectives of GEAC as below:
(i) To make decisions regarding validity of GM research.
(ii) Safety of introducing GMO for public use.

Q 13. What do you mean by 'Biopiracy'? Give an example.

Ans. Biopiracy refers to the use of bio-resources by multinational companies and other organisations without proper authorisations from the countries and people concerned *e.g.*, Basmati rice grown in India is distinct for its unique flavour and aroma but an American company got patent rights on Basmati through US patent.

Q 14. "Industrialised nations are exploiting the bio resources of under industrialised nations." Justify the statement with a suitable example.

Ans. 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 bio resources are patented and used for commercial purposes.

COMMON ERROR

Students do not give justification with example instead they give only irrelevent statements.

Long Answer Type-I Questions

Q 1. When *Bacillus thuringiensis* enters a certain insect's body, the insect gets killed, but itself remains unaffected. Explain how it is possible? *(CBSE 2020)*

Ans. Soil bacterium *Bacillus thuringiensis (Bt)* produces proteins that kill certain insects like lepidopterans

(tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes).*Bacillus thuringinesis* forms some intracellular protein crystals. These crystals contain a toxic insecticidal protein. The *Bt* toxin protein exists as an inactive toxin and is converted into an active form due to the alkaline pH of the alimentary canal that solubilitises the crystals. The activated toxin binds to the surface of midgut epithelial cells and creates pores which cause cell swelling and lysis and finally cause the death of the insect.

Q 2. On spraying *Bacillus thuringiensis* on an infected cotton crop field the pests are killed by the toxin, however the toxin although produced by the bacteria does not affect it. Explain giving reason.

(CBSE 2023)

Ans. Some strains of *Bacillus thuringiensis* produce proteins that kill certain insects such as armyworm, beetles, flies and mosquitoes. *B. thuringiensis* forms crystals of protein during their growth that comprise of a toxic insecticidal protein. The *Bt* toxin protein exist as inactive protoxins but once an insect ingest the inactive toxin, it is converted into an active form of toxin due to the alkaline pH of the gut which solubilise the crystals. The activated toxin binds to the surface of midgut epithelial cells and create pores that cause cell swelling and lysis and eventually cause death of the insect.

Q 3. What are Cry proteins? Name an organism that produces it. How has man exploited this protein to his benefit?

Ans. The soil bacterium *Bacillus thuringiensis* produces crystal proteins called cry proteins that are toxic to larvae of insects like tobacco bud worm, beetles and mosquitoes.

The cry proteins exist as inactive protoxin and gets converted into active toxin when ingested by the insect, as the alkaline pH of gut solubilses the crystal. The activated toxin binds to surface of epithelial cells of midgut and create pores. This causes lysis of cells leading to death of insects. The genes encoding this protein are isolated from bacterium and are incorporated into crop plant to make them insect-resistant.

Q 4. A farmer grew 2 varieties of corn crop in field A and B. He grew normal corn crops in field A and GM corn crops in field B. He observed corn borers attacked only in field A. To control it, spores of *Bt* were sprayed in field A.

(i) Name the gene in the spores responsible for the control of this pest.

(ii) What effect will the spores of *Bt* have on the insect pest?

(iii) How has field B developed resistance against this pest. *(CBSE SQP 2023-24)*

Ans. (i) Cry I Ab

(ii) The spores of Bt contain crystalline toxin which is inactive; for this crystalline toxin protein to become active it needs alkaline pH, which is present in insect gut. The gut lining is broken down/mid gut epithelial cells become porous/ swollen/cell lysis.

(iii) The *Bt*-toxin gene is cloned and inserted into the plant genome by recombinant DNA technology. These Genetically Modified (GM) plants express the *Bt*-toxin genes and become pest-resistant.

Q 5. How has the use of *Agrobacterium* as vectors helped in controlling *Meloidogyne incognita* infestation in tobacco plants? Explain in correct sequence.

(CBSE 2018)

Ans. A nematode *Meloidogyne incognita* infects the roots of tobacco plants and causes a great reduction in yield. A novel strategy was adopted to prevent this infestation which was based on the process of RNA interference (RNAi).

(I) Using *Agrobacterium* vectors, nematode-specific genes were introduced into the host plants.

(ii) The introduction of DNA was such that it produced both sense and anti-sense RNA in the host cells.

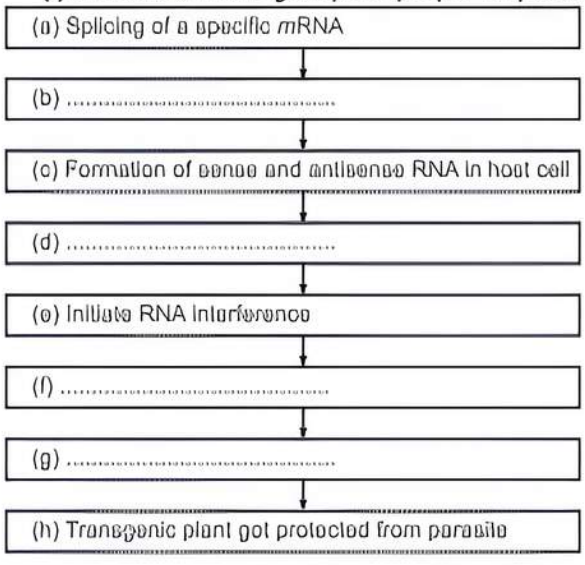
(iii) These two RNA's being complementary to each other formed a double stranded (*ds*RNA) that initiated RNAi and thus, silence specific *m*RNA of the nematode.

(iv) The consequence was that the parasite could not survive in a transgenic host expressing specific interfering RNA.

(v) The transgenic plant therefore got itself protected from the parasite.

Q 6. Given below is an incomplete flowchart 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?

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

(d) *ds*RNA (double stranded RNA).

(f) Silenced specific *m*RNA of the nematode.

(g) Parasite could not survive.

(ii) RNAi silences the gene at translation level.

TiP

Students are advised to complete the flowchart carefully giving proper sequence in the process of production of nematode resistant tobacco plants.

Q 7. Lipoprotein Lipase Deficiency (LPLD) is a genetic disorder in which a person has a defective gene for lipase. This leads to high triglycerides, stomach pain, fat deposits under the skin. It may eventually affect the liver, pancreas and may also cause diabetes. The disorder occurs if a child acquires defective genes from both parents (autosomal recessive). ERT (enzyme replacement treatment) is one of the treatments offered to patients with LPLD.

(i) (a) What procedure is followed in ERT?

(b) What could be one possible drawback of ERT?

(ii) How can LPLD be treated using Biotechnology? Elaborate. *(CBSE SQP 2023-24)*

Ans. (i) (a) Functional enzyme lipase is given to the patient by injection.

(b) ERT procedure is not completely curative.

(ii)
- The disease can be treated by using Gene therapy.
- Gene therapy is a collection of methods that allows correction of a gene defect that has been diagnosed in a child/embryo.
- Here genes are inserted into a person's cells and tissues to treat a disease. Correction of a genetic defect involves delivery of a normal gene into the individual or embryo to take over the function of and compensate for the non-functional gene.

Q 8. Explain the various steps involved in the production of artificial insulin. *(CBSE 2017)*

Ans. The various steps involved in the production of artificial insulin are:

(i) Insulin contains two short polypeptide chains: chain A and chain B linked together by disulphide bridges.

(ii) In mammals, insulin is synthesised as a pro-hormone. It contains an extra stretch called C-peptide.

(iii) C-peptide is absent in the mature insulin and is removed during maturation into insulin.

(iv) Production of insulin by rDNA techniques was achieved by an American company, Eli Lilly in 1983.

(v) It prepared two DNA sequences corresponding to A and B, chains of human insulin and introduced them in plasmids of *E.coli* for production.

(vi) The A and B chains produced were separated, extracted and combined, by creating disulfide bonds to form human insulin.

Q 9. Two children, A and B aged 4 and 5 years respectively visited a hospital with a similar genetic disorder. The girl A was provided enzyme-replacement therapy and was advised to revisit periodically for further treatment. The girl, B was, however, given a therapy that did not require revisit for further treatment.

(i) Name the ailments the two girls were suffering from.

(ii) Why did the treatment provided to girl required repeated visits?

(iii) How was the girl B cured permanently?

(CBSE 2019)

Ans. The two girls were suffering from:

(i) ADA (Adenosine Deaminase) Deficiency which is a form of SCID (Severe Combined Immunodeficiency)—a type of disorder that affects the immune system. The disease is caused by mutation in a gene on chromosome 20. The gene codes for the enzyme Adenosine Deaminase (ADA). Without this enzyme, the body is unable to break down a toxic substance called deoxyadenosine. The toxin builds up and destroys infection-fighting immune cells called T and B lymphocytes.

(ii) Girl A was given Enzyme replacement therapy in which lymphocytes isolated from patient's blood are cultured *in vitro*. Functional ADA cDNA are then introduced into the cultured lymphocytes. These lymphocytes are returned back to the patient's body. Lymphocytes are not immortal. Therefore, repeated infusion of genetically engineered lymphocytes is required and hence it is not a permanent treatment but the patient has to revisit periodically in the future.

(iii) Girl B was treated with gene therapy through the gene isolated from bone marrow cells producing ADA. It is introduced into cells at early embryonic stages which is a permanent cure, so the patient is cured permanently.

COMMON ERROR

Students do not give complete explanation of the treatment given to girls but only write the names of therapies.

Q 10. Describe with example, why transgenic animals are produced.

Ans. Transgenic animals are produced for the following purposes:

(i) To allow the study of how genes are regulated and how they affect normal function of body and its development *e.g.*, information obtained about biological role of insulin like growth factor.

(ii) To increase our understanding on how genes contribute to development of diseases.

(iii) To produce useful biological compounds by introducing a portion of DNA that codes for that product from other organisms, *e.g.*, α-1 antitrypsin, a protein used to treat emphysema.

(iv) For testing the safety of vaccine *e.g.*, polio vaccine in transgenic mice.

(v) To test the toxicity of drugs.

Q 11. Write an account on the production of human insulin in transgenic organisms.

Ans. Human insulin consists of two short polypeptide chains: chain A and B linked by disulfide bonds. Insulin is secreted as pro hormone which has to be processed before it becomes a mature and functional hormone. The pro hormone contains other polypeptides called C-peptide which is removed during maturation. Using genetic engineering, the two DNA sequences coding for chains A and B of human insulin are introduced into plasmid of *E.coli* to produce insulin. The two chains produced are extracted and combined by creating disulfide bridges.

Q 12. "RNA interference has been used to produce transgenic tobacco plants to protect them from the infestation by specific nematodes." Explain the novel strategy exploited by the biotechnologists.

(CBSE 2023)

Ans. A nematode, Meloidogyne incognita, infects the roots of tobacco plants which reduces the production of tobacco. The infection can be prevented using the RNA interference (RNAi) process which is checked by silencing of specific *m*RNA due to a complementary *ds*RNA. The *ds*RNA binds and prevents translation of the mRNA. By using Agrobacterium vectors, nematode-specific genes were introduced into the host plants which produce both sense and antisense 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, silences the specific *m*RNA of the nematode. The parasite cannot survive in a transgenic host and so, prevents the plants from pests.

Q 13. (i) Write the complete name of the diagnostic test for AIDS. Explain the principle it works on.

(ii) Name the type of genetic material present in AIDS causing pathogen. *(CBSE 2022, Term-2)*

Ans. (i) ELISA, which stands for Enzyme-Linked Immunosorbent Assay, it used to detect HIV infection. If an ELISA test is positive, the western blot test is usually administered to confirm the diagnosis. The working principle of ELISA is antigen-antibody interaction.

(ii) AIDS causing pathogen is HIV. It is a retrovirus which means it carries single stranded RNA as its genetic material rather than the double-stranded DNA human cells carry.

Q 14. What is RNA Silencing? How is this strategy used to create pest - resistant plants?

Ans. RNA silencing is a technique which involves silencing or disabling of specific *m*RNA due to complementary *ds*RNA molecule that binds to and prevent translation of *m*RNA.

His strategy is used to prevent infection of roots of tobacco plants by nematode *Meloidogyne incognita*. In this strategy, complementary *ds*RNA is produced against specific *m*RNA. The source of this complementary RNA could be from an infection by viruses having RNA genomes. Using *Agrobacterium* vector nematode specific genes were introduced into host plant. The introduction of DNA was such that it produced both sense and anti-dense RNA in the host cell. These two RNA's being complementary to each other formed a double strand RNA that initiated RNAi and thus silenced specific *m*RNA of the nematode. The consequence was that parasite could not survive in transgenic host.

TiP

Period complete explanation of the reason for using RNA silencing strategy to create pest-resistant plants.

Q 15. Some multinational companies and other organisations are using bio resources for commercial benefits, without proper authentication and compensation to concerned authorities.

(i) Give the term for this unauthorised act.

(ii) Suggest any two ways to get rid of this.

Ans. (i) This unauthorised act is Bio piracy

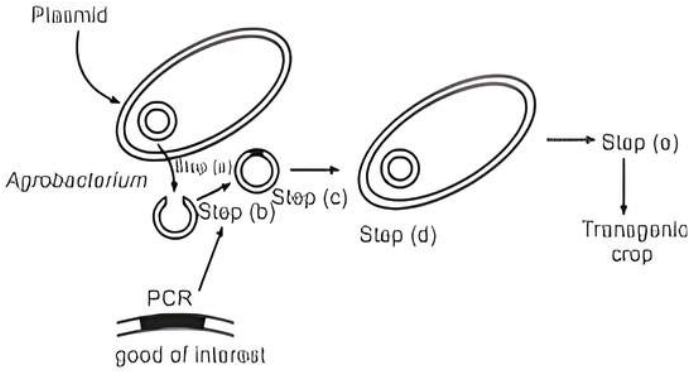
(ii) The two ways are:

(a) Benefits of bio resources should be shared between developed and developing nations.

(b) Laws should be developed to prevent unauthorised exploitation of these bio resources.

Long Answer Type-II Questions

Q 1. In the given figure, *Agrobacterium* is utilised for the production of a transgenic crop. Explain the steps a, b, c, d and e shown in the figure.



Ans. **(i) Step (a):** Plasmid is removed and cut open with restriction endonuclease.

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

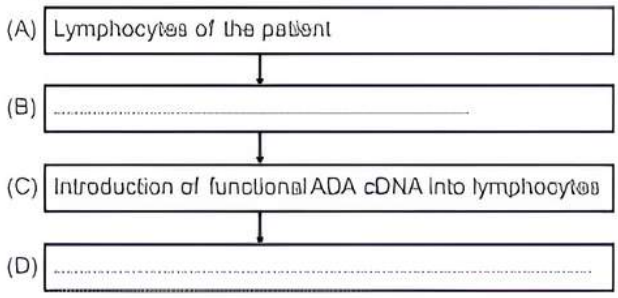
(iii) Step (c): New gene is inserted into plasmid.

(iv) Step (d): Plasmid is put back into *Agrobacterium*.

(v) Step (e): *Agrobacterium* based transformation is made.

Q 2. 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:

(i) Complete the missing steps (B) and (D).



(ii) Identify the disease to be cured.
(iii) Why the above method is not a complete solution to the problem?
(iv) Scientists have developed a method to cure this disease permanently. How?

Ans. (i) **Step (B):** Lymphocytes are grown in culture medium.
Step (D): Infusion of genetically engineered lymphocytes into patients.
(ii) The disease to be cured is Adenosine Deaminase (ADA) deficiency.
(iii) As genetically engineered lymphocytes are not immortal, the patient requires periodic infusion of cells.
(iv) If the gene isolated from bone marrow cells producing ADA is introduced into cells at early embryonic stages, it could be a permanent cure.

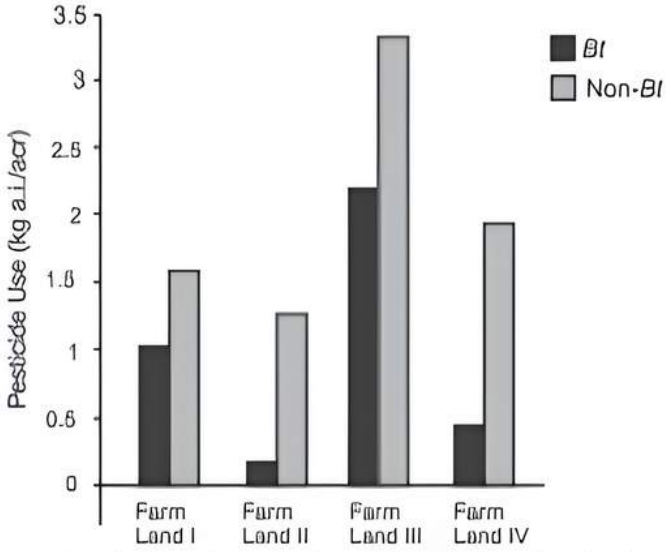
Q 3. What is Gene therapy? Illustrate using example of Adenosine deaminase deficiency.

Ans. Gene therapy is a collection of methods that allows correction of a gene defect. In this method, genes are inserted into the cells and tissues of an individual to correct certain hereditary diseases. It involves delivery of a normal gene into the individual or embryo to replace the defective mutant allele of the gene. Viruses which attack the host cell and introduce genetic material into host are used as vectors.
For example, Adenosine Deaminase (ADA) deficiency can be cured by bone marrow transplantation in some children but is not curative for Gene therapy. lymphocytes are grown in a culture and functional ADA cDNA is introduced into these lymphocytes. These lymphocytes are then transferred into body of patient who requires infusion of such genetically engineered lymphocytes.

Q 4. (i) Name the source from which insulin was extracted earlier. Why is this insulin no more in use by diabetic people?
(ii) Explain the process of synthesis of insulin by Eli Lilly Company. Name the technique used by the company.
(iii) How is the insulin produced by human body different from the insulin produced by the above mentioned company?

Ans. (i) 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.
(ii) Eli Lily used the following procedure for insulin synthesis:
(a) Two DNA sequences corresponding to A and B chains of insulin were prepared.
(b) These sequences were then introduced in plasmids of *E.coli*.
(c) The two insulin chains are produced separately.
(d) The two chains are extracted and combined by creating disulphide bonds to form the assembled mature molecule of insulin.
(iii) The pro-hormone produced in the human body has an extra stretch of C-peptide as compared to that produced by the company.

Q 5. GM crops especially *Bt* crops are known to have higher resistance to pest attacks. The substantiate this an experimental study was conducted in four different farm lands growing *Bt* and non *Bt* Cotton crops. The farm lands had the same dimensions, fertility and were under similar climatic conditions. The histogram below shows the usage of pesticides on *Bt* crops and non-*Bt* crops in these farm lands.



(i) Which of the above four farm lands has successfully applied the concepts of biotechnology to show better management practices and use of agrochemicals? If you had to cultivate, which crop would you prefer (*Bt* or Non-*Bt*) and why?
(ii) Cotton Bollworms were introduced in another experimental study on the above lands wherein no pesticide was used. Explain what effect would a *Bt* and Non-*Bt* crop have on the pest.
(CBSE SQP 2022 Term-2)

Ans. (i) Farm land II.
I would prefer *Bt* crop. Because the use of pesticides is highly reduced for *Bt* crop decrease of pesticides used is also more significant for *Bt* crop.

(ii) In *Bt* cotton, a cry gene has been introduced from bacterium *Bacillus thuringiensis* (*Bt*) which causes synthesis of a toxic protein. This protein becomes active in the alkaline gut of bollworm feeding on cotton, punching holes in the lining causing death of the insect.

However; a Non-*Bt* crop will have no effect on the cotton bollworm/the yield of cotton will decrease/non-*Bt* will succumb to pest attack.

Q 6. Answer the following questions based on *Bt*-crops:

(i) Why do farmers prefer to grow *Bt* cotton crop than genetically unmodified cotton crops?

(ii) Name any two insects that are killed by *Bt* toxin.

(iii) Explain the mechanism by which *Bt* toxin kills the insects but not the bacterium which possesses the toxin. *(CBSE 2023)*

Ans. (i) Because *Bt* cotton is resistant to many insect species while genetically unmodified cotton crops are not. Thus, *Bt* cotton doesn't need any pesticide thereby making it cost effective for the farmers and environment friendly tool.

(ii) Caterpillars and beetals.

(iii) *Bt* toxin does not kill the bacteria because when it is present in the bacteria, it is in an inactive and crystalline form. It becomes active and toxic when it is consumed by insects due to the alkaline pH of the alimentary canal that solubilises the crystals. The activated toxin (delta endotoxins) binds to the epithelial cells in the midgut of an insect and creates pores that cause lysis and swelling, eventually killing the insect.

Q 7. 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. 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

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

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

(ii) Study of disease

(a) Study of genes which are responsible for diseases in human and their treatment.

(b) Transgenic models have been developed for many human diseases like cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's disease.

(iii) Biological products

(a) Useful biological products can be produced by introducing into transgenic animals, the portion of DNA (or genes) which codes for a particular product.

(b) For example, human protein (α-1-antitrypsin) is used to treat emphysema.

(c) In 1997, the first transgenic cow, Rosie, produced human protein-enriched milk (2.4 g/L).

(d) The milk contained the human alpha-lactalbumin and was more nutritionally balanced for human babies than natural cow milk.

(iv) Vaccine safety

(a) Transgenic mice are developed to test safety of vaccines, before being used on humans.

(b) For example, polio vaccine.

(v) Chemical safety testing

(a) Transgenic animals are made to carry genes, which make them more sensitive to the toxic substances than non-transgenic animals.

(b) On exposing to the toxic substances, their effects are studied in less time.

(Any four)

TiP

Read the question carefully to explain the reasons for developing transgenic animals or the areas for their utilisation.

Chapter Test

Multiple Choice Questions

Q 1. Which step has been taken by Government of India to cater to the requirement of patent terms and other emergency provisions in this regard?

a. Biopiracy Act
b. Indian Patents Bills
c. ETI Act
d. Negotiable Instruments Act

Q 2. Potential pathogens for bioweapons are:

a. *Bacillus anthracis* b. *Yerisinia pestis*
c. *Vibrio cholerae* d. All of these

Q 8. Select the incorrect matched pair:

a. Monoclonal antibodies - Hybridomas
b. PCR - Phenylketonuria
c. Bioweapons - *Bacillus anthracis*
d. Tracy - First transgenic animal for food production

Assertion and Reason Type Questions

Directions (Q.Nos. 4-5): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Select the correct answer to these questions from the codes a, b, c and d as given below.*

a. Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
b. Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
c. Assertion is true but Reason is false.
d. Both Assertion and Reason are false.

Q 4. **Assertion (A):** *Agrobacterium tumefaciens* is called natural genetic engineer.
Reason (R): *Agrobacterium tumefaciens* infects all broad-leaved agricultural crops but does not infect cereal crops.

Q 5. **Assertion (A):** ADA deficiency cannot be cured permanently by gene therapy.
Reason (R): 'The genetically engineered lymphocytes can survive only in culture conditions.

Case Study Based Questions

Case Study 1

Transgenic Cow

Q 6. Transgenic cows have extra gene or genes inserted into their DNA. Firstly, the gene for the desired product is identified and sequenced. Then a gene construct containing this desired gene is introduced into female cow cells by transfection. Transgenic bovine cells are selected and fused with bovine oocytes that have had all of their chromosomes removed. Once fused with the oocyte, the transgenic cells chromosomes are reprogrammed to direct development into an embryo which can be implanted into a recipient cow. The resulting transgenic cow only express the transgene in her milk. This is because expression of the transgene is controlled by a promoter specific to lactating mammary cells. The first transgenic cow was 'Rosie'.

(i) **The gene construct with desired gene is introduced into female cow cells by:**
a. transformation b. transduction
c. transfection d. transplantation

(ii) **Production of transgenic cow fulfil the objective of:**
a. increased milk production
b. increased meat production
c. molecular farming
d. All of the above

(iii) **The name of first transgenic cow is:**
a. Tracy b. Rosie c. Dolly d. Andi

(iv) **Transgenic cow is produced through the implantation of ..... containing transgene into recipient cow.**
a. ova b. embryo
c. mammary cell d. Both a. and b.

Case Study 2

Q 7. A transgenic animal contains in its genome, a gene or genes, introduced by one or the other technique of transfection. The gene introduced by transfection is known as transgene. In animals, transfection specifies the introduction of a DNA segment, either naked or integrated into a vector, into an animal cell. The same phenomenon is known as transformation in all other organisms.
Read the given passage carefully and give the answer of the following questions:

(i) **What is called the animals that have had their DNA manipulated to process and express foreign DNA?**
(ii) **Which animals are 95% of the transgenic animals?**
(iii) **What is ANDI?**
(iv) **Name any one genetic modified organism.**

Very Short Answer Type Questions

Q 8. **Give the name of the Indian variety of rice patented by an American company.**
Q 9. **Give the name of the bacterium that produces *Bt* toxin.**
Q 10. **Name the genes that code for cotton bollworms.**

Short Answer Type Questions

Q 11. **Describe DNA probes.**
Q 12. **Suggest an advantage of *Bt* toxin in transgenic *Bt* crops.**

Long Answer Type -I Question

Q 13. **Compare and contrast the advantages and disadvantages of production of genetically modified organisms.**

Long Answer Type -II Question

Q 14. **Write a self-explanatory note on Bacillus thuringiensis.**