CHAPTER

10 Biotechnology and its Applications

10.1. Biotechnological Applications in Agriculture

1. The Bt toxin in genetically engineered Bt cotton kills the pest by:
(A) creating pores in the midgut.
(B) damaging the respiratory system.
(C) degenerating the nervous system.
(D) altering the pH of body fluids. **[Re-NEET 2024]**

2. Following are the steps involved in action of toxin in Bt Cotton.
(I) The inactive toxin converted into active form due to alkaline pH of gut of insect.
(II) *Bacillus thuringiensis* produce crystals with toxic insecticidal proteins.
(III) The alkaline p[illegible] solubilises the crystals.
(IV) The activated toxin binds to the surface of midgut cells, creates pores and causes death of the insect.
(V) The toxin proteins exist as inactive protoxins in bacteria.
Choose the correct answer from the options given below:
(A) (V) → (III) → (II) → (I) → (IV)
(B) (II) → (III) → (I) → (V) → (IV)
(C) (I) → (V) → (II) → (IV) → (III)
(D) (II) → (V) → (III) → (I) → (IV) **[Re-NEET 2024]**

3. Given below are two statements:
Statement I: RNA interference takes place in all Eukaryotic organisms as method of cellular defence.
Statement II: RNA*i* involves the silencing of a specific mRNA due to a complementary single standed RNA molecule that binds and prevents translation of mRNA.
In the light of the above statements, choose the correct answer from the options given below.
(A) Statement I is true but Statement II is false.
(B) Statement I is false but Statement II is true.
(C) Both Statement I and Statement II are true.
(D) Both Statement I and Statement II are false.
[Re-NEET 2024]

4. Match List I with List II:

List I	List II
(a) α-1 antitrypsin	(i) Cotton bollworm
(b) *CryIAb*	(ii) ADA deficiency
(c) *CryIAc*	(iii) Emphysema
(d) Enzyme replacement therapy	(iv) Corn borer

Choose the correct answer from the options given below:

	(a)	(b)	(c)	(d)
(A)	(iii)	(i)	(ii)	(iv)
(B)	(iii)	(iv)	(i)	(ii)
(C)	(ii)	(iv)	(i)	(iii)
(D)	(ii)	(i)	(iv)	(iii)

[NEET 2024]

5. What triggers activation of protoxin to active Bt toxin of *Bacillus thuringiensis* in bollworm?
(A) Moist surface of midgut
(B) Alkaline pH of gut
(C) Acidic pH of stomach
(D) Body temperature **[NEET 2019]**

6. In RNAi, the genes are silenced using:
(A) dsDNA (B) dsRNA
(C) ssDNA (D) ssRNA.
[NEET Odisha 2019]

7. Which of the following is true for Golden rice?
(A) It is vitamin A enriched, with a gene from daffodil.
(B) It is pest resistant, with a gene from *Bacillus thuringiensis*.
(C) It is drought tolerant, developed using *Agrobacterium* vector.
(D) It has yellow grains, because of a gene introduced from a primitive variety of rice. **[NEET 2019]**

8. Which part of the tobacco plant is infected by *Meloidegyne incognitia*?
(A) Leaf (B) Stem
(C) Root (D) Flower
[NEET Phase-I 2016]

9. In Bt cotton, the Bt toxin present in plant tissue as pro-toxin is converted into active toxin due to:

(A) alkaline pH of the insect gut

(B) acidic pH of the insect gut

(C) action of gut microorganisms

(D) presence of conversion factors in insect gut.

[AIPMT Cancelled 2015]

10. The crops engineered for glyphosate are resistant/ tolerant to:

(A) fungi (B) bacteria

(C) insects (D) herbicides.

[AIPMT Cancelled 2015]

11. Golden rice is a genetically modified crop plant where the incorporated gene is meant for biosynthesis of:

(A) vitamin-B (B) vitamin-C

(C) omega 3 (D) vitamin-A.

[AIPMT Latest July 2015]

12. Which of the following Bt crops is being grown in India by the farmers?

(A) Maize (B) Cotton

(C) Brinjal (D) Soyabean **[NEET 2013]**

13. RNA interference involves:

(A) synthesis of mRNA from DNA

(B) synthesis of cDNA from RNA using reverse transcriptase

(C) silencing of specific mRNA due to complementary RNA

(D) interference of RNA is synthesis of DNA.

[NEET Karnataka 2013]

14. Consumption of which one of the following foods can prevent the kind of blindness associated with vitamin-A deficiency?

(A) Flavr savr tomato (B) Canolla

(C) Golden rice (D) Bt brinjal

[AIPMT Screening 2012]

15. Tobacco plants resistant to a nematode have been developed by the introduction of DNA that produced (in the host cells):

(A) both sense and antisense RNA

(B) a particular hormone

(C) an antifeedant

(D) a toxic protein **[AIPMT Mains 2012]**

16. Consider the following four statements (I-IV) and select the option which includes all the correct ones only.

(I) Single cell *Spirulina* can produce large quantities of food rich in protein, minerals, vitamins, etc.

(II) Body weight-wise the microorganism *Methylophilus methylotrophus* may be able to produce several times more proteins than the cows per day.

(III) Common button mushrooms are a very rich source of vitamin-C.

(IV) A rice variety has been developed which is very rich in calcium.

Options:

(A) Statements (III), (IV)

(B) Statements (I), (III) and (IV)

(C) Statements (II), (III) and (IV)

(D) Statements (I), (II) **[AIPMT Mains 2012]**

17. The process of RNA interference has been used in the development of plants resistant to:

(A) fungi (B) viruses

(C) insects (D) nematodes.

[AIPMT Screening 2011]

18. *Bacillus thuringiensis* forms protein crystals, which contain insecticidal protein:

(A) binds with epithelial cells of midgut of the insect pest ultimately killing it

(B) is coded by several genes including the gene *cry*

(C) is activated by acid of pH of the foregut of the insect pest

(D) does not kill the carrier bacterium which is itself resistant to this toxin. **[AIPMT Mains 2011]**

19. The genetically-modified (GM) brinjal in India has been developed for:

(A) insect-resistance

(B) enhancing self life

(C) enhancing mineral content

(D) drought-resistance. **[AIPMT Screening 2010]**

20. Some of the characteristics of Bt cotton are:

(A) long fibre and resistance to aphids

(B) medium yield, long fibre and resistance to beetle pests

(C) high yield and production of toxic protein crystals which kill dipteran pests

(D) high yield and resistance to bollworms.

[AIPMT Screening 2010]

21. An improved variety of transgenic Basmati rice:

(A) does not require chemical fertilizers and growth hormones

(B) gives high yield and is rich in vitamin-A

(C) is completely resistant to all insect pests and diseases of paddy

(D) gives high yield but has no characteristic aroma.

[AIPMT Screening 2010]

22. The bacterium *Bacillus thuringiensis* is widely used in contemporary biology as a/an:

(A) indicator of water pollution

(B) insecticide

(C) agent for production of dairy products

(D) source of industrial enzyme.

[AIPMT Screening 2009]

23. What is true about Bt toxin?

(A) The inactive protoxin gets converted into active form in the insect gut.

(B) Bt protein exists as active toxin in the *Bacillus*.

(C) The activated toxin enters the ovaries of the pest to sterilize it and thus prevent its multiplication.

(D) The concerned *Bacillus* has antitoxins.

[AIPMT Screening 2009]

24. Transgenic plants are:

(A) produced by a somatic embryo in artificial medium

(B) generated by introducing foreign DNA into a cell and regenerating a plant from that cell

(C) produced after protoplast fusion in artificial medium

(D) grown in artificial medium after hybridization in the field. **[AIPMT Screening 2009]**

25. A transgenic food crop, which may help in solving the problem of night blindness in developing countries is:

(A) Flavr savr tomatoes (B) Starlink maize

(C) Bt soyabean (D) Golden rice.

[AIPMT Screening 2008]

26. Main objective of production/use of herbicide resistant GM crops is to:

(A) eliminate weeds from the field without the use of manual labour

(B) eliminate weeds from the field without the use of herbicides

(C) encourage eco-friendly herbicides

(D) reduce herbicide accumulation in food particles for health safety. **[AIPMT Screening 2008]**

27. *Cry*-I endotoxins obtained from *Bacillus thuringiensis* are effective against:

(A) mosquitoes (B) flies

(C) nematodes (D) bollworms.

[AIPMT Screening 2008]

28. Golden rice is a transgenic crop of the future with the following improved trait:

(A) insect resistance

(B) high lysine (essential amino acid) content

(C) high protein content

(D) high vitamin-A content. **[AIPMT 2006, 05]**

29. *Bacillus thuringiensis* (Bt) strains have been used for designing novel:

(A) biofertilizers

(B) bio-metallurgical techniques

(C) bio-mineralization processes

(D) bioinsecticidal plants. **[AIPMT 2005]**

30. Which one of the following bacteria has found extensive use in genetic engineering work in plants?

(A) *Clostridium septicum*

(B) *Xanthomonas citri*

(C) *Bacillus coagulens*

(D) *Agrobacterium tumefaciens* **[AIPMT 2003]**

31. Introduction of food plants developed by genetic engineering is not desirable because:

(A) economy of developing countries may suffer

(B) these products are less tasty as compared to the already existing products

(C) this method is costly

(D) there is danger of coming viruses, allergens and toxins with introduced crop. **[AIPMT 2002]**

32. One of the most important reasons why wild plants should thrive is that they are good sources of:

(A) highly nutritive animal feed

(B) unsaturated edible oils

(C) genes for resistance to disease and pests

(D) very rare and highly sought after fruits of medical importance. **[AIPMT 2000]**

33. The first transgenic crop was:

(A) tobacco (B) cotton

(C) pea (D) flax. **[AIPMT 1999]**

10.2. Biotechnological Applications in Medicine

34. Match List-I with List-II

List-I	List-II
(a) Genetically engineered Human Insulin	(i) Gene therapy
(b) GM cotton	(ii) *E. coil*

(c) ADA Deficiency	(iii)Antigen-antibody interaction
(d) ELISA	(iv)*Bacillus thuringiensis*

Choose the correct answer from the options given below:

	(a)	(b)	(c)	(d)
(A)	(iii)	(ii)	(iv)	(i)
(B)	(ii)	(i)	(iv)	(iii)
(C)	(iv)	(iii)	(i)	(ii)
(D)	(ii)	(iv)	(i)	(iii)

[Re-NEET 2024]

35. Which one of the following techniques does not serve the purpose of early diagnosis of a disease for its early treatment?

(A) Polymerase Chain Reaction (PCR) technique

(B) Enzyme Linked Immuno-Sorbent Assay (ELISA) technique

(C) Recombinant DNA Technology

(D) Serum and Urine analysis **[NEET 2023]**

36. In gene therapy of Adenosine Deaminase (ADA) deficiency, the patient requires periodic infusion of genetically engineered lymphocytes because:

(A) gene isolated from marrow cells producing ADA is introduced into cells at embryonic stages

(B) lymphocytes from patient's blood are grown in culture, outside the body

(C) genetically engineered lymphocytes are not immortal cells

(D) retroviral vector is introduced into these lymphocytes. **[NEET 2022]**

37. Statement related to human insulin are given below. Which statement(s) is/are correct about genetically engineered Insulin?

(I) Pro-hormone insulin contain extra stretch of C-peptide.

(II) A-peptide and B-peptide chains of insulin were produced separately in *E.coli*, extracted and combined by creating disulphide bond between them.

(III) Insulin used for treating diabetes was extracted from cattles and pigs.

(IV) Pro-hormone Insulin needs to be processed for converting into a mature and functional hormone.

(V) Some patients develop allergic reactions to the foreign insulin.

Choose the most appropriate answer from the options given below:

(A) (II) only

(B) (III) and (IV) only

(C) (III), (IV) and (V) only

(D) (I), (II) and (IV) only **[NEET 2022]**

38. When gene targeting involving gene amplification is attempted in an individual's tissue to treat disease, it is known as:

(A) biopiracy (B) gene therapy

(C) molecular diagnosis (D) safety testing.

[NEET 2021]

39. For effective treatment of the disease, early diagnosis and understanding its pathophysiology is very important. Which of the following molecular diagnostic techniques is very useful for early detection?

(A) Western Blotting Technique

(B) Southern Blotting Technique

(C) ELISA Technique

(D) Hybridization Technique **[NEET 2021]**

40. With regard to insulin choose correct options.

(I) C-peptide is not present in mature insulin.

(II) The insulin produced by rDNA technology has C-peptide.

(III) The pro-insulin has C-peptide.

(IV) A-peptide and B-peptide of insulin are interconnected by disulphide bridges.

Choose the correct answer from the options given below.

(A) (II) and (IV) only

(B) (II) and (III) only

(C) (I), (III) and (IV) only

(D) (I) and (IV) only **[NEET 2021]**

41. Now a days it is possible to detect the mutated gene causing cancer by allowing radioactive probe to hybridise its complimentary DNA in a clone of cells, followed by its detection using autoradiography because:

(A) mutated gene does not appear on photographic film as the probe has complementarity with it

(B) mutated gene partially appears on a photographic film

(C) mutated gene completely and clearly appears on a photographic film

(D) mutated gene does not appear on a photographic film as the probe has no complementarity with it.

[NEET 2021]

42. The Adenosine deaminase deficiency results into:

(A) addison's disease

(B) dysfunction of immune system

(C) parkinson's disease

(D) digestive disorder. **[NEET 2021]**

43. Which of the following is not an application of PCR (Polymerase Chain Reaction)?

(A) Detection of gene mutation

(B) Molecular diagnosis

(C) Gene amplification

(D) Purification of isolated protein **[NEET 2021]**

44. Which of the following statements is not correct?

(A) The proinsulin has an extra peptide called C-peptide.

(B) The functional insulin has A and B chains linked together by hydrogen bonds.

(C) Genetically engineered insulin is produced in *E. coli.*

(D) In man insulin is synthesised as a proinsulin.

[NEET 2020]

45. Match the following columns and select the correct option.

Column I	Column II
(a) Bt cotton	(i) Gene therapy
(b) Adenosine deaminase deficiency	(ii) Cellular defence
(c) RNAi	(iii) Detection of HIV infection
(d) PCR	(iv) *Bacillus thuringiensis*

Select the correct option.

	(a)	(b)	(c)	(d)
(A)	(iii)	(ii)	(i)	(iv)
(B)	(ii)	(iii)	(iv)	(i)
(C)	(i)	(ii)	(iii)	(iv)
(D)	(iv)	(i)	(ii)	(iii)

[NEET Sept. 2020]

46. Which kind of therapy was given in 1990 to a four-year-old girl with Adenosine Deaminase (ADA) deficiency?

(A) Gene therapy (B) Chemotherapy

(C) Immunotherapy (D) Radiation therapy

[NEET Phase-II 2016]

47. The two polypeptides of human insulin are linked together by:

(A) hydrogen bonds (B) phosphodiester bond

(C) covalent bond (D) disulphide bridges.

[NEET 2016]

48. The first human hormone produced by recombinant DNA technology is:

(A) insulin (B) estrogen

(C) thyroxin (D) progesterone.

[AIPMT 2014]

49. *In-vitro* clonal propagation in plants is characterised by:

(A) PCR and RAPD

(B) Northern blotting

(C) Electrophoresis and HPLC

(D) Microscopy. **[AIPMT 2014]**

50. Which one of the following vectors is used to replace the defective gene in gene therapy?

(A) Ti plasmid (B) Adenovirus

(C) Cosmid (D) Ri plasmid

[NEET Karnataka 2013]

51. PCR and Restriction Fragment Length Polymorphism are the methods for:

(A) study of enzymes

(B) genetic transformation

(C) DNA sequencing

(D) genetic fingerprinting. **[AIPMT Screening 2012]**

52. Which one of the following is now commercially produced by biotechnological procedures?

(A) Nicotine (B) Morphine

(C) Quinine (D) Insulin

[AIPMT Mains 2012]

53. The genetic defect - Adenosine Deaminase (ADA) deficiency may be cured permanently by:

(A) periodic infusion of genetically engineered lymphocytes having functional ADA *c*DNA.

(B) administering adenosine deaminase activators.

(C) introducing bone marrow cells producing ADA into cells at early embryonic stages.

(D) enzyme replacement therapy.

[AIPMT Screening 2009]

54. Production of a human protein in bacteria by genetic engineering is possible because:

(A) the human chromosome can replicate in bacterial cell.

(B) the mechanism of gene regulation is identical in humans and bacteria.

(C) bacterial cell can carry out the RNA splicing reactions.

(D) the genetic code is universal. **[AIPMT 2005]**

55. ELISA is used to detect viruses, where:

(A) DNA-probes are required

(B) southern blotting is done

(C) alkaline phosphatase is the key reagent

(D) catalase is the key reagent. **[AIPMT 2004]**

56. Hybridoma cell are:

(A) only cells having oncogenes

(B) product of spore formation in bacteria

(C) nervous cells of frog

(D) hybrid cell resulting from myeloma cells.

[AIPMT 2000]

57. Genetically engineered bacteria have been successfully used in the commercial production of:

(A) human insulin (B) testosterone

(C) thyroxine (D) melatonin **[AIPMT 1996]**

10.3. Transgenic Animals

58. Read the following four statements (I-IV) about certain mistakes in two of them.

(I) The first transgenic buffalo, Rosie produced milk which was human α-lactalbumin enriched.

(II) Restriction enzymes are used in isolation of DNA from other macromolecules.

(III) Downstream processing is one of the steps of r-DNA technology.

(IV) Disarmed pathogen vectors are also used in transfer of r-DNA into the host.

Which are the two statements having mistakes?

(A) Statements (II) and (III)

(B) Statements (III) and (IV)

(C) Statements (I) and (III)

(D) Statements (I) and (II) **[AIPMT Mains 2011]**

59. Genetic engineering has been successfully used for producing:

(A) transgenic mice for testing safety of polio vaccine before use in humans

(B) transgenic models for studying new treatments for certain cardiac diseases

(C) transgenic cow-Rosie which produces high fat milk for making ghee

(D) animals like bulls for farm work as they have super power. **[AIPMT Screening 2010]**

60. In transgenics, expression of transgene in target tissue is determined by:

(A) enhancer (B) transgene

(C) promoter (D) reporter. **[AIPMT 2004]**

61. Producing a giant mouse in the laboratory was possible through:

(A) gene mutation (B) gene manipulation

(C) gene synthesis (D) gene duplication.

[AIPMT 2000]

62. The first successfully cloned mammals (animal) that gained worldwide publicity was:

(A) Molly (a sheep) (B) Polly (a sheep)

(C) Chance (a bull) (D) Dolly (a sheep)

[AIPMT 2000]

10.4. Ethical Issues

63. Given below are two statements:

Statement I: The Indian Government has set up GEAC, which will make decisions regarding the validity of GM research.

Statement II: Biopiracy is the term used to refer to the use of bio-resources by native people.

In the light of above statements, choose the correct answer from the options given below:

(A) Statement I is true but Statement II is false.

(B) Statement I is false but Statement II is true.

(C) Both Statement I and Statement II are true.

(D) Both Statement I and Statement II are false.

[Re-NEET 2024]

64. Exploitation of bioresources of a nation by multinational companies without authorisation from the concerned country is referred to as:

(A) biowar (B) bioweapon

(C) biopiracy (D) bioethics.

[NEET Odisha 2019, NEET 2018]

65. In India, the organisation responsible for assessing the safety of introducing genetically modified organisms for public use is:

(A) Research Committee on Genetic Manipulation (RCGM)

(B) Council for Scientific and Industrial Research (CSIR)

(C) Indian Council of Medical Research (ICMR)

(D) Genetic Engineering Appraisal Committee (GEAC)

[NEET 2018]

66. Which body of the Government of India regulates GM research and safety of introducing GM organisms for public services?

(A) Bio-safety committee

(B) Indian Council of Agricultural Research

(C) Genetic Engineering Approval Committee

(D) Research Committee on Genetic Manipulation

[NEET Phase-II 2016]

SOLUTIONS

1. (A) *Bacillus thruingiens* (Bt) is a soil bacterium produces proteins which kill insects. Intracellular protein crystals which contain a toxic insecticidal protein called Bt toxin are formed by this bacteria. The Bt toxin protein exists as an inactive toxin which is converted into an active form due to the alkaline pH of the alimentary canal. The activated toxin attach to the surface of midgut epithelial cells leads to create pores which cause swelling and lysis of cell and ultimately cause the death of the insect.

2. (D) *Bacillus thuringiensis* produce crystals with toxic insecticidal proteins. The toxin proteins exist as inactive protoxins in bacteria. The alkaline pH solubilizes the crystals. The inactive toxin is converted into active form due to the alkaline pH of the gut of the insect. The activated toxin binds to the surface of midgut cells, creates pores, and causes death of the insect.

3. (A) RNA interference (RNAi) is a process observed in eukaryotic organisms, where it serves as a defense mechanism against viruses and regulates gene expression.

This method involves silencing of a specific mRNA due to a complementary ds L-RNA molecule that binds to and prevents the mRNA translation (silencing).

4. (B) Transgenic animals are used to produce useful biological products that can be created by the introduction of the portion of DNA (or genes), which codes for a particular product such as human protein (α-1-antitrypsin) used to treat emphysema.

The proteins encoded by the genes *cryIAc* and *cryIIAb* control the cotton bollworms, and proteins encoded by *cryIAb* controls corn borer. Enzyme replacement therapy is done to treat Adenosine deaminase (ADA) deficiency in which functional ADA is given to the patient by injection. But, it is not completely curable.

5. (B) *Bacillus thuringiensis* is a Gram-positive, spore-forming bacterium which is mainly found in the soil. It produces protein Bt that are toxic to insects. The proteins produced by Bt genes, in presence of alkaline medium bind to the receptors present on the insect's membrane, resulting in the formation of pores on the membranes. This disrupts the digestive process and leads to the death of the insect.

Related Theory

Bacillus thuringiensis is a source of cry gene. It makes proteins that are toxic to some insects when eaten, but not others. Specific Bt toxin gene was isolated from Bacillus thuringiensis and introduced in cotton plant to produce variety Bt cotton, which was resistant to the attack of bollworms.

6. (B) A nematode *Meloidegyne incognitia* infects the roots of tabacco plants and cause a great reduction in yield. RNA interference was adopted to prevent this infestation. RNAi takes plece in all eukaryotic organisms as a method of cellular defence. In RNAi, a specific mRNA is silenced by a complementary dsRNA molecule that binds to it and stops mRNA translation (silencing). As a result, the corresponding protein is no longer produced.

7. (A) Golden rice is a newly developed genetically modified variety of rice produced by genetic engineering. Golden rice is vitamin A enriched rice, with a gene from daffodil and is rich in carotene. Golden rice differs from its parental strain by incorporating three genes for the biosynthesis of β-carotene. The parental strain in their leaves will naturally produce β-carotene, where it is involved in photosynthesis.

8. (C) *Meloidegyne incognitia* is a nematode which infects the root of tobacco plant and cause root knot disease. The disease is characterised by the presence of characteristic swellings called galls or root-knots on the roots of infected plants. Symptoms include stunted growth, wilting and susceptibility to other pathogens leading to poor yields.

9. (A) The Bt toxin dissolve in the high pH insect gut and become active. The toxins then attack the gut cells of the insect, punching holes in the lining. The Bt spores spills out of the gut and germinate in the insect causing death within a couple of days.

Related Theory

Even though the toxin does not kill the insect immediately, treated plant parts will not be damaged because the insect stops feeding within hours. Bt spores do not spread to other insects or cause disease outbreaks on their own. It is very specific in action on the target. Different strains of Bt are specific to different receptors in insect gut wall. Bt toxicity depends on recognizing receptors, damage to the gut by the toxin occurs upon binding to a receptor.

10. (D) Glyphosate (N-phosphomethyl glycine) is systematic broad-spectrum herbicide used to kill weeds, especially broad leaves and grasses. It is used to engineer new crops for having herbicides tolerance.

11. (D) Golden rice is a genetically modified variety of rice, *Oryza sativa*, which has been a fortified food for areas where there is a shortage of dietary vitamin A. It contains a precursor of pro-vitamin A, called β-carotene, which has been introduced into the rice through genetic engineering.

12. (B) Bt cotton are obtained by genetic engineering of plants by incorporating Bt gene, to protect plants from pests.

Related Theory

The Bt toxin is produces by Bacillus thuringiensis. protein exist as inactive protoxin 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. Therefore, it does not kill the bacteria.

13. (C) All eukaryotic species use RNA interference (RNAi) as cellular defense. This technique involves the silencing of a particular mRNA because the corresponding dsRNA molecule attaches to the mRNA and stops it from being translated. This

complementary RNA may have originated from a virus infected with an RNA genome that replicates through an intermediate RNA.

14. (C) Golden rice is a genetically modified crop that has been produced to biosynthesise β-carotene, which is precursor of vitamin-A. By the consumption of golden rice kind of blindnesss associated with vitamin-A deficiency can be prevented.

Related Theory

- *Golden rice, created 20 years ago and intended as an additional intervention to combat vitamin A deficiency, is closer to being released for cultivation and human consumption in the Philippines and Bangladesh.*

15. (A) Using *Agrobacterium* vectors, nematode specific genes are introduced into host plants. The introduction of DNA produces both sense and antisense RNA in host cells. These two RNA's being complementary form a double stranded RNA (dsRNA) that initiates the RNA's and silence the specific mRNA of the nematode. As a result of this, the parasite cannot survive in the transgenic host expressing specific interfering RNA.

Related Theory

- *Antisense RNA can be produced by inverting a cDNA copy of an mRNA with respect to the promoter in an expression vector. This yields a full length complementary copy of the mRNA sequence. Antisense RNA molecule are thought to interact with mRNA molecule by base pairing to form double stranded RNA.*

16. (B) 250 gm biomass of *Methylophilus methylotrophus* produce 25 tonn protein/day while cow of 250 kg produces only 200 gm protein/day.

Related Theory

- *Spirulina is a dietary supplement made from blue-green algae or cyanobacteria, known as Arthrospira platensis. Spirulina is rich in proteins, vitamins, and minerals. The cyanobacteria, through the process of photosynthesis, converts sunlight into nearly all essential nutrients.*

17. (D) Using *Agrobacterium* vectors, nematode specific genes are introduced into host plants. *E.g.*, the development of plants resistant to nematodes like *Meloidegyne incognitia*, which infects the roots of tobacco plants and causes a great reduction in yield.

18. (A) The Bt toxin protein exist as inactive protoxin 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 which cause cell swelling and lysis and finally cause death of the insect.

Related Theory

- *'Cry' protein producing gene is transferred to the plant to provide resistance against insect larvae.*

19. (A) Bt brinjal, a genetically engineered variety of eggplant, provides effective protection against lepidopteron, coleopterans and dipterans. insects, in particular the Brinjal Fruit and Shoot Borer (*Leucinodes orbonalis*) (FSB) without the application of pesticides.

Related Theory

- *Bt brinjal, a genetically-modified (GM) crop was banned in 2010 following concerns raised about public health and biodiversity.*
- *GM crops are broadly classified in this data product as herbicide-tolerant (HT), insect-resistant (Bt), or stacked varieties that are a combination of both HT and Bt traits.*

20. (D) Bt-cotton, shows high yield and resistance to cotton bollworms. The proteins encoded by *cry*IIAb and *cry*IAc are used to control cotton bollworms not dipterans. Dipterans include mosquitoes and flies they do not attack cotton plant.

Mnemonics

- *Bacillus thuringiensis in Bt cotton kills insects named lepidopterans, coleopterans, and dipterans. These can be learned as:*

LuCiD

L *— Lepidopteran;*

C *— Coleopteran;*

D *— Dipteran*

21. (B) *Oryza sativa* is an improved transgenic Basmati rice, called as golden rice is nutritionally enriched in vitamin A.

22. (B) *Bacillus thuringiensis* produce endotoxin which when ingested and released in the gut of the larvae of insect pest, disrupts the insect gut lining thereby killing them.

23. (A) The Bt toxin exist as inactive protoxin 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.

24. (B) Transgenic plants are the ones, whose DNA is modified using genetic engineering techniques. The aim is to introduce a new trait to the plant which does not occur naturally in the species. A transgenic plant contains a gene or genes that have been artificially inserted.

25. (D) Golden rice (*Oryza sativa*), is a genetically modified variety of rice, which developed as a fortified food for areas where there is a shortage

of dietary vitamin A and helps in night blindness, caused by the deficiency of vitamin A. Flavr Savr is a genetically modified tomato, in which the shelf life of tomato is increased by deactivation of an enzyme polygalacturonase using antisense RNA. The Bt soyabean has been developed to give resistance against caterpillar pest. Starlink maize is a genetically modified crop containing protein *cry* 9C from the *Bacillus thuringiensis* (Bt), providing resistance from caterpillars.

26. (D) Genetic engineering has helped to develop such transgenic crop plants which are resistant to herbicides so that they are not damaged when farmers spray herbicides in the fields. Herbicide resistant plants have been developed in such a way that they continue to produce normal crop yield and at the same time remain unaffected by the activity of herbicides. These plants also reduces the use of weeding labour, farmer's cost and increases yield.

27. (D) Proteins encoded by the genes *cry*IAc and *cry*IIAb control cotton bollworms. It is resistant to only certain specific taxa of pests.

Related Theory

The Bt gene with the resistance gene attached is inserted into plant cells. Any plant cell that has the Bt gene must also have the resistance gene that was attached to it. Researchers grow the plant cells in the presence of the antibiotic or herbicide and select the plant cells that are unaffected by it.

Caution

Students may get confused between cryIAc and cryIIAb that control cotton bollworms while that of cryIAb controls corn borers.

28. (D) Plants that generate more food can be created through genetic alteration. For instance, a plant with enhanced insect resistance might be created.

Wild rice now produces β-carotene thanks to a gene that researchers inserted to it. The wild rice now has a golden colour as a result. Humans require β-carotene to produce vitamin A, which is necessary for healthy vision.

Golden rice has the advantage that it can be consumed in regions where vitamin A deficiency is frequent, preventing night blindness.

29. (D) *Bacillus thuringiensis* produce endotoxin (*cry* proteins) during the stationary phase of its growth cycle which when ingested and released in the gut of the larvae of insect pest, disrupts the insect gut lining thereby causing cell swelling and lysis, eventually causing death of the insect. In this way, it act as a bio-insecticide.

30. (D) For GM plants, the bacterium most frequently used is called *Agrobacterium tumefaciens*. The gene of interest is transferred into the bacterium and the bacterial cells then transfer the new DNA to the genome of the plant cells. The plant cells that have successfully taken up the DNA are then grown to create a new plant.

Related Theory

Bacteriophage λ is one of the most widely used vectors used to carry recombinant DNA into bacterial cells.

31. (D) One specific concern is the possibility for GMOs to negatively affect human health. This could result from differences in nutritional content, allergic response, or undesired side effects such as toxicity, organ damage, or gene transfer.

Related Theory

Some benefits of genetic engineering in agriculture are increased crop yields, reduced costs for food or drug production, reduced need for pesticides, enhanced nutrient composition and food quality, resistance to pests and disease, greater food security, and medical benefits to the world's growing population.

32. (C) The preservation of wild kinds and plants is crucial because they include genes that make them resistant to disease and pests. They serve as a gene bank for the creation and improvement of novel kinds as well as a source for genes that are disease resistant.

33. (A) The first transgenic plant was a tobacco plant which bear resistance to antibiotics and was created in 1983 in China.

Caution

Students may get confused and choose (B) cotton but Bt cotton was commercially introduced in the US in 1995.

34. (D) Genetically engineered human insulin isolated from *E.coli* bacterium.

Genetically modified cotton was developed by using a bacterium *Bacillus thuringiensis*.

ADA deficiency damages the function and development of immune cells and it is treated by gene therapy.

ELISA is enzyme linked immunosorbent assay, its work on the principle of antibody-antigen interaction.

35. (D) All of the given techniques can be used for early diagnosis of a disease for its early treatment. However, if we have to choose the technique that does not primarily serve this purpose, then the answer would be (D) Serum and Urine analysis.

Serum and urine analysis can be used to detect the presence of certain biomolecules, such as enzymes or proteins, which may indicate the presence of a disease. However, this technique may not always be able to provide an early diagnosis of a disease. In some

cases, the biomolecules may only be detectable at later stages of the disease, when it has already progressed significantly.

Related Theory

PCR, ELISA, and recombinant DNA technology are all highly sensitive and specific techniques that can detect the presence of a disease even at its early stages, allowing for early treatment and better patient outcomes.

36. (C) Gene therapy can be used to address ADA deficiency. In gene therapy, the patient's lymphocytes are from the blood grown in a culture outside of the body, and a functioning ADA, cDNA is inserted into the lymphocytes (using a retroviral vector). The patient is subsequently returned to lymphocytes that have undergone genetic engineering. However, these cells are not immortal, the patient requires frequent infusions of them.

37. (A) The technique of changing an organism's genetic makeup is known as genetic engineering. Recombinant DNA technology is used to carry out genetic engineering. Genetic engineering can be used to create insulin on a massive scale for the treatment of diabetic patients.

(1) The peptide is absent from insulin made through genetic engineering.

(2) In *E. coli*, the A-peptide and B-peptide chains of insulin were made independently. Disulfide linkages are then formed between these peptide chains, allowing for their extraction and recombination. Instead of being isolated from cattle and pigs, genetically modified insulin used to treat diabetes was created artificially using *E. coli*. Proinsulin requires additional processing in order to function.

(3) In addition to the peptide chains known as "A" and "B," proinsulin also contains the "C" peptide, which is necessary for its functionality.

(4) The C-peptide is eliminated from proinsulin during maturation, hence it is absent from genetically modified insulin. However, some individuals who received animal-derived insulin experienced allergic reactions or other forms of reactions to the alien protein.

38. (B) Gene therapy is an experimental technique that involves insertion of genes into person's cells and tissues to treat or prevent disease. The basics of the process are the identification of the gene in question, duplication of that gene and insertion of the gene into the human genome needing the gene. The gene that needs to be altered or replaced must be identified.

Related Theory

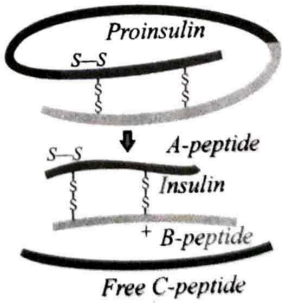
There are two types of gene therapy treatment: Somatic cell gene therapy and germline therapy. Somatic cell gene therapy involves obtaining blood cells from a person with a genetic disease and then introducing a normal gene into the defective cell.

39. (C) ELISA – Enzyme Uinked Immuno Sorbent Assay is based on the principle of antigen-antibody reaction. Infection by pathogen is an antigen it can be detected by the presence of antibodies synthesized against it.

Related Theory

By amplification of the DNA of virus or bacteria present in the patient helps to identify even the concentration of pathogen is very low in the body of the patient. A single stranded DNA or RNA is tagged with a radioactive molecule (probe) is allowed to hybridized to its complementary DNA in clone of cells followed by detection using autoradiography. Thus, the mutated gene can be detected as it will not hybridize with the probe.

40. (C) Insulin consists of two short polypeptide chains, i.e., chain-A and B, linked together by disulphide bridges. In mammals, insulin is synthesised as a prohormone (needs to be processed before it becomes a fully mature and functional hormone) which contains an extra stretch called the C-peptide. C-peptide is not present in the mature insulin and is removed during maturation into insulin. Thus, the main challenge for the production of insulin using rDNA techniques was getting insulin assembled into a mature form.



Maturation of Pro-Insulin into Insulin

41. (D) By using an X-ray film and a process called autoradiography, radioactively labelled molecules can be seen. A radioactive molecule is attached to a single-stranded DNA or RNA to create a probe.

An autoradiogram is used to detect the mutant gene after allowing the probe to hybridise with its complementary DNA in a cell clone.

Due to the probe's lack of complementarity with the mutant gene, the altered gene will not be seen on the photographic film.

The probe won't be able to attach to the mutant gene because it lacks complementary DNA, which prevents it from appearing on the photographic film.

42. (B) Adenosine deaminase enzyme is crucial for the immune system to function. ADA deficiency is caused due to the deletion of the gene for adenosine deaminase. The buildup of deoxyadenosine caused by this defect causes T-cells to proliferate and grow in the thymus. Affected people often have a small, undeveloped thymus. The immune system is either severely damaged or nonexistent. Therefore, an ADA deficiency prevents the immune system from operating normally.

43. (D) Polymerase chain reaction can be used to detect mutations in genes in suspected cancer patients. This technique can be used to identify many other genetic disorders. It serves the purpose of early diagnosis. This technique is based on enzymatic replication of DNA. Purification of isolated protein is done before amplification of DNA. It is one of the step of recombinant DNA technology.

44. (B) Disulphide bonds bind the A and B chains together to form the functional insulin.

45. (D) Specific Bt toxin gene was isolated from *Bacillus thuringiensis* and introduced in cotton plant to produce variety Bt cotton, which was resistant to the attack of bollworms. *Bacillus thuringiensis* toxins kill insects by forming pores into cell membranes of the insect midgut. The first clinical gene therapy was given in 1990 to a 4 year old girl with Adenosine deaminase (ADA) deficiency, which is a metabolic disorder that causes immunodeficiency. RNAi or RNA interference occurs in all eukaryotic organism as a method of cellular defense mechanism. It is a biological process in which RNA molecules are involved in sequence-specific suppression of gene expression by double-stranded RNA, through translation or transcriptional repression. PCR is used for the detection of HIV virus in suspected AIDS patients. It is used to detect HIV's genetic material, called RNA.

46. (A) Gene therapy is an experimental technique in which genes are introduced into individual cells or tissues, to cure some hereditary diseases in which a defective allele of a gene is replaced with normal one. The first approved gene therapy was given on 14th September 1990, to a four-year-old Ashanti DeSilva who had genetic defect leading to ADA-SCID, a severe immune system deficiency.

Related Theory

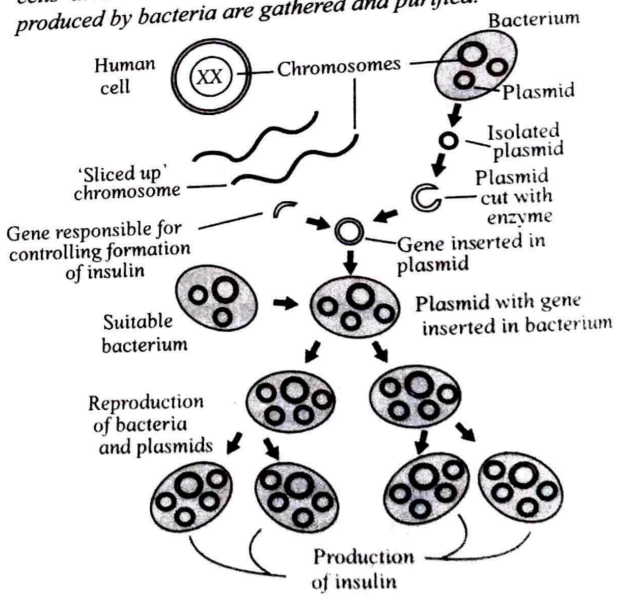
Introduction of genetically engineered lymphocytes into ADA deficient patients is not a permanent cure because these cells are not immortal and the patient requires periodic infusion of such genetically engineered lymphocytes. A possible permanent cure can be isolating the gene producing adenosine deaminase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

47. (D) In 1983, Eli lily an American company prepared two DNA sequences A and B, introduced them in plasmids of *E.coli* to produce insulin chains. The A chain and B chain are the two peptide chains that are produced separately, extracted and combined by disulphide bridges that bind the two polypeptide chains of human insulin together.

48. (A) Insulin was the first hormone to be produced in 1978 with the help of recombinant DNA technology from *E. coli*. Human insulin (Humulin) was developed by Genentech, the first American biotechnology company, was licensed to Eli lily and became the first marketable product created through rDNA technology.

Related Theory

Insulin is a protein that acts as a hormone to stimulate uptake of blood sugar into tissues, such as the liver and the muscles. The gene responsible for producing human insulin protein is isolated. Then, a circular piece of DNA called a plasmid is removed from a bacterial cell and the gene for insulin is inserted into the plasmid ring. Many plasmids with the insulin gene are inserted into multiple bacterial cells. The bacterial cells divides continuously. Human insulin protein molecules produced by bacteria are gathered and purified.



Synthesis of Human Insulin by Genetic Engineering

49. (A) For clonal propagation of plants, PCR and RAPD are used. In *in-vitro* clonal propagation or micropropagation, desired genes are amplified to produce multiple copies. PCR or Polymerase Chain Reaction is the technique used to produce multiple copies of DNA. RAPD or Random Amplified Polymorphic DNA is a PCR based technique used for the identification of genetic changes in desired DNA sample in plants.

50. (B) Certain crucial viral genes can be removed and replaced with a cassette that encodes a foreign therapeutic gene in adenovirus vectors, which can result in replication defects. Such a vector is utilised in gene therapy, vaccinations, and cancer treatment.

51. (D) RFLP and PCR are the basis of DNA fingerprinting, and is used to identify individuals from the body fluids samples. Sequencing DNA means determining the order of the four nitrogenous bases that make up the DNA molecule.

Related Theory

- *There are various methods for analysing DNA to establish if two samples are the same or different. This is sometimes referred to as DNA fingerprinting. If two DNA samples have the same fingerprint, then there is a very high statistical likelihood that they came from the same person. Such an approach can also be used to establish paternity.*

Caution

- *Earlier RFLP and VNTR were used as genetic markers for DNA fingerprinting. But in latest, short tandem repeats are used.*

52. (D) Insulin is now being commercially produced by genetic engineering.

Related Theory

- *Insulin consists of two short polypeptide chains: chain A and chain B, that are linked together by disulphide bonds. Insulin, in mammal is synthesized as a prohormone which contains an extra stretch called the C-peptide. During maturation this C-peptide is removed.*

53. (C) Introduction of genetically engineered lymphocytes into ADA deficiency patients 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.

Related Theory

- *SCID is caused by mutations in a gene that encodes an enzyme called Adenosine Deaminase (ADA). ADA is essential for the metabolic function of a variety of body cells but especially T-cells. The absence of this enzyme leads to an accumulation of toxic metabolic by-products within lymphocytes that cause the cells to die.*

54. (D) Genetic code may be defined as the sequence of nucleotides in polynucleotide chain which determines the sequence of amino acids in a polypeptide chain. Thus the genetic code is universal. There is no ambiguity regarding genetic code. It means that each codon codes for the same amino acid in all organisms including bacteria, plants and animals. Bacterial cells lack the machinery needed for processing of primary transcript, and hence cannot replicate human chromosome. Prokaryotic genes are polycistronic and eukaryotic genes are monocistronic which means that gene regulation is not same in both. Prokaryotic RNA does not undergo splicing.

Related Theory

- *Splicing refers to editing of the precursor messenger RNA (pre-mRNA) transcript into a mature messenger RNA (mRNA) wherein introns are removed and exons are joined together i.e., they are ligated. Splicing occurs within the nucleus after transcription.*

55. (C) ELISA (Enzyme Linked Immunosorbent Assay) screening test is the initial test to diagnose AIDS. The test works by detecting antibodies/substances or protein which are produced in the blood when virus is present. Alkaline phosphatase and peroxidases are commonly used enzymes as key reagent to perform the ELISA test.

56. (D) Hybridoma cells are hybrid cells obtained from the artificial fusion of an antibody-producing lymphocyte and a myeloma cell from a lymphoid tumour. Such cells can produce a clone that may be maintained in tissue culture and used for the continuing production of monoclonal antibody.

57. (A) Nowadays, human insulin is made by genetically modified bacteria that have human insulin-producing genes put into a vector DNA and delivered into the host bacterium *E. coli*.

58. (D) Rosie was the first transgenic cow. It was considered different from a normal cow as it produced human protein-enriched milk rich in 'human α-lactalbumin' and was nutritionally a more balanced product for human babies than the normal cow milk. Restriction enzymes are DNA cutting enzymes. Each enzyme recognizes one or a few target sequences and cuts DNA at or near those sequences. So, it is used in isolation of a part of DNA from the whole DNA macromolecule. It is not used to isolate DNA from other molecules.

59. (A) Transgenic animals are being produced as they can act as models for chemical safety testing and vaccine safety testing. Transgenic mice are being used to test the safety of the polio vaccine. If successful and found to be reliable, they could replace the use of monkeys to test the safety of batches of the vaccine.

60. (D) Reporter genes allow for the identification of transformed cells without the need for selective media, as they encode proteins that are more readily apparent. The GUS gene, encodes the enzyme β-glucuronidase, is extensively used as a marker of plant transformation.

Related Theory

- *Silencer is a DNA sequence capable of binding transcription regulation factors, called repressors. DNA contains genes and provides the template to produce messenger RNA (mRNA). Thus, silencers prevent genes from being expressed as proteins.*

61. (B) Transgenic giant mice have been produced in the laboratory by gene manipulation. Genetic manipulation is the transfer of genes to fertilised eggs as well as to stem cells.

Related Theory

- *Gene manipulation is the process of directly manipulating the gene of an organism where the new DNA can be inserted randomly, or it can be targeted at a specific part of the genome, giving it a desired phenotype.*

62. (D) Dolly was a domestic sheep who was the first creature to be created by the nuclear transfer method from an adult somatic cell. The generation of a healthy clone demonstrated that a cell obtained from a particular section of the body could duplicate an entire individual because the cell used as the donor for the cloning of Dolly was taken from the mammary gland. As it was the first successful animal clone, it received widespread attention.

63. (A) Biopiracy is the common term that use to describe the exploitation of biological resources by the private enterprises in an unauthorized way.

64. (C) The use of bio-resources by multinational corporations and other organisations without formal authorization from the countries and people concerned or with payment in lieu of compensation is referred to as "biopiracy."

Related Theory

- *The use of disease-causing microorganisms, poisons, or organic biocides, such as Bacillus anthracis or Yersinia pestis, to kill, harm, or immobilise cattle, vegetation, or human life, is known as biowar.*
- *The employment of biological toxins or infectious agents like bacteria, viruses, and fungi with the goal of killing people, animals, or plants is known as biological warfare, germ warfare, or bioweapon. The study of bioethics focuses on moral questions that arise as a result of biological and medical advancements.*

65. (D) In India, GEAC is an apex biotechnology regulatory body which regulates the use, manufacture, storage, export and import of hazardous microorganisms or genetically-engineered organisms and cells. It comes under Ministry of Environment and Forest. RCGM monitors the safety related aspect of on-going research projects or activities involving hazardous microorganisms, GM organisms and cells and products thereof. It comes under Department of Biotechnology. CSIR is a leading scientific and technology research organisation. ICMR is the apex body in India for the formulation, coordination and promotion of biomedical research.

Related Theory

- *GEAC was renamed as Genetic Engineering Appraisal Committee from Genetic Engineering Approval Committee on August 6, 2010.*

66. (C) The functions of Genetic Engineering Approval Committee (GEAC) is to appraise activities involving large scale use of hazardous microorganisms and recombinants in research and industrial production from the environmental angle. It makes decisions regarding the validity of GM (genetically modified) research and the safety of introducing genetically modified organisms for public services.

Related Theory

- *The Institutional Biosafety Committee (IBC) is responsible for reviewing, approving, and monitoring all UNC research projects involving biological materials that may pose differing levels of safety, health, or environmental risk to plants, animals, or humans. The Indian Council of Agricultural Research (ICAR) is responsible for the organisation and management of research and education in the field of Agriculture, Animal Science, and Fisheries in India. Research Committee on Genetic Manipulation (RCGM) monitor the safety of on-going research projects and activities (including small scale field trials, import, export, etc.) involving genetically engineered organisms.*