Biotechnology and its Applications

Chapter 34

FACT/DEFINITION TYPE QUESTIONS

1. 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

2. *Bacillus thuringiensis* (*Bt*) strains have been used for designing novel
(a) bio-fertilizers
(b) bio-metallurgical techniques
(c) bio-mineralization processes
(d) bio-insecticidal plants

3. The genetically-modified (GM) brinjal in India has been developed for
(a) insect-resistance
(b) enhancing shelf life
(c) enhancing mineral content
(d) drought-resistance

4. *Bt* toxin kill the larvae of certain insects
(a) by binding of activated toxin on mid gut epithelial cells, creating pores, leading to swelling and lysis.
(b) by stopping transcription of larval cells.
(c) by altering central dogma taking place in the cells of gut of larva.
(d) by stopping protein synthesis.

5. *Cry* protein is obtained from
(a) *Bacillus thuringiensis*
(b) *Bacillus subtilis*
(c) *Clostridium welchi*
(d) *E. coli*

6. *Cry*-genes have been introduced in
(a) cotton and corn (b) rice
(c) potato and soyabean (d) all of the above

7. *Bt* toxin is harmful to insects like
(a) lepidoterans (tobacco budworm, armyworms)
(b) coleopterans (beetles)
(c) dipterans (flies and mosquito)
(d) all of the above

8. RNA interference (RNAi) technique has been devised to protect the plants from nematode is silenced by _____ produced by the host plant.
(a) dsDNA (b) ssDNA
(c) dsRNA (d) target proteins

9. Tobacco plants resistant to a nematode have been developed by the introduction of DNA that produced (in the host cells)
(a) both sense and anti-sense RNA.
(b) a particular hormone.
(c) an antifeedant.
(d) a toxic protein.

10. C-peptide of human insulin is
(a) a part of mature insulin molecule.
(b) responsible for formation of disulphide bridges.
(c) removed during maturation of pro-insulin to insulin.
(d) responsible for its biological activity.

11. The first human drug made using recombinant DNA technology was
(a) glyphosatase (b) TPA
(c) insulin (d) erythropoietin

12. *E. coli* are used in production of
(a) rifampicin (b) LH
(c) ecdysone (d) interferon

13. The first clinical gene therapy was given in 1990 to a 4 years old girl with enzyme deficiency of
(a) adenosine deaminase (ADA)
(b) tyrosine oxidase
(c) monamine oxidase
(d) glutamate dehydrogenase

14. In some children, ADA deficiency can be cured by
(a) bone marrow transplantation
(b) enzyme replacement therapy
(c) both (a) and (b)
(d) none of the above

15. The site of production of ADA in the body is
(a) bone marrow (b) lymphocytes
(c) blood plasma (d) monocytes

16. Genes of interest can be selected from a genomic library by using
(a) restriction enzymes (b) cloning vectors
(c) DNA probes (d) gene targets

17. DNA or RNA segment tagged with a radioactive molecule is called _____ .
(a) vector (b) probe
(c) clone (d) plasmid

18. The transgenic animals are those which have
(a) foreign DNA in some cells.
(b) foreign DNA in all of their cells.
(c) foreign RNA in all of their cells.
(d) both (a) and (c)

19. Today, transgenic models exist for many human diseases which includes
(i) Cancer (ii) Cystic fibrosis
(iii) Rheumatoid arthritis (iv) Alzhiemer's disease
(a) (i) and (iii) only (b) (ii) and (iii) only
(c) (i), (ii) and (iii) only (d) all of these

20. The protein α-1 antitrypsin is used to treat the
(a) cancer (b) rheumatoid arthritis
(c) Alzheimer's disease (d) emphysema

21. Maximum number of existing transgenic animals is of
(a) fish (b) mice
(c) cow (d) pig

22. GEAC stands for
(a) Genome Engineering Action Committee
(b) Ground Environment Action Committee
(c) Genetic Engineering Approval Committee
(d) Genetic and Environment Approval Committee

23. How many varieties of rice has been estimated to be present in India?
(a) 2,000 (b) 20,000
(c) 200,000 (d) 2,000,000

24. Which variety of rice was patented by a U.S. company even though the highest number of varieties of this rice is found in India ?
(a) Sharbati Sonara (b) Co-667
(c) Basmati (d) Lerma Roja

25. Biopiracy is related to
(a) bioresearches
(b) traditional knowledge
(c) biomolecules and genes discovered
(d) all of the above

26. The use of bioresources by multinational companies and other organizations without proper authorisation from the countries and people concerned without compensatory payment is called
(a) bioethics (b) biopiracy
(c) bioterror (d) bioweapon

27. Which step of Government of India has taken to cater requirement of patent terms and other emergency provisions in this regard ?
(a) Biopiracy act
(b) Indian patents bill
(c) RTI act
(d) Negotiable instruments act

STATEMENT TYPE QUESTIONS

28. Which of the following statement is correct about *Bt* toxin ?
(a) *Bt* protein exists as active toxin in the *Bacillus.*
(b) The activated toxin enters the ovaries of the pest to sterilize it and thus prevent its multiplication.
(c) The concerned *Bacillus* has antitoxins.
(d) The inactive protoxin gets converted into active form in the insect gut.

29. Find out the incorrect statement.
(a) Human protein used to treat emphysema is α-1 antitrypsin.
(b) Human insulin is being commercially produced from a transgenic species of *Agrobacterium tumefaciens.*
(c) Rosie, the first transgenic cow, produced human protein enriched milk.
(d) *Cry* I *Ab* endotoxins obtained from *Bacillus thuringiensis* is effective against corn borers.

30. Which one of the following statement(s) is/are correct about Genetic Engineering Approval committee (GEAC) ?
(a) It will make decision regarding the validity of GM research.
(b) It will make the safety of introducing GM - organism for public services.
(c) Its genetic modification of organism can have unpredictable results when such organisms are introduced into the ecosystem. Therefore, the Indian government has set up organisation such as GEAC.
(d) All of the above

31. Which one of the following statement is correct?
(a) The proteins encoded by the genes *cry* I *Ac* and *cry* II *Ab* control cotton bollworms.
(b) Protein encoded by *cry* I *Ab* controls corn borer.
(c) Both (a) and (b)
(d) Proteins encoded by *cry* I *Ac* and *cry* I *Ab* control flies.

32. Which of the following is a correct statement?
(a) "*Bt*" in *Bt*-cotton indicates that it is genetically modified organism produced through biotechnology.
(b) Somatic hybridization involves fusion of two complete plant cells carrying desired genes.
(c) The anticoagulant hirudin is being produced from transgenic *Brassica napus* seeds.
(d) "*Flavr Savr*" variety of tomato has enriched the production of ethylene which improves its taste.

33. Which of the following statement(s) is/are correct?
(a) The procedure for chemical safety testing / toxicity is the same as that used for testing toxicity of drugs.
(b) Transgenic animals are more sensitive to the toxic substances than non-transgenic animals.
(c) Golden rice, a genetically engineered rice has high vitamin A (retinol) content.
(d) All of the above

34. Which of the following statements is correct?
(a) The current interest in the manipulation of microbes, plants and animal has raised serious ethical issues.
(b) One possible risk of genetic engineering is the accidental production of dangerously resistant microorganisms.
(c) Although risks are possible, genetic engineering appears to offer more of contribution to human welfare than threats.
(d) All of the above

35. Select the correct statement.
(a) Genetic engineering works only on animals and has not yet been successfully used on plants.
(b) There are no risks associated with DNA technology.
(c) The first step in PCR is heat which is used to separate both the strands of target DNA.
(d) DNA from one organism will not bond to DNA from another animal.

36. Which of the following statements (i - v) is/are incorrect ?
(i) Recombinant DNA technology is used to improve crop plants by increasing their productivity, by making them more nutritious and by developing disease resistant.
(ii) *Bt* cotton is resistant to bollworm infestation.
(iii) *Bacillus thuringiensis* can form cry protein during any phase of their growth.
(iv) *Bacillus thuringiensis* is not harmed by self cry protein because of its occurrence as protoxin (inactive).
(v) Protoxin cry protein is changed into active cry protein in the stomach of insects due to alkaline pH in stomach.
(a) Only (iii) (b) (i) and (iv)
(c) All of these (d) None of these

37. Read the following four statements (i-iv) and answer the question ?
(i) The first transgenic buffalo, Rosie produced milk which was human alpha-lactal albumin enriched.
(ii) Restriction enzymes are used in isolation of DNA from other macro-molecules.
(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) (ii) and (iii) (b) (iii) and (iv)
(c) (i) and (iii) (d) (i) and (ii)

38. Read the following statements and choose the correct statements.
(i) Gene therapy has been tested on a large number of patients with a wider variety of inherited genetic disorders, and in numerous cases it has produced a complete cure.
(ii) Genetic engineering has been used to produce insulin for curing the diabetes.
(iii) DNA hybridization is the base pairing of DNA from two different sources.
(iv) Genetic engineering is a technique of plant breeding.
(a) (i) and (ii) (b) (ii) and (iii)
(c) (i), (ii) and (iii) (d) All of these

39. Which of the following statement(s) is/are incorrect?
(i) Insulin was originally extracted from pancreas of slaughtered pigs and cattle.
(ii) Animal insulin is difficult to obtain.
(iii) Animal insulin is identical to human insulin.
(iv) Non-human insulin caused some patients to develop allergy.
(v) Recombinant insulin is actually obtained from *E. coli* in bacterial cell.
(a) Only (i) and (ii) (b) Only (iii) and (iv)
(c) Only (iii) (d) Only (v)

40. Transgenic animals are produced
(i) to study how genes are regulated and how they affect the normal functions of body and its development.
(ii) to study diseases.
(iii) to obtain useful biological products .
(iv) to test vaccine safety and chemical safety.
(a) (i), (ii), (iii) and (iv) (b) (i) and (iv)
(c) (ii) and (iv) (d) Only (i)

41. When a patient with defective ADA was treated, which of the following steps was performed for gene therapy?
(i) Lymphocytes were obtained from the patients.
(ii) Lymphocytes are transferred to culture dishes.
(iii) Lymphocytes were transfected with normal ADA genes.
(iv) The transfected cells are returned to the patients.
(a) All of these (b) (iii) and (iv)
(c) Only (iv) (d) SCID cannot be treated

42. The given statements are the steps in one type of gene therapy.
(i) Inject engineered cells into patients bone marrow.
(ii) Viral DNA carring the normal allele inserts into chromosome.
(iii) Let retrovirus infect bone marrow cells that have removed from patient and cultured.
(iv) Insert RNA version of normal allele into retrovirus.
The correct sequence is
(a) (i), (ii), (iii) and (iv) (b) (iv), (iii), (ii) and (i)
(c) (i), (ii), (iv) and (iii) (d) (iv), (iii), (i) and (ii)

ASSERTION/REASON TYPE QUESTIONS

In the following questions, a statement of Assertion is followed by a statement of Reason.
(a) If both Assertion and Reason are true and the Reason is the correct explanation of the Assertion.
(b) If both Assertion and Reason are true but the Reason is not the correct explanation of the Assertion.
(c) If Assertion is true but Reason is false.
(d) If both Assertion and Reason are false.

43. **Assertion** : Blood clotting is prevented by Hirudin protein.
Reason : The gene encoding for the Hirudin protein is transferred into *Brassica napus*, where accumulation of hirudin occurs in the seeds.

44. **Assertion :** An application of tissue culture is the production of transgenic plants.
Reason : A transgenic organism is one that contains and expresses a transgene.

45. **Assertion :** *Flavr Savr* tomato is transgenic tomato that is capable of remaining fresh and retaining the flavour for a longer time.
Reason : In this, production of pectin degrading Polygalactouronase is blocked.

46. **Assertion :** ELISA is based on the principle of antigen antibody interaction.
Reason : Pathogen infection is usually detected by presence of antigens or detection of antibodies synthesized against the pathogen.

47. **Assertion :** The GEAC (Genetic Engineering Approval Committee) has been set up by the Indian Government.
Reason : Introduction of GMO could have unpredictable result in the ecosystem.

MATCHING TYPE QUESTIONS

48. Match the following and choose the correct combination from the options given below :

	Column - I		**Column - II**
A.	*Escherichia coli*	I.	*nif* gene
B.	*Bacillus thuringiensis*	II.	Interferon
C.	*Rhizobium meliloti*	III.	*Bt* toxin
D.	*Agrobacterium tumefaciens*	IV.	Vector

(a) A – II; B – I; C – (IV); D – III
(b) A – II; B – I; C – (III); D – IV
(c) A – II; B – III; C – I; D – IV
(d) A – IV; B – I; C – II; D – III

49. Match the items given in column - I with those in column - II and choose the correct option.

	Column - I		**Column - II**
A.	GMO	I.	Increased shelf life
B.	Flavr - Savr tomato	II.	Bioresources
C.	Biopiracy	III.	rDNA
D.	*E.coli*	IV.	Insulin

(a) A – III; B – I; C – II; D – IV
(b) A – II; B – I; C – III; D – IV
(c) A – II; B – III; C – I; D – IV
(d) A – IV; B – I; C – II; D – III

50. Match column-I with column-II and identify the correct option.

	Column - I		**Column - II**
A.	Gene therapy	I.	*Rhizobium*
B.	Biofertilizer	II.	*Cry* gene
C.	*Bt* cotton	III.	SCID
D.	Humulin	IV.	Diabetes

(a) A – II; B – I; C – IV; D – III
(b) A – III; B – I; C – II; D – IV
(c) A – II; B – III; C – I; D – IV
(d) A – IV; B – I; C – II; D – III

51. Match column-I with column-II and choose the correct option.

	Column - I		**Column - II**
A.	Golden Rice	I.	*Cry* protein
B.	*Bt* toxin	II.	Rich in vitamin A
C.	RNAi	III.	First trangenic cow
D.	Rosie	IV.	Gene silencing

(a) A – II; B – I; C – IV; D – III
(b) A – II; B – I; C – III; D – IV
(c) A – II; B – III; C – I; D – IV
(d) A – IV; B – I; C – II; D – III

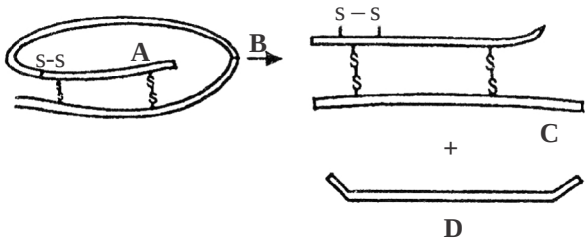
52. Match column-I with column-II and choose the correct option.

	Column - I		**Column - II**
A.	Forensic science	I.	AIDS
B.	ELISA	II.	Radioactive DNA/RNA
C.	Probe	III.	Emphysema
D.	α-1-antitrypsin	IV.	DNA fingerprinting

(a) A – II; B – I; C – IV; D – III
(b) A – II; B – I; C – III; D – IV
(c) A – II; B – III; C – I; D – IV
(d) A – IV; B – I; C – II; D – III

DIAGRAM TYPE QUESTIONS

53. Which of the following is the correct set of the labels A, B, C and D in the given figure of maturation of pro-insulin into insulin ?



	A	**B**	**C**	**D**
(a)	Proinsulin	cell peptidases	Insulin	Free C-Peptide
(b)	Insulin	cell peptidases	Free C-Peptide	Proinsulin
(c)	Insulin	Free C-Peptide	cell peptidases	Proinsulin
(d)	Insulin	Proinsulin	Free C-Peptide	cell peptidases

CRITICAL THINKING TYPE QUESTIONS

54. Transgenic plants are the ones
(a) generated by introducing foreign DNA into a cell and regenerating a plant from that cell.
(b) produced after protoplast fusion in artificial medium.
(c) grown in artificial medium after hybridization in the field.
(d) produced by a somatic embryo in artificial medium.

55. Transgenic animals 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.

56. Silencing of mRNA has been used in producing transgenic plants resistant to
(a) bollworms (b) nematodes
(c) white rusts (d) bacterial blights

57. Which one of the following techniques made it possible to genetically engineer living organism ?
(a) Recombinant DNA techniques
(b) X-ray diffraction
(c) Heavier isotope labelling
(d) Hybridization

58. Which of the following Bt crops is being grown in India by the farmers?
(a) Cotton (b) Brinjal
(c) Soyabean (d) Maize

59. A transgenic food crop which may help in solving the problem of night blindness in developing countries is
(a) golden rice (b) *Bt* soyabean
(c) *flavr - savr* tomato (d) starlink maize

60. Which of these is used as vector in gene therapy for SCID?
(a) Arbovirus (b) Rotavirus
(c) Retrovirus (d) Parvovirus

61. The genetic defect, adenosine deaminase (ADA) deficiency may be cured permanently by
(a) administering adenosine deaminase through injection
(b) bone marrow transplantation
(c) enzyme replacement therapy
(d) introducing isolated gene from marrow cells producing ADA into the cells at early embryonic stages

62. Genetically engineered bacteria have been successfully used in the commercial production of
(a) human insulin (b) testosterone
(c) thyroxine (d) melatonin

63. 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 articles for health safety.

64. Biotechnology deals with industrial scale production of biopharmaceuticals and biological products using genetically modified
(a) microbes only
(b) fungi only
(c) plants and animals only
(d) all of the above

65. *Cry* II *Ab* and *cry* I *AC* produce toxins that control
(a) cotton bollworms and corn borer respectively.
(b) cotton borer and cotton bollworms respectively.
(c) tobacco budworms and nematodes respectively.
(d) nematodes and tobacco budworms respectively.

66. *Bt* toxin is
(a) intracellular lipids.
(b) intracellular crystalline protein.
(c) extracellular crystalline protein.
(d) intracellular polysaccharide.

67. 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 in synthesis of DNA.

68. The RNAi stands for
(a) RNA inactivation (b) RNA initiation
(c) RNA interference (d) RNA interferon

69. What is the disadvantage of using porcine insulin (from pig) in diabetic patients?
(a) It leads hypercalcemia.
(b) It is expensive.
(c) It may cause allergic reactions.
(d) It can lead to mutation in human genome.

70. Which technique would to be completely curative in SCID ?
(a) Gene therapy in adult stage.
(b) Gene therapy in embryonic stage.
(c) Bone marrow transplantation.
(d) Enzyme replacement therapy.

71. In order for gene therapy to be most effective, genes should be inserted in
(a) WBC (b) RBC
(c) stem cells (d) all of these

72. Which of the following is based upon the principle of antigen-antibody interaction?
(a) PCR (b) ELISA
(c) r-DNA technology (d) RNA

73. Deliberate alteration of genome for treatment of disease is called
(a) transformation rescue
(b) imprinting
(c) exon shuffle
(d) gene therapy

Hints & Solutions

Chapter 34 : Biotechnology and its Applications

1. (c) Golden rice is vitamin A rich variety developed by rDNA technology and used in the treatment of vitamin A deficiency.

2. (d) *Bt* cotton, a transgenic crop variety has been introduced in India. The *Bt* cotton variety contains a foreign gene obtained from *Bacillus thuringiensis*. This bacterial gene protects cotton from the ball worm, a major pest of cotton.

3. (a) The genetically modified brinjal in India has been developed for insect resistance. *Bt*-brinjal is a transgenic brinjal that is developed by inserting a crystal gene from the *Bacillus thuringiensis* into the brinjal's genome. This process of insertion is accomplished using *Agrobacterium* mediated recombination.

4. (a) *Bacillus thuringiensis* (or Bt) is a gram-positive, soil-dwelling bacterium and commonly used as a biological pesticide. It also occurs naturally in the gut of caterpillars of various types of moths and butterflies, as well on leaf surfaces, aquatic environments, animal faeces, insect-rich environments, and flour mills and grain-storage facilities. *Bacillus thuringiensis* forms protein crystal (which contains insecticidal protein) during a particular phase of their growth. Bt toxin kills larvae of certain insects by binding the activated toxin on mid gut epithelial cells, creating pores which causes swelling and lysis of the cells leading to the death of the insect larva.

5. (a) Cry protein is a large family of crystalline toxins produced from soil bacterium, *Bacillus thuringiensis*. These proteins are harmless to vertebrates, but they are highly toxic to insects and nematodes. Their value in controlling insects that destroy crops and transmit human diseases is well established. The Cry proteins exist as inactive protoxins and get converted into active toxin when ingested by the insect, as the alkaline pH of gut solubilises the crystals.

6. (d) Cry genes encoding the protein (Bt protein) are isolated from the bacterium and incorporated into several crop plants like cotton, tomato, corn, rice, soyabean, etc. The proteins encoded by the following cry genes control the pest given against them:

- cry I Ac and cry II Ab control cotton bollworms.
- cry I Ab controls corn borer.
- cry III Ab controls Colorado potato beetle.
- cry III Bb controls corn rootworm.

7. (d) Bt toxins is harmful to insects like lepidopteron (tobacco budworm, army worm), coleopterans (beetles) and dipterans (flies and mosquito) because they kill larvae of certain insects by binding the activated toxins on midgut epithelial cells, creating pores which causes swelling and lysis of the cells leading to the death of the insect larva.

8. (c) RNA interference (RNAi) technique has been developed to protect the plants from nematode which is silenced by dsRNA produced by the host plant. It is a biological process in which RNA molecules inhibit gene expression, typically by causing the destruction of specific mRNA molecules.

9. (a) Several nematodes parasitise a wide variety of plants & animals including human beings. A nematode *Meloidogyne incognitia* infects the roots of tobacco plants & causes a great reduction in yield. In RNA interference technique, sense & antisense RNA fuse to form dsRNA that silents the expression of m-RNA of nematode. RNA interference is a novel strategy adopted to prevent infestation of nematode *Meloidogyne incognitia* in roots of tobacco plants.

10. (c) Insulin is made up of 51 amino acids arranged in two polypeptide chains, A having 21 amino acids and B with 30 amino acids that are linked together by disulphide bridges. In mammals, including humans, insulin is synthesized as a pro-hormone (like a pro-enzyme, the pro-hormone also needs to be processed before it becomes a fully mature and functional hormone) which contains an extra stretch called the C peptide. This C peptide is not present in the mature insulin and is removed during maturation into insulin. The main challenge for production of insulin using rDNA techniques was getting the insulin assembled into a mature form.

11. (c) Recombinant DNA technology is the joining together of DNA molecules from two different species that are inserted into a host organism to produce new genetic combinations that are of significance to science, medicine, agriculture, and industry. Insulin

was the first human drug made using recombinant DNA technology. In 1983, Eli lilly, an American company, prepared two DNA sequences coding for chains A and B of human insulin and introduced them into plasmids of *Escherichia coli* to produce insulin. Recombinant insulin is synthesized by inserting the human insulin gene into *E. coli*, or yeast (*Saccharomyces cerevisiae*) which then produces insulin for human use.

12. (d) *E. coli* is used in production of interferon. Interferon is a protein released by animal cells, usually in response to the entry of a virus, which has the property of inhibiting virus replication.

13. (a) Gene therapy is an experimental technique that uses genes to treat or prevent disease. The first clinical gene therapy was given for treating adenosine deaminase deficiency. A four-year old girl became the first gene therapy patient on September 14, 1990 at the NIH Clinical Center. Adenosine deaminase deficiency, also called ADA deficiency or ADA-SCID is an autosomal recessive metabolic disorder that causes immunodeficiency. ADA deficiency is due to a lack of the enzyme adenosine deaminase.

14. (c) Adenosine deaminase deficiency (also called ADA deficiency or ADA-SCID) is an autosomal recessive metabolic disorder that damages the immune system and causes severe combined immunodeficiency (SCID). The main symptoms of ADA deficiency are pneumonia, chronic diarrhoea, and widespread skin rashes. ADA deficiency can be cured by bone marrow transplantation and enzyme replacement therapy.

15. (b) ADA is a genetic (inherited) condition that results in an immune deficiency disorder called severe combined immunodeficiency disease. The main site of production of ADA in the body is lymphocytes [a form of small leucocyte (white blood cell) with a single round nucleus, occurring especially in the lymphatic system and which plays a large role in defending the body against disease].

16. (c) A hybridization probe is a fragment of DNA of variable length which is used in DNA samples to detect the presence of nucleotide sequence (the DNA target) that are complementary to the sequence in the probe. The probe hybridize to single–stranded DNA whose base sequence allow probe target base-pairing due to complementary between the probe and target.

17. (b) DNA or RNA segment tagged with a radioactive molecule is called probe. They are used to detect the presence of complementary sequences in nucleic acid samples. Probes are used for identification and isolation of DNA and RNA.

18. (b) Transgenic animals are those animals which have had a foreign gene intentionally inserted into their genome.

19. (d) Transgenic animals play a number of critical roles in drug discovery and development. Importantly, they enable scientists to study the function of specific genes at the level of the whole organism which has enhanced the study of physiology and disease biology and facilitated the identification of new drug targets. Mice are being used as models, for example, to study obesity, heart disease, diabetes, arthritis, cancer, cystic fibrosa, substance abuse, anxiety, ageing, Alzheimer's disease and Parkinson's disease. They are also used to study different forms of cancer.

20. (d) Emphysema is a condition in which the air sacs of the lungs are damaged and enlarged, causing breathlessness. The protein alpha - 1 antitrypsin is used to treat the emphysema. Alpha - 1 antitrypsin is a protein made by cells in the liver and passes out into the bloodstream and can travel to the lungs. Its main function is to protect the lungs from damage caused by other types of proteins.

21. (b) Animals that have their DNA manipulated to possess and express an extra (foreign) gene are known as transgenic animals. Transgenic mice, rabbits, pigs, sheep, cows and fish have been produced, although over 95 per cent of all existing transgenic animals are mice.

22. (c) The Indian Government has set up organizations such as GEAC (Genetic Engineering Approval Committee), which will make decisions regarding the validity of GM research and the safety of introducing GM organisms for public services.

23. (c) Around 200000 varieties of rice has been estimated to be present in India.

24. (c) Basmati rice was patented by a US company even though the highest number of varieties of this rice is found in India.

25. (d) Biopiracy is the practice of commercially exploiting naturally occurring biochemical or genetic material, especially by obtaining patents that restrict its future use, while failing to pay fair compensation to the community from which it originates. Biopiracy is related to bioresearches, traditional knowledge and biomolecules and genes discovered.

26. (b) Refer to answer 25.

27. (b) The Indian Parliament has recently cleared the second amendment of the Indian Patents Bill, that takes such issues into consideration, including patent terms emergency provisions and research and development initiative.

28. (d) About *Bt* toxin, it is true, that the inactive protoxin gets converted into active form in the insect gut due to the alkaline pH of the gut which solubilises the crystals. There are several advantages in expressing Bt toxins in transgenic *Bt* crops. The level of toxin expression can be very high, thus delivering sufficient

dosage to the pest.

The toxin expression is contained within the plant system and hence only those insects that feed on the crop perish. The toxin expression can be modulated by using tissue-specific promoters and replaces the use of synthetic pesticides in the environment.

29. (b) Insulin chain A and B are produced separately in plasmid of *E. coli*, extracted and combined by creating disulfide bond to make it human insulin (active form) called humulin.

30. (d) All the statements regarding GEAC are correct. The Genetic Engineering Approval Committee (GEAC) permitted certain companies as well as the research institutes for conducting the field trials of 5 GM (genetically modified) crops. The trials for development of genetically modified cotton, maize, castor, wheat and rice were permitted.

31. (c) Statement (a) and (b) are correct. (d) Proteins encoded by cry 1 Ac and cry 1 Ab controls cotton bollworms and cry1Ab controls corn borer.

32. (c) Hirudin extracted from leeches was the first anticoagulant used in humans in 1905. Its gene was chemically synthesized and was transferred into *Brassica napus* where hirudin accumulates in seeds. The hirudin is extracted and purified and used as medicine. Today hirudins are produced as recombinant proteins based on the leech anticoagulant protein sequence. It prevents coagulation by acting as an antithrombin.

33. (d) All the statements are correct.

34. (d) All the statements are correct.

35. (c) Statement (c) is correct. The first step in PCR (polymerase chain reaction) is heat which is used to separate both the strands of target DNA. PCR is a laboratory technique used to make multiple copies of a segment of DNA. PCR is very precise and can be used to amplify, or copy, a specific DNA target from a mixture of DNA molecules.

36. (c) *B thuringiensis* forms protein crystals during a particular phase of their growth.

37. (d) Transgenic Rosie is actually cow. Restriction enzymes cut the DNA at specific sites.

38. (b) Statement (ii) and (iii) are correct.

39. (c) Statement (iii) is incorrect. Insulin is a hormone made by the beta cells in the pancreas. Animal insulin is not identical to human insulin. Animal insulin was extracted from the pancreases of cattle and pigs. The sequence of amino acids (the building blocks that make up the protein) is slightly different in insulins from the different species. Compared to human insulin, porcine (pork) insulin has one different amino acid and bovine (beef) insulin three different amino acids. These very slight differences do not affect the way in which the insulin works inside the human body. Pork insulin is structurally closer to human insulin than is beef insulin. These days, animal insulins are made from highly purified pancreas extracts and are marketed as 'natural' insulins.

40. (a) All the statements regarding transgenic animals are correct.

41. (a) All the given steps are performed for gene therapy in the treatment for defective ADA. Adenosine deaminase deficiency (also called ADA deficiency or ADA-SCID) is an autosomal recessive metabolic disorder that that damages the immune system and causes severe combined immunodeficiency (SCID). ADA deficiency can be cured by bone marrow transplantation and enzyme replacement therapy.

42. (b) Gene therapy is the introduction of normal genes into cells in place of missing or defective ones in order to correct genetic disorders. The correct sequence of the steps in gene therapy is: (iv), (iii), (ii), (i).

43. (b) Hirudin protein prevents blood clotting. The gene that codes for this protein has been synthesized chemically and then transferred to *Brassica napus* for it to accumulate in the seeds.

44. (b) Production of transgenic plants is an application of plant tissue culture in various fields of biology. An organism that contains genes, transferred through genetic organism is a transgenic organism.

45. (a) *Flavr Savr* Tomato remains fresh by blocking the protein degrading enzyme, polygalactouronase.

46. (a) Enzyme Linked Immuno Sorbent Assay is used to detect diseases such as AIDS. Presence of pathogen usually causes secretion of antibodies by the host to act against the pathogen which is detected by ELISA.

47. (a) The GEAC set up by the Government of India makes discussions upon the validity of GM research and assesses the associated safety and risks of introduction of GM organisms for public services.

48. (c) A: *E. coli* is used in production of interferon. Interferon is a protein released by animal cells, usually in response to the entry of a virus, which has the property of inhibiting virus replication.

B: *Bacillus thuringiensis* is a bacterium that produces proteins which are toxic to insects.

C: *Rhizobium meliloti* is a soil bacterium that forms nitrogen-fixing nodules on the roots of certain genera of leguminous plants. The nif genes are genes encoding enzymes involved in the fixation of atmospheric nitrogen into a form of nitrogen available to living organisms. The nif genes are found in both free-living nitrogen-fixing bacteria and in symbiotic bacteria associated with various plants.

D: *Agrobacterium tumefaciens* is a small motile bacterial rod that can reduce nitrates and cause galls on plant stems (called crown gall disease of plants). *Agrobacterium* potentially might be a very useful vector for introducing any desired DNA into plants.

49. (a) A: GMO (genetically modified organism) is any organism whose genetic material has been altered using genetic engineering techniques (recombinant DNA).

B: Flavr - Savr tomato is a genetically-modified tomato which was the first genetically engineered whole food to be granted a licence for human consumption. It has increased shelf life.

C: Bio piracy is related to bioresearches, traditional knowledge and biomolecules and genes discovered.

D: *E coli* are used in the production of insulin. Recombinant insulin is synthesized by inserting the human insulin gene into *E. coli*, or yeast (*Saccharomyces cerevisiae*) which then produces insulin for human use.

50. (b) A: Gene therapy is the first clinical therapy which is given to a 4 year old girl with adenosine deaminase deficiency (caused due to deletion of the gene for adenosine deaminase).

B: Biofertilizer is a substance which contains living microorganisms which, promotes growth by increasing the supply or availability of primary nutrients to the host plant. Bio-fertilizers such as *Rhizobium, Azotobacter, Azospirilium* and blue green algae (BGA) have been in use a long time.

C: Bt cotton is a genetically modified variety of cotton producing an insecticide. Bt cotton was created through the addition of genes encoding toxin crystals in the Cry group of endotoxin. When insects attack and eat the cotton plant the Cry toxins are dissolved due to the high pH level of the insects stomach.

D: Humulin is used for a preparation of insulin produced by genetic engineering and structurally identical to insulin made by the human pancreas. It is used to treat diabetes.

51. (a) A: Golden rice is genetically modified rice that has been engineered to have high levels of beta carotene in it. It is a pre cursor of vitamin A, which gives it a characteristic golden colour.

B: Bt toxin is a pesticidal toxins (e.g., CryAb1) produced by the soil *bacterium Bacillus thuringiensis*, which are lethal to corn earworms, Colorado potato bugs and others.

C: RNAi is a biological process in which RNA molecules inhibit gene expression, typically by causing the destruction of specific mRNA molecules. RNA interference (RNAi) technique has been devised to protect the plants from nematode is silenced by dsRNA produced by the host plant.

D: Rosie is the first transgenic cow (genetically modified cow). Rosie's milk contains the human gene alpha-lactalbumin into their DNA. The extra gene may come from the same species or from a different species.

52. (d) A: Forensic science is the scientific method of gathering and examining information about the past which is then used in a court of law. It is related to DNA fingerprinting.

B: ELISA (Enzyme-linked immunosorbent assay),used in AIDS, is a rapid immunochemical test that involves an enzyme used for measuring a wide variety of tests of body fluids. ELISA tests detect substances that have antigenic properties, primarily proteins rather than small molecules and ions, such as glucose and potassium.

C: Probe is a radioactive DNA/RNA.

D: Alpha 1 antitrypsin is used to treat emphysema (a condition in which the air sacs of the lungs are damaged and enlarged, causing breathlessness). Alpha - 1 antitrypsin is a protein made by cells in the liver and protect the lungs from damage caused by other types of proteins called enzymes.

53. (a) The given figure shows the maturation of pro- insulin into insulin. The parts marked a s A, B, C and D are respectively pro-insulin, cell peptideres, insulin and free C- peptide.

54. (a) Transgenic plants are the ones generated by introducing foreign DNA into a cell and regenerating a plant from that cell.

55. (a) Transgenic animals have been successfully used for producing transgenic mice through genetic engineering. Many transgenic mice are designed to increase our understanding of how genes contribute to development of diseases. Transgenic mice are being developed for use in testing the safety of vaccine before they are used in human beings. For example, transgenic mice are being used to test the safety of polio vaccine.

56. (b) In this technique, nematode specific genes are introduced in the host plant in such a way that it produces both sense and antisense RNA. The two RNA's being complementary to each other formed a double stranded RNA (dsRNA) that initiated RNA interference (RNA i). This (dsRNA) bind to and

prevent translation of specific mRNA of nematode (gene silencing). Thus, transgenic plants based on RNAi technology are resistant to nematode.

57. (a) Recombinant DNA technology is the process of joining together two DNA molecules from two different species that are inserted into a host organism to produce new genetic combination.

58. (a) *Bt* cotton is being grown in India by the farmers. *Bt* cotton is pest resistant plant which decreases the pesticides use. *Bt* toxin is produced by a bacterium *Bacillus thuringiensis* (*Bt* for short). *Bt* toxin gene has been cloned from the bacteria and been expressed in plants to provide resistance to insects without the need for insecticides.

59. (a) A transgenic food crop which may help in solving the problem of night blindness in developing countries is golden rice. Golden rice is genetically modified rice that has been engineered to have elevated levels of beta carotene in it. It is a pre cursor of vitamin A, which gives it a characteristic golden colour.

60. (c) In gene therapy of SCID, WBCs are extracted from bone marrow of patients and a good copy of human gene encoding ADA is introduced via retrovirus as vector.

61. (d) The disorder ADA deficiency is caused due to deletion of the gene for adenosine deaminase. 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. But both these approaches are not completely curative as the patient requires periodic infusion of such genetically engineered lymphocytes or hormonal injections. However, if the gene isolated from marrow cells producing ADA is introduced into cells at early embryonic stages, it could be a permanent cure.

62. (a) Human insulin has 53 amino acids in two polypeptides (A and B) connected by two S -S (disulphide) linkages. In 1983, American company **Eli Lilly** prepared two DNA sequences corresponding to A and B insulin chains. When introduced in plasmids of *E.coli*, insulin chains were formed. They were extracted and fused to produce humulin (human insulin).

63. (d) Main objective of production/use of herbicide resistant GM crops is to reduce herbicide accumulation in food articles for health safety. GM plants have been useful in many ways. Genetic modifications has made crops more tolerant to abiotic stresses, reduced reliance on chemical pesticides and enhanced nutritional value of food.

64. (d) Biotechnology is the exploitation of biological processes for industrial and other purposes, especially the genetic manipulation of microorganisms (like microbes, fungi, plants and animals) for the production of antibiotics, hormones, etc.

65. (a) *Bt* toxin genes were isolated from *Bacillus thuringiensis* and incorporated into several crop plants such as cotton. The choice of genes depends upon the crop and the targeted pest, as most of Bt toxins are insect group specific. The toxin is coded by gene named cry. Two *cry* genes - *cry* I *Ac* and *cry* II *Ab* have been incorporated in cotton. The proteins encoded by genes *cry* II *Ab* and *cry* I *Ac* control cotton bollworms and that of *cry* I *Ab* controls cornborer.

66. (b) Bt toxin (obtained from *Bacillus thuringiensis*) is intracellular crystalline protein which are toxic to insects. It is widely used as a biological pesticide.

67. (c) RNAi is a method of cellular defense in all eukaryotes. It is a system within living cells that helps to control the activity of specific genes. This method involves silencing of mRNA due to complementary double stranded RNA that prevents translation of target gene or mRNA [silencing]. Source of ds RNA is retrovirus (having RNA genome) or transposons (mobile genetic material).

68. (c) RNAi stands for RNA interference. It is a process within living cells that moderates the activity of their genes. It has an important role in defending cells against parasitic nucleotide sequences - viruses and transposons but also in directing development as well as gene expression.

69. (c) Human insulin (humulin) was the first genetically engineered product produced by an American firm **Eli-Lilly** (5th July 1983). Insulin was earlier extracted from pancreas of slaughtered cattle and pigs. Such insulin however caused some patients to develop allergy and other type of reactions to the foreign proteins.

70. (b) Gene therapy is the technique of genetic engineering to replace a faulty gene by a normal healthy functional gene. Gene therapy is being tried for sickle cell anaemia and severe combined immuno-deficiency (SCID).

As a first step towards gene therapy, lymphocytes are extracted from the bone marrow of the patient and are grown in a culture outside the body. A functional ADA cDNA (using a retroviral vector) is then introduced into these lymphocytes, which are reinjected to the patient's bone marrow. But as these cells do not always remain alive, the patient requires periodic infusion of such genetically engineered lymphocytes. However, if the isolated gene from bone marrow cells producing ADA is introduced into cells at early embryonic stages, it can be a permanent cure.

71. (c) In order for gene therapy to be most effective, genes should be inserted in stem cells because stem cells have the ability to self-renew. For each organ in the

mature body, there are specific stem cells that can make all the different kinds of cells in that organ. For example, in the blood system, hematopoietic ("blood-forming") stem cells (HSC) give rise to each of the different types of blood cells such as red blood cells (RBC), white blood cells (WBC) and platelets.

72. (b) The ELISA is a fundamental tool of clinical immunology, and is used as an initial screen for HIV delection. Based on the principle of antigen-antibody interaction, this test allows for easy visualization of results.

73. (d) Gene therapy is a rapidly growing field of medicine in which genes are introduced into the body to provide treatment for a particular disease. Genes control heredity and provide the basic biological code for determining the specific function of a cell. Gene therapy seeks to provide genes that correct the disease-controlling functions of cells that are not doing their job.