Chapter 34. Biotechnology and Its Applications

1. 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-II 2016)

2. The two polypeptides of human insulin are linked together by
(a) covalent bond
(b) disulphide bridges
(c) hydrogen bonds
(d) phosphodiester bond. *(NEET-I 2016)*

3. Which part of the tobacco plant is infected by *Meloidogyne incognita*?
(a) Stem (b) Root
(c) Flower (d) Leaf
(NEET-I 2016)

4. Golden rice is a genetically modified crop plant where the incorporated gene is meant for biosynthesis of
(a) omega 3 (b) vitamin A
(c) vitamin B (d) vitamin C.
(2015)

5. The introduction of T-DNA into plants involves
(a) exposing the plants to cold for a brief period
(b) allowing the plant roots to stand in water
(c) infection of the plant by *Agrobacterium tumefaciens*
(d) altering the pH of the soil, then heat-shocking the plants. *(2015)*

6. In Bt cotton, the Bt toxin present in plant tissue as protoxin is converted into active toxin due to
(a) action of gut microorganisms
(b) presence of conversion factors in insect gut
(c) alkaline pH of the insect gut
(d) acidic pH of the insect gut.
(2015 Cancelled)

7. Which body of the Government of India regulates GM research and safety of introducing GM organisms for public services?
(a) Genetic Engineering Approval Committee
(b) Research Committee on Genetic Manipulation
(c) Bio-safety committee
(d) Indian Council of Agricultural Research
(2015 Cancelled)

8. The crops engineered for glyphosate are resistant/tolerant to
(a) insects (b) herbicides
(c) fungi (d) bacteria.
(2015 Cancelled)

9. The first human hormone produced by recombinant DNA technology is
(a) insulin (b) estrogen
(c) thyroxin (d) progesterone.
(2014)

10. Which of the following Bt crops is being grown in India by the farmers?
(a) Brinjal (b) Soybean
(c) Maize (d) Cotton
(NEET 2013)

11. RNA interference involves
(a) synthesis of cDNA and RNA using reverse transcriptase
(b) silencing of specific *m*RNA due to complementary RNA
(c) interference of RNA in synthesis of DNA
(d) synthesis of *m*RNA from DNA.
(Karnataka NEET 2013)

12. Which one of the following vectors is used to replace the defective gene in gene therapy?
(a) Adenovirus
(b) Cosmid
(c) Ri plasmid
(d) Ti plasmid
(Karnataka NEET 2013)

13. 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 *(2012)*

14. Tobacco plants resistant to a nematode have been developed by the introduction of DNA that produces (in the host cells)
(a) both sense and anti-sense RNA
(b) a particular hormone
(c) an antifeedant
(d) a toxic protein. *(Mains 2012)*

15. What is it that forms the basis of DNA fingerprinting?
(a) The relative proportions of purines and pyrimidines in DNA.
(b) The relative difference in the DNA occurrence in blood, skin and saliva.
(c) The relative amount of DNA in the ridges and grooves of the fingerprints.
(d) Satellite DNA occurring as highly repeated short DNA segments. *(Mains 2012)*

16. The first clinical gene therapy was given for treating
(a) diabetes mellitus
(b) chicken pox
(c) rheumatoid arthritis
(d) adenosine deaminase deficiency. *(Mains 2012)*

17. Maximum number of existing transgenic animals is of
(a) fish (b) mice
(c) cow (d) pig. *(2011)*

18. The process of RNA interference (RNAi) has been used in the development of plants resistant to
(a) nematodes (b) fungi
(c) viruses (d) insects. *(2011)*

19. *Bacillus thuringiensis* forms protein crystals which contain insectidical protein. This 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 pH of the foregut of the insect pest.
(d) does not kill the carrier bacterium which is itself resistant to this toxin. *(Mains 2011)*

20. Silencing of *m*RNA has been used in producing transgenic plants resistant to
(a) bollworms (b) nematodes
(c) white rusts (d) bacterial blights. *(Mains 2011)*

21. Read the following four statements (A-D) about certain mistakes in two of them.
(A) The first transgenic buffalo, Rosie produced milk which was human alpha-lactalbumin enriched.
(B) Restriction enzymes are used in isolation of DNA from other macromolecules.
(C) Downstream processing is one of the steps of rDNA technology.
(D) Disarmed pathogen vectors are also used in transfer of rDNA into the host.
Which of the two statements have mistakes?
(a) B and C (b) C and D
(c) A and C (d) A and B *(Mains 2011)*

22. 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. *(2010)*

23. 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. *(2010)*

24. 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. *(2010)*

25. 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. *(2010)*

26. Which one of the following is now being commercially produced by biotechnological procedures?
(a) Nicotine (b) Morphine
(c) Quinine (d) Insulin
(Mains 2010)

27. What is true about Bt toxin?
(a) Bt protein exists as active toxin in the *Bacillus*.
(b) The activated toxin enters the ovaries of the pest to sterilise 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. *(2009)*

28. 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. *(2009)*

29. The bacterium *Bacillus thuringiensis* is widely used in contemporary biology as
(a) insecticide
(b) agent for production of dairy products
(c) source of industrial enzyme
(d) indicator of water pollution. *(2009)*

30. What is antisense technology?
(a) When a piece of RNA that is complementary in sequence is used to stop expression of a specific gene
(b) RNA polymerase producing DNA
(c) A cell displaying a foreign antigen used for synthesis of antigens
(d) Production of somaclonal variants in tissue cultures *(2009)*

31. *Cry I* endotoxins obtained from *Bacillus thuringiensis* are effective against
(a) nematodes (b) boll worms
(c) mosquitoes (d) flies. *(2008)*

32. A transgenic food crop which may help in solving the problem of night blindness in developing countries is
(a) Bt soybean
(b) Golden rice
(c) Flavr Savr tomatoe
(d) Starlink maize. *(2008)*

33. Main objective of production/use of herbicide resistant GM crops is to
(a) encourage eco-friendly herbicides
(b) reduce herbicide accumulation in food articles for health safety
(c) eliminate weeds from the field without the use of manual labour
(d) eliminate weeds from the field without the use of herbicides. *(2008)*

34. Human insulin is being commercially produced from a transgenic species of
(a) *Rhizobium* (b) *Saccharomyces*
(c) *Escherichia* (d) *Mycobacterium*.
(2008)

35. A genetically engineered micro-organism used successfully in bioremediation of oil spills is a species of
(a) *Trichoderma* (b) *Xanthomonas*
(c) *Bacillus* (d) *Pseudomonas*.
(2007)

36. Golden rice is a promising transgenic crop. When released for cultivation, it will help in
(a) producing a petrol-like fuel from rice
(b) alleviation of vitamin A deficiency
(c) pest resistance
(d) herbicide tolerance. *(2006)*

37. *Bacillus thuringiensis* (Bt) strains have been used for designing novel
(a) biofertilizers
(b) bio-metallurgical techniques
(c) bio-mineralization processes
(d) bioinsecticidal plants. *(2005)*

38. 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. *(2005)*

39. 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. *(2005)*

40. DNA fingerprinting refer to
(a) molecular analysis of profiles of DNA samples
(b) analysis of DNA samples using imprinting devices
(c) techniques used for molecular analysis of different specimens of DNA
(d) techniques used for identification of fingerprints of individuals. *(2004)*

41. The *Ti* plasmid, is often used for making transgenic plants. The plasmid is found in
(a) *Azotobacter*
(b) *Rhizobium* of the roots of leguminous plants
(c) *Agrobacterium*
(d) Yeast as a 2 mm plasmid. *(2004)*

42. ELISA is used to detect viruses where the key reagent is
(a) alkaline phosphatase
(b) catalase
(c) DNA probe
(d) RNase. *(2004, 2003)*

43. The term 'humulin' is used for
(a) hydrolytic enzyme
(b) powerful antibiotic
(c) human insulin
(d) isoenzyme. *(1999)*

44. The first transgenic crop was
(a) tobacco (b) cotton
(c) pea (d) flax. *(1999)*

45. The transgenic animals are those which have
(a) foreign RNA in all its cells
(b) foreign DNA in some of its cells
(c) foreign DNA in all its cells
(d) both (a) and (b). *(1995)*

Answer Key

1.	(a)	**2.**	(b)	**3.**	(b)	**4.**	(b)	**5.**	(c)	**6.**	(c)	**7.**	(a)	**8.**	(b)	**9.**	(a)	**10.**	(d)
11.	(b)	**12.**	(a)	**13.**	(c)	**14.**	(a)	**15.**	(d)	**16.**	(d)	**17.**	(b)	**18.**	(a)	**19.**	(a)	**20.**	(b)
21.	(d)	**22.**	(a)	**23.**	(a)	**24.**	(d)	**25.**	(b)	**26.**	(d)	**27.**	(d)	**28.**	(a)	**29.**	(a)	**30.**	(a)
31.	(b)	**32.**	(b)	**33.**	(c)	**34.**	(c)	**35.**	(d)	**36.**	(b)	**37.**	(d)	**38.**	(d)	**39.**	(d)	**40.**	(a)
41.	(c)	**42.**	(a)	**43.**	(c)	**44.**	(a)	**45.**	(c)										

EXPLANATIONS

1. (a) : Gene therapy is a technique of genetic engineering which involves replacement of a faulty/ disease causing gene by a normal healthy functional gene. The first clinical gene therapy was given in 1990 to a 4-year old girl with adenosine deaminase (ADA) deficiency. This enzyme is very important for the immune system to function. The deficiency of this enzyme can lead to severe combined immune deficiency (SCID).

2. (b) : Human insulin is made up of 51 amino acids arranged in two polypeptide chains. Chain A has 21 amino acids and chain B has 30 amino acids. The two polypeptide chains are interconnected by disulphide bridges or S-S-linkages.

3. (b) : *Meloidogyne incognita* is a nematode which infects the roots of the tobacco plants and causes a great reduction in the yield.

4. (b) : Golden rice is a transgenic variety of rice (*Oryza sativa*) which contains good quantities of □-carotene (provitamin A - inactive state of vitamin A). □-carotene is a principal source of vitamin A. Since the grains of this rice is yellow in colour due to □-carotene and commonly called golden rice.

5. (c) : Ti plasmid (tumor inducing) from the soil bacterium *Agrobacterium tumefaciens* is effectively used as vector for gene transfer to plant cells. The part of Ti plasmid transferred into plant cell DNA, is called the T-DNA. This T-DNA with desired DNA spliced into it is inserted into the chromosomes of the host plant where it produces copies of itself, by migrating from one chromosomal position to another at random. Such plant cells are then cultured, induced to multiply and differentiate to form plantlets. Transferred into soil, the plantlets grow into mature plants, carrying the foreign gene, expressed throughout the new plant.

6. (c) : Soil bacterium *Bacillus thuringiensis* produces proteins that kill certain insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes). *B. thuringiensis* forms some protein crystals. These crystals contain a toxic insecticidal protein. This toxin does not kill the *Bacillus* (bacterium) because it exists as inactive protoxins in them. But, once an insect ingests it, it is converted into an active form of toxin due to the alkaline pH of the alimentary canal. The activated toxin binds to the surface of midgut epithelial cells and create pores that cause swelling and lysis and finally cause death of the insect.

7. (a) : Genetic modification of organisms can have unpredictable results, when such organisms are introduced into the ecosystem. Therefore, the Indian Government has set up organizations such as GEAC (Genetic Engineering Approval Committee), which makes decisions regarding the validity of GM research and the safety of introducing GM-organisms for public services.

8. (b) : Glyphosate is a broad spectrum herbicide which especially kills broad leaved herbs. Crop plants may also get affected by the herbicide, thus now crop plants are genetically engineered for glyphosate resistance. So, when glyphosate herbicide is applied, only weeds and no crop plants get harmed.

9. (a) : The recombinant DNA technological processes have made great impact in the area of health care by mass production of safe and more effective therapeutic drugs. In 1983, Eli Lily, an American company, first prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *Escherichia coli* to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin (humulin).

10. (d) : Bt toxin genes were isolated from *Bacillus thuringiensis* and incorporated into the several crop plants such as cotton. The choice of genes depends upon the crop and targeted pest, as most Bt toxins are insect-group specific. The toxin is coded by a gene named *cry*. These are numerous genes. Two *cry* genes *cry* I Ac and *cry* II Ab have been incorporated in cotton. The genetically modified crop is called Bt cotton as it contains Bt toxin genes against cotton bollworms.

11. (b) : RNA interference (RNAi) is the phenomenon of inhibiting activity of a gene through production of both sense and antisense RNA. RNAi takes place in all eukaryotic organisms as a method of cellular defense. This method involves a specific *m*RNA silencing. It is due to a complementary dsRNA molecule which binds to

and prevents translation of the *m*RNA causing its silencing.

12. (a) : Gene therapy is a corrective therapy that is given to patients of diseases caused by some gene defects. Here, genes are inserted into a person's cells and tissues to treat disease by replacing the defective gene. The normal gene delivered into the individual or embryo takes over the function and compensate for the normal gene. Viral vectors like adenovirus are generally used to deliver the normal gene.

13. (c) : *Refer to answer 4.*

14. (a) : Many nematodes live in plants and animals including human beings. A nematode *Meloidogyne incognita* infests the roots of tobacco plants and causes a great reduction in yield. A novel strategy was adopted to prevent this infection that was based on the process of RNA interference (RNAi). RNA interference (RNAi) is the phenomenon of inhibiting activity of a gene by synthesis of RNA molecules complementary to the *m*RNA. The normal (*in vivo* synthesized) *m*RNA of a gene is said to be "sense" because it carries the codons that are "read" during translation. Normally, the complement to the *m*RNA "sense" strand will not contain a sequence of codons that can be translated to produce a functional protein: thus, this complementary strand is called "anti-sense RNA". The anti-sense RNA and *m*RNA molecules will anneal to form duplex RNA molecules (or double stranded RNA) and the duplex RNA molecules can not be translated. Thus, the presence of anti-sense RNA will block translation of the *m*RNA of the affected gene. In fact, recent evidence indicates that these RNA duplexes are often rapidly degraded *in vivo*.

15. (d) : DNA fingerprinting is a technique of determining nucleotide sequences of certain areas of DNA which are unique to each individual. The difference of about 0.1% or 3×10^6 base pairs (out of 3×10^9 bp) provides individuality to each human being. Human genome possesses numerous small noncoding but inheritable sequences of bases which are repeated many times. These sequences occur near telomere, centromeres, Y chromosome and heterochromatic area. The area with same sequence of bases repeated several times is called repetitive DNA. It is separated as satellite from the bulk DNA during density gradient centrifugation and hence called satellite DNA where, repetition of bases is in tandem. Satellite DNAs show polymorphism (the occurrence of mutations in a population at high frequency), which is the basis of genetic mapping of human genome as well as DNA fingerprinting. While mutations in genes produce alleles with different expressions, mutations in noncoding repetitive DNA have no immediate impact. These mutations which have piled up with time form the basis of polymorphism.

16. (d) : Gene therapy is a collection of methods that allows correction of a gene defect that has been diagnosed in a child/embryo. Here genes are inserted into a person's cells and tissues to treat a disease. Correction of a genetic defect involves delivery of a normal gene into the individual or embryo to take over the function of and compensate for the non-functional gene. The first clinical gene therapy was given in 1990 to a 4 - year old girl with adenosine deaminase (ADA) deficiency. This enzyme is very important for the immune system to function. SCID is caused due to defect in the gene for the enzyme adenosine deaminase. In some children ADA deficiency can be cured by bone marrow transplantation. Here, the isolated gene from bone marrow cells producing ADA is introduced into cells at early embryonic stages; it can be a permanent cure.

17. (b)

18. (a) : *Refer to answer 14.*

19. (a) : *Refer to answer 6.*

20. (b)

21. (d) : In 1997, the first transgenic cow, Rosie, produced human protein enriched milk. The milk contained the human alpha-lactalbumin and was nutritionally a more balanced product for human babies than natural cow-milk. Isolation of DNA from other macromolecule is achieved by treating the bacterial cells/plant or animal tissue with enzymes such as lysozyme (bacteria), cellulase (plant cells), chitinase (fungus).

22. (a) : The genetically modified (GM) Bt brinjal in India has been developed mainly for insect resistance. Through genetic engineering Bt toxin genes were isolated from *Bacillus thuringiensis* and incorporated into the several crop plants such as cotton, brinjal.

23. (a) : Many transgenic animals are designed to increase our understanding of how genes contribute to the development of diseases. These are specially made to serve as models for human

diseases so that investigation of new treatments for diseases is made possible. Today transgenic models exist for many human diseases such as cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's. Transgenic mice are being developed for use in testing the safety of vaccines before they are used on humans. Transgenic mice are being used to test the safety of the polio vaccine.

24. (d) : Bt toxin genes were isolated from *Bacillus thuringiensis* and incorporated into cotton plant. The genetically modified crop is called Bt cotton. Bt cotton has the following useful characteristics: pest resistance, herbicide tolerance, high yield and resistance to bollworm infestation.

25. (b)

26. (d) : Insulin is now being commercially produced by genetic engineering. Insulin consists of two short polypeptide chains: chain A and chain B, that are linked together by disulphide bonds. Insulin, in mammal is synthesised as a prohormone which contains an extra stretch called the C-peptide. During maturation this
C-peptide is removed. The production of insulin could only have been commercially possible if somehow the maturation process of C-peptide been skipped.
This problem was solved in 1988 by Eli Lilly, an American company which prepared functionable insulin from two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E.coli* to produce insulin chains. In this way, chains A and B were produced separately which was extracted, combined by creating disulfide bonds to get human insulin.

27. (d) : *Refer to answer 6.*

28. (a) : The plants produced through genetic engineering contain gene or genes usually from an unrelated organism. Such genes are called transgenes and the plants having transgenes are called transgenic plants. Recombinant DNA techniques are being used to improve crop plants by increasing their productivity, by making them more nutritious, and by developing disease resistance. Transgenic plants have a natural resistance to herbicides and pests. In the future, plants may have an ability to fix atmospheric nitrogen and an increased ability to grow in arid and salty soils.

29. (a) : *Refer to answer 6.*

30. (a) : *Refer to answer 14.*

31. (b) **32. (b)**

33. (c) : 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.

34. (c) : *Refer to answer 26.*

35. (d) : Bioremediation is the process of using living micro-organisms to clean up a contaminated site. Micro-organisms do this by removing toxins from materials. They decompose these compounds by using enzymes, specific proteins that control reactions in living cells. Organisms that produce enzymes capable of degrading petroleum are useful in cleaning up oil spills. Some common ones that break down oil are genetically engineered species of *Pseudomonas* and *Azotobacter.* Bioremediation accounts for 5 to 10 percent of all pollution treatment and has been used successfully in cleaning up leaking underground gasoline storage tanks. Bioremediation has many applications, from the ordinary garden compost to the removal of selenium and other toxic metals from waste. The best agents for bioremediation are the ones that can break down contaminants without becoming contaminated or harmful themselves.

36. (b) : *Refer to answer 4.*

37. (d) : *Bacillus thuringiensis* strains have been used for designing bioinsecticidal plants. A gene from this bacteria have insecticidal property which is transferred to cotton plants to produce Bt cotton which is resistant to bollworm insect which is a major pest of cotton. Similarly insects affecting maize; cabbage, sunflower etc., are also controlled by mutant strains of *Bacillus thuringiensis* bacteria.

38. (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. These 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.

39. (d) : Golden rice is a transgenic crop rice with high vitamin A content. It has been developed by transferring beta carotene synthesizing gene into the transgenic rice. Beta carotene is the precursor of vitamin A. This transgenic rice has been crossed with the already adapted varieties of rice to make them grow well in a particular area. It is very useful for the people suffering from vision impairment due to vitamin A deficiency.

40. (a) : *Refer to answer 15.*

41. (c) : *Refer to answer 5.*

42. (a) : ELISA (enzyme linked immunosorbent assay) screening test is the initial test to diagnose AIDS. The test works by detecting anitibodies/ 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. These enzymes are used to provide antibody-antigen complex in a specialised ELISA plate or tray. In ELISA test for detecting a particular antigen, its antibody is buffered and a drop of serum (supernatant of centrifuged blood) poured over it. If the latter contains antigen, it will produce antigen-antibody complex. A second enzyme labelled antibody is added. It forms enzyme-antigen-antibody complex, if the antigen is present. Substrate is now added. It produces a stain if the antigen is present.

43. (c) : Human insulin (humulin) is the first therapeutic product produced by means of recombinant technology by Eli lilly and Co. on July 5, 1983.

44. (a) : Transgenic plants are those plants in which a foreign gene has been introduced and stably integrated into host DNA. The first transgenic plants were produced in tobacco (*Nicotiana tabacum*). A gene resistant to PPT (L-phosphinothricin), an active ingredient of herbicide 'Basta', was isolated from *Medicago sativa*. It inhibits the enzyme GS (glutamine synthase) which is involved in ammonia assimilation. This gene resistant to PPT was incorporated into tobacco, as a result of which transgenic tobacco was produced which was resistant to PPT.

45. (c) : Transgenic organism is one that has become transformed following the introduction of novel genes into its genome. It is most frequently achieved by integration of cloned DNA sequences following their injection into the fertilized egg. This fertilized egg divides mitotically to form the whole organism so that all the cells of the organism will carry the transferred gene. The transferred genes are known as transgenes. Transgenesis can be done by pronuclear microinjection and somatic cell nuclear transfer or cloning. Transgenic animals produced by this technology include mice, *Drosophila*, *Xenopus* and some of the fish species.