CHAPTER > 12

Biotechnology and its Applications

NEET KEY NOTES

- **Biotechnology** has enabled people to genetically modify microbes, plants and animals and their metabolic machinery in such a way that new strains with novel capabilities can be created. It has enabled the production of biopharmaceuticals and biologics using such organisms at the industrial scale.
- The applications of biotechnology include therapeutics, diagnostics, genetically modified crops, processed food, bioremediation, waste treatment and energy production.
- Biotechnology consists of three critical research areas which are
  - Providing the best catalyst in the form of improved organism usually a microbe or pure enzyme.
  - Creating optimal conditions through engineering for a catalyst to act.
  - Downstream processing technologies to purify the protein or organic compound.

Biotechnological Applications in Agriculture

- Food production can be increased by opting agrochemical based agriculture, organic agriculture and genetically engineered crop-based agriculture.
- The **Green Revolution** succeeded in tripling the food supply by using better management practices and agrochemicals (fertilisers and pesticides). Further increase in yield by using these methods is not feasible. To overcome this, genetically modified crops are being used.

Genetically Modified Organisms (GMOs)

- By employing recombinant DNA techniques, **Genetically Modified Organisms** (GMOs) have been produced by the addition of one or more genes from an unrelated organism.
- The **GM plants** have enhanced crop yield and nutritive value of food (vitamin-A enriched golden rice), reduced post-harvest loss, increased efficiency of mineral usage by plants, reduced reliance on chemical pesticides (pest resistant crops) and have made crops more tolerant of stresses.
- Some of the applications of biotechnology in agriculture are the production of pest resistant plants, which could decrease the amount of pesticide used. *Bacillus thuringiensis* (*Bt*) is the bacteria from which *Bt* toxin gene was extracted and cloned to produce pest and insect resistant plants. Examples are *Bt* cotton, *Bt* corn, *Bt* rice, *Bt* tomato, etc.
- ***Bt* cotton** Some strains of *Bacillus thuringiensis* produce proteins that kill certain insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes).
  - *B. thuringiensis* produces crystals which contain a toxic **insecticidal protein**. This toxin protein is present in the bacterium as an inactive protoxin but as soon as an insect ingests the inactive solubilisation of the protein crystals due to the protoxin it gets converted into an active form of toxin due to alkaline pH of gut. The activated toxin binds to the surface of midgut epithelial cells and creates

pores that cause cell swelling and lysis and eventually lead to the death of the insect.

- The gene from *B. thuringiensis* has been incorporated into several crop plants like cotton, maize, rice, etc. The toxin is coded by the gene named, ***cry***. The protein encoded by the genes *cry* IAc and *cry* IIAb control the cotton bollworms whereas the gene, *cry* I Ab controls corn borer.

- **Pest resistant plants** Several nematodes parasites a wide variety of plants and animals including human beings.
  - A nematode, *Meloidogyne incognita*, infects the roots of tobacco plants and causes reduction in yield. The infestation of these nematodes can be prevented by the use of a nobel strategy called **RNA interference** (RNAi). RNAi takes place in all eukaryotic organisms as a method of cellular defence by silencing of specific *m*RNA due to complementary *ds*RNA molecule that binds to and prevents translation of the *m*RNA.
  - The source of complementary *ds*RNA may be from an infection by viruses having RNA genomes or mobile genetic elements (transposons) that replicate through an RNA intermediate.
  - Nematode specific-genes were introduced into host plant using *Agrobacterium* vectors, where it produced both sense and anti-sense RNA. These two RNAs, being complementary formed a double-stranded RNA that initiated RNAi and thus, silenced the specific *m*RNA of the nematode. The parasite could not survive in a transgenic host expressing specific interferring RNA. The transgenic plant therefore protected itself from the parasite.

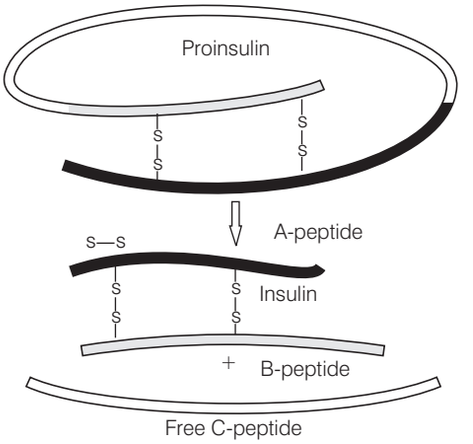
Biotechnological Applications in Medicine

Recombinant DNA technology has also made a major impact in the area of healthcare by enabling the mass production of safe and more effective therapeutic drugs.

At present about 30 recombinant therapeutics have been approved for human use all over the world. In India, 12 out of these, therapeutics are being marketed.

Genetically Engineered Insulin

- Adult-onset diabetes can be controlled by taking insulin at regular intervals. Insulin was earlier extracted from pancreas of slaughtered cattle and pigs (animal source). This insulin caused some patients to develop allergy or other type of reactions to the foreign protein.
- Insulin consists of two short polypeptide chains, i.e. chain A and chain B, that are linked together by disulphide bridges.
- In humans, insulin is synthesised as a pro-hormone, which contains an extra stretch called **C-peptide**, which is absent in mature insulin. The main challenge for the production of insulin using *r*DNA technique was getting insulin assembled into a mature form.



Maturation of pro-insulin into insulin (simplified)

- In 1983, an American company **Eli Lilly**, artificially synthesised human insulin by preparing two DNA sequences corresponding to peptide chains-A and B of human insulin and introduced them in plasmids of *E. coli* to produce insulin chains. These chains were combined by creating disulphide bonds to form human insulin (humulin).

Gene Therapy

- It is a collection of methods which allow correction of gene defects, diagnosed in a child or an embryo. It involves replacing a defective mutant gene with a **functional gene**.
  It works effectively against single gene disorders, enzymatic disorders and immunodeficiency disorders.
- The **first gene therapy** was performed in a 4 year old girl in 1990, who had Adenosine Deaminase (ADA) deficiency. The enzyme, adenosine deaminase is crucial for the immune system to function. In some children, this deficiency can be cured by bone marrow transplantation or enzyme replacement therapy, but both the techniques do not completely cure the disease.
- The first step of this technique involves the extraction of lymphocyte producing stem cells from bone marrow of ADA deficient patient. A retroviral vector is then used to insert a normal functional ADA *c*DNA into these lymphocytes and are later returned to the patient's bone marrow where they multiply to have functional gene that produces enzyme.
- However, these cells are not immortal, the patient requires periodic infusion of such genetically engineered lymphocytes. If the gene isolates from marrow cells producing ADA is introduced into cells at early embryonic stages, it could be a permanent cure.

Molecular Diagnosis

- For effective treatment of a disease, early diagnosis and understanding its pathophysiology is very important. Using conventional methods of diagnosis (serum and urine analysis, etc) early detection is not possible.
- Molecular diagnosis of diseases is carried out using techniques like *r*DNA technology, PCR, ELISA, etc. These techniques help in early detection of the etiologic agent.
- **Polymerase Chain Reaction** (PCR) helps in the detection of very low concentration of bacteria or virus by amplification of their nucleic acid. It is also used to detect HIV in suspected AIDS patients and gene mutations in suspected cancer patients too.
- A single-stranded DNA or RNA, tagged with a radioactive molecule (probe) is allowed to hybridise to its complementary DNA in a clone of cells followed by detection using **autoradiography**. The clone having the mutated gene will hence not appear on the photographic film as the probe will not have complementarity with the mutated gene.
- **ELISA** is based on the principle of antigen-antibody interaction. Infection by pathogen can be detected by the presence of antigens like proteins, glycoproteins, etc., or by detecting the antibodies synthesised against the pathogen.

Transgenic Animals

- These are the animals which have their DNA manipulated to possess and express an extra (foreign) gene. Examples are transgenic rats, rabbits, pigs, sheep, etc. Out of all the existing transgenic animals, 95 per cent are mice.
- Several benefits and uses of transgenic animals are
  - **Normal physiology and development** They are designed to allow the study of gene regulation, their effect on normal functioning of body and its development, e.g. study of complex 13 factors involved in growth such as insulin like growth factor.
  - **Study of diseases** They help to understand how genes contribute to the development of a disease by serving as models for human diseases such as cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's disease. This allows the investigation of new treatments for diseases.
  - **Biological products** Transgenic animals can be created using *r*DNA technology to produce useful biological products. One example is the introduction of human α-1 antitrypsin gene in sheep to produce α-1-antitrypsin to treat emphysema. In 1997, first transgenic cow '**Rosie**' produced milk containing human protein, α-lactalbumin, which was nutritionally more balanced for human babies than natural cow-milk enriched milk (2.4 g/L).
  - **Vaccine and chemical safety testing** These can also be used for vaccine and chemical safety testing before being used on humans. Transgenic animals are made that carry genes which make them more sensitive to toxic substances than non-transgenic animals. These give the results in less time.
  - **Chemical safety testing** This is also known as toxicity/safety testing. Transgenic animals are made which carry genes that make them sensitive to toxic substances. The animals are then exposed to the toxic substances and the effects are studied.

Ethical Issues

- Ethics include rules of conduct by which a community regulates its behaviour and decides whether an activity is lawful or not.
- The genetic modification of organisms can have unpredictable results when such organisms are introduced into the ecosystem.
- The usage of such modified living organisms for public services has also created problems with patents granted for the same.
- In order to control these issues, the Indian government has setup organisations such as **GEAC** (**Genetic Engineering Approval Committee**) to regulate research, testing and commercial release of GM crops, foods and organisms.

Biopatent

- It is a type of license granted for biological resources. It protects invention, processes and products obtained for a period of time from being commercially used by others.
- Ethical standards are required to regulate the mortality of all human activities in relation to the biological world.
- In 1997, an American company got patent rights on Basmati rice through the US Patent and Trademark Office. This allowed the company to sell a new variety of Basmati, in the US and abroad. This new variety of Basmati had actually been derived from Indian farmer's varieties by crossing Indian Basmati with semidwarf varieties and was claimed as an invention or a novelty.
- Several attempts have also been made to patent uses, products and processes based on Indian traditional herbal medicinces, e.g. turmeric and neem.

Biopiracy

- It refers to use of bioresources by multinational companies and other organisations without proper authorisation from the countries or people concerned without any payment.
- The Indian Parliament has recently cleared the second amendment of the **Indian Patents Bill** that takes such issues of biopiracies into consideration including patent terms, emrgency provisions and research and development initiative.

Mastering NCERT

MULTIPLE CHOICE QUESTIONS

TOPIC 1 ~ *Biotechnological Applications in Agriculture*

1 Biotechnology mainly deals with
(a) industrial scale production of biopharmaceutical
(b) biological use of genetically modified microbes, fungi, plants and animals
(c) Both (a) and (b)
(d) None of the above

2 The application of biotechnology includes all except
(a) waste treatment
(b) energy production
(c) genetically modified crops
(d) conventional hybridisation

3 Applications like bioremediation, processed food, therapeutics and diagnostics are related to
(a) biochemistry (b) microbiology
(c) biotechnology (d) medical science

4 Which of the following is/are the critical research area(s) of biotechnology?
(a) Providing best catalyst
(b) Creating optimal conditions for catalyst function
(c) Developing downstreaming processing technique
(d) All of the above

5 Which of the following is for increasing food production?
(a) Agrochemical based agriculture
(b) Organic agriculture
(c) Genetically engineered crop-based agriculture
(d) All of the above

6 Organic agriculture is a technique of raising crops for
(a) increased food production
(b) reduction in required labour
(c) increasing the use of agrochemicals
(d) None of the above

7 Use of genetically modified crops in crop field may
(a) reduce the harmful effects of fertilisers
(b) maximise yield
(c) be environment friendly
(d) All of the above

8 Plants, bacteria, fungi and animals whose genes have been altered by manipulation are called
(a) genetically modified organisms
(b) hybrid organisms
(c) pest resistant organisms
(d) insect resistant organisms

9 Golden rice is a genetically modified crop plant with the incorporated gene is meant for biosynthesis of ***CBSE-AIPMT 2015***
(a) vitamin-B (b) vitamin-C
(c) omega-3 (d) vitamin-A

10 Consumption of which one of the following foods can prevent the kind of blindness associated with vitamin-A deficiency? ***CBSE-AIPMT 2012***
(a) *Flavr Savr* tomato (b) Canolla
(c) Golden rice (d) *Bt* brinjal

11 Which toxin is produced by *Bacillus thuringiensis*?
(a) *Bt* toxin (b) An acid
(c) *t*-toxin (d) None of these

12 The bacterium, *Bacillus thuringiensis* is widely used in contemporary biology as an alternative of
(a) insecticides
(b) agent for the production of dairy products
(c) source of industrial enzyme
(d) indicator of water pollution

13 Which bacterium was the first to be used as biopesticide on the commercial scale in the world?
(a) *Bacillus thuringiensis*
(b) *Escherichia coli*
(c) *Pseudomonas aeruginosa*
(d) *Agrobacterium tumefaciens*

14 GM crops are designed to develop natural resistance from insects and pests. Which of the following crops are modified using *Bacillus thuringiensis*?
(a) Corn and cotton
(b) Tomato and rice
(c) Patato and soybean
(d) All of the above

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

16 Insect resistant transgenic cotton has been produced by inserting a piece of DNA from
(a) an insect
(b) a bacterium
(c) a wild relative of cotton
(d) a virus

17 Some strains of *Bacillus thuringiensis* produce proteins that kill insects like
(a) lepidopterans (b) coleopterans
(c) dipterans (d) All of these

18 *Bt* toxin is
(a) intracellular crystalline protein
(b) extracellular crystalline protein
(c) intracellular monosaccharide
(d) extracellular polysaccharide

19 *Bacillus thuringiensis* forms protein crystals which contain a
(a) toxic insecticidal protein
(b) non-toxic insecticidal protein
(c) simple protein
(d) simple lipids

20 *Bt* toxin protein crystals present in bacterium *Bacillus thuringiensis*, do not kill the bacteria because
(a) bacteria are resistant to the toxin
(b) bacteria enclose toxins in a special sac
(c) toxins occur as inactive protoxins in bacteria
(d) None of the above

21 *Bt* toxin kills insects by
(a) inhibiting protein synthesis
(b) generating excessive heat
(c) creating pores in the midgut epithelial cells, leading to cell swelling and lysis
(d) obstructing a biosynthetic pathway

22 The *Bt* toxin protein
(a) increases the protein content
(b) causes death of the insect ingesting it
(c) stops egg laying of adult
(d) generating excessive heat

23 The choice of genes of *Bacillus thuringiensis* which is to be incorporated into crop depends upon
(a) crop (b) targeted pest
(c) toxin (d) Both (a) and (b)

24 The crops having *cry* genes need
(a) no insecticide
(b) small amount of insecticide
(c) large amount of insecticide
(d) None of the above

25 *cry* IIAb and *cry* IAc produce toxins that control
(a) cotton bollworms and corn borer, respectively
(b) corn borer only
(c) cotton bollworms only
(d) nematodes and tobacco budworms, respectively

26 *Bt* corn has been made resistant to corn borer by the introduction of gene
(a) *cry* IAc (b) *cry* IIAb
(c) *cry* IAb (d) *cry* IIAc

27 *cry* IIAb and *cry* IAb produce toxins that control ***AIIMS 2018***
(a) cotton bollworms and corn borer, respectively
(b) corn borer and cotton bollworms, respectively
(c) tobacco budworms and nematodes, respectively
(d) nematodes and tobacco budworms, respectively

28 Which of the following nematodes infects the root of the tobacco plants which reduces the production of tobacco?
(a) *Wuchereria*
(b) *Ascaris*
(c) *Meloidegyne incognita*
(d) *Enterobius*

29 A novel strategy was adopted to prevent *Meloidogyne incognita* infection in tobacco plants that was based on the process of
(a) DNA interference (b) RNA interference
(c) RNA initiation (d) DNA initiation

30 In which of the following plants, resistance against a nematode was introduced by implying RNAi?
(a) Tomato (b) *Bt* cotton
(c) Tobacco (d) Golden rice

31 RNAi stands for
(a) RNA interference (b) RNA interferon
(c) RNA inactivation (d) RNA initiation

32 RNAi takes place in all eukaryotic organisms as a method of
(a) insect resistant (b) cellular defence
(c) translation (d) None of these

33 Silencing of an unwanted gene could be achieved by the use of
(a) RNAi (b) DNA polymerase
(c) Restriction enzymes (d) None of these

34 'Silencing of *m*RNA molecule' in order to control the production of a harmful protein has been used in the protection of plants from
(a) bettles (b) armyworm
(c) budworm (d) nematodes

35 Transposons are also known as
(a) silenced genes
(b) mobile genetic elements
(c) pleiotropic genes
(d) Both (a) and (b)

36 Tobacco plant resistant to a nematode have been developed by the introduction of DNA, which is produced (in the host cells) as
(a) an antifeedant
(b) both sense and antisense RNAs
(c) a particular hormone
(d) toxic protein

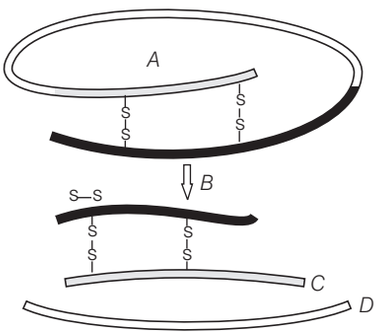
TOPIC 2 ~ *Biotechnological Applications in Medicine*

37 The first human hormone produced by recombinant DNA technology is ***CBSE-AIPMT 2014***
(a) insulin
(b) oestrogen
(c) thyroxin
(d) progesterone

38 What is the demerit of using bovine insulin (from cow) and porcine insulin (from pig) in diabetic patients?
(a) It leads to hypercalcemia
(b) It is expensive
(c) It may cause allergic reactions
(d) It may lead to mutations in human genome

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

40 Select the correct set of the names labelled *A, B, C* and *D* in the given diagram.



(a) A–A-peptide, B–B-peptide, C–Proinsulin, D–Free C-peptide
(b) A–Proinsulin, B–A-peptide, C–B-peptide, D–Free C-peptide
(c) A–Free C-peptide, B–A-peptide, C–B-peptide, D–Proinsulin
(d) A–A-peptide, B–B-peptide, C–Free C-peptide, D–Proinsulin

41 Which polypeptide chain is removed during the maturation of proinsulin into insulin?
(a) A-chain (21 amino acids)
(b) B-chain (30 amino acids)
(c) C-chain (33 amino acids)
(d) A and B-chains

42 Which step was proved to be the main challenge in the production of human insulin by recombinant DNA technology?
(a) Splitting A and B–peptide chain
(b) Addition of C-peptide to proinsulin
(c) Getting insulin assembled into mature form
(d) Removal of C-peptide from active insulin

43 In 1983, which of the following companies prepared human insulin?
(a) Genetech (b) Eli Lilly
(c) GEAC (d) None of these

44 Second generation vaccines are prepared by recombinant DNA technology. Which of the following is/are examples of such vaccines?
(a) Herpes virus vaccine
(b) Hepatitis-B virus vaccine
(c) Solk's polio vaccine
(d) Both (a) and (b)

45 Treatment of a genetic disorder by manipulating genes is called
(a) gene therapy
(b) *r*DNA technology
(c) bone marrow transplantation
(d) enzyme replacement therapy

46 For the first time, gene therapy was tried on a 4 year old girl in 1990 to treat which of the following enzyme deficiency?
(a) Cytosine Deaminase (CDA)
(b) Adenosine Deaminase (ADA)
(c) Tyrosine oxidase
(d) Glutamate trihydrogenase

47 Which kind of therapy was given in 1990 to a 4 year old girl with Adenosine Deaminase (ADA) deficiency? ***NEET 2016***
(a) Gene therapy
(b) Chemotherapy
(c) Immunotherapy
(d) Radiation therapy

48 A patient has a defective gene for the enzyme Adenosine Deaminase (ADA). He/She lacks functional cells and therefore, fails to fight the infecting pathogens. The cells are
(a) B-lymphocytes
(b) Phagocytes
(c) T-lymphocytes
(d) Both (a) and (c)

49 Adenosine Deaminase (ADA) deficiency can be cured by …*A*… and …*B*… but it is not fully curative. Here, *A* and *B* can be
(a) A–gene therapy, B–radiation therapy
(b) A–bone marrow transplantation, B–enzyme replacement therapy
(c) A–organ transplantation, B–hormone replacement therapy
(d) A–radiation therapy, B–enzyme replacement therapy

50 Which of the following is commonly used as a vector for introducing a DNA fragment in human lymphocytes? ***NEET 2018***
(a) λ-phage (b) Ti plasmid (c) Retrovirus (d) pBR322

51 What might be an advantage of beginning gene therapy prior to birth?
(a) This would give the body plenty of time
(b) The body would not reject it as it has not yet recognised 'self'
(c) The cells being extremely young are more receptive of gene therapy
(d) There probably is not any advantage

52 Using conventional method for diagnosis is not very relevent because
(a) not reliable (b) early detection is not possible
(c) results are incorrect (d) All of these

53 Which one of the following molecular diagnostic techniques is used to detect the presence of a pathogen in its early stage of infection?
(a) Angiography
(b) Radiography
(c) Enzyme replacement technique
(d) Polymerase Chain Reaction (PCR)

54 PCR is used to
(a) detect HIV in suspected AIDS patients
(b) detect mutations in the genes of suspected cancer patients
(c) diagnose many genetic disorders
(d) All of the above

55 A single strand of nucleic acid tagged with a radioactive molecule is called
(a) plasmid
(b) vector
(c) probe
(d) selectable marker

56 In which of the following methods, a probe is allowed to hybridise to its complementary DNA in the clone of cells?
(a) Gene therapy
(b) Autoradiography
(c) Polymerase chain reaction
(d) Enzyme-Linked Immuno Sorbent Assay (ELISA)

57 Technique used to detect mutated genes is called
(a) gel electrophoresis
(b) polymerase chain reaction
(c) gene therapy
(d) autoradiography

58 Which of the following techniques is based on the principle of antigen-antibody interaction?
(a) PCR
(b) ELISA
(c) Recombinant DNA technology
(d) Gene therapy

TOPIC 3 ~ *Transgenic Animals*

59 Animals whose DNA is manipulated to possess and express an extra (foreign) gene are known as
(a) transgenic animals
(b) hybrid animals
(c) transversion animals
(d) All of the above

60 Transgenic animals are those which have foreign
(a) DNA in all of their cells
(b) Proteins in all of their cells
(c) RNA in all of their cells
(d) RNA in some of their cells

61 Of all the existing transgenic animals, 95% are
(a) pigs (b) cows
(c) mice (d) rats

62 Transgenic animals can be used to
(a) study normal physiology
(b) study vaccine safety
(c) to produce biological products
(d) All of the above

63 Transgenic animals that serve as model to study many human diseases such as …… .
(a) Alzheimer's disease (b) cancer
(c) night blindness (d) Both (a) and (b)

64 Which of the following transgenic human protein products developed *via r*DNA technology and used to treat emphysema?
(a) α-1 antitrypsin (b) α-1 globulin
(c) Cry IAb protein (d) Cry IIAc protein

65 Which gene was introduced in the first transgenic cow?
(a) Human α-lactalbumin
(b) α-1-antitrypsin
(c) β-1-antitrypsin
(d) *cry* IAc

66 When was the first transgenic cow, Rosie, produced?
(a) 1995 (b) 1997 (c) 1985 (d) 1987

67 The first transgenic cow, Rosie produced
(a) human protein enriched milk (2.4 g/L)
(b) human protein enriched milk (2.8 g/L)
(c) human calcium enriched milk (2.4 g/L)
(d) human calcium enriched milk (2.8 g/L)

68 Which of the following transgenic animals are used in testing safety of polio vaccine before they are used on human?
(a) Transgenic cow
(b) Transgenic monkey
(c) Transgenic mice
(d) Transgenic sheep

69 What is the term used for animals that made to carry genes, which make them more sensitive to the toxic substances than other normal animals?
(a) Transgenic (b) Transversion
(c) Transition (d) Transformant

TOPIC 4 ~ *Ethical Issues*

70 In India, the organisation responsible for assessing the safety of introducing genetically modified organisms for public use is ***NEET 2018, CBSE-AIPMT 2015***
(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 Approval Committee (GEAC)

71 A monopoly granted to a person who has either invented a new and useful article, made improvement in an existing article or invented a new process of making an article is called
(a) bioethics
(b) patent
(c) biopiracy
(d) genetic recombination

72 Biopatent means
(a) right to use an invention
(b) right to use biological resources
(c) right to use applications are processes
(d) All of the above

73 Basmati is unique for its aroma and flavour, whose *A*… documented varieties are cultivated in *B*… . Here, *A* and *B* refer to
(a) A–27, B–America (b) A–30, B–America
(c) A–27, B–India (d) A–30, B–India

74 A new variety of rice was patented by a foreign company, though such varieties have been present in India for a long time. This is related to ***NEET 2018***
(a) Lerma Rojo (b) Sharbati Sonora
(c) Co-667 (d) Basmati

75 Which Indian plants have either been patented or attempts have been made to patent them by Western nations for their use?
(a) Basmati rice (b) Turmeric
(c) Neem (d) All of these

76 Which of the following option is related to bioethics?
(a) Process of discovery and commercialisation of new products
(b) Use of bioresources without proper authorisation
(c) Both (a) and (b)
(d) Standards used to regulate human activities in relation to the biological world

77 Exploitation of bioresources of a nation by multinational companies without authorisation from the concerned country is referred to as ***NEET (Odisha) 2019, NEET 2018***
(a) bioweapon (b) biopiracy
(c) bioethics (d) biowar

78 Biopiracy is related to which of the following?
(a) Traditional knowledge exploitation
(b) Biomolecules and regarding bioresources exploitation
(c) Stealing of bioresources
(d) All of the above

79 Which step has been taken by Indian Parliament to meet and fulfil the requirements of patent terms and other emergency provisions in this regard?
(a) Biopiracy act
(b) Indian Patents Bill
(c) Biowar act
(d) Bioethics act

NEET

SPECIAL TYPES QUESTIONS

I. Assertion and Reason

■ **Direction** (Q. No. 80-88) *In each of the following questions, a statement of Assertion (A) is given followed by corresponding statement of Reason (R).*
Of the statements, mark the correct answer as

(a) If both A and R are true and R is the correct explanation of A
(b) If both A and R are true, but R is not the correct explanation of A
(c) If A is true, but R is false
(d) If A is false, but R is true

80 **Assertion** (A) Many crops are incorporated with foreign genes to make them tolerant to abiotic stresses.
Reason (R) Genomes of many plants are manipulated or altered by combining them with other genes to get desired traits.

81 **Assertion** (A) A crop expressing a *cry* gene is usually resistant to a group of insects.
Reason (R) Cry proteins produced from *Bacillus thuringiensis* are toxic to larvae of certain insects.

82 **Assertion** (A) RNAi is a cellular defence mechanism in eukaryotes.
Reason (R) It is silencing of a specific *t*RNA.

83 **Assertion** (A) *Agrobacterium tumefaciens* is popular in genetic engineering because this bacterium is associated with the stems of all cereal and pulse crops.
Reason (R) Using *Agrobacterium* as vector, the genes can be transferred in biotechnological techniques.

84 **Assertion** (A) Recombinant therapeutics do not induce unwanted immunological responses.
Reason (R) The human body does not recognise them as foreign elements.

85 **Assertion** (A) ADA deficiency disorder is caused due to the excessive synthesis of gene for adenosine deaminase.
Reason (R) It affects the human immune system.

86 **Assertion** (A) The ADA gene provides instruction for producing the enzyme adenosine deaminase.
Reason (R) This enzyme is found throughout the body but is most active in lymphocytes.

87 **Assertion** (A) Transgenic plant production can be achieved *via* recombinant DNA technology.
Reason (R) An organism that contains and expresses a transgene is called transgenic organism.

88 **Assertion** (A) ELISA is based on the principle of antigen-antibody interaction.
Reason (R) It helps in early detection of diseases or pathogens by the amplification of their nucleic acid.

II. Statement Based Questions

89 Which one of the following is not a critical research area of biotechnology?
(a) The imporvement of organism, usually a microbe or a pure enzyme by providing best catalyst
(b) The development of optimal conditions through engineering for a catalyst to act
(c) The downstream processing which includes separation of desired product, purification of products and formulation with preservatives
(d) The improvement of quality of agrochemicals through genetic engineering

90 Which of the following statement(s) is/are true about Green Revolution?
(a) It succeeded in tripling the food supply
(b) Used agrochemicals
(c) Used improved crop varieties
(d) All of the above

91 Choose the correct statement about agrochemicals.
(a) These are expensive for farmers
(b) These have harmful effects on environment
(c) Genetically modified crops are less expensive than agrochemicals
(d) Both (a) and (b)

92 Which statement is true about *Bt* toxin?
(a) *Bt* proteins exist as active toxins in the *Bacillus*
(b) The inactive protoxin gets converted into active form in the insect gut
(c) The *Bacillus* has antitoxins to combat the effects of *Bt* toxin
(d) The activated toxin enters the ovaries of the pest to sterilise it and thus, prevent its multiplication

93 Which of the following is true for Golden rice?
NEET 2019
(a) It is pest resistant, with a gene from *Bacillus thuringiensis*
(b) It is drought tolerant, developed using *Agrobacterium* vector
(c) It has yellow grains, because of a gene introduced from a primitive variety of rice
(d) It is vitamin-A enriched, with a gene from daffodil

94 Which of the following statements is an advantage of recombinant therapeutics?
(a) Recombinant therapeutics are very easy to produce
(b) Production of recombinant therapeutics is a cheap process
(c) Recombinant therapeutics do not induce unwanted immunological response
(d) None of the above

95 Consider the following statements about insulin and select the incorrect.
(a) Human insulin is made up of 51 amino acids arranged in two polypeptide chains
(b) The two polypeptide chains are interconnected by disulphide bridges
(c) In mammals including humans, insulin is synthesised as a prohormone, which contains an extra stretch called the C-peptide
(d) C-peptide is present in the mature insulin

96 Which of the following statements is/are incorrect?
(a) Insulin used for diabetes, was easier extracted from the pancreas of slaughtered pig and cattle
(b) Animal insulin is slightly different from the human insulin
(c) Animal insulin causes some undesirable side effects such as allergy
(d) None of the above

97 Which of the following statements is incorrect for polymerase chain reaction?
(a) PCR can detect pathogen before it produce symptoms
(b) PCR requires amplification of nucleic acid
(c) It detects genetic defects
(d) PCR is useful only when pathogen concentration is very high in the body

98 Which one of the following statements gives the correct explanation for autoradiography?
(a) Clones which have unmutated genes will not appear on the photographic film
(b) Clones which have mutated genes will not appear on the photographic film
(c) The probe used will have only complementary genes with unmutated protein of DNA
(d) All of the above

99 Which of the following statement(s) is/are true?
(a) Biowar is the use of biological weapons against humans and/or their crops and animals
(b) Bioethics is an unauthorised use of bioresources and traditional knowledge related to bioresources for commercial benefits
(c) Biopatent is the exploitation of bioresources of other nations without proper authorisation
(d) All of the above

100 Which of the following statements are not considered as the advantages of biotechnology?
I. Creation of processed fermented food.
II. Production of pest resistant crops.
III. Plants yielding more nutritious and tastier fruits.
IV Production of new types of medicines to fight fatal disease.

Choose the correct option.
(a) Only IV (b) I and III
(c) I, II and III (d) None of these

101 Which of the following ways are suitable for increasing food production?
I. The yield of crops can be increased due to use of improved variety of crops and use of agrochemicals.
II. The use of manure, biofertilisers, biopesticides and biocontrol agents to increase the crop production.
III. The use of genetically modified crops to increase the crop production.

Choose the correct option.
(a) I and II (b) I and III
(c) II and III (d) All of these

102 Genetic modification has
I. reduced reliance on chemical pesticides.
II. reduced post-harvest losses.
III. increased efficiency of minerals usage by the plants.
IV. enhanced nutritional value of the food.

Which of the statements given above are correct?
(a) I, II, III and IV (b) I, II and III
(c) II, III and IV (d) III and IV

103 Consider the following statements.
I. *Bt* toxin gene has been cloned from the bacteria.
II. Genetic engineering works only on animals and has not yet been successfully used on plants.
III. Strains of *Bacillus thuringiensis* are used in producing bioinsecticidal plants.

Which of the above statements are correct?
(a) I and II (b) I and III
(c) II and III (d) I, II and III

104 *Bacillus thuringiensis* forms the protein crystals which contain a toxic insecticidal protein. This protein
I. is activated by alkaline pH of the gut of the insect pest.
II. binds with the epithelial cells of the midgut of the insect pest ultimately killing it.
III. does not kill the carrier bacterium which is itself resistance to this toxin.

Which of the statements given above are correct?
(a) I and II (b) I and III (c) II and III (d) I, II and III

105 Find the correct statements from the following.

AIIMS 2018

I. Gene therapy is a genetic engineering technique used to treat diseases at molecular level.

II. Calcitonin is medically useful recombinant product in the treatment of infertility.

III. *Bt* toxin is a biodegradable insecticide obtained from *Bacillus thuringiensis*.

(a) Only I (b) Only II (c) I and III (d) I and II

106 Which statement is correct about golden rice .

I. It is a transgenic variety of rice.

II. It contains a good quality of β-carotene (provitamin-A).

III. β-carotene is a principal source of vitamin-C.

IV. The grains of the rice are red in colour due to β-carotene.

(a) I and II (b) II, III and IV

(c) I, III and IV (d) I, II, III and IV

107 Read the following statements.

I. *E. coli* is a bioweapon.

II. *Agrobacterium tumefaciens* is used as a vector for introducing nematode specific genes in the tobacco plants.

III. The first ever transgenic cow is Dolly.

IV. α-I antitrypsin is used to treat emphysema.

Choose the correct option.

(a) I and III (b) II and III

(c) I, II and IV (d) I, II, III and IV

108 Consider the following statements about therapeutic drugs.

I. The recombinant DNA technology is used for the production of therapeutic drugs which are safe and effective.

II. It avoids unwanted immunological responses as is common in case of similar products isolated from non-human sources.

III. About 55 recombinant therapeutics have been approved for human use in the world including India.

Which of the above statements are correct?

(a) I and II (b) I and III

(c) II and III (d) I, II and III

109 Consider the following statements.

I. Earlier, insulin was extracted from pancreas of slaughtered cattle and pigs which was more efficient than the genetically engineered insulin.

II. PCR technique is being used for the detection of HIV in suspected AIDS patients and genetic mutations in suspected cancer patients.

III. Cystic fibrosis, haemophilia, cancer, Parkinson's disease, etc., are treated by gene therapy.

Which of the above statements are correct?

(a) I and II (b) I and III

(c) II and III (d) None of these

110 Which of the following statements is/are correct about Adenosine Deaminase (ADA) deficiency?

I. In the absense of adenosine deaminase enzyme, purine metabolism is disturbed and erythrocytes fail to function.

II. ADA deficiency is caused by the deletion of the gene for ADA.

III. ADA patients can be permanently cured by bone marrow transplantation and enzyme replacement therapy.

IV. For permanent cure, the genes isolated from the bone marrow cells producing ADA is introduced into cells at early embryonic stages and replaced with faulty genes.

(a) I, II and III (b) II and IV

(c) I, III and IV (d) None of these

111 Choose the correct statements for molecular diagnosis of diseases.

I. Using conventional methods of diagnosis (serum and urine analysis, etc), early detection is possible.

II. By the time when the pathogen has produced a disease symptom, the concentration of pathogen is already very high in the body.

III. The clone having the mutated gene will not appear on the photographic film.

IV. ELISA is based on the principle of antigen-antibody interaction.

(a) II and IV (b) I and III

(c) I and II (d) II and III

112 Choose the correct statements for the uses of PCR technique in diagnosis.

I. It is used to detect HIV in suspected AIDS patients.

II. It is used to detect mutations in the genes in suspected cancer patients.

III. It is used to detect different common diseases in pigs, sheep and cows.

IV. It is a good technique to identify many other genetic disorders.

(a) I and II (b) III and IV

(c) I, II and IV (d) II, III and IV

113 Choose the correct pair of characteristics of molecular probe is

I. a single-stranded DNA or RNA tagged with a radioactive molecule.

II. a double-stranded DNA tagged with a radioactive molecule.

III. does not show complementarity with the mutated gene.

IV. shows complementarity with mutated gene.

(a) I and II (b) I and III
(c) II and III (d) III and IV

114 Consider the following statements.

I. Transgenic animals are more sensitive to the toxic substance than non-transgenic animals.

II. Useful biological products can be produced by introducing the portion of DNA which codes for a particular product into transgenic animals.

III. Transgenics are designed to allow the study of gene regulation.

IV. Transgenic animals are used to study the normal physiology and development.

Which of the above statements are correct?

(a) I, II, III and IV (b) I and II
(c) I and III (d) None of these

115 Read the following statements.

I. Pigs are the most preferred mammals for studies of gene transfer.

II. A trans gene is a foreign gene incorporation of which in a host cell can make it transgenic.

III. ADA deficiency causes Severely Combined Immuno Deficiency (SCID).

IV. Two insulin polypeptides are cross-linked *via* H-bonds.

Which of the above statements are correct?

(a) Only II (b) II and III
(c) I, II and III (d) Only IV

116 The aims and objectives of Genetic Engineering Approval Committee are

I. to permit the use of genetically modified organisms and their product for commercial applications.

II. to adopt the procedures for restriction, production and application of GM organisms.

III. approval to conduct large scale field trails and release of transgenic crops in the environment.

Which of the above statements are correct?

(a) I and II (b) I and III
(c) II and III (d) I, II and III

117 Go through the following statements.

I. A retrovirus is a DNA virus that can synthesise RNA during infection.

II. Genetically modified food products sometimes cause toxicity and allergic reactions.

III. The protein encoded by *cry*II Ab control corn borer.

IV. Transposons are mobile genetic elements.

Which of the above statements are incorrect?

(a) I and IV (b) II and III
(c) I and III (d) I, II, III and IV

118 Consider the following statements.

I. *Flavr Savr* is a genetically modified tomato, which remains fresh and retains its flavour much longer than the normal tomato due to blocking of synthesis of fruit softening enzyme polygalacturonase.

II. Recently, the US Government has patented the Indian 'basmati' rice as Rice-Tec.

III. Viruses, bacteria and some other harmful organisms can be used as bioweapons in biological wars.

Which of the above statements are correct?

(a) I and II (b) I and III
(c) II and III (d) None of these

III. Matching Type Questions

119 Match the following columns.

	Column I		Column II
A.	Lepidopterans	1.	Tobacco budworm and armyworm
B.	Coleopterans	2.	Beetles
C.	Dipterans	3.	Flies and mosquitoes

Codes

	A	B	C		A	B	C
(a)	1	2	3	(b)	2	3	1
(c)	3	2	1	(d)	1	3	2

120 Match the following columns.

	Column I		Column II
A.	*Bt* tobacco	1.	Vitamin-A
B.	Lepidopterans	2.	High yield and pest resistant
C.	*Bt* cotton	3.	*Meloidogyne incognita*
D.	Golden rice	4.	Tobacco budworm

Codes

	A	B	C	D		A	B	C	D
(a)	3	4	2	1	(b)	1	2	4	3
(c)	4	2	3	1	(d)	3	1	2	4

121 Match the following columns.

	Column I		Column II
A.	Gene therapy	1.	Effort to replace non-functional gene
B.	Humulin	2.	A single-stranded DNA or RNA tagged with a radioactive molecule
C.	Probe	3.	Diagnostic test
D.	ELISA	4.	Diabetes

Codes

	A	B	C	D		A	B	C	D
(a)	1	4	2	3	(b)	4	2	3	1
(c)	2	3	1	4	(d)	3	1	4	2

122 Match the following columns.

	Column I		Column II
A.	Rosie	1.	Emphysema
B.	Biopiracy	2.	Right granted for biological entities
C.	Biopatent	3.	Unauthorised use of biological products and processes
D.	α-1-antitrypsin	4.	Transgenic cow

Codes

	A	B	C	D		A	B	C	D
(a)	4	3	2	1	(b)	3	2	1	4
(c)	2	1	4	3	(d)	4	1	3	2

123 Match the following columns.

	Column I		Column II
A.	Golden rice	1.	Armyworm
B.	*Bt* toxin	2.	Rich in vitamin-A
C.	RNAi	3.	Cry protein
D.	Lepidopterans	4.	Gene silencing

Codes

	A	B	C	D		A	B	C	D
(a)	2	3	4	1	(b)	3	4	1	2
(c)	4	1	2	3	(d)	2	1	3	4

NCERT & NCERT Exemplar

MULTIPLE CHOICE QUESTIONS

NCERT

124 The source of complementary RNA for RNA interference as a means of cellular defence in eukaryotic organism is
(a) an infection by bacteria having RNA genome
(b) an infection by viruses having RNA genome
(c) mobile genetic elements that replicate *via* an RNA intermediate
(d) Both (b) and (c)

125 Crystals of *Bt* toxin produced by some bacteria do not kill the bacteria themselves because
(a) bacteria are resistant to toxin
(b) toxin is immature
(c) toxin is inactive
(d) bacteria enclose toxin in a special sac

NCERT Exemplar

126 Pathophysiology is the
(a) study of physiology of pathogen
(b) study of normal physiology of host
(c) study of altered physiology of host
(d) None of the above

127 α-antitrypsin is
(a) an antacid
(b) an enzyme
(c) used to treat arthritis
(d) used to treat emphysema

128 Choose the correct option regarding retrovirus.
(a) A RNA virus that can synthesise DNA during infection
(b) A DNA virus that can synthesise RNA during infection
(c) A *ss*DNA virus
(d) A *ds*RNA virus

129 Golden rice is
(a) a variety of rice grown along the yellow river in China
(b) long stored rice having yellow colour tint
(c) a transgenic rice having gene for β-carotene
(d) wild variety of rice with yellow coloured grains

130 *Bt* cotton is not
(a) a GM plant
(b) insect resistant
(c) a bacterial gene expressing system
(d) resistant to all pesticides

131 What triggers activation of protoxin to active *Bt* toxin of *Bacillus thuringiensis* in bollworm?
NEET 2019, CBSE-AIPMT 2015, NCERT Exemplar
(a) Moist surface of midgut
(b) Alkaline pH of gut
(c) Acidic pH of stomach
(d) Body temperature

132 A protoxin is
(a) a primitive toxin
(b) a denatured toxin
(c) a toxin produced by protozoans
(d) an inactive toxin

133 In RNAi, genes are silenced using
NEET (Odisha) 2019
(a) *ss*DNA (b) *ds*DNA
(c) *ds*RNA (d) *ss*RNA

134 Silencing of a gene could be achieved through the use of
(a) RNAi only
(b) antisense RNA only
(c) Both (a) and (b)
(d) None of the above

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

136 ADA is an enzyme which is deficient in a genetic disorder SCID. What is the full form of ADA?
(a) Adenosine Deoxyaminase
(b) Adenosine Deaminase
(c) Aspartate Deaminase
(d) Arginine Deaminase

137 The first clinical gene therapy was done for the treatment of
(a) AIDS
(b) cancer
(c) cystic fibrosis
(d) SCID (Severe Combined Immuno Deficiency) resulting from the deficiency of ADA

138 The site of production of ADA in the body is
(a) erythrocytes
(b) lymphocytes
(c) blood plasma
(d) osteocytes

139 A probe which is a molecule used to locate homologous sequences in a mixture of DNA or RNA molecules could be
(a) a single-stranded RNA
(b) a single-stranded DNA
(c) either single-stranded RNA or DNA
(d) can be *ss*DNA but not *ss*RNA

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

Answers

› *Mastering NCERT with MCQs*

1 (c)	**2** (d)	**3** (c)	**4** (d)	**5** (d)	**6** (d)	**7** (d)	**8** (a)	**9** (d)	**10** (c)	**11** (a)	**12** (a)	**13** (a)	**14** (d)	**15** (b)
16 (b)	**17** (d)	**18** (a)	**19** (a)	**20** (c)	**21** (c)	**22** (b)	**23** (d)	**24** (a)	**25** (c)	**26** (c)	**27** (a)	**28** (c)	**29** (b)	**30** (c)
31 (a)	**32** (b)	**33** (a)	**34** (d)	**35** (b)	**36** (b)	**37** (a)	**38** (c)	**39** (c)	**40** (b)	**41** (c)	**42** (c)	**43** (b)	**44** (d)	**45** (a)
46 (b)	**47** (a)	**48** (d)	**49** (b)	**50** (c)	**51** (b)	**52** (b)	**53** (d)	**54** (d)	**55** (c)	**56** (b)	**57** (d)	**58** (b)	**59** (a)	**60** (a)
61 (c)	**62** (d)	**63** (d)	**64** (a)	**65** (a)	**66** (b)	**67** (a)	**68** (c)	**69** (a)	**70** (d)	**71** (b)	**72** (d)	**73** (c)	**74** (d)	**75** (d)
76 (d)	**77** (b)	**78** (d)	**79** (b)											

› *NEET Special Types Questions*

80 (a)	**81** (b)	**82** (c)	**83** (d)	**84** (a)	**85** (d)	**86** (b)	**87** (b)	**88** (c)	**89** (d)	**90** (d)	**91** (d)	**92** (b)	**93** (d)	**94** (c)
95 (d)	**96** (d)	**97** (d)	**98** (b)	**99** (a)	**100** (d)	**101** (d)	**102** (a)	**103** (b)	**104** (a)	**105** (c)	**106** (a)	**107** (c)	**108** (a)	**109** (c)
110 (b)	**111** (a)	**112** (c)	**113** (b)	**114** (a)	**115** (b)	**116** (d)	**117** (c)	**118** (b)	**119** (a)	**120** (a)	**121** (a)	**122** (a)	**123** (a)	

› *NCERT & NCERT Exemplar Questions*

124 (d)	**125** (c)	**126** (c)	**127** (d)	**128** (a)	**129** (c)	**130** (d)	**131** (b)	**132** (d)	**133** (c)	**134** (c)	**135** (c)	**136** (b)	**137** (d)	**138** (b)
139 (c)	**140** (c)													

Answers & Explanations

2 (*d*) The application of biotechnology includes waste treatment, energy production and genetically modified crops for agriculture. It does not include conventional hybridisation technique.

6 (*d*) Organic agriculture is the technique of raising crops, which is aimed at reducing the need for chemical fertilisers and pesticides, which are harmful to both mankind and environment. Food production in organic agriculture is comparatively low as compared to other methods, which include the use of pesticides and herbicides.

8 (*a*) Genes of plants, bacteria, fungi and animals have been altered by genetic manipulations. Therefore, these organisms are called Genetically Modified Organisms (GMOs). These are used in research, medicine, food production, etc.

10 (*c*) Golden rice is a variety of *Oryza sativa* (rice) produced through genetic engineering to biosynthesise beta-carotene, a precursor of vitamin-A in the edible part of rice. Its consumption prevents night blindness which is associated with vitamin-A deficiency.

12 (*a*) *Bacillus thuringiensis* forms protein crystals during a particular phase of their growth. These crystals contain a toxic insecticidal protein called *Bt* toxin. Due to this, it is widely used as an alternative of insecticides.

13 (*a*) *Bacillus thuringiensis*, spores were first used as biopesticides on a commercial scale in the world. *Bt* toxin gene has been cloned from the bacteria and has been expressed in plants to provide resistance to insects without the need of insecticides.

15 (*b*) *Bt* cotton is the first and only transgenic crop approved initially for cultivation by the farmers in India in six states namely, Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Tamil Nadu.

16 (*b*) Insect resistant transgenic cotton has been produced by inserting a piece of DNA from a bacterium *Bacillus thuringiensis* into the genome of cotton.

17 (*d*) *Bacillus thuringiensis* produces proteins that kill insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes), etc.

19 (*a*) *Bacillus thuringiensis* forms protein crystals which contain a toxic insecticidal protein (*Bt* toxin). This protein binds with epithelial cells of midgut of the insect pest and ultimately kill it.

20 (*c*) *Bt* toxin protein crystals present in bacterium, *Bacillus thuringiensis,* do not kill the bacterium itself. This is because the toxin occurs as inactive protoxin in bacterium.

21 (*c*) *Bt* toxins are initially inactive protoxins but after ingestion by the insects, the inactive toxins become active due to the alkaline pH of the gut which solublises the crystals. The activated toxin binds to the surface of the midgut epithelial cells thus, creating pores which cause cell swelling and lysis, eventually leading to death of the insects.

22 (*b*) The *Bt* toxin proteins produced by *Bacillus thuringiensis* if ingested by the insect, becomes active in their gut and binds with epithelial cells, of their midgut creating pores and ultimately death of insects takes place.

24 (*a*) The crops having *cry* genes are *Bt* crops, which need no insecticide. As *Bacillus thuringiensis* is a natural insecticide with biopesticidal properties that make it useful for pest control in certain situations.

27 (*a*) *Bt* toxin genes are isolated from *Bacillus thuringiensis* and incorporated into several crop plants such as cotton. The toxin is coded by a gene named *cry*. The proteins encoded by the gene *cry* IIAb and *cry* I Ac control the cotton bollworms and that of *cry* IAb have corn borers.

30 (*c*) Tobacco plants have been made resistant to nematodes using RNAi, which is a cellular defence mechanism against viruses.

33 (*a*) Silencing of an unwanted gene could be achieved through the use of RNA interference technique. This method induces silencing of a specific *m*RNA due to a complementary *ds*RNA molecule that binds to and prevents the translation of the *m*RNA.

36 (*b*) In RNA interference process, by using *Agrobacterium* vector, nematode specific genes were introduced into the host plants, which produced both sense and antisense RNAs in the host cells.

37 (*a*) The first human hormone produced by recombinant DNA technology is insulin. It is a peptide hormone, which controls the level of glucose in blood.

38 (*c*) Insulin obtained from the pancreas of cattle and pigs, though caused some patients to develop allergy or other types of reactions in response to the foreign protein.

41 (*c*) Insulin contains two short polypeptide chains, chain-A and chain-B, linked by disulphide bridges. In mammals, insulin is synthesised as prohormone (that needs to be processed to become mature and functional hormone). It contains an extra stretch called C-peptide. This C-peptide is absent in mature insulin and as such is removed during the maturation of proinsulin into insulin.

42 (*c*) The main challenge for the production of insulin using *r*DNA technique was getting insulin assembled into a mature form, which does not contain any extra stretch called C-peptide.

43 (*b*) In 1983, Eli Lilly, an American company prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E. coli* to produce insulin chains. The chains-A and B produced were separated, extracted and combined by creating disulphide bonds to form human insulin (humulin).

44 (*d*) The second generation vaccines are produced with the help of genetic engineering techniques. Two examples of such vaccines are hepatitis-B vaccine and herpes virus vaccine.

These are more uniform in quality and produce less side effects as compared to first generation vaccines produced by conventional methods.

45 (*a*) Treatment of a genetic disorder by manipulating genes is called gene therapy. Correction of a genetic drift involves delivery of a normal gene into the individual or embryo to take over the function and compensate for the non-functional gene.

46 (*b*) For the first time in 1990, M Blease and WF Andresco of National Institute of Health, attempted gene therapy on a 4 year old girl with Adenosine Deaminase (ADA) deficiency. ADA deficiency is caused due to the deletion of gene for adenosine deaminase.

48 (*d*) The patient has a defective gene for the enzyme Adenosine Deaminase (ADA). This enzyme is involved in maturation of B and T-lymphocytes and is crucial for the functioning of immune system due to this, he/she lacks functional lymphocytes and therefore, fails to fight the infecting pathogens.

50 (*c*) Usually a retrovirus is used as a vector for introducing a DNA fragment in human lymphocytes. These are used as vector in gene therapy to introduce the desired gene, so as to replace the functioning of the defected gene.

On the other hand,

- λ-phage allows cloning of DNA fragments up to 23 Kb lengths.
- Ti plasmid is usually used for plants.
- pBR322 is an artificial cloning vector, commonly used for bacteria.

53 (*d*) PCR helps in early detection of pathogens by amplification of their nucleic acids. Thus, very low concentration of bacteria or virus can be detected by this technique.

54 (*d*) PCR is now routinely used to detect HIV in suspected AIDS patients. It is also used to detect mutations in the genes of suspected cancer patients too. It is a powerful technique useful to identify many other genetic disorders.

55 (*c*) The molecular probes are usually single-stranded pieces of DNAs (sometimes RNAs) which are labelled with radioisotopes such as ^{32}P.

58 (*b*) ELISA is based on the principle of antigen-antibody interactions. It can detect infections caused by pathogens by detecting the presence of antigens (proteins, glycoproteins etc.) or by antibodies synthesised against the pathogen.

63 (*d*) Transgenic animals are specially made to serve as models for human diseases, so that investigation of new treatment for diseases can be conducted. Currently transgenic models exist for many human diseases such as Alzheimer's, cancer, cystic fibrosis, rheumatoid, arthritis.

65 (*a*) Gene for human, i.e. α-lactalbumin was introduced into the first transgenic cow to produce human protein enriched milk. The milk contained the human α-lactalbumin and was nutritionally a more balanced product for human babies than natural cow milk.

67 (*a*) In 1997, the first transgenic cow, Rosie, produced human protein enriched milk (2.4 g/L). The milk contained the human α-lactalbumin and was nutritionally more balanced for the human babies than normal cow milk.

68 (*c*) Transgenic mice are developed to test the safety of polio vaccine before being used on humans. If successful and found to be reliable these could replace the use of monkeys to test the safety of batches of the vaccine.

69 (*a*) The term transgenic is used for animals who are made to carry the genes, which make them more sensitive to the toxic substances than other normal animals.

70 (*d*) In India, Genetic Engineering Approval Committee, i.e. GEAC is responsible for assessing the safety of introducing genetically modified organisms for public use. GEAC comes under the Ministry of Environment and Forests.

71 (*b*) A monopoly granted to a person who has either invented a new and useful article, made improvement in an existing article or invented a new process of making an article is called patent.

72 (*d*) A biopatent is a government protection granted for biological entities and their products. It gives protection to inventions, processes or products obtained along with the right to the inventor to make and sell or use the product or processes for limited period of time.

Thus, it is the right to use an invention, biological resources, applications and processes of the product.

74 (*d*) In 1997, an American company got patent rights on Basmati rice through the US Patent and Trademark office. This 'new' variety of Basmati had actually been derived from Indian farmer's varieties and was produced by crossing Indian Basmati with semidwarf varieties.

Other options are

- Lerma Rojo and Sharbati Sonora are high yielding varieties of wheat.
- Co-667 is a variety of soybean.

75 (*d*) Patents have been taken out by Western nations on Indian plants such as Basmati rice (*Oryza sativa*), turmeric (*Curcuma longa*) and neem (*Azadirachta indica*), black pepper (*Piper nigrum*), pomegranate (*Punica granatum*), Indian mustard (*Brassica compestris*), etc. US, Japanese and German companies are the principal patenting pirates in these cases.

77 (*b*) Exploitation of bioresources of a nation by multinational companies without authorisation from concerned country is referred to as biopiracy. For example, a patent granted in USA covers the entire basmati rice germplasm of our country.

79 (*b*) To meet and fulfil the requirements of patent terms and other emergency provisions in this regard, the Indian Parliament has prepared and passed the Indian Patents Bill. 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, etc.

80 (*a*) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

The genomes of plants are manipulated or altered by combining them with other genes to get desired traits. GM crops are the crops with incorporated foreign genes that have made more tolerant to abiotic stresses (cold, drought, salt, heat, etc).

81 (*b*) Both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion. The correct explanation is

Bacillus thuringiensis (*Bt*), a soil bacterium produces a Cry protein (crystal protein) as this protein is toxic to the larvae of certain insects. There are several kinds of Cry proteins. Each Cry protein is toxic to a different group of insects. The gene encoding Cry protein, that is *cry* gene, has been isolated and transferred into several crops, making the crops resistant to groups of insects.

82 (*c*) Assertion is true, but Reason is false. Reason can be corrected as

RNAi (RNA interference) takes place in all eukaryotic organisms as a method of cellular defence. This method involves silencing of a specific *m*RNA due to a complementary *ds* RNA molecule that binds to and prevents translation of the *m*RNA (silencing).

83 (*d*) Assertion is false, but Reason is true. Assertion can be corrected as

Agrobacterium tumefaciens is popular in genetic engineering. As it contains a large Ti plasmid (tumour inducing plasmid) and it can transfer a part of its plasmid DNA to the host plant. Therefore, the bacterium can be used as the vector and helps in the transfer of genes in biotechnological techniques.

84 (*a*) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

Since, recombinant therapeutics are identical to human proteins, the human body does not recognise them as foreign elements.

Thus, they do not induce unwanted immunological responses and are free from risk of infection.

85 (*d*) Assertion is false, but Reason is true. Assertion can be corrected as

ADA deficiency disorder is caused due to the lack of gene which codes for adenosine deaminase. This enzyme is crucial for the immune system to function. Thus, ADA deficiency affects the immune system of the human.

86 (*b*) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.

The ADA gene provides instructions for producing the enzyme adenosine deaminase. This enzyme is produced in all cells, but the highest levels of adenosine deaminase occur in the immune system cells called the lymphocytes, which develop in lymphoid tissues. Lymphocytes are a part of the immune system, which defend the body against potentially harmful invaders, such as viruses or bacteria.

87 (*b*) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.

Transgenic plants can be produced using recombinant DNA technology. Genetic modification can be done to induce insect resistance genes, abiotic stress resistance, etc. The organisms (plants, animals, fungi, bacteria) which contain and express transgenes are called transgenic organisms.

88 (*c*) Assertion is true, but Reason is false. Reason can be corrected as

PCR helps in early detection of diseases or pathogens by the amplification of their nucleic acid.

ELISA (Enzyme Linked Immuno Sorbent Assay) is based on the principle of antigen-antibody interaction. Infection by pathogen can be detected by the presence of antigens or by detecting the antibodies synthesised agaisnt the pathogen.

89 (*d*) The statement in option (d) is incorrect. It can be corrected as

The improvement of quality of agrochemicals does not come under the critical research areas of biotechnology.

There are three critical research areas of biotechnology

- Providing best catalyst as improved organism, usually a microbe or pure enzyme.
- Creating optimal conditions by engineering for a catalyst to act.
- Downstream processing technologies to purify the proteins/organic compounds.

91 (*d*) The statements in options (a) and (b) are correct regarding agrochemicals. The statement in option (c) is incorrect and can be corrected as

Genetically modified crops are more expensive than agrochemicals because production of genetically modified crops require highly skilled scientists, expensive machineries, time and many other factors. However, generation of agrochemicals is quite simple process and less expensive than production of GMOs.

92 (*b*) The statement in option (b) is correct for *Bt* toxin. Other statements are incorrect and can be corrected as

- *Bt* toxin protein crystals present in bacterium *Bacillus thuringiensis* do not kill the bacteria themselves because toxins occur as inactive protein in bacteria.
- After ingestion by the insects, the inactive toxins become active due to the alkaline pH of the gut, which solublise the crystals.
- The activated toxin binds to the surface of the midgut epithelial cells thus, creating pores which cause cell swelling and lysis, eventually causing the death of insect.

93 (*d*) The statement in option (d) is true.

Golden rice is genetically engineered variety of rice to biosynthesise β-carotene which is a precursor of vitamin-A. It contains *psy* gene (phytoene synthase) which is derived from daffodil.

Other statements are incorrect for golden rice and can be corrected as

- The grains of golden rice appear yellow due to high level of β-carotene in it.
- Golden rice is neither drought tolerant nor pest resistant.

94 (*c*) The statement in option (c) is the correct advantage of therapeutic recombinants. Rest of the statements are incorrect and can be corrected as

- Recombinant therapeutics are very difficult to produce.
- Production of recombinant therapeutics is an expensive process.

95 (*d*) The statement in option (d) is incorrect about insulin and can be corrected as

C-peptide is not present in mature insulin.

Rest of the statements are correct.

97 (*d*) The statement in option (d) is incorrect and can be corrected as

PCR is useful even when the pathogen concentration is extremely low in the body. It can be detected by amplification of their nuleic acid by PCR.

Rest of the statements are correct.

98 (*b*) The statement in option (b) shows the correct explanation for autoradiography. Rest of the statements are incorrect and can be corrected as

The clone having the mutated genes will not appear on photographic film because probe will not have complimentarity with mutated gene.

99 (*a*) The statement in option (a) is correct. Statements in options (b) and (c) are incorrect and can be corrected as

- Rules of conduct that may be used to regulate all the activities in relation to the biological world constitute bioethics.
- A patent is the right granted by the government to an inventor for biological entities and their products to prevent others to make commercial use of one's invention whereas, the exploitation of bioresources of other nations without proper authorisation is called biopiracy.

103 (*b*) Statements I and III are correct. Statement II is incorrect and can be corrected as

Genetic engineering successfully works on both plants and animals. Infact, it is easier to produce transgenic plants rather than transgenic animals.

104 (*a*) Statements I and II are correct, while statement III is incorrect. It can be corrected as

Bacillus thuringiensis forms the protein crystals, which contain a toxic insecticidal protein. This toxin does not kill the carrier bacterium because the toxin exists as inactive protoxin in it.

105 (*c*) Statements I and III are correct, while statement II is incorrect and can be corrected as

Calcitonin is a thyroid hormone, which regulates the concentration of calcium and phosphorus in the blood. It has no correlation with the treatment of infertility.

106 (*a*) Statements I and II are correct statements about golden rice. Statements III and IV are incorrect and can be corrected as

- It contains 'beta-carotene' gene from daffodil plants and also genes from some bacteria. This gene codes for β-carotene which is a principal source of vitamin-A. Golden rice corrected the night blindness caused due to the deficiency of vitamin-A.
- The rice grains are golden yellow in colour due to the presence of β-carotene.

107 (*c*) Statements I, II and IV are correct, while statement III is incorrect. It can be corrected as

The first ever transgenic cow was Rosie, who produced human protein enriched milk (2. 4 g/L). The milk contained the human alpha-lactalbumin and was nutritionally a more balanced diet for human babies than natural cow milk.

108 (*a*) Statements I and II are correct about therapeutic drugs. Statement III is incorrect and can be corrected as

At present, about 30 recombinant therapeutics have been approved for human use in the world including India.

109 (*c*) Statements II and III are correct, while statement I is incorrect. It can be corrected as

Earlier, insulin was extracted from the pancreas of slaughtered cattle and pigs, but some patients began to develop allergies. The injection of this insulin into patients occasionally produces sensitivity reaction and side effects. Hence, it was less efficient than the genetically engineered insulin.

110 (*b*) Statements II and IV are correct. Statements I and III are incorrect and can be corrected as

- In the absence of adenosine deaminase enzyme, purine metabolism is disturbed and T-lymphocytes fail to function.
- Bone marrow transplantation and enzyme replacement therapy are not permanent cures of ADA deficiency.

111 (*a*) Statements II and IV are correct for molecular diagnosis, whereas statements I and III are incorrect.

These can be corrected as

- Using conventional methods of early diagnosis (serum and urine analysis, etc.) early detection is not possible.
- The clone having the mutated gene will appear on the photographic film because the probe will not have complementarity with the mutated gene.

112 (*c*) Statements I, II and IV show the correct uses of PCR technique in diagnosis. Statement III is incorrect and can be corrected as

PCR is not used to detect different common diseases in pigs, sheep and cows.

113 (*b*) Statements I and III show the correct pair of characteristics of molecular probe.

A single-stranded DNA or RNA tagged with a radioactive molecule (such as ^{32}P) is called a probe. It does not show the complementarity with DNA.

115 (*b*) Statements II and III are correct, while statements I and IV are incorrect and can be corrected as

- Mice are the most preferred mammals for the studies of gene transfer studies as their generation time is short, easy to keep, etc.
- The two insulin polypeptides are cross-linked *via* disulphide bonds.

117 (*c*) Statements I and III are incorrect and can be corrected as

- A retrovirus is RNA virus that can synthesise DNA during infection.
- The protein encoded by *cry* IIAb is used to control cotton bollworms.

Rest of the statements are correct.

118 (*b*) Statements I and III are correct. Statement II is incorrect and can be corrected as

In 1997, an American company Rice Tec got patent rights on Basmati rice through the US patent and Trademark Office.

124 (*d*) The source of the complementary RNA for RNA interference could be from an infection by viruses having RNA genomes or mobile genetic elements (transposons) that replicate *via* an RNA intermediate.

126 (*c*) Pathophysiology is the study of the altered physiology in the body of the host occurs in response to any disease or injury, e.g. if someone ingests a toxin, it may result into a variety of physical changes, such as inflammation in the stomach lining.

127 (*d*) α-antitrypsin is used to treat emphysema, as it inhibits the enzymes of inflammatory cells that contribute to the respiratory complications.

128 (*a*) A retrovirus is a single-stranded RNA virus that can synthesise DNA during infection. In this virus, RNA is reverse transcribed into DNA.

130 (*d*) *Bt* cotton is not resistant to all pesticides infact, it is made resistant to certain taxa of pests only. It is a genetically modified plant whose genes have been altered to make it insect resistant through the introduction of *Bt* toxin gene. *Bt* cotton plants are resistant only to cotton bollworms and corn borer.

131 (*b*) Alkaline pH of the insect gut triggers activation of protoxin to active *Bt* toxin of *Bacillus thuringiensis* in bollworm. The inactive protoxins contain toxic insecticidal protein crystals. When the alkaline pH of insect gut solubilises the crystals, the activated toxin binds to the epithelial cells of the midgut and creates pores. It causes the cell to swell and burst, eventually causing the death of the insect.

133 (*c*) In RNAi, the genes are silenced using *ds*RNA. RNA interference (RNAi) takes place in all eukaryotic organisms as a method of cellular defence. This method involves silencing of a specific *m*RNA due to a complementary *ds*RNA molecule that binds to and prevents translation of the *m*RNA (silencing).

134 (*c*) Gene silencing could be achieved through various routes including RNAi and the use of antisense RNA.

135 (*c*) In mammals, including humans, insulin is synthesised as a prohormone, which needs to be processed before it becomes a fully mature and functional hormone. It contains an extra stretch called C-peptide which is removed during maturation of proinsulin to insulin.

136 (*b*) ADA is an enzyme which is deficient in patients suffering from the genetic disorder, SCID. ADA stands for Adenosine Deaminase. This enzyme is crucial for the immune system to function.

139 (*c*) A probe is a single-stranded RNA or DNA tagged with a radioactive molecule. It is used to detect the complementary sequences by hybridisation technique.

140 (*c*) GEAC stands for Genetic Engineering Approval Committee. The Indian government has setup this organisation to make decisions regarding the validity of GM research and the safety of introducing GM organisms for public services.