

Biotechnology and its Applications

CHAPTER 12

**EXAM
DRILL**

ANSWERS

1. (b)
2. (b) : Nematode specific genes were introduced in tobacco by *Agrobacterium*.
3. (c) : *Blakeslea trispora* has been extensively studied for its ability to produce β -carotene.
4. (c)
5. (c)
6. Measures taken to prevent any risk to plants, animals and microbes from transgenic organisms is known as biosafety.
7. Patients suffering from SCID do not have functional T-lymphocytes thus they cannot provide immune responses against invading pathogens. SCID or severe combined immunodeficiency is caused due to defect in the gene for the enzyme adenosine deaminase. The patients do not have functional T-lymphocytes.
8. Roundup ready is a herbicide resistant transgenic plant group which is tolerant to the herbicide roundup.

OR

Hirudin is a protein that prevents blood clotting. Its gene was chemically synthesised and are transferred into *Brassica napus* where hirudin accumulates in seeds.

9. Some organisations and multinational companies exploit by patenting biological resources of other nations without proper authorisation from the countries concerned, this is called biopiracy.
10. Advantages of producing GMOs :
 - (i) It has made crops tolerant to abiotic stresses like cold, drought, salt, heat, etc.
 - (ii) It enhances nutritional value of food, e.g., vitamin A enriched rice.
11. (d) : *Agrobacterium tumefaciens* causes crown gall disease on a wide range of dicot (broad leaved) plants especially members of rose family by transferring its own DNA into plant cells. But in laboratory, the ability to move all sorts of genes into plants has made the microbe the standard tool for investigating plant genetics and modifying crops.
12. (b) : Genetically modified (GM) plants contain incorporated genes with better quality and efficacy in some traits which make them more useful in those traits or quality. Golden rice is a transgenic variety of rice which contains

good quantities of β -carotene which is a principal source of vitamin A.

13. (d) : The very first transgenic plant was a tobacco plant.

14. (a)

15. (i) (d)

(ii) (d) : Transgenic salmon is produced by fusion of genetically modified sperms with normal ova of the same species. These fishes are large and rapidly growing due to presence of additional gene encoding for growth hormone.

- (iii) (a)

(iv) (a) : ANDI, the first transgenic monkey was born on Oct 2, 2000.

(v) 'E' is transgenic chicken. It is resistance to Avian Leukosis Virus (AIV) which is a serious viral pathogen of chicken. It is produced by introducing a defective genome of this virus into the genome of the chicken.

16. (i) Disulphide bonds

(ii) A chains consists of 21 amino acids and B chain consists of 30 amino acids.

- (iii) Eli Lilly

- (iv) (b)

(v) (c) : Proinsulin has three chains – A, B, and C. Chain C is removed prior to insulin formation.

17. The two methods are :

- (i) It can be cured by bone marrow transplantation
- (ii) It can be treated by enzyme replacement therapy.

OR

The Bt toxin protein exists as inactive protoxins but once the targeted insect ingests the inactive toxin it is converted into an active form of toxin due to the alkaline pH of the alimentary canal that solubilises the crystals. The activated toxin binds to the surface of midgut epithelial cells and create pores which cause cell swelling and lysis and finally cause death of the insect.

18. Insulin is synthesised as prohormone which needs to be processed before it becomes fully mature and functional hormone. The prohormone is a single polypeptide chain with an extra stretch called the C-peptide. This is removed during maturation.

19. The Indian parliament has recently cleared the second ammendment of the Indian Patents Bill, that takes such issues into consideration, including patent terms, emergency provisions and research and development initiatives.

20. (i) Genetically engineered strains of *Bacillus amyloliquefaciens* has been prepared for production of amino acids on a large scale.

(ii) Multiple genes of *Pseudomonas* may sometimes be needed for efficient biodegradation.

21. (i) In 1997, an American company got patent rights on Basmati rice through the US patent and trademark office.

(ii) Disadvantages of producing genetically modified crops are : Crop plants engineered for herbicide tolerance can cross-breed with weeds, resulting in the transfer of the herbicide resistance genes from the crops into the weeds.

They can cause unintended harm to other organisms.

22. (i) *Cry* proteins are poisonous insecticidal proteins which are secreted in crystal form during a specific growth process. The toxin is coded by a gene called *Cry*.

(ii) *Bacillus thuringiensis*

23. (i) First transgenic plant was tobacco.

(ii) Two therapeutically important products obtained through recombinant genetic engineering are :

(a) Insulin

(b) Vaccines.

24. Ti plasmid (tumour inducing) from the soil bacterium *Agrobacterium tumefaciens* is effectively used as vector for gene transfer to plant cells. It induces tumour in broad leaf plants such as tomato, tobacco and soybean. *Agrobacterium* is called natural genetic engineer because genes carried by this plasmid produce effect in several parts of the plant. It induces formation of cancerous growth called crown gall tumour. Hence, for genetic engineering purposes, *Agrobacterium* strains are developed in which tumour forming genes are deleted. 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.

25. Two genes *cryIAc* and *cryIAb* control cotton bollworms. These two genes were isolated from *Bacillus thuringiensis* and incorporated into cotton plant. The genetically modified plant is called Bt cotton as it contains Bt toxin genes. The bacterium *Bacillus thuringiensis* produces Bt toxin proteins as inactive protoxins. When the insect larvae ingest any plant part, toxin becomes active in the alkaline pH of the gut and kills the insect pests. That is how Bt cotton attains resistance against bollworm.

26. Adenosine deaminase (ADA) enzyme is crucial for the immune system to function. Its deficiency is caused due to the deletion of the gene for adenosine deaminase. In some patients, ADA deficiency can be cured by the bone marrow transplantation. It can be treated by enzyme replacement therapy, in which functional ADA is given to the patient by injection.

Two disadvantages of enzyme replacement therapy are :

(i) It is not permanent cure because the patient of ADA

deficiency do not have functional T-lymphocytes, they cannot provide immune responses against invading pathogens.

(ii) It is a costly method.

27. Human insulin is made up of 51 amino acids arranged in two polypeptide chains – chain A and chain B, that are linked together by disulphide bridges. A chain consists of 21 amino acids and B chain consists of 30 amino acids. In mammals, including humans, insulin is synthesised as a pro-hormone (like a proenzyme, the pro-hormones also needs to be processed before it fully matures) which contains an extra stretch called the C-peptide. This C-peptide is not present in the mature insulin and is removed during maturation into insulin. The main challenge for production of insulin using rDNA technique was getting insulin assembled into a mature form.

In 1983, Eli Lilly an American company, first 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. Chains A and B were produced separately, extracted and combined by creating disulphide bonds to form human insulin.

28. (i) Increase in food production can be brought about by three important means–

(a) Agro-chemical based agriculture

(b) Organic agriculture

(c) Genetically engineered crop-based agriculture

(ii) Genetically engineered crop-based agriculture has made way as an alternative path of increasing the yield and reducing the dependence and harmful effects of chemical fertilisers and pesticides. The solution is the use of genetically modified crops. Plants, bacteria, fungi and animals whose genes have been changed by manipulations are called genetically modified organisms (GMOs). Crops in which foreign genes have been introduced through genetic engineering are called genetically modified crops or GM crops.

29. Applications of recombinant DNA technology :

(i) Molecular analysis of diseases : DNA research has helped in understanding the molecular basis of diseases like sickle cell anaemia, thalassaemia, etc.

(ii) Production of proteins in abundance : Several proteins have been produced in abundance for curing diseases.

(iii) Laboratory diagnostic applications : rDNA technology makes the diagnosis of many diseases simple and quick.

(iv) Gene therapy : The genetic diseases like sickle cell anaemia can be cured through gene therapy.

OR

Advantages of producing transgenic animals are:

(i) Transgenic animals are specifically designed to study how genes are regulated and how they affect the normal functions of the body and its development e.g., study of complex factors involved in growth. By introducing genes

from other species that alter the formation of this factor and studying biological effects that results, information is obtained about the biological role of the factor in the body.

(ii) Many transgenic animals are developed to increase our understanding of how genes contribute to the development of disease 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, alzheimer's disease, haemophilia, thalassaemia, etc.

(iii) Medicines required to treat certain human diseases can contain biological products, but such products are often expensive to make. Transgenic animals that produce useful biological products can be created by the introduction of the portion of DNA (or genes) which codes for a particular product.

30. (a) Adenosine deaminase deficiency

(b) As genetically engineered lymphocytes are not immortal, the patient requires periodic infusion of cells.

(c) If the gene isolated from bone marrow cells producing ADA is introduced into cells at early embryonic stage it could be a permanent cure.

31. The recombinant DNA technological processes have made immense impact in the area of healthcare by enabling mass production of safe and more therapeutic drugs. Some of the areas are :

(i) In 1983, Eli Lilly an American company, first 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. Chains A and B were produced separately, extracted and combined by creating disulphide bonds to form human insulin.

(ii) Genetic engineering also enables a technique called gene therapy to replace a faulty gene by a normal healthy functional gene. Correction of genetic defect involves delivery of a normal gene into the individual or embryo to take over the function and compensate for the non-functional gene. The diseases for which scientist are making serious attempts to control through gene therapy are severe combined immunodeficiency (SCID) disease, Duchenne muscular dystrophy and cystic fibrosis.

(iii) It is well known that an early diagnosis and understanding its pathophysiology are very important for the effective treatment of the disease. Using conventional methods of diagnosis (serum and urine analysis, etc.) early detection is not possible. Recombinant DNA technology, polymerase chain reaction (PCR) and enzyme linked immunosorbent assay (ELISA) are some of the techniques that serve the purpose of early diagnosis.

The vaccines produced through genetic engineering methods are called recombinant vaccines or 'second generation vaccines'. They have gene inserts for the surface proteins of a pathogen that elicit immunity but do not result in infection.

These plasmids are inserted in bacteria or yeast cells that express the viral proteins which are then injected into the human host as vaccine. They are recognised as foreign agent and an immune response is elicited. Hepatitis-B vaccine and polio vaccine are the examples of recombinant DNA vaccine.

OR

(i) Green revolution is the third agricultural revolution between 1950 to 1960s, that increased agricultural products worldwide. Green revolution was helpful in tripling food supply to meet the requirement of growing population by better management practices and use of agrochemicals.

(ii) Potential applications of GM plants are :

(a) Development of abiotic stress resistance plants against cold, drought, salt, heat and excess light.

(b) Development of pest and insect resistant crops :

A nematode *Meloidogyne incognita* infects the roots of tobacco plants and causes a great deduction in yield.

Using *Agrobacterium* vectors, nematode-specific genes were introduced into the host plant. The introduction of DNA was such that it produced both sense and anti-sense RNA in the host cells. These RNA's being complementary to each other formed a double stranded (dsRNA) that initiated RNA and thus silenced specific mRNA of the nematode. The consequence was that the parasite could not survive in a transgenic host expressing specific interfering RNA. The transgenic plant therefore got itself protected from the parasite.

Bt cotton : The cotton carrying Bt toxin gene is called Bt cotton. The Bt toxin proteins exist as inactive protoxins but once an insect ingests the inactive toxin it is converted into an active form and kills the insect. Bt-toxins are insect group-specific. The toxin is coded by a gene named *cry*. Two *cry* genes *cry* IAc and *cry* IIAb have been incorporated in cotton. The genes *cry* IAc and *cry* IIAb control cotton bollworms *cry* IAb- has been introduced in Bt corn to protect from corn borer.

(c) Minimise post-harvest losses : 'Flavr Savr', the genetically modified tomato contains a transgene where the expression of a native tomato gene that allows tomatoes to ripen faster has been blocked.

This gene produces enzyme polygalacturonase which promotes softening of the fruit. The production of this enzyme was reduced in the Flavr Savr transgenic tomato. Thus, fruit remains fresh for a longer period than the fruit of normal tomato variety which reduce post harvest loss. It retains flavour, has superior taste and higher quantity of total soluble solids.

32. An example of use of biotechnology to minimise the use of insecticides in agriculture is the production of transgenic Bt cotton. Soil bacterium *Bacillus thuringiensis* produces proteins that kill certain insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes), etc., *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 the crystals, it is converted into an active form of toxin due to the alkaline pH of the alimentary canal. Through genetic engineering Bt toxin genes were isolated from *Bacillus thuringiensis* and incorporated into several crop plants such as cotton. The choice of genes depends upon the crop and targeted pest, as most Bt toxins are insect-group specific. The toxin is coded by a gene named *cry*. Two *cry* genes *cryIAc* and *cryIIAb* have been incorporated in cotton. The genetically modified crop is called Bt cotton as it contains Bt toxin genes against cotton bollworms.

OR

(a) (i) Transgenic animals that produce useful biological products can be created by the introduction of the DNA segment (or gene) which code for a particular product such as human protein (α -1-antitrypsin) used to treat emphysema. Similar attempts are being made for treatment of phenylketonuria (PKU) and cystic fibrosis.

(ii) Transgenic animals are being made that carry genes which make them more sensitive to toxic substances than non-transgenic animals. They are then exposed to the toxic substances and the effects are studied.

(b) Transgenic animals are those animals which contain in their genome, a foreign gene introduced by recombinant DNA technology. Such gene is called transgene. Examples of transgenic animals are transgenic mice and transgenic rabbit, etc.

Rosie is the first transgenic cow which contains human gene coding for protein *alpha*-lactalbumin. The gene is expressed in mammary tissues and the protein is secreted in milk. This milk is nutritionally a more balanced product for human babies than natural cow milk.

33. (i) A patent is the right granted by a government to an inventor to prevent others from commercial use of his invention. When patents are granted for biological entities and for products derived from them, these patents are called biopatents. Primarily, industrialised countries, like U.S.A, Japan and members of European union are awarding biopatents. Biopatents are awarded for strains of microorganisms, cell lines, genetically modified strains of plants and animals, DNA sequences, the proteins encoded by DNA sequences, various biotechnological procedures, product applications, etc.

Biopatent system allows private, monopoly right over cells, genes, animals and plants. It means people will not share vital research information because they are afraid that it will be patented by someone else. The people will not research in areas that are dominated by patents. It will lead to research programmes dominated by patentability and profitability rather than need. It gives the patent holder monopoly control over resources of food medicine. The important advantages of biopatents is that they are a direct incentive for genetic engineering.

(ii) Bioweapons used during the 20th century are :

(a) During world war I, German agents ran an anthrax factory in Washington on the docks in Baltimore. They used the anthrax to infect some 3000 horses and mules destined for the allied forces in Europe. Many of the soldiers on the western front got infected.

(b) In 1940, Nazi prisoners were infected with *Rickettsia* sp. hepatitis A, *Plasmodium* sp. and treated with investigational vaccines and drugs.

(c) During world war II, United States, Britain and other countries developed anthrax weapons. In 1942, the British army began testing anthrax bomb on Geruinard Island. The experiments established the consequences of using anthrax as a weapon of mass destruction.

OR

(i) Advantages of GMOs to a farmer are:

(a) Crops become more tolerant to abiotic stresses like cold, drought, salt and heat.

(b) Dependence on chemical pesticides has reduced, *i.e.* pest-resistant crops.

(c) Helped to reduce post harvest losses.

(d) Efficiency of mineral usage increased in plants, preventing early exhaustion of fertility of soil.

(v) Enhanced nutritional value of food, e.g., vitamin-A enriched rice.

(ii) Biotechnology has influenced our lives in following ways:

(a) It has provided us with genetically modified crops of better quality and high nutrient value.

(b) It has made available better and safer recombinant vaccines.

(c) It has helped to develop transgenic animals that can produce human proteins.

(d) It has enabled gene therapy for curing genetic diseases.

(e) Environment pollution has also been taken care of with the help of genetically engineered microbes.

