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Biotechnology and Its Applications

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Multiple Choice Questions (MCQs)

Q. 1 *Bt* cotton is not

(a) a GM plant
(b) insect resistant
(c) a bacterial gene expressing system
(d) resistant to all pesticides

Ans. ***(d)*** *Bt* cotton is a genetically modified plant whose genes have been altered by the manipulations to make it insect resistant through the introduction of *Bt* toxin gene.

Bt toxin is produced by a bacterium called *Bacillus thuringiensis* (*Bt*). *Bt* toxin gene has been cloned from the bacteria which is expressed in plants to provide resistance to insects.

Some strains of *Bacillus thuringiensis* produce proteins that kills certain insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes).

Bt cotton is made resistant to certain taxa of pests only (as mentioned above). It is quite likely that in future, some other pests may infest these *Bt* cotton plants.

Q. 2 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 pro-insulin to insulin
(d) responsible for its biological activity

Thinking Process

Mature functional insulin is obtained by the processing of pro-hormone, which contains extra peptide called C-peptide.

Ans. ***(c)*** The connecting peptide or C-peptide is a short protein containing 31 amino acids. It connects the A and B chain of proinsulin molecule. After the processing of proinsulin molecule, C-peptide is removed leaving behind A and B chains which bound together by disulphide bonds to constitute a insulin molecule.

Q. 3 GEAC stands for

(a) Genome Engineering Action Committee
(b) Ground Environment Action Committee
(c) Genetic Engineering Approval Committee
(d) Genetic and Environment Approval Committee

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

Q. 4 Antitrypsin is

(a) an antacid
(b) an enzyme
(c) used to treat arthritis
(d) used to treat emphysema

Ans. *(d)* α-antitrypsin is a protease inhibitor that is produced by the introduction of specific sequence of DNA (or genes) which codes for a particular product in the transgenic animals. It is used to treat emphysema as it inhibits the enzymes of inflammatory cells that contributes to the respiratory complications.

Q. 5 A probe which is a molecule used to locate specific sequences in a mixture of DNA or RNA molecules could be

(a) a single stranded RNA
(b) a single stranded DNA
(c) either RNA or DNA
(d) can be *ss*DNA but not *ss*RNA

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

Q. 6 Choose the correct option regarding retrovirus.

(a) a RNA virus that can synthesis DNA during infection
(b) a DNA virus that can synthesis RNA during infection
(c) a *ss*DNA virus
(d) a *ds*RNA virus

Thinking Process

HIV is the most common example of retrovirus.

Ans. *(a)* A retrovirus is a single-stranded RNA virus that stores its nucleic acid in the form of *m*RNA genome (5'cap and 3'poly A tail).

In most viruses, DNA is transcribed into RNA, and then RNA is translated into protein. However, in retroviruses their RNA is reverse-transcribed into DNA, which is integrated into the host cell's genome (when it becomes a provirus) and then undergoes the usual transcription and translational process to express the genes carried by the virus,

i.e., RNA → DNA → RNA → Polypeptide.

Q. 7 The site of production of ADA in the body is

(a) erythrocytes (b) lymphocytes (c) blood plasma (d) osteocytes

Ans. *(b)* ADA gene is responsible for producing the enzyme adenosine deaminase. Which is primarily involved in the development and maintenance of immune system.

It is produced in all cells, but the highest level of adenosine deaminase occurs in the cells of immune system called lymphocytes, which develop in lymphoid tissues. ADA converts deoxyadenosine (toxic to lymphocytes) to deoxyinosine (non-toxic form).

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Q. 8 A protoxin is

(a) a primitive toxin (b) a denatured toxin
(c) toxin produced by Protozoa (d) inactive toxin

Ans. ***(d)*** A protoxin is an inactive toxin. The word 'pro' in protoxin signifies 'inactive form' *B. thuringiensis* forms protein crystal is which contain a toxic insecticidal protein (*Bt* toxin).

Bt toxins are initially inactive protoxins but once ingested by insect, the inactive toxin, gets converted into an active form due to the alkaline pH of the gut which solubilises the crystals.

Q. 9 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 these

Ans. ***(c)*** Pathophysiology is the study of functional changes in the body of the host that occur 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.

Q. 10 The trigger for activation of toxin of *Bacillus thuringiensis* is

(a) acidic pH of stomach
(b) high temperature
(c) alkaline pH of gut
(d) mechanical action in the insect gut

Ans. ***(c)*** *Bt* toxins are initially inactive protoxins but after ingestion by the insect these inactive toxin becomes active due to the alkaline pH of the gut which solublise the crystals.

Hence, high pH value is required to make *Bt* toxins active. Under high temperature and acidic pH, *Bt* toxins remain insoluble and inactive.

Q. 11 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

Ans. ***(c)*** Golden rice is a genetically modified crop with enhanced nutritional value. It is rich in vitamin-A, β-carotene and was developed at Swiss Federal Institute of Technology.

It contains 'β carotene' gene from daffodil plant and also genes from some bacteria. Golden rice prevents child blindness which is caused due to the deficiency of vitamin-A.

Q. 12 In RNAi, genes are silenced using

(a) *ss* DNA (b) *ds* DNA (c) *ds* RNA (d) *ss* RNA

Thinking Process

RNA interference (RNAi) process is used to produce pest resistant plants.

Ans. ***(c)*** A nematode *Meloidegyne incognitia* infects the roots of tobacco plants which reduces the production of tobacco. It can be prevented by using RNA interference process, which is checked by silencing of specific *m*RNA due to a complementary *ds*RNA. *ds*RNA binds and prevents the translation of *m*RNA (silencing).

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Q. 13 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

Ans. *(d)* The first clinical gene therapy was done for the treatment of SCID (Severe Combined Immuno Deficiency) resulting from the deficiency of ADA.

The SCID patient has a defective gene for the enzyme Adenosine Deaminase (ADA). due to which he/she lacks functional T-lymphocytes and therefore, fails to fight the infecting pathogen.

Q. 14 ADA is an enzyme which is deficient in a genetic disorder SCID. What is the full form of ADA?

(a) Adenosine Deoxy Aminase (b) Adenosine Deaminase

(c) Aspartate Deaminase (d) Arginine Deaminase

Ans. *(b)* ADA is an enzyme which is deficient in a genetic disorder SCID. ADA stands for adenosine deaminase. This enzyme is crucial for the immune system to function.

Q. 15 Silencing of a gene could be achieved through the use of

(a) short interfering RNA (RNAi) only (b) antisense RNA only

(c) Both RNAi and antisense RNA (d) None of these

Thinking Process

Gene silencing is a molecular process involved in the down regulation of specific genes and is used as a genetic defense system against viruses and other, organisms

Ans. *(c)* Gene silencing could be achieved through various routes including the use of RNAi, antisense RNA, ribozymes, etc. All these mechanisms interrupts or suppresses the expression of genes at transcriptional or translational level.

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Very Short Answer Type Questions

Q. 1 In view of the current food crisis, it is said, that we need another green revolution. Highlight the major limitations of the earlier green revolution.

Ans. *Major limitations of the earlier green revolution are as follows*

(i) Generally undesired characters also breed along with desired ones.

(ii) Regular use of fertilisers affected both soil fertility and quality.

(iii) Extensive use of pesticides/insecticides/weedicides resulted in harmful effects on the natural components of the ecosystem.

So, another green revolution that can curb these problems and enhance the quality food production in limited land resources is certainly required.

Q. 2 Expand GMO. How is it different from a hybrid?

Ans. GMO stands for Genetically Modified Organism that contains one or more genes from an entirely different species and is genetically altered during molecular genetics such as gene cloning, protein engineering etc.

On the other hand, hybrids contains the recombinant genome of different alleles present in the population of the same species,

Q. 3 Differentiate between diagnostics and therapeutics. Give one example and for each category.

Ans. A diagnostic technique helps us to identify a disease. *e.g.,* ELISA for HIV. A therapeutic agent on the other hand helps in the treatment of a disease. *e.g.,* antibiotics for bacterial infections.

Q. 4 Give the full form of ELISA. Which disease can be detected using it? Discuss the principle underlying the test.

Ans. **ELISA** stands for Enzyme Linked Immuno Sorbent Assay. It is used for the detection of (HIV) AIDS disease.

ELISA is based on the principle of antigen-antibody interaction. Infection by pathogen can be detected by the presence of antigens (proteins, glycoprotieins, etc.) or by detecting the antibodies synthesised by the host against the pathogen.

Q. 5 Can a disease be detected before its symtoms appear? Explain the principle involved.

Ans. When the symptoms of the disease are not yet visible,the pathogen concentration is very low so, the detection by conventional diagnostic tests is very difficult.

However, detection of a disease before the appearance of symptoms is possible by the amplification of victim's nucleic acid by PCR.

The principle involved here is that a single DNA molecule can be copied endlessly in a test tube using primers, DNA polymerase enzyme and free nucleotides. The desired DNA of the pathogen is amplified by PCR from a limited amount of DNA template.

Q. 6 Write a short note on biopiracy highlighting the exploitation of developing countries by the developed countries.

Ans. **Biopiracy** is the term used to refer the use of bio-resources by the multinational companies and other organisations without proper authorisation from the countries and from the people concerned without compensatory payment.

Most of the industrialised nations are rich financially but poor in biodiversity and traditional knowledge. In contrast, the developing and the underdeveloped world is rich in biodiversity and traditional knowledge related to bio-resources.

So, sometimes industrialised nations tend to exploit the resources or biodiversity of developing nations, for their own advantages.

Q. 7 Many proteins are secreted in their inactive form. This is also true to many toxic proteins produced by microorganisms. Explain how the mechanism is useful for the organism producing the toxin?

Ans. Many proteins including certain toxins are secreted in their inactive form. They get activated only when exposed to a specific trigger (pH, temperature etc.). This mechanism is advantageous to the organism (*e.g.,* bacteria) producing the toxins, as the bacteria does not get killed by the action of proteins present in the toxin.

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Q. 8 While creating genetically modified organisms, genetic barriers are not respected. How can this be dangerous in the long run?

Ans. Genetic modification of organisms can have unpredictable results when such organisms are introduced into the ecosystem. Because the real effects of gene manipulation are visible only when such organisms interact with other components and organisms of the ecosystem.

Q. 9 Why has the Indian parliament cleared the second amendment of the country's patents bill?

Ans. Amendments to the patent bill has empowered India to prevent unauthorised exploitation of our bio-resources and traditional knowledge by other countries. This bill also considers patent terms and initiated research development in this field.

Q. 10 Give any two reasons why the patent on Basmati should not have gone to an American Company.

Ans. The patent on Basmati should not have gone to an American Company, *because of the following reasons*

(i) The Basmati rice variety has been grown in India since time immemorial. Traditionally, it belongs to India.

(ii) The new variety of Basmati that got patent rights to an American Company is actually derived from 'Indian farmers variety'.

Q. 11 How was insulin obtained before the advent of *r*DNA technology? What were the problems encountered?

Ans. Insulin is used for diabetes treatment and it was earlier extracted from the pancreas of slaughtered cattle and pigs.

This insulin caused some patients to develop allergy or other types of reactions to the foreign protein.

Q. 12 With respect to understanding diseases, discuss the importance of transgenic animal models.

Ans. *Transgenic animals are important in the following fields*

(i) They are being used in basic science research to elucidate, the role of genes in the development of diseases like cancer, cystic fibrosis, rheumatoid arthritis and alzheimer's.

(ii) They are valuable tools in the drug development process itself.

(iii) They can produce medicines or human proteins (insulin, growth hormone, etc.) in large quantities.

(iv) Transgenics can be a source of transplant organs as well.

Q. 13 Name the first transgenic cow. Which gene was introduced in this cow?

Ans. Rosie was the name of first transgenic cow. Gene for human alpha lactalbumin was introduced in its genes, which made the milk nutritionally more balanced than normal cow milk.

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Q. 14 PCR is a useful tool for early diagnosis of an infectious disease. Elaborate.

Ans. PCR is a very sensitive technique which enables the amplification of desired DNA from a limited amount of DNA template.

Hence, it can detect the presence of an infectious organism in the infected patient at an early stage of infection (even before the infectious organism has multiplied to large number).

Q. 15 What is GEAC and what are its objectives?

Ans. GEAC (Genetic Engineering Approval Committee) is an Indian Government Organisation.
Its objectives include

(i) Examine the validity of Genetic Modification (GM) of organism research.

(ii) Inspect the safety of introducing GMO for public services.

Q. 16 For which variety of Indian rice, the patent was filed by a USA company?

Ans. Indian Basmati rice was crossed with semi-dwarf variety and was claimed as a new variety for which the patent was field by a USA company.

Q. 17 Discuss the advantages of GMO.

Ans. *Advantages of GMO are*

(i) GMO food crops have shorter growing cycles, greater resistance to both insects and diseases, higher yields and higher nutritional value.

(ii) GMO animals have increased production and nutritive values, *e.g.,* GM, cows may produce more milk.

(iii) The World Health Organisation or WHO, claims that GMO plants and animals may allow food prices to drop as food sources become more abundant.

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Short Answer Type Questions

Q. 1 Gene expression can be controlled with the help of RNA. Explain the method with an example.

Ans. RNAi technology is used to block the expression of certain genes and also referred to as gene silencing. During this process, a complementary RNA to the *m*RNA being produced by the gene is introduced into the cell. This RNA binds to the *m*RNA making it double stranded and therefore, stops the process of translation.

e.g., a nematode *Meloidegyne incognitia* infects the roots of tobacco plants which reduces the production of tobacco.

It can be prevented by using RNA interference (RNAi) process which is checked by silencing of specific *m*RNA due to a complementary *ds*RNA.

*ds*RNA binds and prevents the translation of *m*RNA (silencing). By using *Agrobacterium* vectors, Nematode-specific genes were introduced into the host plants which produces both sense and anti-sense RNA in the host cells.

These two RNAs are complementary to each other and form a double-stranded RNA (*ds*RNA) that initiates RNAi and hence, silence the specific *m*RNA of the nematode. The parasite cannot survive in transgenic host and so prevents the plants from pests.

Q. 2 Ignoring our traditional knowledge can be prove costly in the area of biological patenting. Justify.

Ans. Human communities have always generated, refined and passed on the knowledge from generation to generation. Such knowledge is called traditional knowledge and is often an important part of the cultural identities. A number of cases relating to traditional knowledge have attracted international attention.

As a result, the issue of traditional knowledge has been brought to the general debate surrounding intellectual property. These cases involve, what is often referred to as 'biopiracy'.

The examples of turmeric and neem (Indian traditional herbal medicine) illustrates the issues that can arise when patent protection is granted to inventions relating to traditional knowledge which is already in the public domain. In these cases, invalid patents were issued because the patent examiners were not aware or the relevant traditional knowledge.

e.g., India is one of the country possessing the richest diversity of rice (2000 varieties). Basmati rice is distinct for its unique aroma and flavour and 27 documented varieties of Basmati are grown in India. There is reference to Basmati in ancient texts, folklore and poetry, as it has been grown for centuries.

In 1997, an American company Rice teen. 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. Indian Basmati was crossed with semi-dwarf varieties and claimed as an invention or a novelty. The patent extends to functional equivalents, implying that other people selling Basmati rice could be restricted by the patent.

If we are not vigilant and we do not immediately counter these patent applications, other countries/individuals may encash on our rich legacy and we may not be able to do anything about it.

However, India achieved success in contesting patent for Basmati, rice as on September 2000 Rice teen withdraw the claims contested by India. Therefore, ignoring our traditional knowledge, can be proved costly in the area of biological patenting.

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Q. 3 Highlight any four areas where genetic modification of plants has been useful.

Ans. Genetically Modified Plants (GMOs) are the plants, whose genes have been altered by manipulation.

Genetic modification of plants is useful in different areas. *Because of following reasons*

(a) It increases tolerance against abiotic stresses (cold, drought, salt, heat).

(b) It reduces reliance on chemical pesticides (pest-resistant crops).

(c) It reduces post-harvest losses.

(d) It increases the efficiency of minerals used by plants (this prevents early exhaustion of fertility of soil).

(e) It enhances nutritional value of food, *e.g.,* vitamin-A enriched rice (golden rice).

(f) It creates tailor-made plants to supply alternative resources such as starch fuels and pharmaceuticals to industries.

Q. 4 What is a recombinant DNA vaccine? Give two examples.

Ans. Recombinant DNA vaccines are produced by using genetically engineered plasmids that have gene inserts possessing the surface proteins of a pathogen. After the binding of pathogens to these surface proteins, a weak immune response is elicited but it do not results in infection.

These plasmids are inserted in bacteria or yeast cells that expresses the viral proteins, which are then injected into the human host as vaccine, where they are recognised as foreign and an immune response is elicited.

Recombinant hepatitis-B vaccine and polio vaccine are the examples.

Q. 5 Why is it that the line of treatment for a genetic disease is different from infectious diseases?

Ans. The line of treatment for a genetic disease is different from infectious diseases because genetic diseases cannot be treated with any medication, only the signs and symptoms can be taken care of. The only way to treat them is by the manipulation of genes to correct or replace the faulty genes.

On the other hand, *infectious diseases* are caused by pathogens and therefore, can be treated by substances that kill the pathogen or hamper its growth.

Q. 6 Discuss briefly how a probe is used in molecular diagnostics.

Thinking Process

A single stranded DNA or RNA tagged with a radioactive molecule is called probe.

Ans. Early detection of a disease is not possible by conventional diagnostic methods. So, some techniques have been implanted for early diagnosis like PCR, recombinant DNA technology and ELISA.

In recombinant DNA technology, a probe is used. It is allowed to hybridise to its complementary DNA in the clone of cells. The cells are then detected by autoradiography.

The cell with mutated gene will not be observed on the photographic film because, the probe will not have complementarity with the mutated gene.

Q. 7 Who was the first patient to be treated with gene therapy? Why was the given treatment recurrent in nature?

Ans. Gene therapy is a collection of methods that allows the correction of gene defects diagnosed in a child or embryo. Correction of a genetic defect involves the delivery of a normal gene into the individual or embryo to take over the function of and compensate for the non-functional gene.

The first clinical gene therapy was given in 1990 to a 4 yrs old girl with Adenosine Deaminase (ADA) deficiency.

ADA deficiency is caused due to the deletion of gene for Adenosine Deaminase. It can be cured by bone marrow transplantation or by enzyme replacement therapy. In both the approaches, it is not completley curable.

It may recurrent in nature because in the process of gene therapy, lymphocytes used are found to be mortal in nature and the patient requires periodic infusion of such genetically engineered lymphocytes.

For permanent cure, gene isolated from the bone marrow cells producing ADA is introduced into the cells at early embryonic stages.

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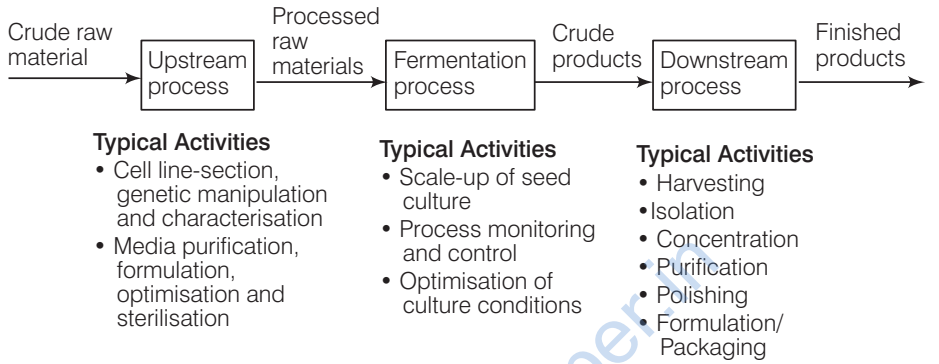
Q. 8 Taking examples under each category, discuss upstream and downstream processing.

Ans. The fermentation process is the basis of many industries in order to produce diverse products. Fermentation means a process in which microorganisms that are cultured on a large scale, convert a substrate into a product which is useful to human.

The fermentation process is divided into two stages namely

Upstream and downstream processing both of these processes can be discussed taking an example of citric acid production.



The upstream processing in biotechnology involves identifying a material. This forms the initial process of fermentation. It deals with inoculum preparation, preparation of culture media, scale up of the entire process and inoculation.

When the products are subjected to a series of processes including separation and purification of the product, it is collectively known as downstream processing. It deals with the post-harvest product, *i.e.,* recovery-clarification, purification, polishing and formulation till the packaging of the desired product.

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Q. 9 Define antigen and antibody. Name any two diagnostic kits based upon them.

Ans. An antigen is a foreign substance that elicits the immune response and results in the formation of an antibody.

Antibody is a protein that is synthesised by the body in response to an antigen.

Antigen and antibody shows high degree of specificity in binding to each other.

Two diagnostic kits based on antigen-antibody interaction are

(a) ELISA for HIV.

(b) Pregnancy test kits.

Q. 10 ELISA technique is based on the principles of antigen-antibody interaction. Can this technique be used in the molecular diagnosis of a genetic disorder, such as phenylketonuria?

Thinking Process

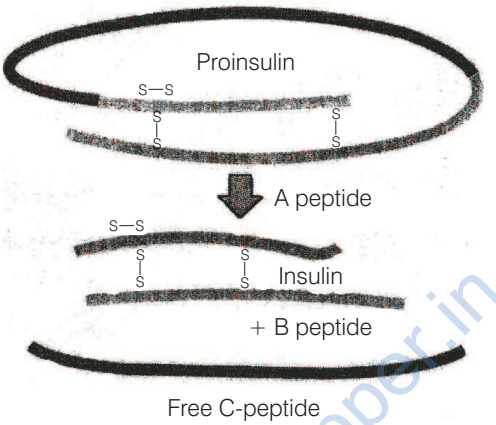
ELISA is based on the principle of antigen - antibody interaction. Any infection coused by a pathogen can be detected by the presence of antigens (proteins, glycoproteins, etc.) or by detecting the antibodies synthesised against the pathogen.

Ans. *Yes*, one can use antibody against the enzyme (that is responsible for the metabolism of phenylanaline) to develop ELISA based diagnostic technique. The patient, in which the enzyme-protein complex is absent would give a negative result in ELISA when compared to the normal individual.

Q. 11 How is a mature, functional insulin hormone different from its pro-hormone form?

Ans. Mature functional insulin is obtained by the processing of pro-hormone which contains an extra peptide called C-peptide or connecting peptide.

It connects the A and B chains in proinsulin. This C-peptide is removed during the maturation of pro-insulin to insulin and A and B chains gets linked by disulphide linkage.



Maturation of proinsulin to insulin

Q. 12 Gene therapy is an attempt to correct a genetic defect by providing a normal gene into the individual. By this the normal function can be restored. An alternate method would be to provide the gene product (protein/enzyme) known as enzyme replacement therapy, which would also restore the function. Which in your opinion is a better option? Give reason for your answer.

Ans. Gene therapy would be a better option because it has the potential to completely cure the patient. It is because the correct gene once introduced in the patient, can continue to produce the correct protein enzyme. Enzyme therapy does not offer permanent cure as it needs to be given to the patient on regular basis. It is also more expensive.

Q. 13 Transgenic animals are the animals in which a foreign gene is expressed. Such animals can be used to study the fundamental biological process, phenomenon as well as for producing products useful for mankind. Give one example for each type.

Ans. Transgenic animals are the animals in which a foreign genes are expressed. Such animals can be used to study the fundamental biological process/phenomenon, *e.g.,* by using model organisms like mouse we can determine how genes are regulated (gene regulation), how they affect the normal functions of the body and its development, etc.

Transgenic animals are also used for producing products useful for mankind, *e.g.,* Transgenic cow (rosie). Which produced human protein enriched milk (2.4 g/L). The milk contained the human alpha-lactalbumin and was nutritionally a more balanced product for human babies than natural cow-milk.

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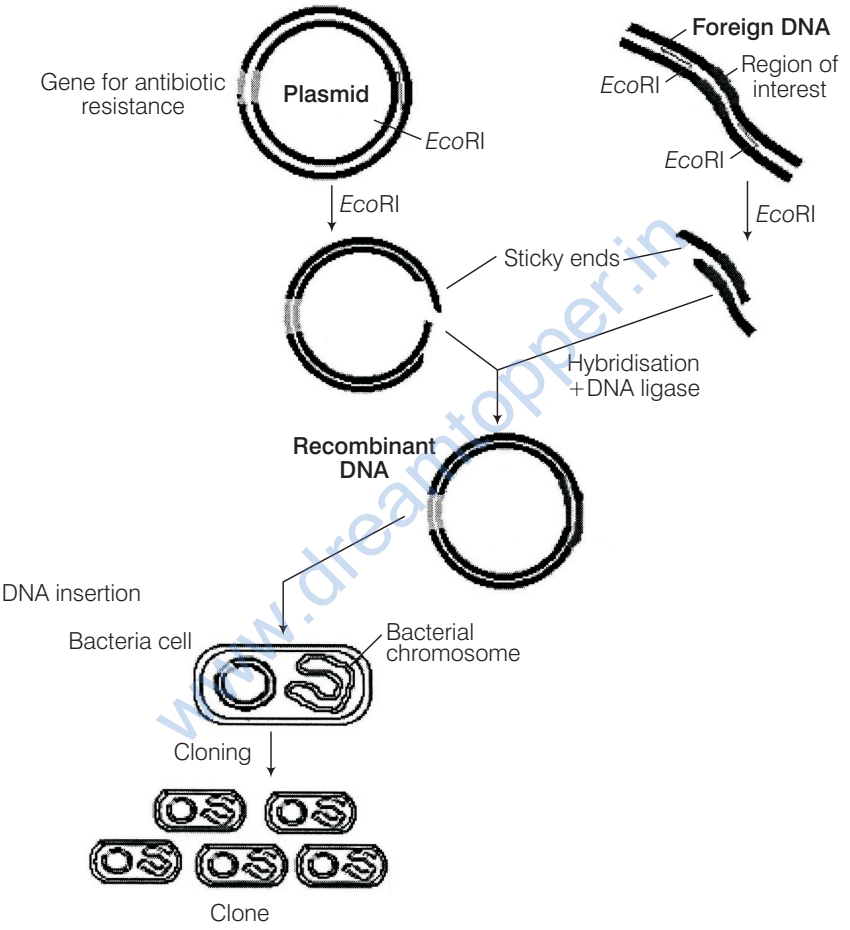
Q. 14 When a foreign DNA is introduced into an organism, how is it maintained in the host and how is it transferred to the progeny of the organism?

Ans. Foreign gene is usually ligated to a plasmid vector and introduced in the host. As plasmid replicates, and makes multiple copies of itself, so does the foreign gene gets replicated and its several copies are made. When the host organism divides, its progeny also receives the plasmid. DNA containing the foreign gene.

The whole process can be visualised in the figure given below



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Q. 15 *Bt* cotton is resistant to pest, such as lepidopteran, dipterans and coleopterans. Is *Bt* cotton also resistant to other pests as well?

Ans. *Bt* cotton is made resistant to certain specific taxa of pests (lepidopteran, dipterans and coleopterans). It is quite likely that in future, some other pests may infest these *Bt*-cotton plants. It is similar to immunisation against smallpox which does not provide immunity against other pathogens like those, that causes cholera, typhoid etc.

Long Answer Type Questions

Q. 1 A patient is suffering from ADA deficiency. Can he be cured? How?

Thinking Process

A patient suffering from ADA deficiency can be cured by using 'gene therapy'. Gene therapy is a collection of methods that allows the correction of a gene defect that has been diagnosed in a child/embryo.

Ans. ADA enzyme is crucial for the immune system to function. Deletion of the gene for adenosine deaminase results into ADA deficiency.

In some children, ADA deficiency can be cured by bone-marrow transplantation, while in others it can be treated by enzyme replacement therapy, in which functional ADA is given to the patient by injection. But the problem with both of these approaches is that they are not completely curative.

It may recurrent in nature as in the process of gene therapy, lymphocytes used are found not to be immortal in nature and the patient requires a periodic infusion of such genetically engineered lymphocytes.

For permanent cure, gene isolated from the bone-marrow cells producing ADA is introduced into cells at early embryonic stages.

Q. 2 Define transgenic animals. Explain in detail any four areas where they can be utilised.

Ans. Animals that have had their DNA manipulated to possess and express an extra (foreign) gene are known as transgenic animals.

Following are the four main areas where they can be utilised

(i) **To Study Normal Physiology and Development**

These animals can be used to study that which factor/gene products are needed at what time of development. By the expression of certain genes, they help scientists to understand the normal gene expression at various stages of growth and development.

(ii) **Study of Diseases**

Transgenic animals can be created to serve as models for various human diseases. They also help us to understand the involvement of various genes in diseases like cancer, Parkinson' disease etc.

(iii) **Vaccine Safety**

Transgenic animals can be used to test vaccines like polio vaccine. Transgenic mice have shown promising results in this area and would replace the vaccine testing on monkeys in the years to come.

(iv) **Chemical Safety Testing**

Transgenic animals are created which are more sensitive to certain chemicals/drugs. These are used to study the toxicity or side effects of that chemical/drug. The advantage is that we get results faster.

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Q. 3 You have identified a useful gene in bacteria. Make a flow chart of the steps that you would follow to transfer this gene to a plant.

Ans. *After identifying a useful gene in bacteria, following steps should be followed*

(i) Isolation of useful gene using restriction endonucleases

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(ii) Transferring the gene to a suitable vector to create a recombinant DNA molecule

↓

(iii) Transfer of these recombinant DNA molecules to the target cells.

↓

(iv) Screening of cells for transformation

↓

(v) Selection of transformed cells

↓

(vi) Regeneration of plants from the transformed cells to get transgenic plants.

Q. 4 Highlight five areas where biotechnology has influenced our lives.

Ans. *Biotechnology has influenced our lives in the following ways*

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

(ii) It has made better and safer recombinant vaccines available to the human.

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

(iv) It has enabled the cure of genetic diseases using gene therapy.

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

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Q. 5 What are the various advantages of using genetically modified plants to increase the overall yield of the crop?

Ans. *Genetically modified plants have been useful in many ways as follows*

(i) These plants are more tolerant to abiotic stresses (cold, drought, salt, heat).

(ii) They have reduced the reliance on chemical pesticides (pest-resistant crops).

(iii) They helped to reduce post harvest losses.

(iv) They increases the efficiency of mineral usage by plants (this prevents early exhaustion of fertility of soil).

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

In addition to these uses, GM plants have been used to create tailor-made plants to supply alternative resources to industries, in the form of starches, fuels and pharmaceuticals.

Q. 6 Explain with the help of one example how genetically modified plants can

(a) Reduce usage of chemical pesticides.

(b) Enhance nutritional value of food crops.

Ans. **(a)** Genetically modified plants can reduce the usage of chemical pesticides by introducing pest resistant plants.

e.g., There are several nematodes that parasitie, a wide variety of plants and animals including human beings. A nematode *Meloidogyne incognita* infects the roots of tobacco plants and causes a great reduction in yield. A novel strategy was adopted to prevent this infestation which was based on the process of **RNA interference** (RNAi).

Using *Agrobacterium* vectors, nematode-specific genes were introduced into the host plant. The introduction of DNA was such that it produced both sense and antisense RNA in the host cells.

These two RNA's being complementary to each other formed a double stranded RNA that initiated RNAi and thus, silenced the specific *m*RNA of the nematode. The consequence was that the parasite could not survive in a transgenic host expressing specific interfering RNA.

(b) Genetically modified plants can enhance nutritional value of food crops.

e.g., 'Golden rice' developed at Swiss Federal Institute of technology is an example of nutritionally modified crop. It is rich in vitamin-A (β-carotene). The rice grains are golden-yellow in colour. It contains 'beta-carotene' gene from daffodil plant and also from some bacteria. Golden rice can prevent child blindness which is caused due to the deficiency of vitamin-A.

Q. 7 List the disadvantages of insulin obtained from the pancreas of slaughtered cows and pigs.

Ans. *The disadvantages of insulin obtained from the pancreas of slaughtered cows and pigs are*

(i) Insulin being a hormone is produced in very little amounts in the body. Hence, a large number of animals need to be sacrificed for obtaining small quantities of insulin. This makes the cost of insulin very high (Demand being many fold higher than supply).

(ii) Slaughtering of animals is not ethical.

(iii) There is a potential of immune response in humans against the administered insulin which is derived from animals.

(iv) There is possibility of slaughtered animals being infested with some infectious microorganism which may contaminate insulin.

Q. 8 List the advantages of recombinant insulin.

Ans. *The advantages of recombinant insulin are*

(i) There is no need of animals to be sacrificed for the production of recombinant insulin.

(ii) Recombinant insulin was not found allergic to patients, while the insulin from an animal source caused some patients to develop allergy or other types of reactions to the foreign protein.

(iii) The cost of recombinant insulin is not very high. (Supply being many fold higher than demand).

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Q. 9 What is meant by the term biopesticide? Name and explain the mode of action of a popular biopesticide.

Ans. *Biopesticide is a pesticide which is*

(i) Not chemical in nature.

(ii) More specific in action against the pest.

(iii) Safer for environment than chemical pesticides.

A popularly known bio-pesticide is *Bt* toxin, which is produced by a bacterium called *Bacillus thuringiensis. Bt* toxin gene has been cloned from this bacterium and expressed in plants. *Bt* toxin protein when ingested by the insect, gets converted to its active form due to the alkaline pH of the gut.

The activated toxin binds to the surface of midgut epithelial cells and create pores that causes swelling and lysis of the cell and eventually kills the insect.

Q. 10 Name the five key tools for accomplishing the tasks of recombinant DNA technology. Also mention the functions of each tool.

Ans. *The key tools for accomplishing the tasks of recombinant DNA technology with their functions are mentioned below*

(i) **Restriction endonucleases** for cutting the desired DNA at desired places.

(ii) **Gel electrophoresis** for separating the desired DNA fragments.

(iii) **Ligase enzyme** for creating recombinant DNA molecule.

(iv) **DNA delivery system** like electroporation, microinjection, gene gun method, etc.

(v) **Competant host** (usually bacteria/yeast) to take up the recombinant DNA.

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