CBSE Class 12 Biology
NCERT Exemplar Solutions
CHAPTER 12
BIOTECHNOLOGY AND ITS APPLICATIONS

Multiple Choice Questions (MCQs)

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) Resistant to all pesticides

Explanation: (d) Resistant to all pesticides because of the gene incorporated from *Bacillus thuringiensis.*

2. C-peptide of human insulin is:

(a) A part of mature insulin molecule

(b) Responsible for formation of disulphide bridges

(c) Removed during maturation of pro-insulin to insulin

(d) Responsible for its biological activity.

Ans. (c) Removed during maturation of pro-insulin to insulin

Explanation: In mammals, insulin is synthesized as a pro-hormone which later matures into insulin. The pro-insulin contains an extra bond called c-peptide which is removed during maturation.

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) Genetic Engineering Approval Committee

Explanation: (c) Genetic Engineering Approval Committee which permits research work in genetics.

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4. α-1 antitrypsin is:

(a) An antacid

(b) An enzyme

(c) Used to treat arthritis

(d) Used to treat emphysema

Ans. (d) Used to treat emphysema

Explanation: (d) Used to treat emphysema

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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) Either RNA or DNA

Explanation: (c) Either RNA or DNA

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6. Choose the correct option regarding Retrovirus:

(a) An RNA virus that can synthesise DNA during infection

(b) A DNA virus that can synthesise RNA during infection

(c) A ssDNA virus

(d) A dsRNA virus

Ans. (a) An RNA virus that can synthesise DNA during infection

Explanation: A retrovirus is a single-stranded positive sense RNA virus with a DNA intermediate and, as an obligate parasite, targets a host cell.

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

(a) Erythrocytes

(b) Lymphocytes

(c) Blood plasma

(d) Osteocytes

Ans. (b) Lymphocytes

Explanation: (b) Lymphocytes are involved in secretion of ADA.

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8. A protoxin is:

(a) A primitive toxin

(b) A denatured toxin

(c) Toxin produced by protozoa

(d) Inactive toxin

Ans. (d) Inactive toxin

Explanation: For example; Bt toxin protein exists as inactive protoxin but becomes active due to the pH of gut once it is inside the gut of the insect.

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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 the above

Ans. (c) Study of altered physiology of host

Explanation: Pathophysiology is a combination of pathology and physiology. While physiology is about various biological processes, pathology is about diseased state.

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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) Alkaline pH of gut

Explanation: Alkaline pH of gut of insects converts inactive protoxin into active toxin. This kills the insect.

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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 beta carotene

(d) Wild variety of rice with yellow coloured grains

Ans. (c) A transgenic rice having gene for beta carotene

Explanation: (c) A transgenic rice having gene for beta carotene is called golden rise due to its colour.

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12. In RNAi, genes are silenced using:

(a) ss DNA

(b) ds DNA

(c) ds RNA

(d) ss RNA

Ans. (c) ds RNA

Explanation: (c) ds RNA

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13. The first clinical gene therapy was done for the treatment of:

(a) AIDS

(b) Cancer

(c) Cystic fibrosis

(d) SCID (Servere Combined Immuno Deficiency resulting from deficiency of ADA)

Ans. (d) SCID (Servere Combined Immuno Deficiency resulting from deficiency of ADA)

Explanation: The first clinical gene therapy was given in 1990 to a 4-year old girl with

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adenosine deaminase (ADA) deficiency.

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) Adenosine deaminase

Explanation: (b) Adenosine deaminase commonly called ADA.

15. Silencing of a gene can be achieved through the use of:

(a) RNAi only

(b) antisense RNA only

(c) both RNAi and antisense RNA

(d) none of the above

Ans. (c) both RNAi and antisense RNA

Explanation: (c) both RNAi and antisense RNA

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Very Short Answer Type Questions

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 Green Revolution are as follows:

(a) It was mainly based on better management of farm practices

(b) It involved use of agrochemicals (pesticides and fertilizers); which has many side effects

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

Ans. GMO stands for Genetically Modified Organism. A hybrid is produced after crossing two different kinds of individuals, while a GMO is produced by alteration in gene which is carried out in vitro.

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

Ans. Diagnostics relate to finding a suspected disease while therapeutics relate to treatment. Serum analysis is a diagnostic procedure, while administering antibiotic is in the domain of therapeutics.

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 Immunosorbent Assay. AIDS can be detected using this procedure. Antigen-antibody reaction is the underlying principle in this test.

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

Ans. Detection of a disease before the appearance of symptoms is now possible by using biotechnology. PCR (Polymerase Chain Reaction) helps in doing this. Use of PCR can amplify the nucleic acids of bacteria or virus. This can help in detecting their presence even when they are in low concentration.

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

Ans. Use of bio-resources by MNCs and other organizations without authorization from the countries and people is called biopiracy. Some MNCs make some minor tweaking to get the patent on products or processes which have been under the domain of traditional knowledge of any country. By obtaining the patent, these companies get a license to exploit the worldwide market. This leaves the people (with traditional knowledge) at the losing end. Patent on turmeric by an American company is a good example of biopiracy. Tumeric is being used as an antiseptic in India since ages and hence is part of the traditional knowledge.

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

Ans. When the toxin is present in inactive form, it doesn't harm the organism which produces the toxin. For example; B. thuringiensis produces an insecticidal toxin which does not kill this bacterium. This toxin becomes active when it enters alkaline pH of the gut of an insect and the insects killed in the process.

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

Ans. When a genetically modified organism is introduced in the ecosystem; it can have dire consequences for the ecosystem. Thus, not respecting the genetic barriers (while creating genetically modified organisms) can have long term repercussions on the ecosystem.

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

Ans. It was observed that some MNCs or other organizations obtained patent on products or services which had been part of the traditional knowledge of developing countries. This act had the potential of exploitation of indigenous people by not providing adequate compensation and by commercial exploitation. To prevent such a misuse of patent, the Indian Parliament cleared the second amendment of the country's patent bill.

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

Ans. Following are the two reasons why patent on Basmati should not have gone to an American Company:

- 27 documented varieties of Basmati is being grown in India and thus it is an integral part of traditional farm practices in India.
- Patent could have prevented Indian people from growing Basmati rice.

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11. How was Insulin obtained before the advent of rDNA technology? What were the problems encountered?

Ans. Before the advent of rDNA technology, insulin was mainly obtained from pancreas of slaughtered animals. This often resulted in unwanted side effects in the users.

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

Ans. Transgenic animals can serve as models to understand progression of various disease in human. Transgenic models exist for many human diseases like cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's. These animals can be observed to understand the causative gene for a particular disease. This can help in devising suitable treatment for a particular diseases.

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

Ans. Rosie was the first transgenic cow and it was produced in 1997. The gene for human protein alpha-lactalbumin was introduced in this cow. Thus, the cow could produce protein-enriched milk. This milk was nutritionally more balanced than natural cow milk.

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

Ans. Use of PCR can amplify the nucleic acids of bacteria or virus. This can help in detecting their presence even when they are in low concentration. This helps in early detection of a disease which was not possible with conventional diagnostic tools. By the time conventional diagnostic tools could detect a disease it was very late because of very high concentration of pathogens. But early detection by using PCR can help in timely and more efficient treatment.

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15. What is GEAC and what are its objectives?

Ans. GEAC stands of Genetic Engineering Approval Committee. This committee has been formed by the Government of India. Following are its main objectives:

- Validity of GM research.
- Assessing safety of introduction of GM products among the public.

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

Ans. The patent was filed for Basmati rice.

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17. Discuss the advantages of GMO.

Ans. Following are the advantages of GMO:

- GM crops are more tolerant to various stresses.
- GM crops reduce the reliance on pesticides and synthetic fertilizers.
- GM crops can enhance nutrient value of a particular food.

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Short Answer Type Questions

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

Ans. Gene expression can be controlled with the help of RNA interference (RNAi). RNAi takes place in all eukaryotic organisms and is part of the cellular defense. Under this method, a complementary dsRNA binds to and prevents translation of mRNA (silencing) and thus silences a specific mRNA. Thus gene expression which could have been carried out by the mRNA does not happen.

This method has been used to encounter a nematode in plants. Agrobacterium is used as vector to introduce nematode specific gene into the host plant. The introduction of DNA results in production of sense and anti-sense RNA in the host cells. These two RNAs form dsRNA and silence the specific mRNA.

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

Ans. Traditional knowledge accumulates over thousands of generations. It carries knowledge of cost effective ways to tackle many problems related to human life. Patent is granted to a new product or service which is based on entirely novel concept. Once an organization or an individual obtains a patent for a particular product or service; it gets the sole right to reap commercial benefits from that product or service. In most of the cases, the patent holder tends to overexploit the market during the patent period. If we used traditional knowledge instead, it will help us in saving a lot of money. This shows that ignoring our traditional knowledge can prove costly in the area of biological patenting.

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

Ans. Genetic modification of plants has been useful in following areas:

- Increased tolerance to abiotic stress (drought, salinity, high temperature, etc.)
- Increased tolerance to biotic stress; like pests and weeds.
- Increased efficiency of mineral usage from soil.
- Enhanced nutritional value.

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

Ans. A vaccine which is prepared by using recombinant DNA technology is called a rDNA vaccine. Enzo Paolette and Dennis Panicali from New York State Department of Health were able to transform small pox vaccine so that it could be effective against some other diseases. Thus, they were the pioneers in making rDNA vaccine. Hepatitis B vaccine and HPV vaccine are two examples of rDNA vaccines.

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

Ans. An infectious disease happens because of some pathogen. The line of treatment in such condition is focused on eliminating the causative pathogen from the body. But a genetic disease happens because of some anomaly in the genotype. No antibiotic have effect on genotype anomaly. Hence, line of treatment for a genetic disease is entirely different from infectious disease.

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

Ans. For molecular diagnostics: a single strand DNA or RNA is tagged with a radioactive probe. It is then introduced into the host cell and allowed to hybridize with its complementary DNA in a clone of cells which are formed in vitro. The cloned cells are then observed using radiography. This helps in detecting the problems.

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7. Who was the first patient who was given gene therapy? Why was the given treatment recurrent in nature?

Ans. A four year old girl was the first patient to be given gene therapy. She was suffering

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from adenosine deaminase (ADA) deficiency and this therapy was given in 1990. The treatment with gene therapy involves manipulating the DNA of lymphocytes from the patient's body. The modified lymphocytes are grown in vitro and then infused into the patient's body. We know that lymphocytes are not immortal but they have a definite life span. Due to this, this treatment is recurrent in nature.

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

Ans. Upstream processing: This involves identifying a material which can be transformed for making the final product. Let us take example of making Bt cotton. In this, extracting the gene for insecticide toxin from B. thuringiensis is an example of upstream processing. Similarly, introducing this gene into cotton is an upstream process.

Downstream processing: This involves suitable purification and isolation of final product. Let us take that example of fermentation to understand this. Purification of alcohol through distillation is part of downstream processing.

9. Define Antigen and Antibody. Name any two diagnostic kits based upon them.

Ans. Antigen: A foreign substance which elicits an immune response from the body is called an antigen.

Antibody: A protein which is synthesized in response to an antigen in the body is called antibody.

Two diagnostic kits; based on antigen and antibody are as follows:

(a) ELISA kit

(b) Pregnancy test kit

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?

Ans. Yes. One can use antibody against the enzyme (that is responsible for the metabolism of

phenylalanine) to develop ELISA based is diagnostic technique. The patient where the enzyme protein is absent would give negative result in ELISA when compared to normal individual.

11. How is a mature, functional insulin hormone different from its prohormone form?

Ans. Insulin in its pro-hormone form is not active and it needs to be mature to become the functional insulin. The pro-hormone form of insulin contains an extra stretch of polypeptide called C peptide. When insulin becomes mature, it is devoid of C peptide.

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. Enzyme replacement therapy works on artificially administering the required enzyme into the patient's body. This helps in management of the disease. But this needs frequent re-administration of enzyme and other necessary drugs to continue the therapy. In most of the cases; the therapy is costly and is a cause of financial and emotional drain on the patient. Using gene correction is a permanent solution. For example; a person with ADA deficiency can be permanently cured if the required gene is introduced during the embryo stage. This will ensure a better quality of life for the patient.

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. Following are the examples of various uses of transgenic animals:

(a) **Fundamental biological processes:** Transgenic animals can be used to understand insulin-like growth factors in humans.

(b) **Study of Diseases:** Many transgenic animals are introduced with genes for certain disease. Then progression and possible cure for such disease can be studied using these

animals.

(c) **Biological Products:** A transgenic cow Rosie could produce protein enriched milk

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. When a foreign DNA is introduced into an organism; it binds with the chromosome of the host organism because of recombination. When progeny of the host organism is produced (through sexual or asexual reproduction) the new gene is passed on to the progeny because of inheritance. This is similar to any defective gene being passed on from one generation to next generation.

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

Ans. The genes from Bacillus thuringiensis are pest specific. This means that they are highly effective against a select group of pests but do not harm other insects. As a corollary; Bt cotton is not resistant to other pests. This is in fact an advantage from the perspective of maintaining biodiversity in the environment. Beneficial insects are saved from harm because farming of Bt cotton does not need use of pesticides.

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Long Answer Type Questions

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

Ans. A person suffering from ADA deficiency can be cured by various methods which are discusses below:

(a) **Bone Marrow Transplantation:** This is a costly and risky surgical procedure. It requires a suitable donor which is difficult to find. An identical twin is supposed to be the best donor; because chances of tissue rejection are very high in bone marrow transplantation.

(b) **Enzyme Replacement Therapy:** Enzyme replacement therapy is based on administering the missing enzyme to the patient by injection. This involves recurrent treatment that has escalated the cost this therapy.

(c) **Gene Therapy:** Gene therapy involves taking out the lymphocytes from the patient's blood. Then are lymphocytes are genetically engineered to add the missing gene. Recombinant lymphocytes are grown in suitable medium and then administered to the patient. This too is not a permanent cure because lymphocytes have a certain lifespan. The patient needs to be administered lymphocytes after frequent intervals. However, the gene isolated from marrow cells producing ADA is introduced into cells at early embryonic stage could be permanent cure for this disease.

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

Ans. Transgenic animals are the animals in which a foreign gene is expressed. Transgenic rats, pigs, cows, rabbits, sheep and fish have been produced. However, more than 95% of all transgenic animals are mice.

Four areas in which transgenic animals can be utilized are as follows:

(a) **Fundamental Biological Processes:** Transgenic animals can be used to understand insulin-like growth factors in humans. A particular factor can be introduced from another animal and then the behvaiour of this factor can be studied in the transgenic animal.

(b) **Study of Diseases:** Many transgenic animals are introduced with genes for certain disease. Then progression and possible cure for such disease can be studied using these animals. Today, models of transgenic animals exist in which cancer, cystic fibrosis, rheumatoid arthritis, etc. can be studied.

(c) **Biological Products:** A transgenic cow Rosie could produce human protein enriched milk. This milk contains 2.4 g of human alphalactalbumin per litre. This milk is nutritionally balanced for babies than normal cow milk.

(d) **Vaccine Safety:** Before approval for use in humans, any vaccine needs to prove its safety on model animals. For example; transgenic mice has been used to study safety of polio vaccine.

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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. Following are the steps for transferring the useful gene to a plant.

(a) Isolation of useful gene using Restriction Endonucleases

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

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

(d) Screening of cells for transformation

(e) Selection of transformed cells

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

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

Ans. (a) **Food Security:** The earlier Green Revolution has certain limitations. Biotechnology can help in overcoming those limitations. It can help in improving the food production to meet the growing demand because of growing population. Production of Spirulina is an example which shows that huge quantity of nutrient can be produced by minimum use of land.

(b) **Medicine:** Many vaccines and other pharmaceuticals products have been made through biotechnology. Several diagnostic techniques; using biotechnology; has made it easier to diagnose a disease in time and has helped in better cure.

(c) **Environmental Protection:** Use of Bt cotton helps in minimising the use of pesticides. This is beneficial for the environment because it helps in saving useful insets.

(d) **Crime Detection:** DNA fingerprinting can be used to trace the identity of a criminal by using even the smallest remains of criminal's body parts.

(e) **Legal Disputes:** Parentage disputes are being settled with the use of DNA fingerprinting.

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

Ans. Advantage of using GM plants are as follows:

- GM crops are more tolerant to abiotic stresses; like drought, salinity, high temperature, etc. Thus, GM modified crops can be also grown in areas which are not ideal for cultivation.
- GM crops reduce the need for chemical pesticides. This helps in saving many useful insects which otherwise get killed by chemical pesticides. It is important to remember that many insects facilitate pollination in crops.
- Mineral usage by plant is more efficient in case of GM crops. This prevents early exhaustion of soil nutrients.
- GM crops can have enhanced nutritional value. For example; golden rice is fortified with vitamin A. Similarly; carrot has been fortified with iron.
- GM crops can be tailor-made to provide alternate resources to industries; such as starch or fuel.

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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) Bt cotton contains the gene which has pesticidal role. This gene is pest-specific and affects only certain pests. By encountering most of the common pests of cotton, Bt cotton minimizes the use of chemical pesticides.

(b) Biofortification involves addition of nutrients through genetic engineering. This can also, be achieved through conventional breeding methods. Biofortification is beneficial because a plant product has inbuilt extra nutrient in it. This means that nutrients need not be added at the processing stage. This can help in tackling hidden hunger among the poor. Golden rice is an example of rice which has been fortified with vitamin A.

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

Ans. Following are the disadvantages of insulin from slaughtered animals:

(a) Demand for insulin is very high which necessitates slaughtering of a large number of animals.

(b) Slaughtering of animals amounts to cruelty against animals.

(c) Insulin from animal origin can result in allergic reactions because of body's tendency to encounter foreign substance.

(d) The slaughtered animal can be infected with some dangerous microbes. This can contaminate the insulin.

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8. List the advantages of recombinant insulin.

Ans. Following are the advantages of recombinant insulin:

(a) Recombinant insulin can be prepared on large scale without worrying about the source animal.

(b) Batch to batch consistency can be maintained and quality can also be maintained.

(c) Helps in preventing cruelty against animals.

(d) Chances of allergic reactions have been minimized.

(e) Chances of transmission of infection from source animals have been nullified.

(f) Recombinant insulin has almost replaced animal-sourced insulin from around the world.

(g) This paves the way for forms of insulin which need not be given through injections.

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9. What is meant by the term bio-pesticide? Name and explain the mode of action of a popular bio-pesticide.

Ans. A biological agent which works as pesticide is called bio pesticide.

Bio pesticides can be of following types:

(a) **Microbial:** Many Bacteria and fungi have pesticidal properties.

(b) **Herbal:** Some plants; like neem and canola can help in controlling pesticides.

(c) **Plant Incorporated Protectants:** These are incorporated into the genes of a plant through genetic engineering. Bt cotton is an example of plant with incorporated pesticidal property. Bacillus thuringiensis affects the pests of Lepidoptera, Coleoptera and Diptera. It is a well-known example of microbial pesticide. A gene in B. thuringiensis produces a toxin which remains inactive in the bacterium. Once this toxin enters the gut of the pest; the alkaline pH makes it active. The toxin results in perforations in the gut of the pest and eventually the pest is killed. This gene has been incorporated in Bt cotton, Bt tomato, Bt brinjal, etc. These GM crops are giving good results.

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

Ans.

Key tools in rDNA technology	Functions
(a) Restriction endonuclease	(a) Cutting the desired DNA at desired locations.
(b) Gel electrophoresis	(b) Separating the desired DNA fragments.
(c) Ligase enzyme	(c) Creating recombinant DNA molecule
(d) DNA delivery system	(d) To introduce gene in the host