Biotechnology & Its Applications

1. Which one of the following transgenic animals is being used to test the safety of the polio vaccine ? (2024)

(A) Sheep

(B) Goat

(C) Pig

(D) Mice

Ans. (D) Mice

2. The improved trait that is found in the genetically modified transgenic crop Golden rice is : (2024)

(A) High lysine content

(B) Insect resistant

(C) High protein content

(D) High vitamin-A content

Ans. (D) High vitamin-A content

For Questions number 3 to 4, two statements are given one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below. (2024)

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is notthe correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

3. Assertion (A) : Agrobacterium tumefaciens is a pathogen of several monocot plants.

Reason (R) : It is able to deliver a piece of DNA known as T-DNA to transform normal plant cells into a tumor.

Ans. (D) Assertion (A) is false, but Reason (R) is true.

4. Assertion (A) : Indian Government has set up an organisation known as GEAC to decide the validity of GM research.

Reason (R) : Genetic modification of organisms has no effect when such organisms are introduced in the ecosystem.

Ans. (C) Assertion (A) is true, but Reason (R) is false.

Previous Years' CBSE Board Questions

10.1 Biotechnological Applications in Agriculture

MCQ

1. 'cry genes' that code for insecticidal toxins are present in

(a) Cotton bollworms (b) Nematodes

(c) Corn borer (d) Bacillus thuringiensis.
(2020 C)

VSA (1 mark)

2. What are cry genes? In which organism are they present?
(AI 2017)

3. Write the function of cryIAc gene.
(AI 2015C)

SA I (2 marks)

4. List any four ways by which GMOs have been useful for enhanced crop output.
(Delhi 2019)

5. Name one toxin gene isolated from B. thuringiensis and its target pest.
(2019 C)

6. Why does the toxin produced by B. thuringiensis not kill the Bacillus ?
(2019 C)

7. Why does Bt toxin not kill the bacterium that produces it, but kill the insect that ingests it?

(Delhi 2014)

8. What does 'cry' genes in Bacillus thuringiensis code for? State its importance in cotton crop.

(Al 2014 C)

SA II (3 marks)

9. On spraying Bacillus thuringiensis on an infected cotton crop field, the pests are killed by the toxin, however, the toxin although produced by the bacteria does not affect it. Explain giving reason. **(2023)**

10. (a) Write the scientific name of the nematode that infests the tobacco plants and the part that it infests.

(b) How is Agrobacterium used to protect tobacco plant from this attack?
(2023)

11. What is cry-proteins? With the help of a suitable example, explain how it acts as a biological pesticide.
(2022)

12. When Bacillus thuringiensis enters a certain insect's body, the insect gets killed, but itself remain unaffected. Explain how it is possible?
(2020)

13. Cotton bollworms enjoy feeding on cotton plants but get killed when feed on Bt cotton plant. Justify the statement.
(2020)

14. Many people are apprehensive of accepting GM crops. Give three reasons so as to convince them to use these crops.
(2019)

15. A corn farmer has perennial problem of corn-borer infestation in his crop. Being environmentally conscious he does not want to spray insectides. Suggest solution based on your knowledge of biotechnology. Write the steps to be carried out to achieve it. **(2019)**

16. Why do lepidopterans die when they feed on Bt cotton plant? Explain how does it happen.

(Delhi 2017)

17. What is GMO? List any five possible advantages of a GMO to a farmer.
(Delhi 2016)

18. One of the major contributions of biotechnology is to develop pest-resistant varieties of cotton plants. Explain how it has been made possible.
(Foreign 2015)

19. Describe any three potential applications of genetically modified plants.
(AI 2015 C, 2014 C)

LA (5 marks)

20. (b) Answer the following questions based on Bt-crops:

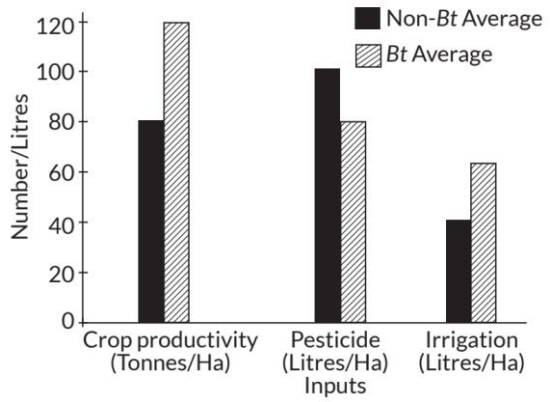
(i) Why do farmers prefer to grow Bt cotton crop than genetically unmodified cotton crops?

(ii) Name any two insects that are killed by Bt toxin.

(iii) Explain the mechanism by which Bt toxin kills the insects but not the bacterium which possesses the toxin.

(2023)

21. There are two different farm lands, one where Bt-cotton crop was cultivated and the other where non Bt-cotton crop (indigenous) was cultivated. Farmers responsible for this experimental cultivation were free to use the farming practices of their choice. During the cultivation period, the data was collected with respect to the amount of pesticide used, water required for irrigation and at harvesting time, the crop productivity. Based on the data collected, a bar graph was plotted which is shown below.



Answer the following questions:

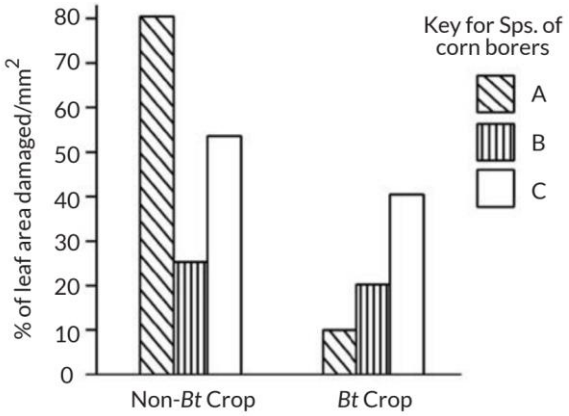
(i) Write your interpretation, with reason, on the basis of the three parameters plotted in the graph.

(ii) Which one of the crops would you like to cultivate in your farm and why?

(iii) Which one out of these two crops would a farmer from Rajasthan like to cultivate and why?

(Term II, 2021-22)

22. To save the crop plant from the attack of various insect pests the biotechnologists have developed many pest resistant plants. One such example is Bt corn plant. In this plant'cry' genes were introduced which produces cryproteins in the plant that has toxic effect on the pest (corn borer). Thus saves the corn plant from the attack of the corn borer. An experimental field study was conducted by the scientists to see the efficacy of the Bt corn plant against the attack of corn borers. Three different species of corn borers namely 'A', 'B', 'C' were collected and were independently fed on non Bt corn plants and Bt corn plants separately for the same period. The extent of the damage caused to the leaf area of the plant was observed and noted down. With the help of the observations and data collected the following bar graph was plotted. Study the graph and answer the questions that follow.



(i) Identify the species of the corn borer that was most successfully controlled by Bt corn plant. Give appropriate reason for your inference.

(ii) Identify the species of the corn borers which shows least impact of toxin produced by Bt genes.

(iii) What would be your advice as a Scientist, to the farmers for growing this particular Bt corn variety in the area which is infested by species-'B' of corn borers?

(iv) Name one Bt gene that encodes protein in corn plants to control corn borers.

(Term II, 2021-22)

23. (a) Name the insect that attacks cotton crops and causes lot of damage to the crop. How has Bt cotton plant overcome this problem and saved the crop. Explain.

(b) Write the role of gene crylAb. **(2020)**

24. Explain the application of biotechnology in producing Bt cotton.

(Delhi 2015 C)

10.2 Biotechnological Applications in Medicine

MCQ

25. Which one of the following is not the product of transgenic experiments?

(a) Pest resistant crop variety (b) High nutritional value in grains

(c) Production of insulin by rDNA technique (d) Drought resistant crops

(2020)

VSA (1 mark)

26. Mention the chemical change that proinsulin undergoes, to be able to act as mature insulin. **(2018)**

27. Suggest any two possible treatments that can be given to a patient exhibiting adenosine deaminase deficiency.
(AI 2015)

OR

A boy has been diagnosed with ADA deficiency. Suggest any one possible treatment. **(Delhi 2014 C)**

28. Why do children cured by enzyme-replacement therapy for adenosine deaminase deficiency need periodic treatment?
(AI 2015 C)

29. State the role of C peptide in human insulin. **(AI 2014)**

SA I (2 marks)

30. Explain how recombinant DNA technology is used to detect a disease even before clinical symptom appears.
(2023)

31. How does a gene therapy involving direct modification of the cells, in order to achieve a therepeutic goal is used in the treatment of ADA deficiency? Explain.
(Term II, 2021-22)

32. Give a schematic representation of the transformation of a pro-insulin into insulin. **(2019)**

33. What is gene therapy? Name the first clinical case in which it was used.
(Delhi 2014)

34. Why is proinsulin so called? How is insulin different from it?
(AI 2014 C)

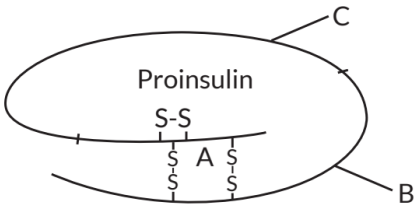
35. (a) Name the deficiency for which first clinical gene therapy was given.

(b) Mention the cause of and one cure for this deficiency.
(AI 2014C)

SA II (3 marks)

36. One of the potential uses of genetic engineering is in correction of a gene defect that has been diagnosed in a child/embryo. Explain how gene therapy is of help in ADA deficiency. **(2022 C)**

37. Insulin in the human body is secreted by pancreas as prohormone/proinsulin. The schematic polypetide structure of proinsulin is given below. This proinsulin needs to undergo processing before it becomes functional in the body. Answer the questions that follow:



(a) State the change the proinsulin undergoes at the time of its processing to become functional.

(b) Name the technique the American company Eli Lilly used for the commercial production of human insulin.

(c) How are the two polypeptides of a functional insulin chemically held together? **(2020)**

38. (a) Mention the cause of ADA deficiency in humans.

(b) How is gene therapy carried out to treat the patients suffering from this disease.?

(c) State the possibility of a permanent cure of this disease.
(2020)

39. (a) Write the difference between proinsulin and mature insulin.

(b) How did American company Eli Lilly produce human insulin using rDNA technique? **(2020)**

40. Two children, A and B aged 4 and 5 years respectively visited a hospital with a similar genetic disorder. The girl A was provided enzyme replacement therapy and was advised to revisit periodically for further treatment. The girl, B was, however, given a therapy that did not require revisit for further treatment.

(a) Name the ailments the two girls were suffering from.

(b) Why did the treatment provided to girl A required repeated visits?

(c) How was the girl B cured permanently?
(Delhi 2019)

41. A child is born with ADA-deficiency.

(a) Suggest and explain a procedure for possible life-long (permanent) cure.

(b) Name any other possible treatment for this disease.
(2019)

42. Explain the various steps involved in the production of artificial insulin.
(AI 2017)

43. Explain enzyme-replacement therapy to treat adenosine deaminase deficiency. Mention two disadvantages of this procedure. **(AI 2016)**

44. Recombinant DNA-technology is of great importance in the field of medicine. With the help of a flow chart, show how this technology has been used in preparing genetically engineered human insulin.
(Delhi, Al 2015)

45. How did an American Company, Eli Lilly use the knowledge of rDNA technology to produce human insulin?
(AI 2015)

46. Mention the cause of ADA deficiency in humans. How has genetic engineering helped patients suffering from it? **(AI 2015C)**

LA (5 marks)

47. Read the following paragraph and answer the questions that follow:

Biotechnology revolves around the "gene of interest", with an objective to open various avenues for human welfare in health, medicine, pharma, agriculture etc. using different techniques, tools and processes. One of the breakthroughs of biotechnology in medicine is the gene therapy.

(i) Name the human disease for which the gene therapy was used for the first time.

(ii) Explain the steps of gene therapy carried to cure the disease using the lymphocytes of the patient. Why is this therapy not a permanent cure of the disease?

(iii) Write the possible permanent cure of the therapy that is in progress.
(Term-11, 2021-22)

48. Explain the application of rDNA technology to produce insulin. **(AI 2015)**

10.3 Transgenic Animals

VSA (1 mark)

49. What are transgenic animals? Give an example. **(AI 2016)**

SA I (2 marks)

50. What are transgenic animals? How was the first transgenic cow found to be more useful than the normal cow for humans?
(2020)

51. How have transgenic animals proved to be beneficial in:

(a) Production of biological products

(b) Chemical safety testing.
(AI 2014)

SA II (3 marks)

52. What are transgenic animals? How are they being used for vaccine safety and chemical safety testing? Explain.
(2020 C)

10.4 Ethical Issues

VSA (1 mark)

53. What is biopiracy? **(Delhi 2017, Al 2016, Delhi 2015)**

54. Mention two objectives of setting up GEAC by our Government.
(AI 2016)

SA I (2 marks)

55. Name the Indian crop variety for which in 1997 an American company got patent right through the US Patent and Trademark Office. Why did the company claim it to be an invention or a novelty?

(2021 C)

56. Why has the Indian Government set up the organisation named GEAC? Give any two reasons.

(2019)

57. (a) What is biopiracy?

(b) State the initiative taken by the Indian parliament against it.
(Delhi 2014)

CBSE Sample Questions

10.1 Biotechnological Applications in Agriculture

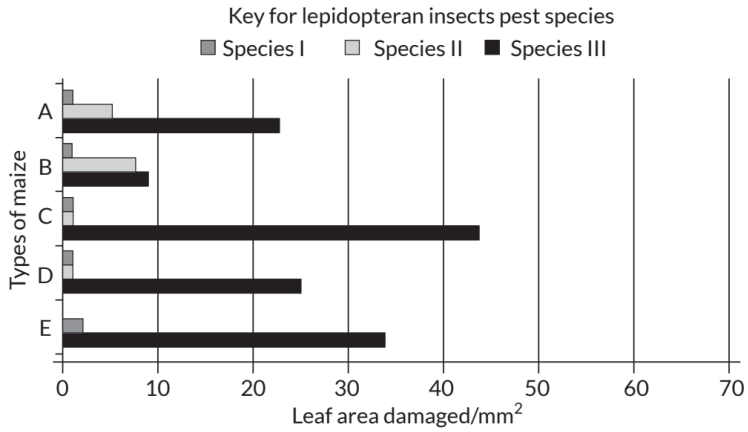
LA (5 marks)

1. Insects in the Lepidopteran group lay eggs on maize crops. The larvae on hatching feed on maize leaf and tender cob. In order to arrest the spread of three such Lepidopteran pests, Bt maize crops were introduced in an experimental field.

A study was carried out to see which of the three species of lepidopteran pests was most susceptible to Bt genes and its product.

The lepidopteran pests were allowed to feed on the same Bt-maize crops grown on 5 fields (A-E).

The graph below shows the leaf area damaged by these three pests after feeding on maize leaves for five days.



Insect gut pH was recorded as 10, 8 and 6 respectively for Species I, II and III respectively.

(a) Evaluate the efficacy of the Bt crop on the feeding habits of the three species of stem borer and suggest which species is least susceptible to Bt toxin.

(b) Which species is most susceptible to Bt-maize? Explain why?

(c) Using the given information, suggest why similar effect was not seen in the three insect species?

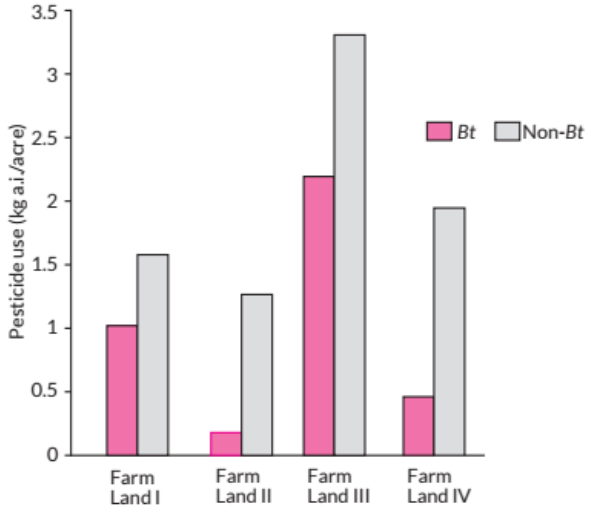
(2022-23)

2. GM crops especially Bt crops are known to have higher resistance to pest attacks. To substantiate this an experimental study was conducted in 4 different farmlands growing Bt and non Bt-Cotton crops.

The farm lands had the same dimensions, fertility and were under similar climatic conditions. The histogram below shows the usage of pesticides on Bt crops and non-Bt crops in these farm lands.

(a) Which of the above 4 farm lands has successfully applied the concepts of Biotechnology to show better management practices and use of agro-chemicals? If you had to cultivate, which crop would you prefer (Bt or Non-Bt) and why?

(b) Cotton bollworms were introduced in another experimental study on the above farm lands wherein no pesticide was used. Explain what effect would a Bt and Non-Bt crop have on the pest.



10.2 Biotechnological Applications in Medicine

VSA (1 mark)

3. Differentiate between pro-insulin and mature insulin.
(2020-21)

Detailed SOLUTIONS

Previous Years' CBSE Board Questions

1. (d): 'Cry genes' are the specific genes produced in bacteria Bacillus thuringiensis. The gene codes for insecticidal toxin called Cry proteins.

2. 'cry genes' are specific genes that encode Cry proteins. They are produced in Bacillus thuringiensis. Man had developed several transgenic crops by introducing these genes from bacteria to crop plants such as Bt cotton, Bt corn, etc.

3. crylAc gene controls cotton bollworms in Bt cotton.

4. Genetically modified organisms have been useful for enhanced crop output as it has :

(i) made crops more tolerant to abiotic stresses (cold, drought, salt, heat).

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

(iii) increased efficiency of mineral usage by plants (this prevents early exhaustion of fertility of soil).

(iv) enhanced nutritional value of food, e.g., Vitamin 'A' enriched rice.

5. Cry IAC gene is isolated from Bacillus thuringiensis. It controls cotton bollworm in Bt cotton.

6. B. thuringiensis forms toxic 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 that solubilises the crystals.

7. 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 that solubilises the crystals. The activated toxin binds to the surface of midgut epithelial cells and creates pores which cause cell swelling and lysis and finally cause death of the insect.

8. cry genes code for certain crystal (cry) proteins that are toxic to insect larvae. The genes cryIAc and cryIIAb control cotton bollworm. When these genes are

introduced into cotton plants through genetic engineering, these plants become resistant to the attack of cotton bollworm.

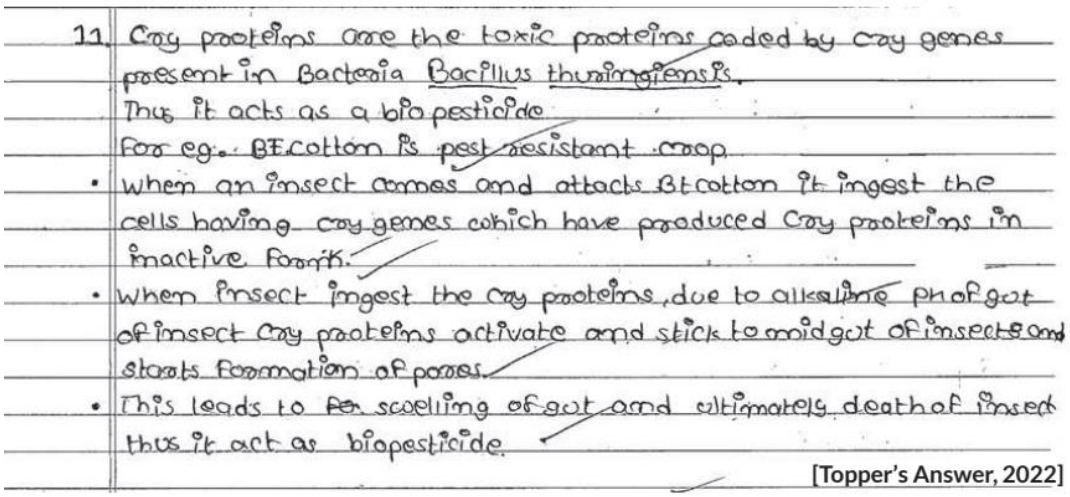
9. Soil bacterium Bacillus thuringiensis produces proteins that kill cotton field pests. B. thuringiensis forms some protein crystals. These crystals contain a toxic insecticidal protein.

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 that solubilises the crystals. The activated toxin binds to the surface of mid gut epithelial cells and creates pores which cause cell swelling and lysis and finally cause death of the insect.

10. (a) A nematode Meloidogyne incognita infests the roots of tobacco plants and causes a great reduction of yield.

(b) Using Agrobacterium vectors, nematode-specific anti-sense genes are introduced into the host plant. The introduction of DNA produces anti-sense RNA in the host cells. The transgenic host plants expresses anti-sense RNA. As a consequence, nematode infestation fails in the transgenic plants because the complementary antisense RNA forms a double stranded RNA (dsRNA) which interferes or blocks the translation and thus, silences the mRNA of the nematode. The result was that the parasite could not survive in transgenic plant. In such way, the transgenic plant gets protected from the parasite.

11.



11. Cry proteins are the toxic proteins coded by cry genes present in Bacteria Bacillus thuringiensis.
Thus it acts as a biopesticide
For eg.: BT cotton is pest resistant crop.
- When an insect comes and attacks Bt cotton it ingest the cells having cry genes which have produced Cry proteins in inactive form.
- When insect ingest the cry proteins, due to alkaline ph of gut of insect cry proteins activate and stick to midgut of insects and starts formation of pores.
- This leads to scwelling of gut and ultimately death of insect thus it act as biopesticide.

[Topper's Answer, 2022]

12. 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 that solubilises the

crystals. The activated toxin binds to the surface of midgut epithelial cells and creates pores which cause cell swelling and lysis and finally cause death of the insect.

13. Cotton bollworms enjoy feeding on cotton plants but get killed when feed on Bt cotton plant because the latter is genetically modified for pest resistance specifically to bollworm infestation. This happens because two genes cryIAc and cryIIAb isolated from Bacillus thuringiensis and incorporated into cotton plant.

The genetically modified plant 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.

14. Genetically modified crops are helpful in following ways:

(i) GM crops are more tolerant to abiotic stresses (cold, drought, salt, heat).

(ii) GM crops reduced reliance on chemical pesticides (pest-resistant crops).

(iii) GM crops increases efficiency of mineral usage by plants (this prevents early exhaustion of fertility of soil).

15. The plants can be made resistant to insects by introducing insect-resistant genes in their genetic material. To make corn free from corn-borer infestation, cry gene, i.e., Bt toxin gene should be extracted from Bacillus thuringeinesis. The steps to carry out this biotechnological process are as follows:

(i) Bt toxin gene crylAb gene should be extracted from the bacteria.

(ii) Bt toxin gene is then introduced in plant cells and expressed to provide resistance from corn borer without the need for insecticide.

(iii) The toxic protein encoded by gene cry/Ab controls corn borer without causing harm to the environment.

(iv) Bt toxin protein exists as inactive protoxins but once an insect ingests the inactive toxin, it is converted into the active form of toxin due to alkaline pH of the gut which solubilizes the crystals which contain toxic insecticidal protein. The activated toxins bind the surface of midgut epithelial cells and create pores that cause cell swelling and lysis and eventually cause the death of insects (corn borer).

16. Two genes crylAc and cryllAb 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 (lepidopterans) 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.

17. Bacteria, fungi, plants and animals whose genes have been altered by manipulation are called genetically modified organisms (GMO). Applications of genetically modified plants are as follows:

(i) Genetically modified plants are resistant to (a) diseases resulting from viral, bacterial and fungal infections, (b) pests, such as nematodes and insects and (c) pesticides.

(ii) GM plants can tolerate adverse abiotic stresses such as cold, drought, salt, heat.

(iii) GM plants show increased efficiency of mineral usage (this prevents early exhaustion of fertility of soil).

(iv) GM plants have high nutritional value, e.g., vitamin A enriched rice.

(v) Plants such as poplar (Populus) trees have been genetically engineered to clean up heavy pollution from contaminated soil. (vi) GM plants help to reduce post-harvest losses, e.g., Flavr Savr transgenic tomato.

18. Refer to answer 16.

19. Applications of genetically modified plants are as follows:

(i) Genetically modified plants are resistant to (a) diseases resulting from viral, bacterial and fungal infections (b) pests, such as nematodes and insects and (c) pesticides.

(ii) GM plants can tolerate adverse abiotic stresses such as cold, drought, salt, heat.

(iii) GM plants show increased efficiency of mineral usage (this prevents early exhaustion of fertility of soil).

20. (b) (i) Bt cotton crop has higher productivity and input of pesticides is lesser therefore farmers prefer to grow Bt cotton crop.

(ii) Tobacco budworm and beetles are killed by Bt-toxin.

(iii) Bt toxin kills the insects but not the bacterium which possesses the toxin because B. thuringiensis forms protein crystals during a particular phase of their growth. These crystals contain a toxic insecticidal protein. The Bt toxin protein exist as inactive protoxins but once an insect ingests the inactive toxin, it is converted into an active form of toxin due to the alkaline pH of the gut which solubilise the crystals. The activated toxin binds to the surface of midgut

epithelial cells and create pores that cause cell swelling and lysis and eventually cause death of the insect.

21. (i) On the basis of three parameters, the following interpretations can be drawn by looking at the graph:

(a) Average crop productivity was much higher in case of Bt crop (120 tonnes/Ha) as compared to the non-Bt crop (80 tonnes/Ha). This is due to the fact that Bt crop is resistant to insects, nematodes, lepidopterans etc., and hence leads to higher productivity.

(b) The input of pesticide in case of Bt crop is less as compared to non-Bt crops because Bt crops are resistant to insects. The Bt toxin genes are insect group specific.

(c) The Bt crop needs more water for their growth hence the amount of irrigation in litres/Ha is more in Bt crop as compared to non Bt-crop.

(ii) Looking at the higher productivity and lesser input of pesticides in Bt crops, I would like to cultivate Bt crop in my farm as plant productivity is higher and input of pesticides is lesser in Bt crops.

(iii) A farmer from Rajasthan would like to grow non-Bt crop as there is scarcity of water in Rajasthan and non-Bt crop requires less water.

22. (i) Species A is most successfully controlled by Bt corn plant as the proportion of leaf area damage reduced significantly when they fed on Bt crop.

(ii) Species B of corn borer shows least impact of toxin produced by Bt genes. as % change of leaf area damage between non-between and Bt crop by species B is not significant.

(iii) Since species B of corn borers is more resistant to this particular Bt corn variety, the farmer should be advised to grow different variety of Bt corn to get maximum yield.

(iv) Crylab controls corn borer.

23. (a) The insect that attacks cotton crops and causes a lot of damage to cotton crops is known as cotton bollworm. Bt cotton is genetically modified for pest resistance. Two genes crylAc and cryllAb 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 (lepidopterans) 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.

(b) Crylab gene is isolated from Bacillus thuringiensis and is introduced in Bt corn to protect the plant from corn borer.

24. Bt cotton is produced by using biotechnology. 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 bacteria 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 its alimentary canal that solublises the crystals.

Through genetic engineering Bt toxin genes were isolated from Bacillus thuringiensis and incorporated into the several crop plants such as cotton. The choice of genes depends upon the crop and targeted pest, as most Bt toxins are insect-group specific.

The toxin is coded by a gene named cry. Two cry genes crylAc and cryllAb have been incorporated in cotton. The genetically modified crop is called Bt cotton as it contains Bt toxin genes against cotton bollworms. Similarly, crylAb has been introduced in Bt corn to protect the same from corn borer.

25. (c)

26. Proinsulin has three polypeptide chains (A, B and C) which need to be processed before it becomes fully mature and functional insulin. C peptide chain is removed during maturation of insulin and only two polypeptide chains i.e., A-chain and B-chain joined by disulphide bond are present in mature insulin.

27. The possible treatments that can be given to a patient exhibiting adenosine deaminase (ADA) deficiency are:

(i) bone marrow transplantation

(ii) enzyme replacement therapy.

28. The lymphocytes are not immortal but have a short- life span. So, the patient requires the periodic infusion of genetically engineered lymphocytes in enzyme replacement therapy.

29. The C-peptide is an extra stretch present in the proinsulin. It is not present in mature insulin and is removed during processing of proinsulin to insulin.

30. In DNA recombinant technology, single stranded DNA or RNA tagged with a radioactive molecule that allowed to hybridise its complementary DNA of cells.

Normally detection of pathogen occurs only when the disease symptoms start to appear as the concentration of the pathogens is very high.

The concentration of pathogens is very low before clinical symptoms appear. So, by using PCR (polymerase chain reaction) amplification of the nucleic acid in the pathogen allow to detect the pathogen at very low concentration. Using autoradiography, we can detect disease. The clone having the mutated gene will not appear on the photographic film, because the probe used will not be complementary to the mutated gene. In this way mutated gene can be detected and help in detection of a disease.

31. In order to the treat ADA, the lymphocytes from the blood of the patient are grown in a culture outside the body. A functional ADA cDNA (using a retroviral vector) is then introduced into these lymphocytes, which are reinjected into the patient's bone marrow. But as these cells do not always remain alive, the patient requires periodic infusion of such genetically engineered lymphocytes. However, if the isolated gene from bone marrow cells producing ADA is introduced in embryonic stage, it could be a permanent cure.

32.

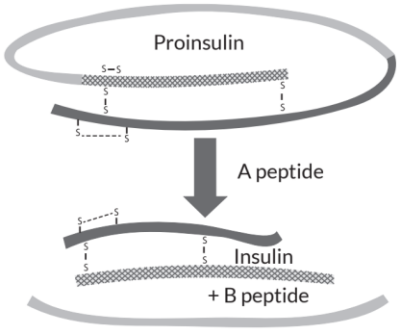


Fig.: Maturation of pro-insulin into insulin (simplified)

33. Gene therapy is the technique of genetic engineering which involves replacement of a faulty gene by a normal healthy functional gene. The first clinical gene therapy was given in 1990 to a 4 years old girl with adenosine deaminase deficiency (ADA deficiency). This enzyme is very important for the immune system to function.

34. Proinsulin is the prohormone which needs to be processed before it becomes a fully mature and functional hormone. Proinsulin 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.

35. (a) The first clinical gene therapy was given to 4-year-old girl with adenosine deaminase deficiency in 1990.

(b) ADA deficiency is caused by the deletion of ADA gene. The lymphocytes are not immortal. They have a life span, hence with the formation of new

lymphocytes, the patient requires the periodic infusion of genetically engineered lymphocytes in enzyme replacement therapy.

36. Gene therapy is the technique of genetic engineering which involves replacement of a faulty gene by a normal healthy functional gene. The gene therapy for the treatment of ADA deficiency is a method to correct the genetic defect involving delivery of a normal gene into the individual to take over the function of non-functional gene. The enzyme ADA (adenosine deaminase) is crucial for the immune system to function.

The disorder is caused due to the deletion of the gene for adenosine deaminase. In order to the treat this genetic defect, the lymphocytes from the blood of the patient are grown in a culture outside the body.

A functional ADA cDNA (using a retroviral vector) is then introduced into these lymphocytes, which are reinjected into the patient's bone marrow. But as these cells do not always remain alive, the patient requires periodic infusion of such genetically engineered lymphocytes. However, if the isolated gene from bone marrow cells producing ADA is introduced in embryonic stage, it could be a permanent cure.

37. (a) Proinsulin has three polypeptide chains (A, B and C) which need to be processed before it becomes fully mature and functional insulin. C peptide chain is removed during maturation of insulin and only two polypeptide chains i.e., A-chain and B-chain joined by disulphide bond are present in mature insulin.

(b) Recombinant DNA technology

(c) In mature insulin, two polypeptide chains A and B are held together by disulphide bonds.

38. (a) ADA deficiency in humans is due to a defect in gene that synthesise enzyme adenosine deaminase.

(b) In gene therapy, lymphocytes are extracted from the bone marrow of the patient and are grown in a culture outside the body. A functional ADA cDNA (using a retroviral vector) is then introduced into these lymphocytes, which are reinjected to the patient's bone marrow. But these cells do not remain alive always and the patient requires periodic infusion of such genetically engineered lymphocytes.

(c) As on date there is no permanent cure of this disease. However, if the isolated gene from bone marrow cells producing ADA is introduced into cells at early embryonic stages, then it can be a permanent cure.

39. (a) Mature insulin is made up of 51 amino acids arranged in two polypeptide chains, chain A having 21 amino acids and chain B with 30 amino acids. This

hormone develops from a storage product called proinsulin which has three chains A, B and C. C chain with 33 amino acids is removed prior to insulin formation.

(b) 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 Escherichia coli to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin (humulin). It is recombinant DNA technological process.

40. (a) Both the girls A and B were suffering from SCID (Severe Combined Immune Deficiency) syndrome produced by the deficiency of enzyme Adenosine deaminase (ADA).

(b) The treatment provided to girl A required repeated visits because enzyme replacement therapy is not permanent cure. This is because these patients do not have functional T-lymphocytes, therefore they cannot provide immune responses against invading pathogens.

(c) The girl B was treated by the transplanted stem cells that are injected into the bloodstream. They will then become healthy white blood cells that replenish immune functions - essentially building a whole new, functional immune system for the girl B. The immune system regains complete function and hence girl B was permanently cured.

41. (a) The gene therapy for the treatment of ADA deficiency is a method to correct the genetic defect. In order to the treat this genetic defect, the lymphocytes from the blood of the patient are grown in a culture outside the body. A functional ADA cDNA (using a retroviral vector) is then introduced into these lymphocytes, which are reinjected into the patient's bone marrow. But as these cells do not always remain alive, the patient requires periodic infusion of such genetically engineered lymphocytes. However, if the isolated gene from bone marrow cells producing ADA is introduced in embryonic stage, it could be a permanent cure.

(b) The possible treatments that can be given to a patient exhibiting adenosine deaminase (ADA) deficiency is 'bone marrow transplantation!

42. The steps involved in the production of artificial insulin or humulin are as follows:

(i) Isolation of donor or DNA segment - A useful DNA segment is isolated from the donor organism.

(ii) Formation of recombinant DNA (rDNA) - Both the vector and donor DNA segments are cut in the presence of restriction endonuclease. In the presence of ligase DNA segments of both are joined to form rDNA.

(iii) Production of multiple copies of rDNA - In this process multiple copies of this recombinant DNA are produced.

(iv) Introduction of rDNA in the recipient organism - The rDNA is inserted into a recipient organism.

(v) Screening of the transformed cells - The recipient (host) cells are screened in the presence of rDNA and the product of donor gene. The transformed cells are separated and multiplied.

43. 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. It can be treated by enzyme replacement therapy, in which lymphocytes from blood of patient are grown in culture outside the body. A functional ADA cDNA is then introduced into these lymphocytes, which are subsequently returned to the patient.

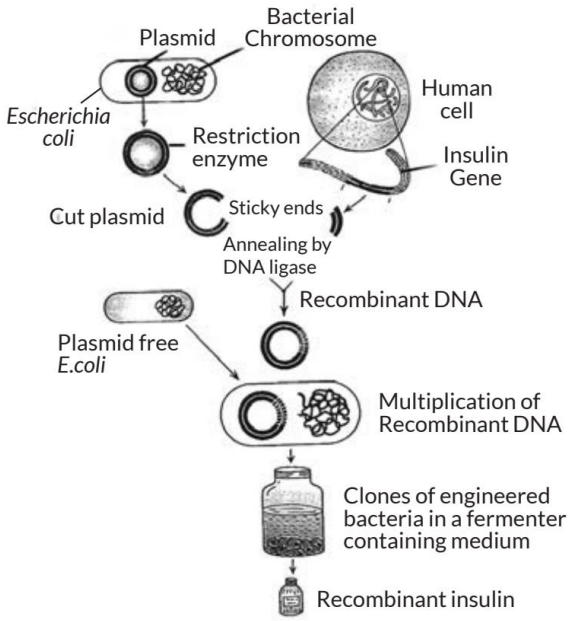
Two disadvantages of enzyme replacement therapy are:

(i) It is not a permanent cure because the patients of ADA deficiency do not have functional T-lymphocytes, they cannot provide immune responses against invading pathogens.

(ii) It is an expensive method.

44. The recombinant DNA technology process has made great impact in the area of health care by mass production of safe and more effective therapeutic drugs. Further, the recombinant therapeutics do not induce unwanted immunological responses.

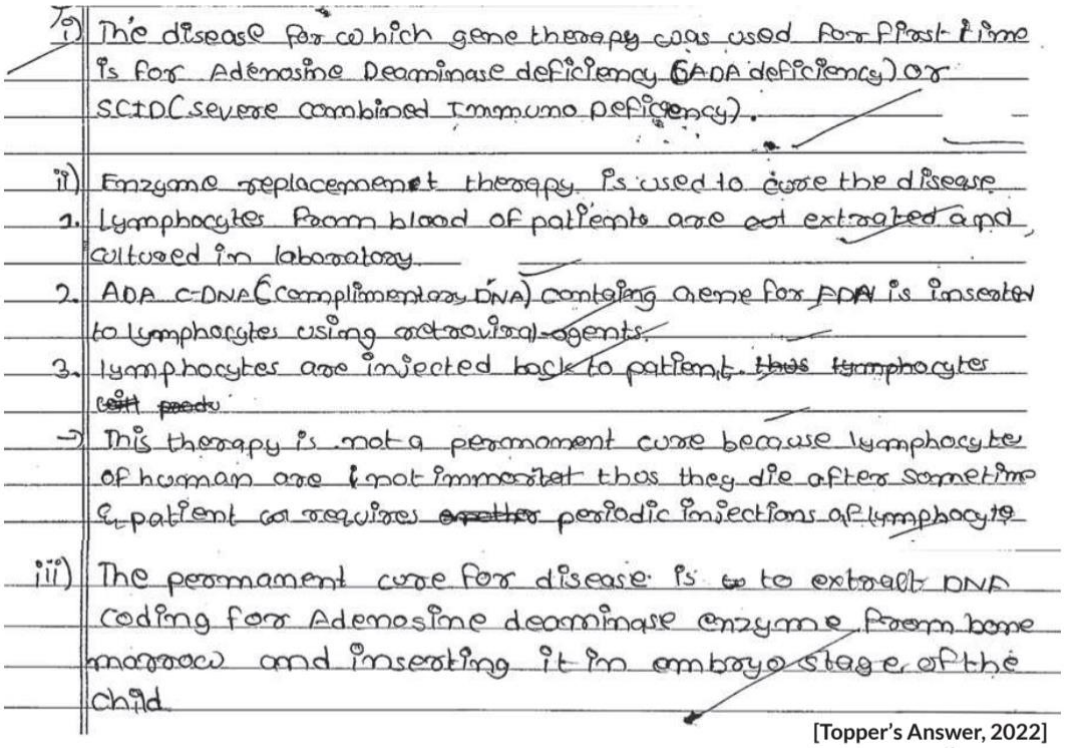
Flow chart showing preparation of genetically engineered human insulin is as follows:



45. 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 Escherichia coli to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin (humulin). It is recombinant DNA technological process.

46. ADA deficiency in humans is due to a defect in gene that synthesise enzyme adenosine deaminase. In gene therapy, lymphocytes are extracted from the bone marrow of the patient and are grown in a culture outside the body. A functional ADA cDNA (using a retroviral vector) is then introduced into these lymphocytes, which are reinjected to the patient's bone marrow. But these cells do not remain alive always and the patient requires periodic infusion of such genetically engineered lymphocytes. As on date there is no permanent cure of this disease. However, if the isolated gene from bone marrow cells producing ADA is introduced into cells at early embryonic stages, then it can be a permanent cure.

47.



i) The disease for which gene therapy was used for first time is for Adenosine Deaminase deficiency (ADA deficiency) or SCIDC severe combined Immuno peficency).

ii) Enzyme replacement therapy is used to cure the disease.
1. Lymphocytes from blood of patients are ~~not~~ extracted and cultured in laboratory.
2. ADA c-DNA (Complimentary DNA) containg gene for ADA is inserted to lymphocytes using retroviral agents.
3. lymphocytes are injected back to patient. ~~thus~~ ~~lymphocytes~~ ~~cell~~ ~~produ~~

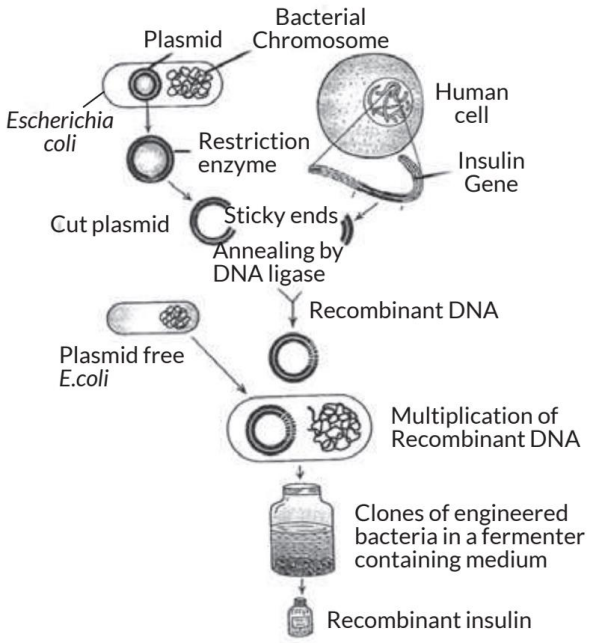
→ This therapy is not a permanent cure because lymphocyte of human are ~~i~~not immortal thus they die after sometime & patient ~~co~~ requires ~~another~~ periodic injections of lymphocytes

iii) The permanent cure for disease is ~~to~~ to extract DNA coding for Adenosine deaminase enzyme from bone marrow and inserting it in embryo stage of the child.

[Topper's Answer, 2022]

48. 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 Escherichia coli to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin (humulin). It is recombinant DNA technological process.

Flow chart showing preparation of genetically engineered human insulin is as follows:



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

50. Transgenic animals are those animals which contain a foreign gene in their genome, introduced by recombinant DNA technology. Such gene is called transgene. Examples of transgenic animals are transgenic mice, 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.

51. (a) 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.

(b) 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.

52. 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.

Genetically modified organisms such as mice are being formed for use in testing the safety of vaccines before they are used on human beings. Transgenic mice are being used to test the safety of the polio vaccine. 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.

53. Biopiracy is the commercial exploitation or patenting of biological resources of a nation by some other organisation or company without proper authorisation and without compensatory payment from concerned country and people.

54. GEAC is Genetic Engineering Approval Committee. It makes decisions regarding the validity of GM research and the safety of introducing GM organisms for public services. The objectives of setting up GEAC by our government is as follows:

(i) To permit the use of GM organisms and their products for commercial applications.

(ii) To approve for conduct of large-scale field trials and release of transgenic crops in the environment.

55. 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. Indian Basmati was crossed with semi-dwarf varieties and claimed as an invention or a novelty.

56. Refer to answer 54.

57. (a) Biopiracy is the commercial exploitation or patenting of biological resources of a nation by some other organisation or company without proper authorisation and without compensatory payment from concerned country and people.

(b) The Indian parliament has recently passed the second amendment of the Indian patent bill that considers issue related to patent terms, emergency provisions and research and development initiative.

CBSE Sample Questions

1. (a) Species III is least susceptible to Bt toxin.

(b) Species I is most susceptible to toxic protein secreted by Bacillus thuringiensis. The insecticidal protein is converted to active form due to alkaline pH of gut of insect, which binds to surface of midgut epithelial cell and create pores that cause cell swelling and lysis and eventually the death of insect.

(c) All species do not show similar effect to Bt toxin because of difference in pH of gut. As Bt toxin proteins are secreted in inactive form and gets activated at alkaline pH of gut. All three species have different pH of gut, thus show different effects.

2. (a) Farm I and II shows better management practices and use of agro chemicals. If I had to cultivate, I would personally prefer Bt crop, because the use of pesticides is highly reduced for Bt crops.

(b) In Bt cotton, a cry gene has been introduced from bacterium Bacillus thuringiensis (Bt) which causes synthesis of a toxic protein. This protein becomes active in the alkaline gut of bollworm feeding on cotton, punching holes in the lining causing death of the insect.

However, a non Bt crop will have no effect on the cotton bollworm and the yield of cotton will decrease as non Bt will succumb to pest attack.

3. Pro-insulin contains an extra stretch called the C peptide which is not present in the mature insulin.