Biotechnology and its Applications

Standard difficulty · 20 questions · 40 marks · Time: 42 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. Bt toxin is produced by:

(a) Escherichia coli **(b)** Thermus aquaticus
(c) Agrobacterium tumefaciens **(d)** Bacillus thuringiensis

2. Which of these is a transgenic cow (1997) whose milk contains human α-lactalbumin?

(a) Rosie **(b)** Biopiracy **(c)** GEAC **(d)** ELISA

3. The Bt toxin becomes active in the insect gut because of:

(a) the acidic pH **(b)** digestive lipases
(c) the low temperature **(d)** the alkaline pH

4. Mature human insulin has an A chain of 21 and a B chain of 30 amino acids, joined by disulphide bridges (two between the chains, one within A). How many disulphide bridges are there in 9 insulin molecules?

(a) 18 **(b)** 270 **(c)** 459 **(d)** 27

5. Milk from Rosie contained 2.4 g of human α-lactalbumin per litre. How much of the protein is in 80 litres?

(a) 194.4 g **(b)** 1,920 g **(c)** 192 g **(d)** 19.2 g

6. A farm used 300 L of insecticide a season on ordinary cotton and 150 L on Bt cotton. The percentage reduction is:

(a) 40% **(b)** 50% **(c)** 25% **(d)** 65%

7. How many nucleotides of mRNA code for both insulin chains, made from separate mRNAs (51 amino acids in all), including stop codons?

(a) 159 **(b)** 153 **(c)** 51 **(d)** 53

8. Assertion (A): The Bt toxin does not kill the Bacillus thuringiensis bacterium that makes it.
Reason (R): Transgenic crops need more chemical pesticide than ordinary crops.

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

Section B — Short answer — 8 × 2 = 16 marks

9. What are GMOs? Give two benefits of GM crops.

10. How many polypeptide chains, amino acids and disulphide bridges are there in 3 molecules of mature human insulin? What part of proinsulin is removed?

11. A field of Bt corn carrying cryIAb needed 50% less insecticide than the 150 L used before. How much insecticide was used, and which pest does the gene control?

12. Rosie's milk had 2.4 g of human α-lactalbumin per litre. How much protein is there in 75 litres? Why was this milk considered better for human babies?

13. What is meant by (a) α-1-antitrypsin from transgenic animals and (b) RNAi in tobacco?

14. How many nucleotides of mRNA, including the stop codon, code for the insulin A chain (21 amino acids)? How many are needed for 11 such chains made from separate mRNAs?

15. A 10-year-old child has ADA deficiency. What is the function of ADA, and how was the first gene therapy (1990) done? Why is it not a permanent cure?

16. How does biotechnology help medicine through (i) transgenic mice for vaccine safety and (ii) Humulin?

Section C — Word problems — 4 × 4 = 16 marks

17. Explain how Bt cotton is made pest-resistant.

18. Explain how human insulin is made by recombinant DNA technology. How many amino acids and disulphide bridges are there in 29 insulin molecules? Why did Eli Lilly make the two chains separately?

19. Explain how Bt cotton kills insects without harming the bacterium that makes the toxin. Which pest does cryIAb control? If a field's yield rose by 40% from 2,200 kg after planting Bt cotton, what was the new yield?

20. Describe how α-1-antitrypsin from transgenic animals and gene therapy for ADA deficiency are used in medicine. What ethical issues does genetic modification raise, and what is India's safeguard?

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Answer key

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Q	Answer	Working
1	**(d) Bacillus thuringiensis**	—
2	**(a) Rosie**	—
3	**(d) the alkaline pH**	—
4	**(d) 27**	per molecule: 51 amino acids, 3 disulphide bridges, 2 chains
5	**(c) 192 g**	80 × 2.4
6	**(b) 50%**	(300 − 150) ÷ 300 × 100
7	**(a) 159**	3 nucleotides per codon
8	**(c) A is true, but R is false.**	A is true: it is made as an inactive protoxin, activated only by the alkaline pH of the insect gut. R is false.
9	**Plants, bacteria, fungi or animals whose genes have been altered by manipulation. GM crops tolerate abiotic stresses, need fewer chemical pesticides, lose less after harvest, use minerals better and can have better nutritional value (any two).**	—
10	**6 chains, 153 amino acids, 9 disulphide bridges; the C peptide**	A chain 21 + B chain 30 amino acids; two bridges between the chains and one within A
11	**75 L; the corn borer**	150 × 0.5
12	**180 g; it is nutritionally more balanced for human babies than natural cow milk**	75 × 2.4
13	**(a) A human protein used to treat emphysema; (b) tobacco made resistant to the nematode Meloidogyne incognita by silencing its mRNA**	—
14	**66; 726**	(21 + 1) × 3
15	**ADA (adenosine deaminase) is needed for the immune system to work. Lymphocytes from the patient were grown outside the body, given a functional ADA cDNA with a retroviral vector, and returned to the patient. Lymphocytes are not immortal, so the treatment must be repeated**	a permanent cure needs the gene put into bone-marrow cells at an early embryonic stage
16	**(i) Used to test the safety of the polio vaccine before it is used on humans; (ii) human insulin made in E. coli by Eli Lilly in 1983**	—

Q	Answer	Working
17	**Bacillus thuringiensis forms crystal proteins that kill certain insects. The protein exists as an inactive protoxin; in the alkaline gut of an insect that eats it, the crystals dissolve and the activated toxin binds to midgut epithelial cells, creating pores that make them swell and burst, killing the insect. The cry genes crylAc and cryllAb, which control cotton bollworms, have been put into cotton; crylAb controls the corn borer.**	—
18	**Insulin has an A chain (21 amino acids) and a B chain (30) joined by disulphide bridges. Eli Lilly (1983) made two DNA sequences for the A and B chains, put them into plasmids of E. coli, produced the chains separately, then joined them by disulphide bonds to form human insulin. 29 molecules: 1,479 amino acids and 87 bridges. In the body insulin is made as proinsulin with a C peptide that must be removed, which was hard to do in bacteria**	—
19	**Bacillus thuringiensis makes the Bt toxin as an inactive crystalline protoxin. An insect eats it; the alkaline pH of the gut dissolves the crystals and activates the toxin, which binds the midgut epithelial cells and makes pores, so they swell and burst and the insect dies. crylAb controls the corn borer. New yield 3,080 kg**	2,200 × 1.4
20	**A-1-antitrypsin from transgenic animals: a human protein used to treat emphysema. Gene therapy for ADA deficiency: lymphocytes given a functional ADA cDNA with a retroviral vector (first done in 1990). Ethical issues: unpredictable effects of GM organisms in the ecosystem, animal welfare in transgenic research, and biopiracy (for example the basmati patent). India set up GEAC to judge GM research and the safety of GM organisms, and has amended its patent laws to protect its bio-resources**	—

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