Engineering Life: Miracles in Biotechnology (Advanced)

Standard difficulty · 20 questions · 40 marks · Time: 36 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. A bacterium doubles in number every 20 minutes. Starting with 90 cells, how many are there after 140 minutes (if none die)?
   (a) 23,040 **(b)** 1,260 **(c)** 5,760 **(d)** 11,520

2. A fermenter's microbe count: 0 h: 40, 2 h: 45, 4 h: 49, 6 h: 71, 8 h: 107, 10 h: 104, 12 h: 103, 14 h: 90. During which interval do the microbes grow most rapidly?
   (a) 6 to 8 hours **(b)** 8 to 10 hours **(c)** 4 to 6 hours **(d)** 0 to 2 hours

3. Which of these is an example of modern biotechnology?
   (a) making cheese **(b)** fermenting dhokla batter
   (c) making buttermilk **(d)** growing Bt corn

4. Using biotechnology for developing new medicines from marine organisms belongs to:
   (a) blue biotechnology **(b)** none of these: it is not biotechnology
   (c) green biotechnology **(d)** red biotechnology

5. Biotechnology is the use of:
   (a) living organisms or their parts to make products useful to people
   (b) computers to study cells
   (c) chemicals with no living things
   (d) only machines to make food

6. In making human insulin with bacteria, which step comes immediately after this one: "DNA ligase joins the insulin gene into the plasmid"?
   (a) the insulin is collected and purified
   (b) a bacterial plasmid is cut open with the same restriction enzymes
   (c) the transformed bacteria multiply in a fermenter
   (d) the recombinant plasmid is put into a bacterium such as E. coli

7. Which bio-enzyme in a washing powder is best at removing a stain of blood?
   (a) protease **(b)** amylase **(c)** lipase **(d)** DNA ligase

8. Assertion (A): Bacteria that double every 20 minutes grow from 130 to 8,320 cells in 120 minutes.
   Reason (R): Each doubling adds the starting number of cells once more.
   (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. A culture starts with 280 bacteria, which double every 20 minutes. How many are there after 120 minutes?

10. Bacteria doubling every 30 minutes grow from 160 to 163,840. How long did this take?

11. A microbe divides every 15 minutes. How many generations (doublings) take place in 11 hours?

12. Microbe counts in a fermenter: 0 h: 20, 2 h: 22, 4 h: 38, 6 h: 107, 8 h: 104, 10 h: 106, 12 h: 83, 14 h: 58. Find the average growth rate between 4 and 6 hours.

13. A fermenter holds 30,000 litres of nutrient medium. The inoculum added is 2% of this volume. How many litres of inoculum are needed?

14. Microbe counts in a fermenter: 0 h: 40, 2 h: 44, 4 h: 49, 6 h: 72, 8 h: 133, 10 h: 132, 12 h: 133, 14 h: 108. Name the growth phase between 6 and 8 hours.

15. Name the bio-enzyme that breaks down a stain of cooked rice starch on clothes.

16. Which colour of biotechnology (blue, green or red) covers improving the nutritional quality of food crops?

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

17. A student records the number of microorganisms in a fermenter: 0 h: 30, 2 h: 31, 4 h: 32, 6 h: 51, 8 h: 116, 10 h: 116, 12 h: 115, 14 h: 99. (a) What is the greatest rise in any 2-hour interval? (b) Name the phase between 8 and 10 hours. (c) What is the largest population recorded? (d) Suggest why the population falls at the end.

18. What happens when yeast is mixed with sugar in warm water, and why?

19. A continuous-culture fermenter holds 8,000 litres. Fresh medium flows in at 310 litres per hour and the same volume of spent broth is removed. (a) How many litres are removed in a day? (b) How many hours does it take to replace a volume equal to the whole tank? (c) In which growth phase does this keep the microbes? (Give the answer to 2 decimal places where needed.)

20. An engineered E. coli culture used to make insulin starts with 330 cells and doubles every 20 minutes. Find (a) the number of doublings in one hour, (b) the number of cells after one hour and (c) the number of cells after 3 hours.

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Answer key

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Q	Answer	Working
1	**(d) 11,520**	140 ÷ 20 = 7 doublings: 90 × 2^7
2	**(a) 6 to 8 hours**	the largest rise is 36 (log phase), from 71 to 107
3	**(d) growing Bt corn**	it involves moving or changing genes
4	**(a) blue biotechnology**	blue: marine and freshwater organisms
5	**(a) living organisms or their parts to make products useful to people**	for example microbes making curd or insulin
6	**(d) the recombinant plasmid is put into a bacterium such as E. coli**	the order: 1. the human insulin gene is cut out with restriction enzymes; 2. a bacterial plasmid is cut open with the same restriction enzymes; 3. DNA ligase joins the insulin gene into the plasmid; 4. the recombinant plasmid is put into a bacterium such as E. coli; 5. the transformed bacteria multiply in a fermenter; 6. the insulin is collected and purified
7	**(a) protease**	proteases break down proteins
8	**(c) A is true, but R is false.**	A is true: 6 doublings: 130 × 2^6 = 8,320. R is false.
9	**17,920**	120 ÷ 20 = 6 doublings; 280 × 2^6
10	**300 minutes**	163,840 ÷ 160 = 1,024 = 2^{10}: 10 doublings × 30
11	**44**	11 × 60 ÷ 15
12	**34.5 per hour**	(107 − 38) ÷ 2 h
13	**600 litres**	2 × 30,000 ÷ 100
14	**log phase**	change +61: fast rise
15	**amylase**	it is mainly starch
16	**green**	agriculture and food crops
17	**(a) 65; (b) stationary phase; (c) 116; (d) nutrients run out and toxic wastes build up, so more cells die than are formed**	(a) the rises are 1, 1, 19, 65, 0, −1, −16; (b) nearly flat; (c) the highest count
18	**It froths and smells of alcohol after a few minutes: the yeast breaks down the sugar by fermentation, giving carbon dioxide (the froth) and ethanol.**	marking: each point in the model answer
19	**(a) 7,440 litres; (b) 25.81 hours; (c) log phase**	(a) 310 × 24; (b) 8,000 ÷ 310; (c) fresh food in and waste out keep them growing fast
20	**(a) 3; (b) 2,640; (c) 168,960**	(a) 60 ÷ 20; (b) 330 × 2^3; (c) 330 × 2^9

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