

Membranes, Proteins, DNA and Gene Expression practice questions

31 questions · 107 marks · mark scheme at the back

For Pearson Edexcel International AS Biology XBI11 and International A Level Biology YBI11. **A Level only** is IA2 content (Units 4 to 6), not needed for the International AS.

Name

Total / 107

Gas exchange, membranes and transport Spec 2.1-2.5

1 UNIT 1 STYLE [1 mark]

Which change would cause the greatest decrease in the rate of diffusion of oxygen across the wall of an alveolus?

- A. ☐ Doubling the surface area of the alveolus
- B. ☐ Doubling the thickness of the alveolar wall
- C. ☐ Doubling the oxygen concentration in the alveolus
- D. ☐ Halving the thickness of the capillary wall

2 UNIT 1 STYLE [3 marks]

A gas exchange surface has an area of 80 mm^2 , a thickness of $0.4 \text{ }\mu\text{m}$ and a difference in oxygen concentration across it of 15 arbitrary units. A second surface has an area of 40 mm^2 , a thickness of $0.4 \text{ }\mu\text{m}$ and a concentration difference of 15 arbitrary units. Use Fick's law to calculate the relative rate of diffusion across each surface, and state the ratio of the first to the second.

Answer = ...

3 UNIT 1 STYLE**[4 marks]**

Explain how the structure of the mammalian lung is adapted for rapid gaseous exchange.

4 UNIT 1 STYLE**[1 mark]**

Which statement about cholesterol in an animal cell-surface membrane is correct?

- A. ☐ It forms channels through which ions pass
- B. ☐ It lies between the phospholipid tails and helps to regulate the fluidity of the membrane
- C. ☐ It forms the outer carbohydrate layer used in cell recognition
- D. ☐ It is a protein that carries glucose across the membrane

5 UNIT 1 STYLE**[4 marks]**

In an investigation of membrane fluidity, a human cell and a mouse cell were fused. The surface proteins of the human cell were labelled with a green fluorescent marker and those of the mouse cell with a red fluorescent marker. The fused cells were kept at different temperatures. The table shows the percentage of the fused cells in which the two markers had completely mixed after 40 minutes. Use the data to explain how the experiment supports the fluid mosaic model of membrane structure.

Mixing of fluorescent markers after 40 minutes

Temperature / °C	Cells with markers completely mixed / %
4	5
15	20
25	55
37	95

6 UNIT 3 STYLE

[6 marks]

A student wants to investigate the effect of temperature on the permeability of the membranes of beetroot cells. Describe how the student could carry out this investigation, including how to control variables, how the results would be measured and one safety precaution.

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7 UNIT 1 STYLE

[4 marks]

Cylinders of potato were left in sucrose solutions of different concentrations for 24 hours. The percentage change in mass of the cylinders was calculated. Determine the sucrose concentration at which there would be no net movement of water into or out of the potato cells, and explain what happens to the cells at 0.8 mol dm⁻³.

Percentage change in mass of potato cylinders	
Sucrose concentration / mol dm ⁻³	Percentage change in mass
0.0	+14
0.2	+8
0.4	+1
0.6	-6
0.8	-12

Answer = ...

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Compare and contrast facilitated diffusion and active transport.

Proteins and enzymes Spec 2.6-2.8

Which statement correctly describes the formation of a peptide bond?

- A. ☐ A condensation reaction between the amino group of one amino acid and the carboxyl group of another, releasing water
- B. ☐ A hydrolysis reaction between the amino group of one amino acid and the carboxyl group of another, using water
- C. ☐ A condensation reaction between the R groups of two amino acids, releasing water
- D. ☐ A hydrolysis reaction between the R groups of two amino acids, using water

Describe how two amino acids are joined to form a dipeptide.

Explain how the primary structure of a protein determines its tertiary structure. Name the types of bond that hold the tertiary structure.

12

UNIT 1 STYLE

[4 marks]

Compare and contrast the structure and function of haemoglobin and collagen.

13

UNIT 1 STYLE

[3 marks]

Explain why an enzyme is specific for its substrate and how it speeds up a reaction.

14

[4 marks]

The enzyme catalase breaks down hydrogen peroxide to produce oxygen. The table shows the volume of oxygen collected over the first 60 seconds. Calculate the initial rate of the reaction in $\text{cm}^3 \text{s}^{-1}$, using the first 20 seconds of the results, and explain why the rate of reaction between 40 and 60 seconds is lower.

Volume of oxygen collected	
Time / s	Volume of oxygen / cm ³
0	0.0
10	6.5
20	11.0
30	14.0
40	15.5
50	16.3
60	16.5

Answer = ...

[illegible]

15

[6 marks]

A student investigated the effect of pH on the initial rate of reaction of catalase with hydrogen peroxide. She added the enzyme to each buffered hydrogen peroxide solution and measured the volume of oxygen collected in 2 minutes. Suggest how her method could be improved so that the initial rates can be compared validly, and describe how she should process her results.

[illegible]

16 UNIT 1 STYLE

[1 mark]

Which of the following is an extracellular enzyme?

- A. ☐ Catalase in a liver cell
- B. ☐ Amylase secreted into the small intestine
- C. ☐ DNA polymerase in the nucleus
- D. ☐ An enzyme of respiration in a mitochondrion

DNA, the genetic code and gene expression Spec 2.9-2.14

17 UNIT 1 STYLE

[1 mark]

Which statement correctly describes the bonds in a DNA molecule?

- A. ☐ Phosphodiester bonds between bases on opposite strands; hydrogen bonds between nucleotides on the same strand
- B. ☐ Hydrogen bonds between bases on opposite strands; phosphodiester bonds between nucleotides on the same strand
- C. ☐ Peptide bonds between bases on opposite strands; hydrogen bonds between nucleotides on the same strand
- D. ☐ Hydrogen bonds between bases on opposite strands; peptide bonds between nucleotides on the same strand

18 UNIT 1 STYLE

[4 marks]

Describe the structure of a DNA molecule.

19 UNIT 1 STYLE

[5 marks]

Describe how DNA is replicated. Include the role of DNA polymerase.

In the Meselson and Stahl experiment, bacteria were grown for many generations in a medium containing heavy nitrogen (^{15}N) and then transferred to a medium containing light nitrogen (^{14}N). DNA was extracted from the bacteria at intervals and centrifuged. The table shows the bands of DNA seen. Explain how these results support the semi-conservative model of replication and show that the conservative model is incorrect.

Bands of DNA in the centrifuge tube	
Generations in ^{14}N	Bands seen
0	One heavy band
1	One band, intermediate density
2	One intermediate band and one light band, in equal amounts

Compare and contrast the structure and function of mRNA and tRNA.

Inheritance, cystic fibrosis and genetic screening Spec 2.15-2.18

Two people who both have blood group AB (genotype $I^A I^B$) have a child. Which blood group could the child NOT have?

- A . ☐ Group A
 B . ☐ Group B
 C . ☐ Group AB
 D . ☐ Group O

The table describes the members of one family in which some individuals have a genetic condition. Use the table to deduce whether the allele that causes the condition is dominant or recessive. Explain your answer.

Family with a genetic condition			
Individual	Sex	Condition	Parents
I-1	Male	Not affected	—
I-2	Female	Not affected	—
II-1	Female	Affected	I-1 and I-2
II-2	Male	Not affected	I-1 and I-2

27 UNIT 1 STYLE

[3 marks]

Red-green colour blindness is caused by a recessive allele (X^b) on the X chromosome. A man with normal colour vision and a woman who is a carrier of the allele plan to have a child. Draw a genetic diagram and give the probability that their first child is a colour-blind boy.

Answer = ...

28 UNIT 1 STYLE

[5 marks]

Explain how a mutation in the gene for the CFTR protein leads to the symptoms of cystic fibrosis in the gaseous exchange system and the digestive system.

29 UNIT 1 STYLE

[4 marks]

Compare and contrast amniocentesis and chorionic villus sampling.

30 UNIT 1 STYLE

[3 marks]

A couple who are both carriers of the cystic fibrosis allele decide to have a child by IVF with pre-implantation genetic diagnosis (PGD). Describe how PGD is carried out.

31 UNIT 1 STYLE

[6 marks]

Discuss the ethical and social issues relating to prenatal genetic screening, from religious, moral and social viewpoints.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [1]

B B. Rate is inversely proportional to thickness, so doubling thickness halves the rate. A, C and D all increase the rate.

2. [3]

- rate = (area × concentration difference) ÷ thickness (1)
- first surface: $(80 \times 15) \div 0.4 = 3000$ (arbitrary units); second surface: $(40 \times 15) \div 0.4 = 1500$ (arbitrary units) (1)
- ratio 2 : 1 / first is twice as fast (1)
- Accept correct working shown for one mark if the values are not worked out. Ignore units.

3. [4]

- many alveoli / alveoli are small sacs, giving a large surface area (to volume ratio) (1)
- wall of alveolus and capillary wall are one cell thick / thin / flattened cells, so a short diffusion distance (1)
- dense network of capillaries / rich blood supply, so oxygen is removed and a steep concentration gradient is maintained (1)
- ventilation brings in fresh air / removes carbon dioxide, maintaining concentration gradients (1)
- elastic fibres allow recoil to expel air (1)
- Max 4

4. [1]

B B. Cholesterol sits between the phospholipid tails and regulates fluidity. It is a lipid, not a protein or a carbohydrate, and it does not form channels.

5. [4]

- markers mixed in most cells at 37 °C / mixing increases with temperature (e.g. 5 % at 4 °C to 95 % at 37 °C) (1)
- so proteins (of both cells) can move within the membrane / are not fixed in position (1)
- supports the fluid part of the model: the membrane is not rigid / the phospholipids can move, allowing proteins to move sideways (1)
- proteins are scattered within the bilayer, not in a continuous layer, so they are free to mix (supports mosaic) (1)
- less mixing at low temperature as phospholipids have less kinetic energy / membrane less fluid (1)
- Max 4

6. [6]

- cut beetroot cylinders of the same diameter and length / same surface area, and rinse them to remove pigment from damaged cells (1)
- put the same volume of distilled water in each tube, and use a range of temperatures (water baths) such as 10 to 70 °C (1)
- leave the same time in each (e.g. 10 minutes) / same mass of beetroot (1)
- measure the colour of the liquid with a colorimeter (blue-green filter), zeroed using distilled water / compare with colour standards (1)
- repeat at each temperature and calculate a mean (1)
- control: a tube at room temperature / identical tube without heating (1)
- safety: use a thermostatic water bath / take care with hot water / wear eye protection / use tile when cutting (1)
- Max 6

7. [4]

- where line / values cross zero change in mass, between 0.4 and 0.6 mol dm⁻³ (1)
- 0.43 mol dm⁻³ (accept 0.41 to 0.46) (1)
- at 0.8 mol dm⁻³ the solution has a lower water potential than the cells, so water leaves the cells by osmosis (1)
- through a partially permeable membrane, down the water potential gradient, so the cells lose mass / the cells become flaccid / plasmolysed (1)

8. [4]

- similarity: both involve (specific) transport proteins / carrier proteins (1)
- similarity: both move substances across a membrane (1)
- difference: facilitated diffusion is down a concentration gradient, active transport is against a gradient (1)
- difference: active transport uses ATP / energy, facilitated diffusion does not (1)
- difference: facilitated diffusion can use channel proteins, active transport uses only carrier proteins (1)
- Max 4

9. [1]

A A. Peptide bonds form between the carboxyl group of one amino acid and the amino group of the next, in a condensation reaction that releases water. R groups are not involved in the peptide bond.

10. [3]

- condensation reaction (1)
- between the carboxyl group of one amino acid and the amino group of the other / OH from the carboxyl and H from the amino group removed (1)
- water released / peptide bond formed between C and N (1)

11. [5]

- primary structure is the sequence of amino acids / R groups (1)
- determines where hydrogen bonds / ionic bonds / disulfide bonds can form between R groups (1)
- so the chain folds into a specific three-dimensional shape (1)
- so a change in one amino acid can change the folding / the three-dimensional shape (1)
- hydrogen bonds and ionic bonds (1)
- disulfide bonds (between cysteine R groups) (1)
- hydrophobic interactions between non-polar R groups (1)
- Max 5

12. [4]

- similarity: both have quaternary structure / more than one polypeptide chain / both are proteins (1)
- haemoglobin is globular and collagen is fibrous (1)
- haemoglobin is soluble (hydrophilic R groups outside), collagen is insoluble (1)
- haemoglobin has four chains each with a haem group, collagen has three chains in a triple helix (1)
- haemoglobin transports oxygen, collagen provides strength / support (1)
- Max 4

13. [3]

- active site has a specific shape / three-dimensional structure (1)
- complementary to the substrate / only one substrate fits, forming an enzyme-substrate complex (1)
- active site shape is determined by the tertiary structure / the primary structure (1)
- lowers the activation energy (1)
- active site changes shape slightly (induced fit), putting strain on bonds in the substrate (1)
- Max 3

14. [4]

- change in volume ÷ change in time (1)
- $11.0 \div 20$ (1)
- $0.55 \text{ cm}^3 \text{ s}^{-1}$ (1)
- correct answer with no working gains 3 marks; do not accept $0.65 \text{ cm}^3 \text{ s}^{-1}$ (first 10 s only)
- substrate concentration has fallen / substrate used up, so fewer collisions and fewer enzyme-substrate complexes formed (1)

15. [6]

- measure volume at regular short intervals (e.g. every 10 seconds) rather than one reading at 2 minutes (1)
- plot volume against time and calculate the initial rate from the gradient of a tangent at time zero (1)
- keep temperature constant / use a water bath for all pH values (1)
- same volume and concentration of enzyme and hydrogen peroxide for each pH (1)
- bring solutions to temperature before mixing (1)
- repeat each pH at least three times and calculate a mean / identify anomalies (1)
- use a gas syringe for accurate volumes (1)
- Max 6

16. [1]

B B. Amylase is secreted and acts outside the cells that make it. The others all work inside cells.

17. [1]

B B. Hydrogen bonds link complementary bases across the two strands; phosphodiester bonds link the sugar and phosphate of adjacent nucleotides along each strand.

18. [4]

- two polynucleotide strands wound in a double helix (1)
- each strand has a sugar-phosphate backbone, of deoxyribose and phosphate linked by phosphodiester bonds (1)
- bases A, T, C, G; A pairs with T, C pairs with G (complementary base pairing) (1)
- held by hydrogen bonds between the bases (1)
- strands are antiparallel (1)
- Max 4

19. [5]

- DNA unwinds / helicase breaks the hydrogen bonds between the strands (1)
- each strand acts as a template (1)
- free nucleotides pair with complementary bases on the template (A-T, C-G) (1)
- DNA polymerase joins the nucleotides (1)
- forming phosphodiester bonds (between adjacent nucleotides) (1)
- semi-conservative: each new molecule has one old strand and one new strand (1)
- Max 5

20. [5]

- after 1 generation, all DNA is intermediate density, so each molecule has one ^{15}N strand and one ^{14}N strand (1)
- conservative model predicts one heavy band and one light band after 1 generation, which was not seen, so it is refuted (1)
- after 2 generations, light DNA (both strands ^{14}N) and intermediate DNA (one strand ^{14}N and one ^{15}N) are present (1)
- semi-conservative model: the old strands (^{15}N) each pair with new ^{14}N strands, and the new strands then act as templates producing $^{14}\text{N}/^{14}\text{N}$ molecules (1)
- each original ^{15}N strand is conserved in a new molecule (1)
- Max 5

21. [4]

- mRNA is complementary to the template strand: first two codons AUG GAA (1)
- last two codons AAA UGA (1)
- methionine – glutamic acid – lysine (1)
- UGA is a stop codon, so there is no further amino acid (1)
- If mRNA is wrong, allow one mark for the correct sequence of amino acids from a wrong mRNA sequence (error carried forward).

22. [1]

B B. Degenerate means more than one codon can code for the same amino acid.

23. [4]

- genetic code is degenerate / the new codon may code for the same amino acid (1)
- so a substitution changes at most one codon / one amino acid (1)
- deletion shifts the reading frame / frameshift (1)
- all the codons after the deletion change, so many amino acids differ / the protein's primary and tertiary structure change (1)
- and so the protein may not function (1)
- Max 4

24. [3]

- both are single-stranded polynucleotides / contain ribose and uracil (1)
- mRNA is a long linear strand with codons; tRNA is a short folded molecule with an anticodon (1)
- mRNA carries the code from DNA to the ribosome; tRNA brings amino acids to the ribosome (1)
- tRNA has an amino acid binding site / has hydrogen-bonded base pairs within the molecule; mRNA does not (1)
- Max 3

25. [1]

D D. The possible child genotypes are $I^A I^A$ (A), $I^A I^B$ (AB) and $I^B I^B$ (B). Neither parent has an I^O allele, so group O is not possible.

26. [4]

- the allele is recessive (1)
- I-1 and I-2 are not affected but have an affected child, II-1 (1)
- if the allele were dominant, one of the parents would have to be affected (1)
- so I-1 and I-2 must both be heterozygous / carriers (1)
- II-1 is homozygous recessive (1)
- Max 4

27. [3]

- parents $X^B Y$ and $X^B X^b$; gametes X^B , Y and X^B , X^b (1)
- offspring $X^B X^B$, $X^B X^b$, $X^B Y$, $X^b Y$ (1)
- probability 1 in 4 / 25 % / 0.25 (1)

28. [5]

- mutation changes the sequence of amino acids / protein structure so the chloride channel protein does not work (1)
- chloride ions not secreted out of the cells, so less water leaves the cells by osmosis (1)
- mucus is thick and sticky (1)
- gaseous exchange: airways blocked / mucus traps bacteria and causes infections, reducing the surface area for gas exchange (1)
- digestive: pancreatic duct blocked so enzymes cannot reach the small intestine, so less digestion and absorption (1)
- mucus cannot be moved by cilia / bacteria are trapped and not removed (1)
- Max 5

29. [4]

- similarity: both are prenatal tests / involve inserting a needle guided by ultrasound / carry a risk of miscarriage (1)
- similarity: both obtain fetal cells for DNA or chromosome analysis (1)
- difference: amniocentesis takes amniotic fluid, CVS takes placental cells / chorionic villi (1)
- difference: amniocentesis is done later in pregnancy (about 15 weeks), CVS earlier (about 11 weeks) (1)
- difference: CVS gives results earlier (1)
- Max 4

30. [3]

- embryos are made by in vitro fertilisation and allowed to develop to about 8 cells (1)
- one or two cells are removed from each embryo and the DNA is tested for the cystic fibrosis allele (1)
- only embryos without two copies of the allele are implanted into the uterus (1)

31. [6]

- religious: some religious groups believe life is sacred from conception, so termination after screening is wrong (1)
- religious: others accept screening to avoid severe suffering / views differ within religions (1)
- moral: parents' right to information and choice / autonomy (1)
- moral: every life has value / a fetus has a right to life / disability rights (1)
- social: pressure on parents to screen or to terminate / stigma towards people with the disorder (1)
- social: discrimination, for example by insurers or employers / privacy of genetic information (1)
- social: cost and access / reduces burden on families and health services (1)
- conclusion that weighs both sides (1)
- Max 6