



Cells (Form and function) practice questions

24 questions • 81 marks • mark scheme at the back

For IB Diploma Biology, Standard Level and Higher Level (first assessment 2025). **HL only** is additional higher level content, for HL students only.

Name

Total / 81

Membranes and membrane transport **Spec B2.1**

1 PAPER 1A STYLE [1 mark]

Which substance crosses a lipid bilayer without membrane proteins most rapidly by simple diffusion?

- A. ☐ Sodium ions
- B. ☐ Glucose
- C. ☐ Oxygen
- D. ☐ Amino acids

2 PAPER 1A STYLE [1 mark]

Which statement distinguishes active transport by pump proteins from facilitated diffusion through channel proteins?

- A. ☐ Only active transport is selective for specific particles
- B. ☐ Only active transport can move particles against a concentration gradient
- C. ☐ Only facilitated diffusion involves integral membrane proteins
- D. ☐ Only facilitated diffusion depends on the hydrophobic core of the membrane

3 PAPER 2A STYLE [4 marks]

Draw a labelled two-dimensional diagram of the fluid mosaic model of membrane structure.

4

[5 marks]

Frog (*Xenopus*) egg cells normally have very few aquaporins in their plasma membrane. In an experiment, one group of egg cells was injected with mRNA coding for an aquaporin and a control group was injected with water. All the cells were then placed in a dilute solution and their volume was measured. The data are for practice. (a) Calculate the percentage increase in volume of the aquaporin cells after 180 s. [1] (b) Explain the difference between the two groups. [3] (c) Suggest why the volume of the control cells still increased slightly. [1]

Relative volume of egg cells in a dilute solution (volume at 0 s = 1.00)		
Time / s	Control cells	Aquaporin cells
0	1.00	1.00
60	1.01	1.10
120	1.02	1.21
180	1.03	1.32
240	1.04	Cells burst

Answer =

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5

[6 marks]

Explain how the structure of the plasma membrane allows it to control the movement of substances into and out of cells.

[illegible]

6 PAPER 2A STYLE

[4 marks]

HL only

Explain how sodium-potassium pumps generate a membrane potential in neurons.

7 PAPER 2B STYLE

[5 marks]

HL only

Explain how sodium-dependent glucose cotransporters allow cells of the small intestine to absorb glucose even when the glucose concentration inside the cell is higher than in the lumen.

8 PAPER 1A STYLE

[1 mark]

HL only

Which describes the nicotinic acetylcholine receptor?

- A. ☐ A voltage-gated channel that lets K^+ leave the neuron
- B. ☐ A neurotransmitter-gated channel that opens when acetylcholine binds, letting Na^+ in
- C. ☐ A pump protein that uses ATP to move acetylcholine across the membrane
- D. ☐ A voltage-gated channel that opens at the threshold potential, letting Na^+ in

Organelles and compartmentalization Spec B2.2

9

PAPER 1A STYLE

[1 mark]

Which structure is considered an organelle?

- A. ☐ Cell wall
- B. ☐ Cytoskeleton
- C. ☐ Ribosome
- D. ☐ Cytoplasm

10

PAPER 1B STYLE

[6 marks]

Liver tissue was homogenised in an ice-cold, isotonic, buffered solution and separated by differential centrifugation. Each fraction was tested for DNA and for the activity of two enzymes: succinate dehydrogenase, a Krebs cycle enzyme, and acid phosphatase, a hydrolytic enzyme found in lysosomes. The data are for practice. (a) Identify, with a reason, the fraction that contains most nuclei. [1] (b) Deduce which fraction contains most mitochondria. [1] (c) Suggest why some acid phosphatase activity is found in pellet 2. [1] (d) Explain why the homogenate was kept ice-cold, isotonic and buffered. [3]

Percentage of the total DNA and enzyme activity found in each fraction				
Fraction	Centrifugation	DNA / %	Succinate dehydrogenase activity / %	Acid phosphatase activity / %
Pellet 1	1 000 × g for 10 min	95	4	3
Pellet 2	10 000 × g for 20 min	2	88	30
Pellet 3	20 000 × g for 30 min	1	6	55
Final supernatant	None	2	2	12

11 PAPER 2A STYLE

[2 marks]

Outline the advantage of separating the nucleus and cytoplasm into separate compartments.

12 PAPER 2A STYLE

[3 marks]

Explain, using lysosomes and phagocytic vacuoles as examples, the advantages of compartmentalization in the cytoplasm of cells.

13 PAPER 1A STYLE

[1 mark]

HL only

Which feature of the mitochondrion allows a high concentration of protons to build up quickly during aerobic respiration?

- A. ☐ The large surface area of the cristae
- B. ☐ The small volume of the intermembrane space
- C. ☐ The enzymes of the Krebs cycle in the matrix
- D. ☐ The double membrane surrounding the mitochondrion

14 PAPER 2A STYLE

[3 marks]

HL only

Explain how the structure of the chloroplast is adapted for photosynthesis.

15 PAPER 2A STYLE

[2 marks]

HL only

Outline why the nuclear membrane needs pores, and why it breaks into vesicles during mitosis.

HL only

Explain how a protein that is secreted from a cell is synthesized, processed and released.

[illegible]

Cell specialization Spec B2.3

Which human cell normally has the largest diameter?

- A. ☐ Red blood cell
- B. ☐ Lymphocyte
- C. ☐ Egg cell
- D. ☐ Head of a sperm cell

Diffusion of acid into agar cubes

Side length / cm	Surface area / cm ²	Volume / cm ³	SA:V	Volume changed colour after 4 min / %
1	6	1	6 : 1	94
2	24	8	?	66
3	54	27	2 : 1	49

Answer =

[illegible]

(a) State the two properties of stem cells. [2] (b) Outline the role of the stem cell niche in adult bone marrow. [2]

[illegible]

20 PAPER 2A STYLE

[3 marks]

Distinguish between totipotent, pluripotent and multipotent stem cells, giving an example of each.

21 PAPER 1A STYLE

[1 mark]

HL only

Which adaptation increases the surface area of the membrane of proximal convoluted tubule cells that faces the filtrate?

- A. ☐ Biconcave shape
- B. ☐ Microvilli
- C. ☐ Invagination of the basal membrane
- D. ☐ Lamellar bodies

22 PAPER 2A STYLE

[4 marks]

HL only

Compare and contrast the adaptations of type I and type II pneumocytes.

PAPER 2B STYLE

HL only

[illegible]

PAPER 2A STYLE

HL only

Mark scheme

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

1. [1]

C C: oxygen is small and non-polar, so it passes between the phospholipids; ions and polar molecules do not readily enter the hydrophobic core [1]

2. [1]

B B: pumps use energy from ATP to move particles against a concentration gradient; both processes are selective and both use integral proteins [1]

3. [4]

- phospholipid bilayer drawn with two layers, heads facing outwards and tails inwards [1]
- hydrophilic regions and hydrophobic region correctly labelled [1]
- integral protein shown embedded in / spanning the bilayer [1]
- peripheral protein shown attached to one surface only [1]
- glycoprotein with carbohydrate chain shown on the extracellular side only [1]
- cholesterol shown within the hydrophobic region, between the hydrocarbon tails [1]
- Labels must point clearly to the structure; do not accept proteins drawn on top of the bilayer as integral
- max 4

4. [5]

- (a) $(1.32 - 1.00) \div 1.00 \times 100 = 32\%$ [1]
- (b) aquaporin mRNA is translated, so aquaporins are inserted into the plasma membrane [1]
- (b) aquaporins increase the permeability of the membrane to water [1]
- (b) solute concentration inside the cell is higher than in the dilute solution, so water enters by osmosis [1]
- (b) water enters faster, so volume increases faster / cells burst [1]
- (b) max 3
- (c) water can still cross the bilayer slowly by diffusing between phospholipids / a few aquaporins are present OWTTE [1]

5. [6]

- phospholipids form a bilayer with a hydrophobic (hydrocarbon) core [1]
- core has low permeability to ions / polar molecules / large molecules, so it acts as a barrier [1]
- small non-polar molecules such as O_2 / CO_2 cross by simple diffusion between phospholipids [1]
- simple diffusion is not selective / depends only on size and hydrophilic or hydrophobic properties [1]
- channel proteins allow facilitated diffusion of specific ions [1]
- channels can be gated / opened or closed to control permeability [1]
- aquaporins allow rapid movement of water by osmosis [1]
- pump proteins use energy from ATP to move specific particles against a concentration gradient [1]
- the proteins present determine which particles cross, giving selective permeability [1]
- max 6

6. [4] HL only

- pump uses energy from ATP / is active transport [1]
- ATP phosphorylates the pump, causing a change in shape [1]
- three Na^+ pumped out for every two K^+ pumped in [1]
- net movement of positive charge out of the cell, so the inside becomes negative relative to the outside [1]
- builds concentration gradients: Na^+ high outside, K^+ high inside [1]
- contributes to a resting potential of about -70 mV [1]
- membrane is more permeable to K^+ than Na^+ , so K^+ diffusing out makes the inside more negative [1]
- max 4

7. [5] HL only

- sodium-potassium pumps actively pump Na^+ out of the cell using ATP [1]
- this keeps the Na^+ concentration inside the cell low / creates a Na^+ gradient into the cell [1]
- cotransporter in the membrane facing the lumen moves Na^+ and glucose into the cell together [1]
- Na^+ moves down its concentration gradient [1]
- glucose moves against its concentration gradient [1]
- indirect active transport: the cotransporter does not use ATP directly [1]
- glucose then leaves the cell into the blood by facilitated diffusion [1]
- the same mechanism reabsorbs glucose in the proximal convoluted tubule of the nephron [1]
- max 5

8. [1] HL only

B B: it is a neurotransmitter-gated ion channel; the sodium and potassium channels are the voltage-gated examples [1]

9. [1]

C C: ribosomes are organelles; the cell wall, cytoskeleton and cytoplasm are not [1]

10. [6]

- (a) pellet 1, because it contains most of the DNA / 95 % of the DNA [1]
- (b) pellet 2, because it has the highest succinate dehydrogenase activity / 88 % [1]
- (c) some lysosomes are similar in size / density to mitochondria, so they sediment with them OWTTE [1]
- (d) cold reduces enzyme activity / stops hydrolytic enzymes digesting the organelles [1]
- (d) isotonic solution prevents water moving into or out of organelles by osmosis / stops organelles bursting or shrinking [1]
- (d) buffer keeps pH constant so proteins / enzymes are not denatured [1]

11. [2]

- transcription (in the nucleus) is separated from translation (in the cytoplasm) [1]
- mRNA can be modified after transcription before it meets ribosomes [1]
- for example, introns removed [1]
- in prokaryotes mRNA may meet ribosomes immediately, so this is not possible [1]
- max 2

12. [3]

- enzymes and substrates / metabolites can be concentrated, so reactions are faster [1]
- incompatible processes are kept separate [1]
- lysosomes contain hydrolytic / digestive enzymes that would digest cell components if free in the cytoplasm [1]
- lysosome contents can be kept at acid pH, the optimum for these enzymes [1]
- phagocytic vacuole forms by endocytosis of a pathogen; lysosomes fuse with it so digestion happens inside a compartment [1]
- max 3

13. [1] HL only

B B: protons are pumped into a small volume, so their concentration rises quickly [1]

14. [3] HL only

- thylakoid membranes have a large surface area / are stacked in grana [1]
- for many photosystems / more light absorption [1]
- small volume of fluid inside the thylakoids [1]
- so a steep proton gradient builds quickly for ATP production [1]
- stroma compartmentalizes the enzymes and substrates of the Calvin cycle [1]
- max 3

15. [2] HL only

- pores allow mRNA to leave the nucleus [1]
- pores allow proteins (such as enzymes or histones) to enter from the cytoplasm [1]
- membrane breaks into vesicles so spindle microtubules can reach / attach to / move chromosomes [1]
- vesicles later fuse to re-form nuclear membranes around each set of chromosomes [1]
- Award [1] max for pores and [1] max for vesicles
- max 2

16. [7] HL only

- protein synthesized by ribosomes bound to the rough ER [1]
- free ribosomes make proteins retained in the cell, so secreted proteins are made on the rER [1]
- polypeptide enters the lumen of the rER [1]
- protein transported from the rER to the Golgi apparatus in vesicles [1]
- vesicles fuse with the cis face of the Golgi apparatus [1]
- protein processed / modified in the Golgi apparatus, for example carbohydrate added [1]
- secretory vesicles bud from the trans face of the Golgi apparatus [1]
- protein folds / is modified in the rER lumen, for example carbohydrate added [1]
- vesicles move to the plasma membrane [1]
- vesicle fuses with the plasma membrane and the protein is released by exocytosis [1]
- fusion and budding are possible because membranes are fluid [1]
- Do not credit clathrin as coating the vesicles that carry the protein from the rER to the Golgi apparatus
- max 7

17. [1]

C C: the egg is about 110 μm across; red blood cells are about 7-8 μm and a sperm head about 5 μm [1]

18. [5]

- (a) $24 \div 8 = 3 : 1 / 3 \text{ cm}^{-1}$ [1]
- (b) the higher the SA:V, the greater the percentage of volume that changed colour / positive correlation [1]
- (c) exchange depends on surface area but the need for exchange depends on volume [1]
- (c) large cells have a smaller SA:V, so materials cannot be exchanged / reach the centre fast enough [1]
- (c) so cells must stay small / divide before they become too large [1]
- (c) max 2
- (d) any one: cells are not cubes / agar is not living and has no metabolism / agar has no plasma membrane or membrane proteins [1]

19. [4]

- (a) can divide endlessly / repeatedly [1]
- (a) can differentiate along different pathways / into different cell types [1]
- (b) bone marrow contains stem cells that produce blood cells [1]
- (b) the niche maintains the stem cells (undifferentiated) [1]
- (b) the niche promotes proliferation and differentiation when more blood cells are needed [1]
- (b) max 2

20. [3]

- totipotent: can form any cell type, including placenta / a whole organism, for example the zygote / very early embryo cells [1]
- pluripotent: can form any body cell but not a whole organism, for example embryonic stem cells [1]
- multipotent: can form a limited range of related cell types, for example bone marrow stem cells [1]
- An example is needed for each mark

21. [1] HL only

B B: microvilli form a brush border facing the filtrate; invagination is on the basal side, facing the blood [1]

22. [4] HL only

- both are cells in the wall / epithelium of the alveolus [1]
- type I are extremely thin / flattened, whereas type II are thicker / rounded [1]
- type I give a short diffusion distance for O_2 and CO_2 [1]
- type II contain many secretory vesicles / lamellar bodies [1]
- type II discharge surfactant into the alveolar lumen (by exocytosis) [1]
- type I cover most (about 95%) of the alveolar surface, whereas type II cover only a small part of it [1]
- Do not accept 'type II cells are fewer in number'
- At least one similarity and one difference are needed for full marks
- max 4

23. [7] HL only

- both contain contractile myofibrils / are striated [1]
- cardiac cells are branched, whereas striated fibres are unbranched [1]
- cardiac cells are short, whereas striated fibres are very long [1]
- cardiac cells usually have one nucleus, whereas striated fibres have many nuclei [1]
- branching / intercalated discs let impulses spread quickly through the heart wall, so it contracts as a unit [1]
- many nuclei are needed to supply mRNA / proteins for a large volume of cytoplasm [1]
- for being a cell: one continuous plasma membrane surrounds the fibre [1]
- against: formed by fusion of many cells / multinucleate, so not a typical cell [1]
- conclusion with a reason, for example an atypical cell / exception to the cell theory [1]
- max 7

24. [4] HL only

- sperm: acrosome contains enzymes to digest a path through the zona pellucida [1]
- sperm: midpiece has many mitochondria to provide ATP for movement [1]
- sperm: flagellum for swimming [1]
- sperm: small / streamlined with little cytoplasm [1]
- egg: large, with cytoplasm / nutrients for the early embryo [1]
- egg: zona pellucida for sperm binding / protection [1]
- egg: cortical granules release contents (by exocytosis) to prevent polyspermy [1]
- Award [2] max for sperm and [2] max for egg
- max 4