



Cells (Form and function) practice questions

13 questions · 42 marks · mark scheme at the back

For IB Diploma Biology SL undefined. **HL only** is additional higher level content, for HL students only.

Name

Total / 42

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 =

[illegible]

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]

Organelles and compartmentalization Spec B2.2

6

PAPER 1A STYLE

[1 mark]

Which structure is considered an organelle?

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

7

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

8

PAPER 2A STYLE

[2 marks]

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

9

PAPER 2A STYLE

[3 marks]

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

Cell specialization Spec B2.3

10

PAPER 1A STYLE

[1 mark]

Which human cell normally has the largest diameter?

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

Agar cubes containing an indicator were placed in acid. The indicator changes colour as acid diffuses into the agar. After 4 minutes the percentage of each cube's volume that had changed colour was estimated. The data are for practice. (a) Calculate the surface area-to-volume ratio of the 2 cm cube. [1] (b) Describe the relationship between SA:V and the percentage of volume that changed colour. [1] (c) Explain what these results suggest about the constraints on cell size. [2] (d) State one way in which agar cubes are a simplified model of cells. [1]

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 =

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

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

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. [1]

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

7. [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]

8. [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

9. [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

10. [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]

11. [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]

12. [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

13. [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