



Cell specialization: practice questions

8 questions • 29 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 / 29

1 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

2 PAPER 1B STYLE [5 marks]

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 =

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3 PAPER 2A STYLE

[4 marks]

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

4 PAPER 2A STYLE

[3 marks]

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

5 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

6 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

[illegible]

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

2. [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]

3. [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

4. [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

5. [1] **HL only**

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

6. [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

7. [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

8. [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