1.2 Cells: 1-hour Pack

AQA 7402 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question is about the resolution and magnification of microscopes.

(a) Define the term resolution as applied to microscopy. **(1)**

(b) Explain why an electron microscope has a higher resolution than a light microscope. **(2)**

(c) A transmission electron micrograph of a mitochondrion measured 500 mm across the printed image. The actual length of the mitochondrion was 4.2 micrometres. Calculate the magnification of this image. Give your answer to 2 significant figures. **(3)**

(d) Suggest two limitations of using a transmission electron microscope (TEM) to study a living cell such as this mitochondrion. **(2)**

(Total for Question 1 is 8 marks)

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2 This question is about mitosis and the cell cycle.

(a) State what happens during interphase, mitosis and cytokinesis in the cell cycle. **(3)**

(b) Table 2 gives brief descriptions of stages of mitosis, labelled W, X, Y and Z, in a random order. **(4)**

W: Chromosomes line up individually along the equator of the cell, attached to spindle fibres.

X: Chromatids are pulled to opposite poles of the cell by the spindle fibres.

Y: Chromosomes condense and become visible; the nuclear envelope breaks down.

Z: Chromatids arrive at the poles and uncoil; nuclear envelopes reform.

Identify which stage of mitosis (prophase, metaphase, anaphase or telophase) matches each description.

(c) A microscope field of view of a root tip squash showed 240 cells in total, of which 18 cells were undergoing mitosis. Calculate the mitotic index for this sample. **(2)**

(d) A tumour biopsy was found to have a much higher mitotic index than the surrounding healthy tissue. Explain why this might indicate that the tissue is cancerous. **(2)**

(Total for Question 2 is 11 marks)

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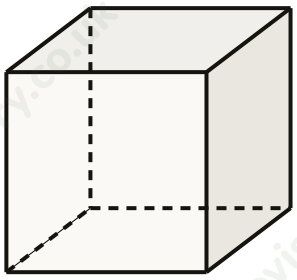
3 This question is about diffusion and the surface area to volume ratio of cells and organisms.

(a) Define the term diffusion. **(1)**

(b) State three factors that affect the rate of diffusion across a cell-surface membrane. **(3)**

(c) A cell is cube-shaped with sides of length 3 mm. Calculate the surface area, the volume, and the surface area to volume ratio of this cell. Show your working. **(4)**

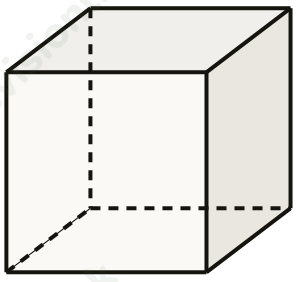
Diagram NOT accurately drawn



3 mm

(d) A larger cube-shaped organism has sides of length 9 mm. Calculate its surface area to volume ratio, and explain why larger organisms like this often need specialised exchange surfaces rather than relying on diffusion over their whole body surface. **(4)**

Diagram NOT accurately drawn



9 mm

(Total for Question 3 is 12 marks)

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4 The fluid mosaic model describes the cell-surface membrane as a phospholipid bilayer with proteins embedded within it, and cholesterol molecules interspersed among the phospholipids.

(a) Explain why phospholipids naturally form a bilayer in a watery environment such as blood plasma. **(2)**

(b) Explain the role of cholesterol in maintaining the fluidity and stability of the membrane at both high and low temperatures. **(3)**

(c) Two membrane proteins are described as an intrinsic (integral) channel protein and an extrinsic (peripheral) glycoprotein. Distinguish between these two types of membrane protein in terms of their position in the membrane. **(2)**

(d) Explain the function of a glycoprotein on the outer surface of a cell-surface membrane in cell recognition. **(1)**

(Total for Question 4 is 8 marks)

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5 A student examined a prepared root-tip squash of an onion (Allium cepa) under a light microscope to investigate the cell cycle. She counted 200 cells in the field of view and classified each by stage: 168 cells were in interphase, 14 were in prophase, 8 were in metaphase, 6 were in anaphase and 4 were in telophase.

(a) Calculate the mitotic index of this tissue sample, giving your answer to 3 significant figures. (Mitotic index = number of cells in mitosis / total number of cells observed.) **(3)**

(b) Explain why the number of cells observed in interphase is much greater than the number observed in any single stage of mitosis. **(2)**

(c) A tumour sample from the same tissue type shows a mitotic index of 0.420. Suggest an explanation for this higher value, and explain why an abnormally high mitotic index is of concern in a clinical context. **(3)**

(Total for Question 5 is 8 marks)

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Mark scheme · 1.2 Cells: 1-hour Pack

Question 1

(a) the minimum distance between two points/objects at which they can still be distinguished as separate (oe) **B1**

(a) Answer: The minimum distance between two points that can still be seen/distinguished as two separate points

(b) electrons have a much shorter wavelength than light **B1**

(b) a shorter wavelength gives a higher resolution (allows smaller/closer structures to be distinguished) **B1**

(b) Answer: Electrons have a much shorter wavelength than light, and a shorter wavelength gives a higher resolution

(c) converts 500 mm to 500000 micrometres **M1**

(c) magnification = image size / actual size = 500000 / 4.2 (dependent on M1) **dM1**

(c) x120000 (1.2×10^5) awrt 2 s.f. **A1**

(c) Answer: x120000 (1.2×10^5) to 2 s.f.

(d) specimens must be dead, dehydrated, chemically fixed and stained, and viewed in a vacuum, so cannot be living (oe) **B1**

(d) only a thin 2D section is seen, so the whole 3D living structure / dynamic processes cannot be observed (oe, any second valid point) **B1**

(d) Answer: TEM specimens must be dead, dehydrated and stained (viewed in a vacuum), so living processes cannot be observed; only a thin 2D section is seen, not the whole 3D living structure

Question 2

(a) interphase: cell grows and DNA/organelles are replicated (cell prepares for division) **B1**

(a) mitosis: the nucleus divides, producing two genetically identical nuclei **B1**

(a) cytokinesis: the cytoplasm (and cell membrane) divides, producing two separate daughter cells **B1**

(a) Answer: Interphase: cell growth and DNA replication/organelle duplication; Mitosis: nuclear division producing two genetically identical nuclei; Cytokinesis: division of the cytoplasm to form two separate daughter cells

(b) W = metaphase **B1**

(b) X = anaphase **B1**

(b) Y = prophase **B1**

(b) Z = telophase **B1**

(b) Answer: W = metaphase; X = anaphase; Y = prophase; Z = telophase

(c) 18 / 240 **M1**

(c) 0.075 (or 7.5%) cao **A1**

(c) Answer: 0.075 (7.5%)

(d) a higher mitotic index means a greater proportion of cells are dividing at any one time **B1**

(d) this suggests mitosis/the cell cycle is no longer controlled properly (uncontrolled cell division), characteristic of a tumour **B1**

(d) Answer: A high mitotic index shows that a large proportion of cells are dividing at any given time, indicating uncontrolled cell division (loss of control of the cell cycle), which is characteristic of a tumour

Question 3

(a) net movement of molecules/particles from a region of higher concentration to a region of lower concentration (down a concentration gradient), due to random motion; requires no metabolic energy (oe) **B1**

(a) Answer: Net movement of molecules/particles from a region of higher concentration to a region of lower concentration (down a concentration gradient), as a result of their random motion; requires no input of metabolic energy

(b) surface area available for diffusion (larger SA = faster rate) **B1**

(b) concentration gradient/difference in concentration (steeper gradient = faster rate) **B1**

(b) thickness of membrane/diffusion distance, or temperature (thinner/warmer = faster rate) **B1**

(b) Answer: Any three of: surface area available for diffusion; the concentration gradient (difference in concentration); the thickness of the membrane/diffusion distance; temperature

(c) surface area = $6 \times 3^2 = 54$ mm^2 **M1**

(c) volume = $3^3 = 27$ mm^3 **M1**

(c) ratio = 54 / 27 (dependent on both previous marks) **dM1**

(c) 2 : 1 (or 2.0) cao **A1**

(c) Answer: SA = 54 mm^2; V = 27 mm^3; SA:V ratio = 2 : 1

(d) surface area = $6 \times 9^2 = 486$ mm^2 and volume = $9^3 = 729$ mm^3 **M1**

(d) ratio = 0.67 : 1 awrt (486/729 = 0.667) cao **A1**

(d) as size/volume increases, the SA:V ratio decreases, so the diffusion distance/pathway to the centre increases **B1**

(d) surface area is too small relative to volume to supply oxygen/nutrients or remove waste/heat fast enough by diffusion alone, so specialised exchange surfaces are needed **B1**

(d) Answer: SA:V ratio = 0.67:1 (486 mm^2 : 729 mm^3). Larger organisms have a smaller SA:V ratio, so diffusion alone across the outer body surface cannot supply oxygen/nutrients or remove wastes fast enough, so specialised exchange surfaces (with adaptations to increase SA and reduce diffusion distance) are needed

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Question 4

(a) phospholipids are amphipathic: the phosphate head is hydrophilic and the fatty acid tails are hydrophobic oe **B1**

(a) in water, the hydrophilic heads orientate towards the water on both sides while the hydrophobic tails face inwards, away from water, forming a bilayer oe **B1**

(a) Answer: Because phospholipids have a hydrophilic head and hydrophobic tails, they arrange with heads facing the water on both sides and tails facing each other, forming a bilayer.

(b) cholesterol molecules fit between the phospholipids, binding to their fatty acid tails oe **B1**

(b) at high temperatures cholesterol restricts the movement of phospholipids, reducing fluidity and preventing the membrane becoming too fluid/permeable oe **B1**

(b) at low temperatures cholesterol prevents phospholipids from packing too closely together, maintaining fluidity and preventing the membrane becoming too rigid oe **B1**

(b) Answer: Cholesterol sits between phospholipid tails; at high temperatures it restricts movement to stop the membrane becoming too fluid, and at low temperatures it prevents tight packing, stopping the membrane becoming too rigid, so fluidity is maintained across a range of temperatures.

(c) intrinsic (integral) proteins span or are embedded within the phospholipid bilayer oe **B1**

(c) extrinsic (peripheral) proteins are attached to the surface of the bilayer (do not span it) oe **B1**

(c) Answer: Intrinsic proteins are embedded within (or span) the bilayer; extrinsic proteins sit on its surface without spanning it.

(d) the carbohydrate (glycolipid/glycoprotein) chains act as antigens/cell-surface receptors that allow the immune system (or other cells) to recognise the cell as self or identify it as a specific cell type oe **B1**

(d) Answer: Glycoproteins act as antigens or recognition sites, allowing cells (including immune cells) to identify the cell as self or as a particular cell type.

Question 5

(a) cells in mitosis = 14 + 8 + 6 + 4 = 32 **M1**

(a) mitotic index = 32 / 200 **M1**

(a) 0.160, cao **A1**

(a) Answer: 0.160

(b) interphase is the longest part of the cell cycle, during which the cell grows and replicates its DNA, so at any moment most cells are in interphase oe **B1**

(b) each stage of mitosis is comparatively brief, so fewer cells are 'caught' in that stage at any one time oe **B1**

(b) Answer: Interphase takes up most of the cell cycle (growth and DNA replication occur here), while each mitotic stage is brief, so far fewer cells are seen in mitosis at any snapshot in time.

(c) a higher mitotic index suggests a much greater proportion of cells are undergoing mitosis at any time, i.e. the cells are dividing more frequently/rapidly oe **B1**

(c) this suggests loss of normal control over the cell cycle (e.g. checkpoint failure, uncontrolled proliferation), characteristic of cancerous/tumour cells oe **B1**

(c) uncontrolled cell division can lead to tumour growth, so a high mitotic index is used clinically as an indicator of tumour grade/how aggressively it may grow oe **B1**

(c) Answer: A mitotic index of 0.420 suggests cells are dividing much more frequently, indicating a loss of normal cell cycle control typical of tumour cells; clinically this is used as a marker of how aggressively a tumour may grow.

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