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AS Level Biology

Topic 4: Cell Division and Transport Across Cell Membranes

AQA Biology (7401) | Mark Scheme | 100 marks

Instructions

- Answer **all** questions.
- In calculations show your working and give your answer to an appropriate number of significant figures.
- In extended-response questions you should write in clear, well-organised continuous prose.
- There are 17 questions in this paper. The total mark is **100**.

1. This question is about the cell cycle.

(a) Name the stage of the cell cycle in which DNA is replicated. **(1)**

✓ (S phase of) interphase (1)

(b) State two events, other than DNA replication, that occur during interphase. **(2)**

✓ the cell grows / increases in size (1)

✓ organelles (e.g. mitochondria) are replicated / proteins are synthesised / ATP content increases (any one) (1)

(c) Name the two main events that occur after interphase to complete the cell cycle. **(2)**

✓ mitosis (nuclear division) (1)

✓ cytokinesis (cytoplasm/cell division) (1)

2. This question is about the stages of mitosis.

(a) Describe what happens during *prophase*. **(2)**

✓ the chromosomes condense / become visible (shorter and thicker) (1)

✓ the nuclear envelope breaks down (and spindle fibres form) (1)

(b) Describe what happens during *metaphase*. **(2)**

✓ the chromosomes line up along the equator/middle of the cell (1)

✓ spindle fibres attach to the centromeres (of the chromosomes) (1)

(c) Describe what happens during *anaphase*. **(2)**

✓ the centromeres divide and the sister chromatids separate (1)

✓ the chromatids are pulled to opposite poles by the spindle fibres (1)

(d) Describe what happens during *telophase*. **(2)**

✓ the chromatids reach the poles and decondense / become longer and thinner (1)

✓ a (new) nuclear envelope re-forms around each group of chromosomes (1)

3. This question is about the importance of mitosis.

(a) State two reasons why mitosis is important to a multicellular organism. **(2)**

✓ growth (increase in cell number) (1)
✓ repair / replacement of cells / asexual reproduction (any one) (1)

(b) Explain why it is important that mitosis produces two genetically identical daughter cells. **(2)**

✓ DNA is replicated and each cell receives one copy of each chromosome (1)
✓ so the cells have the same genes / can carry out the same functions (genetic stability is maintained) (1)

4. A student examined a root tip and counted the number of cells in each stage of the cell cycle. Out of 200 cells, 160 were in interphase.

(a) Calculate the percentage of cells in interphase. **(1)**

✓ (160/200) × 100 = 80% (1)

(b) The mitotic index is the proportion of cells undergoing mitosis. Calculate the mitotic index for this sample. Give your answer to 2 decimal places. **(2)**

✓ cells in mitosis = 200 - 160 = 40 (1)
✓ mitotic index = 40/200 = 0.20 (1)

(c) Suggest what a high mitotic index in a sample of tissue might indicate. **(1)**

✓ a high rate of cell division / rapid growth (e.g. cancerous/tumour tissue) (1)

5. Uncontrolled cell division can lead to the formation of tumours.

(a) Explain how uncontrolled mitosis can lead to the formation of a tumour. **(2)**

✓ cells divide repeatedly/uncontrollably by mitosis (1)
✓ producing a mass/group of cells (a tumour) (1)

(b) Some cancer treatments work by disrupting the cell cycle. Suggest how a drug that prevents the formation of spindle fibres could be used to treat cancer. **(2)**

✓ without spindle fibres the chromosomes cannot be moved/separated (1)
✓ so mitosis cannot occur / cell division is prevented (stopping the tumour growing) (1)

6. This question is about binary fission in prokaryotic cells.

(a) Describe the process of binary fission in a prokaryotic cell. **(3)**

✓ the circular DNA replicates (and plasmids replicate) (1)
✓ the cell grows and the (two copies of the) DNA move to opposite ends/poles of the cell (1)
✓ the cytoplasm divides to produce two daughter cells (each with one copy of the circular DNA) (1)

(b) State one way in which binary fission differs from mitosis. **(1)**

✓ there is no spindle / no chromosomes (as in mitosis) / plasmids are replicated and shared (any one) (1)

7. This question is about the structure of the cell-surface membrane, described by the fluid-mosaic model.

(a) Explain why the model of the membrane is described as 'fluid'. **(1)**

✓ the phospholipids (and proteins) can move (around within the layer) / are not fixed (1)

(b) Explain why the model is described as a 'mosaic'. **(1)**

✓ the proteins are scattered/dotted throughout the bilayer (in a pattern) / vary in shape and size (1)

(c) Describe the arrangement of the phospholipids in the membrane. **(2)**

✓ they form a bilayer (two layers) (1)

✓ with hydrophilic heads facing outwards (to the water) and hydrophobic tails facing inwards (1)

(d) State the role of cholesterol in the cell-surface membrane. **(2)**

✓ it adds strength / stability / rigidity to the membrane (1)

✓ it reduces the fluidity and movement of phospholipids / makes the membrane less permeable to ions and small molecules (1)

8. Substances can cross cell membranes by diffusion.

(a) Define the term *diffusion*. **(2)**

✓ the net movement of particles from a region of higher concentration to a region of lower concentration (1)

✓ down a concentration gradient (a passive process) (1)

(b) Explain why oxygen can diffuse directly through the phospholipid bilayer. **(2)**

✓ oxygen is small and non-polar / lipid-soluble (1)

✓ so it can pass between/through the phospholipids of the bilayer (1)

(c) State three factors that affect the rate of diffusion across a membrane. **(3)**

✓ the concentration gradient (1)

✓ the thickness/diffusion distance of the membrane (1)

✓ the surface area (of the membrane) (temperature also accepted) (1)

9. This question is about facilitated diffusion.

(a) Explain why some substances must enter cells by facilitated diffusion rather than by simple diffusion through the bilayer. **(2)**

✓ they are large / polar / water-soluble / charged (e.g. ions, glucose) (1)

✓ so they cannot pass directly through the (hydrophobic) phospholipid bilayer (1)

(b) Describe how a channel protein allows ions to cross the membrane by facilitated diffusion. **(2)**

✓ the channel protein forms a (water-filled) pore through the membrane (1)

✓ specific ions move through it down their concentration gradient (1)

(c) Describe how a carrier protein transports a molecule such as glucose across the membrane by facilitated diffusion. **(2)**

✓ the molecule binds to the carrier protein, which is specific/complementary in shape (1)

✓ the protein changes shape and releases the molecule on the other side (down the gradient) (1)

10. This question is about osmosis.

(a) Define *osmosis*. **(3)**

✓ the (net) movement of water molecules (1)
✓ from a region of higher water potential to a region of lower water potential (1)
✓ through a partially permeable membrane (1)

(b) State the water potential of pure water in kPa. **(1)**

✓ 0 (kPa) (1)

(c) Explain why the addition of solute to pure water lowers its water potential. **(1)**

✓ the solute particles attract / lower the proportion of free water molecules, making the water potential more negative (1)

11. A student placed plant tissue into solutions of different concentrations and measured the change in mass.

(a) Explain what would happen to a plant cell placed in a solution with a lower (more negative) water potential than the cell. **(3)**

✓ water leaves the cell by osmosis (down the water potential gradient) (1)
✓ the cell loses mass / the cytoplasm and membrane shrink away from the wall (plasmolysis) (1)
✓ the cell becomes flaccid (1)

(b) Describe and explain what would happen to an animal cell (e.g. a red blood cell) placed in pure water. **(3)**

✓ water enters the cell by osmosis (1)
✓ because the cell has a lower (more negative) water potential than pure water (1)
✓ the cell swells and bursts (lysis), as it has no cell wall (1)

(c) In this type of experiment, the point where there is no change in mass can be used to estimate the water potential of the tissue. Explain why. **(2)**

✓ no net movement of water occurs (no change in mass) (1)
✓ so the water potential of the solution equals the water potential of the cells/tissue (1)

12. This question is about active transport.

(a) Define *active transport*. **(2)**

✓ the movement of molecules/ions from a region of lower concentration to a region of higher concentration (against the concentration gradient) (1)
✓ using ATP (energy) and carrier proteins (1)

(b) Explain why active transport requires ATP but facilitated diffusion does not. **(2)**

✓ active transport moves substances against the concentration gradient, which requires energy (1)
✓ facilitated diffusion moves substances down the gradient (a passive process, so no energy is needed) (1)

(c) Suggest why a cell that carries out a large amount of active transport contains many mitochondria. **(2)**

✓ mitochondria are the site of (aerobic) respiration, which produces ATP (1)
✓ active transport requires a (constant) supply of ATP / energy (1)

13. In the small intestine (ileum), glucose is absorbed into epithelial cells by co-transport with sodium ions.

(a) Describe how a sodium-potassium pump creates a sodium ion concentration gradient across the membrane of an epithelial cell. **(2)**

✓ sodium ions are actively transported out of the epithelial cell (into the blood) using ATP (1)
✓ this lowers the sodium ion concentration inside the cell (creating a gradient) (1)

(b) Describe how glucose is then absorbed from the gut lumen into the epithelial cell by co-transport. **(3)**

✓ sodium ions diffuse from the lumen into the cell (down their concentration gradient) through a co-transport protein (1)
✓ glucose is carried in at the same time (against its concentration gradient) (1)
✓ the energy for this comes (indirectly) from the sodium ion gradient (1)

(c) Explain why this is described as an example of indirect active transport. **(1)**

✓ glucose is moved against its gradient using the sodium ion gradient (which was set up using ATP), not ATP directly (1)

14. A student investigated the effect of solute concentration on the change in mass of potato tissue. Five potato cylinders of equal mass were placed in sucrose solutions of different concentrations for one hour.

(a) State the independent variable and the dependent variable in this investigation. **(2)**

✓ independent variable: (sucrose) solution concentration / water potential of the solution (1)
✓ dependent variable: change in mass (of the potato cylinders) (1)

(b) State two variables that should be kept constant to make this a valid investigation. **(2)**

✓ temperature (1)
✓ time in solution / volume of solution / size (surface area) of the potato cylinders (any one) (1)

(c) Explain why the student calculated the percentage change in mass rather than the actual change in mass. **(2)**

✓ the cylinders may not have had exactly the same starting mass (1)
✓ so percentage change allows a fair/valid comparison between samples (1)

(d) Describe how the student could use a graph of percentage change in mass against sucrose concentration to find the concentration at which the potato has the same water potential as the solution. **(2)**

✓ plot percentage change in mass against concentration and draw a line of best fit (1)
✓ read off the concentration where the line crosses zero change in mass (no net movement of water) (1)

15. This question is about the role of membrane proteins.

(a) Membranes contain receptor proteins. Describe the role of a receptor protein. **(2)**

✓ it binds to a specific molecule (e.g. a hormone) that is complementary in shape (1)
✓ this triggers a response inside the cell (cell signalling) (1)

(b) Some membrane proteins act as antigens. State the function of an antigen on a cell-surface membrane. **(1)**

✓ it allows the cell to be recognised (as self or non-self) by the immune system (1)

(c) Explain how increasing temperature can increase the permeability of a cell membrane. **(3)**

✓ the phospholipids gain kinetic energy and move more / move apart (1)
✓ at high temperatures the membrane proteins denature / lose their shape (1)
✓ so more substances can pass through the gaps / the membrane becomes more permeable (1)

16. This question is about meiosis and the production of gametes. (You are not required to describe the detailed stages.)

(a) State the type of cell division that produces gametes. **(1)**

✓ meiosis (1)

(b) Explain why gametes must be produced by a division that halves the chromosome number. **(2)**

✓ gametes are haploid (have half the number of chromosomes) (1)

✓ so that when two gametes fuse at fertilisation, the diploid number is restored (1)

(c) State two ways in which mitosis differs from meiosis. **(2)**

✓ mitosis produces two cells, meiosis produces four cells (1)

✓ mitosis produces genetically identical (diploid) cells, meiosis produces genetically different (haploid) cells (1)

17. This question is about adaptations of exchange surfaces involving membranes.

(a) Explain how having a large number of microvilli on the surface of an epithelial cell increases the rate of absorption. **(2)**

✓ microvilli increase the surface area of the (cell-surface) membrane (1)

✓ so there is more room for carrier/channel proteins / a faster rate of absorption (1)

(b) Explain why a cell that absorbs glucose by facilitated diffusion will absorb it faster if it has more carrier proteins in its membrane. **(2)**

✓ more carrier proteins means more sites for glucose to bind / be transported (1)

✓ so more glucose can be moved per unit time (faster rate, until another factor is limiting) (1)

(c) An epithelial cell that absorbs amino acids by active transport is found to contain many mitochondria and a folded (microvilli) membrane. Explain how each of these features increases the rate of absorption. **(4)**

✓ many mitochondria carry out (aerobic) respiration to produce ATP (1)

✓ ATP is needed for active transport (against the concentration gradient) (1)

✓ microvilli increase the surface area of the membrane (1)

✓ so more carrier/transport proteins can be present, increasing the rate of absorption (1)