1.10 Cell Division and Stem Cells: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 The cell cycle is the sequence of stages a cell goes through between one division and the next. Its three main stages are: Mitosis; Interphase; Cytokinesis (listed here in the wrong order).

(a) State the correct order in which these three stages occur in one full cell cycle. **(2)**

(b) During interphase, before mitosis begins, a cell's DNA replicates (is copied). **(2)**
Explain why the DNA must replicate before the cell divides by mitosis.

(Total for Question 1 is 4 marks)

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2 Required practical: a student prepares and views a root tip squash slide, in order to observe cells at different stages of the cell cycle in the root tip of an onion or garlic.

(a) Describe how the student should prepare the root tip squash slide, including the equipment/reagents used and one safety precaution. **(4)**

(b) Explain why the tip of the root, rather than a section further up the root, is used for this practical. **(2)**

(c) The student views the slide and counts 250 cells in the field of view. Of these, 20 cells are seen to be undergoing mitosis. Calculate the mitotic index (the percentage of cells undergoing mitosis) for this sample. **(2)**

(d) Suggest one reason why the mitotic index might be higher in cells taken from close to the root tip than in cells taken from further up the root. **(1)**

(Total for Question 2 is 9 marks)

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3 A stem cell is a type of cell found in both animals and plants.

(a) Define the term 'stem cell'. **(1)**

(b) State one difference between an embryonic stem cell and an adult stem cell, in terms of the range of cell types each can differentiate into. **(2)**

(c) State where meristem tissue (which contains plant stem cells) is found in a plant. **(2)**

(Total for Question 3 is 5 marks)

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4 Cloning by mitosis: A horticulturalist takes a cutting and induces it to grow roots and form a new plant genetically identical to the parent. Describe the cellular process that results in the new plant being genetically identical to the parent.

(a) Describe how mitosis leads to genetically identical cells that form the cloned plant. **(4)**

(Total for Question 4 is 4 marks)

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5 A required-practical style task measures plant root growth over time. Priya measures root length every 24 hours for four days and obtains: Day 0 = 5.0 mm, Day 1 = 7.2 mm, Day 2 = 9.6 mm, Day 3 = 12.0 mm, Day 4 = 14.4 mm.

(a) Calculate the mean daily increase in root length between Day 0 and Day 4. Give your answer in mm per day to two significant figures. **(3)**

(Total for Question 5 is 3 marks)

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6 Design improvement: In a cell culture experiment measuring rate of cell division, the student keeps temperature constant but forgets to control nutrient concentration. State one dependent variable, one control variable that should be kept constant, and suggest a way to control nutrient concentration.

(a) State an appropriate dependent variable for the experiment. **(1)**

(b) State one control variable that must be kept constant besides temperature. **(1)**

(c) Suggest a practical method to keep nutrient concentration the same across all cultures. **(2)**

(Total for Question 6 is 4 marks)

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7 Using stem cells to treat patients carries some medical risks.

(a) Give one medical risk associated with using stem cells to treat patients. **(1)**

(b) Suggest why using a patient's own adult stem cells, rather than stem cells from a donor, might reduce this risk. **(2)**

(Total for Question 7 is 3 marks)

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8 Explain how this difference accounts for the fact that gardeners can grow a complete new plant from a small cutting, but doctors currently cannot grow a complete new organ from a small piece of adult human tissue.

(Total for Question 8 is 3 marks)

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9 Some people argue that embryonic stem cell research should be limited. Give one scientific benefit and one ethical concern related to embryonic stem cell research.

(a) Give one scientific benefit of embryonic stem cell research and explain it. **(2)**

(b) Give one ethical concern and explain it. **(2)**

(Total for Question 9 is 4 marks)

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10 Explain the potential advantages and disadvantages of using stem cell therapy to treat a degenerative disease such as Parkinson disease. Your answer should include scientific and ethical considerations.

(Total for Question 10 is 6 marks)

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Mark scheme · 1.10 Cell Division and Stem Cells: 1-hour Pack

Question 1

(a) correctly identifies Interphase as the first stage of the cycle **B1**

(a) correctly identifies Mitosis as the second stage and Cytokinesis as the third (last) stage **B1**

(a) Answer: Interphase, then Mitosis, then Cytokinesis.

(b) each new (daughter) cell produced by mitosis needs a complete copy of the DNA/full set of chromosomes, oe **B1**

(b) so that each daughter cell is genetically identical to the parent cell (and to each other), oe **B1**

(b) Answer: Each daughter cell needs a complete copy of the DNA (full set of chromosomes) so that it is genetically identical to the parent cell.

Question 2

(a) cuts a few mm from the very tip of the root using a scalpel or mounted needle, oe **B1**

(a) places the root tip in warm, dilute hydrochloric acid for a few minutes, to soften/macerate the tissue, oe **B1**

(a) adds a stain (e.g. acetic orcein or toluidine blue) to stain the chromosomes, then squashes the tip gently under a cover slip (using a mounted needle or thumb) to spread the cells into a single layer, oe **B1**

(a) safety precaution, e.g. wears eye protection and gloves when handling the dilute acid and stain, oe **B1**

(a) Answer: Cut a few mm from the root tip; place it in warm, dilute hydrochloric acid for a few minutes to soften the tissue; add a stain such as acetic orcein; squash gently under a cover slip to spread the cells into a single layer. Wear eye protection and gloves when handling the acid and stain.

(b) the root tip contains meristem tissue, where cells are actively dividing by mitosis, oe **B1**

(b) sections further up the root contain far fewer actively dividing cells, as the cells there have already differentiated, oe **B1**

(b) Answer: The root tip contains meristem tissue, where cells actively divide by mitosis. Further up the root, most cells have already differentiated, so far fewer are dividing.

(c) (20 / 250) * 100, oe **M1**

(c) 8% cao **A1**

(c) Answer: 8%

(d) the root tip contains meristem tissue, where a much higher proportion of cells are actively dividing (undifferentiated) compared with tissue further from the tip, oe **B1**

(d) Answer: Close to the tip is meristem tissue, where a much higher proportion of cells are actively dividing, compared with tissue further from the tip, which contains mostly differentiated (non-dividing) cells.

Question 3

(a) an undifferentiated cell that can divide (by mitosis) to produce more cells, and that can differentiate into one or more types of specialised cell, oe **B1**

(a) Answer: An undifferentiated cell that can divide by mitosis and can differentiate into one or more types of specialised cell.

(b) embryonic stem cells can differentiate into almost any type of cell in the body, oe **B1**

(b) adult stem cells can only differentiate into a limited/smaller range of cell types, e.g. bone marrow stem cells can only produce different types of blood cell, oe **B1**

(b) Answer: Embryonic stem cells can differentiate into almost any type of cell in the body, whereas adult stem cells can only differentiate into a limited range of cell types (e.g. bone marrow stem cells can only produce different types of blood cell).

(c) at the tips of roots, oe **B1**

(c) at the tips of shoots, oe **B1**

(c) Answer: At the tips of roots and at the tips of shoots.

Question 4

(a) states that DNA is replicated before division **M1**

(a) states that mitosis separates identical chromatids into daughter nuclei **M1**

(a) states that cell differentiation then forms tissues and organs from these identical cells **A1**

(a) links these steps to the cloned plant being genetically identical to the parent, oe **A1**

(a) Answer: DNA is replicated, mitosis separates identical chromatids so daughter cells have the same chromosomes; these identical cells differentiate to form tissues and organs so the new plant is genetically identical.

Question 5

(a) uses difference / time: (14.4 - 5.0) / 4 **M1**

(a) evaluates calculation: 9.4 / 4 **M1**

(a) 2.35 mm per day or 2.4 mm per day to two significant figures cao **A1**

(a) Answer: 2.4 mm per day

Question 6

(a) rate of cell division measured as number of cells per unit time or increase in cell count over a fixed period, oe **B1**

(a) Answer: Rate of cell division measured as number of cells per hour.

(b) nutrient concentration or pH or oxygen supply, oe **B1**

(b) Answer: Nutrient concentration (or pH or oxygen supply).

(c) suggests a method, eg prepare a single batch of culture medium and aliquot equal volumes to each culture **M1**

(c) explains how this ensures same nutrient concentration across samples, oe **A1**

(c) Answer: Prepare one batch of culture medium and add equal volumes to each culture so each receives the same nutrient concentration.

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Question 7

(a) e.g. transfer of a viral infection from the donor/culture to the patient, or rejection of the transplanted cells by the patient's immune system, oe **B1**

(a) Answer: The transplanted cells could be rejected by the patient's immune system (or a viral infection could be transferred from the donor).

(b) the patient's own stem cells are genetically identical to the patient's own cells, oe **B1**

(b) so they are less likely to be recognised as foreign and rejected by the patient's immune system, oe **B1**

(b) Answer: The patient's own stem cells are genetically identical to the patient, so they are less likely to be recognised as foreign and rejected by the immune system.

Question 8

in plants, cells in the meristem remain able to differentiate into any type of plant cell throughout the plant's life, oe **B1**

in mature animals, most cells have already differentiated and lost the ability to change into a different cell type, oe **B1**

so a plant cutting can develop all the specialised cells/tissues of a whole new plant, but a piece of adult human tissue does not contain enough cells still able to differentiate into all the different cell/tissue types needed for a whole organ, oe **B1**

Answer: Plant meristem cells stay able to differentiate throughout the plant's life, so a cutting can grow all the specialised tissues of a new plant. Most mature animal cells have already differentiated and cannot change type, so a piece of adult human tissue cannot regrow a whole new organ.

Question 9

(a) states a benefit, eg potential to create specialised cells for therapy **M1**

(a) explains how this could treat disease or replace damaged tissues, oe **A1**

(a) Answer: Benefit: can produce specialised cells for therapy; this could replace damaged tissues in conditions such as spinal injury or diabetes.

(b) states an ethical concern, eg destruction of embryos or consent issues **M1**

(b) explains why this is a concern, for example belief that embryos have moral status or concerns about exploitation, oe **A1**

(b) Answer: Concern: involves destruction of embryos; some people believe embryos have moral status and this raises ethical objections.

Question 10

Level 3 Detailed explanation including several scientific advantages and disadvantages and ethical considerations. Clear reasoning linking how stem cells can replace damaged neurons, possible risks such as immune rejection or tumour formation, and ethical issues with embryonic cells; balanced conclusion. **5-6**

Level 2 Some explanation of scientific advantages and disadvantages and at least one ethical point. Partial linkage between science and ethics, but lacking balance or detail. **3-4**

Level 1 Simple statements about advantages or disadvantages with little or no development or ethical consideration. **1-2**

Indicative content:

- Advantage: stem cells can differentiate into neurons to replace lost cells and restore function
- Advantage: potential to target specific damaged areas, reducing symptoms or slowing progression
- Disadvantage: risk of immune rejection if cells are not patient derived
- Disadvantage: possibility of uncontrolled growth or tumour formation from stem cell implants
- Ethical: use of embryonic stem cells involves destruction of embryos and raises moral objections
- Ethical: adult stem cells avoid embryo issues but may be less versatile
- Consideration: need for long-term studies, informed consent and regulation
- Consideration: balance potential patient benefit against ethical concerns and safety risks

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