B1bD Cell Division and Stem Cells: Exam Drill

AQA 8464 · Calculator allowed · about 90 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Cells divide by two main processes: mitosis and meiosis. Answer the following.

(a) State one purpose of mitosis in multicellular organisms. **(1)**

(b) Give one way in which a gamete differs from a body cell. **(1)**

(c) Explain why mitosis produces two genetically identical daughter cells. **(2)**

(Total for Question 1 is 4 marks)

2 The cell cycle has several stages including interphase and mitosis. Name two events that occur during interphase.

(a) Name an event that occurs during interphase (first event). **(1)**

(b) Name another event that occurs during interphase (second event). **(2)**

(Total for Question 2 is 3 marks)

3 A student examines onion root tips to estimate the proportion of cells in mitosis. She observes 18 cells in mitosis and 162 cells not in mitosis.

(a) Calculate the mitotic index for the sample. Give your answer as a percentage to two significant figures. **(3)**

.....

(Total for Question 3 is 3 marks)

---

4 A second student examines a different onion root tip sample. She counts 24 cells in mitosis out of a total of 160 cells.

(a) Calculate the mitotic index for this sample. Give your answer as a percentage to one decimal place. **(3)**

.....

(b) State whether this mitotic index is higher or lower than the one calculated in question 3, and give a reason. **(1)**

(Total for Question 4 is 4 marks)

---

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)

6 Stem cells can be classified as embryonic stem cells or adult stem cells. Answer briefly.

(a) State one characteristic of embryonic stem cells. **(1)**

(b) State one limitation of adult stem cells compared with embryonic stem cells. **(1)**

(Total for Question 6 is 2 marks)

---

7 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 7 is 4 marks)

---

8 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 8 is 4 marks)

9 A population of stem cells divides every 12 hours. Starting with 250 stem cells, calculate how many cells there will be after 48 hours, assuming each division doubles the number of cells and no cells die.

(a) Calculate the number of cells after 48 hours. **(3)**

.....

(Total for Question 9 is 3 marks)

---

10 The graph below shows the number of cells in culture measured each day for five days: Day 0: 1.0×10^4 cells, Day 1: 1.8×10^4, Day 2: 3.2×10^4, Day 3: 5.6×10^4, Day 4: 10.0×10^4. Use the data to answer the following.

(a) Calculate the fold increase in cell number between Day 0 and Day 4. Give your answer to two significant figures. **(2)**

.....

(b) Comment briefly why growth appears approximately exponential over these days. **(2)**

(Total for Question 10 is 4 marks)

---

11 Error analysis: In a mitotic index experiment, Callum stains cells and counts phases but forgets to use the same magnification for all slides. State one likely effect of this error on the mitotic index results and explain why.

(a) State one likely effect of using different magnifications on different slides. **(1)**

(b) Explain why different magnifications cause this effect. **(2)**

(Total for Question 11 is 3 marks)

12 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 12 is 4 marks)

---

13 A single zygote undergoes mitotic divisions to form a ball of cells. If the zygote divides 6 times, how many cells are present? Show your working.

(a) Calculate the number of cells after 6 divisions starting from one zygote. **(4)**

.....

(Total for Question 13 is 4 marks)

---

14 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 14 is 6 marks)

15 Flow cytometry data: A researcher measures cell cycle distribution in a sample and reports 60% of cells in G1 phase, 25% in S phase and 15% in G2/M. If the sample has 2.4×10^6 cells overall, calculate how many cells are in S phase. Show working.

(a) Calculate the number of cells in S phase and give your answer in standard form where appropriate. **(4)**

.....

(Total for Question 15 is 4 marks)

---

16 Stretch question: A tumour suppressor gene normally prevents uncontrolled cell division. A mutation causes a loss of function in the suppressor gene. Explain how this mutation can lead to cancer. Include reference to cell cycle control and genetic changes.

(a) Explain how loss of function mutation in a tumour suppressor gene may lead to cancer. **(5)**

(Total for Question 16 is 5 marks)

Mark scheme · B1bD Cell Division and Stem Cells: Exam Drill

Question 1

- (a) **B1** growth or repair of tissues or replacement of cells, oe cao
- **(a) Answer: Growth, repair or replacement of cells.**
- (b) **B1** has half the number of chromosomes (haploid) compared with body cell (diploid) or is involved in sexual reproduction, oe
- **(b) Answer: A gamete is haploid (half the chromosome number) compared with a body cell.**
- (c) **M1** chromosomes are copied during DNA replication before division
- (c) **A1** each daughter cell receives an identical set of chromosomes so they are genetically identical, oe
- **(c) Answer: Because chromosomes are replicated before division and each daughter cell receives an identical set of chromosomes.**

Question 2

- (a) **B1** DNA replication (duplication of chromosomes) cao
- **(a) Answer: DNA replication.**
- (b) **B1** cell growth or increased organelle number or protein synthesis, oe
- (b) **B1** metabolic activity such as respiration increased, oe
- **(b) Answer: Cell growth and increased organelle number.**

Question 3

- (a) **M1** correct method: mitotic index = number in mitosis / total cells
- (a) **M1** substitutes numbers: 18 / (18 + 162)
- (a) **A1** 10.0% cao
- **(a) Answer: 10.0%**

Question 4

- (a) **M1** correct method: mitotic index = number in mitosis / total cells
- (a) **M1** substitutes numbers: 24 / 160
- (a) **A1** 15.0% cao
- **(a) Answer: 15.0%**
- (b) **B1** states higher, since 15.0% is greater than the 10.0% found in question 3 oe
- **(b) Answer: Higher: 15.0% is greater than the 10.0% found in question 3, so a greater proportion of cells in this sample were undergoing mitosis.**

Question 5

- (a) **M1** uses difference / time: (14.4 - 5.0) / 4
- (a) **M1** evaluates calculation: 9.4 / 4
- (a) **A1** 2.35 mm per day or 2.4 mm per day to two significant figures cao
- **(a) Answer: 2.4 mm per day**

Question 6

- (a) **B1** pluripotent or can differentiate into many different cell types, oe cao
- **(a) Answer: Pluripotent; they can differentiate into many different cell types.**
- (b) **B1** less versatile or multipotent only, so can become fewer cell types, oe cao
- **(b) Answer: They are less versatile (multipotent) and can become fewer cell types.**

Question 7

- (a) **M1** states a benefit, eg potential to create specialised cells for therapy
- (a) **A1** explains how this could treat disease or replace damaged tissues, oe
- **(a) Answer: Benefit: can produce specialised cells for therapy; this could replace damaged tissues in conditions such as spinal injury or diabetes.**
- (b) **M1** states an ethical concern, eg destruction of embryos or consent issues
- (b) **A1** explains why this is a concern, for example belief that embryos have moral status or concerns about exploitation, oe
- **(b) Answer: Concern: involves destruction of embryos; some people believe embryos have moral status and this raises ethical objections.**

Question 8

- (a) **B1** rate of cell division measured as number of cells per unit time or increase in cell count over a fixed period, oe
- **(a) Answer: Rate of cell division measured as number of cells per hour.**
- (b) **B1** nutrient concentration or pH or oxygen supply, oe
- **(b) Answer: Nutrient concentration (or pH or oxygen supply).**
- (c) **M1** suggests a method, eg prepare a single batch of culture medium and aliquot equal volumes to each culture
- (c) **A1** explains how this ensures same nutrient concentration across samples, oe
- **(c) Answer: Prepare one batch of culture medium and add equal volumes to each culture so each receives the same nutrient concentration.**

Question 9

- (a) **M1** correct method: number after n divisions = initial x 2^n with n = 48/12 = 4
- (a) **M1** substitutes: 250 x 2^4
- (a) **A1** 4000 cells cao
- **(a) Answer: 4000 cells**

Question 10

- (a) **M1** correct method: fold increase = Day4 / Day0
- (a) **A1** 10.0 x 10^4 / 1.0 x 10^4 = 10 or 1.0 x 10^1 -> 10 to two sig fig cao
- **(a) Answer: 10**
- (b) **M1** states that each cell divides to produce two daughter cells so population doubles repeatedly
- (b) **A1** links repeated doubling to exponential increase in cell numbers, oe
- **(b) Answer: Because cells divide repeatedly and each division increases the number of cells so the population doubles repeatedly, producing exponential growth.**

Question 11

- (a) **B1** counts would be inconsistent or mitotic index could be over or under estimated, oe
- **(a) Answer: The mitotic index results would be inconsistent, possibly over or under estimated between slides.**
- (b) **M1** states that different magnifications change the field of view and apparent cell size or number
- (b) **A1** explains that more or fewer cells will be visible at once leading to inconsistent counts and hence wrong mitotic index, oe
- **(b) Answer: Different magnifications change the field of view and apparent cell size so more or fewer cells are visible, causing inconsistent counts and incorrect mitotic index values.**

Question 12

- (a) **M1** states that DNA is replicated before division
- (a) **M1** states that mitosis separates identical chromatids into daughter nuclei
- (a) **A1** states that cell differentiation then forms tissues and organs from these identical cells
- (a) **A1** links these steps to the cloned plant being genetically identical to the parent, oe
- **(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 13

- (a) **M1** correct method: cells = 1 x 2^6
- (a) **M1** evaluates $2^6 = 64$
- (a) **M1** substitutes: 1 x 64
- (a) **A1** 64 cells cao
- **(a) Answer: 64 cells**

Question 14

- **Level 3** (5-6): 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.
- **Level 2** (3-4): Some explanation of scientific advantages and disadvantages and at least one ethical point. Partial linkage between science and ethics, but lacking balance or detail.
- **Level 1** (1-2): Simple statements about advantages or disadvantages with little or no development or ethical consideration.
- **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

Question 15

- (a) **M1** uses percentage method: 25% of 2.4 x 10^6
- (a) **M1** converts percentage to fraction: 0.25 x 2.4 x 10^6
- (a) **M1** evaluates multiplication: 0.25 x 2.4 = 0.6
- (a) **A1** 0.6 x 10^6 = 6.0 x 10^5 cells cao
- **(a) Answer: 6.0 x 10^5 cells**

Question 16

- (a) **M1** states that tumour suppressor proteins normally inhibit cell cycle progression or promote DNA repair/apoptosis
- (a) **M1** states that loss of function removes this inhibition so cells can divide unchecked
- (a) **M1** mentions accumulation of additional mutations or genomic instability as a consequence
- (a) **A1** explains that uncontrolled cell division leads to tumour formation and spread, oe
- (a) **A1** may include reference to failure of apoptosis or failure to repair DNA increasing cancer risk, oe
- **(a) Answer: Loss of tumour suppressor removes inhibition of the cell cycle or reduces DNA repair/apoptosis, allowing cells with DNA damage to divide unchecked and accumulate further mutations, leading to tumour formation.**