



Cells (Continuity and change) practice questions

21 questions • 68 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 / 68

Cell and nuclear division **Spec D2.1**

1 PAPER 1A STYLE [1 mark]

What achieves the splitting of the cytoplasm during cytokinesis in a plant cell?

- A. ☐ A ring of contractile actin and myosin proteins pinching the cell membrane inwards
- B. ☐ Vesicles that assemble sections of membrane and cell wall across the cell
- C. ☐ Spindle microtubules pulling the two halves of the cell apart
- D. ☐ The nuclear membrane re-forming across the middle of the cell

2 PAPER 1A STYLE [1 mark]

In a micrograph of a root tip, a cell shows two groups of V-shaped chromosomes moving towards opposite poles. Which phase of mitosis is the cell in?

- A. ☐ Prophase
- B. ☐ Metaphase
- C. ☐ Anaphase
- D. ☐ Telophase

3 PAPER 1A STYLE [1 mark]

An organism has a diploid number of 8. How many different combinations of chromosomes can be produced in its gametes by random orientation of bivalents alone?

- A. ☐ 4
- B. ☐ 8
- C. ☐ 16
- D. ☐ 256

4 PAPER 2A STYLE [3 marks]

Explain why cytokinesis is usually equal, and outline one example of unequal cytokinesis.

5 PAPER 2A STYLE

[4 marks]

Explain how non-disjunction can lead to a child with Down syndrome.

6 PAPER 1B STYLE

[5 marks]

HL only

Students counted cells in micrographs of normal tissue and of a tumour from the same organ (the data are for practice). (a) Calculate the mitotic index of the normal tissue. [1] (b) Calculate the mitotic index of the tumour tissue. [1] (c) Deduce, with a reason, which tissue is proliferating faster. [1] (d) Suggest two reasons why the mitotic index of a sample might be inaccurate. [2]

Cells counted in five fields of view			
Tissue	Cells in interphase	Cells in mitosis	Total cells
Normal	475	25	500
Tumour	352	88	440

Answer =

7 PAPER 2A STYLE

[4 marks]

HL only

Outline what happens during interphase and how cyclins control progression through the cell cycle.

8 PAPER 2B STYLE

[7 marks]

Explain how meiosis halves the chromosome number and produces genetically different haploid nuclei.

Gene expression Spec D2.2 HL only

9 PAPER 1A STYLE

[1 mark]

HL only

Which statement correctly compares a liver cell and a skin cell from the same person?

- A. ☐ They have different genomes and the same proteome
- B. ☐ They have the same genome and different transcriptomes
- C. ☐ They have the same transcriptome and different proteomes
- D. ☐ They have different genomes and different transcriptomes

HL only

What is the effect of methylation of cytosine bases in the promoter of a gene?

- A. ☐ The base sequence of the gene is changed
- B. ☐ Transcription of the gene is repressed
- C. ☐ Translation of the mRNA is increased
- D. ☐ The mRNA is broken down more quickly by nucleases

HL only

Outline two ways in which a cell can regulate the amount of a protein it produces.

.....

.....

.....

.....

.....

.....

.....

HL only

Researchers measured differences in DNA methylation between the two members of pairs of monozygotic twins. A higher score means the twins' methylation patterns are more different (the data are for practice). (a) Describe the trend shown by the data. [1] (b) Explain why monozygotic twins are used to investigate the effect of the environment on gene expression. [2] (c) Suggest why twins who had lived apart for longer showed larger differences. [1]

Difference in methylation between members of twin pairs (arbitrary units, means)

Age of twins / years	Mean difference in methylation	Mean years lived apart
3	0.8	0
18	1.9	1
35	3.4	14
50	4.6	27

.....

.....

.....

.....

.....

.....

.....

13 PAPER 2A STYLE

[3 marks]

HL only

Explain how the presence of lactose changes gene expression in *E. coli*.

[illegible]

14 PAPER 2B STYLE

[6 marks]

HL only

Explain how epigenetic tags can affect the phenotype of cells and offspring without changing the genotype. Refer to tignons and ligers in your answer.

This image shows a full page of primary-ruled notebook paper. It features ten sets of horizontal lines across the page. Each set consists of three lines: a solid top line, a dashed middle line, and a solid bottom line. The lines are evenly spaced and extend from the left margin to the right edge of the page. There are no margins or other markings present.

Water potential Spec D2.3

15 PAPER 1A STYLE

[1 mark]

A cell is placed in a solution that is isotonic to its cytoplasm. Which statement is correct?

- A. ☐ No water molecules cross the cell membrane
- B. ☐ Water moves into and out of the cell at equal rates
- C. ☐ Water moves into the cell faster than it leaves
- D. ☐ Water moves out of the cell faster than it enters

16 PAPER 1A STYLE

[1 mark]

HL only

Where would a negative pressure potential be found?

- A. ☐ In a turgid leaf mesophyll cell
- B. ☐ In a plasmolysed epidermal cell
- C. ☐ In xylem vessels transporting sap under tension
- D. ☐ In a beaker of pure water at atmospheric pressure

[illegible]

Percentage change in mass of potato cylinders		
Sucrose concentration / mol dm ⁻³	Mean percentage change in mass / %	Standard error / %
0.0	+18.0	1.1
0.2	+7.5	0.9
0.4	-3.0	2.6
0.6	-11.5	1.0
0.8	-17.0	1.2

[illegible]

19 PAPER 2A STYLE

[4 marks]

Compare and contrast the effects of a hypotonic medium on a red blood cell and on a plant cell, and explain why fluids given intravenously are isotonic.

20 PAPER 2A STYLE

[3 marks]

HL only

Cell X has a solute potential of -900 kPa and a pressure potential of $+350$ kPa. Adjacent cell Y has a water potential of -700 kPa. (a) Calculate the water potential of cell X. [1] (b) Deduce the direction of net water movement between the cells and explain your answer in terms of potential energy. [2]

Answer =

21 PAPER 2B STYLE

[5 marks]

HL only

Explain, in terms of solute potential and pressure potential, the changes that occur when plant tissue is bathed in a hypertonic solution.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [1]

B B

2. [1]

C C

3. [1]

C C ($2^4 = 16$, since $n = 4$)

4. [3]

- each daughter cell must receive at least one mitochondrion / chloroplast / organelles that can only be made by division of pre-existing ones [1]
- each daughter cell receives a nucleus / enough cytoplasm to survive OWTTE [1]
- oogenesis: almost all cytoplasm passes to the (secondary) oocyte / ovum, small polar bodies formed [1]
- OR budding in yeast: a small bud receives a nucleus and pinches off from the larger parent cell [1]
- max 3

5. [4]

- non-disjunction is failure of chromosomes / chromatids to separate in meiosis [1]
- homologous chromosomes fail to separate in meiosis I / sister chromatids fail to separate in meiosis II [1]
- a gamete receives two copies of chromosome 21 / 24 chromosomes [1]
- fertilised by a normal gamete with 23 chromosomes [1]
- zygote has three copies of chromosome 21 / trisomy 21 / 47 chromosomes [1]
- max 4

6. [5] **HL only**

- (a) $25 \div 500 = 0.05$ [1]
- (b) $88 \div 440 = 0.20$ [1] Accept answers as percentages (5%, 20%)
- (c) tumour, because a higher proportion of its cells are in mitosis / higher mitotic index [1] ECF from (a) and (b)
- (d) difficulty identifying early prophase / late telophase / cells overlapping [1]
- only a small number of fields / cells counted, not representative [1]
- cells counted twice / missed when counting [1]
- max 2 for (d)

7. [4] **HL only**

- interphase consists of G1, S and G2 [1]
- metabolically active / biosynthesis of proteins and other components / cell grows (in G1 and G2) [1]
- DNA is replicated in S phase [1]
- number of mitochondria / chloroplasts increases by growth and division [1]
- concentrations of different cyclins rise and fall during the cycle [1]
- a threshold level of a specific cyclin is needed to pass each checkpoint [1]
- max 4

8. [7]

- DNA is replicated before meiosis so each chromosome has two (sister) chromatids [1]
- chromosomes condense by supercoiling (around histones) [1]
- homologous chromosomes pair to form bivalents in prophase I [1]
- crossing over between non-sister chromatids at chiasmata [1]
- produces new combinations of alleles / recombinant chromatids [1]
- bivalents line up at the equator in metaphase I in random orientation [1]
- orientation of each bivalent is independent of the others, giving 2^n combinations [1]
- spindle microtubules / motor proteins move chromosomes to the poles [1]
- homologous chromosomes separate in meiosis I / first segregation, halving the chromosome number [1]
- sister chromatids separate in meiosis II / second segregation [1]
- four haploid nuclei are produced from one diploid nucleus [1]
- max 7

9. [1] HL only

B B

10. [1] HL only

B B

11. [4] HL only

- transcription factors bind to specific base sequences in DNA [1]
- at the promoter, where RNA polymerase binds [1]
- activators binding to enhancers increase transcription / repressors decrease it [1]
- control of the rate of mRNA degradation (by nucleases) [1]
- mRNA may persist for minutes up to days [1]
- longer-lasting mRNA can be translated more times, so more protein is made [1]
- max 4

12. [4] HL only

- (a) difference in methylation increases with age (and years lived apart) [1]
- (b) monozygotic twins have identical genomes / same base sequences [1]
- so differences in methylation / gene expression must be caused by the environment [1]
- (c) more time in different environments / diets / exposures to pollutants alters methyl tags differently [1]

13. [3] HL only

- without lactose, a repressor protein binds to the operator (of the lac operon) [1]
- this blocks RNA polymerase so the genes are not transcribed [1]
- lactose / allolactose binds to the repressor, changing its shape [1]
- repressor detaches from the operator, so RNA polymerase transcribes the genes [1]
- enzymes for uptake / breakdown of lactose / β -galactosidase are produced [1]
- max 3

14. [6] HL only

- epigenetic tags do not change the base sequence of DNA, so the genotype is unchanged [1]
- methylation of cytosine in a promoter represses transcription [1]
- methylation of histones can repress or activate transcription [1]
- changes the pattern of gene expression / which proteins are made, so changes the phenotype [1]
- patterns of tags lead to differentiation / epigenesis [1]
- tags can remain in place during mitosis / be passed to daughter cells [1]
- most but not all tags are removed from the ovum and sperm [1]
- so some tags pass to offspring / effect depends on which parent an allele came from (imprinting) [1]
- liger (male lion × tigress) is larger than tigon (male tiger × lioness) though both have lion and tiger genes [1]
- strong paternal growth-promoting imprinting from the lion father is not balanced by the weaker maternal growth-restraining imprinting of a tigress OWTTE [1]
- tigon: strong maternal growth restraint from the lioness and weak paternal growth promotion from the tiger, so not enlarged [1]
- max 6

15. [1]

B B

16. [1] HL only

C C

17. [3]

- water molecules are polar / have δ^+ hydrogen and δ^- oxygen [1]
- Na^+ ions are attracted to the δ^- oxygen of water molecules [1]
- Cl^- ions are attracted to the δ^+ hydrogen of water molecules [1]
- glucose is polar and forms hydrogen bonds with water molecules [1]
- each solute particle becomes surrounded by water molecules / solvation [1]
- max 3

18. [6]

- (a) $(1.76 - 1.60) \div 1.60 \times 100 = +10\%$ [1]
- (b) isotonic point is where percentage change is zero / line crosses the x-axis [1]
- between 0.2 and 0.4 mol dm^{-3} , about 0.34 mol dm^{-3} [1] Accept 0.32 – 0.36
- (c) standard error shows how precisely the mean is known / how close the sample mean is likely to be to the true mean [1] Do not accept spread of the data alone (that is standard deviation)
- 0.4 mol dm^{-3} , as it has the largest standard error [1]
- (d) one of: temperature / size or surface area of cylinders / source of potato / time / volume of solution / blotting method [1]

19. [4]

- both: water enters the cell by osmosis [1]
- red blood cell swells and may burst / haemolysis, as it has no cell wall [1]
- plant cell becomes turgid / develops turgor pressure, but the cell wall prevents bursting [1]
- isotonic IV fluids cause no net water movement into or out of blood cells [1]
- so blood cells do not burst or crenate / shrink [1]
- max 4

20. [3] HL only

- (a) $\psi_w = -900 + 350 = -550 \text{ kPa}$ [1]
- (b) from X to Y [1] ECF from (a)
- water moves from higher (less negative) to lower water potential / to where it has lower potential energy [1]

21. [5] HL only

- $\psi_w = \psi_s + \psi_p$ [1]
- the solution has a lower / more negative water potential than the cells [1]
- water leaves the cells by osmosis (from higher to lower water potential) [1]
- solute potential of the cells becomes more negative as cell sap becomes more concentrated [1]
- pressure potential falls (to zero) as the protoplast stops pushing on the wall / cells become flaccid [1]
- plasmolysis: the membrane pulls away from the cell wall [1]
- net water loss stops when the water potential of the cells equals that of the solution [1]
- tissue loses mass / becomes shorter / softer [1]
- max 5