



Cells (Unity and diversity) practice questions

23 questions • 74 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 / 74

Origins of cells

Spec A2.1

HL only

1 PAPER 1A STYLE

[1 mark]

HL only

Which feature of the early Earth allowed high levels of ultraviolet light to reach the surface?

- A. ☐ High concentrations of methane in the atmosphere
- B. ☐ The absence of free oxygen, so no ozone layer could form
- C. ☐ High temperatures caused by the greenhouse effect
- D. ☐ Frequent volcanic eruptions releasing water vapour

2 PAPER 1A STYLE

[1 mark]

HL only

Which observation supports the hypothesis that RNA was the first genetic material?

- A. ☐ DNA is chemically more stable than RNA.
- B. ☐ Ribosomal RNA catalyses the formation of peptide bonds.
- C. ☐ RNA contains the base uracil instead of thymine.
- D. ☐ mRNA carries the genetic code from the nucleus to the ribosomes.

3 PAPER 1A STYLE

[1 mark]

HL only

Which observation is the strongest evidence that all living organisms share a last universal common ancestor?

- A. ☐ All organisms need liquid water.
- B. ☐ Almost all organisms use the same genetic code.
- C. ☐ Fossil microorganisms occur in rocks 3.5 billion years old.
- D. ☐ Some organisms live near hydrothermal vents.

HL only

Students repeated a spark-discharge experiment based on the Miller-Urey method, using two gas mixtures with and without electric sparks. Each flask was run for 7 days and the liquid was then analysed by chromatography. The data are for practice and are not from a real study. (a) Identify the flask that produced the greatest variety of amino acids. [1] (b) Calculate how many times greater the total yield of amino acids was in flask 1 than in flask 3. [1] (c) State the purpose of flask 2. [1] (d) Many scientists now think the early atmosphere contained mainly CO₂, N₂ and water vapour. Evaluate the extent to which these data support the hypothesis that amino acids formed spontaneously on the early Earth. [3]

Amino acids produced by spark discharge (practice data)				
Flask	Gas mixture	Sparks	Number of different amino acids detected	Total yield of amino acids / mg
1	CH ₄ , NH ₃ , H ₂ , H ₂ O	yes	11	24.0
2	CH ₄ , NH ₃ , H ₂ , H ₂ O	no	0	0.0
3	CO ₂ , N ₂ , H ₂ O	yes	3	0.6
4	CO ₂ , N ₂ , H ₂ O	no	0	0.0

[illegible]

HL only

Outline the reasons that viruses are considered to be non-living. [3]

[illegible]

PAPER 2A STYLE

HL only

[illegible]

PAPER 2A STYLE

HL only

[illegible]

PAPER 2B STYLE

HL only

[illegible]

Cell structure Spec A2.2

- 9** PAPER 1A STYLE [1 mark]
- Which cell normally has no nucleus when it is mature?
- A. ☐ Skeletal muscle fibre
 - B. ☐ Aseptate fungal hypha
 - C. ☐ Phloem sieve tube element
 - D. ☐ Phloem companion cell
- 10** PAPER 1A STYLE [1 mark]
- Which structure in Paramecium is mainly involved in homeostasis?
- A. ☐ Cilia
 - B. ☐ Contractile vacuole
 - C. ☐ Food vacuole
 - D. ☐ Oral groove
- 11** PAPER 1A STYLE [1 mark]
- HL only**
- What is the basis of cell differentiation in a multicellular organism?
- A. ☐ Loss of the genes that a cell does not need
 - B. ☐ Different patterns of gene expression
 - C. ☐ Mutations that occur during development
 - D. ☐ Different numbers of chromosomes in each cell type

Diameters of five cheek cells (practice data)

Answer =

[illegible]

Answer =

[illegible]

14 PAPER 2A STYLE

[4 marks]

Distinguish between the structure of a Gram-positive bacterium, such as Staphylococcus, and an animal cell. [4]

15 PAPER 2A STYLE

[4 marks]

Outline the advantages of cryogenic electron microscopy and of immunofluorescence for studying cells. [4]

16 PAPER 2B STYLE

[6 marks]

HL only

Explain the evidence that mitochondria and chloroplasts originated by endosymbiosis. [6]

Viruses

Spec A2.3

HL only

17

PAPER 1A STYLE

[1 mark]

HL only

Which feature is shared by all viruses?

- A. ☐ An envelope derived from host cell membrane
- B. ☐ A capsid made of protein
- C. ☐ Double-stranded DNA
- D. ☐ The enzyme reverse transcriptase

18

PAPER 1A STYLE

[1 mark]

HL only

During the lysogenic cycle of bacteriophage lambda, what happens to the viral DNA?

- A. ☐ It is packed into new capsids straight away.
- B. ☐ It is transcribed to make enzymes that lyse the cell.
- C. ☐ It is integrated into the host chromosome and replicated when the host divides.
- D. ☐ It is broken down by host enzymes.

The viral load (number of copies of HIV RNA per cm³ of blood) was monitored in two groups of patients. One group took a single antiviral drug and the other took a combination of three drugs with different targets. The data are for practice. (a) Calculate the percentage decrease in viral load in the single-drug group between week 0 and week 8. [1] (b) Describe the trend in viral load in the single-drug group after week 8. [1] (c) Explain the change in viral load in the single-drug group after week 8. [2] (d) Suggest why the viral load stayed low in the combination group. [2]

Viral load in patients with HIV (practice data)		
Time / weeks	Single drug / copies per cm ³	Three-drug combination / copies per cm ³
0	100 000	100 000
4	2 000	1 500
8	1 500	200
12	9 000	below 50
16	40 000	below 50
24	90 000	below 50

Answer =

[illegible]

Compare and contrast the structure of bacteriophage lambda and HIV. [4]

[illegible]

Mark scheme

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

1. [1] **HL only**

B B [1]

2. [1] **HL only**

B B [1]

3. [1] **HL only**

B B [1]

4. [6] **HL only**

- (a) flask 1 / CH₄, NH₃, H₂ and H₂O with sparks [1]
- (b) $24.0 \div 0.6 = 40$ (times) [1]
- (c) control / shows that the energy from sparks is needed for amino acids to form / shows the amino acids are not contaminants OWTTE [1]
- (d) amino acids formed from inorganic gases when energy was supplied, so spontaneous formation is possible [1]
- (d) but with the mixture closest to the likely early atmosphere (flask 3) only 3 types / 0.6 mg formed / yield 40 times lower [1]
- (d) so the mixture in flask 1 may not represent early Earth and support is limited [1]
- (d) only monomers were tested / no polymers or cells formed [1]
- (d) no repeats shown / one trial per condition, so reliability is unknown [1]
- (d) sparks may not represent other early energy sources such as ultraviolet light OWTTE [1]
- max 3 for (d)

5. [3] **HL only**

- not made of cells / have no cytoplasm / no plasma membrane of their own [1]
- no metabolism of their own / do not respire / produce no ATP [1]
- have few or no enzymes [1]
- cannot reproduce independently / only reproduce inside a host cell [1]
- rely on host ribosomes for protein synthesis [1]
- do not grow / no homeostasis / no excretion [1]
- max 3

6. [3] **HL only**

- fatty acids are amphipathic / have a hydrophilic head and a hydrophobic tail [1]
- in water they coalesce into a bilayer with the tails inside, away from water [1]
- the bilayer closes into a sphere / vesicle without enzymes or an energy input [1]
- this forms a membrane-bound compartment [1]
- so the internal chemistry can become different from that outside [1]
- molecules such as RNA are concentrated inside, so they react more often [1]
- max 3

7. [4] HL only

- (a) molecular clock: number of base differences in conserved genes, assuming a roughly constant rate of mutation [1]
- (a) molecular clock calibrated using dated fossils [1]
- (a) radiometric dating of rocks containing the oldest fossils / microfossils / stromatolites [1]
- (a) carbon isotope ratios: rocks enriched in carbon-12 indicate biological activity [1]
- max 2 for (a)
- (b) fossilised microbe-like filaments / tubes found in ancient sea-floor hydrothermal vent precipitates [1]
- (b) genomic analysis of conserved sequences / genes traced back to LUCA [1]
- (b) these genes suit vent conditions: anaerobic / high temperature / use of H_2 and CO_2 / iron-sulfur proteins [1]
- max 2 for (b)

8. [7] HL only

- cells today only arise by division of pre-existing cells, so the first cells must have arisen another way [1]
- carbon compounds formed spontaneously on the early Earth [1]
- catalysis was needed to speed up reactions [1]
- early catalysts could have been RNA / ribozymes / mineral surfaces [1]
- self-replication of molecules was needed so that information could be inherited [1]
- RNA can be replicated by complementary base pairing [1]
- RNA could act as both the genetic material and an enzyme [1]
- self-assembly of molecules into larger structures / polymers / membranes [1]
- compartmentalisation: a membrane enclosed the molecules [1]
- fatty acids form vesicles spontaneously [1]
- allowing the internal chemistry to differ from the outside [1]
- scientific hypotheses must be testable [1]
- the exact conditions on pre-biotic Earth cannot be replicated [1]
- the first protocells did not fossilise, so there is no direct evidence [1]
- max 7

9. [1]

C C [1]

10. [1]

B B [1]

11. [1] HL only

B B [1]

12. [5]

- (a) $100\text{ }\mu\text{m} \div 40 = 2.5\text{ }\mu\text{m}$ [1]
- (b) mean = $(22 + 25 + 24 + 26 + 23) \div 5 = 24$ eyepiece units [1]
- (b) $24 \times 2.5 = 60\text{ }\mu\text{m}$ [1] ECF from (a)
- (c) the eyepiece scale does not change size but the specimen is magnified less, so one eyepiece unit represents a different (larger) length of specimen OWTTE [1] Accept $10\text{ }\mu\text{m}$ at $\times 100$
- (d) cells vary in size, so a mean is more representative / reduces the effect of one unusual cell / random error [1]

13. [3]

- (a) $20\text{ mm} = 20\text{ }000\text{ }\mu\text{m}$ [1]
- (a) $20\text{ }000 \div 0.5 = \times 40\text{ }000$ [1]
- (b) $60\text{ }000\text{ }\mu\text{m} \div 40\text{ }000 = 1.5\text{ }\mu\text{m}$ [1] ECF from (a)

14. [4]

- bacterium has no nucleus / DNA in a nucleoid region, whereas the animal cell has a nucleus with a double membrane and pores [1]
- bacterial DNA is naked / not bound to histones, whereas eukaryotic DNA is bound to histones [1]
- bacterial DNA is a single loop / circular, whereas eukaryotic chromosomes are linear [1]
- 70S ribosomes in the bacterium, 80S ribosomes in the animal cell cytoplasm [1]
- bacterium has a cell wall (of peptidoglycan); the animal cell has none [1]
- no membrane-bound organelles in the bacterium; the animal cell has mitochondria / ER / Golgi apparatus / lysosomes [1]
- bacterial cytoplasm is not compartmentalised [1]
- bacterium is smaller [1]
- max 4. Do not accept 'bacteria have no DNA'.

15. [4]

- cryo-EM: rapid freezing preserves molecules in their natural shape / without ice crystals [1]
- cryo-EM: many images are combined by computer to give a 3D structure [1]
- cryo-EM: near-atomic resolution / proteins need not be crystallised / used for membrane proteins or virus capsids [1]
- immunofluorescence: fluorescently tagged antibodies bind specific proteins / antigens [1]
- immunofluorescence: shows the location of a specific protein within the cell [1]
- immunofluorescence: several proteins can be labelled in different colours at once / used with a light microscope [1]
- max 4, with at least one point for each technique

16. [6] HL only

- mitochondria and chloroplasts descended from prokaryotes taken into a larger cell by endocytosis [1]
- all eukaryotes descend from a common ancestor with a nucleus, which then gained mitochondria [1]
- chloroplasts were gained later, in some eukaryotes only (algae and plants) [1]
- they have 70S ribosomes, like prokaryotes [1]
- unlike the 80S ribosomes in the eukaryotic cytoplasm [1]
- they have naked circular DNA, like prokaryotes [1]
- not linear chromosomes bound to histones [1]
- they can replicate / divide by a process like binary fission [1]
- the cell cannot make them from scratch [1]
- they have a double membrane, consistent with being taken in by a host cell / inner membrane resembles a prokaryote membrane [1]
- their gene sequences are most similar to aerobic bacteria (mitochondria) / cyanobacteria (chloroplasts) [1]
- the theory explains a wide range of observations, which makes it strong [1]
- max 6

17. [1] HL only

B B [1]

18. [1] HL only

C C [1]

19. [6] HL only

- (a) $(100\,000 - 1\,500) \div 100\,000 \times 100 = 98.5\%$ [1]
- (b) increases from 1 500 to 90 000 copies per cm^3 / rises back almost to the starting level by week 24 [1]
- (c) HIV has a high mutation rate / reverse transcriptase makes errors / does not proofread [1]
- (c) some variants are resistant to the drug [1]
- (c) the drug selects for resistant variants, which multiply / natural selection [1]
- max 2 for (c)
- (d) a variant would need mutations giving resistance to all three drugs at the same time [1]
- (d) this is very unlikely / the probability is very low [1]
- (d) the drugs act on different targets, so replication is blocked at more than one stage [1]
- max 2 for (d)

20. [4] HL only

- both have a protein capsid [1]
- both have nucleic acid as genetic material / both lack cytoplasm [1]
- lambda has double-stranded DNA; HIV has single-stranded RNA [1]
- lambda is not enveloped; HIV is enveloped in host cell membrane [1]
- HIV has glycoproteins in its envelope that bind host receptors; lambda binds the host with its tail [1]
- lambda has an icosahedral head and a tail; HIV has a cone-shaped capsid [1]
- HIV carries reverse transcriptase / integrase / protease; lambda carries no enzymes [1]
- max 4, with at least one similarity for full marks

21. [5] HL only

- the phage tail attaches to specific receptors on E. coli [1]
- viral DNA is injected; the capsid stays outside [1]
- the viral DNA circularises [1]
- viral genes are transcribed by host RNA polymerase [1]
- and translated by host ribosomes to make capsid proteins / viral enzymes [1]
- the host supplies ATP / energy, nucleotides and amino acids [1]
- viral DNA is replicated many times [1]
- new phages are assembled / DNA is packed into heads [1]
- viral enzymes break down the cell wall [1]
- the cell lyses / bursts, releasing many (about 100) phages [1]
- released phages infect other cells [1]
- max 5

22. [3] HL only

- viruses are very diverse in structure / in genetic material (DNA or RNA, single- or double-stranded) [1]
- suggesting they did not all descend from one common ancestor [1]
- their shared features may be the result of convergent evolution [1]
- because all share the same extreme obligate parasitism / way of life [1]
- the genetic code is shared with living organisms, suggesting origins from cells [1]
- some may have escaped from cells (e.g. as plasmids), others reduced from parasitic cells [1]
- max 3

23. [3] HL only

- influenza has an RNA genome with a high mutation rate / its RNA polymerase does not proofread [1]
- mutations change the surface antigens haemagglutinin / neuraminidase [1]
- this is antigenic drift [1]
- antibodies / memory cells from earlier vaccines no longer bind / recognise the new strain [1]
- segments from two strains can mix in one host (antigenic shift), producing a new subtype [1]
- the vaccine is matched to the strains predicted to circulate [1]
- max 3