



Origins of cells: practice questions

8 questions • 26 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 / 26

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

```
=====
=====
=====
=====
=====
=====
=====
=====
=====
```

HL only

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

[illegible]

6

PAPER 2A STYLE

[3 marks]

HL only

Explain how vesicles could have formed spontaneously on the early Earth and why this was a necessary step in the origin of cells. [3]

[illegible]

7

PAPER 2A STYLE

[4 marks]

HL only

(a) Outline two approaches used to estimate the date of the last universal common ancestor (LUCA) or of the first cells. [2] (b) Describe the evidence that LUCA evolved in the vicinity of hydrothermal vents. [2]

[illegible]

8

PAPER 2B STYLE

[7 marks]

HL only

Explain the requirements that had to be met for the first cells to arise from non-living matter, and why hypotheses about the origin of cells are difficult to test. [7]

[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