bio letters

Biology
Higher level
A2.1 Origin of cells Paper 1A

11 May 2026

Zone A afternoon | **Zone B** morning | **Zone C** afternoon

1 hour [Paper 1A]

Instructions to candidates

- Answer all questions.
- For each question, choose the answer you consider to be the best.
- A calculator is required for this paper.
- This paper generally presents questions in the same order the concepts are presented in the syllabus guide. The earlier questions are usually but not always easier than the later questions. Although most questions focus on this topic only, some are linked to other topics.
- This paper contains challenging IB-style problems. It is meant to enrich your learning and improve your mastery of the concepts presented in this topic after you have studied it.
- All of the questions here are original and written by me.
- **None of the questions are from past papers**.
- The maximum mark for paper 1A is **[40 marks]**.

1. Which of the following gases are present at high levels in pre-biotic Earth?

I. Oxygen

II. Carbon dioxide

III. Methane

A. I only

B. II only

C. II and III only

D. I and III only

2. What is the importance of understanding pre-biotic conditions on Earth?

A. It explains that energy of pre-biotic reactions are supplied by high temperatures

B. It shows how ultraviolet radiation could have entered the atmosphere

C. It reveals how carbon compounds like methane and carbon dioxide evolved into more complex chemicals

D. It guides hypotheses about the origin of cells

3. Why did pre-biotic Earth have no ozone layer?

A. High levels of greenhouse gases

B. Low levels of greenhouse gases

C. High levels of oxygen

D. Low levels of oxygen

4. Why is the presence of a source of energy important in understanding origin of cells?

A. Ultraviolet radiation as an energy source could explain plant evolution

B. High temperatures as an energy source could explain thermoregulation

C. Ultraviolet radiation as an energy source could explain why reactions occurred

D. High temperatures as an energy source could explain climate change dangers

5. Why are cells the smallest unit of life?

A. Larger units of life are able to carry out all life functions

B. Larger units of life are less efficient at performing all life functions

C. Units of life smaller than cells do not exist

D. Units of life smaller than cells cannot exist on their own

6. What is the difference between living and non-living matter?

A. The presence or absence of some life functions

B. The presence or absence of all life functions

C. The presence or absence of carbon compounds

D. The presence or absence of inorganic compounds

7. Can living and non-living matter share similarities?

A. No because they are fundamentally different

B. No because living organisms have specific life functions

C. Yes because not all life functions are specific to living organisms

D. Yes because the definition of non-living matter like viruses is theoretical

8. Fire can grow and spread, like cells. Why is fire not considered living?

I. It can only grow when supplied with oxygen

II. Fire growth is not regulated

III. Some cells can grow without oxygen

A. I only

B. II only

C. I and II only

D. I and III only

9. Why are viruses considered non-living?

A. They depend on a few functions

B. Their functions are carried out by other organisms

C. The hosts they infect depend on their life functions

D. Some of their life functions are independently done

10. What should an entity that has a membrane but no further compartmentalization be classified as?

A. A prokaryote because they have no membrane-bound organelles

B. Non-living because compartmentalization is an essential feature of cells

C. Living because not all organisms have complex compartmentalization

D. It depends on the presence or absence of other life functions

11. Is ‘evolution’ of the first cell the same as ‘evolution’ in Darwinian theory?

A. Yes because both contexts involve development of more complex structures

B. Yes because the first cell contains genetic material

C. No because evolution does not always lead to more complex structures

D. No because the evolution of the first cell does not involve genetic change

12. Why is it difficult to explain the spontaneous origin of cells?

A. The only cells we can study have come from pre-existing cells

B. We can only hypothesize since it happened a long time ago

C. Protocells are complex to study compared to cells

D. It is unknown how chemicals evolved into protocells and eventually cells

13. What are protocells?

A. Hypothetical living cells used to explain the origin of cells

B. Hypothetical non-living structures used to explain the origin of cells

C. Viruses that evolved into the first cells according to the virus-first hypothesis

D. Cells with high proton concentrations for aerobic respiration

14. Why are protocells useful in understanding the origin of cells?

A. They represent early forms of life before the evolution of complex features

B. They represent laboratory models of early cells that can be studied

C. They represent an intermediate stage between non-living and living

D. They represent synthetic models of the first cells on earth

15. What does water in the Miller–Urey experiment represent?

A. The aqueous cytoplasm of the first cells

B. Oceans in pre-biotic Earth

C. Metabolism involving hydrolysis

D. Condensation of amino acids into peptides

16. What does the gas mixture in the Miller–Urey experiment represent?

A. The mineral-rich environment near hydrothermal vents

B. The low oxygen atmosphere after photosynthesis evolved

C. The possible composition of the atmosphere in pre-biotic Earth

D. The gases released by the first cells during respiration

17. What does the lightning in the Miller–Urey experiment represent?

A. Energy used by the first cells to synthesize biomolecules

B. Energy used by the first protocells for self-assembly

C. Energy used by the last universal common ancestor before speciation

D. Energy used to drive chemical reactions

18. What is one limitation of the Miller–Urey experiment?

A. It showed how some biomolecules could form abiotically but not how they can be organized into a self-sustaining system

B. It showed how all biomolecules could form abiotically but not how they can be organized into a self-sustaining system

C. It showed that proteins can form abiotically but not why all organisms have the same codons

D. It showed that proteins can form abiotically but not how some prosthetic groups can be incorporated into a quaternary structure

19. Should experiments with limitations still be considered useful?

A. Yes because they can still lead to insightful results

B. Yes because the nature of science requires that limitations exist

C. No because they make the results less reliable

D. No because hypotheses must be falsifiable by nature

20. After Miller and Urey published their results in 1953, scientists attempted variations of their experiment but some only produced amino acid precursors. What is a correct conclusion?

A. Conditions in the Miller–Urey experiment most resemble pre-biotic Earth

B. The Miller–Urey experiment is outdated and requires revision

C. Living organisms are needed to convert precursors to amino acids

D. The results depend on the pre-biotic conditions the scientists assume

21. The Miller–Urey experiment uses electrodes to represent lightning as a source of energy, but scientists hypothesize that pre-biotic Earth conditions had high temperatures and UV penetrance as energy sources. What is a correct conclusion?

A. This suggests that most sources of energy on pre-biotic Earth would have produced organic compounds

B. The experiment is a model that shows that energy sources can drive formation of organic matter from inorganic compounds

C. Lighting occurs more spontaneously than high temperatures and UV light which suggests that organic compounds form under specific energy sources

D. The electrodes may have acted as catalysts which enhanced the rate of formation of organic compounds for practical reasons

22. Why is it important for fatty acids to spontaneously form spherical bilayers?

A. It makes the evolution of the first cells from chemicals more plausible

B. It enables fatty acids to form continuous bilayer sheets for higher energy

C. The spherical shape is most suitable for the evolution of the first cells

D. It reduces the energy expenditure of the first cells

23. What happens when fatty acids coalesce in water?

A. They form continuous bilayer sheets

B. They form spherical bilayers

C. They form hydrophobic and hydrophilic bilayers

D. They form bilayers with membrane proteins

24. Which of the following necessary requirements for the evolution of the first cells do RNA molecules fulfil?

I. Compartmentalization

II. Catalysis

III. Self-assembly

A. I only

B. II only

C. I and II only

D. II and III only

25. What are ribozymes?

A. Enzymes that cells use to synthesize ribosomes in the nucleus

B. Enzymes that cells use to synthesize ribosomes on the endoplasmic reticulum

C. RNA molecules used to synthesize ribosomal proteins

D. RNA molecules used to synthesize proteins by ribosomes

26. What is the Last Universal Common Ancestor (LUCA)?

A. The last microorganism of the first cells on Earth before speciation

B. The species from which all current life on Earth has evolved from

C. The last individual to outcompete other ancestors from the first cells

D. The species that first evolved and gave rise to subsequent life

27. What is the most likely mechanism by which LUCA may have led other ancestors into extinction?

A. Predation

B. Competition

C. Parasitism

D. Co-mutualism

28. Why is the universal genetic code evidence for the existence of a Last Universal Common Ancestor (LUCA)?

A. It is likely that all organisms evolved the same codons from one ancestor

B. It is likely that all organisms evolved the same codons from multiple ancestors

C. It is likely that all organisms evolved the same amino acids from one ancestor

D. It is likely that all organisms evolved the same amino acids from multiple ancestors

29. Why are shared genes across all organisms evidence for the existence of a Last Universal Common Ancestor (LUCA)?

A. Shared genes only exist through ancestry

B. Shared genes are more likely than not to exist through ancestry

C. Shared genes indicate more ancient origins than recent divergence

D. Shared genes prove the existence of the last universal common ancestor

30. What is a molecular clock?

A. The time it takes for carbon in molecules to radioactively decay

B. The time it took for the first cells to evolve from chemicals

C. The time it takes for DNA or protein sequences to change

D. The time it took for the last universal common ancestor to evolve

31. How is genomic analysis used to estimate dates of the first cells?

A. Differences in ancient genetic sequences are used to estimate time of divergence

B. Differences in modern genetic sequences are used to estimate time of divergence

C. Fossils are genetically analyzed to estimate the existence of the first cells

D. Radioactive decay of carbon in genetic sequences is used to estimate the existence of the first cells

32. What is carbon dating?

A. Method to estimate age of dead organisms by measuring carbon levels

B. Method to estimate age of dead organisms by measuring radioactive carbon levels

C. Methods to estimate age of dead organisms by measuring radioactive carbon levels in DNA sequences

D. Methods to estimate age of dead organisms by measuring radioactive carbon levels in DNA and protein sequences

33. Why is carbon dating used to estimate dates of the Last Universal Common Ancestor (LUCA)?

A. It provides a maximum estimated date for early life

B. It provides a minimum estimated date for early life

C. It shows which organisms are most closely related to LUCA

D. It shows which organisms are most likely to have evolved from LUCA

34. What is the role of fossils in estimating dates of the Last Universal Common Ancestor (LUCA)?

A. They provide evidence for the existence of cells many years ago

B. They provide evidence for the existence of protocells many years ago

C. They provide evidence for the kinds of genes that LUCA used

D. They provide evidence for the features that LUCA had

35. What does fossilized evidence of life from ancient seafloor hydrothermal vent precipitates show about the Last Universal Common Ancestor (LUCA)?

A. It provides evidence for the habitat and niche of LUCA

B. It provides evidence of the kind of environment that LUCA evolved in

C. It provides evidence for the genes that LUCA may have used

D. It provides evidence for the estimated time that LUCA may have existed in

36. Why are hypotheses about the origin of cells difficult to test?

A. Experiments are unable to model pre-biotic Earth conditions

B. Experiments are only partially able to model pre-biotic Earth conditions

C. Scientists have no evidence of the first cells on Earth

D. Scientists have no evidence of how protocells evolved into the first cells

37. What do genomic analyses show about the evolution of the Last Universal Common Ancestor (LUCA) in the vicinity of hydrothermal vents?

A. Non-coding genes provide evidence for the metabolism of LUCA

B. Ancient genes provide evidence for the metabolism of LUCA

C. Modern genes provide evidence for the metabolism of LUCA

D. Conserved genes provide evidence for the metabolism of LUCA

38. When scientists begin conducting genomic analyses to investigate the Last Universal Common Ancestor (LUCA), they often begin with bacterial and archaeal genes. What is a possible explanation for this?

A. Bacteria and archaea are both unicellular like the first cells

B. Bacteria and archaea have more similar molecular clocks than eukaryotes

C. Bacteria and archaea evolved earlier than eukaryotes

D. Bacteria and archaea show highly conserved DNA and protein sequences

39. How are theories about the origin of cells similar to the virus-first hypothesis?

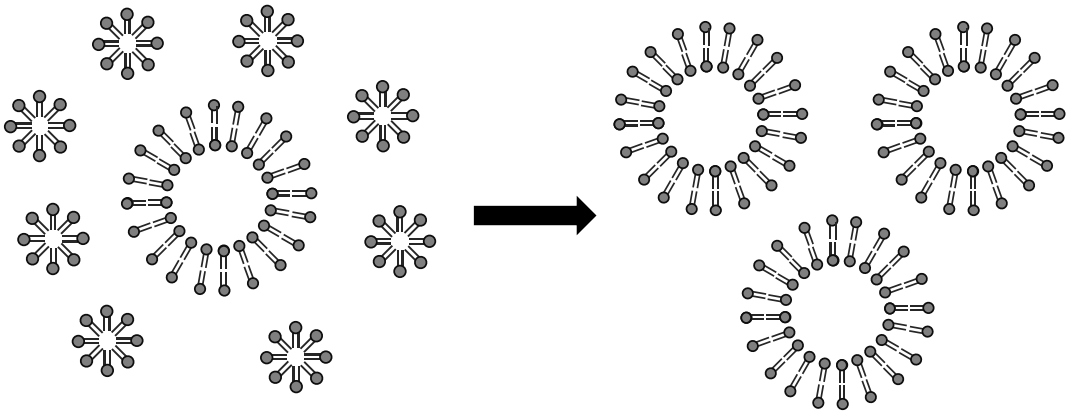
A. Living cells evolved from non-living structures

B. Non-living structures may have evolved from living cells

C. The evolution of the first cells and viruses occurred simultaneously

D. Viruses evolved from the first cells before the last universal common ancestor

40. In an experiment, scientists added spherical monolayers to vesicles, which caused them to elongate and eventually divide into multiple vesicles, as shown in the diagram. What is a valid interpretation of these results?



A. Fatty acids may have provided a mechanism of heredity in protocells

B. Fatty acids may have provided a mechanism of heredity in the first cells

C. Fatty acids may have provided a mechanism of division in protocells

D. Fatty acids may have provided a mechanism of division in the first cells

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References:

40. Zhu, Ting F., and Jack W. Szostak. “Coupled Growth and Division of Model Protocell Membranes.” Journal of the American Chemical Society, vol. 131, no. 15, Mar. 2009, pp. 5705–13. https://doi.org/10.1021/ja900919c.