Year 12 HL

IB BIOLOGY

A2.1 Origin of Cells

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A2.1.1—Conditions on early Earth and the pre-biotic formation of carbon compounds

A2.1.2—Cells as the smallest units of self-sustaining life

A2.1.3—Challenge of explaining the spontaneous origin of cells

A2.1.4—Evidence for the origin of carbon compounds

A2.1.5—Spontaneous formation of vesicles by coalescence of fatty acids into spherical bilayers

A2.1.6—RNA as a presumed first genetic material

A2.1.7—Evidence for a last universal common ancestor

A2.1.8—Approaches used to estimate dates of the first living cells and the last universal common ancestor

A2.1.9—Evidence for the evolution of the last universal common ancestor in the vicinity of hydrothermal vents

Watch the video "Can Science Explain the Origin of Life"
https://www.youtube.com/watch?v=fgQLyqWaCbA *and answer these questions:*

https://edpuzzle.com/media/5d762a6be6fcb7410fa05f64

1. Briefly outline how evolution has allowed simple life forms to evolve into more complex life forms.

2. How does the fossil record support Darwin's theory of evolution?

3. What do the records suggest that all life on Earth originated from and when?

4. Why could the first reproducing creature not have developed through biological evolution?

5. What is the current theory of the origin of life?

6. In what two ways is the chemistry of life special?

7. What is "the vital force" and why did scientists suggest this idea?

8. What did Wohler produce accidentally in 1828 and why was this significant?

9. What are meteorites and why are they important in the study of the origin of life?

10. Describe “chemical evolution”.

11. What is self-assembly? What sort of biological molecules may build in this way?

12. Can science currently explain the origin of life? Explain your answer.

Conditions needed for life on Earth and Miller and Urey Experiment

A2.1.1—Conditions on early Earth and the pre-biotic formation of carbon compounds

A2.1.3—Challenge of explaining the spontaneous origin of cells

https://www.youtube.com/watch?v=NNijmxsKGbc

What four processes are needed for spontaneous life to occur on Earth?

Where might some of the molecules necessary for life have come from?

What two things are needed for organic molecules to be formed?

In what type of places are these conditions likely to be found?

What gases were in the early atmosphere?

When did oxygen appear on Earth?

What two sources of energy might be responsible for converting the simple gases into organic molecules?

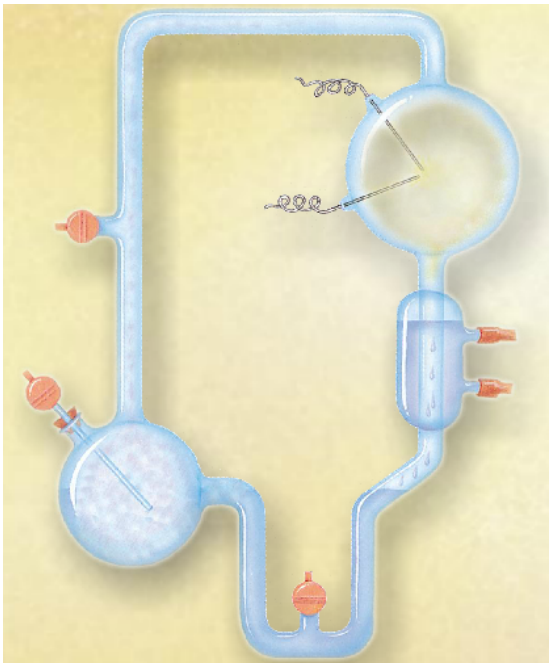
What did the researchers find in the water after 1 week?

What happened to these simple compounds?

What conclusion can be drawn from this and other similar experiments?

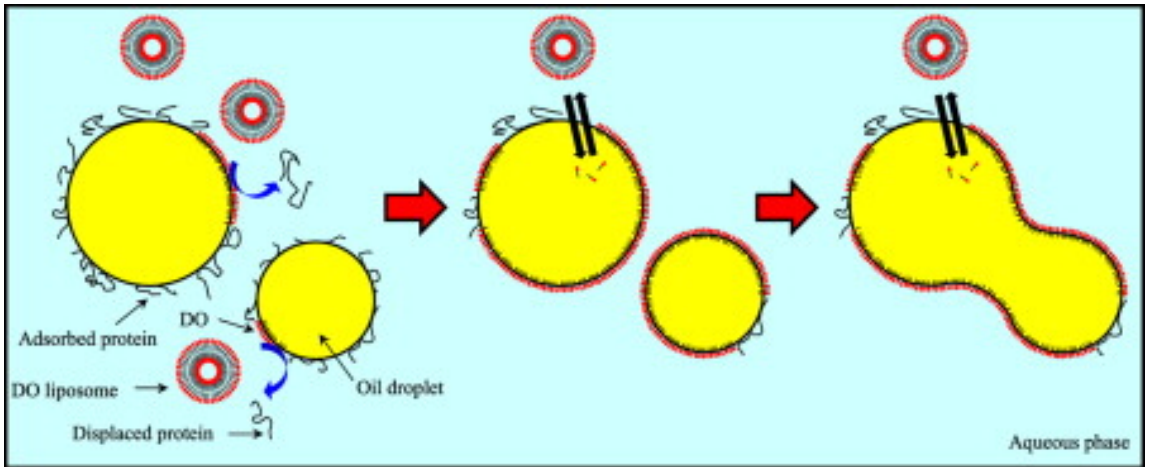
A2.1.4—Evidence for the origin of carbon compounds

Annotate the diagram of Miller and Urey's apparatus below. Why is each part necessary?



Pasteur and Spontaneous Generation

A2.1.5—Spontaneous formation of vesicles by coalescence of fatty acids into spherical bilayers



_____ is the process where _____

to form a larger oil droplet. It mainly depends on processing of emulsions, environmental conditions around oil droplets, and interfacial structures between _____.

A2.1.6—RNA as a presumed first genetic material

Chemical Properties: RNA possesses unique chemical properties that make it a potential candidate for the first genetic material. It can store genetic information in its sequence of nucleotides, similar to DNA. Additionally, RNA has the ability to catalyse biochemical reactions as enzymes, exhibiting both information storage and catalytic functions.

Self-Replication: RNA molecules have the capacity for self-replication, as demonstrated by ribozymes. Ribozymes are RNA molecules that can catalyse their own replication in a process known as RNA replication. This self-replication capability suggests that RNA could have served as both a genetic material and an enzyme in early forms of life.

Prebiotic Availability: It is hypothesised that RNA precursors, such as nucleotides, could have been present on the early Earth through prebiotic synthesis. Experiments and studies have shown that the building blocks of RNA, including nucleotides, can be formed under conditions simulating the primordial Earth. This supports the notion that RNA could have been available as a genetic material in the early stages of life's emergence.

RNA World Hypothesis: The RNA World hypothesis proposes that RNA played a central role in the early evolution of life. According to this hypothesis, RNA was the primary genetic material that stored genetic information and catalysed essential biochemical reactions. Over time, RNA molecules could have given rise to more complex molecules, including DNA and proteins, through a gradual process of molecular evolution.

Supporting Evidence: The discovery of ribozymes, RNA molecules capable of catalysing specific reactions, provides evidence for the functional versatility of RNA. Moreover, studies have shown that RNA can carry out enzymatic activities similar to protein enzymes, further supporting its potential as a primitive genetic material.

A2.1.7—Evidence for a last universal common ancestor

A2.1.8—Approaches used to estimate dates of the first living cells and the last universal common ancestor

A2.1.9—Evidence for the evolution of the last universal common ancestor in the vicinity of hydrothermal vents

1. Which statement is part of the cell theory?

A. Cells are composed of organic molecules.

B. Cells have DNA as their genetic material.

C. Cells have cytoplasm surrounded by a membrane.

D. Cells come from pre-existing cells.

(Total 1 mark)

2. Which of the following is a characteristic of organelles?

A. They are only found in eukaryotic cells

B. They are only found in prokaryotic cells

C. They are sub-cellular structures

D. They are all membrane bound

(Total 1 mark)

3. Which type of cell is likely to have arisen first?

A. Prokaryote

B. Animal cell

C. Plant cell

D. Virus

(Total 1 mark)

4. The spontaneous origin of life on Earth is thought to have involved the non-living synthesis of simple organic molecules.

(a) List **two** other processes needed for the spontaneous origin of life.

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(2)

(b) Outline the evidence that the spontaneous generation of cells does not now occur.

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(3)

5. (a) State **two** properties of RNA that would allow it to play a role in the origin of life.

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(2)

(b) Outline the experiment of Miller and Urey into the origin of organic compounds.

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(3)

6. Discuss the endosymbiotic theory for the origin of eukaryotes.

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(Total 6 marks)

1. D

[1]

2. C

[1]

3. A

[1]

4. (a) simple molecules must polymerize/assemble into polymers;
origin of self-replicating molecules / formation of self-replicating molecules;
simple molecules must become isolated from the surroundings/enclosed in membranes;

2 max

(b) Pasteur's experiments;

Sterilised broth;
The container was designed to not allow contamination;
No growth occurred in the uncontaminated container / growth only occurred in the container that allowed contamination; 3 max

5. (a) RNA can replicate;
can act as a catalyst;
can code for information; 2 max

(b) simulated conditions of pre-biotic earth (in closed container);
water vapour;
mixture of ammonia, methane, hydrogen / reducing atmosphere;
sparks/electric (discharge to simulate lightning);
condenser / cooling of mixture;
obtained amino acids; 3 max

6. eukaryotes evolved from prokaryotes;
mitochondria/chloroplasts evolved from (independent) prokaryotic cells;
taken in by larger (heterotrophic) cell by endocytosis;
theory supported by characteristics of chloroplasts/mitochondria;

[2 max] *for mitochondria/chloroplast characteristics:*
mitochondria/chloroplasts have naked DNA;
mitochondria/chloroplasts divide/carry out fission;
mitochondria/chloroplasts have 70S ribosomes / synthezise own proteins;
mitochondria/chloroplasts have double membranes;
cristae similar to mesosomes / thylakoid have similar structures in prokaryotes;

but theory cannot be falsified as it predicts something occurring in the past;
theory does not explain the origins of cilia/flagella/linear chromosomes/meiosis;
weaker evidence that cilia/flagella evolved from attached bacteria/spirochetes; 6 max