Origins of Life (Summer 2022)

4.9 Exam - Unit 4 » Unit 4 Exam

Question 1

Which of the following is NOT a reason that aggregates (i.e. protocells) are important to the origins of life?

- A. They co-localize and protect metabolic and genetic components
- B. They are necessary for the formation of autocatalytic sets
- C. They help define the individual, which allows for selection
- D. They help with metabolism through chemical gradients
- E. They help with metabolism through electron transfer reactions

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Question 2

The evolution of protocells began with a prebiotic soup and eventually led to the emergence of LUCA. Which of the following steps li occurred before LUCA?

- A. Aggregation led to self-assembled protocells
- B. Chemical evolution decreased the molecular diversity of protocells while increasing functional complexity
- C. "First life" underwent Darwinian evolution, leading to LUCA
- D. A and B
- E. A, B, and C

Question 3

What is LUCA (Last Universal Common Ancestor)?

- A. A single cell that is the ancestor to all known life on Earth
- B. A population of cells that are ancestors to all known life on Earth
- C. The first protocells capable of undergoing adaptive evolution
- D. A population of cells that are ancestors to all eukaryotic life but not prokaryotic life on Earth
- E. B and C

Question 4

How can biogeochemistry be useful when looking for signatures of life?

- A. Biogeochemistry studies the phylogenies of organisms, tracing them back to LUCA
- B. DNA information can be preserved in the rock record over billions of years, indicating the presence of past life
- C. Once the mineral composition of a sample is determined, a molecular fossil is always found
- D. Changes in the cycles of key bioelements (C, H, N, O, S), as well as their isotopic ratios, may indicate the presence of past life
- E. Changes in the cycles of key bioelements (C, H, N, O, S) always indicates biotic processes

Question 5

Which of the following is a way that isotopes can be used to identify signatures of life on early Earth?

- A. Stable isotopes can be used to determine the half-life of a sample
- B. Radioactive isotopes can be used to examine the different isotopic ratio of a particular element in a rock sample
- C. The kinetic isotope effect can indicate the past presence of a metabolism that led to a different isotopic ratio in a sample
- D. When the number of protons changes in a chemical element, these isotopes indicate metabolic activity
- E. The presence of isotopes in a sample means life was present

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Question 6

In the RNA World Theory, a protocell encapsulating RNA would have needed to grow, divide, and evolve. Could these processes be po to the emergence of RNA ribozymes which catalyze the replication of RNA?

- A. No; There is no known mechanism of RNA replication that can occur in the absence of ribozymes
- B. No; All of the molecular fossils we have contain ribozymes
- C. Maybe; There are no outstanding issues with the RNA World Theory
- D. Maybe; RNA can polymerize chemically in the absence of ribozymes (Nonenzymatic RNA Polymerization)
- E. Yes; RNA today replicates despite the absence of enzymes in modern cells

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Question 7

Which of the following is NOT a necessary step when performing "in vitro evolution" with RNA molecules?

- A. Isolate the RNA molecules with the desired function
- B. Make copies of the selected (i.e. fit) RNA molecules
- C. Generate diversity through mutations
- D. After one generation, start over with a new population of molecules
- E. Have a large starting population of RNA molecules

Question 8

By using "in vitro evolution," what have we learned about molecules, like proteins and RNA?

- A. RNA can catalyze many classes of chemical reactions
- B. Proteins evolved in vitro look the same as proteins in modern biology
- C. RNA cannot self-replicate
- D. Among random sequences, highly active molecules with complex functions are always found
- E. RNA cannot bind to other biomolecules

Question 9

What essential properties of living systems are seen in autocatalytic sets?

- A. Both systems always introduce variation through genetic mutations and use template-based replication
- B. Both systems are catalytically closed and self-sustaining from resources available in the environment
- C. Both systems are self-sustaining without requiring "food" from the environment and don't produce waste products
- D. Both systems require a bilayer membrane and resources from the environment
- E. Both systems introduce variation through genetic mutations and can evolve

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Question 10

How do simple autocatalytic systems differ from biological replication?

- A. Autocatalytic systems are unable to grow and replicate
- B. Autocatalytic systems lack diversity
- C. Diversity in simple autocatalytic systems is not inherited by the next generation
- D. There can only ever be one autocatalytic set in a population
- E. Autocatalytic systems cannot be encapsulated in a membrane

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Question 11

Which of the following is a reason that autocatalytic sets are thought to play a key role in the emergence of life?

- A. Autocatalytic sets can evolve and become more complex
- B. Autocatalytic sets exist in real chemical and biological networks
- C. Autocatalytic sets use genetic information to pass on diversity
- D. A and B
- E. A, B, and C

Question 12

If we look at modern processes of metabolism, genetic transmission, and evolution, it is difficult to imagine these processes spontan arising. What is an approach that researchers take to navigate this challenge?

- A. Examine precursors and simpler versions of these processes
- B. Examine methods of chemical evolution that could give rise to incrementally more complex systems
- C. Examine how surface evolvers can evolve adaptively prior to cells or genetics
- D. A and B
- E. A, B, and C

Question 13

The fate of new mutants is determined by two processes: selection and drift. If a new mutant is governed by drift, which of the follow

- A. The new mutant doesn't have a selective advantage over the existing population
- B. It is likely that the new mutant will eventually reach a frequency of 100% in the population
- C. The new mutant likely has a higher fitness than the existing population
- D. This new mutant arose at a higher point in the fitness landscape
- E. A and B

Question 14

"Surface evolvers" are surface-associated metabolisms with spatial structures that do not require bounded cells. Why might these p important role in the origins of life?

- A. Through surface evolvers, adaptive evolution can begin before cells or genetics
- B. Surface evolvers could naturally give rise to cells through a relatively simple adaptive path
- C. It may be easier for these surface systems to arise spontaneously than an enclosed cell
- D. These non-genetic systems are even simpler than other theories about cells without genes or genes without cells
- E. All of the above

Question 15

When *E. coli* is fed glucose, it has two primary waste products: acetate and glycerol. If *E. coli* is grown on glucose for hundreds of ge what would you expect to occur?

- A. Spatial niche specialists would emerge wherever glucose is present
- B. Two metabolic niche specialists would emerge (acetate and glycerol specialists), in addition to the original glucose specialist
- C. Three metabolic niche specialists (glucose, acetate, and glycerol) would compete with one another, eventually leading to the extinction of two
- D. The *E. coli* would evolve to metabolize acetate and glycerol instead of glucose
- E. The *E. coli* would become poisoned from its own waste products

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Question 16

The phrase "life preempts life" has been proposed to mean that once cellular life emerged, it would have prevented additional instar from becoming established enough for us to see. If this is true, what might this occurrence be an example of?

- A. The kinetic isotope effect
- B. Niche construction
- C. The RNA World
- D. The evolution of autocatalytic subsets
- E. In vitro evolution

Question 17

Which of the following is a way that researchers can learn about early life on Earth?

- A. Studying the stable isotopes in rock samples, indicating the presence of early life
- B. Studying the biochemical properties shared by all modern life to deduce what LUCA looked like
- C. Studying chemical evolution in the lab to learn how autocatalytic sets may evolve in a prebiotic context
- D. A and B
- E. A, B, and C