Origins of Life (Summer 2020)

Question 1

There were many reactions on early Earth that generated a complex chemical library. Which of the following was likely NOT a major prebiotic organic material?

- A. UV photolysis
- B. Hydrothermal vents
- C. Comets
- D. Electric discharge
- E. Precipitation (i.e. rain and snow)

Question 2

If we accept recent lunar impact evidence, and impacts on Earth were not very frequent but prolonged (~4.1 to 3.2 Ga), what would th about early life on Earth?

- A. There was only one major impact that was cataclysmic around 3.9 bya
- B. There was a delivery of biomolecules (e.g. amino acids, sugars) to Earth
- C. Impacts affected life, but it still persisted
- D. B and C
- E. A, B, and C

Question 3

Out of the following, which is the most likely to have been one of the earliest forms of life on Earth?

- A. Sulfur-oxidizing bacteria
- B. Nematodes (microscopic worms)
- C. Cyanobacteria
- D. Zircons
- E. Bristlemouth fish

Question 4

We often think of life as living at the same conditions humans live at. However, many organisms have been found living under very d conditions. Which of the following is one reason that the true limits of life may not have been found?

- A. We do not have estimates for the range of conditions on other planets in our solar system
- B. We have yet to discover extremophiles capable of surviving multiple extremes
- C. We haven't sent microbes into space yet to see if they survive
- D. There are unexplored regions of Earth with even more extreme conditions, where microbes may be discovered
- E. We haven't studied extremophiles in highly saline environments

Question 5

When considering life's origin and evolutionary history on Earth, why is it important to study extremophiles?

- A. Extreme environments have only recently appeared on Earth, allowing us to see how microbes rapidly evolve to new conditions
- B. We know life originated in an extremely dry, hot environment like the Atacama Desert
- C. The only evidence for life prior to 3 billion years ago are stromatolites
- D. The current planetary surface conditions have only occurred for a short period of time, whereas extreme environments have existed throughout life's hist
- E. Chemolithoautotrophs can only be found in extremely acidic environments

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Question 6

The atmosphere during the Archaean Eon was composed of methane and carbon dioxide, void of oxygen gas. In Cuatro Ciénegas, the the "Archaean Domes" is thought to simulate this ancient atmosphere. Given the microbial mats that comprise these domes, how is possible?

- A. The microbes in the mats work together to prevent carbon dioxide from entering the dome
- B. The bottom layer of methanogens produces methane, while the outer layers shield the inside of the dome from the input of oxygen
- C. The bottom layer of photosynthetic bacteria produces oxygen that fills the dome
- D. The high nutrient content in Cuatro Ciénegas increases the activity of the microbes
- E. The entire mat is composed of methanogens that produce methane to fill the domes

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Question 7

Scientists try to determine the chemical inventory possible in nature from which life could be built. Which of the following is NOT an that would help determine this?

- A. The Miller-Urey experiment
- B. Submarines examining the molecules emitted from hydrothermal vents
- C. Examining the composition of meteorites
- D. Robots sampling the surfaces of planets that may have never seen life
- E. Lysing bacteria, and seeing if it will self assemble into new life.

Question 8

Which of the following do we know about the role of phosphate in biology?

- A. The structural, physical, and chemical roles of phosphate
- B. When life began to use phosphate
- C. Where early phosphate came from
- D. A and B
- E. A, B, and C

Question 9

When looking at the behavior of elements on an electron level, why might carbon be an ideal candidate to form the basis of life?

- A. Carbon is a noble gas, making it very stable
- B. Carbon can form four bonds to create complicated 3D structures with a variety of other elements
- C. Carbon has more electrons available to form bonds than any other element
- D. Carbon can only form 2D structures, making it ideal to create polymers
- E. Carbon is the only element able to bond with both hydrogen and oxygen

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Question 10

All life on Earth is based on reactions of carbon and water. Which of the following is a way that water is important for life?

- A. If water is added to a mixture of biomolecules, they will never turn into tar
- B. A water molecule is nonpolar, making it less likely to react with other molecules
- C. The ocean was the only source of water on early Earth (~4.2 – 3.8 Ga), providing the only aqueous environment for life to form
- D. Water is a part of the condensation and hydration reactions that can be used to form and breakdown peptides and nucleic acid polymers
- E. Hydrogen and oxygen are more stable in their gaseous forms, creating a hospitable atmosphere on Earth

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Question 11

On planets with different surface chemistries than Earth, it may be possible that other elements, such as silicon, borane, or metal ox be bases for another biochemistry. Despite this, why are carbon and water chemistries more likely for life on other planets?

- A. Carbon, hydrogen, and oxygen have higher cosmic abundances
- B. The only lakes and oceans present in our solar system are made of water
- C. Silicon, borane, and metal oxides are not present in our solar system
- D. Only carbon can form four bonds with other elements
- E. Biomolecules are only reactive in water

Question 12

At the origins of life, complex phospholipids were likely not available. There were, however, simpler lipids that can be found in mete certain prebiotic reactions. How were these prebiotic lipids similar to phospholipids found in cells today?

- A. They were all zwitterionic
- B. They have chemically diverse headgroups
- C. They were just as stable as phospholipids
- D. They were still able to form the same complex membranes seen today
- E. They were unable to self assemble

Question 13

The formose reaction is proposed to synthesize which biomolecule in prebiotic environments?

- A. Lipids
- B. Amino acids
- C. Sugars
- D. Nucleic acids
- E. Phosphate

Question 14

We have two nucleic acid polymers that are different in several ways. Which of the following is NOT true?

- A. RNA cannot base pair, only DNA forms the hydrogen bonds predicted by Watson and Crick
- B. RNA has uracil; DNA has thymine
- C. RNA has a 2' OH; DNA does not
- D. RNA tends to be less stable but catalytic, DNA is more stable for information coding
- E. The sugar present in RNA is ribose; DNA has deoxyribose

Question 15

Which of the following are scientists able to do through prebiotic synthesis?

- A. Create nucleic acids from a mixture of black sludge (i.e. tar)
- B. Produce biomolecules (e.g. sugars, lipids, nucleobases, amino acids) that are necessary components of life as we know it
- C. Mix biomolecules (e.g. sugars, lipids, nucleic acids, proteins) at appropriate ratios, which creates life
- D. Recreate the Last Universal Ancestor (LUCA)
- E. Make RNA capable of catalyzing its own replication

Question 16

In an autocatalytic reaction, a species acts to increase the rate of its producing reaction. Which of the following is an example of an a autocatalytic reaction?

- A. The circulation of seawater in the ocean
- B. The processes of hydration and dehydration in tidal pools
- C. Silicon reacting with water to form silicon oxides
- D. A nonpolar molecule passing through a phospholipid bilayer
- E. The Brusselator, where a limit cycle is formed, periodically passing through a set of paired values at an increasing rate

Question 17

When examining evidence for life early in Earth's history, what presents a challenge?

- A. Microbial life does not leave biosignatures for us to detect in rocks
- B. We do not have an estimate for the age of the Earth
- C. A lot of abiotic processes produce patterns or structures that look like life
- D. All crustal rocks older than 3 billion years have been destroyed
- E. The cataclysmic event likely erased all life on early Earth