Instructions

Question 1

Is it possible that the first stages in life's origin (e.g. a new different form of life from a chemical mixture) could re-occur on present-day Earth?

- A. Yes; we have detected several examples of this "alt-life" in various environments
- B. Yes; but it would likely be devoured or absorbed and avoid being detected because "life preempts life"
- C. No; if this had occurred, we would have detected it
- D. No; we know there is only one Last Universal Common ancestor (LUCA)
- E. No; there are no known environments on present-day Earth where this might occur

Question 2

Which of the following is evidence that life emerged quickly?

- A. In order for the Great Oxidation Event to occur 2.3 billion years ago, microorganisms must have been evolving for 2.2 billion years prior
- B. We were able to re-program planaria to have two heads
- C. Experiments show that the Miller-Urey experiment yielded amino acids which then evolved quickly into autocatalytic sets
- D. Carbon inclusions in a 4.1 billion-year-old zircon show evidence for life around the same time the planet became hospitable (i.e. water was present)
- E. Using a molecular clock to estimate how DNA mutates, it is likely that LUCA is over 4 billion years old

Question 3

Origins of life research will often limit complexity to better understand a specific condition under which life may or may not arise, and to make interpretation of the results possible. Which constraint(s) would a scientists be using when studying UV irradiation of interstellar ices containing ammonia and carbon dioxide?

- A. Location
- B. Reactants
- C. Energy
- D. A and B
- E. A, B, and C

Question 4

When interpreting the geologic record, what presents a major challenge?

- A. We have too many samples to analyze and it is costly
- B. Because of crustal destruction, we do not have groups of rocks from 4 billion years ago to create a complete understanding of the environment
- C. Experiments never agree with geological samples
- D. Chaotic events (like volcanic eruptions) erased all of the rock record
- E. The production of crust never exceeded the rate of destruction

Question 5

Throughout Earth's history, the crust has changed dramatically. Which of the following is NOT a way that crustal rocks have been altered over time?

- A. Subduction from the surface into the mantle
- B. Atmospheric weathering
- C. Oxidation following the Great Oxidation Event
- D. Solidification of Earth's core
- E. Collision of continents due to plate tectonics

Question 6

By studying pattern formation, researchers hope to learn how much structure and patterning can occur in the natural world of pure physical laws, without any living processes. How does this study of pattern formation pertain to the origin of life?

- A. There were likely no patterns present at the origin of life
- B. The only patterns seen today are caused by living processes
- C. If structure can occur in the natural world, then life likely didn't arise until 2 billion years ago
- D. This natural patterning might make it easy for certain types of evolutionary or life-like processes to begin
- E. The patterns formed by nature are pretty to look at

Question 7

Using stability analysis, we can determine interesting regimes of F and k, where patterns form for two chemical species, U and V. In one simulation, a steady-state pattern is formed, where high and low concentrations of U and V are separated by small spatial distances. Why is this important for the origin of life?

- A. It demonstrates that early life must have formed a steady-state pattern, without a process of replication or growth
- B. It demonstrates that entropy in a system can increase over time, changing from a distinct pattern to diffused particles
- C. It demonstrates that it is possible to get very complicated chemistry forming next to other complicated chemistry over stable and segregated spatial scales
- D. It demonstrates that only one chemical species can exist in a given environment
- E. It demonstrates that it is impossible to have chemical species diffused evenly throughout an environment without being separated by some spatial distance

Question 8

When studying the origin of life, what is one reason that researchers focus on common features across all of life, such as the Central Dogma?

- A. They are using our understanding of the origin of life to inform us about how a cell functions today
- B. The working definition of life includes all of these features
- C. They believe that first stages in the origin of life included all of these features of modern life (e.g. uses DNA, RNA, a cell membrane, ribosomes etc.)
- D. They are trying to use existing composition, structure, and function of modern life to inform us about the origin of life
- E. There are no common features across all of life

Question 9

What happens as a result of mRNA entering a ribosome?

- A. The ribosome eventually polymerizes a chain of amino acids to form a functional protein
- B. The ribosome eventually synthesizes more DNA
- C. The ribosome breaks down and disperses through the cell
- D. The mRNA exits the ribosome and then exits the cell
- E. The ribosome makes copies of the mRNA, which are stored in the cell membrane

Question 10

When looking at the minimal gene set of all organisms, a large portion of these genes are related to what two conserved features?

- A. The generation of lipids for the cell membrane and metabolism (generating energy)
- B. The Central Dogma (transcription, translation, ribosomal proteins) and metabolism (generating energy)
- C. The Central Dogma (transcription, translation, ribosomal proteins) and the size of the cell
- D. Cell-to-cell signaling and metabolism (generating energy)
- E. The generation of lipids for the cell membrane and the size of the cell

Question 11

When looking for life in a particular environment, which of the following would be evidence that life might be present?

- B. The presence of self-propagating matter capable of adaptive evolution
- C. The presence of proteins with L-amino acids and nucleic acids with D-sugars
- D. A process where DNA is read into RNA which is fed through a ribosome to form proteins
- E. The presence of cities on the surface of a planet
- E. All of the above

Question 12

In addition to determining the efficiency of the ribosome, what are other potential applications of Landauer Bound in origin of life research?

- A. Calculating the number of atoms present in a fractured crystal
- B. Calculating the minimal energy required (i.e. electric spark) to implement the abstract computation (i.e. a mixture of gases) into a more ordered computation (i.e. amino acids) in the Miller-Urey experiment
- C. Calculating the minimal energy required (i.e. ATP) to implement the abstract computation (i.e. pool of nucleotides) into a more ordered computation (string of nucleotides) in DNA replication
- D. B and C
- E. A, B, and C

Question 13

In our lecture on Biological Similarity, we reviewed the many similarities of biological organisms. If these features are shared across all of life, why are they not included in the working definition of life, when determining if something else is an instance of life?

- A. These traits have only recently emerged in the last billion years
- B. All of these features emerged after the Last Universal Common Ancestor (LUCA)

- C. These traits are the result of the historical factors that occurred in the origin of life on Earth; a more general understanding is necessary to examine other instances
- D. Scientists decided that only three traits should be included in the working definition to create a more general understanding
- E. We expanded the working definition of life to be more general when we found self-propagating and evolving matter on Mars

Question 14

There are many different stages and examples of life. Which of the following is an example of "almost life," which has many properties of life but is not considered alive?

- A. Genetically-modified organisms (e.g. two-headed planaria)Genetically-modified organisms (e.g. two-headed planaria)
- B. Jupiter's red spot
- C. Extremophiles (e.g. tardigrades)
- D. A chemical oil droplet system which displays many different complex behaviors
- E. A colony of ants

Question 15

When searching for life in the universe, why do we consider hypothetical examples of life (e.g. cell-less, non-liquid, life in polar/nonpolar solvents)?

- A. We know different solvents exist on other planets and moons (e.g. liquid ethane/methane on Titan)
- B. Diffusion models often lead to results that are not cell-like
- C. We have created these forms of "weird life" experimentally in the lab
- D. A and B
- E. A, B, and C