

Course Materials for Week 1: Origin of Life

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Assignment Questions

1. What finding did Dr. Szostak describe to support the theory that simple lipids could have spontaneously assembled into protocell membranes in the primitive Earth? (choose all that apply)
 - a. That the electric discharge used in the Miller-Urey experiment is similar to lightning in the ash clouds of erupting volcanoes.
 - b. That shaking fatty acids in water with some salt and buffer can produce vesicles with several layers of membrane.
 - c. That clay minerals can catalyze the formation of vesicles.
 - d. None of the above
2. Which of the following natural conditions could have supported nucleic acid replication in primitive cells (choose all that apply)?
 - a. Hot springs for polymerization of nucleic acids
 - b. A frozen pond for denaturation of double strands
 - c. A frozen pond, for polymerization of nucleic acids
 - d. Hot springs for denaturation of double strands
 - e. None of the above
3. Which of the following statements about primitive and modern nucleotides are thought to be true? (choose all that apply)
 - a. Modern nucleotides react well spontaneously and can be easily used as substrates.
 - b. Primitive nucleotides did not react well spontaneously and required sophisticated catalysts to polymerize into nucleic acids.
 - c. None of the above
4. Which of the following conditions are thought to be favorable for the first primitive cells to form and divide in the primitive Earth: (choose all that apply)

- a. Hot temperatures
 - b. Cold temperatures
 - c. Clay minerals
 - d. None of the above
5. An important breakthrough in our understanding of how the first cells evolved was the discovery that RNA could have an important function besides simply delivering genetic information. What is this function? (choose one answer)
- a. structural function
 - b. catalytic function
 - c. a and b
 - d. none of the above
6. When it comes to the *permeability* of modern and primitive cell membranes: (choose all that apply)
- a. Primitive membranes are better barriers than modern membranes
 - b. Modern membranes are better barriers than primitive membranes.
 - c. None of the above
7. Which of the following statements about primitive and modern nucleotides are thought to be true? (choose all that apply)
- a. Primitive nucleotides were *more* polar than modern nucleotides, so they probably tended to leak out of the cell *more* than modern nucleotides.
 - b. Modern nucleotides are probably *more* polar than primitive nucleotides, so they probably tend to leak out of the cell *less* than primitive nucleotides.
 - c. None of the above
8. In the list below, which of these statements support the 'RNA World' theory? (choose all that apply)
- a. The ribosome's peptidyl transferase center is composed of RNA molecules
 - b. Modern co-factors contain nucleotide-like domains
 - c. Ribonucleotides are synthesized from deoxynucleotides
 - d. Modern RNA molecules have catalytic activities
 - e. None of the above

9. Which of the following conditions are thought to be favorable to the polymerization of diluted nucleotides into nucleic acids? (choose all that apply)
- a. The presence of certain types of clay minerals
 - b. The application of an electric discharge
 - c. Conditions of high temperature and high pressure
 - d. Freezing conditions
 - e. None of the above
10. According to Dr. Szostak, what molecules created in the Miller-Urey experiment are central to the emergence of life on our planet? (choose all that apply)
- a. Amino acids
 - b. High-energy intermediates, like cyanide and acetylene
 - c. Nucleotides
 - d. Lipids
 - e. None of the above
11. In the Materials and Methods section of a *Science* paper discussing the emergence of cellular life on Earth, you read the following description: (choose all that apply)

Myristoleic acid molecules were resuspended in water containing NaOH, at a final concentration of 80 mM. This solution was then vortexed and agitated overnight. RNA was incubated with 0.5 mg of montmorillonite and agitated.

After 10 days, 7.5 μ l of washed clay/RNA solution was added to 12.5 μ l of 80 mM myristoleate micelles. The reaction was mixed overnight. The solution was then analyzed by light microscopy.

What type of result would you expect to find from this experiment?

- a. Montmorillonite particles bound to RNA molecules
- b. Montmorillonite particles bound to RNA molecules and encapsulating fatty acid vesicles
- c. Fatty acid vesicles encapsulating montmorillonite particles bound to RNA molecules
- d. Montmorillonite particles encapsulating fatty acid vesicles

e. None of the above

Assignment Answers

1. B and C

2. C and D

3. C

4. A, B, and C

5. B

6. C

7. B

8. A, B, and D

9. A and D

10. A and B

11. C

In-Class Quiz Questions

1. In the Materials and Methods section of a *Science* paper discussing the emergence of cellular life on Earth, you read the following description:

Capric acid was resuspended in water containing NaOH, at a final concentration of 90 mM. This solution was then vortexed and agitated.

In a fresh tube, 1 mg of montmorillonite was incubated with RNA and agitated for 10 days, then washed. 3.5 μ l of the washed montmorillonite/RNA solution was added to 11.5 μ l of a new buffer solution, mixed, and incubated overnight.

What would you expect to see following analysis by light microscopy?

- a. Montmorillonite particles encapsulating fatty acid vesicles
 - b. Montmorillonite particles encapsulating fatty acid micelles and RNA molecules
 - c. Montmorillonite particles bound to RNA molecules
 - d. Fatty acid vesicles encapsulating montmorillonite particles bound to RNA molecules
 - e. None of the above
2. In the list below, which of these statements support the 'RNA World' theory? (choose all that apply)
- a. The ribosome's peptidyl transferase center is composed of RNA molecules
 - b. Deoxynucleotides are synthesized from ribonucleotides
 - c. Modern RNA molecules have catalytic activities
 - d. Primitive membranes were made up of RNA molecules
 - e. Modern co-factors contain nucleotide-like domains
 - f. None of the above
3. Describe one cellular or molecular process discussed in Dr. Szostak's talk, which presents a selective advantage and supports the application of Darwin's evolutionary theory to the emergence of cellular life on earth.

In-Class Quiz Answers

1. C

2. A, B, C, and E

3.

i) Nucleic acids with catalytic activities would have had advantages, especially self-replicating activity

ii) Membrane-bound nucleic acids would have had an advantage compared to free-floating nucleic acids

iii) In part 2, the Donnan effect and heterogeneous cell membranes drive the growth of cells, creating an evolutionary advantage for cells that can be more heterogeneous and self-replicate (both of these can be facilitated with autocatalytic activity)