UGS303 Extraterrestrial Life
Spring 2015
Review Questions for Second Exam

A. Molecules of Life: what are they, what are they made of, how do they interact?

1. Draw a schematic representation of proteins and nucleic acids, identifying the parts. Draw the chemical process of peptide bond formation.

2. Define what a "codon" is and describe its function in the genetic code.

3. How are proteins made under the direction of DNA? Clearly describe transcription and translation. Starting with a DNA codon, TCC, transcribe it into the mRNA codon and translate it into the corresponding amino acid. Identify one mutation to the mRNA that would *not* cause a change in the amino acid.

4. Be able to identify basic molecules needed for life from diagrams or chemical formulae.

B. Origin of Life: understand the problems and the different ideas for solving them.
NOTE: Questions 11-14 will not be covered explicitly on quizzes or tests, but material may be used to construct answer to question 15.

1. What are the three basic steps needed to get from simple molecules (like H_2O, NH_3, and CH_4) to a primitive life form?

2. What is Strecker synthesis? Explain the synthesis of glycine in the Miller-Urey experiment. What criticisms question the relevance of the Miller-Urey experiment? Describe some other possible ways to get monomers on the early Earth.

3. What difficulty is encountered when we try to understand how polymers of amino acids arose on the early Earth? How does Sidney Fox argue that this difficulty was overcome?

4. Explain the difficulty in making nucleic acids on the early Earth. Describe the new developments in synthesizing nucleotides that do not proceed through making sugars and bases separately.

5. Describe the results of considering probability theory as it applies to connecting enough monomers together in the correct order to make an "interesting" polymer. What conclusion is suggested by these considerations?

6. Describe the two general categories of theories for the transition to life. Which category would be favored by considerations of probability theory? Summarize the discussion about the odds of getting a complex molecule by random events.

7. Describe the "evolution in a test tube" experiments of Sol Spiegelman. What implications do these experiments have for the transition to life?

8. Outline the standard picture of the origin of life by chemical evolution on Earth. Discuss the proteins-first and nucleic-acids-first scenarios. Discuss the pros and cons of each scenario, including recent developments.

9. Explain Shapiro's idea for the transition from protolife to life with both proteins and nucleic acids, based on the interpreter molecules.

10. Describe the RNA world as a nucleic-acids-first scenario. Why is this the most popular scenario now? What are the pros and cons for this picture?

11. Summarize the ideas about alternative polymers (e.g., PNA) and the importance of membranes. Describe the scenario of de Duve for a thioester-based protolife that precedes and leads to the RNA world.

12. Describe the idea of the origin of life by chemical evolution in space, including evidence that molecules relevant to the origin of life have been delivered to Earth from space.

13. Explain the ideas of A. G. Cairns-Smith regarding the origin of life.

14. Discuss the arguments for and against exotic life forms based on Si instead of C, other solvents, etc.

15. Construct and explain a complete story for the origin of life beginning with simple molecules (simpler than monomers) and leading to a simple form of life, including both proteins, nucleic acids, and membranes. You can pick and choose from the various ideas that we have discussed, but make sure that you can explain them clearly and that you have a consistent picture.

16. Give your estimate for f_ℓ and explain your reasoning. Be sure to consider very small values as well as values close to 1.

C. Survey of our Solar System for Sites for Life: understand atmospheric evolution, greenhouse effect, the Viking experiments, and new developments

1. What atmospheric gases contribute to the greenhouse effect?

2. Describe the properties of Venus and explain how it developed into its current (very hot) state.

3. What implications does the fate of Venus have for the concept of the habitable zone and your estimate of n_e or f_ℓ?

4. Describe the properties of Mars and explain how it evolved to its current (cold) state. How would its evolution affect your estimate of n_e or f_ℓ?

5. Explain how each of the life detection experiments on Viking worked, what they found, and how the results were interpreted.

6. Describe the Martian meteorite, ALH84001. What is its history, and how did it get to Earth? What is the evidence in the meteorite that bacteria once lived on Mars? Why is this interpretation not generally accepted?

7. Describe recent results from probes sent to Mars and their implications for Mars as a possible site for life.

8. Describe the Sagan/Salpeter ideas for life on Jupiter.

9. Describe the conditions found on Europa, Enceladus, and Titan and explain why they may be interesting for life. Describe the results of the Huygens probe of Titan.

10. Describe the various methods that can be used to search for evidence of past or current life on planets in our solar system. How can we search for (non-intelligent) life in other planetary systems?

Broader Questions

1. Describe the increase in complexity at the microscopic level from simple molecules to life. Consider a hydrogen atom in a water molecule in the ocean of the early Earth. Construct a plausible story about how it wound up in a protein in an early life form.

2. What are the primary remaining problems in understanding the origin of life?