UGS303 Extraterrestrial Life
Review Questions for Third Test
Spring 2016

This test covers Chapters 6 through 7. That means it covers the Drake equation factors f_i, f_c, and L. Material presented in class, including the class projects, may also be used on the test.

A.   Biological Evolution: understand the fossil record, the idea of biological evolution, and different ideas for how it works.

1.   Describe in general terms how radioactive dating of fossils is done. How is it used to assign ages to fossils?

2.   Describe the 3 domains of life and some differences between them. What methods are used for classifying organisms, and how does the classification help us understand the relationship between species?

3.   On a scale of hundreds of millions to billions of years, cite 7 or 8 important events in the fossil record of life on Earth, along with the time that they occurred.

4.   Explain how evolution occurs. Your answer should explain random, inheritable variations and selection pressure. Explain the roles of both heredity and environment. What is genetic drift? When is it important? What is a beneficial mutation and what is a harmful mutation?

5.   How is sexual reproduction important in evolution?

6.   Distinguish between gradualism and punctuated equilibrium.

7.   Describe the different interpretations of the Burgess Shale by Gould and by Conway Morris in the context of whether evolution tends to produce "higher" life forms. What do they mean by contingency and convergent evolution? Consider the Lemski E. coli experiment. Does it provide a counter-example to the arguments of Gould regarding contingency?

8.   What comparison between the animals on the Galapagos Islands and those on the Cape Verde Islands led Darwin to his ideas on evolution, as opposed to the standard idea of his time, that all organisms were created especially for their local environment.

B.   Evolution of Intelligence: understand what is meant by intelligence and how it has changed in the process of evolution; understand the evolution leading to H. sapiens.

1. Define intelligence. In your own words, explain the graph that plots the number of bits of information versus time in the past. What criticisms could we make of this graph?

2. On a scale of millions of years, combine the information on the evolution of our class, order, family, genus, and species from the tables on various pages in the book. Give times, fossils, and characteristics (about 8 entries).

3. Describe primate evolution from the late Cretaceous period up until 6 million years ago.

4. Describe hominid evolution from 6 Myr ago until the present time. Explain the separate lines leading to bigger brains and bigger teeth, mentioning a few key fossils or species. Discuss some ideas for what factors drove the selection for large brains in the line leading to H. sapiens. What are some factors working against big brains?

5. What are the possible implications of the fact that it took over 4 billion years for life on Earth to evolve to human level intelligence?

6. Describe recent information on human evolution coming from comparisons of the human and chimpanzee genomes.

7. Review the arguments by Ward and Brownlee in their book **Rare Earth**, that complex, intelligent life has much more stringent environmental requirements. Explain the Galactic Habitable Zone. Why might intelligent life be rare in regions close to the center of our Galaxy?

8. How does evidence of intelligence in other species affect your thinking about f_i?

9. All of the material in chapter 6 addresses the Drake Equation factor, f_i. Select your value for f_i and give your arguments in favor of it. Be sure to consider arguments for and against your choice.

    Warning: Do not confuse this factor with f_ℓ, which is given at this point, nor f_c, which is yet to come.

C.   Considerations about f_c.

1. Our cultural evolution over the past 10,000 years has led to our capability to communicate with ETI. Select 3 milestones in cultural evolution, indicate their approximate date, and explain their significance. Draw a diagram that indicates the connections between agriculture, specialization, barter, taxes, written language, *etc*. How likely is it that each of these milestones would occur on other planets with intelligent life?

2.   Discuss the importance of the following developments and the evidence as to whether they arose independently more than once or not: agriculture, written language, metal use, centralized states, and the industrial/technological revolution.

3.   An interest in interstellar communication requires a worldview with a particular combination of understandings and beliefs. What are the necessary components of such a worldview?

4.   How did the following people contribute (or not) to the development of our worldview?

— ancient civilizations	— Kepler
— the ancient Greeks	— Galileo
— Ptolemy	— Newton
— Aquinas	— Darwin
— Bruno	— Miller and Urey
— Copernicus	— Drake
— Brahe	

5.   What are the arguments for why a civilization with a technology advanced enough for interstellar communication would also be *interested* in such communication? What are the arguments against this view?

6.   Do science and technology confer a selective advantage on the society that develops them? Cite examples in support of your answer.

7.   Suggest several reasons for the value of f_c to be less than 1. That is, what are some possible scenarios for intelligent life on another planet NOT to develop the capability for and interest in interstellar communication?

8.   What value have you chosen for f_c? Explain your choice in detail.

D.   How Long Does a Technological Civilization Last (L)?

1.   Describe four scenarios in which a civilization would cease to be communicable and note the timescales of relevance.

2.   Describe problems of resource depletion, pollution, and climate change that might limit L.

3.   Describe the population explosion. What was the demographic transition? How does the population explosion affect other societal problems that may threaten our civilization?

4.   What is the relation between economic development, population growth, and resource depletion?

5. Which catastrophes "share" the possible effect of a drastic rise or drop in global temperature? On what timescales might they be a problem?

6. Identify several astronomical catastrophes that could end our technological civilization. Briefly describe the effects of each and their possible impact on the value of L.

7. List the threats to our civilization that are likely to operate on the following timescales: decades, centuries, millennia, millions of years, billions of years.

8. What value have you chosen for L? What are your reasons for choosing it? (Include possible threats you discount as well as those you believe will limit L). Be sure to connect your estimate correctly to what you believe will be the most likely reason that a civilization ends.

E.   The Future of Humankind in the Solar System

1. Describe a scenario for terraforming Mars.

2. Define briefly the following terms: terraforming, space colony, Von Neumann device, Dyson sphere.

3. Define and explain the four quantities that characterize rockets. Give an example of each quantity.

4. Describe the limitations of chemical fuels and the advantages and difficulties associated with using nuclear reactions.

F.   Broader Questions

1. Describe the further increase in complexity associated with the evolution of intelligence.

2. Some have argued that societies that develop the capability for interstellar communication, namely sophisticated technology, will also develop the tendency toward self-destruction, either by resource depletion or by nuclear war, thus ensuring a low value for L. What do you think of this argument?

3. Compare the pace of chemical, biological, and cultural evolution. Which sets the timescale for the emergence of new technological civilizations?