Review Questions for the Final Exam – Astronomy 5, Spring 2017

Consult also the study questions made available for the midterm exam

1. The total lifetime of the Sun is close to 10 billion years. Estimate the lifetime of a star three times as massive as the Sun, and explain why it is likely or unlikely for complex, multi-cellular life to be able to evolve on a planet in the habitable zone around that star.

2. What were the factors that may have contributed to the remarkable explosion of diversity and functionality during the Cambrian Era? Why did this happen only in the Cambrian period, some 3 billion plus years after life first arose on the planet? That is, why did it take so long?

3. Why have most SETI searches been carried out at radio wavelengths?

4. What is a stromatolite, and why is it important for our understanding of the evolution of life on Earth?

5. What is a "hot Jupiter"? How do hot Jupiters violate the expectations that we might have for Jovian planets, based on the nebular hypothesis for the formation of the solar system? How might we preserve the nebular hypothesis and still be able to explain hot Jupiters?

6. What is a "super-Earth" and in what ways might it present a more challenging environment for complex life to subsist than the Earth. Are there any ways in which a super-Earth might be a better habitat than the Earth?

7. Can interstellar travel be seriously considered as a viable solution to overpopulation on the Earth? Why or why not? What might be other, reasonable motives to undertake interstellar travel?

8. What are the underlying assumptions of the "Fermi Paradox"?

9. If the Galilean satellites of Jupiter always keep the same face pointed toward Jupiter because they are tidally "locked on" to Jupiter, how can they be heated by tidal friction?

10. What are the advantages of liquid water over other possible liquids as a medium in which life might have arisen?

11. What lines of strong evidence led investigators to conclude that the KT extinction occurring 65 million years ago was caused by the impact of a large body, perhaps an asteroid, 10 – 15 km in diameter? How do we know that this event occurred exactly 65 million years ago?

12. How is RNA different from DNA and how is it similar? What is the usual role of RNA? … of DNA? What are some of the reasons why many scientists think

that life may have started with RNA as the carrier of genetic information, rather than DNA?

13. If intelligence has obvious survival advantages for a species, why didn't it emerge more quickly during the course of evolution? What are some of the costs of advanced intelligence?

14. What are the three branches on the tree of life, and which branch are we on? What characteristics differentiate the organisms on our branch from the others?

15. What are the four major categories of robotic spacecraft? Which of these is the most complex, and why?

16. Mars is a barren planet with no standing liquid water anywhere on its surface. Why, then, is there so much interest in Mars as an abode for life? What kind of life might be present there, and where might it reside?

17. What characteristics define a "life" form?

18. What are the metabolic requirements of life?

19. Silicon is an abundant element that has a chemistry similar to that of carbon. Consequently, some have discussed the possibility of silicon-based life elsewhere in the cosmos. What are the major drawbacks of silicon as an alternative to carbon-based, organic chemistry as the basis for life?

20. By measuring the relative abundances of two stable isotopes of oxygen – ^{16}O and ^{18}O – in some fossil deposit, or in an ice core, or in a coal bed, or in some sedimentary layer, what can one determine about the conditions that pertained at the time those deposits were laid down? Why do these isotopes make that kind of measurement possible?

21. What is the evidence that the abundance of atmospheric oxygen rose from a very low value before about 2.7 Gyr ago to a substantial fraction of its present abundance over a period of about 2 billion years?

22. Some multiple-celled organisms existed prior to the Cambrian epoch. Why is the fossil record for such organisms relatively poor? What kind of fossils are present from the pre-Cambrian era?

23. What is a "molecular clock", and what can it be used for? What are some of its pitfalls?

24. What are 4 problems that plants had to cope with in making the transition from the sea to land, and what evolutionary developments allowed them to cope with those problems?

25. Why did animals suddenly begin to diversify only in the Cambrian period, some 3 billion plus years after life first arose on the planet?

26. What positive feedbacks have probably amplified the heating of the Earth's atmosphere during periods of global warming?

27. What are the two key pieces of evidence that the Moon was created in a collision between some Mars-sized body and the Earth? Do we know when the Moon was created? If so, how do we know?

28. What are the three requirements for a planetary magnetic field, and how does the Earth meet them?

29. What is the evidence that Europa has a substantial liquid ocean under its surface layer of ice? What might be responsible for keeping that ocean in liquid form?

30. What is the evidence that Enceladus, a moon of Saturn, has liquid water underneath its icy surface?

31. Describe the landscape of the continents during the Cambrian Era. What organisms were the first to adapt to living on land? What kinds of organisms came later, and in what order?

32. Titan satisfies many of the requirements of a habitable body (what are they?). What is the biggest drawback of Titan as an abode for life?

33. What defines a *habitable zone* around a star? What assumptions go into the notion of a habitable zone? Where in the solar system might there be life outside of the traditionally-defined habitable zone? What constrains the habitable zone of the Galaxy?

34. What are the essential differences between a star, a brown dwarf, and a planet? At approximately what masses are the dividing lines between these categories?

35. When did predation first arise?

36. How might plate tectonics favor the habitability of a planet?

37. What is the history and expected future of solar energy output? Has it been constant, and if not, why has it been changing, and what effects have those changes had on the Earth? What effects are they expected to have in the future?

38. Jupiter's atmosphere probably has an abundance of organic molecules. Why, then, is Jupiter not a particular propitious place to for life to have arisen?

39. In what ways have humans, for better or for worse, taken control of the process of evolution on our planet?

40. The Sagan-Drake equation is a device for telling us what we need to learn before we can reliably estimate how many technological civilizations there are in the Galaxy. Explain.

41. Give three of the many hypotheses that can be offered to account for the fact that no extraterrestrial civilization has yet been encountered or observed.

42. Give three of the many serious consequences of prolonged global warming.

43. Most stars are in multiple star systems. What consequences can this multiplicity have for habitability, and in what kinds of multiple star systems is it likely that the multiplicity has only a minimal effect on the habitability?

44. What methods have successfully been used to detect exoplanets?

45. How can carbon isotopes reveal the presence or absence of ancient life on our planet?

46. What is believed to have been the root cause of the Permian-Triassic mass extinction? What other factors may have contributed to the severity of that event?

47. What was the importance of the Miller-Urey experiment for our understanding of the initial conditions for the evolution of life on Earth?

48. What is the "snow line" and what relevance does it have for planet formation.

49. What role is played by dark matter in the formation of structures in the universe? Give examples of what this question means by "structures".

50. What is the very probable root cause of our planet's sixth mass extinction?

51. What was the cause of the Earth's 5^{th} mass extinction? With this in mind, comment on how chance plays an important role in evolution.

52. When did the oxygen content of the Earth's atmosphere first reach levels comparable to the current level?

53. When did the oxygen content of the Earth's atmosphere become high enough to be toxic to many of the earliest, anaerobic single-celled organisms, forcing them to live in anoxic, confined environments?

54. What are the banded iron formations, and what can they tell us about the natural history of the Earth?

55. What is the earliest evidence for fossil life forms? What is the earliest evidence of any kind that life was present on Earth?

56. What are the advantages of aerobic metabolism, as compared with anaerobic metabolism?

57. What role might the Moon have played in the evolution of life on the Earth?

58. If there is life on Mars, what would you judge would be the most likely manifestation of it? That is, what terrestrial analog would you point to as a possible "cousin"?

59. What energy sources might be available to life on Europa?

60. Fill in the blank: All early life must have been ____ organisms, because the Earth's atmosphere was oxygen-free during it's early years.

61. What is the earliest known fossil of a once-living organism, and when did it live?

62. What are ways that we might encounter intelligent extraterrestrial civilizations besides exchanging direct, purposive communications?

63. If the ocean was such a good environment for organisms for hundreds of millions of years, why was there an evolutionary impetus to move to land?

64. What characteristics of a signal coming from somewhere in the cosmos might lead us to conclude that it does not have a natural origin?

65. Why doesn't Mars have plate tectonics?

66. How can we determine global average temperatures during the past million years or so?

67. Explain the role of positive feedback loops in giving rise to a runaway greenhouse effect, or in amplifying the relatively weak forcings of the Milankovitch cycles. (see also question #68)

68 What is the difference between the ice ages that have taken place over the past few million years, and the "Snowball Earth" episodes that occurred between 750 and 580 million years ago?

69. What are the Milankovich cycles, and what effect do they have on the ice ages?

70. Why is it likely that planets are rare around stars that are more than twice as old as the Sun? (hint: think of the role of heavy elements)

71. How can gravitational lensing be used to find planets? What is the lensing signature of a planet?

72. Who, or what, are the Denisovans? What genetic relationship do they bear to homo sapiens?

73. Describe what is meant by *convergent evolution*. What factors might cause two unrelated species to undergo convergent evolution?

74. Dim stars have small habitable zones, but then any planet in the habitable zone in a dim star faces two problems that reduce its habitability. What are those two problems?