

**SPU-14: HOW TO BUILD A HABITABLE PLANET  
FINAL EXAM 18 December 2011**

**365 points**

**READ THROUGH THE WHOLE EXAM BEFORE STARTING. ANSWER QUESTIONS THAT  
ARE QUICK AND EASY FOR YOU FIRST**

**We will take the best three answers of questions 7, 8, 9, 10 and 15**

NAME \_\_\_\_\_

**1. TRUE - FALSE. If the statement is false, modify it to make it true. Simply adding a negative is not sufficient. The modification should demonstrate you know the material. Be alert for multiple falsehoods. (52 points total)**

\_\_\_\_\_ (A) A system that exhibits “chaotic” behavior cannot be predicted on any time scale.

\_\_\_\_\_ (B) The background radiation of the universe is black body radiation left over from the original energy of the Big Bang.

\_\_\_\_\_ (C)  $^{26}\text{Al}$  in meteorites provides evidence for the Big Bang

\_\_\_\_\_ (D) Alpha decay involves the ejection of a helium atom (one proton, two neutrons) from a heavy nucleus, such as Th and U.

\_\_\_\_\_ (E) The Sun will eventually turn into a supernova as it finally uses up its hydrogen fuel.

\_\_\_\_\_ (F) The structure of minerals is largely determined by the ionic radii of the constituent atoms and the laws of symmetry.

\_\_\_\_\_ (G) Jupiter and the other outer planets contain far less mass of Fe, Mg, and Si than inner planets such as Mars, Pluto, and Earth.

\_\_\_\_\_ (H)  $^{12}\text{C}$  is a radioactive element that enables us to date the age of formation of the Earth.

\_\_\_\_\_ (I) Siderophile elements such as Au, W, C and Hf are strongly concentrated in Earth’s crust.

\_\_\_\_\_ (J) Some of the outer planets have dozens of moons, and all of them were captured from the vast numbers of objects coming from the Kuiper Belt and Oort Cloud.

\_\_\_\_\_ (K) Earth began with far more water than it has today, because water is steadily lost from the upper atmosphere owing the low atomic weight of hydrogen.

\_\_\_\_\_ (L) The outer core is solid and the inner core liquid because the temperature increases with depth in the earth.

\_\_\_\_\_ (M) Plate tectonics succeeded as a theory because study of the oceans finally showed how the continents could move through the mantle as Wegener originally suggested.

\_\_\_\_\_ (N) The primary pattern of deep mantle convection is reflected in the positions and spreading rates of the global system of ocean ridges.

\_\_\_\_\_(O) Hydrothermal vents are the spectacular lava fountains that occur at active ocean ridges, spewing lava at temperatures of more than a thousand degrees into the water column.

\_\_\_\_\_(P) Hydrothermal activity at ocean ridges is a significant source of new water injected into the oceans from the mantle .

\_\_\_\_\_(Q) Spreading rates of the various plates can vary by a factor of 100, from about 1 meter per year to 100 meters per year.

\_\_\_\_\_(R) ) There is evidence from living organisms that life began in multiple ways at multiple times, contributing to the diversity of modern cells and organisms.

\_\_\_\_\_(A) The number of genera through Earth's history has remained roughly constant, with the exception of brief dips associated with mass extinctions.

\_\_\_\_\_(T) The reduced reservoirs of the planetary fuel cell include the mantle and also the organic molecules made by life.

\_\_\_\_\_(U) Most mass extinctions result from meteorite impacts.

\_\_\_\_\_(V) Milankovitch cycles occur on time scales of  $10^5$ - $10^6$  years, but there is also evidence of "abrupt" climate change that can happen on the scale of 10000-20000 years.

\_\_\_\_\_(W) Metal resources such as Cu are in dangerously short supply and human civilization is likely to run out of them or make them very expensive on the 100-200 year time scale.

\_\_\_\_\_(X) The concentration of CO<sub>2</sub> in the atmosphere (about 1%) has increased since the onset of the industrial revolution by a factor of ten.

\_\_\_\_\_(Y) Modern human civilization has occurred only in the last 0.1% of Earth's history.

\_\_\_\_\_(Z) Solar systems like our own have not yet been found using the new methods of planet-finding, but this may be an artifact of the methods used and the length of time the search has been going on.

**2.** Compare and contrast the events and evidence associated with the Big Bang and with the origin of the solar system. (28 points)

3. Explain briefly the significance of the following for the topics developed in this course: (36 points)

Differential volatility

Oort cloud

Silica tetrahedron

Beta decay

Red Beds

Positive Eu anomaly in the Lunar Highlands

4. Explain how melting occurs at divergent and convergent plate boundaries. Be sure to use diagrams to illustrate your answer. Be as thorough as you can, draw cross sections through the Earth for each setting, and show how melting occurs using diagrams of pressure vs. temperature. (25 points)

**5.** Isostasy is an important control on the overall topography of Earth's surface. What is isostasy? How does it explain depth vs. age for the sea floor, the depth variations along ocean ridges, the difference between continents and oceans, and the origin of mountains? What does it tell us about Earth's interior? Be sure to use diagrams to illustrate your answer. (30 points)

6. What are the three types of plate boundaries? Illustrate your answer with appropriate sketches. (18 points)

7. What is the evidence for long term climate stability at Earth's surface? Explain how the carbon cycle provides for this long term stability, even in the face of catastrophes such as the proposed "Snowball Earth" episodes. (20 points)

8. Compare and contrast prokaryotic and eukaryotic cells. Make a rough sketch to indicate some of the major differences between them. When in Earth history did each arise? Are they still present today, or has life evolved beyond and left behind these very primitive organisms?  
(20 points)

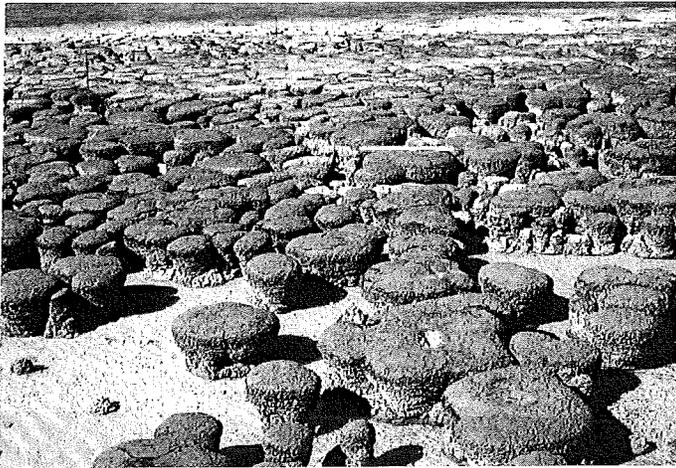
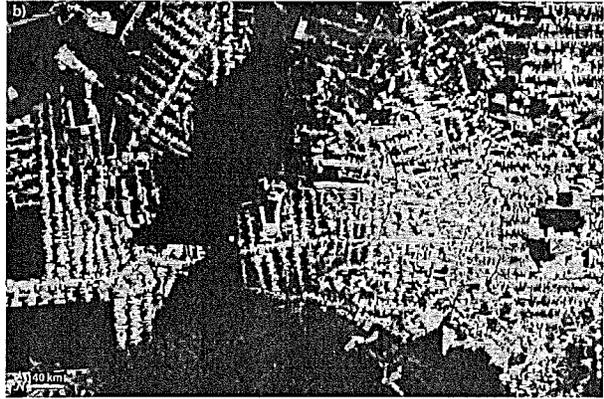
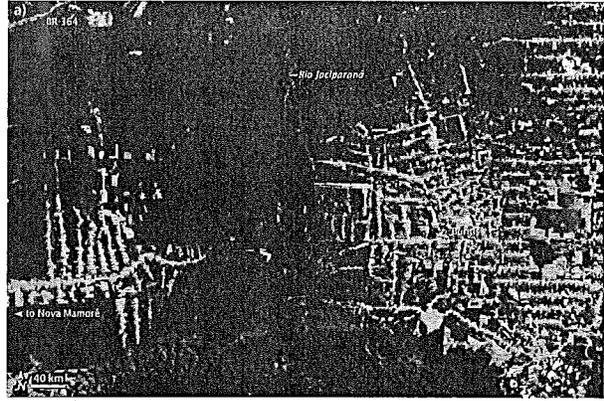
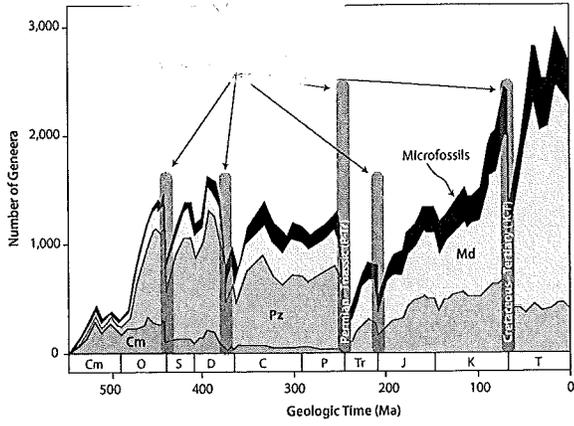
9. What are the various lines of evidence for the unity of life suggesting derivation by evolution from a common ancestor? (20 points)

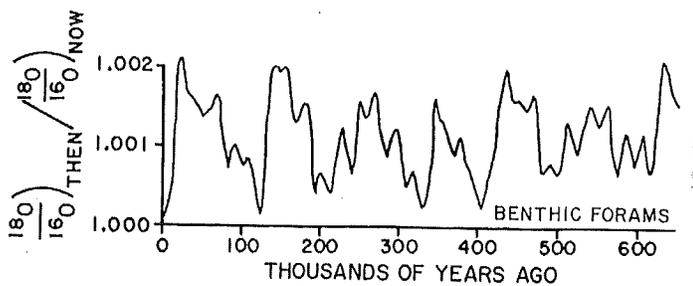
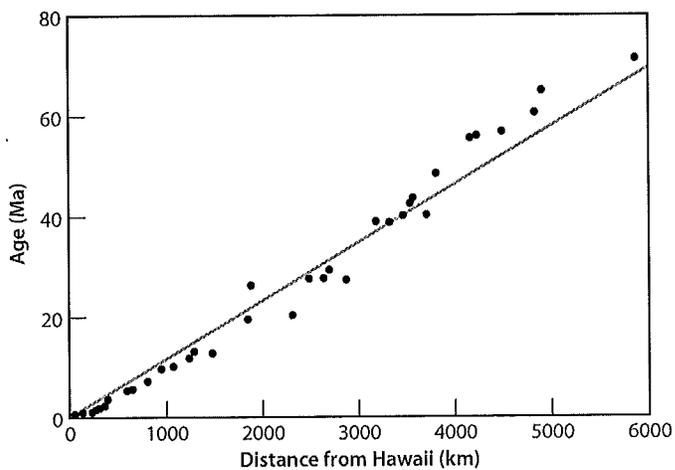
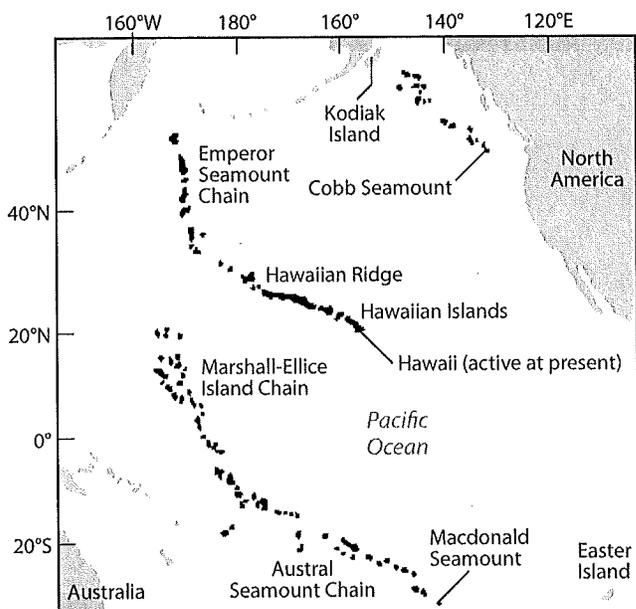
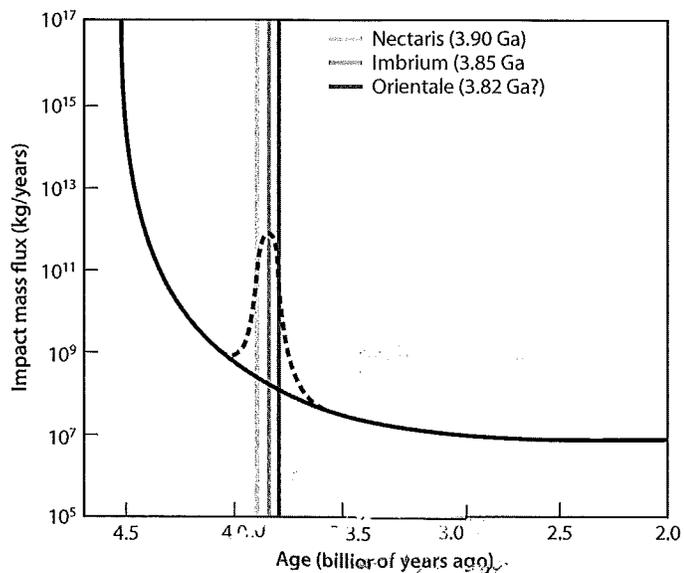
**10.** What are the “energy revolutions” in Earth’s history, and approximately when did each occur? (20 points)

**11.** There is abundant evidence for a major change in the oxidation of Earth’ surface between about 2700 Ma and 1700Ma. Describe this evidence, using C, Fe and S. Is it likely that O<sub>2</sub> in the atmosphere rose to modern levels during this time? (35 points)

**12.** Compare and contrast the environmental issues for human civilization associated with water resources and with fossil fuels. Use concrete examples and diagrams to illustrate your answer. (25 points)

**13.** On the following two pages are six figures, some with labels removed. Below each figure, identify what it is that is shown, and what importance it had for the topics covered in the course. (36 points).





**14.** What is the Drake equation and what is it used to estimate? I do not expect you to reproduce the whole equation. Discuss various terms in the equation that you recall and point out what is likely the most important term. What is the range of “answers” to the Drake equation, and what according to your personal intuition is the likely answer? (20 points)

**15.** Pose a question worth about 20 points that you think should have been on this exam and answer it (20 points).

