

Name _____

BEP 210 – Epic of Evolution Midterm Exam - March 16, 2005

This exam is closed-book and closed-note.

Part 1 (60 points): Answer 12 of the following 15 short questions. Please cross out the 3 that you do not do. Each of these questions is worth 5 points. Please *do not* feel obligated to use all of the space provided.

- 1) Which milestone came first: the annihilation of p^+ and p^- (protons and antiprotons) or the annihilation of e^- and e^+ (electrons and positrons)? Using the concept $E=mc^2$ and what you know about the early period after the Big Bang, explain why they occurred in this order.

- 2) We believe the universe is homogeneous: on large enough scales, it is more or less the same everywhere. Assuming that is the case, what is the point of building bigger and bigger (and more and more expensive) telescopes? Don't we just see more and more examples of the same kinds of objects (stars, galaxies, etc.) that we can see for much less money in our immediate neighborhood?

- 3) What role does gravity play in making a star like the Sun shine? Using your answer, explain why Jupiter doesn't shine, even though it --- just like the Sun --- is composed mainly of hydrogen and helium.

- 4) What crucial "raw material" was present during the period of Big Bang nucleosynthesis, but is NOT present in the interior of stars (like our Sun)? What force is responsible for the material's disappearance in the intervening time? What force makes it possible for nuclear processes in stars to proceed despite the absence of this raw material? Explain.

- 5) In Martin Rees's book, Just Six Numbers, he discusses the number E which is the fraction of mass that is converted into energy during the processes that make the Sun shine. In our universe, $E=0.007$. Imagine another universe, in which the Strong Force is a little weaker so that E is a little smaller, say 0.006. How would stars be different in such a universe, and why?

- 6) If you simmer a pot of stew with the lid on, it might not convect and you might burn the bottom part of the stew. Take the lid off, and the stew will circulate (convect). The same process occurs if, at a Japanese restaurant, you are brought miso soup with the lid on. While the lid is on, the soup is not convecting. However, the moment you take the lid off, the soup begins to convect, and you can see the rolling cells of convecting miso.
 - (a) Explain why this happens.
 - (b) Explain how this is similar to the earth.

- 7) At a subduction zone, cold rock that has been sitting beneath the ocean seafloor sinks down into the warmer mantle. Even though this makes that part of the mantle colder, rock there begins to melt, and this melt rises to form volcanoes like Mt. St. Helens and Krakatoa. Explain why this melting occurs within subduction zones.

8) The surface of Mercury is covered with craters. The surface of Mars has many fewer craters than Mercury. The surface of Venus has even fewer craters than Mars. What does this tell you about the geology of these planets?

9) Describe the three kinds of plate boundaries. Give an example for each of a place on the earth where you could go to find one.

10) Earth's outer core is liquid iron, and though earth's inner core is even hotter, it is solid. Describe the effects that temperature and pressure have on determining whether a material is liquid or solid, and then explain why the inner core is solid.

11) Describe 2 kinds of evidence indicating that all modern creatures share a common ancestor.

12) Snowflakes and biological traits both arise as the outcome of emergence. Describe 3 ways that generating an organism is different from generating a snowflake.

13)

a) Why is "enclosure" a key necessity of an organism?

b) What serves as the enclosure of modern cells?

c) Explain what is meant by saying that "enclosure" is an emergent property.

14) Explain how gene duplications can generate protein families with related but distinctive properties.

15) Explain what is meant by saying that the ancestor of mice and humans lived 75 million years ago (MYA) and the ancestor of flies and humans lived 600 MYA.

Part 2 (40 points): Answer 4 of the following 6 short questions. Please cross out the 2 that you do not do. Each of these questions is worth 10 points. Please *do not* feel obligated to use all of the space provided.:

1) The milestone of "decoupling" is very important in the history of our universe. Describe and explain decoupling and its significance. Be sure to include the following:

(a) What formed for the first time at decoupling, and why it couldn't have formed earlier.

(b) What "decoupled" and why.

(c) What remnant from the time of decoupling can be directly observed today, and how has it changed since decoupling.

(d) Why decoupling is significant for the formation of galaxies and stars.

2) Light (and other electromagnetic waves) from distant galaxies is "red-shifted."

Carefully explain why, in two different ways:

(a) Using the Doppler effect. (Be sure your answer here includes an explanation of what the Doppler effect is.)

(b) Using the idea of the "stretching" of space.

3) (a) Describe the differences between the ways energy flows during the mechanisms of conduction, convection, and radiation.

(b) As Earth cools off, energy is leaving Earth at the enormous rate of 42.4 terawatts. Starting from the core, and moving upward, discuss how the mechanisms of conduction, convection and radiation factor into the flow of energy across the different layers within Earth.

4) Geoscientists believe that early on in Earth's history, perhaps only about 40 million years after the start of the solar system, much of Earth may have been molten. Describe the stages involved with the assembly of Earth and the processes that led to its being totally or mostly molten.

5) Describe the general features of phototaxis by a bacterium and chemotaxis by an amoeba, noting in what ways the two systems share common features and in what ways they are different.

6) How does the story of the Hox proteins illustrate conservation, innovation, and diversification in evolution?