AST 309L: Review Sheet for Exam 4

Exam 4 covers a diverse set of topics, but they are all united by the underlying question: is the type of development of life from bacteria to complex creatures with intelligence like ours likely to develop on other planets? In other words, is evolution, especially with respect to intelligence, "convergent?" Or are the events that led us here so chancy, so improbable, that evolution elsewhere would almost certainly have led in some unimaginably different direction? Ultimately this question can only be answered by searching for and finding (or not finding) signals from alien civilizations (topic of last section of this course), but we still want to be aware of the arguments surrounding this basic question.

The mixture of textbook readings, outside readings, and lecture notes covers a large number of topics, and they are somewhat independent. For example, there are many topics covered in the lecture notes, and in the outside readings, that are not covered in the textbook. On the exam there will be a roughly equal emphasis given to the three sets of study materials; since much of the lecture material is not covered elsewhere, you will be a significant disadvantage if you did not attend class much, although some of it can be obtained from the online lectures.

Here are the readings that will be covered on the exam. I realize it is a massive amount of material to read and remember, but you have also had a lot of time to read it, we have discussed a lot of it repeatedly in class, and I only expect you to get the basic ideas; also, the topics are so crucial and (I think) interesting for this course that I felt you should be exposed to all of it. Try not to get worried or confused or sidetracked or frustrated by the fact that there are so many different opinions expressed, or that there are no agreed-upon answers to even the most basic questions in these areas—that is the point here, and your real assignment is to understand the variety of evidence and arguments for different points of view. That is the situation (often hidden from students or the public) for any topic, in any subject, and being aware of, and comfortable with, this state of affairs has important implications about knowledge in general, and even extraterrestrial intelligence.

1. For the textbook, I suggest you read pp. 53-59 in ch.3 on evolution in general, although I won't test you on any specifics, and it is somewhat historical. Do read pp. 73-74 on mutation and evolution again (we covered it briefly for exam 2); this material is basic for much of what we have discussed, so it is important that you are comfortable with it. The bulk of the reading is:

Ch.4—sections 4.1 (radioactive dating) and 4.5 (climate regulation—especially CO2 cycle, ice ages). I won't test you on formation of the Earth (4.2), and have decided that, while I hope you do read sec. 4.3 on geological processes, there is too much material to include it on this exam.

Review questions that will be useful to try are 1-3, 5, 13-15.

Ch. 5—sections 5.3 through 5.6. These parallel some of the material covered in class.

All the review questions 9 through 18 in ch. 5 are good ones to think about.

2. Lectures—there are three parts available online at the course website. One pdf of the presentation materials (lots of images) up to April 8 are also available. I will not be putting the later presentations online because it was mostly a visual way for me to work through some of the lecture notes.

3. Outside readings—there are TWO outside reading packets, each containing roughly ten articles, nearly all of them short. After reading these you should take some notes that just summarize what the main idea or point of the each article was, especially as it applies to convergent evolution in general (outside readings part 1) and with respect to intelligence (outside readings part 2). The basic thing I want you to get out of the articles in the outside readings is to be able to summarize their main point, not specific facts. I will allow you to bring to the next

exam a 4x6 card listing the first author, however much of the title you want, and a sentence or two summarizing what the article is about. You will put your name on the card and turn it in after the exam. Only list the author's last name and a few phrases reminding you about the main points. This card is to help you keep straight which article I am asking about on the exam, so don't think of it as containing notes for the exam. For example, I might ask "In the paper 'Origin of Intelligence' by Smith, the author argues that birds a. are capable of expressing theoretical concepts; b. have sonic patterns that qualify them as having musical intelligence; c. are smarter than humans; d. are simpletons compared to rodents." So your "note card" would just remind you which of the many papers the Smith paper is; you will have to remember the bird part yourself.

I suggest that after you have completed all the reading and reviewed a little, you try to discuss, and explain if possible (not just list) the major evolutionary events that have occurred in the history of life on Earth, and how they might relate to the question of convergence of complex life. These events might include …eukaryotic cells…meiotic sex…the Cambrian explosion…mass extinctions…global glaciations…factors involved in human intelligence. Then you should consider the various genome-level processes that may play a role in evolution, from the mutation-selection model to different processes such as neutral evolution (genetic drift), viral transduction, etc. These were explained in class and in the class notes. Try to summarize all the environmental, and genome-level, factors that we have encountered and what they suggest about the possibility of similar life forms on extraterrestrial planets (convergence) You should also be able to give, in clear language, a set of arguments for and against the idea that (our kind of) intelligence is a convergent property of evolution, garnering all the evidence and examples you can.

I have tried to select test questions that are more or less equally divided between those based on textbook reading, class discussion, and outside reading.

Here are some sample questions. As usual, I've tried to make most of them more difficult than the average question.

1. Which probably came second in the following list?
a. Cambrian explosion. b. eukaryotic cells
c. photosynthesis d. meiotic sex
[So you should be able to put these in time order and comment on each. Which one may approximately coincide with the increase in the Earth's atmospheric oxygen content?]

2. Which of the following *least* seriously contradicts the idea of natural selection?
a. viral transduction b. genetic drift (neutral evolution) c. punctuated equilibrium
[You may have to think about this a little, but if you are stymied, you don't understand these terms.]

3. The ability of a planet to regulate its temperature, in particular to keep it within liquid water limits, is often claimed necessary for most life to survive. This temperature regulation might be difficult for an extraterrestrial planet
a. without any volcanic activity.
b. without a sufficient supply of water vapor in its atmosphere.
c. without a sufficient supply of oxygen in its atmosphere.
d. if its mantle convection were too strong.
e. without some process like our ozone layer that shields the surface from ultraviolet radiation.

4. Assuming a "snowball Earth" episode occurred, why did the Earth ever unfreeze?
a. A change in the tilt of the Earth's rotational axis.

b. Because ice reflects less light than liquid water.
c. The resulting increase in geological activity.
d. There was no place for volcano- produced greenhouse gas to go.
e. Ice can dissolve carbon dioxide better than liquid water can.

5. Which of the following would lead us to be most optimistic concerning human-like intelligence in extraterrestrial creatures?
a. Piaget's developmental phase model of intelligence.
b. Contextualism or relativism of intelligence.
c. Gardner's modular model of intelligence.
d. Models in which intelligence is largely shaped by social interactions
[Note: this is an example of a question that you are unlikely to get correct unless you came to class, or at least understood the outline given in the online notes (in the latter case probably with some online searching required on your part).]

6. Which example of intelligent behavior is *least* easily explained in Calvin's scheme (as described in his article on the evolution of intelligence)?
a. giving a moving and eloquent speech
b. being able to identify painters by examples of their works
c. composing a song
d. playing basketball well
[If you understood what Calvin was claiming, this question is amazingly easy, yet I have used the question many times in the past and a surprisingly large fraction of students miss it—really read the article!]

7. One of the arguments made by Pfleiderer et al. ("What Extraterrestrial Life Might Look Like") for the likelihood of ETI is
a. a particularly important aspect of intelligence is, to various degrees, exhibited in many, if not all, animals on earth.
b. convergence of overall anatomical structure may or may not occur, but brains with interconnected neurons have occurred almost universally in terrestrial animals.
c. any organism in any environment is likely, given enough time, to develop categories like space, time, and causality, in order to cope with their environment.
[Note: this article is short and extremely interesting if you can get past the academic-oriented language, so I hope you see that two of the above choices have nothing to do with the main point of the article, and what that point is.]

8. One of the basic points of Mandler's article on conceptual development in infants is that concepts and ideas must develop
a. from perceptual analysis, or schema, due to integrated sensory input.
b. from motor activity ("action schema," e.g. movements of limbs, grasping, manipulating objects).
c. independently of the ability to categorize, which occurs significantly later.
d. along the lines originally proposed by Piaget.
[Note: although Mandler's article is on a very interesting topic (how we acquire concepts), it is one of the most difficult of the readings in terms of length and level of presentation. You will have to read it all the way to the end to be able to confidently answer this question.]