AST309L-Scalo: REVIEW SHEET FOR 1st EXAM

This exam covers these main topics: Drake equation, theories for the formation of planets, the detection of extrasolar planets, and considerations of habitability. This corresponds to the textbook readings in the course syllabus. There is also some material on what distinguishes science from non-science and pseudoscience—this is important because many people claim that astrobiology is “not really science.” However I will only ask a couple of questions about this on the exam. Note: pp. 12-13 in Ch. 1 will not be covered on the exam. There were also outside readings, two chapters from a book by Koerner and LeVay, that you are responsible for reading; a few questions based on this material will appear on the exam, and it will be helpful anyway in understanding the significance of disks and the methods of planet detection.

In addition to the review questions given below (I included a large number), the review questions at the end of the textbook chapters are all good, as are the “Think About It…” exercises scattered through the text. The more of these you think about and try to answer, the better you will do on the exam and the better you will understand the material, but I realize this depends on how much time you have to study, and how interested you are. I recommend that you start looking through these questions now, to get a feel for the level of familiarity and understanding you will need in order to do well on the exam. Sample multiple choice questions very similar to those you’ll see on the exam are also given on this review sheet.

A. Some review questions. Be sure you can give clear, and in some cases concise, answers. Some of these are similar to questions occurring on the exam, although they will be encountered in the form of multiple-choice questions. **There are also four “homework questions” that I have sent you via class email, whose answers you should already have found**.

1.What are the factors that are important in estimating the number of communicating civilizations in our Galaxy ("N" in the Drake equation)?

2.In descriptive terms, how is N related to the distance to the nearest communicating civilization?

3.If you lived on a planet orbiting some other star in our Galaxy, what would likely be the distance, on average, to the nearest star?

4.If you were to send a signal at the speed of light to a civilization all the way across our Galaxy, about how long would it take? (e.g. A century? A million years? A billion? You just need to be able to give a rough number like this.)

5.On p. 276 of your text is shown a photo of Frank Drake's license plate that says "NEQLSL" meaning N=L.

6.In order for N to be large enough so that communicating civilizations are nearby (say within 100 l.y.) what is required?

7.What is the fundamental reason we think that planets are necessary for life?

8.What are the main reasons for thinking that planets are common around other stars?

9.What is the evidence for disks around young stars? How might this suggest that planets are forming or will form there?

10.Explain why "infrared excesses" in the spectrum of a star might be a sign that the star possesses a disk. Why might an infrared excess NOT be a sign of a disk? What else could it be?

11. The "proplyds" images by the Hubble Space Telescope in the visual part of the spectrum appear quite a bit smaller than the probable disks imaged by the infrared satellite IRAS and subsequent infrared observations. Explain why this makes sense. (If you can answer this, you are in good shape for this part of the exam.)

12. What physical processes are thought to be responsible for forming protostellar disks? For converting disk material into planets?

13.Explain in some detail the standard theory for the origin of the planets in the solar system, What is the difference between terrestrial and giant (Jovian) planets in this scenario? How does this theory depend crucially on the lifetimes of protostellar disks?

14.What do the peculiarities of the orbits and rotational directions of some of the outer planets and their satellites suggest about physical processes that occurred in the early solar system?

15.List and describe various observational methods for searching for planets, including their advantages and limitations. (The answer to this would be fairly lengthy.) Explain why it is so difficult observationally to directly detect a planet orbiting another star.

16. Which of the proposed methods for detecting invisible planets around nearby stars can best or only be used in cases where our line of sight to the star lies perpendicular to the plane of the planet's orbit (i.e. planet's orbit is in the plane of the sky)? How about the parallel case?

17. What are “free-floating planets” and how might one be discovered?

18. What is the current status of detections of extrasolar planets? Discuss the masses and orbital characteristics. What are the selection effects that cause us not to be able to reach definitive conclusions about, say, the fraction of stars with planets? Why is it that the confirmed detection of extrasolar planets around a pulsar might not be very useful, or at least ambiguous, for answering the planet formation questions of most interest for our course?

19. List a few of the major proposed space missions (SIM, Kepler, TPF/Darwin) designed to detect extrasolar planets, and the techniques they will employ.

20. What is the fundamental reason why Kepler will be able to detect smaller-mass planets than ground-based programs?

21. Certain elements have recently been discovered in the atmosphere of an exoplanet. What elements? What property of this exoplanet system allows astronomers to see these elements? What do these observations tell us about the eolution of the exoplanet?

22. Discuss several things that could "go wrong" in the evolution of a planetary system and not result in the formation of planets at all, or a terrestrial-like planet, or a habitable planet.

23. Discuss which spectral or other "biosignatures" are expected to be useful in searching for life around extrasolar terrestrial-like planets. (There are several of them.)

24. Explain the concept of a liquid water habitable zone. What determines (a) its distance from the star, and (b) its inner and outer limits?

25. Explain what might be the habitability problem(s) for planets orbiting stars much more massive than the sun, binary star systems, or extremely old stars. What about "rogue" or "free-floating" planets? What about very low-mass stars?

26. Why might a massive moon like Earth's moon be necessary for life**?** [It's not just tides—see ch.10] Why would this make life unlikely for planets orbiting extrasolar planets?

27. Why might giant planets be necessary for life to develop on terrestrial-like planets?

B. Sample multiple choice questions.

Here are some sample questions to give you a feel for what the exam questions will be like. These questions may or may not be on the exam, or appear in different form. They are meant for you to see if you have studied sufficiently—if you have trouble with them, then you need to study more. I recommend that you do not try to find the answers to these questions if you haven't yet nearly completed your studying—you will be wasting time looking for answers or discussing them with others, time better spent trying to better-understand the material.

1. According to your textbook, one of the major features that distinguishes science from other fields of inquiry is that science
a. is not tied to any philosophical belief that the world is inherently understandable.
b. contains unifying theories that explain a large body of observations.
c. is based on the evaluation and verification of large numbers of facts.
d. does not assume that the simplest explanation is probably the best.

2. What is the fundamental distinction between stars on the one hand and planets or brown dwarfs on the other?
a. Gravity doesn't play a major role in holding brown dwarfs and planets together.
b. Brown dwarfs and planets don't emit light of their own, but can only be seen by reflected light.
c. Stars derive their energy from nuclear reactions, the other two don't.

3. Giant planets are mostly hydrogen and helium while there are little of these in the terrestrial planets. The physical process most responsible for this difference is
a. enhanced, or "runaway," collisional accumulation of planetesimals.
b. slower speeds in the outer solar system led to more coalescence instead of shattering.
c. gravitational accretion of disk gas (rather than solids) was only possible in the outer solar system.

4. Which of the following methods for detecting planets around nearby stars can best be used in cases where our line of sight to the star lies perpendicular to the plane of the planet's orbit (i.e. the planet's orbit is in the plane of the sky)?
a. reflected light or direct detection b. wavy motion of the star's path in the sky (astrometric method)
c. periodic Doppler effect for spectral lines from the parent star (velocity perturbations)
d. transits (eclipses) e. timing method

5. Except for a small number of cases, the only detected and confirmed extrasolar planets around solar-type stars were detected using which method?
a. wavy motion of the star's motion through the sky b. periodic Doppler effect for spectral lines from the parent star
c. variations in arrival times of light from a star d. transits (eclipses) e. infrared emission

6. What is one surprising result of the planet detections made so far?
a. Most of the orbits are so nearly circular. b. The planets are so much more massive than Jupiter.
c. So few of the planets are much smaller than Jupiter.
d. The orbital sizes (semimajor axes) of many of the planets are so small.

7. Which of the following methods of planet detection is most sensitive to planets FAR from their parent star?
a. astrometric b. radial velocity c. transit d. direct or reflected light

8. What technique will the Kepler space mission use to detect planets?
a. astrometric b. radial velocity c. transit d. direct or reflected light

9. For which of the following methods of detecting exoplanets is spatial resolution a severe problem?
a. direct or reflected light detection b. radial velocity c. transits d. timing

10. How do we know that a "hot Jupiter" is not a "hot Earth," i.e. a giant rocky planet?
a. A rocky planet would evaporate at such high temperatures.
b. We can see spectral lines of H in most of these planets' atmospheres.
c. Because one exoplanet was detected using two methods, which allows us to determine its mass and size, so its density.
d. A giant rocky planet would move around its parent star more slowly than observed.

11. One reason that might be valid for not expecting life on a planet orbiting a very high-mass (blue) star is
a. no habitable zone possible—star is too hot.
b. habitable zone too far from the star.
c. the lifetime of the star is probably too short for life to begin.
d. no habitable zone possible—star is too luminous.

12. The surface of Venus is very hot, *much* hotter than was expected. What is the crucial difference between the evolution of Venus and Earth which explains the huge temperature difference between the two planets?
a. Venus had a lot more volcanic activity than Earth.
b. Venus was too warm for the water vapor to turn into liquid form.
c. Venus was formed with, or produced, a lot more carbon dioxide, a greenhouse gas, in its atmosphere.
d. Venus does not have a large moon like the Earth's.