Astronomy 309L (49550)—Scalo Fall 2008
The Search for Extraterrestrial Intelligence

Syllabus

Classroom and time: Welch 3.502, T Th 12:30-1:45

Professor: John Scalo
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Office hours: **M4:30-5:30, W4:45-6:00**.

Meetings at other times can usually be easily arranged. However I urge you to feel free to call me at my home or office, or to talk to me after class (in the foyer just outside the classroom--I have free time after most of our classes); for short questions there is usually no need for you to walk all the way to my office, and I welcome phone calls at home.

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Class Website: link to it through http://www.as.utexas.edu/astronomy/education/courses.html
Or directly at http://www.as.utexas.edu/astronomy/education/fall08/scalo/309l.html
You should be able to link to these sites through this word document, which you can download from the class website. The course website will contain the syllabus, an outline of most class lectures, and illustrations you can download; extra reading in the form of articles that will be assigned (you can read them online or print them); a link to eGradebook so you can check your exam scores; and a simple way for me to distribute handouts or make slight revisions to the reading assignments (see "Announcement" at the web site). I urge you to check the website often.

Required book: Life in the Universe, 2nd edition, by J. O. Bennett and S. Shostak
(2007, Pearson: Addison- Wesley). ***Make sure it is the 2nd edition.***
Student Companion Website http://wps.aw.com/aw_bennett_liu_2
(This book is expensive, but is really the ideal book for the course. You should be able to get the "rebate" by selling your book at the end of the semester, unless you form a deep emotional attachment to it, as I'm sure you will. Current online prices are not substantially cheaper after the 2-day shipping you would need; used versions go down to ~$80, but can't guarantee 2nd edition in many cases, and would need rapid shipping. Do not delay in obtaining the book and spending time going through it.)

This is a rapidly growing interdisciplinary field, so the textbook will have to be supplemented by the lectures and by a few outside readings provided for you to download at the course website or that you will read online. More detailed guides to the reading assignments for each of the five parts (and exams) of the course will be handed out separately.

Grading: 100% of your grade will be based on **five exams**, roughly one every five class periods. All exams will be weighted equally *except* that your lowest exam score will only receive a weight of 1/2 compared to the others. So you have to take all the exams, but if you have an off day (or week, etc.) it won't hurt your final grade too much. The topics and dates of the exams (tentative—any changes will be announced heavily in class and at the class website) are listed below. There will be no comprehensive final. The exams will consist almost entirely of multiple choice questions, depending on class size. I will try to prepare you for the nature of the exam questions by occasionally giving sample questions during lectures, by trying to point out the types of information that I expect you to understand or remember, and giving examples on review sheets.

In case of medical or other non-academic emergencies or situations, contact me as early as possible—it will usually be possible for you to take an exam a day or so early or late in these cases (but not for academic reasons).

We will try to get exam grades available to you through the UT eGradebook system (at https://utdirect.utexas.edu/diia/egb/) within one, or at most two days of the time of the exam. Often you should be able to get your exam grades on the same day (or evening) as you take the exam.

Final grades are assigned on the basis of A=87-100, B=78-86.9, C=67-77.9, D=55-66.9, F<55.

Homework: The homework in this class will be ungraded except in the sense that references to it will appear on each exam in the form of a few exam questions. Usually once per week I will send out class email containing one or more questions relating to the topic we are covering. You should try to answer these (for yourself, not to me) within a day or two of receipt of the email. Most of these questions will be basic and fairly easy, and serve the purpose of having you keep up with the reading and lectures (lagging on these is the most common cause of grade decline in this class); many will involve searching the internet concerning developments too recent to be covered in your text (e.g. some recent developments in Mars and Titan missions). These questions will be much more difficult to answer if you wait until just before the exam—it will take you longer to dig up the answers during a time when you should be just studying for the exam. I will always insert exam questions that directly test whether you know the answers to these questions—that is how you will be "graded" on these homework questions.

Another continuing assignment will be to subscribe to and look at the astrobiology "news" reports at www.astrobionet.com. I will include 1-3 questions on these "news stories" on each exam.

Just under the cutoff? If at the end of the semester you are just under the cutoff for a grade (by, say, one, or two, or 0.3, percentage points), whether you are just under a D, say, or an A, do *not* call or write asking me to lower the cutoff--this is unfair to all concerned. Cutoffs will *not* be lowered to accommodate your individual score. Scores at the end of the semester are *not* rounded up, so, for example, a 77.7 will get you a C.

Special requests: If you have *any* special request of *any* sort (excluding those not allowed, like lowering the grade cutoff), please put the request in writing, preferably by email, or call me on the phone. Please state clearly and explicitly your request and why it is reasonable. Include a phone number so that I can contact you about your request.

Obviously (I hope) this procedure does not apply to minor requests such as "Could you write a little larger on the board?" etc. Any suggestions for improvement of the class as we proceed will be greatly appreciated, either in person, by phone, or by email.

Attendance: Although I will not take attendance records, you should keep in mind that the exams are based heavily on the lecture material (as well as the textbook and any other readings), and that the "notes" that I will make available to you are only outlines or abstracts of my lectures. The biggest single danger in this course is that you fall far enough behind, either through lack of reading or spotty attendance, that you cannot really understand the material being covered. In addition, I often try to give examples of future exam questions during lecture. I therefore urge you to attend all classes, and ask questions if you don't understand something.

Dropping the course: (see http://registrar.utexas.edu/calendars/08-09/index.html and *General Information*, ch.4, for details of required approvals).The College of Natural Sciences adheres strictly to the published deadlines.

Sept 2: Dropping courses electronically: During the first four class days, students may add and drop courses… …

Sept 12: Last day to drop a class with possible refund: During days five through twelve students may drop courses by phone, but must go to the department offering the course to seek permission to add a course. Be advised that some departments do not allow adds/drops after the fourth class day. For those departments that do allow adds/drops, the add-transactions before the twelfth class day will be processed by terminal in the respective department.

Sept 24: Deadline for dropping a course without possible academic penalty: The deadline for dropping a course without possible academic penalty is the end of the fourth class week. During this period a Q is automatically assigned but no refund is provided. If at all possible a substantial course grade should be assigned by this deadline to assist students in making an informed decision about dropping a course.

Oct 22: Last day to drop a course, except for urgent and nonacademic reasons, with Dean's approval: After the end of the fourth week of class, and until the deadline for dropping courses, a student wishing to drop a course will get the forms from the Dean's Office (WCH 1.106) and ask the instructor to complete the drop form that assigns a Q or an F. The symbol Q indicates an average of C or better at the time of the drop, or that no grade has yet been assigned, or that due to the student's performance and the nature of the course, no academic penalty is in order, or that for documented non-academic reasons, no academic penalty is in order. Also last day to change to or from pass/fail or credit/no credit basis.

Non-academic Q-drop: After the last day for academic Q-drop, students with substantiated non-academic reasons (as determined by the Dean's Office) may be allowed to drop a course. Faculty will be asked to provide information on student performance up to the time of the non-academic Q-drop request but are not responsible for making the decision about assigning a grade of Q. Students who experience significant non-academic problems such as extended health-related problems or family emergencies are urged to contact the Dean's Office.

The College of Natural Sciences is not obliged to honor the "one free drop" policy of some other colleges (e.g. Liberal Arts), so do not ask me for a Q drop after the deadline (March 25) for academic reasons (i.e. because your grade is low), no matter what a counselor in your college may have told you.

Incompletes: An incomplete (X) will only be considered for students who cannot complete the required course work for reasons other than lack of diligence (illness or other imperative nonacademic reasons), but only if the student has a passing grade on the work completed.

Cheating: Academic dishonesty will result in failure of the course and a report to the Dean of Students, who will decide on further action. Because of the large size of this class and the temptations involved, it will be important to keep your eyes from wandering and to guard your own exam. Students near the rear of class should try to sit one seat apart. Also, bring your UT ID card with you to exams and be prepared to show this card if asked.

Student observing opportunities: (call 471-5007 or see http://outreach.as.utexas.edu/public/viewing.html for Monday updates; information below is tentative)

Students interested in observing the night sky through small telescopes have several opportunities. **1**. The Painter Hall Observatory has UT Student/Staff Night on Fridays and Public Night is on Saturdays. These sessions are free and open to all ages; no reservations are required. **2**. The Astronomy Department sponsors weekly "Star Parties" on the 18th floor observing deck of R. L. Moore Hall on Wednesdays. This is free and open to the public. Call phone number or see url listed above for current times.

***Course Description* (please read carefully)**

This course is concerned with the possibilities and implications of extraterrestrial life and intelligence. In a sense, it is really a class about possibilities and probabilities, since we have very little evidence on which to form a conclusion, and part of the goal is to understand that no conclusions are required or even possible, in this subject or elsewhere. The major issues include whether habitable planets around other stars are commonplace, how likely or unlikely life is elsewhere (based on theories and evidence about the origin of life on earth), whether we should expect life to commonly develop into complex organisms, and toward creatures possessing "intelligence," language, technology, etc. (and whether we actually understand these terms, and whether they are even universal among terrestrial humans), speculations concerning the nature and lifetimes of alien civilizations, strategies for communication with extraterrestrials, interstellar travel, and the question of whether we have been visited by extraterrestrials. *Please note from the outset that the course is highly interdisciplinary by nature, and that only a fraction of the material (maybe a quarter to a third) is directly astronomical.*

At one level, the subject of extraterrestrial life can be discussed in terms having to do with the physical and biological sciences. For example, the question of which stars are most likely to have planets bearing life will involve discussions of the origin of planetary systems, current searches for planets around other stars, and theories and evidence related to the origin of life on earth. Whether or not you think creatures even remotely like us, or even like bacteria, will develop elsewhere depends on your view of how particular forms of biological complexity developed during the history of the Earth, whether that development was gradual and spontaneous, or triggered by external or catastrophic events, like mass extinctions. The subject matter will gradually shift away from the physical sciences as we inquire into the development of prebiological chemical evolution, biological evolution, "intelligence," language, cognition, and how they might differ (or not exist, or be replaced by alternative concepts) in extraterrestrial life forms. Almost every question will involve an impossible choice between what are usually called "*convergence*" and "*contingency*," which will be explained in class.

Most of the course will be devoted to two areas: 1. The formation and detection of extraterrestrial planets, and 2. Theories and experiments concerning the origin and earliest evolution of life here and elsewhere. That is most of the subject of "astrobiology" or "exobiology." This subject has experienced a huge resurgence of scientific interest in the past decade due to several factors that we will explore in detail. Astrobiology has finally become a legitimate field of science, with its own institutes, funding programs, and even universities that offer advanced degrees in the subject. Other aspects of the problem, like "listening" for signals or signs of extraterrestrial technological civilizations ("SETI" programs) and even potential designs for star travel vehicles are also under study, so we will devote a significant fraction of time to these topics, but only at the end of the course.

The material will be almost entirely non-mathematical, concentrating on a number of key ideas that can be understood without math, although they do require a solid conceptual grasp of the subjects, and *a degree of comfort using graphs as an important quantitative tool.* You will be required to become familiar with a lot of elementary but diverse material from astronomy, chemistry, and a bit of geology and cell biology. This material requires no background, nor gives any advantage to those who do have some background—it is really at an elementary level. If you are not willing to study interdisciplinary material, please drop the course now, but don't complain in the end that this wasn't a straight astronomy class! *I suggest you immediately look through your textbook to get a feel for the nature of the topics* we will be covering. There is a fairly large vocabulary of terminology with which you must become comfortable—I cannot overstress the importance of being able to speak about the topics covered in this class coherently and comfortably. It is my repeated observation that students who have trouble on exams, even though they think they studied diligently, are not comfortable with the terminology, and so are not really making sense of the exam questions; conversely, the students who do well in this class are usually able to explain the material in words to someone unfamiliar with the subject matter.

AST309L: SCHEDULE OF TOPICS, READINGS, AND EXAM DATES

I will list topics according to the organization of the textbook (e.g. 5.2 means section 5.2 in Bennet and Shostak's book). Although I like the clarity and production of our textbook, the one poor feature, in my opinion, is the order of presentation of the topics. For that reason we are covering the material in a different order than presented in the textbook. I have gone through this before and am sure there is very little confusion caused by (say) terminology in Ch. 10 that depends on Ch. 7 (which you won't have read yet). However this re-ordering does make it very important for you to keep a copy of this reading list handy.

The course is divided into five sections, with an exam after each section. The exam dates are only a little tentative, and time constraints may cause one or more of them to shift by one class day, or force us to delay covering some of the material until the next exam. I will give you plenty of advanced warning if such a change is coming and will try to avoid it. But the plan is: An exam every three weeks, on Thursdays, beginning Sept. 18. The exception is Part III, for which we should only need two weeks.

I. Habitable planets

Overview in terms of the "Drake equation" (**12.1**) [Will begin lectures with this material] Don't worry about math, just try to get the main ideas. The most important concept is the question of "contingency vs. convergence," a theme that recurs for nearly every topic in the entire course. You should understand why there can be no final answers to questions like this (related to determinism vs. randomness).

Ch. 1 Overview by topic—brief but important. Know what this subject is about, since it is a new one.

Ch. 2 Mostly history. Only read 2.2 (Copernican revolution) + 2.4 (Gravity and the nature of theories)

Ch. 3 **(3.1), 3.2** (sizes, distances, elements from stars, time), **3.3** (objects in our solar system, *EZ introduction to disk and planet formation theories (much more detail in class),* **3.4** (review of background physics—light, phase changes,…) We won't spend much time on this review material, but you will have to read it and I will test you on it, in the context of astrobiology.

Ch. 10 Evolution of habitability. **10.1** Habitable zone, **10.2** Venus as example, **10.3** Surface habitability, **10.4** Future of life on Earth. ***Skip 10.5***

Ch. 11 Extrasolar planets—detection and biosignatures. *Much* more detail in lectures.
11.1 (phases of stellar evolution, properties, spectral types, stellar masses and lifetimes. *Which stars would make suitable stars for planets with life?*), **11.2** Extrasolar planets, **11.3** Rare Earth? **Skip 11.4.**

[Depending on time available, we may have to postpone 11.2 to the 2nd exam material.]

.....Our first exam will occur here (Thurs. Sept. 18) .....

II. Origin of life by chemical evolution

Ch. 5. The nature of life on earth—characteristics of life, cells, metabolism, genomes, extremophiles.
Read 5.1 to 5.5, skip 5.6.
Topics I will cover in more depth in class are:
Elementary background on molecular bonds, chemical reactions and cell biology.
Why carbon? Why water? Alternative biochemistries.
Molecular basis of life—prebiotic organic molecules; amino acids, nucleotides, proteins, nucleic acids.

Ch. 6. Origin and Evolution of Life on Earth—We will only cover the "Origin" part of this chapter here, which means only subsections **6.1** and **6.2**, especially **6.2**. I will fill in more detail in class, especially concerning origin of life scenarios and problems.
Alternate biochemistries again; strange life forms, artificial (digital) life (if time permits).
Some outside reading possible.

……Second exam here (Thurs. Oct. 9)……

III. Life in the Solar System?

Chapters 7 through 9. We will spend only three lecture periods on this material, but you are responsible for reading all of it.

Ch.7 Searching for life in our solar system

Ch.8 Mars

Ch.9 Jovian moons (+ additional readings on Titan mission)

.....Third exam here (Thurs. Oct 23).....

IV. Terrestrial biological evolution and intelligence; extraterrestrial "intelligence"?

Ch. 4. Habitability of the Earth—ages from radiometric dating, formation of Earth and Moon, Hadean Earth, climate regulation, geological setting for evolutionary development. **Read 4.1 to 4.6 (entire chapter)**

Back to **Ch. 6 (**sections on evolution):

6.3 Development of life on Earth. Empirical timeline, interpretations, implications for extraterrestiral complex life. Contingency vs. convergence is a major issue here, as it is in most of the course.
Class lectures: Major developments in history of life, from molecular level to oxygenation of atmosphere.

6.4 Impacts and mass extinctions—biological development driven by catastrophic events, severe environmental changes (e.g. snowball Earth episodes, oxygen holocaust, major impacts, episodes of intense volcanism…)

6.5 Human evolution-- discussion of problematic status of human uniqueness; development of cognitive function in organisms including humans; nature of "intelligence(s)".
If time: speculations on postbiological evolution, alternatives to development of complexity with alternative biochemistries, ...

……Fourth exam here (Thurs. Nov. 13)……..

V. Modes of contact

Ch. 12 The search for extraterrestrial intelligence (SETI)—listening strategies

12.1 Drake equation (review). Emphasis on importance of lifetime of a technological civilization—how could L be large enough to allow contact?

12.2 Intelligence—This will be supplemented with outside readings from cognitive science, cross-cultural and animal studies, artificial intelligence research. We will discuss in detail in class lectures. This is crucially important in designing strategies for signal detection (see below).

12.3 Searching for intelligence. SETI experiments (proposed encoding and signaling techniques, "magic frequencies," ongoing SETI programs)
If time: The nature of language and its possible alternatives.
Skip 12.4 for now.

Ch. 13 Interstellar Travel and the Fermi Paradox-- limiting factors, proposed designs. Possibility of exotic physics; Galactic colonization and the "Where are they?" conundrum.
Contact—Implications of search and discovery In-class lecture (time permitting): UFOs, artifacts, abduction phenomena,... (Read ch.12.4 for traditional scientist perspective).

..... Fifth (last) exam here, on last class day (Thurs. Dec. 4)……

There is no comprehensive final. You should be able to compute your final average score (we will give you a formula to help) and so you will know your letter grade in the course after receiving the results of the 5th exam. The only exceptions would be extreme borderline cases (e.g. a final average of 77. 96).