Astronomy 309L (47965)— Spring 2013
The Search for Extraterrestrial Life and Intelligence
Syllabus

Classroom and time: Welch 3.502, MWF 9-10.

Professor: John Scalo
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Email: scalo@astro.as.utexas.edu
Office hours: M, T 2:30-3:30, 4:30-5:30 (will be shifted to W Th when exam is on Fri.)
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. I welcome phone calls at home—it is an extremely efficient way for us to communicate while a particular question or problem is on your mind. Any time before 9pm is fine. Sending me email is ok, but I usually cannot give adequate answers to subject matter questions by email.

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Class Website: Materials for the course—this syllabus, some outlines of lectures, extra readings that will be assigned, messages, etc. will be available at Blackboard, and/or sent to you via class email. Your exam grades will also be posted at Blackboard. Please download and read "First Day Handout for Undergraduates" from the Astronomy Department website, or from Course Documents at Blackboard, as well as the pdf of this syllabus.

There is also a *textbook* website (see below).

Required book: *Life in the Universe*, **3rd** edition, by J. O. Bennett and S. Shostak (2011).
Student Companion Website: http://wps.aw.com/aw_bennett_liu_3

This 3rd edition is available at local bookstores. It is definitely the best (and nearly only) up-to-date textbook for a class at this level. It comes with the access code (inside front cover) you need in order to register at the student companion website, giving you access to the textbook in ebook form, quiz questions for each chapter, self-guided tutorials, interactive figures and photos, links to astrobiology-related web sites, a math review, and more. The textbook is expensive, but 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.

Purchasing this textbook *used***,** online or otherwise, may be tricky and is not recommended. If you do, be sure you are purchasing a 3rd edition. Also, a used book will not have a valid access code to the student companion site: You would have to purchase an access code separately, online from the publisher—I think it's about $30-40, which makes the total higher than a new book, as far as I can tell. At this time the lowest used 3rd edition at amazon is $93 (new is $112). If you can find a used 3rd edition for as little as $60 dollars, then it might be a viable option.

Do *not* purchase a 2nd edition of the textbook. This subject ("astrobiology") has developed very rapidly in the past several years, so that edition is partly out of date, has different page numberings, and

In any case, *purchase it now; you should have it in-hand by Wednesday, Jan. 16, at latest.* Note: If you purchase a 3nd edition online, you cannot afford to wait 4-10 days for delivery, so you'll have to specify two-day shipping.

Other required reading: Astrobiology is a rapidly growing interdisciplinary field, so the textbook will have to be supplemented by a several outside readings provided for you to download at Blackboard (as pdfs), or that you can read online (through the UT electronic library, or at a url I will supply). More detailed guides to the reading assignments for each of the five parts of the course will be handed out separately. The textbook reading assignments corresponding to each exam is given separately below. A day-by-day calendar of lecture topics and readings will be distributed separately.

Grading: 95% of your grade will be based on **five exams**, spaced roughly equally through the semester. The other 5% of your grade will be based on attendance.

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 are listed below. There will be no comprehensive final, and no "optional

final" exam. The exams will consist entirely of multiple choice questions, unless our class size is unusually small. 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, pointing you to the useful end-of-chapter and online review questions, 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 Blackboard 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.

The remaining 5% of your grade will be based on attendance; the manner in which attendance is monitored will depend on the size of our class and other considerations. I will send you a separate email/document when I am certain about the procedure. You will not be penalized if an emergency keeps you from attending a class—I'll explain in class.

Final grades are assigned on the basis of A=87-100, B=77-86.9, C=67-77.9, D=55-66.9, F<55. *No plus or minus grades are assigned in this class.*

Homework: There is homework in this class, but it will be ungraded *except* in the sense that references to it will appear on each exam in the form of a few exam questions. In other words, your homework will be graded as part of each exam. A. Once every week or two I will send out class email containing one or more questions relating to the topic we are covering. B. I will also assign and discuss homework questions as part of the lectures. C. Finally, there are selected end-of-chapter and online review questions that form a part of the homework; some of these questions will appear, often in modified form, on exams.

I will 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 http://astrobio.net/astrobiological_news.php. I will include 1-3 questions based on these "news stories" on each exam. Sometimes these will be included as "extra credit" questions on exams.

Extra Credit: Besides the possible "extra credit exam questions" mentioned above, a short "research paper" may be used to increase your final percentage grade by up to 5%. These papers should reflect intense and independent outside research on a particular topic, and will require significant reading and time; *more details and a list of possible topics will be provided separately.*

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 76.7 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. A short email or just telling me before or after class will do.

Any suggestions for improvement of the class as we proceed will be greatly appreciated, either in person, by phone, or by email. I think there is not much purpose, and certainly no benefit to you, when I receive your comments on the Course-Evaluation Survey after the class has ended. Instead, I hope we can both "self-correct" if there are particular problems.

Attendance: 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. Even the simple forced repetition of having to encounter the material in class three times a week is an important way to enhance your familiarity with the material, and your grade. Another, important, reason why attendance is important in this particular class is that a significant part of my lectures will *not* be a simple overlap with the textbook. Finally, at least initially, *I will **n**ot put lecture slides online*, or only do so selectively, perhaps as an outline. I therefore urge you to attend all classes, and ask questions if you don't understand something.

Over the years, I have finally come to see that, especially for a MWF9am class, attendance needs to be enforced in some way—the correlation of low grades with lack of attendance (and participation) has become very clear in the past several years, so I will monitor attendance and accordingly assign 5% of your final percentage average on this basis.

Dropping the course: See *General Information*, Registrar's web site, for details of required approvals. Brief list of dates are at the online academic calendar. The College of Natural Sciences adheres strictly to the published deadlines. Please notice the 12th class day (last day to drop a class with possible refund), the deadline for dropping a course without possible academic penalty, and the last day to drop a course, except for urgent and nonacademic reasons, with Dean's approval.

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. If our enrollment is small enough, students will be required to sit one seat apart during exams. Because of the increasing frequency of clear infractions, please protect your work, even your "homework."

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

This course is concerned with the possibilities and implications of extraterrestrial life and intelligence. 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), how we might detect such life remotely, the possibilities of life within our own solar system, whether we should expect that complex organisms, especially creatures possessing "intelligence," language, technology, etc. are common, strategies for communication with extraterrestrials, the possibilities for interstellar travel, and (if time permits) 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) is directly astronomical.*

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.* If you are at all uncomfortable with elementary mathematics (or even if you're not), take a look at the "Math Review" at the textbook web site; the most important are "Powers of Ten," "Scientific Notation," and "Working with Units."

You will be required to become familiar with a lot of elementary but diverse material from astronomy, planetary science, chemistry, and molecular 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. Also, look through the list of topics and readings beginning on the next page for an outline.

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.

Schedule of readings, topics, and exam dates is on next page.

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 Bennett and Shostak's book). A section in parentheses (e.g. (3.1)) means "Skim, but not covered on exam." 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.*

A table giving the lecture topics and reading assignments for each class day will be made available online, separately.

The course is divided into five sections, with an exam after each section. There are about 8-9 lectures between each exam, except for Exam III, for which we will only spend about 5 lectures. I will distribute a more detailed list of readings and corresponding lecture dates during the second week of classes.

I. <u>Background, Exoplanets, Habitable Planets</u> (8 lectures)

Ch. 1. Sections 1.1-1.4. Overview by topic—Basically "What is astrobiology?" Brief (11 pages) but important.
Reading Chapter 1 will help you understand what this course is about.

Section 12.1. Overview in terms of the "<u>Drake equation</u>" (**12.1**) Don't worry about math, just try to get the main ideas. We will spend about two entire lectures on this topic.

[You can skip Ch. 2 if you have had an astronomy class recently, although you might be interested in the history of the subject (2.1). None of this material will directly appear on the exam.]

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,
3.4 (review of background physics—light, phase changes.

Ch. 10 Habitability.
→Read pp. 241-243 in sec. 7.1 on "Does life need liquid water?"
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—search, detection results, and biosignatures. Really "The search for Earth II."
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 (lots of material here). [we *may* postpone spectral biomarkers, pp. 381-382, and
11.3 The possibility that Earth is rare to next exam]
Skip 11.4 (classifying stars). *We will spend most time on 11.2.*

.....*Our first exam will occur here (Wed, Feb 6)* .....

<u>II. Origin of life by chemical evolution</u> (8 lectures)

Ch.11.2 pp. 381-382: How could we detect life on extrasolar planets? (Spectral biomarkers)

Ch.11.3 The possibility that Earth is rare (<u>"Rare Earth?"</u> First examples of "contingency."]

Ch. 5. <u>The nature of life on earth</u>—characteristics of life, cells, metabolism, genomes, extremophiles.
Read **5.1** (defining life; possible outside articles), **5.2** (cells), **5.**3 (metabolism), **5.**4 (DNA and heredity),
5.5 (life at the extremes), → Read pp. 241-243 in sec. 7.1 on "Does life need liquid water?"
Skip sec. 5.6.
Emphasized in lectures (with outside notes provided): Elementary background on molecular bonds, chemical reactions and cell biology. Why carbon? Why water? Why polymers? Molecular basis of life—prebiotic organic molecules; amino acids, nucleotides, proteins, nucleic acids.

Ch. 6. <u>Origin [and Evolution] of Life on Earth</u>—We will only cover the "Origin" part of this chapter here, which means subsections
6.1 (searching for life's origins) and
6.2 (origin of life—will spend most of our time here, especially on "RNA world;" requires you understand lecture material mentioned above in connection with Ch. 5)
6.6 (artificial life; possibly omitted, depending on time).

……*Second exam here (Wed, Feb 27*)……

III. Life in the Solar System? (Only five lectures, but you are responsible for all of it.)
Ch.7 Searching for life in our solar system
Ch.8 Mars
Ch.9 Moons of giant planets (emphasis on Titan and Europa)
.....*Third exam here (Wed, March 20,* [Wednesday after Spring Break])**.....**

IV. Development of Complex Life; Relation to History of Earth's Environment (9 lectures)
Ch. 4. Habitability of the Earth
4.1 (geology and life**),**
4.2 (radiometric ages),
4.3 (Hadean Earth and the dawn of life),
4.4. Geology and habitability, *not on exam*],
4.5 (Climate regulation and change).
Skip sec. 4.6 (origin of our moon).

Chapter 4 is about the earliest development of life on Earth and its relation to geological/climatic conditions.
Then: Back to **Ch. 6 (**sections on evolution of life on Earth):
6.3 Development of life on Earth. Empirical timeline, interpretations, implications for extraterrestrial 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 Appearance of human-like cognition-- discussion of problematic status of human uniqueness; development of cognitive function in organisms including humans; nature of "intelligence(s)" will be probably be postponed to exam V.
……*Fourth exam here (Friday, April 12)*…….

V. Modes of contact (9 lectures)
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 may 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.
[12.4 UFOs, artifacts, abduction phenomena,,... (Read ch.**12.4** for traditional scientist perspective; 12.4 will not be on the exam.)]

Ch. 13 Interstellar Travel and the Fermi Paradox
13.1, 13.2. Limiting factors and proposed designs for starflight.
13.3. The Fermi paradox: Galactic colonization and the "Where are they?" conundrum.
[Skip 13.4 (theory of relativity) except for your own interest.]
..... *Fifth (last) exam here, on last class day (Friday, May 3)……*

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.
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