Astronomy 309L (46880)— **Spring 2016**
The Search for Extraterrestrial Life and Intelligence
Course Syllabus

Classroom and time: Welch Hall 3.502 (enter from outside the building), T Th 11-12:15

Professor: John Scalo
Office: R.L. Moore (RLM) 15.318 (R.L. Moore is at the corner of Dean Keaton and Speedway)
Phone: 478-2748 (home: best place to call me); office number is 471-6446.
Email: scalo@astro.as.utexas.edu
Office hours: M 2:30-3:15, F 3:00-4:00 (may be shifted when exam is near).

Alternatives to office hours:

1. We can talk outside the classroom (in the foyer) after class—I will almost always be free after our class.
2. In effect, I have daily phone office hours. Use my home phone number. Students are always reluctant to do this, but I don't know why. It's so much easier than walking to my office, and you can call back if you think of something later. I welcome phone calls at home – it is an efficient way for us to communicate while a particular question is on your mind. It also provides a tool for both of us to assess your progress in terms of explanatory understanding (which is a primary objective in my classes). Calling any time before 9pm is fine; call back if I don't answer, don't leave a message; weekends are even better because I'm home a larger fraction of the day. Sending me email is ok, but I usually cannot give adequate answers to subject matter questions by email.

Teaching Assistant: The TA is knowledgeable, helpful, and friendly, so seek his guidance when you need it.

Name	Office	Office hours	email	Phone
Nicholas Miller	RLM 13.126	M 2:30-4 + TBA	nmiller@astro.as.utexas.edu	471-1309

Materials: The items you need to purchase or obtain are:

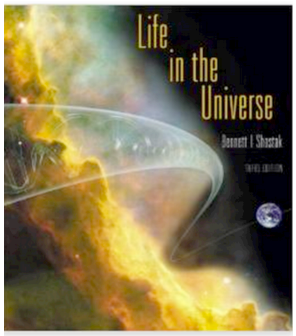
- → Textbook (immediately if you can and if you haven't already)
- → Some #2 pencils (for each exam—we supply the scantrons)
- → The Canvas app for your phone and/or laptop (at iTunes or elsewhere), which we will use for attendance. If you have a flip phone, no problem, just sign a sheet after class.

I assume you have convenient access to the internet, and that you check your email regularly.

Course web site: All materials will be available via Canvas or sent to you by email, including notes, outside readings, exam review sheets, etc.

→*Please download and read "First Day Handout for Undergraduates"* from the files section of our Canvas page, where you can always find a current version of this syllabus. Also, you'll find the announcements for student observing opportunities and "star parties" there in a few days.

Required textbook: *Life in the Universe*, **3rd** edition, by J. O. Bennett and S. Shostak (2011) *with access to the* Student Companion Website:
http://wps.aw.com/aw_bennett_liu_3/174/44767/11460576.cw/index.html.



The book comes with an 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.

--Do not buy anything but the 3rd addition with access code. In particular, a new (4th) edition just came out, but it is more expensive and not that much improved, and will makes things too confusing for you.

--The coop should have the textbook in stock "any day now." The cost is something like $140. At amazon.com the book sells new for about $130. Rentals start at $31. Unfortunately, the rental is not a new book, and will not have the access code for the textbook website. You can live without it, but there are a few things, like some of the assigned review questions, that you won't have, or will have to copy off of someone else's access. You could purchase an access code separately, online from the publisher web site—I think it's about $40-50, which makes the total nearly as high as a new book, as far as I can tell. The kindle version is not mush less in cost.

--Purchasing this textbook *used*, online or otherwise, will be tricky and is not recommended. If you do, *be sure you are purchasing a 3rd edition*. The second edition will be cheap but useless. Also, a used book will not have a

valid access code to the student companion site; as remarked above and explained more in class, this access code is useful, but in a jam you can get by without it.
--These publishers are vigilant, and have apparently cut off (nearly) all other paths to free or inexpensive new books, as far as I can tell.
→In any case, *purchase it now. You should have it in-hand by Thursday, Jan. 21, if not sooner, or you will already be behind in the readings.* If you have some temporary difficulty, such as insufficient funds, please call me at the number above.
Other required reading: Several sources of outside readings, including my notes, will be provided for you to download at Canvas (as pdfs), or will be sections from books that are available at UT's EBL electronic library. More detailed guides to the reading assignments for each of the five parts of the course will be handed out separately.

Lectures, homework, exams: Overall organization of the course

■ The rhythm of the class is simple: 4 or 5 in-class lecture periods, then an exam. With so much weight given to exams, and so much time between Th and the following T classes, a major factor in your success will be attendance, and diligent reading and review between classes.
Grading: Short version. **85% of your grade is based on 5 exams (17% each), 5% on attendance, and 10% on homework,** most of which will be submitted through Canvas. The homework may also include short written assignments based on readings, depending on the size of the class. Dates of exams are below.
Final letter grades: Final grades in our class will be assigned on the following basis.

A = 87.0 to 100 B = 77.0 to 86.9 C = 67.0 to 76.9 D = 57.0 to 66.9 F < 57.0

➡ Final percentages will *not* be "rounded up." 86.87 is a B, not an A.
➡ *Plus/minus grades will not be assigned in this class.*

■ **There are *five exams*, counting 85% of your final grade.**
--All exams are 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), it won't hurt your final grade *too* much.
--*The exam dates are all Tuesdays* except for the last exam.

***Ex 1*: T Feb 10 *Ex 2*: T Mar 3 *Ex 3*: T Mar 31 *Ex 4*: T April 21 *Ex 5*: Th May 7**

These dates are firm, unless we detect an error within the next few days. Exam scores should be ready by the morning following the exam, or even late the afternoon if the exam. If you have a legitimate problem with an exam date (but not things like other exams on the same date), there will be an opportunity to take the exam a day or two early, or, if a serious emergency or health problem, a day late. All early and late exams will be handled **by the TA (Nicholas Miller) and you are responsible for arranging any such exams with him.**
--Given the likely size of the class, all the exams will be multiple-choice questions, usually about 30-35 questions.
--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 Canvas within one, or at most two days of the time of the exam.
--<u>There will be no comprehensive final</u> (the amount and variety of topics is immense).

■ **Ten percent of your grade is based on homework assignments.** Most of the homework will consist of "take home quizzes" that you will answer through Canvas, after having some time to think about the answers. Other homework may include written answers to your choices from a set of questions I send you. These are expected to be about 1-2 concise paragraphs long, and are graded on how well they demonstrate your understanding of the answer by answering clearly and in your own words. Fluff or copied phrases will be given a low score, probably zero.

The accumulation of these homework assignments count for 10 percent of your grade. There will be roughly one or two for each exam, and remember that they are intended as an aid in studying. They are intended to require little time if you are caught up with the reading and lectures.

In addition, some homework questions do not require that you turn in anything. Instead, they are "due" on the days of exams, when the multiple choice equivalent of the homework questions will appear on the exam; some of these will be taken from the review questions at the end of each chapter. All information about the homework questions will be transmitted to you via Canvas.

■ **Five percent of your grade is based on *attendance*.** You'll use the Canvas app to enter a password as the answer to a quiz that we have during each class. *Get the Canvas application. Attendance also affects your grade indirectly*:
The exams are weighted heavily toward the lecture material, as well as the textbook readings. Studies I've done in the past indicate an average difference of nearly a full letter grade between students who attend regularly and those that don't. In semesters for which I counted attendance, it was rare for a student who didn't have at least about 80---90% attendance to receive a grade of "A."

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. Instead, you should trust in my flexibility when it comes time for final grades, as some of you who were in my class last semester may know.
Extra Credit: Extra credit assignments will be offered, but they will not be trivial. Their nature depends on the final size of our class, so I'll give you an update later in the semester. In any case, you should not assume there will be some fast-and-easy paper you can throw together at the end in order to improve your grade. Plan in advance if you decide you may need the extra credit assignment, since I will make it due well before the last exam. I will also try to make the choice of topics such that they are
Student feedback: 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. It could be something as simple but important as "Could you write a little larger on the board?" or "Would you try to stop speaking when facing the board?" etc. Or you may have more serious and/or in-depth comments. And of course positive comments are also very useful, and not just because they give me a warm feeling of encouragement. For the small things, you can just tell me after class, or by email, but most students feel more comfortable with complete anonymity.

For that purpose, we have an anonymous comment web site where you can say anything you want, always trying to be constructive, of course, at ant time. A link to this SurveyMonkey.com site (assuming it is still working) is on the home page for our course in Canvas. I'll place it here in the syllabus while I'm at it:
https://www.surveymonkey.com/s/J87V3P6 (Links to an external site.)
I periodically read these carefully, and can address some remarks in class, or at least try to use this feedback as an in-semester tool for improvement of the class.
Special requests: Students with disabilities or other special needs may request appropriate accommodations for the exams or more general accommodations from the Division of Diversity and Community Engagement, Services for Students with Disabilities, 512-471-6259, http://www.utexas.edu/diversity/ddce/ssd/
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. Notice the 12th class day (last day to drop a class with possible refund), the deadline for dropping a course without academic penalty, and the last day to drop a course, except for urgent 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; I'll place info at Canvas when I have it in case you're interested. You can find PDF versions here: http://outreach.as.utexas.edu/pdf/rlm.pdf and http://outreach.as.utexas.edu/pdf/painter.pdf
The website for public viewing is here: http://outreach.as.utexas.edu/public/viewing.html
What is this course really about? A little more detail, and a warning.

This course is concerned with the possibilities and implications of extraterrestrial life and intelligence, and a few more subtle themes that will become apparent. The standard major topics 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.

That probably sounds pretty dry, so this semester we'll begin with something called "The Fermi Paradox," which is all about star travel and colonization of our galaxy, and why and whether we are alone in our galaxy. First, you'll become experts on "The Drake Equation," which is really a simple mnemonic device for seeing the big picture, and can be a lot of fun if you let it.

WARNING: *Please note from the outset that the course is highly interdisciplinary by nature, and that only a fraction of the material (maybe a 1/4 to 1/3) is directly astronomical.* I have worked in this area as part of my research for about 15 years, and studied and taught it nearly every year for about 30 years. My problem for this course, then, is the urge to and habit of overstuffing the course with more and more material, and especially updates (your book is several years old), thinking that students will be able to discriminate between something that is just interesting to know and something that will be on an exam, but more often than not it just leads to confusion. For that reason, I'm attempting to whittle the material down to a cleaner, less comprehensive, learning experience.

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. My goal is to show you how simple it is. **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.

The material will be *almost* entirely non-mathematical, nothing beyond simple arithmetic, concentrating on a number of key ideas that can be understood without math. However, 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, you should consider the following your first assignment:

As listed as "required reading" in the list of topics and lectures (next page), look through the "Math Review" at the textbook web site; the most important are "Powers of Ten," and "Scientific Notation." Without some comfort with these, it will be difficult to understand what is going on. Most of the numbers will come early, in the first couple of weeks.

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." Dates corresponding to lectures will be filled in a little later. *It is important that you keep this outline handy.*

The course is divided into five sections, with an exam after each section. There are about 5 lectures between each exam, except for Exam 5, for which we will only have time for about 4 lectures.]

The "zeroeth" part of the course is whatever background you need to review in order to deal with the rest of the course. You have to be somewhat independent and responsible in doing this (mostly boring) background study.

Part Zero. Background reading. These will not be discussed except briefly in class, but it is extremely important that you read them at the level appropriate to your own background. You won't understand an important early part of the course without it. *This is why it is so important to obtain a textbook as soon as possible.*

[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 that 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.
We need all this background in order not to allow our investigation of the subject to degenerate into pure speculations. We will only cover it briefly in lecture, so make sure to read it soon.

■ **Required readin**g for the next two topics: Essential math review in Appendix C of your textbook. especially: **C1**. Powers of Ten; **C2.** Scientific Notation; don't worry much about C.3 (Units) , but do read **C.4** (Finding a Ratio—it's only a page long). Even if you think you are already comfortable with math at this level, I urge everyone to read it and get accustomed to the way numbers are presented in your textbook (and by me).

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Part I of course: Overview (ch.1),The Drake equation (12.1); Habitable Planets (Ch 10, 9, 11.1).

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, and will allow you to easily understand The Drake Equation.

Section 12.1 Overview in terms of the "Drake equation" (**12.1**) There is math, but mostly try to get the main ideas. We will spend about two entire lectures on these topics.

■ There will be some extra notes provided online concerning the Drake equation.

Ch. 10 **Habitability—focus on planets with liquid water.**

■ Read pp. 241-243 in sec. 7.1 on "Does life need liquid water?" It's crucial! Then:
10.1 Habitable zone
10.2 Venus as example of habitability thwarted by temperature and lack of liquid water.
10.3 Surface habitability. We'll consider the atmospheric gases that are important, radiation from the young Sun, etc.
10.4 Future of life on Earth. It's not a pretty end, but you have a few billion years before it occurs.

Skip section 10.5.

Ch.9 *An unconventional habitable zone: Moons of giant planets* (emphasis on Titan and Europa)

[We won't have time to cover all of the material on life in the solar system (Chapters 7-9), except in a nutshell fashion. However we WILL cover most of Chapter 9, the sections on the moons of giant planets.]

Ch. 11 **11.1** *What types of stars should we search for signs of life or intelligence?* Phases of stellar evolution, properties, spectral types, stellar masses and lifetimes. *Which stars would make suitable stars for planets with life?*

Part of the above material (11.1) may have to be postponed to the second exam. I'll let you know well in advance.

.....Our first exam will occur here (Tuesday, Feb 10) .....

II. "Extrasolar Planets" + 1 part of "Origin of life by chemical evolution"

Ch. 11 (cont'd) [We already covered 11.1 on exam 1, which was intended to summarize the course and understand the main problem. Here we are discussing the first of the "Drake equation factors," the likelihood that there are other planets around other stars, and that some of them are conducive to life, conservatively something like life on Earth.]

11.2 Extrasolar planets: detection methods, radial velocity and transit results. (Lots of material)

11.2 on extrasolar planets will take about 2.5 lectures.

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

11.3 The possibility that Earth is rare ("Rare Earth?" First examples of "contingency.")

One lecture on 11.2 and 11.3

Skip 11.4 (classifying stars).

Ch. 5. The nature of life on earth—We'll cover this only up to the molecular/cellular level, most important for origin models. Try to remember, at this point we are not interested in whether there are animals or other complex creatures, only how life operates at the microscopic, molecular level.

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. Textbook is skimpy here—I'll supply outside material.

Lectures will also cover parts of the following sections, which you should read in detail.

5.1 Defining life; possible outside articles.

5.2 Cells.

5.3 Metabolism.

5.4 DNA and heredity—This plays such an important role in the subject that we'll spend most of our time discussing this molecule, and especially its cousin (ancestor?), RNA, if we have time. More likely postponed to section III.

.....Second exam here (Tuesday, March 2).....

III. Origin and earliest development of life on Earth (only 5 lectures, but is less material than in previous parts).:***I'll periodically fill in more accurately the rest of this outline, e.g. topics of lectures on each class date, as we approach each section.***

Ch. 5 (cont'd) + Ch. 6: ***Lectures will be somewhat independent of the textbook reading.***

5.4 DNA and heredity—if we didn't cover on Exam 2. You can't understand one of the most important topics in the course, "RNA world," without reading this carefully. You also will not understand how relative ages lineage of organisms are obtained from bioinformatics trees.

5.5 Life at the extremes), PLUS→ Read pp. 241-243 in sec. 7.1 on "Does life need liquid water?" (again) This time there will be extensive in-class coverage beyond what is in the textbook.

Skip sec. 5.6.

Ch. 6. We will only cover the "Origin" part of this chapter here, which means subsections

6.1 Searching for life's origins.

6.2 Origin of life—will spend most of our time here, especially on "RNA world". This requires that you understand lecture material mentioned above in connection with Ch. 5)

.....Third exam here (Tuesday, March 31).....

IV. Development of *Complex* Life; Relation to History of Earth's Environment (9 lectures). Here we will try to see the overall development from bacteria, to animals, to the kind of cognition that humans (and some other animals) appear to possess.

Ch. 4. Habitability of the Earth -- Chapter 4 is about the earliest development of life on Earth and its relation to geological/climatic conditions. The "Hadean" era of Earth's evolution.

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).

Then: Back to **Ch. 6.** Sections on evolution of life on Earth—this is about *later* development of life, especially "complex life." Concentration on the timing and importance of a few major events.

6.3 Development of life on Earth. Empirical timeline, interpretations, implications for extraterrestrial complex life. *An emphasis will be on what we can learn from "evolutionary trees," and on showing you that they are simple enough that you can construct one yourself.*

Class lectures*: Major developments in history of life, from molecular level to oxygenation of atmosphere; One entire lecture on the "Cambrian explosion," which is arguably the first appearance of "animals."*

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…)

[Uncertain if we'll reach 6.5 by exam 4]

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 (Tuesday, April 21)……

V. Modes of contact (4-5 lectures)

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

12.1 Drake equation review. Emphasis on lifetime of a technological civilization.

12.2 Intelligence—This may be supplemented with outside readings from cognitive science, cross-cultural and animal studies, artificial intelligence research. Topic is important in designing strategies for signal detection.

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,,… (Conventional scientist perspective; *12.4 not 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 (Thursday, May 7)……

There is no comprehensive final. You should be able to compute your final average score (we will give you a formula to help), and therefore know your letter grade in the course, after receiving the results of the 5th exam.