Astronomy 106 : Winter 2015
Aliens

Course Description
Does ET exist? Has he/she/it been here before? Want to try to communicate – should we? In this course we will discuss the on-going search for extra-terrestrial life. We will place a strong focus on the scientific hurdles that lie in our understanding the development of life and for its potential evolution towards interstellar travel and communication. The framework of the course will be based upon the Drake Equation, which was first posed to estimate the total number of intelligent civilizations that might exist in the galaxy at a given time. Thus we will take a census of the potential for life beyond Earth through an exploration of our own solar system. We will then survey beyond our own star system to the exciting search for "extra-solar" planets and their biological potential. We will end with a group activity where students and instructors will try to estimate how many ET civilizations might exist and then move on to discuss our future potential to travel to the stars.
This course is intended for non-science majors with a basic high school background.

Locations and Times
Section 2 - Friday 10am-11am - 182 Dennison
Section 1 - Friday 11am-12pm - 182 Dennison
Students can attend either lecture section

Resources
There is *no assigned textbook* for this class; reference materials from the internet will be linked in the syllabus, or placed in the ctools 'Resources' folder and used to augment the material discussed in class.

There are some *awesome* books out there for those of you who really want to learn extra in this class:
How to find a habitable planet by James Kasting, 2010.
How to build a habitable planet by Wallace and Broecker, 2012.

Both books are on course reserve at Shapiro also, for those not wishing to purchase them.

Instructors
Prof. Eric F. Bell Room 300E West Hall ericbell@umich.edu
Instead of email, please use Piazza for all logistical or content-related questions
Formal Office hours: 1-2pm Fridays or by appointment
Ms. Olga Borovikova oborovik@umich.edu
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Important Dates
First day of class is Friday January 9. Tuesday January 27 is the last day for the regular drop/add period. No class on Friday March 6 (mid-winter break). Late drop deadline is Friday March 20. The last day of class is Friday April 17. Link to a summary of LSA important dates. **No final exam.**

Assessment

Grades will be assigned based on the score you accumulate during the class.
A-/A/A+ : 11500 / 12000 / 12500
B-/B/B+ : 10000 / 10500 / 11000
C-/C/C+ : 8500 / 9000 / 9500
D : 7000
The following assessments offer the possibility of you showing your understanding of the science of extraterrestrial life.

In Class Assessments [1300 points available]
Coming to class is *very strongly recommended*. There is no textbook that covers everything that you need to think about for this class. Our analysis of previous semesters has shown that if you don't come to class, you'll do a terrible job of homework and online quizzes; the majority of students who don't come to class - as measured by a zero i>clicker score - have failed the class, and the small fraction who pass typically end up with worse than a B-.

To give you the opportunity to increase your score in addition to learning more efficiently and effectively, we will offer 100 points per class for answering i>clicker questions (any answer gains credit, and students will gain a fraction of those points if they do not answer all questions, e.g., if they got to class late). We will start awarding points on Jan 16. **Students must have at least 900 points in this category to be able to earn an A or A+** (i.e., having >900 points in this category 'unlocks' A or A+ as grade possibilities).

i>clicker devices are available for purchase from the Computer Showcase in the Michigan Union and Pierpont Commons. ***Personal devices with the web-clicker subscription may not be used in this class.*** The cost for a new i>clicker is $38; used ones, if available, cost $28. Students can explore additional information about clickers at http://computershowcase.umich.edu/remotes/.

Clickers must be registered on the Astro 106 ctools site, not on the i>clicker website. Those with Clickers not registered by Thursday Feb 5 on the Astro 106 ctools website will not receive any participation credit for the semester.

Online weekly quizzes [5200 points available]
Online quizzes will be posted in CTools Test Center each Monday, starting with the 2nd week of class (e.g., posted Jan 12, due Jan 16), and will be due 9am Friday of that week. These will typically be multiple-choice questions based on the previous class and assigned reading/viewing materials. 400 points are available per quiz.

Homeworks [6600 points available]
There will be 3 homeworks, worth 2200 points each, due on Feb 6 (Friday 9am), Mar 13 (Friday 9am) and Apr 13 (Monday 9am). The homeworks cover a representative range of topics covered in the class. Each homework should be done carefully (it is an online form to make grading easier, but the questions are challenging and require working through carefully in advance, probably on paper, to get them right).

Stretch Assignments [4400 points available]
While these are still to be finalized (1/8/15), there are anticipated to be a total of 5 stretch assignments, worth 2200 points each, of which students can choose to do none, one or two. Perhaps there is a topic or two that you really want to dig into in more depth. Perhaps you made a mess of a few quizzes. Perhaps there was a homework you didn't hand in. Perhaps you really want an A. These stretch assignments offer an alternative path to demonstrate your understanding of the science relevant to extraterrestrial life. These assignments are challenging but more fun or thought provoking than a normal assignment and will require you to read ahead and do some independent study and research. These assignments are assessed

according to a strict rubric, which is provided with each assignment description.

Wave 1 : due Feb 20 complete up to one of the following :

- The Earth and its siblings in a cosmic context. Read, and provide a 2-3 page discussion of an important theme in How to find a habitable planet or How to build a habitable planet.
- Planet discovery and characterization. Document your hunt for a planetary transit at http://www.planethunters.org/

Wave 2 : due Mar 27 complete up to one of the following :

- Deep time, vast space and enormous energies : It is truly remarkable how large and old the Universe are. This assignment offers a quantitative exploration of the timescales, distance scales and energy and time requirements to visit extraterrestrial civilizations.
- Craft a message to extraterrestrials. Completed in pairs, ideally from different majors (ideally one with stronger quantitative background/interests, and one with stronger humanities/social sciences background/interests). Describe the purpose of your message, considerations for making sure it's general enough to be interpretable as signifying intelligent life. How will it be sent, what is its significance, and what kind of response might one expect?

Here are two example paths to an A - you can explore many different pathways to success in our gradebook, called Gradecraft.

'Standard build' path to an A :

attend and use i>clicker in 12/13 classes [1200 points],
earn 90% average in quizzes [4700 points],
complete 3 homeworks, earning 95% in each [6300 points]
Total : 12200 points (A)

'I want to stretch!' path to an A+ - choosing what assignments you want to do, and being able to earn an A even if you get some answers wrong in quizzes and homeworks… :

attend and use i>clicker in 12/13 classes [1200 points],
earn 75% average in quizzes (getting 1-2 questions wrong each week) [3900 points],
complete 2 homeworks (say you don't want to do HW3), earning 80% in each [3500 points],
complete 2 stretch assignments earning 90% in each [4000 points]
Total : 12600 points (A+)

Academic Integrity

A useful collection of resources on Academic Integrity at the University of Michigan can be found at: http://www.lib.umich.edu/acadintegrity/. Any incidents of plagiarism, cheating, or homework copying will be reported to Academic Affairs.
Note : quizzes need to be completed alone. You can discuss homeworks with peers, but you need to complete your homework yourself.

Learning outcomes :

Number of alien civilizations

Be able to understand conceptual framework for Drake equation, express why this is a useful construct for thinking about number of communicating civilizations

· know how we estimate number of stars, result
· Be able to explain planet detection methods (doppler, transit - includes telescopes, photometry, spectroscopy), understand how they limit our census, understand current idea of planets around other stars
· be able to explain difference between gas giants and terrestrial planets, and how we decide which is which (density)

· be able to explain how habitable zone is defined, have some sense for how it depends on stellar parameters, have some conception of how habitability depends on planetary parameters
· be able to explain where chemical elements come from, and ubiquity of molecules in space, and be able to use this insight to assess the (minimal) impact of this on the ability of organic life to arise elsewhere.
· to be able to relate scientific understanding of development of life on earth to defend an estimate of fraction of habitable planets that develop life
· to be able to relate scientific understanding of the development of complex life on earth to defend an estimate of the fraction of life which is complex, intelligent and can communicate with others
· to be able to relate understanding of civilizations and and understanding of possible dangers to civilization to defend an estimate of the lifetime of a civilization

Alien contact

· Appreciate challenges of interstellar communication (power requirements, space is huge and unlimited choice of frequencies, what does an intelligent signal look like?)
· be able to articulate some basic contact scenarios, the danger of cultural misunderstandings
· Understand and be able to articulate the Fermi Paradox :
  ○ Appreciate challenges of interstellar travel (power requirements, long timescales, dangers)
  ○ Appreciate limitations of human-centric conception of aliens (evolution, environment, communication, motivations)
· Be able to discuss (lack of) evidence for alien visitations, UFOs, alien influence on human history
· know what techniques are used and what challenges lie in our search for life in the Solar system

Syllabus and Reading assignments

(last updated on Jan 7)

Jan 9
SLIDES

Fermi's Paradox
-- "Where are they?"
-- Drake Equation
-- Historical perspective & aliens in popular culture

Assigned reading:

1. Scientific American Article on the Fermi Paradox

Supplemental reading:

1. Wikipedia article on the Fermi paradox (Generally, I'll link to Wikipedia only when it the article is of high-quality and summarizes an issue well, and has good links for further investigation. See also Harvard Writing Center's take on using Wikipedia)
2. Wikipedia article on UFOs (a very good attempt to discuss a hard area to objectively explore; also a great set of links; also fact sheet on Project Blue Book).

Jan 16
SLIDES

What is Life?
-- Elements of life

Assigned reading:

1. What is life? The 7 characteristics of living things
2. Extremophiles: Tardigrades
3. Neil Tyson: Origins of the elements in our bodies

Quizzes and i>clicker both start Jan 16

Jan 23
SLIDES

The development of life
-- *Origin of the elements*
-- *Origin of Life*
-- *How did the first living thing happen?*
-- *Evolution through natural selection*
-- *What do we know from the fossil record?*

Assigned activities:
1. NOVA: Origins of life
2. NOVA: Let's make a microbe tutorial (do the reality checks too)
3. *If* you need brushing up on half-lives : Half-life podcast at Kahn Academy

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Jan 30
SLIDES

The evolution of complex animals and intelligence
-- *Complex life developed late in the Earth's history*
-- *Mass extinctions*
-- *Is the development of intelligent life inevitable?*

Assigned activities:
1. Peter Ward: Mass extinctions

Feb 6
SLIDES

Lifetime of intelligent civilizations *(in-class discussion - bring a laptop and do the readings!)*
-- *Astronomical catastrophes*
-- *Technological Singularity*
-- *Civilization collapse and self-destruction?*

Assigned activities:
1. Phil Plait: How to defend Earth from killer asteroids
2. NYT: The coming Singularity
3. Jared Diamond: Why societies collapse [this talk is a little dry, and you'll have to take notes to keep track (I took a page of notes), but it's a ***very*** thought-provoking talk, give it a chance]

***Homework 1* due on Feb 6, 9pm**

Feb 13
SLIDES

The Drake Equation (link to in-class discussion)
-- *A framework for thinking about extraterrestrial life*
-- *Why are we estimating the number of stars?*
-- *The basics of estimation*
-- *How many stars are in the Milky Way? What type of stars are they?*

Assigned activities:
1. Carl Sagan: Evaluating the Drake equation [His estimates are quite optimistic]
2. Wikipedia: Main sequence stars [in particular : what powers them and their lifetimes]
3. Refresher: Tutorial on scientific notation

Feb 20
SLIDES

Exoplanet Detection Methods (I)
-- *Direct Imaging*
-- *Indirect methods (astrometry and doppler)*

Assigned activites:
1) http://www.bbc.co.uk/science/space/universe/sights/extrasolar_planets#p009gxf2 is a podcast that is part of the 'Sky at Night' which is a looonngg-running astronomy program on

the BBC. The old fellow is Sir Patrick Moore, the presenter of this programme for many many years - he inspired many young British children into astronomy.
2) http://planetquest.jpl.nasa.gov/page/methods

Supplemental websites :
1) electromagnetic spectrum
2) A really neat Doppler effect applet

Stretch assignments : Wave 1 (hand in during class)

Feb 27
SLIDES

Indirect Exoplanet Detection Methods (II)
-- Doppler and astrometry
-- Transits & Kepler Mission
Habitable Zones

Assigned readings:
1) Read this webpage on the habitable zone
2) Goldilocks and other Habitable Zones for Life

Supplemental websites :
A somewhat disorganized but interesting discussion of Stars and Habitable Planets

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Mar 13
SLIDES

Habitable zones (sorry I spaced on it last class)
What are exoplanets like?

Assigned readings:
1) Read this article on Kepler discoveries. Also, remind yourselves of the habitable zone stuff; we'll be doing both today.

Homework 2 due on March 13, 9*pm*

Mar 20
[no need for slides!]

Drake Equation Summary *(in-class discussion)*
-- How many advanced civilizations are in the Galaxy today?

You need to bring ~1 page of notes (perhaps the raw materials for your ctools quiz) to class with justified ranges for different Drake Equation parameters, in preparation for the class discussion. Bring your laptop too.

Assigned readings:
1. Carl Sagan: Evaluating the Drake equation [His estimates are quite optimistic]
2. Wikipedia: Drake equation This is a different formulation of the Drake equation, which is essentially equivalent

Rate of star formation * Lifetime of civilization ~ Number of stars * Lifetime of civilization/lifetime of Galaxy

i.e., the lifetime of the Galaxy moves from $f_L=L/T_{galaxy}$ to the beginning of the equation to make $R_*=N_*/T_{galaxy}$

QUIZ DUE 9am Mar 27 (opens 8am Mar 3/23), @ CTools Test Center

Mar 27 — Interstellar travel
-- The physics and constraints of space travel

Assigned reading/viewing:
1. Wikipedia: Interstellar travel
2. Play with it: Scale of the Universe

Supplemental websites : Wiki: Rocket
Stretch Assignments Wave 2 (hand in during class)

Apr 3 — SETI

Apr 10 — Contact scenarios *(in-class discussion)*
-- When cultures meet…
-- Should we search for aliens?
-- Would we even recognize a signal if we detected it?

Homework 3 due on April 13 (Monday), 9am

Apr 17 — Looking for life in the solar system
-- Where should we look for life in the solar system
-- Habitable Moons
