ASTR-301: Astrobiology

Spring Semester, 2021

Class Schedule: Monday & Wednesday, 4:30-5:45pm

Online Synchronous, with Blackboard

Instructor: Michael E. Summers

Draft Syllabus Updated January 25, 2021

Catalog description: This course will provide a scientific perspective on the story of life in the universe, from the origin of the universe to the origin and evolution of life on Earth, how life in turn has influenced the evolution of the Earth, and the prospects for life elsewhere. Topics include the origin of the Earth, the origin of life, the co-evolution of life and the Earth, habitability of planets, and the search for extraterrestrial life.

The theme for this course will be "habitability" of planets and moons.

Introduction

Astrobiology is the multidisciplinary study of the origin, evolution and distribution of life in the universe. Major questions that inform astrobiology include:

- **How and when did life originate on the Earth?**
- **What controls the formation of habitable planets?**
- **How does life respond to evolving planetary environments?**
- **Does life exist elsewhere?**
- **How does intelligence evolve?**
- **Are there intelligent civilizations elsewhere?**

This course will provide a scientific perspective on the origin and evolution of life in the universe; the origin and evolution of life on Earth; and how life, in turn, has significantly influenced the evolution of the Earth. Topics include the origin of the solar system, possible mechanisms and sites for the origin of life, the co-evolution of life and the Earth, habitability of planets, extra-solar planets and implications for life, and the search for extraterrestrial life.

The goals of this course are to provide the student with:
(1) an introduction to the science of astrobiology,
(2) an overview of the important questions and issues that frame astrobiology,
(3) a review of the relevant science (physics, chemistry, and biology) background,
(4) an in-depth look at the origin of life on Earth,
(5) an overview of the possibilities for life elsewhere, and
(6) an examination of the scientific tools of the field, including those used to search for extraterrestrial life.
(7) an overview of the major techniques that have allowed the detection of numerous extra-solar planets,
(8) an understanding of what is thought to make a planet habitable, and
(9) an overview of the results and implications from research on extremophiles for the science of astrobiology,

Contact Information:
Lecturer: Michael E. Summers; Office:
Email msummers@gmu.edu, is the best means to contact me.
Virtual Office Hours: Tuesday, 2:00-3:00pm (***by appointment please!***)

My office hours are listed above. You can also contact me via email or ask me after class for an appointment. You are encouraged to contact me if you are having any problems with the course, have questions on the material, or have any questions about astronomy or science in general. It will help me tremendously if we schedule a time in advance to chat, so that I can be sure to be available and plan to allow sufficient time for discussion. I have a complicated schedule this semester, and I occasionally get called into unplanned and unexpected meetings. Thus, I cannot promise to be available every day during office hours - so appointments are essential. If you cannot talk during normal office hours, then I will set up another time to meet with you that is mutually acceptable.

Required Textbook:
Earth: Evolution of a Habitable World, Jonathan Lunine, 2nd edition, Cambridge University Press, 2013. ISBN 978-0-521-85001-8 (paperback). This is available at the bookstore, but also on Amazon.com for about $65 new and less than $20 for used copies.

Supplemental - not required:
The text "**Astrobiology: An Interdisciplinary Approach**" by J. I. Lunine, Addison-Wesley, 2002, is also high recommended, but it is out of print and may be difficult to obtained. I will have selected sections of this test copied and available with my notes.

Course format and evaluations:
(1) Lecture and discussion covering material in the text and supplementary materials
(2) Homework assignments – Pet Planet Project (approximately 8-10 units)
(3) Two in-semester exams
(4) Final paper – Pet Planet Project
(5) Quizzes

Class lecture notes, as well as additional readings, will be posted on GMU Blackboard.

(i) You are responsible for reading and understanding all the material in the required text, as well as all additional readings.
(ii) Read the assigned material BEFORE in-class discussion. Participate in classroom discussions!
(iii) Attending online class is essential to successful completion of this course.

Lectures: The lectures will follow the chapters of the text; additional materials that represent recent discoveries in astrobiology will also be presented. You are responsible for all of the material covered in lecture in addition to that in the assigned readings. Again, you should read the assigned material BEFORE they are discussed in class.

Chapters in the Lunine text that will be covered in detail are indicated by bold text

1) **An Introductory Tour of the Cosmic Neighborhood**

2) Largest and Smallest Scales
3) Forces and Energy
4) Fusion, Fission, and Element Formation
5) Cosmic and Terrestrial Ages
6) Other Uses of Isotopes for Earth History
7) Relative Age Dating of Cosmic by Cratering
8) Relative Age Dating of Terrestrial Events: Geological Layering
9) Plate Tectonics
10) Formation of the Solar System
11) The Hadean Earth
12) The Archeon Eon: Properties and Sites for the Origin of Life
13) The Archeon Eon: Mechanisms for the Origin of Life
14) The First Greenhouse Crisis
15) Climate Histories of Mars and Venus, Habitability of Planets
16) Earth in Transition: Archeon to Proterozoic
17) The Oxygen Revolution
18) The Phanerozoic: Flowering and Extinction of Complex Life
19) Climate Change across the Phanerozoic
20) The Age of Humankind
21) Climage Change Over Past few Hundred Thousand Years
22) Human-Induced Global Warming
23) Limited Resources: The Human Delemma
24) Epilogue

Weekly Course Plan (Tentative – this may change. Changes will be announced class and in a revised syllabus that will be posted on Bb.

Week 1 – Introduction
Syllabus
Introduction to Astrobiology
Context: Solar System, Extrasolar Planets
Reading Assignment: Lunine chapters 1, 2, 3, 4, and 5
Week 2 – Timeline of the Earth and Universe
Read Lunine chapters 6, 7, 8, and 9
Week 3 – Formation of the Earth and Solar System
Formation of sun and planets
Read Lunine chapter 10
Week 4 – The Hadean Earth
The Environment for life's origin on Earth
The Habitable Zone
Read chapters 11, 12
Week 5 – The Origin of Life
Theories and Mechanisms
Read chapter 13
Week 6 - The Greenhouse Effect and Climate
The Greenhouse Effect

The varieties of exoplanets
Reach chapters 14, 15

Week 7 – Co-Evolution of Life and the Earth

Archeon Era
Extremophiles
Oxygen
Read chapters 16, 17

Week 8 – Complex Life

The Phanerozoic
Speciation and Extinctions
Read chapter 18

Week 9 – Recent Evolution

Climate Change
Read chapter 19

Week 10 – The age of Humankind

Read chapters 20, 21, 22

Week 11 – Robotic search for life elsewhere

Solar system life

Week 12 – Telescopic search for life on extrasolar planets

Biomarkers in atmospheres

Week 13 – SETI

How does SETI work?

Week 14 – The Fermi Paradox

Where are they?

Availability of Lectures and Presentations: After each lecture, I will post the lecture PowerPoint file on Blackboard that contains that day's presentation which you can download.

PLEASE DO NOT SHARE ANY COURSE CONTENT WITH ANYONE OUTSIDE OF OUR CLASS! THIS MATERIAL IS PROPRIETARY AND IS THE TOPIC OF A BOOK IN PREPARATION.

Blackboard: The course is available on Blackboard with your GMU login name and password.

Attendance: Because you are responsible for all THE materials AND announcements (including exam information, and e.g., change in dates), attending class is essential. Oral announcements made in class are binding and it is your responsibility to find out what has occurred in any class you might miss.

Quizzes: A very short quiz on the assigned reading will be given about once a week. These quizzes will typically be 3-4 questions and take about 5 minutes, assuming you have read the assigned material. The signed quiz will stand for the attendance. You should expect a quiz at the beginning of each lecture period over the assigned readings for that class. **THERE ARE NO MAKEUPS ON QUIZZES.**

As a rule of thumb - you should spend at least as much time studying on your own as you spend in the classroom.

Please be on time for the online lectures. Arriving late will negate your opportunity to take the quiz and be counted in attendance.

Class Schedule

First Day of Classes: Monday, January 25, 2021
No Spring Recess for 2021
Last Day of Classes: Friday, April 30, 2021
Exam Period: Monday, May 3 – Monday, May 10

Exam Schedule:

Exam #1 – TBD
Exam #2 – TBD
Final Paper and presentation are due at the time that is scheduled for the final exam.

Exam and Homework Policies:

- Anyone caught cheating on an exam or quizzes will be given a zero for that exam/quiz and might be referred to the George Mason University Honor Council.
- All exams/quizzes are closed book, computer, phone, and notes, etc.
- Generally, late homework is not accepted. Students might be permitted to submit late homework/pet planet project on a case-by-case basis.
- If you have a conflict and cannot take an exam on the scheduled day, let me know ahead of time. Late exams will be permitted with an acceptable explanation and if performed within one week of the original exam. Make-up exams must be scheduled IN ADVANCE with instructor permission.

Course Policy and Grading:

Homework:	20%
Two exams:	30%
Final paper:	40%
Participation/quizzes	10%

Numerical Grade Ranges:
A: 90-100%
B: 80-90%
C: 70-80%
D: 60-70%
F: Below 60%

Classroom conduct: Discussions, whether face-to-face or electronic, should be conducted with a high level of respectful civil discourse. Disruptive behavior in a virtual

classroom environment will not be tolerated and may result in a student being asked to leave the class, or temporarily barred from participating in class activities.

GMU Email: In order to comply with student privacy laws, faculty and students need to use their GMU email accounts when corresponding with each other and the instructor.

Religious Holidays and Observations:

http://ulife.gmu.edu/calendar/religious-holiday-calendar/ is available to help minimize difficulties for students of different faiths. It is the student's responsibility to speak to the instructor in advance should their religious observances impact their participation in class activities and assignments.

Students with Disabilities:
If you are a student with a disability and/or you need academic accommodations, please see me and contact the Office of Disability Resources at 703/993-2474. All academic accommodations must be arranged through that office.

George Mason University Honor Code:
http://www.gmu.edu/departments/unilife/pages/honorcode.html

GMU is an Honor Code university; please see the University Catalog for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously, and violations are treated gravely.

What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form.

Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind), please ask for guidance and clarification.

To promote a stronger sense of mutual responsibility, respect, trust, and fairness among all members of the George Mason University community and with the desire for greater academic and personal achievement, we, the student members of the University Community have set forth this:

Student members of the George Mason University community pledge not to cheat, plagiarize, steal, or lie in matters related to academic work.

If you have questions about the meaning of these terms, please ask. We expect you to hold to this standard by carefully citing sources used in your work and by doing your own work on tests and individual assignments.

At a minimum follow these guidelines:

- Work identified as individual should be strictly your own.
- Cheating on exams or presenting another's work as your own (plagiarism) will result in a zero grade for the assignment. **ALL MATERIAL SUBMITTED IN WRITING WILL BE SCANNED WITH PLAGIARISM CHECKING SOFTWARE. PLAGIARISM WILL BE FORWARDED TO THE HONOR COUNCIL.**
- Material that is drawn from written or electronic sources must be appropriately cited. For on-line discussion it is usually enough to simply reference a text page or web site. In a paper, a bibliography and appropriate in-text citations are mandatory. If in doubt about how to do this contact an instructor.

Useful Campus Resources:

University Catalog: http://catalog.gmu.edu/
University Policies: http://universitypolicy.gmu.edu/

Supplemental Course Material

- **Frontiers of Astrobiology,** Edited by C. Impey, J. Lunine, and J. Funes, Cambridge, 2014.

- **Physics and Chemistry of the Solar System**, 2nd Edition, J.S. Lewis, Academic Press, 2004.

- **Theory of Planetary Atmospheres**, 2nd Edition, J.W. Chamberlain, D.M. Hunten, Academic Press, 1986.

- **Photochemistry of Planetary Atmospheres**, Y.L. Yung, W.B. Demore, Oxford, 1998.

- **Astrobiology, a Multidisciplinary Approach**, J.I. Lunine, Addison-Wesley, 2004.

Useful astrobiology websites:

Space News
http://www.space.com
Astronomy Picture of the Day (APOD)
http://apod.nasa.gov/apod/astropix.html
Bad Astronomy
http://www.slate.com/blogs/bad_astronomy.html
The Space Calendar
http://www2.jpl.nasa.gov/calendar/
Earth Science Picture of the Day (EPOD)

http://epod.usra.edu
The Astrobiology Magazine
http://www.astrobio.net
National Aeronautics and Space Administration
http://www.nasa.gov
The NASA Watch Website
http://www.nasawatch.com
The NASA Astrobiology Institute
http://nai.nasa.gov/
NASA: Updates on all US space missions
www.nasa.gov
New Horizons – Pluto mission
http://pluto.jhuapl.edu/
The Exo-planet Encyclopedia
http://exoplanet.eu/
The SETI Institute
http://www.seti.org
The Kepler Website
www.kepler.nasa.gov
SETI at home
http://setiathome.berkeley.edu
Citizen Science Projects
http://en.wikipedia.org/wiki/List_of_citizen_science_projects

ADDITIONAL NOTES

- **If you email me, please remember to include your name and the course that you are taking.**
- **There are no makeups on quizzes.**
- **I do NOT accept any work by phone images.**