ASTR-301: Astrobiology
Spring Semester, 2020
Class Schedule: Monday & Wednesday, 10:30-11:45pm
Location: Exploratory Hall 1004
Instructor: Michael E. Summers
Syllabus Updated January 20, 2020

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: Planetary Hall 235
Email msummers@gmu.edu, which is the best means to contact me.
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 visit 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 would help me tremendously if we schedule a time in advance to meet, so that I can be sure to be available and plan to allow sufficient time for discussion. I have a complicated schedule, and I occasionally get called into unplanned and unexpected meetings. Thus, I cannot promise to be available every day that office hours are posted - so appointments are essential. If you cannot meet during normal office hours, then I will set up another time to meet with you that is mutually workable.

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 at $62 new and between $32-75 used.

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 obtained used.

Course format:
(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

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 additional readings.
(ii) Read the assigned readings BEFORE in-class discussion. Participate in classroom discussions!
(iii) Attending 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 in class. You are responsible for all of the material covered in lecture, in addition to that assigned as well as that presented in the text. You should read the assigned chapters BEFORE they are discussed in class.

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

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 – may change. Changes will be announced on Bb)

1 – Introduction
Syllabus
In the News… Proxima Centauri b
Introduction to Astrobiology
Context: Solar System, Extrasolar Planets
Read Lunine chapters 1, 2, 3, 4

2 – Timeline of the Earth and Universe
Read Lunine chapters 5, 6, 7, 8, 9

3 – Formation of the Earth and Solar System
Formation of sun and planets
Read Lunine chapter 10

4 – The Hadean Earth
The Environment for life's origin on Earth
The Habitable Zone
Read chapters 11, 12

5 – The Origin of Life
Theories and Mechanisms
Read chapter 13

6 - The Greenhouse Effect and Climate
The Greenhouse Effect
The varieties of exoplanets
Reach chapters 14, 15

7 – Co-Evolution of Life and the Earth
Archeon Era
Extremophiles
Oxygen
Read chapters 16, 17

SPRING BREAK

8 – Complex Life
The Phanerozoic
Speciation and Extinctions
Read chapter 18
9 – Recent Evolution
Climate Change
Read chapter 19
10 – The age of Humankind
Read chapters 20, 21, 22
11 – Robotic search for life elsewhere
Solar system life
12 – Telescopic search for life on extrasolar planets
Biomarkers in atmospheres
13 – SETI
How does SETI work?
14 – The Fermi Paradox
Where are they?

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

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

Attendance: Because you are responsible for all materials or announcements (including exam information, and e.g., change in dates), attending class is to your benefit. 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.

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. Arriving late may negate your opportunity to take the quiz and be counted in attendance.

Course Exams

Exam Schedule:
Exam #1 – Wednesday, March 4
Exam #2 – Wednesday, April 29
Final Paper and Presentation Due at the time scheduled for the final exam.

Exam and Homework Policies:

- Anyone caught cheating on an exam or talking after the exams has been handed out will be given a zero for that exam, and be referred to the George Mason University Honor Council.
- The exams and quizzes are closed book, computer, phone and notes.
- All exams are closed book, computer, phone, and notes.
- IF YOU ARRIVE MORE THAN 20 MINUTES LATE FOR AN EXAM, OR AFTER ANYONE ELSE HAS FINISHED THE EXAM, YOU MAY NOT TAKE THE EXAM LATE.
- USE OF A CELL PHONE DURING EXAMS OR QUIZZES WILL CONSTITUTE CHEATING
- Generally, late homework is not accepted. Students will be permitted to submit late homework 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 if 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:	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 the classroom environment will not be tolerated and may result in a student being asked to leave the classroom, or temporarily barred from participating in class activities. Cell

phones and pagers should be turned off before entering the classroom (unless there is a potential family emergency involved.

Policy on use of personal Technology in the classroom:

Laptops are permitted ONLY for use only for this course and its related activities.
Email and web surfing are not allowed, and are distracting to both the student and classmates. Use of laptop or cell phones during class has been demonstrated to lower your understanding and retention of class material. Also, use of your laptop during lectures is known to lower the retention and understanding by your classroom neighbors as well.

Please use common courtesy and do not use your laptop for any activities other than those related to this course. Cellphones must be turned off or on vibrate. Please do not take calls or text in the lectures. If you use your cell phone you will be asked to leave the class and not return during that period.

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.
- 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 more formal 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