AST 183: Life in the Universe

College of the Environment, Forestry, & Natural Sciences
Department of Astronomy and Planetary Science
Semester: Fall 2019
Prerequisites: None
Location: Physical Sciences Bldg., Rm. 103
Meeting Time & Format: Lectures, Tuesdays & Thursdays, 4:00pm – 5:15pm (3 credit hours)

Instructor: Dr. Mark Salvatore, mark.salvatore@nau.edu, (928) 523-0324
Office Location: 225A Physical Sciences Bldg. (second floor, northwest corner)
Office Hours: Typically Thursdays from 1:00pm–2:30pm (appointments), Fridays from 10:00am–12:00pm (walk-ins), or email me to find a time that works for you!
Undergraduate Teaching Assistant (TA): René Muller, krm525@nau.edu
TA Office Hours: By appointment.

Course Purpose

Course will survey the scientific topics that comprise the key elements of "Astrobiology." These include the philosophical foundations of astrobiology as a science, astronomical sources of life's chemical building blocks and habitable environments, extremophilic organisms, the history of life on Earth, the role of asteroid/comet impacts and micro-meteoritic dust, feasibility of space travel, and the search for life in the solar system and beyond. Letter grade only.

Course Description (Fall, 2019)

The Milky Way galaxy contains approximately 250 billion stars, and the known universe is likely home to approximately one trillion galaxies. What are the chances that life is unique to one medium-sized planet around an average star, located in a minor arm of a relatively small galaxy? Or, to put it bluntly like the brilliant nuclear physicist Enrico Fermi, "where is everybody?" This course takes a multi-faceted approach at understanding life on Earth and whether life might exist elsewhere in the universe. Over the duration of the semester, this course will broadly cover a range of geological, biological, chemical, and astronomical principles that, together, encompass the relatively new field of study known as *astrobiology*.

The class is broadly split into three sections. First, we will discuss the definition of life and the conditions necessary to support life as we know it. Second, we will investigate whether life could have existed (or currently exists?) on other planetary bodies within our own solar system. Lastly, we will broaden our search for life to other solar systems and galaxies, moving away from the hard sciences and more towards a theoretical perspective on life outside of the Earth. Throughout the course, we will be reviewing the scientific method and how to differentiate between "real" and "pseudo" science.

This course satisfies a Science and Applied Science requirement and is designed to appeal to a broad audience. The 3 credit hour lecture (AST 183) alone satisfies a 3-hour liberal sciences requirement and, in tandem with the corresponding 1 credit hour lab course (AST 184L), also satisfies a lab science requirement.

Course Objectives & Learning Outcomes

This course has several objectives and learning outcomes that will be addressed during the lecture and assessed through in-class assignments, homework, and examinations. By the end of the semester, students will be able to:

- Demonstrate an understanding of the scientific method and how scientific research is conducted;
- Identify how biology, chemistry, geology, and astronomy all contribute to the field of astrobiology;
- Define "life" and its chemical, physical, and environmental requirements;
- Describe the origin and evolution of life on Earth;
- Critically and scientifically assess the possibility of life beyond Earth;
- Demonstrate an understanding of the structure, scale, and history of the universe; and
- Discuss the scientific, ethical, political, and spiritual consequences of (the search for) life outside of Earth in a civil, respectful, and engaging fashion.

Assessment

Students will be assessed on the above objectives through a series of in-class assignments, homework, and examinations. See the attached grading rubric for open-ended questions. The modes of assessment and how they relate to the content of this course are discussed below.

In-Class Assignments: A series of interactive in-class questions will be assigned before or during each lecture, and students will be expected to respond using either BBLearn of the *iClicker* Classroom Response System. These questions are designed to gauge your understanding of the material that is covered in lecture and in the required readings. Each *iClicker* question is worth one point; 0.5 points is awarded for simply submitting an answer and another 0.5 points is awarded for a correct answer. **It is your responsibility to purchase an *iClicker* and to register it with this class on BBLearn. Students will be given one week to purchase an *iClicker* before scores will begin being recorded on Tuesday, September 3rd.**

Homework Assignments: Homework assignments are designed to strengthen your understanding of lecture materials and to prepare for examinations. Assignments will be posted on BBLearn as well as handed out during lecture. **Homework should not be submitted electronically except in the case of excused exemptions discussed with the professor prior to the due date.** Assignments will have specific due dates; any homework turned in after the specified date and time will incur a 30% penalty, and homework is not accepted more than 24 hours after it is due. A grading rubric for written homework assignments is provided in the pages to follow.

Online Discussions: Students will be randomly assigned to discussion boards on BBLearn where they will be tasked with reading short prompts and engaging in discussions with other students. Students should use information learned and discussed in class to debate with each other regarding the validity of the prompt. Criteria and expectations for a passing grade are provided in the grading rubric that can be found in the pages to follow. **Discussion boards will be open for an entire week before the due date and will be closed at the start of class on the day the discussion is due.**

Examinations: This course will consist of two non-cumulative mid-semester examinations and one cumulative final examination. Exams will consist primarily of multiple choice and matching questions, with several short-answer questions also included. **No make-up exams will be offered without prior approval from the professor.**

Disposition & Engagement: An important part of the learning process revolves around your attendance, participation, and engagement both during lecture and outside of class. Ask questions, and come to lecture prepared to learn. Interruptions and inappropriate behavior will not be tolerated, as it is disrespectful to other and to the academic learning environment. Your professionalism, courtesy, and engagement in the class are critical components of your success. By default, your "disposition & engagement" grade will reflect your graded performance in the class. If you are disruptive or unprepared, your grade will suffer; if you are engaged and prepared, your grade will improve.

Office Hour Visitation: Speaking with faculty and asking questions is an important part of higher education. Students must attend at least one office hour session with Dr. Salvatore during the semester, either to ask specific questions about course content or to answer some questions from Dr. Salvatore. Don't wait until the last minute – office hours get busy towards the end of the semester!

Grading System: The breakdown of points is approximately as follows, and any changes to the class scoring rubric will be discussed with the class prior to implementation:

In-Class Exercises & Questions	*40 points*	*Final Examination (Cumulative)*	*50 points*
Homework Assignments (~10 pts. each)	*60 points*	*Disposition & Engagement*	*25 points*
Online Discussions (6 pts. each)	*30 points*	*Office Hour Visitation*	*15 points*
Mid-Term Examinations (40 pts. each)	*80 points*	***TOTAL***	***300 points***

Your course grade will be based on the total points earned, and a letter grade will be assigned using the grading scale below:

A: ≥270 points (≥90%)
B: 240 – 269 points (80% – 89.9%)
C: 210 – 239 points (70% – 79.9%)
D: 180 – 209 (60% - 69.9%)
F: ≤ 170 points (< 60%)

Required Materials & Technology

REQUIRED: Bennett., J., & S. Shostak (2016), Life in the Universe (4th Edition). Pearson, San Francisco, CA. ISBN: 978-0-13-408908-9.
(Note: You may be able to find used copies of the 3rd Edition of this text for much cheaper than the 4th Edition. Feel free to purchase this earlier edition, but be aware that some content and page numbers might be different. It is your responsibility to identify these differences and to keep up with the required readings.)

Students are expected to complete the assigned readings (either in the textbook or provided as supplemental materials) prior to each class. These readings will provide additional information regarding the lecture materials.

REQUIRED: An *iClicker*. Some tips:

- *iClickers* can be shared with other students, as long as those other students are not in this class, and those students don't need the *iClicker* at the same time that you do.
- *iClickers* can be purchased either at the campus bookstore or online.
- Remember that you must register your *iClicker* to this class on BBLearn in order to receive credit!

Class, Departmental, & University Policies

- Please disclose any disabilities or special requirements to the NAU Disabilities Resources Office, who will contact me privately regarding any accommodations. I want to make sure that every student has an equal opportunity to learn and succeed.
- Don't cheat. You're paying good money to learn, and if you don't appreciate the knowledge gained right now, you will in the future. *If you feel like you need to cheat in order to succeed in this class, come talk to the professor to establish a more sustainable plan for succeeding.*
- While attendance in class is not mandatory, remember that your *iClicker* grade is largely based on your in-class participation.
- As a courtesy to the instructor and to your fellow students, please come to class on time. Students who arrive late for exams will not be given extra time. In-class points missed due to tardiness cannot be made up.
- Please silence all cellular devices during class. Please refrain from any other "electronic distractions" (e.g., text messaging, browsing social media) during class. If you are anticipating cellular disruptions during class for any personal or professional reasons, please notify the professor prior to class.
- Class disruptions are defined as activities that distract the instructor or other students from delivering or learning the course materials. Such activities include talking or whispering during class, habitual tardiness or leaving class early, or electronic distractions. Disruptive students will be asked to leave the classroom, and repeat offenders may be withdrawn from the class.
- Neither audio nor video recording will be permitted except under special circumstances prescribed by the NAU Disability Resources Office or discussed with the professor prior to class.
- **Additional departmental and university policies can be found at www.physics.nau.edu/SYLLABI/POLICY/policy.html**. This course falls under all departmental and university policies unless otherwise stated in this document.

Course Schedule

The following course schedule includes the daily lecture topics, dates of examinations, due dates for homework, and the required reading materials. Remember that all readings listed for a given lecture must be read prior to class, and students will be held responsible for the content of these readings.

This schedule is subject to change, and any significant changes will be discussed with the class prior to their implementation.

Week	Date	Topic	Reading	HW
1	Tu, 08/27/2019	Course Introduction	Ch. 1	
	Th, 08/29/2019	The Scientific Method	Ch. 2	
2	Tu, 09/03/2019	From Atoms to Zygotes: Introduction to Inorganic and Organic Chemistry	Ch. 3.3, 5.2	
	Th, 09/05/2019	Physical Structure of the Universe	Ch. 3.1-3.2	
3	Tu, 09/10/2019*	Physical Structure of the Solar System	Ch. 3.4-3.5, 4.6, 10.1, 10.3	HW #1 Due
	Th, 09/12/2019*	Introduction to Terrestrial Geology	Ch. 4.1-4.4	
4	Tu, 09/17/2019	Conditions Resulting in Life on Earth	Ch. 4.4-4.5	Discussion #1 Due
	Th, 09/19/2019	**EXAM #1**		
5	Tu, 09/24/2019	Defining Life	Ch. 5.1-5.4, 9.4	
	Th, 09/26/2019	The Theory of Evolution	Ch. 5.1, 5.5-5.6	
6	Tu, 10/01/2019	Formation of Life on Earth	Ch. 6.1-6.2	HW #2 Due
	Th, 10/03/2019	Evolution (and Extinctions) of Life on Earth	Ch. 6.3-6.4	
7	Tu, 10/08/2019	Evolution of Humans and Artificial Life	Ch. 6.5-6.6	Discussion #2 Due
	Th, 10/10/2019	Conditions Necessary for Life Outside of Earth?	Ch. 7.1	
8	Tu, 10/15/2019	Life in the Inner Solar System	Ch. 7.2, 10.2	HW #3 Due
	Th, 10/17/2019	Mars: Geologic Evolution	Ch. 8.1-8.2	
9	Tu, 10/22/2019	Mars: Environmental Evolution	Ch. 8.3-8.5	Discussion #3 Due
	Th, 10/24/2019	Life in the Outer Solar System?	Ch. 9	
10	Tu, 10/29/2019	The Future of Life on Earth	Ch. 10.4-10.5	HW #4 Due
	Th, 10/31/2019*	**EXAM #2**		
11	Tu, 11/05/2019	Habitability Outside of Our Solar System	Ch. 11.1-11.3, 11.5	
	Th, 11/07/2019	Habitability of Extrasolar Planets	Ch. 11.4	
12	Tu, 11/12/2019	The Search for Extraterrestrial Life	Ch. 12.1-12.3	Discussion #4 Due
	Th, 11/14/2019	UFOs and Aliens	Ch. 12.4	
13	Tu, 11/19/2019	Human Exploration of Our Solar System	*Supplemental Readings*	HW #5 Due
	Th, 11/21/2019	Interstellar Travel	Ch. 13.1-13.2	
14	Tu, 11/26/2019	The Fermi Paradox	Ch. 13.3	Discussion #5 Due
	Th, 11/28/2019	*University Closed: Thanksgiving Break*		
15	Tu, 12/03/2019	*Should* We Search for Extraterrestrial Life?	*Supplemental Readings*	HW #6 Due
	Th, 12/05/2019	Final Exam Review		
16	W, 12/11/2019	**FINAL EXAM (3:00 pm – 5:00 pm)**		

*Mark will not be present on these days – a guest lecturer or exam proctor will be present and attendance is still required!

Grading Rubrics

Online Discussions

Students will engage in online discussions related to short prompts designed to spark conversation and debate. There will be no "right" or "wrong" sides of the discussions and debates, although students are required to use information discussed in class or provided in the textbook in their responses. The rubric below should be consulted when participating in these online discussions to ensure that full credit is received.

As a general note, have **fun** with these posts! Don't be afraid to argue a point that you don't necessarily believe. For example, if the post is about the possibility of the existence of aliens, feel free to discuss why there is likely an alien civilization watching us from a distance like animals in a zoo. Just be sure to use arguments from class or the textbook to support your answer and follow the other criteria provided below.

Criteria	One (1) Point	Zero (0) Points
Number of posts	Students publish at least two posts on the discussion board. *An extra point can be earned if four or more posts are published.*	Students publish fewer than two posts on the discussion board.
Timeliness of first post	Students publish their first post on the discussion board before 11:59pm on the Friday before it is due.	Students publish their first post on the discussion board after 11:59pm on the Friday before it is due.
Quality of posts	Posts are clear, well-articulated, well-argued, and contain proper grammar, punctuation, and sentence structure. Posts are designed to spark additional discussion by asking questions or soliciting feedback.	Posts are unclear, poorly articulated, or abrupt in nature. Posts do not attempt to further the discussion.
Content of posts	Posts reference critical information discussed in class or found in the textbook.	Posts do not involve topics discussed in class or covered in the required readings.
Connectivity of posts	Posts connect to larger themes covered in the course as well as the course objectives and learning outcomes.	Content of the posts do not extend beyond the
Nature of posts	Posts are courteous and respectful in nature.	Posts are mean-spirited, aggressive, or offensive in nature. Blatant or repeated offenders will receive zero credit for the entirety of the online discussion.

Homework and Written Questions

The following rubric is provided as a guide for answering open-ended questions in AST 183. Also provided below is an example open-ended question, responses that correspond to those specific grades, and an explanation of why points were deducted. Note that these percentages refer roughly to the percentage of points possible for that given question. For example, 50% of a 2-point question corresponds to 1 point. Please consult this rubric often, and feel free to contact Dr. Salvatore with any specific questions regarding this rubric or your grade on a specific question.

Remember that plagiarism (copying directly from the textbook, other resource, or other student without reinterpretation) is **cheating** and will not be tolerated in this class. If you feel that you need to cheat in order to succeed in this class, please schedule a meeting with Dr. Salvatore to discuss other options. Punishments for cheating can include permanent removal from class!

Rough Grade	Explanation
100%	A correct answer was provided, and the answer satisfies the following: • All aspects of the question were addressed in their entirety; • If requested, an explanation was provided; • References to the answer's source were provided (e.g., textbook page number or section title) (homework only).
75%	A fundamentally correct answer was provided, although the answer suffers from one of the following flaws: • Not all aspects of the question were addressed in their entirety; • If requested, the provided explanation was unclear, too short, or long-winded; • References to the answer's source were omitted (homework only).
50%	A fundamentally correct answer was provided, although the answer suffers from two or more of the following flaws: • Not all aspects of the question were addressed in their entirety; • If requested, the provided explanation was unclear, too short, or long-winded; • References to the answer's source were omitted (homework only).
25%	A fundamentally incorrect answer was provided, although the answer did include two or more of the following: • All aspects of the question were addressed in their entirety; • If requested, an explanation was attempted; • References to the attempted answer's source were provided (homework only).
0%	The answer was left blank, or a fundamentally incorrect answer was provided in addition to suffering from two or more of the following flaws: • Not all aspects of the question were addressed in their entirety; • If requested, the provided explanation was unclear, too short, or long-winded; • References to the answer's source were omitted (homework only).

Examples of Open-Ended Grades, Answers, and Explanations

Question: Name and describe three reasons why life on Earth is carbon-based. (3 points)

Grade	Answer	Explanation
3 pts (100%)	*(1) Carbon is widely abundant throughout both the solar system and the universe, so there is plenty of material to use in the synthesis of life. (2) Carbon can easily combine with both itself and other elements, making it both versatile and allowing it to easily form complex molecules. (3) Lastly, even though carbon can form multiple types of strong bonds, its low melting and boiling points allow it to break apart and recombine easily. (Textbook, Section 5.2, pg. 166).*	Provides the correct answers to all three requested reasons. Provides clear and concise explanations (that clearly demonstrate that the student understands the question and concepts). Provides a reference to the answer's source.
2 pts (<75%)	*Carbon is abundant, easily combines with itself (versatile), and has low melting and boiling points. (Textbook, Section 5.2, pg. 166).*	While the provided answers are correct, the explanation was too short to determine if the student truly understands the material (or if they were simply copying from the textbook).
1.5 pts (50%)	*Carbon is abundant, easily combines with itself (versatile), and has low melting and boiling points.*	Provided answers are correct, but the response suffers from both a short and/or unconvincing explanation as well as a lack of reference to the answer's source.
1 pt (>25%)	*(1) Carbon is essential to inorganic molecules, which are the building-block of life. (2) Carbon is pretty rare throughout the solar system, which is why life is unique to Earth and couldn't possibly form anywhere else. (3) Carbon has a high melting point, which prevents it from breaking apart easily.*	An acceptable attempt was made to provide three reasons, and an attempt was made to provide a reasonable explanation. However, the answers are largely incorrect, and references to the answer's source were omitted.
0 pts (0%)	*Carbon is essential to inorganic molecules, which are the building-block of life, and carbon has a high melting point, which prevents it from breaking apart easily.*	A fundamentally incorrect answer, only describes two reasons, and references to the answer's source were omitted.