AST 183: Life in the Universe

College of the Environment, Forestry, & Natural Sciences
Department of Astronomy and Planetary Science
Semester: Fall 2023
Prerequisites: None
Location: Liberal Arts (Bldg. 18), Rm. 120
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: Tuesdays 3pm – 4pm, Wednesdays 3pm – 4:30pm, or by appointment
Undergraduate Teaching Assistant (TA): Hayden Green, hwg22@nau.edu

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 2023)

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 Dr. 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 is intended for a broad audience and is rooted in the *Scientific Inquiry* liberal studies essential skill. The 3-credit hour lecture (AST 183) alone satisfies a *Science and Applied Science (SAS)* liberal studies distribution requirement, while adding the 1-credit hour lab (AST 183 + 184L) satisfies a *Science and Applied Science with embedded Lab Science (LAB)* distribution requirement. However, AST 184L is not a required corequisite for AST 183.

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 questions/activities, online homework assignments, and examinations. The modes of assessment and how they relate to the content of this course are discussed below.

In-Class Assignments: Questions will be asked of students throughout the class period using the *TopHat* interactive software, which is automatically linked through the course Canvas page! Be sure to visit the Canvas page and click on the TopHat icon to register with the software. You will then be able to respond to any in-class questions or prompts on your laptop, tablet, or mobile device. In-class questions are graded both for participation (attendance) and accuracy.

Homework Assignments: Homework assignments are designed to strengthen your understanding of lecture materials and to prepare for examinations. Some assignments will consist of multiple choice questions, while others (like "*Getting to Know Our Robot Overlords!*") will require some additional critical thinking and written submissions. All homework will be administered through Canvas. Late assignments will be accepted up to 24-hours after the due date for a 30% point deduction and will not be accepted beyond 24-hours late.

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 lectures prepared to learn. Interruptions and inappropriate behavior will not be tolerated, as it is disrespectful to others 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.

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 Assignments & Questions	*100 points*	*Final Examination (Cumulative)*	*100 points*
Homework Assignments	*100 points*	*Disposition & Engagement*	*50 points*
Mid-Term Examinations	*150 points*	***TOTAL***	***500 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: ≥ 450 points (≥90%)
B: 400 – 449 points (80% – 89.9%)
C: 350 – 399 points (70% – 79.9%)
D: 300 – 349 (60% - 69.9%)
F: < 300 points (< 60%)

Required Materials & Technology

(1) REQUIRED: Bennett, J., & Shostak, S. (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.

(2) REQUIRED: In-class access to a laptop, tablet, phone, or mobile device to access Canvas and *TopHat*.

(3) REQUIRED: A free "research preview" account with **chat.openai.com** (***ChatGPT***) for completing the "*Getting to Know Our Robot Overlords!*" homework assignments.

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 in-class assignments grade is largely based on 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 (*Bennett & Shostak*, 2016)	HW Due Dates
1	Tu, 08/29/2023	Course Introduction	Ch. 1	
	Th, 08/31/2023	The Scientific Method	Ch. 2	
2	Tu, 09/05/2023	From Atoms to Zygotes: Introduction to Inorganic and Organic Chemistry	Ch. 3.3, 5.2	GTKORO #1
	Th, 09/07/2023	Physical Structure of the Universe	Ch. 3.1-3.2	Homework #1
3	Tu, 09/12/2023	Physical Structure of the Solar System	Ch. 3.4-3.5, 4.6, 10.1, 10.3	GTKORO #2
	Th, 09/14/2023	Introduction to Terrestrial Geology	Ch. 4.1-4.4	Homework #2
4	Tu, 09/19/2023	Conditions Resulting in Life on Earth	Ch. 4.4-4.5	GTKORO #3
	Th, 09/21/2023	**EXAM #1**		
5	Tu, 09/26/2023	Defining Life	Ch. 5.1-5.4, 9.4	
	Th, 09/28/2023	The Theory of Evolution	Ch. 5.1, 5.5-5.6	
6	Tu, 10/03/2023	Formation of Life on Earth	Ch. 6.1-6.2	GTKORO #4
	Th, 10/05/2023	Evolution (and Extinctions) of Life on Earth	Ch. 6.3-6.4	Homework #3
7	Tu, 10/10/2023	Evolution of Humans and Artificial Life	Ch. 6.5-6.6	GTKORO #5
	Th, 10/12/2023	Conditions Necessary for Life Outside of Earth?	Ch. 7.1	
8	Tu, 10/17/2023	Finding Life in the Inner Solar System	Ch. 7.2, 10.2	GTKORO #6
	Th, 10/19/2023	Mars: Geologic Evolution	Ch. 8.1-8.2	Homework #4
9	Tu, 10/24/2023	Mars: Environmental Evolution	Ch. 8.3-8.5	GTKORO #7
	Th, 10/26/2023	Finding Life in the Outer Solar System?	Ch. 9	
10	Tu, 10/31/2023	The Future of Life on Earth	Ch. 10.4-10.5	GTKORO #8
	Th, 11/02/2023	**EXAM #2**		
11	Tu, 11/07/2023	Habitability Outside of Our Solar System	Ch. 11.1-11.3, 11.5	
	Th, 11/09/2023	Habitability of Extrasolar Planets	Ch. 11.4	
12	Tu, 11/14/2023	The Search for Extraterrestrial Life	Ch. 12.1-12.3	GTKORO #9
	Th, 11/16/2023	UFOs and Aliens	Ch. 12.4	Homework #5
13	Tu, 11/21/2023	Human Exploration of Our Solar System	*Supplemental Readings*	GTKORO #10
	Th, 11/23/2023	*University Closed: Thanksgiving Break*		
14	Tu, 11/28/2023	Interstellar Travel	Ch. 13.1-13.2	
	Th, 11/30/2023	The Fermi Paradox	Ch. 13.3	Homework #6
15	Tu, 12/05/2023	*Should* We Search for Extraterrestrial Life?	*Supplemental Readings*	GTKORO #11
	Th, 12/07/2023	Final Exam Review		
16	We, 12/13/2023	**FINAL EXAM (Canvas, open for any two hour period from 7:00am - 11:59pm)**		

Grading Rubric for Written Questions and Responses

The following rubric is provided as a guide for answering open-ended questions in AST 183. 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; ● An explanation was provided (if requested); and ● References to the answer's source were provided (if requested).
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; ● The provided explanation (if requested) was unclear, too short, or long-winded; and/or ● References to the answer's source were omitted (if requested).
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; ● The provided explanation (if requested) was unclear, too short, or long-winded; and/or ● References to the answer's source were omitted (if requested).
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; ● An explanation was attempted (if requested); and/or ● References to the attempted answer's source were provided (if requested).
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; ● The provided explanation (if requested) was unclear, too short, or long-winded; and/or ● References to the answer's source were omitted (if requested).

COVID-19 Requirements and Information

Additional information about the University's response to COVID-19 is available from the **Jacks are Back!** web page located at https://nau.edu/jacks-are-back.

Syllabus Policy Statements

ACADEMIC INTEGRITY

NAU expects every student to firmly adhere to a strong ethical code of academic integrity in all their scholarly pursuits. The primary attributes of academic integrity are honesty, trustworthiness, fairness, and responsibility. As a student, you are expected to submit original work while giving proper credit to other people's ideas or contributions. Acting with academic integrity means completing your assignments independently while truthfully acknowledging all sources of information, or collaboration with others when appropriate. When you submit your work, you are implicitly declaring that the work is your own. Academic integrity is expected not only during formal coursework, but in all your relationships or interactions that are connected to the educational enterprise. All forms of academic deceit such as plagiarism, cheating, collusion, falsification or fabrication of results or records, permitting your work to be submitted by another, or inappropriately recycling your own work from one class to another, constitute academic misconduct that may result in serious disciplinary consequences. All students and faculty members are responsible for reporting suspected instances of academic misconduct. All students are encouraged to complete NAU's online academic integrity workshop available in the E-Learning Center and should review the full *Academic Integrity* policy available at https://policy.nau.edu/policy/policy.aspx?num=100601.

COPYRIGHT INFRINGEMENT

All lectures and course materials, including but not limited to exams, quizzes, study outlines, and similar materials are protected by copyright. These materials may not be shared, uploaded, distributed, reproduced, or publicly displayed without the express written permission of NAU. Sharing materials on websites such as Course Hero, Chegg, or related websites is considered copyright infringement subject to United States Copyright Law and a violation of NAU Student Code of Conduct. For additional information on ABOR policies relating to course materials, please refer to ABOR Policy 6-908 A(2)(5).

COURSE TIME COMMITMENT

Pursuant to Arizona Board of Regents guidance (ABOR Policy 2-224, *Academic Credit*), each unit of credit requires a minimum of 45 hours of work by students, including but not limited to, class time, preparation, homework, and studying. For example, for a 3-credit course a student should expect to work at least 8.5 hours each week in a 16-week session and a minimum of 33 hours per week for a 3-credit course in a 4-week session.

DISRUPTIVE BEHAVIOR

Membership in NAU's academic community entails a special obligation to maintain class environments that are conductive to learning, whether instruction is taking place in the classroom, a laboratory or clinical setting, during course-related fieldwork, or online. Students have the obligation to engage in the educational process in a manner that does not interfere with normal class activities or violate the rights of others. Instructors have the authority and responsibility to address disruptive behavior that interferes with student learning, which can include the involuntary withdrawal of a student from a course with a grade of "W". For additional information, see NAU's *Disruptive Behavior in an Instructional Setting* policy at https://nau.edu/university-policy-library/disruptive-behavior.

NONDISCRIMINATION AND ANTI-HARASSMENT

NAU prohibits discrimination and harassment based on sex, gender, gender identity, race, color, age, national origin, religion, sexual orientation, disability, veteran status and genetic information. Certain consensual amorous or sexual relationships between faculty and students are also prohibited as set forth in the *Consensual Romantic and Sexual Relationships* policy. The Equity and Access Office (EAO) responds to complaints regarding discrimination and harassment that fall under NAU's *Nondiscrimination and Anti- Harassment* policy. EAO also assists with religious accommodations. For additional information about nondiscrimination or anti-harassment or to file a complaint, contact EAO located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011, or by phone at 928-523-3312 (TTY: 928-523-1006), fax at 928-523-9977, email at equityandaccess@nau.edu, or visit the EAO website at https://nau.edu/equity-and-access.

TITLE IX

Title IX of the Education Amendments of 1972, as amended, protects individuals from discrimination based on sex in any educational program or activity operated by recipients of federal financial assistance. In accordance with Title IX, Northern Arizona University prohibits discrimination based on sex or gender in all its programs or activities. Sex discrimination includes sexual harassment, sexual assault, relationship violence, and stalking. NAU does not discriminate on the basis of sex in the education programs or activities that it operates, including in admission and employment. NAU is committed to providing an environment free from discrimination based on sex or gender and provides a number of supportive measures that assist students, faculty, and staff.

One may direct inquiries concerning the application of Title IX to either or both the Title IX Coordinator or the U.S. Department of Education, Assistant Secretary, Office of Civil Rights. You may contact the Title IX Coordinator in the Office for the Resolution of Sexual Misconduct by phone at 928-523-5434, by fax at 928-523-0640, or by email at titleix@nau.edu. In furtherance of its Title IX obligations, NAU promptly will investigate or equitably resolve all reports of sex or gender-based discrimination, harassment, or sexual misconduct and will eliminate any hostile environment as defined by law. The Office for the Resolution of Sexual Misconduct (ORSM): Title IX Institutional Compliance, Prevention & Response addresses matters that fall under the university's Sexual Misconduct policy. Additional important information and related resources, including how to request immediate help or confidential support following an act of sexual violence, is available at https://in.nau.edu/title-ix.

ACCESSIBILITY

Professional disability specialists are available at Disability Resources to facilitate a range of academic support services and accommodations for students with disabilities. If you have a documented disability, you can request assistance by contacting Disability Resources at 928-523-8773 (voice), ,928-523-8747 (fax), or dr@nau.edu (e-mail). Once eligibility has been determined, students register with Disability Resources every semester to activate their approved accommodations. Although a student may request an accommodation at any time, it is best to initiate the application process at least four weeks before a student wishes to receive an accommodation. Students may begin the accommodation process by submitting a self-identification form online at https://nau.edu/disability-resources/student-eligibility-process or by contacting Disability Resources. The Director of Disability Resources, Jamie Axelrod, serves as NAU's Americans with Disabilities Act Coordinator and Section 504 Compliance Officer. He can be reached at jamie.axelrod@nau.edu.

RESPONSIBLE CONDUCT OF RESEARCH

Students who engage in research at NAU must receive appropriate Responsible Conduct of Research (RCR) training. This instruction is designed to help ensure proper awareness and application of well-established professional norms and ethical principles related to the performance of all scientific research activities. More information regarding RCR training is available at https://nau.edu/research/compliance/research-integrity.

MISCONDUCT IN RESEARCH

As noted, NAU expects every student to firmly adhere to a strong code of academic integrity in all their scholarly pursuits. This includes avoiding fabrication, falsification, or plagiarism when conducting research or reporting research results. Engaging in research misconduct may result in serious disciplinary consequences. Students must also report any suspected or actual instances of research misconduct of which they become aware. Allegations of research misconduct should be reported to your instructor or the University's Research Integrity Officer, Dr. David Faguy, who can be reached at david.faguy@nau.edu or 928-523-6117. More information about misconduct in research is available at https://nau.edu/university-policy-library/misconduct-in-research.

SENSITIVE COURSE MATERIALS

University education aims to expand student understanding and awareness. Thus, it necessarily involves engagement with a wide range of information, ideas, and creative representations. In their college studies, students can expect to encounter and to critically appraise materials that may differ from and perhaps challenge familiar understandings, ideas, and beliefs. Students are encouraged to discuss these matters with faculty.

Last revised August 4, 2022