

AST 183: Life in the Universe



College of the Environment, Forestry, & Natural Sciences
Department of Astronomy and Planetary Science

Semester: Spring 2021

Prerequisites: None

Location: Virtual (Zoom Room: [849 5571 5234](#), Zoom Password: *Life!*)

Meeting Time & Format: Lectures, Tuesdays & Thursdays, 2:20pm – 3:35pm (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 (Virtual): Tues. (1:00pm – 2:20pm) and Thurs. (3:35pm – 4:45pm). Same Zoom as class!

Undergraduate Teaching Assistants (TAs): Amanda Radke (aer366@nau.edu), Kendall Koga (kjk284@nau.edu), and Clarke Morley (dm2638@nau.edu)

TA Office Hours: By appointment, contact any of the above TAs.

College of the
Environment, Forestry,
and Natural Sciences

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 (Spring, 2021)

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 associated 1 credit hour lab course (AST 184L), also a lab science requirement.

To ensure rapid responses, please submit any questions, comments, or concerns related to this course through the following Google Form: <https://forms.gle/LpeK5q1So9TWYmUN8>

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:

1. Demonstrate an understanding of the scientific method and how scientific research is conducted;
2. Identify how biology, chemistry, geology, and astronomy all contribute to the field of astrobiology;
3. Define “life” and its chemical, physical, and environmental requirements;
4. Describe the origin and evolution of life on Earth;
5. Critically and scientifically assess the possibility of life beyond Earth;
6. Demonstrate an understanding of the structure, scale, and history of the universe; and
7. 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 short quizzes, homework assignments, and examinations. This strategy was designed to ensure that students are rewarded for their efforts and can receive their grades rapidly. All assessment will be performed through BBLearn unless otherwise noted. The modes of assessment and how they relate to the content of this course are discussed below, and the due dates for all assignments are provided in the course schedule on Page 4.

Pre-Class Assignments: Students will be assigned several questions via BBLearn to answer after reviewing course content and before the class meets. These questions will help students to master course content while preparing them for in-class discussions as part of the “flipped classroom” structure of this course.

In-Class Activities and Assignments: During the scheduled class period, there will be a variety of discussions, assignments, questions, exercises, and activities that will ensure that students are remaining engaged. These aspects of the class are also important ways to meet with fellow students, to identify where you may be struggling with different course topics, and to offer and receive help from other students in the class. Approximately half of all grades assigned to in-class activities will be awarded for simple participation, while the other half of the grades will come from demonstrated mastery of the course content.

Homework Assignments: Homework assignments are designed to strengthen your understanding of lecture materials and to prepare for examinations. Homework assignments will be posted to BBLearn at least one week prior to the due date.

Examinations: This course will consist of two non-cumulative mid-semester examinations and one cumulative final examination. Exams will be administered via BBLearn in a similar manner to the homework assignments. **No make-up exams will be offered without prior approval.**

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 class prepared to learn. Interruptions, inappropriate behavior, and a lack of professionalism during the remote learning sessions 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.

Virtual Office Hour Visitation: Speaking with faculty and asking questions is an important part of higher education. Students must attend at least one virtual office hour session with Dr. Salvatore or a Teaching Assistant 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:

<i>Pre-Class Assignments (~2 pts. each)</i>	<i>40 points</i>	<i>Final Examination (Cumulative)</i>	<i>40 points</i>
<i>In-Class Assignments (~2 pts. each)</i>	<i>40 points</i>	<i>Disposition & Engagement</i>	<i>25 points</i>
<i>Homework Assignments (~10 pts. each)</i>	<i>60 points</i>	<i>Office Hour Visitation</i>	<i>15 points</i>
<i>Mid-Term Examinations (40 pts. each)</i>	<i>80 points</i>	<i>TOTAL</i>	<i>300 points</i>

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

Required Materials & Technology

REQUIRED: Regular and stable internet access to stay engaged on BBLearn and Zoom.

Students are expected to have completed the assigned modules prior to each class session.

BBLearn Course Number: 1211-2360

Zoom Meeting ID: 849 5571 5234

Zoom Meeting Password: Life!

Zoom meeting can only be accessed by registered NAU Zoom users only!

Course Registration Link:

<https://nau.zoom.us/meeting/register/tZAkcuivrz4oGdCT7H6u8tho3-eD6kWQcYp>

OPTIONAL: Bennett., J., & S. Shostak (2016), Life in the Universe (4th Edition). Pearson, San Francisco, CA. ISBN: 978-0-13-408908-9.

(Note: This textbook will serve as a supplement to the online nodes and modules, and students will not be responsible for materials not covered in the modules and only discussed in the text. Students may also be able to find used copies of the 3rd Edition of this text for much cheaper than the 4th Edition, but be aware that some content and page numbers might be different.)

Class, Departmental, & University Policies (more formal policies, including additional information related to COVID-19, can be found in the last two pages of this syllabus)

- Always remember that your instructors and everyone at Northern Arizona University is trying their best to ensure that you receive the highest quality and most enjoyable educational experience possible, especially during this time of COVID-19 and remote instruction. With that in mind, please let me know if you are struggling to keep up (or stay engaged) with this class and we'll figure out how to help the situation improve. I promise that your grade will not suffer due to infrequent technical difficulties or similar issues, as long as you contact me and try to fix the problem as efficiently as possible.
- Please be courteous to the instructor and to your fellow classmates while attending class via Zoom. Remain on mute, turn off your digital notifications, behave like an adult on camera, etc. Students who cause disruptions to the learning experience will be removed from the Zoom channel, while repeated offenders will be removed from the class in its entirety. I do not tolerate repeated disruptions, as students are paying good money to enroll in classes and to learn as much as possible, and they have the right to do so without being distracted.
- 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 with me to establish a more sustainable plan for succeeding.***
- While attendance will not be directly taken during class, your participation in in-class activities and discussions is a significant component of your grade. Please keep this in mind as you decide whether to attend class – I am limited in my ability to help your grade at the end of the semester if you have not been attending class regularly!
- Classes will be recorded for pedagogical purposes, but recordings will not be shared with students unless prior arrangements have been made. Lectures and videos should not be recorded by students or shared outside of the class without permission from the instructor. All presented content is the creative property of the instructor and NAU.
- 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	Node	Modules	Assignments Due	Optional Reading (Textbook)
1	Tu, 01/12/2021	Course Introduction	1	None		Ch. 1
	Th, 01/14/2021	Syllabus Overview		1.1		
2	Tu, 01/19/2021	Science and the Scientific Method	2	2.1 – 2.2		Ch. 2
	Th, 01/21/2021	Introduction to the Physical Sciences		2.3 – 2.6		
3	Tu, 01/26/2021	Our Place in Space, Part 1	3	3.1 – 3.3	HW #1	Ch. 3
	Th, 01/28/2021	Our Place in Space, Part 2		3.4 – 3.6		
4	Tu, 02/02/2021	The Formation and Evolution of Earth	4	4.1 – 4.5		Ch. 4
	Th, 02/04/2021	EXAM #1				
5	Tu, 02/09/2021	Defining Life and Habitable Environments	5	5.1 – 5.3	HW #2	Ch. 5
	Th, 02/11/2021	Formation of Life on Earth, Part 1		6.1 – 6.3		
6	Tu, 02/16/2021	Formation of Life on Earth, Part 2	6	6.4 – 6.5		Ch. 4
	Th, 02/18/2021	Different Scenarios for the Origin of Life		6.6 – 6.7		
7	Tu, 02/23/2021	The Theory of Evolution	7	7.1 – 7.2	HW #3	Ch. 6
	Th, 02/25/2021	Major Events in the History of Life		7.3 – 7.4		
8	Tu, 03/02/2021	The Future of Life on Earth	8	7.5 – 7.6		Ch. 7-10
	Th, 03/04/2021	Life in Our Solar System?, Part 1		8.1 – 8.4		
9	Tu, 03/09/2021	Life in Our Solar System?, Part 2	8	8.6 – 8.8	HW #4	Ch. 7-10
	Th, 03/11/2021	Mars		8.5		
10	Tu, 03/16/2021	EXAM #2				
	Th, 03/18/2021	Searching for Life Outside of Our Solar System	9	9.1 – 9.4		Ch. 11-12
11	Tu, 03/23/2021	Intelligence		9.5		
	Th, 03/25/2021	The Drake Equation	9.6			
12	Tu, 03/30/2021	Space Exploration, Part 1	10	10.1	HW #5	None
	Th, 04/01/2021	Space Exploration, Part 2		10.2		
13	Tu, 04/06/2021	Interstellar Travel, Part 1	10	10.3		Ch. 13
	Th, 04/08/2021	Interstellar Travel, Part 2		10.3		
14	Tu, 04/13/2021	UFOs and Aliens	11	11.1	HW #6	Ch. 13
	Th, 04/15/2021	<i>The Fermi Paradox</i>		11.2		
15	Tu, 04/20/2021	<i>Should We Search for Extraterrestrial Life?</i>	11	11.3		Ch. 13
	Th, 04/22/2021	Margin, Recap, and Review		12		
16	Th, 04/29/2021	FINAL EXAM (12:30 pm – 2:30 pm)				

Course Structure, Nodes, and Modules

1. **Node #1: Course Introduction**
 - 1.1. Module 1.1: Course Syllabus, Structure, and Expectations
2. **Node #2: The Fundamentals**
 - 2.1. Module 2.1: Science vs. Pseudoscience
 - 2.2. Module 2.2: The Scientific Method and the Theory of Gravity
 - 2.3. Module 2.3: Introduction to Chemistry
 - 2.4. Module 2.4: Introduction to Biology
 - 2.5. Module 2.5: Introduction to Geology
 - 2.6. Module 2.6: How Do We Study Outer Space?
3. **Node #3: The Structure of Space and Our Place Within It**
 - 3.1. Module 3.1: The Scale of the Universe and Our Place Within It
 - 3.2. Module 3.2: The Big Bang
 - 3.3. Module 3.3: Recycling of Stellar Materials
 - 3.4. Module 3.4: The Nebular Theory
 - 3.5. Module 3.5: Habitable Zones
 - 3.6. Module 3.6: Dark Matter and Dark Energy
4. **Node #4: The Formation and Evolution of Earth**
 - 4.1. Module 4.1: Geologic Time
 - 4.2. Module 4.2: Earth Accretion, Formation, and Differentiation
 - 4.3. Module 4.3: Plate Tectonics
 - 4.4. Module 4.4: Earth's Atmosphere and Magnetic Field
 - 4.5. Module 4.5: The Formation of the Moon
5. **Node #5: Conditions Necessary for Life on a Planet**
 - 5.1. Module 5.1: Habitable Environments
 - 5.2. Module 5.2: Why is Life Carbon-Based?
 - 5.3. Module 5.3: The Role of Water in Habitability
6. **Node #6: The Formation of Life on Earth**
 - 6.1. Module 6.1: When Did Life Begin?
 - 6.2. Module 6.2: Where and How Did Life Begin?
 - 6.3. Module 6.3: What Did Early Life Look Like?
 - 6.4. Module 6.4: The Energy for Life
 - 6.5. Module 6.5: Metabolism and DNA
 - 6.6. Module 6.6: RNA World
 - 6.7. Module 6.7: Panspermia
7. **Node #7: The Evolution of Life on Earth**
 - 7.1. Module 7.1: The Theory of Evolution
 - 7.2. Module 7.2: Human Evolution
 - 7.3. Module 7.3: Major Evolutionary Events in Earth History
 - 7.4. Module 7.4: Mass Extinctions
 - 7.5. Module 7.5: Artificial Life
 - 7.6. Module 7.6: The Future of Life on Earth
8. **Node #8: The Habitability of Other Planets in Our Solar System**
 - 8.1. Module 8.1: Mercury
 - 8.2. Module 8.2: Venus
 - 8.3. Module 8.3: The Moon
 - 8.4. Module 8.4: Asteroids and Comets
 - 8.5. Module 8.5: Mars
 - 8.6. Module 8.6: The Jupiter System
 - 8.7. Module 8.7: The Saturn System
 - 8.8. Module 8.8: The Uranus and Neptune Systems
9. **Node #9: The Habitability of Exoplanets and Other Distant Life**
 - 9.1. Module 9.1: Properties of Stars
 - 9.2. Module 9.2: Discovering and Studying Exoplanets
 - 9.3. Module 9.3: Solar System Similarities
 - 9.4. Module 9.4: Surface vs. Subsurface Habitability
 - 9.5. Module 9.5: Intelligence
 - 9.6. Module 9.6: The Drake Equation
10. **Node #10: Space Exploration and the Search for Life**
 - 10.1. Module 10.1: The History of Space Exploration
 - 10.2. Module 10.2: The Present and Future of Space Exploration
 - 10.3. Module 10.3: Interstellar Travel
11. **Node #11: UFOs, Aliens, and the Fermi Paradox**
 - 11.1. Module 11.1: UFOs and Evidence for Alien Visitations
 - 11.2. Module 11.2: The Fermi Paradox
 - 11.3. Module 11.3: *Should We Search for Extraterrestrial Life?*
12. **Node #12: Course Conclusion**
 - 12.1. Module 12.1: Course Wrap-Up

COVID-19 REQUIREMENTS AND INFORMATION

The following statements in red set forth in this document's first section are specific to NAU's response to the COVID-19 situation. The requirements outlined below are mandatory until further notice. They are based upon current public health conditions and guidance and may change as circumstances warrant or new information becomes available. 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/lumberjack-responsibilities>.

FACE COVERING AND PHYSICAL DISTANCING REQUIREMENTS

Appropriate face masks or other suitable face coverings must be worn by all individuals when present in classrooms, laboratories, studios, and other dedicated educational spaces. To maximize the benefits of physical distancing as an important strategy to help reduce community transmission of the SARS-CoV-2 virus, instructors may implement mandatory student seating arrangements or specific seat assignments. Instructors may remove students who do not cooperate with these requirements from the instructional space in the absence of an approved accommodation arranged through Disability Resources. Failing to comply with these requirements may constitute a violation of the university's *Disruptive Behavior in an Instructional Setting* policy available at <https://nau.edu/university-policy-library/disruptive-behavior>.

USE NAUFLEX TO HELP MAINTAIN PHYSICAL DISTANCING

NAUFlex (available at <https://nau.edu/nauflex/student>) is designed to help all students actively participate in their coursework during the required day and time of a course when they are not physically present in the classroom. This course design model allows students to be fully engaged with faculty and peers and receive the high-quality educational experience for which NAU is known.

CLASS SESSION RECORDINGS FOR STUDENTS AND FACULTY USE ONLY

Certain class sessions may be audio or video recorded to help reinforce live instruction during the COVID-19 pandemic. These recordings are for the sole use of the instructor and students enrolled in the course. Recordings will be stored in approved, accessible repositories. By enrolling, students agree to have their image and classroom statements recorded for this purpose, to respect the privacy of their fellow students, and university-owned intellectual property (including, but not limited to, all course materials) by not sharing recordings from their courses. Questions regarding restrictions on the use of classroom audio or video recordings may be addressed to the appropriate academic unit administrator.

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>.

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 conducive 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, or veteran status. Due to potentially unethical consequences, 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 is the primary federal law that prohibits discrimination on the basis of sex or gender in educational programs or activities. Sex discrimination for this purpose includes sexual harassment, sexual assault or relationship violence, and stalking (including cyber-stalking). Title IX requires that universities appoint a "Title IX Coordinator" to monitor the institution's compliance with this important civil rights law. NAU's Title IX Coordinator is Elyce C. Morris. The Title IX Coordinator is available to meet with any student to discuss any Title IX issue or concern. You may contact the Title IX Coordinator by phone at 928-523-3515, by fax at 928-523-0640, or by email at elyce.morris@nau.edu. In furtherance of its Title IX obligations, NAU will promptly investigate and equitably resolve all reports of sex or gender-based discrimination, harassment, or sexual misconduct and will eliminate any hostile environment as defined by law. Additional important information about Title IX and related student 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), 928-523-6906 (TTY), 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.

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.