NAU NORTHERN ARIZONA UNIVERSITY

Department of Astronomy and Planetary Science

AST 183 Life in the Universe

2022 Spring | 3 Credit Units | Updated January 15, 2022

Modes of Instruction:

- Meets Tuesdays and Thursdays 2:20 pm - 3:35 pm in Cline Library, Room 102. Currently NAU is requiring in-person attendance for classes and masks are required for all students. For those that are ill and cannot safely attend class, you may attend via the livestream Zoom, but you must contact the instructors before class begins or your attendance will not be counted. The remote class will be livestreamed on Zoom at https://nau.zoom.us/j/6032695475 (passcode 22). Slides and a recording of class will also be posted on BbLearn.
- Class Email List: Both Dr. Trujillo and TA Jarod Despain monitor our class email list. If you use this, we both can see your message so we can respond to you faster and your message is less likely to wind up in our individual spam folders. The list is nau.ast183@gmail.com
- Class Discord Channel: There is a class Discord Channel, where there is space to chat with other students and both Dr. Trujillo and TA Jarod Despain can answer questions. To add yourself visit https://discord.gg/ecbGJsxe.
- Instructor: Dr. Chad Trujillo — Email: chad.trujillo@nau.edu
  Physical Office: Physical Sciences (#19) 312 — mobile: (808) 756-4393
  Virtual Office: Zoom https://nau.zoom.us/j/6032695475 passcode 22
  If I'm not in the Zoom room, then once you join the Zoom room, I will get a notification that you are there. Please wait a few minutes after connecting so I have time to initiate connection. Office Hours: Mon and Thu 12pm – 1pm and by appointment, all office hours will be on Zoom. If you call my mobile, I probably won't answer because I get a lot of spam calls. But if you leave a voicemail or text me, I should probably be able to respond in a couple of hours unless it's outside normal business hours.
- Teaching Assistant: Jarod Despain — Email: jad729@nau.edu
  Virtual Office Hours: Monday/Wednesday 12:00pm - 2:00pm, Tuesday/Thursday 4:00pm - 5:15pm
  Virtual Office: Zoom https://nau.zoom.us/j/2957395414 Password: 541657
  mobile: (505) 402-1838
- You can also send class questions or feedback anonymously to Dr. Trujillo at https://goo.gl/forms/BSvNSPSML7WXMzm22 .

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 lifes 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: 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. There is a separate, stand-alone 1 credit hour lab course (AST 184L) that satisfied the lab science requirement.

Course Student 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, as follows.

Attendance: An important part of the learning process revolves around your attendance, participation, and engagement both during lecture and outside of class. Come to class 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.

In-class exercises: We will have in-class assessments (typically multiple-choice questions) during nearly every class period. These questions are designed to gauge your understanding of the material that is covered in lecture and in the required readings. We will also have in-class small-group discussions during most meetings. Sometimes these discussions will consist of conceptual problems or questions to work on together; in other times, they will be more discussion oriented. In-class participation or synchronous remote participation (with prior notification of instructor) is required.

Homework assignments: Homework assignments are designed to strengthen your understanding of the course material and to prepare for examinations. Assignments will be posted on BbLearn most Fridays (except before the week of exams and a few other special cases). Assignments are due by 11:59 p.m. the following Thursday.

Examinations: This course will consist of two non-cumulative mid-semester examinations and one cumulative final examination. Exams will consist primarily of multiple choice questions, with several short-answer essay questions also included. Examinations may take place on BbLearn depending on how the semester progresses.

Health and Safety: We are currently in a pandemic. For the most current policies for NAU, see the Jacks Are Back webpage https://nau.edu/legacy/jacks-are-back/ . Currently, masks are required in all classrooms (it is each person's individual responsibility to bring a mask) and vaccinations as well as boosters are encouraged. If you feel unwell, you should not attend class in person – you should attend via Zoom links above or view the lectures and slides online asynchronously. Your attendance will be counted if you email the instructor and TA prior to the class start time. More frequently updated general guidance can be found on the CDC COVID-19 webpage https://www.cdc.gov/coronavirus/2019-nCoV/index.html .

It is very likely that medical guidance will change over the course of the semester. This is a science class, so I expect all of us to comply with the latest science and medical guidance as it changes throughout the semester as issued by the CDC and/or NAU.

Grading System: Letter grades will be assigned as follows: A at 90%, B at 80%, C at 70%, D at 60% and F below 60%. The requirements for grades may be relaxed based on class performance, but they will not be made more stringent.

- Final Exam: The registrar has set our final exam to take place on **Thursday May 5 12:30 pm - 2:30 pm**. The final will be worth 20% of the grade.
- Mid-Term Exams: There will be two mid-term exams. These will each be worth 7.5% of the grade for a total of 15%.

- Homework: There will be a homework assigned most weeks of the semester except for the week before exams (so you don't have homework due on the same week as an exam) and the last week (reading week). These will count for a total of 45% of the grade. As there are 9 homeworks expected, each will count for 5% of the grade. These will usually be assigned through BbLearn on Fridays and be due the following Thursday by 11:59pm, also turned in through BbLearn. This is the largest single part of the grade.
- Attendance and Participation: Attendance and Participation will together count towards 20% of the grade. Both will be assessed through online short quizzes during lecture. These quizzes are ungraded (i.e. an incorrect answer still counts as participation) and are used as metric of class understanding of recently presented material.
- Extra Credit: There will be extra credit which will be given with most homeworks. It will generally involve doing something outside the normal scope of the course and involve a more extended essay response than most homework essay questions. These will count as a fraction of a typical homework grade, not more than 1% of total grade.

Readings and Materials:

- Required Textbook: Bennett., J., & S. Shostak (2016), Life in the Universe (4th Edition). Pearson, San Francisco, CA. ISBN: 978-0-13-408908-9. This book is a paperback textbook, so the purchase price of $140 on Amazon or $218 at the NAU Bookstore is exorbitant. The cheapest option I could find is the Digital Book which you can rent for $55 from the NAU Bookstore in BryteWave Format or the same price on Amazon free Kindle apps (not Kindle E-readers). You may be able to find prior versions at a lower price, but understanding the differences between them and the 4th Edition are the responsibility of the student. If the textbook presents a financial burden for some students, please contact us to see if there is another solution we can come up with.
- Computer: You will need a computer to complete all or nearly all assignments on BbLearn. If you don't have one the Cline Library rents computers.
- iClicker Cloud: NAU is offering iClicker services through smartphones (iClicker Student app, formerly iClicker Reef) or laptops at no cost to students. This will be used throughout the semester for online polling so you should always bring your device to class. You can register for AST 183 here: https://join.iclicker.com/6F8PT . Information on how to use the app can be found here: https://macmillan.force.com/iclicker/s/article/Checklist-Getting-Started-with-the-iClicker-Student-App . If you forget your device in class, you can respond on a piece of paper and hand it in during class.
- Any required supplementary readings will be made available on BbLearn.
- Calculator: A scientific calculator will be useful for in-class exams, and is much more functional than trying to use your smartphone. The Texas Instruments XI-30XIIS Solar (about $13 on Amazon) requires no batteries and will last decades. The Cline Library also rents these for free.

Class Outline: On the next page is an approximate outline of the topics covered by week. These will be adjusted based on the pace of the class. Also, there is the possibility of in-person class cancellation

or move to a virtual class in the event of adverse weather, terrorist threat, or pandemic outbreak. If I deem conditions unsafe for any reason, I will cancel in-person class and notify the class by email prior to 12:20pm (2 hours before class) the day of class. Anytime NAU is closed, this class will become a virtual class. If circumstances make both in-person and real-time virtual class difficult, a virtual lecture will be made available online.

Week	Date	Topic	Reading	Assignments Due
1	Tue Jan 11	Course Introduction, Policies and How to Get an A	p. xiv-xv, Chapter 1 & Syllabus	
	Thu Jan 13	Science and the Scientific Method Part 1	Chapter 2	
2	Tue Jan 18	Science and the Scientific Method Part 2	Chapter 2	
	Thu Jan 20	Introduction to the Physical Sciences	Chapter 2	Homework 1
3	Tue Jan 25	Our Place in Space, our Universe	Chapter 3	
	Thu Jan 27	Our Place in Space, our Solar System	Chapter 3	Homework 2
4	Tue Feb 1	Formation and Geology of Earth	Chapter 4	
	Thu Feb 3	Habitability of Earth	Chapter 4	Homework 3
5	Tue Feb 8	What is Life?	Chapter 5	
	Thu Feb 10	**Midterm 1** (Covering Homeworks 1 - 3)		Midterm 1
6	Tue Feb 15	Evolution	Chapter 6	
	Thu Feb 17	Turning Points for Life on Earth	Chapter 6	Homework 4
7	Tue Feb 22	Habitability in Our Solar System	Chapter 7	
	Thu Feb 24	Life in the Inner Solar System	Chapter 7	Homework 5
8	Tue Mar 1	Geology of Mars	Chapter 8	
	Thu Mar 3	Environmental Evolution of Mars	Chapter 8	Homework 6
9	Tue Mar 8	Life in the Outer Solar System	Chapter 9	
	Thu Mar 10	**Midterm 2** (Covering Homeworks 4 - 6)		Midterm 2
10	**Mar 14, 0018**	**Spring Break, No Classes**		
11	Tue Mar 22	Habitable Zone in Our Solar System	Chapter 10	
	Thu Mar 24	Extinction of Life on Earth	Chapter 10	
12	Tue Mar 29	Finding Exoplanets	Chapter 11	
	Thu Mar 31	Habitability of Exoplanets	Chapter 11	Homework 7
13	Tue Apr 5	Intelligence & the Drake Equation	Chapter 12	
	Thu Apr 7	The Search fo Extraterrestrial Life	Chapter 12	
14	Tue Apr 12	UFOs and Aliens - Are They Among Us?	Chapter 12	
	Thu Apr 14	Interstellar Travel	Chapter 13	Homework 8
15	Tue Apr 19	The Fermi Paradox	Chapter 13	
	Thu Apr 21	Should We Search for Extraterrestrial Life?	Epilogue & Supplemental Reading	Homework 9
16	Tue Apr 26	Review 1		
	Thu Apr 28	Review 2 & Contest		
17	Thursday May 5 12:30pm - 2:30pm	**Final Exam** (Covering all material)		Final Exam

Fig. 1.— Schedule for lectures and assignments for AST 183.

Lecture Attendance: You are expected to attend every Lecture if it is safe for you to do so. You may miss 2 Lectures over the semester without penalty (no excuse needed) if you notify Dr. Trujillo and TA Jarod Despain ahead of time. Institutional or medical excuses do not count towards this. Additional absences may be granted for learning-related matters (conferences, etc.) with advance notice.

NAU is encouraging all courses to provide resources for students who cannot attend class due to illness or quarantine. Therefore, currently all lectures will be livestreamed on Zoom. If you plan to attend class remotely, you must notify Dr. Trujillo and TA Jarod Despain ahead of class start time or you will lose attendance credit. Since some students may have technical issues during class, these class lectures will be recorded and put on BbLearn. All slides will be available on BbLearn as well.

Although the lectures will be available on Zoom, the main course presentation will be directed towards the in-person students that are currently registered. It is likely that some things will not transmit on Zoom properly, but I cannot take much class time to troubleshoot these issues because that takes class time from the hundreds of in-person students who are currently registered.

Lecture and Homework Policy:

- For all homework, as in life, you may work together. However, understand that solving problems by yourself is a core skill in academic inquiry. The submitted homework you must create yourself - in other words, you cannot copy and distribute your work to other students. You must also reference other people that helped you with the homework. The reason for this is because in the real world, not attributing your sources does helpers a disservice at best and at worst is plagiarism, one of the worst actions in academia.
- Calculations: There will be exercises where a calculation is required. In these problems, you must show your work **in enough depth that a typical student in the class could follow your reasoning**. This is because (1) if you make a mistake in computing the final answer, you can still get partial credit for the approach you use and (2) when doing example calculations in real life (such as in a published paper or thesis), you will have to show your work so that others can follow.
- Late policy: you can turn in 2 Homework assignments in this course 3 days late (due on Sunday at 11:59pm) for full credit if you notify Dr. Trujillo and TA Jarod Despain *prior* to the original deadline. No other excuse is needed. You cannot "bank" this time (turning in 1 assignment 6 days late) or "gift" your late assignment quota to others. The reason for this is that you normally have a week to do each assignment, and it takes several days to grade it after all assignments are turned in. So a more lenient late policy delays timely return of the homeworks to all students which makes it difficult to prepare for exams. No homework will be accepted beyond the 3 day extension.

Exam Policy:

- Due to potential pandemic restrictions, I am planning that all exams will be taken through BbLearn. There will be a time limit, and exams must be taken concurrently with in-class students.

- Exams are designed to test individual knowledge. However, there may be opportunities for group work on tests, but these will be clearly announced ahead of time. In the absence of such an announcement, working together on a test, even virtually, is considered cheating.
- Exams may not necessarily be taken in person due to pandemic restrictions. One week ahead of each exam, the exam policy will be announced, which will be guided by current NAU and CDC guidelines on pandemic restrictions. An opportunity for feedback will be given.
- As in the homework, all work on exams must be shown for full credit.

Plagiarism and Cheating: Plagiarism is using someone else's work or ideas and passing them off as your own (and in fact, you can even self-plagiarize, but that's probably not relevant to this class). It is considered the most serious breach of scientific integrity. Evidence of this is work suspiciously similar to other's work (exact same wording, or very similar wording) with no attribution. This is considered cheating in this course. All people involved in cheating and/or plagiarism will be given a zero on the assignment / exam and the Department Chair will be informed, regardless of who cheated off whom. Repeat offenses will be escalated to the Dean following the NAU Academic Integrity Policy.

E-learning Resources Policy: Much of our course work will take place electronically, including (but not limited to) out-of-class communication, presentation of reading materials, distribution of homework and possibly virtual lectures. It is the responsibility of the student to check email and BbLearn regularly. The student must also allow ample time prior to deadlines to navigate any technological issues that may arise such as computer crashes, internet outages, software version mismatches, etc. Students are also strongly encouraged to back up all data. ITS has an excellent support network and students having issues with online learning are encouraged to contact them.

Academic Contact Hour Policy: The Arizona Board of Regents Academic Contact Hour Policy (ABOR Handbook, 2-224) states that for a 3 credit course such as this one, a student should expect to spend a **minimum** of 9 hours per week on average. Class time is 2.5 hours per week. Therefore, at least 6.5 hours per week should be spent outside of class on homework, studying, and preparation.

Financial Hardship: If you are experiencing financial hardship that makes it difficult for you to meet the class requirements, please communicate with us and we will find an accommodation.

Disability Resources: If disability accommodations would benefit you, please contact me and/or the Disability Resource office at NAU. Many services and accommodations are available at no cost to NAU students. We will try to meet all accommodations, but if what we are doing is not working out for you please let us know and we will try to find something that works.

University Policies: The following pages contain the NAU Policy Statements for Course Syllabi. They take precedence over anything earlier in this document.

NAU NORTHERN ARIZONA UNIVERSITY

SYLLABUS REQUIREMENTS

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.

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, 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.

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 1, 2021