Astrobiology: A Planetary Perspective

PTYS/ASTR/GEOS 214

Kuiper 308 – T-Th – 9:30 - 10:45 am

Description of Course

This course explores key questions in astrobiology and planetary science about the origin and evolution of life on Earth and the possibility that such phenomena have arisen elsewhere in the Universe. We examine what it means for a planet to be alive at scales ranging from cellular processes up to global impacts of biological activity. We survey international space-exploration activities to search for life within the Solar System, throughout our Galaxy, and beyond.

PTYS 214 is a Tier II Natural Science course in the University general education curriculum. PTYS 214 is cross listed with ASTR 214 and GEOS 214. The course is equivalent to ASTR 202 (students may not receive credit for both courses).

Course Prerequisites or Co-requisites

None

Instructor and Contact Information

Instructor: Professor Dante Lauretta, Lunar and Planetary Laboratory, University of Arizona

Office: **Kuiper Building** (1629 E University Blvd) 401 and **Drake Building** (1415 N 6th Ave) 104R

Email: lauretta@arizona.edu

Office Hours: Kuiper 401, Tuesday: 11 am – 12 pm and Wednesday: 11 am - 12 pm

By appointment (Zoom or in person) – contact Nancy Ramos (nancyramos@email.arizona.edu) to schedule

Teaching Assistant: Mackenzie Mills, Lunar and Planetary Laboratory, University of Arizona

Office: **Kuiper Building** (1629 E University Blvd) 316

Email: mackenziemills@email.arizona.edu

Office Hours: Kuiper 316, Tuesday: 3 – 4 pm and Thursday: 2 – 3 pm

Web Information: https://d2l.arizona.edu/d2l/home/1060792

Course Format and Teaching Methods

The course content will be a combination of innovative delivery from the instructor, active learning both in and out of the classroom, and collaborative team projects. Content will combine Geology, Atmospheric Science, Biology, Neuroscience, Technology, and Cultural Studies.

The course content will be presented and evaluated through a combination of:

- TED-style talks focused on *Key Questions* in astrobiology
- In-class discussions and activities
- Asynchronous content directed by student interest
- Weekly thinking and reflection assignments
- Group projects with regular *Team Reports* and *Individual Contribution Summaries*

Details are provided in the following sections.

Course Objectives

During this course students will:

- Identify and interrelate the wide variety of disciplines that address the fundamental questions:
  - Where did we come from?
  - What is the meaning of life?
  - Are we alone in the Universe?
- Communicate and justify how interdisciplinary approaches contribute to understanding the origin and history of life on Earth.
- Use core values, concepts, theories, and quantitative methods from planetary science and biology to identify promising targets in the search for extraterrestrial life.
- Examine the role and importance of space exploration from various cultural perspectives.
- Engage in critical and conceptual thinking about the societal impact of discovering life on another planet.

Expected Learning Outcomes

Students will demonstrate:

- The ability to utilize multiple perspectives and make meaningful connections across disciplines and social positions, think conceptually and critically, and solve problems
- Competency in working with numerical information by critically analyzing quantitative information, generating ideas that are supported by quantitative evidence, assessing the relevance of data and its associated implications in a variety of contexts, and communicating those ideas and/or associated interpretations using various formats (graphs, data tables, illustrations, video presentations, or written reflections).
- Understanding of the values, practices, and/or cultural products of at least one non-US culture/society with an active space program; relate how these values, practices and/or cultural products have shaped their space exploration activities; and reflect on how the student's own background has influenced their perceptions of other societies and their sense of place in the global community.

Makeup Policy for Students Who Register Late

Students who register after the first-class meeting may make up missed assignments within one week of joining the class. They will also be able to join any existing activities related to mission team formation and assignment of roles and responsibilities.

Course Communications

The instructor is available via email and by appointment. All course material will be posted on D2L. Instructor presentations, and student mission-team progress reports will be delivered in person or via Zoom when the instructor is traveling. Students are expected to work in small groups outside of class. The instructor can assist students in setting up these breakout meetings.

Required Texts or Readings

Life in the Universe, 4th edition, Jeffrey O. Bennett and Seth Shostak

Availability: Available for purchase. Copies on reserve in the LPL Library and the Steward Observatory Parker Library

Required or Special Materials

Preparation of recorded PowerPoint or Video presentations for in-class reports

Assignments and Examinations: Schedule/Due Dates

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TED-style talks focused on *Key Questions*

Instructor-delivered content will be in the form of "TED-talks", 15–30-minute stories in short verse framed in personal relevance and rooted in big concepts. The talks will be centered on quantitative approaches to addressing *Key Questions*, providing repeated examples of science traceability for the students to incorporate into their mission design.

In-class discussions and activities

Students will engage with instructor-delivered content through in-class discussion and activities. These will be designed to engage students in topics using student-driven ideas, inquiries, questions, and contexts. The course will be centered on what has been dubbed "The Hard Problems" in astrobiology and neuroscience:

- What is the "spark of life" that transforms inert matter into a living being?
- What arrangement of matter and energy results in a conscious, self-aware being?
- Are these events rare or common in the Universe?
- Why are we driven to seek out extraterrestrial life and civilizations?
- How do different cultures approach these questions?
- What would it mean to world societies if we succeeded in finding extraterrestrial life?

Asynchronous content directed by student interest

Student engagement with each question will be enhanced through asynchronous content. Each question will have multi-disciplinary ways to approach the answer. Prior to each class discussion, students will research related content in one of these areas (examples for the "Are there oceans elsewhere in the Solar System?" topic):

- Geology (e.g., How do we know that icy satellites have subsurface oceans?)
- Atmospheric Science (e.g., How did geysers create one of Saturn's rings?)
- Biology (e.g., How can we use principles of evolution to evaluate what alien aquatic life would look like on an ocean world?)
- Neuroscience (e.g., What kind of sensing and communication strategies would life develop in a subsurface ocean?)
- Technology (e.g., How will the Europa Clipper (NASA) and JUICE (ESA) missions to Jupiter increase our understanding of these satellites?)
- Society/Culture (e.g., How do the European nations prioritize and implement deep space missions? What impact do these activities have on their society?)

Students will post and interact with their content in a group chat (Padlet). Content can be online articles, videos, podcasts, creative work, or any source they can justify. Highlights from this content will be incorporated into the class discussions. Students will be responsible for four such posts in each of the six categories listed above (24 total) throughout the semester.

Weekly thinking and reflection assignments

Students will submit content every week for regular, low-stakes assessment. In weeks that contain team *Mission Reports*, students will submit their *Individual Contribution Summaries* (see Signature Assignment section below). Students will receive feedback and an initial score on both the team and individual submissions. They can revise and resubmit these products for re-evaluation any time prior to the next mission milestone.

In weeks without a *Mission Report*, students will submit a *Weekly Reflection Journal*. The instructor will provide a rubric for these journals that maps to the course objectives. These journals will keep the students focused on the big questions, how other societies approach these questions, their level of confidence in the quantitative evidence presented to address the key questions, and the significance of these investigations to themselves, humanity, and their place in the Universe.

Signature Assignment

Signature Assignments in this course will have both an Individual and a Group component. For the individual component, each student will develop, articulate, and investigate their own *Key Question* related to the history of life on Earth or the search for life elsewhere in the Universe. Assignment of these key questions will occur in the first two weeks of the course. Students will then team up to work together and develop an astrobiology mission concept that addresses all their collective *Key Questions*. Through their study of international space exploration activities, students will see how their mission concept fits into the social and political context of a space-faring nation.

The structure of the activity is based on the concept of *Science Traceability* – a process from spacecraft development for translating high-level science questions into detailed science implementation plans. Starting with their list of *Key Questions*, student teams plan a trip through time and space to a *Target Environment* at a distinct point in history. For example, teams may target the Hadean Earth, the Cambrian Explosion, the K-Pg impact, ancient Mars, modern-day Titan, Europa, or a distant exoplanet. Students research and synthesize quantitative scientific data to describe the state of knowledge about their *Target Environment*. They then develop *Scientific Measurement Objectives* to address their *Key Questions*. Finally, the teams research, analyze, and design their *Mission Implementation Plan*, working with a 24-hour measurement period (limited by our nascent time travel technology), a fixed data limit, and choosing from a pre-selected suite of science instruments based on spacecraft heritage designs.

Each team will provide regular *Mission Reports* on their progress five times throughout the semester. These reports will include written, graphical, and video components. The video component will be viewed during dedicated class periods, allowing students to see the progress of other teams. The final project is an illustrated *Written Report* and accompanying *Mission Overview Video*.

Students assume two specific mission responsibilities choosing one from:

1. Project Management: Keep the team organized, oversee timely development of *Mission Reports*, track team progress against addressing *Key Questions*
2. Environmental Science: Research and Develop the *Target Environment* content
3. Measurement Science: Research and Develop the *Scientific Measurement Objectives* content
4. Engineering: Research and Develop the *Mission Implementation Plan* content

And one from:

1. Videography: Produce the *Video Presentations*
2. Graphic Art: Produce the *Illustration and Graphic Design* elements
3. Editing: Produce the *Written Report*

   Each student will also submit an *Individual Contribution Summary* at each *Mission Report* milestone. These summaries describe their mission responsibilities, contributions to the report, mission progress towards addressing their individual *Key Question*, and any issues or concerns.

Team reports will contain the following items:

Mission Report #1 (9/7/21)

- Video Presentation: *Meet the Team*
- Written Report: *Individual Key Questions and their Relevance to Astrobiology*
- Individual Contribution Summaries

Mission Report #2 (10/5/21)

- Video Presentation: *Mission Key Questions*
- Written Report: *Target Environments Under Consideration and Traceability to Key Questions*
- Individual Contribution Summaries

Mission Report #3 (11/2/21)

- Video Presentation: *What is Known about* [Target Environment]*?*
- Written Report: *Scientific Measurement Objectives Under Consideration and Traceability to Target Environment*
- Individual Contribution Summaries

Mission Report #4 (11/30/21)

- Video Presentation: *Scientific Measurement Objectives*
- Written Report: *Mission Implementation Plan Status and Traceability to Scientific Measurement Objectives*
- Individual Contribution Summaries

Final Examination or Project

Final Mission Report (12/14/21)

- Video Presentation: *Complete Mission Overview*
- Written Report: *Final Mission Report*
- Individual Final Reflection

Schedule of Key Questions/Activities

8/24/21	What is Life? What is Consciousness?
8/26/21	Did asteroids deliver the building blocks of life to Earth?
8/31/21	How did the Solar System form?
9/2/21	How did the Earth form?
9/7/21	Team Mission Status Report #1
9/9/21	What is the basic unit of life?
9/14/21	What is the role of information in life? What is entropy?
9/16/21	How did life originate?
9/21/21	Are there analogs to the early Earth in the Solar System?
9/23/21	How did Earth's atmosphere reach its current composition?
9/28/21	When and how did intelligence first evolve?
9/30/21	Where is the best place to find life outside the Solar System?
10/5/21	Team Mission Status Report #2
10/7/21	When and how did the first nervous system evolve? When did vision and other senses evolve?
10/12/21	Why is matter conscious? Why is matter intelligent? What is the difference?
10/14/21	Can life spread beyond a planet? Beyond a solar system?
10/19/21	Has intelligence evolved independently in different animal lineages on Earth?
10/21/21	Are there oceans elsewhere in the Solar System?
10/26/21	When and how did life move to land?
10/28/21	How are plants, fungi, and animals different? How are they the same?
11/2/21	Team Mission Status Report #3
11/4/21	How and why is the history of Mars different than Earth?
11/9/21	Did an asteroid kill the dinosaurs?
11/11/21	How did the mammals evolve?
11/16/21	How did human society evolve? How and why did technology evolve?
11/18/21	Where is the best place to find evidence of life on Mars?
11/23/21	THANKSGIVING – NO CLASS
11/25/21	THANKSGIVING – NO CLASS
11/30/21	Team Mission Status Report #4
12/2/21	How can we detect ET technology? Should we message ET beings?
12/7/21	What are the possible futures for humanity?
12/14/21	Team Mission Final Report (Note: 8 am start time)

Legend	
Date	Instructor out of town, office hours by Zoom appointment only
Topic	Class discussion led by Mackenzie
	Mission Status Report
	Holiday – no class

Grading Scale and Policies

The grade distribution for the course is as follows:

A:	≥90%	= excellent (regular grade)
B:	≥80% – <90%	= good (regular grade)
C:	≥70% – <80%	= satisfactory (regular grade)
D:	≥60% – <70%	= poor (regular grade)
E:	<60%	= failure (regular grade)

Final grades will be calculated based on:

- 40%: **Mission Reports** and **Individual Contribution Summaries**
- 20%: **Individual Final Reflection**
- 20%: **Asynchronous Content**
- 20%: **Weekly Reflection Journals**

Bibliography

Deamer, David. "Origin of Life: What Everyone Needs to Know." Oxford University Press (2020)

Godfrey-Smith, Peter. "Metazoa: Animal Life and the Birth of the Mind." Farrar, Straus, and Giroux (2020).

Harari, Yuval Noah. "Sapiens: A Brief History of Humankind." Random House, (2014).

Harris, Ananka. "Conscious: A Brief Guide to the Fundamental Mystery of the Mind." Harper (2019)

Kershenbaum, Arik. "The Zoologist's Guide to the Galaxy: What Animals on Earth Reveal About Aliens – and Ourselves." Penguin Press (2021)

Zimmer, Carl. "Life's Edge: The Search for What It Means to Be Alive." (2021).

Incomplete (I) or Withdrawal (W):

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete and http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal respectively.

Dispute of Grade Policy

Each team member will receive instructor feedback on each *Mission Report* and *Individual Contribution* Summary. Students may revise and resubmit their previous report in advance of the next deadline for reconsideration of the initial assigned grade.

Honors Credit

Students wishing to take this course for Honors Credit should enroll in one of the Honors sections.

Jovian Satellites Observation Project – Students enrolled in an Honors section will participate in a telescopic observing campaign of the moons of Jupiter. Students will take images of Jupiter and its moons during evening telescope observing sessions organized for this class on the UA Mall outside the Kuiper building. Images will be taken once each night over a roughly 18-day period, observing as the four largest moons orbit around Jupiter. Each image of the Jovian system through the telescope must be accompanied by a selfie of the student observer with the telescope in the background on the same night. Students will then convert their images into a time lapse animation and an accompanying explanatory video demonstrating how and why the positions of the moons change.

Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

Additional Resources for Students

UA Academic policies and procedures are available at http://catalog.arizona.edu/policies

Campus Health
http://www.health.arizona.edu/
Campus Health provides quality medical and mental health care through virtual and in-person care.
Phone: 520-621-9202

Counseling and Psych Services (CAPS)
https://health.arizona.edu/counseling-psych-services
If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care, including short-term counseling services.
For medical appointments: 520-621-9202.
For After Hours care: 520-570-7898.
For the Counseling & Psych Services (CAPS) 24/7 hotline: 520-621-3334.

The Dean of Students Office's Student Assistance Program and Life challenges
http://deanofstudents.arizona.edu/student-assistance/students/student-assistance
Student Assistance helps students manage crises, life traumas, and other barriers that impede success. The staff addresses the needs of students who experience issues related to social adjustment, academic challenges, psychological health, physical health, victimization, and relationship issues, through a variety of interventions, referrals, and follow up services. If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful.
Email: DOS-deanofstudents@email.arizona.edu
Phone: 520-621-7057

Survivor Advocacy Program
https://survivoradvocacy.arizona.edu/
The Survivor Advocacy Program provides confidential support and advocacy services to student survivors of sexual and gender-based violence. The Program can also advise students about relevant non-UA resources available within the local community for support.
Email: survivoradvocacy@email.arizona.edu
Phone: 520-621-5767

Academic Advising
If you have questions about your academic progress this semester, please reach out to your academic advisor (https://advising.arizona.edu/advisors/major). Contact the Advising Resource Center (https://advising.arizona.edu/) for all general advising questions and referral assistance. Call 520-626-8667 or email to advising@arizona.edu

COVID Mitigation Efforts

As we enter the Fall semester, the health and wellbeing of everyone in this class is the highest priority. Accordingly, we are all required to follow the university guidelines on COVID-19 mitigation. Please visit https://covid19.arizona.edu/ for the latest guidance.

Confidentiality of Student Records

http://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa?topic=ferpa

University-wide Policies link

Links to the following UA policies are provided here, https://academicaffairs.arizona.edu/syllabus-policies:

- Absence and Class Participation Policies
- Threatening Behavior Policy
- Accessibility and Accommodations Policy
- Code of Academic Integrity
- Nondiscrimination and Anti-Harassment Policy
- Subject to Change Statement

Classroom attendance:

- If you feel sick or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.
- Notify your instructor(s) if you will be missing a course meeting or an assignment deadline.
- Non-attendance for any reason does not guarantee an automatic extension of due date or rescheduling of examinations/assessments.
- Please communicate and coordinate any request directly with your instructor.
- If you must miss the equivalent of more than one week of class, you should contact the Dean of Students Office DOS-deanofstudents@email.arizona.edu to share documentation about the challenges you are facing.
- Voluntary, free, and convenient COVID-19 testing is available for students on Main Campus.
- COVID-19 vaccine is available for all students at Campus Health.
- Visit the UArizona COVID-19 page for regular updates.