From Fossils to Fermi's Paradox

Origin and Evolution of Intelligent Life

BPRO 28800 BIOS 13142 ASTR 18700 PSYC 28810

Winter 2021

Instructors:

Paul Sereno
Org. Bio. & Anatomy
A 405
dinosaur@uchicago.edu

Leslie Rogers
Astronomy & Astrophysics
ERC 537
larogers@uchicago.edu

Sarah London
Psychology
BPSB 125C
london@uchicago.edu

Teaching Assistants:

Stephanie Baumgart
Org. Bio. & Anatomy
slbaumgart@uchicago.edu

Marianna Karagiannis
Evo. Bio./Geo. Sci.
mkaragiannis@uchicago.edu

Andrew Neil
Astronomy & Astrophysics
aneil@uchicago.edu

Aware Deshmukh
Astronomy & Astrophysics
awared@uchicago.edu

Yuri Sugano
Neuroscience
ysugano@uchicago.edu

Lecture Time (CST): T/TH, 9:40-11:00am (remote and recorded/posted later).
Group Discussion Sessions (CST): F, 9:10-10:00am, 10:20-11:10am, 11:30am-12:20pm, 12:40-1:30pm (remote).

Required Texts (online): *Fermi's Paradox: Cosmology and Life,* M. Bodin (2014)
Improbable Destinies, J. Losos (2017)
Bird Brain: An Exploration of Avian Intelligence, N. Emery (2016)
Other Materials (online): Lecture notes-slides & supplemental readings.

Course Description: From the perspectives and ideas of a broad range of scholars, this course approaches Fermi's question— "Are we alone in the universe? —in the light of recent evidence primarily from three fields —the history and evolution of life on Earth (paleontology), the meaning and evolution of complex signaling and intelligence (cognitive science), and the distribution, composition and conditions on planets and exoplanets (astronomy). It also considers the history and parameters governing extrasolar detection and signaling. The aim of the course is to assess the interplay between convergence and contingency in evolution, the selective advantage of intelligence, and the existence and nature of life elsewhere in the universe— in order to better understand the ultimate meaning of human existence.

Lecture Objectives: The five sections of lectures aim to:

- ***Section I*** Introduce the major course themes and big questions.
- ***Section II*** Provide an overview of the evolution of life and intelligence.
- ***Section III*** Consider the evolution and distribution of rocky bodies in the universe and limits of habitability.
- ***Section IV*** Provide insight into how we have tried so far to detect and contact other worlds.
- ***Section V*** Consider the consequences of chance events and inevitable outcomes on Earth and elsewhere in the universe regarding our place in space and time.

Discussion Sessions: Weekly (Friday) discussion sessions will focus on major questions raised during that week's lectures and required readings. TAs and students will engage to clarify, agree and disagree about points raised that week. Each discussion session will have one biology TA and one astronomy TA, because areas of expertise will fluctuate throughout the quarter. A Piazza forum will be used as well for students to clarify points, ask additional questions, or discuss intriguing points as needed throughout the week. Professors and TAs

are also available to meet with students by appointment, feel free to send us an email to schedule a Zoom call.

Blog posts: We will also utilize a blog through Canvas. At the end of each week, students are required to thoughtfully respond to the material using either a guiding prompt or address your own interests. These posts will be graded following the rubric. Your main post should be submitted by 11:59pm the following Monday (three days after a given discussion). Students are also encouraged to look through each other's posts and comment and engage with each other for additional participation points. If this deadline doesn't work for you on a given week, we do have a late policy incorporated into the rubric such that, at most, you lose 10% of your grade for a given post for submitting it when you can. We do encourage you to keep up with the material but realize it's one helluva time to be taking a class.

Grades & Logistics: Blog posts will be 40% of your grade (~8 posts, 5% each). Participation in discussion sessions and commenting on other students' blog posts will comprise 20% of your grade. The final project will be 40% of your grade. For this project, students are expected to synthesize a key idea or research problem related to the course subject (rubric provided). Lecture notes and slides will be posted on Canvas/Box, and the lectures will be recorded and made available. Students are expected to attend or view all lectures and participate in weekly group discussions. Students should contact a TA in advance, if they are unable to attend an end-of-week discussion session. We do understand this is a difficult time and a particularly stressful way to take a class, so reach out if something comes up or you need anything.

Accommodations: If you need course accommodations, register with the Student Disabilities Services as early in the quarter as possible: https://disabilities.uchicago.edu/students/. The paperwork takes a couple weeks to process. Please notify the instructors as early as possible in the quarter as well.

LECTURE SCHEDULE AND READINGS

Readings may change as the quarter progresses, and we will notify you of any changes. The syllabus will be kept updated on Canvas and in Box.

I. "ARE WE ALONE IN THE UNIVERSE?"

Jan 12 **1** **From Fossils to Fermi's Paradox** ***Paul Sereno***

1.1 Bodin: Ch. 11, pp. 193-214, Fermi's paradox – establishing contact.
1.2 Bodin: Ch. 15, pp. 275-295 Extraterrestrial life.

II. WHERE DID THE 'MIND' AND 'INTELLIGENCE' COME FROM?

Jan 14 **2** **Life's tree, mindful descent** ***Mark Westneat***

2.1 Losos: Ch. 1, pp. 27-55, Evolutionary déjà vu.
2.2 Losos: Ch. 3, pp. 81-107, Evolutionary idiosyncracies.
2.3 Bodin: Ch. 6, pp. 103-120, Life.

Jan 19 **3** **Feathered genius** ***Sarah London***

3.1 Emery: Ch. 3, pp. 82-87, The avian sound control system.
3.2 Emery: Ch. 7, pp. 174-182, Human language and birdsong.

Jan 21	**4**	**The neuroethology of alien life** **4.1** Ulinski, P.S. (1984). Design features in vertebrate sensory systems. *American Zoologist*, 24:717-731. **4.2** Emery: Ch. 3, pp. 10-25, The evolution of avian intelligence.	***Daniel Margoliash***
Jan 26	**5**	**Fermi's Paradox, alien life, & the end of civilization** **5.1** 2020 Doomsday Clock Statement, *Bulletin of the Atomic Scientists*	**Dan Holz**

III. HOW DO PLANETS FORM AND SOME SUSTAIN LIFE?

Jan 28	**6**	**Diversity of rocky worlds** **6.1** Seager, S. (2009). Is there life out there? The search for habitable exoplanets. pp. 1-46. **6.2** Seager, S. (2013). Exoplanet habitability. *Science* 340:577-580. **6.3 (Suppl.)** Astrobiology: A history of exobiology and astrobiology at NASA (graphic history), *Living Beyond the Solar System,* NASA*,* Issue 6:1-42.	***Leslie Rogers***
Feb 2	**7**	**Planetary formation** **7.1** Canup, R.N. (2004). Origin of terrestrial planets and the earth–moon system. *Physics Today* 57:56-62.	***Fred Ciesla***
Feb 4	**8**	**Climate, habitability on exoplanets** **8.1** Kasting J.F., O.B. Toon, and J.B. Pollack (1988). How climate evolved on the terrestrial planets. *Scientific American* 256:90-97. **8.2** Bodin: Ch. 14, pp. 261-274, Alien life.	***Dorian Abbot***
Feb 9	**9**	**Evolution of planetary systems** **9.1** Soter, S. (2007). Are planetary systems filled to capacity? *American Scientist* 95:414-421.	***Daniel Fabrycky***
Feb 11	**10**	**Atmospheric evolution: The cosmic shoreline** **10.1** Caitling, D. and K. Zahnle (2009). The escape of planetary atmospheres. *Scientific American* 300:36-43. **10.2 (Suppl.)** Bostrom, N. (2008). Where are they? Why I hope the search for extraterrestrial life finds nothing. *MIT Technology Review* 2008 (May/June):72-77.	***Edwin Kite***

IV. HOW CAN WE DETECT 'OTHERS' OUT THERE?

Feb 16	**11**	**Detecting celestial bodies, biosignatures** **11.1** Bodin: Ch. 12, pp. 215-238, Searching for life. **11.2** NAS Study Group (2018). The state of the field of exoplanets, In: *NAS Exoplanet Science Strategy Report*, NAS Press, 186 pp., Ch. 2 (pp. 10-41).	***Jacob Bean***

Feb 18	**12**	**21st century: Century of biology on Earth & beyond** **12.1** NASA Technosignatures Workshop (2018). NASA and the search for technosignatures, Ch. 1 & 2, pp. 4-22. **12.2** Kiang et al. (2018). Exoplanet biosignatures: At the dawn of a new era of planetary observations. *Astrobiology* 18:619-629.	***Jill Tartar***

V. HOW MUCH OF EVOLUTION IS CONTINGENT ON PREVIOUS ADAPTATIONS?

Feb 23	**13**	**Evolutionary novelties and the octopus** **13.1** Albertin et al. (2015). The octopus genome and evolution of the cephalopod neural and morphological novelties. *Nature* 524:220-224. **13.2** Wells, M.J. (1978). (2015). Introduction. In: Octopus: *Physiology and Behavior of an Advanced Invertebrate*. University of Cambridge, 1-419 pp. [pp. 8-9] **13.3** Kröger, B. et al. (2011). Cephalopod origin and evolution: A congruent picture emerging from fossils, development and molecules. *Bioessays* 33:602-613. **13.4 (Suppl.)** Wang, Z.Y and C.W. Ragsdale (2019). Cephalopod nervous system organization. *Oxford Res Encyclopedia*	***Clifton Ragsdale***
Feb 25	**14**	**Parallel propensities** **14.1** Losos: Ch. 2, pp. 27-55, Replicated reptiles. **14.2** Luo, Z.-X. (2007) Transformation and diversification in early mammal evolution. *Nature* 450:1011-1019.	***Zhe-Xi Luo***
Mar 2	**15**	**Dinosaurs as evolutionary companions** **15.1** Losos: Introduction, pp. 1-24. **15.2** Losos: Conclusions, pp. 311-335. **15.3** Emery: Ch. 1, pp. 17-38.	***Paul Sereno***
Mar 4	**16**	***Homo sapiens*: Sole survivor of a diverse lineage?** **16.1** Marean, C.W. (2015). The most invasive species of all. *Scientific American* 2015 (August): 33-39.	***Zeray Alemseged***
Mar 9	**17**	**Cosmic bang, time-space** **17.1** Bodin: Ch. 4, pp. 47-61 Origin of the universe. **17.1** Bodin: Ch. 4, pp. 62-77 Evolution of the universe.	***Michael Turner***
Mar 10		***Final Project for graduating students due* 5:00pm CST***	
Mar 11	**18**	**How to talk so science journalists will listen**	***Lisa Grossman***
Mar 13-15		***Reading period***	
Mar 18		***Final Project due* 11:59pm CST**	

* Graduating students are not expected to include content from the final week of lecture into their final project. Grades for graduating students are due Saturday March 13th, so TAs need to grade the projects and get them back to the professors before discussion sections on Friday.