

BIOS 4550/8803. Origin of complex life: from cells to societies

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Fall Semester 2026, 3 credits Time: TBD Location: TBD

Instructor

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Overview

'Origin of Complex Life' is an active-learning class where students will gain a comprehensive overview of how complex life arose on Earth. Life on Earth started out simple (not even cellular!), and some lineages progressively evolved to be larger and more complex. The world we live in today looks the way it does because of a few key evolutionary steps, termed "major transitions in evolution", in which more complex organisms evolved from consortia of simpler ancestors. For example, eukaryotic cells arose from a symbiosis between prokaryotes, and multicellular organisms evolved from single-celled ancestors. In this class you will learn the both how major transitions can occur in evolution and what we know about how complex life has evolved on Earth. By the end of this course, you should learn:

- 1) Basic evolutionary principles, including descent with modification, natural selection, adaptation, and neutral evolutionary processes such as genetic drift.
- 2) How social evolution can lead the origin of new kinds of organism (*i.e.*, Evolutionary Transitions in Individuality).
- 3) How innovations in information storage, processing and transfer (*e.g.*, the genetic code, sexual recombination, intelligence, language, trade, and money) can spur biological revolutions, and how this is distinct from an evolutionary transition in individuality.
- 4) How similar principles underlie diverse and independent steps in the evolution of complex life. We will consider how what we've learned about the evolution of complex life on Earth may apply elsewhere in the Universe.

You will also learn to read, analyze and discuss scientific papers, learn how to use simple mathematical models to make inference in to evolutionary processes, and if you are in 8803, how to write a compelling scientific paper. Finally, it is my hope that this course will give you a new perspective on Life (not necessarily your own, but I'm cool with that too), causing you to view the world through a new lens.

Prerequisites: Biological Principles (BIOL 1510) or permission from the instructor. Note, however, that this class will cover topics in evolutionary biology at a fairly advanced level. While we cover the necessary background material, prior experience with evolutionary biology will be helpful. If you have any questions about your preparedness for the class, please contact the instructor.

Evaluation

4550

Class participation	25%
Journal Club	25%
Quizzes (2 for 10% each)	20%
Take home exams (three for 10% each)	30%

8803

Class participation	15%
Journal Club	15%
Quizzes (2 for 10% each)	20%
Exams (3 for 10% each)	30%
Final project (review paper, data analysis, model, etc.):	20%

Final grades will be assigned using a 90-80-70-60 scale.

Participation: Participation is important in this small course. If you're going to learn the material and (for the more junior members of the class) think like a scientist, you need to become an active participant in figuring things out- it is critical that you ask questions, chat with colleagues, and give considered, thoughtful feedback.

Discord. A great way to participate is via our class Discord server! Please join today! It is where most of our discussions will be, even if we host files on canvas. <https://discord.gg/Jt32DpjQ>

Journal club. Every week we will discuss a paper or book chapter. Each student will have the opportunity to co-present a paper. See the document "Leading a discussion on a scientific paper" (posted in Canvas, <https://canvas.gatech.edu>) for guidelines on how to prepare to lead discussion on your paper, as well as how you will be graded.

In-class paper discussion:	15% (10% for 8801; grading rubric on Canvas)
Posting questions to Learning Catalytics 24 hours before JC:	10% (5% for 8801)

Sign up for your Journal Club [here!](#)

Quizzes: The quizzes will be in class, multiple choice, and not super long. Given the rise of LLMs, we need to have some reality check that you know your stuff.

Exams: There will be three take home exams during the semester. These will largely consist of essay style questions, and will cover both lecture material and the papers we've read. I may also ask you to find, read, and analyze literature that was not directly covered in the course (google scholar is your friend!). All three exams will be given equal weight, though the final exam will contain cumulative elements that build on prior material.

You are allowed to work collaboratively on the exams, but the work turned in must be *entirely* your own. Any suspected plagiarism will be reported to the Office of Student Integrity.

Final project (8803 only): Graduate students will need to complete a written project. This will be decided in consultation with Dr. Ratcliff. I am totally open to whatever you find most interesting- it could be a review paper examining what is known about one major evolutionary transition, a scientific paper generated by analyzing publicly-accessible data, or a paper describing a mathematical or simulation model you created. It should be written as if you were going to submit it to a journal in your field. I therefore impose no length requirements, but will grade it as if it were being submitted for consideration by peer review.

As you will see on the schedule (next page), there will be several opportunities for feedback on this project. These won't be graded, but will help you craft an excellent paper.

Policy on the use of generative AI in class. Use it if you want to! I love this tech. Just use it wisely. There is a huge risk in this technology too: there is a risk they 'hallucinate' (aka, make stuff up),

injecting bullshit into your science. This is a *massive liability*: it could seriously harm your career if you are a practicing scientist. I will be on high alert for what looks like LLM hallucinations: citations that do not exist, etc. **If you turn in a paper that contains hallucinations, I will take off a letter grade per (perceived) hallucination.** I know that sounds harsh, but it's actually really lenient compared to what can happen in the real world. How do you avoid hallucinations? Two things: 1) Don't ask the LLM to come up with content for you! Use it for help writing, formatting, etc, but provide it with all the content. 2) Be extremely skeptical of everything it outputs. Fully vet everything that is generated. Take complete ownership of the written document.

Even if you are not using a LLM as part of your writing workflow, you have to assume that people read your work as if you are. So double check your work!

Finally, I recommend exploring LLMs beyond ChatGPT. I personally really like Claude 2.0, which has a huge context window and also a more natural writing voice than ChatGPT. I also recommend Poe.com, which is a front end to many LLMs.

Regrade Policy: Students have 14 days from when an assignment was returned to submit a regrade request. Any requests after this time will not be considered. To reduce statistical bias I will not regrade single problems, but instead will regrade entire assignments.

Resources

- Device capable of logging into Discord.
- Papers will be posted to Canvas, as assigned throughout the semester.

Honor Code: Any violations of the GT Honor Code will result in referral to the Office of Student Integrity with a penalty ranging from no credit for the assignment in question, to a grade of "F" for the class. I don't want to see you fail, and will be glad to answer questions about class activities, problem sets, projects, or exams and the Honor Code.

Academic Integrity: Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code and Student Code of Conduct, available online at:

http://www.deanofstudents.gatech.edu/integrity/policies/honor_code.php

<http://www.deanofstudents.gatech.edu/codeofconduct>.

Learning Accommodations: If needed, I will make classroom accommodations for students with learning disabilities. These accommodations must be arranged in advance and in accordance with the Office for Disability Services (<http://disabilityservices.gatech.edu/>).

Illness: if you are feeling sick, don't come to class. Attendance is not mandatory (you're an adult, I do not need to force you to come to class). Obviously, I think coming to class is both fun and essential for success in this class, so I recommend doing it. If you are going to miss a quiz or your journal club presentation, please do clear your absence with the Dean of Students.

Schedule of Topics and Assignments

Note: The schedule is subject to modification. Readings from the primary literature will be posted on canvas.

Class	Date	Topic	Readings & Assignments
1		Welcome and course overview	
2		Introduction to Evolution I- Descent with modification, Hierarchical structure of life	
3		Intro to Evolution II: Phylogenetic reasoning	
-		Institute Holiday, no class	
4		Introduction to Evolution III- Evolutionary process basics, selection and adaptation	
5		Journal club 1	Genome evolution and adaptation in a long-term experiment with <i>Escherichia coli</i> . Barrick et al, 2009. Please upload your questions by Thursday, 10am!
6		Introduction to Evolution IV- Evolutionary processes basics, drift	
7		A bit of philosophy: what is an individual in biology?	
8		Journal club 2	Darwinian Individuals. Peter Godfrey Smith, 2012
9		Evolutionary Transitions in Individuality I (history)	
10		Evolutionary Transitions in Individuality II (process)	
11		Journal club 3	Major evolutionary transitions in individuality. Stu West, 2015.
12		Social Evolution I- Kin selection	
13		Social Evolution II- Kin selection	
14		Journal club 4	Ancestral Monogamy Shows Kin Selection Is Key to the Evolution of Eusociality. Hughes et al, 2008.
15		Social Evolution III- Multilevel selection	
16		Social Evolution IV- Multilevel selection	8803: Choose project topic.
17		Journal club 5	Simpson's Paradox in a Synthetic Microbial System. Chuang et al, 2009. Exam 1 handed out
18		Origin of Life 1 (Tony Burnett)	Quiz 1 (in class)
19		Protocells	
20		Journal club 6	Evolutionary transition from a single RNA replicator to a multiple replicator network. Mizuuchi et al, 2022.
21		Origin of Life 2 (Tony Burnett)	Exam 1 due on Canvas (midnight)
22		Fossil record of pre-Ediacaran life (Tony Burnett)	
23		Journal club 7	Actin cytoskeleton and complex cell architecture in an Asgard archaeon. Rodrigues-Oliveira, 2022.

24	Endosymbiosis and Origin of Eukaryotic Cells I (Ozan Bozdag)	8803: Run an outline of your project by Dr. Ratcliff.
25	Endosymbiosis and Origin of Eukaryotic Cells II (Ozan Bozdag)	
26	Journal club 8	Energetics of Genome Complexity. Lane and Martin, 2010. [This is the only paper we are assigning that I think is fatally flawed, but there's a lesson in that]. AND A non-adaptive explanation for macroevolutionary patterns in the evolution of complex multicellularity. Bingham and Ratcliff, 2023 (very short)
27	Origin of Multicellular Organisms I	
28	Origin of Multicellular Organisms II	
29	Journal club 9	<i>De novo</i> evolution of macroscopic multicellularity. Bozdag et al, 2023. Exam 2 handed out
30	Spring Break, no class	
31	Superorganisms I	
32	Superorganisms II	Quiz 2 (in class)
33	Journal club 10	The Honeybee as a Superorganism. Seeley, 1989.
36	Information transfer: origin of the genetic code	Exam 2 due on Canvas (midnight)
37	Synthesizing information: evolution of learning and intelligence	
38	Information transfer: evolution of language	8803: If you want comments on your paper, please give a draft to Dr. Ratcliff by this day.
39	Journal club 11	On Having No Head: Cognition throughout Biological Systems. Baluska and Levin, 2016. Please upload questions by Sunday at 10am!
40	The cooperative revolution of a market economy I. Trade.	Final exam handed out
41	Journal club 12	Detecting evolutionary forces in language change. Newberry et al., 2017.
42	The cooperative revolution of a market economy II. Money.	
43	Conflict resolution at the higher-level: strategies for collective resource management	
44	Journal club 13	Are Humans Stalled Part Way Through A Major Transition? Steve Stearns, 2007. Final exam due at midnight 8803: Final draft of your project is due.

