BIOS 4550 / 8550

The Origin of Complex Life: from cells to societies

Fall Semester 2026 · 3 credits · Time & Location: MWF 12:30–1:20 pm, Mason 5134 · Last revised 11 August 2026

Instructor
Dr. Will Ratcliff

Contact information and office hours will be posted on Canvas.

Overview

Around four billion years ago, Earth was a sterile ball of rock wrapped in a hot, acidic ocean. Today it is covered in forests, coral reefs, cities, and minds capable of asking how any of it came to be. This active-learning course is about that transformation: how life climbed from simple chemistry to human-society-scale complexity, told not as a list of facts but as a single, causally connected story.

Running through that entire story is a single process: the Darwinian Algorithm. Whenever a system reproduces with heritable variation and is subject to differential success, it will evolve and adapt. The conditions are simple, general, and say nothing about DNA, or cells, or even chemistry: they are substrate-independent. Whenever a system closes this loop, it undergoes what amounts to a phase transition, not because anything is directing it, but because it cannot not. On the early Earth the algorithm ran first on molecules, then on cells, then on bodies, then on colonies so tightly integrated that they became individuals in their own right, losing their evolutionary autonomy in the process. Eventually, on a planet that had evolved brains complex enough for language, it came to run on ideas.

The organizing theme of the course is that each of these phase transitions opened a new informational space for the Darwinian Algorithm to explore. The genetic code let information be stored in a polymer, decoupled from the function of any single molecule; language let it spread from brain to brain rather than only from parent to offspring. Each new space unlocked the next, and the world we live in is the accumulated result.

By the end of this course, you should understand:

1) The core of evolutionary theory: descent with modification, natural selection, adaptation, and neutral processes such as genetic drift. We cover this from the ground up, so no prior background in evolution is assumed.
2) How the same process, the Darwinian Algorithm, builds new levels of biological individuality: how a collective becomes a new higher-level organism (it is Darwinized) while its former members lose their evolutionary autonomy (they are de-Darwinized). These are the Evolutionary Transitions in Individuality.
3) How innovations in the storage, processing, and transfer of information (the genetic code, sexual recombination, intelligence, language, and markets) open new spaces for evolution to explore, and how this is distinct from a transition in individuality.
4) How the same handful of principles underlies diverse and independent steps in the evolution of complex life, and what that implies for how likely such life is to arise elsewhere in the universe.

You will also learn to read, analyze, and discuss scientific papers, to use simple mathematical models to make inferences about evolutionary processes, and, if you are in 8550, to write a compelling scientific paper. It is my hope that, taken together, this will give you a new perspective on Life (not necessarily your own, but I am cool with that too): a way of seeing the world as the accumulated product of a single, substrate-independent process that keeps opening new informational spaces to run in, building complexity that would have been unimaginable to the molecules that started it.

Prerequisites

Biological Principles (BIOL 1510) or permission from the instructor. Note, however, that this class covers 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

Component (4550)	Weight
Class participation	25%
Journal club	25%
Quizzes (2 × 10%)	20%
Take-home exams (3 × 10%)	30%

8550

Component (8550)	Weight
Class participation	15%
Journal club	15%
Quizzes (2 × 10%)	20%
Exams (3 × 10%)	30%
Final project (review, 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 are 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 happen, even though we host files on Canvas. **I count Discord activity toward your participation grade, and it is the easiest way to get credit for daily participation.**

Journal club

Every week we will discuss a paper or book chapter. The reading list is posted on Canvas and may be adjusted during the semester. 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. https://canvas.gatech.edu

In-class paper discussion: 15% (10% for 8550; grading rubric on Canvas)

Posting questions to Canvas 24 hours before journal club: 10% (5% for 8550)

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. Quiz dates will be announced in class and posted on Canvas.

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 have 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. Exam distribution and due dates will be posted on Canvas.

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 (8550 only)

Graduate students will complete a written project, 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 peer review.

There will be several opportunities for feedback on this project over the course of the semester, with milestone dates posted on Canvas. These check-ins will not be graded, but will help you craft an excellent paper.

Policy on the use of generative AI

Use it if you want to! I love this tech. Just use it wisely. There is a huge risk in this technology too: these models can "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, and the like. If you turn in a paper that contains hallucinations, I will take off a letter grade per (perceived) hallucination.

How do you avoid hallucinations? Two things. First, do not ask the LLM to come up with content for you; use it for help with writing, formatting, and the like, but provide it with all the content yourself. Second, be extremely skeptical of everything it outputs. Fully vet everything that is generated, and take complete ownership of the written document.

Even if you are not using an 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!

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 required

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

Honor code

Any violation 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 do not 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 and 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, do not come to class. Attendance is not mandatory (you are 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, so I recommend doing it. If you are going to miss a quiz or your journal club presentation, please clear your absence with the Dean of Students.