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

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Spring Semester 2022, 3 credits Time: MW 12:30- 1:45 pm Location: Van Leer C241

Instructor

Dr. Will Ratcliff
Office: 330 Cherry Emerson
Email: will.ratcliff@biology.gatech.edu
Office hours: Monday 2-3 pm

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 decent 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

Attendance and class participation	25%
Journal Club	25%
Exams (three for 16.6% each)	50%

8803

Attendance and class participation	25%
Journal Club	25%
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.

Learning Catalytics: A learning catalytics account is required and will be used for interactive lecture sessions, which will contribute to the "participation" portion of your course grade (participation also includes attendance), and problem sets. While you are welcome to use your laptop or cell phone to access learning catalytics during class, when we are not using the platform I ask that you close your laptops and put your cell phones away.

To access a learning catalytics course, a student must create a student account and join a session. Students can create account at https://learningcatalytics.com/users/sign_up. Student account pricing: $12 for 6 months of access. With a student account, you can:

* Participate in class on-line sessions using your laptop, smartphone, or tablet
* Use learning catalytics in an unlimited number of classes

Please create a login name that your instructors can recognize—i.e., use your GT username, your GT email, your actual name, or a nickname you have made known to your instructor. I prefer that you use your @gatech.edu email address. After you have created your account, you can use it in any number of courses during the subscription period (semester, quarter, or year). Help is available at http://help.pearsoncmg.com/learning_catalytics/student/en/index.htm.

Participation: Participation is important in this small course (there is a reason I cap enrollment). 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. Class attendance (measured by Learning Catalytics) and participation will count towards 25% of your grade.

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% (grading rubric on Canvas)
Posting questions to Learning Catalytics 24 hours before JC:	10%

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.

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 Learning Catalytics.
- Papers and book excerpts 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/).

COVID-19 protocols: This class is delivered in person. However, I will be livestreaming class for those that cannot make it in person, or do not wish to be there in person. While I think the learning experience will be much better in person, I get that some of you may not be comfortable with that, and that's totally fine. We can discuss ways to have a hybrid class work- usually students in the online section have a hard time participating, so it will be a work in progress.

While GT does not require it, I strongly encourage you to protect yourself and your fellow students by wearing a mask while in class. If you feel sick, please use the online option to attend class, unless you are so sick you cannot participate at all. If that's the case, just email me about it, no biggie.

Schedule of Topics and Assignments

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

Class	Date	Topic	Readings & Assignments
1	10-Jan	Welcome and course overview. Evolution Primer I, Descent with Modification	
2	12-Jan	Introduction to Evolution II- Hierarchal structure of life and understanding phylogenies, Evolutionary process basics, selection and adaptation	
3	19-Jan	Introduction to Evolution III- Evolutionary processes basics, drift	
-	-	Journal club 1	Genome evolution and adaptation in a long-term experiment with *Escherichia coli*. Barrick et al, 2009. **Please upload your questions by Tuesday, 10am!**
4	24-Jan	Evolutionary Transitions in Individuality I (history & process)	
5	26-Jan	Evolutionary Transitions in Individuality II (history & process)	
-	-	Journal club 2	Major evolutionary transitions in individuality. Stu West, 2015.
6	31-Jan	A bit of philosophy: what is an individual in biology? (Pedro Márquez-Zacarías)	
7	2-Feb	A bit of philosophy: what is an individual in biology? (Pedro Márquez-Zacarías)	
-	-	Journal club 3	Darwinian Individuals. Peter Godfrey Smith, 2012
8	7-Feb	Social Evolution I- Kin selection	
9	9-Feb	Social Evolution II- Kin selection	
-	-	Journal club 4	Ancestral Monogamy Shows Kin Selection Is Key to the Evolution of Eusociality. Hughes et al, 2008.
10	14-Feb	Social Evolution III- Multilevel selection	
11	16-Feb	Social Evolution IV- Multilevel selection	**8803: Choose project topic.**
-	-	Journal club 5	Simpson's Paradox in a Synthetic Microbial System. Chuang et al, 2009. **Exam 1 handed out**
12	21-Feb	Origin of Life 1 (Tony Burnetti)	
13	23-Feb	Origin of Life 2 (Tony Burnetti)	
-	-	Journal club 6	Heated gas bubbles enrich, crystallize, dry, phosphorylate and encapsulate prebiotic molecules. Braun group, 2019.
14	28-Feb	Protocells	**Exam 1 due in class**
15	2-Mar	Fossil record of pre-Ediacaran life (Tony Burnetti)	
-	-	Journal club 7	Converting *Escherichia coli* into an archaebacterium with a hybrid heterochiral membrane. Caforio et al, 2018.

24	7-Mar	Endosymbiosis and Origin of Eukaryotic Cells I (Ozan Bozdag)	**8803: Run an outline of your project by Dr. Ratcliff.**
25	9-Mar	Endosymbiosis and Origin of Eukaryotic Cells II (Ozan Bozdag)	
26	-	Journal club 8	Energetics of Genome Complexity. Lane and Martin, 2010. Plus response by Lynch. [This is the only paper we are assigning that I think is fatally flawed, but there's a lesson in that].
27	14-Mar	Origin of Multicellular Organisms I	
28	16-Mar	Origin of Multicellular Organisms II	
29	-	Journal club 9	"Light-regulated collective contractility in a multicellular choanoflagellate". Brunet et al, 2019. **Exam 2 handed out**
30	21-25 Mar	**Spring Break, no class**	
31	28-Mar	Superorganisms I (Sophia Wiesenfeld)	
32	30-Mar	Superorganisms II (Dr. Ratcliff wants to bring a colony of bees to class. We'll see if he pulls it off!). (Sophia Wiesenfeld)	
33	-	Journal club 10	The Honeybee as a Superorganism. Seeley, 1989.
36	4-Apr	Information transfer: origin of the genetic code	**Exam 2 due in class**
37	6-Apr	Synthesizing information: evolution of learning and intelligence	
38	-	Journal club 11	On Having No Head: Cognition throughout Biological Systems. Baluska and Levin, 2016.
39	11-Apr	Information transfer: evolution of language	**8803: If you want comments on your paper, please give a draft to Dr. Ratcliff by this day.**
40	13-Apr	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	18-Apr	The cooperative revolution of a market economy II. Money.	
43	20-Apr	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 in class** **8803: Final draft of your project is due.**
45	25-Apr	Astrobiology: how should we think about life elsewhere in the universe?	