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

Last revised 26 November 2018

Spring Semester 2018, 3 credits Time: MWF 10:10 – 11:00 pm Location: Cherry Emerson 204

**Instructor**

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Office hours: Monday 1-2 pm & by appt.

**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 1510/11; BIOS1107 and 1107L or 1207L) 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**

**4450**

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 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% 0f your grade.

**Journal club.** Every Friday 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, and there is no cumulative final exam.

*Collaboration*. 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 publically-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. I suspect that outstanding papers actually could be submitted for publication, after revision, which would be a neat bonus!

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.

**Extensions, Late Assignments, and Re-Scheduled/Missed Exams:** Unexcused late assignments/exams will be penalized at 10% per day. Whenever possible, please discuss any circumstances that would cause you to miss an assignment or turn it in late with Dr. Ratcliff as soon as you can.

**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/).

**Statement of Intent for Inclusivity:** As a member of the Georgia Tech community, I am committed to creating a learning environment in which all of my students feel safe and included. Because we are individuals with varying needs, I am reliant on your feedback to achieve this goal. To that end, I invite you to enter into dialogue with me about the things I can stop, start, and continue doing to make my classroom an environment in which every student feels valued and can engage actively in our learning community.

**Schedule of Topics and Assignments**

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

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| **Class** | **Date** | **Topic** | **Readings & Assignments** |  |
| 1 | 8-Jan | “Freezing rain” cancelled classes |  |  |
| 2 | 10-Jan | Welcome and course overview |  |  |
| 3 | 12-Jan | Introduction to Evolution I- Darwinian algorithm, hierarchal structure of life and understanding phylogenies |  |  |
| - | 15-Jan | *MLK* *Jr. Day (no class)* |  |  |
| 4 | 17-Jan | Introduction to Evolution II- Evolutionary process basics, selection and adaptation |  |  |
| 5 | 19-Jan | Introduction to Evolution III- Evolutionary processes basics, drift |  |  |
| 6 | 22-Jan | Journal club 1 | Genome evolution and adaptation in a  long-term experiment with *Escherichia coli*. Barrick et al, 2009.  **Please upload your questions by Sunday, 10am!** |  |
| 7 | 24-Jan | Evolutionary Transitions in Individuality I (history) |  |  |
| 8 | 26-Jan | Evolutionary Transitions in Individuality II (process) |  |  |
| 9 | 29-Jan | Journal club 2 | Major evolutionary transitions in individuality. Stu West, 2015. **Please upload your questions by Sunday, 10am!** |  |
| 10 | 31-Jan | A bit of philosophy: what is an individual in biology? |  |  |
| 11 | 2-Feb | Journal club 3 | Darwinian Individuals. Peter Godfrey Smith, 2012 |  |
| 12 | 5-Feb | Social Evolution I- Kin selection |  |  |
| 13 | 7-Feb | Social Evolution II- Kin selection |  |  |
| 14 | 9-Feb | Journal club 4 | Ancestral Monogamy Shows  Kin Selection Is Key to the  Evolution of Eusociality. Hughes et al, 2008. |  |
| 15 | 12-Feb | Social Evolution III- Multilevel selection |  |  |
| 16 | 14-Feb | Social Evolution IV- Multilevel selection | **8803: Choose project topic.** |  |
| 17 | 16-Feb | Journal club 5 | Simpson's Paradox in a Synthetic Microbial System. Chuang et al, 2009. **Exam 1 handed out** |  |
| 18 | 19-Feb | Origin of Life 1 (Tony Burnetti) |  |  |
| 19 | 21-Feb | Origin of Life 2 (Tony Burnetti) |  |  |
| 20 | 23-Feb | Journal club 6 | How did LUCA make a living? Chemiosmosis  in the origin of life. Lane et al, 2010. |  |
| 21 | 26-Feb | Protocells | **Exam 1 due in class** |  |
| 22 | 28-Feb | Fossil record of pre-Ediacaran life (Tony Burnetti) |  |  |
| 23 | 2-Mar | Journal club 7 | Adaptive artificial evolution of droplet protocells in a 3D-printed fluidic chemorobotic platform with configurable environments. Parrilla-Gutierrez et al, 2017. |  |
| 24 | 5-Mar | Endosymbiosis and Origin of Eukaryotic Cells I  (Ozan Bozdag) | **8803: Run an outline of your project by Dr. Ratcliff.** |  |
| 25 | 7-Mar | Endosymbiosis and Origin of Eukaryotic Cells II  (Ozan Bozdag) |  |  |
| 26 | 9-Mar | Journal club 8 | Energetics of Genome Complexity. Lane and Martin, 2010. |  |
| 27 | 12-Mar | Origin of Multicellular Organisms I |  |  |
| 28 | 14-Mar | Origin of Multicellular Organisms II |  |  |
| 29 | 16-Mar | Journal club 9 | Life cycles, fitness decoupling and the evolution of multicellularity. Hammerschmidt et al, 2014.  **Exam 2 handed out** |  |
| 30 | 19-23 Mar | **Spring Break, no class** |  |  |
| 31 | 26-Mar | Superorganisms |  |  |
| 32 | 28-Mar | Information transfer: origin of the genetic code |  |  |
| 33 | 30-Mar | Journal club 10 | The Honeybee as a Superorganism. Seeley, 1989. |  |
| 36 | 2-Apr | Information transfer: evolution of sex | **Exam 2 due in class** |  |
| 37 | 4-Apr | Synthesizing information: evolution of learning and intelligence |  |  |
| 38 | 6-Apr | Journal club 11 | On Having No Head: Cognition throughout Biological Systems. Baluska and Levin, 2016. |  |
| 39 | 9-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 | 11-Apr | The cooperative revolution of a market economy I. Trade. | **Final exam handed out** |  |
| 41 | 13-Apr | Journal club 12 | Detecting evolutionary forces in language change. Newberry et al., 2017. |  |
| 42 | 16-Apr | The cooperative revolution of a market economy II. Money. |  |  |
| 43 | 18-Apr | Astrobiology: how should we think about complex life elsewhere in the universe? |  |  |
| 44 | 20-Apr | Journal club 13 | Are Humans Stalled Part Way Through A Major Transition? Steve Stearns, 2007.  **Final exam (not cumulative) due in class**  **8803: Final draft of your project is due.** |  |
| 45 | 23-Apr | Journal club 14 | Student choice! |  |