**Molecular Evolution, EEOB 566**

**Course overview**

What a great time this is to be a biologist! Nowhere is this more evident than in evolutionary genomics, where are now able to sequence and study genomes with astonishing precision and depth. Because of this, my inbox is filled daily with all kinds of wonderful new discoveries about life, about genomes, about the *molecular evolution* of organisms, and how this is shaped by drift and selection. In EEOB 566 we will explore this world. And it will be an adventure, I promise! It also will challenge all of us, including me, of course. I learn so much every time I teach this class, from my personal reading but even more from our many in-depth discussions as a class.

What will we actually do? Well, 566 is a seminar/discussion course covering the fundamentals of gene and genome evolution as well as advanced topics. The overall objective is to develop an understanding of modes and mechanisms of gene and genome evolution, and to be able to *express* this understanding in conversation. Using an introductory textbook supplemented by current literature, we survey the field and consider many different topics in depth. We will emphasize original scientific literature and the present state of the field. Everyone in in the class also will gain experience in synthesizing the literature on a specific topic in gene and genome evolution, and will have the opportunity to share this synthesis in the form of a mini-lecture and review paper.

**Recommended (not required) textbook**

*Molecular and Genome Evolution*, by Dan Graur, 2016 (Sinauer Press).

**Learning outcomes**

This course will enable you to understand the fundamental processes that shape gene and genome evolution in eukaryotes. After the course, my hope is that you will be able to describe:

* patterns and processes that shape genic evolution, protein evolution, and non-coding sequences;
* the primary forces and mechanisms that are responsible for genome size evolution;
* the molecular clock and why there exists rate variation;
* the centrality of transposable elements to genome evolution;
* the diversity of organellar genomes;
* the nature of horizontal transfer of DNA through non-sexual (horizontal) means;
* and other topics too numerous to mention!

You also will be able to visualize the numerous connections between molecular evolutionary processes and biological phenomena at other scales of organization, from the cellular to the ecological.

**Course content and approach**

We will meet twice weekly for 90 minutes, from **9:30-11:00 Tuesdays and Thursdays**, although as I note below I expect that there will be occasions when our discussion may overflow a bit longer. Because of our present COVID-19 world, the course will **only meet virtually via Zoom**, but because we will be a small class this should work out just fine. Each class period will consist of a discussion of relevant literature (to be placed in our shared class folder on Cybox) that we all will read for the specific class period.

Please do your best to **be prepared for each class period and for our discussion**, and please also contribute to our collective conversation on a daily basis, even if only through questions about ideas that you find confusing. In fact, questions may be the most important part of our conversations! Remember, our goals are to enhance our individual and collective understanding of sometimes complicated concepts or methods or results, to probe and share our thinking about implications, and to enhance our ability to express this understanding in a supportive environment. This latter element, by the way, will likely be important to your professional success.

Following each discussion, two students will be randomly chosen to summarize the discussion with a synopsis, to be placed in our shared class folder.

The course format changes in the final 2-3 weeks, when we transition from paper discussion to focused, student-selected presentations (see **Individual Projects**, also attached).

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| **Molecular Evolution (566), Fall, 2020** |
|  **Date (T)** | **Topic (Graur chapter)** | **Date (Th)** | **Topic (Graur chapter)** |
| Aug. 18 | Introduction, the genetic code, mutation (1) | Aug. 20 | Sequence evolution (3) |
| Aug. 25 | Rate variation, molecular clocks (4) | Aug. 27 | Sequence diversity I: how much and where? (2) |
| Sept. 1 | Sequence diversity II: evolutionary forces (2) | Sept. 3 | Coalescence, lineage sorting, gene vs. species trees (5) |
| Sept. 8 | Adaptive molecular evolution  | Sept. 10 | Origin of genes I (8) |
| Sept. 15 | Origin (and loss!) of genes II (de novo & loss) | Sept. 17 | Gene duplication I: mechanisms, theory (7) |
| Sept. 22 | Gene duplication II: examples, copy number variation | Sept. 24 | Gene conversion and concerted evolution (7) |
| Sept. 29 | Genome duplication I: short-term consequences (7) | Oct. 1 | Genome duplication II: long-term consequences (7) |
| Oct. 6 | Transposable elements I (9) | Oct. 8 | Transposable elements II (9) |
| Oct. 13 | Transposable elements III (9) | Oct. 15 | Comparative genomics I: within species  |
| Oct. 20 | Comparative genomics II: among species (11) | Oct. 22 | Comparative genomics III: genome size evolution (11) |
| Oct. 27 | Promoter evolution, TEs, genome size mash-up (12) | Oct. 29 | Horizontal transfer (9) |
| Nov. 3 | Mitochondrial and plastid genomes (9, just a bit) | Nov. 5 | Intergenomic, intraspecific DNA transfer (9, just a bit) |
| Nov. 10 | Student presentations | Nov. 12 | Student presentations |
| Nov. 17 | Student presentations | Nov. 19 | Student presentations |
| Nov. 24 | Student presentations (if needed) | Nov. 26 | Time to get back to your thesis projects ☺ |

* This is largely a discussion class, where we meet to discuss and synthesize current literature in molecular evolution, in the context of broader issues in the field. We meet on Tuesdays and Thursdays from 9:30 - 11:00.
* There are no tests. Course grades will be determined by participation (2/3; including discussion summaries) and by individual projects (1/3). All papers and discussion summaries will be posted in our shared folder, as will be all pertinent course materials.

**Individual Projects Molecular Evolution (566)**

**Individual Purpose**

1. To develop an in-depth understanding of an issue in molecular evolution that we will not have time to cover together as a class.

2. To gain experience in delivering a teaching lecture by presenting to the class what you have learned (lucidly and effectively).

**Collective Purpose**

1. To broaden our exposure to issues that we will not formally cover during the course.

2. To appreciate the diversity of approaches that legitimately may be used in lecture style and organization.

**Procedure**

1. Select a topic of interest. You might feel more comfortable delaying this decision until you have a clearer sense of the scope of the field and of the class. The topic should be ***broad enough*** to be of interest to a wide variety of readers/listeners. As an example, the evolution of intron sequences in the cpDNA gene *rpl16* in the bamboo genus *Chusquea* is not an appropriate focus, but the evolution of non-coding DNA is. See the difference? When you have some notion of what topic or topics might interest you, please come see me so we can discuss your choices. ***Please do this by October 1 (calendar alert\*)***.

2. Study the relevant literature, paying particular attention to***central issues and ideas***, although practical applications and examples may also be important.

3. Write a paper, which should be thought of as a ***mini-review***, as if you are targeting one of *Trends* or *Current Opinions* journals. There is no required format except the rather obvious one that it be well-written and thorough in coverage and documentation. Lengths are expected to vary according to topic, but there is a limit of 2000 words, excluding citations and figure legends. Figures and tables are limited to 4 in number. ***Papers are due on November 5th (calendar alert\*)***, but are welcome prior to this time. If you wish for me to view an early draft, I will happily comment on content and organization, but not wording or clarity of expression.

1. The final two weeks of the semester will consist of formal presentations by each class member (order to be determined later). You should plan on giving a 25 minute powerpoint lecture. The goal is to impart in the rest of us an understanding of your topic. Feel free to electronically distribute handouts if they will assist in understanding your lecture (*but no required reading*). Similarly, you might include literature lists for everyone’s files (*again, no assigned reading*!). Your presentation will be qualitatively graded by everyone in the class according to the criteria you would use in evaluating, say, a department seminar, i.e., clarity and polish of presentation (orally and visuals), intellectual depth, lucidity regarding status of field and where it is headed. ***Powerpoints will be shared in our class Cybox folder, so that everyone can review and learn from your work***.