BIOL 445/645 Molecular Ecology and Evolution

**Prerequisite:** Biol 362 Principles of Genetics & Biol 481 Principle of Evolution
introductory courses Statistics will also be very helpful.

**Meeting times:**
- Lectures: T, TH 11:30-12:30 IRV 208
- Lab: T 2:00-5:00 IRV 303

**Instructors:**
- Matt Olson: office WRRB 230
- phone 474-2766
- email matt.olson@uaf.edu
- Office hours: Thursday 9-10 or by appointment.

**Course Description:** This course is an introduction to theory and computational techniques used in to analyze and interpret DNA sequence variation among populations and closely related species. This vibrant and fast-developing discipline has implications for sciences ranging from global change biology to anthropology and forensics. The lecture will cover many of the major topics in molecular ecology and evolution including DNA sequence curation and alignment, phylogenetic analysis, and population genetics. It will focus on two complementary and interdependent issues: (1) the reconstruction of the evolutionary histories of genes and organisms, and (2) the evolution of hereditary molecules. The first reflects on molecular phylogenetics and coalescent theory, whereas the second deals with the rates at which DNA and proteins evolve and the effects of selection, drift, gene flow, and mutation on patterns of DNA and protein variation. The laboratory will be a hands-on introduction to computational techniques in molecular evolution. We’ll use a mish-mash of different programs to introduce techniques for data manipulation and analysis.

**Course goals:** By the end of this course students will have a general knowledge of the issues facing the field of molecular ecology and evolution. The computer lab is designed to give undergraduates hands-on experience and an opportunity to develop an original scientific project. For undergraduates, this will be a capstone experience that is meant to allow students to draw from their diverse academic backgrounds and experience the creative side of biological research. For graduate students, this course is meant to be a beginning. It will offer an opportunity to integrate an aspect of molecular evolution into your current research and will give you perspective for future forays in the field.
**Course format and student assessment**

The course will consist of discussions and computer labs on Tuesdays, and discussions on Thursdays. Students will be expected to prepare for each discussion by reading and analyzing assigned literature. Literature will be drawn from textbooks and the primary literature. Questions will be assigned for you to think about while reading and that will serve as a starting point for discussions. Class time will be spent on analysis and discussion of the readings, so sufficient preparation is essential for mastery of the subject.

**Grading:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Participation</td>
<td>15%</td>
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<tr>
<td>Problem sets and Think pieces</td>
<td>50%</td>
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<tr>
<td>Labs (5)</td>
<td>25%</td>
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<tr>
<td>Analysis Project</td>
<td>10%</td>
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**Participation:** I am assuming that any student signing up for a course called “Molecular Ecology and Evolution” is self-motivated to learn the material. This doesn’t give you the right to slack off, but should be a motivating factor for you. I expect everyone to show up for every class unless you are sick or have an acceptable excuse. “Participation” doesn’t mean just showing up, though. This is a small class, so participation means engaging in the material. Class sessions will follow a discussion format. For each topic you will be assigned readings along with questions. The questions are meant to guide you through the reading and give you something to focus on. You should also take notes as you read so that you are prepared for a discussion. We will review the answers to these questions during our discussion, but you should also strive to come up with some of your own questions regarding the readings. So,... participation means being fully engaged and prepared for class.

**Problem sets/Think pieces:** To help you synthesize and learn to apply the issues covered in lecture and lab, problem sets will be assigned some weeks. These will be due the following week. You may work on the homework problem sets or in groups, but if you work in a group you should contribute equally and write up and turn in separately. Late problem sets will be marked down 10% for each week it is late.

For some of the readings you will be asked to write a “think piece.” This is a type of article in journalism that contains discussion, analysis, opinion, etc. and is not a simple factual summary. The purpose is to engage your creativity and summarize your thoughts, responses and questions in preparation for or after a class discussion.

Think pieces should be no more than 1 page typed and carefully proofread. Grading will be based on demonstration that you are engaging in the material and are thinking beyond and integrating ideas from the readings. You should also try, when possible to tie in and make connections with other portions of the course.

**Lab Assignments:** There will be 5 short lab assignments due the week following the lab
Analysis Project: You will be asked to conduct a computational based project whereby you will analyze a data set and interpret the statistical outcomes. Data can be derived from your personal data, data from your professor or a colleague, or from sequences downloaded from an online database. Graduate students are expected to work alone; undergraduates can work together, if you wish. A 2 page Project Proposal is due on October 26. You will base asked to write a short report in manuscript style describing your motivation, the methods, results and discussion. More details on the organization of proposals will be provided as the deadline nears.

Overall Course Grades will be determined as follows:

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<tr>
<th>Numerical Score</th>
<th>Grade</th>
<th>Grade Points Per Credit</th>
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<tbody>
<tr>
<td>95.0-100%</td>
<td>A+</td>
<td>4.0</td>
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<tr>
<td>90.0-94.9</td>
<td>A</td>
<td>4.0</td>
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<tr>
<td>88.0-89.9</td>
<td>A-</td>
<td>3.7</td>
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<td>86.0-87.9</td>
<td>B+</td>
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<td>80.0-85.9</td>
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<td>78.0-79.9</td>
<td>B-</td>
<td>2.7</td>
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<td>76.0-77.9</td>
<td>C+</td>
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<td>70.0-75.9</td>
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<tr>
<td>68.0-69.9</td>
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<td>66.0-67.9</td>
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<td>60.0-65.9</td>
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<td>58.0-59.9</td>
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<td>0.7</td>
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<td>Below 58.0</td>
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Texts and readings:

There are several good books in the field of molecular evolution but none is very good at integrating molecular evolution with bioinformatics and genomics. I will be assigning readings from different texts and the primary literature. The supplemental texts below will be available on reserve in the Biology library.

Supplemental texts. We will have readings from some of these. They are all on reserve in the library.

*Avise's book is a classic in molecular ecology.*

*comprehensive overview of phylogeny construction*

*a good general reference, but covers much of the same material as Li.*
* Great guide to fundamental population genetics concepts

* a good laboratory notebook that covers several molecular and analytical techniques useful for systematics

* This book is a very readable and approachable treatise covering the theoretical and empirical effects of adaptive evolution on gene sequence evolution. We have read this in past years, but probably will not refer to it much this year.

* This is probably the best reference text for molecular evolution, but it can be very mathematical and difficult at times. It is now out of print. The text covers phylogenetics, coalescent theory, and higher level mechanisms for molecular evolution such as gene duplication and transposition.

* a good text for learning phylogenetic theory

* this is a very thorough lab notebook covering all types of molecular techniques from PCR to cloning to working with RNA and proteins and beyond. A must for any molecular evolution laboratory. We won’t use this much this semester.

* perhaps the most thorough and readable text covering the theory of the coalescent process

When more than one reading is suggested, there may be some overlap in topics covered in different books. This is meant to give you options because you may find certain discussions of topics to be more lucid than others.
Students with Disabilities:
Needs of students with disabilities will be accommodates following University policies. Any student needing accommodation of a disability should provide me with a letter from the Office of Disability Services. The Office of Disability Services also requires students contact them at least 3 days in advance of any exam for which they need special arrangements. Please talk to instructor privately if you have questions or require assistance. The UAF Center for Health and Counseling also provides disability services: http://www.uaf.edu/chc/disability.html.

Important Course Policies:
Plagiarism and fabrication of data are unacceptable practices in this course, science, and your creative life in general. All of your work should be your own and only your own unless it is explicitly assigned and completed as a group. Plagiarism, data fabrication, or cheating will result in immediate removal from the course, delivery to the Dean of Student Affairs and the University Disciplinary and Honor Code Committee, and a course grade of “F”. See pages 100-101 of the fall 2009 class schedule to review the University’s guidelines for the Students Code of Conduct.
<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Readings</th>
<th>Lab (IRV 303)</th>
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<tbody>
<tr>
<td>Week 1</td>
<td>Introduction</td>
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<td>Sept 3</td>
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<td>Week 2</td>
<td>Alignment, Homology and Genetic Variation</td>
<td>PH Chapter 5 (think piece 1)</td>
<td>Phenotype and the T-field common garden</td>
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<td>Sept 8-10</td>
<td>No Class on 10th</td>
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<td>Read Pauley &amp; Perry</td>
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<tr>
<td>Week 3</td>
<td>Detecting and measuring molecular variation</td>
<td>CH1&amp;2 PEG (think piece 2)</td>
<td>Introduction to resources / Alignment</td>
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<tr>
<td>Sept 15-17</td>
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<td>CH1 Wakeley</td>
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<tr>
<td>Week 4</td>
<td>Detecting and measuring molecular variation</td>
<td>CH1 PG</td>
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<td>Sept 22-24</td>
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<td>CH1 Wakeley (think piece 3)</td>
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<td>Week 5</td>
<td>Measuring molecular variation / Genetic drift</td>
<td>CH1 Wakeley</td>
<td>cDNA alignment/DNAsp</td>
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<td>Sept 29-Oct 1</td>
<td></td>
<td>CH2 PG (think piece 4)</td>
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<tr>
<td>Week 6</td>
<td>Population Genetic models</td>
<td>Selections from Ch3 Wakeley</td>
<td>SimCoal/Arlequin</td>
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<td>Oct 6-8</td>
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<tr>
<td>Week 7</td>
<td>Deviations in Site Frequency Spectra</td>
<td>Selections from Ch3 &amp;4 Wakeley</td>
<td>SimCoal/Arlequin</td>
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<td>Oct 13-15</td>
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<tr>
<td>Week 8</td>
<td>Genetic Drift and Effective population size</td>
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<td>Oct 20-22</td>
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<tr>
<td>Week 9</td>
<td>Recombination and Linkage Disequilibrium</td>
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<td>DNAsp/rsq</td>
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<td>Oct 27-29</td>
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<td>Week 10</td>
<td>Population structure</td>
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<td>Nov 3-5</td>
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<tr>
<td>Week 11</td>
<td>Intro to phylogeny</td>
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<td>Arlequin/ Structure</td>
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<td>Nov 10-12</td>
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<tr>
<td>Week 12</td>
<td>Intro to phylogeny</td>
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<td>PAUP* or other</td>
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<td>Nov 17-19</td>
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<td>Week 13</td>
<td>Demography</td>
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<td>Nov 24-26</td>
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<td>Week 14</td>
<td>Identification of genes of importance</td>
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<td>Dec 1-3</td>
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<td>Dec 8-10</td>
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HA = Higgs and Attwood; HMM = Hillis, Moritz, & Mable; PH = Page and Holmes; F = Felsenstein.