Syllabus ENTOM/GENETICS/ZOO 624 Molecular Ecology

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Time: Tuesdays and Thursdays 11:00-12:15
Location: 150 Russell Labs
Office Hours: Tuesdays and Thursdays 12:15-1:15, or by appointment.

***Description of Course* (3 units):** Molecular ecology is an exciting field that is taking advantage of the rapid development of new techniques in molecular genetics as well as advances in the theoretical and statistical approaches to study fundamental processes in evolution and ecology. It has influenced fields as diverse as behavioral ecology, medicine, forensics, and conservation biology. This course surveys recent developments in the field of Molecular Ecology, and provides the theoretical background necessary to conduct research. This is **an upper division undergraduate and graduate level course** (see distinction in grading), with three hours of instruction per week. Expect to spend six hours outside class completing the required reading and homework. A course background satisfying lower division biology and genetics requirements is required (Genetics 466, Genetics 467, Biocore 381/382, or graduate standing).

Learning Outcomes: Upon completion of this course, students will be able to 1) identify the common molecular markers and molecular genetic techniques used by molecular ecologists; 2) understand the importance of genetic diversity in species biology, including 3) how different ecological and evolutionary processes shape genetic variation; 4) interpret data and communicate the results of common molecular genetic analyses; 5) thoughtfully evaluate whether molecular genetic techniques and data are appropriate for answering scientific questions; 6) be familiar with the primary literature in the fields of Molecular Ecology.

Course Reading Material: You will read 13 scientific articles over the course of the semester, which are available as pdf files on Learn@UW and listed below in the week due. No text is required, but you should consider *Molecular Ecology* by J.R. Freeland, S.D. Petersen, and H. Kirk (2nd ed., Wiley, 2011) as a supplementary reference. This is available as a course reserve at Steenbock Library.

Laboratory Sessions: To help you conceptualize genetic variation and how it is analyzed, we will use computer simulations and software during three class sessions. Please note the schedule- will meet in the CALS computer lab (Animal Sciences Bldg. Room 150) that day.

Course Grading	**Undergraduate Students**	**Graduate Students**
Participation	5%	5%
Problem Sets and Tutorials (5)	25%	25%
Quizzes (Best 5 of 6)	25%	25%
Final Exam	25%	25%
Journal Article Review	20%	n/a
Graduate Student Review Paper	n/a	20%

Grade Scale: **A** 92.5-100%, **AB** 87.5-92.4%, **B** 82.5-87.4%, **BC** 77.5-82.4%, **C** 69.5-77.4%, **D** 59.5-69.4%,
F <59.5%. All assignments and exams will be graded on a scale from 1 to 100.

Incompletes: To qualify for an incomplete, you must have 1) completed all course work except the final, 2) have a C average or above, and 3) provide documentation for an unforeseen circumstance (illness, accident, sudden death in family) before the last day of finals week.

Lab Tutorials and Problem Sets: These assignments will help you develop hands-on experience working with real biological data. You will learn how to use simulations and mathematical operations to interpret data and to solve applied problems in molecular ecology. Group participation for the completion of labs and problem sets is encouraged.

Lab Tutorial 1: What are the consequences of population size change on genetic diversity and species biology?
Lab Tutorial 2: What is the relationship between gene flow and landscape variables?
Lab Tutorial 3: How can you test different models of evolution using simulations?

Quizzes: In-class quizzes will be given at the start of six classroom sessions, drawing from lecture material and reading assignments. Your best five quizzes will count towards your grade.

Journal Article Review (Undergraduates Only): You will read, summarize and critique an article from the journal *Molecular Ecology* (a recent paper published in 2013-2015). In particular, you will assess the data and methods used in this paper, and make recommendations on improving the study design and following up with a novel, but related, research question. Further guidelines will be given before the assignment is due. Expect to write 3-4 pages, single-spaced, including an experimental design flow-chart and a table or figure.

Review Paper (Graduate Students Only): You will review recent scientific literature assessing methodological developments on a topic in Molecular Ecology. Expect to write 8-10 pages, single-spaced, including tables, figures and references (minimum 10 references). Please set up a meeting with me to discuss your proposed review.

Final Exam: The final will be a cumulative exam covering all lecture material, readings and problem sets. There will be a review session preceding the exam.

Schedule of Lectures

	Date	***Title***	***Assigned Reading***
Genetics Review	Jan 17	Course Introduction: History of Molecular Ecology	
	Jan 19	DNA Structure and Inheritance, Molecular Markers, Genomics and Next-Generation Sequencing	Schlotterer 2004 [1]
Individuals and Groups	Jan 24	Individuality and Parentage: Molecular Fingerprints	Jones *et al.* 2009 [2]
	Jan 26	Relatedness and Reproductive Strategies	
Studying a single population	Jan 31	**QUIZ 1,** Population Genetic Diversity and Effective Population Size	Waples 2005 [3]
	Feb 2	**Lab Tutorial 1**	
	Feb 7	Expansions and Bottlenecks	Tsutsui *et al*. 2000 [4]
	Feb 9	Conservation Genetics	**Problem Set 1 Due**

Studying multiple Populations	Feb 14	**QUIZ 2,** Population Structure	
	Feb 16	Cluster Analysis, Principle Component Analysis	François and Durand 2010 [5]
	Feb 21	Gene Flow Estimation	
	Feb 23	Landscape Genetics	Manel and Holderegger 2013 [6]
Studying Lineages	Feb 28	**QUIZ 3,** Coalescent Theory, Gene Trees and the Two-population Divergence Model	Hein and Schierup 2005 [7]
	Mar 2	**Lab Tutorial 2**	
	Mar 7	Phylogeography and Comparative Phylogeography	
	Mar 9	Approximate Bayesian Computation (ABC)	
	Mar 14	**Lab Tutorial 3**	
	Mar 16	Mutation Models, Molecular Clocks & Divergence Time Estimation	Ho 2014 [8]
		SPRING BREAK	
	Mar 28	**QUIZ 4,** Temporal Sampling: Ancient DNA and Genetic Epidemiology	Holmes 2008 [9]
	Mar 30	Species Trees, Phylogenetics and Barcoding	**Problem Set 2 Due**
	Apr 4	Environmental Genomics	
Linkage, Recombination and Selection	Apr 6	**QUIZ 5,** Recombination and Linkage Disequilibrium	
	Apr 11	Natural Selection	**Journal Article Review Due**, Hohenlohe *et al.* 2010 [10]
	Apr 13	Genome Scans and Gene-Environment Correlations	
Genes to Phenotypes	Apr 18	**QUIZ 6,** Quantitative Genetics	**Review Paper Due**
	Apr 20	QTL Mapping, Genome-Wide Association Studies	
	Apr 25	Gene Expression and Gene Networks	Renaut and Bernatchez 2010 [11]
Genomes	Apr 27	Gene Families and Genome Evolution	
	May 2	Future of Molecular Evolution and Molecular Ecology	
	May 4	Review Session	
	May #	**Final Exam**	

***Bibliography of Course Reading Assignments*:**

1. Schlötterer, C., *The evolution of molecular markers- just a matter of fashion?* Nature Reviews Genetics, 2004. **5**(1): p. 63-69.
2. Jones, A.G., et al., *A practical guide to methods of parentage analysis.* Molecular Ecology Resources, 2009. **10**(1): p. 6-30.
3. Waples, R.S., *Genetic estimates of contemporary effective population size: to what time periods do the estimates apply?* Molecular Ecology, 2005. **14**(11): p. 3335-3352.

4. Tsutsui, N.D., et al., *Reduced genetic variation and the success of an invasive species.* Proceedings of the National Academy of Sciences, 2000. **97**(11): p. 5948-5953.
5. François, O. and E. Durand, *Spatially explicit Bayesian clustering models in population genetics.* Molecular Ecology Resources, 2010. **10**(5): p. 773-784.
6. Manel, S. and R. Holderegger, *Ten years of landscape genetics.* Trends in Ecology & Evolution, 2013. **28**(10): p. 614-621.
7. Hein, J., M.H. Schierup, and C. Wiuf, *Chapter 1. The basic coalescent*, in *Gene Genealogies, Variation and Evolution: A Primer in Coalescent Theory*. 2005, Oxford University Press: Oxford. p. 1-32.
8. Ho, S.Y.W., *The changing face of the molecular evolutionary clock.* Trends in Ecology & Evolution, 2014. **29**(9): p. 496-503.
9. Holmes, E.C., *Evolutionary history and phylogeography of human viruses.* Annual Review of Microbiology, 2008. **62**: p. 307-328.
10. Hohenlohe, P.A., P.C. Phillips, and W.A. Cresko, *Using population genomics to detect selection in natural populations: key concepts and methodological considerations.* International Journal of Plant Sciences, 2010. **171**(9): p. 1059-1071.
11. Renaut, S. and L. Bernatchez, *Transcriptome-wide signature of hybrid breakdown associated with intrinsic reproductive isolation in lake whitefish species pairs (Coregonus spp. Salmonidae).* Heredity, 2010. **106**(6): p. 1003-1011.

University Policies That Apply to This Course:
The University of Wisconsin - Madison is dedicated to a safe, supportive and non-discriminatory learning environment. It is the responsibility of all undergraduate and graduate students to familiarize themselves with University policies regarding Network Use, Disability Accommodations, Misconduct, Religious Beliefs Accommodation, and FERPA.

Disability Accommodations: I wish to fully include persons with disabilities in this course. Please contact me no later than January 29 if you need accommodations in the curriculum, instruction, or assessments in this course to enable you to fully participate. I will maintain confidentiality of the information you share with me. If you need a Verified Individualized Services and Accommodations plan (VISA), please contact the McBurney Disability Resource Center as soon as possible: http://www.mcburney.wisc.edu/students/howto.php.

Religious Observances Policy: Please approach me in advance if you have a conflict between a religious observance and scheduled quiz or lab session. I will find an alternative time for you to complete the assignment. Students should notify me within the first three weeks of the beginning of classes of the specific days or dates on which they will request accommodation. For additional information, please refer to Chapter UWS 22: Accommodation of Religious Beliefs.

Academic Misconduct: Academic honesty and integrity are fundamental to the mission of higher education in the University of Wisconsin System. Students are responsible for the honest completion and representation of their work, for the appropriate citation of sources, and for respect of others' academic endeavors. Students who violate these standards are subject to disciplinary action. UWS Chapter 14 identifies procedures to be followed when a student is accused of academic misconduct. For additional information, please refer to the section in the Student Handbook entitled Student Academic Disciplinary Procedures.

Network Use Policies: Please read the UW-Madison's Responsible Use of Information Technology Policy.

Your Rights Concerning Disclosure of Academic Records: FERPA – the Family Educational Rights and Privacy Act of 1974, as amended – is a federal law that governs the privacy of student educational records, access to those records, and disclosure of information from them. For more information, please refer to Student Privacy Rights (FERPA).