THE UNIVERSITY of WISCONSIN MADISON
Department of Entomology

ENTOM/GENETICS/ZOO 624 Molecular Ecology Syllabus

General Course Information

Credits: 3
Course Webpage: https://canvas.wisc.edu/courses/447219
Course Attributes: Honors, graduate
Meeting Time: Tuesdays and Thursdays 11:00-12:15
Location: 147 Russell Labs (T), A120 Russell Labs (Th)
Instructional Mode: in-person
Credit hours follow the traditional Carnegie definition: 2.5 hrs in class, 5 hours outside
Regular and Substantive Student-Instructor Interaction: Regular and substantive student-instructor interaction, as defined by the US Department of Education (Within 34 C.F.R. §600.2), includes direct instruction, providing feedback on student work, providing information about course content, facilitating discussion of course content, and regular interaction in a lab setting.

Other Course Information

Instructor: Dr. Sean Schoville
Contact: E-mail: sean.schoville@wisc.edu; Phone: 608-262-2956
Office: 637 Russell Labs
Office Hours: Tuesdays and Thursdays 12:15-1:00, or by appointment.

***Course Description*:** Basic principles of molecular ecology. Lecture topics include population genetics, molecular phylogenetics, rates and patterns of evolution, genome evolution, and molecular ecology. Enroll Info: None

Requisites: BOTANY/GENETICS/ZOOLOGY 466, GENETICS 467 or BIOCORE 383 or graduate student standing

Course Learning Outcomes

Upon completion of this course, students (both undergraduate and graduate) will:
1) demonstrate knowledge about the significance of genetic diversity in species biology
2) differentiate how ecological and evolutionary processes shape genetic variation
3) analyze genetic data and communicate the results
4) evaluate whether genetic data are appropriate for answering scientific questions
5) summarize and critique the primary literature in the field of Molecular Ecology.

Graduate students will further:
6) evaluate, compare and critique alternative statistical or analytical approaches in the field of Molecular Ecology.

Course Grading

University policy states that courses serving both undergraduate and graduate students establish a higher standard of performance for graduate students for the same grade. The additional graduate student work generally occurs outside the common class time.

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. This class does not use a grading curve.

Assignment	**Learning Outcomes**	**Undergraduate Students**	**Graduate Students**	**Due Date**
Participation	3, 4, 5	5%	5%	Weekly
Lab Tutorial Answers (12)	1, 2, 3, 4	25%	25%	Weekly
Quizzes (Best 5 of 6)	1, 2	25%	25%	Biweekly
Journal Article Review	4, 5	20%	n/a	Apr 6
Graduate Student Review Paper	5, 6	n/a	20%	Apr 6
Final Exam	1, 2, 4	25%	25%	May 7 10:05-12:05

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.

Course Reading Material

You will read six scientific articles over the course of the semester, which are available as pdf files on Canvas and listed below on the calendar. You should read these over the weekend, prior to our Tuesday discussion of these papers.

No text is required, but you could consider *Molecular Ecology* by J.R. Freeland (3rd ed., Wiley, 2020) as a useful supplementary reference. The second edition can be downloaded freely at: http://onlinelibrary.wiley.com/book/10.1002/9780470979365.

Laboratory Sessions

To help you conceptualize genetic variation and how it can be analyzed, we will use computer simulations and software during 12 laboratory sessions at our regular class time. Please note that on Thursdays we will meet in the A120 Russell Labs computer lab.

Lab Tutorials: 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: How can you use R and the command line to analyze genetic data?
Lab Tutorial 2: How do you measure genetic diversity?
Lab Tutorial 3: What are the consequences of population size change on genetic diversity and species biology?
Lab Tutorial 4: How do you measure and identify population structure?
Lab Tutorial 5: What is the relationship between gene flow and landscape variables?
Lab Tutorial 6: How can you test different models of evolution using simulations?
Lab Tutorial 7: How do use phylogenies to study biogeography?
Lab Tutorial 8: How do you analyze and date a phylogeny?
Lab Tutorial 9: How do you conduct a microbiome analysis?
Lab Tutorial 10: How do you test for natural selection in populations?

Lab Tutorial 11: How do you conduct a genome-wide association analysis?
Lab Tutorial 12: How do you compare gene expression profiles in an experiment?

Other Assignments

Quizzes: Timed online quizzes (20min) will be given on a Thursday and must be completed by Sunday. They will allow open notes, 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 2019-2024). 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 are provided in the rubric. 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 (statistical and/or analytical) 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. Further guidelines are provided in the rubric.

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

General Guidelines for Exam Proctoring: Proctoring is conducted by the instructor during in-person quizzes and exams.

How to Succeed in this Course

Teamwork and discussion are **essential** to learning in this course. You'll be working in groups in the lab sessions, and I suggest you come prepared to lectures by reading and generating questions about the assigned papers. Here are some resource links to important campus services:

- *University Health Services*
- *Undergraduate Academic Advising and Career Services*
- *Office of the Registrar*
- *Office of Student Financial Aid*
- *Dean of Students Office*

How to Evaluate this Course

Student participation is an integral component of this course, and your confidential feedback is important to me. UW-Madison uses a digital course evaluation survey tool called AEFIS. You will receive an official email two weeks prior to the end of the semester, with a link to log into the course evaluation with your NetID. Evaluations are anonymous. I strongly encourage you to participate in the course evaluation.

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Schedule of Lectures, Labs and Assignments

	Date	*Title*	*Assigned Work*
Individuals & Relatives	Jan 21	Course Introduction: History of Molecular Ecology	
	Jan 23	Identifying Individuals, Parents and Relatedness Within Groups	Archie et al. [1]
Studying a single Populations	Jan 38	Population Genetic Diversity and Effective Population Size	
	Jan 30	**Lab Tutorial 1:** Using R and the command line	Tsutsui et al. [2], **QUIZ 1**
	Feb 4	Expansions, Bottlenecks and Conservation Genetics	
	Feb 6	**Lab Tutorial 2:** genetic diversity	
	Feb 11	Intersection of Ecology and Evolution: Rapid Evolution and Genetic Rescue	
	Feb 13	**Lab Tutorial 3:** population size change	**QUIZ 2**
Studying multiple Populations	Feb 18	Population Structure	
	Feb 20	**Lab Tutorial 4:** population structure	Epps et al. [3]
	Feb 25	Gene Flow and Landscape Genetics	
	Feb 27	**Lab Tutorial 5:** gene flow on landscapes	**QUIZ 3**
Studying Lineages and Clades	Mar 4	Coalescent Theory, Gene Trees and the Two-population Divergence Model	
	Mar 6	**Lab Tutorial 6:** approximate Bayesian computation	Smith et al. [4]
	Mar 11	Phylogeography and Genetic Epidemiology	
	Mar 13	**Lab Tutorial 7:** phylogeography and phylogenetics	**QUIZ 4**
	Mar 18	Phylogenetics, Species Trees, Mutation Models and Divergence Time Estimation	
	Mar 20	**Lab Tutorial 8:** phylogenetic dating	
	Mar 24-28: Spring Break		
	Apr 1	Barcoding and Environmental Genomics	
	Apr 3	**Lab Tutorial 9:** microbiome analysis	Whitehead *et al.* [5], **QUIZ 5, Review Paper Due Apr 06**
Recombination and Selection	Apr 8	Natural Selection, Recombination and Linkage Disequilibrium	
	Apr 10	**Lab Tutorial 10:** genome scans	

Genes to Phenotype and Genomics	Apr 15	Quantitative Genetics, QTL Mapping, Genome-Wide Association Studies	
	Apr 17	**Lab Tutorial 11:** GWAS	Renaut and Bernatchez [6], **Quiz 6**
	Apr 22	Gene Expression and Gene Networks	
	Apr 24	**Lab Tutorial 12:** gene expression analysis	
	Apr 29	Gene Families and Genome evolution	
	May 1	Future of Molecular Evolution and Molecular Ecology, Review Session	
	May 07	**Final Exam 10:05AM – 12:05AM**	

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

1. Archie, E.A., C.J. Moss, and S.C. Alberts, *The ties that bind: genetic relatedness predicts the fission and fusion of social groups in wild African elephants.* Proceedings of the Royal Society of London B: Biological Sciences, 2006. **273**(1586): p. 513-522.
2. 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.
3. Epps, C.W., et al., *Highways block gene flow and cause a rapid decline in genetic diversity of desert bighorn sheep.* Ecology letters, 2005. **8**(10): p. 1029-1038.
4. Smith, S.D., Pennell, M.W., Dunn, C.W. and Edwards, S.V., 2020. *Phylogenetics is the new genetics (for most of biodiversity)*. Trends in Ecology & Evolution, **35**(5): p. 415-425.
5. Whitehead, A., et al., *When evolution is the solution to pollution: Key principles, and lessons from rapid repeated adaptation of killifish (Fundulus heteroclitus) populations.* Evolutionary applications, 2017. **10**(8): p. 762-783.
6. 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.

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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 coursework.

***Institutional statement on diversity*:** Diversity is a source of strength, creativity, and innovation for UW-Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals. The University of Wisconsin-Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background – people who as students, faculty, and staff serve Wisconsin and the world.
https://diversity.wisc.edu/

Disability Accommodations: The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform me of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. I will work either directly with you or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA.
http://mcburney.wisc.edu/facstaffother/faculty/syllabus.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.

Rules, Rights and Responsibilities: See your Rules, Rights and Responsibilities as students.

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.

Academic Records, Data Transparency and Intellectual Property: 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).

The privacy and security of faculty, staff and students' personal information is a top priority for UW-Madison. The university carefully evaluates and vets all campus-supported digital tools used to support teaching and learning, to help support success through learning analytics, and to enable proctoring capabilities. View the university's full teaching and learning data transparency statement.

Lecture materials and recordings for this course are protected intellectual property at UW-Madison. Students in this course may use the materials and recordings for their personal use related to participation in this class. Students may also take notes solely for their personal use. If a lecture is not already recorded, you are not authorized to record my lectures without my permission unless you are considered by the university to be a qualified student with a disability requiring accommodation. [Regent Policy Document 4-1]. Students may not copy or have lecture materials and recordings outside of class, including posting on internet sites or selling to commercial entities. Students are also prohibited from providing or selling their personal notes to anyone else or being paid for taking notes by any person or commercial firm without the instructor's express written permission. Unauthorized use of these copyrighted lecture materials and recordings constitutes copyright infringement and may be addressed under the university's policies, UWS Chapters 14 and 17, governing student academic and non-academic misconduct.