University of Wyoming

BOT 4790/5790

Advanced Evolutionary Analysis (J-Term 2025)

Format: Hybrid (synchronous + asynchronous), in-person preferred for synchronous but remote accommodated.

Meeting Location: SIB 3030 or https://uwyo.zoom.us/j/92058215599

Instructor: Catherine Wagner (with help from Sean Harrington)

Course Dates: January 5–30, 2025

Instructor contact information:
catherine.wagner@uwyo.edu
Office: Berry Center 144

Office hours and/or open-door policy: I am available during working hours for the duration of the course either in my office (Berry 144) or via email/zoom.

Course prerequisites, co-requisites, enrollment restrictions: LIFE 3500 or equivalent is a prerequisite.

Course Overview

This intensive J-Term course provides training in advanced evolutionary analysis with a focus on population genomic and phylogenomic inferences using next-generation sequencing data. Students will learn fundamental concepts in evolutionary biology while engaging in hands-on analysis of genomic datasets. By necessity, this work will involve skill development in data science and high-performance computing (HPC), utilizing ARCC (Advanced Research Computing Center) resources. The course will emphasize reproducible workflows, critical evaluation of analytical methods, and independent project development.

Learning Objectives

By the end of the course, students will be able to:

1. Use HPC systems for large-scale genomic analyses.
2. Apply version control and reproducibility practices using Git and GitHub.
3. Process next-generation sequencing data from reads to variant call format (VCF).

4. Evaluate and filter genomic data for downstream analyses.
5. Conduct phylogenetic analysis from SNP datasets using maximum likelihood approaches.
6. Perform population genomics analyses including PCA, admixture, demographic modeling, and distance metrics.
7. Design and execute an independent evolutionary analysis project.

Course Structure

The structure of the course will combine live guidance with flexible independent analysis time. Students are encouraged to attend in-person but remote participation will be accommodated.

The first two weeks of class (prior to the start of the Spring semester) will be focused on general skill-building and workshop-style material. The second two weeks will be dedicated to individual student projects, with instructional content targeted on specific student needs. We will arrange meeting times in the second two weeks based on student availability given other course conflicts after the semester start.

This course is designed to provide an immersive experience in evolutionary data analysis. The format combines structured instruction with flexible independent work, allowing students to build practical skills while pursuing their own research questions in evolutionary biology.

Assessment

- **Participation and Engagement:** 40%
- **Hands-on Exercises:** 30%
- **Independent Project & Final Presentation:** 30%

Required assignments and projects.

- Active and engaged participation in class sessions
- 4x problem sets (hands-on exercises)
- Final paper and presentation

Resources

- ARCC High Performance Computing resources
- GitHub for code and workflow management
- Software packages: FastQC, BWA, GATK, VCFtools, IQtree, RAxML, dadi/fastsimcoal, R (adegenet, SNPRelate)

Policies

- **Attendance:** Active participation in synchronous sessions is expected, either in-person or via zoom.
- **Academic Integrity:** All students must adhere to the University of Wyoming's policies on academic honesty.
- **Collaboration:** Students are encouraged to collaborate and share code, but final projects must reflect individual effort.

General requirements and expectations for the course: Attendance is required, and late work will be downgraded 10% per day unless otherwise discussed with the instructor.

Final Project Date: January 30th, 2026

Grading Scale and Grading Policies: The class will be graded based on letter grades. Grades will be assigned to the categories   listed above and averaged.

Attendance and Absence policies. For in-person courses, state the class absence policies, as well as University policies on excused absences as outlined in UW SAP 2-100.2 (Student Attendance Policy). For online courses, state the class participation policies, what constitutes participation and how that will be evaluated.

Classroom Behavior Policy: At all times, treat your presence in the classroom and your enrollment in this course as you would a job. Act professionally, arrive on time, pay attention, complete your work in a timely and professional manner, and treat all deadlines seriously. You will be respectful towards your classmates and instructor.Spirited debate and disagreement are to be expected in any classroom and all views will be heard fully, but at all times we will behave civilly and with respect towards one another. Personal attacks, offensive language, name-calling, and dismissive gestures are not warranted in a learning atmosphere. As the instructor, I have the right to dismiss you from the classroom, study sessions, electronic forums, and other areas where disruptive behavior occurs.

Academic Freedom and Institutional Discrimination: UW Regulation 2-15 on Academic Freedom states, "Academic freedom in teaching protects the rights of Academic Personnel to teach according to their expertise. Academic Personnel are entitled to freedom in discussing their subject. Academic Personnel have a responsibility to ensure that their teaching is effective and consistent with the standards of the discipline, understanding that disciplines may have diverse points of view on any given subject. Teaching may involve controversial material; however, with academic freedom in the classroom, Academic Personnel also have the responsibility to respect others' freedom to express disagreement and alternate opinions." Additionally, "Academic freedom does not negate the rights of students and the public to disagree with Academic Personnel's work, although students are expected to learn material with which they may disagree." Also adopted by UW in it's Academic Freedom policy, "Students should be free to take reasoned exception to the data or views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled."

Classroom Statement on Diversity: The University of Wyoming values an educational environment that supports students of all backgrounds and viewpoints. Diversity of viewpoints is considered a resource for learning. Topics may be difficult, not only intellectually but emotionally; however, discussions are essential to meeting the course's student learning outcomes and assisting students in developing problem-solving and critical-thinking skills. During all conversations, respect and civility are of utmost importance.

Disability Support: The University of Wyoming is committed to providing equitable access to learning opportunities for all students.   If you have a disability, including but not limited to physical, learning, sensory or psychological disabilities, and would like to request accommodation in this course due to your disability, please register with and provide documentation of your disability as soon as possible to Disability Support Services (DSS), Room 109 Knight Hall. You may also contact DSS at (307) 766-3073 or udss@uwyo.edu. It is in the student's best interest to request accommodation within the first week of classes, understanding that accommodations are not retroactive. Visit the DSS website for more information at: www.uwyo.edu/udss.

Academic Dishonesty Policies: Academic dishonesty will not be tolerated in this class. Cases of academic dishonesty will be treated in accordance with UW Regulation 2-114. The penalties for academic dishonesty can include, at my discretion, an "F" on an exam, an "F" on the class component exercise, and/or an "F" in the entire course. Academic dishonesty means anything that represents someone else's ideas as your own without attribution. It is intellectual theft – stealing - and includes (but is not limited to) unapproved assistance on examinations, plagiarism (use of any amount of another person's writings, blog posts, publications, and other materials without attributing that material to that person with citations), or fabrication of referenced information. Facilitation of another person's academic dishonesty is also considered academic dishonesty and will be treated identically.

AI Technology: Students are permitted to use advanced automated artificial intelligence or machine learning tools on assignments in this course if that use is properly documented and credited.

Duty to Report: UW faculty are committed to supporting students and upholding the University's non-discrimination policy. Under Title IX, discrimination based upon sex and gender is prohibited. If you experience an incident of sex- or gender-based discrimination, we encourage you to report it. While you may talk to a faculty member, understand that as a "Responsible Employee" of the University, the faculty member MUST report information you share about the incident to the university's Title IX Coordinator (you may choose whether you or anyone involved is identified by name). If you would like to speak with someone who may be able to offer privacy or confidentiality, there are people who can meet with you. Faculty can help direct you or you may find info about UW policy and resources at http://www.uwyo.edu/reportit. You do not have to go through the experience alone. Assistance and resources are available, and you are not required to make a formal complaint or participate in an investigation to access them.

Green Dot Program at UW: Here at The University of Wyoming, we are committed to reducing and preventing power-based personal violence such as sexual assault, relationship violence, and stalking. Green Dot is a bystander intervention program to reduce these forms of violence with one thought; If

everyone does one thing, no one will have to do everything. A Green Dot is your choice at any moment to make campus safer by promoting safety for everyone and letting others know that you will not tolerate violence. A Green Dot is any behavior, choice, word or attitude that sends a clear message that: 1. Violence is not okay with you, and 2. Everyone is expected to do their part.

Additional information on Green DOT training and resources are available at: http://www.uwyo.edu/greendot/

Substantive changes to syllabus: All deadlines, requirements, and course structure are subject to change if deemed necessary by the instructor. Students will be notified verbally in class and via email of these changes.

Student Resources:
DISABILITY SUPPORT SERVICES: udss@uwyo.edu, 766-3073, 109 Knight Hall, www.uwyo.edu/udss
COUNSELING CENTER: uccstaff@uwyo.edu, 766-2187, 766-8989 (After hours), 341 Knight Hall,
www.uwyo.edu/ucc
ACADEMIC AFFAIRS: 766-4286, 312 Old Main, www.uwyo.edu/acadaffairs
DEAN OF STUDENTS OFFICE: dos@uwyo.edu, 766-3296, 128 Knight Hall, www.uwyo.edu/dos
UW POLICE DEPARTMENT: uwpd@uwyo.edu, 766-5179, 1426 E Flint St, www.uwyo.edu/uwpd
STUDENT CODE OF CONDUCT WEBSITE: www.uwyo.edu/dos/conduct
UW TUTORING RESOURCES: https://www.uwyo.edu/step/index.html

Weekly Schedule

Week 1 (Jan 6–10): Foundations; From Reads to Variants

- **Topics:**
    - Course introduction
    - Intro to computing in genomics (working in bash, file systems)
    - Next-generation sequencing (NGS) basics
    - Variant calling pipeline
    - VCF structure
    - Data processing and filtering (quality, depth, missing data) decisions and impacts
- **Activities:**
    - Hands-on intro to computing
    - Working with NGS data
    - Working with .vcf files

Week 2 (Jan 13–17): HPC Foundstiona continued, and Population Genomic Analyses

- **Topics:**
    - Intro to MedicineBow
    - Git & GitHub for version control and collaboration
    - Population structure: PCA, admixture analysis; Phylogenetics from SNP data: intro to IQtree / RAxML; Genetic distances: pairwise Fst, distance matrices in R;

- **Activities:**
    - Filtering and curating datasets
    - Analyzing population structure
    - Building and interpreting phylogenetic trees

Week 3 (Jan 20–30): Independent Projects & Presentations

- **Topics (targeted at particular student needs/interests):**
    - Potentially could include: Demographic modeling: intro to dadi / fastsimcoal; GWAS; additional phylogenetics; others as determined by student needs/interests
    - Independent project work
    - Instructor check-ins and feedback sessions
    - Final presentations and wrap-up

- **Activities:**
    - Student-led analyses
    - Project planning: students define independent project goals
    - Final presentations of results and reflections