Syllabus for the course
Evolutionary Genomics
J-term 2022
BIOL 4585

Instructor information
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Course information
Course website: https://www.jcbnunez.org/biol4585j
GitHub site: https://github.com/Jcbnunez/biol4585j-yey2sn
Course Collab Site: 22J BIOL 4585-001 (CGSAS)
Course Location: Chemistry Bldg 306
Class Number: 10072
Units: 3 units
Dates: 01/03/2022 - 01/14/2022
Meets: Mo, Tu, We, Th, Fr -- 10:00am - 3:30pm
Instruction Mode: In Person
Office Hours during J-term: by appointment, in person or via zoom.
The drop deadline is January 4, and the withdrawal deadline is January 5, 2022

Course description

From blue whales to bacteria our planet is filled with incredible biodiversity living in complex ecosystems. Evolution is the primary driving force of this astounding natural variation. At the center of it all lies DNA, the molecule that carries life's instructions. Changes to this molecule can have fundamental consequences for species. In this course, we will utilize cutting edge genomics techniques to understand how natural populations survive, evolve, and adapt in the context of complex ecological interactions. These knowledge helps us understand how species got to where they are (including humans), and where are they going. This is of great importance if we hope to tackle the challenges of disease evolution, climate change, habitat fragmentation, and pollution.

This is an advanced course designed for students interested in learning how use genomic data to infer signatures of adaptation and historical demography from natural populations. This course is intensive and will provide a full two-week immersion program into the world of genomics. We will cover theory, primary literature, and hands-on exercises to understand advance topics in evolutionary & ecological genomics. For undergraduates, the course requires a fundamental knowledge of general biology. Programming in R and Unix is preferable but not required, as there will be resources to learn these programming languages. As part of this course, the students will engage in analyses of real and simulated genomic data. Primary literature will be assigned for 8 of the 10 class meetings. Each meeting will be divided in three portions. First a lecture, second a student-lead discussion on a selected paper, lastly a practicum on genomics data. The course will culminate with a genomics data challenge, where student groups will be given "unknown" data and their challenge is to characterize the "mystery dataset" as well as present their findings to the class in oral and written form.

Course goals

After completion of this course, students will be able to:

- Learn the fundamentals to analyze genomic data.
- Construct testable hypothesis about genetic variation and natural selection that can be explored using genomic data.

- Synthesize knowledge from primary literature into cohesive arguments to discuss scientific findings.

Course Meeting requirements

This is a J-term intensive course that will meet Mo, Tu, We, Th, and Fr, from 10:00am - 3:30pm

How to prepare?

Students are expected to prepare before each meeting. This entails studying the assigned reading carefully to participate in the class discussion or presentation. Each class, a single student (or a group of students; depending on enrollment) is expected to lead the primary discussion. The student will guide the class using a power-point presentation and/or other audiovisual tools. Students not presenting are expected to actively participate in each session.

Each day, the class will transition into a hands-on workshop focusing on data analysis. This portion of the class can advance at a very fast pace. Thus, it is important for students to approach instructor if they need additional guidance.

Grading Policy

This course will be graded based on a point system. Points will be assigned for participation, leading a paper discussion, small coding quizzes, small writing assignments, and a final presentation.

Total class points are distributed as follows:

Grades will be assigned as follows:

Class participation (500 pts)

Students will be given points for actively participating in class (up to 50 pts per class x 10 sessions). Participation will be assessed based on a predetermined rubric.

Class discussion leader (700 pts)

Students will obtain points based on their performance when leading the week's discussion. This will be assessed based on a predetermined rubric.

Reading summaries (700 pts)

Every day, students will turn-in a short (~1/2 page long) reading summary of the daily assigned reading. This will be assessed based on a predetermined rubric. 100 pts per paper (x 7 papers).

Final presentation (800 pts)

For the final project, students will analyze a mystery dataset and will use their new skills to discover what processes are at play in the dataset. This dataset will be given on the Friday of week one (giving a whole week for students to play with the data). Prior to final submission, the students will have the opportunity to obtain feedback from the instructor via an online platform and class dialogue. This assignment will be assessed based on a predetermined rubric.

Coding homework (200 pts)

I will give a small coding quiz at the end of each practicum to test newly acquired coding skills. Each mini quiz is worth 30-25 pts. These are low-stakes quizzes meant to help solidify new concepts. These quizzes are intended for students who are brand new to coding.

Percent Cutoff	Letter Grade
97.0%	A+
93.0%	A
90.0%	A-
87.0%	B+
83.0%	B
80.0%	B-
77.0%	C+
73.0%	C
70.0%	C-
69.0%	F

No “D” grade will be given in this class. If a student is not making satisfactory progress, they should meet with the instructor ASAP to discuss potential courses of action.

Work Expectations

Classes will meet once a day for two weeks from 10:00 am to 3:30 pm. In each class, the students will read 1 paper. It is expected that students will devote enough time to read and digest the paper (at least 1.5 hours, per paper, the day before). It is expected that students will be fully committed and immersed in the class for two-week duration of the J-term. This course is equivalent to 3 units.

Class environment

This class is intended to be an inclusive learning environment that respects student’s individuality and lived experiences across race, ethnicity, socioeconomic status, sexuality, gender identity, religion, ability, etc. The instructor will strive to ensure that each student experiences a fair, respectful, and constructive learning environment. It is extremely important for students to reach out to the instructor if any of these conditions are not met, and/or if the student feels that they are experiencing a hostile or unfair learning environment.

To ensure respectful interactions within the class, please let me know If your name and/or preferred pronouns differ from those by which the instructor has identified you.

Special accommodations and resources available to students

Disabilities

UVA is committed to full inclusion of all students. Students with a documented disability are welcome to contact the instructor early in the semester to arrange accommodations. Students may also speak with the Student Disability Access Center to discuss the process for requesting accommodations.

Cultural and religious

Any student wishing to observe holidays not sanctioned by the university must contact the instructor at the beginning of the semester. *Impromptu* requests won’t be considered.

Other important resources

CAPS/Timely Care/Talk Now
434-243-5150
https://www.studenthealth.virginia.edu/timelycare

UVA Title IX Office
434-297-7988
https://eocr.virginia.edu/title-ix

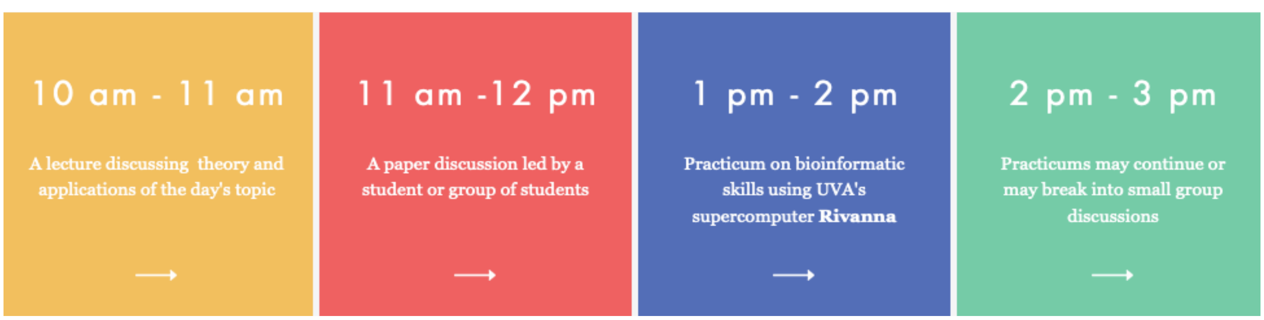
Honor Code

Students are required to complete their work independently, except where group projects are specifically encouraged. Violation of the Academic Honor code is a serious issue, with serious consequences. The following are examples of violations:

- Unauthorized collaboration on technical assignments, such as computer science programs, laboratory reports, etc.
- Submission of written work which is in whole or in part plagiarized from other sources: this includes papers or material copied from fellow students, from published sources such as articles, books, websites, or internet paper mills.
- Altering of exam or homework answers for resubmission and additional credit, and submission of the same written work to each of two different courses.
- Cheating from a fellow student or from prohibited materials on an in-class exam. The consequences of these violations range from loss of credit, to temporary – or permanent – separation from the University.

Please review the Academic Code at: https://honor.virginia.edu/

Tentative Daily Schedule



Lesson Plan Summaries for BIOL4585-j2022: Evolutionary Genomics

Week 1:

Lesson 1 (Jan 3): This lesson has four goals. 1) Get to know other students in the class and form working groups. 2) Understand the expectation and dynamics of the class. 3) Learn **how to operate the supercomputer**, learn the basic functions for moving bioinformatic files around. 4) learn the properties and structures of files in biology. A complete guide to this lecture can be found here: https://github.com/Jcbnunez/biol4585j-yey2sn/tree/main/Class_Materials/1.Introduction_to_Rivanna

Lesson 2 (Jan 4): This lesson has two goals. 1) Complete a group discussion on the history of DNA sequencing (paper 1; Shendure et al.). 2) Learn how to use R to analyze biological datasets. This **introduction to R** will cover primarily the *tidiverse* library. A complete guide to this lecture can be found here: https://github.com/Jcbnunez/biol4585j-yey2sn/tree/main/Class_Materials/2.Introduction_to_R

Lesson 3 (Jan 5): This lesson has two goals. 1) Complete a paper discussion on applications of phylogenetics (paper 2; Dunn et al.). 2) Learn how to manipulate DNA data to **build, analyze and visualize phylogenetic trees**. A complete guide to this lecture can be found here: https://github.com/Jcbnunez/biol4585j-yey2sn/tree/main/Class_Materials/3.Phylogenies

Lesson 4 (Jan 6): This lesson has three goals. 1) Complete a paper discussion on HIV evolution (paper 3; Rambaut et al.). 2) Learn the basics of **genome assembly** from short reads. A complete guide to this lecture can be found here: https://github.com/Jcbnunez/biol4585j-yey2sn/tree/main/Class_Materials/4.Genome_assembly

Lesson 5 (Jan 7): This lesson has 2 goals. 1) Complete a paper discussion on inbreeding depression for the Isle Royale Wolfs (paper 4; Robinson et al.). 2) Learn the basics of mapping reads to genomes using **burrows-wheeler aligners**. A complete guide to this lecture can be found here: https://github.com/Jcbnunez/biol4585j-yey2sn/tree/main/Class_Materials/5.SNP_calling

Week 2:

Lesson 6 (Jan 10): This lesson has three goals. 1) Complete a paper discussion on the genetic history of humanity (paper 5; Li et al.). 2) Understand the genomic signatures produced by the basic evolutionary forces: selection, drift, and migration. 3) learn how to find signatures of these evolutionary forces in panels of genomic data using dimensionality reduction (**Principal component analysis**; PCA). A complete guide to this lecture can be found here: https://github.com/Jcbnunez/biol4585j-yey2sn/tree/main/Class_Materials/6.PCA

Lesson 7 (Jan 11): This lesson has two goals. 1) Complete a paper discussion on human demography (paper 6; Novembre et al.). 2) Learn the **fundamental summary statistics** used to describe genetic variation in population genetics and how to estimate them on genomic data. A complete guide to this lecture can be found here: https://github.com/Jcbnunez/biol4585j-yey2sn/tree/main/Class_Materials/7.Genetic_Diversity

Lesson 8 (Jan 12): This lesson has two goals. 1) Complete a paper discussion on natural selection (paper 7; Gould and Lewontin). 2) Learn how to use **population genetics summary statistics** to detect the action of natural selection and how to estimate them on genomic data. A complete guide to this lecture can be found here: https://github.com/Jcbnunez/biol4585j-yey2sn/tree/main/Class_Materials/8.Selection

Lesson 9 (Jan 13): This lesson has two goals. 1) Complete a paper discussion on natural selection in the intertidal (paper 8; Nunez et al). 2) Open time to work on the genomics challenge.

Lesson 10 (Jan 14): Final presentations

Bibliography you will need to read for this class

- Shendure, J., Balasubramanian, S., Church, G. et al. DNA sequencing at 40: past, present and future. Nature 550, 345–353 (2017). Where to access: https://doi.org/10.1038/nature24286

- Casey W. Dunn, Sally P. Leys, Steven H.D. Haddock, The hidden biology of sponges and ctenophores, Open Access Published: March 31, 2015. Where to access: https://doi.org/10.1016/j.tree.2015.03.003

- Rambaut, A., Posada, D., Crandall, K. et al. The causes and consequences of HIV evolution. Nat Rev Genet 5, 52–61 (2004). Where to access: https://doi.org/10.1038/nrg1246

- Jacqueline A. Robinson, Jannikke Räikkönen, Leah M. Vucetich, John A. Vucetich, Rolf O. Peterson, Kirk E. Lohmueller, Robert K. Wayne. Genomic signatures of extensive inbreeding in Isle Royale wolves, a population on the threshold of extinction. Science Advances, 29 May 2019, Vol 5, Issue 5. Where to access: https://doi.org/10.1126/sciadv.aau0757

- Jun Z. Li, Devin M. Absher, Hua Tang, Audrey M. Southwick, Amanda M. Casto, Sohini Ramachandran, Howard M. Cann, Gregory S. Barsh, Marcus Feldman, Luigi L. Cavalli-Sforza, Richard M. Myers. Worldwide Human Relationships Inferred from Genome-Wide Patterns of Variation, Science • 22 Feb 2008, Vol 319, Issue 5866, pp. 1100-1104, https://doi.org/10.1126/science.1153717

- Novembre, J., Johnson, T., Bryc, K. et al. Genes mirror geography within Europe. Nature 456, 98–101 (2008). Where to access: https://doi.org/10.1038/nature07331

- S. J. Gould and R. C. Lewontin. The spandrels of San Marco and the Panglossian paradigm: a critique of the adaptationist programme. Published:21 September 1979. Where to access: https://doi.org/10.1098/rspb.1979.0086

- Joaquin C. B. Nunez, Patrick A. Flight, Kimberly B. Neil, Stephen Rong, Leif A. Eriksson, David A. Ferranti, Magnus Alm Rosenblad, Anders Blomberg, David M. Rand. Footprints of natural selection at the mannose-6-phosphate isomerase locus in barnacles. Proceedings of the National Academy of Sciences Mar 2020, 117 (10) 5376-5385; Where to access: https://doi.org/10.1073/pnas.1918232117

Participation Rubric Example:

How many points given?	Example of 100%	Example of 50%	Example of 0-10% points
Understanding the material	The student's participation is constructive and reflects a critical understanding of the material regarding what was done in the paper(s) and its major conclusions	The student's participation is constructive however understanding the basic science in the paper(s) is unclear or need further digestion.	The student's participation is disruptive of the class
Connecting the dots	The student can argue how the findings of the paper(s) fits into the overall theory or topic.	The student's participation is constructive, however there is no clear connection with the overarching topic.	The student's participation is disruptive of the class

Presentation Rubric Example:

How many points given?	Example of 100%	Example 80%	Example 50%	Example 0-10%
Visual Flow	The power-point presentation is well organized, legible, and only uses text when necessary	The power-point presentation is well organized, legible, however is heavily polluted with unnecessary text	The power-point presentation is generally disorganized, text heavy, and fill of typos.	The power-point presentation shows slides not at all connected with the talk/topic being presented.
Talk	Presenters give a well-rehearsed, properly timed talk.	Presenters give a well-rehearsed talk. However, it goes over the time limit.	The presenter's talk is not rehearsed or polished.	The presenter's talk is not rehearsed or polished and goes over time limit
Data visualizations	Graphs are legible and well explained during the talk.	Graphs are legible but not properly explained	Graphs are not legible and not properly explained	No data graphs are presented
Content	The topic is well presented. The students discuss the	The topic is adequately presented. The students discuss some	The topic is marginally well presented. The	The topic is not well presented. The students miss all key

	science, the methods, and the significance of the paper	but not all the science, the methods, and the significance of the paper	students missed more than one (but not all) key aspects of the science, the methods, and the significance of the paper	aspects of the science, the methods, and the significance of the paper