



QBIO 577 Fall 2024

Computational Molecular Biology Laboratory

Units: 2.0

**Fall 2024
2.00 - 3:50pm Tuesdays**

Location: GFS 223

Instructor: Prof. Adam MacLean
Office: RRI 403H
Office Hours: contact Prof to schedule
Contact Info: 213-740-7055, macleana@usc.edu

Instructor: Prof. Geoffrey Fudenberg
Office: RRI 413E
Office Hours: contact Prof to schedule
Contact Info: 213-740-0778, fudenber@usc.edu

Description: This course covers dynamical modeling for systems biology and machine learning for genome sciences. The course combines theory with practical, hands-on experience. Exercises will involve working in the programming languages Python and Julia, as well as readings from the current literature.

Goals:

- To gain **familiarity with the theoretical underpinnings of** computational biology methods for genomics data analysis and dynamical systems modeling.
- To gain **competency in the application of** computational biology methods in various programming environments.
- To gain **exposure to the usage of** these approaches across a wide range of topics in the recent literature.

Text: There is no required textbook. Readings will be assigned weekly (see schedule).

Course Contents: This course will cover topics including: systems biology, signaling networks, machine learning, genome biology, epigenomics, and structural genomics. The suggested background for this course includes: linear algebra, calculus, and familiarity with a scripting language (e.g. Python or Julia).

Homework: Homework projects will be assigned throughout the semester. Each project should be submitted by the specified due date. Points will be subtracted for projects submitted late.

Grade: Course grades will be calculated as follows, from homework assignments and participation. Participation in every lecture will be graded by attendance and the submission of short (4 sentence) summaries of lectures.

Percentage of final grade	
Homework Projects (MacLean):	35 %
Homework Projects (Fudenberg):	35 %
Participation:	30 %
Total:	100

Course Schedule: A Weekly Breakdown

Weeks 1-6: Systems biology

(8/27) Week 1: Introduction to Julia for (computational) biology

Reading: *Julia for biologists* www.nature.com/articles/s41592-023-01832-z.

(9/3) Week 2: Systems biology in Julia: modeling from first principles, networks & motifs

Reading: *Network motifs (Alon)* <https://www.nature.com/articles/nrg2102>.

(9/10) Week 3: Analyzing models: equilibria, stability, and bifurcations
Reading: *Modeling Life* (Garfinkel, Shevtsov, Guo), Chapter 3

(9/17) Week 4: Stochastic dynamics in biology
Reading: *Noise in Biology* (Tsimring)
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4033672/>

(9/24) Week 5: Parameter inference and model selection
Reading: *Simulation and inference algorithms*
<https://royalsocietypublishing.org/doi/10.1098/rsif.2018.0943>.

(10/1) Week 6: Going further in computational biology with Julia
Guest speaker: Jesse Kreger, Ph.D.
Reading: *Modeling myeloid-derived suppressor cells*
<https://doi.org/10.1158/2326-6066.CIR-22-0617>

(10/8) Week 7: In-class workshop: coding and assignments

Weeks 8-15: Machine learning + genome biology

(10/15) Week 8: Genome biology, 1D profiles & 2D maps
Reading: *ChIP-seq and beyond: new and improved methodologies to detect and characterize protein-DNA interactions.*
<https://www.nature.com/articles/nrg3306>

(10/22) Week 9: Unsupervised Learning 1. PCA, dimensionality reduction.
Reading: *A Tutorial on Principal Component Analysis*
<https://arxiv.org/pdf/1404.1100.pdf>

(10/29) Week 10: Unsupervised Learning 3: Single-cell RNA-seq analysis pipelines
Reading: *Revealing the vectors of cellular identity with single-cell genomics*
<https://www.nature.com/articles/nbt.3711>

(11/5) Week 11: Unsupervised Learning 2. Clustering.
Reading: *Heterochromatin diversity modulates genome compartmentalization and loop extrusion barriers*
<https://www.biorxiv.org/content/10.1101/2021.08.05.455340v1.full>,
A reanalysis of mouse ENCODE comparative gene expression data
<https://f1000research.com/articles/4-121/v1>

(11/12) Week 12: Supervised Learning 1: Classification
Reading: *Sequence and chromatin determinants of cell-type-specific transcription factor binding.* <https://genome.cshlp.org/content/22/9/1723.full>

(11/19) Week 13: Supervised Learning 2: Convolutional Neural Networks (CNNs).

Reading: *A primer on deep learning in genomics.*

<https://www.nature.com/articles/s41588-018-0295-5>.

(11/26) Week 14: Supervised Learning 3: Residual Neural Networks

Reading: Sequential regulatory activity prediction across chromosomes with convolutional neural networks (*Basenji*)

<https://genome.cshlp.org/content/28/5/739.full>

(12/3) Week 15: In-class workshop: coding and assignments

Statement for Observance of Religious Holidays:

The university's policy grants students excused absences from class to observe religious holidays (<http://orl.usc.edu/religiouslife/holydays/absences.html>). In this case, please contact your instructor in advance to agree on alternative course requirements.

Statement for Students with Disabilities:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to your instructor as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity:

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: <http://www.usc.edu/dept/publications/SCAMPUS/gov/>. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: <http://www.usc.edu/student-affairs/SJACS/>.

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are

equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Student Health Counseling Services - (213) 740-7711 – 24/7 on call
engemannshc.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call
engemannshc.usc.edu/rsvp

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086

equity.usc.edu, titleix.usc.edu

Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421

studentaffairs.usc.edu/bias-assessment-response-support

Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710

studentaffairs.usc.edu/sssa

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101

diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu

Non-emergency assistance or information.