INTEGBIO 134L – Practical Genomics (4 units)

To be offered every: **Fall**
Unit Value: **4**
Group: **A (Evolution and Genetics)**
Instructor: **Peter Sudmant & Becca Tarvin**
Office: **5002 VLSB / 3120 VLSB**
Course Fee: **$25 (starting in 2021)**
Email: psudmant@berkeley.edu, rdtarvin@berkeley.edu
2021 information: **In person, TTh 8-9:30am; lab F 9-12 or 3-6pm**
Instructional Format: **Lecture, Lab**
Ideal Course Schedule: Two lectures per week, 1.5 hours per lecture, 3-hour lab
Final Assessment: A written final exam and a final project
Target enrollment: 1 lecture section, 2 lab sections (30 students, 1 GSI each)
Classroom: lecture hall for computer lab for both lecture and lab
Prerequisites: Bio1A and Bio1B

Course description and aims
Genome sequencing and analyses have transformed biology over the past two decades. This course provides a hands-on introduction to the world of computational biology and bioinformatics. Students will apply state-of-the-art techniques to analyze genome and microbiome data from the UC Berkeley campus fox squirrels and local California ground squirrels each week. Students will master practical bioinformatics skills and then take on their own scientific research projects, all using genomic data collected specifically for this course. In addition to learning about methods and techniques, we will explore key advances in the field of genomics over the past two decades of both humans and non-model organisms that have driven the current revolution in genome sciences.

Assessment:
Lab Assignments: 25%
Midterm: 20%
Final Project: 35%

- Pre-proposal 5%
- peer review 5%
- final proposal 5%
- report 10%
- presentation 10%

Final Exam: 20%

Final Project: Students will perform a genomic analysis on data generated by the course or publicly available data. The final project consists of four graded components.

1. Each student with submit a project proposal which will be graded on the following components: background, hypothesis, methodological approach, and expected outcomes.
2. Students will each perform a peer review of three fellow student's proposals. Reviews consist of a short summary and suggested feedback.
3. Students will, either independently, or with a partner, carry out the proposed research project, with feedback both from peer review and instructors. Students will submit a final report consisting of the methods applied and the results including at least one figure and one table.
4. Students will present a 15-min final presentation and be graded on their communication of the motivation, approach, and results of their research project.

Tentative Course Schedule

08/26/2021	History of genomics and sequencing technologies (Sudmant, lecture)
LAB	Introduction to Jupyter notebooks, bash, and datatypes
08/31/2021	Genome Sequencing I
09/02/2021	Genome Sequencing II
LAB	Examining biological data using bash
09/07/2021	Genome Assembly I
09/09/2021	Pairwise Alignment
LAB	Mapping reads and pairwise alignment
09/14/2021	Genome Assembly II
09/16/2021	Sequence modeling, prediction, and annotation I
LAB	Genome annotation
09/21/2021	Sequence modeling, prediction, and annotation II
09/23/2021	Sequence modeling, prediction, and annotation III
LAB	Population genetics
09/28/2021	Genetic Diversity
09/30/2021	GWAS I
LAB	Working with RNAseq data / visualization
10/05/2021	GWAS II
10/07/2021	Midterm
LAB	No Lab
10/12/2021	Project Overview; Transcriptomics
10/14/2021	Metagenomics
LAB	Metagrnomics with dada2

10/19/2021	Phylogenetics I
10/21/2021	Scientific Collecting
LAB	Field collection & phylogenetics
10/26/2021	Phylogenetics II
10/28/2021	Non-model Genomics I
LAB	Project proposals due. Peer review of project proposal during lab
11/02/2021	Non-model Genomics II
11/04/2021	Non-model Genomics III
LAB	Students work with instructors to form teams and work on projects
11/09/2021	The future of genomics
11/11/2021	Veteran's Day (no class)
LAB	Student open-hours
11/16/2021	Open coding hour / Special topic
11/18/2021	Open coding hour / Special topic
LAB	Student open-hours
11/23/2021	Open coding hour / Special topic
11/25/2021	Thanksgiving
LAB	Thanksgiving
11/30/2021	Student presentations
12/02/2021	Student presentations
LAB	Student presentations
	Final Exam to take place during scheduled time (TBD)

Relevant Readings (although we will not be following these in class)

Brawand, D. *et al.* The evolution of gene expression levels in mammalian organs. *Nature* **478**, 343–348 (2011).

Consortium (IWGSC), T. I. W. G. S. et al. Shifting the limits in wheat research and breeding using a fully annotated reference genome. Science 361, eaar7191 (2018).

Hoff, K. J., Lange, S., Lomsadze, A., Borodovsky, M. & Stanke, M. BRAKER1: Unsupervised RNA-Seq-Based Genome Annotation with GeneMark-ET and AUGUSTUS. *Bioinformatics* **32**, 767–769 (2016).

International Human Genome Sequencing Consortium. Initial sequencing and analysis of the human genome. *Nature* **409**, 860 (2001).

Jain, M. *et al.* Nanopore sequencing and assembly of a human genome with ultra-long reads. *Nature Biotechnology* **36**, 338–345 (2018).

Kunte, K. *et al. doublesex* is a mimicry supergene. *Nature* **507**, 229–232 (2014).

Mudge, J. M. & Harrow, J. The state of play in higher eukaryote gene annotation. *Nature Reviews Genetics* **17**, 758–772 (2016).

Novembre, J. *et al.* Genes mirror geography within Europe. *Nature* **456**, 98–101 (2008).

Prum, R. O. et al. A comprehensive phylogeny of birds (Aves) using targeted next-generation DNA sequencing. Nature 526, 569 (2015).

Rogers, R. L. et al. Genomic takeover by transposable elements in the Strawberry Poison Frog. Mol Biol Evol 35, 2913–2927 (2018).

Rothschild, D. *et al.* Environment dominates over host genetics in shaping human gut microbiota. *Nature* **555**, 210–215 (2018).

Shendure, J. *et al.* DNA sequencing at 40: past, present and future. *Nature* **550**, 345–353 (2017).

Shulse, C. N. et al. High-throughput single-cell transcriptome profiling of plant cell types. Cell Rep. 27, 2241–2247 (2019).

Xue, Y. *et al.* Mountain gorilla genomes reveal the impact of long-term population decline and inbreeding. *Science* **348**, 242–245 (2015).