SB220 Syllabus for 2021/2022 Spring Term

Summary:
This course provides a framework for thinking quantitatively, logically, statistically, thermodynamically, and kinetically about biological processes and biological assays. Our goal is to enable students to conceive and execute graduate-level research projects in systems biology. The course opens with a critical analysis of past student qualifying exams and student proposals for their own. These discussions germinate two parallel tracks: (1) introducing basic ideas in chemical kinetics, thermodynamics, dynamical systems, and genetic analysis through a “canon” of examples of molecular systems biology; and (2) a practical introduction to problems in statistics and probability in biology and biological measurement.

The course will give students skills to design experiments and associated analyses, and it will test their ability to apply these skills to through problem sets, literature reviews, and a project proposal. The course is a core requirement for the SSQBio Graduate Program. Recognizing the diversity of students in our program, the principle of this course is that “foundations matter”: we will introduce challenges to quantitative thinking even in technically-accessible topics.

Key dates:

1/25/22 – Tuesday – First lecture

3/12-20/22 – Spring recess (1 week)

3/22/22 – Tuesday – lectures continue

4/26/22 – Tuesday – last lecture

4/27/22 – Wednesday –Spring terms ends

5/1/22 onwards: Student PQE1 exams

Class no.	Date	Instructor	Module	Topic	Related P-Set	TF Section	Reading
1	1/25	Klein Murray		Introduction, motivation			

2	1/27	Klein	PQE workshop	Estimation and the quantities that matter	PS0		
3	2/1	Murray	PQE workshop	Critical analysis of past PQE1 proposals			
4	2/3	Klein	PQE workshop	Critical analysis of past PQE1 proposals			
5	2/8	Klein Murray	PQE workshop	PQE1 proposal pitches			
6	2/10	Klein Murray	PQE workshop	PQE1 proposal pitches			
7	2/15	Murray	SysBio	Biology as computation			
8	2/17	Murray	SysBio	Steady state & Equilibria			
9	2/22	Klein	Probability and stats	Introduction; Prediction and inference; Binomial estimation as a motivation	PS1		
10	2/24	Klein	Probability and stats	Events, Law of total probability, conditional probability, Bayes' Theorem, parameter	PS2		

				estimation			
11	3/1	Klein	Probability and stats	Philosophy of measurement; Intro to statistics: concepts surrounding measurement error; metrics of assay performance; estimators; bias and error	PS3		
12	3/3	Klein	Probability and stats	Bootstrap procedures	PS3		[2] An Introduction to Statistical Learning, James, Witten, Hastie, Tibshirani. http://www-bcf.usc.edu/~gareth/ISL/ISLR%20Seventh%20Printing.pdf Chapters 1,2
13	3/8	Murray	SysBio	Lac Operon – Part 1			
14	3/10	Murray	SysBio	Lac Operon – Part 2			
				SPRING BREAK			

15	3/22	Murray	SysBio	Cell cycle – Part 1			
16	3/24	Murray	SysBio	Cell cycle – Part 2			
17	3/29	Klein	Probability and stats	The origin of key distributions seen in biology – Part 1: Binomial, Poisson statistics and shot noise; exponential distributions			
18	3/31	Klein	Probability and stats	The physical origin of key distributions seen in biology – Part 2: negative binomials; the Central Limit Theorem			
19	4/5	Murray	SysBio	Luria Delbruck			
20	4/7	Klein	Probability and stats	Hypothesis testing: type I and II errors; back-of-the-envelope T-tests; build-your-own non-parametric tests			
21	4/12	Klein	Probability	Multiple hypothesis	PS4		

			and stats	testing: the problem; error rates; Bonferroni and Benjamini-Hochberg corrections			
22	4/14	Klein	Probability and stats	Statistical learning	PS4		
23	4/19	Murray	SysBio	Cooperativity from a biochemical perspective	PS5		[2] An Introduction to Statistical Learning, James, Witten, Hastie, Tibshirani. http://www-bcf.usc.edu/~gareth/ISL/ISLR%20Seventh%20Printing.pdf Chapters 1,2
24	4/21	Klein and Murray	SysBio	Critical analysis of a research paper			
25	4/26	Klein	SysBio	Robustness as a design principle			