BISC 204: Biological Modeling (with Lab), Spring 2018

LEARNING OBJECTIVES

1. Translate narrative descriptions of biological processes into conceptual models.
2. Represent conceptual models with systems of mathematical equations.
3. Understand model parameters, variables, boundary conditions, equilibria and limits both conceptually and quantitatively.
4. Write computer code to simulate biological models and combine data with models.
5. Combine data and models to quantify uncertainty in processes and parameters.

COURSE ASSESSMENTS

Assessment	Due	Points
Problem Sets (50 pts each)	10am 20 Feb, 19 Mar, 30 Apr	3 PSs = 150 total
Pre-Labs (2 pts credit/non)	Wed 10pm before each lab	12 labs = 24 total
Lab Reports (40 points/lab)	Thu noon, 8 & 22 Feb, 8 Mar, 5 & 19 Apr	5 labs = 200 total
5-min Model Presentation	In-Class on 10 May	15 total
Final Lab Report	4pm on 22 May	100 total
Class Citizenship		10 total
		500 total

LABORATORY

Our weekly lab meetings will be used to apply the concepts that we develop during class to real examples across many sub-disciplines of biology. Attendance for lab is mandatory, and if you cannot attend lab due to a religious holiday, documented illness, or other reason, please let me know as early as possible, and/or communicate with your class dean and have them write me an email.

The main goal for our laboratory meetings is to practice the skills needed to develop, write, program, and interpret biological models from a broad range of sub-disciplines in biology with the R statistical computing language. I've selected many of the lab exercise examples to center broadly on the topic of disease, since this topic has common threads that highlights complex systems, bridges multiple biological scales, and emphasizes the societal importance of using and understanding mathematical models. To me, one of the most exciting things about this course is realizing that similar tools can be used to investigate a tremendously wide range of topics within biology (and outside biology too), and I hope that by the end of the course you find this exciting (and useful) as well.

Each lab exercise (except for Lab 1) will be spread across two weeks. There is a Pre-Lab exercise due before every lab meeting, which will help to prime your thinking and expose you to some content before the lab meeting. A Lab Report will be due one week after the end of each pair of Lab Exercises. The Lab Report will contain: 1) Written/graphical answers to a set of questions within the lab assignments, and 2) Self-standing R code that demonstrates how you arrived at your answers. Lab Report Guidelines will be distributed at the first lab meeting. You may work with other classmates on your Lab Reports but you must indicate people that you worked with on the Lab Report that you hand in, and ***your Lab Report (both the written answers and code) must be unique and in your own words***.

PROBLEM SETS

There will be three Problem Sets assigned during the semester. Each Problem Set will contain approximately 3-4 questions with multiple parts that require you to synthesize material covered in the course up to that point. Because topics within this course build upon one another, the Problem Sets will be cumulative with respect to content, although emphasis will be place on the material covered since the previous Problem Set. You may use your class notes, readings, and lab code and notes to help you to answer the questions. You may work in groups to answer the Problem Sets but you must indicate people that you worked with on the Problem Set that you hand in, and ***your answers to the Problem Sets must be unique and in your own words***.

FINAL LAB REPORT

The final assessment for this course is an extended format Lab Report (8 pages, maximum, including figures and tables) where you will develop, implement, and evaluate a model within a biological system of your own choice. The final Lab Report is an individual assignment (i.e., you may not work in groups on the same model), and during the last three weeks of lab we will work in peer groups in a workshop format where you will formally get feedback and can bounce ideas off of other classmates as you develop your project. You may use systems highlighted by our course reading that we did not deeply investigate in lab (and there will be many of these!), or you may choose another system that is of interest to you. There is no Final Exam for this course, and the Final Lab Report is due at 4pm on the last day of Finals Period, 22 May.

COURSE READINGS

Course reading is due before class on the day that it is listed. M refers to sections from the Modeling Life (2017) book, which is available as a PDF on the course website. Some of your Pre-Lab Assignments will use the R for Data Science Book by

Grolemund and Wickham, which is freely available online at: http://r4ds.had.co.nz/. Other readings listed on the Course Schedule are also available as PDFs on the course website in the 'Reading' folder.

COURSE SCHEDULE

	Day	Date	Topic	Reading/Due
UNIT 1 - DYNAMIC MODELING				
Biological systems can be described, written, and programmed as dynamic equations				
1	Mon	29-Jan	Intro: What is a model?	M1.1-1.3 (1-23)
2	Thu	1-Feb	Modeling Change	M1.4 (23-43)
L1	Thu	1-Feb	**R Intro: Newborn Sex Ratios**	**Lab 1 Pre-Lab**
3	Mon	5-Feb	Vector Fields & Trajectories	M1.5-1.6 (48-61)
4	Thu	8-Feb	Euler's Method	M1.7 (63-67)
L2a	Thu	8-Feb	**HIV Dynamics, Part 1**	**Lab 1 Report, Lab 2a Pre-Lab**
5	Mon	12-Feb	Derivatives & Integrals 1	M2.1-2.5 (69-112)
6	Thu	15-Feb	Equilibria, Part 1	M3.1-3.2 (115-133)
L2b	Thu	15-Feb	**HIV Dynamics, Part 2**	**Lab 2b Pre-Lab**
7	Tue	20-Feb	*No Class*	**Problem Set 1**
8	Thu	22-Feb	Method of Least-Squares	SM 6.1 (on Sakai)
L3a	Thu	22-Feb	**The 2014 Ebola Epidemic, Part 1**	**Lab 3a Pre-Lab, Lab 2 Report**
9	Mon	26-Feb	Optimization	M7.7 (414-422)
10	Thu	1-Mar	Equilibria, Part 2	M3.3-3.4 (133-148)
L3b	Thu	1-Mar	**The 2014 Ebola Epidemic, Part 2**	**Lab 3b Pre-Lab**
11	Mon	5-Mar	Basins of Attraction	M3.5 (148-156)
12	Thu	8-Mar	Bifurcations of equilibria	M3.6 (148-168)
L4a	Thu	8-Mar	**Population Dynamics, Part 1**	**Lab 4a Pre-Lab, Lab 3 Report**
13	Mon	12-Mar	Oscillation	M4.1-4.2 (171-195)
14	Thu	15-Mar	Bifurcation in Non-equilibrium Systems	M4.3 (197-204)
L4b	Thu	15-Mar	**Population Dynamics, Part 2**	**Lab 4b Pre-Lab**
15	Mon	19-Mar	Excitable Systems	M4.4 (206-222), **Problem Set 2**
			SPRING BREAK	
UNIT 2 - BUILDING, USING, AND INTERPRETING NOVEL MODELS				
Dynamic Models can be used to generate and test hypotheses and inform real-world decisions.				
16	Mon	2-Apr	Models and Hypotheses	
17	Thu	5-Apr	Vector-borne Disease	Magori & Drake (2013)
L5a	Thu	5-Apr	**Bubonic Plague, Part 1**	**Lab 5a Pre-Lab, Lab 4 Report**
18	Mon	9-Apr	Defining random samples	Gotelli & Eliison Ch 2
19	Thu	12-Apr	Sources of Model/Data Uncertainty	Dietze Ch 2.3
L5b	Thu	12-Apr	**Bubonic Plague, Part 2**	**Lab 5b Pre-Lab**
20	Thu	19-Apr	Novel Model Development	Otto & Day Ch 2
L6a	Thu	19-Apr	**Your Own Models, Part 1**	**Lab 6a Pre-Lab, Lab 5 Report**
21	Mon	23-Apr	Assessing Model Performance	Dietze Ch 16
22	Thu	26-Apr	Model Selection	Bolker Ch 1.3
L6b	Thu	26-Apr	**Your Own Models, Part 2**	**Lab 6b Pre-Lab**
23	Mon	30-Apr	Models & Decision Making, Part 1	**Problem Set 3**
24	Thu	3-May	Models & Decision Making, Part 2	Dietze Ch 17
L6c	Thu	3-May	**Your Own Models, Part 3**	**Lab 6c Pre-Lab**
25	Mon	7-May	Synthesis Discussion	
26	Thu	10-May	5-minute Model Presentations	
LX	Thu	10-May	**Swing Lab for Snow Days (no lab on last day if no labs are cancelled)**	
		22-May	**Final Lab Report due by 4pm**	