Course Title: Theoretical Biology and Models IB 496 JO (offered Fall 2015, alternate, odd-numbered years thereafter)
Instructor: James O'Dwyer
Class hours/week: Lecture-lab (2 hrs) twice per week (MW 2pm-3:50pm)
Office hours: Friday 3pm in 183 Morrill or by appointment

Course Description:
In seeking to understand how biological systems function and change over space and time, biologists are increasingly using mathematical and computer-based models to complement fieldwork and experimental data. These models not only provide a context in which to understand and answer existing questions, but can also lead us to new questions and new insights; the most exciting part of theoretical biology is when a model tells us something unexpected, outside of our intuition. In this class we will start from the basic idea of how to encode mechanism into a mathematical model, and we will develop the skills to find solutions to these models and relate them to biological data. We will focus on examples drawn from ecology and evolutionary biology, and along the way we will discuss primary literature designed to relate the lectures and labs to research questions in these fields.

Prerequisites:
Math 220 or 221

Textbook:
Otto & Day. 2007. A Biologist's Guide to Mathematical Modeling in Ecology and Evolution. Princeton University Press

Journal articles:
Readings from primary literature for discussion sections, and tutorials for computer labs, will all be made available online.

Grading:

Mid-term Exam	15 %
Final Exam	20 %
Problem sheets	20 %
Group project paper	15 %
Group project presentation	10 %
Discussion Participation	20 %

Expectations: My primary expectation is that students come into the class ready to learn some new skills and develop new perspectives. As part of this expectation, both attendance and punctuality are essential---for you as students and also for me as instructor. This commitment to participate and excel also extends to the weekly readings and discussion session, where students will be expected to prepare by reading and (most importantly) thinking about the assigned readings. If you have any questions along the way, please feel free to contact me by email or come over to my office hours.

All students should follow University of Illinois "Code of Policies and Regulations Applying to All Students." The Code is available online at: http://www.admin.uiuc.edu/policy/code/index.html

Class Format:
The first lecture-lab session each week will combine a short lecture presenting the principles and fundamental knowledge necessary to understand the topic, with hands-on training in simulation and data analysis, using the open source software "R" and "R Studio", and additional software as needed for specific topics or projects.

The second lecture-lab session each week will begin with a discussion session based on specific primary literature, chosen to bring out at a research level some of the issues covered in Monday's lecture. The second half of Wednesday sessions will continue the computer lab started on Monday, and towards the middle and end of the semester will incorporate group project work and presentations.

Computer Requirement
Students are required to have a laptop computer to complete in-class computational assignments in class. If a student cannot bring her/his laptop then he/she must pair up with someone who has a laptop for in-class assignments and discussion. Much of the work in this class will require computer access in and out of class.

Exams:
A midterm and final exam, in total worth 35% of the final grade, will be given on key concepts learned from lecture material. Students with a valid reason for missing an exam will be given an opportunity to take a make-up exam at the discretion of the instructor. Valid reasons include only medical reasons (with a note from McKinley), tragedy in your immediate family, or religious observances and practices.

Problem sheets:
Four problem sheets applying skills learned in the lectures will be given throughout the term, to be completed independently outside of class. The solutions to these problems are in total worth 20% of the final grade. Times and locations to submit problem solutions will be given during the lectures, and problems submitted late will be graded at the discretion of the instructor, with a maximum grade of 70%.

Group project:
Group projects will begin in week five. Students are encouraged to bring their own data, and should discuss the nature of their data with the instructor. Projects can also involve data provided by the instructor, or can be computational or theoretical in nature. Assessment will be in the form of an 8-10 page paper written independently by each participant, and a group presentation of around 15 minutes. In total, the paper and presentation are worth 25% of the final grade.

Discussion participation:
Readings will be provided online in advance of Wednesday's discussion session. Students grade will be determined in part by participation in online forum prior to each discussion session, with expectations and suggested topics of discussion specified for each reading, and in part from active participation in classroom discussion sessions. In total this participation is worth 20% of the final grade.

Weekly Schedule

Unit 1: Mechanisms into Models

Week	**Class Format**	**Topic**
1	Lecture	Introduction: The role of theory in science
	Lab	Downloading and installing software: R and R studio
2	Lecture	Mechanism: Growth
	Lab	Getting to grips with R
	Discussion	Are there general laws in biology?
	Lab	Getting to grips with R
3	Lecture	Mechanism: Competition I
	Lab	Logistic Equation and Chaos
	Discusssion	Complex behavior in Simple Ecological Models
	Lab	Logistic Equation and Chaos
4	Lecture	Mechanism: Competition II
	Lab	Competition equations and niche differences
	Discussion	Paradox of the Plankton
	Lab	Competition equations and niche differences
5	Lecture	Mechanism: Predator-prey
	Lab	Lotka-Volterra equations
	Discussion	Paradox of Enrichment
	Lab	Lotka-Volterra equations
6	Lecture	Mechanism: Selection
	Lab	Hardy-Weinberg
	Lecture-lab	**Midterm**

Unit 2: Stability and Complexity

Week	Class Format	Topic
7	Lecture	Equlibrium
	Lab	Analysis of stability
	Discussion	Bistability in algal systems
	Lab	Introduction to group project work
8	Lecture	Matrices and Linear Algebra
	Lab	Demography and age-structure
	Discussion	Loggerhead sea turtles and implications for conservation
	Lab	Group project work
9	Lecture	Large, complex communities
	Lab	Food webs
	Discussion	Are large complex systems unstable?
	Lab	Group project work
10	Lecture	Spatial Modeling I
	Lab	Dispersal
	Discussion	The importance of being spatial
	Lab	Group project work
11	Lecture	Spatial Modeling II
	Lab	Species Distribution Models
	Discussion	Species loss and global change
	Lab	Group project work

Unit 3: Stochasticity

Week	Class Format	Topic
12	Lecture	Probability theory Part 1
	Lab	Demographic Stochasticity
	Discussion	Island Biogeography
	Lab	Group Project Work
13	Lecture	Probability theory Part 2
	Lab	Environmental Stochasticity
	Discussion	Extinction risk
	Lab	Group project work
14	Lecture	Probability theory Part 3
	Lab	Coalescent models and phylogenetic trees
	Discussion	Phylogenetic Diversity
	Presentations	Group project presentations
15	Lecture	Overview and Review
	Lab	Overview Review
	Presentations	Group project Presentations
	Presentations	Group project Presentations