# BIOL 404-02/504-03: INTRODUCTION TO QUANTITATIVE BIOLOGY

M. Drew LaMar
Fall 2014
Millington 112
TR 9:30–10:50 am
Office hours: M 4–5 pm; R 11 am–12 pm
Office hour location: Millington 234

**Overview:** This course will be an overview of the mathematical tools used in quantitative analysis and modeling of biological systems. The goal is to develop quantitative reasoning skills through the use of mathematical modeling, data analysis, and computer simulation. This is a unique course in the biology curriculum by covering both organismal and cellular biology through the use of mathematical, statistical and computational approaches, and by focusing on the development of skills in model development, validation and refinement.

**Expectations**: You will attend 2 lectures each week. Homework will be given throughout and due each week. There will be 2 midterms worth 15% each. Participation, via in-class, Blackboard discussion, blog postings, and reading quizzes, will be part of your grade as well. You will start a project about mid-semester, which is explained in more detail below.

**Grading:**

- Homework: 30%
- Midterms: 30%
- Final: 20%
- Participation: 10%
- Project: 10%

**Homework**: Homework will be due each week on Monday at 11:59 pm on Blackboard. For each assignment, 70% of your grade will be on completion, with the other 30% based on correctly answering two questions from your homework on Blackboard. Two of your lowest homework grades will be dropped.

**Midterms**: Midterms are scheduled for the following dates: *Tuesday, September 30* and *Tuesday, November 11*. **No make-ups will be given.** To account for legitimate exam absences, the points from one missed exam will be folded into your final, which will then be worth 45% of your grade.

**Final**: Tuesday, December 9, 9 am – 12 pm. Location TBA.

**Participation**: Participation breakdown is as follows: 5% for weekly blog posts and 2 reviews/comments to other student's posts; 3% for short online Blackboard reading quizzes (due every Monday and Wednesday at 11:59 pm); 2% for in-class and Blackboard discussions.

**Project:** You will be expected to pick a modeling paper from the primary literature. Your goal will be to rediscover results from the paper via analysis or computer simulation, critique assumptions, and possibly extend/refine the model.

**Required texts:**

- “Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking,” by Harvey Motulsky
- “Complex Population Dynamics: A Theoretical/Empirical Synthesis,” by Peter Turchin
- “An Introduction to Systems Biology: Design Principles of Biological Circuits,” by Uri Alon

**Software:** Excel, R, and Netlogo

**Prerequisite:** BIOL 220, BIOL 225 and MATH 111/131

## Timeline

| Date | Topic | Readings for today |
|---|---|---|
| 08/28 (R) | Introductions and overview of course | None |
| 09/02 (T) | Statistics, probability, and sampling | Motulsky: Ch. 1-3 |
| 09/04 (R) | Introduction to confidence intervals | Motulsky: Ch. 4, 6 |
| 09/09 (T) | Types of random variables | Motulsky: Ch. 7-9 |
| 09/11 (R) | Gaussian distribution and averages | Motulsky: Ch. 10, 12 |
| 09/16 (T) | Theory of confidence intervals | Motulsky: Ch. 13, 14 |
| 09/18 (R) | P-values and hypothesis testing | Motulsky: Ch. 15-17 |
| 09/23 (T) | Interpretation of significance and power | Motulsky: Ch. 18-20 |
| 09/25 (R) | Key concepts and traps in statistics | Motulsky: Ch. 44-45 |
| 09/30 (T) | Exam #1 | None |
| 10/02 (R) | No class | Graur: Ch. 2: pp. 39-47 |
| 10/07 (T) | Population genetics: Selection & Drift | Graur: Ch. 2: pp. 47-53 |
| 10/09 (R) | Population genetics: Gene substitution | Graur: Ch. 2: pp. 53-64 |
| 10/14 (T) | Fall Break | None |
| 10/16 (R) | "Are There Laws of Genome Evolution?" | Koonin article |
| 10/21 (T) | Introduction to theoretical ecology | Turchin: Ch. 1 |
| 10/23 (R) | Exponential growth and self-limitation | Turchin: Ch. 2.1-2.3 |
| 10/28 (T) | Predator-prey cycles and process order | Turchin: Ch. 2.4, 2.5 (to end of p. 39), 2.6 |
| 10/30 (R) | Single-species: Model types and drivers | Turchin: Ch. 3.1, 3.2 |
| 11/04 (T) | Age- and stage-structured models | Turchin: Ch. 3.3, 3.5 |
| 11/06 (R) | Trophic Interaction: Functional responses | Turchin: Ch. 4.1, 4.2-4.2.1 |
| 11/11 (T) | Exam #2 | None |
| 11/13 (R) | Mathematical theory vs. Empirical dynamics | Turchin: Ch. 5 |
| 11/18 (T) | Introduction to Systems Biology | Alon: Ch. 1 |
| 11/20 (R) | Basics of transcription networks | Alon: Ch. 2 |
| 11/25 (T) | Autoregulation | Alon: Ch. 3 |
| 11/27 (R) | Thanksgiving | None |
| 12/02 (T) | Feed-forward loops | Alon: Ch. 4 |
| 12/04 (R) | Global structure of transcription networks | Alon: Ch. 5 |