Biology 311. Systems Biology:
An Introduction for the Quantitative Sciences
Spring 2017

Meeting times and locations

Lectures: Tue, Thu 3:05-4:20pm (FFSC 4233)

Instructors

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Synopsis

The aim of this course is to provide an introduction to the field of systems biology. Students will learn approaches that are used to integrate biological data with mathematical, statistical, and computational methods in order to gain new insights into the structure and behavior of complex cellular systems.

Prerequisites

There are no prerequisites but this course is intended for students with prior training in quantitative fields (computer science, math, physics, statistics, engineering). Some familiarity with mathematical concepts (e.g. differential equations) and computer programming is assumed.

Course website

See the Biology 311 Website at https://github.com/Bio311-class/Bio311-Spring2017/wiki.

Required Texts

[1] Benfey, P. 2014. Quickstart Molecular Biology. Cold Spring Harbor Laboratory Press, New York.

Primary literature

[1] Spellman, P.T., et. al. 1998. Comprehensive Identification of Cell Cycle-regulated Genes of the Yeast *Saccharomyces cerevisiae* by Microarray Hybridization. Mol Biol Cell, 9:3273-3297.

[2] Lee, T.I., et. al. 2002. Transcriptional Regulatory Networks in *Saccharomyces cerevisiae*. Science, 298:799-804.

[3] Orlando, D. A. et al. 2008. Global control of cell cycle transcription by coupled CDK and network oscillators. Nature, 453: 944-947.

[4] Shen-Orr, S.S., et. al., Network Motifs in the Transcriptional Regulation Network of *Escherichia coli*. Nature, 31:64-68.

Office hours

The course TA will set up regular office hours. Instructors are available *by appointment*. Please email, call, or meet with us after class to setup an appointment.

Grading

Reading Quizzes, 15%
Individual Homeworks, 40%
Group Homeworks 17.5%
Group Poster and Final Presentation, 25%
Group Participation, 2.5%

Format

The course is composed of lectures, computational "labs", and group based projects. A set of lectures reviewing key biological phenomena and systems biology concepts will start the semester. Each topic will be considered from the perspective of the molecular and cellular mechanisms involved, the dynamical behavior of the phenomena under consideration, and the measurement techniques that biologists use to quantify the phenomena.

Following the review of key biological concepts we will revisit many of these topics from a quantitative perspective, discussing mathematical and statistical methods used in their analysis, and developing computer simulations to explore the dynamical behavior of gene networks.

The latter half of the course will be project-based active learning. We will divide the class into groups of 3-4 students. Each group will work work with data from genome-wide gene expression and protein-DNA interaction experiments in order to develop models of transcriptional networks.

Learning objectives

1. Learn and understand questions and concepts important to the field of systems biology presented in the course.
2. Apply the methodology of the field in hands-on projects with data and networks for the purpose of solidifying understanding of systems biology concepts.
3. Become proficient in reading the relevant primary literature, connecting the key concepts to lecture content and hands-on projects.
4. Communicate your methods and findings to the scientific community (your peers, your instructors) in the form of a poster session. Understand and apply the importance of peer review in the form of peer evaluations.

Assignments

Reading quizzes During the first few weeks of class, short quizzes (10 multiple choice or T/F questions) on textbook readings will be taken at the beginning of class. We will then have a lecture on that reading assignment.

Reading assignments Readings assignment will be based on articles from the primary literature. These assignments will be composed of short-answer questions designed to help solidify concepts discussed in lecture.

Computational assignments Several class sessions will focus on developing computer simulations of gene networks, using the programming language R. Computational homework assignments will require you to extend these simulation models to explore new network types and behaviors.

Group projects The group projects will involve analysis of gene expression microarray and ChIP data sets, from studies on budding yeast or the salt-adapted archaeon *Halobacterium.* There will be several group homework assignments and preparation and presentation of a scientific poster.

Group homework The group homework will entail submission of intermediate drafts of figures and text for the final poster. These homework assignments are intended to keep the group on track for completion of the network analysis. One homework per group will be submitted.

Group participation During the latter portion of the course, which is focused on group projects, consistent attendance and participation of every group member is especially important. To encourage this we have allotted 2.5% of the total grade to a participation score. Each unexcused absences (see below) or late attendance (more than 10 minutes late) will result in a loss of 1/5 of the group participation grade (0.05% of the total grade). To register your presence in each class session, please sign the attendance sheet at the front of the classroom.

Expectations and policies

Students are expected to:

1. **Come to class on time.**
2. Submit homeworks, progress reports, and final papers by their due dates.
3. Meet with other members of their project group outside of class at least two hours per week.
4. Participate in oral presentations, both during their own group's presentations and by providing useful feedback to members of others groups.
5. Adhere to the Duke Community Standard (see "Academic Integrity" below). A zero tolerance policy is in effect: any assignments violating the Standard will receive a 0 grade.

Missed class time and late submissions

Students are expected to attend and participate in every class session. In the case of illness or extraordinary personal circumstance students should notify the instructors and their academic deans by means of a Short-Term Illness Notification Form (STINF), or in the case of long-term medical or personal circumstances students should request a letter from their academic dean. Homework assignments that are submitted late without a STINF or instructor approval will receive half credit if submitted within 48 hours of the due date, or zero credit thereafter. If you are frequently ill, and submit more than two STINFs we will ask you to provide a doctor's or dean's letter explaining the circumstances.

Students who will miss a class session due to religious observance should submit a Religious Observance Notification Form *no later than one week prior to the date of the holiday.*

Students who are members of a varsity athletic team, and who may be required to miss some class time, should provide the instructors with a copy of their spring semester travel schedule during the first week of classes. Students should also complete an online "Notification of Varsity Athletic Participation (NOVAP)" form *no later than one week prior to each absence.*

Students who are seniors, and will be travelling for interviews, should notify the instructors *at least one week in advance about missed class time.*

If you miss a quiz due to illness, religious observance, athletic participation, or any other approved reason *you must take a make-up quiz within 48 hours or a zero score will be assigned.*

Students with excused absences are still expected to complete and submit homework assignments on time.

Academic Integrity

All students are expected to adhere to, and have an obligation to act, in accordance with the Duke Community Standard. For more information about the community standard please refer to the documents available at: https://studentaffairs.duke.edu/conduct/about-us/duke-community-standard. Any violations of the community standard will be referred to the undergraduate judicial board.

Especially as it applies to written assignments and group posters, a strict adherence to the plagiarism policy described in the Community Standard will be observed. We have a zero tolerance policy. Any assignments suspected of plagiarism will receive a zero.

Detailed Syllabus, Spring 2017

Date	*Topic*
Jan 12	Introduction [Schmid, Magwene]
Jan 17	Proteins & Signal Transduction [Schmid] Reading assignment: Ch. 5
Jan 19	Transcription and gene regulation [Schmid] Reading assignment: Ch. 3 Quiz 1: Proteins & Signals
Jan 24	Cellular networks [Schmid] Reading assignment: Ch. 4, 6, 7 Quiz 2: Transcription
Jan 26	Modeling small network motifs [Magwene] Quiz 3: Cellular networks
Jan 31	Genomics & transcriptomics [Schmid] Reading assignment: Ch. 2
Feb 2	Protein-DNA interactions [Schmid] Quiz 4: Genomics & transcriptomics
Feb 7	Introduction to R [Magwene] Quiz 5: Protein-DNA interactions
Feb 9	Practicing your R skills [Schmid, Ding] Individual HW 1 Due: Network motif models
Feb 16	Visualizing large scale data [Magwene]
Feb 21	Hierarchical clustering [Magwene]
Feb 23	Gene ontology [Magwene]
Feb 28	In class HW & clustering/visualization practice [Schmid, Ding]
Mar 2	How to read a scientific paper [Schmid] Individual HW 2 Due: Clustering
Mar 7	Discussion of Spellman paper [Schmid] Reading assignment: Spellman et al. 1998
Mar 9	Discussion of Lee paper [Schmid] Reading assignment: Lee et al. 2002
Mar 11-19	SPRING BREAK
Mar 21	Introduction to group projects [Schmid]
Mar 23	Group work Individual HW 3 Due: Questions on Spellman and Lee papers
Mar 28	Group work
Mar 30	Group work Group clustering HW due
Apr 4	Group work
Apr 6	Group work
Apr 11	Group work Group TF network HW due
Apr 13	Group work

Apr 18	Group work Group Literature Synthesis HW due
Apr 21	Draft posters due by 5pm on Fri, Apr 21
Apr 25	Group Poster Feedback Session
Apr 27-Apr 30	*Undergraduate Reading Period*
May 1	Final Poster File Due By 10am, May 1
May 4	POSTER PRESENTATIONS DURING FINAL EXAM TIME SLOT 9AM-12PM