Biological Complexity

For Quantitatively-oriented Biologists

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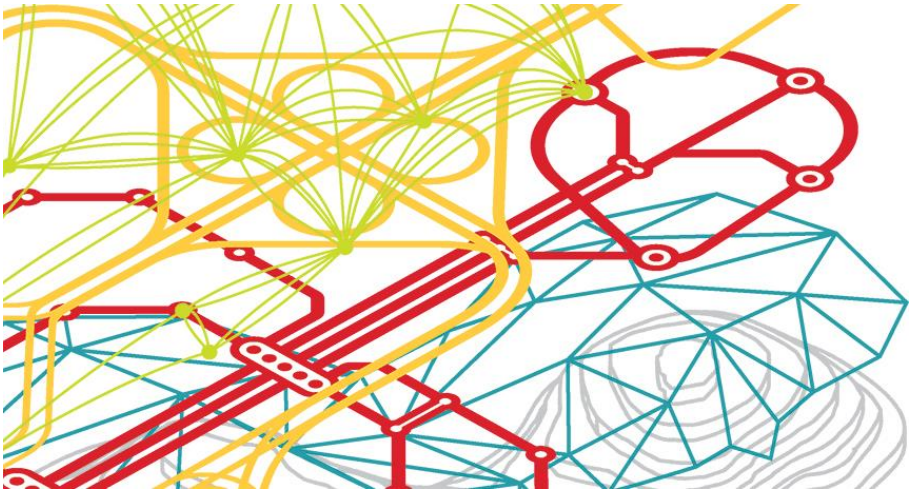

From "Big biological datasets map life's networks". Science News.

Description and Goals:

This course is intended for quantitatively-inclined Biology students, and presents a tour of biological complexity as three distinct topical areas: Genes and Systems I, Genes and Systems II, and Organismal Self-organization. This course is designed to be a broad survey of major theoretical and empirical concepts, exemplified by various statistical and computational models in the field (e.g. Phylogenetic Trees, AVIDA-Ed). The reading list will be available as a collection of books and articles available either online or at the University Library.

These materials are presented in a manner fundamentally different from other biological classes. The reason for this is to challenge any potential preconceptions about biological systems and quantitative modeling. There is also an emphasis on methodology, which we approach through integration into a broader set of themes. Students are evaluated through their completion of two Homework assignments, a set of exercises using a digital evolution tool, and various opportunities for class participation.

Grading: the grading criterion will be as follows.

Activity	Share of Final Grade
Homework 1	20%
Homework 2	20%
AVIDA-ED Project	45%
Participation	15%

The course grade will be based on a) two homework assignments, 2) a term project (exploring evolution with AVIDA-ED), and 3) course participation.

Schedule

Introduction: Week 1

Section #1: Genes and Systems.

Week	Topic
2	Genes and Gene Action
3	Epistasis and Expression
4	Evolution: observational methods
5	Evolution: theory
6	Landscapes and Neutral Networks

Demo of AVIDA-ED (avida-ed.msu.edu).
Artificial life and simulated evolution. AVIDA-ED related term project due on final day of class.

Section #2: Cells, Organs, and Organismal Self-organization I.

Week	Topic
7	Simple Models of Regulation
8	Genetic Regulatory Networks
9	Multi-scale Processes (Cellular Differentiation)
10	Statistical Physics Models and Game Theory
11	Complex Traits

Homework 1: Phylogenetics and Tree-building

Objectives for HW1: understand the context in which a tree is an appropriate way to think about evolution, build a phylogenetic tree, become familiar with some of their features, become acquainted with several famous applications of phylogeny.

Section #3: Cells, Organs, and Organismal Self-organization II.

Week	Topic
12	Life as Levels of Organization
13	Physiomics (-omics beyond the gene)
14	Modularity and Development
15	Epigenetic Landscapes
16	Phenotype-building

Homework 2: Population Genetics

Objectives for HW2: understand the basic logic and linear algebra of a single locus, two-allele model of Hardy-Weinberg equilibrium, understand the effects of gene action on a phenotype, extrapolate this model to a two locus, two-allele situation (e.g. the *Agouti* mouse phenotype).

Final project: Laboratory evolution using AVIDA-ED

Objectives for final project: Each student will complete the AVIDA-ED lab book (https://avida-ed.msu.edu/files/curricula/Avida-EDLabBookFall2016.pdf), and provide a write-up of all methods and results in a digital laboratory notebook.

The student will also choose one exercise from the AVIDA-ED curriculum webpage (https://avida-ed.msu.edu/curriculum/), and provide a write-up of all methods and results in a digital laboratory notebook.