BE777, Computational Genomics, Syllabus (Fall 2011)

Instructors: Yu (Brandon) Xia, Daniel Segrè

Course type: Lecture
Time: MW 10:00-12:00
First session: 2011-09-07, 10:00 am
Location: SOC B63, Sociology Bldg., 96-100 Cummington St.

Course Description: This course covers selected topics in computational genomics, and is divided into two parts. In the first part, Prof. Yu (Brandon) Xia will discuss molecular and genome evolution, and advanced algorithms in computational genomics. In the second part, Prof. Daniel Segrè will discuss system-level modeling of transcriptional and metabolic networks.

Office Hours: By appointment.

Grading: Homework assignments: 60%; Exams: 40%

TENTATIVE SCHEDULE

PART 1: Evolutionary Genomics (Brandon Xia)
Useful Text (not required): Wen-Hsiung Li, Molecular Evolution
1. Intro to molecular evolution; dynamics of genes in populations (Sep 7)
2. Evolutionary change in nucleotide sequences (Sep 12)
3. Estimating the number of nucleotide substitutions (Sep 19)
4. Rates and patterns of nucleotide substitution; sequence alignment (Sep 21)
5. Molecular clocks; molecular phylogenetics; DNA polymorphism (Sep 26)
6. Evolution by gene duplication; genome organization and evolution (Sep 28)

PART 2: Selected Algorithms in Computational Genomics (Brandon Xia)
Useful Text (not required): Richard Durbin et al, Biological sequence analysis
1. Parsing sequence data: Hidden Markov models, conditional random fields (Sep 28)
2. Microarray data analysis: statistics, clustering, dimensionality reduction (Oct 3)
3. Sequence motif discovery: Expectation Maximization, Gibbs sampling (Oct 5)
4. Data integration: supervised machine learning methods (Oct 12)
5. Modeling networks: Bayesian networks, Markov random fields (Oct 17)

Exam on Parts 1 and 2 (Oct 24)

PART 3: Systems Biology of Transcriptional Networks (Daniel Segrè)
Recommended Text (not required): Uri Alon, An introduction to Systems Biology
1. Systems biology of transcriptional regulation (Oct 26)
2. Evolution of regulatory networks and the emergence of network motifs (Oct 31)
3. Coherent feed forward loops (Nov 2)
4. Incoherent feed forward loops (Nov 7)
5. Other network motifs; Convergent evolution of network motifs (Nov 9)
6. Natural selection of gene circuits; benefit-cost analysis; optimal design (Nov 14)
7. Network motifs in developmental, signal transduction and neuronal nets (Nov 16)

PART 4: Systems Biology of Metabolic Networks (Daniel Segrè)
Useful Texts (not required): Heinrich and Schuster, The Regulation of Cellular Systems; Stephanopoulos, Aristidou, Nielsen, Metabolic Engineering; Bernhard O. Palsson, Systems Biology, Properties of Reconstructed Networks.

1. The logic of metabolism, major pathways and measurement of metabolic fluxes (Nov 21)
2. Kinetic modeling of metabolic networks (Nov 28)
3. Intro to constrained-based genome-scale models of metabolism: flux balance analysis (Nov 30)
4. Applications of flux balance analysis: gene deletions and epistasis (Dec 5)
5. From system-level to ecosystem-level metabolism (Dec 7)

Exam on Parts 3 and 4 (Dec 12)