BIOL 6V95 Special Topics in Molecular & Cell Biology: Molecular Evolution

TR 11:30am-12:45pm

Instructor Dr. Faruck Morcos — Office BSB 12.601
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Department of Biological Sciences
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Pre-requisites

Biochemistry I, Classical and Molecular Genetics or Professor approval.

Course Description

This course describes principles and models of evolutionary theory at the molecular level. It focuses primarily on the evolution of nucleotide sequences including genes, pseudogenes and genomes as well as amino acid sequences used to study the evolution of proteins, protein complexes and interactions. Phylogenetics and current leading quantitative models of sequence evolution are discussed in detail. Recent methods on amino acid evolution and its implication to molecular structure and function are also studied. Relevant examples of molecular evolution presented in this course include protein interactions, signaling networks and viral evolution.

Outcomes

Students will be able to:

1. Explain in detail the main principles of molecular evolutionary theory, specifically devoted to the study of nucleotide and amino acid sequences and apply those principles to discern how evolutionary trees are constructed.

2. Dissect and recognize the primary models of sequence substitution using quantitative concepts from probability and concepts from evolutionary theory. The student should be able to use these models to infer phylogenies or ancestral sequences.

3. Describe the fundamentals of protein evolution and to distinguish the difference between various models of residue evolution and their particular applications. The student should be able to use these models and apply them to known families of proteins and macro complexes and distinguish structural and functional properties provided by evolutionary information.

4. Apply the concepts and models of molecular evolution to subareas of study like signaling networks or viral evolution. The student should be able to extrapolate this knowledge into new systems of interest that might not have been studied before.

5. Students will be able to connect the most recent models of evolution at the nucleotide and amino acid level to an ongoing question in biological sciences. They will get experience doing bibliographic research of advanced topics and will get experience generating research proposals alike to the ones done in current research laboratories.

Textbook

- Graur and Li. *Fundamentals of Molecular Evolution.* Sinauer Associates Inc. 2015 (**required**)

- Neil Shubin. Your Inner Fish: A Journey into the 3.5-Billion-Year History of the Human Body. Vintage, 2009 (reference)

Class Schedule

Jan 9: Tue	Introduction & Historic perspective on Molecular Evolution
Jan 11: Th	Evolutionary Theory
Jan 16: Tue	Evolutionary Theory (cont.)
Jan 18: Th	Modern molecular clock
Jan 23: Tue	Extended Evolutionary Synthesis
Jan 25: Th	Population Genetics
Jan 30: Tue	Origins of life: RNA world
Feb 1: Th	Evolutionary change in nucleotide sequences
Feb 6: Tue	Models of amino acid and nucleotide substitution
Feb 8: Th	Models of amino acid and nucleotide substitution (cont.)
Feb 13: Tue	Distance and similarity metrics for sequences
Feb 15: Th	Molecular Phylogenetics
Feb 20: Tue	**Midterm 1**
Feb 22: Th	Inference of Trees and ancestral sequences
Feb 27: Tue	Gene duplication and concerted evolution
Mar 1: Th	Biophysics of Protein Evolution
Mar 6: Tue	Mutations and Protein Stability
Mar 8: Th	Molecular evolution of protein interactions
Mar 13-15	SPRING BREAK
Mar 20 : Tue	Amino acid coevolution
Mar 22: Th	Methods to study amino acid coevolution
Mar 27: Tue	Sequence evolution and protein contact inference
Mar 29: Th	Residue coevolution and protein structure
Apr 3: Tue	Coevolutionary Protein Dynamics
Apr 5: Th	**Midterm 2**
Apr 10: Tue	Evolution of protein interfaces
Apr 12: Th	Modeling protein complexes and macro molecules
Apr 17: Tue	Specificity in Signaling Networks
Apr 19: Th	Coevolutionary landscapes of functional interactions
Apr 24: Tue	Viral Evolution and immune system
Apr 26: Th	Review and concluding remarks
Final Exam	**Date:** TBD **Time:** TBD , **Place:** TBD

Course Policies

Grading

The grade is composed by a weighted average of the grades in midterm exams (20 % each), a final exam (30 %), homework assignments (15 %). Students work on an final research project worth 15 % of the grade.

Homeworks

The class will include problem sets that can be solved in groups of 1-3 students. Each student must hand in the solutions written **individually**. Working in groups to discuss and solve the solutions is not only accepted but *encouraged*. Solving problems in groups is shown to be beneficial for learning and promotes rational discussions and disseminates information faster. Groups larger than 3 are not accepted because they diminish the group's capacity to interact and solve the problems jointly. Groups composition is flexible, however, changes must be reported at least 5 days prior to the problem set deadline.

Final Project

The research project involves applying the concepts learned in class to develop a proposal to investigate a novel question in molecular evolution. Students have to turn in a report that has to include a bibliographic survey, problem description and preliminary results. More details about the final project are specified in a separate document.

Academic Honesty

Students are expected to follow the rules and guidelines of academic honesty established by the University of Texas. Be honest about your contributions to homeworks, work on your own during exams and spend enough time reading and understanding class materials. This creed was voted on by the UT Dallas student body in 2014. It is a standard that Comets choose to live by and encourage others to do the same:

"As a Comet, I pledge honesty, integrity, and service in all that I do"

Note: The descriptions and timelines contained in this syllabus are subject to change at the discretion of the Professor.