Molecular Evolution (BIOL 375.00/790.64/793.03, Fall 2021)
Instructor: Dr Weigang Qiu, Professor, Department of Biological Sciences
Course Format: In-person
Room: Hunter West 509
CUNY COVID Policy: fully & properly masked; 6-foot distancing if not fully vaccinated
Class Hours: Mon. & Thur 4:10-5:25 pm
Office Hours: Format & date/hours to be announced
Email: wqiu@hunter.cuny.edu

Course Description:
Molecular evolution is the study of the change of DNA and protein sequences through time. Theories and techniques of molecular evolution are widely used in species classification, biodiversity, comparative genomics, and molecular epidemiology. Contents of the course include:

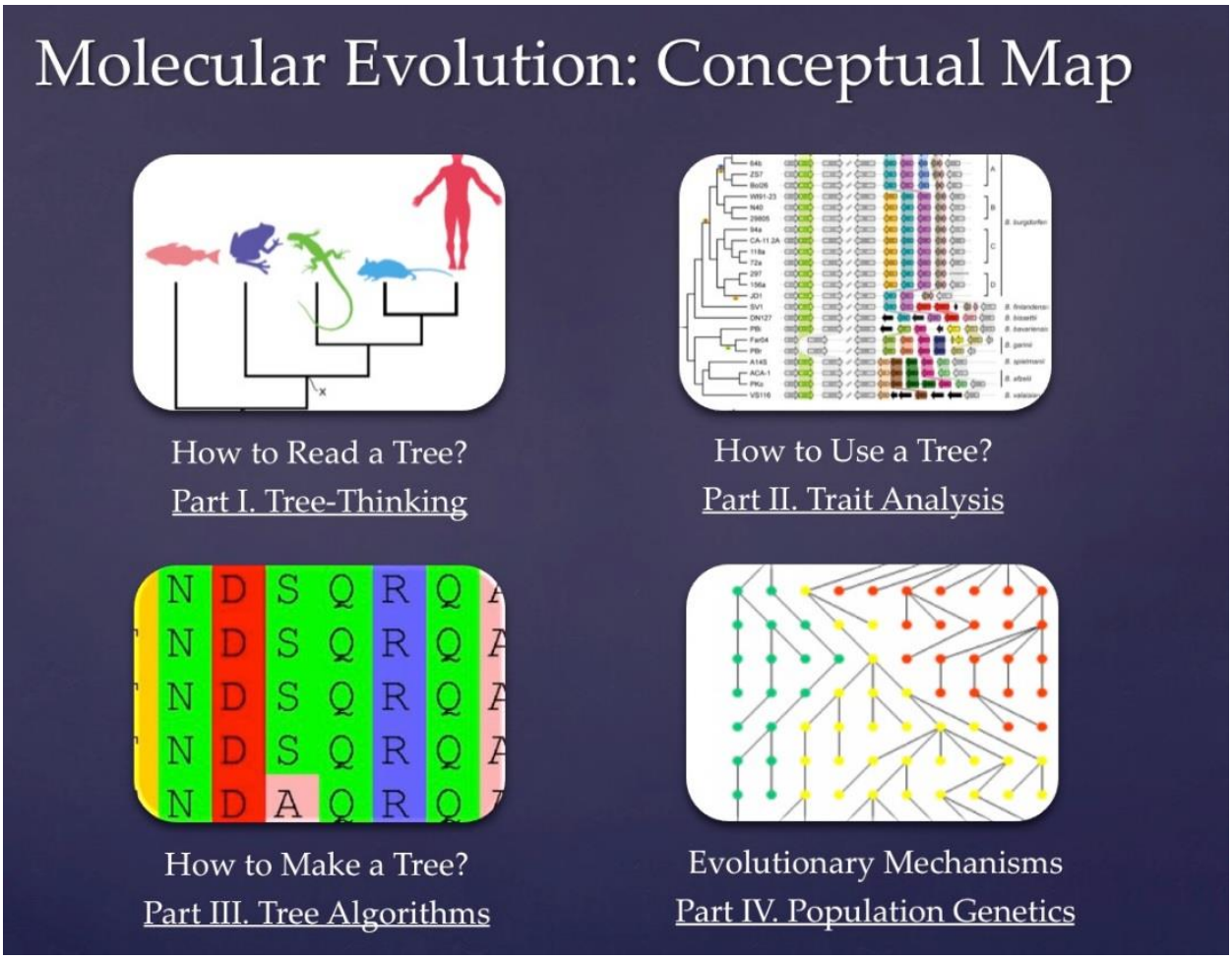
- Population genetics, which is a theoretical framework for understanding mechanisms of sequence evolution through mutation, recombination, gene duplication, genetic drift, and natural selection.
- Molecular systematics, which introduces statistical models of sequence evolution and methods for reconstructing species phylogeny.
- Bioinformatics, which provides hands-on training on data acquisition and the use of software tools for phylogenetic analyses.

This 3-credit course is designed for upper-level biology-major undergraduates. Hunter pre-requisites are BIOL203, and MATH150 or STAT113.

Instructor reserves the right to make changes to the syllabus as needed.

Learning Goals

- Be able to describe evolutionary relationships using phylogenetic trees
- Be able to use web-based as well as stand-alone software to infer phylogenetic trees
- Understand mechanisms of DNA sequence evolution
- Understand algorithms for building phylogenetic trees



Textbook and Resources:

- (**Required**) Graur, 2016, Molecular and Genome Evolution, First Edition, Sinauer Associates, Inc. ISBN: 978-1-60535-469-9. Publisher's Website (Student discount: a 15% discount and receive free UPS standard shipping). A reference copy of the textbook is available in Hunter Library

- (***Recommended***) Baum & Smith, 2013. Tree Thinking: an Introduction to Phylogenetic Biology, Roberts & Company Publishers, Inc.
- NCBI sequence databases
- R/RStudio Tools
    - R source: download & install from a mirror site
    - R Studio: download & install
    - APE package
- A Molecular Phylogeny Web Server

Grading Methods & Scales

- In-class exercises & assignments — 90 pts
- Three mid-term exams — 30 x 3 = 90 pts
- Comprehensive final exam — 50 pts
- Attendance & participation — 20 pts

NO LATE ASSIGNMENTS WILL BE ACCEPTED. All assignments will be submitted via Blackboard, which will close at midnight (11:59 PM EST) for each due date unless otherwise noted.

A+ A A-	97.5 – 100 92.5 – 97.4 90.0 – 92.4	B+ B B-	87.5 – 89.9 82.5 – 87.4 80.0 – 82.4	C+ C D	77.5 – 79.9 70.0 – 77.4 60.0 – 69.9	F	0.0 – 59.9

Course Calendar & Content

Conceptual Map	**Date**	**Topic**	**Reading & Slides**	**In-Class Exercises & Assignments**
Part 1. Tree-Thinking	Aug 26 (Thursday)	Introduction: What is Evolution?		Assignment 1 (10 pts; Due Aug 31)
	Aug 30 (Monday)	Tree vocabulary	Graur (2016). Introduction (pgs 1-3)	In-Class Exercise 1 (10 pts)
	Sept 2 (Thursday)	Species relatedness	Graur (2016). Chapter 5. Molecular Phylogenetics (pgs 170-175; 201-202)	Assignment 2 (20 pts; Due Sept 10)
	Sept 9 (Thursday)	Root & unrooted trees		In-Class Exercise 2 (10 pts)
	Sept 13 (Monday)	Tree distances & tree pruning	Chapter 5. Molecular Phylogenetics (pgs 177-180)	In-Class Exercise 3 (10 pts)
	Sept 20 (Monday)	Gene tree vs Species tree (gene orthology & branch collapsing)	Chapter 5. Molecular Phylogenetics (pgs 199-200)	In-Class Exercise 4 (20 pts)
	Sept 23 (Thursday)	Review session: • Tree vocabulary • Determine species relatedness • Calculate tree distances • Make rooted tree • Prune leave nodes • Gene orthology/paralogy • Branch support & branch collapsing	• 2 slide presentations • 2 assignments • 4 in-class exercises	
	Sept 27 (Monday)	**Mid-term Exam I (30 pts)**		
Part 2. Analysis of Trait Evolution	Sept 30 (Thursday)	Character, character states, and character-state matrix	Textbook Chapter 5, (pgs 180-183)	In-Class Exercise #5 (10 pts)
	Oct 4 (Monday)	Homoplasy & Consistency	Lecture slides posted (Part 2)	Exercise #5 (due 8pm)
	Oct 7 (Thursday)	Parsimony analysis (1)	Textbook Chapter 5, pages 188-191	Exercise #6. Lizard card & phylogeny

	Oct 14 (Thursday)	Parsimony analysis (2)		Exercise #7. Post-order traversal
	Oct 18 (Monday)	Genome & gene structure		Exercise #8. Tree Quiz #2
	Oct 21 (Thursday)	Review: • Character, character states, and character-state matrix: data types • Ancestral and derived states • Homoplasy (3 types) and consistency index • Forward inference: start from root • Backward inference: Ancestral-state reconstruction using post-order traversal • Case studies/Applications: Anoles, DNA alignments, morphology, geographic origins, forensics	• Lecture slides for Part 2 • 4 exercises (#5-8) • Review slides for Part	
	Oct 25 (Monday)	**Mid-term Exam 2 (30 pts)**		
Part 3. Tree Algorithms	Oct 28 (Thursday)	No class		
	Nov 1 (Monday)	Overview & parsimony method	Chapter 5, pages 191-194	
	Nov 4 (Thursday)	Alignment & genetic distances	Chapter 3. (pages 93-100).	Exercise #9. Parsimony method
	Nov 8 (Monday)	Models of sequence evolution Distance method	Chapter 3, (pages 79-88); Chapter 5, pages 184-187	Exercise #10. Parsimony tree (spike protein)
	Nov 11 (Thursday)	Distance method (continued)		Exercise #11. Alignment scores and sequence distances
	Nov 15 (Monday)	Tree testing	Chapter 5, pages 194-198	Exercise #12. Distance tree
	Nov 18 (Thursday)	Tree testing		
	Nov 22 (Monday)	Review: • Choice of phylogenetic markers (mtDNA vs 16S rRNA, protein vs DNA; ortholog vs paralogs) • Workflow of phylogenetic tree: BLAST; multiple alignement; phylogenetic reconstruction; bootstrap	Chapter 5, pages 207-209	Exercise #13. Tree testing

		• Alignment score & BLAST e-value • Methods for phylogenetic reconstruction: optimality search (e.g., maximum parsimony) versus distance methods (UPGMA & neighbor-joining) • Genetic distance, Jukes-Cantor correction, tradeoff between model accuracy & model complexity (ie., number of paramters in a model) • Tree testing (accuracy vs precision); bootstrap support		
	Nov 29 (Monday)	**Mid-term Exam 3 (30 pts)**		
Part 4. Population Genetics	Dec 2 (Thursday)	Gene structure & KaKs analysis		Exercise #14. Eukaryotic gene structure
	Dec 6 (Monday)	Evolutionary rates; SNPs and allele frequencies		
	Dec 9 (Thursday)	Genetic drift		Exercise #15.

	Dec 13 (Monday)	• Comprehensive Review
		• **Submit your Teacher's Evaluation**, using either:
		  ○ Personal computer at www.hunter.cuny.edu/te
		  ○ Smartphone at www.hunter.cuny.edu/mobilete		

	To be determined	**Comprehensive Final Exam (50 pts)** **3PM-5PM**		

Hunter Policies

CUNY COVID Policy

Fall 2021 Safety Guidance

Getting the COVID-19 vaccine is the single most important step you can take to end this pandemic for good. CUNY's vaccination policy requires all students taking in-person and hybrid classes to get vaccinated and upload proof of vaccination in CUNYfirst.

Hunter College Policy on Academic Integrity

"Hunter College regards acts of academic dishonesty (e.g., plagiarism, cheating on examinations, obtaining unfair advantage, and falsification of records and official documents) as serious offenses against the values of intellectual honesty. The College is committed to enforcing the CUNY Policy on Academic Integrity and will

pursue cases of academic dishonesty according to the Hunter College Academic Integrity Procedures."

Do not share your answers with anyone else. Do not copy from any other's answers.

You are expected to complete all quizzes, assignments, exercises, and exams by yourself. Discussion with peers is however allowed, with the exception of exams. In all submitted course work, exactly replicated answers will be investigated as possible cases of plagiarism. If plagiarism is suspected, the instructor will assign zero point or demand re-testing. If you choose the re-testing option, please be aware that the re-testing will be implemented with a strict time limit to ensure academic integrity. Further, questions on the makeup tests will differ from those in the original examand may possibly be more challenging.

ADA Policy

"In compliance with the American Disability Act of 1990 (ADA) and with Section 504 of the Rehabilitation Act of 1973, Hunter College is committed to ensuring educational parity and accommodations for all students with documented disabilities and/or medical conditions. It is recommended that all students with documented disabilities (Emotional, Medical, Physical, and/or Learning) consult the Office of AccessABILITY, located in Room E1214B, to secure necessary academic accommodations. For further information and assistance, please call: (212) 772-4857 or (212) 650-3230."

Hunter College Policy on Sexual Misconduct

"In compliance with the CUNY Policy on Sexual Misconduct, Hunter College reaffirms the prohibition of any sexual misconduct, which includes sexual violence, sexual harassment, and gender-based harassment retaliation against students, employees, or visitors, as well as certain intimate relationships. Students who have experienced any form of sexual violence on or off campus (including CUNY-sponsored trips and events) are entitled to the rights outlined in the Bill of Rights for Hunter College.

1. Sexual Violence: Students are strongly encouraged to immediately report the incident by calling 911, contacting NYPD Special Victims Division Hotline (646-610-7272) or their local police precinct, or contacting the College's Public Safety Office (212-772-4444).
2. All Other Forms of Sexual Misconduct: Students are also encouraged to contact the College's Title IX Campus Coordinator, Dean John Rose (jtrose@hunter.cuny.edu or 212-650-3262) or Colleen Barry (colleen.barry@hunter.cuny.edu or 212-772-4534) and seek complimentary services through the Counseling and Wellness Services Office, Hunter East 1123.

CUNY Policy on Sexual Misconduct Link