BIOL 4225A/7111A SPECIAL TOPICS: MOLECULAR EVOLUTION
Tues/Thurs 9:35am-10:55am Cherry Emerson 204

Instructor: Soojin Yi (soojin.yi@biology.gatech.edu),

Office Hours: Wednesdays 1-2 (this time is subject to change). If it doesn't work with you, I encourage you to make appointment to see me.

Grading Scheme:	**UG**	**G**
Class Participation	20%	10%
Paper Critiques	20%	20%
Presentation (25~30 minutes + 10 min discussion)	30%	30%
Final Project (Presentation + Paper)	30%	40%

Supplementary Texts (not required):
Main text: *Fundamentals of Molecular Evolution* by Dan Graur, Wen-Hsiung Li. Sinauer Associates, ISBN: 0878932666

- *Molecular Evolution and Phylogenetics* by Nei, M. & Kumar, S. Oxford Univ. Press. ISBN: 0195135849
- *Molecular Evolution* by Wen-Hsiung Li. Sinauer Associates, ISBN: 0878934634
- *Population Genetics: A Concise Guide* by John Gilespie. Johns Hopkins University Press. ISBN: 0801857554

These books are on reserve in the library.

Class Participation and Attendance: Class participation is critical. Attendance will be periodically checked and will be counted towards your grades.

Paper Critiques: Papers to be discussed in the class in some classes should be read by all students. To encourage reading, everyone should submit a one-page paper critique of the assigned papers before the class. The critiques will be scored as 1, 0.5 or 0. If your critique clearly demonstrates that you have read the paper, you will get a 1. Missing critique will be scored as zeros. A score of 12 will be counted as a full credit.

Presentation: A list of papers for presentation is provided below. Students can choose one paper and present it for 25~30 minutes during some classes. The presenter is also expected to lead a short (~10 minutes) discussion.

Group Projects: For graduate students, 3-student group projects are required. Each group is to pick one topic and write a critical review/synthesis paper. The paper should be written in a format for *Trends in Ecology and Evolution* review articles, citing at least 15 papers. The majority of these papers should be critically read and discussed by the members of the group. The review/synthesis article should contain detailed information on the contribution of each member of the group. The first thing to do is to form a group, then pick a topic. The topic has to be picked, in consultation with the instructor, as a group by March 17 (before the spring break). Each group will present their work in a class (either April 19, 21, and 26).

It is expected that most group members will receive similar scores for the group paper, but in certain circumstances, determined by the contribution list, members will be differentially scored. Undergraduate students are also expected to read several papers and meet the instructor for discussion. I will organize these sessions with each of you.

Syllabus (Subject to Change)

Jan. 18. Introduction to the History of Molecular Evolution. Chapter 3
What is molecular evolution?
Models of Nucleotide Substitution I.
Why do we need 'models of nucleotide substitution'?
One-parameter method
Two-parameter method

Jan. 20. Models of Nucleotide Substitution Continued Chapter 3
Rates and Patterns of Nucleotide Substitution. Chapter 4
Other more sophisticated methods of multiple hit corrections
Examples of Neutral rate variation between species
Male-driven evolution
Hominoid-rate slowdown

Jan. 25. Models of Nucleotide Substitution Continued. Chapter 3
Rates and Patterns of Nucleotide Substitution. Chapter 4
What if data are from protein-coding sequences?
Ka and Ks, dN and dS
Problems in current models and methods

Jan. 27 Student Presentations/Discussions 1, 2: Examples of Neutral Evolutionary Rate Variation

- Makova, K.D., and Li, W.-H. 2002. Strong male-driven evolution of DNA sequences in humans and apes. *Nature 416,* 624-626.

- Elango, N., Thomas, J. W., Program, N. C. S., Yi, S. 2006. Variable molecular clocks in hominoids. *Proc. Nat. Acad. Sci. USA 103*, 1370-1375

Feb. 1. Rates and Patterns of Nucleotide Substitution Continued.
Variation in Protein-Coding Regions and Other Selected Regions
Purifying Selection versus Positive Selection
When genes evolve slow and fast
Usage of statistical methods in understanding molecular evolutionary studies

Feb. 3 Student Presentations/Discussions 3, 4

- King, M.-C., & Wilson, A. C. 1975. Evolution at two levels in humans and chimpanzees. Science 188: 107-116.

- Clark, A. G., S. Glanowski, R. Nielsen, P. D. Thomas, A. Kejeriwal, M. A. Todd, D. M. Tanenbaum, D. Civello, F. Lu, B. Murphy, S. Ferriera, G. Wang, X. Zheng, T. J. White, J. J. Sninsky, M. D. Adams, and M. Gargill. 2003. Inferring nonneutral evolution from human-chimp-mouse orthologous gene trios. Science 302:1960-1963.

Feb. 8. Molecular Population Genetics I. Selection. Chapter 2
Deterministic models of natural selection
Balancing selection, positive selection, purifying selection, disruptive selection

Feb. 10. Student Presentations 3, 4: Determinants of protein molecular evolutionary rates

- Drummond, D. A., A. Raval, and C. O. Wilke. 2006. A single determinant dominates the rate of yeast protein evolution. Mol. Biol. Evol. 23:327-337. (Note: the presenter may also check Kim, S-H. and Yi, S. (2007). Understanding relationship between sequence and functional evolution in yeast proteins. Genetica, 131: 151-156).

- Martin, A. P., Palumbi, S. R., Body size, metabolic rate, generation time, and the molecular clock. 1993. *Proc. Nat. Acad. Sci. USA 90*, 4087-4091.

Feb. 15. Molecular Population Genetics II. Genetic Drift. Chapter 2
Definition of genetic drift
Some mathematical facts
Consequences of genetic drift

Feb. 17. Molecular Population Genetics III. Effective Population Size. Supplementary Material.

Various ways to estimate effective population size
Why does it matter?

Feb. 22. Student Presentations/Discussions 5, 6. Debate on the role of effective population size on genome evolution.

- Lynch, M., and Conery, J.S. (2003). The origins of genome complexity. Science 302, 1401-1404.

- Bundle: Yi, S., and J. T. Streelman. 2005. Genome size is negatively correlated with effective population size in ray-finned fish. Trends Genet. 21, 643-646.

Feb. 24 Combining Molecular Population Genetics and Divergence I.
Fixation probability under the influence of selection and drift
Conditional Fixation

Mar. 1. Combining Molecular Population Genetics and Divergence II. Test of Neutrality. Supplementary Material.

Mar. 3. Student Presentation 7, 8. Examples of Nonneutral Evolution

- Enard, W., Przeworski, M., Fisher, S.E., Lai, C.S.L., Wiebe, V., Kitano, T., Monaco, A.P., and Paabo, S. 2002. Molecular evolution of FOXP2, a gene involved in speech and language. *Nature 418*, 869-872.

- Nielsen, R., Bustamante, C., Clark, A. G., Glanowski, S.*, et al.*, 2005. A scan for positively selected genes in the genomes of humans and chimpanzees. *PLoS Biology 3*, e170.

Mar. 8. Genomic Data and Inference of Natural Selection. Supplementary Material.
We will review recent literature on selection on human genome

Mar. 10. Molecular Phylogenetics I. Chapter 5.
History of molecular phylogenetics
Methods of molecular phylogenetics

Mar. 15. Molecular Phylogenetics II. Chapter 5.

Mar. 17. Student Presentations 9, 10. Mitochondrial Eve/Y-chromosome evolution.

- Vigilant, L., M. Stoneking, H. Harpending, K. Hawkes, and A. C. Wilson. 1991. African populations and the evolution of human mitochondrial DNA. *Science 253*,1503-1507.

- Underhill, P. A., P. Shen, A. A. Lin, L. Jin, G. Passarino, W. H. Yang, E. Kauffman, B. Bonne-Tamir, J. Bertranpetit, P. Francalacci, M. Ibrahim, T. Jenkins, J. R. Kidd, S. Q. Mehdi, M. T. Seielstad, R. S. Wells, A. Piazza, R. W. Davis, M. W. Feldman, L. L. Cavalli-Sforza, and P. J. Oefner. 2000. Y chromosome sequence variation and the history of human populations. *Nat Genet 26*, 358-361.

Topic for group project is due.

Mar. 22 spring break

Mar. 24. Spring break

Mar. 29. Gene Duplication and Chromosomal Evolution I. Chapter 6.

Mar. 31. Guest lecture. TBA

Apr. 5. Student Presentations 11, 12. Gene Duplication and Chromosomal Evolution.

- Lynch M and JS Conery, 2000. The evolutionary fate and consequences of duplicate genes. *Science 290*, 1151-1155

- Kellis M, Birren BW, Lander ES: Proof and evolutionary analysis of ancient genome duplication in the yeast *Saccharomyces cerevisiae*. 2004. *Nature 428,* 617-624.

Apr. 7. Evolution of Biological Networks. Supplementary material.

Apr. 12. Student Presentations 13, 14. Evolution of Networks.

- Bundle: Jeong H, Mason SP, Barabasi AL, Oltvai ZN. 2001. Lethality and centrality in protein networks. *Nature 411,* 41-42. Fraser HB, Hirsh AE, Steinmetz LM, Scharfe C, Feldman MW. 2002. Evolutionary Rate in the Protein Interaction Network. *Science 296,* 750-752.

- Kim PM, Lu LJ, Xia Y, Gerstein MB. 2007. Relating three-dimensional structures to protein networks provides evolutionary insights. *Science 314*, 1938-1941.

Apr. 14. Practice of Molecular Evolution/Evolutionary Genomics.

Apr. 19. Group Presentation and Discussion 1

Apr. 21. Group Presentation and Discussion 2

Apr. 26 Group Presentation and Discussion 3

Apr. 29. TBA