BIOL 4225/7111 Molecular Evolution
Fall 2015

Instructor: Soojin Yi
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Office hour: by appointment (email)
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Tues/Thursday 9:35am-10:55am, Howey S107

Texts (not required):
Main text: *Fundamentals of Molecular Evolution* by Dan Graur, Wen-Hsiung Li. Sinauer Associates, ISBN: 0878932666 (available from the Instructor and also in the GT library)

Population Genetics: A Concise Guide by John Gilespie. Johns Hopkins University Press. ISBN: 0801857554 (Available from the Instructor and also in the GT library)

Supplementary Texts:
Molecular Evolution and Phylogenetics by Masatoshi Nei, Sudhir Kumar. Oxford University Press. ISBN: 0195135849 (available from the Instructor)

Molecular Evolution by Wen-Hsiung Li. Sinauer Associates, ISBN: 0878934634

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

Class Participation: Students are to be expected to attend all classes and actively participate in the class. The instructor will note class participation and count toward the final grade.

Quiz/Homeworks: To encourage participation there will be occasional quizzes and homeworks in the class. They will count toward your participation scores.

Paper Critiques: Papers to be discussed 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. If you copy abstract/summary or other parts of the paper, you will get a zero. If you have read the paper but completely missed the point, you will get a 0.5. Missing critique will be scored as zeros.

Presentation: A list of papers for presentation is provided. Students can choose one paper and present the paper as well as other related papers on the same topic for 25~30 minutes during some classes. The presenter is also expected to lead a short (~10 minutes) discussion.

Midterm Homework: In lieu of a midterm, a homework will be given before the fall break. The homework will be analyses of sequence data and infer different evolutionary forces using the

ideas learned in the class. The homework should be in a short paper format. Homework is due back in two and half weeks. Students are encouraged to discuss and work together. However if two homeworks appear very similar both students will get zeros. If a clear act of plagiarism is determined, the students will get a failing grade.

Group Projects: All students are to form a 3-student group for a final group project. 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 25 papers. 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 before the fall break. Each group will present their work.

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.

Detailed topics: this list is tentative and subject to change.

Date	**Topic**	**Suggested Reading**
Aug. 18	History of molecular evolution Models of nucleotide substitution I.	G&L Ch. 2, 3 Supplementary Material
Aug. 20	Models of nucleotide substitution II.	G&L Ch. 2, 3
Aug. 25	Other methods of multiple hit corrections Patterns and rates of nucleotide substitutions	G&L Ch. 3
Aug. 27	Examples of neutral rate variation Hominoid-rate slowdown Male-driven evolution	G&L Ch. 3,4
Sep. 1	Protein-coding sequence evolution Ka, Ks, dN and dS	G&L Ch. 3, 4
Sep. 3	protein-coding sequence evolution continued **Student presentations/discussion 1, 2:** examples of evolutionary rate variation **Presenter: TBA** **(Note added on 08/28: The instructor will present these papers since nobody has signed on yet. But you have to submit the critiques)**	G&L Ch. 3, 4 see paper list paper critiques due
Sep. 8	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 molecular evolutionary studies Molecular population genetics I. selection Deterministic models of natural selection Balancing selection, positive selection, purifying selection,	G&L Ch. 4 JG Ch.3

	disruptive selection	
Sep. 10	Natural Selection continued **Student presentations/discussions 3, 4, 5:** Selection in protein-coding sequences **Presenters** **3: Tobias Hoffmann** **(Note added on 09/07: The instructor will present papers 4 and 5 since nobody has signed on yet. But you have to submit the critiques for all three papers)**	G&L Ch. 4 JG Ch.3 see paper list paper critiques due
Sep. 15	Molecular population genetics II. genetic drift Definition of genetic drift Some mathematical facts Consequences of genetic drift	JG Ch.2
Sep. 17	Molecular population genetics continued **Student presentations/discussions 6, 7** Determinants of protein molecular evolutionary rates **Presenters:** **6: Curtis Balusek** **7:**	see paper list paper critiques due
Sep. 22	Molecular population genetics III. effective population size.	Supplementary Material
Sep. 24	Molecular population genetics continued **Student presentations/discussions 8, 9:** Genetic drift and genome evolution **Presenters:** **8: Menghan Li** **9: Florence Pham**	see paper list paper critiques due
Sep. 29	Combining molecular population genetics and divergence I. Fixation probability under the influence of selection and drift Conditional fixation	Supplementary Material
Oct. 1	Combining molecular population genetics and divergence II. Tests of neutrality	Supplementary Material
Oct. 6	**Student presentations/discussions 10, 11, 12** Examples of non-neutral evolution **Presenters: TBA** **10: Jung Mok** **11: Nick Schappaugh**	paper critiques due
Oct. 8	Molecular phylogenetics I. Why and how of molecular Phylogeny **12: Juan Castro**	G&L Ch. 5 paper critique due **Note: Group Assignment Due/Homework given**

Oct. 13	Student Recess	
Oct. 15	**Student presentations/discussions 13, 14** Genomic data and inference of natural selection **Presenters** **13: Minjae Kim** **14: Luis Orellana**	paper critiques due
Oct. 20	Molecular phylogenetics II. Some interesting Observations and facts **Student presentations/discussions 15** Human Evolution **Presenter: Shelby Busby**	paper critique due
Oct. 22	**Student presentations/discussions 16, 17, 18** Human Evolution **Presenters: TBA** **16: Amal Punnoose** **17: Max Beecroft** **18: Binbin Huang**	paper critiques due **Homework Due**
	drop date: Oct. 25	
Oct. 27	Gene duplication and chromosomal evolution **Student presentation/discussion 19** Gene duplication and chromosomal evolution **Presenter: Sweta Singh**	G&L Ch. 6 paper critique due
Oct. 29	**Student presentation/discussion 20, 21, 22** Gene duplication and chromosomal evolution **Presenters** **20: Yuehui Zhao** **21, 22: Anthony Hazel**	paper critiques due
Nov. 3	Evolution and Development	Supplementary Material
Nov. 5	New Topics in Molecular Evolution **Student presentations** **23: Claire Hansen** **24: Yael Toporek**	Supplementary Material Paper critiques due
Nov. 10	Group Presentation and Discussion 1	Groups provide material
Nov. 12	Group Presentation and Discussion 2	Groups provide material
Nov. 17	Guest Lecture: Dr. Isabel Mendizabal Human Evolution	
Nov. 19	Group Presentation and Discussion 3	Groups provide material
Nov. 24	Guest Lecture: Dan Sun Evolution of Chromosomes and Genes	
Nov. 26	Thanksgiving	
Dec. 1	Group Presentation and Discussion 4	Groups provide

		material
Dec. 3	Group Presentation and Discussion 5	Groups provide material

Suggested papers for presentations for BIOL 7111 A
Here's the list of suggested papers for presentations. Please think about which papers you would like to present. Note that we may add/remove specific papers in later dates. If you have suggestions for specific papers, please contact the instructor.

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

- Bundle: Bohossian HB, Skaletsky H, Page DC: Unexpectedly similar rates of nucleotide substitution found in male and female hominids. Nature 2000, 406:622-625. 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

Student Presentations/Discussions 3, 4, 5: Selection in protein-coding sequences

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

- 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.

- Haygood R, Fedrigo O, Hanson B, Yokoyama K-D, Wray GA. 2007. Promoter regions of many neural- and nutrition-related genes have experienced positive selection during human evolution. Nature Genet *39(9):* 1140-1144.

Student Presentations 6, 7: 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). **Curtis Balusek**

- Wolf YI, Carmel L, Koonin EV. 2006. Unifying measures of gene function and evolution. Proc Biol Sci 273(1593): 1507-1515.

- (additional reading: 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)

Student Presentations/Discussions 8, 9. Genetic drift and genome evolution

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

- 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. Charlesworth B, Barton N: Genome size: does bigger mean worse? Curr Biol 2004, 14:R233-R235. **Florence Pham**

Student Presentation 10, 11. 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. **Jung Mok**
- (Bundle) Krause, K., Lalueza-Fox, C., Orlando, L., Enard, W., Green, R. E., Burbano, H. A., Hublin, J. J., Hänni, C., Fortea, J., de la Rasilla M., Bertranpetit, J., Rosas, A., Pääbo, S., 2007. The derived FOXP2 variant of modern humans was shared with Neanderthals. *Curr. Biol.* 17: 1908-1912.; Coop, G., Bullaughey, K., Luca, F., and M. Przeworski 2008. The timing of selection at the human FOXP2 gene. *Mol. Biol. Evol.* 25: 1257-1259 **Nick Schappaugh**

Student Presentation 12, 13, 14. Genomics and Evolution of Prokaryotes Data and Inference of Natural Selection

- Wiser, M. J., Ribeck, N. and Lenski, R. E. 2013. Long-term dynamics of adaptation in asexual populations. Science 342, 1364-1367. **Juan Castro (Oct. 8)**
- Barrick, J. E. et al. 2009. Genome evolution and adaptation in a long-term experiment with Escherichia coli. *Nature 461*, 1243-1247. **Minjae Kim (Oct. 15)**
- Gubry-Rangin et al. 2015. Coupling of diversification and pH adaptation during the evolution of terrestrial Thaumarchaeota. *PNAS 112*, 9370-9375. **Luis Orellana (Oct. 15)**

Student Presentations 15, 16, 17, 18 Human Molecular 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. **Shelby Busby**

- Patterson N, Richter DJ, Gnerre S, Lander ES, Reich D. 2006. Genetic evidence for complex speciation of humans and chimpanzees. *Nature 441,* 1103-1108. **Amal Punnoose**

- Presgraves DC, Yi S. 2009. Doubts about complex speciation between humans and chimpanzees. *Trends Ecol Evol 24,* 533-540. **Max Beecroft**

- Huerta-Sánchez, et al. 2014. Altitude adaptation in Tibetans caused by introgression of Denisovan-like DNA. *Nature* 512, 194-197. **Binbin Huang**

Student Presentations 19, 20, 21, 22. Gene Duplication and Chromosomal Evolution.

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

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

- Lior Patcher's blog post on May 26, 2015 titled "Patcher's P-value Prize" and comments therein. Because this is a long post and even longer comments, this material will consist of two presentations. Two students, preferably those who are interested in genomics/statistics, need to consult with each other beforehand to decide on which comments to take. It will be impossible to talk about all comments, I will leave it to the presenters' discretion to choose a few notable ones to discuss in depth during the class. **Anthony Hazel**

Additional Papers Student Presentations TBA