**Evolutionary Genetics**

**Daniel R. Matute, Ph.D.**

**BIOL 454-001**

**Office hours: On request.**

**Text (optional): Coop, G. Population and Quantitative Genetics.** <https://github.com/cooplab/popgen-notes/blob/master/popgen_notes.pdf>

**Additional texts:** Gillespie, J. H. Population genetics: a concise guide. JHU Press. 2010

Hartl, Daniel L., Andrew G. Clark, and Andrew G. Clark. Principles of population genetics. Sinauer associates. Fourth Edition. 2004

Coyne, Jerry A. Why evolution is true. Penguin, 2009.

Nielsen, Rasmus, and Montgomery Slatkin. *An introduction to population genetics: theory and applications*. Sinauer Associates, 2013.

Wakeley, John. Coalescent theory: an introduction. Vol. 1. Roberts & Company Publishers, 2009.

**Course Goals:** The aim of the course is to provide an overview of the evolutionary processes that originate and shape genetic variation. The course will have a heavy quantitative emphasis and **you will be challenged to understand derivations, experiments, and conclusions**.

**SYLLABUS**

M: Monday, W: Wednesday, F: Friday.

**MODULE 1. Evolutionary forces**

**Week 1:**

M: Introduction (lecture, synchronous)

W: Evidence of evolution (lecture)

F: Essay. 500-word critique on a piece of popular press

**Week 2: Principles of probability**

M: Phenotypic and genetic variation (lecture)

W: Basic probability (lecture)

 Recommended reading: Coop, Appendix A

F: Probability problem set.

**Week 3: Mutation**

M: Hardy Weinberg Equilibrium (lecture)

 Recommended reading: Coop, Chapter 2

W. Kong, A., Frigge, M.L., Masson, G., Besenbacher, S., Sulem, P., Magnusson, G., Gudjonsson, S.A., Sigurdsson, A., Jonasdottir, A., Jonasdottir, A. and Wong, W.S., 2012. Rate of de novo mutations and the importance of father’s age to disease risk. *Nature*, *488*(7412), pp.471-475.

Scally, A., 2016. The mutation rate in human evolution and demographic inference. Current opinion in genetics & development, 41, pp.36-43.

Besenbacher, S., Hvilsom, C., Marques-Bonet, T., Mailund, T. and Schierup, M.H., 2019. Direct estimation of mutations in great apes reconciles phylogenetic dating. Nature ecology & evolution, 3(2), pp.286-292.

Chintalapati, M. and Moorjani, P., 2020. Evolution of the mutation rate across primates. Current Opinion in Genetics & Development, 62, pp.58-64.

F: HWE and Mutation Problem set.

**Week 4: Recombination**

M: Linkage disequilibrium (lecture)

 Recommended reading: Coop, Chapter 3, pages 47-52

W: Bell, A.D., Mello, C.J., Nemesh, J., Brumbaugh, S.A., Wysoker, A. and McCarroll, S.A., 2020. Insights into variation in meiosis from 31,228 human sperm genomes. *Nature*, pp.1-6.

Clyde, D., 2020. Sequencing sperm to untangle meiotic variation. *Nature Reviews Genetics*, *21*(8), pp.447-447.

Sardell, J.M. and Kirkpatrick, M., 2020. Sex differences in the recombination landscape. *The American Naturalist*, *195*(2), pp.361-379.

Coop, G., Wen, X., Ober, C., Pritchard, J.K. and Przeworski, M., 2008. High-resolution mapping of crossovers reveals extensive variation in fine-scale recombination patterns among humans. *Science*, *319*(5868), pp.1395-1398.

Ortiz-Barrientos, D., Engelstädter, J. and Rieseberg, L.H., 2016. Recombination rate evolution and the origin of species. *Trends in ecology & evolution*, *31*(3), pp.226-236.

F: Linkage Disequilibrium problem set.

**Week 5: Neutral theory + Drift**

M**:** Neutral theory (lecture).

 Recommended reading: Coop, Chapter 4

W**:** Kern, A.D. and Hahn, M.W., 2018. The neutral theory in light of natural selection. *Molecular biology and evolution*, *35*(6), pp.1366-1371.

Jensen, J.D., Payseur, B.A., Stephan, W., Aquadro, C.F., Lynch, M., Charlesworth, D. and Charlesworth, B., 2019. The importance of the neutral theory in 1968 and 50 years on: a response to Kern and Hahn 2018. *Evolution*, *73*(1), pp.111-114.

Nei, M., Suzuki, Y. and Nozawa, M., 2010. The neutral theory of molecular evolution in the genomic era. *Annual review of genomics and human genetics*, *11*, pp.265-289.

F: Drift problem set

**Week 6: Selection**

M: Selection (lecture)

 Recommended reading: Coop, Chapter 11

W:Harris, R.B., Sackman, A. and Jensen, J.D., 2018. On the unfounded enthusiasm for soft selective sweeps II: Examining recent evidence from humans, flies, and viruses. *PLoS genetics*, *14*(12), p.e1007859.

Jensen, J.D., 2014. On the unfounded enthusiasm for soft selective sweeps. *Nature communications*, *5*(1), pp.1-10.

Schrider, D.R. and Kern, A.D., 2017. Soft sweeps are the dominant mode of adaptation in the human genome. *Molecular biology and evolution*, *34*(8), pp.1863-1877.

Booker, T.R., Jackson, B.C. and Keightley, P.D., 2017. Detecting positive selection in the genome. *BMC biology*, *15*(1), p.98.

Fan, S., Hansen, M.E., Lo, Y. and Tishkoff, S.A., 2016. Going global by adapting local: A review of recent human adaptation. *Science*, *354*(6308), pp.54-59.

F: Problem Set. Selection

**Week 7: Inbreeding**

M: Inbreeding (lecture)

 Recommended reading: Coop, Chapters 6-7

W: Ramachandran, S., Deshpande, O., Roseman, C.C., Rosenberg, N.A., Feldman, M.W. and Cavalli-Sforza, L.L., 2005. Support from the relationship of genetic and geographic distance in human populations for a serial founder effect originating in Africa. *Proceedings of the National Academy of Sciences*, *102*(44), pp.15942-15947.

Hedrick, P.W. and Garcia-Dorado, A., 2016. Understanding inbreeding depression, purging, and genetic rescue. Trends in ecology & evolution, 31(12), pp.940-952.

Huisman, J., Kruuk, L.E., Ellis, P.A., Clutton-Brock, T. and Pemberton, J.M., 2016. Inbreeding depression across the lifespan in a wild mammal population. Proceedings of the National Academy of Sciences, 113(13), pp.3585-3590.

F: Interview with Joffre.

**Week 8: Speciation.**

M: Speciation (Lecture)

W: Harvey, M.G., Singhal, S. and Rabosky, D.L., 2019. Beyond reproductive isolation: Demographic controls on the speciation process. *Annual Review of Ecology, Evolution, and Systematics*, *50*, pp.75-95.

Martin, C.H. and Richards, E.J., 2019. The paradox behind the pattern of rapid adaptive radiation: how can the speciation process sustain itself through an early burst?. Annual Review of Ecology, Evolution, and Systematics, 50, pp.569-593.

Lamichhaney, S., Han, F., Webster, M.T., Andersson, L., Grant, B.R. and Grant, P.R., 2018. Rapid hybrid speciation in Darwin’s finches. *Science*, *359*(6372), pp.224-228.

F: Interview with Dagilis. Dagilis, A.J., Kirkpatrick, M. and Bolnick, D.I., 2019. The evolution of hybrid fitness during speciation. PLoS genetics, 15(5), p.e1008125.

**WEEK 9: REVIEW+MIDTERM**

**MODULE 2. APPLICATIONS**

**Week 10: Quantitative genetics and Mapping**

M: Quantitative genetics

 Recommended reading: Coop, Chapters 7,8

W: Interview with Coughlan. Coughlan, J.M., Brown, M.W. and Willis, J.H., 2020. The genetic architecture and evolution of life history divergence among perennials in the Mimulus guttatus species complex. *bioRxiv*.

F: Gienapp, P., Fior, S., Guillaume, F., Lasky, J.R., Sork, V.L. and Csilléry, K., 2017. Genomic quantitative genetics to study evolution in the wild. *Trends in Ecology & Evolution*, *32*(12), pp.897-908.

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Bazakos, C., Hanemian, M., Trontin, C., Jiménez-Gómez, J.M. and Loudet, O., 2017. New strategies and tools in quantitative genetics: how to go from the phenotype to the genotype. *Annual review of plant biology*, *68*.

Keele, G.R., Crouse, W.L., Kelada, S.N. and Valdar, W., 2019. Determinants of QTL mapping power in the realized Collaborative Cross. *G3: Genes, Genomes, Genetics*, *9*(5), pp.1707-1727.

F: Quantitative genetics problem set

**Week 11: The Coalescent**

M: The coalescent

W: Kingman, J.F.C., 1982. The coalescent. *Stochastic processes and their applications*, *13*(3), pp.235-248.

Sukumaran J, Knowles LL. Multispecies coalescent delimits structure, not species. Proceedings of the National Academy of Sciences. 2017 Feb 14;114(7):1607-12.

Palamara, P.F., Terhorst, J., Song, Y.S. and Price, A.L., 2018. High-throughput inference of pairwise coalescence times identifies signals of selection and enriched disease heritability. *Nature Genetics*, *50*(9), pp.1311-1317.

F: Interview with Comeault. *Drosophila* phylogeny

F: Coalescent Problem set.

**MODULE 3. THE CUTTING EDGE**

**Week 12: Genetic privacy**

M: Genetic counseling and privacy

W: Edge, M.D. and Coop, G., 2020. Attacks on genetic privacy via uploads to genealogical databases. *Elife*, *9*, p.e51810.

Edge, M. and Coop, G., 2019. How lucky was the genetic investigation in the golden state killer case?.

Kennett, D., 2019. Using genetic genealogy databases in missing persons cases and to develop suspect leads in violent crimes. *Forensic science international*, *301*, pp.107-117.

F: Problem set. Pedigrees.

**Week 13: Hominids**

M: A brief history of the history of the human species

W: Lewontin, R. C. (1972). "The Apportionment of Human Diversity". Evolutionary Biology. pp. 381–398: <https://link.springer.com/chapter/10.1007/978-1-4684-9063-3_14>

Reich, D. (2018). Who we are and how we got here. Chapter 1,2

Reich, D. (2018). Who we are and how we got here. Chapters 4-7.

Tung, J. and Barreiro, L.B., 2017. The contribution of admixture to primate evolution. Current opinion in genetics & development, 47, pp.61-68: <https://www.sciencedirect.com/science/article/pii/S0959437X16302052>

F:Synchronous session to discuss human history

**Week 14: Race**

M:The genetic basis of race

W: Reich D. How Genetics Is Changing Our Understanding of ‘Race’. NY Times. March 23, 2018: <https://www.nytimes.com/2018/03/23/opinion/sunday/genetics-race.html>

How Not To Talk About Race And Genetics: <https://www.buzzfeednews.com/article/bfopinion/race-genetics-david-reich#.spzPpLXRL>

Revisiting Race in a Genomic Age (Lee, S., Koenig, B.A., Richardson S). Chapters 1-3.

Saini., A. (2019). Superior. Chapters 5 and 10.

Reich, D. (2018). Who we are and how we got here. Chapter 11.

F: Synchronous session to discuss human race

**Week 15: Review and Final**

M: Review

W: Final

**Grading**

Paper presentation (primary) 15%

Paper presentation (Secondary) 10%

Interview essays 15%

Midterm exam 15%

Problem sets 15%

Final Exam 15%

Participation/Piazza 15%

**Grading Scale:**

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|  | **A = 92.9 - 100****A- = 89.9 - 92.8** **B+ = 87.9 - 89.8****B = 82.9 - 87.8** **B- = 79.9 - 82.8**  | **C+ = 77.9 - 79.8****C = 72.9 - 77.8** **C- = 69.9 - 72.8** **D+ = 67.9 - 69.8****D = 59.9 - 67.94** | **F = 0 - 59.8** |

**Notes:**

* You need to register Piazza:

piazza.com/unc/fall2020/biol454

* I strongly recommend you become familiar with zoom. You will need to record videos and distribute them.
* We will discuss reviews and primary literature on Wednesdays. You must sign up to discuss two papers, one as a primary and one as a secondary panelist. If you are the primary, your job is to lead the discussion. If you are a secondary, your job will be to keep the discussion going. Sign up for the papers at: <https://docs.google.com/spreadsheets/d/1xrdt1GE8s4l4HrFDMegbZEwh9yq4zmQ7nFyyGoUt7CI/edit?usp=sharing>
* The group of primaries and secondary panelists must record their discussion on zoom and send me the link on Monday 12m or before. I will review the content and give you the green light to publish the video to the class or suggest edits.
* For each interview, you must write a 300 concise and forceful opinion on the content of the interview. All submissions must be done in Sakai. The opinion is due the Monday after the interviews are released.
* Final Exam will include material from the whole semester.

**All aspects of the UNC Honor Code will be enforced.**

**GRADES**

**Quizzes** There will be 12 quizzes during the semester. These quizzes will happen at any point in the semester and will be unannounced. The three worst grades will be dropped.

**Paper Presentations**: Each student will lead the discussion of a weekly paper (posted on sakai).

**Grade Complaints**: Re-grade requests are allowed. Such requests must be made in within one week of receiving a grade and they must be made in written form. In these cases, I will regrade the whole quiz/exam.

**TECHNOLOGY USE**

* Use of computers is allowed but only for taking notes. The instructor has the right to end any session if ANY of the students is found using facebook, twitter, youtube or any other social media. In such a case, the instructor will assume that the topics to be covered that day were covered.
* Recording and distributions of lectures is prohibited. Use of cell phones and similar devices is prohibited.