

Biology 128FCS
**Evolutionary Genomics: Who are we, where have we been,
and where are we going?**
Wednesdays, BioSci 130
3:05 – 5:35 p.m.
Fall 2016

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Synopsis:

We are now nearly a decade into the genomics revolution. In a matter of only a few years, this technical revolution has generated data that allow us to gaze into our past, present, and future in ways that were beyond imagining when Darwin's theory of Natural Selection was introduced to the world more than 150 years ago. The unification of genomic data, bioinformatic analysis, and evolutionary theory has transformed our understanding of human history, our place within the Tree of Life, and the impact that our species is having on those with whom we share the planet. Evolutionary genomics has also allowed powerful new insights into human vulnerabilities to disease pandemics, their origins, and their likely trajectories. This course will draw from the primary literature to familiarize students with the multifaceted power of genomics, with a slant towards examining human history and disease from an evolutionary perspective. When possible, published studies will be read along with reports from the popular press in order to provoke discussion of science communication strategies. Readings will be drawn from a wide variety of sources, from some published more than a century ago, up through the contemporary popular press. As 50% of your grade, students will be responsible for choosing a relevant topic for scholarly exploration and evaluation. The results of this project will be presented in both written (a critical essay) and verbal (a class presentation) formats.

This Syllabus:

IS A WORK IN PROGRESS AND IS SUBJECT TO CHANGE. This is the first time that I am teaching this class, so there is no template, but more importantly, genomics and its applications to evolutionary biology, human evolution, disease dynamics, etc. change by the day. Virtually every week there is a new study on one of these subjects, published in top journals, and covered in the popular press. I want to take advantage of this excitement and novelty, and leave plenty of room to be nimble so that we can focus on new and exciting results.

Required Readings:

These will come from a variety of sources, from text books, to articles from the primary literature, to the popular press. ***These will all be made available to you in Sakai by the Friday before the following class.*** Typically, there will be two readings, anywhere from 5 - 20 pages each. On occasion, especially early on, I might assign a lengthy book chapter or two.

Expectations:

This is a seminar course, and as such, it falls on you, the student, to actively participate in the learning process. Though I will often give a brief lecture as part of the class sessions, the success of the course, and the amount that you and the other students will actually learn, will depend entirely on your careful assessment of the assigned reading materials, and your participation in discussion. Each week, ***by 10:00 a.m. on the day of class***, you will be required to email to me a short synopsis (2 -3 paragraphs) of the reading materials. ***Most importantly, this synopsis should include at least 2 – 3 questions provoked by the reading.*** We will use these questions as catalysts for discussion. ***50% of your grade will be drawn from these synopses, along with your participation in class discussion.***

Discussion leaders will be assigned for each meeting. Your job will be to introduce the topic and the reading material, and then help lead the discussion. I will provide you with a compiled list of questions provided by the other students (including your own). Together, we will then work through the questions, feeling quite free to deviate from the list and to explore other questions as they arise.

The remaining 50% of your grade will be based on your independent project, described below.

Project Guidelines:

Subject: Choose a subject that is of interest to you. Ideally, this will emerge from some topic or issue covered in the readings and discussion, but this is not mandatory. The important criterion is that the subject be compelling to you and at least relevant to the subjects covered in the course.

Scope: Given the resources and time available, a review and analysis of the pertinent literature is the most realistic approach to take with your project.

Project Report (written): Your paper should be *about* 10 pages in length (1.5 spacing); long enough to summarize and analyze your project thesis, but not so long as to be tedious. You should cite at least 10 – 15 references from the primary or secondary literature. If fewer than 10 references are available, that is a clear indication that there simply isn't much known about your subject, and therefore, is probably not suitable for a project of this nature.

Project Presentation (visual and oral): The talk must be limited to 10 minutes. You should use a mixture of word and image slides. You should leave your audience with both new knowledge, and new questions.

Project Proposal (due on Thursday, November 2nd): This should be approximately three – five paragraphs and should be structured along the lines of: 1) what is the subject? 2) why is it interesting/important? And 3) what kinds of information sources are available to you? You will not be graded on the synopsis, but it will be my test of whether you have chosen an appropriate area for analysis.

Class Meetings:

August 31 - Introduction to the Course

September 7 - *Evolutionary theory/Natural Selection*

Required Reading:

- 1858 Darwin and Wallace papers to the Linnean Society
- Gould, "Ever Since Darwin" (selected chapters)
- Stott, "Darwin's Ghosts" (Chapter 12)

Discussion Leaders:

- 1) Darwin paper and Gould reading – **Sam**
- 2) Wallace paper and Stott reading – **Victoria**

September 14 - *Phylogenetics and phylogenomics: how we can use genetic and genomic data to infer historical events*

Required Reading:

- Baum & Smith, "Tree Thinking" (Chapters 1 & 2)
- Hall, "Phylogenetic Trees Made Easy" (Chapter 6)

Discussion Leaders:

- 3) Hall - **Sophia**
- 4) Baum & Smith - **D'amy**

September 21: CLASS CANCELLED DUE TO DLC 50TH ANNIVERSARY EVENTS --- Students are required to attend at least two talks at some point over the 2-day symposium to be held at the Washington-Duke Inn. As part of this assignment, you will be required to write a short summary (one paragraph per talk), summarizing the talks that you heard and what you learned from them. You will receive special admission passes for the Symposium.

September 28: *Phylogeography: mapping phylogenies onto the landscape; differential extinction and survival of genetic lineages (aka, lineage sorting); the coalescent process (aka, finding the last common ancestor of gene lineages, and what that can reveal about past events)*

Required Reading:

- Avise, "Phylogeography: the history and formation of species" (Chapters 1 & 2)

Discussion Leaders:

- 5) (Chapter 1)- **Nikhil**
- 6) (Chapter 2)- **Michelle**

October 5: TOUR OF THE DUKE LEMUR CENTER! (Rain date October 12th)

October 12: *Gene flow, selection, and introgression: the population level forces that shape genome content and structure*

Required Reading:

- Harrison & Larson (2014), Hybridization, Introgression, and the Nature of Species Boundaries. *Journal of Heredity*, 105: 795-809
- Tigano & Friesen (2016), Genomics of local adaptation with gene flow. *Molecular Ecology*, 25: 2144-2164

Discussion Leaders:

- 7) Tigano & Friesen (2016) - **Conan**
- 8) Harrison & Larson (2014) - **Ulises**

October 19: *Genome sequencing and assembly: how we use technology to reconstruct and understand the genome PLUS overview of human history*

Required Reading:

- Harcourt (2016), Human phylogeography and diversity. *PNAS*, July 19, 2016
- Larsen et al. (in revision), Hybrid *de novo* genome assembly and centromere characterization of the gray mouse lemur (*Microcebus murinus*). Submitted to *Genome Research* special edition

Discussion Leaders:

- 9) Harcourt (2016) - **Harrison**

October 26: *mitochondrial Eve & the Out-of-Africa Hypothesis*

Required Reading:

- Cann et al. (1987), Mitochondrial DNA and human evolution. *Nature*, 325: 31-36
- Lewin (1987), The unmasking of mitochondrial Eve. *Science*, 238: 24-26
- Rodrigues-Flores et al. (2016), Indigenous Arabs are descendants of the earliest split from ancient Eurasian populations. *Genome Research*, 26: 151-162
- Groucutt et al. (2015), Rethinking the dispersal of Homo sapiens out of Africa. *Evolutionary Anthropology*, 24: 149-164

Discussion Leaders:

- 10) Cann et al. (1987), and Rodrigues-Flores (2016) - **Hannah**
- 11) Lewin (1987) and Groucutt et al. (2015) - **Jonathan**

(November 2: Project Proposals due)

November 2: *Ancient DNA: how do we know so much about the Neanderthal genome? How could it be that some of us have a measurable amount of the Neanderthal's genome mixed in with our own? Who were the Denisovians? Why do we even care?*

Required Reading:

- Currat & Excoffier (2011), Strong reproductive isolation between humans and Neanderthals inferred from observed patterns of introgression. *PNAS*, 108: 15129-15134
- Wang et al. (2013), Apparent Variation in Neanderthal Admixture among African Populations is Consistent with Gene Flow from Non-African Populations. *Genome Biology and Evolution*, 5: 2075-2081
- Racimo et al. (2015), Evidence for archaic adaptive introgression in humans. *Nature Reviews Genetics*, 16: 350-371
- Slatkin & Racimo (2016), Rethinking the dispersal of *Homo sapiens* out of Africa. *PNAS*, 113: 6380–6387

Discussion Leaders:

- 12) Currat & Excoffier (2011); Racimo et al. (2015) - **Helena**
- 13) Wang et al. (2013); Slatkin & Racimo (2016) - **Chloe**

November 9: *More insight into genomic introgression among ancient hominins - impacts of climate change on early human phylogeography.*

Required Reading:

- Vattathil & Akey (2015), Small amounts of archaic admixture provide big insights into human history. *Cell*, 163: 281-284
- Meyer et al. (2013), Nuclear DNA sequences from the Middle Pleistocene Sima de los Huesos hominins. *Nature*, 531: 504-507
- Kuhlwilm et al. (2016), Ancient gene flow from early modern humans into Eastern Neanderthals. *Nature*, 530: 429-433
- Vernot et al. (2016), Excavating Neandertal and Denisovan DNA from the genomes of Melanesian individuals. *Science*, 352: 235–239

Discussion Leaders:

- 14) Vattathil & Akey (2015) and Kuhlwilm et al. (2016) - **Ashley**
- 15) Meyer et al. (2016) and Vernot et al. (2016) - **Chris**

November 16: *Ancient introgression and positive selection confer to influence human disease and health.*

Required Reading:

- Vitti et al. (2013), Detecting natural selection in genomic data. *Annual Review of Genetics*, 47: 97-120
- Juric et al. (2016), The Strength of Selection against Neanderthal Introgression. *PLOS Genetics*, DOI:10.1371
- Simonti et al. (2016), The phenotypic legacy of admixture between

modern humans and Neandertals. *Science*, 351: 737-741

- Chen et al. (2015), Analysis of 589,306 genomes identifies individuals resilient to severe Mendelian childhood diseases. *Nature Biotechnology*, doi:10.1038/nbt.3514

Discussion Leaders:

- 16) Vitti et al. (2013) and Simonti et al. (2015) - **Ian**
- 17) Juric et al. (2016) and Chen et al. (2016) - **Megan**

November 23: THANKSGIVING BREAK

(November 29th, 12:00 a.m.: All term papers and Powerpoint presentations due)

November 30: Project Presentations

1) Megan Lemcke: *"Evolutionary Medicine the Future of Medical and Cancer Research"*

2) Conan Juan: *"Introgression from Archaic Hominins and its Effects on Contemporary Human Health"*

3) Sam Lee: *"Mimicry and its role in supergenes and polymorphisms"*

4) Michelle Larsen: *"Impact of Pleistocene Environmental Factors on the Divergence and Speciation of Mammals"*

5) D'amy Steward: *"The Future of Fisheries Management and Conservation: Evolutionary and Seascape Genomics"*

6) Ulises Nino-Espino: *"A new Model"*

7) Chloe McGlynn: *"Blood and Bones What the study of genomic, archaeological, and paleontological data can reveal about ancient human evolutionary history"*

8) Sophia Calvo: *"The History of Humanity: Characterizing the First Colonization of the Americas: Who, How, & When?"*

9) Helena Wu: *"Effects of Endurance Exercise: Evolution and Epigenetics in Humans"*

December 7: Project Presentations

1) Ian Handler: *"A case for a redefinition of the Last Universal Common Ancestor"*

- 2) **Jonathan Stern:** *"Identifying modern-day selection and categorizing biological pathways under selective pressure from the migration Out Of Africa"*

- 3) **Ashley Coats:** *"The impact of environmental factors on human evolution"*

- 4) **Hannah Berg:** *"Exploring epigenetics and evolution through the eyes of Lamarck and Darwin"*

- 5) **Nikhil Sridhar:** *"Supergenes"*

- 6) **Chris Camitta:** *"The evolution of human language: what genes are responsible and why is it unique?"*

- 7) **Harrison Branner:** *"The Denisovan genome: exploring the rise of the genomics revolution and the fall of physical archeology through the lens of Denisovan genomics"*

- 8) **Victoria Grant:** *"Who am I and where do I belong?"*