

# Syllabus

## **Integrative Biology 35ac – Spring 2025 Human Biological Variation (4 units)**

Lectures: TuTh 9:30-11:00 Location: 2050 VLSB

Instructor: Prof. Rasmus Nielsen (he/him/his)

Email: [rasmus\\_nielsen@berkeley.edu](mailto:rasmus_nielsen@berkeley.edu)

Office: 4153c VLSB, through the door to 4153

Office Hours: Mon 1-2 on zoom or in-person. Make an appointment if you have class during this time. Zoom link for office hours only: <https://berkeley.zoom.us/j/5041367200>

GSI 1: Anna Scharnagl Sections: 101, 102, 103

Email: [anna\\_scharnagl@berkeley.edu](mailto:anna_scharnagl@berkeley.edu)

Office Hours: Mon 2:10-3 PM on zoom at:

<https://berkeley.zoom.us/j/94050587354?pwd=NR7eZnZibxKj2SgESY7MpjF8U6znRR.1>

GSI 2: Erin Voss (she/her/hers) Sections: 104, 110, 111

Email: [erinvoss@berkeley.edu](mailto:erinvoss@berkeley.edu)

Office Hours: Tues 4-5 PM in VLSB 3030 and on Zoom at:

<https://berkeley.zoom.us/j/98003819219>.

GSI 3: Levi Yoder Raskin (he/him/his) Sections 112, 113, 114

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Office Hours: Thu 3-4 PM on zoom at:

<https://berkeley.zoom.us/j/4677431046>

GSI 4: Monica Barbara Arniella (she/her/hers) Sections 105, 106, 107

Email: [monica\\_arniella@berkeley.edu](mailto:monica_arniella@berkeley.edu)

Office Hours: Mon 1-2 PM in VLSB 4110 and on Zoom at:

<https://berkeley.zoom.us/j/94070687861?pwd=D0iG5d6agUTF9GqyTFfoOVbT4FgYMC.1>

GSI 5: Danielle Ward (she/her/hers) Sections 108, 109, 115

Email: [danielle\\_ward@berkeley.edu](mailto:danielle_ward@berkeley.edu)

Office Hours: Wed 4-5 PM in VLSB 4003 and on Zoom at:

<https://berkeley.zoom.us/j/94906832456>

**Section room:** 3030 VLSB (except for Lab.4 which is in 1007 VLSB).

**Who to contact:** Matters regarding attendance in lectures should be directed to Monica Arniella. Matters regarding attendance in sections should be directed to your section GSI. DSP matters should be directed to Levi Raskin. Questions regarding exams and grading should be directed to

your section GSI. Questions regarding essays and creative projects should be directed to Anna Scharnagl.

**Prerequisites:** None.

**Course Format:** The course consists of 3 hours of lectures (Tu, Th 9:30 – 11:00 am) and one hour of exercises and/or discussion each week in section.

**Required Text:** There is no textbook but PDFs with required reading for each lecture is posted on bCourses in the 'Files' folder.

**Recordings:** The lectures will be recorded and will be posted as soon as possible on bCourses. However, in-person attendance of the lectures is required. Note that this material is copyrighted and that you cannot share the recordings with other people.

**Requirements and Grading:** Attendance at lectures and participation in classroom discussions and exercises are required of all students. Attendance in lectures counts for 10% of the final grade. You can miss 3 lectures without receiving any reduction in grade. The lab reports from the sections will account for 30% of the final grade. You can miss only one section without receiving deductions in your grade. There is a midterm (taken during class meeting time) and a final, each of which account for 20% of the course grade. The final exam is non-cumulative, and will only cover material from the last half of the course. In addition, there is an essay which will account for 20% of the grade. The midterm and final are open book exams and you can use any resources available to you, but you cannot communicate with other people while you take the exams.

**Make-up exams:** There will be no make-up exams. However, we encourage students to turn in a creative project. If you receive a higher grade for the creative project than for either the midterm or the final, the grade for the creative project will replace the lowest scoring midterm/final grade.

**Creative Project:** If you are worried about your grade, or can't make it to either the midterm or the final, you are invited to turn in a creative project that can replace either the midterm or the final. This project has to focus on a topic covered in class and can be in the form of an art piece, a poem, a song, a short video, or anything else where you can use your creative skills. Use your imagination – there are no rules except that the project somehow has to illustrate or contextualize concepts from class. The project will be evaluated on how well the concepts from the class are illustrated/contextualized as well as the creative effort undertaken. For more information about the Creative Project, please see the file entitled 'Creative Project' and deposited in the 'Files' folder on Bcourses.

**Essay:** There will be an essay accounting for 20% of your final grade due on May 1<sup>st</sup> at noon. For more information about the Essay, including prompts, please see the file entitled 'EssayGuidelines' and deposited in the 'Files' folder on bCourses.

**Deadlines:** Feb 27<sup>th</sup>: submission of essay topics. March 21<sup>st</sup>: submission of essay introduction and bibliography. April 4<sup>th</sup>: submission of creative project proposal. May 1<sup>st</sup>: creative project and essay due. See also Calendar posted on bCourses.

**Note on respectful dialogue:** In this class we encourage students to engage critically with the class material and to share opinions in a free and open discourse. However, we will cover many topics that can be contentious and very personal and it is important to consider how your opinions might affect your fellow students. It is the expectation that all dialogue in this course is civil and respectful of the dignity of each student. Please follow these community expectations for respectful and conscientious dialogue and refrain from marginalization, misrepresentation or the perpetuation of stereotypes.

**Land acknowledgement:** We recognize that Berkeley sits on the territory of xučyun (Huichin [Hoo-Choon]), the ancestral and unceded land of the Chochenyo (Cho-chen-yo) speaking Ohlone people, the successors of the historic and sovereign Verona Band of Alameda County. This land was and continues to be of great importance to the Muwekma (Muh-wek- muh) Ohlone Tribe and other familial descendants of the Verona Band.

We recognize that every member of the Berkeley community has benefitted, and continues to benefit, from the use and occupation of this land since the institution's founding in 1868. Consistent with our values of community and diversity, we have a responsibility to acknowledge and make visible the university's relationship to Native peoples. By offering this Land Acknowledgement, we affirm Indigenous sovereignty and will work to hold the University of California, Berkeley more accountable to the needs of American Indian and Indigenous peoples. This statement was developed in partnership with the Muwekma Ohlone Tribe and is a living document.

### ***Detailed Lecture Schedule***

*See also Calendar posted on bCourses.*

### **Preliminaries and overview of the class**

1. **Biology, Race, and Identity.** In this lecture I will provide an overview of the material covered in class and the central themes of the class. This is a biology class, and we will cover a number of different issues relating to human biological variation including human evolutionary biology and human genomics. However, we will also try to understand how biology, knowledge about biology, and biological narratives affect society, and in this regard we will investigate several different questions: What role does biology play in identity formation and racial formation? What role does biology have in public discourse on race and how does biology affect human interactions and social structures? We will also discuss how new knowledge and technological advances in genetic research affect

society. We will explore the use, and misuse, of genetic research in public discourse, for example to shape racial identity, establish narratives of inequality based on genetics, and in the commercial promotion of DNA testing.

Below is a list of some **books** that I can recommend for interested students who want to go in depth with topics we will cover in the class. You can start on them now, at the beginning of the class, or perhaps after the class if you have become intrigued and want to go into more depth with some of the topics we have covered. These are recommended but not mandatory readings.

- On DNA studies of human evolution: Rutherford, A. (2017) *A Brief History of Everyone Who Ever Lived: The Human Story Retold Through Our Genes*. The Experiment.
- On human evolution primarily from the perspective of physical anthropology: Humpfrey, L. & C. Stringer (2018) *Our Human Story*. Natural History Museum, London.
- On human genetics, evolution, and heredity. Zimmer, C. (2018) *She Has Her Mother's Laugh: The Powers, Perversions, and Potential of Heredity*. Dutton. An extremely well-written book on hereditarian narratives.
- On race and genetics: Rutherford, A. (2020) *How to Argue With a Racist: What Our Genes Do (and Don't) Say About Human Difference*. Weidenfeld & Nicolson.
- A Philosophical Perspective on Human Evolutionary Genomics. Covers many of the topics we discuss in this class: Winther, R.G. (2022) *Our Genes: Human genomic evolution from the perspective of a philosopher*. Cambridge University Press.
- On race and identity formation: Omi, M. & H., Winant. (2015) *Racial Formation in the United States* (3rd ed.). Routledge. Especially Chapter 4 is relevant.
- On genetic determinism and a critique of the hereditarian view: Lewontin, R.C. (1991) *Biology as Ideology: The Doctrine of DNA*. Harper perennial.
- On the new growth of scientific racism: Saini, A (2019). *Superior: The Return of Race Science*. Beacon Press.
- A recent book focusing specifically on the history of Native Americans with great discussions of ethical research practices: Raff, J. (2022) *Origin: A Genetic History of the Americas*. Twelve Books.

## **Section I. Biological Foundations**

In this section we will cover the basic biological and genetic background needed for sections **II** and **III**. Students who have taken college level biology might find a lot of overlap with previous courses, but we will cover interpretation of population-level data in more detail than what students would have encountered in Biology 1A and 1B.

2. **DNA.** This lecture will provide an introduction to molecular biology and genetics for students with little or no previous exposure to biology. We will cover the central dogma of molecular biology, i.e. the process of transcription of DNA into RNA and the subsequent translation into proteins. We will discuss phenotypes and genotypes, and the relationship between the two, the process of Mendelian segregation, and definitions of genes, loci, and alleles. We will also discuss allele frequencies and the idealized concept of a population as defined in population genetics.

**Mandatory readings:** Lecture notes, Lecture 1+2.

**Suggested additional online resources:**

- [https://en.wikipedia.org/wiki/Introduction\\_to\\_genetics](https://en.wikipedia.org/wiki/Introduction_to_genetics)
- <https://en.wikipedia.org/wiki/Allele>
- [https://en.wikipedia.org/wiki/Mendelian\\_inheritance](https://en.wikipedia.org/wiki/Mendelian_inheritance)

3. **Evolution.** We will discuss basic concepts from evolutionary biology and population genetics and introduce the idea that mutation and changes in allele frequencies are the proximal forces underlying evolutionary change. We will then discuss factors that cause allele frequency changes, including genetic drift and natural selection. We will examine examples from viral and bacterial evolution, including HIV and SARS-CoV-2, that illustrate these concepts, and discuss why these pathogens might be here to stay.

**Mandatory readings:**

- (1) Lecture Notes, Lecture 3.
- (2) The genetic basis of human evolution: <https://open.lib.umn.edu/humanbiology/chapter/1-3-the-genetic-basis-of-evolution/>

(3) Mechanisms of evolution: <https://open.lib.umn.edu/humanbiology/chapter/1-4-mechanisms-of-evolution/>

**Suggested additional online resources:**

- A tutorial on genetic drift and related concepts: <https://evolution.berkeley.edu/evolution-101/microevolution/>

4. **Phylogenetics.** Phylogenies form the basis for our understanding of the diversity of life on earth including humans and our close simian relatives. We will discuss how phylogenies are being estimated and interpreted and we will take a deeper dive into the relationship between humans and other simians. We will examine how it was established that the closest relatives to human are chimpanzees and how the molecular clock is used to date the divergence times between our two species.

**Mandatory readings:**

(1) Lecture Notes, Lecture 4.

(2) <https://open.lib.umn.edu/humanbiology/chapter/1-5-introduction-to-phylogenies/>

(3) <https://open.lib.umn.edu/humanbiology/chapter/1-6-how-phylogenies-are-made/>

**Suggested additional online resources:**

- A tree room field guide from UC Museum of Paleontology:  
<https://evolution.berkeley.edu/the-tree-room/field-guide-to-evolutionary-trees/>

5. **Quantifying genetic diversity.** In this lecture we will explain how geneticists are quantifying genetic variation. We will talk about heterozygosity,  $F_{ST}$ , admixture plots, and PCA plots. To understand these ideas better, we will also discuss the concepts of means and variances of a distribution. We will try to understand how geneticists historically have partitioned variance among and within groups and will discuss Lewontin's classical argument that the vast majority of genetic variation in humans is within groups and not between groups.

**Mandatory readings:** Lecture notes, Lecture 5.

**Suggested additional online resources:**

- Video by Sarah Tishkoff on  $F_{ST}$ : <https://www.youtube.com/watch?v=I8RCOI7n4XI>.

## **Section II. The journey to America**

In this section we will cover recent research and knowledge about the process in which humans spread out across the globe – a journey that for some of us ended in America. Many of the lectures will feature researchers from different American communities that will discuss research into the origin and ancestry of their own community. We will start with the early origins of anatomically modern humans in Africa, and then follow the spread of humans across the world, ending with the meetings of different cultures in America.

6. **Human origins.** This lecture will cover early human origins from Lucy over *H. erectus* to anatomically modern humans. We will cover major evolutionary changes such as the emergence of erect bipedal work and the associated anatomical changes, the increase in cranial capacity, and the use of fire and dietary changes.

**Mandatory readings:** <https://open.lib.umn.edu/humanbiology/chapter/1-7-the-evolution-of-primates/>

**Suggested additional online resources:**

- Short National Geographic video: <https://www.youtube.com/watch?v=ehV-MmuvVMU>
- Video on Ardi and other UC Berkeley research:  
<https://www.youtube.com/watch?v=Yjr0R0jgct4>
- PBS Eons: The Humans That Lived Before Us:  
[https://www.youtube.com/watch?v=\\_ANNQKKwWGk](https://www.youtube.com/watch?v=_ANNQKKwWGk)

7. **The spread out of Africa and the meeting with Neanderthals.** The lecture will cover early human dispersal and the meeting with other hominins, particularly Neanderthals. We will discuss anatomical differences between modern humans and Neanderthals and the DNA evidence that led to the conclusion that humans and Neanderthals interbred and that many humans today carry Neanderthal DNA. We will also discuss the consequences today of the

transfer of DNA from Neanderthals to humans and the way the discovery of Neanderthal introgression has changed the representation of Neanderthals.

**Mandatory readings:** Nielsen et al. 2017. Section: Out of Africa and the meeting with Neanderthals.

**Suggested additional online resources:**

- A DW documentary on Neanderthals: <https://www.youtube.com/watch?v=8p8tFcIQ8K4>
- Paabo describes the sequencing of the Neanderthal genome and the discovery of Human/Neanderthal interbreeding (first 17 minutes):  
<https://www.youtube.com/watch?v=R1R8yrEGAgw>.
- A perspective on how the discovery of Neanderthal introgression has changed the representation of Neanderthals:  
<https://journals.sagepub.com/doi/abs/10.1177/194277861600900104>

8. **Australia and Melanesia.** In this lecture we will look at the early migration of anatomically modern humans into South-East Asia and Australia. We will cover the meeting with the enigmatic Denisovans and talk more about introgression of DNA from other hominins into humans.

**Mandatory readings:** Nielsen et al. 2017. Section: The meetings with Denisovans.

**Suggested additional online resources:**

- A brief Aboriginal history: <https://www.aboriginalheritage.org/history/history/>.
- A collection of Aboriginal Dream Time stories: <https://dreamtime.net.au/dreaming/story-list/>
- More on Denisovans: <https://australian.museum/learn/science/human-evolution/the-denisovans/> Paabo describes the sequencing of the Denisovan genome (From 22 minutes): <https://www.youtube.com/watch?v=R1R8yrEGAgw>.

9. **The Americas I (GL)** This lecture will feature a guest appearance by Dr. Andrés Moreno Estrada. Dr. Estrada is a professor at LANGEBIO Cinvestav, Mexico. He works on human



evolution, adaptation, and population history as well as the biomedical implications of human genetic diversity in underserved populations of the world.

**Mandatory readings:** <https://www.annualreviews.org/doi/10.1146/annurev-genom-083115-022331>

**Suggested additional online resources:**

- <https://academic.oup.com/mbe/article/37/4/994/5652085?login=false>
- <https://www.smithsonianmag.com/science-nature/a-history-of-slavery-and-genocide-is-hidden-in-modern-dna-180947707/>
- <https://www.science.org/content/article/latin-america-s-lost-histories-revealed-modern-dna>
- <https://www.nytimes.com/2016/05/28/science/african-american-dna.html>
- <https://carlzimmer.com/tales-of-african-american-history-found-in-dna-49/>
- <https://www.bbc.com/news/world-africa-53527405>
- <https://www.science.org/content/article/european-diseases-left-genetic-mark-native-americans>
- Again, I also highly recommend the recently published book *Origin: A Genetic History of the Americas* by Jennifer Raff.

10. **The Americas II** (GL) The lecture will feature Dr. Jennifer Raff. Dr. Raff is an Associate Professor of Anthropology at Kansas University. She works on the initial peopling of the Americas and subsequent prehistory of Indigenous populations throughout North America.

**Mandatory readings:** Raff, J. Journey into the Americas. *Scientific American* 324(5): 27-33.

**Suggested additional online resources:**

- A recent review of the Peopling of the Americas:  
<https://www.nature.com/articles/s41586-021-03499-y>
- A collection of Indigenous origin stories:  
<https://www.historymuseum.ca/cmc/exhibitions/aborig/fp/fpz2f02e.html>

- A perspective on genomic research with Indigenous people:  
<https://www.nature.com/articles/s41467-018-05188-3>
- Another perspective on DNA analyses with Indigenous people in the US;  
<https://www.sapiens.org/archaeology/chaco-canyon-nagpra/>
- Podcast with Krystal Tsosie: <https://geneticsunzipped.com/transcripts/2021/12/2/krystal-tsosie-native-american-genetics>.
- This is not an online resource, but I highly recommend the recently published book *Origin: A Genetic History of the Americas* by Jennifer Raff to anybody interested in the history of the Americas.

**11. East Asia and South-East Asia.** (GL) This lecture will feature a guest appearance by Melinda Yang, an expert on analyses of ancient DNA from East Asia.

**Mandatory readings:** <https://theconversation.com/ancient-dna-is-revealing-the-genetic-landscape-of-people-who-first-settled-east-asia-139458>

**Suggested additional online resources:**

- <https://www.pivotscipub.com/hpgg/2/1/0001>
- [https://en.wikipedia.org/wiki/Genetic\\_history\\_of\\_East\\_Asians](https://en.wikipedia.org/wiki/Genetic_history_of_East_Asians)
- <https://www.nature.com/articles/d41586-020-01456-9>
- <http://www.pivotscipub.com/hpgg/2/1/0001/html>

**12. South Asia.** (This lecture will feature Priya Moorjani from the MCB department at UC Berkeley, a leading expert on genetic diversity in South Asia.

**Mandatory readings:** <https://www.nature.com/articles/nature08365> (up to and including the Discussion)

**Suggested additional online resources:**

- [https://en.wikipedia.org/wiki/Genetics\\_and\\_archaeogenetics\\_of\\_South\\_Asia](https://en.wikipedia.org/wiki/Genetics_and_archaeogenetics_of_South_Asia)
- <https://www.science.org/content/article/south-asians-are-descended-mix-farmers-herders-and-hunter-gatherers-ancient-dna-reveals>
- Lecture with Dr. Moorjani: <https://www.youtube.com/watch?v=euLgYgVpEgU>

**13. Africa and African Americans.** This class will feature a guest lecture by Michael Campbell from University of Southern California who is a leading expert on genetic variation in Africa and in the African diaspora.

**Mandatory readings:** Campbell, M.C. 2010. The peopling of the African continent and the diaspora into the new world. *Current Opinion in Genetics & Development* 29: 120-132.

**Suggested additional online resources:**

- The Wikipedia page is quite comprehensive:  
[https://en.wikipedia.org/wiki/Genetic\\_history\\_of\\_Africa](https://en.wikipedia.org/wiki/Genetic_history_of_Africa).
- A news story on current genetic research in Africa and associated challenges:  
<https://www.ft.com/content/eed0555c-5e2b-11ea-b0ab-339c2307bcd4>

**14. Midterm.** The midterm will be in-class.

**15. Europe and the Middle East.** This lecture will cover the transition from paleolithic to the neolithic in the Middle East and in Europe, the successive migrations and population movement inside Europe over the past 5k years, and patterns of diversity and migration in the Roman empire. We will particularly examine how ancient DNA has helped elucidate cultural processes and patterns, and how genetic variation in Europe today reflects the past processes of colonization and migration. We will discuss how social processes of past societies leave traces in the genomes of modern individuals.

**Mandatory readings:** Nielsen et al. 2017. Section: The peopling of Europe.

**Suggested additional online resources:**

- <https://sciencenews.dk/en/the-vikings-had-a-mishmash-of-genes-from-all-over-europe>
- <https://www.science.org/content/article/many-imperial-romans-had-roots-middle-east-genetic-history-shows>

- <https://www.mpg.de/13979712/1009-wisy-052382-social-inequality-in-bronze-age-households>

16. **Polynesia.** (GL) This lecture will feature Keolu Fox, Professor of Anthropology at UCLA, and an associate of the Indigenous Futures lab.

**Mandatory readings:** <https://www.smithsonianmag.com/science-nature/genetic-study-maps-when-and-how-polynesians-settled-the-pacific-islands-180978733/>

**Suggested additional online resources:**

- <https://www.nature.com/articles/s41467-018-05188-3>
- A review of the Peopling of the Pacific primarily focusing on DNA evidence:  
<https://www.sciencedirect.com/science/article/pii/S0047248414002632>
- A comprehensive review of the Peopling of the Pacific focusing on archaeology and linguistics:  
<https://www.annualreviews.org/doi/full/10.1146/annurev.anthro.012809.104936>

### **Section III. Human biological diversity and race**

17. **Diet.** In this lecture we will focus more on how humans have adapted to their shifting diets. We will discuss how humans have adapted to diets that are more or less vegetarian by modulating fatty acid synthesis. We will also discuss how humans have adapted to milk consumption independently in three different regions of the world: Europe, the Middle East, and East Africa. Finally, we will cover risk of obesity and Type-2-Diabetes and the connection to past human adaptation.

**Mandatory readings:** [https://www.cell.com/current-biology/pdf/S0960-9822\(17\)30878-3.pdf](https://www.cell.com/current-biology/pdf/S0960-9822(17)30878-3.pdf)

**Suggested additional online resources:**

- <https://www.annualreviews.org/doi/10.1146/annurev-genom-091416-035340>
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4163920/>
- <https://www.nytimes.com/2018/10/17/us/white-supremacists-science-dna.html>

**18. Infectious Disease.** In this lecture I will give a brief introduction to the human immune system and then discuss how humans and human pathogens have co-evolved. We will return to discussions of viral evolution and why viruses such as Influenza, HIV, and SARS-CoV2 are so difficult to eliminate. We will also discuss the evolutionary causes of auto-immune diseases and allergies.

**Mandatory readings:**

[https://www.jstor.org/stable/pdf/10.13110/humanbiology.89.1.03.pdf?refreqid=excelsior%3A634dc6177d23bc38de802df8028b2a74&ab\\_segments=&origin=&acceptTC=1](https://www.jstor.org/stable/pdf/10.13110/humanbiology.89.1.03.pdf?refreqid=excelsior%3A634dc6177d23bc38de802df8028b2a74&ab_segments=&origin=&acceptTC=1)

**Suggested additional online resources:**

- <https://www.nature.com/articles/nrg2698>
- <https://www.nature.com/articles/nrg3734>
- <https://www.nature.com/articles/nrg3905>

**19. Hair, eye, and skin pigmentation.** Pigmentation is a human trait that has received a lot of interest because it forms a basis for social construction of racial categories. In this lecture we will discuss biology of pigmentation, and variability in pigmentation, among humans. We will discuss the relevance of pigmentation for UV damage and vitamin D deficiency and the evolutionary processes that have helped shape variability in pigmentation. We will also discuss the role of human pigmentation in the construction of human racial categories.

**Mandatory readings:** <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8359960/>

**Suggested additional online resources:**

- [https://en.wikipedia.org/wiki/Human\\_skin\\_color](https://en.wikipedia.org/wiki/Human_skin_color)
- Additional readings: *Part One: Skin in the Game* in A. Rutherford. 2020. *How to Argue With a Racist: What Our Genes Do (and Don't) Say About Human Difference*. Hachette UK, 2020

**20. Sex.** We learn in school that sex (not to be confused with gender) is determined by your chromosomes; if you have 2 X chromosomes you are female, if you have an X and a Y chromosome, you are male. In this lecture we will take a look at the underlying biology and

explore how sex chromosomes determine sex. We will also explore situations that are not as simple, where chromosomal complement does not determine binary sex. Finally, we will discuss sex determination systems where there are more than two sexes and/or where sex is determined by environmental factors.

**Mandatory readings:** <https://www.nature.com/scitable/topicpage/genetic-mechanisms-of-sex-determination-314/>

**Suggested additional online resources:**

- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4077654/>
- <https://embryo.asu.edu/pages/sex-determination-humans>
- [https://en.wikipedia.org/wiki/Sex-determination\\_system](https://en.wikipedia.org/wiki/Sex-determination_system)
- [https://en.wikipedia.org/wiki/Sex\\_and\\_gender\\_distinction](https://en.wikipedia.org/wiki/Sex_and_gender_distinction)
- <https://www.plannedparenthood.org/learn/gender-identity/sex-gender-identity>

21. **Heritability.** We will introduce the concept of heritability and how it is defined genetically and mathematically. We will then discuss methods that have been used for estimating heritability in humans and other organisms and also discuss some of the challenges associated with accurate estimation of heritability in humans. We will discuss the impact of arguments of heritability on the discourse on causes of inequality and the connections between genetic determinism and racism.

**Mandatory readings:**

- Lecture Notes, Lecture 21.
- <http://www.nealelab.is/blog/2017/9/13/heritability-101-what-is-heritability>

**Suggested additional online resources:**

- <https://en.wikipedia.org/wiki/Heritability>
- <https://link.springer.com/content/pdf/10.1023/A:1018352202363.pdf>
- I can recommend the classical book by Gould for a historical perspective: Gould, S. J. (1981). *The Mismeasure of Man*. W. W. Norton & Company.

**22. Finding the genetic basis of human traits.** In this lecture we will discuss the common methods used by geneticists to identify which genetic variants underly human traits, particularly susceptibility to disease. We will talk about association analyses and Genome Wide Association Studies (GWAS) and introduce the Manhattan plot. We will talk about prediction of human traits and discuss some of the historical successes and failures of GWAS, and the challenges of confounders.

**Mandatory readings:**

- Lecture Notes, Lecture 22
- <https://magazine.scienceforthepeople.org/vol23-3-bio-politics/genetic-basis-genome-wide-association-studies-risk/>

**Suggested additional online resources:**

- [https://en.wikipedia.org/wiki/Genome-wide\\_association\\_study](https://en.wikipedia.org/wiki/Genome-wide_association_study)
- <https://medlineplus.gov/genetics/understanding/genomicresearch/gwastudies/>
- <https://www.nature.com/articles/s41576-019-0127-1>

**23. Consumer genetics.** Following the explosion in GWAS studies, a number of companies have been established that use genetic prediction to appeal to consumers in one way or another. In this lecture we will look more at methods for genetic prediction and critically assess the claims of some of the consumer genetics companies.

- **Mandatory readings:** Notes and <https://blogs.scientificamerican.com/observations/the-problem-with-direct-to-consumer-genetic-tests/>

**Suggested additional online resources:**

- <https://medlineplus.gov/genetics/understanding/dtcgeneticstesting/dtcrisksbenefits/>

**24. Genetic ancestries.** Consumer genetics companies have introduced ancestry assignment as a new integral part of American culture. We will look under the hood of ancestry assignment methods to understand the underlying genetic and statistical methodology and assumptions and we will look at maps of inferred genetic ancestry in the United States. We will also discuss the impact of genetic ancestry analyses for identity formation.

**Mandatory readings:**

- Lecture Notes, Lecture 24.
- <https://as.nyu.edu/content/dam/nyu-as/cns/documents/2021raceandracismworkshop/2007%20Bolnick.pdf>

**Suggested additional online resources:**

- <https://compass.onlinelibrary.wiley.com/doi/10.1111/soc4.13011?af=R>
- <https://humgenomics.biomedcentral.com/articles/10.1186/s40246-014-0023-x>
- <https://daily.jstor.org/the-trouble-with-native-dna/>
- <https://www.dukeupress.edu/hawaiian-blood>

25. **The history of Eugenics and racial science.** Eugenics is the idea that the human species can be improved by selective breeding. This lecture will cover the history of eugenics including Galton and the early eugenicists, eugenic laws in America, the consequences of eugenic programs in the middle 20<sup>th</sup> century, and the modern resurgence of eugenic thinking in the light of genomic discoveries. We will also discuss the history of race science, including phrenology, and its connection to eugenics.

**Mandatory readings:** <https://www.nature.com/articles/35038589>

**Suggested additional online resources:**

- NIH resources on eugenics: <https://www.genome.gov/about-genomics/fact-sheets/Eugenics-and-Scientific-Racism>
- <https://www.newyorker.com/books/page-turner/the-forgotten-lessons-of-the-american-eugenics-movement>
- This is not online, but if you are interested in eugenics in the past and present, I highly recommend Rutherford's recent book: Rutherford, A. (2022) *Control: The Dark History and Troubling Present of Eugenics*. W. W. Norton & Company
- Youtube video with Rutherford: <https://www.youtube.com/watch?v=8DgU1-ide3s>

26. **Concepts of race.** Discussions of race is an integral part of public discourse in the US – but what is race really? We will discuss different definitions of race from a historical perspective



and examine arguments regarding the biological reality of race in the light of modern genomic evidence. We will also explore how arguments of race as a social construct can be aligned with the lived experiences of many people of race as a very real thing. Finally, we will discuss Omi and Winant's theory of racial formation and the concept of racial projects.

**Mandatory readings:** <https://www.discovermagazine.com/planet-earth/race-is-real-but-its-not-genetic>

**Suggested additional online resources:**

- Chapter 4 of Omi, M. and H., Winant. 2015. *Racial Formation in the United States* (3rd ed.), New York: Routledge
- [https://en.wikipedia.org/wiki/Race\\_and\\_genetics](https://en.wikipedia.org/wiki/Race_and_genetics)
- [https://en.wikipedia.org/wiki/Race\\_\(human\\_categorization\)](https://en.wikipedia.org/wiki/Race_(human_categorization))
- <https://race.undark.org/articles/race-is-a-biological-fiction-it-is-also-a-powerful-social-reality>

**27. Race and genetics in America today.** We will look at race concepts in the United States today and the role of biological narratives in modern race debates. We discuss the resurgence of genetic determinism and common hereditarian fallacies in public discourse. We will look at inequality today, and discuss historical and modern narratives of inequality and the role of hereditarian ideas in modern claims of meritocracy. We will also examine the causes of disparities between races in modern United States.

**Mandatory readings:** <https://inequality.org/facts/racial-inequality/>

**Suggested additional online resources:**

- [https://en.wikipedia.org/wiki/Biological\\_determinism](https://en.wikipedia.org/wiki/Biological_determinism)
- <https://www.washingtonpost.com/news/monkey-cage/wp/2015/09/28/born-that-way-scientific-racism-is-creeping-back-into-our-thinking-heres-what-to-watch-out-for/>
- National Geographic's Race Card Project:  
<https://www.nationalgeographic.com/history/topic/race-in-america>

- This is not an online resource, but for students interested in gaining a deep understanding of narratives of inequality I recommend: Piketty, T. (2020) *Capital and Ideology*. Harvard University Press. (Warning: 1,150 pages!).

28. **Review.** This lecture is reserved for class review and Q&A for the final. No assigned readings.