**S15056: The Evolution of Sex**

*About the instructor:*

I am a first-year MIT Biology Ph.D. student who recently joined David Page's lab at the Whitehead Institute, which has studied the evolution of sex chromosomes for more than 30 years. Prior to coming to MIT, I worked at the Rockefeller University in Paul Cohen's lab and studied how we might be able to uncouple obesity and disease. I did my undergrad education at Wesleyan University in Middletown, Connecticut and was also in a research lab there! My first research experience was studying how the ribosome—life’s oldest molecular machine—works in atomic detail. Outside of science, I love to engage with the visual arts, specifically photography. I grew up in Port St. Lucie, Florida and so love the outdoors, which formed my initial desire to study the natural world.

*Course description:*

This course will plot the evolutionary trajectory of the biological phenomena involving the exchange of genetic material (DNA) between two members of the same species, the broadest definition of “sex” (v.) currently accepted. We will start by reviewing the basics of how genetic material is inherited and specifies traits in all life forms known. Then, we will examine ways in which bacteria have evolved billion-year-old mechanisms of exchanging their genetic material. Next, we will examine the appearance of classical sexual reproduction in unicellular eukaryotes via meiosis. Moving into the metazoa, we will then explore how “dimorphic gametes” arose and how they form the currently accepted biological definitions of “male” and “female.” Finally, we will look at the emergence of the sex chromosomes in many species—including our own.

This course reverses the order in which we’re typically taught about biological sex. Often courses begin with the human/mammalian case of XX and XY chromosomes, even though these are some of the more recent additions to life on earth and some of the least understood at the molecular level. We will spend our final week in the course examining how our understanding of the evolution and biology of sex affects the more human realms of medicine and society.

*Course expectations:*

This course should be appropriate and accessible to all who are curious about the material and who have had at least one life science class in middle or high school. Some of the topics may be more advanced, but I hope that this class will serve to expose curious minds to topics that they wouldn’t otherwise learn about in a relatively stress-free environment. I will include two **OPTIONAL** background readings—one more accessible, and one more challenging before each class and I expect that those who will gain the most from the lectures will have read through these before class. **I encourage the most-engaged members of the course write up an OPTIONAL** **1500-word essay due at the end of the course answering one question: How does your understanding of biological sex affect the way you view the world?**

*Course format:*

The course will consist of six Zoom lectures throughout the summer. Each lecture will incorporate time for questions at both the midpoint and at the end of class. Two main readings will be distributed online at least one week before class, with additional videos and readings listed to expand on the topics for that lecture. All work outside of class is **OPTIONAL**. Time permitting, students may self-organize into small discussion groups to reflect on the material that they’ve learned throughout lecture. I strongly encourage this mostly to get to know one other, as you may be from different backgrounds and yet you all share at least one common interest (this course!). There will be an optional final essay due at the end of the course.

*Course schedule:*

The course will begin on Saturday, July 9th and end on Saturday, August 13th, a total of six weeks. All sessions will occur via Zoom on Saturdays from **1-2PM EST**. There will be six sessions in total, which are outlined below. All resources are provided to students under academic fair use.

1. **Session 1: DNA is the hereditary material**

Main readings:

* [Lodish et al (2008), *Molecular Cell Biology (6th edition)*; “Chapter 4: Basic Molecular Genetic Mechanisms”](https://drive.google.com/file/d/1xFwfBRCwEF_WSaI5oy3YBareOYwy7bdk/view?usp=sharing)
* [Mendel, Gregor (1865), *Proceedings of the Brünn Natural History Society*; “Experiments in Plant Hybridization”](http://www.esp.org/foundations/genetics/classical/gm-65.pdf)

Other materials:

* [Cobb, Matther (2017), *PLOS Biology;* “60 years ago, Francis Crick changed the logic of biology”](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5602739/)
* [Lander, Eric (2012), *MIT OpenCourseware*; “Transcription and Translation, excerpt 1 | MIT 7.01SC Fundamentals of Biology”](https://www.youtube.com/watch?v=tMr9XH64rtM&t=157s)
* [Lander, Eric (2012), *MIT OpenCourseware*; “Transcription and Translation, excerpt 2 | MIT 7.01SC Fundamentals of Biology”](https://www.youtube.com/watch?v=uBRdfsz_YB4)

1. **Session 2: Sexual recombination in bacteria**

Main readings:

* Kimball JW (2017), Kimball's Biology Pages. ["Genetic Recombination in Bacteria"](http://www.biology-pages.info/A/Avery.html).
* [Didelot & Maiden (2010), *Trends in Microbiology*. “Impact of recombination on bacterial evolution”](https://www.cell.com/trends/microbiology/fulltext/S0966-842X(10)00059-4?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0966842X10000594%3Fshowall%3Dtrue#relatedArticles)

Other materials:

* [Henrik’s Lab (2021), “Transformation, Transduction and Conjugation (Horizontal Gene Transfer in Bacteria)”](https://www.youtube.com/watch?v=7tLV20dk-FM)
* [Davies & Davies (2010), *Microbiology and Molecular Biology Reviews*; “Origins and Evolution of Antibiotic Resistance”](https://journals.asm.org/doi/full/10.1128/MMBR.00016-10)
* [Koonin & Makarova (2019), *Philosophical Transactions of the Royal Society B*; “Origins and evolution of CRISPR-Cas systems”](https://royalsocietypublishing.org/doi/full/10.1098/rstb.2018.0087)
* [Pursey et al (2021), *Philosophical Transactions of the Royal Society B*; “CRISPR-Cas is associated with fewer antibiotic resistance genes in bacterial pathogens”](https://royalsocietypublishing.org/doi/full/10.1098/rstb.2020.0464?casa_token=Iyw--LAn41UAAAAA%3A71XhKpxR7pS8Uzo9yQE4K9jDr8lpaTZy9jPzmegg5XieHoFq43zxDizvW31DfGhoMIHofFZvvraucfA)

1. **Session 3: Eukaryotic sexual reproduction and meiosis**

Main readings:

* [*Wikipedia*, “Origin and function of meiosis”](https://en.wikipedia.org/wiki/Origin_and_function_of_meiosis#cite_note-pmid19139151-4)
* [Wilkins & Holliday (2009), *Genetics*; “The Evolution of Meiosis From Mitosis”](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2621177/)
* [Bernstein & Bernstein (2017), *Sexual Communication in Archaea, the Precursor to Eukaryotic Meiosis*; Chapter 7: Sexual Communication in Archaea, the Precursor to Eukaryotic Meiosis”](https://link.springer.com/content/pdf/10.1007/978-3-319-65536-9.pdf)

Other materials:

* [Lenormand et al (2016), *Philosophical Transactions of the Royal Society B*; “Evolutionary mysteries in meiosis”](https://royalsocietypublishing.org/doi/10.1098/rstb.2016.0001)
* [Maynard Smith, John (1978), *The Evolution of Sex*; Chapter 5-7](https://archive.org/details/evolutionofsex0000mayn/page/n9/mode/2up)

1. **Session 4: Multicellular life and dimorphic gametes**

Main readings:

* [Dawson, Ines (2017); *Draw Curiosity*; “Why Did Two Sexes Evolve?”](https://www.youtube.com/watch?v=ehuEaLvA1B4)
* [Parker, Baker, & Smith (1972), *Journal of Theoretical Biology*; “The origin and evolution of gamete dimorphism and the male-female phenomenon”](https://www.sciencedirect.com/science/article/abs/pii/0022519372900070)

Other materials:

* TBD

1. **Session 5: Sex chromosomes**

Main readings:

* [Page, David, *TedXBeaconStreet*; “Why Sex Really Matters”](https://www.youtube.com/watch?v=nQcgD5DpVlQ)
* [Bellott et al (2014), *Nature*; “Mammalian Y chromosomes retain widely expressed, dosage-sensitive regulators”](https://www.pagelab.wi.mit.edu/_files/ugd/8c39a0_d2b6d4e6d0e546839ce3eb3eda301b8f.pdf)

Other materials:

* [Furman et al (2020), *Genome Biology & Evolution*; “Sex Chromosome Evolution: So Many Exceptions to the Rules”](https://academic.oup.com/gbe/article/12/6/750/5823304)
* [*SciShow* (2021); “Why Y Chromosomes Won’t Be Around Forever”](https://www.youtube.com/watch?v=of7vrIIcTa0)

1. **Session 6: Biological sex in medicine and society**

Main readings:

* [Woodruff, Teresa (2014), *Proceedings of the National Academy of Sciences*; “Sex, equity, and science”](https://www.pnas.org/doi/epdf/10.1073/pnas.1404203111)
* [Zeeman et al (2018), *European Journal of Public Health*, “A review of lesbian, gay, bisexual, trans and intersex (LGBTI) health and healthcare inequalities”](https://academic.oup.com/eurpub/article/29/5/974/5151209?login=true)

Other materials:

* [Teo, Thomas, *Theoretical psychology*; “Theory and empirical research: Can scientific ideas be violent?”](https://www.academia.edu/download/28738311/Teo2011Can.pdf)
* [Schonig, Jordan (2020), *Film & Media Studies with Jordan Schonig*; “Judith Butler's Theory of Gender Performativity, Explained”](https://www.youtube.com/watch?v=0XFg8f1STLk)
* [Schonig, Jordan (2020), *Film & Media Studies with Jordan Schonig*; “Judith Butler's Gender Performativity, Part 2: What is “Performativity?””](https://www.youtube.com/watch?v=0_DZgwQcUl8&t=0s)