The Genetics of Species Interactions
Bio 490S-02
MW 3:05-4:20
Languages 208
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What mutations in *Yersinia pestis* made the changes that let the Black Death sweep across half the world? How can one new allele cause the rapid formation of dozens of new species? What are some of the key genetic innovations that turned wolves into pets?

A complex web of species interactions shapes the living world that we see; but what is the basis of these interactions? What genes control the traits (physical and behavioral) that affect these interactions? How are the genetic patterns of such diverse interactions as human disease, parasitism, mimicry, and speciation studied? In this course we will discuss the genetics of species interactions across a wide range of taxa and types of interactions by focusing on specific case studies, including humans, domesticated species, and natural systems. Class sessions will alternate background material with student-led discussions of the primary literature. Over the course of the semester students will research a topic of interest and develop a question into a research proposal.

Course objectives:
By the end of the course, students will be able to:
1. Describe and analyze real biological examples of antagonistic and mutualistic interactions.
2. Explicitly connect the genetic, mechanistic, and ecological/evolutionary levels of interactions.
3. Compare patterns of interactions across multiple taxa.
4. Develop a novel research question and identify appropriate experimental methods to address it.
5. Lead an interactive discussion of a scientific paper.

Assignments:
Weekly quizzes: Two papers will be assigned each week, to be read before the class session in which we will be discussing them. Each week will have a short (3-5 question) quiz on Sakai, which will be due by noon the day of the discussion. Technical problems will not be considered an excuse for missing a quiz, so I'd encourage you to submit them early. I will drop the lowest quiz grade for each student.

Leading the discussion: Each of you will take turns leading the class discussion. The week before you lead, I will meet with you to talk about the papers and make sure you're on track to for leading. Discussion leaders will also be responsible for

emailing a list of 4-6 questions to the class at least three days before the discussion will take place.

Two shorter writing assignments, each 3-4 pages (double-spaced):
First paper: Pick an interaction of your choice; it can be either one that you find that you think is interesting, one that was mentioned in class, or one that we haven't talked about yet, but not one that we've already discussed in depth. Research the genetic mechanisms underlying it and describe how those translate into traits and ecological/evolutionary consequences.

Second paper: Explicitly compare/contrast two interactions. They may be as close (humans interacting with two different pathogens) or as distant (a plant defending against herbivores and an animal evading predation) as you would like, although pick two that have enough similarities that you can make a meaningful comparison. You can pick whatever interactions you want, including any that we have or will discuss in class. Your comparison must include some consideration of the genetics and the ecological/evolutionary implications of the interactions, ideally explicitly connecting the two.

Research proposal: For your final assignment, you will write a research proposal (similar to a grant proposal) for a project investigating a question that you have identified and researched. This question must be a novel and feasible problem, in any system that you want to propose. A rubric for the assignment will be distributed later in the semester. Components of this project will include:

> A short (5 minutes) presentation of background material on a topic that you're interested in doing your proposal on. This presentation doesn't have to include original ideas, just a start on the background research. Presentations will be the week of Oct 26.
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> An abstract (<500 words), due to me by Nov 2. I'll give you feedback on this, to help ensure that your project is moving in the right direction.
>
> A written proposal, 7-10 pages double-spaced. This must include background information, 2-3 specific aims for the research, experimental approach and justification for each one, and a conclusion summarizing the intellectual merit of the project.
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> A presentation to the class. Using PowerPoint or another presentation software, you will each give a 12 minute presentation of your project, including context, methodology, and what it will contribute to the body of knowledge.

Attendance and Participation:
Because this is a discussion-based course, attendance and participation are very important. And because there is no textbook, missing background days will also be

hard to make up. Each student will get three absences that can be made up with a 2 page paper summarizing the topic that we talked about or the papers that we discussed. These make-up papers will be due within a week of the absence. Any more absences for any reason other than an illness (all cases of illness require that a STINF be submitted), athletic event, or religious observance will not be possible to make up. In the case of a personal or family emergency, please speak to your academic dean. For more information on excused absences, please refer to the academic policies on the Student Affairs website.

During discussions and class activities, merely being present is not sufficient; being in the room will only get you half of the participation points for the day. Everyone is expected to speak up at least once per discussion. Participation grades will not be determined by number of times you speak, but by how well your participation demonstrates your engagement with the material (note: this doesn't mean you have to have the right answer to get participation points; questions demonstrate engagement just as well as knowing the answer).

Grading:
The course grade will be calculated as follows:

Attendance/participation	15%
Leading the class discussion	25%
Weekly quizzes and short assignments	10%
Paper #1	7%
Paper #2	7%
Presentation	6%
Final research proposal	20%
Final presentation	10%

Text: No textbook for this course; all readings will be posted on Sakai.

Disability Statement: Any students with concerns about accommodations for a disability are encouraged to speak to the Office of Services for Students with Disabilities at 684-5917 or disabilities@aas.duke.edu.

Academic Integrity: All students in the course are expected to maintain the Duke Community Standard. Plagiarism is not acceptable; this includes not only unattributed information, but any wording that is identical or highly similar to another source, even if cited. Make sure everything is in your own words, and if you have any questions, ask first. All cases of academic dishonesty will be referred to the Office of Student Conduct, as well as incurring a grade of zero on the assignment.

Tentative schedule:

Week 1:
Aug 29 Introduction

Aug 31 Mini-discussion
Fossoy *et al* 2016. Ancient origin and maternal inheritance of blue cuckoo eggs.

Week 2: Pollination: a color-change locus, pollinator preference, and speciation
Sep 5
Sep 7 Bradshaw and Schemske 2003. Allele substitution at a flower colour locus produces a pollinator shift in monkeyflowers.
Yuan *et al* 2013. Genetic dissection of a major anthocyanin QTL contributing to pollinator-mediated reproductive isolation between sister species of *Mimulus*.

Week 3: Genetics of speciation
Sep 12
Sep 14 Noor *et al* 2001. Chromosomal inversions and the reproductive isolation of species.
Matute and Gavin-Smyth 2014. Fine mapping of dominant X-linked incompatibility alleles in *Drosophila* hybrids.

Week 4: Gene-for-gene: genetics and mechanisms of disease resistance in plants
Sep 19 **First paper due**
Sep 21 Karasov *et al* 2014. The long-term maintenance of a resistance polymorphism through diffuse interactions.
Horger *et al* 2012. Balancing selection at the tomato *RCR3* guardee gene family maintains variation in strength of pathogen defense.

Week 5: Mimicry: wing patterning in *Heliconius* butterflies
Sep 26
Sep 28 Reed *et al* 2011. *optix* drives the repeated convergent evolution of butterfly wing pattern mimicry.
The Heliconius Genome Consortium. Butterfly genome reveals promiscuous exchange of mimicry adaptations among species.

Week 6: Ancient Diseases: virulence in Bubonic plague and potato blight
Oct 3
Oct 5 Rasmussen *et al* 2015. Early divergent strains of *Yersinia pestis* in Eurasia 5,000 years ago.
Martin *et al* 2013. Reconstructing genome evolution in historic samples of the Irish potato famine pathogen.

Week 7: Co-diversification: a new detoxification gene and subsequent speciation
Oct 10 Fall break, no class
Oct 12 **Second paper due**
Ehrlich and Raven 1964. Butterflies and plants: a study in coevolution

Wheat *et al* 2007. The genetic basis of a plant-insect coevolutionary key innovation.

Week 8: Predation: crypsis and mutations in a color gene in field mice
Oct 17
Oct 19 Hoekstra *et al* 2004. Ecological genetics of adaptive color polymorphism in pocket mice: geographic variation in selected and neutral genes.
Linnen *et al* 2013. Adaptive evolution of multiple traits through multiple mutations at a single gene.

Week 11: Parasitism: the genetic architecture of defense
Oct 24
Oct 26 Routtu and Ebert 2014. Genetic architecture of resistance in *Daphnia* hosts against two species of host-specific parasites.
Barribeau *et al* 2014. Gene expression differences underlying genotype-by-genotype specificity in a host-parasite system.

Week 10: **Student background presentations**
Oct 31
Nov 2

Week 9: Parasitism: overdominance, sickle cell anemia and resistance to malaria
Nov 7 **Research abstracts due**
Nov 9 Piel et al 2010. Global distribution of the sickle cell gene and geographical confirmation of the malaria hypothesis.
Williams *et al* 2005. Negative epistasis between the malaria-protective effects of α^{+}-thalassemia and the sickle cell trait.

Week 12: Domestication: how have we changed the species around us?
Nov 14
Nov 16 Axelsson *et al* 2010. The genomic signature of dog domestication reveals adaptation to a starch-rich diet.
Montague *et al* 2014. Comparative analysis of the domestic cat genome reveals genetic signatures underlying feline biology and domestication.

Week 13:
Nov 21
Nov 23 Thanksgiving break, no class

Week 14: Student presentations
Nov 28
Nov 30

Week 15: Student presentations
Dec 5
Dec 7