Study Guide for Exam 3

(Exam 3 will be held Tuesday, April 16, 2019)

This study guide will grow with a new section added after each lecture, so please revisit it often! Pace your studying so that you master each set of concepts before the next lecture.

Tuesday, March 12: Introduction to natural selection

- What are the three ingredients required for natural selection?
- What is the result of natural selection?
- When does natural selection not lead to evolution?
- What is the difference between viability and fecundity?
- Define fitness (Darwinian fitness, not physical fitness)
- Does “survival of the fittest” accurately describe natural selection? Why or why not?
- What tends to happen to populations of daisies that become established on small islands?
- Why did soapberry bugs in Florida evolve smaller beaks whereas those in south-central US evolved larger beaks?

Thursday, March 14: Natural selection at a single locus

- What gene controls bony armor in threespine sticklebacks? Is it dominant? If so, which allele is dominant?
- Threespine stickleback populations evolve when they become permanently trapped in inland freshwater lakes. Describe the typical evolutionary change that happens in these freshwater stickleback populations.
- What is a selective sweep? What is meant when the term “hitchhiking” is used in the context of a selective sweep?
- How does the G allele from the PtFT2 locus benefit European aspen living in the northern half of Sweden?
- Is it possible for a trait to become fixed in a population when it is not the underlying cause of fitness differences? (Hint: consider Fig. 3.14 in the textbook.)

Tuesday, March 26: Modeling natural selection

- Be sure you can obtain allele frequencies if you are given genotype frequencies.
- Be sure you can obtain genotype frequencies if you are given allele frequencies (and asked to assume random mating).
- Be sure you understand how to calculate the mean fitness.

- Be sure you can compute genotype frequencies after selection given the fitness of each genotype and genotype frequencies before selection.

Thursday, March 28: Rise and fall of the melanic peppered moth

- Why did the dark melanic allele evolve to near fixation in British peppered moths in the late 1800s?
- Define selection coefficient. What does it mean if the selection coefficient is 0? What does it mean if the selection coefficient is 1?
- Use the "Peppered moth in the 1800s" applet to estimate the selection coefficient needed to explain the rise of the melanic phenotype from a frequency of 0.01 to 0.99 over 50 years.
- Why did the light colored allele evolve to near fixation in recent decades?
- Use the "Peppered moth in the 1900s" applet to explore values of the selection coefficient in a model that attempts to explain the recent demise of the melanic phenotype. Does it appear that selection pressure has been constant over the 40 years from 1960 to 2000? If not, has selection against the melanic phenotype increased or decreased?

Tuesday, April 2: Balancing selection, quantitative traits, heritability

- How does the model for β-hemoglobin (sickle-cell vs. normal alleles) differ from the model for peppered moth (melanic vs. normal alleles)?
- Plotting mean fitness (vertical axis) against allele frequency (horizontal axis), what is the main difference between the mean fitness curve for balancing selection compared to the mean fitness curve for directional selection?
- How does a quantitative trait differ from a Mendelian trait?
- What is a purely additive locus? What is additive genetic variance?
- What effect does environmental variation have on trait variance compared to the additive genetic variance?
- How is heritability (h^2) defined in terms of variance? How is it possible for a trait that is genetically determined to have low heritability?
- Heritability is the slope of a line in what kind of plot? That is, what quantities are plotted on the horizontal and vertical axes of this plot?
- What is the selection differential (S)?
- What is the response to selection (R)?
- How does the breeder's equation relate heritability, selection differential, and the response to selection?

Thursday, April 4: Quantitative trait evolution by natural selection

- Does dominance in a locus increase or decrease the phenotypic (trait) variance compared to the additive genetic variance?
- How would you calculate the heritability of a trait if the additive, environmental, and dominance variance components are known?
- The selection gradient is the slope of a line in what kind of plot? That is, what quantities are plotted on the horizontal and vertical axes of this plot?
- Why did the mean beak depth of Geospiza fortis (Medium Ground Finch) birds increase from 1976 to 1978? Was the selection gradient positive, negative, or zero during the 1977 drought? Is this an example of directional, stabilizing, or disruptive selection?
- Which of the following types of selection primarily affects the variance of a trait? Which primarily affects the mean of the trait? Choices: directional, stabilizing, disruptive.
- Is a trait that undergoes a shift in mean across generations necessarily under selection? That is, what is the difference between selection "of" a trait and selection "for" a trait?

Tuesday, April 9: Molecular evolution, sexual selection

- Which sites in a protein-coding DNA sequence are most likely to be selectively neutral (i.e. redundancy in the genetic code allows for any mutation at the site without affecting the amino acid inserted into the polypeptide)?
- What pattern of substitutions in an alignment of the same sequence across diverse taxa tells you that a region of DNA not only codes for a protein but also that the protein is important to the fitness of the organisms? (See the RuBisCO large subunit DNA handout on the Exam Review page of the course website.)
- What is the difference between sexual selection and natural selection?
- What is the difference between intersexual selection and intrasexual selection?
- What is sperm competition and how does the female *Parnassius* butterfly shown in class with the plug in her abdomen have to do with sperm competition? Is sperm competition classified as intra- or inter-sexual selection?
- Does intrasexual selection involve male-male or female-female interactions? Why is it usually one and not the other?
- What different forms can intrasexual selection take?
- What is the "good genes" hypothesis? Is it an example of intra- or inter-sexual selection? Explain the example given in class (use Figs. 6.11 and 10.16 in your explanation)

- Can sexual selection favor traits in organisms that natural selection would tend to reduce or eliminate? Can you name an example?

Thursday, April 11: Sexual selection, Hardy-Weinberg

- What is Fisher's runaway sexual selection? How is it similar to the good genes hypothesis, and how is it different?
- What was confirmed by Andersson's long-tailed widowbird experiment? What was the primary conclusion?
- What did Savalli later find when he performed a similar experiment on a different widowbird species?
- Haldane's 1924 model for the rise of the peppered moth melanic phenotype in the late 1800s predicts a perfect straight line (no change in allele or genotype frequencies at all) if the selection coefficient is set to zero. What assumption of this model is violated by every real population?
- If you could assume that a population was in Hardy-Weinberg equilibrium, what predictions could you make about allele frequencies? Genotype frequencies?
- What 4 assumptions are required for Hardy-Weinberg equilibrium?
- Some amount of self-fertilization ("selfing") is common in flowering plants that have bisexual flowers , which produce both sperm (2 of the 3 cells composing a pollen grain) and eggs. If a plant population was in Hardy-Weinberg equilibrium, but began reproducing only by selfing, what effect would this have on allele frequencies in subsequent generations? Genotype frequencies?
- Is inbreeding (e.g. selfing) expected to result in evolution by itself?

About the exam

- The 100 points is distributed as follows:
  - 40 points are in the form of pure matching questions
  - 6 points involve matching but ask for some explanation of your choice
  - 6 points are in the form of multiple choice questions
  - 3 points involve labeling a diagram
  - 20 points are in the form of short-answer/fill-in-the-blank questions
  - 20 points involve an exercise similar to that in the "Natural selection genotype/allele frequencies" handout
  - 5 points involve using formulas presented in lecture (the formulas will be provided, but you need to know what the individual terms mean)
- A multiplication table and list of formulas will be provided, as well as a list of fractions and their decimal equivalents

- About 20% of the test requires you to remember aspects of some of the case studies used to illustrate natural selection. Case studies include island daisies, soapberry bugs, peppered moths, Darwin's finches, hemoglobin in humans, sticklebacks, and aspens.