Worksheet: Natural Selection and Speciation

1. What is absolute fitness? Relative fitness? How are they measured? Absolute fitness is quantified as the mean number of surviving offspring for a particular genotype across all individuals of that genotype in the population. Relative fitness is the ratio of the absolute fitness of a particular genotype divided by the absolute fitness of the fittest genotype in the population.

2. Darwin made a simple and cogent argument for natural selection as a mechanism of evolution. Describe the three empirical observations that Darwin made upon which he based his argument and the logical deduction that follows from these observations. His first observation was that individuals of a species vary in their traits and that this variation is heritable. Second, he observed that organisms produce more offspring than survive. Third, he recognized the role of competition in nature and the degree to which competition for limited resources acts to limit individual survival and reproduction. The logical consequence Darwin put forth based on these observations was that the most competitive individuals would persist and reproduce, whereas those that are not would die. Over time, individuals with favorable traits will become more common in the population.

3. The insecticide DDT has been widely used to control the mosquitoes that carry malaria. How would you explain the fact that many mosquito populations are now resistant to DDT? As a powerful insecticide, DDT can kill mosquitoes that carry malaria. Because DDT was widely applied to control mosquito populations, a random mutation at a single locus emerged that conferred DDT resistance to mosquitoes carrying malaria. As a result, the DDT resistance mutation is present at low frequencies in populations that had previously been sprayed with DDT. If DDT is applied to these populations, natural selection will favor individuals that are resistant to DDT. Because DDT exerts a strong selection force against non-resistant mosquitoes, the frequency of DDT resistant individuals increases in these populations.

4. Do individuals or populations evolve through the process of natural selection? Explain your answer. Populations evolve; individuals do not. As an evolutionary process, natural selection involves changes in allele frequencies in a population; that is, favorable traits become more common in a population over time. Therefore, natural selection is a population level phenomenon in which individuals in a population who are more well suited (i.e., have more favorable adaptations) to their environment tend to survive longer (differential survival) and produce more offspring (differential reproduction) than those who are less well suited. Because natural selection occurs at the level of the population, the population is considered the unit of evolution.

5. What is the difference between a gene and an allele? A gene is a heritable sequence of DNA that codes for a particular characteristic of an organism (e.g., flower color, beak size). An allele is one of two or more alternate forms of a gene (e.g., white or purple flowers, large or small beak size, etc.).

6. *Ensatina* salamanders occur at mid-elevations in the Coast Range and Sierra Nevada of California and are living examples of evolutionary divergence and ecotype variation.

   a. Explain how this pattern of ecotypic variation could occur. *Ensatina* salamanders occur over a large geographic range in CA that itself has a wide range of local habitat variation. About 5 million years ago, a common ancestral species migrated southward from Oregon to occupy mid-
elevations in the Coast Ranges and Sierra Nevada (forming a ring-shaped geographic range). Sub-populations of *Ensatina* adapted to local environmental conditions across their geographic range. Neighboring sub-populations can interbreed. [However, those occurring in the far south on either side of the ring either cannot interbreed or do so rarely. Thus, a reproductive barrier exists that likely occurred because those southern populations on either side of the ring have been separated for a long time and appear to have diverged genetically to the point where they have become reproductively isolated.]

b. What evolutionary forces could cause the observed color and pattern differences on the skin among sub-populations of *Ensatina* salamanders? Why might these color and pattern differences have occurred? What type of selection pressure might have been responsible? Mutation and natural selection are most likely to introduce new color variants in the populations. Such color and pattern differences likely arose due to natural selection that favored those color/patterns. A likely selection pressure that might have led to the observed color/pattern variation is predation because color and pattern can act as camouflage (called cryptic coloration) and provide protection from visual predators like birds of prey. The cryptic coloration specific to a sub-population would be specific to the local habitat conditions, such as the color pattern of the soil and vegetation.

7. Three general types of selection occur in populations. Using a frequency distribution to represent the variation of a trait within a population, illustrate the three types of selection and explain how they occur. Refer to the frequency distributions presented in lecture. Directional selection occurs when the traits favored by selection are at one end of the frequency distribution of alleles, causing a shift in allele frequencies to a new optimum. Stabilizing selection occurs when the traits favored by selection are those near the average of the frequency distribution, causing the allele frequencies to remain stable. Disruptive selection occurs when the traits favored by selection are alternative forms at either end of the frequency distribution (i.e., extremes); this causes the frequency distribution of alleles to become bimodal.

8. Plot the relationship between beak size and frequency based on the data presented in “Graphing The Data” on page 183 in your textbook. How much did mean beak size change due to selection? What type of selection occurred? Before selection, mean beak size was 11.3 mm; after selection it was 12.5 mm. Thus, a 1.2 mm increase in beak size was observed due to selection. This suggests that directional selection occurred.

9. Explain the difference between allopatric and sympatric speciation in how they each occur. Allopatric and sympatric speciation both involve the evolution of new species from a single ancestral population due to restricted gene flow among individuals in a population, but differ in how gene flow is restricted. In allopatric speciation, a geographic barrier restricts gene flow among individuals in the population, whereas in sympatric speciation gene flow is restricted among individuals in the population due to reproductive isolation. There are two types of isolating mechanisms that can occur in sympatric speciation: post-zygotic isolation (e.g., polyploidy) and adaptive isolation.