Evolution of Populations II

Slide 2 As discussed in the previous lesson, evolution is defined as a change in the genetic structure of a population. Populations that are not evolving for a particular character or characters are said to be in Hardy-Weinberg equilibrium. This equilibrium rests on five basic assumptions, as listed on this slide. If any of these assumptions are violated in a population, allele and genotype frequencies will change. When this happens, the population is no longer in Hardy-Weinberg equilibrium, and is said to be evolving. In this lesson, we will take a closer look at the agents of evolutionary change that cause populations to evolve.

Slide 3 To start, remember that our hypothetical population was isolated. This means that no individuals are leaving the population, and none are entering the population from the outside. You could surmise that if one or several new individuals entered the population and contributed their alleles to the genetic makeup of the population by breeding, the allele frequencies might change, depending on the genetic makeup of the new individuals. The magnitude of change would depend on the number of individuals entering, their genotypes, and the size of the population. When individuals migrate between populations to contribute their alleles to new populations, we call this gene flow. Gene flow is one agent of evolutionary change.

Slide 4 We also stated that our population was large, and that all members mated to produce offspring. Because of this, many individuals contributed their alleles to the offspring generation, and the allele frequencies were maintained. What might happen if the population was small, though, say a population with 10 members, or 5, or 3? In a small population, the consequences of not mating, i.e., not contributing your alleles to the next generation, may very well be that your alleles are lost permanently. Essentially, there is a smaller chance that other members will carry and contribute the same alleles in the same frequencies, simply because there are fewer individuals. The change in allele frequencies due to chance events, such as missed mating opportunities, is called genetic drift.

Genetic drift is a significant problem in the conservation of many endangered species. A goal of most conservation plans is the maintenance of relatively high levels of genetic diversity in threatened or endangered populations. The small size of endangered populations, however, often makes this very challenging.

Slide 5 Similarly, consider how allele frequencies might change if our large population was suddenly reduced in size by half, or by 90%. There is a good chance that the allele frequencies in the resulting smaller population will differ to some degree from the original, larger population. As a result, when the population re-establishes its original size, allelic and genotypic frequencies will be changed. This type of occurrence is not uncommon. For example, many populations go through such bottlenecks, when a significant portion of the population is lost or separated due to a die-off or a substantial environmental change. Similarly, a few individuals from a population may colonize a new habitat, such as an island. Again, the genetic makeup of the resulting population in the new habitat will likely differ from the original population. This phenomenon is a specific type of genetic drift called the founder effect. It is believed that the diversification of the picture-winged fruit fly on the Hawaiian islands is largely a result of the founder effect. In this case, there were likely at least 45 founder events where some members of a population on one island founded a new population on another island.

Slide 6 In our hypothetical population, mating between individuals was also random with regard to gene A. Because of this, the chance of inheriting either of the alleles was based solely on the frequencies of each allele. In most natural populations, however, mating is non-random, in that potential mates are selected to some degree by their partners, and vice versa. Take a second to look around the computer lab, for example. Would you mate with just anyone of the opposite sex, or would you be more inclined to specifically choose a mate based on various characters? Similar mate selection processes occur in many types of organisms. Non-random mating, also known as sexual selection, can greatly affect allele frequencies in populations over time.

Slide 7 We also assumed that in our population there was no benefit for individuals to have a particular genotype. If, for example, there was an advantage to carrying and expressing one of the alleles of gene A, we could expect that allele to increase in frequency over time, because individuals carrying that allele would be more likely to survive and reproduce. This is natural selection, an agent of evolution that we have considered in more detail in a previous lesson.

Slide 8 Finally, we did not consider what would happen if new, unique alleles were introduced into the population, such as a third allele of gene A. This theoretically could happen by immigration of new individuals carrying the new allele into the population, or by mutation of the alleles that already exist in the population. Both of these processes can play significant roles in affecting the genetic structure of populations. Mutations, in fact, are the ultimate source of genetic variation, and help provide novel genetic material on which natural selection may act. Although mutation rates are generally extremely low, over many generations they play a significant role in the evolution of populations.

Slide 9 Although we have now covered a number of mechanisms of evolution individually, it is important to realize that in natural populations these mechanisms do not generally act alone. Rather, evolution, or the genetic change of populations, is often the sum of several or even all of these processes working together. In some cases, certain processes may play more important roles than others, but generally over time more than one of these processes contribute to the evolution of populations.

Take for instance the finches of the Galapagos Islands. It is probable that the various species of finch on the island arose from a single ancestor species that colonized the islands from the South American mainland. The founding population likely differed to some degree genetically from the mainland population, resulting in a founder effect. Over time, the finches were exposed to different selective pressures resulting from the different habitats on the islands, and so natural selection must have played a role in the diversification and speciation process. You could probably also imagine that as the finches diversified, different phenotypes could have resulted in different mating behaviors. As a result, sexual selection likely played a role in the diversification process. In addition, there is always the possibility that favorable mutations could have occurred in the DNA of certain individuals on the island, resulting in their increased fitness and contribution to the gene pool of their populations.