

❖ **5-6 Genetic drift and gene flow**

➤ *Reading: 7<sup>th</sup> edition 460-462, 506; 6<sup>th</sup> edition 450-452, 503.*

❖ **Allele frequencies change because of genetic drift**

- *Genetic drift occurs because populations are not infinitely large*
- On average, allele frequencies do not change after random mating. But in any one population, allele frequencies will change slightly each generation because the population size is finite.
- The rate of change in allele frequency because of genetic drift is small in large populations and larger in small populations.
- *Bottlenecks and founder events*
- A bottleneck in population size and a founder event both affect allele frequencies. A bottleneck is a reduction in size of an existing population while a founder event is the establishment of a new population of smaller size. Both cause more rapid changes in allele frequencies than would occur in a large stable population.
- Extreme bottlenecks and founder events lead to the loss of many alleles along with the increase in frequency of a few alleles.
- Cheetahs probably experienced an extreme bottleneck in size. There are so few genetic differences between individuals that skin can be successfully grafted between unrelated individuals, something that is impossible in other mammals.
- *Founder events are important for the study of human genetic diseases*
- Isolated populations founded by a few individuals may have some genetic diseases in high frequency that are rare elsewhere.
- Huntington's disease (HD) is a late-onset dominant lethal condition. In the US population, the frequency of HD is about 1/10,000. The gene causing HD was identified by studying an extended family in San Luis, Venezuela, where almost 25% of the residents develop HD. One of the individuals who founded San Luis carried an HD allele. Selection against the HD allele is weak because its effects usually appear relatively late in life.
- A founder effect could also explain the high prevalence of type II diabetes in Native Americans. Native Americans are probably descended from relatively small populations that came from eastern Asia 15,000 to 20,000 years ago. Other evidence that Native Americans are descended from a small number of ancestors is that they lack the B allele of the ABO blood type gene and the APOE\*2 allele.

❖ **Non-Darwinian evolution**

- *Eventually, drift will cause the loss of one of two neutral alleles initially present.*
- Neutral mutations are those that have no effect on fitness. An example of a neutral mutation is one that changes the DNA sequence of a gene but not the amino acid sequence.
- How long it takes for a neutral allele to be lost depends on how large the population is, but it will eventually happen even in very large populations.

- Many new neutral alleles are created each generation by mutation. Most will be lost because of genetic drift but a few will be substituted. The substitution of neutral alleles is called non-Darwinian evolution or neutral evolution.
- *The rate of substitution of neutral alleles is approximately constant*
- By comparing DNA sequences in species that diverged at a known time in the past, the substitution rate in animals has been estimated to be roughly  $2 \times 10^{-9}$  per nucleotide per year.
- Once the rate is known, it can be used to estimate the time a pair of species diverged.
- The constant rate of substitution is called a molecular clock.

#### ❖ Gene flow

- *Gene flow reduces differences between populations*
- Gene flow results from the movement of individuals or gametes.
- In the absence of gene flow, isolated populations will tend to become more different because of the combined effects of genetic drift, mutation and natural selection.
- *Gene flow is important for genetically engineered plants and animals.*
- Gene flow spreads engineered mutations from one variety of a species to another of the same species. A variety of rice called Liberty Link Rice (LL601) was engineered to be resistant to the Liberty herbicide<sup>1</sup>. This variety was not approved for human consumption but was grown in a few test plots in several states from 1998 to 2001. In July 2006, traces of LL601 were found in other varieties of rice in Arkansas and Missouri. The news of this discovery resulted in a 10% drop in rice prices. In September, 2006, 33 of 162 samples of rice shipped to Europe contained traces of LL601. Subsequently, Japan declared a month-long ban on the importation of rice from the US, and the European Union required testing of all imported US rice.
- Gene flow also spreads genes from domesticated species to closely related natural species. Fish raised in hatcheries can interbreed with wild fish in the same streams. Farmed Atlantic salmon are known to interbreed with other salmon species on both the east and west coasts of the US. In this case, the concern is with making the wild species less well adapted. Farmed salmon grow faster than wild species but have higher death rates.
- Gene flow of engineered genes to wild relatives might result in the evolution of weeds that are resistant to some herbicides or herbivores. Varieties *Brassica napus*, the species that produces canola oil, have been engineered to carry genes conferring resistance to several herbicides used for weed control. Some of those genes have been found in *Brassica rapa*, a wild relative. At present, no “superweeds” have because of gene flow from genetically modified species. It is hotly debated as to whether there is a significant risk.

#### ❖ Sample questions

- *Which word best fills the blank in the following sentence? The discovery of an allele from LL601 rice in other varieties of rice illustrates the importance of \_\_\_\_\_.*
  - a. natural selection

• \_\_\_\_\_

<sup>1</sup> See <http://www.sciencemag.org/cgi/content/full/313/5794/1714a>

- b. genetic drift
  - c. recombination
  - d. gene flow
  - e. mutation
- *Which pair of words best fills the blanks in the following sentence? The substitution of neutral alleles is called \_\_\_\_\_ evolution because it is not caused by \_\_\_\_\_.*
- a. Darwinian, genetic drift
  - b. non-Darwinian, genetic drift
  - c. Darwinian, natural selection
  - d. non-Darwinian, natural selection
  - e. None of the above.
- *What is the approximate rate of substitution of neutral mutations in animals?*
- a.  $2 \times 10^{-11}$  per nucleotide per year
  - b.  $2 \times 10^{-9}$  per nucleotide per year
  - c.  $2 \times 10^{-7}$  per nucleotide per year
  - d. 1/1000 per nucleotide per year
  - e. 2% per year.
- *Which phrase best fills the blank in the following sentence? The high frequency of an allele causing Huntington's disease in San Luis, Venezuela is the result of \_\_\_\_\_.*
- a. gene flow
  - b. a founder event
  - c. directional selection
  - d. balancing selection
  - e. Hardy-Weinberg.

Correct answers: d, d, b, b