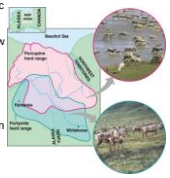
- Chapter 23 – The Evolution of Populations

Population Genetics

- Microevolution – change in the genetic makeup of a population from generation to generation
- Population genetics – the study of how populations change genetically over time
- Population – a localized group of individuals capable of interbreeding and producing fertile offspring (of the same species)
- Gene pool – the aggregate of genes in a population at any one time
- Modern Synthesis – integrated theory of evolution, "individuals are selected, populations evolve"



Hardy-Weinberg Theorem

- Theorem – the frequencies of alleles and genotypes in a population's gene pool remain constant from generation to generation, provided that only Mendelian segregation and recombination of alleles are at work
- Describes how Mendelian inheritance preserves genetic variation from one generation to the next in populations that are not evolving.
- Can use this theorem to understand long-term evolutionary changes

Hardy-Weinberg Equilibrium

- $p + q = 1$
  - p represents the frequency of one allele
  - q represents the frequency of the second allele
- $p^2 + 2pq + q^2 = 1$
  - p^2 represents homozygous dominant
  - 2pq represents heterozygous (but why multiply by 2?)
  - q^2 represents homozygous recessive
- If a population was in equilibrium, these frequencies would remain the same generation after generation

Example

- Codominant wild flowers: 320 red, 160 pink, 20 white.
- 2 alleles: C^R and C^W
- What is the frequency of the C^R and C^W alleles?
- (320 x 2) + 160 = 800 total C^R alleles; total of 1000 alleles in population, 800/1000 = .8, the frequency of the C^R allele.
- p + q = 1, .8 + q = 1, q = .2, the frequency of the C^W allele

Example (cont.)

- What are the frequencies for each genotype?
- p = .8, p^2 = .64 or 64% (C^RC^R)
- q = .2, q^2 = .04 or 4% (C^WC^W)
- 2pq = 2 x .8 x .2 = .32 or 32% (C^RC^W)
- What does this mean?
  - If the population were at equilibrium, allele and genotype frequencies would remain constant from one generation to the next, meaning they are not evolving.
  - A series of criteria must be met for this to occur

Conditions for H-W Equilibrium

1. Extremely large population size – the smaller the population, the greater chance for genetic drift
2. No gene flow – the transfer of alleles between populations
3. No mutations – mutations will modify the gene pool by removing, adding, or modifying genes
4. Random mating – if choose mates, random mixing of gametes does not occur
5. No natural selection

H-W practice problem.

- On planet Zor there are red and white Zoridians. Red color is dominant over white. Upon examination of 900 natives, 120 were found to be white. What is the frequency of the red and white alleles? What is the frequency of the homozygous dominant, recessive, and heterozygous genotypes?

Answer

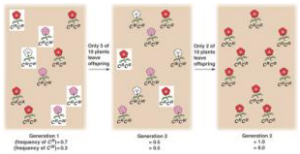
- 120 = q^2 or rr
- q^2 = 120/900 = 0.13, frequency of homozygous recessive
- q = $\sqrt{0.13}$ = 0.36, frequency of recessive allele
- p = 1-q, 1-0.36 = 0.64, frequency of dominant allele
- p^2 = 0.64 * 0.64 = 0.41, frequency of homozygous dominant
- 2pq = 1-p^2-q^2, 1-0.41-0.13 = 0.46 or
- 2pq = 2(0.64)(0.36) = 0.46, frequency of heterozygous

Microevolution

- Evolutionary change on a very small scale, a change in the genetic make up of a population from generation to generation
  - Genetic Drift
    - Bottleneck effect
    - Founder effect
  - Gene Flow
  - Natural Selection
    - Genetic variation
    - Modes of selection
    - Sexual selection

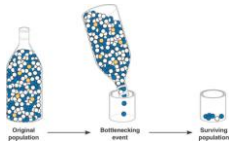
Genetic Drift

- Unpredictable fluctuations in allele frequencies from one generation to the next because of a small population size. Smaller population, greater chance for deviation from expected value.
- Bottleneck and founder effect – 2 situations that can increase genetic drift.



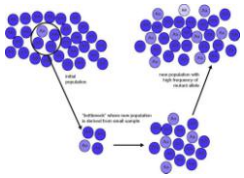
Genetic Drift – Bottleneck Effect

- Reduction of a population size through a sudden environmental change, like a natural disaster
- The surviving population is no longer genetically representative of the original population



Genetic Drift – Founder Effect

- When a few individuals become isolated from a larger population and this smaller group forms a new population with a new gene pool that is not reflective of the original population.
- Could occur from a bottleneck or when a small group colonizes a location.



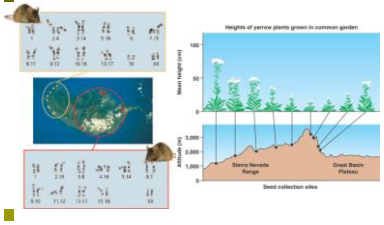
Gene Flow

- Genetic additions or subtractions from a population resulting in a movement of fertile organisms into a, or from a, gene pool.
- Tends to reduce differences between populations.
- If extensive enough, could cause 2 separate populations to become one population with a common gene pool

Natural Selection

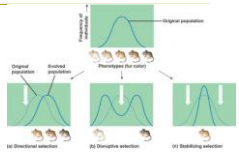
- Genetic Variation:
  - Polymorphism – coexistence of 2 or more distinct forms of individuals (morphs) within the same population
    - Phenotypic polymorphism: 2 or more distinct morphs are each represented in high enough frequency to be noticed
    - Genetic polymorphism: a continuum, similar to human height
  - Geographic variation – differences between the gene pools of separate populations

Geographic Variation



Modes of Natural Selection

- Fitness – the contribution an individual makes to the gene pool of the next generation, relative to the contributions of others



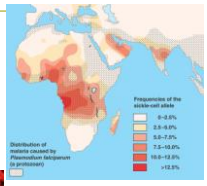
  - Directional – favors variants at one extreme
  - Disruptive – favors variants at both extremes
  - Stabilizing – favors intermediate forms in a population, selects against extremes

Preservation of Genetic Variation

- Diploidy - 2nd set of chromosomes hides variation in the heterozygote
- Balancing selection or balanced polymorphism – environment/natural selection maintains stable frequencies in 2 or more polymorphic forms; includes
  - Heterozygote Advantage
  - Frequency-dependent

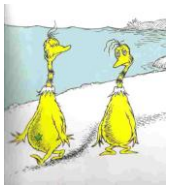
Balanced polymorphism

- Heterozygote advantage – individuals who are heterozygous for a particular gene locus have a greater fitness than the homozygotes
- Example: sickle-cell and malaria



Frequency-Dependent Selection

- The fitness of any one morph declines if it becomes too common
- Example: Dr. Seuss's Sneetches
- After watching a segment on the Sneetches, explain how these creatures model the concept of frequency-dependent selection.



Sexual Selection

- Natural selection for mating success
- Results in *sexual dimorphism*, marked differences between the secondary sexual characteristics
  - Intrasexual selection – direct competition among individuals of one sex for mates, usually males
  - Intersexual selection – individuals from one sex choose/select mates from the other sex, usually females