BIG IDEA!

Big Idea #1: The process of evolution drives the diversity and unity of life

Key Terms for this section:

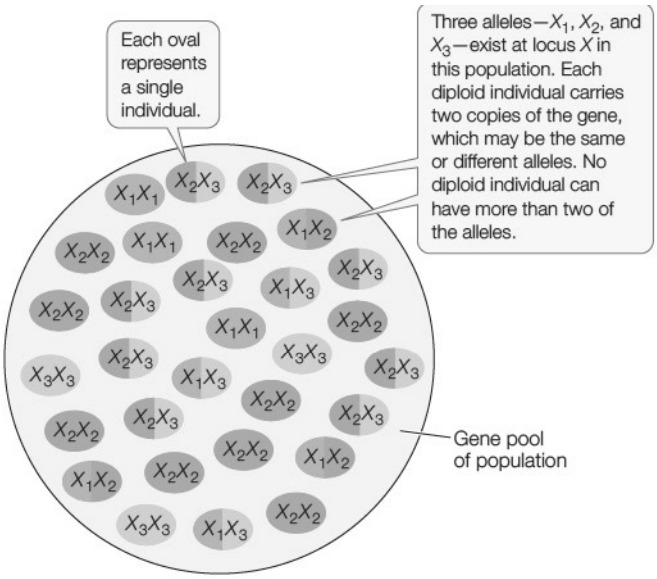
- □ adaptation
- □ adaptive radiation
- □ allele
- □ allopatric speciation
- □ analogous structures
- □ antibiotic resistance
- □ artificial selection
- □ bottleneck effect
- □ cladograms
- □ clade
- □ common ancestor
- □ convergent evolution
- □ directional selection
- □ disruptive selection
- □ divergent evolution
- □ emigration
- □ evolution
- □ fertility
- □ Founder effect
- □ gene flow
- □ gene pool
- □ genetic drift
- □ homologous structures
- □ hybrid
- □ immigration
- □ isolation types
- □ limited resources
- □ mutation
- □ natural selection
- □ outgroup
- □ phenotype
- □ phylogenetic tree
- □ population
- □ protobiont
- □ random mating
- □ reproductive isolation
- □ serial endosymbiosis
- □ sexual selection
- □ speciation
- □ species
- □ stabilizing selection
- □ sterility
- □ sympatric speciation
- □ variation
- □ vestigial organs
- □ viability

1.A Change in the genetic makeup of a population over time is evolution.

- **Natural selection is a major mechanism of evolution.**
- **Natural selection acts on phenotypic variations in populations.**
- **Evolutionary change is also driven by random processes.**
- **Biological evolution is supported by scientific evidence from many disciplines, including mathematics.**

Survival and reproduction are necessary to affect future generation's changes in allele frequencies.

- Ecosystems possess unique carrying capacities that address limited resources, competition, and reproductive potential. Organisms that survive and reproduce will pass on traits to the next generation.
- **Variation** occurs within a population and is heritable.
- Evolution occurs as traits accumulate in a population.
- The size of the gene pool affects the rate of **mutation**.



A Gene Pool, Hillis, Savada, Heller and Price. Principles of Life, 2012. Gordonsville, VA: W.H. Freeman & Co., 2012

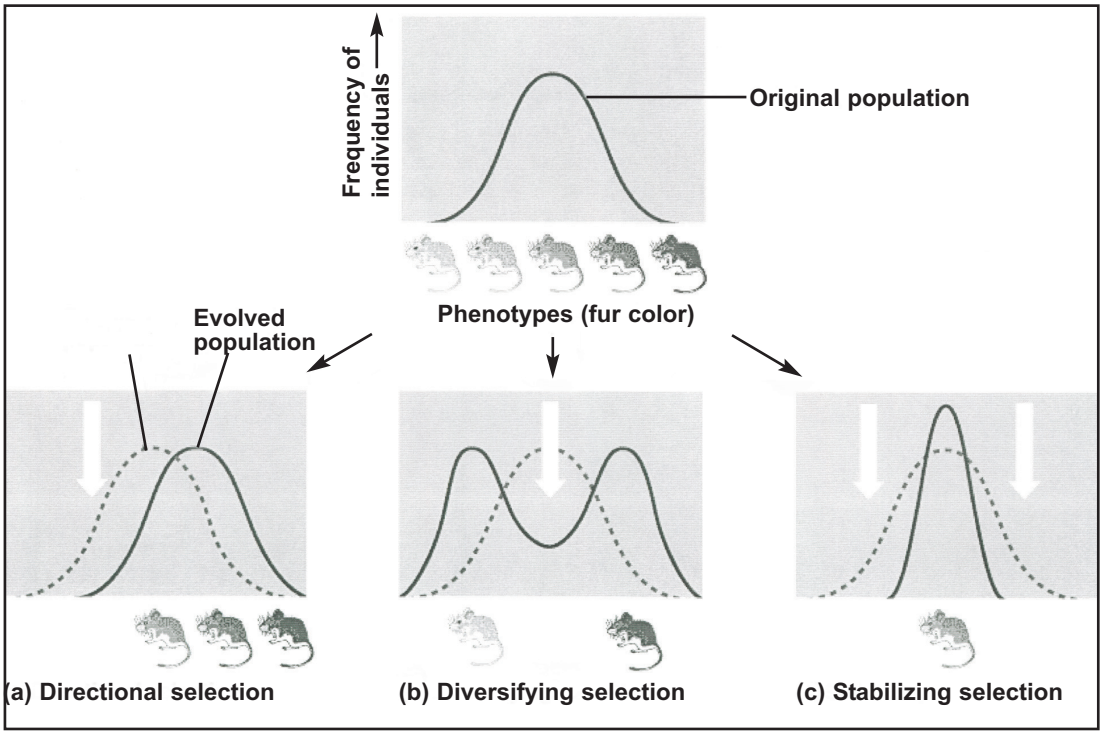
Natural selection is a driving force for evolution and may act upon a population in a variety of ways.

- **Natural selection** describes a process where the organisms with the most favorable traits in an environment have an increased reproductive fitness.
- **Mutation** introduces new alleles. A mutation is an error in the DNA that happens during DNA replication or meiosis.
- **Emigration** and **immigration** impact allele frequency. As individuals move into or out of an area, it is called **gene flow**.

- **Genetic drift** can affect allele frequencies by random chance altering allele frequencies when populations are small. It often occurs following a bottleneck or founder effect.
- Mating patterns, such as **inbreeding** and **selection**, affect allele frequency.
- **Sexual selection** occurs when mating is not completely random. Individuals that are selected more often as mates will contribute more alleles to future generations than the less desirable mates.

Specific phenotypes provide adaptations to populations which make them more likely to survive and reproduce in a given ecosystem.

- **Stabilizing selection** favors individuals with intermediate phenotypes and extreme phenotypes are selected against; heterozygote advantage is an example of stabilizing selection
- **Directional selection** favors individuals with one extreme phenotype while the other extreme is selected against
- **Distruptive selection** favors the extreme phenotypes while the intermediate *phenotypes are selected against.*



Campbell, Neil A. Reece; Jane B., BIOLOGY, 6th Edition, © 2002. Reprinted by permission of Pearson Education, Inc., Upper Saddle River, New Jersey.

Evolution follows several different patterns based upon different pressures.

- **Convergent evolution** occurs when two populations of dissimilar organisms evolve similar morphological traits because they are exposed to similar selection pressures.
- **Parallel evolution** is similar to convergent evolution, however the organisms do not need to occupy the same niches.
- **Divergent evolution** occurs when organisms have evolved new traits in their environments that cause them to phenotypically diverge from a common ancestor.
    - **Adaptive radiation** occurs as a species diverges across several different ecosystems.

Variation within a population is a necessary condition for natural selection to occur. This variation occurs through the following processes:

- Mutation
- Crossing over
- Random assortment
- Random fertilization
- Diploidy

The Hardy-Weinberg equilibrium provides a mathematical way to study the allele frequency changes within a population.

- If the following Hardy-Weinberg conditions are maintained, the population's allele and genotype frequencies will remain constant:
    - ✓ Large breeding population
    - ✓ Random mating
    - ✓ No mutation of alleles
    - ✓ No differential migration
    - ✓ No selection

- If *A* and *a* are alleles for a gene and each individual (diploid) carries two alleles, then *p* is the frequency of the *A* (dominant) allele and *q* is the frequency of the *a* (recessive) allele.
- Populations in genetic equilibrium are represented by the following equations:

$$p + q = 1.0 \ (100\%)$$

$$p2 + 2pq + q2 = 1$$

where: p^2 = frequency of the homozygous dominant genotype

$2pq$ = frequency of the heterozygous genotype

q^2 = frequency of homozygous recessive genotype

Evidence for evolution spans several scientific disciplines and helps us to determine evolutionary relationships.

- Examination of the amino acid sequences of DNA through molecular biology techniques reveals that closely related species exhibit similar nucleotide sequences.
    - Closely related species share a higher percentage of the amino acid sequence than distantly related species.
- Structural similarities of body parts give rise to the understanding of evolutionary relationships.
    - Analogous structures: structures that appear similar in two unrelated organisms
    - Vestigial organs: organs that have no apparent function, but resemble ancestral structures
    - Homologous structures: structures with different apparent functions, but similar structural anatomy

Can you:

□ identify the mechanisms of how variation occurs in a given population?

□ explain how the effects of genetic drift vary based upon population size?

□ discuss the different types of selection, and how each drives evolution?

□ determine the frequency of the dominant allele if the frequency of the recessive allele is given?

□ determine the frequency of the recessive allele if the percentage of the population with the recessive phenotype is given?

□ calculate the percentage of the population with recessive allele if the percentage of the population expressing the dominant allele is given?

□ differentiate between the frequency of an allele and the frequency of a genotype?

□ interpret a graph showing how evolution favors different phenotypes?

□ explain the changes in a gene pool as a result of emigration and immigration?

□ explain how certain pressures can increase or decrease the fitness of a particular population?

1.B Organisms are linked by lines of descent from common ancestry.

- **Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.**
- **Phylogenetic trees and cladograms are graphical representations of evolutionary history that can be tested.**

Similarities within the genetic code of all organisms support structural and functional similarities between organisms.

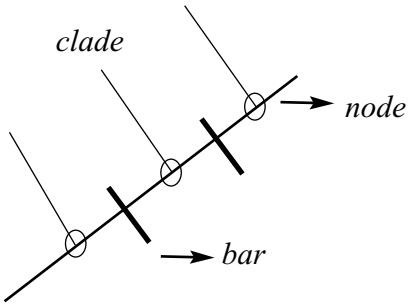
- There are striking similarities between DNA, RNA and amino acids across all domains.

Specific cellular similarities support relatedness between organisms.

- Cytoskeletal elements, membrane bound organelles including mitochondria and chloroplasts, chromosome structure and the endomembrane system maintain similarities across many different species.

Phylogenetic trees and cladograms are diagrams that show evolutionary relationships between organisms.

- Phylogenies are based upon DNA, RNA, amino acid sequences or morphological data.
- All phylogenies need to be rooted and a have a **common ancestor** to the organisms at that root.
- The organisms with the *fewest number of differences* have shared a common ancestor most recently.
- An **outgroup** can be used as a reference point. The outgroup will have all shared traits and derived traits will be more evident.
- A **node** represents a hypothetical ancestor and includes the common ancestor plus all of the descendents. It is signified by a **O** where two lines meet.
- **Bars** are located between **clades** and are labeled with a new trait that prior organisms did not have.



There is a diverse array of modern organisms. All of these organisms evolved from a common ancestor through similar evolutionary processes.