Evolution

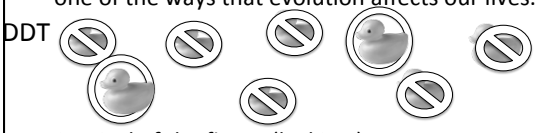
- **Evolution** = genetic change in a population over time
- Evolution is **BOTH**
  1. An observation (we see it happening today)
  2. AND a theory (extensive evidence supports the hypothesis that evolution doesn't just happen today, it's happened since life began)

Evidence for Evolution Theory

1. Direct observation – we see it happening today
2. The fossil record
3. Biogeography
4. Comparative anatomy
5. Comparative embryology
6. Molecular Biology

Biology and Society: Mosquitoes, Microbes, and Malaria

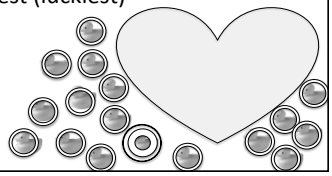
– The evolution of pesticide-resistant insects is just one of the ways that evolution affects our lives.



– Survival of the fittest (luckiest)

An understanding of evolution informs every field of biology, for example,

- Medicine,
- Agriculture,
- Biotechnology
- Conservation biology.



Molecular Biology

– The hereditary background of an organism is documented in
  - its DNA and
  - the proteins encoded by the DNA.
– Evolutionary relationships among species can be determined by comparing
  - genes and
  - proteins of different organisms.

How does evolution happen?

1. Natural Selection
2. Sexual Selection
3. Genetic Drift
4. Gene Flow

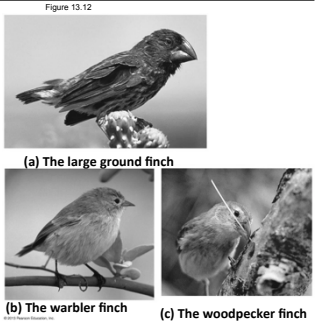
All of these require **genetic diversity** – so **mutation** is a requirement for all evolution

NATURAL SELECTION

– Darwin noted the close relationship between adaptation to the environment and the origin of new species.

– The evolution of finches on the Galápagos Islands is an excellent example.

Figure 13.12



(a) The large ground finch

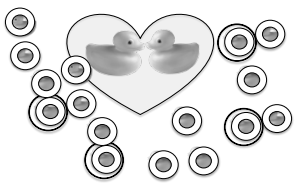
(b) The warbler finch

(c) The woodpecker finch

Darwin's Theory of Natural Selection

– Darwin based his theory of natural selection on two key observations.

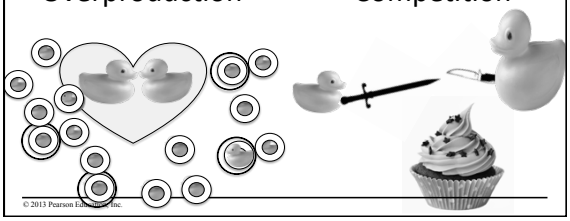
1. All species tend to produce excessive numbers of offspring.
2. Organisms vary, and much of this variation is heritable.



Darwin's Theory of Natural Selection

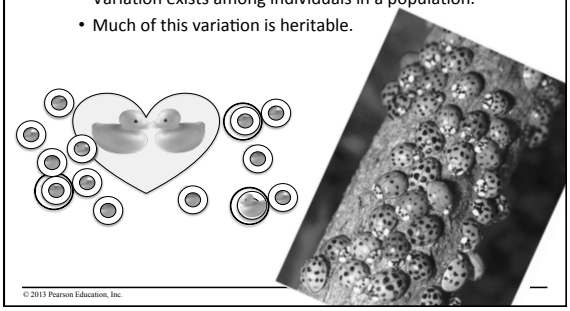
– **Observation 1: Overproduction and competition**
  - All species have the potential to produce many more offspring than the environment can support.
  - This leads to inevitable competition among individuals.

Overproduction Competition



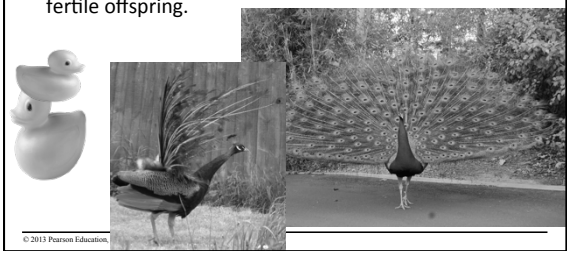
Darwin's Theory of Natural Selection

– **Observation 2: Individual variation**
  - Variation exists among individuals in a population.
  - Much of this variation is heritable.



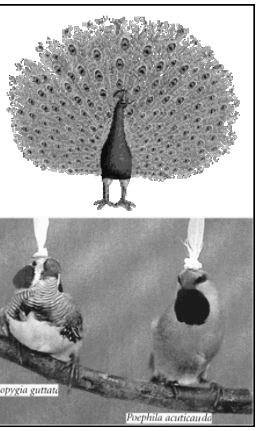
Darwin's Theory of Natural Selection

- **Inference: Unequal reproductive success (natural selection)**
  – Those individuals with traits best suited to the local environment generally leave a larger share of surviving, fertile offspring.



Sexual Selection

- When a genetic trait becomes more abundant in a population because it helps you to get more mates, *not because it helps you live longer*. Examples??



Genetic Drift

Genetic drift is:

- A change in the gene pool of a small population

EX: The **bottleneck effect**:

- Results from a drastic reduction in population size

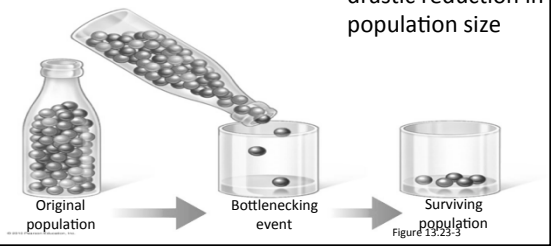
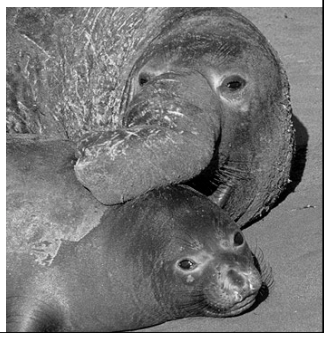


Figure 13.23-3

Bottleneck Example

- Bottlenecking in a population usually reduces genetic variation because at least some alleles are likely to be lost from the gene pool.
- Elephant Seals experienced a genetic bottleneck about 160 years ago



Genetic Flow

- Is genetic exchange with another population
- Tends to **reduce** genetic differences between population

Practice Exam Question

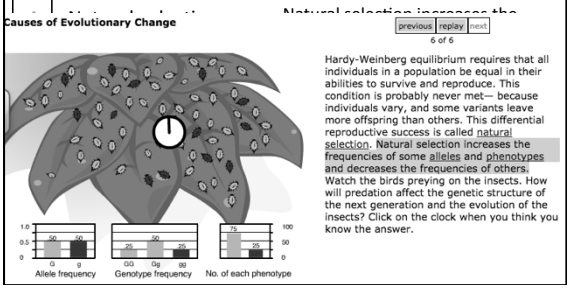
Of the following situations that pertain to evolution, which one is false?

A. Organisms inherit traits from their parents.
B. Organisms can adapt to prepare their offspring for future events.
C. Evolution can happen by chance.

Evolution can happen by natural selection and genetic drift, only genetic drift is random

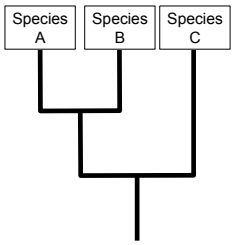
Practice Exam Question

Which mechanism of evolution actually reduces the chances of speciation?



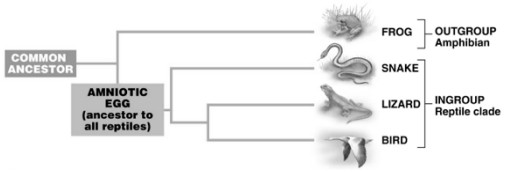
7.12 Evolutionary relationships may be represented by branching trees

- **Phylogenetic trees** are one way to reflect the evolutionary history of organisms.
- Phylogenetic trees present a hypothesis about the evolutionary history of related species.



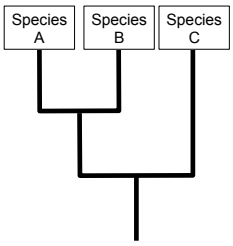
7.12 Clades can be thought of representing a branch on the tree of life

- A **clade** is a any group of species that consists of an ancestral species and all its descendants.
- The analysis of clades is called **cladistics**.



7.12 Reading phylogenetic trees can provide insights into the interrelationships of life

- The tips of the tree represent groups of the most recently evolved species.
- To determine how closely related two species are, find their most recent common ancestor.



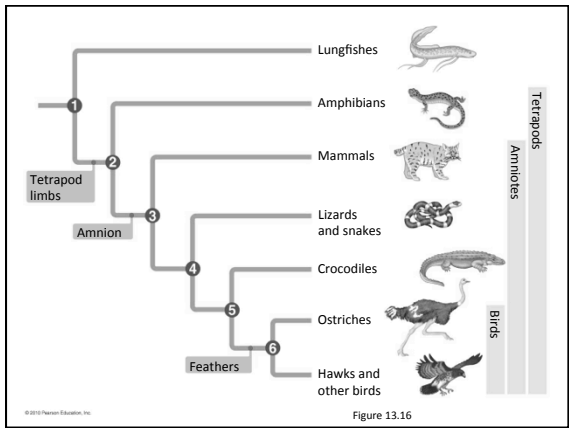


Figure 13.16

What is a species?

- The word "species" is derived from a Latin word meaning "appearance."
- However, appearance alone cannot be used to tell one species from another.

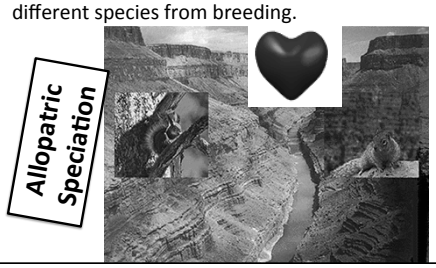
What is a species?

- The most commonly used definition of **species** is a population that is capable of interbreeding to produce healthy, fertile offspring.

What types of species might not fit the definition above?

Reproductive barriers maintain species

- For species that we can define as a group of individuals capable of successfully interbreeding, what keeps them separate?
- One or more **reproductive barriers** prevent members of different species from breeding.

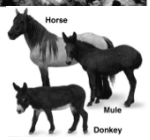


Reproductive barriers maintain species

1. **Behavioral isolation:** Members of a species often identify each other through specific rituals.
2. **Mating time differences**: Many species are able to reproduce only at specific times.
3. **Habitat isolation**: If species live in slightly different habitats, they may never meet.

Reproductive barriers maintain species

4. **Mechanical incompatibility**: Members of different species often cannot mate because their anatomies are incompatible.
5. **Gametic incompatibility**: The gametes (sperm and egg of different species usually cannot fertilize each other.
6. **Hybrid weakness**: Offspring of two species may be unfit, or they may be sterile.



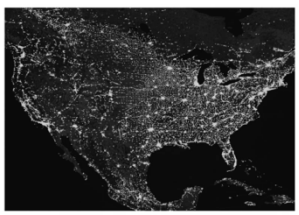
THE MODERN SYNTHESIS: DARWINISM MEETS GENETICS

– The **modern synthesis** is the fusion of
- genetics with
- evolutionary biology.

Populations as the Units of Evolution

– A population is
- a group of individuals of the same species, living in the same place at the same time and
- the smallest biological unit that can evolve.

(a) Two dense populations of trees separated by a lake



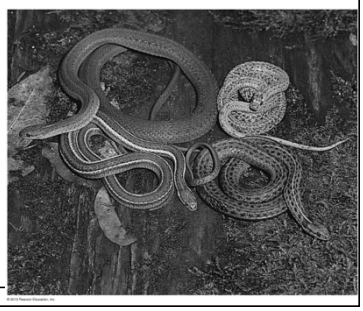
(b) A nighttime satellite view of North America

Populations as the Units of Evolution

- The total collection of alleles in a population at any one time is the **gene pool**.
- When the relative frequency of alleles changes over a number of generations, evolution is occurring on its smallest scale.

Genetic Variation in Populations

- Individual variation abounds in all species.
  - Not all variation in a population is heritable.
  - Only the genetic component of variation is relevant to natural selection.



Genetic Variation in Populations

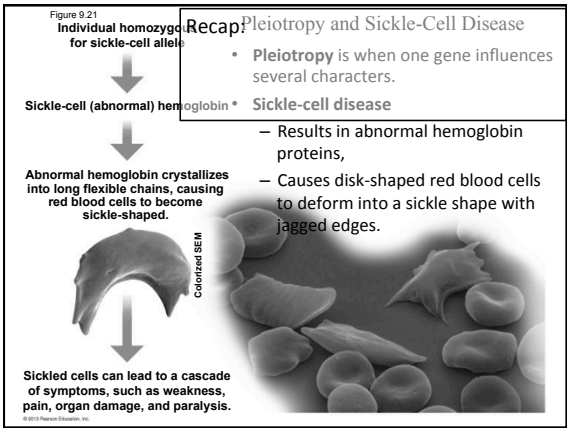
- Variable traits in a population may be
  1. polygenic, resulting from the combined effects of several genes, or
     - Polygenic traits tend to produce phenotypes that vary more or less continuously.
  2. Determined by a single gene.
     - Single-gene traits tend to produce only a few distinct phenotypes.
- Genetic variation results from processes that both involve randomness:
  1. Mutations, changes in the nucleotide sequence of DNA, and
  2. Sexual recombination, the shuffling of alleles during meiosis.

What makes a trait an adaptation?

Changes as environment changes

– example sickle ce

Figure 9.21



Recap: Pleiotropy and Sickle-Cell Disease

- **Pleiotropy** is when one gene influences several characters.
- **Sickle-cell disease**
  - Results in abnormal hemoglobin proteins,
  - Causes disk-shaped red blood cells to deform into a sickle shape with jagged edges.

Why is this an adaptation?

Sickle-cell disease:

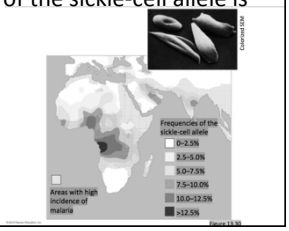
- A genetic disorder
- Affects about 1/400 African- Americans
  - Abnormally shaped red blood cells cause painful and life-threatening complications.

The Genetics of Sickle Cell

Heterozygous individuals for the sickle-cell allele:

Ss

- Do not develop sickle-cell anemia
- Are more resistant to malaria
  – In the African tropics, where malaria is most
- Common, the frequency of the sickle-cell allele is highest.



Analyzing Gene Pools

– A gene pool
  - consists of all the alleles in a population at any one time and
  - is a reservoir from which the next generation draws its alleles.
– Alleles in a gene pool occur in certain frequencies.

Analyzing Gene Pools

- Alleles can be symbolized by
  - p for the relative frequency of the dominant allele in the population,
  - q for the frequency of the recessive allele in the population, and
  - $p + q = 1$.
- Note that if we know the frequency of either allele in the gene pool, we can subtract it from 1 to calculate the frequency of the other allele.

Analyzing Gene Pools

- Genotype frequencies can be calculated from allele frequencies (if the gene pool is stable = not evolving).
- The Hardy-Weinberg formula
  - $p^2 + 2pq + q^2 = 1$
  - can be used to calculate the frequencies of genotypes in a gene pool from the frequencies of alleles.