

CHAPTER 13

How Populations Evolve

- All humans are connected by descent from African ancestors



- The same types of bones make up the forelimbs of humans, cats, whales, and bats

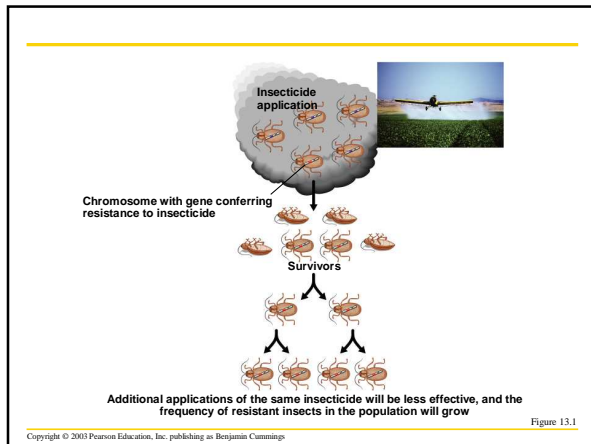


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BIOLOGY AND SOCIETY: **PERSISTENT PESTS**

- Mosquitoes and malaria
 - In the 1960s, the World Health Organization (WHO) began a campaign to eradicate the mosquitoes that transmit malaria
 - It used DDT, to which some mosquitoes have evolved resistance

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CHARLES DARWIN AND *THE ORIGIN OF SPECIES*

- Charles Darwin's *On the Origin of Species by Means of Natural Selection*
 - Was published on November 24, 1859
 - Focused biologists' attention on the great diversity of organisms

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- The basic idea of natural selection is that
 - Organisms can change over generations
 - Individuals with certain heritable traits leave more offspring than others.

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- The result of natural selection is evolutionary adaptation.



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Darwin's Cultural and Scientific Context

- *The Origin of Species*
 - Challenged the notion that the Earth was relatively young and populated by unrelated species.

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The Idea of Fixed Species

- The Greek philosopher Aristotle held the belief that species are fixed and do not evolve
 - The Judeo-Christian culture fortified this idea and suggested that the Earth is only about 6,000 years old.

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Lamarck and Adaptive Evolution

- In the mid-1700s, the study of fossils began to take form as a branch of science
- Naturalist Georges Buffon
 - Suggested that the Earth might be older than 6,000 years
 - Observed similarities between fossils and living species.

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- Jean Baptiste Lamarck
 - Suggested that organisms evolved by the process of adaptation
 - Also suggested some erroneous ideas, such as the inheritance of acquired characteristics.

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The Voyage of the Beagle

- In December 1831, Darwin left Great Britain on the *HMS Beagle* to explore the world.

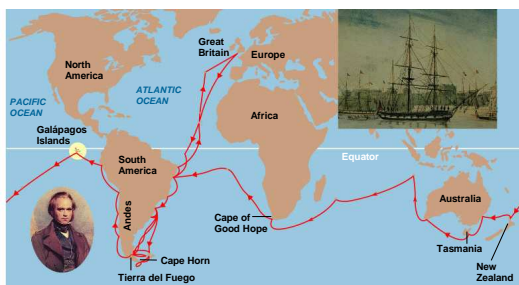


Figure 13.3

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The Galapagos Islands are located about 900 Km off the west coast of Ecuador.

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-
- On his journey on the *Beagle*, Darwin
 - Collected thousands of specimens
 - Observed various adaptations in organisms.

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-
- Darwin was intrigued by
 - The distribution of organisms on the Galápagos Islands
 - The fact that Galápagos organisms resembled those in South America.



Figure 13.4

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The New Geology

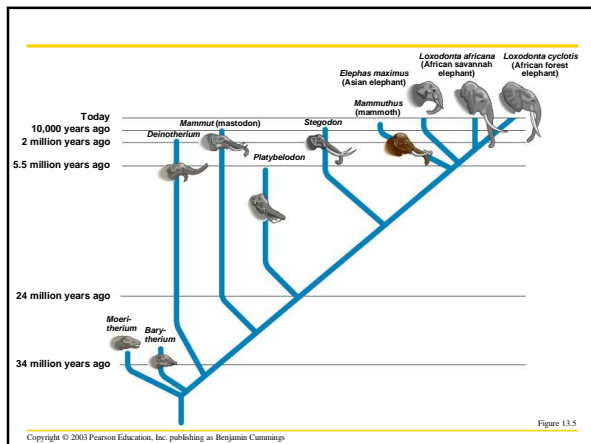
- Darwin was strongly influenced by the writings of geologist Charles Lyell
- Darwin reasoned that
 - The Earth is very old and has been shaped by slow processes
 - Subtle processes occurring over long periods of time can cause great change.

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Descent with Modification

- Darwin made two main points in *The Origin of Species*
 - Organisms inhabiting Earth today descended from ancestral species
 - Natural selection was the mechanism for descent with modification.

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Figure 13.5

EVIDENCE OF EVOLUTION

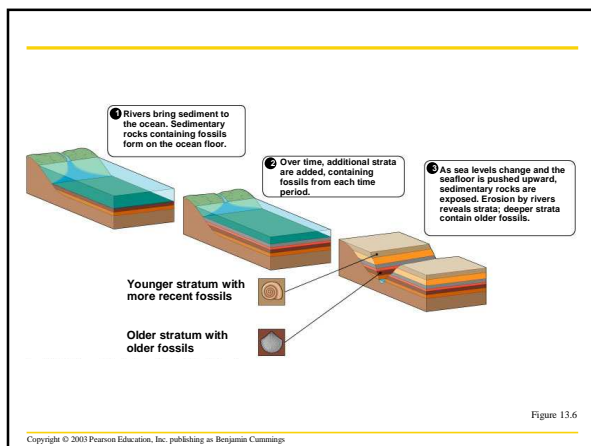
- Biological evolution has left marks of evidence.

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The Fossil Record

- Fossils
 - Are preserved remnants or impressions left by organisms that lived in the past
 - Are often found in sedimentary rocks.

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- The fossil record
 - Is the chronology of fossil appearances in rock layers
 - Testifies that organisms have appeared in a historical sequence
 - Fits with other evidence of evolution.

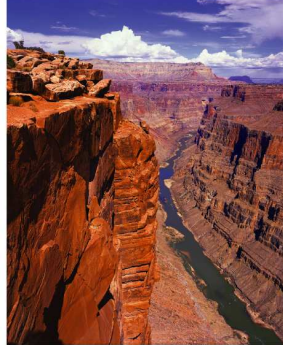


Figure 13.7

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- Paleontologists
 - Are scientists that study fossils
 - Have discovered many transitional forms that link past and present.

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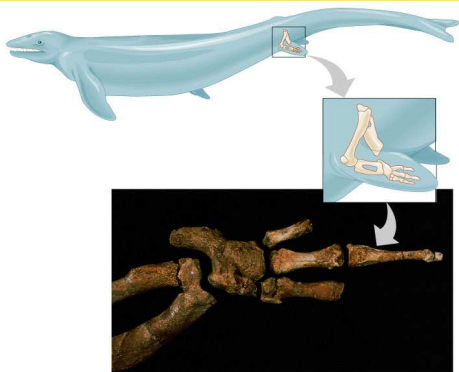


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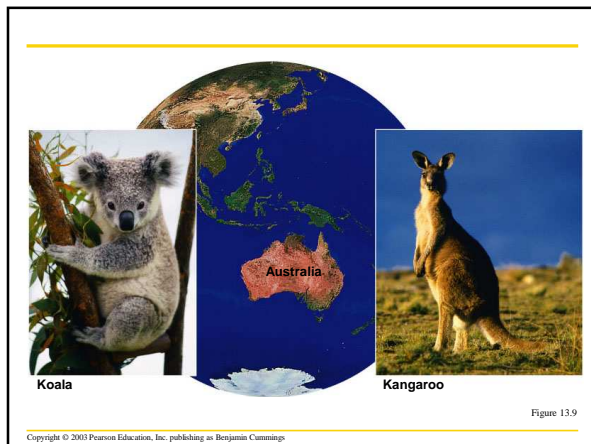
Biogeography

- Biogeography
 - Is the study of the geographic distribution of species
 - First suggested to Darwin that today's organisms evolved from ancestral forms.

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- Many examples from biogeography support evolutionary theory.

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Comparative Anatomy

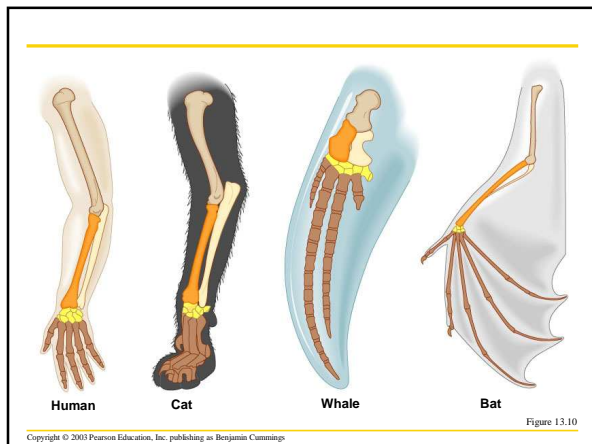
- Comparative anatomy
 - Is the comparison of body structure between different species
 - Confirms that evolution is a remodeling process.

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Homology

- Is the similarity in structures due to common ancestry
p. 252 See Fig. 13.10 for example of homologous structures of diverse mammals' forelimbs.

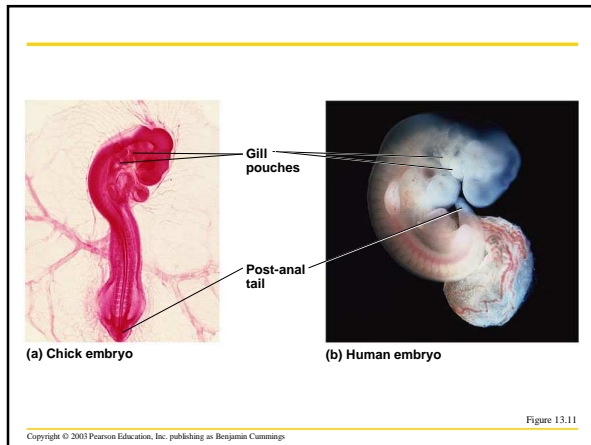
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Comparative Embryology

- Comparative Embryology is the comparison of structures that appear during the development of different organisms
 - Comparative embryology of vertebrates supports evolutionary theory.

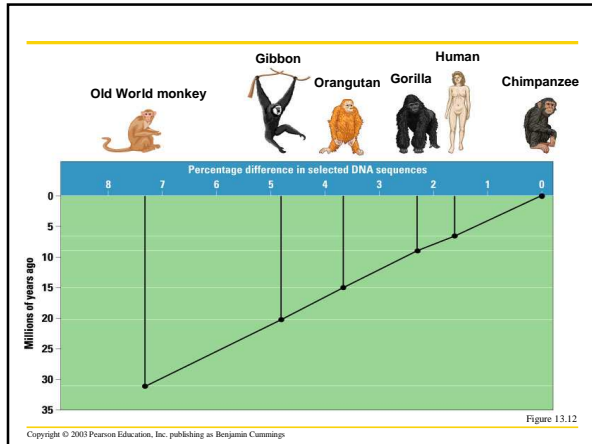
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Molecular Biology

- Evolutionary relationships among species
 - Leave signs in DNA and proteins
 - Can be determined by comparing genes and proteins of different organisms.


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NATURAL SELECTION AND ADAPTIVE EVOLUTION

- Darwin's finches
 - Are an excellent example of natural selection and adaptive evolution.





(a) Large ground finch (b) Small tree finch (c) Woodpecker finch

Figure 13.13

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Darwin's Theory of Natural Selection

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

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• Observation 1:
Overproduction

- All species tend to produce excessive numbers
- This leads to a struggle for existence.



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• Observation 2: Individual variation

- Variation exists among individuals in a population
- Much of this variation is heritable.



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• Inference: Differential reproductive success
(natural selection)

- Those individuals with traits best suited for the local environment leave more fertile offspring.

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Natural Selection in Action

- Examples of natural selection include
 - Pesticide resistance in insects
 - The development of antibiotic-resistant bacteria
 - Drug-resistant strains of HIV, the virus that causes AIDS.

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THE MODERN SYNTHESIS: DARWINISM MEETS GENETICS

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

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Populations as the Units of Evolution

- A population
 - Is a group of individuals of the same species living in the same area at the same time
 - Is the smallest biological unit that can evolve.



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- Population genetics
 - Focuses on populations as the evolutionary units
 - Tracks the genetic makeup of populations over time.

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Genetic Variation in Populations

- Individual variation abounds in populations
 - Not all of this variation is heritable
 - Only the genetic component of variation is relevant to natural selection.

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- A population is said to be polymorphic for a characteristic if two or more morphs, or forms, are present in noticeable numbers.



Figure 13.17

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Sources of Genetic Variation

- Mutations and sexual recombination
 - Produce genetic variation.

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- Mutations
 - Are changes in the DNA of an organism, is the ultimate source of all variation; most mutations are likely harmful.
- Sexual recombination
 - Shuffles alleles during meiosis.

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Analyzing Gene Pools

- The gene pool
 - Consists of all alleles of all individuals making up a population.

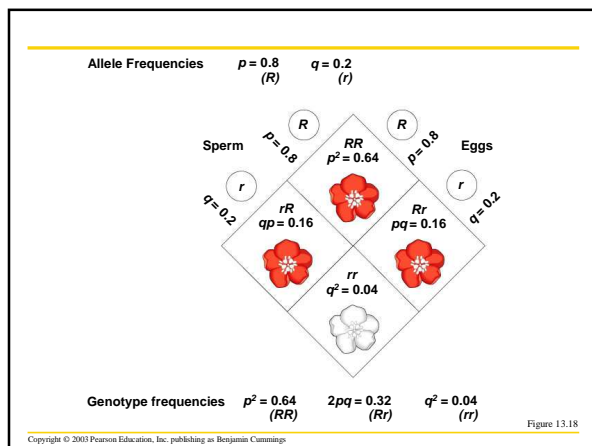
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- Alleles in a gene pool
 - Occur in certain frequencies
 - Can be symbolized by p for the relative frequency of the dominant allele in the population and q for the frequency of the recessive allele in the population.

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- Genotype frequencies
 - Can be calculated from allele frequencies
 - Are symbolized by the expressions p^2 , $2pq$, and q^2

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- The Hardy-Weinberg formula
 - Is a mathematical representation of a gene pool
 - Adds up all of the genotypes in a population.

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Population Genetics and Health Science

- The Hardy-Weinberg formula can be used to calculate the percentage of a human population that carries the allele for a particular inherited disease.



Figure 13.19

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Microevolution as Change in a Gene Pool

- Hardy-Weinberg equilibrium
 - Describes a nonevolving population that is in genetic equilibrium
 - Can be used to determine whether a population is evolving.

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MECHANISMS OF MICROEVOLUTION

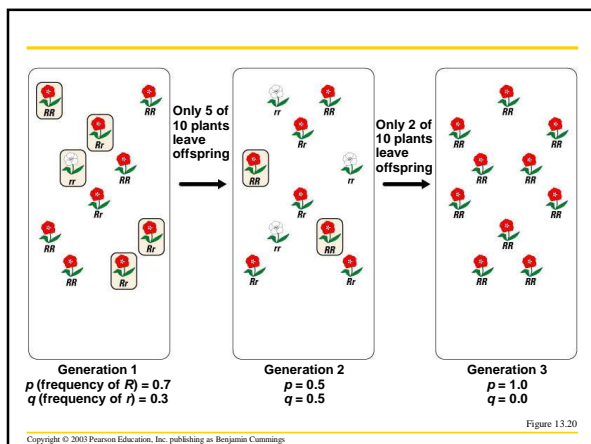
- Four causes of microevolution are
 - Genetic drift
 - Gene flow
 - Mutations
 - Natural selection

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Genetic Drift

- Genetic drift
 - Is a change in the gene pool of a small population due to chance.

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The Bottleneck Effect

- The bottleneck effect
 - Is an example of genetic drift
 - Results from a drastic reduction in population size.

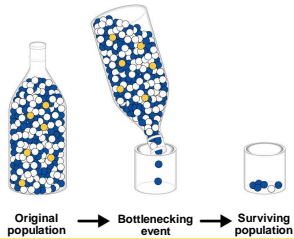


Figure 13.21

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- Bottlenecking in a population reduces genetic variation. Some alleles are likely to be lost from the population.



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The Founder Effect

- The Founder Effect, p.262
 - Is genetic drift in a new colony
 - ex. Galapagos finches

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Genetic Drift and Hereditary Disorders in Human Populations

- The founder effect
 - Explains the relatively high frequency of certain inherited disorders among some populations.

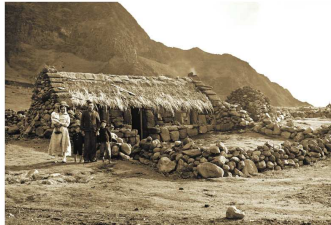


Figure 13.23

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Gene Flow

- Gene flow
 - Is genetic exchange with another population
 - Tends to reduce genetic differences between populations.



Figure 13.24

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Mutations

- Mutations
 - Are changes in an organism's DNA
 - Alone do not have much effect on a large population
 - Can have significant cumulative effects on a population
 - "Over the long term, mutation is, in itself, very important to evolution because it is the original source of the genetic variation that serves as raw material for natural selection." p. 263

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Natural Selection: A Closer Look

- Of all causes of microevolution, only natural selection is generally adaptive pp263-4.

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Darwinian Fitness

- Darwinian fitness
 - Is the contribution an individual makes to the gene pool of the next generation relative to the contributions of other individuals.



Figure 13.25

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Three General Outcomes of Natural Selection

- Directional selection
 - Shifts the phenotypic “curve” of a population
 - Selects in favor of some extreme phenotype.

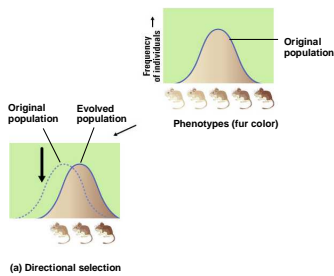


Figure 13.26a

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• Diversifying selection

- Can lead to a balance between two or more contrasting morphs in a population.

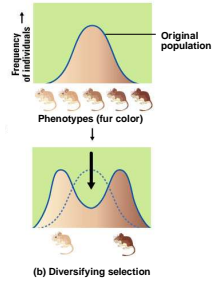


Figure 13.26b

• Stabilizing selection

- Maintains variation for a particular trait within a narrow range.

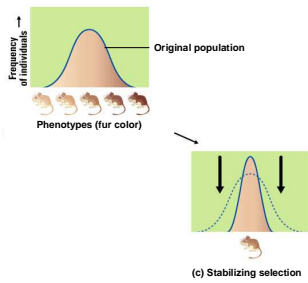


Figure 13.26c

EVOLUTION CONNECTION: POPULATION GENETICS OF THE SICKLE-CELL ALLELE

• Sickle-cell disease

- Affects about one out of every 500 African Americans
- Is more common among African Americans; but why?



Figure 13.27 (inset)

• The sickle-cell allele

- Confers resistance to the disease malaria
- Is adaptive in the African tropics where malaria is common.
- **This is stabilizing selection, p.267**

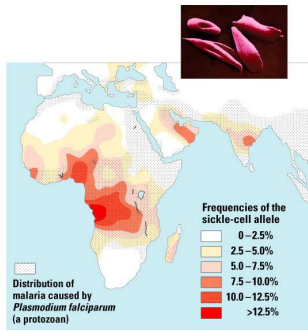


Figure 13.27

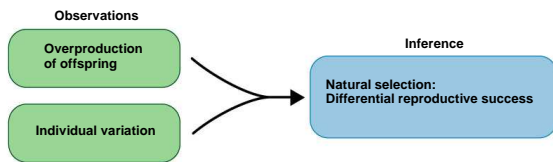
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“Survival to sexual maturity, of course, is prerequisite to reproductive success. . . Production of fertile offspring is the only score that counts in natural selection.”
p.264

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SUMMARY OF KEY CONCEPTS

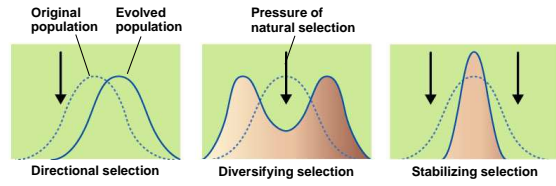
• Darwin’s Theory of Natural Selection



Visual Summary 13.1

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• Natural Selection: A Closer Look



Visual Summary 13.2

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