



Chapter 13

How Populations Evolve

PowerPoint Lectures

Campbell Biology: Concepts & Connections, Eighth Edition

REECE • TAYLOR • SIMON • DICKEY • HOGAN

Lecture by Edward J. Zalisko

Introduction

- In the 1960s, the World Health Organization (WHO) launched a campaign to eradicate malaria.
- They focused on killing the mosquitoes that carry the parasite from person to person by massive spraying of the pesticide DDT.
- Early success was followed by rebounding mosquito populations that had evolved resistance to the pesticide DDT.
- Today, malaria causes more than a million deaths and 250 million cases of illness each year.

Chapter 13: Big Ideas



**Darwin's Theory
of Evolution**



**The Evolution of
Populations**



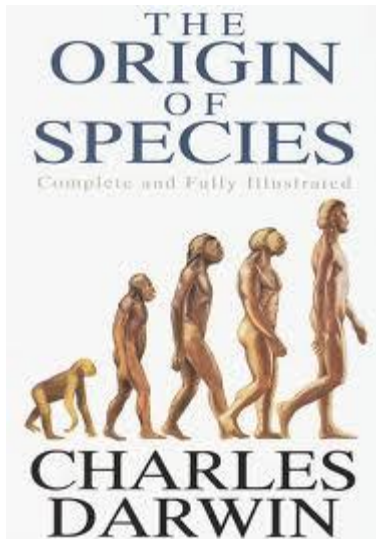
**Mechanisms of
Microevolution**

DARWIN'S THEORY OF EVOLUTION

Charles Darwin



- English Naturalist
- In 1859 he published “*On the Origin of Species by Means of Natural Selection*”



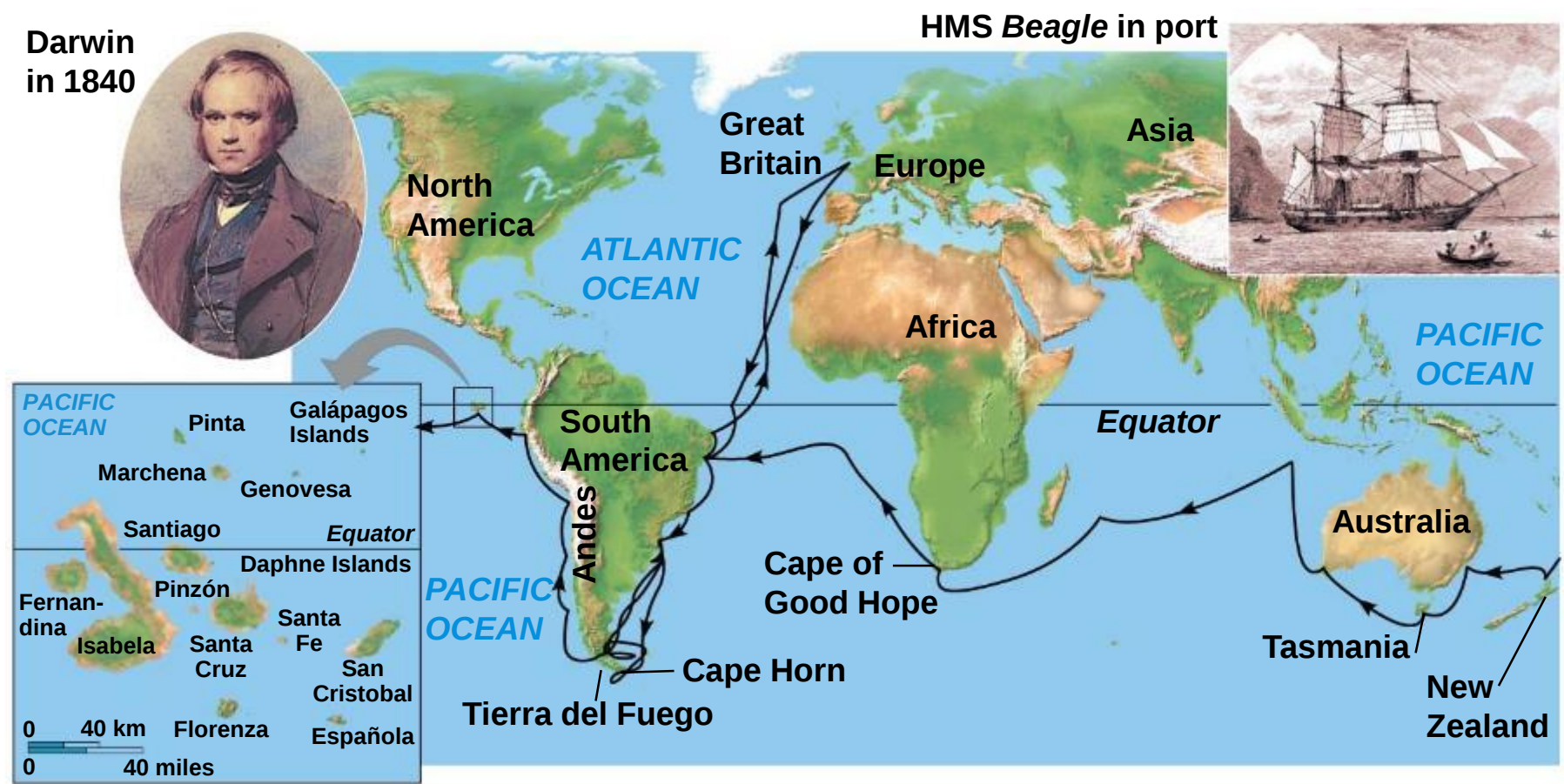
- Convincing evidence that species evolve and a reasonable mechanism explaining how evolution occurs

Background on Darwin



- Dad was a wealthy doctor
- At age 16 Darwin was sent to Edinburgh, Scotland to study medicine
 - Repeatedly skipped lectures to collect biological specimens
- 1827 was sent to Cambridge University to become a minister – He got his degree
 - More interested in natural science
- 1831 (age 22) Darwin went on a voyage with the **HMS Beagle** as a naturalist

Figure 13.1a-0



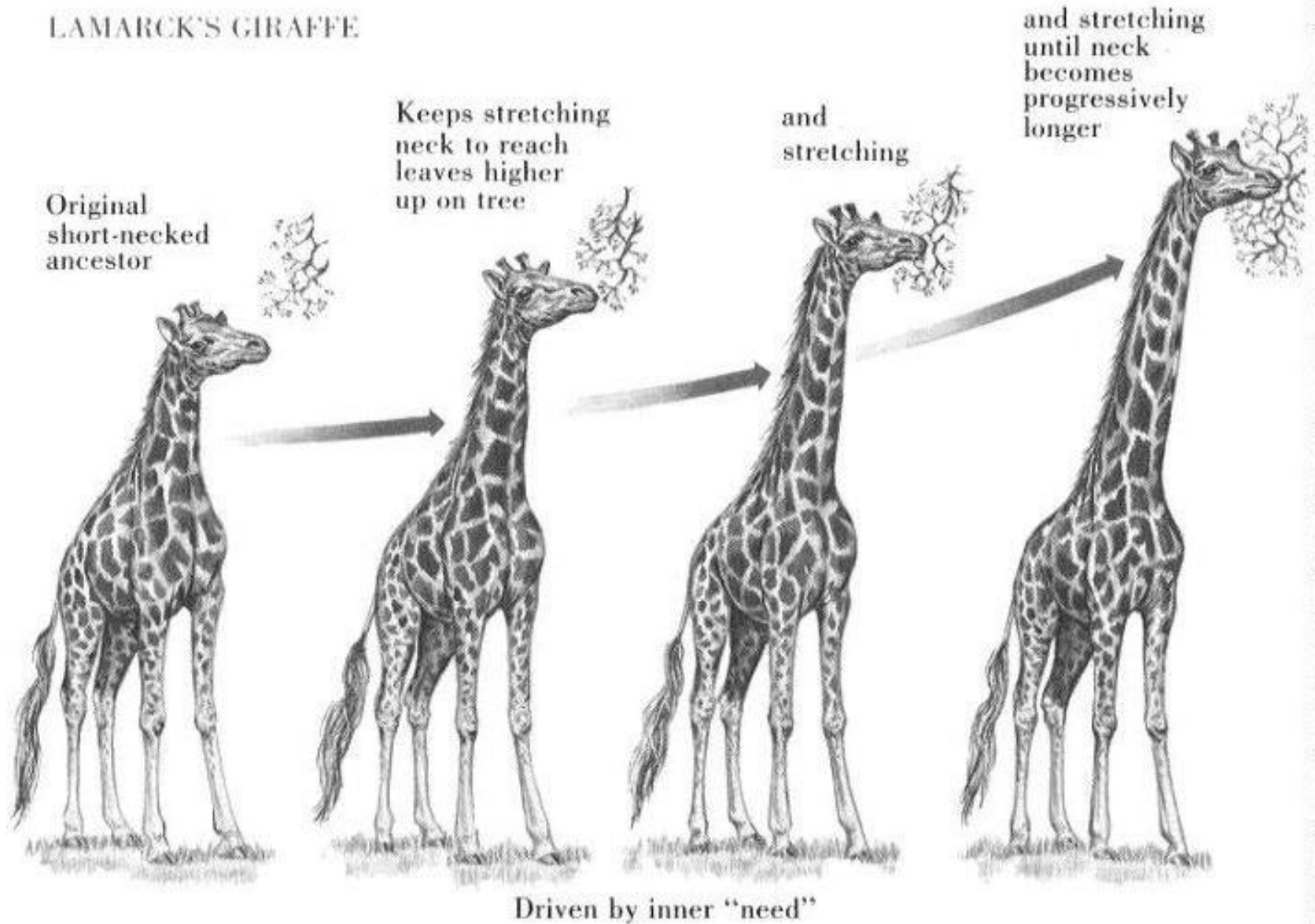


HMS *Beagle* in port

Scientists Before Darwin

- **Lucretius** (2000 years ago)– Roman philosopher that 1st proposed the idea that life evolves
- **Jean Baptiste** _____ (1809) – Changes in species linked to “Physical Conditions of Life”
 - Believed that over the lifetime of an individual, physical features increase in size because of use or disuse
 - These changes then passed to offspring

LAMARCK'S GIRAFFE



Darwin's Observations

- Read Charles _____ book “*Principles of Geology*”
 - Lyell proposed that the surface of the earth changed slowly over time
 - In South America Darwin found fossils of extinct armadillos
 - These fossilized animals closely resembled the armadillos living in the area

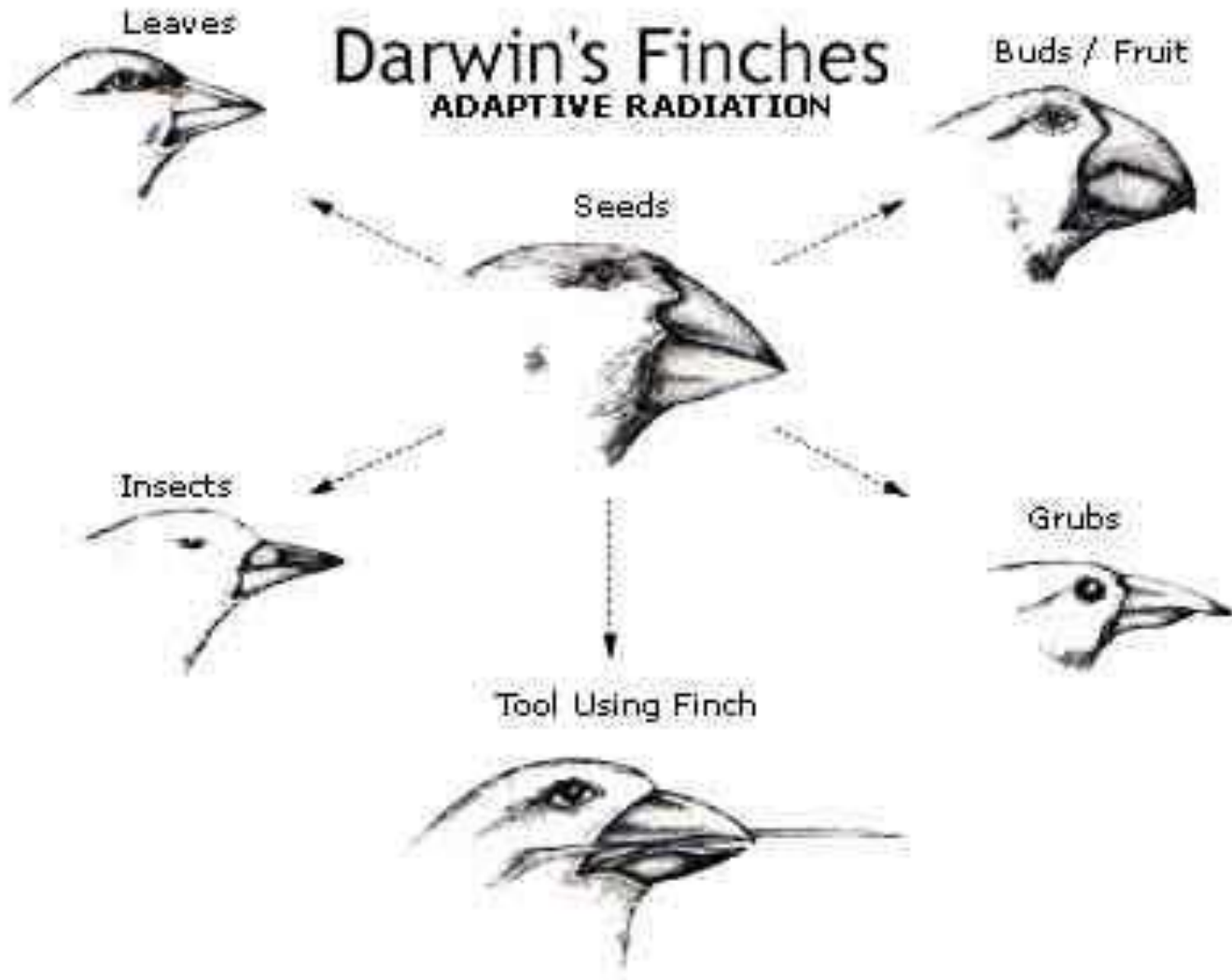


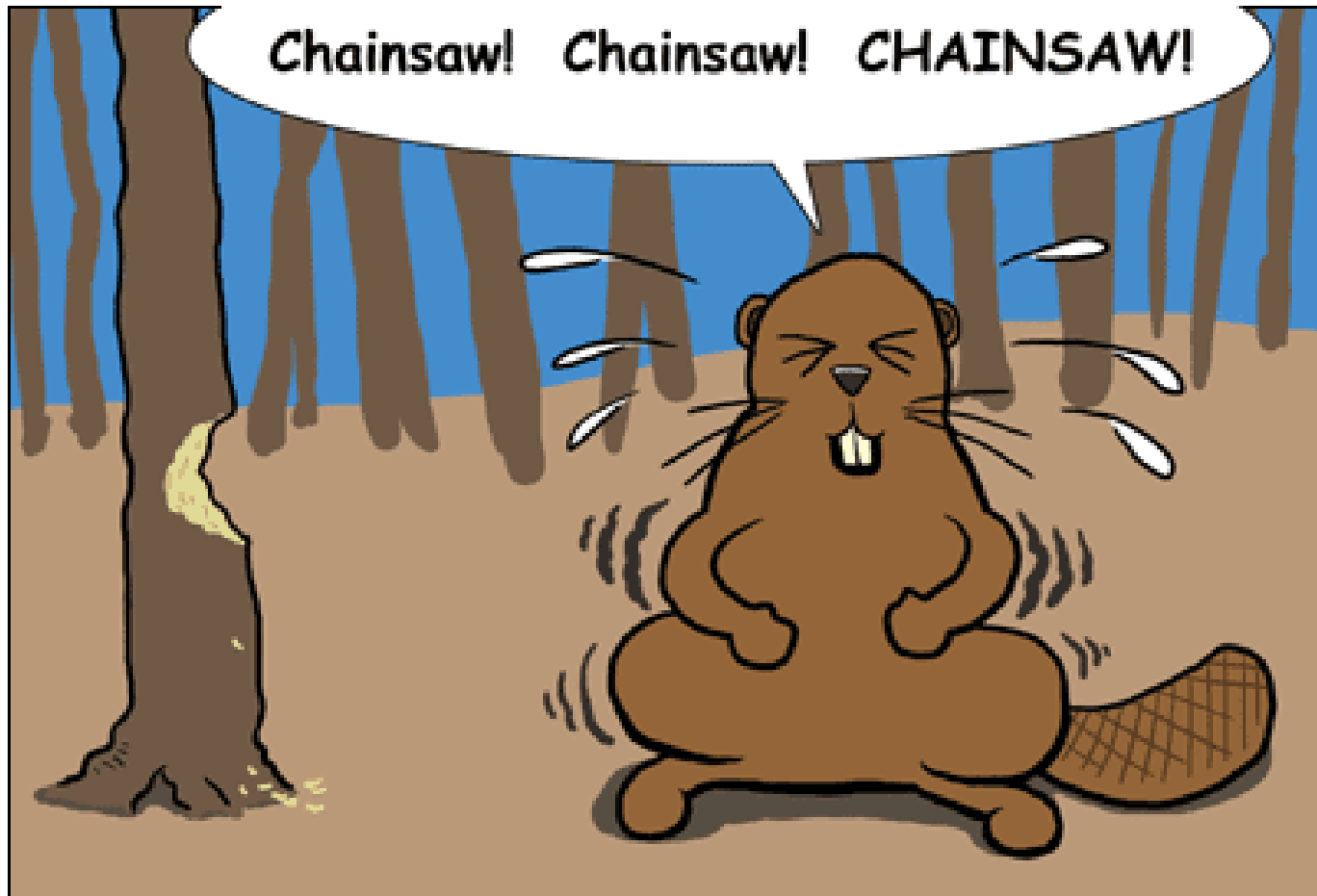
13.1 A sea voyage helped Darwin frame his theory of evolution

- As he reflected on his observations, analyzed his collections, and discussed his work with colleagues, he concluded that the evidence was better explained by the hypothesis that ...

13.1 A sea voyage helped Darwin frame his theory of evolution

- He hypothesized that as the descendants of a remote ancestor spread into various habitats over millions and millions of years, they accumulated diverse modifications, or _____, that fit them to specific ways of life in their environment.
- **An inherited trait that has become common in a population because the trait provides a selective advantage**





Adaptation doesn't involve trying.

13.1 A sea voyage helped Darwin frame his theory of evolution

- Consequently, scientists regard Darwin's concept of evolution by means of natural selection as a _____, a widely accepted explanatory idea that
 - is broader in scope than a hypothesis
 - generates new hypotheses
 - is supported by a large body of evidence

13.1 A sea voyage helped Darwin frame his theory of evolution

- Next we examine lines of evidence for Darwin's theory of ...

_____, the idea that living species are descendants of ancestral species that were different from present-day ones

and that natural selection is the mechanism for evolutionary change.

13.2 The study of fossils provides strong evidence for evolution

-

- are the imprints or remains of organisms that lived in the past
- document differences between past and present organisms
- reveal that many species have become extinct

Figure 13.2a

For example, the fossilized skull of one of our early relatives, *Homo erectus*, represents someone who lived 1.5 million years ago in Africa.



13.2 The study of fossils provides strong evidence for evolution

- The fossil record is incomplete because
 - many of Earth's organisms did not _____ in areas that favor fossilization
 - fossils that did form were in _____ later distorted or destroyed by geologic processes
 - not all fossils that have been preserved are _____
_____ to paleontologists.

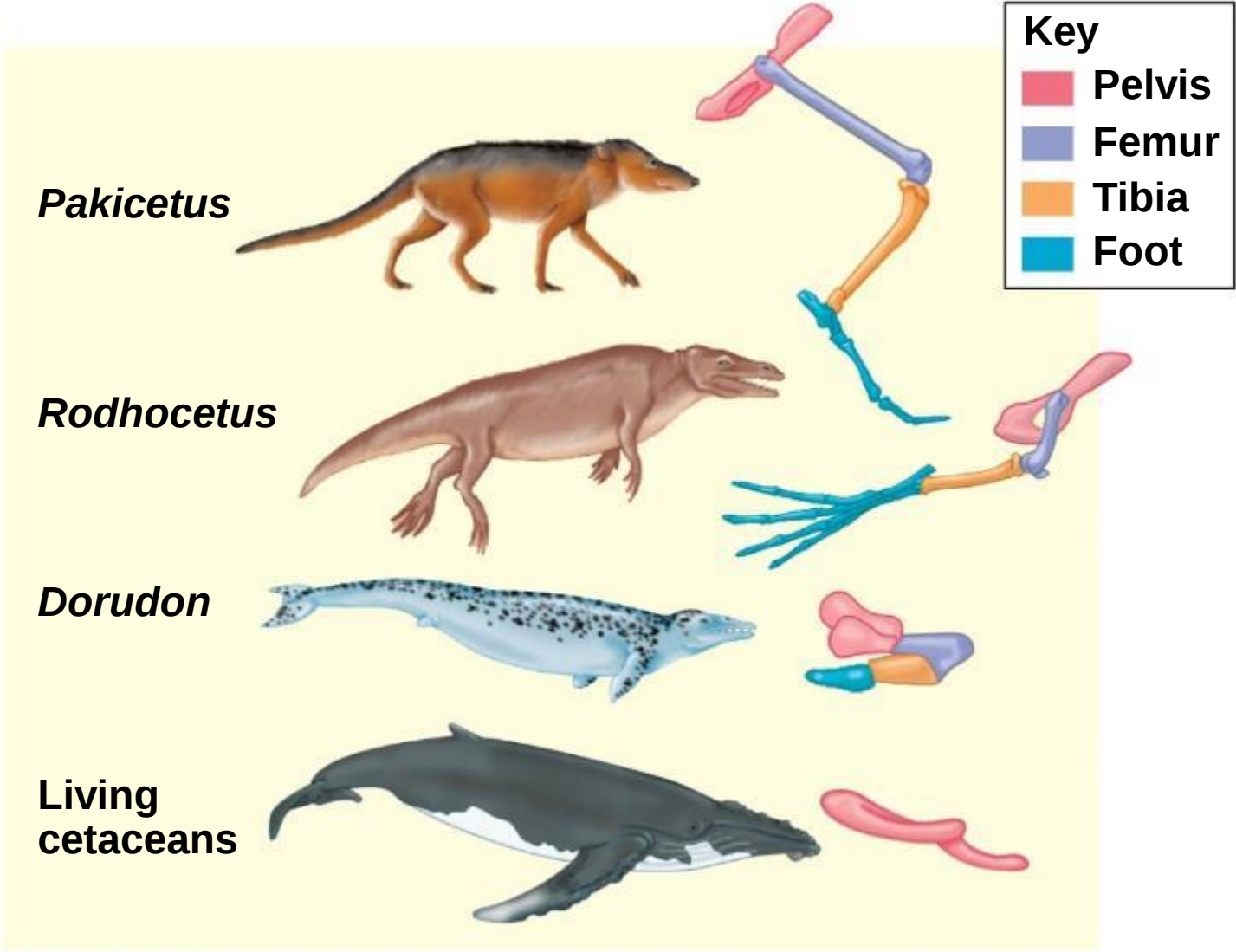
13.3 SCIENTIFIC THINKING: Fossils of transitional forms support Darwin's theory of evolution

- Many fossils _____ early extinct species with species living today.
- A series of fossils traces the gradual modification of jaws and teeth in the evolution of mammals from a reptilian ancestor.
- A series of fossils documents the evolution of whales from a group of land mammals.

13.3 SCIENTIFIC THINKING: Fossils of transitional forms support Darwin's theory of evolution

- Thousands of fossil discoveries have since shed light on the evolutionary origins of many groups of plants and animals, including
 - the transition of fish to amphibian
 - the origin of birds from a lineage of dinosaurs
 - the evolution of mammals from a reptilian ancestor

Figure 13.3b



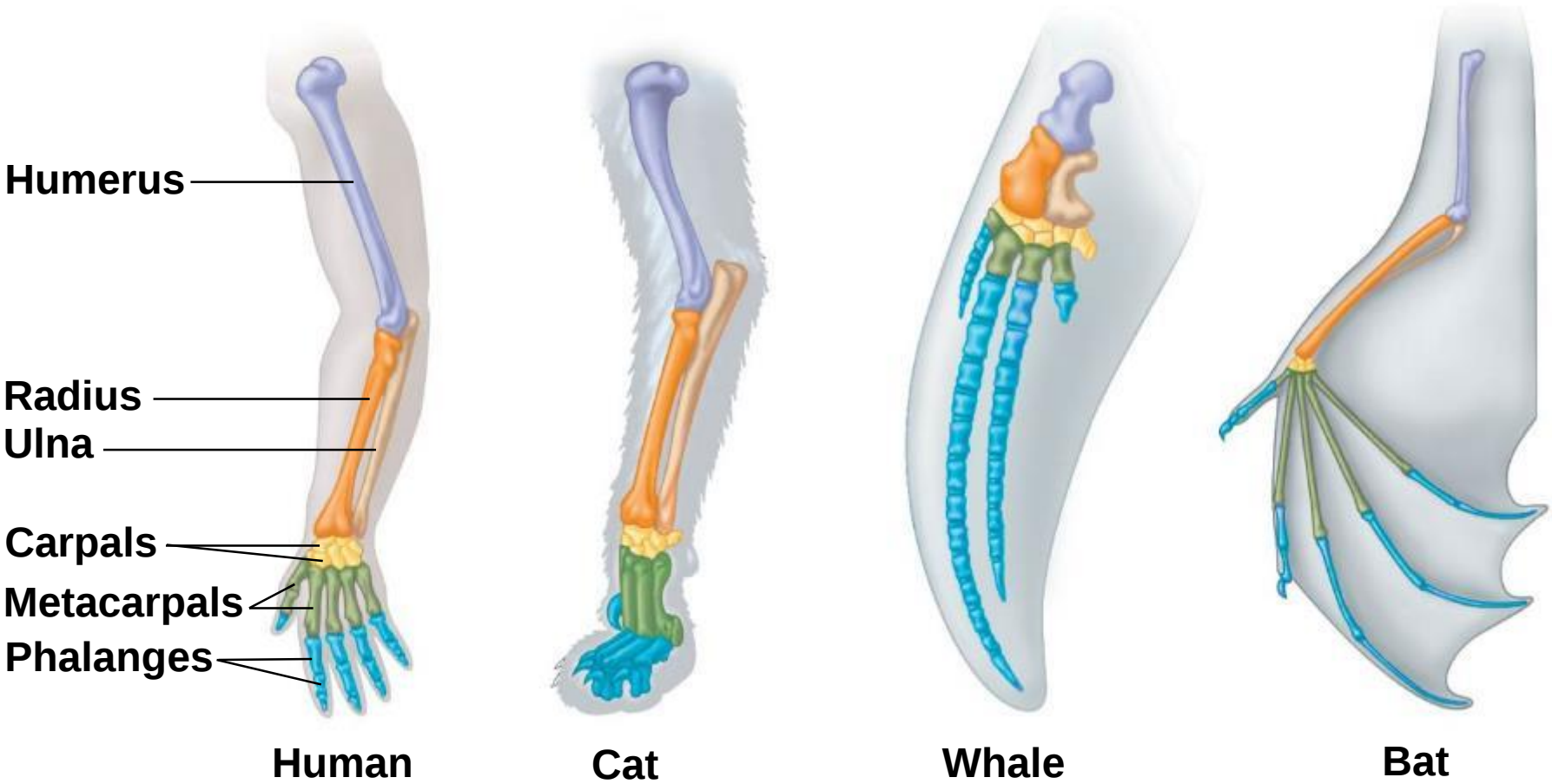
13.4 Homologies provide strong evidence for evolution

- Evolution is a process of _____
- Characteristics present in an ancestral organism are altered over time by natural selection as its descendants face different environmental conditions.
- Evolution is a remodeling process.
- Related species can have characteristics that have an underlying similarity yet function differently.
- Similarity resulting from common ancestry is known as _____.

13.4 Homologies provide strong evidence for evolution

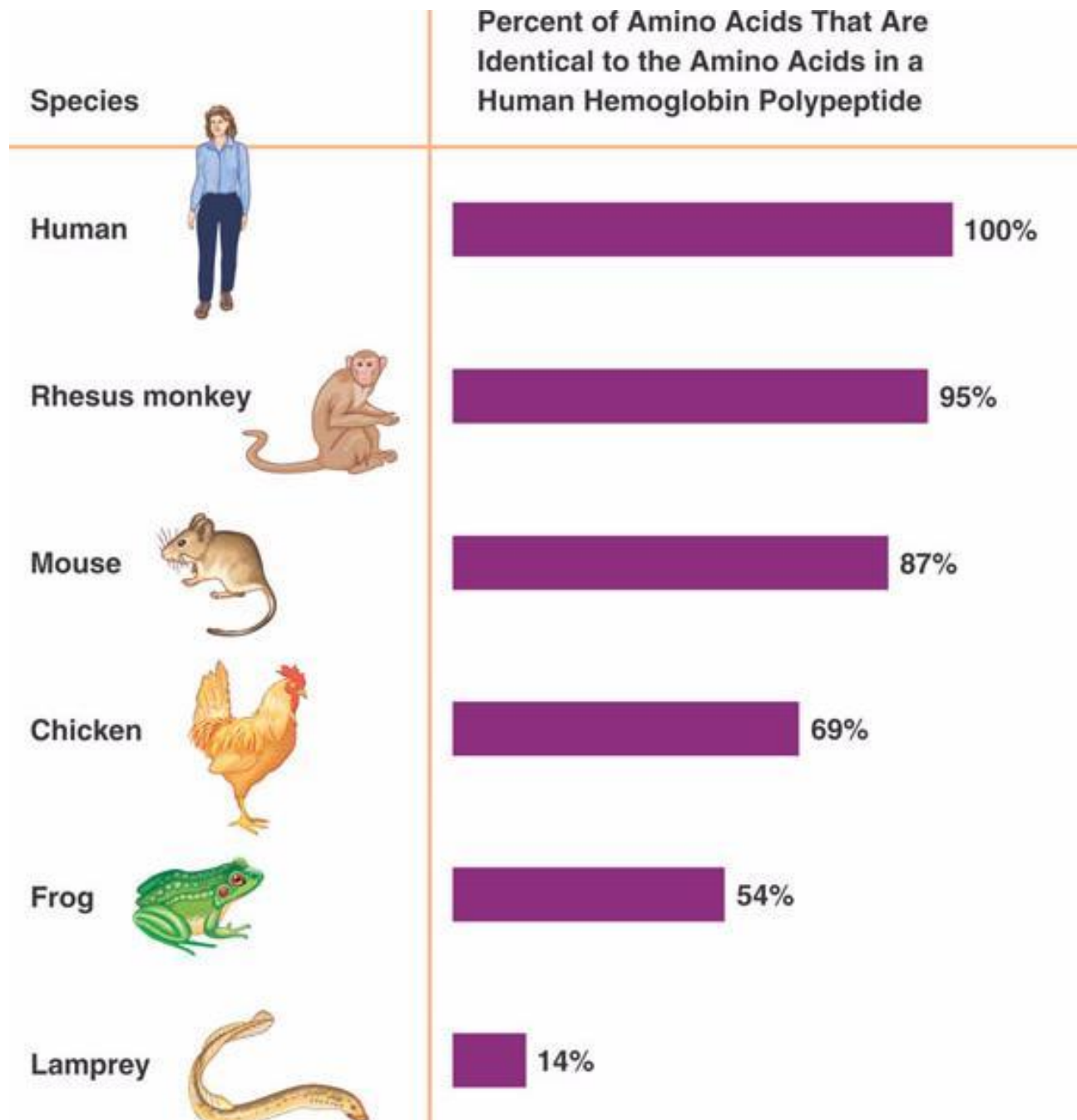
- Darwin cited the _____ similarities among vertebrate forelimbs as evidence of common ancestry.
- As **Figure 13.4A** shows, the same skeletal elements make up the forelimbs of humans, cats, whales, and bats, but the functions of these forelimbs differ.
- Biologists call such anatomical similarities in different organisms _____.

Figure 13.4a



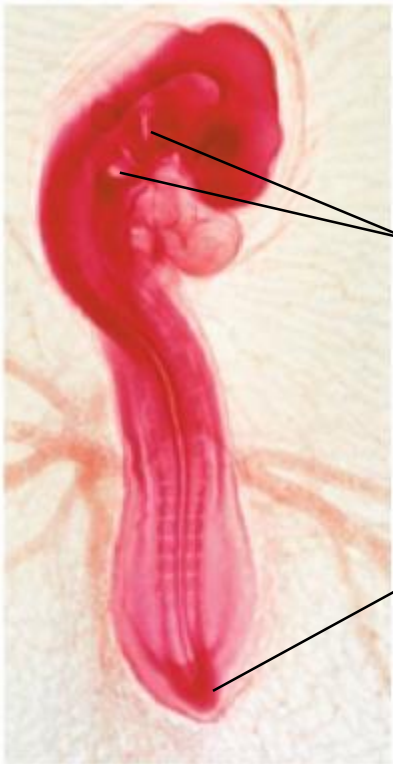
13.4 Homologies provide strong evidence for evolution

- Darwin's boldest hypothesis was that _____
_____.
- Molecular biology provides strong evidence for this claim
 - All forms of life use the same genetic language of DNA and RNA
 - The genetic code—how RNA triplets are translated into amino acids—is essentially universal.



13.4 Homologies provide strong evidence for evolution

- An understanding of homology helps explain why
 - early stages of development in different animal species reveal similarities not visible in adult organisms
- at some point in their development, all vertebrate embryos have
 - a tail posterior to the anus
 - structures called pharyngeal (throat) pouches



Chick embryo



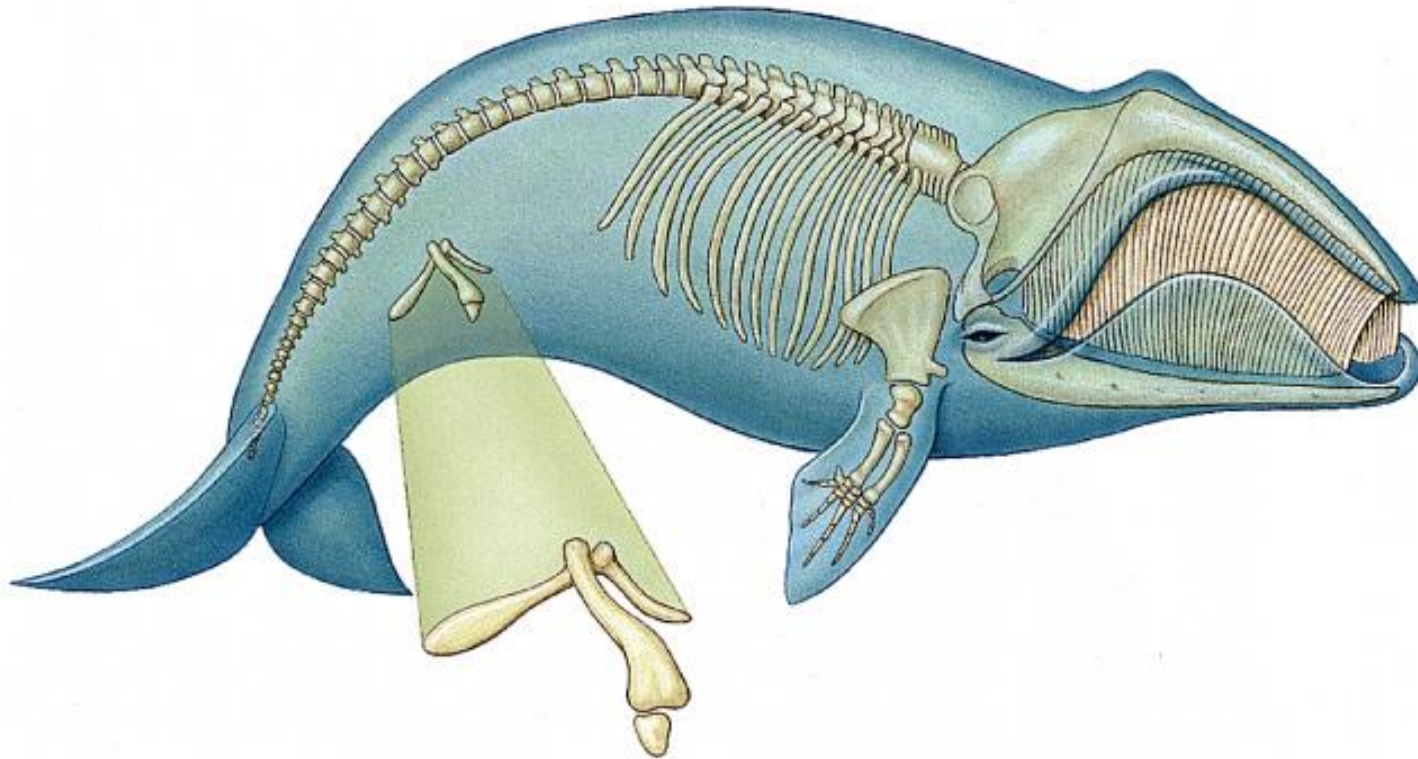
Human embryo

**Pharyngeal
pouches**

**Post-anal
tail**

13.4 Homologies provide strong evidence for evolution

- Some of the most interesting homologies are “leftover” structures that are of marginal or perhaps no importance to the organism.
- These _____ are remnants of features that served important functions in the organism’s ancestors.



Hind limbs (“legs”) of whales – Not used so shrank in size over time

13.5 Homologies indicate patterns of descent that can be shown on an evolutionary tree

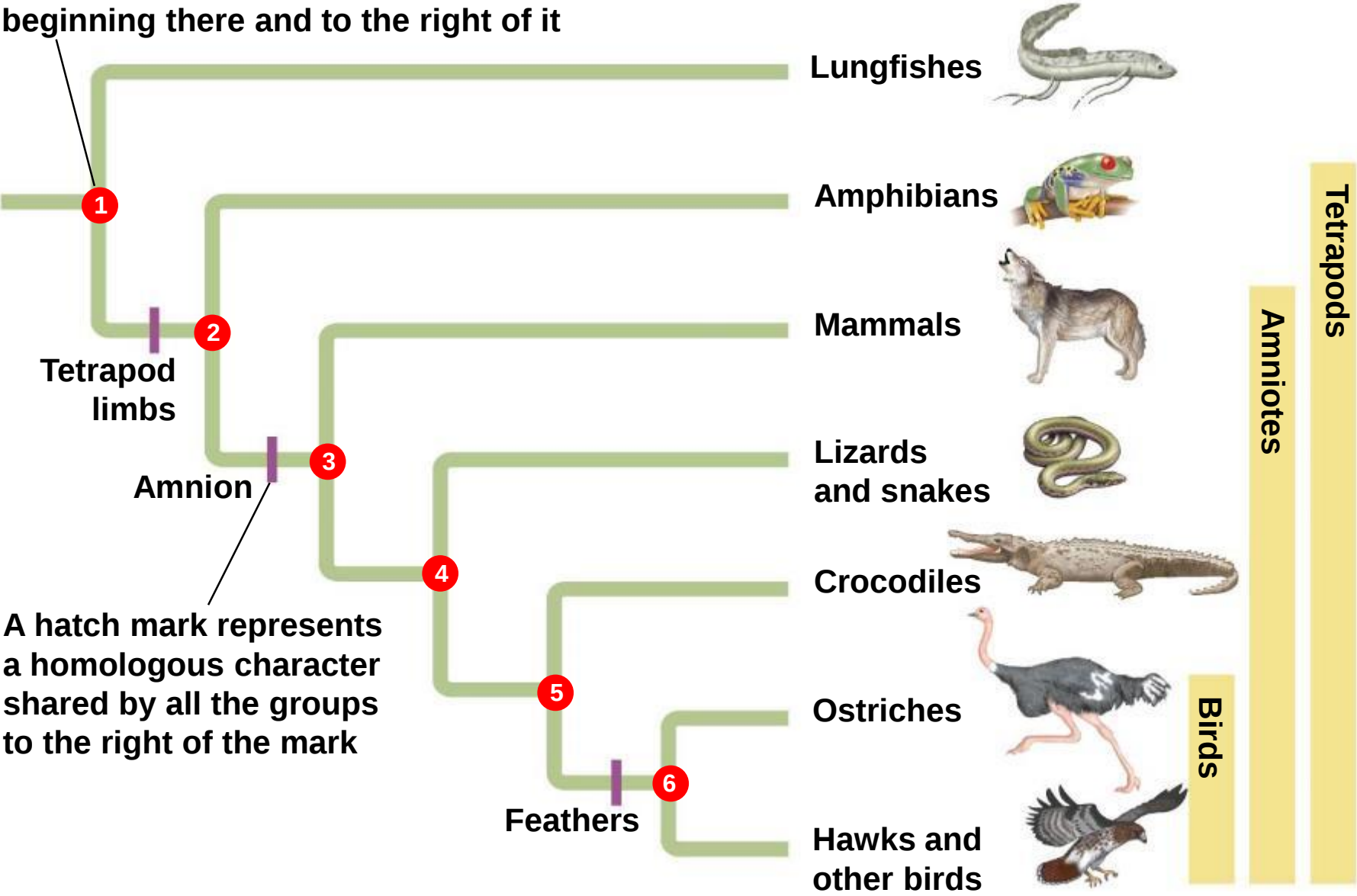
- Darwin was the first to view the history of life as a tree, with multiple branches from a common ancestral trunk to the descendant species at the tips of the twigs.
- Today, biologists represent these patterns of descent with an _____, although today they often turn the trees sideways.

13.5 Homologies indicate patterns of descent that can be shown on an evolutionary tree

- Homologous structures can be used to determine the branching sequence of an evolutionary tree.
- These homologies can include
 - _____ structure and/or
 - _____ structure

Figure 13.5

Each branch point represents the common ancestor of the lineages beginning there and to the right of it

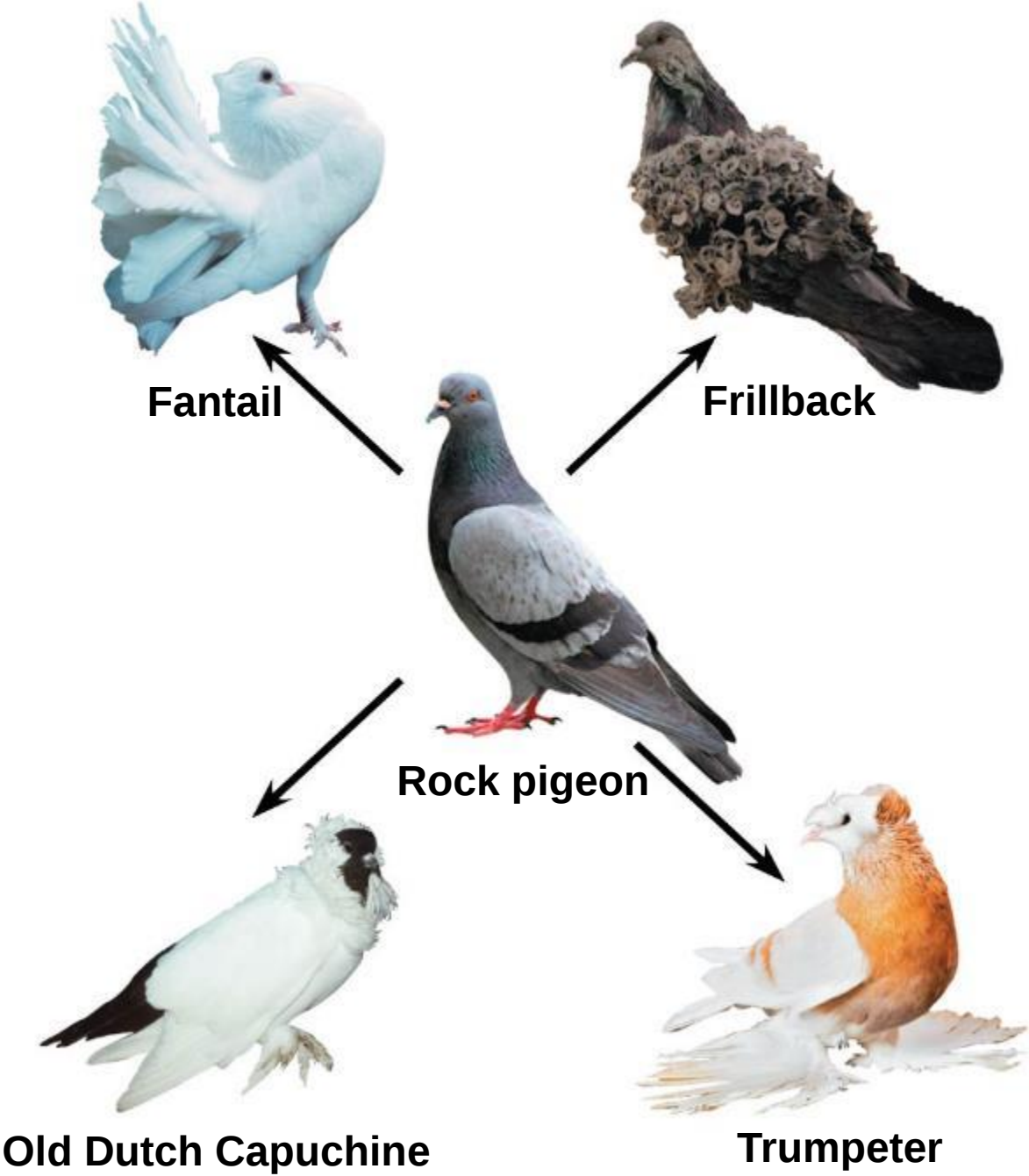


13.6 Darwin proposed natural selection as the mechanism of evolution

- Darwin's greatest contribution to biology was his explanation of _____

- Because he thought that species formed gradually over long periods of time, he knew that he would not be able to study the evolution of new species by direct observation.
- But insights into how incremental change occurs could be seen in examples of _____, in which humans have modified species through selective breeding.

Figure 13.6-0



13.6 Darwin proposed natural selection as the mechanism of evolution

- Darwin knew that individuals in natural populations have small but measurable differences.
- But what forces in nature played the role of the breeder, choosing which individuals became the breeding stock for the next generation?
- Darwin found inspiration in an essay written by economist Thomas Malthus, who contended that much of human suffering—disease, famine, and war—was the consequence of human _____
_____ supplies and other resources.

13.6 Darwin proposed natural selection as the mechanism of evolution

- Darwin deduced that the production of more individuals than the limited resources can support leads to a struggle for existence, with only some offspring surviving in each generation.
- The essence of natural selection is this unequal reproduction.
 - Individuals whose traits better enable them to obtain food or escape predators or tolerate physical conditions will survive and reproduce more successfully, passing these adaptive traits to their offspring.

13.6 Darwin proposed natural selection as the mechanism of evolution

- Darwin reasoned that if artificial selection can bring about so much change in a relatively short period of time, then natural selection could modify species considerably over hundreds or thousands of generations.

13.7 Scientists can observe natural selection in action

- These examples of evolutionary adaptation highlight two important points about natural selection.
 1. Natural selection is more of an _____ process than a creative mechanism.
 2. Natural selection is contingent on time and place, favoring those _____ traits in a varying population that fit the current, local environment.



Natural selection does not grant organisms what they "need".

THE EVOLUTION OF POPULATIONS

13.9 Evolution occurs within populations

- A _____ is a group of individuals of the same species, that live in the same area, and interbreed.
- We can measure evolution as a change in the prevalence of certain heritable traits in a population over a span of generations.

13.9 Evolution occurs within populations

- A _____ consists of all copies of every type of allele, at every locus, in all members of the population.
- _____ is
 - change in the relative frequencies of alleles in a population over a number of generations and
 - evolution occurring on its smallest scale.

MECHANISMS OF MICROEVOLUTION

13.12 Natural selection, genetic drift, and gene flow can cause microevolution

- The three main causes of evolutionary change are
 1. natural selection
 2. genetic drift
 3. gene flow

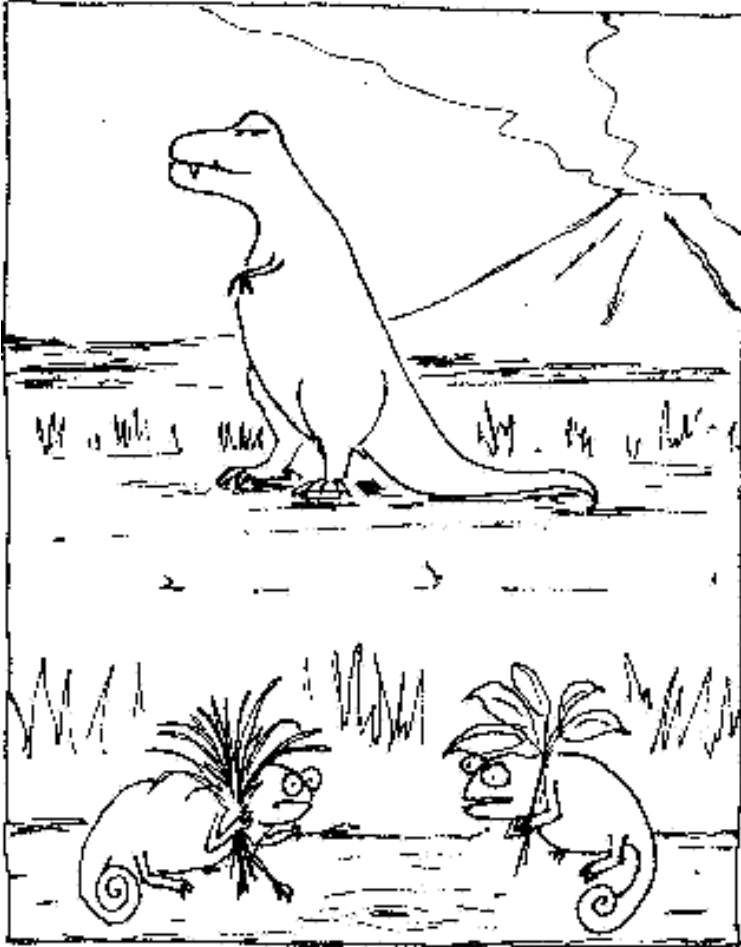
13.12 Natural selection, genetic drift, and gene flow can cause microevolution

1.

- If individuals differ in their survival and reproductive success, natural selection will _____.
- Consider the imaginary iguana population. Individuals with webbed feet (genotype ww) might survive better and produce more offspring because they are more efficient at swimming and catching food than individuals that lack webbed feet.
- Genetic equilibrium would be disturbed as the frequency of the w allele increased in the gene pool from one generation to the next.

Natural Selection

A PLANET LIKE OURS



- “Survival of the Fittest”
- Individuals with the best traits for their environment are more likely to survive and reproduce

13.12 Natural selection, genetic drift, and gene flow can cause microevolution

2.

- In a process called **genetic drift**, chance events can cause allele frequencies to fluctuate unpredictably from one generation to the next.
- The _____ the population, the more impact genetic drift is likely to have.

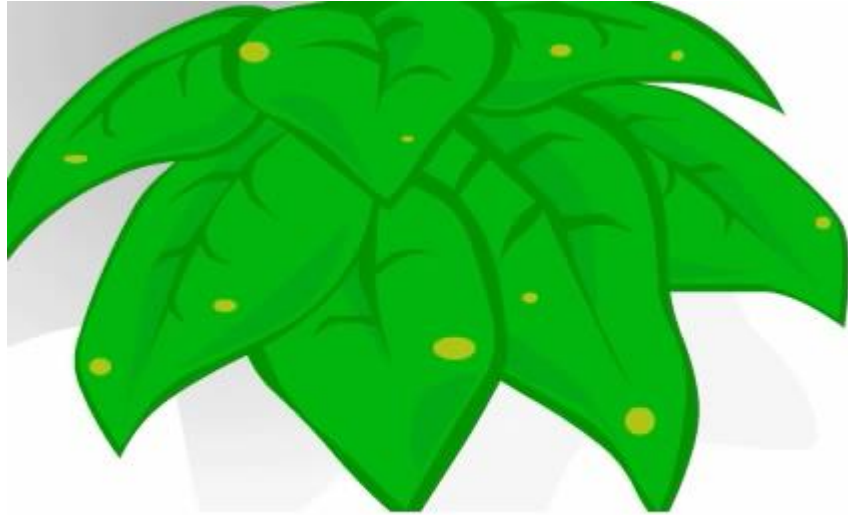
13.12 Natural selection, genetic drift, and gene flow can cause microevolution

- Catastrophes such as hurricanes, floods, or fires may kill large numbers of individuals, leaving a small surviving population that is unlikely to have the same genetic makeup as the original population.
- The _____ leads to a loss of genetic diversity when a population is greatly reduced.

13.12 Natural selection, genetic drift, and gene flow can cause microevolution

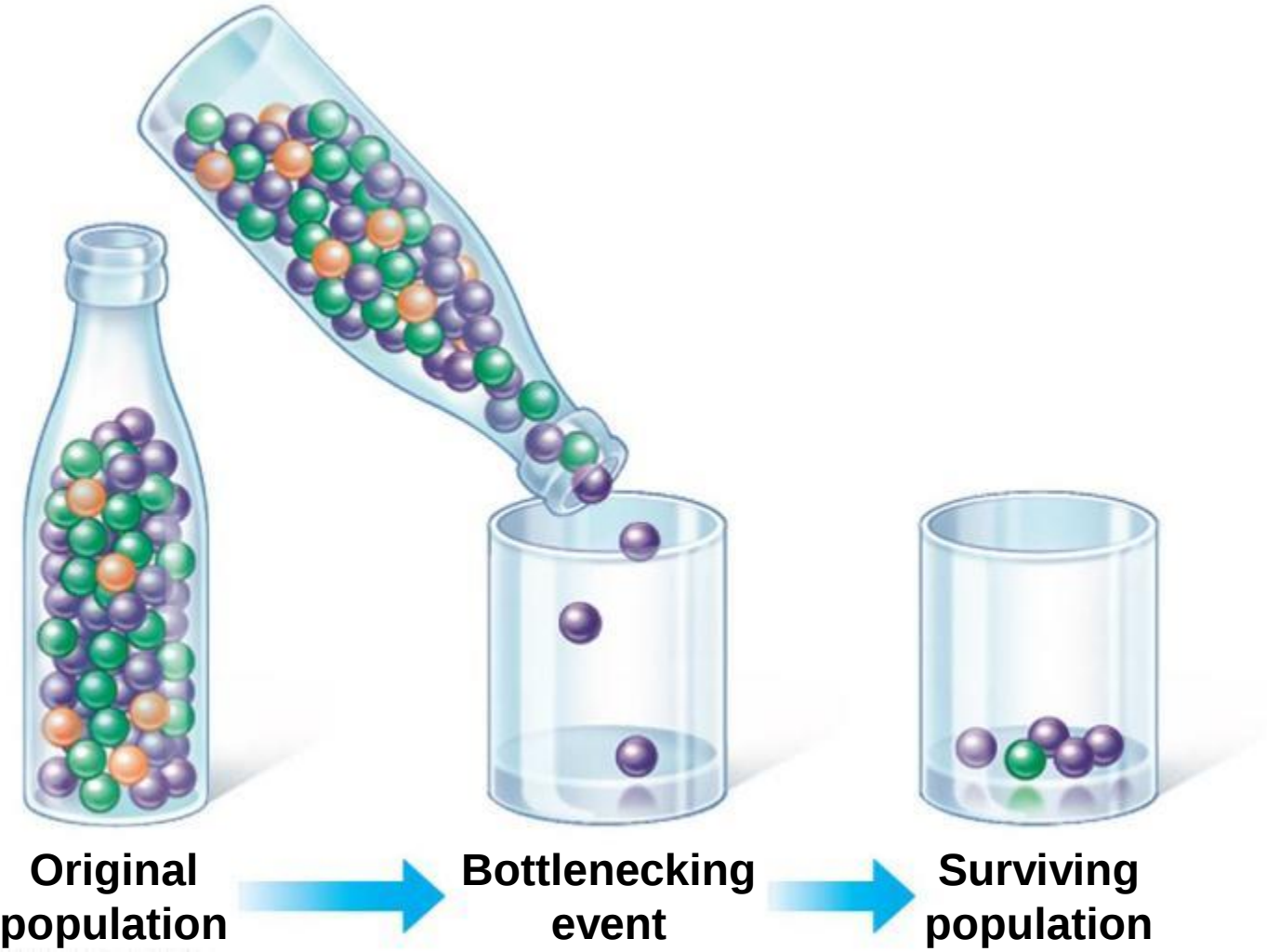
- Analogous to shaking just a few marbles through a bottleneck, certain alleles may be present at higher frequency in the surviving population than in the original population, others may be present at lower frequency, and some (orange marbles) may not be present at all.
- After a population is drastically reduced, genetic drift may continue for many generations until the population is again large enough for fluctuations due to chance to have less of an impact.

Animation: Causes of Evolutionary Change



Copyright © 2005 Pearson Education, Inc.
publishing as Benjamin Cummings

Figure 13.12a-3



13.12 Natural selection, genetic drift, and gene flow can cause microevolution

- One reason it is important to understand the bottleneck effect is that human activities such as overhunting and habitat destruction may create severe bottlenecks for other species.
- Examples of species affected by bottlenecks include the endangered Florida panther, the African cheetah, and the greater prairie chicken.

Figure 13.12b



13.12 Natural selection, genetic drift, and gene flow can cause microevolution

3.

- Allele frequencies in a population can also change as a result of **gene flow**, where a population may gain or lose alleles when fertile individuals move into or out of a population or when gametes (such as plant pollen) are transferred between populations.
- Gene flow tends to reduce differences between populations.

13.12 Natural selection, genetic drift, and gene flow can cause microevolution

- To counteract the lack of genetic diversity in the remaining Illinois greater prairie chickens, researchers added 271 birds from neighboring states to the Illinois populations, which successfully introduced new alleles.
- This strategy worked. New alleles entered the population, and the egg-hatching rate improved to more than 90%.

13.13 Natural selection is the only mechanism that consistently leads to adaptive evolution

- Genetic drift, gene flow, and mutations could each result in _____, but only by chance could these events improve a population's fit to its environment.
- In natural selection, only the genetic variation produced by mutation and sexual reproduction results from _____ events.
 - The process of natural selection, in which some individuals are more likely than others to survive and reproduce, is *not* random.
 - Because of this sorting, only natural selection consistently leads to adaptive evolution.

Figure 13.13



13.13 Natural selection is the only mechanism that consistently leads to adaptive evolution

- The commonly used phrases “struggle for existence” and “survival of the fittest” are misleading if we take them to mean direct competition between individuals.
- Reproductive success is generally more subtle and passive.
- _____ is the contribution an individual makes to the gene pool of the next generation relative to the contributions of other individuals.