


CAMPBELL
BIOLOGY
TENTH EDITION
Reece • Urry • Cain • Wasserman • Minorsky • Jackson

22

**Descent with Modification:
A Darwinian View of Life**

Lecture Presentation by
Nicole Tunbridge and
Matthew Fitzpatrick
© 2014 Pearson Education, Inc.



Endless Forms Most Beautiful

- A new era of biology began in 1859 when Charles Darwin published *The Origin of Species*
- *The Origin of Species* focused biologists' attention on the great diversity of organisms

© 2014 Pearson Education, Inc.

2

- Darwin noted that current species are descendants of ancestral species
- **Evolution** can be defined by Darwin's phrase *descent with modification*
- Evolution can be viewed as both a pattern and a process

© 2014 Pearson Education, Inc.

3

Figure 22.1



© 2014 Pearson Education, Inc.

4

Figure 22.1a



© 2014 Pearson Education, Inc.

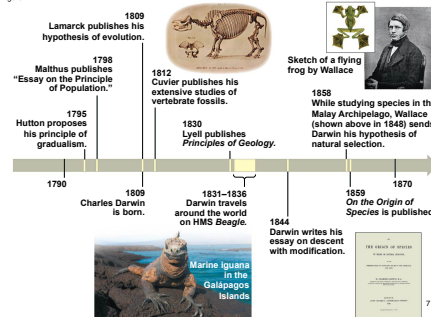
6

Concept 22.1: The Darwinian revolution challenged traditional views of a young Earth inhabited by unchanging species

- Darwin's ideas had deep historical roots

© 2014 Pearson Education, Inc.

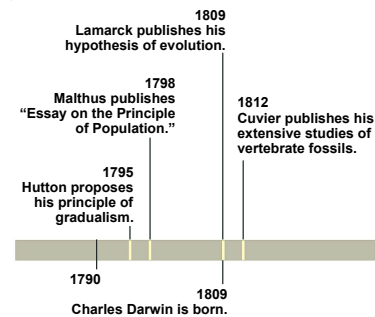
Figure 22.2



© 2014 Pearson Education, Inc.

7

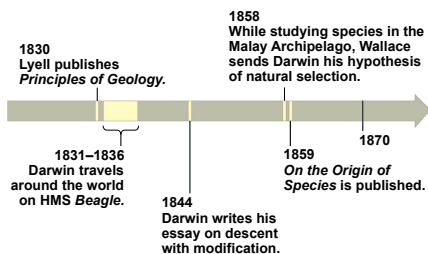
Figure 22.2a



© 2014 Pearson Education, Inc.

8

Figure 22.2b



© 2014 Pearson Education, Inc.

9

Figure 22.2c



1812 Cuvier publishes his extensive studies of vertebrate fossils.

© 2014 Pearson Education, Inc.

10

Figure 22.2d



1831–1836 Darwin travels around the world on HMS Beagle.

© 2014 Pearson Education, Inc.

11

Figure 22.2e



Sketch of a flying frog by Wallace

© 2014 Pearson Education, Inc.

12

Figure 22.2f



1858 While studying species in the Malay Archipelago, Wallace (shown above in 1848) sends Darwin his hypothesis of natural selection.

© 2014 Pearson Education, Inc.

13

Figure 22.2g



1859 *On the Origin of Species* is published.

© 2014 Pearson Education, Inc.

14

Scala Naturae and Classification of Species

- The Greek philosopher Aristotle viewed species as fixed and arranged them on a *scala naturae*
- The Old Testament holds that species were individually designed by God and therefore perfect

© 2014 Pearson Education, Inc.

15

- Carolus Linnaeus interpreted organismal adaptations as evidence that the Creator had designed each species for a specific purpose
- Linnaeus was the founder of taxonomy, the branch of biology concerned with classifying organisms
- He developed the binomial format for naming species (for example, *Homo sapiens*)

© 2014 Pearson Education, Inc.

16

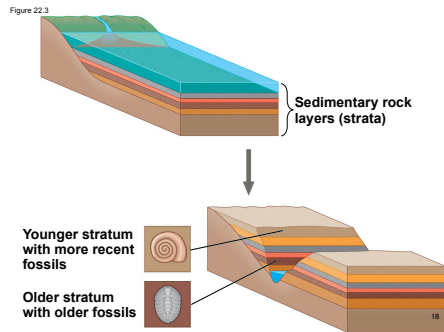
Ideas About Change over Time

- The study of **fossils** helped to lay the groundwork for Darwin's ideas
- Fossils are remains or traces of organisms from the past, usually found in sedimentary rock, which appears in layers called **strata**

17

© 2014 Pearson Education, Inc.

Figure 22.3



© 2014 Pearson Education, Inc.

Video: Grand Canyon



19

© 2014 Pearson Education, Inc.

- **Paleontology**, the study of fossils, was largely developed by French scientist Georges Cuvier
- Cuvier speculated that the boundaries between strata represent catastrophic events

20

© 2014 Pearson Education, Inc.

- Geologists James Hutton and Charles Lyell perceived that changes in Earth's surface can result from slow continuous actions still operating today, and at the same rate
- This view strongly influenced Darwin's thinking

21

© 2014 Pearson Education, Inc.

Lamarck's Hypothesis of Evolution

- Lamarck hypothesized that species evolve through use and disuse of body parts and the inheritance of acquired characteristics
- The mechanisms he proposed are unsupported by evidence

22

© 2014 Pearson Education, Inc.

Figure 22.4



23

© 2014 Pearson Education, Inc.

Concept 22.2: Descent with modification by natural selection explains the adaptations of organisms and the unity and diversity of life

- Some doubt about the permanence of species preceded Darwin's ideas

24

© 2014 Pearson Education, Inc.

Darwin's Research

- As a boy and into adulthood, Charles Darwin had a consuming interest in nature
- Darwin first studied medicine (unsuccessfully), and then theology at Cambridge University
- After graduating, he took an unpaid position as naturalist and companion to Captain Robert FitzRoy for a 5-year around the world voyage on the *Beagle*

25

© 2014 Pearson Education, Inc.

The Voyage of the Beagle

- During his travels on the *Beagle*, Darwin collected specimens of South American plants and animals
- He observed that fossils resembled living species from the same region, and living species resembled other species from nearby regions
- He experienced an earthquake in Chile and observed the uplift of rocks

26

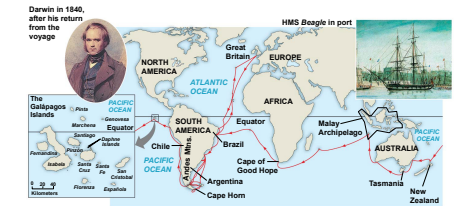
© 2014 Pearson Education, Inc.

- Darwin was influenced by Lyell's *Principles of Geology* and thought that the earth was more than 6,000 years old
- His interest in geographic distribution of species was kindled by a stop at the Galápagos Islands west of South America
- He hypothesized that species from South America had colonized the Galápagos and speciated on the islands

27

© 2014 Pearson Education, Inc.

Figure 22.5



28

© 2014 Pearson Education, Inc.

Figure 22.5a



29

© 2014 Pearson Education, Inc.

Figure 22.5b

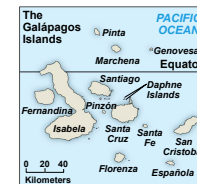


Darwin in 1840, after his return from the voyage

30

© 2014 Pearson Education, Inc.

Figure 22.5c



31

© 2014 Pearson Education, Inc.

Figure 22.5d



HMS Beagle in port

32

© 2014 Pearson Education, Inc.

Video: Albatross Courtship Ritual



33

Video: Galápagos Sea Lion



37

Video: Blue-footed Boobies Courtship Ritual



34

Video: Galápagos Tortoise



38

Video: Galápagos Islands Overview



35

Video: Soaring Hawk



39

Video: Galápagos Marine Iguana



36

Video: Snake Ritual Wrestling



40

Darwin's Focus on Adaptation

- In reassessing his observations, Darwin perceived **adaptation** to the environment and the origin of new species as closely related processes
- From studies made years after Darwin's voyage, biologists have concluded that this is what happened to the Galápagos finches

41

Figure 22.6



(a) Cactus-eater

(b) Insect-eater



(c) Seed-eater

42

Figure 22.6a



(a) Cactus-eater

43

Figure 22.6b



(b) Insect-eater

44

Figure 22.6c



(c) Seed-eater

45

- In 1844, Darwin wrote an essay on **natural selection** as the mechanism of descent with modification, but did not introduce his theory publicly
- Natural selection is a process in which individuals with favorable inherited traits are more likely to survive and reproduce
- In June 1858, Darwin received a manuscript from Alfred Russel Wallace, who had developed a theory of natural selection similar to Darwin's
- Darwin quickly finished *The Origin of Species* and published it the next year

46

The Origin of Species

- Darwin explained three broad observations
 - The unity of life
 - The diversity of life
 - The match between organisms and their environment

47

Descent with Modification

- Darwin never used the word *evolution* in the first edition of *The Origin of Species*
- The phrase *descent with modification* summarized Darwin's perception of the unity of life
- The phrase refers to the view that all organisms are related through descent from an ancestor that lived in the remote past

48

- In the Darwinian view, the history of life is like a tree with branches representing life's diversity
- Darwin reasoned that large morphological gaps between related groups could be explained by this branching process and past extinction events

Figure 22.7

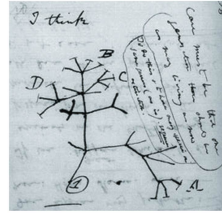


Figure 22.8

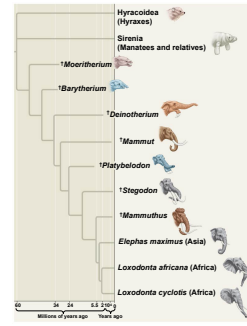


Figure 22.8a

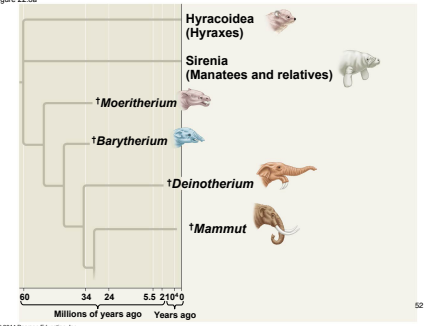
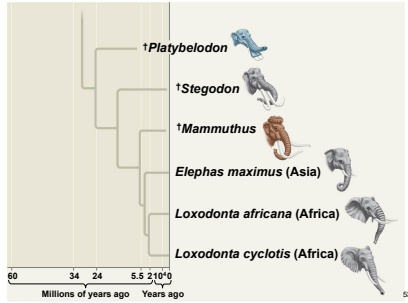


Figure 22.8b



Artificial Selection, Natural Selection, and Adaptation

- Darwin noted that humans have modified other species by selecting and breeding individuals with desired traits, a process called **artificial selection**
- Darwin drew two inferences from two observations

Figure 22.9

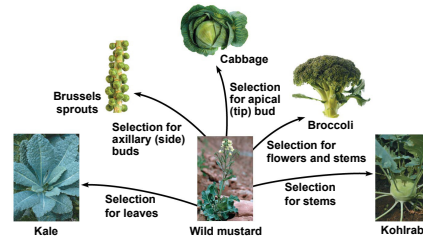


Figure 22.9a



Wild mustard

Figure 22.9b



Kale

Figure 22.9c



Brussels sprouts

Figure 22.9d



Cabbage

Figure 22.9e



Broccoli

Figure 22.9f



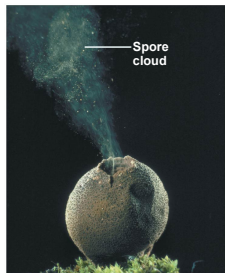
Kohlrabi

- **Observation #1:** Members of a population often vary in their inherited traits

Figure 22.10



- **Observation #2:** All species can produce more offspring than the environment can support, and many of these offspring fail to survive and reproduce



- **Inference #1:** Individuals whose inherited traits give them a higher probability of surviving and reproducing in a given environment tend to leave more offspring than other individuals

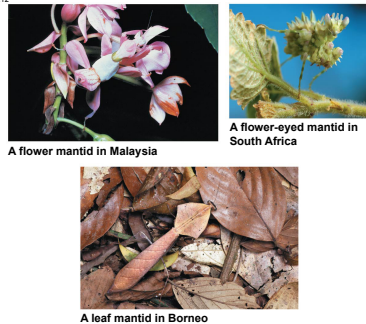
- **Inference #2:** This unequal ability of individuals to survive and reproduce will lead to the accumulation of favorable traits in the population over generations

- Darwin was influenced by Thomas Malthus, who noted the potential for human population to increase faster than food supplies and other resources
- If some heritable traits are advantageous, these will accumulate in a population over time, and this will increase the frequency of individuals with these traits
- This process explains the match between organisms and their environment

Natural Selection: A Summary

- Individuals with certain heritable traits survive and reproduce at a higher rate than other individuals
- Natural selection increases the match between organisms and their environment over time
- If an environment changes over time, natural selection may result in adaptation to these new conditions and may give rise to new species

Figure 22.12



A flower mantid in Malaysia

A flower-eyed mantid in South Africa

A leaf mantid in Borneo

Figure 22.12a



A flower mantid in Malaysia

Figure 22.12b



A flower-eyed mantid in South Africa

Figure 22.12c



A leaf mantid in Borneo

Video: Sea Horses



- Note that individuals do not evolve; populations evolve over time
- Natural selection can only increase or decrease heritable traits that vary in a population
- Adaptations vary with different environments

Concept 22.3: Evolution is supported by an overwhelming amount of scientific evidence

- New discoveries continue to fill the gaps identified by Darwin in *The Origin of Species*
- There are four types of data that document the pattern of evolution
 - Direct observations
 - Homology
 - The fossil record
 - Biogeography

Direct Observations of Evolutionary Change

- Two examples provide evidence for natural selection: natural selection in response to introduced plant species, and the evolution of drug-resistant bacteria

Natural Selection in Response to Introduced Species

- Soapberry bugs use their "beak" to feed on seeds within fruits
- Feeding is most effective when beak length is closely matched to seed depth within the fruit

- In southern Florida soapberry bugs feed on the native balloon vine with larger fruit; they have longer beaks
- In central Florida they feed on the introduced goldenrain tree with smaller fruit; they have shorter beaks
- Correlation between fruit size and beak size has also been observed in Louisiana, Oklahoma, and Australia

- In all cases, beak size has evolved in populations that feed on introduced plants with fruits that are smaller or larger than the native fruits
- These cases are examples of evolution by natural selection
- In Florida this evolution in beak size occurred in less than 35 years

Figure 22.13

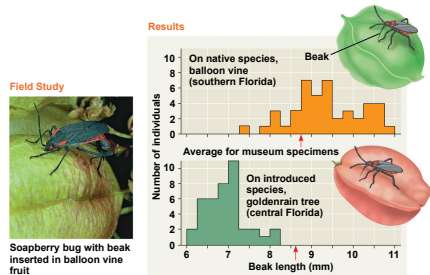


Figure 22.13a



The Evolution of Drug-Resistant Bacteria

- The bacterium *Staphylococcus aureus* is commonly found on people
- One strain, methicillin-resistant *S. aureus* (MRSA) is a dangerous pathogen
- Resistance to penicillin evolved in *S. aureus* by 1945, two years after it was first widely used
- Resistance to methicillin evolved in *S. aureus* by 1961, two years after it was first widely used

- Methicillin works by inhibiting a protein used by bacteria to produce cell walls
- MRSA bacteria use a different protein in cell wall production
- When exposed to methicillin, MRSA strains are more likely to survive and reproduce than nonresistant *S. aureus* strains
- MRSA strains are now resistant to many antibiotics

Figure 22.14

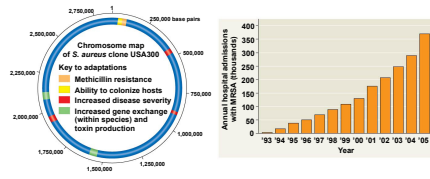


Figure 22.14a

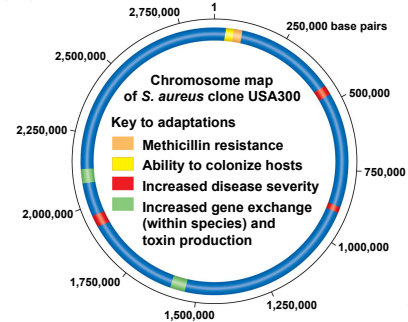
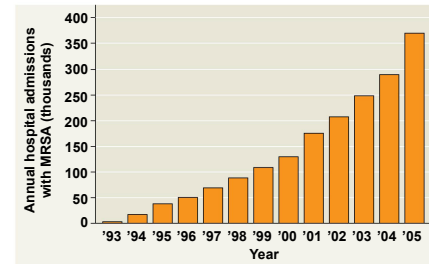


Figure 22.14b



- Natural selection does not create new traits, but edits or selects for traits already present in the population
- The current, local environment determines which traits will be selected for or selected against in any specific population

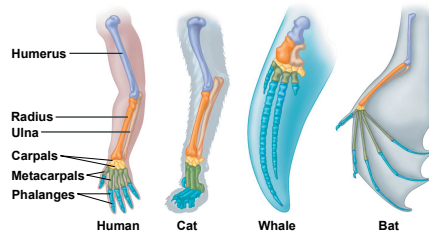
Homology

- Homology** is similarity resulting from common ancestry

Anatomical and Molecular Homologies

- Homologous structures** are anatomical resemblances that represent variations on a structural theme present in a common ancestor

Figure 22.15



- Comparative embryology reveals anatomical homologies not visible in adult organisms
 - For example, all vertebrate embryos have a post-anal tail and pharyngeal arches

Figure 22.16

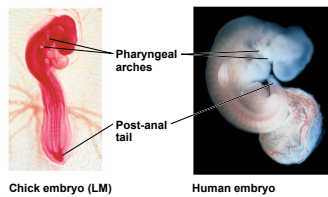


Figure 22.16a

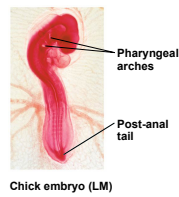
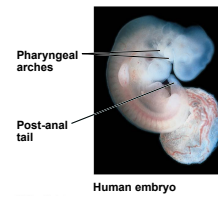


Figure 22.16b



- Vestigial structures** are remnants of features that served important functions in the organism's ancestors
- Examples of homologies at the molecular level are genes shared among organisms inherited from a common ancestor

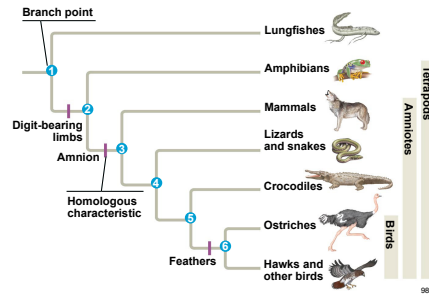
Homologies and "Tree Thinking"

- Evolutionary trees are hypotheses about the relationships among different groups
- Homologies form nested patterns in evolutionary trees
- Evolutionary trees can be made using different types of data, for example, anatomical and DNA sequence data

© 2014 Pearson Education, Inc.

97

Figure 22.17



© 2014 Pearson Education, Inc.

98

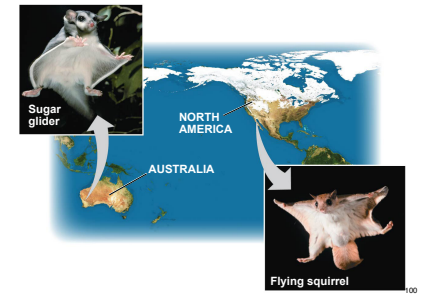
A Different Cause of Resemblance: Convergent Evolution

- Convergent evolution is the evolution of similar, or analogous, features in distantly related groups
- Analogous traits arise when groups independently adapt to similar environments in similar ways
- Convergent evolution does not provide information about ancestry

© 2014 Pearson Education, Inc.

99

Figure 22.18



© 2014 Pearson Education, Inc.

100

Figure 22.18a



Sugar glider

© 2014 Pearson Education, Inc.

101

Figure 22.18b



Flying squirrel

© 2014 Pearson Education, Inc.

102

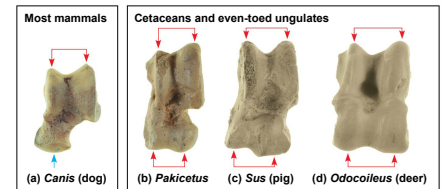
The Fossil Record

- The fossil record provides evidence of the extinction of species, the origin of new groups, and changes within groups over time

© 2014 Pearson Education, Inc.

103

Figure 22.19



© 2014 Pearson Education, Inc.

104

Figure 22.19a



(a) *Canis* (dog)

© 2014 Pearson Education, Inc.

105

Figure 22.19b



(b) *Pakicetus*

© 2014 Pearson Education, Inc.

106

Figure 22.19c

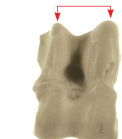


(c) *Sus* (pig)

© 2014 Pearson Education, Inc.

107

Figure 22.19d

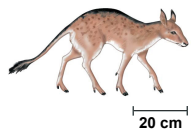


(d) *Odocoileus* (deer)

© 2014 Pearson Education, Inc.

108

Figure 22.LIN01



Diacodexis, an early even-toed ungulate

© 2014 Pearson Education, Inc.

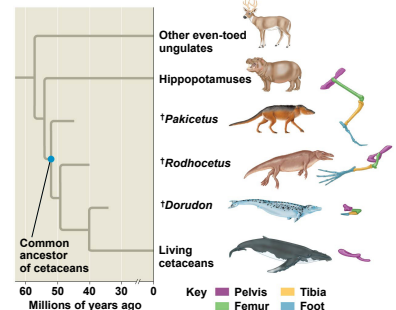
109

- Fossils can document important transitions
 - For example, the transition from land to sea in the ancestors of cetaceans

© 2014 Pearson Education, Inc.

110

Figure 22.20



© 2014 Pearson Education, Inc.

111

Biogeography

- Biogeography, the scientific study of the geographic distribution of species, provides evidence of evolution
- Earth's continents were formerly united in a single large continent called **Pangaea**, but have since separated by continental drift
- An understanding of continent movement and modern distribution of species allows us to predict when and where different groups evolved

© 2014 Pearson Education, Inc.

112

- **Endemic** species are species that are not found anywhere else in the world
- Islands have many endemic species that are often closely related to species on the nearest mainland or island
- Darwin explained that species from the mainland colonized islands and gave rise to new species as they adapted to new environments

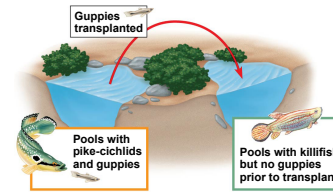
113

What Is Theoretical About Darwin's View of Life?

- In science, a theory accounts for many observations and data and attempts to explain and integrate a great variety of phenomena
- Darwin's theory of evolution by natural selection integrates diverse areas of biological study and stimulates many new research questions
- Ongoing research adds to our understanding of evolution

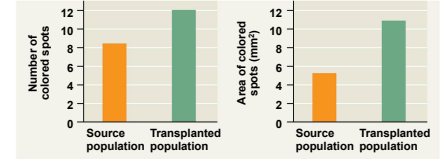
114

Figure 22.LN02a



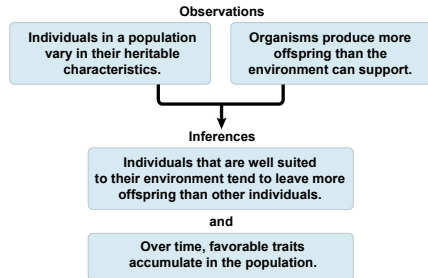
115

Figure 22.LN02b



116

Figure 22.LN03



117

Figure 22.LN04

Month	0	8	12
Mosquitoes Resistant* to DDT	4%	45%	77%

Source: C. F. Curtis et al., "Selection for and against insecticide resistance and possible methods of inhibiting the evolution of resistance in mosquitoes," *Ecological Entomology* 3:273-287 (1978).

*Mosquitoes were considered resistant if they were not killed within 1 hour of receiving a dose of 4% DDT.

118

Figure 22.LN05



119