Descent with Modification: A Darwinian View of Life

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

Neil Campbell and Jane Reece

Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

Overview: 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

- 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

survivorship at extreme conditions

Concept 1: The Darwinian revolution challenged traditional views of a young Earth inhabited by unchanging species

- To understand why Darwin's ideas were revolutionary, we must examine them in relation to other Western ideas about Earth and its life

Scala Naturae and Classification of Species

- The Greek philosopher Aristotle (384-322 B.C.) 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
- Carolus Linnaeus (1707-1778) saw the adaptations as evidence that God had designed each species for a specific purpose. He created taxonomy.

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 or **strata**

the lower the strata the older the sample

- Georges Cuvier developed **Paleontology**, he advocated **catastrophism**, speculating that each boundary between strata represents a catastrophe
- Geologists James Hutton and Charles Lyell perceived that changes in Earth's surface can result from slow continuous actions still operating today
- Lyell's principle of **uniformitarianism** states that the mechanisms of change are constant over time
- This view strongly influenced Darwin's thinking

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

Bonsai trees are "trained" to be dwarf, a seed will produce a normal sized tree

Concept 2: Descent with Modifications by Natural Selection explains adaptations of organisms and the unity and diversity of life

- As the 19th century dawned, it was generally believed that species had remained unchanged since their creation
- However, a few doubts about the permanence of species were beginning to arise

Darwin's Research

- Charles Darwin had a consuming interest in nature through out his life
- 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***

The Voyage of the Beagle

- During his travels on the *Beagle,* Darwin collected specimens of South American plants and animals
- He observed adaptations of plants and animals that inhabited many diverse environments
- Darwin was influenced by Lyell's *Principles of Geology* and thought that the earth was more than 6000 years old
- His interest in geographic distribution of species was kindled by a stop at the Galápagos Islands near the equator west of South America

The Galápagos Islands

Pinta
Genovesa
Marchena
Santiago
Daphne Islands
Pinzón
Fernandina
Isabela
Santa Cruz
Santa Fe
San Cristobal
Florenza
Española

NORTH AMERICA
GREAT BRITAIN
EUROPE
ATLANTIC OCEAN
AFRICA
Equator
SOUTH AMERICA
PACIFIC OCEAN
Andes
Cape of Good Hope
AUSTRALIA
Tasmania
New Zealand
Cape Horn
Tierra del Fuego

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 indeed what happened to the Galápagos finches

(a) Cactus-eater

(c) Seed-eater

(b) Insect-eater

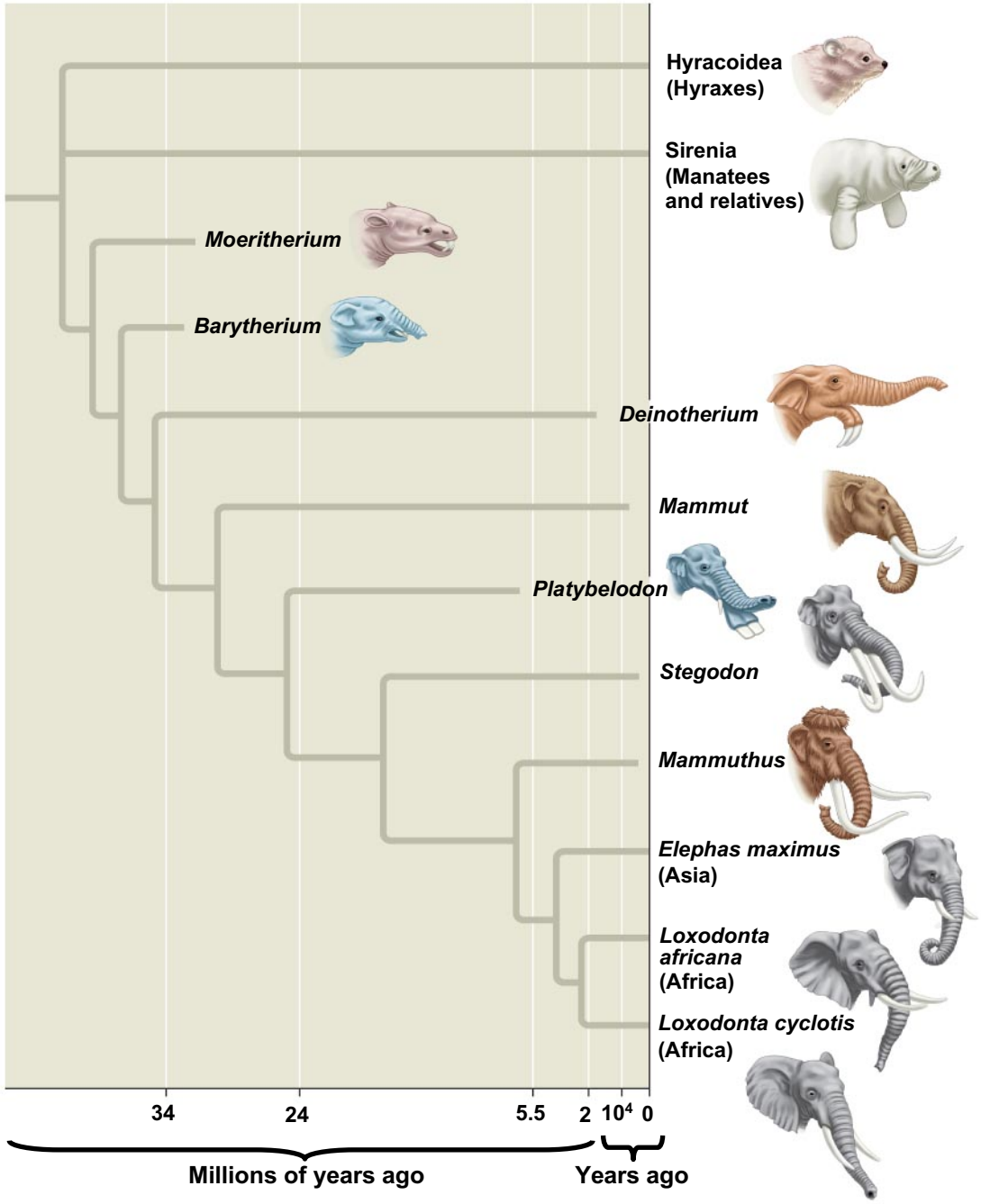
The Origin of Species

- Darwin developed two main ideas:
  - Descent with modification explains life's unity and diversity
  - Natural selection is a cause of adaptive evolution

Descent with Modification

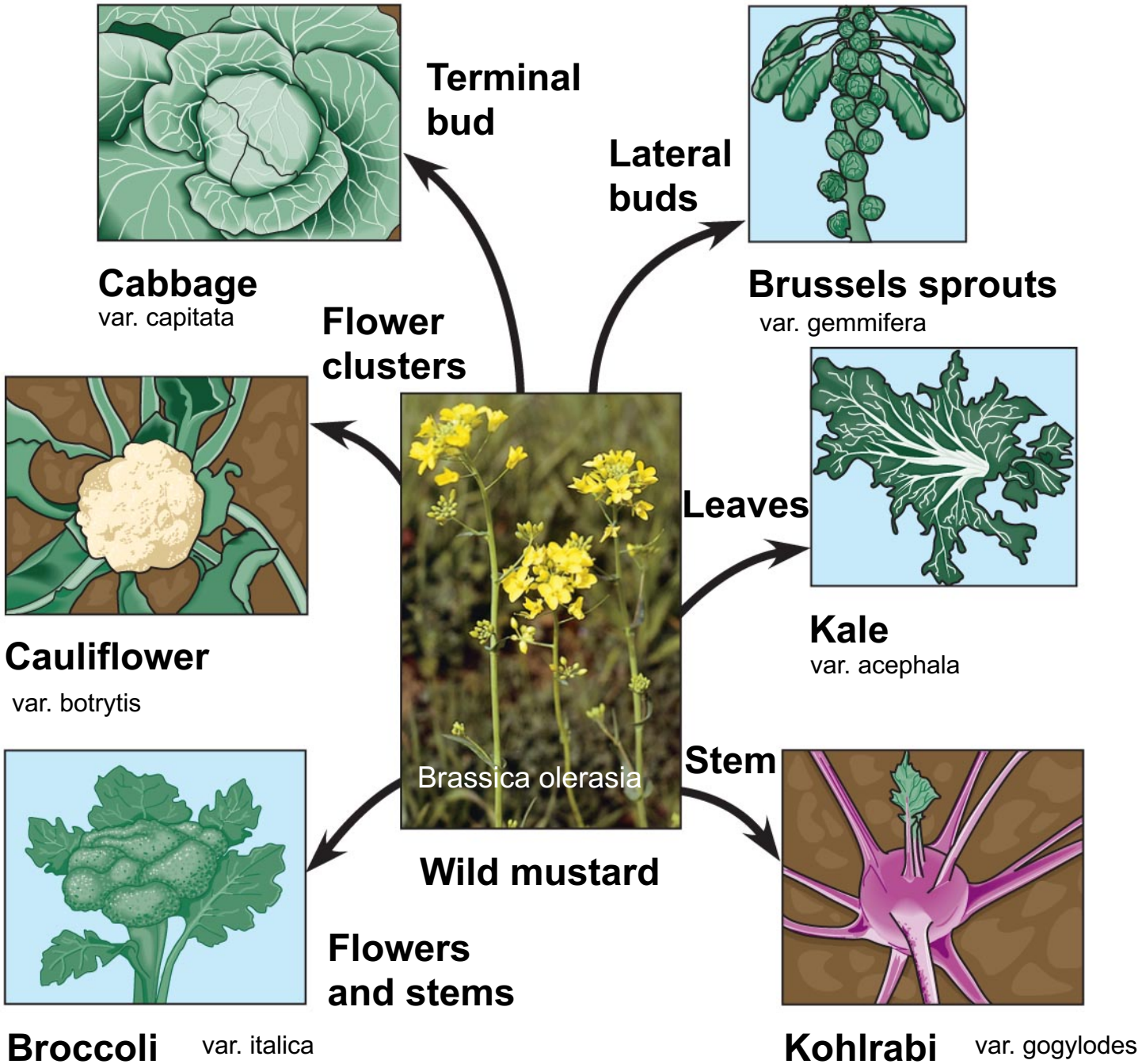
- Darwin never used the word *evolution* in the first edition of *The Origin of Species*
- The phrase *descent with modification* summarized Darwin's perception of the unity of life
- The phrase refers to the view that all organisms are related through descent from an ancestor that lived in the remote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

- In the Darwinian view, the history of life is like a tree with branches representing life's diversity
- Darwin's theory meshed well with the hierarchy of Linnaeus



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 then described four observations of nature and from these drew two inferences
- Observation #1: Members of a population often vary greatly in their traits



- Observation #2: Traits are inherited from parents to offspring
- Observation #3: All species are capable of producing more offspring than the environment can support
- Observation #4: Owing to lack of food or other resources, many of these offspring do not survive

- 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
- "The higher chances of survival, the more offspring they have"
- example: fishes, frogs, birds, insects

- Inference #2: This unequal ability of individuals to survive and reproduce will lead to the accumulation of favorable traits in the population over generations
- "Those that survive will bring the favorable traits with them"

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

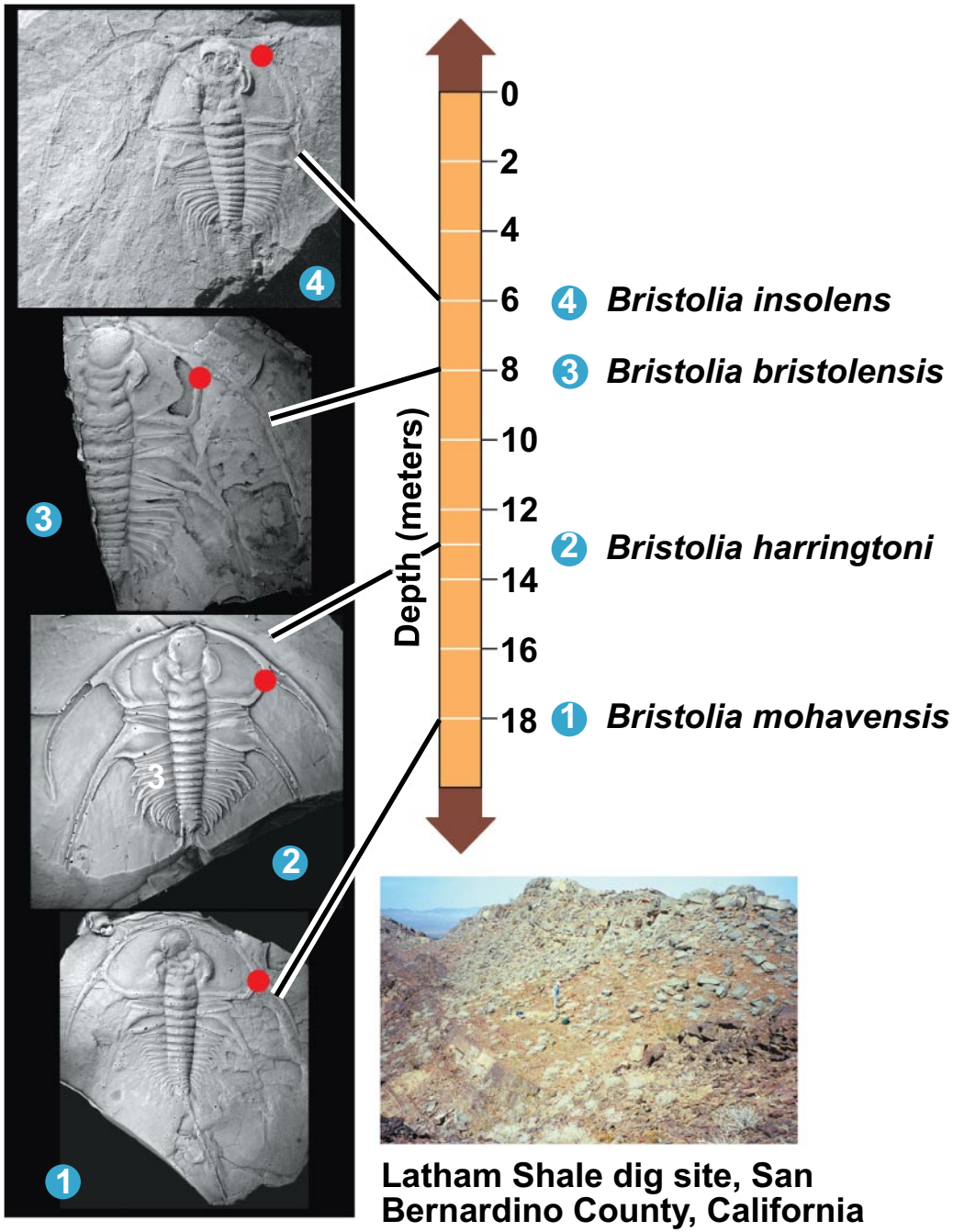
Concept 3: Evolution is supported by an overwhelming amount of scientific evidence

- New discoveries continue to fill the gaps identified by Darwin in *The Origin of Species*
- Direct Observations of Evolutionary Change
  - evolution of drug-resistant TB and MRSA
  - color change in moths, from light to dark due to pollution

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

The Fossil Record

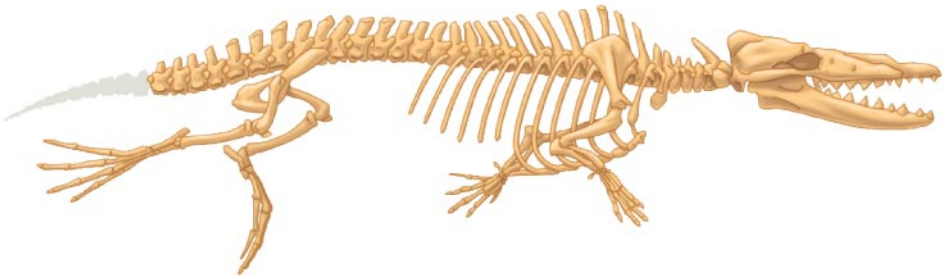
- The fossil record provides evidence of the extinction of species, the origin of new groups, and changes within groups over time



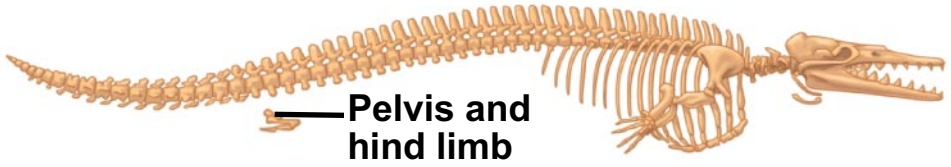
Latham Shale dig site, San Bernardino County, California

- The Darwinian view of life predicts that ***evolutionary transitions*** should leave signs in the fossil record
- Paleontologists have discovered fossils of many such ***transitional forms***

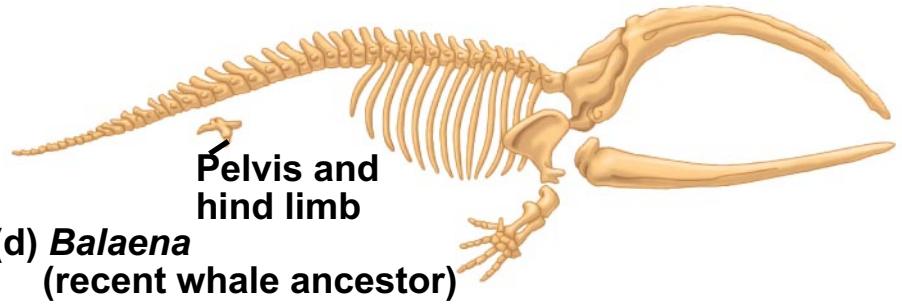
(a) *Pakicetus* (terrestrial)



(b) *Rhodocetus* (predominantly aquatic)



(c) *Dorudon* (fully aquatic)



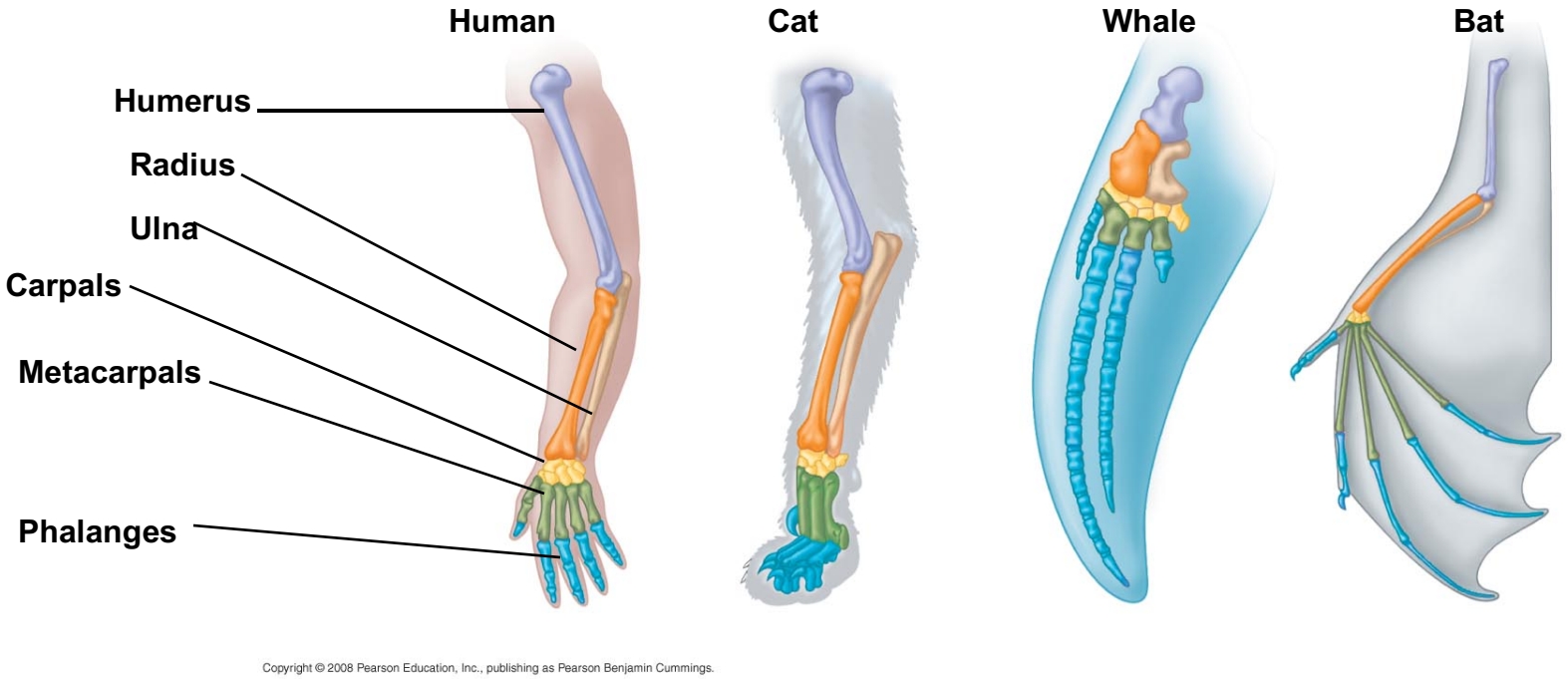
(d) *Balaena*
(recent whale ancestor)

Homology

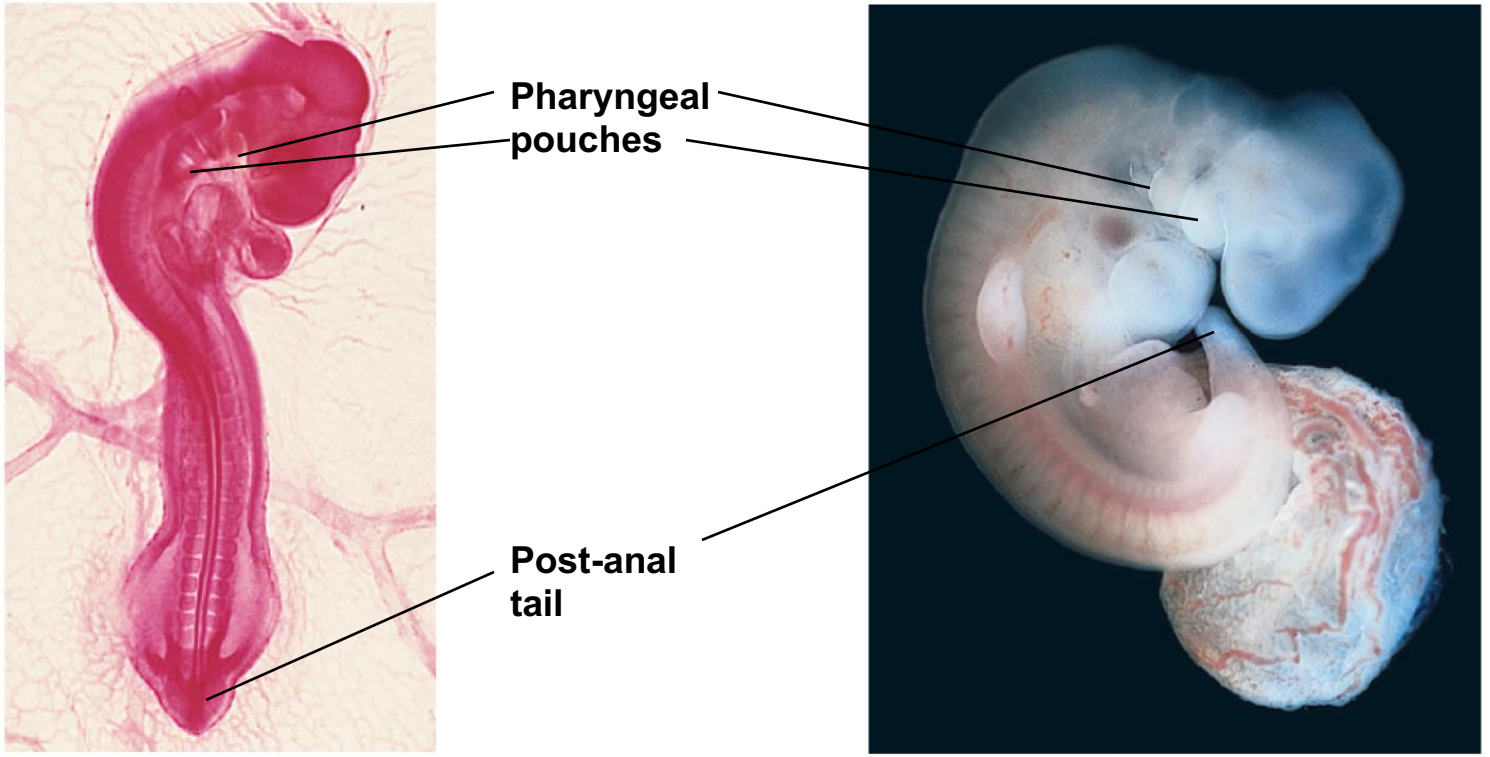
- **Homology** is similarity resulting from common ancestry

Anatomical and Molecular Homologies

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



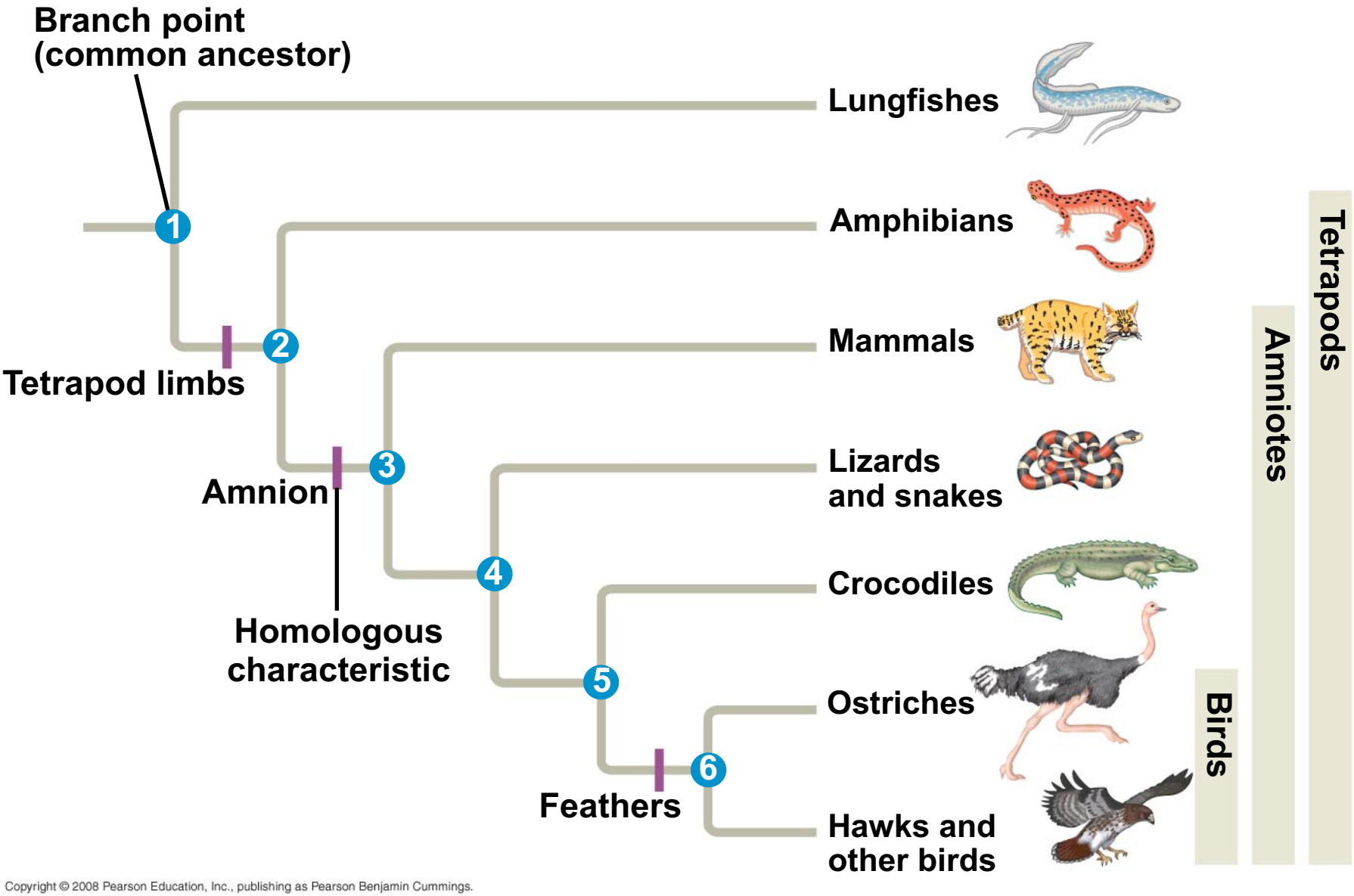
- Comparative embryology reveals anatomical homologies not visible in adult organisms



- **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
  - tail in human embryo
  - teeth in birds

Homologies and "Tree Thinking"

- The Darwinian concept of an **evolutionary tree** of life can explain homologies
- Evolutionary trees are hypotheses about the relationships among different groups
- Evolutionary trees can be made using different types of data, for example, anatomical and DNA sequence data



Observations

Individuals in a population vary in their heritable characteristics.

Organisms produce more offspring than the environment can support.

Inferences

Individuals that are well suited to their environment tend to leave more offspring than other individuals

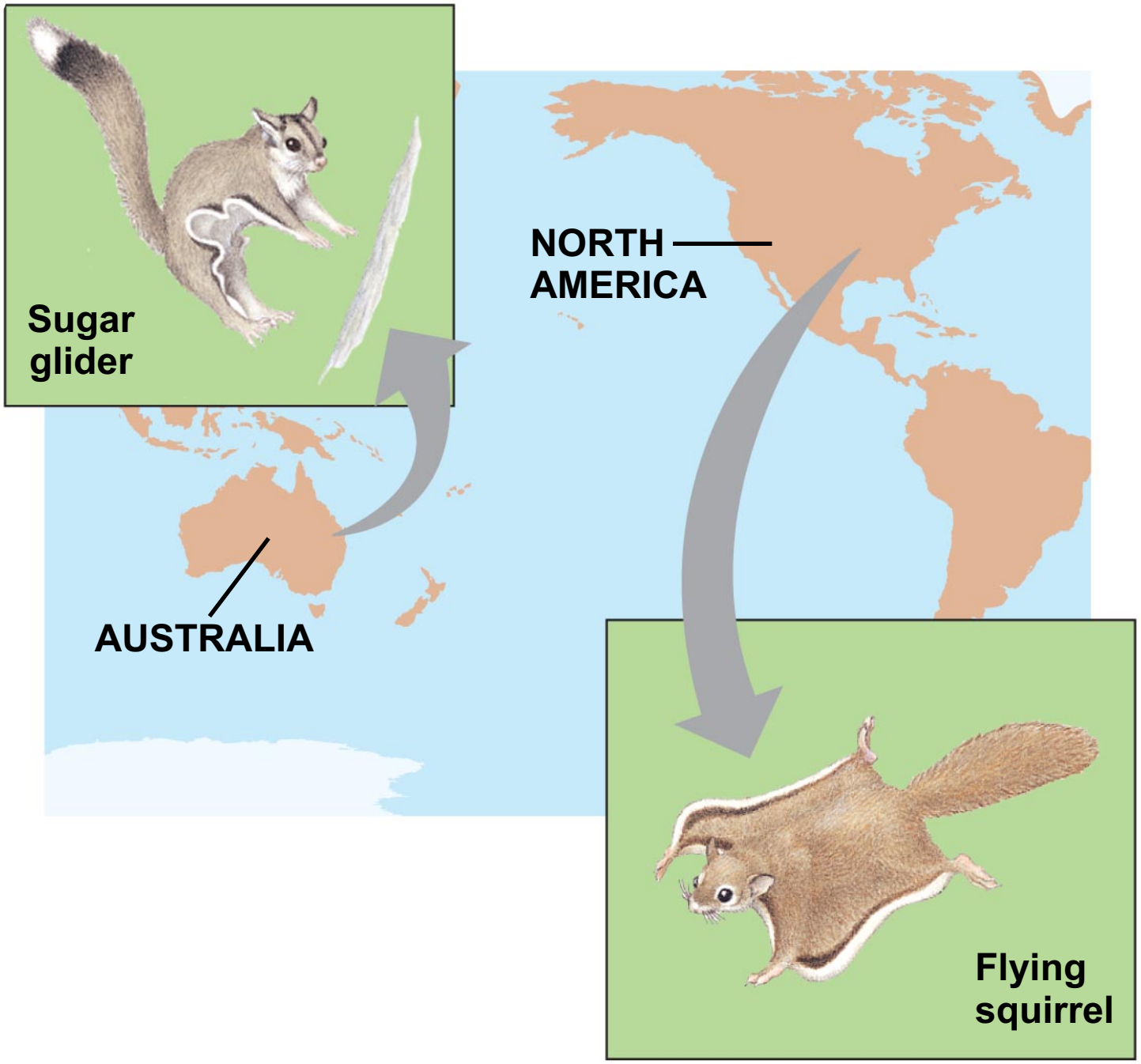
and

Over time, favorable traits accumulate in the population.

The End

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



Biogeography

- Darwin's observations of **biogeography**, the geographic distribution of species, formed an important part of his theory of evolution
- Islands have many **endemic** species that are often closely related to species on the nearest mainland or island

- 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

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