Chapter 22

Descent with Modification: A Darwinian View of Life

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

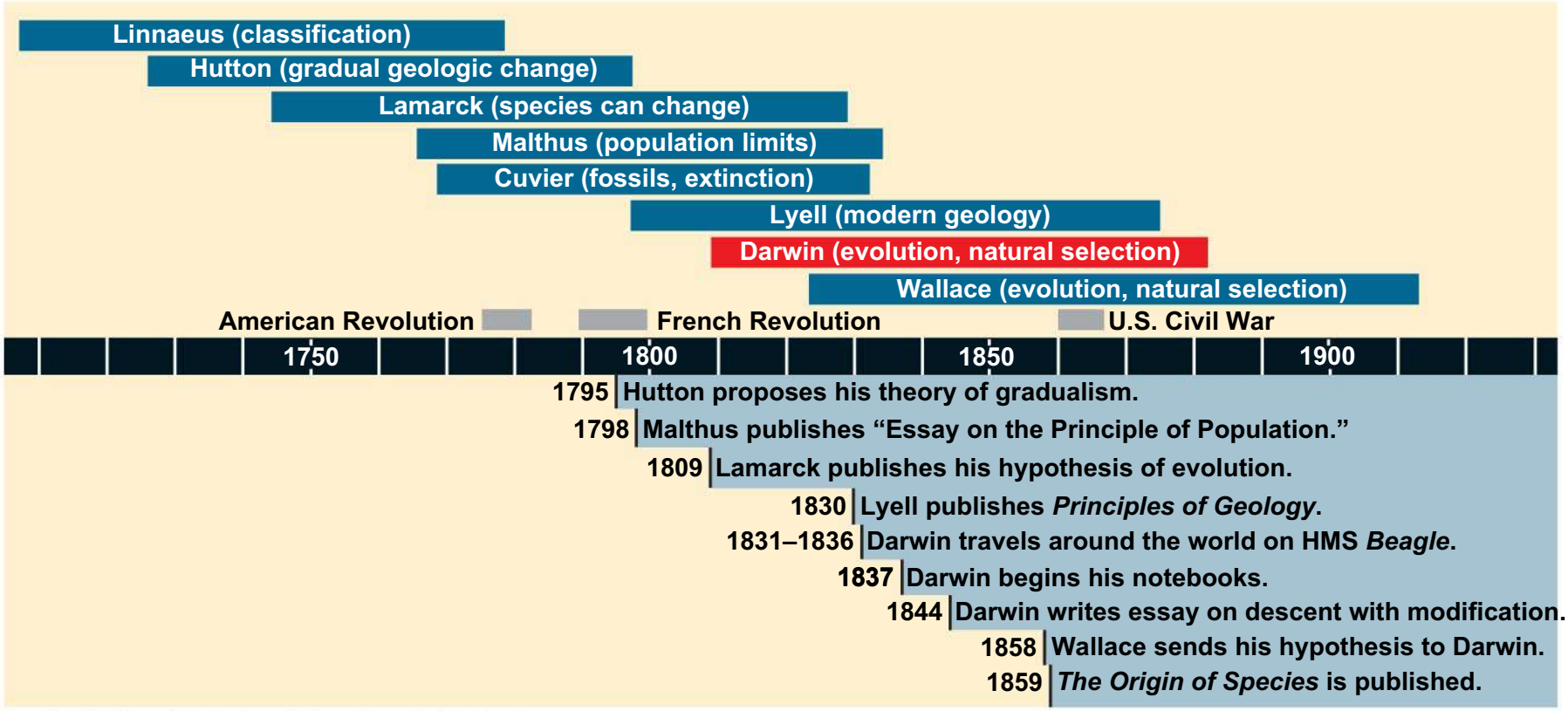
Neil Campbell and Jane Reece

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*** *which* 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.

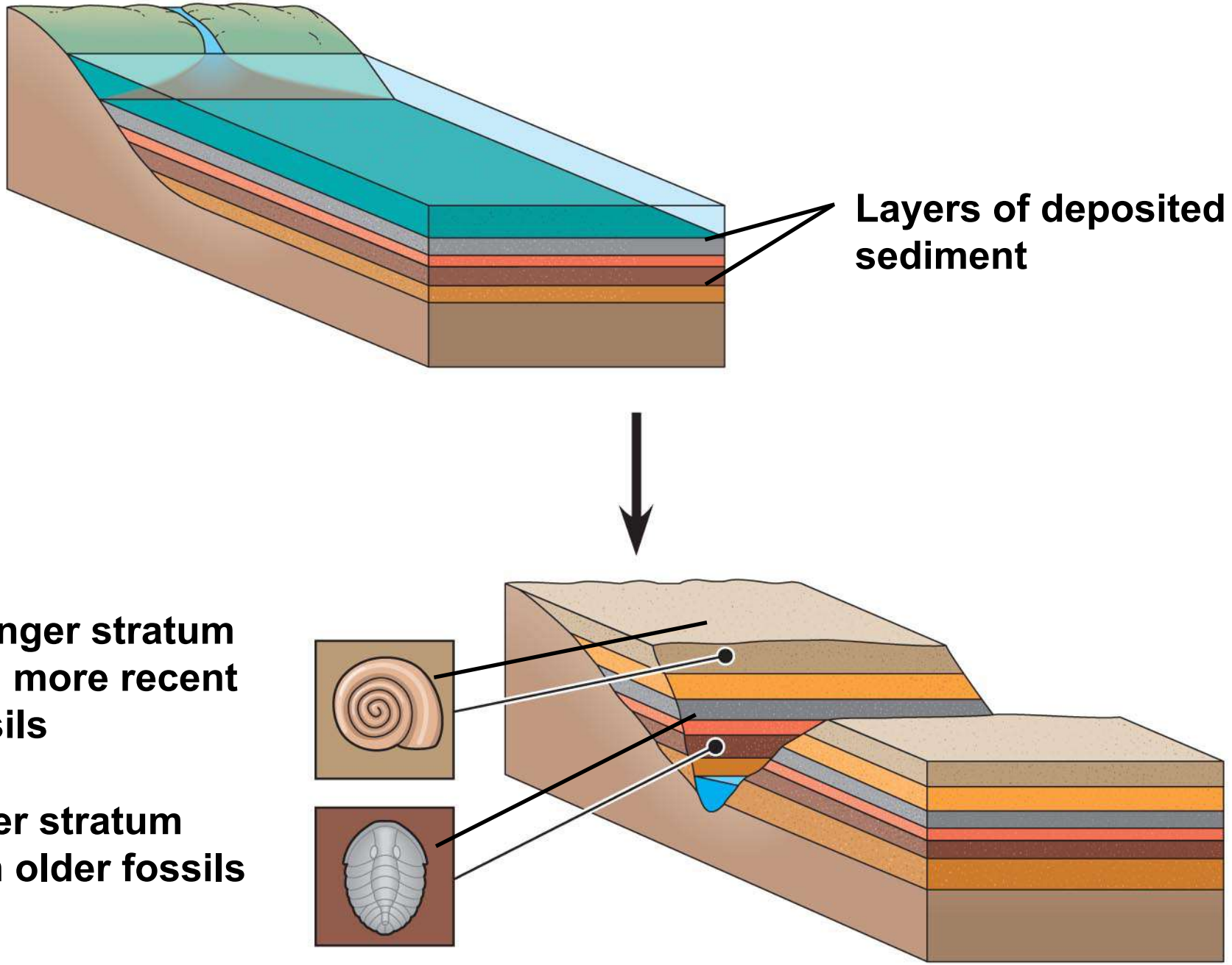
Intellectuals / Ideas in Darwin's Era



Scientisits …

- Carolus **Linnaeus** was the founder of ***taxonomy***, the branch of biology concerned with classifying organisms.
- **Paleontology**, the study of fossils, was largely developed by French scientist Georges Cuvier.
- 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.**

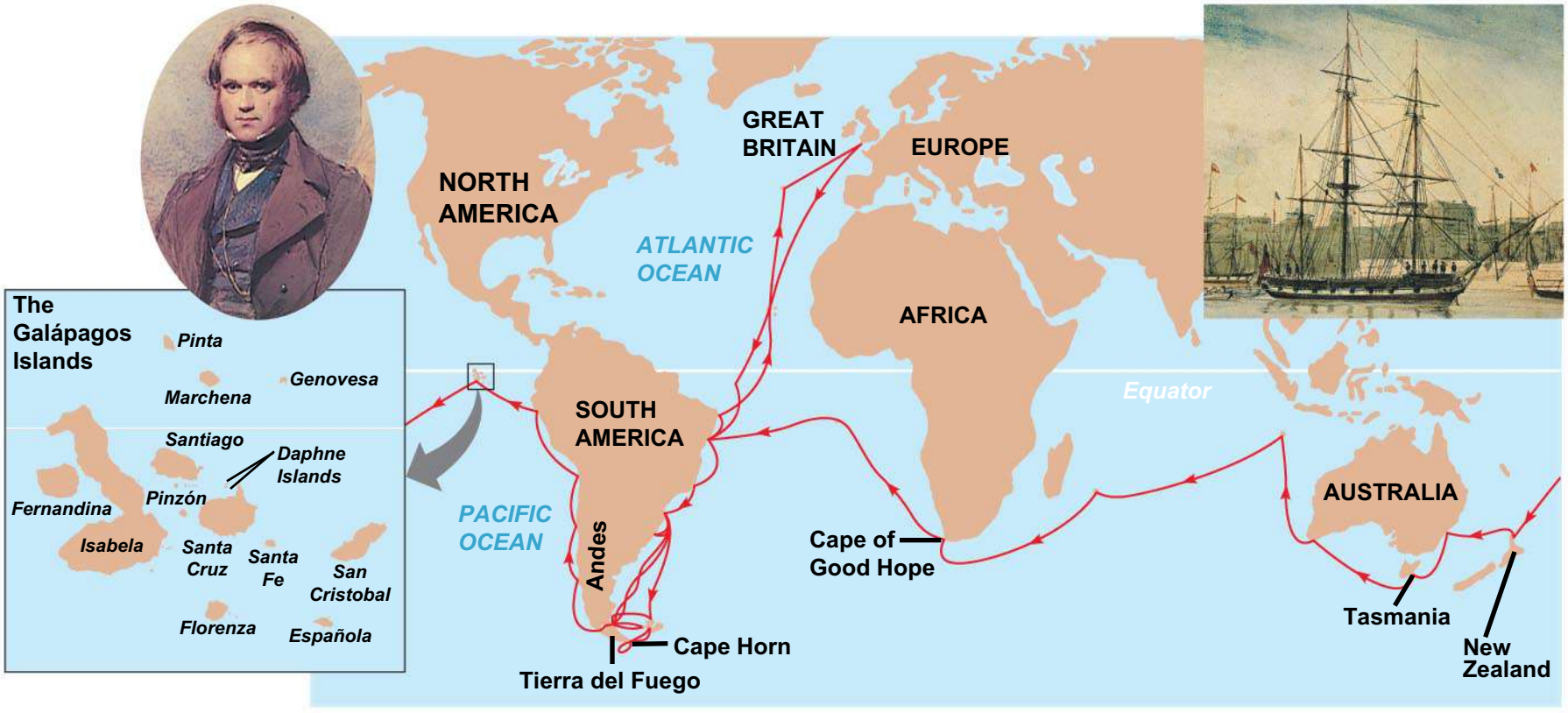
Fossils



Lamarck: Use & Disuse … Darwin: Natural Selection ….

- **Lamarck** hypothesized that species evolve through use and disuse of body parts and the inheritance of acquired characteristics.
- 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's Voyage on the Beagle



Darwin's Focus on Adaptation

- Darwin's interest in geographic distribution of species was kindled by a stop at the Galápagos Islands near the equator west of South America.
- Darwin perceived **adaptation** to the **environment** and the origin of new species as closely related processes.
- Recent biologists have concluded that **speciation** is indeed what happened to the Galápagos finches.

Speciation of Galapagos Finches

(a) Cactus-eater

(c) Seed-eater

(b) Insect-eater

Fig. 22-6a

(a) Cactus-eater

Fig. 22-6b

(b) Insect-eater

Fig. 22-6c

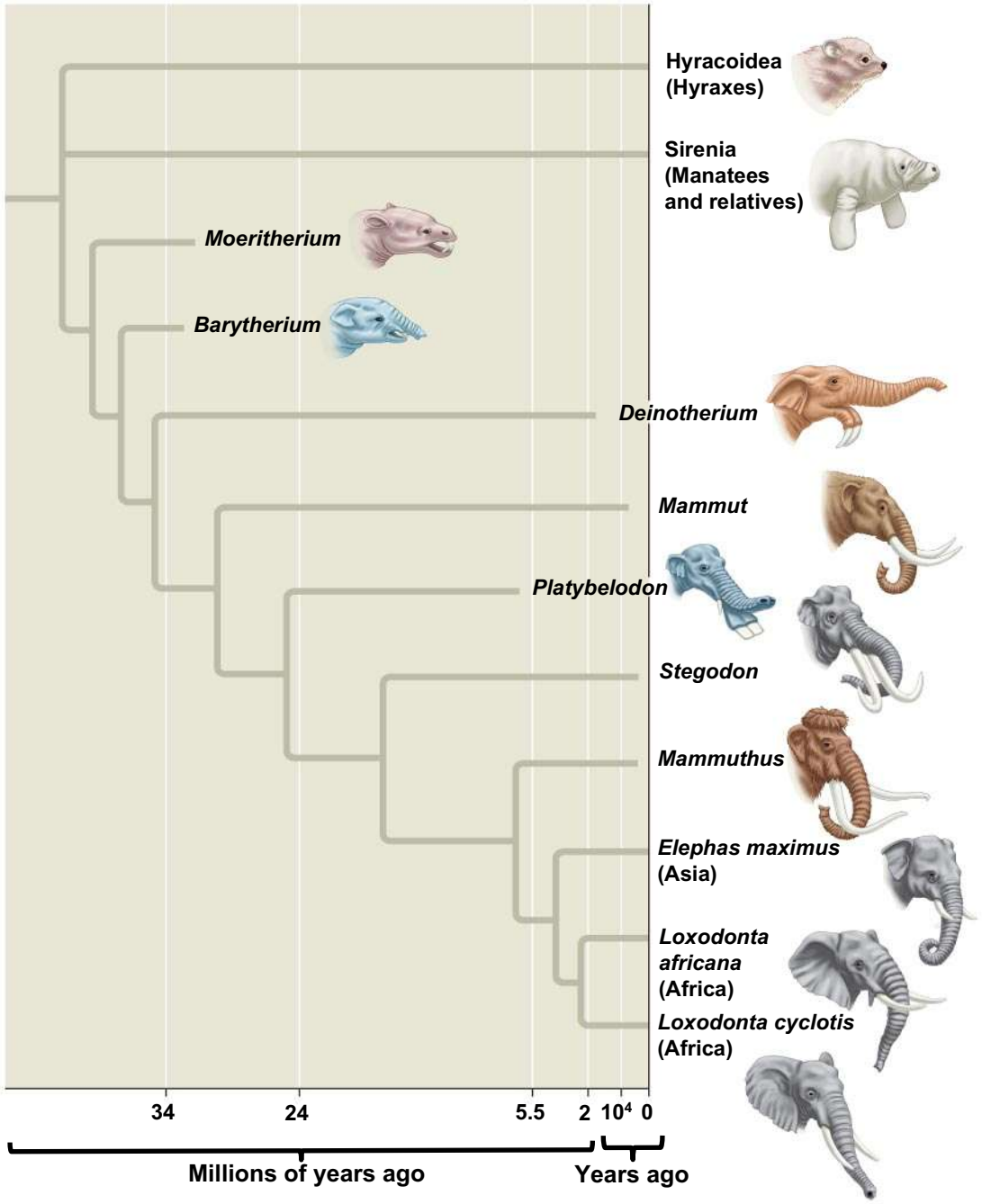
(c) Seed-eater

- In 1844, **Darwin** wrote an essay on the origin of species and **natural selection** but did not introduce his theory publicly, anticipating an uproar.
- In June 1858, Darwin received a manuscript from Alfred 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.

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



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*: Overproduction leads to competition for food or other resources.
- The individuals best adapted to their environment will survive and reproduce.

Descent With Modification:

- *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 the population, and this will increase the frequency of individuals with those adaptations.
- This process explains the match between organisms and their environment.

Natural Selection: A Summary

- ***Survival of the Fittest***: Individuals with certain heritable adaptive characteristics survive and reproduce at a higher rate than other individuals.
- ***Natural selection*** increases the adaptation of organisms to their environment over time.
- ***Speciation***: If an environment changes over time, natural selection may result in adaptation to these new conditions and may give rise to new species.

Predation and Coloration in Guppies : Scientific Inquiry in Natural Selection

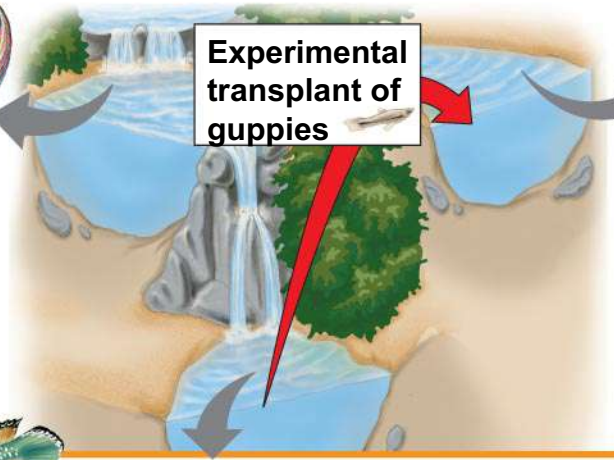
- John Endler has studied the effects of predators on wild guppy populations.
- Brightly colored males are more attractive to females.
- However, brightly colored males are more vulnerable to predation.
- Guppy populations in pools with fewer predators had more brightly colored males.

Natural Selection

EXPERIMENT

Predator: Killifish; preys mainly on juvenile guppies (which do not express the color genes)

Guppies: Adult males have brighter colors than those in "pike-cichlid pools"

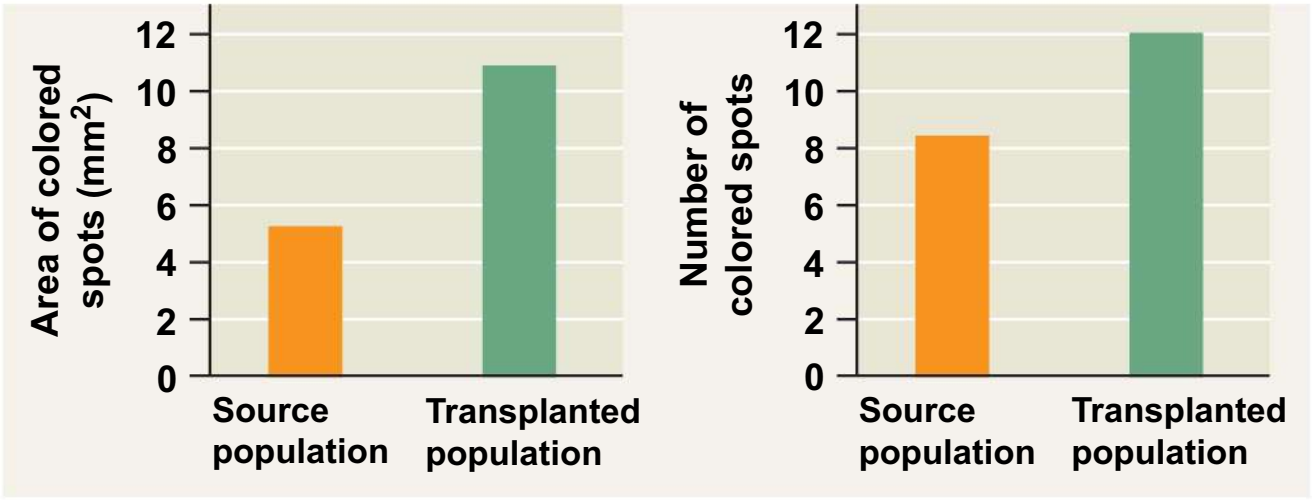


Pools with killifish, but no guppies prior to transplant

Predator: Pike-cichlid; preys mainly on adult guppies

Guppies: Adult males are more drab in color than those in "killifish pools"

RESULTS



Experiment in Natural Selection Results

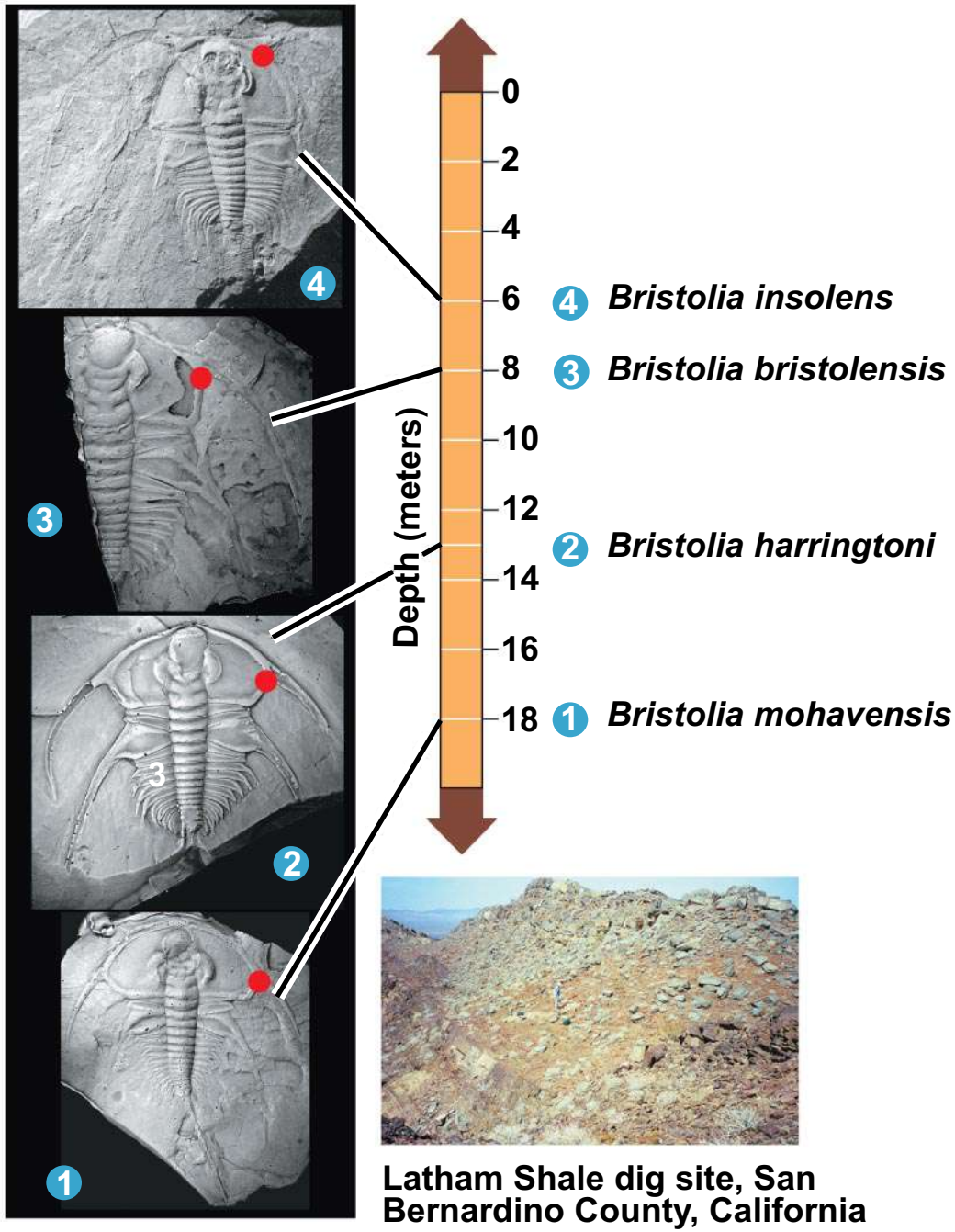
- Endler transferred brightly colored guppies (with few predators) to a pool with many predators. As predicted, over time the population became less brightly colored.
- Endler also transferred drab colored guppies (with many predators) to a pool with few predators. As predicted, over time the population became more brightly colored.

Directional Natural Selection: The Evolution of Drug-Resistant HIV

- The use of drugs to combat HIV selects for viruses resistant to these drugs.
- HIV uses the enzyme reverse transcriptase to make a DNA version of its own RNA genome.
- The drug 3TC is designed to interfere and cause errors in the manufacture of DNA from the virus.
- Some individual HIV viruses have a variation that allows them to produce DNA without errors. These viruses have greater reproductive success.
- The population of HIV viruses has therefore developed resistance to 3TC.

- The ability of bacteria and viruses to evolve rapidly poses a challenge to our society.
- ***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.

Fossil Evidence of Change Over Time



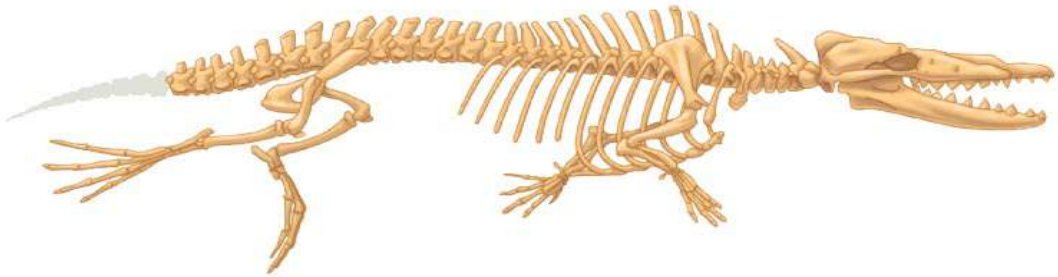
Latham Shale dig site, San Bernardino County, California

Paleontologists

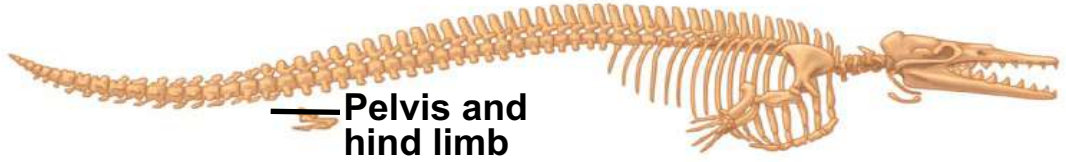
study fossils of possible transitional forms:

Whale Ancestors

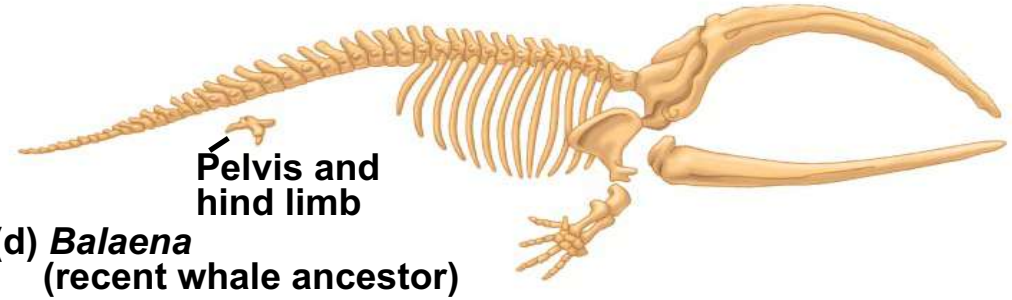
(a) *Pakicetus* (terrestrial)



(b) *Rhodocetus* (predominantly aquatic)



(c) *Dorudon* (fully aquatic)

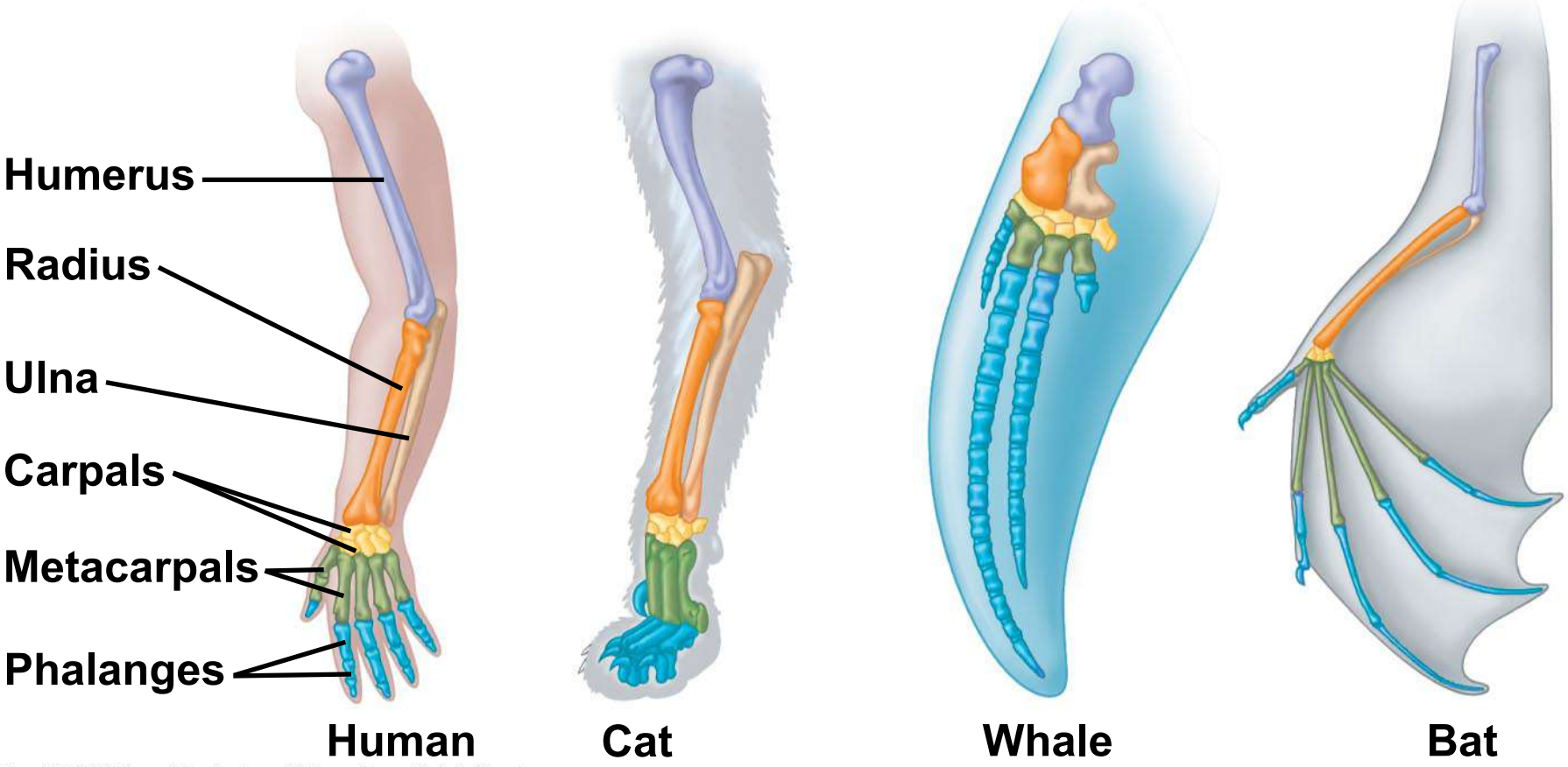


(d) *Balaena*
(recent whale ancestor)

Anatomical and Molecular Homologies

- **Homology** is similarity resulting from common ancestry.
- **Homologous structures** are anatomical resemblances that represent variations on a structural theme present in a common ancestor.

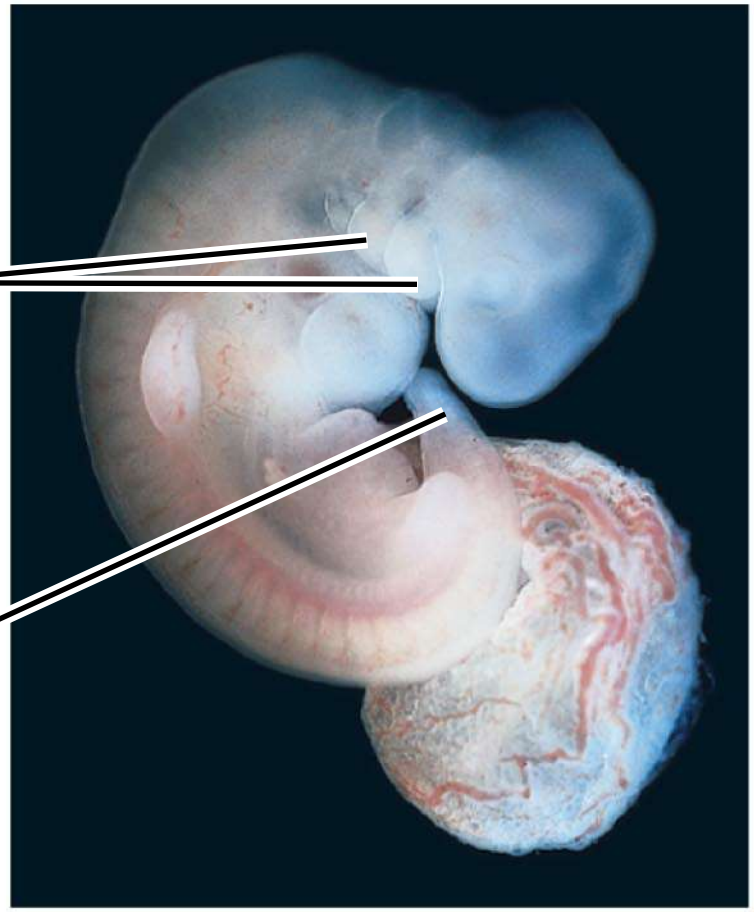
Homologous Structures



Comparative embryology reveals anatomical homologies not visible in adult organisms:

Pharyngeal pouches

Post-anal tail



Chick embryo (LM)

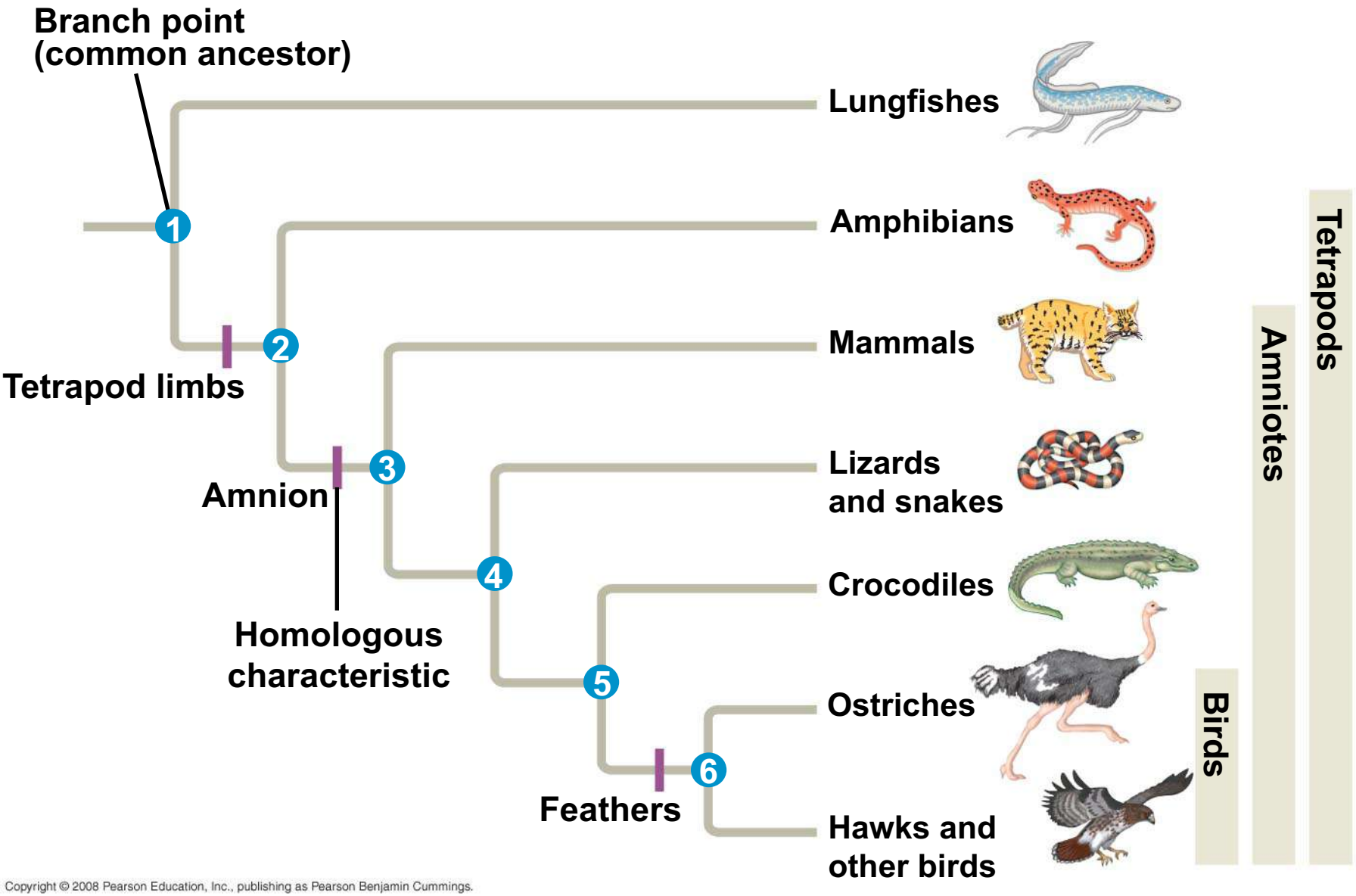
Human embryo

- **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"

- 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.

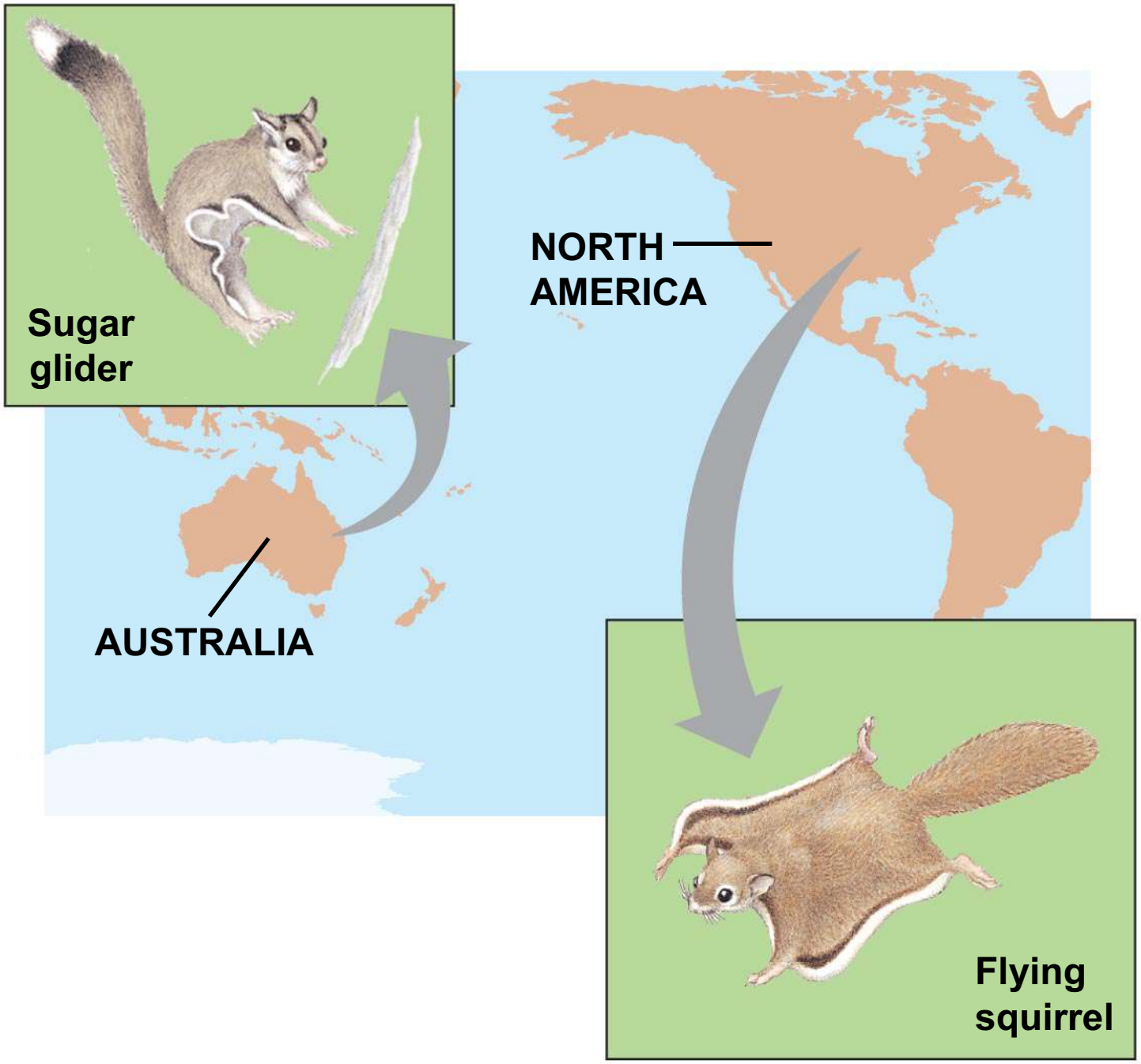
Homologies and "Evolutionary Tree"



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.

Fig. 22-20



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 (found only in that part of the world and nowhere else). Darwin postulated that endemic species are often closely 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.

Darwin : Natural Selection

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.

Mutation = Resistance to DDT. Natural Selection Favors this Resistance --> Number of Resistant Individuals Increases Over Time.

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

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

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).

You should now be able to:

1. Describe the contributions to evolutionary theory made by Linnaeus, Cuvier, Lyell, Lamarck, Malthus, and Wallace.
2. Describe Lamarck's theories, and explain why they have been rejected.
3. Explain what Darwin meant by "descent with modification."
4. Explain Darwin's observations and inferences.
5. Explain why an individual organism cannot evolve.
6. Describe evidence for evolution by natural selection.