


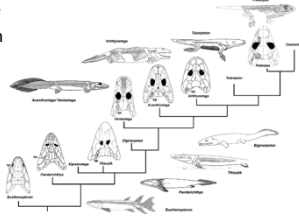
EVIDENCE OF EVOLUTION

- Evolution leaves observable signs.
- We will examine five of the many lines of evidence in support of evolution:
 1. the fossil record,
 2. biogeography,
 3. comparative anatomy,
 4. comparative embryology, and
 5. molecular biology.

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The Fossil Record


- **Fossils** are
 - imprints or remains of organisms that lived in the past
 - often found in sedimentary rocks.



- is the ordered sequence of fossils as they appear in rock layers,
- reveals the appearance of organisms in a historical sequence, and
- fits with the molecular and cellular evidence that prokaryotes are the ancestors of all life.

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Figure 13.6



PLAY Video: Grand Canyon


The Fossil Record

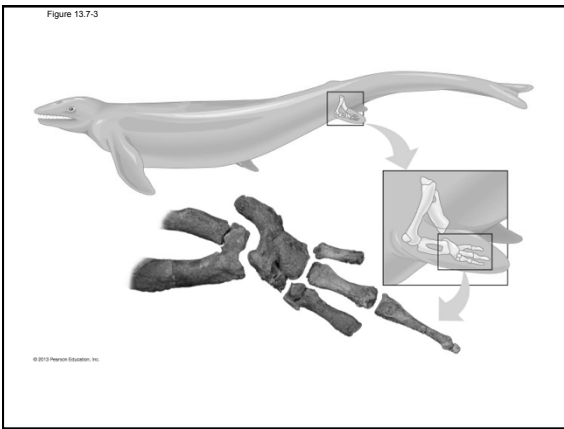
– Paleontologists (scientists who study fossils) have discovered many transitional forms that link past and present.



– Transitional fossils include evidence that

- birds descended from one branch of dinosaurs and
- whales descended from four-legged land mammals.





Biogeography

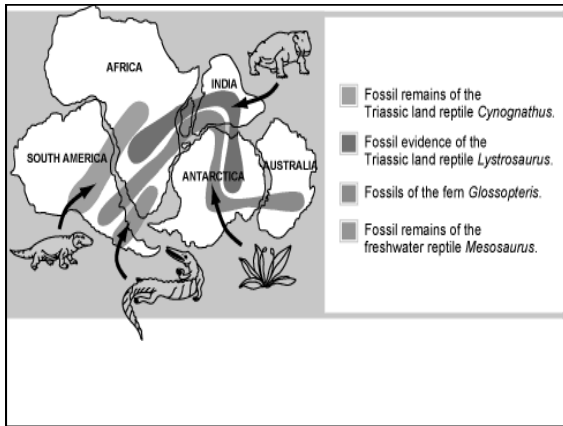
– **Biogeography**, the study of the geographic distribution of species, first suggested to Darwin that today's organisms evolved from ancestral forms.

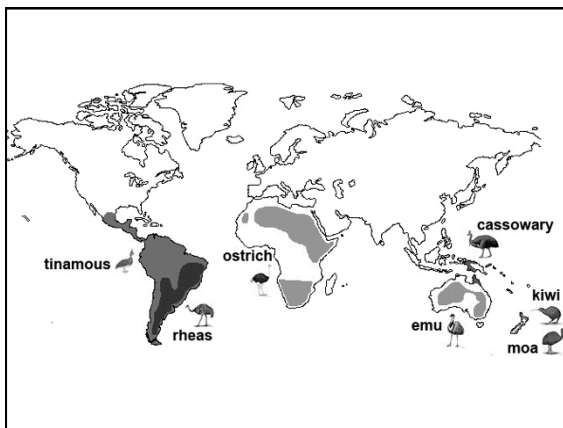
– Darwin noted that Galápagos animals resembled species of the South American mainland more than they resembled animals on similar but distant islands. (*Look like neighbors*)

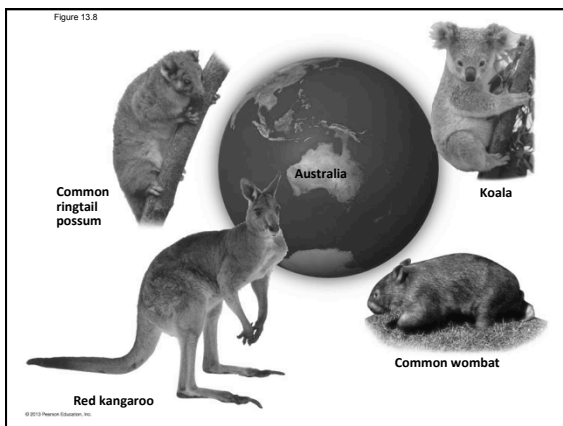
– Many examples from biogeography would be difficult to understand, except from an evolutionary perspective.

– One example is the distribution of marsupial mammals in Australia.

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Comparative Anatomy


PLAY Blast Animation: Evidence for Evolution: Homologous Limbs

– **Comparative anatomy**

- is the comparison of body structure between different species and
- attests that evolution is a remodeling process in which ancestral structures become modified as they take on new functions.

– **Homology is**

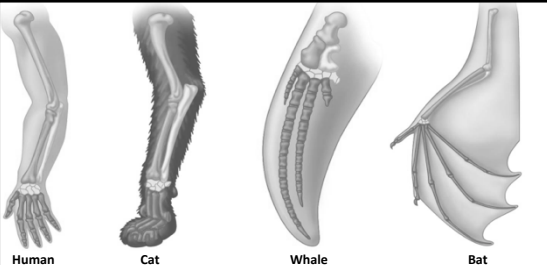
- the similarity in structures due to common ancestry and
- illustrated by the remodeling of the pattern of bones forming the forelimbs of mammals for different functions.



All Mammals

Human
Cat
Whale
Bat

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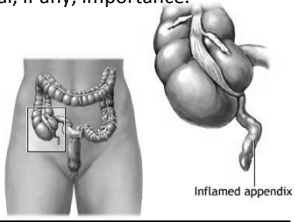
Human Cat Whale Bat

What is a reasonable conclusion you can draw from this?

Comparative Anatomy

• **Vestigial structures**


- Are remnants of features that served important functions in an organism’s ancestors and
- Now have only marginal, if any, importance.



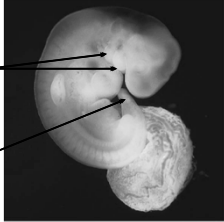
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Comparative Embryology

- Early stages of development in different animal species reveal additional homologous relationships.
 - For example, pharyngeal pouches appear on the side of the embryo's throat, which
 - develop into gill structures in fish and
 - form parts of the ear and throat in humans.
 - Comparative embryology of vertebrates supports evolutionary theory.

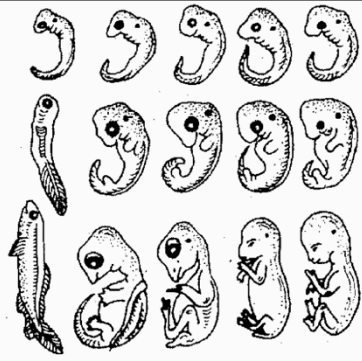


Chicken embryo



Human embryo

Comparative Embryology
“ontogeny recapitulates phylogeny”




Fish Turtle Bird Pig Man

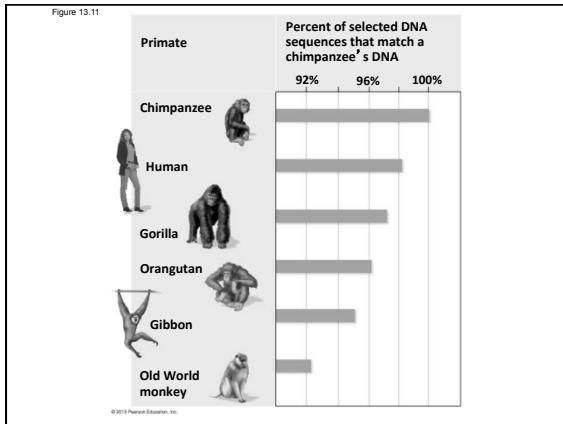
Fig. 9.7. Developmental stages of five vertebrates

Molecular Biology

- The hereditary background of an organism is documented in
 - its DNA and
 - the proteins encoded by the DNA.
- Evolutionary relationships among species can be determined by comparing
 - genes and
 - proteins of different organisms.



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How does evolution happen?


1. Natural Selection
2. Sexual Selection
3. Genetic Drift
4. Gene Flow

All of these require **genetic diversity** – so **mutation** is a requirement for all evolution


NATURAL SELECTION

– Darwin noted the close relationship between adaptation to the environment and the origin of new species.


– The evolution of finches on the Galápagos Islands is an excellent example.



(a) The large ground finch



(b) The warbler finch



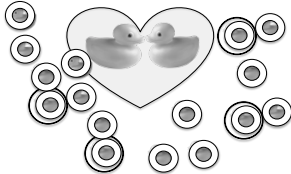
(c) The woodpecker finch

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Darwin's Theory of Natural Selection

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

1. All species tend to produce excessive numbers of offspring.
2. Organisms vary, and much of this variation is heritable.



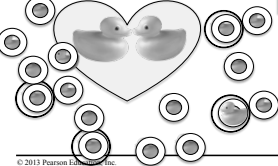
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Darwin's Theory of Natural Selection

– **Observation 1: Overproduction and competition**


- All species have the potential to produce many more offspring than the environment can support.
- This leads to inevitable competition among individuals.

Overproduction




Knives
And food

Competition



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Figure 13.13



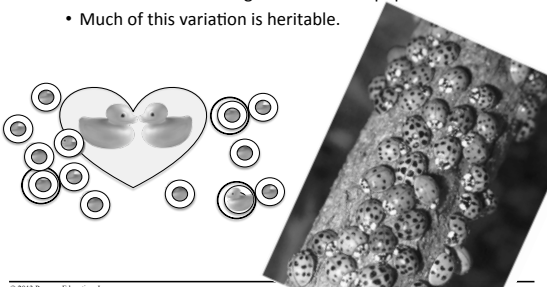
Spray & Hope
R strategist
(rapid reproducer)

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Darwin's Theory of Natural Selection

– **Observation 2: Individual variation**

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




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Darwin's Theory of Natural Selection

– **Inference: Unequal reproductive success (natural selection)**

- Those individuals with traits best suited to the local environment generally leave a larger share of surviving, fertile offspring.

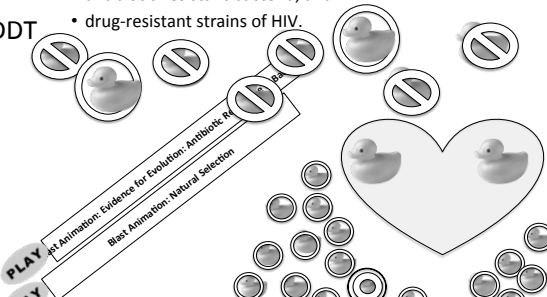


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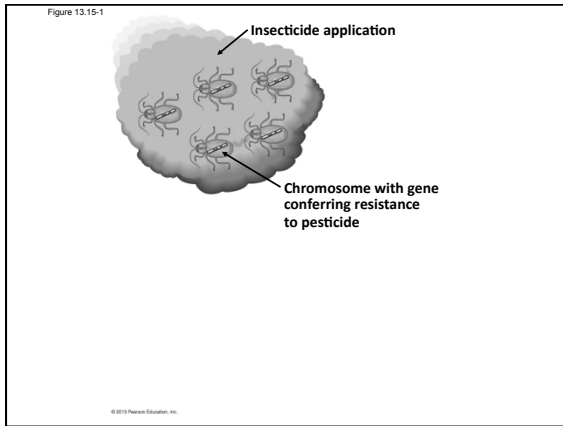
Natural Selection in Action

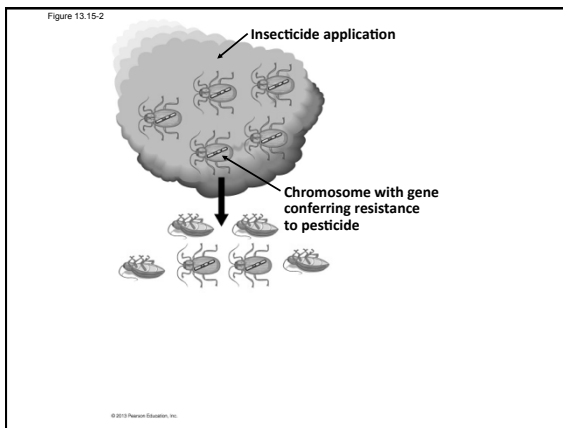
– Examples of natural selection include

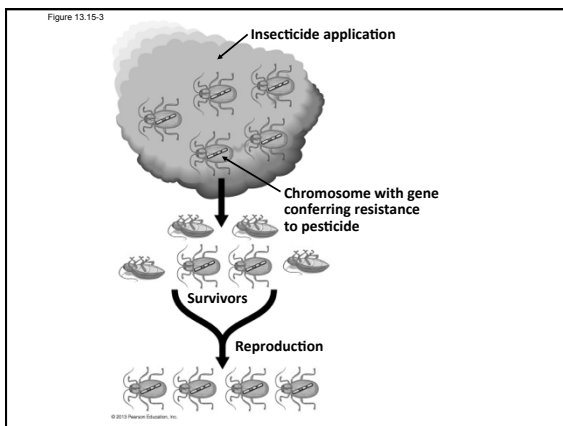
- pesticide-resistant insects,
- antibiotic-resistant bacteria, and
- drug-resistant strains of HIV.



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The Process of Science: Does Predation Drive the Evolution of Lizard Horn Length?

- **Observation:** Flat-tailed horned lizards defend against attack by
 - thrusting their heads backward and
 - stabbing a shrike with the spiked horns on the rear of their skull.
- **Question:** Are longer horn length and spread a survival advantage?
- **Hypothesis:** Longer horn length and spread are a survival advantage.

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The Process of Science: Does Predation Drive the Evolution of Lizard Horn Length?


- **Prediction:** Live horned lizards have longer and more widely spread horns than dead ones.
- **Experiment:** Measure the horn lengths and the tip-to-tip spread distance of side horns from the skulls of
 - 29 killed and
 - 155 living lizards.



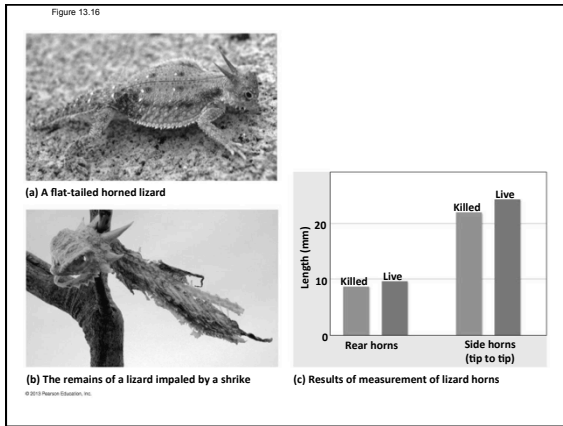
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The Process of Science: Does Predation Drive the Evolution of Lizard Horn Length?

- **Results:** The average horn length and spread of live lizards is about 10% greater than that of killed lizards.



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Sexual Selection

- When a genetic trait becomes more abundant in a population because it helps you to get more mates, *not because it helps you live longer*.
Examples??

Taeniopygia guttata *Psephenus acuticauda*

Genetic Drift

Genetic drift is:

- A change in the gene pool of a small population

EX: The bottleneck effect:


- Results from a drastic reduction in population size

Original population Bottlenecking event Surviving population

Figure 13.23-3


Bottleneck Example

- Bottlenecking in a population usually reduces genetic variation because at least some alleles are likely to be lost from the gene pool.
- Elephant Seals experienced a genetic bottleneck about 160 years ago



Genetic Flow

- Is genetic exchange with another population
- Tends to **reduce** genetic differences between population



7.12 Opening Questions: How can we map our ancestry?

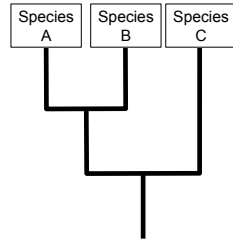
- Sketch out a quick family lineage for your immediate family.
 - How far back can you go? Your grandparents? Great-grandparents? Great-great-grandparents?

What shape best describes your family sketch? Explain.
- We often refer to our “family tree” when discussing our ancestry.

Why might **trees** be a useful term to represent relationships?

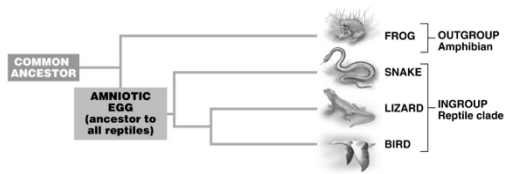
7.12 Evolutionary relationships may be represented by branching trees

- **Phylogenetic trees** are one way to reflect the evolutionary history of organisms.
- Phylogenetic trees present a hypothesis about the evolutionary history of related species.



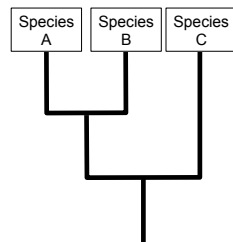
7.12 Clades can be thought of representing a branch on the tree of life

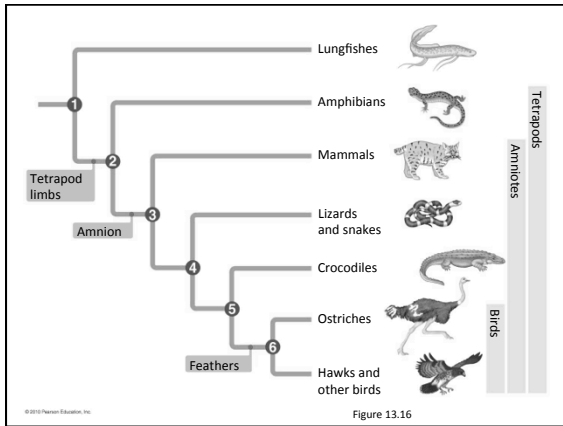
- A **clade** is any group of species that consists of an ancestral species and all its descendants.
- The analysis of clades is called **cladistics**.



7.12 Reading phylogenetic trees can provide insights into the interrelationships of life

- The tips of the tree represent groups of the most recently evolved species.
- To determine how closely related two species are, find their most recent common ancestor.





7.9 Opening Questions: Lions and tigers!
 Oh, my!

- Imagine you are visiting the zoo, and in the Big Cats exhibit you see lions from Africa and tigers from Asia.
- We consider lions and tigers different species. Why?

In captivity, mating between lions and tigers may lead to hybrid "ligers." Are "ligers" a species? Why or why not?

7.9 What is a species?

- The word "species" is derived from a Latin word meaning "appearance."
- However, appearance alone cannot be used to tell one species from another.

DIFFERENT SPECIES

Eastern meadowlark (*Sturnella magna*)
 Western meadowlark (*Sturnella neglecta*)
Even though they look alike, these two species of birds occupy different habitats and do not naturally interbreed.

SAME SPECIES

All dogs are members of the species *Canis lupus familiaris*.

7.9 What is a species?

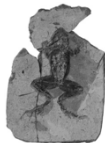
- The most commonly used definition of **species** is a population that is capable of interbreeding to produce healthy, fertile offspring.



What types of species might not fit the definition above?

7.9 What is a species?

- Our earlier definition focused on interbreeding doesn't work for all species.
 - Bacteria reproduce asexually.
 - For extinct organisms, we can't know if they were capable of mating.
- For some organisms, we have to use appearance, or another means, to determine species groups.



7.9 Reproductive barriers maintain species


- For species that we can define as a group of individuals capable of successfully interbreeding, what keeps them separate?
- One or more **reproductive barriers** prevent members of different species from breeding.

What might prevent Eastern and Western meadowlarks from interbreeding?



7.9 Reproductive barriers maintain species

- **Behavioral isolation:** Members of a species often identify each other through specific rituals.
- **Mating time differences:** Many species are able to reproduce only at specific times.
- **Habitat isolation:** If species live in slightly different habitats, they may never meet.



7.9 Reproductive barriers maintain species

- **Mechanical incompatibility:** Members of different species often cannot mate because their anatomies are incompatible.
- **Gametic incompatibility:** The gametes (sperm and egg) of different species usually cannot fertilize each other.
- **Hybrid weakness:** Offspring of two species may be unfit, or they may be sterile.

