Evidence of Evolution by Natural Selection
Evidence supporting evolution

- **Fossil record**
  - transition species

- **Anatomical record**
  - homologous & vestigial structures
  - embryology & development

- **Molecular record**
  - protein & DNA sequence

- **Artificial selection**
  - human-caused evolution
Fossil record

- Layers of sedimentary rock contain fossils
  - new layers cover older ones, creating a record over time
  - fossils within layers show that a succession of organisms have populated Earth throughout a long period of time
Fossil Record
Fossil record

- A record showing us that today’s organisms descended from ancestral species.
**Evolutionary change in horses**

<table>
<thead>
<tr>
<th>Millions of years ago</th>
<th>Body size (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>550</td>
</tr>
<tr>
<td>55</td>
<td>500</td>
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<td>10</td>
<td>50</td>
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<td>5</td>
<td>50</td>
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</tbody>
</table>

- **Hyracotherium**
- **Mesohippus**
- **Merychippus**
- **Equus**
- **Nannippus**
Evolution of birds

- **Archaeopteryx**
  - lived about 150 mya
  - links reptiles & birds

*Theory takes flight*

A computer analysis of skull specimens from the bird-like dinosaur archaeopteryx indicates the creature was a skillful flier, according to a study in the journal Nature.

- Wingspan: 19.6 inches
- Weight: 12 ounces

The scientists point to similarities in the brain lobes responsible for vision, balance and flight coordination.
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Evolution: The Triumph of an Idea,
by Carl Zimmer.
Source: Art by Deborah Perugi,
adapted from Carl Buell’s
cladogram from At the Water’s Edge,
file source:
Cetacean Evolution (Whales, Porpoises, Dolphins)
by Edward T. Babinski
http://www.edwardbabinski.us/babinski/whale_evolution.html

Where are the transitional fossils?
2006 Fossil Discovery of Early Tetrapod

- Tiktaalik
  - “missing link” from sea to land animals
Anatomical record

- Homologous structures
  - similarities in characteristics resulting from **common ancestry**
Homologous structures

- Similar structure
- Similar development
- Different functions
- Evidence of close evolutionary relationship
  - **recent** common ancestor
Homologous structures

- spines
- leaves
- needles
- colored leaves
- succulent leaves
- tendrils

AP Biology
Analogous structures

- Separate evolution of structures
  - similar functions
  - similar external form
  - different internal structure & development
  - different origin
  - no evolutionary relationship

Solving a similar problem with a similar solution

Don’t be fooled by their looks!
Convergent evolution

- Flight evolved in 3 separate animal groups
  - evolved similar “solution” to similar “problems”
  - analogous structures

Does this mean they have a recent common ancestor?
Convergent evolution

- Fish: aquatic **vertebrates**
- Dolphins: aquatic **mammals**
  - similar adaptations to life in the sea
  - not closely related

Those fins & tails & sleek bodies are analogous structures!
Parallel Evolution

- Convergent evolution in common niches
  - filling similar ecological roles in similar environments, so similar adaptations were selected
  - but are not closely related

**marsupial mammals**

**placental mammals**
### Parallel types across continents

<table>
<thead>
<tr>
<th>Niche</th>
<th>Placental Mammals</th>
<th>Australian Marsupials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burrower</td>
<td>Mole</td>
<td>Marsupial mole</td>
</tr>
<tr>
<td>Anteater</td>
<td>Anteater</td>
<td>Numbat</td>
</tr>
<tr>
<td>Nocturnal insectivore</td>
<td>Mouse</td>
<td>Marsupial mouse</td>
</tr>
<tr>
<td>Climber</td>
<td>Lemur</td>
<td>Spotted cuscus</td>
</tr>
<tr>
<td>Glider</td>
<td>Flying squirrel</td>
<td>Sugar glider</td>
</tr>
<tr>
<td>Stalking predator</td>
<td>Ocelot</td>
<td>Tasmanian cat</td>
</tr>
<tr>
<td>Chasing predator</td>
<td>Wolf</td>
<td>Tasmanian “wolf”</td>
</tr>
</tbody>
</table>
Vestigial organs

- Modern animals may have structures that serve little or no function
  - remnants of structures that were functional in ancestral species
  - deleterious mutations accumulate in genes for non-critical structures *without* reducing fitness
    - snakes & whales — remains of pelvis & leg bones of walking ancestors
    - eyes on blind cave fish
    - human tail bone

This is *not* LaMarck’s loss from “disuse”!
Vestigial organs

- Hind leg bones on whale fossils

Why would whales have pelvis & leg bones if they were always sea creatures?
Comparative embryology

- Similar embryological development in closely related species
  - **All** vertebrate embryos have similar structures at different stages of development

h, frog, snake, birds, human, etc.
Molecular record

- Comparing DNA & protein structure
  - universal genetic code!
    - DNA & RNA
  - compare common genes
    - cytochrome C (respiration)
    - hemoglobin (gas exchange)

Why compare these genes?

Closely related species have sequences that are more similar than distantly related species
- DNA & proteins are a molecular record of evolutionary relationships
Comparative hemoglobin structure

Why does comparing amino acid sequence measure evolutionary relationships?

Number of amino acid differences between hemoglobin (146 aa) of vertebrate species and that of humans

- Human: 8
- Macaque: 32
- Dog: 45
- Bird: 67
- Frog: 125
- Lamprey: 125
Building “family” trees

Closely related species (branches) share same line of descent until their divergence from a common ancestor.
Artificial selection

- Artificial breeding can use variations in populations to create vastly different “breeds” & “varieties”

“descendants” of wild mustard
“descendants” of the wolf
Natural selection in action

- Insecticide & drug resistance
  - insecticide didn’t kill all individuals
  - resistant survivors reproduce
  - resistance is inherited
  - insecticide becomes less & less effective