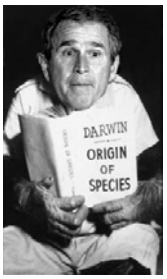
Evolution as Fact and Theory



What is a Scientific Theory?

"A well-substantiated explanation of some aspect of the natural world; an organized system of accepted knowledge that applies in a variety of circumstances to explain a specific set of phenomena."

"A scientific theory is an established and experimentally verified fact or collection of facts about the world. Unlike the everyday use of the word theory, it is not an unproved idea, or just some theoretical speculation."

Examples of Scientific Theories:

- **Atomic theory**
- **Gravitational theory & Relativity**
- **Plate tectonic theory**
- **Heliocentric theory**
- **Evolutionary theory**

Ideas Leading to Darwin's Theory

- **The prevailing view dated back to at least 350 B.C. (Aristotle):**
  - **Species are immutable yielding no change of form through time!**
  - **Earth is young**
  - **Divine creation produced all species**

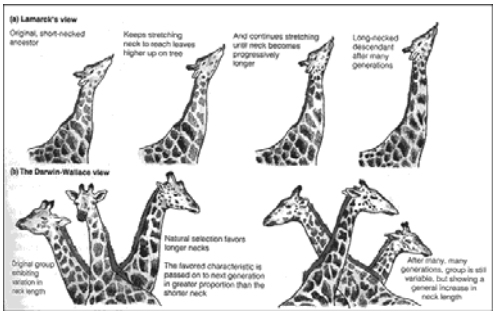
Ideas Leading to Darwin's Theory

- **Changing geological views:**
  - **1790 (James Hutton)**
    - **Proposed GRADUALISM - that landforms have been formed by the very processes that we can witness (e.g., erosion, volcanism, earthquakes)**
  - **1800 (Georges Cuvier)**
    - **One of the first paleontologists. Found fossil assemblages showing shifts in communities. Argued that this was consistent with CATASTROPHISM.**

Ideas Leading to Darwin's Theory

- **Changing biological views:**
  - **1798 (Thomas Malthus)**
    - **Wrote "Essay on the Principle of Population", arguing that unchecked human population growth would lead to famine because resources would become limiting.**
  - **1809 (Jean Baptiste Lamarck)**
    - **Proposed that life has evolved, and argued for a specific mechanism (ACQUIRED CHARACTERISTICS)**

Lamark's vs. Darwin's Theory



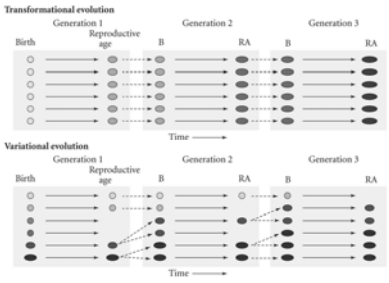
Three theories of the history of life

Evolution **Transformation** **Creationism**

Which theories allow for **extinction** and **divergence** events?

The Logic of Darwin's Theory

- **Through time, this will result in a change in the makeup of the population.**



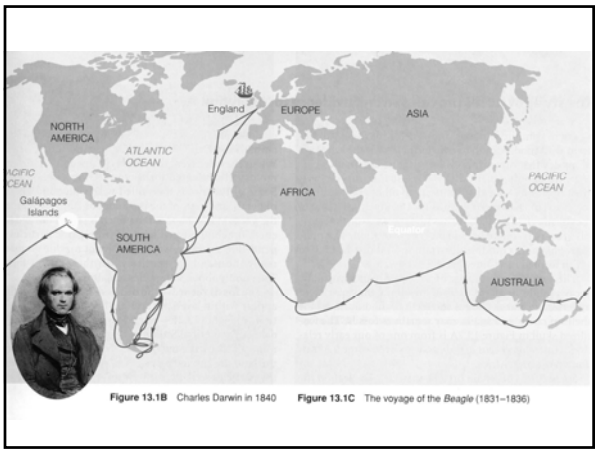
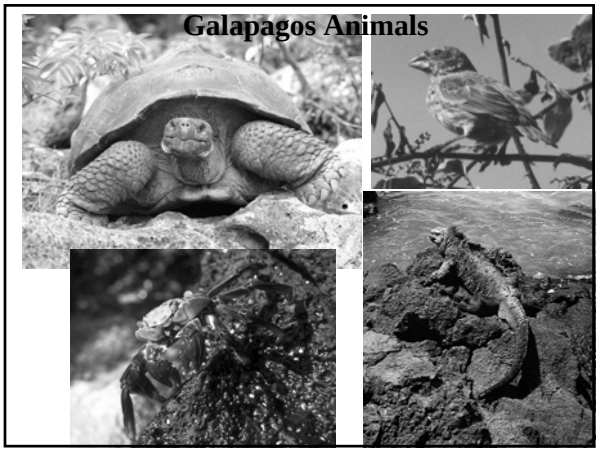
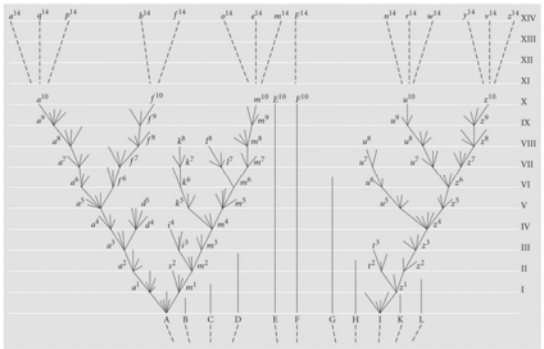


Figure 13.1B Charles Darwin in 1840 **Figure 13.1C** The voyage of the *Beagle* (1831–1836)

Galapagos Animals



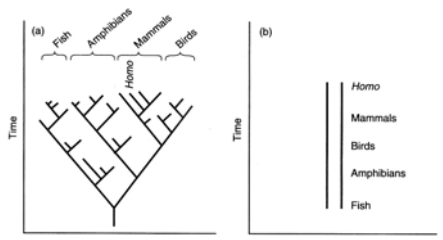
Darwin's representation of hypothetical phylogenetic relationships

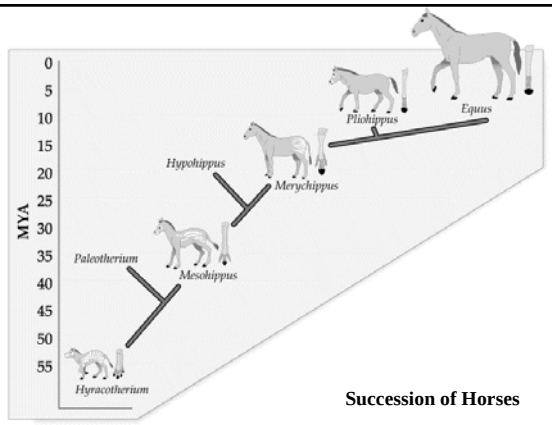


Only Figure in Darwin's Origin of the Species, 1859.

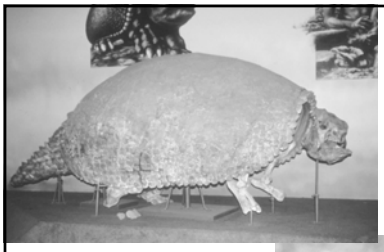
The Cone of Complexity is NOT a linear model!

Figure 1.6 (a) Darwin's theory suggests that evolution has proceeded as a branching tree. Note that *Homo* occupies an arbitrary position in the diagram—it does not have to be the right-hand extreme. The tree should be contrasted with the popular idea (b) that evolution is a one-dimensional progressive ascent of life. In Stephen Jay Gould's words, Darwinian evolution is a bush, not a ladder. (see also Figure 1.2)



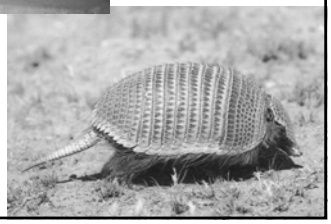


Succession of Horses



Glyptodon

Armadillo



The Logic of Darwin's Theory

- **Darwin recognized (with help from Malthus' essay) that all species have the capacity to achieve huge population sizes through reproduction, but that at some point, resources would become limiting - setting up a struggle for existence.**

The Logic of Darwin's Theory

- **Within a population, there is variation, and some of that variation is heritable.**
- **Some variants have traits that make them more likely to survive and/or reproduce than other variants, and will therefore produce more offspring than the other variants. This is natural selection.**

The Basic Elements of Darwin's Theory

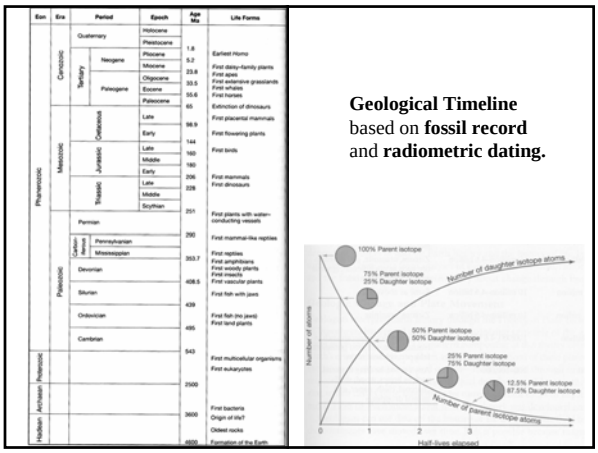
- **Life has evolved.**
- **Evolution has occurred via descent with modification from a common ancestor.**
- **The mechanism driving evolution has been natural selection.**
- **NOT a forward looking process, but fortuitous contingency.**

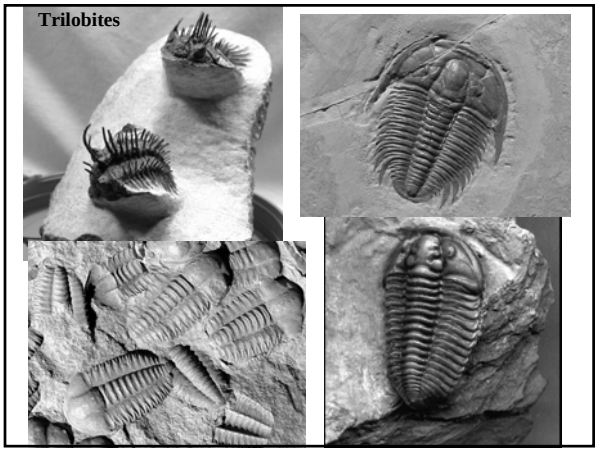
Evolutionary Biology since Darwin - the Modern Synthesis and beyond.

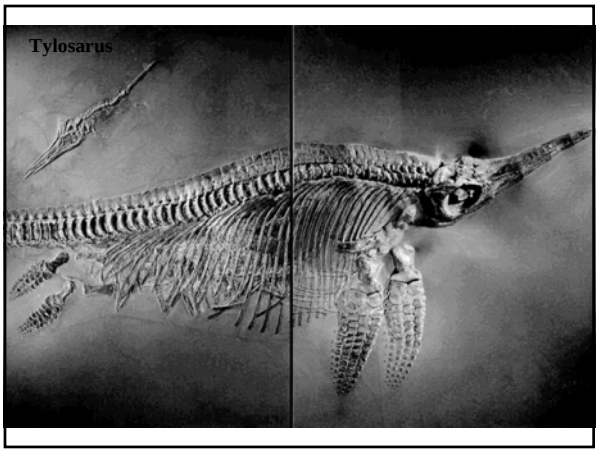
- **Discovery of the genetic basis of heredity.**
- **Development of the idea of mutation as the source of variation.**
- **Integration of microevolution and macroevolution.**
- **Addition of molecular evolution (**including the neutral theory of molecular evolution**), developmental biology, genomics.**

Evidence That Life Has Evolved

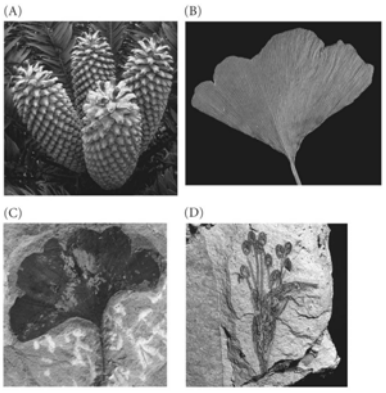
- **Fossil record**
- **Observations of evolution, including speciation.**


Eon
Era
Period
Epoch
Age Ma
Life Forms
Phanerozoic
Cenozoic
Quaternary
Holocene
Pleistocene
1.8
Earliest Homo
Tertiary
Neogene
Pliocene
5.7
Miocene
23.8
First daisy-family plants
First apes
Paleogene
Oligocene
33.5
First extensive grasslands
First whales
Eocene
55.6
First horses
Paleocene
65
Extinction of dinosaurs
Mesozoic
Cretaceous
Late
First placental mammals
Early
98.9
First flowering plants
Jurassic
Late
144
First birds
Middle
160
Early
180
Triassic
Late
206
First mammals
First dinosaurs
Middle
228
Scythian
251
First plants with water-conducting vessels
Paleozoic
Permian
290
First mammal-like reptiles
Carboniferous
Pennsylvanian
Mississippian
323.7
First reptiles
First amphibians
First woody plants
First insects
Devonian
408.5
First vascular plants
Silurian
439
First fish with jaws
Ordovician
495
First fish (no jaws)
First land plants
Cambrian
543
First multicellular organisms
Proterozoic
First eukaryotes
2500
Archean
3600
First bacteria
Origin of life?
Hadean
Oldest rocks
4600
Formation of the Earth
Geological Timeline
based on fossil record
and radiometric dating.
100% Parent isotope
75% Parent isotope
25% Daughter isotope
Number of daughter isotope atoms
50% Parent isotope
50% Daughter isotope
25% Parent isotope
75% Daughter isotope
12.5% Parent isotope
87.5% Daughter isotope
Number of parent isotope atoms
Number of atoms
0
1
2
3
Half-lives elapsed


Trilobites


Tylosarus

Plants



Archaeopteryx

Evidence That Life Evolves Via Descent With Modification

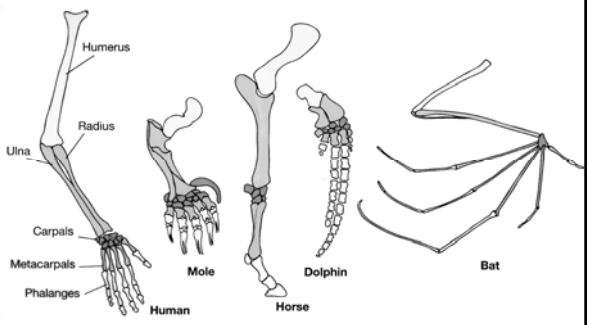
- **Homology (incl. vestigial structures)**
- **Artificial selection**
- **Embryology and developmental genetics**
- **Imperfections**
- **Geographic distributions**

Homology

The presence of similar features in two organisms as a result of their common ancestry.

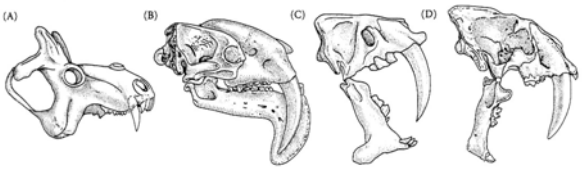
Not always easy to ascertain, might be analogous instead. Beware of similarity via coevolution.

Homology of form



Sabertooth Condition

FIGURE 5.21 Convergent evolution of the "sabertooth" condition of the canine tooth in four distantly related extinct lineages. (A) A mammal-like reptile, the tapinocephalian *Estemmenosuchus*, from the Permian of Russia. This animal was probably an omnivore that used the canines for fighting, rather than for killing prey as in the other species illustrated. (B) A marsupial, *Thylacosmilus*, from the Miocene of South America. (C) A nimravid carnivore, *Barbourofelis*, from the Miocene of North America. (D) A true cat, *Smilodon*, from the Pleistocene of North America. (A after Cowen 1990; B after Riggs 1934; C after Stearn and Carroll 1989; D after Romer 1966.)



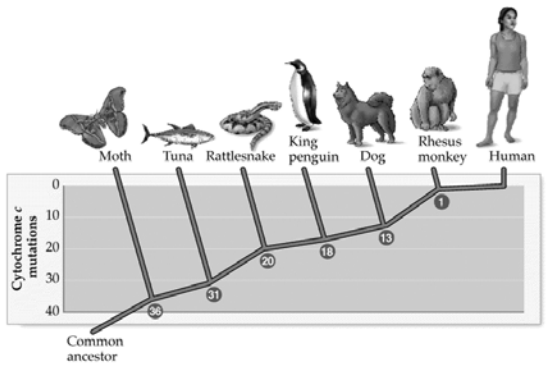
Reptile **Marsupial** **Nimravid** **True Cat**

Smilodon:
Sabertooth Tiger

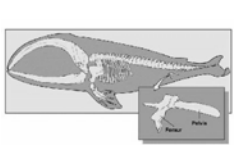
Smilodonichthys:
A Pliocene salmonid fish

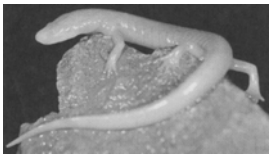
Analogous Structures

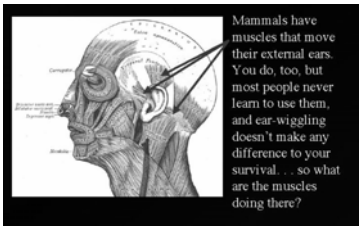
Homology of molecules

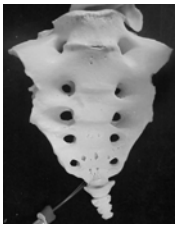


Vestigial Structures: Exhibited by loss of function.

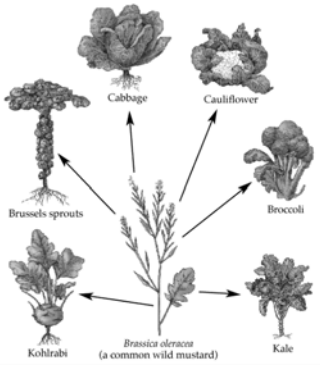








Artificial selection has produced dramatic change in plants...

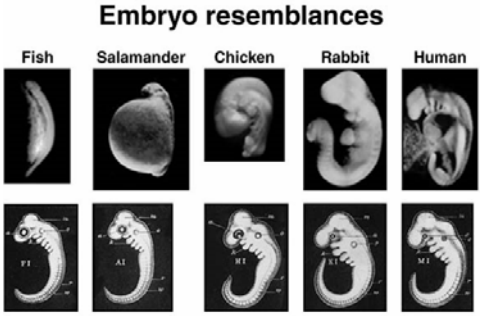


… and animals

Artificial Selection in Pigeons

1.1. Breeds of Pigeons. (A) The wild rock pigeon of Europe is thought to be the ancestor of the domesticated breeds shown here. (B) Fantail. (C) Pouter. (D) Jacobin oriental frill. (E) English pouter. (F) Pomeranian pouter. (G) Carrier. [Based on photographs in W. W. Lord, *The Pigeon*, Levi Publishing Co., 1907.]

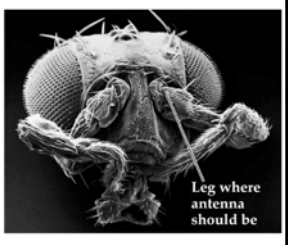
Similarities in early development indicate organisms are derived from a similar plan.



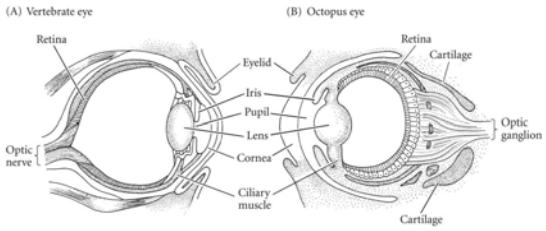
Ontogeny recapitulates Phylogeny?

Developmental genes reveal the basis for alterations of the common plan.

Developmental genes reveal the basis for alterations of the common plan.

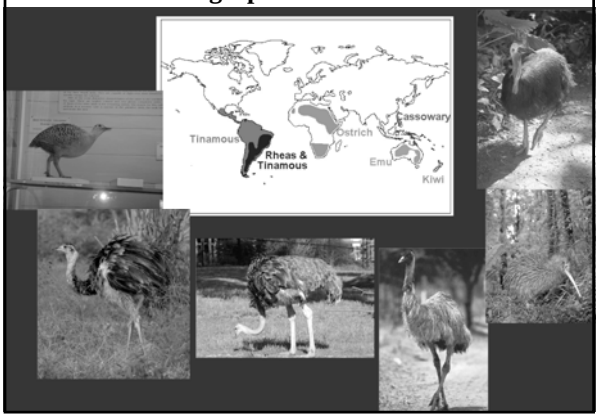


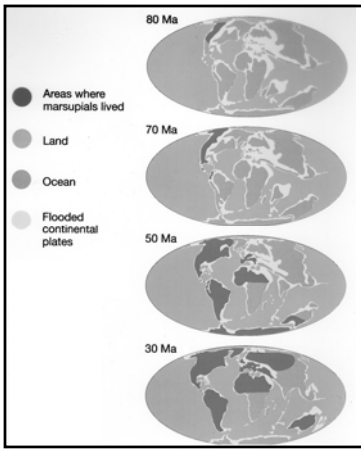
Imperfections of design



Analogous Structures too!

Geographic Distributions





The Evolutionary History of Marsupial Mammals

Requires Integration of:
Plate Tectonics
Fossil Record
Radioisotope Dating

The Basic Elements of Darwin's Theory

- **All life has evolved.**
- **Evolution has occurred via descent with modification from a common ancestor.**
- **The mechanism driving evolution has been natural selection.**

- **Neodarwinian theory is supported by as much scientific evidence as any theory in science.**
- **Thus, as much as is scientifically possible, evolution via descent with modification is a fact.**

The Theoretical Side of Evolution: How Important is Natural Selection vs. Other Evolutionary Forces?

Early Mendelians **Biometricans**