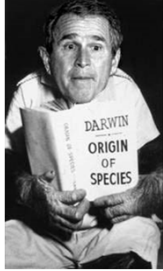


Evolution as Fact and Theory



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

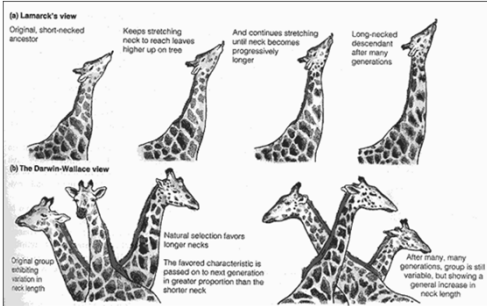
Ideas Leading to Darwin's Theory

- 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)

Lamarck's vs. Darwin's Theory



Three theories of the history of life

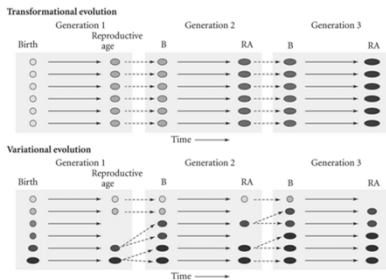


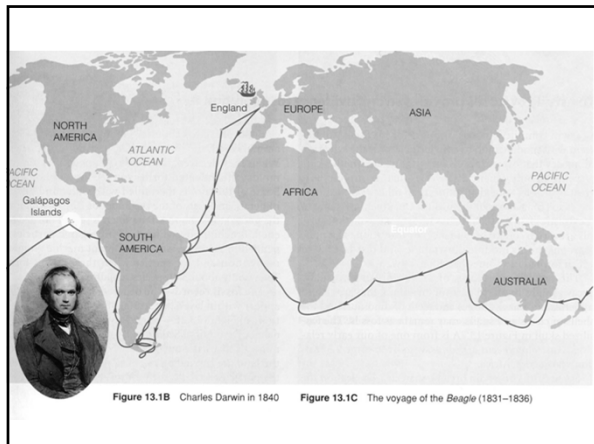
Evolution Transformation Creationism

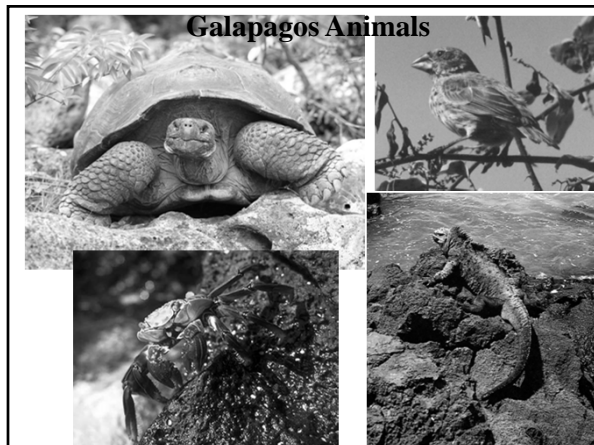
Which theories allow for **extinction** and **divergence** events?

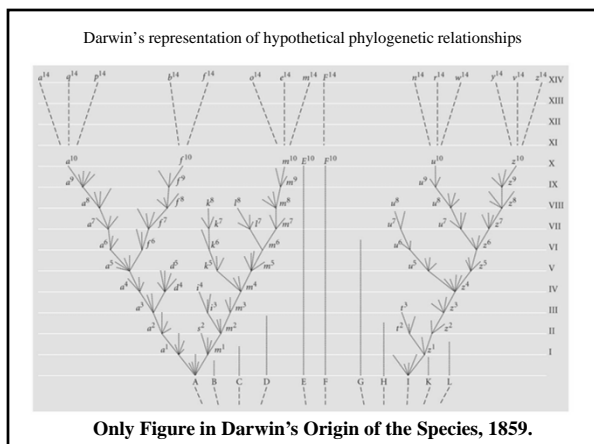
The Logic of Darwin's Theory

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



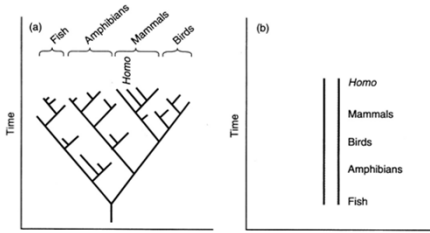






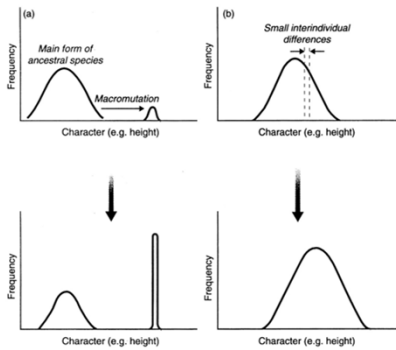
The Cone of Complexity is NOT a linear model!

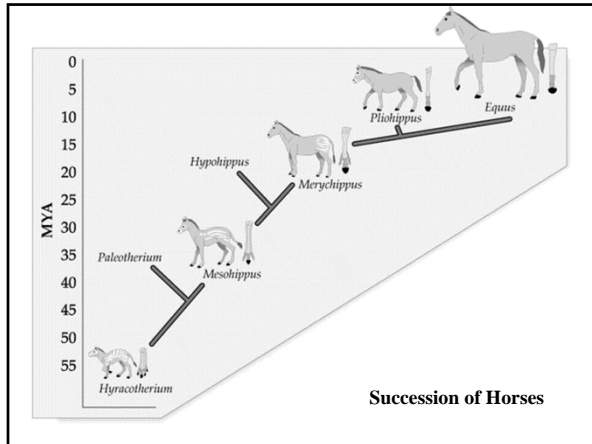
Figure 1.6 (a) Darwin's theory suggests that evolution has proceeded as a branching tree. Note that *Homo* occupies an arbitrary position in the diagram—it does not have to be the right-hand extreme. The tree should be contrasted with the popular idea (b) that evolution is a one-dimensional progressive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

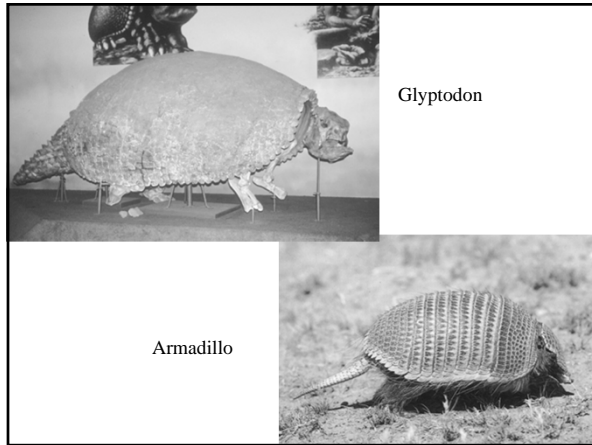


The Theoretical Side of Evolution: How Important is Natural Selection vs. Other Evolutionary Forces?

Saltationists (Early Mendelians) Gradualists (Biometricians)







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

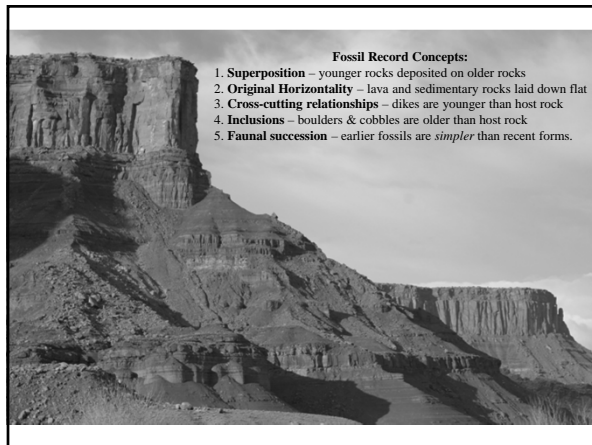
- **Life has evolved.**
- **Evolution has occurred via descent with modification from a common ancestor.**
- **The mechanism driving evolution has been natural selection.**
- **NOT a forward looking process, but fortuitous contingency.**

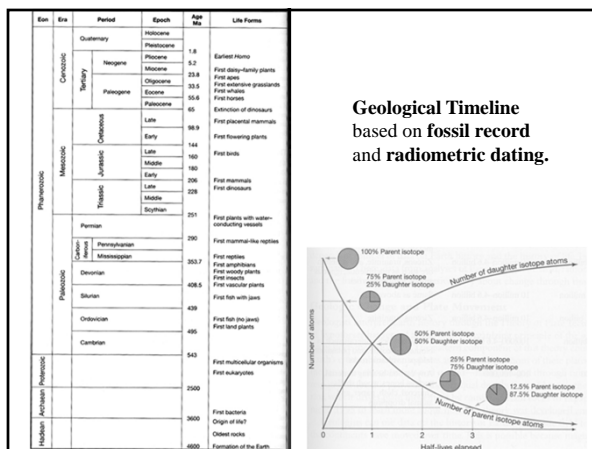
Evolutionary Biology since Darwin - the Modern Synthesis and beyond.

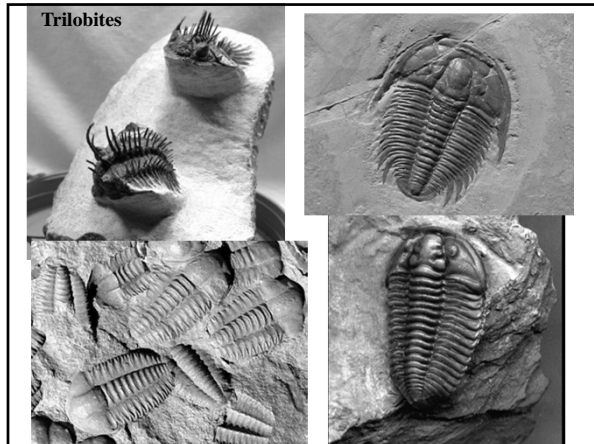
- **Discovery of the genetic basis of heredity.**
- **Development of the idea of mutation as the source of variation.**
- **Integration of microevolution and macroevolution.**
- **Addition of molecular evolution** (including the neutral theory of molecular evolution), **developmental biology,** **genomics.**

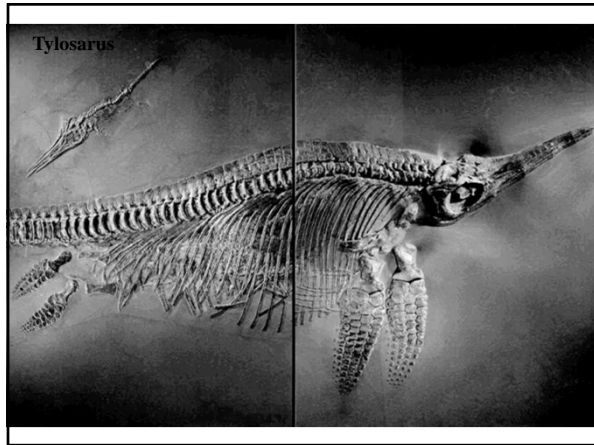
Evidence That Life Has Evolved

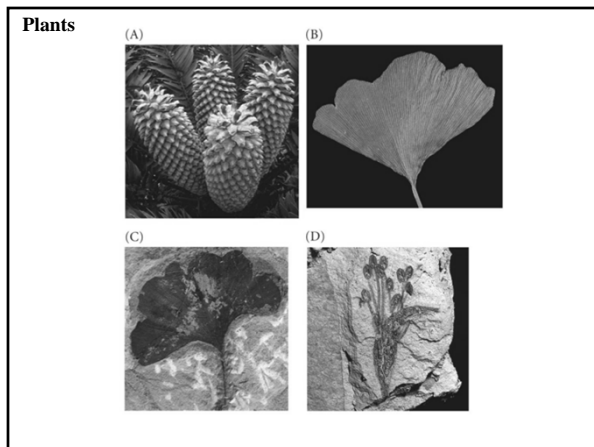
- Fossil record
- Observations of evolution, including speciation.

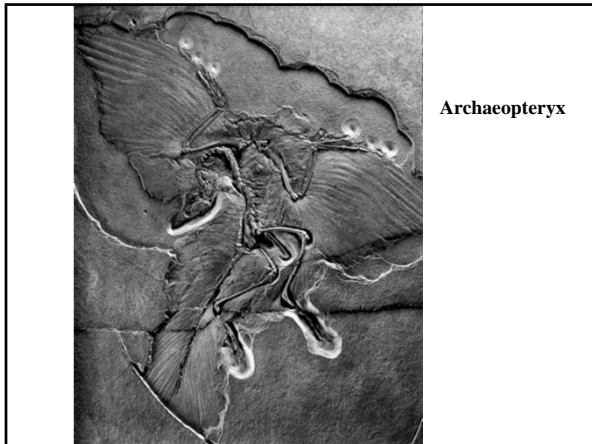












Archaeopteryx

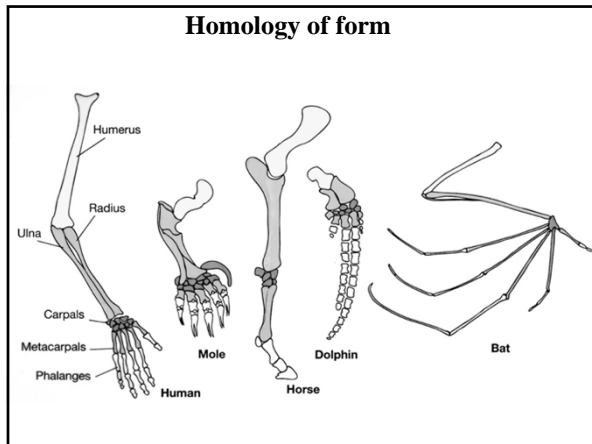
Evidence That Life Evolves Via Descent With Modification

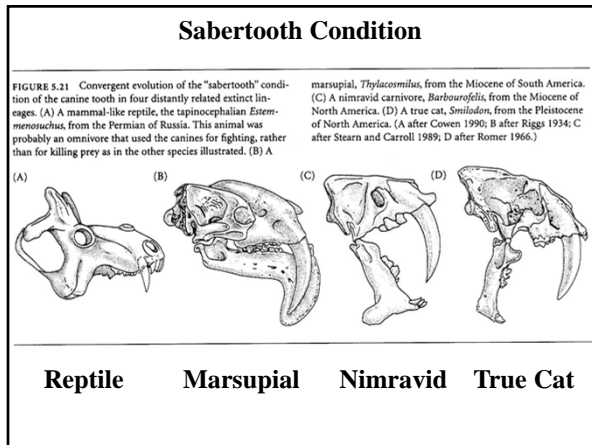
- Homology (incl. vestigial structures)
- Artificial selection
- Embryology and developmental genetics
- Imperfections
- Geographic distributions

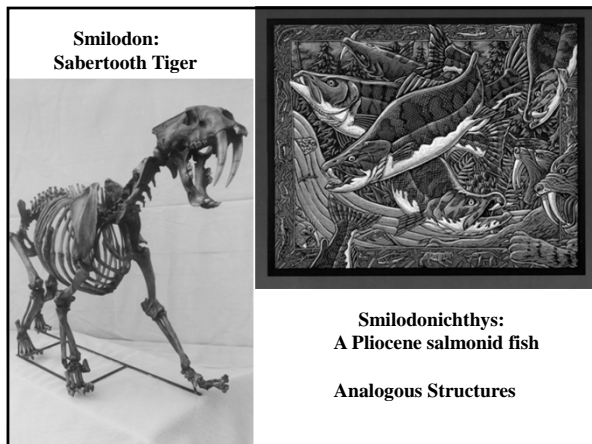
Homology

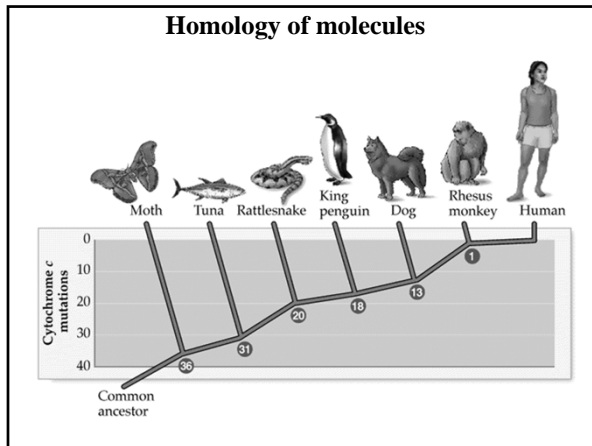
The presence of similar features in two organisms as a result of their common ancestry.

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



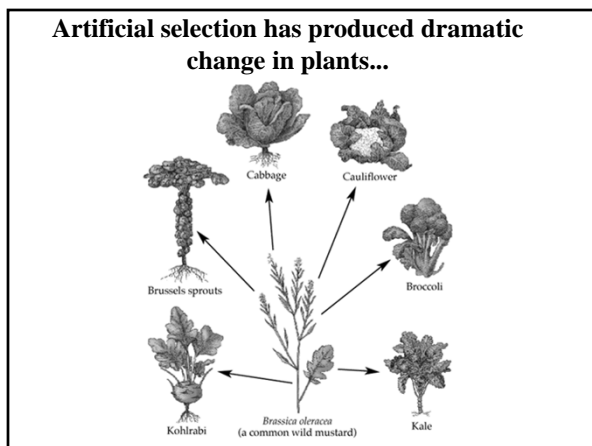






Vestigial Structures: Exhibited by loss of function.

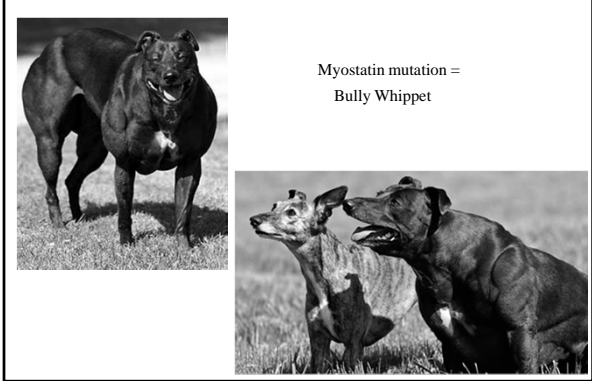
Mammals have muscles that move their external ears. You do, too, but most people never learn to use them, and ear-wiggling doesn't make any difference to your survival... so what are the muscles doing there?



... and animals



... and animals



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

Embryo resemblances

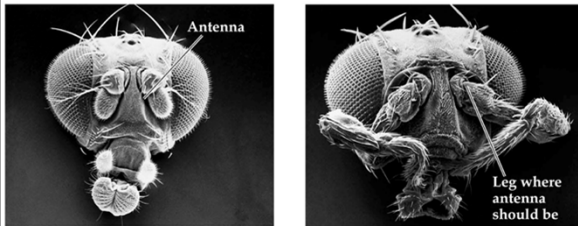


Ontogeny recapitulates Phylogeny?

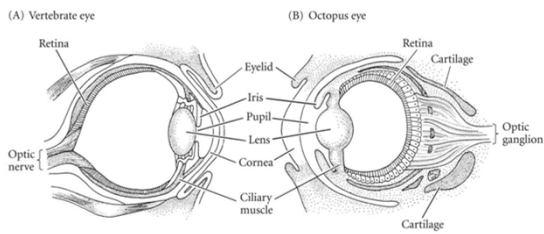
Developmental genes reveal the basis for alterations of the common plan.



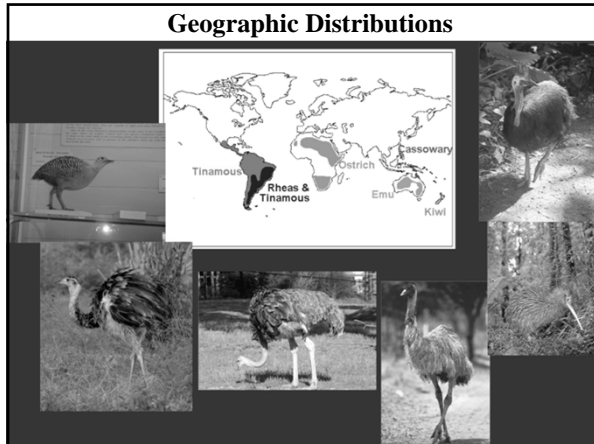
Developmental genes reveal the basis for alterations of the common plan.

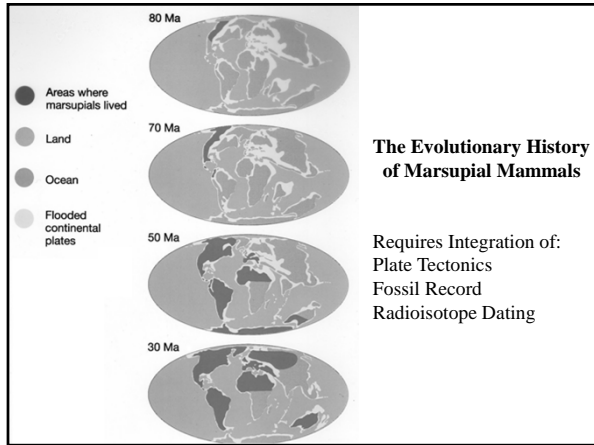


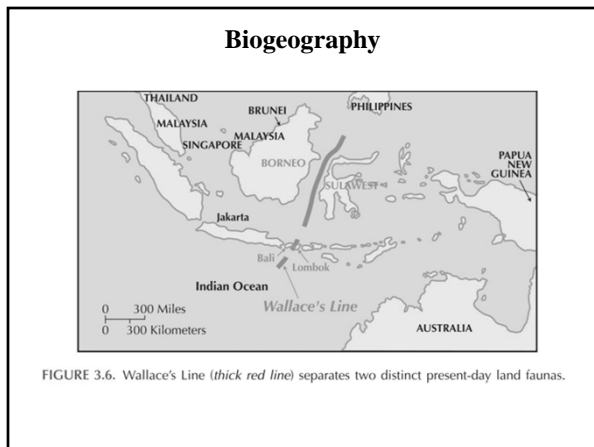
Imperfections of Design



Analogous Structures too!



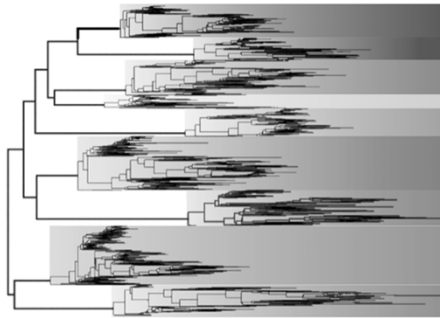




Convergence

Niche	Placental Mammals	Australian Marsupials
Burrower	Mole	Marsupial mole
Anteater	Arctotherium	Numbat (anteater)
Mouse	Mouse	Marsupial mouse
Climber	Lemur	Spotted opossum
Glider	Flying squirrel	Flying phalanger
Cat	Bibacoat	Tasmanian "tiger cat"
Wolf	Wolf	Tasmanian wolf

Divergence



HIV viruses from 9 different patients from successive time intervals

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.
