How Populations Evolve

Nothing in biology makes sense except in the light of evolution.

Theodosius Dobzhansky

Introduction

•Evolution is the central theme of biology. Adaptation is a universal characteristic of living things.

•More than any other idea in biology, evolutionary theory serves to tie the discipline together.

•If you look at any organism critically, you are first struck by the differences from other organisms.

•Further observation often reveals that an organism's features show some relationship to where the organism lives and what it does in its environment.

Evidence of Evolution

•Awareness of each organism's adaptations and how they fit the particular conditions of its environment helps us appreciate the natural world.

•Early Greek philosophers held various views. **Anaximander** (about 2500 years ago) suggested that life arose in water and that simpler forms preceded more complex forms of life.

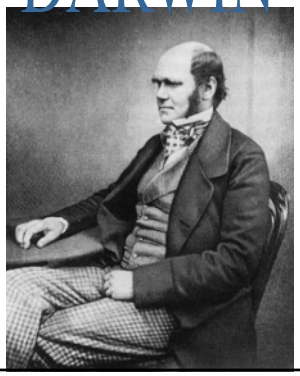
•On the other hand **Aristotle**, who strongly influenced later thinkers, believed that species were fixed and did not evolve.

•This later view was advanced by the **Judeo-Christian** tradition that all species were created in a single act of creation about 6000 years ago.

•**Buffon** (mid-1700s) suggested that Earth was much older and raised the possibility that different species arose from common ancestors, although the later argued against the point.

•**Lamarck** (early 1800s) was the first to support the idea of evolution strongly, but he believed the mechanism for change was the inheritance of acquired traits.

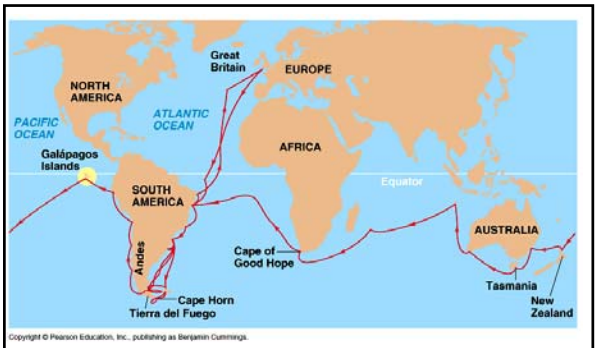
DARWIN



•Born in 1809, **Darwin** joined the crew of the surveying ship Beagle as a naturalist for a world-encircling voyage in 1831.

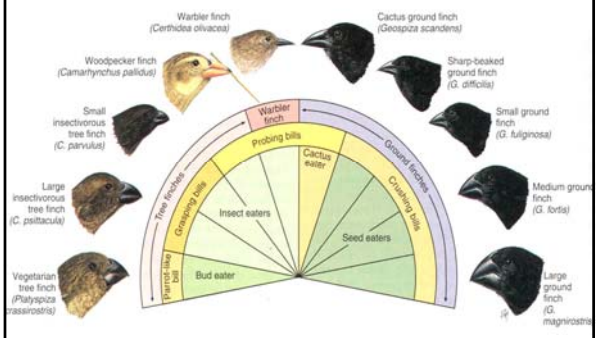
•Comparison of South American fossils with living species there and fossils elsewhere, and observations of organisms and their distributions on the **Gal'apagos Islands** made a particularly strong impression on him.

•Darwin was influenced by Lyell's ***Principles of Geology***, which promoted the idea of continual, gradual, consistent geological change.



•After his return, Darwin began work on an essay to document his observations and his new theory of evolution.

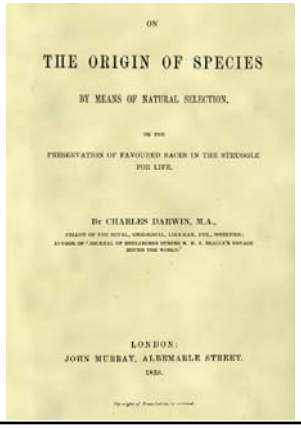
Galapagos Finches



•In the mid-1850s, **Wallace** conceived essentially the same theory, based on his observations in Indonesia. He contacted Darwin, and presentations of both their work were made to the scientific community in 1858.

•Darwin's ***On the Origin of Species by Means of Natural Selection*** was published in 1859 and contains a well-constructed argument for natural selection, backed by considerable evidence. He used the phrase "*descent with modification*."

•Darwin's view of evolution: The history of life is like a **tree**, with multiple branching from the base of the trunk to the tips of the branches. Species on a given branch are more closely related to each other than they are to species on other branches.


ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

The study of fossils provide strong evidence for evolution

- Hard parts, such as skeletons and shells, remain after organic matter has decomposed. Such parts fossilize easily.

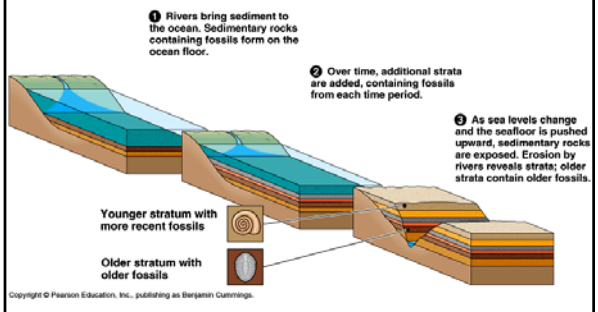
- Some fossils, such as those of leaves, retain remnants of organic matter with molecular fragments that can be analyzed.

- Organisms trapped in tree resin can be fossilized intact, within the fossilized amber, protected from decomposition by bacteria and fungi.

- Petrified fossils form by the slow mineralization of organic materials.

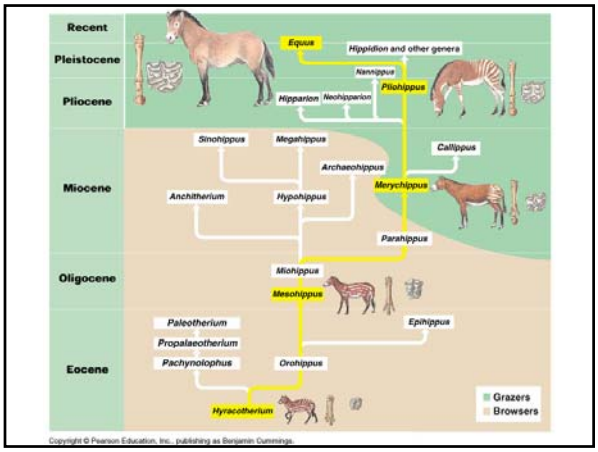
- Fossilized molds of organisms form when a covered area decays and fills in with other sediment.

- The fossil record is an array of fossils appearing within the layers of sedimentary rock. Sedimentary rocks form from accumulation of waterborne sediments. Sedimentary deposits occur in **strata**. Each layer contains fossils of organisms among the deposits, with younger strata on top of older strata.



- The fossil record shows a historical sequence of organisms from the oldest known fossils, prokaryotes, dating from ≈3.5 billion years, through the subsequent appearance of eukaryotes, on through many intermediate steps to modern forms-a sequence that has an overall pattern of change from simple to more complex forms.

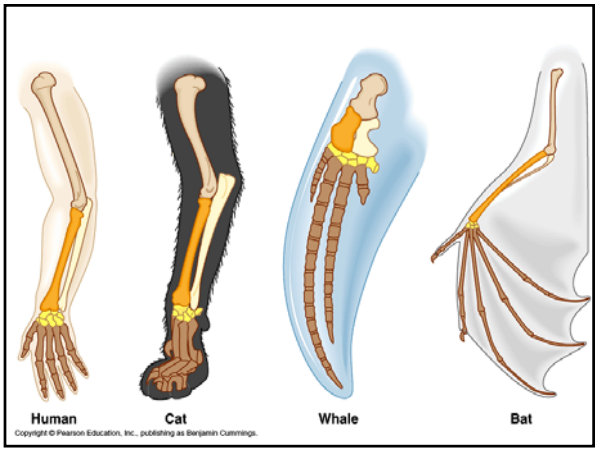
NOTE: Such a sequence, whereby links are seen between extinct organisms and species alive today, is predicted by evolutionary theory. One of the best documented series is the evolution of modern horses.

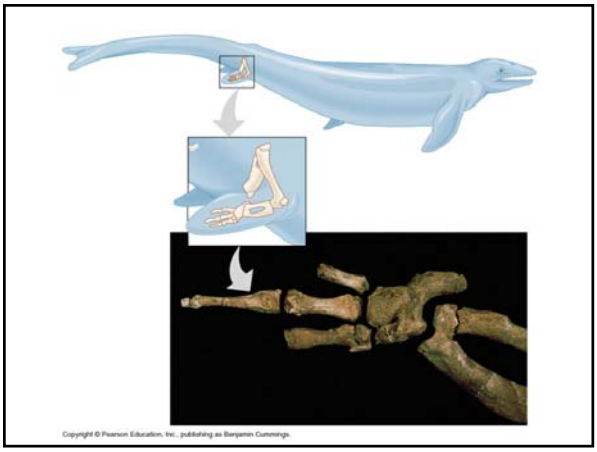


A mass of evidence validates the evolutionary view of life

Biogeography: observations about the distribution of different but obviously related life forms around the world and in neighboring geographical regions. Island forms are most similar to forms found on the closest mainland, rather than those found on ecologically similar but more distant islands.

Comparative anatomy of homologous structures. For example, all mammals have the same basic limb structure.

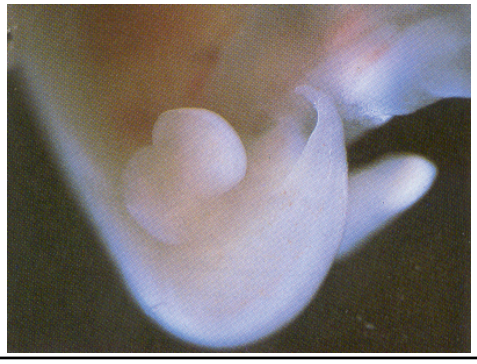




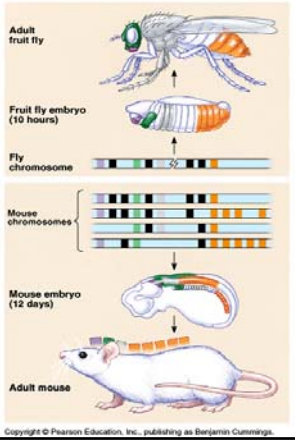
Comparative embryology shows that different organisms go through similar embryonic stages. For example, evidence that all vertebrates evolved from a common ancestor is that all have an embryonic stage in which gill pouches appear in the throat region.

NOTE: In addition to pharyngeal pouches, vertebrates, along with all chordates, also have in common the presence of, at some point in their life cycle, a ***notochord*** a cartilaginous supporting rod), a ***dorsal hollow nerve chord*** (spinal chord), and a ***post-anal tail***.

Human Tail - 5 Week Embryo



Molecular biology demonstrates universality of the genetic code, the conservation of ***amino acid sequences*** in proteins such as hemoglobin, and the presence of very similar ***homeoboxes*** in very different species.



Darwin's Theory & The Modern Synthesis

Darwin proposed natural selection as the mechanism of evolution

- Darwin observed that species tend to produce excessive numbers of offspring, that the expression of traits varies among the individuals of a population, and that many of these traits are heritable.
- English economist **Thomas Malthus's** essay pointed out the inevitable human suffering resulting from populations growing faster than supplies of resources.
- Darwin had personal knowledge of and interest in artificial selection and compared the results of artificial selection to the variation seen among closely related species.

- The ***essence of natural selection is differential reproduction***. Individuals in populations vary. Some individuals are more suitable to a given environment and reproduce more easily and abundantly. The favored characteristics are passed to the next generation and the less-favored characteristics are not.
- Over vast amounts of time, the gradual accumulation of changes in the characteristics among individuals in a population occurs.

Natural selection is a prominent force in nature

- Two good examples of the effects of the process can be described. In both cases, *new populations* have resulted, but *not new species*.
- In the land snail, *Cepea nemoralis*, shell patterns camouflage the sanil in different habitats, with striped snails found in well-lit areas and dark snails found in shady areas.

•In the peppered moth, *Biston betularia*, light forms are adapted to lichen-covered tree bark and dark forms to tree bark without lichen.

i.e.- Industrial melanism

•Natural selection is regional and timely. Populations tend to evolve in response to local environmental conditions during one time period. A particular adaptation may be pointless in the context of other locales or times.

Populations are units of evolution

•Evolution is measured as the change in frequency of a given characteristic within a population over succession of generations.

•Darwin realized this, but he did not know about genetic mechanisms.

•During the 1920s population genetics was combined with Darwinian principles into a comprehensive theory of evolution known as the modern synthesis.

•Central to this synthesis is the sexual species concept. A sexual species is a group of populations whose individuals have the potential to interbreed. A given sexual species has an overall range, with concentrations of individuals in local populations.

•Opportunities for breeding among populations of the same species vary, depending on the species and on the extent of isolation of the populations.