

17-4 Patterns of Evolution

Macroevolution refers to large-scale evolutionary patterns and processes that occur over long periods of time.

Six important topics in macroevolution are:

- **extinction**
- **adaptive radiation**
- **convergent evolution**
- **coevolution**
- **punctuated equilibrium**
- **changes in developmental genes**

Extinction

More than 99% of all species that have ever lived are now extinct.

In the past, most researchers looked for a single, major cause for each **mass extinction**.

Many paleontologists now think that mass extinctions were caused by several factors.

Mass extinctions have:

provided ecological opportunities for organisms that survived
resulted in bursts of evolution that produced many new species.

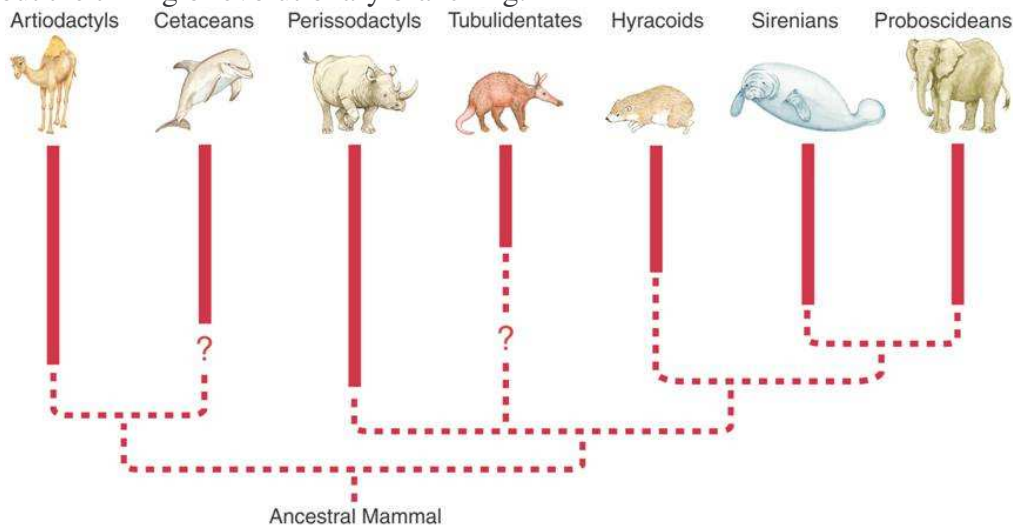
Adaptive Radiation

Adaptive radiation is the process by which a single species or a small group of species evolves into several different forms that live in different ways.

For example, in the adaptive radiation of Darwin's finches, more than a dozen species evolved from a single species. Adaptive radiations can occur on a much larger scale.

The disappearance of dinosaurs then resulted in the adaptive radiation of mammals.

This diagram shows part of the adaptive radiation of mammals, emphasizing current hypotheses about how a group of ancestral mammals diversified over millions of years into several related living orders. Note that the dotted lines and question marks in this diagram indicate a combination of gaps in the fossil record and uncertainties about the timing of evolutionary branching.



Convergent Evolution

Different organisms undergo adaptive radiation in different places or at different times but in similar environments. The process by which unrelated organisms come to resemble one another is called **convergent evolution**. Structures that look and function similarly but are made up of parts that do not share a common evolutionary history are called **analogous** structures.

A dolphin's fluke and a fish's tail fin are analogous structures.

Convergent evolution has resulted in sharks, dolphins, seals, and penguins.

Coevolution

Sometimes organisms that are closely connected to one another by ecological interactions evolve together. The process by which two species evolve in response to changes in each other over time is called **coevolution**.

Punctuated Equilibrium

Darwin felt that biological change was slow and steady, an idea known as **gradualism**.

Biologists have considered two different explanations for the rate of evolution, as illustrated in these diagrams.

Gradualism involves a slow, steady change in a particular line of descent. **Punctuated equilibrium** involves stable periods interrupted by rapid changes involving many different lines of descent. **Punctuated equilibrium** is a pattern of evolution in which long stable periods are interrupted by brief periods of more rapid change.

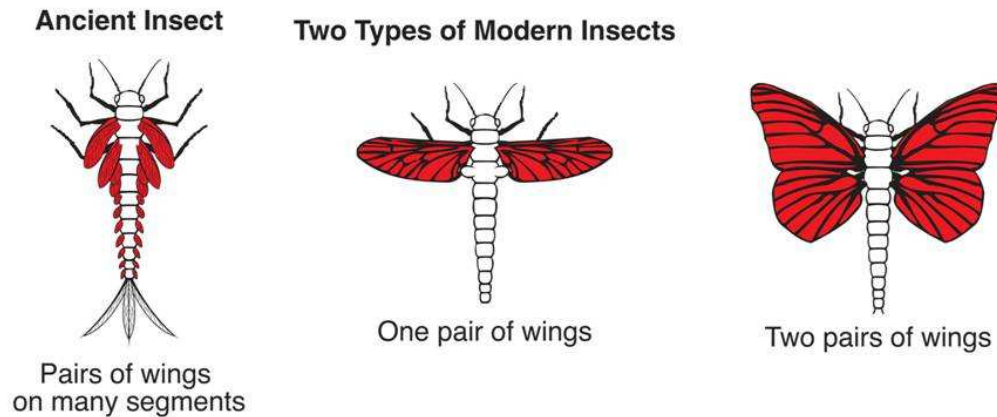
The concept of punctuated equilibrium has generated debate and is still controversial among some biologists today. Evolution has often proceeded at different rates for different organisms at different times during the history of life on Earth.

Developmental Genes and Body Plans

It is suspected that changes in genes for growth and differentiation during embryological development could produce changes in body shape and size.

Small changes in the activity of control genes can affect many other genes to produce large changes in adult animals.

Small changes in the timing of cell differentiation and gene expression can make the difference between long legs and short ones.



Some ancient insects, such as the mayfly nymph (left), had winglike structures on many body segments. Modern insects have only four wings or two wings. **Changes in the expression of developmental genes may explain how these differences evolved.**