Descent with Modification: A Darwinian View of Life

What causes the similarities and differences among Earth's many different species?

Ancient common ancestor

Species accumulate differences from their ancestors as they **adapt to different environments** over many generations.

While different in some ways, these species share many similar features because they descended from a common ancestor. This process of

descent with modification

- **descent**: shared ancestry, resulting in shared characteristics
- **modification**: accumulation of differences

has given rise to the **diversity of life**.

Darwin's interest in the species (or fossils) found in an area was further stimulated by the Beagle's stop at the Galápagos, a group of volcanic islands located near the equator about 900 km west of South America (Figure 22.5). Darwin was fascinated by the unusual organisms there. The birds he collected included several kinds of mockingbirds. These mockingbirds, though similar to each other, seemed to be different species. Some were unique to individual islands, while others lived on two or more adjacent islands. Furthermore, although the animals on the Galápagos resembled species living on the South American mainland, most of the Galápagos species were not known from anywhere else in the world. Darwin hypothesized that the Galápagos had been colonized by organisms that had strayed from South America and then diversified, giving rise to new species on the various islands.

▼ Figure 22.5 The voyage of HMS *Beagle* (December 1831–October 1836).

Darwin's Focus on Adaptation

During the voyage of the Beagle, Darwin observed many examples of **adaptations**, inherited characteristics of organisms that enhance their survival and reproduction in specific environments. Later, as he reassessed his observations, he began to perceive adaptation to the environment and the origin of new species as closely related processes. His explanation of how adaptations arise centered on **natural selection**, a process in which individuals that have certain inherited traits tend to survive and reproduce at higher rates than do other individuals because of those traits.

Within a decade, Darwin's book titled On the **Origin of Species by Means of Natural Selection** (commonly referred to as The Origin of Species) and its proponents had convinced most scientists that life's diversity is the product of evolution. Darwin succeeded where previous evolutionists had failed by presenting a plausible scientific mechanism with immaculate logic and an avalanche of supporting evidence.

▼ Figure 22.6 Three examples of beak variation in Galápagos finches. The Galápagos Islands are home to more than a dozen species of closely related finches, some found only on a single island. A striking difference among them is their beaks, which are adapted for specific diets.

(a) Cactus-eater. The long, sharp beak of the common cactus finch (*Geospiza scandens*) helps it tear and eat cactus flowers and pulp.

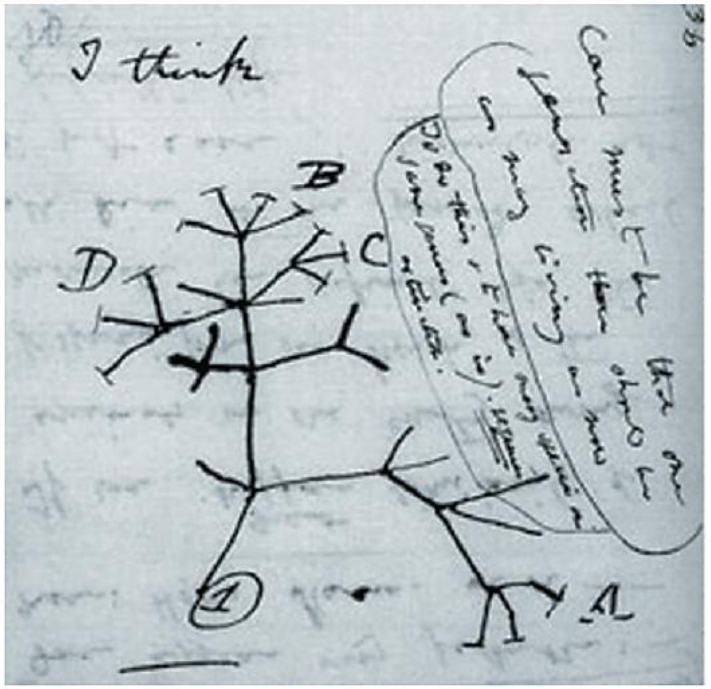
(b) Insect-eater. The green warbler finch (*Certhidea olivacea*) uses its narrow, pointed beak to grasp insects.

(c) Seed-eater. The large ground finch (*Geospiza magnirostris*) has a large beak adapted for cracking seeds found on the ground.

Descent with Modification

In the first edition of The Origin of Species, Darwin never used the word evolution(although the final word of the book is “evolved”). Rather, he discussed descent with modification, a phrase that summarized his view of life. Organisms share many characteristics, leading Darwin to perceive unity in life. He attributed the unity of life to the descent of all organisms from an ancestor that lived in the remote past. He also thought that as the descendants of that ancestral organism lived in various habitats, they gradually accumulated diverse modifications, or adaptations, that fit them to specific ways of life. Thus, Darwin thought of evolution as a process in which both descent (shared ancestry, resulting in shared characteristics) and modification (the accumulation of differences) can be observed.

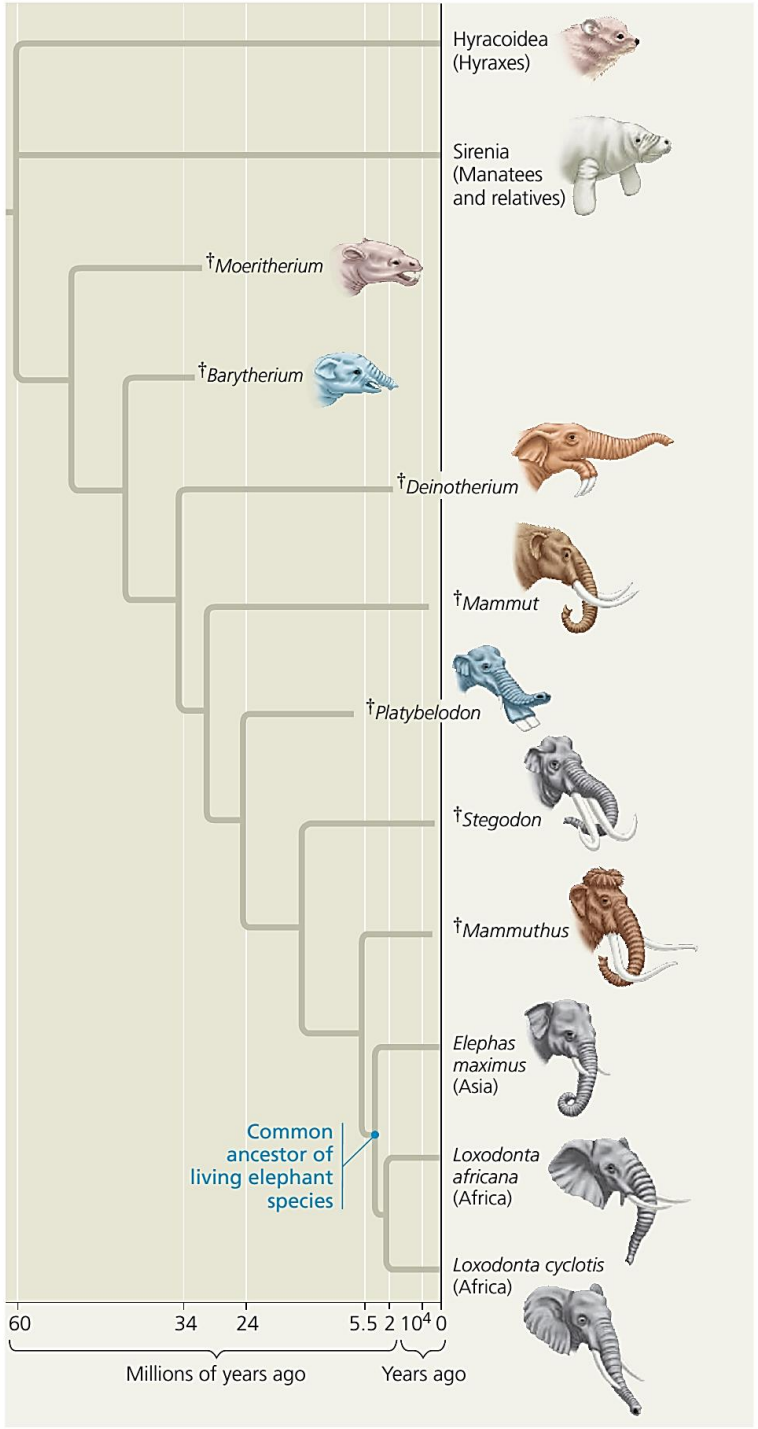
Darwin reasoned that over a long period of time, descent with modification eventually led to the rich diversity of life we see today. He viewed the history of life as a tree, with multiple branchings from a common trunk out to the tips of the youngest twigs (Figure 22.7). In his diagram, the tips of the twigs that are labeled A–D represent several groups of organisms living in the present day, while the unlabeled branches represent groups that are extinct. Each fork of the tree represents the most recent common ancestor of all the lines of evolution that subsequently branch from that point.



▶ Figure 22.7
“I think . . . .” In this 1837 sketch, Darwin envisioned the branching pattern of evolution.
Branches that end in twigs labeled A–D represent particular groups of living organisms; all other branches represent extinct groups.

Darwin thought that such a branching process, along with past extinction events, could explain the large morphological gaps that sometimes exist between related groups of organisms. As an example, let's consider the three living species of elephants: the Asian elephant (Elephas maximus) and two species of African elephants (Loxodonta africana and L. cyclotis). These closely related species are very similar because they shared the same line of descent until a relatively recent split from their common ancestor, as shown in the tree diagram in Figure 22.8. Note that seven lineages related to elephants have become extinct over the past 32 million years. As a result, there are no living species that fill the morphological gap between the elephants and their nearest relatives today, the hyraxes and manatees.

Extinctions like those in Figure 22.8 are common. In fact, many evolutionary branches, even some major ones, are dead ends: Scientists estimate that over 99% of all species that have ever lived are now extinct. As in Figure 22.8, fossils of extinct species can document the divergence of present-day groups by "filling in" gaps between them.



▼ **Figure 22.8 Descent with modification.** This evolutionary tree of elephants and their relatives is based mainly on fossils—their anatomy, order of appearance in strata, and geographic distribution. Note that most branches of descent ended in extinction (denoted by the dagger symbol, †). (Time line not to scale.)