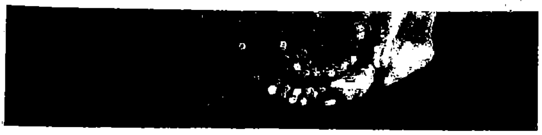
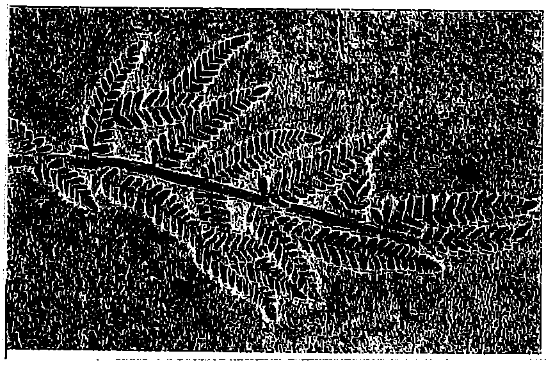




## What the Fossil Record Tells Us

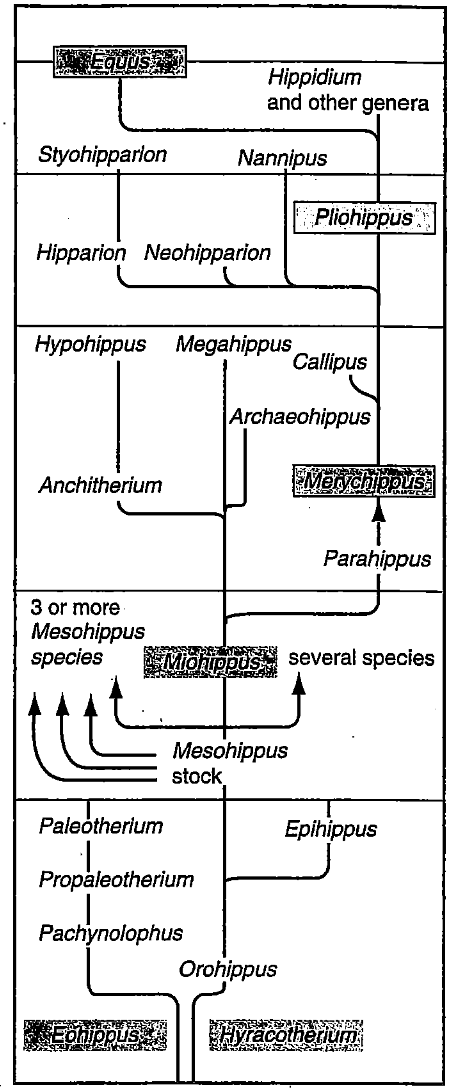
Scientists who study fossils are called **paleontologists** (pay-lee-uhn-TAHL-uh-jihsts). Over the years, paleontologists have collected millions of fossils to make up the **fossil record**. The fossil record represents the preserved collective history of the Earth's organisms. Although incomplete, the fossil record has long inspired scientists. As the naturalist Loren Eisley once wrote, ". . . every bone that one holds in one's hands is a fallen kingdom, a veritable ruined world, a unique object that will never return through time."

*Figure 13–13 About 1 million years ago, this sabertooth cat became trapped in the La Brea tar pits, in what is now California (top). Over time, mud hardened into stone, preserving this impression of a delicate fern (center). Encased in amber, or fossilized tree sap, this lizard has been perfectly preserved (bottom left). This sea lily, a relative of starfish, lived in Earth's oceans about 350 million years ago (bottom center). Each of these microscopic yellow cylinders is a fossil bacterial cell (bottom right).*

Our picture of ancient life has many missing pieces. Still, paleontologists have assembled good evolutionary histories for many animal groups. Figure 13–15, for example, shows the probable relationships between ancient animals whose evolutionary line gave rise to the modern horse. The oldest of these, *Hyracotherium*, which is known as the "dawn horse," was much smaller than modern horses and had very different foot and leg bones. The increase in size and the development of the hooves that facilitate running in these animals have been very dramatic.

The fossil record also tells of major changes that occurred in Earth's climate and geography. Fossil shark teeth have been found in Arizona, indicating that the deserts of the American Southwest were once covered by ancient seas. Giant fossil ferns found in Canada show that North America once had a much warmer, tropical climate. Every period, every epoch in Earth's history had a different climate and contained different kinds of organisms that were adapted to it.

But species do not last forever. As Earth's environments changed over time, many species died out. In the very spot where you now sit and read this book, giant dragonflies with wings that measured almost a meter across may have flitted over swamps filled with giant ferns. Dinosaurs appeared, thrived for a time, and eventually disappeared into Earth's fossil record. The huge fossil skeletons they left behind, when reconstructed, still have the power to amuse and amaze us. **The fossil record shows that change followed change on Earth.**



# 13–4 Evidence from Living Organisms

**Guide For Reading**

- What is the best explanation for the structural and biochemical similarities that exist in living organisms?
- How do similarities in embryo development support the concept of common descent?
- What is a homologous structure?
- How does biochemistry provide evidence for evolution?

Fossils of extinct organisms are not the only evidence that shows the ongoing process of evolution. All living organisms bear traces of the history that links them to their ancestors.

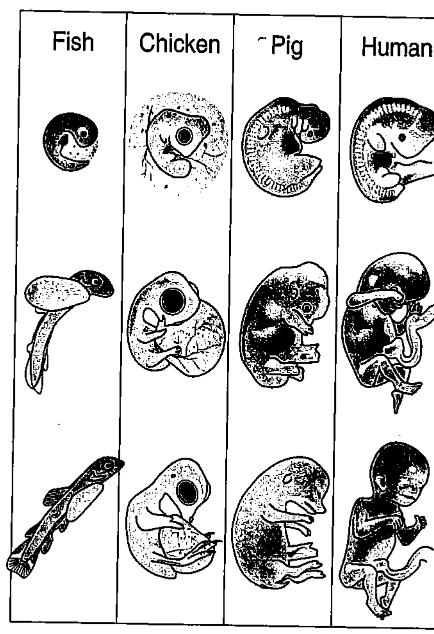
## Similarities in Early Development

In the late nineteenth century, scientists noticed that the embryos of many different animals looked so similar that they were hard to tell apart. **Embryos** are organisms at early stages of development. This does not mean that a human embryo is identical to a fish or a bird embryo. However, as you can see in Figure 13–16, many embryos are similar in appearance, especially during the early stages of development. What do these similarities mean?

The similarities of vertebrate embryos show that similar genes are at work. The genes that control an animal's basic body plan—its head and tail, its right and left, and even the positions of its limbs—are strikingly similar. In fact, a particular group of genes, known as the Hox cluster, establishes the basic pattern of organs and structures arranged from an animal's head to its tail. The common patterns of embryonic development we see in vertebrates occur because all these animals share the same basic control mechanism.

If this principle is true, then what accounts for the differences between species? This is where evolution comes in. The common ancestors of these animals passed on a single genetic pattern of development to their descendants. Evolution, however, acted on mutations, which are changes in the genetic blueprint in an organism's DNA. Over time, these changes produced animals whose adult bodies were as different from each other as fishes and horses are. However, any mutation that produced a large disruption in the pattern of development was probably lethal and was eliminated by natural selection. In contrast, successful mutations—ones that produced favorable structural changes in the adult without breaking down the pattern—were likely retained. As a consequence, genes that control the earliest stages of development in general remain relatively unchanged. Thus the embryos of different species resemble each other. The similarities and differences in embryonic development, which reflect the ancestry of each group of animals, provide additional evidence for evolution.

*Figure 13–16 During certain embryological stages, vastly different organisms show similarities. During later stages of development, however, profound changes occur. Thus the adults bear little resemblance to one another.*




## Similarities in Body Structure

In the embryos of many animals—humans, birds, horses, and whales, for example—the clumps of cells that develop into limbs look quite similar. But as the embryos mature, the limbs grow into arms, wings, legs, and flippers that differ greatly in form and function. These different forelimbs evolved in a series

Today, a large functioning appendix is found in some animals, such as the koala, that eat primarily plant materials. So it is probable that our appendix is left over from a time during which our ancestors needed this organ to digest their food.

## Similarities in Chemical Compounds

All organisms—from bacteria to humans—share many biochemical details. All organisms use DNA and/or RNA to carry information from one generation to the next and to control growth and development. The DNA of all eukaryotic organisms always has the same basic structure and replicates in the same way. The RNAs of various species may act a little differently, but all RNAs are similar in structure from one species to the next. Remember, too, that ATP (adenosine triphosphate) is an energy carrier found in all living systems. A wide variety of complicated proteins, such as cytochrome *c*, are also shared by many organisms.

In the last 30 years, molecular biology has made it possible to make precise comparisons of the biochemical similarities between organisms. The results match the fossil record so closely that they provide more strong evidence for evolution.

## What Homologies Tell Us

Similarities in structure and biochemistry provide powerful evidence that all living things evolved from common ancestors. **The structural and biochemical similarities among living organisms are best explained by Darwin's conclusion: Living organisms evolved through gradual modification of earlier forms—descent from a common ancestor.** In a previous chapter you learned that life's chemical pathways are extremely complex. In a later chapter you will learn that tissues and organs are equally complex. If organisms had arisen independently of one another, there would be very little chance that they would have similar structures and biochemistries. The very complexity of life and its processes supports Darwin's conclusion.

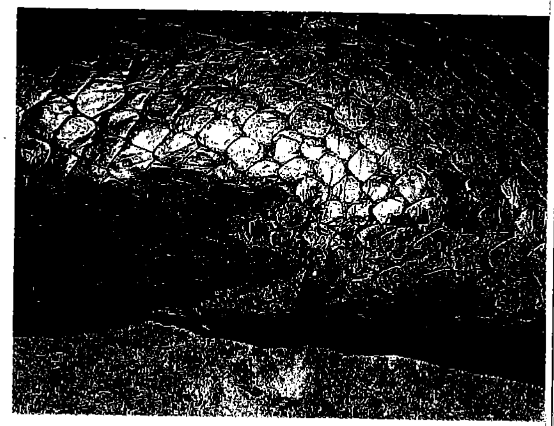


***Figure 13–19*** *If you look closely, you can see the vestigial leg bones of this python, which serve no function in locomotion—the snake can move quite well without them! Another example of a vestigial organ is the human appendix. In a koala, however, the appendix is a functioning organ that helps the animal to digest leaves.*

## 13–4 SECTION REVIEW

1. What is the best explanation for the structural and biochemical similarities that exist in living organisms?
2. What is a vestigial organ?
3. How does evidence from embryology support the concept that all animals evolved from common ancestors?
4. **Critical Thinking—Applying Concepts** How does biochemistry support the idea that all living things evolved from common ancestors?