

10.4 Evidence of Evolution

VOCABULARY

biogeography
homologous structure
analogous structure
vestigial structure

KEY CONCEPT Evidence of common ancestry among species comes from many sources.

MAIN IDEAS

- ▶ Evidence for evolution in Darwin's time came from several sources.
- ▶ Structural patterns are clues to the history of a species.

✦ Connect to Your World

Whenever you need to complete an assignment on an unfamiliar topic, you first need to gather information. The different pieces of information might come from the library, the Internet, your teachers, or maybe even your friends. Together, all these pieces help you to understand the topic. Darwin also drew information from many sources, all of which helped to strengthen his understanding of evolution.

▶ MAIN IDEA

Evidence for evolution in Darwin's time came from several sources.

Darwin found evidence from a wide range of sources to support his argument for evolution. The most important and convincing support came from fossils, geography, embryology, and anatomy.

Fossils

Even before Darwin, scholars studying fossils knew that organisms changed over time. Scientists who study fossils focus on more than just the fossil itself. They also think about its age, its location, and what the environment was like when the organism it came from was alive.

In the late 1700s, geologists wondered why certain types of fossils were found in some layers of rock and not others. Later studies suggested that the fossil organisms in the bottom, or older, layers were more primitive than those in the upper, or newer, layers. Geologists during this time were interested in fossil sequences as a record of natural events such as earthquakes that disturb rock strata, not as proof of evolution. However, these and other findings in the fossil record supported Darwin's concept of descent with modification.

Geography

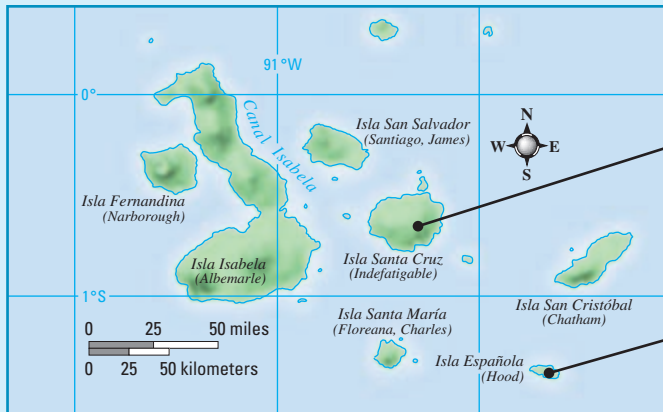
Recall that during the *Beagle* expedition Darwin saw that island plants and animals looked like, but were not identical to, species on the South American continent. He extended this observation, proposing that island species most closely resemble species on the nearest mainland. He hypothesized that at some point in the past, some individuals from the South American mainland had migrated to the islands.



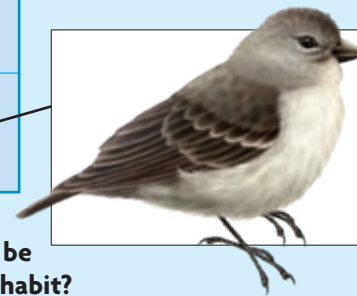
FIGURE 4.1 This trilobite, an early marine invertebrate that is now extinct, was found in this loose rock bed in Ohio. Although far from modern-day oceans, this site is actually the floor of an ancient sea.

FIGURE 4.2 Variation in Galápagos Finches

Finches on certain Galápagos Islands live in different environments and have beaks of different sizes and shapes.



Large cactus finch
Geospiza conirostris
Species in the genus *Geospiza* have thick beaks and can feed on large, hard seeds that require strength for crushing.



Small tree finch
Camarhynchus parvulus
Species in the genus *Camarhynchus* have biting strength at the tips of their beaks, which is useful for tearing vegetation.

Infer What different environmental conditions might be found on the islands that these two species of finch inhabit?

Different ecosystems on each island—with different plants, climates, and predators—had favored different traits in these migrants. Over time, these new traits became well established in the separate island populations, since the islands were too far apart for mating to occur.

One clear example of local adaptation is found in what are now known as Darwin's finches. The finches from the Galápagos Islands, shown in **FIGURE 4.2**, have distinct-looking beaks, as well as different habits, diets, and behaviors that evolved after generations of adaptation to specific island habitats. However, they all share a common ancestor from the South American mainland.

Since Darwin's time, the same pattern of evolution on islands has been studied in many living things, such as fruit flies and honeycreepers on the Hawaiian Islands. Darwin was the first scientist to establish this relationship between island and mainland species. Today this is an important principle of **biogeography**, the study of the distribution of organisms around the world.

Embryology

A study proposing a relationship between crabs, which can walk, and barnacles, which are fixed in one place as adults, fascinated Darwin. He had collected barnacles for many years and had noted that immature crabs and barnacles, called larvae, were similar. As **FIGURE 4.3** shows, barnacle and crab larvae both swim and look alike, but the adult animals look and behave very differently.

FIGURE 4.3 Although adult crabs and barnacles look and behave very differently, they can look identical as larvae. This suggested to Darwin that they share a common ancestor.



Larva

Adult crab

Adult barnacles



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PREMIUM CONTENT

Dinosaur Descendants

Like larvae, embryos of vertebrates can be hard to tell apart. For example, fish, birds, reptiles, and mammals all have gill slits as embryos. The gill slits become gills in adult fish. In mammals, the gill slits develop into structures of ears and throats. These observations formed an important part of Darwin's evidence for common descent. The similar features of embryos in very different organisms suggest evolution from a distant common ancestor.

Anatomy

Some of Darwin's best evidence came from comparing the body parts of different species. Chief among such evidence were homologous structures. **Homologous structures** (huh-MAHL-uh-guhs) are features that are similar in structure but appear in different organisms and have different functions. Their appearance across different species offers strong evidence for common descent. It would be unlikely for many species to have such similar anatomy if each species evolved independently.

The most common examples of homologous structures are the forelimbs of tetrapod vertebrates. The forelimbs of humans, bats, and moles are compared in **FIGURE 4.4**. In all of these animals, the forelimbs have several bones that are very similar to each other despite their different functions. Notice also how the same bones vary in different animals. Homologous structures are different in detail but similar in structure and relation to each other.

In using homologous structures as evidence of evolution, Darwin posed a logical question: If each of these groups descended from a different ancestor, why would they share these homologous structures? A simple answer is that they share a common ancestor.

READING TOOLBOX

VOCABULARY

A tetrapod is a four-limbed animal. *Tetra-* means "four," and *-pod* means "foot."

FIGURE 4.4 Homologous Structures

Homologous structures, though they often have differing functions, are the result of a common ancestor.



Notice that each of these homologous structures uses the same bones in relation to the others.

Apply What body part of a dolphin is homologous to the structures shown above?

The idea of common descent provides a logical explanation for how homologous structures appeared in diverse groups. Having similar structures doesn't always mean two species are closely related, however. Some structures found in different species have the same functions but did not evolve from a common ancestor.

Suppose two organisms have similar needs caused by the environment. For example, two different organisms need to be able to fly. Both can develop similar adaptations using different body parts. Think about the wings of bats and the wings of flying insects. Clearly these organisms differ in more ways than they are similar. Insects are arthropods, while bats are mammals. The wings of bats and insects are called analogous structures, as shown in **FIGURE 4.5. Analogous structures** (uh-NAL-uh-guhs) are structures that perform a similar function—in this case, flight—but are not similar in origin. Bat wings have bones. In contrast, insect wings do not have bones, only membranes. The similar function of wings in bats and flying insects evolved separately. Their ancestors faced similar environmental challenges and came upon similar solutions.

FIGURE 4.5 ANALOGOUS STRUCTURES

Analogous structures evolved separately and are not evidence of a common ancestor. A bat's wing has bones, whereas insect wings do not.



Analyze Using the terms *homologous* and *analogous*, identify which group of structures provides evidence for a common ancestor. Explain.

QUICK LAB INFERRING

Piecing Together Evidence

Evolutionary biologists and paleontologists rarely get all of the pieces of what they are studying. In this activity, you will receive pieces of “evidence” about a picture in order to make observations, inferences, and predictions about it.

PROBLEM How are inferences modified when new information is obtained?

MATERIALS

picture cut into strips

PROCEDURE

1. Using the three strips that your teacher has provided, write down all observations and inferences that you can make about this picture.
2. Make a prediction about the picture's topic, using your observations as supporting evidence for your prediction.
3. Record observations, inferences, and a prediction for each remaining strip of “evidence” that you receive from your teacher.

ANALYZE AND CONCLUDE

1. **Analyze** What inferences did you modify as you gathered more evidence from your teacher?
2. **Provide Examples** What type of evidence might paleontologists find that would allow them to see the big picture of a species' evolutionary past?



FIGURE 4.6 Vestigial structures, such as the wings of an ostrich, are organs or structures that are greatly reduced from the original ancestral form and have little or no current use.

▶ MAIN IDEA

Structural patterns are clues to the history of a species.

Some organisms have structures or organs that seem to lack any useful function, or at least are no longer used for their original purpose. For example, snakes have tiny pelvic bones and stumplike limbs, even though snakes don't walk. Underdeveloped or unused features are called vestigial structures. **Vestigial structures** (veh-STIHJ-ee-uhl) are remnants of organs or structures that had a function in an early ancestor. As vertebrates, snakes share a common ancestor with tetrapods such as lizards and dogs. The tiny pelvic bones and hind limbs in many snakes are homologous to the pelvic bones of tetrapods.

The wings of ostriches are another example of vestigial structures. Ostriches have wings that they use for balance but not to fly, as shown in **FIGURE 4.6**. Over generations, their increasingly large bodies and powerful long legs may have been enough to avoid predators. If ostriches that lived long ago could escape by running or by kicking viciously, their large wings would no longer have been useful. Thus, the genes coding for large wings were not preserved over generations.

Examples of vestigial structures are found in many organisms. In humans, the appendix is an example of a vestigial structure. The appendix is a remnant of the cecum, which makes up a large part of the large intestine in plant-eating mammals. It helps to digest the cellulose in plants. As omnivores, humans do not eat much cellulose. The human appendix does not have the ability to digest cellulose. In fact, it performs no known function at all.

Vestigial structures did not get smaller in one individual organism. It took many generations for those organs to shrink. Today, biologists consider vestigial structures among the most important examples demonstrating how evolution works.

Summarize What are vestigial structures, and how do they demonstrate common ancestry?

10.4 Formative Assessment

REVIEWING ▶ MAIN IDEAS

1. Describe the four sources of evidence for evolution upon which Darwin based his ideas on common descent.
2. Why are **vestigial structures** considered critical evidence of evolution?

CRITICAL THINKING

3. **Hypothesize** Describe how some of the Galápagos finch species, which traditionally were seed eaters, evolved over generations to prefer insects over seeds.
4. **Apply** How can a bat's wing be considered both a **homologous structure** and an **analogous structure**?



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PREMIUM CONTENT

CONNECT TO

HUMAN BIOLOGY

5. Wisdom teeth are a third set of molars that usually appear in humans between the ages of 17 and 25, and often need removing because they crowd out other teeth. Explain why wisdom teeth are vestigial structures.