
Stepping Back in Time

The Grand Canyon, shown here, is an American icon and one of the wonders of the natural world. It is also a record of the past. Look at the rock layers in the picture. If you were to walk down a trail to the bottom of the canyon, with each step-down, you would be taking a step back in time. That’s because lower layers of rock represent the more distant past. The rock layers and the fossils they contain show the prehistory of the region and its organisms over a 2-billion-year time span. Although Charles Darwin never visited the Grand Canyon, he saw rock layers and fossils in other parts of the world. They were one inspiration for his theory of evolution. Darwin’s theory rocked the scientific world. In this concept, you will read why.
What is the Theory of Evolution by Natural Selection?

Eighteenth-century Englishman Charles Darwin is one of the most famous scientists who ever lived. His place in the history of science is well deserved. Darwin’s theory of evolution by natural selection represents a giant leap in human understanding. It explains and unifies all of biology. Darwin’s theory actually contains two major ideas:

1. One idea is that evolution occurs. In other words, organisms change over time. Life on Earth has changed as descendants diverged from common ancestors in the past.
2. The other idea is that evolution occurs by natural selection. Natural selection is the process in which living things with beneficial traits produce more offspring than others do. This results in changes in the traits of living things over time.

In Darwin’s day, most people believed that all species were created at the same time and remained unchanged thereafter. They also believed that Earth was only 6,000 years old. Therefore, Darwin’s ideas revolutionized biology.

How did Darwin come up with these important ideas? It all started when he went on a voyage.

Voyage of the Beagle

In 1831, when Darwin was just 22 years old, he set sail on a scientific expedition on a ship called the *HMS Beagle*. Darwin was the naturalist on the voyage. As a naturalist, it was his job to observe and collect specimens of plants, animals, rocks, and fossils wherever the expedition went ashore. The route the ship took and the stops they made are...
shown on the map below. Darwin was fascinated by nature, so he loved his job on the *Beagle*. He spent more than three years of the five-year trip exploring nature on distant continents and islands. While he was away, a former teacher published Darwin’s accounts of his observations. By the time Darwin finally returned to England, he had become famous as a naturalist.

Figure \(\PageIndex{2}\): Voyage of the Beagle. This map shows the route of Darwin’s 5-year voyage on the HMS Beagle. Each stop along the way is labeled. Darwin and the others on board eventually circled the globe. (CC BY 3.0; Sémhur via Wikimedia.org)

### Darwin’s Observations

During the long voyage, Darwin made many observations that helped him form his theory of evolution. For example:

- He visited tropical rainforests and other new habitats where he saw many plants and animals he had never seen before, such as the giant iguana and booby bird pictured below. These observations impressed him with the great diversity of life.

- He experienced an earthquake that lifted the ocean floor 2.7 meters (9 feet) above sea level. He also found rocks containing fossil seashells in mountains high above sea level. These observations suggested that continents and oceans had changed dramatically over time and continue to change in dramatic ways.

- He visited rock ledges that had clearly once were beaches that had gradually built up over time. This suggested that slow, steady processes also change Earth’s surface.

- He dug up fossils of gigantic extinct mammals, such as the ground sloth, fossils of which are also pictured below. This was hard evidence that organisms looked very different in the past. It suggested that living things — like the Earth’s surface — change over time.

Figure \(\PageIndex{3}\): On his voyage, Darwin saw giant marine iguanas and blue-footed boobies. He also dug up the fossil skeleton of a giant ground sloth-like the one shown here. From left: Giant Marine Iguana, Blue-Footed Boobies, and Fossil Skeleton of a Giant Ground Sloth (credit: From left to right: CC BY 2.0; A. Davey via flickr.com; CC BY 2.0; Nicolas de Camaret via flickr.com; public domain; Mariana Ruiz Villarreal via Wikimedia.org)

### The Galápagos Islands

Darwin’s most important observations were made on the **Galápagos Islands** (shown on the map above of the *Beagle*)
The Galápagos Islands are a group of 16 small volcanic islands that are 966 kilometers (600 miles) off the west coast of South America. Individual Galápagos islands differ from one another in important ways. Some are rocky and dry; others have better soil and more rainfall. Darwin noticed that the plants and animals on the different islands also differed. For example, the giant tortoises on one island had saddle-shaped shells, whereas those on another island had dome-shaped shells, as you can see in the photos below. People who lived on the islands could even tell which island a tortoise came from by its shell. This started Darwin thinking about the origin of species. He wondered how each island came to have its own type of tortoise.

Other Influences on Darwin

Science, like evolution, always builds on the past. Darwin didn’t develop his theory completely on his own. He was influenced by the ideas of earlier thinkers.

Writings of Earlier Scientists

Three scientists whose writings influenced Darwin were Lamarck, Lyell, and Malthus.

1. Jean Baptiste Lamarck (1744–1829) was an important French naturalist. He was one of the first scientists to propose that species change over time. However, Lamarck was wrong about how species change. His idea of the inheritance of acquired characteristics is incorrect. Traits an organism develops during its own life cannot be passed on to offspring, as Lamarck believed.

2. Charles Lyell (1797–1875) was a well-known English geologist. Darwin took his book, Principles of Geology, with him on the Beagle. In the book, Lyell argued that gradual geological processes have slowly shaped Earth’s surface over very long periods of time. From this, Lyell inferred that Earth must be far older than most people believed.

3. Thomas Malthus (1766–1834) was an English economist. He wrote an essay titled On Population. In the essay, Malthus argued that human populations grow faster than the resources they depend on. When populations become too large, famine and disease break out. In the end, this keeps populations in check by killing off the weakest members.

Knowledge of Artificial Selection

These weren’t the only influences on Darwin. He was also aware that humans could breed plants and animals to have...
useful traits. By selecting which plants or animals were allowed to reproduce, they could change an organism’s traits over time. The pigeons in the figure below are good examples. Darwin called this type of change in organisms artificial selection. He used the word artificial to distinguish it from natural selection.

Figure \(\PageIndex{5}\): Artificial Selection in Pigeons. Pigeon hobbyists breed pigeons to have certain characteristics. Both of the pigeons in the bottom row were bred from the common rock pigeon. (CC BY-NC-SA via CK-12 foundation)

### Darwin Develops His Theory

Darwin spent many years thinking about the work of Lamarck, Lyell, and Malthus; what he had seen on his voyage; and what he knew about the artificial selection. What did all this mean? How did it all fit together? Eventually, it all came together in his theory of evolution by natural selection. It’s easy to see how these influences helped shape Darwin’s ideas, although it actually took Darwin years to formulate his theory. His reasoning went like this:

1. Like Lamarck, Darwin assumed that species can change over time. The fossils he found helped convince him of that.
2. From Lyell, Darwin saw that Earth and its life were very old. Thus, there had been enough time for evolution to produce the great diversity of life that Darwin had observed.
3. From Malthus, Darwin knew that populations could grow faster than their resources. This “overproduction of offspring” led to a “struggle for existence,” in Darwin’s words.
4. From artificial selection, Darwin knew that some offspring have chance variations that can be inherited. In nature, offspring with certain variations might be more likely to survive the “struggle for existence” and reproduce. If so, they would pass their favorable variations to their offspring.
5. Darwin coined the term fitness to refer to an organism’s relative ability to survive and produce fertile offspring. Nature selects the variations that are most useful. Therefore, he called this type of selection natural selection.
6. Darwin knew artificial selection could change domestic species over time. He inferred that natural selection could also change wild species over time. In fact, he thought that if a species changed enough, it might evolve into a new species.

### It's Wallace’s Theory Too

Did you ever hear the saying that “great minds think alike?” It certainly applies to Charles Darwin and another English naturalist named Alfred Russel Wallace. Wallace lived at about the same time as Darwin and also traveled to distant places to study nature. Wallace wasn’t as famous as Darwin, but he developed basically the same theory of evolution. While working in what is now Malaysia, Wallace sent Darwin a paper he had written explaining his evolutionary theory. Wallace’s ideas served to confirm what Darwin already thought. It also pushed Darwin to finish and publish his book, On the Origin of Species. Published in 1859, the book changed science forever. It clearly spelled out Darwin’s theory of
evolution by natural selection and provided convincing arguments and evidence to support it.

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**Applying Darwin's and Wallace’s Theory**

The following example applies Darwin’s and Wallace’s theory of evolution by natural selection. It explains how giraffes came to have such long necks, like those shown in the photo below.

- In the past, giraffes had short necks. But there was chance variation in neck length. Some giraffes had necks a little longer than the average.
- Then, as now, giraffes fed on tree leaves. Perhaps the climate became drier, and leaves became scarcer. There would be more giraffes than the trees could support. Thus, there would be a “struggle for existence.”
- Giraffes with longer necks had an advantage. They could reach leaves other giraffes could not. Therefore, long-necked giraffes were more likely to survive and reproduce. In other words, they had greater fitness.
- These giraffes passed the long-neck trait to their offspring. With each successive generation, the population contained giraffes with longer necks. Eventually, all the giraffes had very long necks.

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**Figure \(\PageIndex{6}\). African Giraffes.** Giraffes feed on leaves high in trees. Their long necks allow them to reach leaves that other ground animals cannot. As this example shows, chance variations may help a species survive if the environment changes. Variation among species helps ensure that at least one species will be able to survive environmental change. (CC BY-SA 2.0; Dan Lundberg via [Wikimedia.org](https://creativecommons.org/licenses/by-sa/2.0))

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**Feature: Reliable Sources**

In the first chapter of his book *On the Origin of Species*, Charles Darwin discussed how artificial selection, also called...
selective breeding, had been successful in changing the traits of animals, including pigeons, cats, cattle, and dogs. He used this discussion as a springboard to introduce his idea of natural selection as well as to provide support for it.

The use of selective breeding to change the traits of other species has a very long history. In fact, archaeological evidence indicates that selective breeding of both plants and animals began as early as 10,000 years ago in the Middle East when previous hunter-gatherers began to domesticate animals and cultivate cereal plants. Around this time, changes in climate led to increasing drought, which forced people to concentrate around permanent water sources. These population concentrations could not be supported by wild animals and plants in the vicinity, providing a stimulus for the invention of agriculture and the use of selective breeding to increase the amount of available food. For thousands of years, species of plants such as wheat and rice and of animals such as goats and sheep were selectively bred and changed from their wild ancestors.

In the New World, the wild grain called teosinte, pictured on the left below, was selectively bred by Native Americans to produce larger and more numerous edible kernels. The result was modern maize (commonly called corn), shown on the right in the same picture. After maize was created, it spread across the Americas and was introduced to Europe by European explorers and traders. Today, maize is still a dietary staple and the most widely grown grain crop in the Americas.

Figure \(\PageIndex{7}\): Selective breeding changed teosinte (left) to modern maize (right). The middle ear is a hybrid produced by breeding teosinte with maize. (CC BY 2.5; John Doebley via Wikimedia Commons)

The wild ancestors of domesticated wheat and rice were easy to identify because the modern species resemble their wild counterparts. However, that wasn't the case with maize, which looks very different from teosinte. Maize also appeared quite suddenly in the archaeological record, so its origin has been of special interest.

Go online to learn more about the selective breeding of teosinte to maize. Use only reliable sources such as university
websites to find answers to the following questions:

1. Where and when was teosinte selectively bred to produce maize?
2. How did the change from wild teosinte to modern maize occur so rapidly?
3. What is the genetic basis of this change?

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**Summary**

- Darwin’s theory of evolution by natural selection states that living things with beneficial traits produce more offspring than others do. This leads to changes in the traits of living things over time.
- During his voyage on the *Beagle*, Darwin made many observations that helped him develop his theory of evolution. His most important observations were made on the Galápagos Islands.
- Darwin was influenced by other early thinkers, including Lamarck, Lyell, and Malthus. He was also influenced by his knowledge of artificial selection.
- Wallace’s paper on evolution confirmed Darwin’s ideas. It also pushed him to publish his book, *On the Origin of Species*. The book clearly spells out his theory and provides extensive evidence and well-reasoned arguments to support it.

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**Review**

2. Describe two observations Darwin made on his voyage on the *Beagle* that helped him develop his theory of evolution.
3. What is the inheritance of acquired characteristics? Which scientist developed this mistaken idea?
4. What is artificial selection? How does it work?
5. How did Alfred Russel Wallace contribute to the theory of evolution by natural selection?
6. Apply Darwin’s theory of evolution by natural selection to a specific case. For example, explain how Galápagos tortoises could have evolved saddle-shaped shells.
7. Why did Darwin’s observations of Galápagos tortoises cause him to wonder how species originate?
8. Explain how the writings of Charles Lyell and Thomas Malthus helped Darwin develop his theory of evolution by natural selection.
9. If a person builds big muscles due to a special diet and a lot of weightlifting, are big muscles a trait that will be automatically passed down to their children? Why or why not?
10. If a hypothetical ecosystem had unlimited resources available for all the organisms living in it, how do you think this would affect evolution?
11. What is the best definition of “fitness” in terms of evolution?
   A. The amount of lean muscle mass in an organism
   B. The ability of an organism to exercise for a long period of time
   C. An organism’s ability to survive to an old age
D. An organism’s ability to survive and produce fertile offspring

12. In natural selection, organisms are selected by __________ ; in artificial selection, organisms are selected by __________.

13. Explain why naturally occurring variations between individuals are important for evolution.


15. True or False. The theory of evolution states that living organisms on earth all evolved at once and then stopped changing.

16. True or False. Fossils of extinct animals are one type of evidence that supports Darwin’s theory of evolution.

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https://bio.libretexts.org/link?16768#Explore_More

Darwin’s ideas revolutionized biology as we know it, check out some facts in this video:

Check out this trailer of Darwin’s voyage that "shook the world."