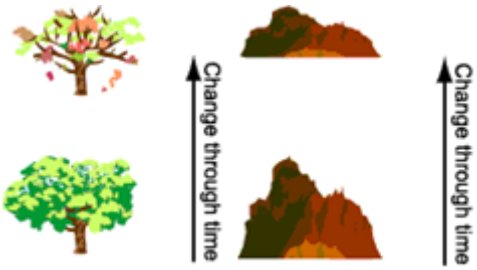
Biology Unit 7 Intro to Evolution

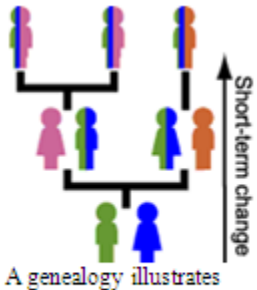
An Introduction to Evolution

**The Definition:**
Biological evolution, simply put, is descent with modification. This definition encompasses small-scale evolution (changes in gene frequency in a population from one generation to the next) and large-scale evolution (the descent of different species from a common ancestor over many generations). Evolution helps us to understand the history of life.

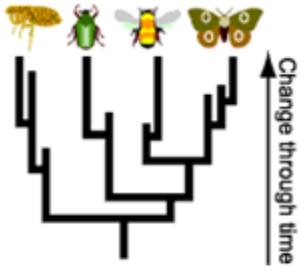
**The Explanation:**
Biological evolution is not simply a matter of change over time. Lots of things change over time: trees lose their leaves, mountain ranges rise and erode, but they aren't examples of biological evolution because they don't involve descent through genetic inheritance.




The central idea of biological evolution is that all life on Earth shares a common ancestor, just as you and your cousins share a common grandmother.



A genealogy illustrates change with inheritance over a small number of years.

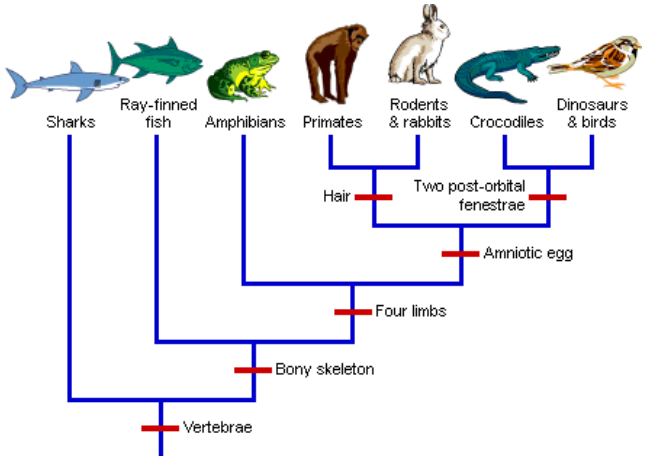


Over a number of years, evolution produces tremendous diversity in forms of life.

Through the process of descent with modification, the common ancestor of life on Earth gave rise to the fantastic diversity that we see documented in the fossil record and around us today. Evolution means that we're all distant cousins: humans and oak trees, hummingbirds and whales.

The History of Life: Looking at the Patterns

The central ideas of evolution are that life has a history—it has changed over time—and that different species share common ancestors.




Here, you can explore how evolutionary change and evolutionary relationships are represented in “family trees,” how these trees are constructed, and how this knowledge affects biological classification. You will also find a timeline of evolutionary history and information on some specific events in the history of life: human evolution and the origin of life.

From www.evolution.berkelev.edu

RISD Curriculum & Instruction

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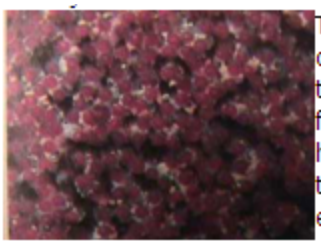
**ev•o•lu•tion** n. 1. A gradual process in which something changes into a different and usually more complex or better form. 2.a. The process of developing. b. Gradual development. 3. Biology a. The theory that groups of organisms change with passage of time, mainly as a result of natural selection, so that descendants differ morphologically and physiologically from their ancestors. b. The historical development of a related group of organisms; phylogeny. . .

Biological evolution is a powerful and important process. It is a process which, over billions of years, gradually selects the organisms that are better adapted to their environments, and in this way takes advantage of random mutations to continuously change life and make all living organisms in existence be the way they are.

Evolution is not a finished event, of which we, humans, are the final product. Rather, it is a continuing process which has been changing and forming life on earth for billions of years and continues to do so for as long as organisms are being born, dying, and competing for what they need to survive and reproduce.

**How Does Evolution Occur?**

Darwin's Theory of Natural Selection has been divided into five parts to explain clearly how evolution happens in nature.


The fish eggs at left are only a small fraction of those laid by a single fish. If all of the fish hatched, there would be too many fish for the environment to support.

1. *Organisms produce more offspring than actually survive.*
Organisms can die from many causes: disease, starvation, and being eaten, among other things. The environment can't support every organism that is born. Many die before they are able to reproduce. One hundred (100) beetles can produce $6.1 \times 10^{28}$ (61 with 27 zeros after it) offspring in less than two years. Each beetle weighs 10 mg, and if they all survive, their total weight would be equal to the weight of the entire earth. Obviously, their environment can't support all of these beetles, and many of them die.


Bear and fish both struggle to survive. This bear, by catching the fish, is succeeding in the struggle and surviving. The fish did not survive, however, but left more fit fish behind.

2. *Every organism must struggle to survive.*
One reason that not all organisms survive is that there are not enough resources to go around. Organisms must struggle to get what they need to survive, competing against other organisms that want the same things they do. They also have to struggle to get away from predators and to overcome disease.

3. *There is variation within a species.*

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Not all of the individuals in a species are exactly the same. There are variations, differences, among members of a species. If you look at the spots on several different ladybugs, or the stripes on zebras, you will notice that they don't all have the same number or arrangement of spots or of stripes. In addition to these easily visible variations, there are differences in skill and behavior, such as differences in how fast the zebras can run. If organisms were all the same, none would be better suited than any other, and selection could not occur.

4. *Some variations allow members of a species to survive and reproduce better than others.*
If an organism has a trait that helps it survive or reproduce, it is more likely to survive and be able to reproduce. A faster cheetah is more likely to catch a gazelle and survive, and a faster gazelle is more likely to escape the cheetah and survive.

5. Organisms that survive and reproduce pass their traits to their offspring, and the helpful traits gradually appear in more and more of the population.
Most of an organism's traits are passed on to its offspring. If more of the organisms with the helpful trait survive, then in the following generations, more and more of the population have that trait. If there are faster cheetahs and slower cheetahs, the faster cheetahs will be better able to catch food and survive. With more of the slower ones dying before they can reproduce, and more of the faster ones surviving and reproducing, over generations the population on the whole will gradually become made up of faster cheetahs.

**Change and Isolation**

Environmental change and isolation of groups of organisms play an important role in evolution.

Environmental change is any change in an environment to which an organism must adapt. Change can be gradual, such as when mountains or deserts form, other species die out, or new species evolve. These things can take millions of years. Change to an environment can also be quick, such as floods, volcanoes, or earthquakes. It can also be caused not by change to the environment itself, but by the organism's movement to a different environment.

Change in an organism's environment forces the organism to adapt to fit the new environment, eventually causing it to evolve into a new species. For example, if a species of animal is mostly limited to eating one kind of leaf and a change occurs: a fungus attacks and kills most of that kind of plant, the animal has to evolve either to fight the fungus or to eat something else.

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The common giraffe (left) and the reticulated giraffe (right) used to be from the same population. Over generations of isolation, separated by the Tana River in Kenya, the two groups have become distinct.

Isolation means that organisms of the same species are separated, and happens when there is something between the organisms that they can't cross. Organisms become isolated as a result of environmental change. The cause of isolation can be gradual, like when mountains or deserts form, or continents split apart. It can also be quick, such as organisms being blown to different places by a storm or tsunami (tidal waves).

When organisms become isolated the two groups are also not able to reproduce together, so variations and mutations that occur in one group are not necessarily found in the other group. The longer the groups are isolated, the more different they are. They eventually become different species. Moreover, if there is a change in the environment of one group it does not necessarily occur in the environment of the other. So they will evolve and adapt differently.

**Sexual Selection**

Up until now, we have discussed reproduction of an organism as resulting from traits that enable it to survive. For example, in a cold climate, lots of fur enables survival, which enables reproduction (which leads to these traits being passed on and becoming more common). This can be called "reproduction through survival." The ability to reproduce, however, also results from traits that are directly related to the ability to reproduce, but play no role in the survival of the individual organism. This is "reproduction through reproduction."

In evolution, having traits that help one survive is very important, but it is only important so that one can reproduce and pass those traits to the next generation. The ones that reproduce pass the traits that helped them to reproduce on to their offspring and the ones that don't reproduce don't have offspring, so their traits disappear from the population. Darwin called this idea "sexual selection".

Many plants have flowers that are pretty and brightly colored. This is because the brightest colors attract bees, butterflies, and other pollinators, which enable the plant to reproduce. If a flower is dully colored, it does not reproduce, and the dull color genes disappear from the population.

**Gradualism and Punctuated Equilibrium**

Gradualism and punctuated equilibrium are two ways in which the evolution of a species can occur. A species can evolve by only one of these, or by both. Scientists

think that species with a shorter evolution evolved mostly by punctuated equilibrium, and those with a longer evolution evolved mostly by gradualism.

Gradualism is selection and variation that happens more gradually. Over a short period of time it is hard to notice. Small variations that fit an organism slightly better to its environment are selected for: a few more individuals with more of the helpful trait survive, and a few more with less of the helpful trait die. Very gradually, the population changes. Change is slow, constant, and consistent.

In punctuated equilibrium, change comes in spurts. There is a period of very little change, and then one or a few huge changes occur, often through mutations in the genes of a few individuals. Mutations are random changes in the DNA that are not inherited from the previous generation, but are passed on to generations that follow. Though mutations are often harmful, the mutations that result in punctuated equilibrium are very helpful to the individuals in their environments. Because these mutations are so different and so helpful to the survival of those that have them, the proportion of individuals in the population who have the mutation/trait and those who don't changes a lot over a very short period of time.

This explanation talks about punctuated equilibrium as the result of one or a few mutations that cause large change. However, punctuated equilibrium is any sudden, rapid change in a species and can also be the result of other causes, such as huge and sudden changes in the environment that result in more rapid changes in the organisms through harsher selection.

The idea of punctuated equilibrium originated long after the idea of gradualism. Darwin saw evolution as being "steady, slow, and continuous". Later, scientists were studying fossils and they found that some species have their evolution almost "mapped out" in fossils. For others they found a few, very different species along the evolutionary course, but very few or no fossils of "in between" organisms. Also, when dating the fossils, scientists saw that in some species change was very slow, but in others, it must have occurred rapidly to be able to produce such change over such a short amount of time. The scientists reasoned that there had to be another way that evolution could have happened that was quicker and had fewer intermediate species, so the idea of punctuated equilibrium was formed.

Adapted from a web site by Shlomiya Bar-Yam;  http://necsi.edu

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Charles Darwin's life represented the essence of science. He was naturally curious and reflective and a keen observer who was always gathering evidence to explain the world around him. Even before Darwin stepped onto the *Beagle,* he was an experienced naturalist. He spent much of his early life outdoors observing nature and during college had many scientists as mentors who engaged in long conversations with him about science. But the voyage of the *Beagle* was the turning point in Charles Darwin's life. It gave a breadth and depth to his experience that was invaluable to his later thinking. During the five-year journey of the *Beagle* (1831–1836), Darwin spent only 18 months at sea. His curiosity, coupled with his frequent bouts of seasickness, inspired him to take long expeditions exploring the natural history and geology of South America, the Galapagos Islands, Tahiti, and Australia. Darwin made careful observations and looked for patterns wherever he went. His key observations about the diversity and distribution of **species** spurred his thinking for *On the Origin* of Species by Means of Natural Selection. Darwin wrote letters to his mentors and sent his collections home throughout his journey. By the time Darwin stepped off the *Beagle,* he was already recognized by the scientific community for his expertise. Upon Darwin's return, he spent eight years studying barnacles and believed that his in-depth knowledge in this one area sparked his thinking in others. In the years following his *Beagle* voyage, Darwin began to develop his revolutionary theory of **natural selection** that explained a mechanism for **evolution.** He carefully explored different lines of evidence, experimenting and gathering information to support his case for evolution. One of Darwin's interests, pigeon breeding, played a significant role in the development of his theory of natural selection and in the way he presented his argument in *On the Origin of Species.* Darwin wanted to understand how new species could be created from a common ancestor by the accumulation of small changes over generations and believed that studying breeding by **artificial selection** of animals like pigeons would offer clues. Darwin spent 20 years gathering evidence and writing about his theory before he published it. He anguished over the controversy it would create in Victorian England. And, if the naturalist Alfred Wallace hadn't come to similar conclusions and written to Darwin for help in presenting them, it might have been even longer before the world heard about *On the Origin of Species*.

"Even without evolution, Darwin would have been one of the great nineteenth-century biologists; even without biology, he would have gone down in history as a great geologist. It is a measure of the importance of the theory of evolution that those other achievements seem modest in comparison to it."

(From Michael White and John Gribbin, *Darwin: A Life in Science,* p. 173.)