Reflect

A 2011 study estimated that approximately 8.7 million species of eukaryotes and about 10,000 species of prokaryotes live on Earth today. This report also suggests that 86% of all species on Earth and 91% of all species in the ocean have not been classified yet. What led to this incredible diversity of species on Earth?

Mechanisms of Biological Evolution

The process of *evolution*, or genetic change over time, has resulted in the wide variety of living things that make their home on this planet. There are five mechanisms that drive evolution. These mechanisms are essentially how evolution "works":

- natural selection
- mutation
- competition
- adaptation
- recombination

The first scientist to suggest the concept of evolution was fascinated by the similarities and differences in organisms. The naturalist Charles Darwin was an explorer who spent five years aboard a ship, HMS Beagle, traveling across the world from his native Britain. During his voyage, Darwin described every species he came across, ultimately cataloging them in his book, *The Zoology of the Voyage of HMS Beagle*.

Natural Selection and Mutations

Darwin introduced the theory of evolution by natural selection in 1859. He suggested that all species descended from one common ancestor and claimed that organisms diversified, or evolved, through a process called **natural selection**.

In natural selection, organisms with characteristics that are well suited for their environment tend to survive and reproduce. When they reproduce, they pass their characteristics on to their offspring through genes. Organisms with characteristics not well suited for their environment are not as likely to survive to reproduce and pass on their characteristics.

The "selection" in natural selection refers to the selective pressure the environment places on populations of organisms. The environment cannot support all of the individuals in a population. There may not be enough food, space, or water for everyone, and predators kill members of the population.

Reflect

These factors place pressure on the population. The organisms that are well adapted to the environment are, in a way, “selected” by the environment to survive.

Scientists have been able to observe natural selection in action in the Galapagos Islands. When a drought occurred, researchers noticed that the characteristics of the local finch population changed. The drought caused the finches’ food source (seeds) to become dry and tough. The researchers observed that finches with large, strong beaks were better able to crack open the seeds than finches with small, weak beaks. The finches with large, strong beaks survived to reproduce and passed on genes for large, strong beaks to their offspring. Fewer finches with small, weak beaks survived. Over time, the population changed to include more finches with large, strong beaks than finches with small, weak beaks.

Mutations generate the raw material for natural selection. A **mutation** is any change in the sequence of DNA in a cell. Mutations can be harmful, beneficial, or neutral, meaning they have no effect on the organism in which the mutation occurs. Mutations occur at random. According to Darwin, when an individual is born with a beneficial mutation, that individual will be more likely to survive than others without the mutation, a principle called “survival of the fittest.” The beneficial mutation will likely be passed on to the next generation.

Look Out!

Natural selection does not result in the “best” organisms. Organisms only need to be “good enough” to survive and pass on their genes. For example, consider the finches described above. A finch’s beak only had to be large and strong enough to open the dry, tough seeds. It didn’t matter if it had the largest and strongest beak of all finches, as long as it could still get food, the bird could survive.

Mutations are random. They do not occur as a result of a “need.” For example, if an organism’s environment suddenly becomes much colder, its DNA will not simply generate a mutation that results in thicker fur. A mutation may naturally arise that results in thicker fur, but an organism cannot generate a mutation for a specific purpose.

Look Out!

Competition

Organisms constantly interact with other organisms. Intraspecific interactions occur between both individuals of the same species and individuals of different species. Some interactions benefit both individuals involved, whereas others benefit one individual to the detriment of the other. The interactions among organisms largely define the properties of populations, communities, and ecosystems.

Competition is an interaction between organisms that are attempting to obtain the same resource. Organisms compete for everything, including space, food, water, mates, and anything else that increases their chances for survival and reproductive success.

competition: interaction between organisms that are attempting to obtain the same resource

The level of competition is directly related to the scarcity of the resource. When resources are abundant, organisms can obtain them without competing for them. When resources are scarce, however, organisms must compete with other organisms to obtain them.

Interspecies Interaction (between different species)

Intraspecies Interaction (between same species)

What Do You Think?

Suppose a species of lizard lives on the coast of a tropical island. This population of lizards has the following skin colors: blue, green, red, yellow, and black. During a storm, a small group of lizards is transported to a neighboring island on a raft of debris. This small group includes blue and red lizards. How do you think will the lizards on the neighboring island differ from those on the home island? Which mechanism of evolution is this an example of?

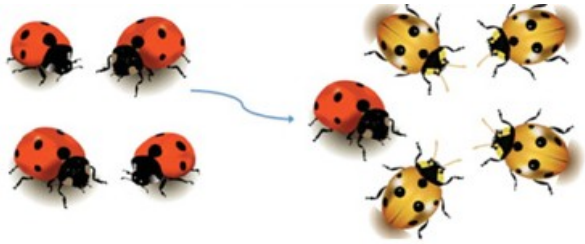
Discover Science: Cuckoo Bees and Genetic Drift in Action

Evolution and the mechanisms that drive it can be difficult for scientists to observe because they typically occur over long periods of time. The small, isolated populations found on island ecosystems provide an opportunity to see these mechanisms in action. For example, five new species of cuckoo bees were recently discovered in Cape Verde, an island nation off the coast of West Africa. Cuckoo bees, much like cuckoo birds, lay their eggs in the nests of other bee species. When the cuckoo bee larva hatches, it eliminates the host's eggs and consumes the food resources in the nest. One of the recently discovered species, *Chiasmognathus batelkai*, is a giant in comparison to the other species in its genus (though it is still quite a small insect). Scientists theorize that its relatively massive size is a result of genetic drift.

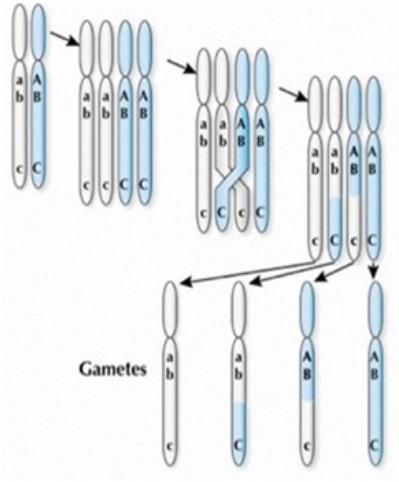
What Do You Think?

Adaptation

Adaptation is changes in allele frequencies via natural selection that increase the average fitness of the population. For example, if having a red allele results in being eaten by a predator and having a black allele does not, a population with many red alleles in its gene pool will adapt to the predator by increasing the frequency of black alleles in its gene pool. The frequency of any allele that increases the reproductive success of individuals carrying the black allele (e.g., an allele that makes individuals with the black allele smell better to mates) may increase via positive selection. Adaptation occurs in response to specific selective pressures. If the selective pressures change, then the benefits of specific adaptations may change as well.

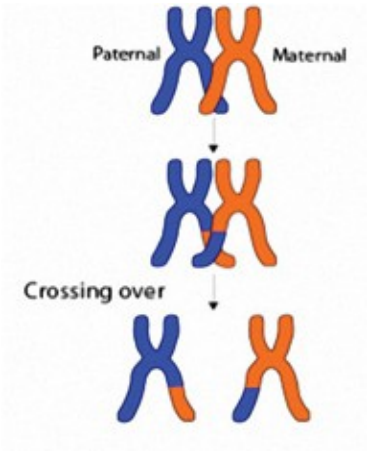


Recombination



Recombination is the process by which genetic material from different individuals combines during sexual reproduction (and some forms of asexual reproduction). Recombination can result in enormous diversity in species. Through sexual recombination, alleles are shuffled and produce multitudes of new combinations within every generation, and organisms are able to generate millions of new allele combinations in their gametes (sex cells).

During prophase 1 of meiosis, sections from one arm of a homologous chromosome break off and cross over to the matching section on the corresponding homologous chromosome. This act of crossing over dramatically widens possibilities for new gene combinations when egg and sperm come together to form a zygote.



This diagram shows crossing over between homologous chromosomes.

Try Now

What Do you Know?

Read the descriptions of concepts from this lesson in the left column below. Match each description with the correct term in the right column. Write the letter of the matching term next to the description.

Concepts	Terms
Genetic material breaks and trades places with other genetic material.	A. Competition
White fur benefiting a rabbit who is now more camouflaged in the snow.	B. Natural Selection
Two different species fighting for the same resource.	C. Crossing over
Produces the raw material for natural selection.	D. Adaptation
An organism survives and reproduces because of inherited characteristics that make it well suited for its environment.	E. Mutation

Connecting With Your Child

Illustrating Evolutionary Mechanisms

To help your child learn more about evolutionary mechanisms, have him or her create a digital slide show presentation that includes illustrations of the five mechanisms of biological evolution: natural selection, competition, adaptations, mutation, and recombination.

The illustrations of the mechanisms of biological evolution should each include a description, an illustration or diagram, and a specific example. If you do not have access to digital resources to create the slide show presentation, your child can use cardstock paper and colored pencils to create a “mock” slide show. The end of the presentation should include five quiz questions on the material covered in the presentation. Have your child present the slide show. At the end of the presentation, try to answer the quiz questions.

Here are some questions to discuss with your child:

- How are mutations and natural selection related?
- How does competition influence species survival?
- How does an adaptation help a population evolve?
- Why is it difficult for scientists to study the mechanisms of evolution?