Environmental Influences on Adaptation

Reflect

Have you ever noticed how the way you feel sometimes mirrors the emotions of the people with whom you spend a lot of time? For example, when you're around happy people, do you tend to become happy? Since the beginning of time, humans have been sensitive to their surroundings and have made changes in response to these altering environments. Whether physically, emotionally, or mentally, humans are able to adjust to the moment. Actually, all organisms are influenced by their environments. We know that some ecosystems favor certain traits, but what happens when a change in the environment occurs? Are these traits modified? How do organisms respond for survival?

Environmental Influences on Adaptation

Environment Change: Adaptation or Extinction

When an environment changes, subsequent shifts occur in its supply of resources or in the physical and biological challenges it imposes. Some individuals in a population may have morphological, physiological, or behavioral traits that provide a reproductive advantage in the face of the shifts in the environment. Natural selection provides a mechanism for species to adapt to changes in their environment. The resulting selective pressures influence the survival and reproduction of organisms over many generations and can change the distribution of traits in the population. This process is called adaptation.

Adaptation leads to organisms that are better suited for the environment. Organisms with traits adaptive to the environmental change pass those traits on to their offspring, those with traits that are less adaptive produce fewer or no offspring. Changes in the physical environment, whether naturally occurring or humanly induced, have thus contributed to the:

- Expansion of some species
- Emergence of new distinct species as populations diverge under different conditions
- Decline or extinction of some species

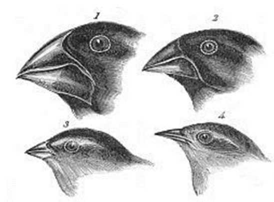
adaptation: trait that allows an organism to better fit in its environment

Reflect

Environment Changes Can Trigger Divergent Evolution

Divergent evolution is the development of new species through accumulation of many small "changes" that originated as a result of natural selective pressures. Essentially, the two new species created will diverge from each other as they further evolve. Darwin's finches on the Galapagos Islands are a clear and famous example of divergent evolution, in which an ancestral species radiates into a number of descendant species with both similar and different traits. Three main triggers of divergent evolution have been identified. They are:

Environmental Change Leads to Divergent Evolution



The beak of each Galapagos finch is suited to its preferred food, suggesting that beak shapes evolved by natural selection in different environments

Overcoming Competition: Two individuals belonging to the same species pose greater competition for each other than two individuals belonging to different species; individuals of the same species would all have the same requirements of food, resources, and mates, etc. If the competition gets too tough, divergence is the result.

Adapting to Micro-Niches: Not all monkeys in the United States live together in one single territory. They are scattered all over. So those in Florida may adapt to a tropical climate while those in South Dakota would adapt to a continental type of climate. This could create two different monkey species.

Neutral Evolution: Sometimes the changes that occur at the genetic level cannot be attributed to a specific trigger. These changes are called neutral mutations. Evolution also takes place in this way. If the accumulative neutral mutations are significant enough to affect the species within their environment, they may give rise to a new species.

Convergent Evolution- Similar Traits in Similar Environments

Spiny protection evolved in echidna, tenrec, and the hedgehog

Convergent Evolution

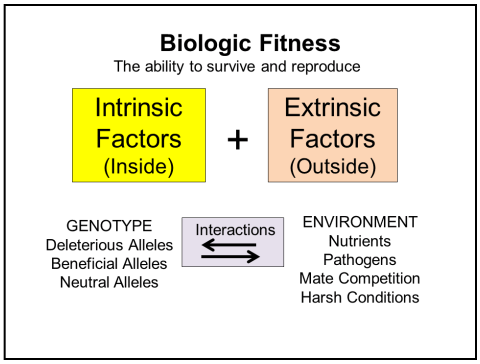
Convergent evolution is the process whereby organisms not closely related independently evolve similar traits as a result of having to adapt to similar environments or ecological niches. The hooves of horses and cows; the long, sticky tongues of the anteater and aardvark; the desert adaptations of the North American kangaroo rat and the Australian mouse; and the spiny fur of the echidna, tenrec, and hedgehog are all examples of convergent evolution. All evolved as similar traits in similar environments.

Reflect

Biological Fitness Affected by Genetic and Environmental Factors

Biological fitness, usually referred to simply as fitness, is the ability of an organism to survive and reproduce. An organism’s overall fitness is determined by many different intrinsic and extrinsic factors.

Intrinsic Factors: Intrinsic factors that affect fitness are usually related to the organism’s genotype. Every organism carries a specific set of alleles, and some of the alleles affect fitness either positively or negatively. An allele that lowers an organism’s fitness is called a deleterious allele; an allele that increases an organism’s fitness is called a beneficial allele. Most alleles are neutral and do not directly increase or decrease the fitness of the organism most of the time.



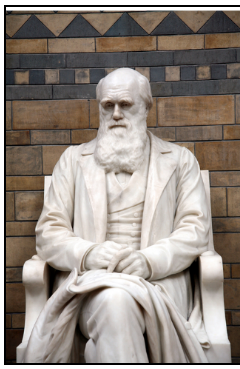
Extrinsic Factors: Extrinsic factors that affect fitness are usually related to the physical and ecological environment in which the organism lives. These include nutrient availability; the presence of pathogens and predators; competition for mates; harsh conditions, such as high temperature or lack of water; and toxins. The overall fitness of an organism can be broken down into components. Separate effects of all of the intrinsic and extrinsic factors, as well as the interactions among different factors, are components of overall fitness.

Most fitness effects are determined by the interaction of multiple factors. For example, consider an allele that provides defense against a pathogen. If the pathogen is not present, the allele will not provide any benefit, but if the pathogen is present, the allele would provide a huge benefit.

Look Out!

Who Was Charles Darwin?

Charles Darwin was a biologist who studied biodiversity and proposed the theory of natural selection to explain the existence of many different species on Earth. Darwin suggested that just as livestock breeders could enhance or increase certain traits in their animals by allowing only animals that possess the desired traits to produce offspring, nature could select which individuals produce the most offspring in any given environment.



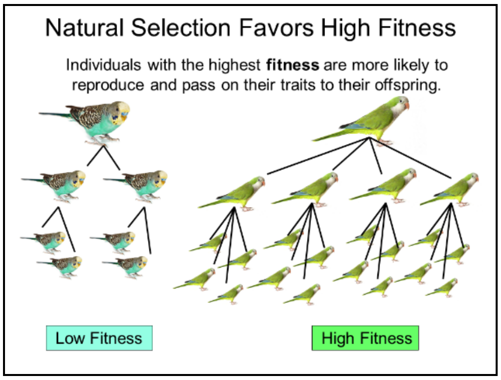
Charles Darwin and Natural Selection

“It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.”

If nature selects different trait values for high reproductive success in different, isolated environments, then individuals in the different environments will begin to diverge from each other, eventually becoming different species.

Reflect

Natural Selection and Reproductive Success

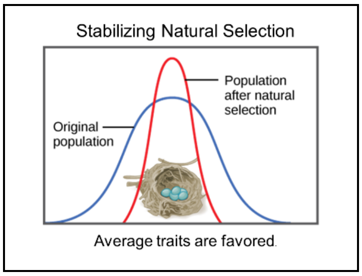


Natural selection occurs when certain alleles (or trait values) affect the reproductive success of the individuals carrying them. Reproductive success is the ability of an organism to pass its genes on to the next generation by producing offspring. An individual has high reproductive success if it successfully procures desirable mates and produces high-fitness offspring. Organisms may have low reproductive success if they have trouble accessing desirable mates or if they produce few offspring with high fitness.

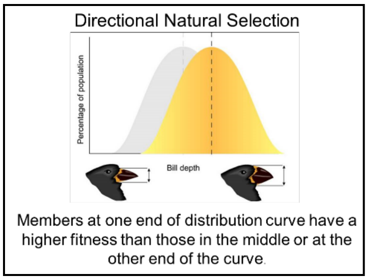
If a certain allele in the gene pool increases the fitness and therefore the reproductive success of the individuals carrying it, then its frequency in the gene pool increases via natural selection. The combination of factors affecting fitness "select" individuals carrying the allele for reproductive success. Allele frequencies can also decline via natural selection. Selection that increases the frequency of an allele is called "positive selection;" selection that decreases the frequency of an allele is called "negative selection."

Types of Natural Selection

Three major types of natural selection produce adaptations due to environmental changes.



Stabilizing favors the average individuals in a population. This process selects against the extreme phenotypes and instead favors the majority of the population that is well adapted to the environment. An example is bird eggs. The number of bird eggs laid in a clutch favors an average number, since too few would result in no viable offspring and too many would use up limited resources. Robins have stabilized the number of eggs to four in a nest.



Directional natural selection favors one extreme phenotype over the mean or other extreme. This type of population would be found in environments that have changed over time. Changes in weather, climate, or food availability lead to directional selection. The population bell curve shifts either farther left or farther right due to directional selection. However, unlike stabilizing selection, the height of the bell curve does not change. One example of directional selection is the beak length of Galapagos finches changing over time due to available food sources. When there was a lack of insects to eat, finches with larger and deeper beaks survived because they could crack seeds. Over time, as insects became more plentiful, directional selection favored finches with smaller and longer beaks.

Look Out!

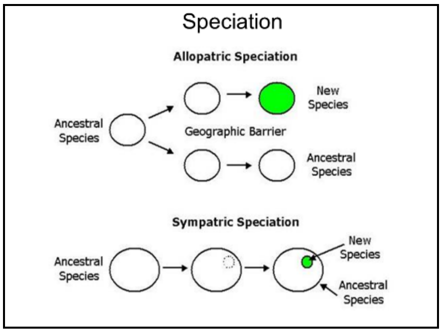
How Bizarre!

When you think of a deer, do you think of a gentle, plant-eating animal? Well, the tufted deer from China has adapted a few bizarre traits! These deer have fangs that protrude out of their mouths up to one and half inches. They are used like horns for mating fights between males. They have even been seen eating carcass meat. How bizarre!

Speciation
New species evolve when populations become isolated and develop two (or more) separate gene pools in which different selection and mutations (DNA alterations) make them very different over time—so different that they can no longer interbreed. There are two main causes of speciation:

Geographic Isolation: Allopatric speciation (also known as geographic speciation) occurs when populations are physically isolated. Extrinsic barriers cause intrinsic (genetic) reproductive isolation such that if the barrier between the populations breaks down, individuals of the two populations can no longer interbreed. Examples are the Galapagos finches and the Grand Canyon squirrels.

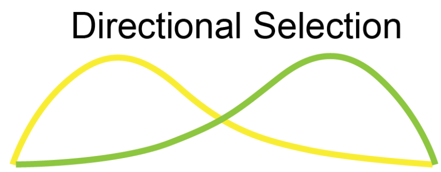
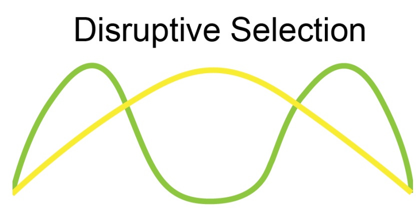
Reproductive Isolation: Parapatric (or sympatric) speciation (also known as side-by-side speciation) occurs with no specific extrinsic barrier to gene flow. The population is continuous but does not mate randomly. This can be due to sexual selection. Two (or more) separate gene pools form and eventually diverge into different species, which are maintained through reproductive isolation.

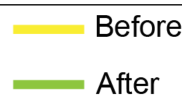


Environmental Influences on Adaptation

Try Now

Match one scenario with one type of selection and graph:

Scenario	Type of Selection	Graph
Human birth weights that are too high or too low both have an increased health risk	Directional Selection	
Gray-haired rabbits do not blend into their surroundings as well as their black- or white-haired siblings.	Stabilizing Selection	
Over time, larger salmon sizes have decreased due to over fishing.	Disruptive Selection	



Draw a line from each statement to indicate if the statement is true or false:

True!

The development of a new species through many small changes over time is known as divergent evolution.
Speciation is the ability of an organism to survive.
Intrinsic factors that impact the fitness of an organism include the environment, shelter, and nutrients.
Barriers may separate a species, and over time, this species may become two distinct species.

False!

Accelerate Learning™

Connecting With Your Child

Create an Adapted Animal

Every organism has a set of adaptations. Some of these adaptations allow it to fit better into its environment. To help your child understand how the environment may influence what adaptations are present in an organism, research online some of the most bizarre and interesting adaptations.

Then, you and your child can make up an animal with as many unique adaptations as you want. You may wish to draw and color this organism on a piece of paper as well.

After the drawing is complete, go through each adaptation and think of how the environment may have influenced the existence of that adaptation.

Here are some questions to discuss with your child:

- How did the environment influence each of these adaptations?
- In what ways are some adaptations beneficial? Harmful?
- Does the environment choose which adaptations will be most fit for a particular ecosystem?