

Phylogenetic Tree - Human origins



What is a species?

A species is a group of interbreeding individuals that share a gene pool and are reproductively isolated from other species. It is impossible to determine whether two organisms are from the same species based on anatomy alone.

What is speciation?

Speciation is the process by which one species splits into two, and is responsible for the formation of new species. Speciation has resulted in our planet having high biodiversity.

How does speciation occur?

The process of speciation occurs in three basic steps:

1. Variation – Variation is the natural differences in a population. It exists between individuals in a population. Darwin concluded that natural selection could only act if there is variation in a population. However, because Darwin didn't have access to genetics, he wasn't able to explain how or why this variation happened.

Since then, scientists have shown that variation is caused by genetic differences which result in different characteristics. And since genes are inherited, so too are the characteristics they carry.

2. Isolation – The formation of a new species requires isolation. This means that different groups of the same population are prevented from breeding. Isolation prevents gene flow through a population, stopping any differences in one population from reaching another population. Isolation can occur in different ways, such as through geographical barriers (e.g. rivers, oceans, mountains and gorges) or climatic barriers (e.g. temperature, rainfall, ocean currents and sunlight).

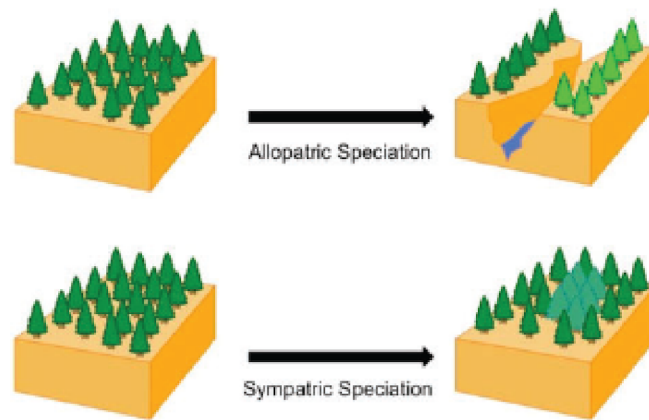
3. Selection - When isolated by a barrier, natural selection affects the genotype and causes changes that prevent groups breeding, even if the groups come back together again sometime in the future. Changes that occur can include:

- Courtship behaviours - animals display different courtship displays or songs
- Breeding season - animals begin breeding at different times of the year
- Chemical barriers - sperm may be killed by the chemistry of the female
- Sterility - animals may breed but their offspring are sterile.

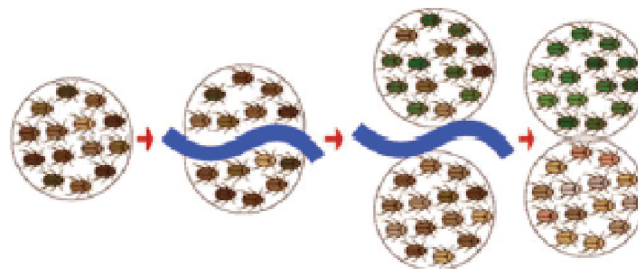


Different types of speciation

There are several types of speciation; **allopatric speciation**, **peripatric speciation**, **parapatric speciation**, **sympatric speciation** and **artificial speciation**.



Allopatric speciation - Occurs when two populations are geographically isolated from one another; distance or an impassable barrier separates them.



For example, a population of squirrels underwent allopatric species when the Grand Canyon formed.



Allopatric speciation - Grand Canyon squirrel

When the Grand Canyon formed, a population of squirrels were divided when a gorge was formed. Unable to make contact anymore the divided population of squirrels was unable to breed and reproduce with each other across this geographic barrier. The squirrel population underwent allopatric speciation.



Today, there are two separate squirrel species inhabiting the north and south rims of the Canyon. Birds and other species that can easily cross this barrier continue to interbreed and have not been divided into separate populations.

Peripatric speciation - When small groups of individuals break off from the larger group and form a new species, this is called peripatric speciation. The main difference between allopatric speciation and peripatric speciation is that in peripatric speciation, one group is much smaller than the other. The unique characteristics of the smaller group are passed on to offspring, making these characteristics more common in this group.

Parapatric speciation - In some cases, a species is spread out over a large geographic area and although it is possible for any member of the species to mate with another member, individuals only mate with those in their own geographic region. Parapatric speciation occurs because populations are divided by differences in the environment as opposed to physical barriers.

For example, parapatric speciation can sometimes occur in polluted environments, such as those affected by mining activities. High levels of minerals such as iron and zinc can prevent many plants from growing. Some plants - such as buffalo grass - is able to tolerate the metals. Buffalo grass has become a unique species, different from the other grasses that grow in areas not polluted mining activities. They pass on their mineral-resistance characteristics to their offspring. Sometimes a species that is formed by parapatric speciation is especially suited to survive in a different kind of environment than the original species.

Sympatric speciation - Occurs when members of a population develop a genetic difference that prevents them from reproducing with members of the original species. This is actually a bit of a controversial theory which some scientists don't believe exists. The idea behind sympatric speciation is that even when there are no physical barriers preventing any members of a species from mating with one another, a new species seems to develop spontaneously. This occurs due to reproductive isolation which may be caused by:

- **Pre-mating** isolating mechanisms, such as behavioural rituals or different mating seasons.
- **Post-mating** isolating mechanisms, such as prevention of insemination. These can result in the offspring being sterile.

Sympatric speciation does not require large-scale geographic distance to reduce gene flow between parts of a population.

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For example, 200 years ago, the ancestors of apple maggot flies laid their eggs only on hawthorns. Today these flies lay eggs on hawthorns (which are native to America) and domestic apples (which were introduced to America by immigrants). Females generally lay their eggs on the type of fruit they grew up in, and males tend to look for mates on the type of fruit they grew up in. So hawthorn flies generally end up mating with other hawthorn flies and apple flies generally end up mating with other apple flies. This means that gene flow between parts of the population that mate on different types of fruit is reduced. This host shift from hawthorns to apples may be the first step toward sympatric speciation - in fewer than 200 years, some genetic differences between these two groups of flies have evolved.



Apple tree



Apple maggot fly



Hawthorn berry

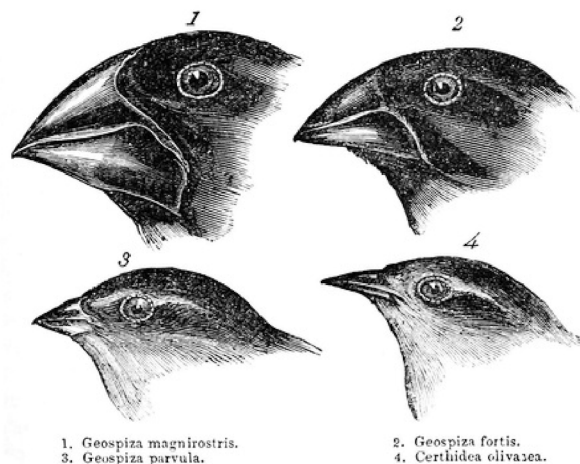
Artificial speciation - Humans have intervened with the natural process of evolution to gradually change the particular features of a species. Selective breeding is the deliberate selection by a breeder of individual plants or animals to provide the genetic material for the next generation. This is achieved through lab experiments, where scientists mostly research insects like fruit flies, and in animal husbandry.

Artificial selection occurs when breeders favour particular inherited features in their livestock and use selective breeding to enhance those features. Unlike natural selection, the traits selected in this type of breeding may not be positively selected in the wild. This can lead to a loss of genetic variability.



Adaptive radiation

All of these mechanisms of speciation can lead to adaptive radiation. Adaptive radiation is the emergence of numerous species from a common ancestor that spreads to new environments. An example of adaptive radiation is Darwin's finches, where the islands of the Galapagos all saw a different species of finch develop.



Key points

Speciation - the process by which one species splits into two, and is responsible for the formation of new species.

Speciation occurs in three basic steps:

1. **Variation** - the natural differences in a population.
2. **Isolation** - different groups of the same population are prevented from breeding.
3. **Selection** - natural selection affects the genotype and causes changes that prevent groups breeding.

There are several types of speciation:

- **Allopatric speciation** - occurs when two populations are geographically isolated from one another.
- **Peripatric speciation** - occurs when small groups of individuals break off from the larger group and form a new species.
- **Parapatric speciation** - occurs because populations are divided by differences in the environment as opposed to physical barriers.
- **Sympatric speciation** - occurs when members of a population develop a genetic difference that prevents them from reproducing with members of the original species
- **Artificial speciation** - occurs when humans intervene with the natural process of evolution to gradually change the particular features of a species.

Adaptive radiation - the emergence of numerous species from a common ancestor that spreads to new environments.

