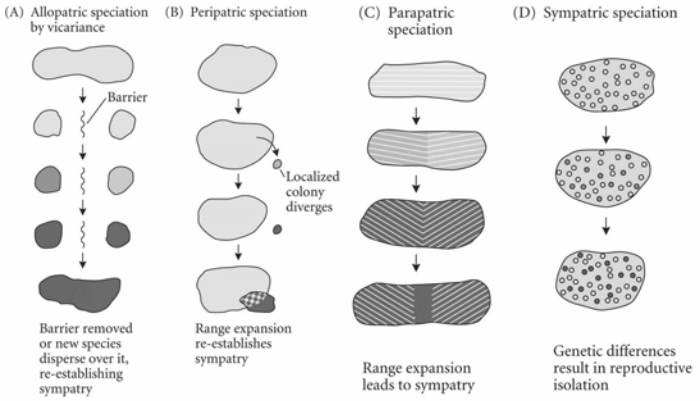
Speciation

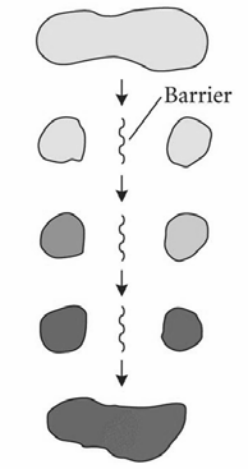
For one species to become two, separate populations of the same species must become reproductively isolated.

For reproductive isolation to evolve, some change must occur in one or both lineages in ecology, behavior, physiology, biochemistry, or genetic system that makes them reproductively incompatible. How one lineage can become incompatible with its closest relative lineage is the key question of how new species are formed.

Speciation can involve the gradual development of reproductive isolation, or in the case of some types of chromosomal change, be nearly instantaneous

Gradual speciation can be defined through the geography of the populations involved.



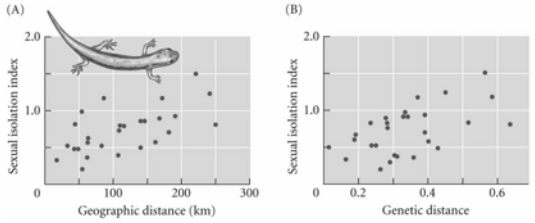


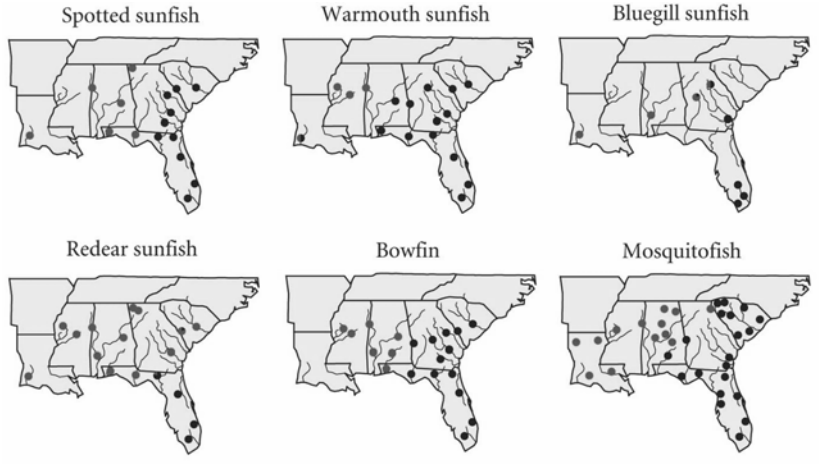
Allopatric speciation is the evolution of reproductive barriers between populations that are geographically separated.

When allopatric populations expand their ranges and come into contact they might

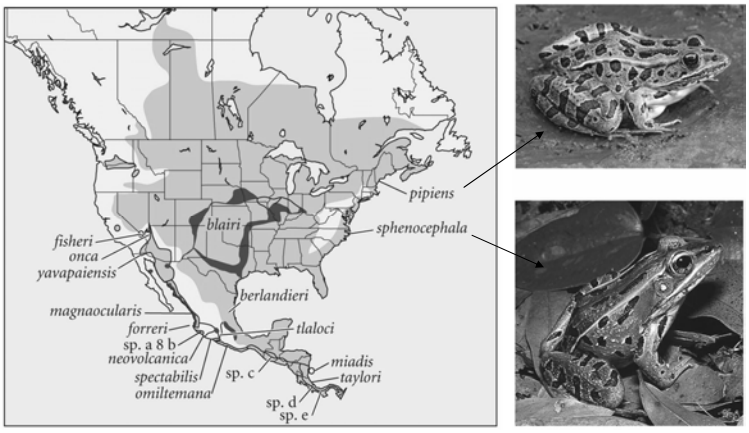
- interbreed and blend to become a single continuous species
- interbreed in the region of contact and form a stable hybrid zone
- not interbreed due to some barrier to reproduction that evolved while they were allopatric

The evidence for allopatric differentiation of geographically separated populations is clear





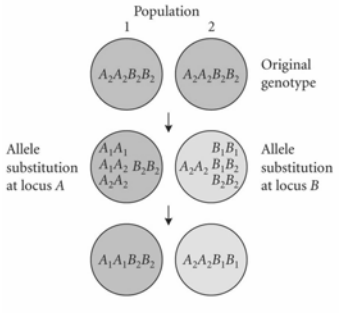
Many species retain their allopatric distributions.



In areas of sympatry reproductive isolation has been found.

How can an allele that makes an individual reproductively incompatible with its relatives increase in frequency in a population?

Allele A_1 increases in one population due to fitness advantages or due to genetic drift.

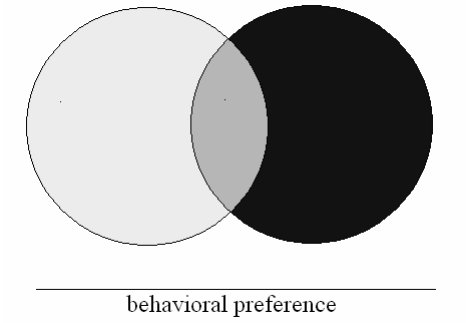


Allele B_1 increases in one population due to fitness advantages or due to genetic drift.

Alleles A_1 and B_1 are incompatible with each other and hybrids ($A_1A_2B_1B_2$) are either not formed or have low fitness when the populations come into contact.

In theory, natural selection can result in the evolution of barriers to reproduction while the populations are allopatric.

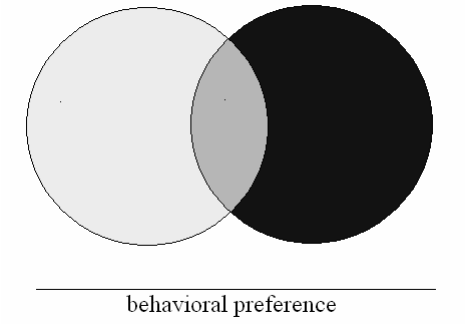
Alternatively, selection can increase the degree of prezygotic isolation among populations that have partial postzygotic isolation.

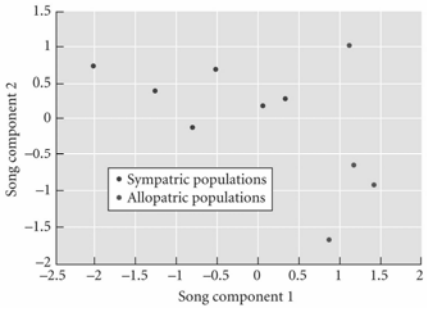


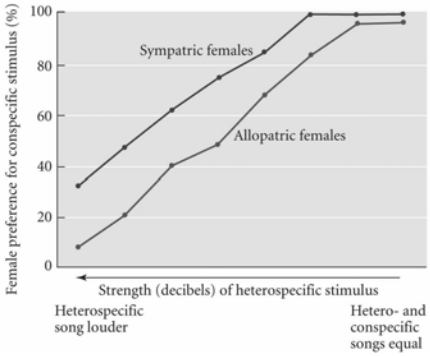
If the hybrid of two forms has lower fitness than nonhybrid offspring, any variation in a prezygotic barrier in the two forms may result in selection that increases the frequency of the alleles that are the basis for the barrier.

The preference may be for any prezygotic barrier - ecological or behavioral.

If the fitness of the hybrid is not reduced (there is no postzygotic isolation), then there will be no selection to reinforce the prezygotic barrier and the populations will likely blend.





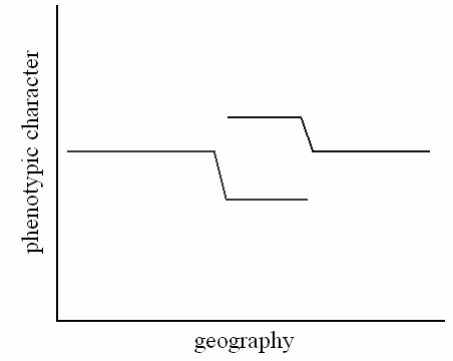


In tree frogs, where partial postzygotic isolation is known, song characteristics are most similar between allopatric populations and most different between sympatric populations.

Females of each species show greater preference for males of their own species when they come from populations that are sympatric with the other species.

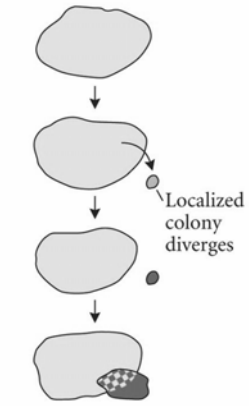
The strength of preference increases with the volume of the call of the other species.

Character displacement - species are more common in allopatry than in sympatry.

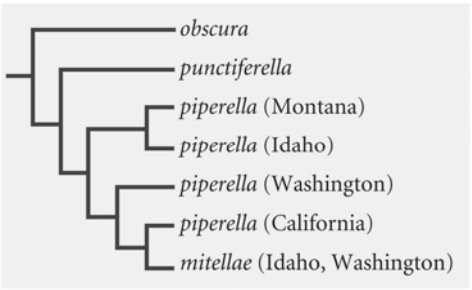


It can be produced by any selection for prezygotic differences. It can also the product of competition for resources in the zone of sympatry.

Peripatric speciation - the development of reproductive isolation in small marginal populations of a species.



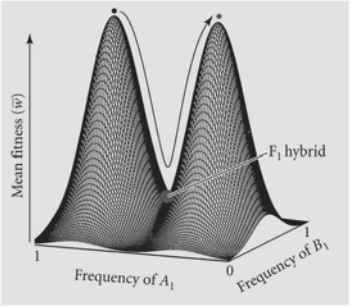
There are many examples of new species that arise from single populations of a widespread species.



Moths of the genus *Greya*

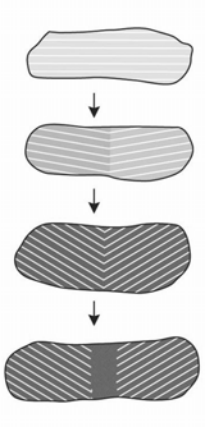
This may not be different from simple allopatric speciation or it may involve some component of genetic drift.

Mayr hypothesized that founder populations, because they are small, may have reduced genetic variation and low fitness due to genetic drift. Drift may increase the frequency of alleles that were rare in the ancestral population. In such a situation, selection for new combinations of alleles that are compatible with the newly fixed alleles may occur and allow increased fitness in the new conditions. A possible result is a reorganization of the genome that makes it incompatible with the ancestral population.



Mayr envisioned a fitness topography where the founder population went through a low fitness valley due to drift and after selection and reorganization, the population evolved to a new fitness peak that is incompatible with the ancestral population.

Parapatric speciation - the origin of new species over the former range of the ancestral species.

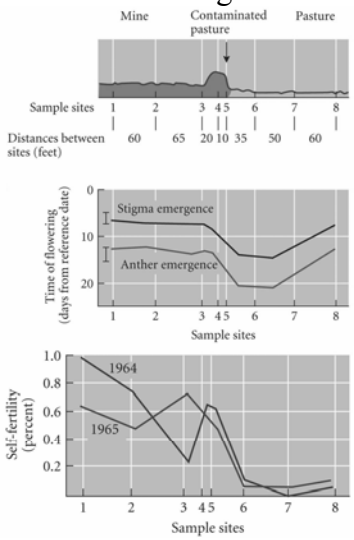


The populations can only diverge if there is relatively strong selection across the geographic range of the species.

A stable hybrid zone may result if there is moderate selection against the hybrids.

Complete divergence can occur if there is strong selection against the hybrids - as in reinforcement of reproductive isolation in formerly allopatric populations.

The pattern produced by parapatric speciation and the reestablishment of contact of formerly allopatric populations is difficult to distinguish.



The best case for parapatric speciation is in populations of plants on contaminated soils.

Adaptation to contaminated soils results in hybrids that are unfit in either environment.

Selection against hybrids has resulted in divergence in flowering time in adjacent populations and selection for self pollination in the population on the contaminated soil.

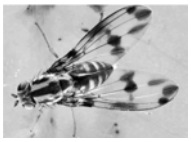
Anthoxanthum odoratum - a grass

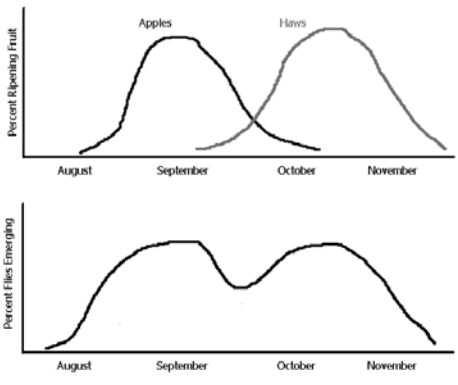
Sympatric speciation - the development of reproductive isolation between forms of a species that live entirely in the same geographic region.

Strong disruptive selection for habitat differences or differences in reproductive timing may result in divergent phenotypes that produce hybrids that are unfit for the same environment for which the parental types are well suited.

Potential scenario: Two homozygous genotypes A_1A_1 and A_2A_2 are well suited to different host plants and their hybrid A_1A_2 has low fitness on both host plants. If another gene is introduced that produces a difference in mating behavior that is correlated with the host plant it will reinforce mating among like genotypes and potentially lead to complete divergence.

Apple maggot flies may be a case of the beginning stages of sympatric speciation.





The apple race emerges early and parasitizes apples. The Haw race emerges late and parasitizes haws. Any mating between a late apple fly and an early haw fly will produce hybrids with an intermediate emergence time with fewer opportunities to parasitize apples.

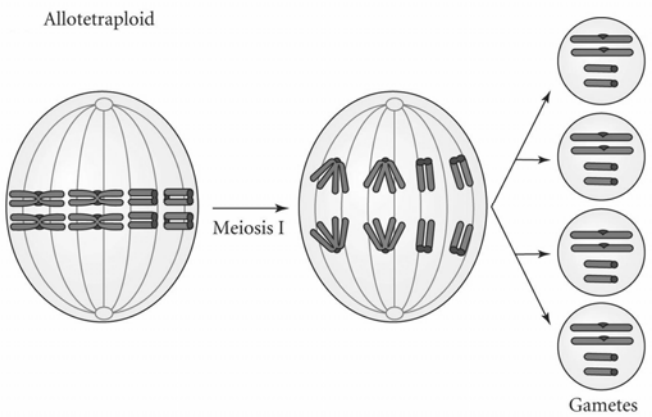
Those that avoid mating with the other race will produce offspring with emergence times appropriate for apples or haws.

The two races already show some preferences in mating for members of their own race.

Speciation by polyploidy and recombination

Hybrid organisms receive two different sets of chromosomes, one from each parent species. They are usually sterile because differences in gene arrangements among chromosomes results in improper synapsis and aneuploid gametes.

Duplication of whole sets of chromosomes (allopolypoidy) may result in gametes that can produce balanced sets of chromosomes.



Allopolyploids with a diploid number of sets of chromosomes from each parent ($2N_A + 2N_B$) produce gametes that are euploid with one set of chromosomes from each parent ($N_A + N_B$).

Such organisms are potentially interfertile or self-fertile but they can't produce fertile offspring in backcrosses with either parent species.

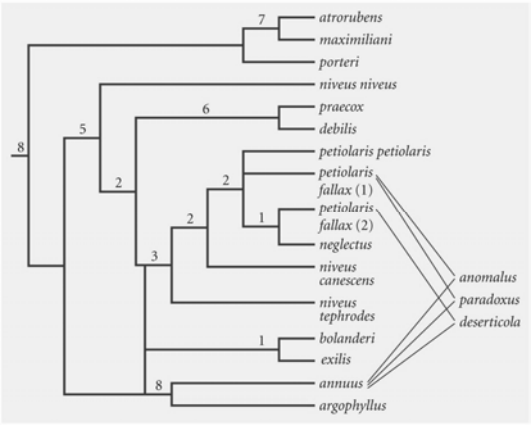
Gamete ($N_A + N_B$) combined with gamete (N_A) produces an allotriploid ($2N_A + N_B$) that produces unbalanced sets of genes in gametes.

Thus, allopolyploids are reproductively isolated from each of their parent species. They can only reproduce with other allopolyploids or through self-fertilization. They are new species as soon as they are formed.

Many species of plants and some animals are polyploid. At least 50% of all flowering plants are polyploid.

Recombinational speciation - some hybrids of two species may be fertile but reproductively isolated from the parent species.

This mode of speciation may be common in plants.



Helianthus anomalus is a product of hybridization and speciation. It lives in saltier and drier habitats than either parent species.