# TOPIC: SPECIATION

**Key Knowledge:**

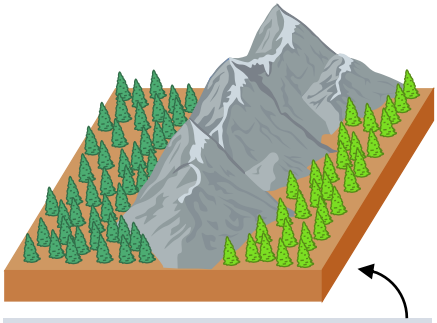
- Evidence of speciation as a consequence of isolation and genetic divergence, including Galapagos finches as an example of allopatric speciation and *Howea* palms on Lord Howe Island as an example of sympatric speciation

## SPECIATION

Speciation describes the formation of new species from pre-existing species. It occurs as a consequence of divergent evolution, whereby a population becomes genetically separated from an ancestral population (i.e. reproductive isolation) and can no longer interbreed to produce fertile, viable offspring. There are numerous caveats that may limit successful identification of species. For instance, certain organisms may not sexually reproduce (e.g. bacteria). Extinct organisms may only be known through the fossil record, making it difficult to ascertain breeding potential. Similarly, organisms from different regions may never come into contact, so there is no information regarding their capacity to interbreed. As a consequence, species classifications may occasionally need to be reinterpreted whenever new evidence is discovered.

## 1. ALLOPATRIC SPECIATION

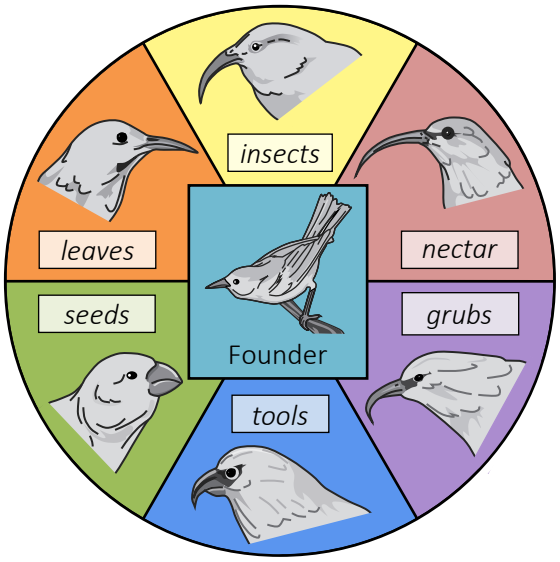
Allopatric speciation occurs when a **geographic barrier** physically separates and isolates two populations (there is **no gene flow**). The two populations may be exposed to different environmental conditions and begin to evolve separately as a result of cumulative mutations, genetic drift and natural selection. Eventually, the two populations reach a degree of **genetic divergence** where they can no longer interbreed in order to produce fertile, viable offspring.



Allopatric: *Geographic isolation*

## DARWIN'S FINCHES

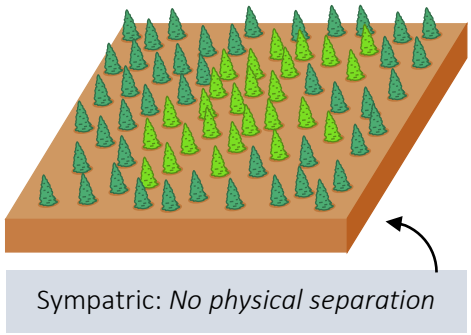
**Adaptive radiation** is the rapid evolutionary diversification of a single ancestral lineage to suit a variety of ecological niches (each with different environmental selection pressures). The finches found on the Galapagos Islands have morphological differences in beak size and shape to suit different dietary intakes. Because these finches are physically separated to different niches, this is considered an example of allopatric speciation. However, there is some debate as to whether these finches should be classified into different species. The morphological differences are not due to different alleles but are instead caused by differential expression of the **BMP4** protein (i.e. epigenetics). Furthermore, interbreeding is possible due to the short distances between the different islands, and the various finches show little variation in their nuclear or mitochondrial DNA sequences, nor in any of their reproductive behaviours (such as plumage pattern or songs).




Different beaks in Galapagos finches due to differential BMP4 expression

## 2. SYMPATRIC SPECIATION

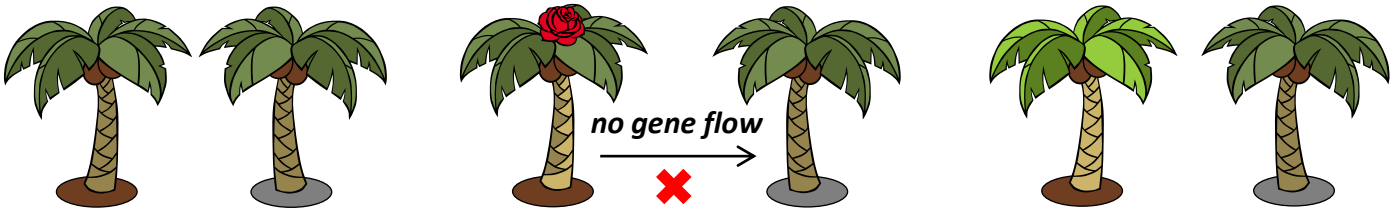
Sympatric speciation does not involve the physical separation of populations. Instead, the offspring become reproductively isolated by a variety of mechanisms (temporal or behavioural separation, chromosomal differences such as polyploidy). The consequence of this is that even though the organisms remain in the same shared habitat, they no longer interbreed (no gene flow), leading to an accumulation of genetic differences and eventual speciation.



Sympatric: *No physical separation*

## *HOWEA* PALM TREES

The *Howea* palm trees are endemic to Lord Howe Island off the Australian coast. While these trees exist in a single location, they are exposed to different soil conditions – either nutrient-rich volcanic soil (acidic) or calcareous soil (basic). The different pH conditions of the two types of soil cause the palms to flower (and hence reproduce) at different times of the year. Palms growing in the acidic soil tend to flower earlier, creating a **temporal separation** between two populations of palm trees – leading to sympatric speciation.




**Disruptive Selection**
*Howea* palms grow on volcanic or calcareous soil

**Reproductive Isolation**
Palms on acidic soil flower earlier than palms on more basic soil

**Speciation**
Non-random mating will lead to genetic divergence

## POLYPLOIDY

Sympatric speciation can also occur from meiotic division errors that result in chromosomal abnormalities. Polyploidy involves the duplication of entire chromosome sets and occurs when meiotic germline cells fail to undergo cytokinesis. This will cause the chromosomal number to double within the defective gamete (i.e. diploid instead of haploid). When a defective gamete is fertilised with a normal gamete, the resulting offspring will have an additional copy of every chromosome (triploid). Polyploid offspring cannot typically interbreed with the original population (their chromosome set is incompatible with the parent population) and will therefore tend to occur more commonly in species that are capable of self-fertilisation (i.e. plants).