

# Chapter 7: Geographic Variation and Speciation

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## INTER-POPULATION GENETIC VARIATION

- One species consists of two populations
  - The individuals of each population tend to mate with the members of their own population
  - This is called **positive assortative mating**

## MODELS OF GEOGRAPHIC VARIATION

- **Polymorphic species:** a species formed of several geographic groups which differ from each other by traits that are easily recognizable
  - Sometimes referred to as morphs, forms or subspecies

## ADAPTIVE VALUE OF GEOGRAPHICAL VARIATION

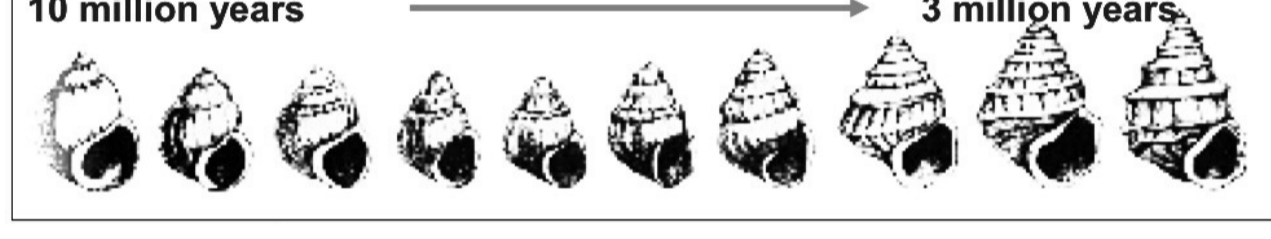
- **Ecogeographic rules:** models of geographic variation that follows climatic gradients for many species within a group of vertebrates
  - **Bergmann's Rule:** In endothermic animals, the populations living in northern regions of the geographic distribution of the species will generally have a **larger size**
    - 72% of birds and 65% of mammals follow Bergmann's rule
  - **Allen's Rule:** In birds and mammals, the northern populations (or species) will generally have **short and massive** extremities, whereas the southern populations (or species) will have **longer and thinner** extremities
  - **Gloger's Rule:** **Darker** pigments in more humid climates

## SPECIES

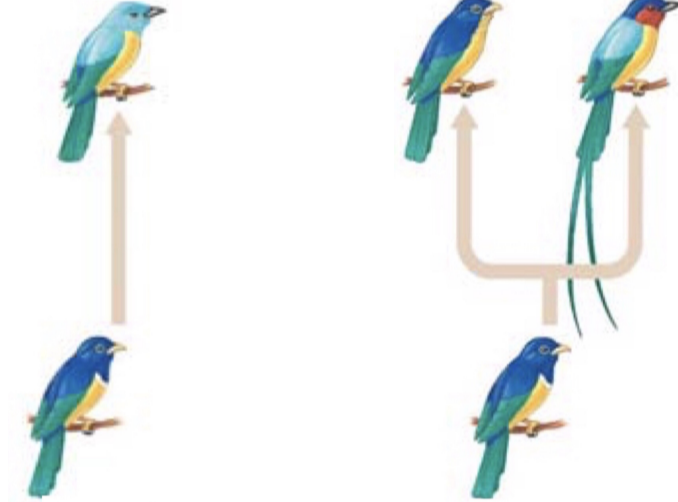
- **Morphological species concept**
  - Brings together individuals possessing similar unique morphological traits, under one species name
  - Specimens belong to a species if they morphologically resemble the "type" specimen (holotype) of a the species
  - Type specimen is determined by the taxonomists as being a typical specimen showing all the unique features of a specimen
    - Called a **holotype**
  - Concept arises from essentialism of Aristotle
- **Morphological variability**
  - A Darwinian concept
  - Morphological variability of a species is now documented through the description of other specimens
    - Called **paratypes**
  - These paratype specimens represent the morphological variability observed within the species
- **Biological Species Concept**
  - A group of populations whose members have the potential to **inbreed** in nature and produce a **viable, fertile offspring** but that do not produce such an offspring because of the presence of a reproductive isolation mechanism in place which prevents interbreeding
    - Only applicable to sexual organisms
    - Only applicable in nature
    - Only verified in an area of sympatry of potential species
    - **Area of Sympatry:** a zone of overlap between the two related species
  - In the laboratory setting, **interbreeding hybrids** are more commonly found than in nature
- **Pre-zygotic Barriers:** prevent the formation of hybrid zygotes and thus, a loss of gametes
  - **Ecological Isolation:** populations on the same continent, but live in different habitats
    - Ex. Savannah vs Forest
  - **Temporal Isolation:** non-synchronized mating or flowering
    - Different seasons or time of the day
    - Common mechanism in plants
  - **Ethological Isolation (Behavioural):** absence of sexual attractiveness
    - Distinct courtship
  - **Mechanical Isolation:** mating or pollen transfer is impossible due to incompatibility of genitals or different flower structures
  - **Gametic Isolation:** The male and female gametes cannot meet or the sperm and pollen cannot survive in the genital tract of the animal or in the flower stigmas
- **Post-zygotic Barriers:** imply loss of gametes
  - **Reduced Hybrid Variability:** hybrids cannot develop or cannot reach sexual maturity
  - **Sterility of Hybrids:** hybrids cannot produce functional gametes
  - **Hybrid Breakdown:** hybrids can be viable and fertile but the offspring are susceptible to cancer and other sicknesses

## ORIGIN OF SPECIES

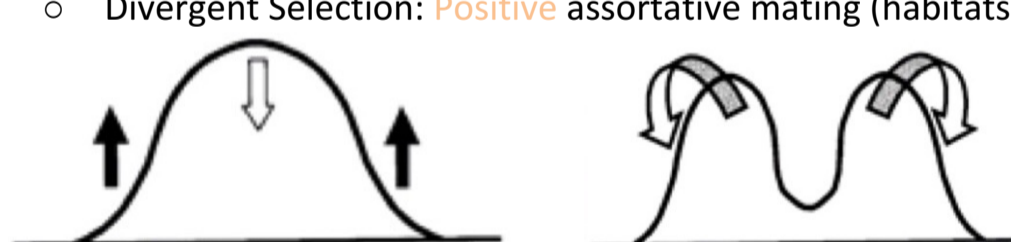
- **Phyletic Speciation (anagenesis):** gradual evolution or "linear" succession of species in a way that the changing species shows different phenotypes through time



- **Multiplication of Species (cladogenesis):** creation of species by establishing a reproductive barrier between them
  - **Cladogenesis** is the only mechanism responsible for the creation of biodiversity



- From a genetic standpoint, a premise for the multiplication of species or the establishment of a reproductive barrier is the **interruption or migration** of gene flow between populations
- Models of speciation (cladogenesis) shows how gene flow can be interrupted
  - **Allopatric Speciation:** a population with continuous distribution divided in two or multiple populations by a geographical barrier
    - Almost a universal process
    - Step 1: Passive isolation of population in species
    - Step 2: Genetic modifications, under the combined effect of isolation and selective pressures, replace a co-adapted system genes by another, more suitable to different ecological conditions
    - Step 3: Acquisition of reproductive isolation before the subsequent overlapping areas
- **Complete Speciation:** no viable hybrids in the contact zone (sympatric area) between species
- The dispersal capabilities of individuals is important in defining the probability of **speciation** in some groups when compared to other groups
- **Sympatric Speciation:** a new species appears within populations (specification without geographic isolation)
  - A rarer process than allopatric speciation
  - **Polyploidy:** multiplying the normal number of chromosomes. This can happen during meiosis if the chromosomes do not split and create diploid gametes, instead of haploids
    - 30%-40% of plants
    - Rarer in mammals
  - Divergent Selection: **Positive** assortative mating (habitats)



## HYBRID ZONES

- Zone of overlap between species
- Species with 3 populations
- Then a barrier to gene flow at one point
- So you have one population that is isolated from the 2 other and this population would evolve
- Other 2 species will also evolve
- And eventually there might be a hybrid zone with 3 possible outcomes
  - **Reinforcement:** enhancement of reproductive barriers in the hybrid zone
    - **Character displacement:** the difference between two related species are often greater in sympatric areas
    - Individual of first species initially had an average beak depth of 9 (when isolated) and the beak depth became smaller to an average of 8 (sympatric area)
    - Individuals of the second species initially had an average beak depth of 10 (when isolated) and the beak depth became larger to an average value of 13 (sympatric area)
    - This can be a result of competition for food
    - Also enhances the difference between the species and ensures there is no mistake done by the females
      - Thus, males and females will recognize their own species because they have different beak depths
  - **Fusion:** if there is no reproductive barrier in a zone of overlap then the species will fuse, thus creation of a new species
    - Difficult to observe because the pattern takes many years to develop
    - 2 species of fish
    - Reproductive barrier = colour, environment where the water is clear the female will choose the right male to mate with based on colour
    - In the natural habitat of these species, the water has become very turbid (dirty) so there is difficulty in distinguishing between the males so there is a lot of mixture of mating
    - Result: New species which is a hybrid between the two species called the Turbid fish
    - Because of pollution, there is a new element to the environment and the reproductive barrier has collapsed because the female can not distinguish between the males
    - The two initial species are losing their genetic integrity
  - **Stability:** a hybrid zone remains and seems to be fairly stable
    - 2 species of frogs
    - The hybrids will not survive very well or reproduce very well
    - This means that the characteristics between the species do not fuse
    - Thus both species keep their genetic integrity
    - Due to altitude the hybrid species do better in the median altitude vs the parents that do better in their corresponding areas
    - The consequence of all these factors is that the hybrid zone is stable
      - Since the reproductive rate is low there are less of these individuals however, they are most abundant in the hybrid zone because the environment favours them here

## TEMPO OF SPECIATION

- Process of speciation: 4 000 yrs to 40 MYR
  - Rarely a speciation process that takes less than 500 000 yrs
- Interesting question: When does the morphological change occur?
  - **Punctuated Equilibrium:** in the early stage of speciation is when all morphological change would occur
    - For the rest of the existence of the species you would have stability
  - **Phyletic Gradualism:** there is a bit of change at speciation, but most of the morphological change would occur after speciation
    - Change in morphology gradually
    - Darwinian view because the population adapted to the environment
    - Possible that there is certain adaptations that would change the colour and morphology of the species, which occurs through the whole existence of the species
  - Conclusion: both patterns are possible in nature and even possible within the same species, as it is based on population size
    - If the population is small in size, then morphological change would be rapid (Punctuated equilibrium)
    - If the population size is large, then evolution (morphological change) would be very slow (Phyletic gradualism)