

# The Origin of Species

## (Ch. 24)

### Species “*Kind*”

- A group of populations whose members can interbreed with one another but cannot (*usually*) interbreed with members of other species. Produce viable offspring. (*biological species definition*)
- Gene flow continues throughout generations.
- Reproductively *united*- change slowly over time.
- Reproductively *isolated*- from other groups or populations.

There are exceptions of different species that do interbreed and produce viable offspring (coyote, wolf and dog).

Subspecies have minor differences among other populations of the same species. They often breed together at areas of contact.

In the field, a species may be identified by morphological similarities. Some measurable method of identification. (Morphological species definition)

### Speciation - formation of new species.

- occurs when population diverge from one another.
- Changes in allele frequency occur causing a divergence of the population leading toward the formation of new species. The final result of changes in a gene pools allele frequency.
- Many gene loci may be involved, creating many differences among the members of the population or only a few loci may be involved if they produce phenotypes that are dramatically different and selected for/against (head shape in Hawaiian *Drosophila*).

## HOW IS ISOLATION MAINTAINED?

- What prevents interbreeding and encourages isolation?

### 1) Reproductive barriers.

#### a) Prezygotic barrier (Pre-mating)

- **Usually enough to prevent mating between species.**

- Habitat isolation:** organism occupies a specific niche. Because they occupy a different niche they may not come into contact with one another. Woodland vs. meadows.
- Temporal isolation:** “calendar” of events. Controlled by temperature/day length. Breed at different times of day or season.  
Ex. Black sage (early spring) and white sage in late spring, early summer.  
Ex. *Drosophila pseudoobscura* in afternoon and *Drosophila persimilis* in morning.
- Behavioral isolation:** visual (firefly), auditory (crickets), chemical (olfactory)/moths signals. Usually things that are used during sexual selection.

(Mating)

- Mechanical isolation:** size and shape of reproductive organs. Transfer of gametes cannot occur. Pollen from anther, grasping of female by male.
- Gametic/Genetic isolation:** gametes are incompatible. Fusion of gametes cannot occur or egg cannot divide. Sperm not able to survive in reproductive tract of female or not recognized by receptors on ovum. Eg. Species specific gametes of plants and aquatic organism since large numbers of gametes are dispersed into environment.

*If you are really determined, then...*

#### b) Postzygotic barriers (Post-mating)

- **Reinforce pre-mating factors.**

- Hybrid inviability/Reduced Hybrid viability:** development of fertilized egg does not take place. Oftentimes due to abnormal cell division since chromosome numbers do not match up. Zygote dies.
- Hybrid sterility/Reduced Hybrid fertility:** hybrid produced unable to reproduce (ex. Mule {Horse [2n = 64] + Donkey [2n = 62]} and many grasses). No flow of genes between species so they remain distinct/separate.
  - The relative fitness of the parents remains zero.

## 2) Geographic Barriers.

- Gene pool of population separated. Allows change in gene pool provided that each population has selection taking place. Leads to speciation: formation of new species.

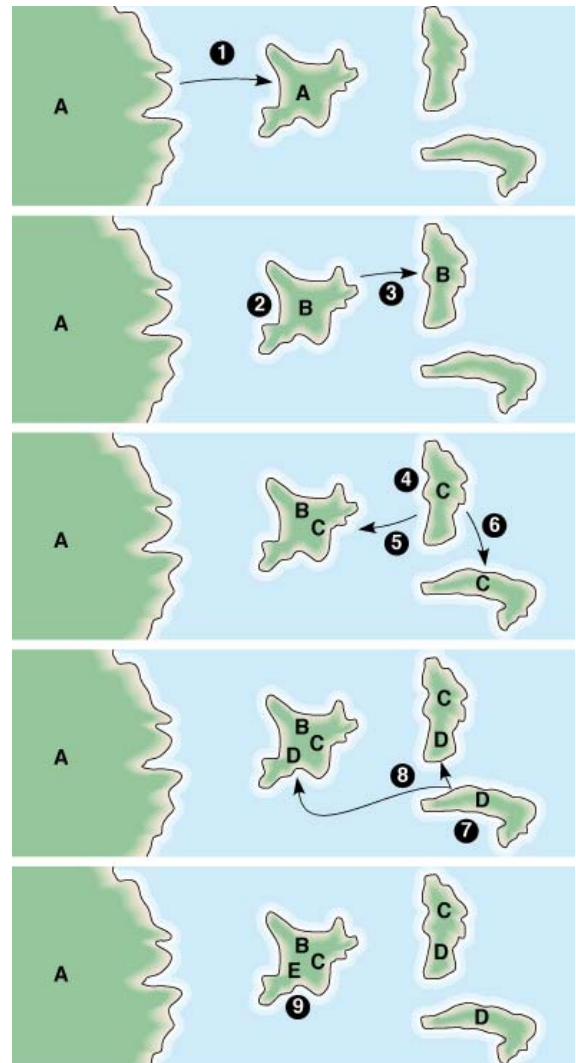
### a) Allopatric speciation. "other country"

- A geographic barrier blocks gene flow.
- Ex. Island, lake, mountain top, retreating water, fire separating populations of grasslands, seed blown to new region by storm, lake drying up (Death Valley and Pupfish)

- After separation genetic drift may occur- divergence of populations gene pool (that is **microevolution**)
- New species are then formed.
- The subset of the population may under-represent the main population. May occur along outer edges of large population that form the fringes of the parent population.
- As increase in population occurs, genetic drift increases the difference between the original and new population.
- May be experiencing environmental/selective pressures different from the main group.

### Adaptive Radiation.

- Diversification of a *group of organisms from a common ancestor*. Numerous species originate from one parent species. Species can exploit new resources.
- Common when a new area is colonized by a small group.
- Ex. Hawaii and Galapagos Is.



### 3) Sympatric speciation. "same country"

- Physical separation of population not required.
- Occurs within a population and establishes a reproductive barrier.
- Genetic change in population causes speciation.

**Polyploidy:** increase in chromosome number.

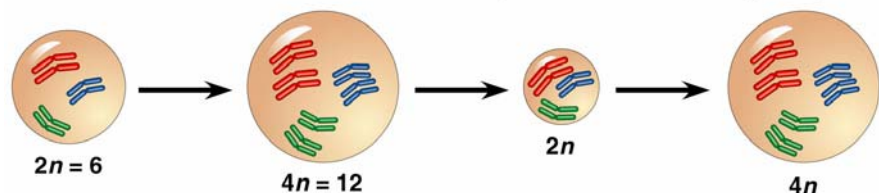
### a) Autopolyploid: $2n \rightarrow 4n$

- One species with 2x the normal chromosome number as original parent species.
- Cannot interbreed with the parent ( $4n + 2n = 0$ )
- Can self-fertilize or mate with other tetraploids. ( $4n + 4n = 4n$ )
- Uncommon in animals (whiptail lizard)

Failure of cell division in a cell of a growing diploid plant after chromosome duplication gives rise to a tetraploid branch or other tissue.

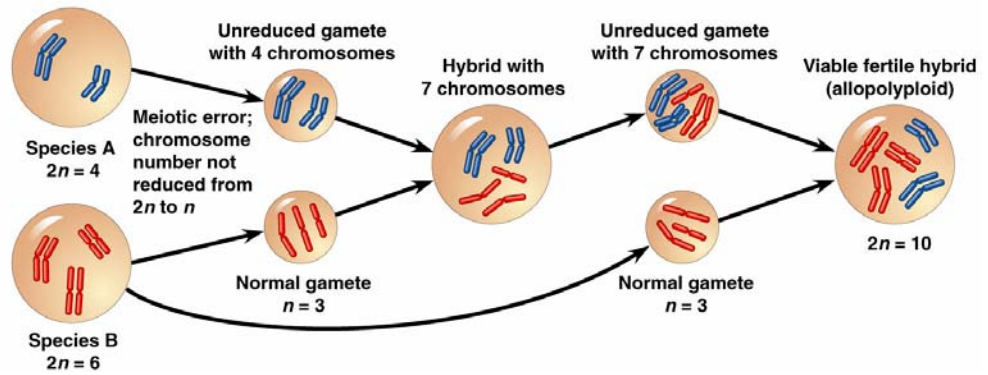
Gametes produced by flowers on this tetraploid branch are diploid.

Offspring with tetraploid karyotypes may be viable and fertile—a new biological species.



b) **Allopolyploid:**  
( $2n + 4n = 6n$ )

- i) Two different, but related species produce a polyploid hybrid. (aka.



Hybridization)

- ii) Usually sterile. Meiosis will not pair up homologs so gametes cannot be formed in new species. (ex. Hybrid of radish and cabbage cross.)  
 iii) Ex. Grasses, Sycamore trees (European and American species combined), Wheat.  
 iv) Common in plant evolution (40% of all plant species?)  
 v) Produce hearty species (hybrid vigor) that retains the best attributes of each parent stock. Ex. Rapid growth and abundant fruit production.

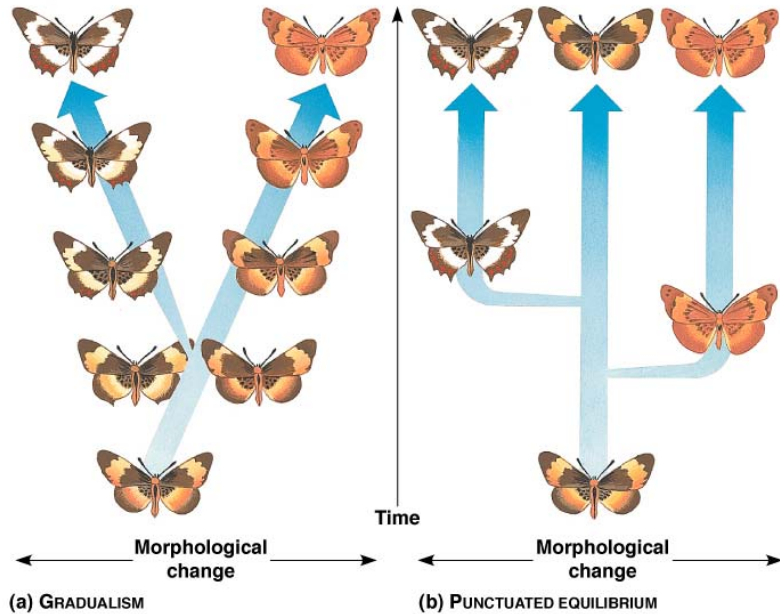
## HOW FAST DOES SPECIATION OCCUR?

Speciation leads to the formation of new species and serves as the foundation for the formation of new genera, families and so forth. This evolution of new taxonomic groups is called **Macroevolution**. Evolutionists agree that natural selection is the mechanism for this process but debate over the rate of this process.

### Two Schools of Thought

#### Gradualism.

- Evolution proceeds slowly and at a constant rate.
- Populations slowly diverge from one another through the gradual accumulation of adaptive characteristics in the population.
- Occurs over long periods of time.
- Darwin was a gradualist.
- As speciation occurs, changes leading to a new species accumulate (slowly) transforming the one species into another. Called **Anagenesis** or **Phyletic evolution**.



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### Punctuated equilibrium.

- Proposed by Niles Eldredge and Stephen Jay Gould
- Species diverge in spurts of rapid speciation separated by long periods without change. Unique features originate “rapidly” at time of split.
- Most of species existence is spent in stasis (*w/o change or in equilibrium*) and a very small amount of time (tens of thousands of years!) is involved in speciation. These changes are brought about by rapid changes in the environment such as a **mass extinction** of species with few survivors. (Founders/bottleneck).

#### ❖ 2 major mass extinction events.

- **Permian Extinction: (250 mya)**
  - Killed 90% of marine animals.
  - Period of extreme volcanism → high CO<sub>2</sub> emission → global warming
- **Cretaceous Extinction: (65 mya)**
  - Killed 50% of marine animals and most dinosaur lineages.
  - Climate cooled.
  - Thought to have been caused by meteor/comet colliding with earth (Impact hypothesis)

- Used to account for abrupt appearance of organisms in the fossil record. Helps eliminate the problem of the absence of transitional fossil forms between strata.
- Use allopatric speciation examples to support theory.
- **Cladogenesis (branching evolution)** occurs when a population is separated or removed from a main population and undergoes changes causing it to be reproductively isolated from main population and therefore a separate species. Favorable genetic combinations can increase rapidly since no gene flow occurs with parent population. Splitting into two distinct groups. Two extant species are formed, increase number of different organisms (biodiversity).

