

Organizing the world of organisms

- The Tree of Life
 - ♦ **species** are the smallest unit at the ends of branches
 - ♦ basic unit for organizing & categorizing living things

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So...what is a species?

- Biological species concept
 - ♦ defined by Ernst Mayr
 - ♦ population whose members can interbreed & produce viable, fertile offspring
 - ♦ reproductively compatible

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Populations, varieties, species...Oh My!

- When do geographically distant populations represent different species?

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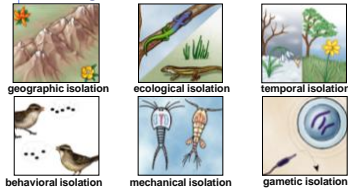
How and why do new species originate?

- Reproductive isolating mechanisms
 - ♦ biological barriers that impede members from producing viable offspring
 - ♦ **before** vs. **after** fertilization
 - ♦ pre-zygotic barriers
 - ♦ before the zygote
 - ♦ post-zygotic barriers
 - ♦ after the zygote

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Pre-zygotic barriers

- Impede mating or hinder fertilization if mating occurs



Geographic isolation

- Species occur in different areas
 - ♦ physical barrier
 - ♦ allopatric speciation
 - ♦ "other country"

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Ecological isolation

- Species occur in same area, but occupy different habitats so **rarely** encounter each other

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Temporal isolation

- Species that breed during different times of day, different seasons, or different years cannot mix gametes

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Behavioral isolation

- Courtship rituals that attract mates & other unique behaviors to a species are effective reproductive barriers

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Mechanical isolation

- Morphological differences can prevent successful mating

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Mechanical isolation

- For many insects, male & female sex organs of closely related species do not fit together, preventing sperm transfer

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Gametic isolation

- Sperm of 1 species may not be able to fertilize eggs of another species
 - ↳ variety of mechanisms
 - **chemical incompatibility**
 - ↳ sperm cannot survive in female reproductive tract
 - **biochemical barrier** so sperm cannot penetrate egg
 - ↳ receptor recognition: lock & key between egg & sperm

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Postzygotic barriers

- prevent **hybrid zygote** from developing into a viable, fertile adult
 - ↳ reduced hybrid viability
 - ↳ reduced hybrid fertility
 - ↳ hybrid breakdown

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zebroid

Reduced hybrid viability

- Genes of different parent species may interact & impair the hybrid's development

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Reduced hybrid fertility

- Even if hybrids are vigorous they may be sterile
 - ↳ chromosomes of parents may differ in number or structure & meiosis in hybrids may fail to produce normal gametes

Mules are vigorous, but sterile

XX
XX
XX
X

Horses have 64 chromosomes (32 pairs)

Donkeys have 62 chromosomes (31 pairs)

Mules have 63 chromosomes!

Hybrid breakdown

- Hybrids may be fertile & viable in first generation, but when they mate offspring are feeble or sterile

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Speciation

- Species are created by a series of evolutionary processes
 - ↳ populations become **isolated**
 - reproductively isolated
 - geographically isolated
 - ↳ isolated populations **evolve independently**
- Isolation
 - ↳ **allopatric**
 - geographic separation
 - ↳ **sympatric**
 - still live in same area

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Allopatric speciation

- Allopatric = "other country"
 - ↳ geographic separation
 - migration
 - physical barrier

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Sympatric speciation

- Sympatric = "same country"
 - isolation even though populations live in same area
 - what causes this isolation?
 - behavioral differences
 - non-random mating
 - physiological differences
 - chromosomal changes
 - polyploidy
 - mostly in plants: oats, cotton, potatoes, tobacco, wheat

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Adaptive radiation

- Evolution of many diversely adapted species when introduced to various new environmental challenges & opportunities

Drosophila

Geospiza

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Adaptive radiation

- Many ecological niches open
- Evolution of many diversely-adapted species from a common ancestor to fill niches
 - Darwin's finches
 - mammals

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Review

- Speciation is a process
 - populations become isolated
 - geographic isolation
 - different environmental conditions
 - food, predators, disease, habitat
 - different selection pressures
 - genetic drift
 - reproductive isolation
 - different selection pressures
 - sexual selection
 - isolated populations evolve independently

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Current debate

- Does speciation happen gradually or rapidly perhaps in response to environmental change
 - Gradualism
 - Charles Darwin
 - Charles Lyell
 - Punctuated equilibrium
 - Stephen Jay Gould
 - Niles Eldredge

Niles Eldredge
Curator
American Museum of Natural History

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Gradualism

- Gradual divergence over long spans of time
 - assume that big changes occur as the accumulation of many small ones

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Punctuated Equilibrium

- Rate of speciation is not constant
 - rapid bursts of change
 - long periods of little or no change
 - species undergo rapid change when they 1st bud from parent population

Time

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Stephen Jay Gould (1941-2002)

- Harvard paleontologist & evolutionary biologist
 - punctuated equilibrium
 - prolific author
 - popularized evolutionary thought

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Evolution is not goal-oriented

An evolutionary trend does not mean that evolution is goal-oriented. The modern horse is the only surviving twig of an evolutionary tree with many divergent trends.

It does not represent the peak of perfection. There is compromise & random chance involved as well

Remember that for humans as well!

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Convergent evolution

- Flight evolved 3 separate times
 - evolving similar solutions to similar "problems"

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Parallel Evolution

- Fill similar niches; have similar adaptations, but are not closely related

Niche	Placental Mammals	Australian Marsupials
Burrower	Mole	Marsupial mole
Anteater	Anteater	Numbat
Nocturnal insectivore	Mouse	Marsupial mouse
Climber	Lemur	Spotted cuscus
Glider	Flying squirrel	Sugar glider
Stalking predator	Ocelot	Tasmanian cat
Chasing predator	Wolf	Tasmanian "wolf"

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Mimicry

- convergent evolution based on similar (protective) appearance



Monarch male poisonous Viceroy male edible



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Coevolution

- Predator-prey relationships
- Parasite-host relationships
- Flowers & pollinators



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