

Chapter 23

The Origin of Species



"That mystery of mysteries..."



So...what is a species?

Biological species concept

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



Distinct species: songs & behaviors are different enough to prevent interbreeding



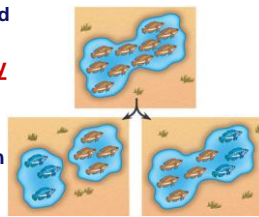
Ernst Mayr
What Evolution Is
2001
Professor Emeritus, Evolutionary Biology
Harvard University
(1904-2005)

"Evolution is so overwhelmingly established that it has become irrational to call it a theory."

How and why do new species originate?

Species are created by a series of evolutionary processes

- populations become **isolated**
 - geographically isolated
 - reproductively isolated
- isolated populations **evolve independently**

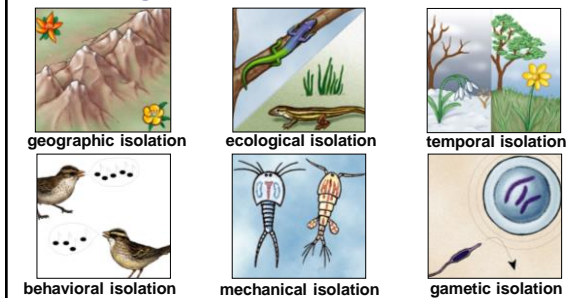


Types of Isolation

- allopatric**
 - geographic separation
- sympatric**
 - still live in same area


Pre-reproduction Barriers

Obstacle to mating or to fertilization if mating occurs



Geographic Isolation

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




Harris's antelope squirrel inhabits the canyon's south rim (L). Just a few miles away on the north rim (R) lives the closely related white-tailed antelope squirrel.

Ecological Isolation


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

lions & tigers could hybridize, but they live in different habitats:

- lions in grasslands
- tigers in rainforest




2 species of garter snake, *Thamnophis*, occur in same area, but one lives in water & other is terrestrial



Temporal Isolation


- Species that breed during different times of day, different seasons, or different years cannot mix gametes
- sympatric speciation**
 - "same country"

Eastern spotted skunk (L) & western spotted skunk (R) overlap in range but eastern mates in late winter & western mates in late summer



Behavioral Isolation

- Unique behavioral patterns & rituals isolate species
 - identifies members of species
 - attract mates of same species
 - courtship rituals, mating calls


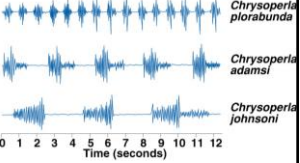


Blue footed boobies mate only after a courtship display unique to their species

sympatric speciation?


Recognizing your own species...

courtship songs of sympatric species of lacewings





Time (seconds)

courtship display of Gray-Crowned Cranes, Kenya




firefly courtship displays



Mechanical Isolation

Even in closely related species of plants, the flowers often have distinct appearances that attract different pollinators. These 2 species of monkey flower differ greatly in shape & color, therefore cross-pollination does not happen.

Plants



sympatric speciation?

Mechanical Isolation

Animals

- For many insects, male & female sex organs of closely related species do not fit together, preventing sperm transfer
- lack of "fit" between sexual organs: hard to imagine for us... but a big issue for insects with different shaped genitals!



Damselfly penises

Gametic Isolation


sympatric speciation?

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

Sea urchins release sperm & eggs into surrounding waters where they fuse & form zygotes. Gametes of different species are unable to fuse.

Post-reproduction Barriers

- Prevent hybrid offspring from developing into a viable, fertile adult
 - reduced hybrid viability
 - reduced hybrid fertility
 - hybrid breakdown




zebroid

Reduced Hybrid Viability

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

Different species of salamander genus, *Ensatina*, may interbreed, but most hybrids do not complete development & those that do are frail.




sympatric speciation?

Reduced Hybrid Fertility

$\begin{matrix} XX \\ XX \\ XX \\ XX \\ X \end{matrix}$

- 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

Horses have 64 chromosomes (32 pairs)

Mules have 63 chromosomes!


Donkeys have 62 chromosomes (31 pairs)

Hybrid Breakdown

sympatric speciation?

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

In strains of cultivated rice, hybrids are vigorous but plants in next generation are small & sterile. 'Parents' on path to separate species.



Rate of Speciation

▪ **Current debate:**

Does speciation happen gradually or rapidly?

◆ **Gradualism**

- Charles Darwin
- Charles Lyell

◆ **Punctuated equilibrium**

- Stephen Jay Gould
- Niles Eldredge

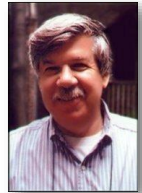


Niles Eldredge
Curator
American Museum
of Natural History

Stephen Jay Gould (1941-2002)

▪ Harvard paleontologist & evolutionary biologist

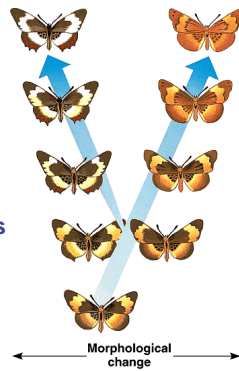
- ◆ punctuated equilibrium
- ◆ prolific author
- popularized evolutionary thought



Gradualism

▪ Gradual divergence over long spans of time

- ◆ assume that big changes occur as the accumulation of many small ones

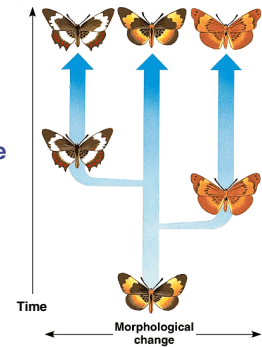


(a) Gradualism model

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



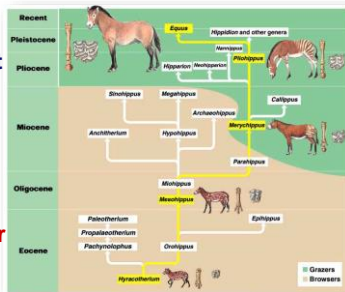
(b) Punctuated equilibrium model

Evolution is not goal-oriented!

An evolutionary **trend** does **not** mean that evolution is **goal-oriented**.

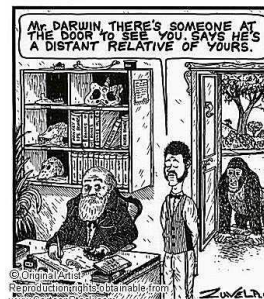
Surviving species do NOT represent the peak of perfection. There is compromise & random chance involved as well

Remember that for humans as well!



Any Questions??

Excerpt from "Why Darwin Matters"



In the legendary debate over evolution at Oxford University in June 1860, Archbishop Samuel Wilberforce sardonically inquired of his debate opponent, Thomas Henry Huxley ("Darwin's Bulldog"), whether he was descended from an ape on his grandfather's or grandmother's side. The legend of the debate is that Huxley followed with his stinging rejoinder: "If question is put to me: Would I rather have a miserable ape for a grandfather or a man highly endowed by nature and possessed of great means of influence and yet who employs these faculties and that influence for the mere purpose of introducing ridicule into a grave scientific discussion, I unhesitatingly affirm my preference for the ape."

