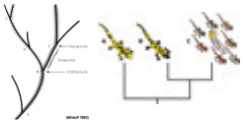
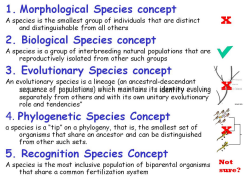
WEDNESDAY

- Species concepts (7 covered)
- Test cases





TODAY

- Rates of Speciation
- Patterns of speciation
- Types of speciation
- Test cases

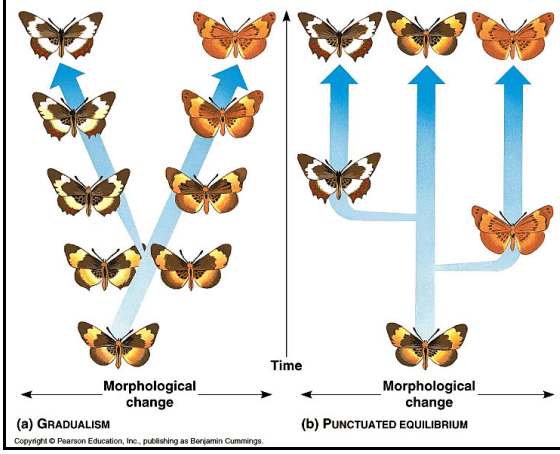
Rates of Speciation

Gradual- speciation takes place over long periods of time by the gradual accumulation of many small changes. This is thought to be the norm for most speciation events

Punctuated- speciation takes place very rapidly and then there are long periods of stasis.

fossil record – "sudden" appearance of new forms – little subsequent change

- rapid morphological evolution
- environment may shift back and forth



African cichlid fishes are a remarkable case of "explosive speciation."
Geology and geography plays an important role. African rift lakes: great fresh-water lakes in east Africa. Formed recently: < 1 million years old. Lake Victoria colonized by one (??) founder 200,000 years ago(??) now has ~ 200 species of fish!.

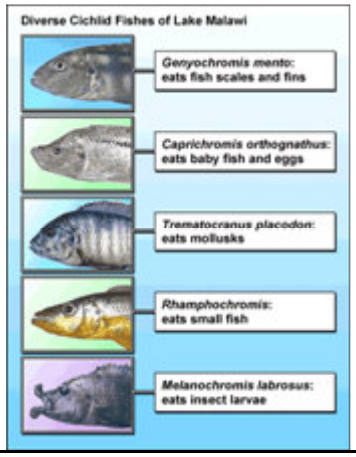
mitochondrial DNA to show that the species in the lake are indeed **monophyletic** (one common ancestor – a clade) and that there is very little sequence divergence between species: confirms short time span.

<u>But</u> there has been remarkable evolution of morphological, ecological and behavioral variation in these fish: All this diversity in 200,000 years with very little genetic differentiation.

Adaptive radiation
one ancestral species many descendant species

Do groups diversify at similar rates? NO

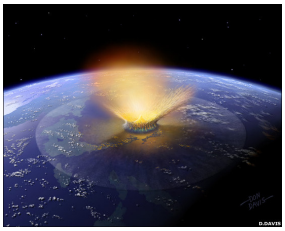
Jaw morphology - has adapted to take advantage of feeding in different ecological niche's



Rates of Speciation…

So, the rates of speciation might be slow or rapid. The rates of **extinction** can be instantaneous, rapid or slow. In cases were certain organisms only have a slight statistical disadvantage, they will eventually lose out and extinction will be slow.

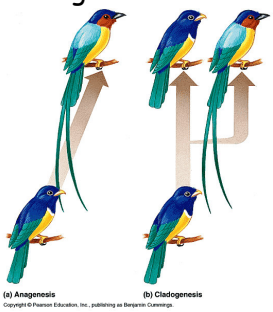
Instantaneous extinction



Rapid extinction

Patterns of Speciation

1. Cladogenesis
2. Anagenesis



Types of Speciation

How do populations become distinct species?

Lack of gene flow and natural selection.

Gene flow is most often cut off by geographic isolation.

Allopatric speciation (with geographic isolation)

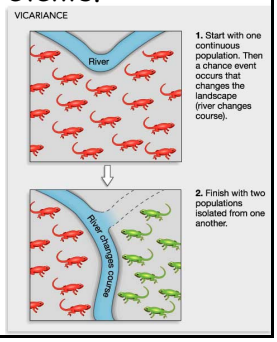
When gene flow is cut off by other factors (non geographical) then:

Non-allopatric speciation (without geographic isolation). There are three types:

Sympatric speciation, Parapatric speciation, Peripatric speciation

Allopatric speciation is dependent on a Vicariant event – This is an event that splits the range of an existing species. These are typically geological events.

- e.g. the formation of glaciers during the ice ages, which divided the ranges of species into smaller areas isolated by glaciers
- others: continental drift, tropics, oceans, sea level changes etc



Allopatric speciation process

Once the physical barrier is formed, gene flow ceases among the members of the allopatric population. Once reproductively isolated, the two populations may diverge genetically through the process of:

(1) natural selection
(2) mutation
(3) genetic drift

As a result of accumulated genetic differences, additional distinguishable morphological and physiological differences may arise, eventually resulting in speciation.

Forms of evidence from nature to support *allopatric vicariant* speciation (in order from strongest to weakest; Coyne & Orr 2004):

1. Geographic concordance of species borders with existing geographic or climatic barriers

2. Allopatry of young sister species

3. Geographic coincidence of species borders or hybrid zones among different taxa in the absence of ecological boundaries

Forms of evidence from nature to support *allopatric vicariant* speciation (in order from strongest to weakest…

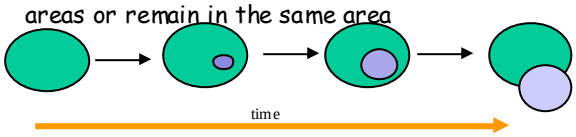
4. Absence of sister species where geographic isolation was unlikely

5. Concordance between present and past geographic barriers with genetic discontinuities within species

6. The increase of reproductive isolation with geographic distance between populations ("clinal isolation")

Non-allopatric (without geographic isolation) divergence with gene flow:

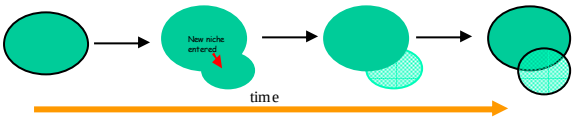
- **Sympatric** - sister species (most closely related species) evolve without preceding geographical isolation, and occurs within the dispersal distance of individuals of a single generation.
- Species may subsequently occupy different areas or remain in the same area



Non-allopatric (without geographic isolation) divergence with gene flow

- **Parapatric** - sister species evolve in segregated habitats across a narrow contact zone

- adaptive responses to different local selection pressures initiate differentiation.
- Divergence proceeds along a spatial (ecological) cline. Reproductive isolation emerges in primary contact.

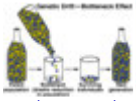


Evidence from nature to support *parapatric speciation* (Coyne & Orr 2004):

1. A pair of closely related species with adjacent distributions
2. Multiple pairs of related species with adjacent distributions particularly at an ecotone (a transition area between two adjacent ecosystems)
3. Morphological or genetic discontinuities at ecotones within species
4. Observations of all stages of parapatric speciation in nature
5. Biogeographic and phylogenetic patterns implying repeated parapatric speciation in a small clade
6. Historical observation of speciation in parapatry

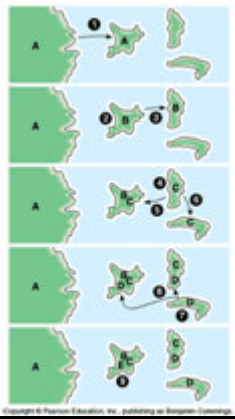
Peripatric speciation

Occurs when small subpopulations settle in new habitats along the periphery of a species' range. Divergence may be particularly fast due to strong genetic drift, and adaptation to the new environments (Natural Selection).

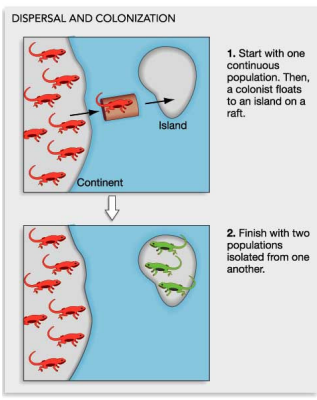


Forms of evidence from nature to support *peripatric speciation*

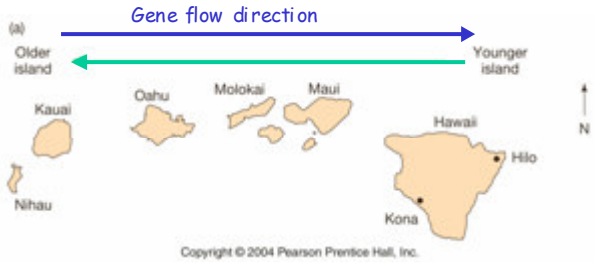
1. Speciation on single oceanic islands
2. Speciation on archipelagos
3. Speciation in peripheral isolates of continental distributions



- **Founder effect** - small population (peripheral) becomes geographically isolated and then reproductively isolated via inbreeding, selection, drift



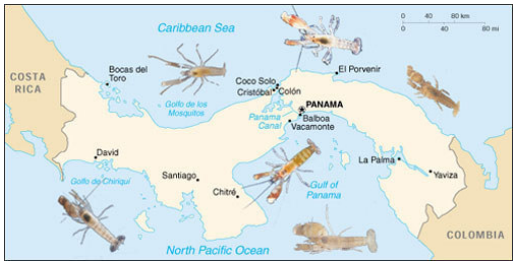
Peripatric speciation on islands



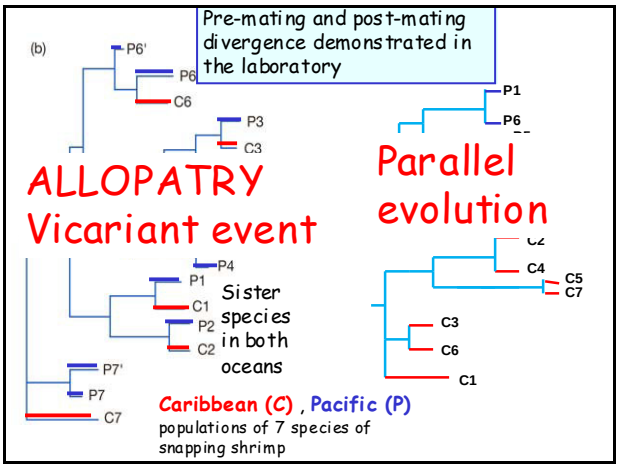
1) closely related species on adjacent islands
2) phylogenetic relations correspond to the manner in which the islands were formed

TEST CASES: Snapping shrimp

The Isthmus of Panama arose some 3 million years ago. Populations of snapping shrimp divided by the Isthmus have diverged into separate species.



Phylogenetic analysis and common garden experiments



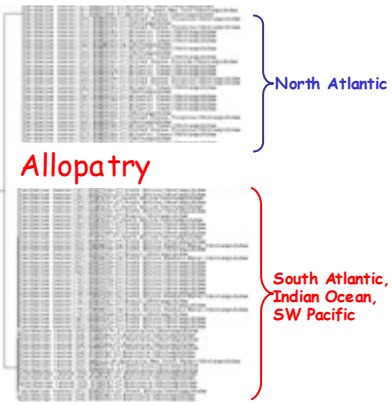
Ragged tooth Shark

Australian Shark and Ray Project

Ragged tooth Shark

Carcharias taurus

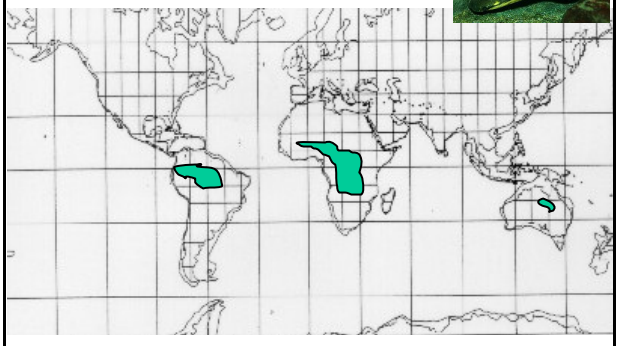
c. 1.9% COI mtDNA divergence between northern and southern populations



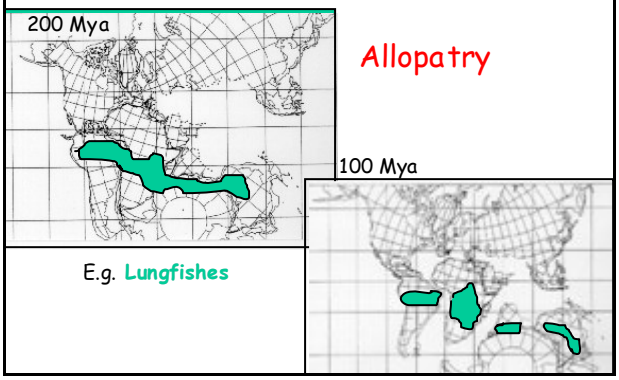
Vicariance: Continental drift and Glaciations

Present Day

E.g. **Lungfishes**

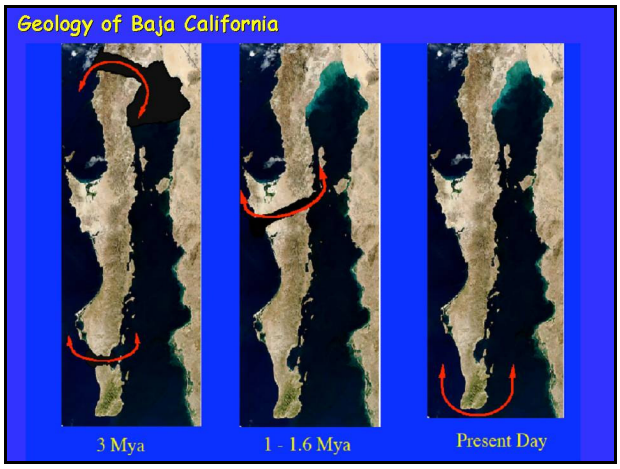


Vicariant events: Continental drift and Glaciations



Allopatry

E.g. Lungfishes

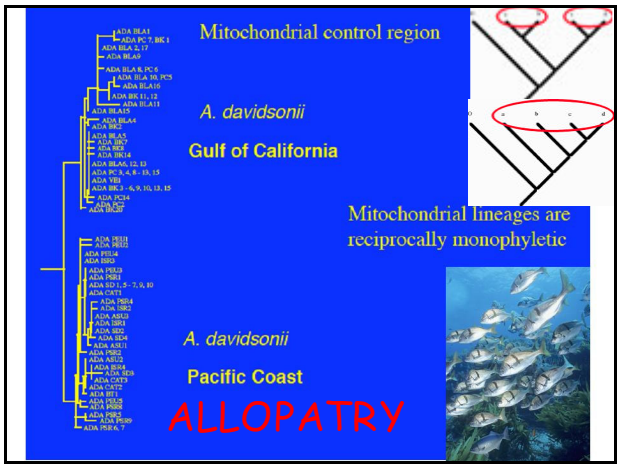


Baja California, Mexico

Disjunct fishes

Vicariance?

Grunter
Anisotremus davidsonii



Grunts (Haemulidae)

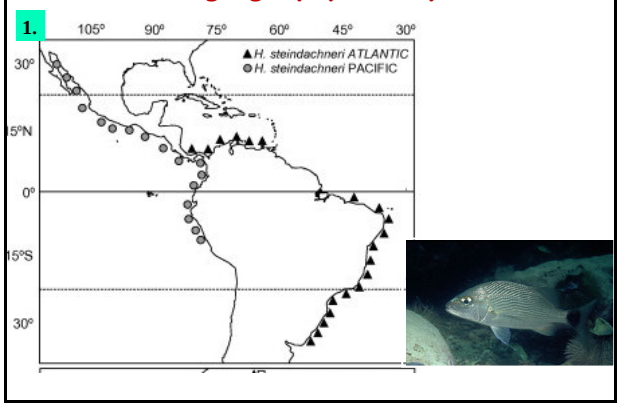
Fifteen species of *Haemulon* are found in the western Atlantic, and five in the eastern Pacific with one nominally shared by both regions

- Are these cases of speciation without geographical isolation (sympatric speciation)?

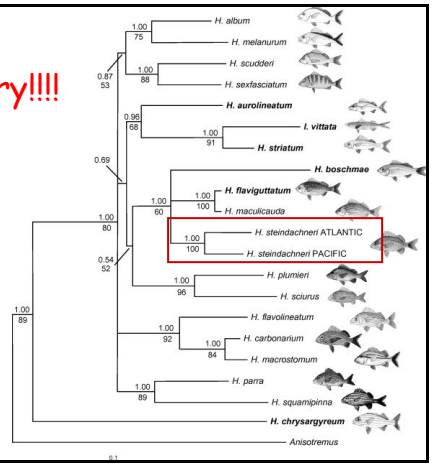
- Do different components of the species pairs occupy different ecological niches?

- Are there biological characters among the species of *Haemulon* that facilitate sympatric speciation?

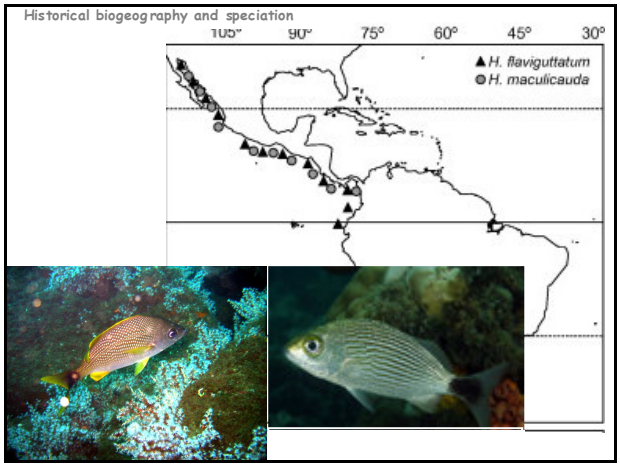
Historical biogeography and speciation



Allopatry!!!!



Historical biogeography and speciation

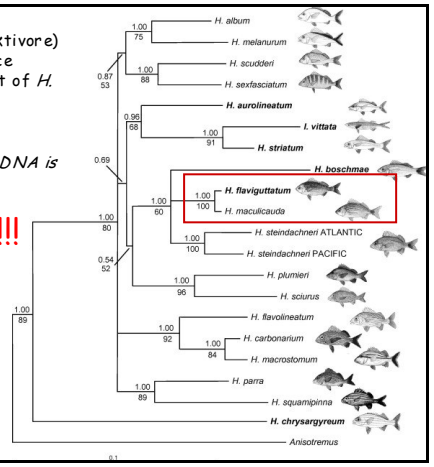


H. Flaviguttatum (planktivore) has an mtDNA sequence almost identical to that of *H. maculicauda* (benthic predator)

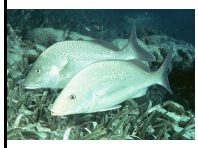
whereas their nuclear DNA is very different

Sympatry!!!!

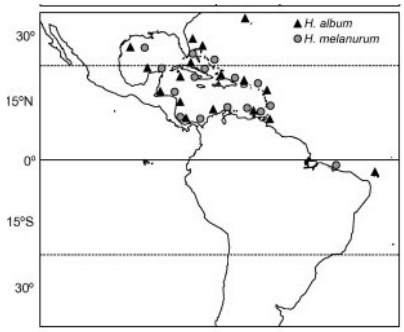
An ancient divergence combined with a more recent transfer of mtDNA from one species to the other via an introgressive hybridization event



H. melanurum



H. album

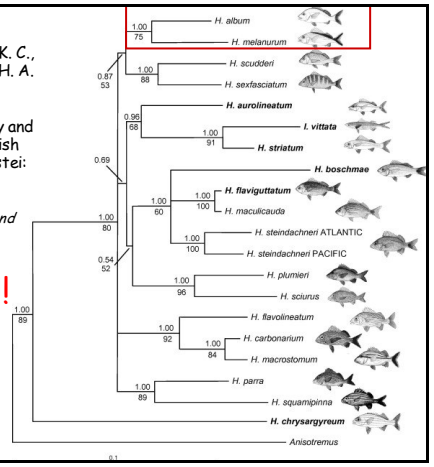


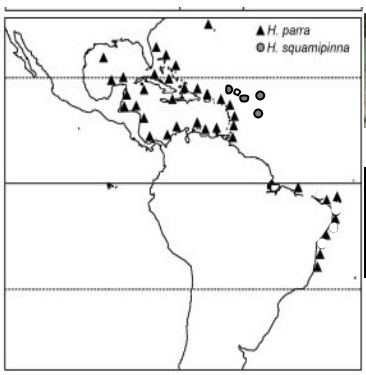
Rocha, L. A., Lindeman, K. C., Rocha, C. R., & Lessios, H. A. (2008).

Historical biogeography and speciation in the reef fish genus *Haemulon* (Teleostei: Haemulidae).

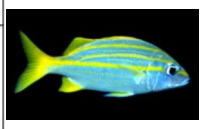
Molecular Phylogenetics and Evolution **In Press, Corrected Proof**.

Sympatry!!!!





H. parra



H. squamipinnus

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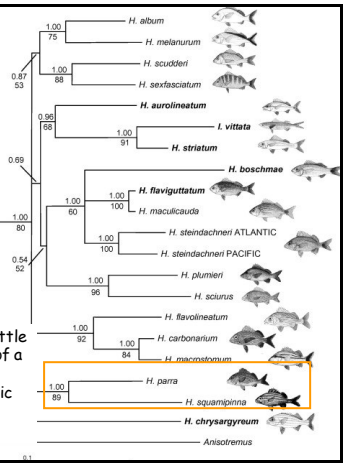

Peripatry!!!!

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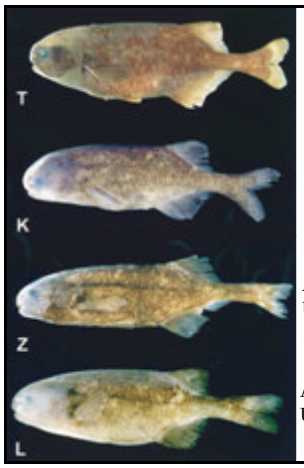
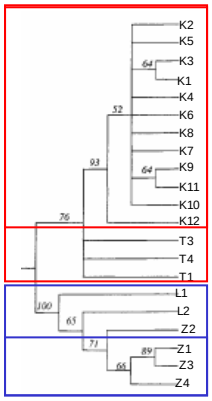


At present only known from the Lower Zambezi River

At present only known from the Middle/lower Zambezi River

At present only known from the Upper/middle Zambezi River

At present only known from the Upper Zambezi River



Parapatry!!!!

sister species evolve in segregated habitats across a narrow contact zone