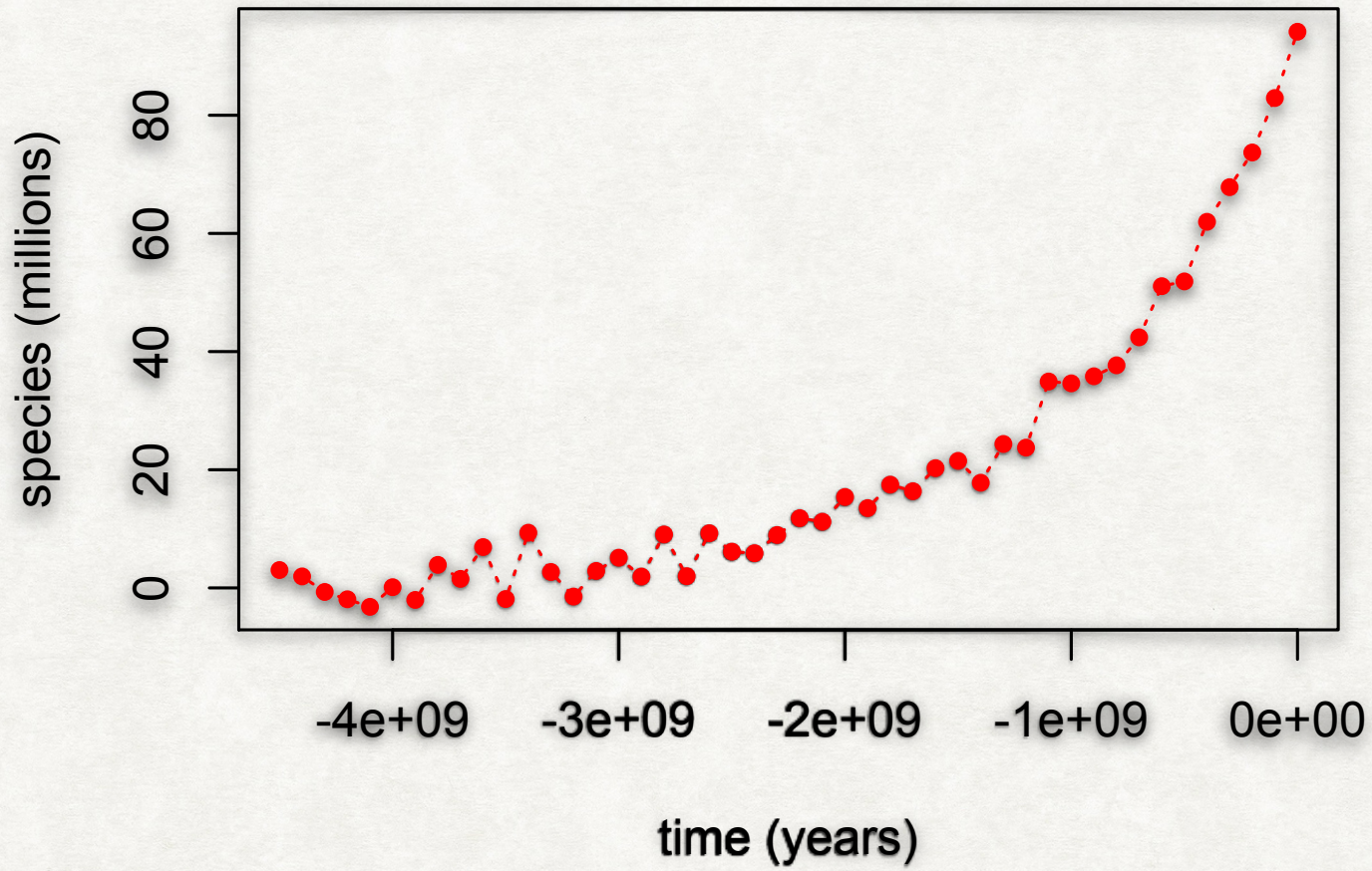
MACROEVOLUTION: THE HISTORY OF LIFE ON EARTH

WHAT PROCESSES SHAPE LIFE ON EARTH?



Note: this is just hypothetical, we don't know the true time course of biodiversity!

PROCESSES DRIVING MACROEVOLUTION

- Change in total number of species on earth (*dN)*:

  $dN = \alpha + \Omega$

  - Alpha (α) is the rate of speciation
  - Omega (Ω) is the rate of extinction

- Total number of species within a fixed area:

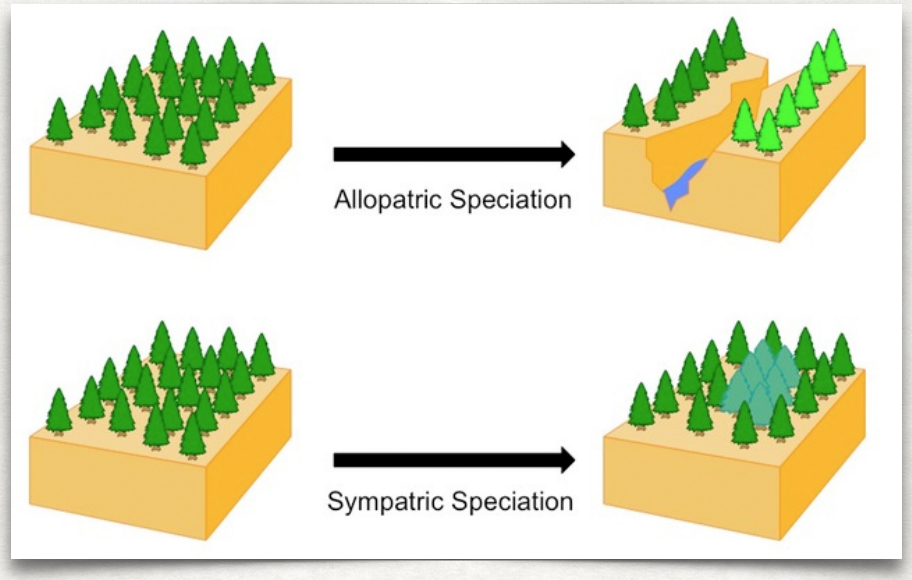
  $dN = (\alpha + I) - (\Omega + E)$

  - *I* is the rate of immigration
  - *E* is the rate of extinction
  - Since we assume there are no aliens, *I* and *E* don't matter for global biodiversity

WHAT PROCESSES CAN GENERATE NEW SPECIES?

- Allopatric speciation: a geographic barrier to gene flow is created (e.g., continental drift results in isolated populations). Over time, the distinct populations become unable to interbreed due to accumulated genetic differences

- Sympatric speciation: a new species is formed *in situ*, i.e. without a physical barrier to gene flow. How can this happen?

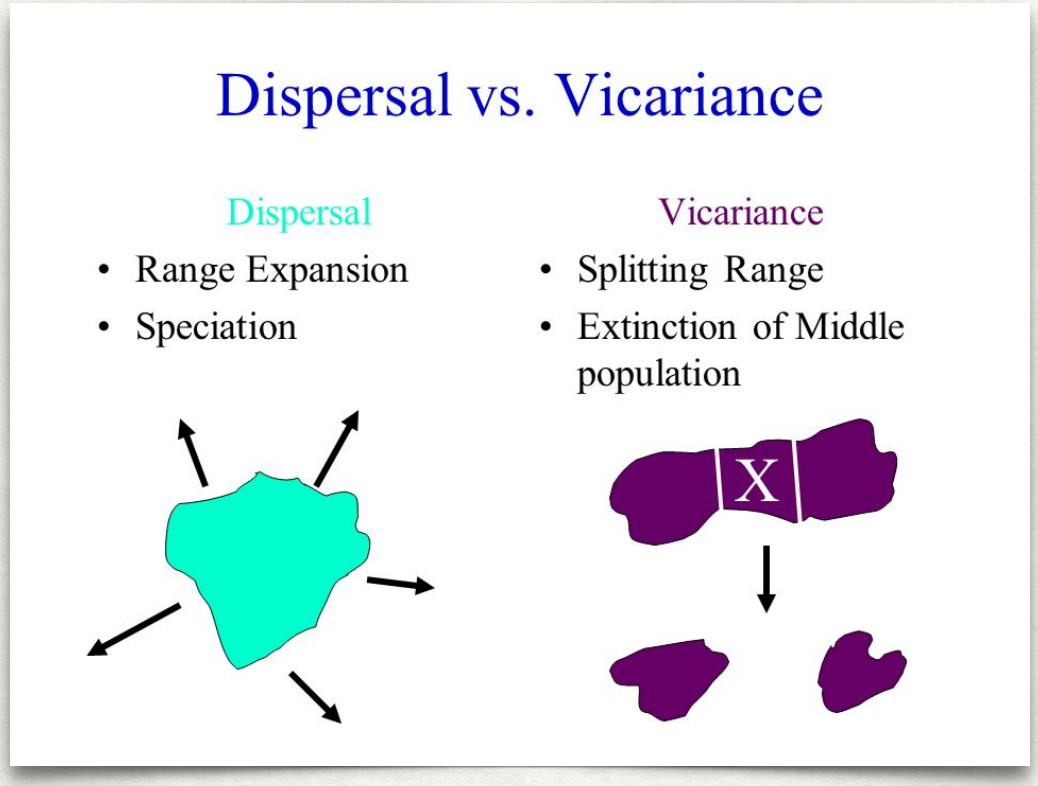


ALLOPATRIC SPECIATION

- Physical barriers to gene flow may include
  - Oceans
  - Rivers
  - Mountains
  - Deserts
  - Sea level change
- ***Suggests that studying the geological processes that drive changes in environment could help explain the geographic distribution of species***

ALLOPATRIC SPECIATION

- Physical barriers may arise in place (i.e., without requiring a species to move, sometimes called *vicariant* speciation) or may arise after *dispersal (*i.e., movement to a new location)



THINK-PAIR-SHARE: VICARIANCE & DISPERSAL

- Consider a species that is initially isolated to a single large island. A subset of individuals migrate to a relatively distant island off the coast and form a new population (population A). Meanwhile, the sea level rise causes the first island to split into 2 islands (populations B & C).
    - Consider population A and population B. What processes might affect the rate of evolutionary change in these populations as compared to population C? (*Hint: consider how the environment might differ for each species)*

ENVIRONMENTAL INTERACTIONS

- ***Abiotic*** interactions may affect species distributions, including:
    - Temperature
    - Rainfall
    - Fire regime
- ***Biotic*** interactions may also affect species success through
    - Competition
    - Mutualism
    - Facilitation
    - Parasitism
    - Predation

WHEN ENVIRONMENT IS CONSERVED, SO IS SPECIES MORPHOLOGY

- *Hypothesis:* when the environment is unchanged, a well-adapted species is unlikely to substantially change

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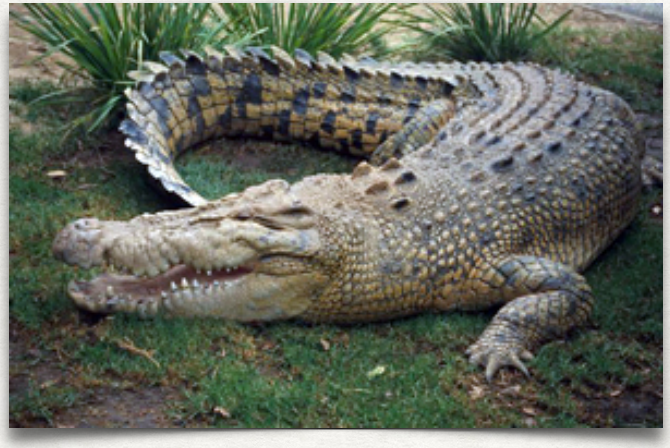

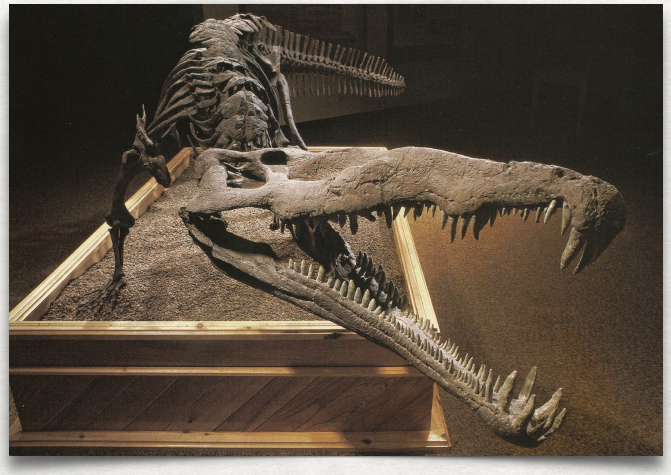

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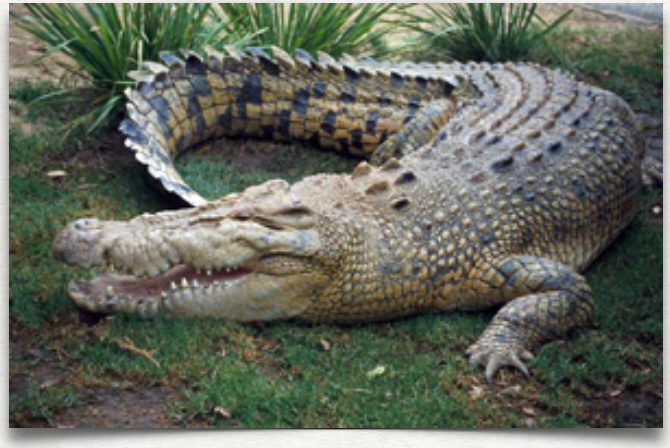

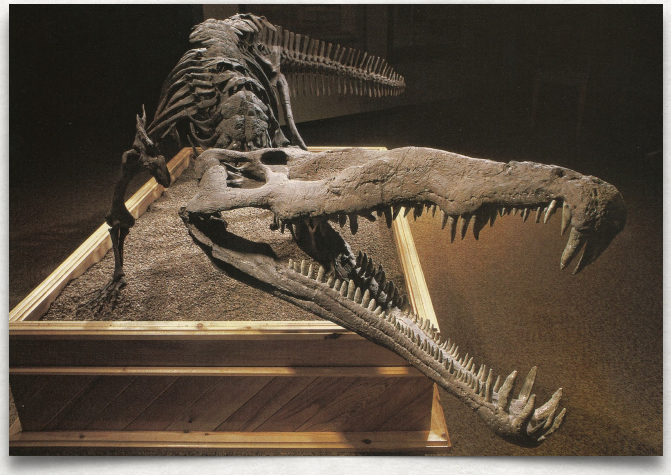

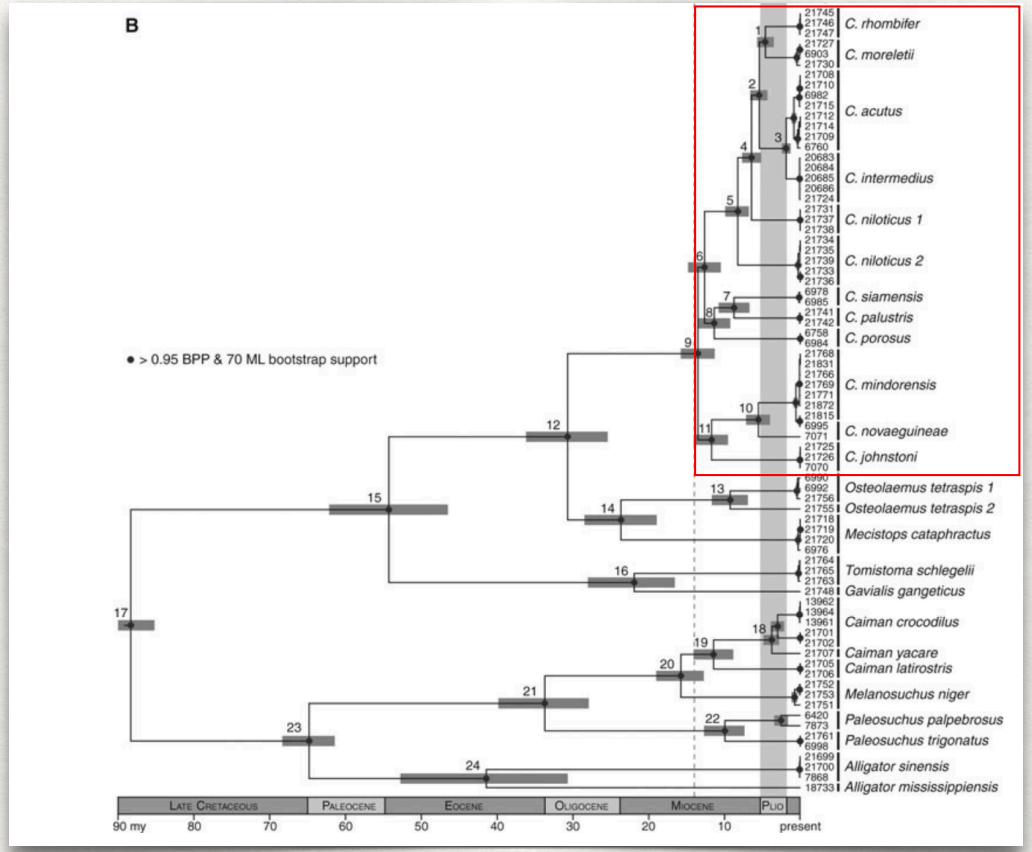

Oaks, *Evolution* (2011)

WHEN ENVIRONMENT IS CONSERVED, SO IS SPECIES MORPHOLOGY

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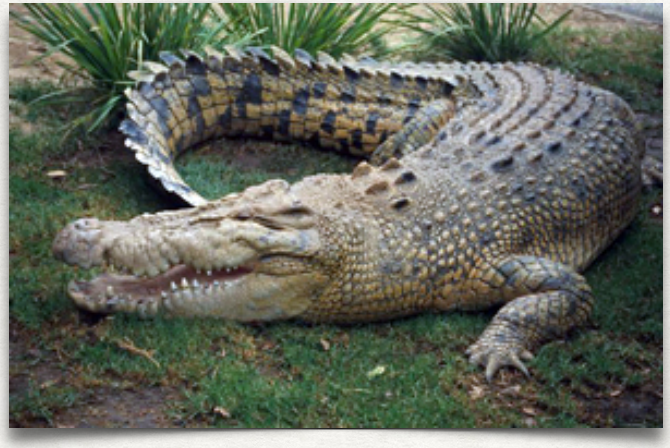

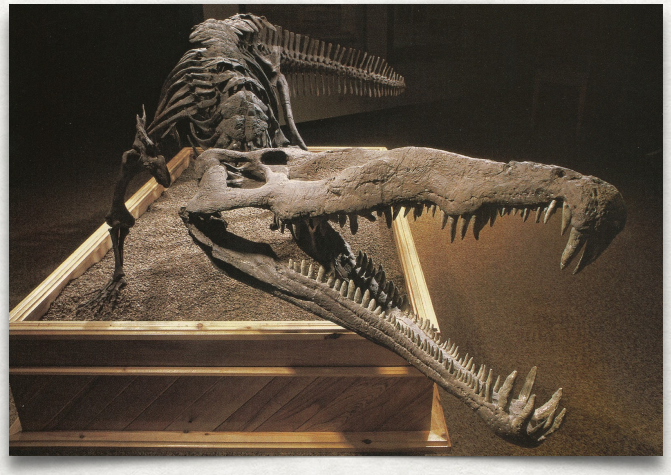

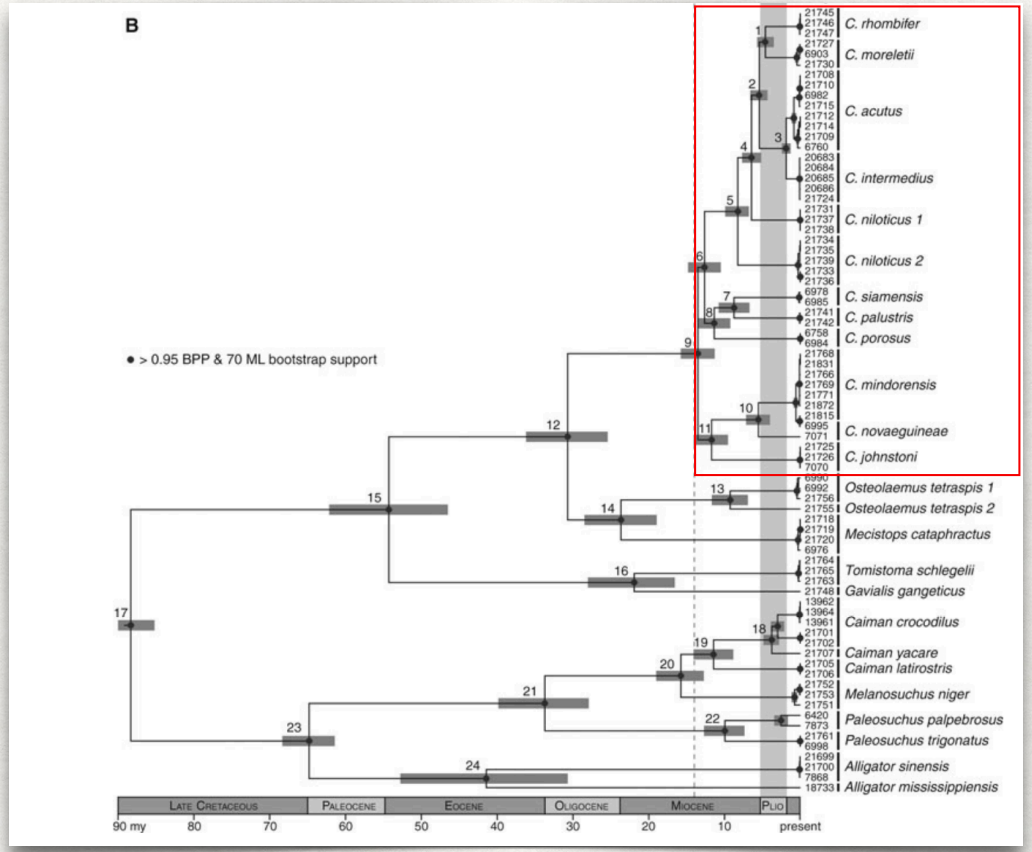

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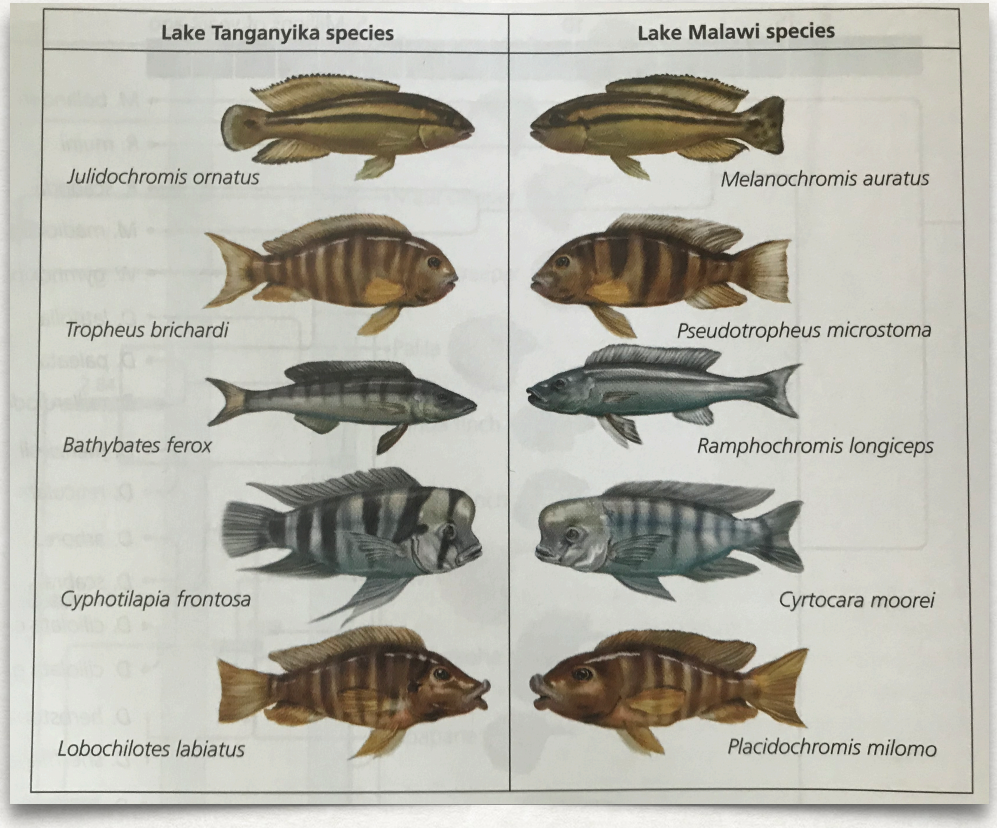
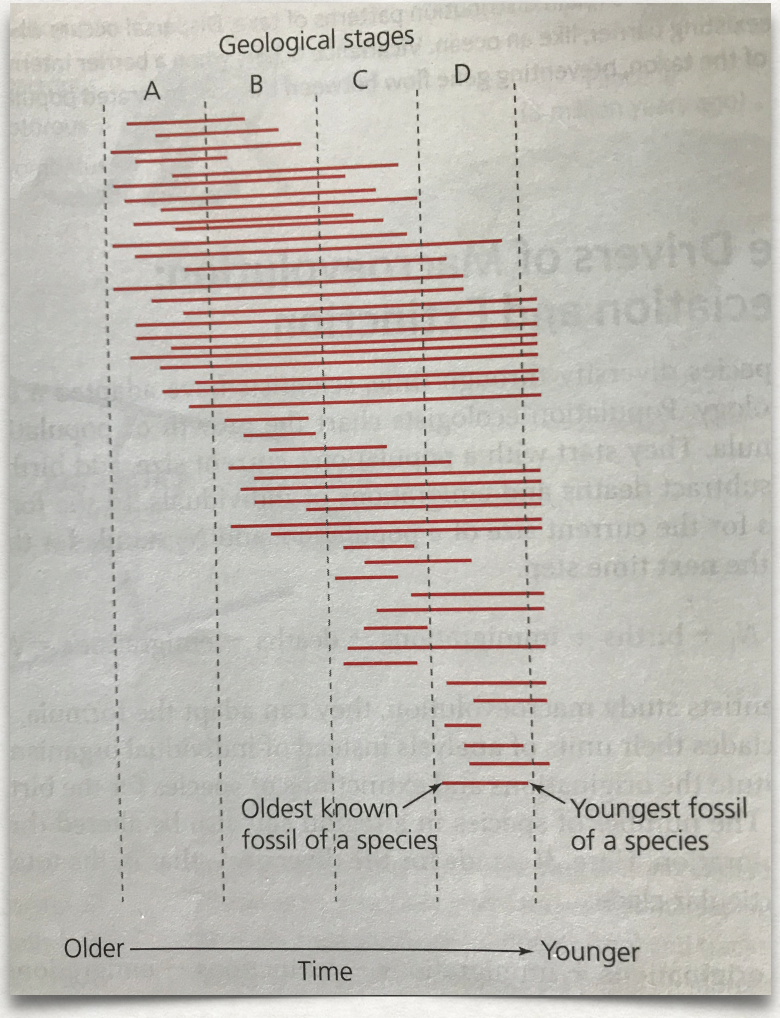
WHEN ENVIRONMENT IS CONSERVED, SO IS SPECIES MORPHOLOGY

- *Hypothesis:* when a species moves into a similar climate with unoccupied niches, it will diversify to fill the unoccupied niches



Zimmer & Emlen, Chapter 14

WHAT PATTERNS EXIST IN THE FOSSIL RECORD?



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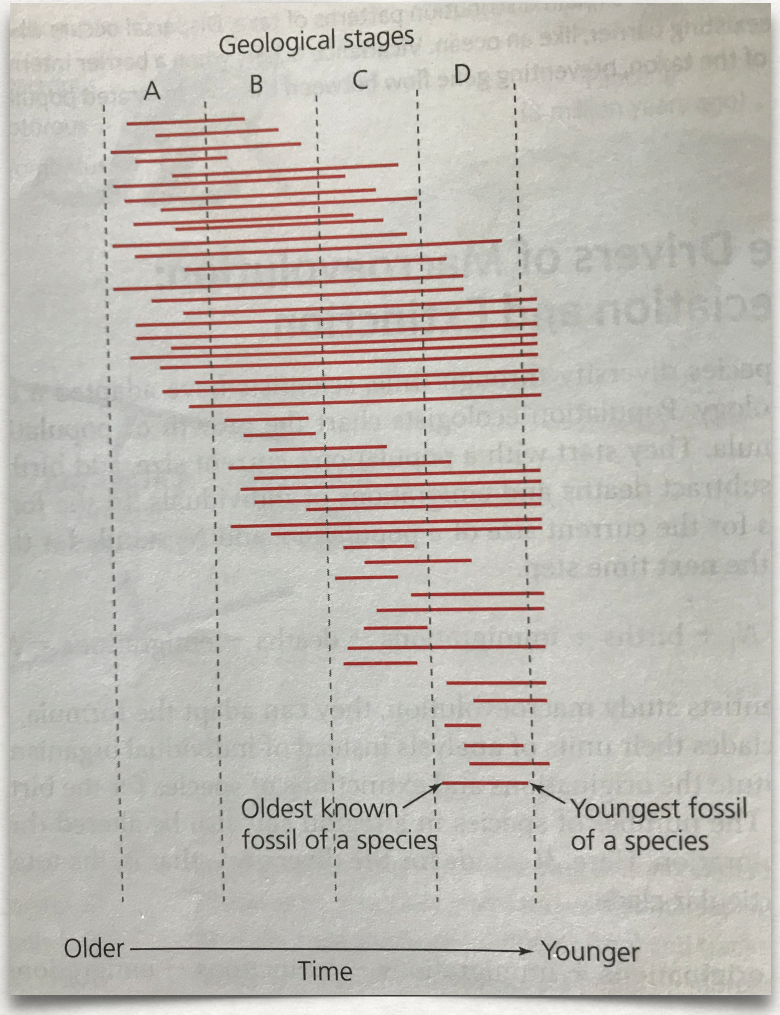

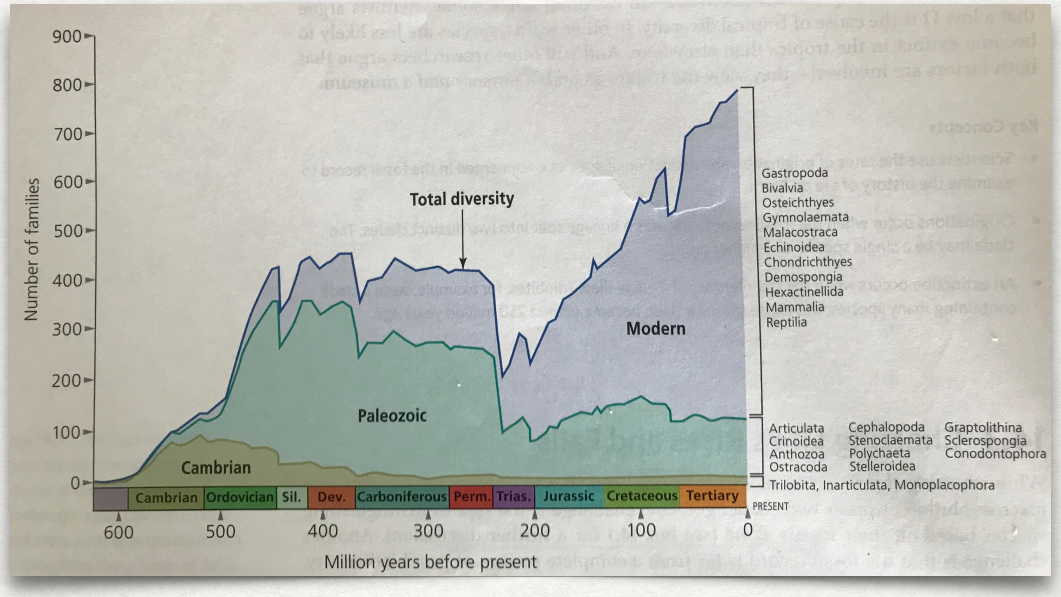

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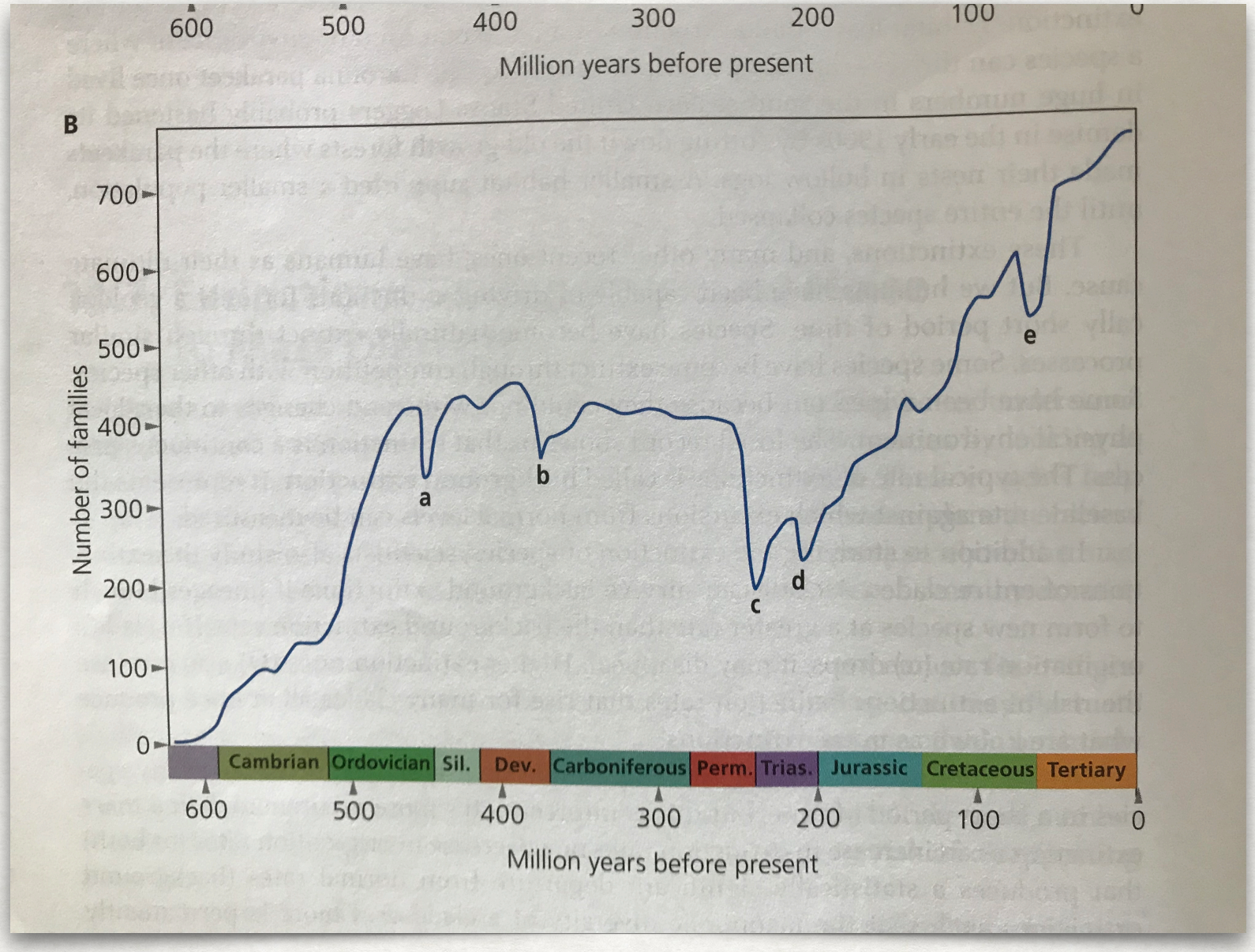
ENVIRONMENTAL CHANGES & MASS EXTINCTIONS



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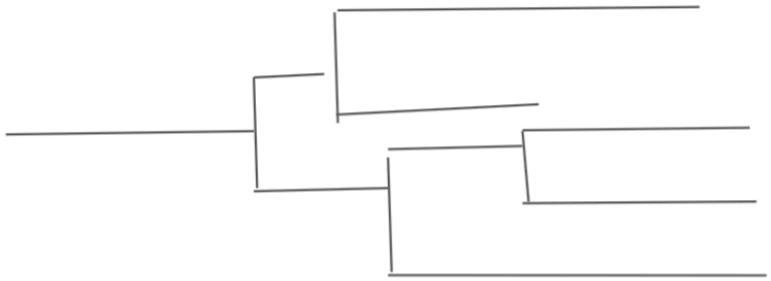
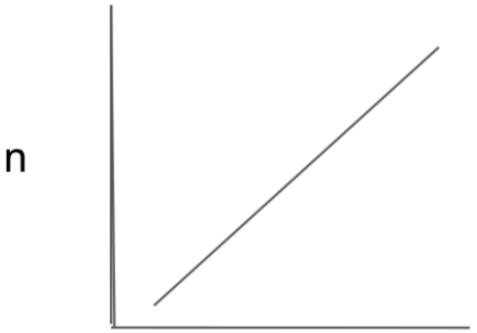
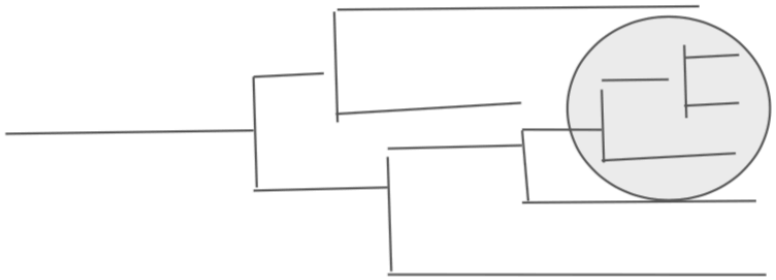
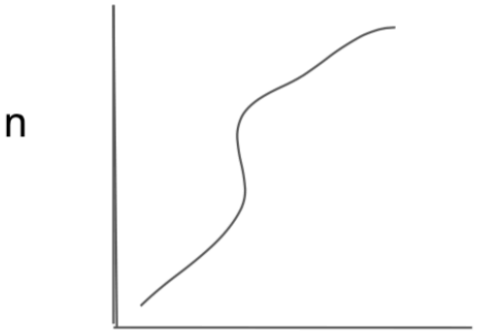
No rate change



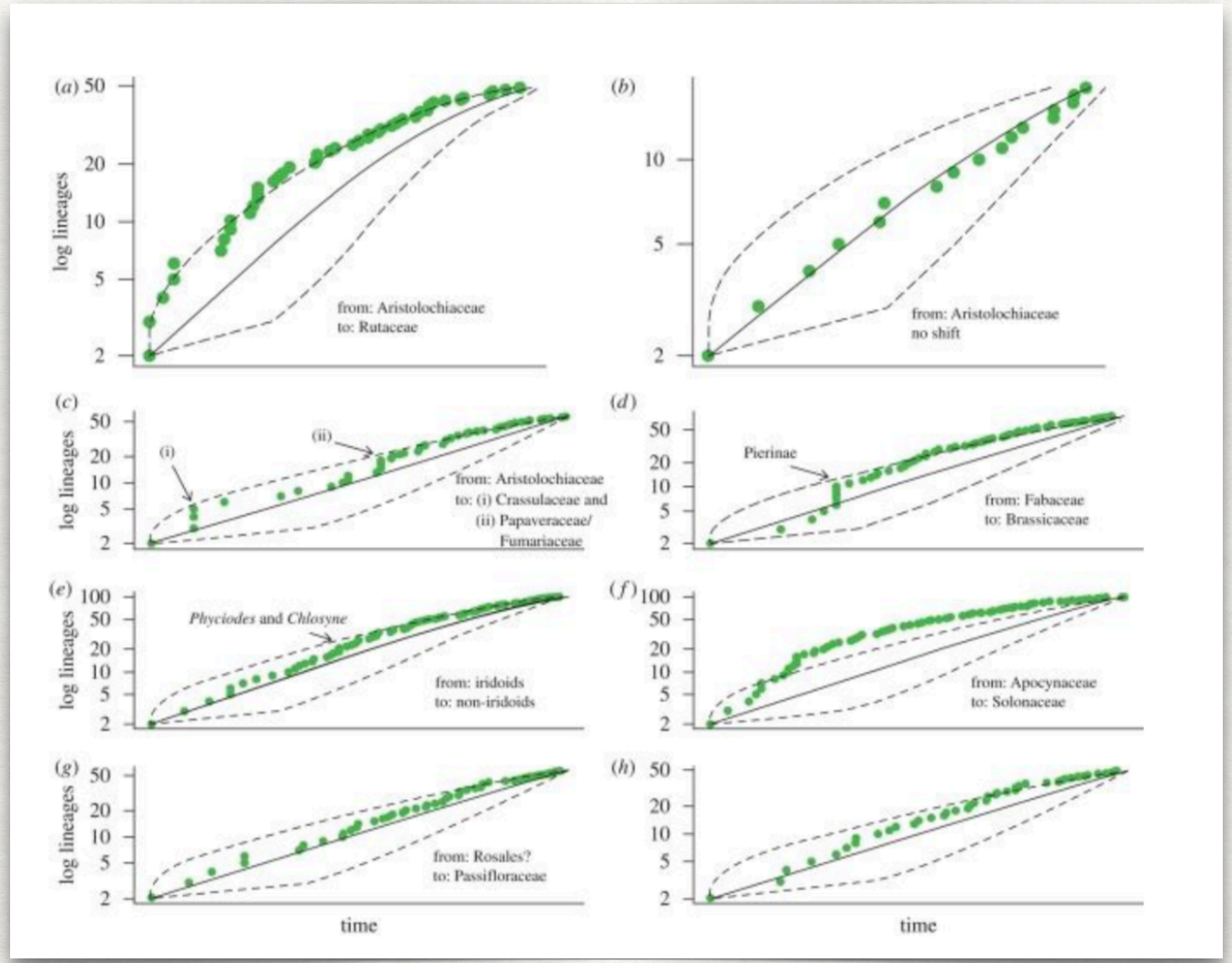


Rate change





MOLECULAR EVIDENCE FOR RADIATIONS



Fordyce, *Proc B*, 2010