Chapter 17: *Speciation and Macroevolution*

Big Idea 1: The process of evolution drives the diversity and unity of life.

17.1 How New Species Evolve

- macroevolution - large-scale evolution
- same processes as microevolution, different scale

What is a species?

- Linnaeus - birds and bats together because they have wings and fly
- now - different species concepts

http://upload.wikimedia.org/wikipedia/commons/2/25/Flickr_-_ggallice_-_Pitcher_plant,_Sarracenia_purpurea,_Cranberry_Glades,_Round_Glade.jpg

Species Concepts

Morphological Species Concept - Linnaeus

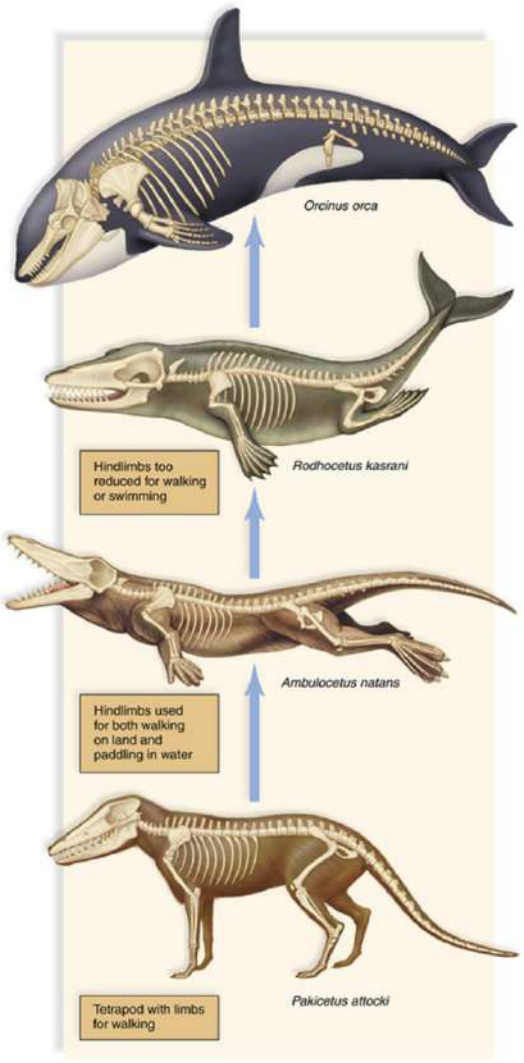
- defined by one or more distinct physical characteristics - diagnostic trait
- lack of measurable traits
- subtle differences
- cryptic species - look similar, but differ in behavioral characteristics
- fossils can't show soft tissue differences

Figure 3A: Northern Leopard Frog (*Rana pipiens*)

Figure 3B: Southern Leopard Frog (*Rana* [illegible]) http://www.explorecuriocity.org/Portals/2/Themes/Biotechnology/classification3b.jpg

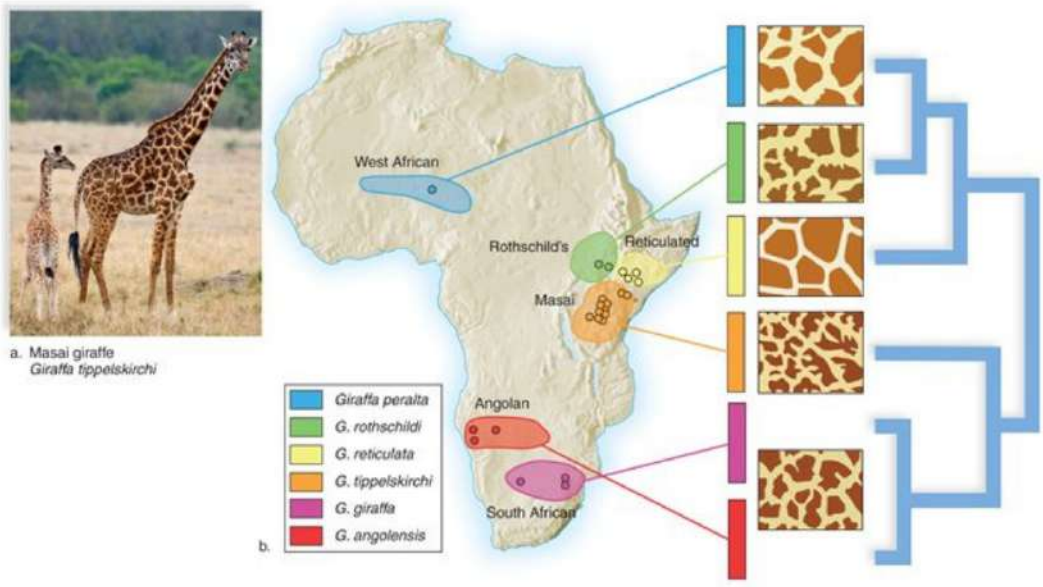
Evolutionary Species Concept

- explain speciation in fossil record
- uses morphological diagnostic traits
- members of a species share an evolutionary pathway - including transitional forms



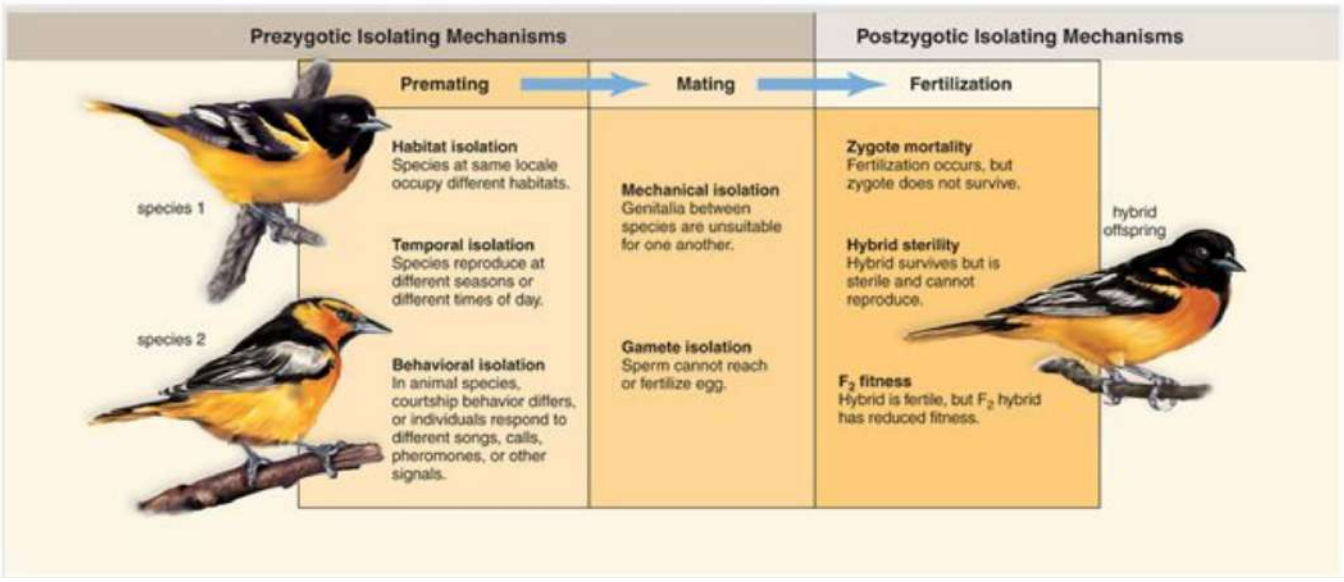
Phylogenetic Species Concept

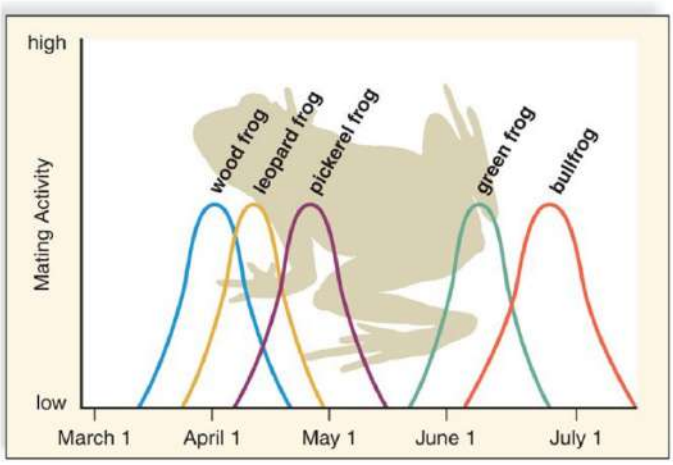
- phylogeny is used to identify species based on a common ancestor
- species is the smallest subset of interbreeding orgs that shares a common ancestor
- monophyly is main criteria (branch containing all descendants of common ancestor)
- does not rely on morphology alone; can use nucleotide seq.

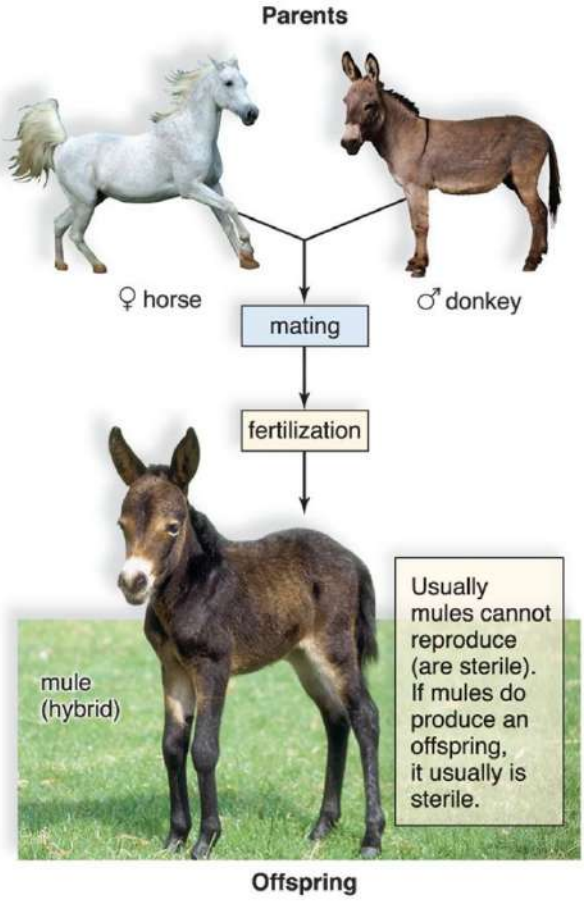


Biological Species Concept

- reproductive isolation - physiological, behavioral and genetic processes that inhibit interbreeding
- if orgs cannot mate and produce fertile offspring in nature, they are diff species
- cannot always be tested
- cannot be applied to asexual orgs or fossils
- can confirm lack of gene flow




high
Mating Activity
low
wood frog
leopard frog
pickerel frog
green frog
bullfrog
March 1
April 1
May 1
June 1
July 1

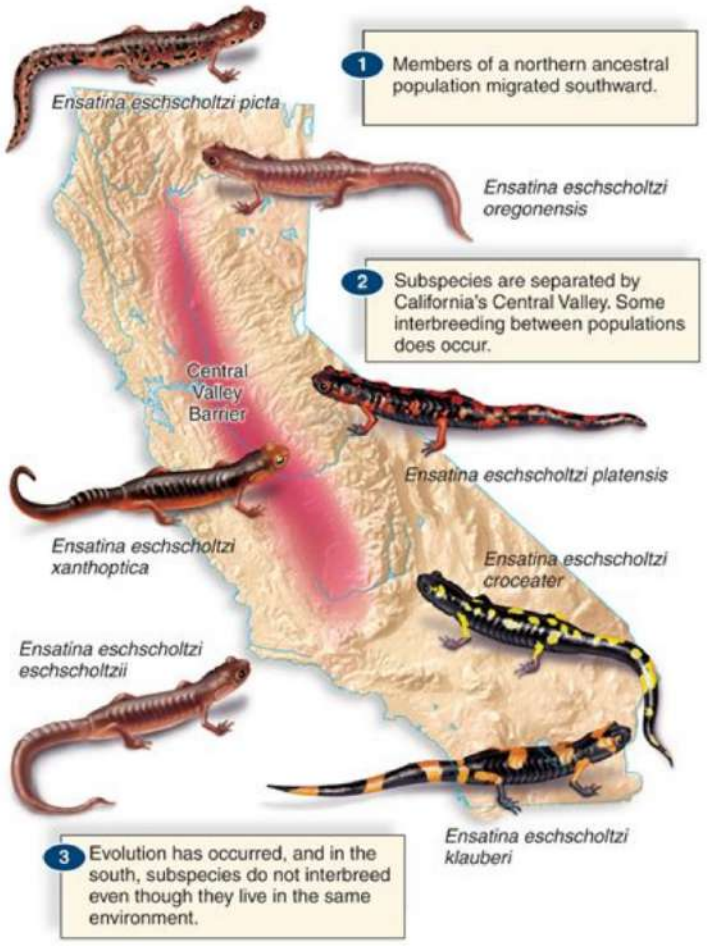

Parents
♀ horse
♂ donkey
mating
fertilization
mule
(hybrid)
Usually mules cannot reproduce (are sterile). If mules do produce an offspring, it usually is sterile.
Offspring

17-2 Modes of Speciation

- speciation - splitting of one species into 2 or more
  - or, transformation of species into new species

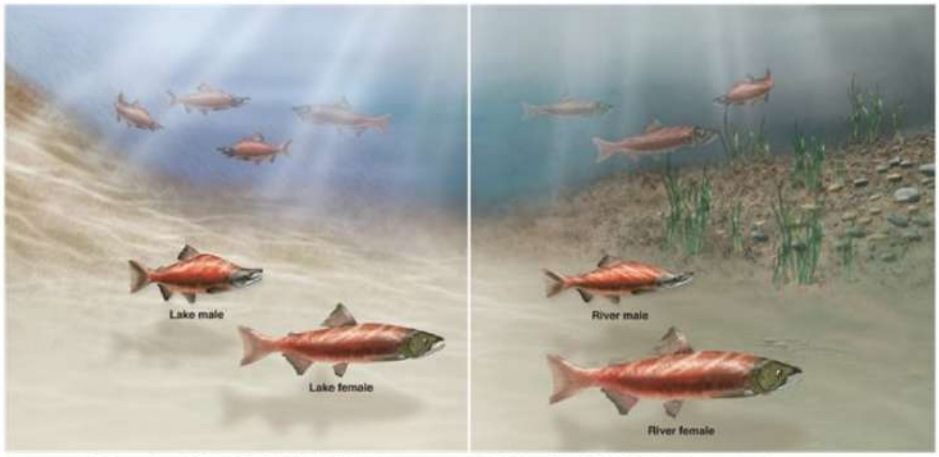
Allopatric Speciation

- Ernst Mayr - biological species concept and allopatric speciation
- result of populations being separated by geographic/physical boundary
- after separation, microevol processes alter gene pool independently
- repro isolation can occur



Example 2

- sockeye salmon
- introduced to Lake Washington; some migrated to Pleasure Point Beach and others to Cedar River
- differ in size and shape
- river males slender for turning in current as part of mating ritual; river females larger for digging deeper nest (eggs avoid current and stay warm)
- reproductively isolated even though both fish can go to either location



a. Sockeye salmon at Pleasure Point Beach, Lake Washington

b. Sockeye salmon in Cedar River. The river connects with Lake Washington.

Reinforcement of Reproductive Isolation

- as repro isolation occurs, postzygotic isolating mech may occur before prezygotic (ex: hybrid sterility)
- natural selection favors a variation that would prevent production of a hybrid in the first place
- reinforcement occurs when populations that were the same species no longer view each other as mates after speciation

http://1.bp.blogspot.com/-A2FM8_iSdik/UJaKYLPACAI/AAAAAAAAS0o/zscNDRoGc4w/s400/CollaredFlycatcher.jpg

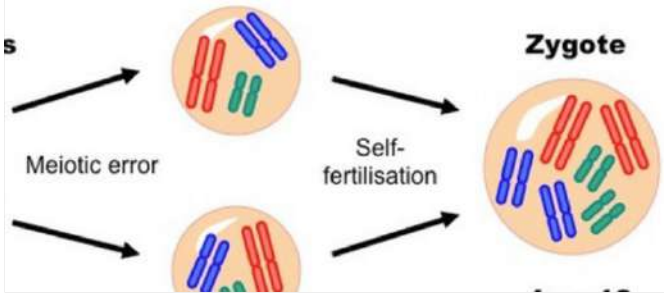
http://ichef.bbci.co.uk/naturelibrary/images/ic/credit/640x395/e/eu/european_pied_flycatcher/european_pied_flycatcher_1.jpg

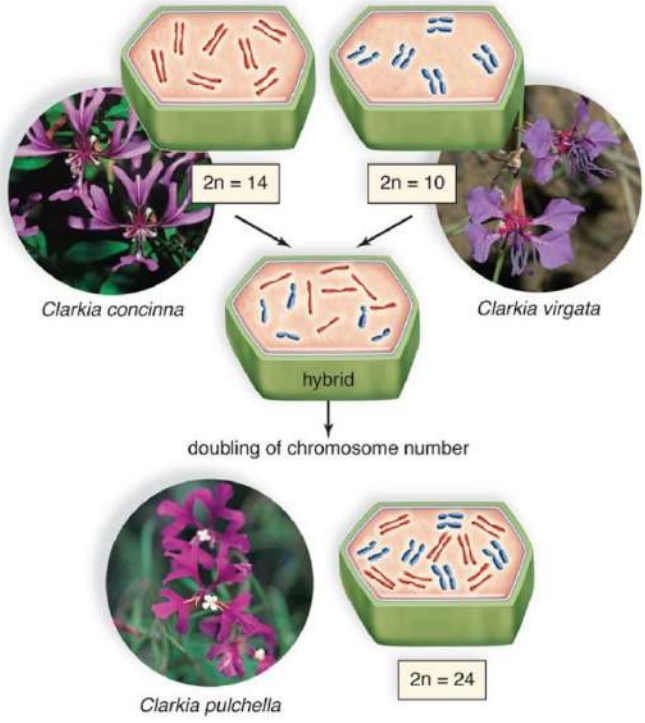
Sympatric Speciation

- speciation without geographic barrier
- difficult to observe in nature
- can result from change in die or specialization to microhabitat
- midas and arrow cichlid ex p. 314

Sympatric Speciation

- polyploidy - chromosome number beyond diploid (2n)
- autoploidy - diploid plant produces diploid gametes due to nondisjunction
  - if it fuses with a haploid gamete, a triploid plant results and is sterile
  - produce fruits without seeds
  - tetraploid plants are fertile (and have large fruits)
- alloploidy - hybridization between 2 species that is followed by chromosome doubling

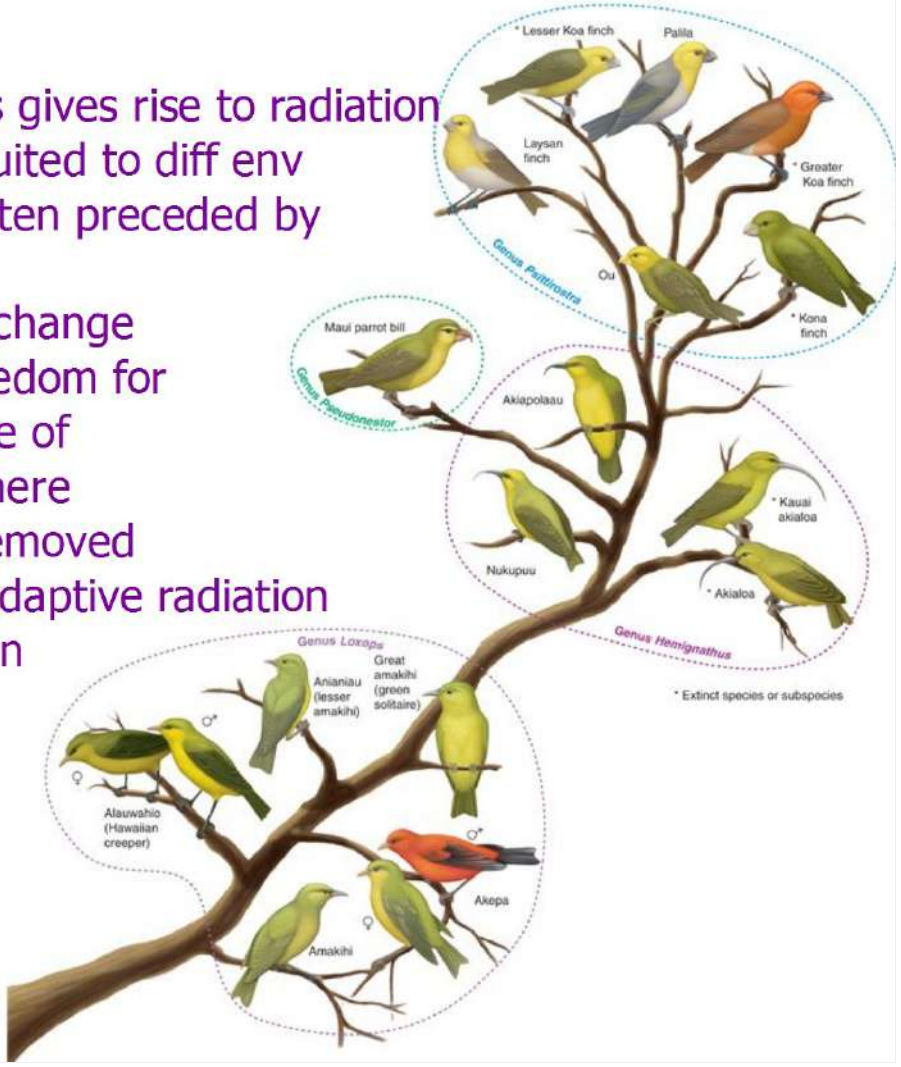




Adaptive Radiation

- single ancestral species gives rise to radiation of new species, each suited to diff env
- sympatric speciation often preceded by removal of competitor, predator or by an env change
- ecological release - freedom for a species to expand use of resources in habitat where competitor has been removed
- mammals underwent adaptive radiation once dinosaur extinction occurred

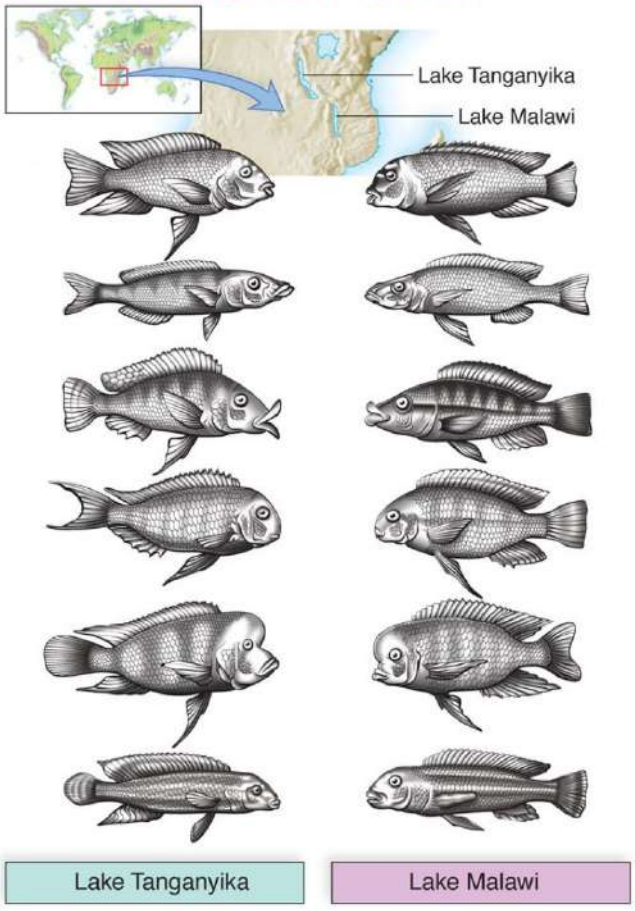
finches again



Convergent Evolution

- similar biological traits develop in unrelated species due to similarity of env
- flight evolved independently in birds and bats
- analagous traits

cichlid



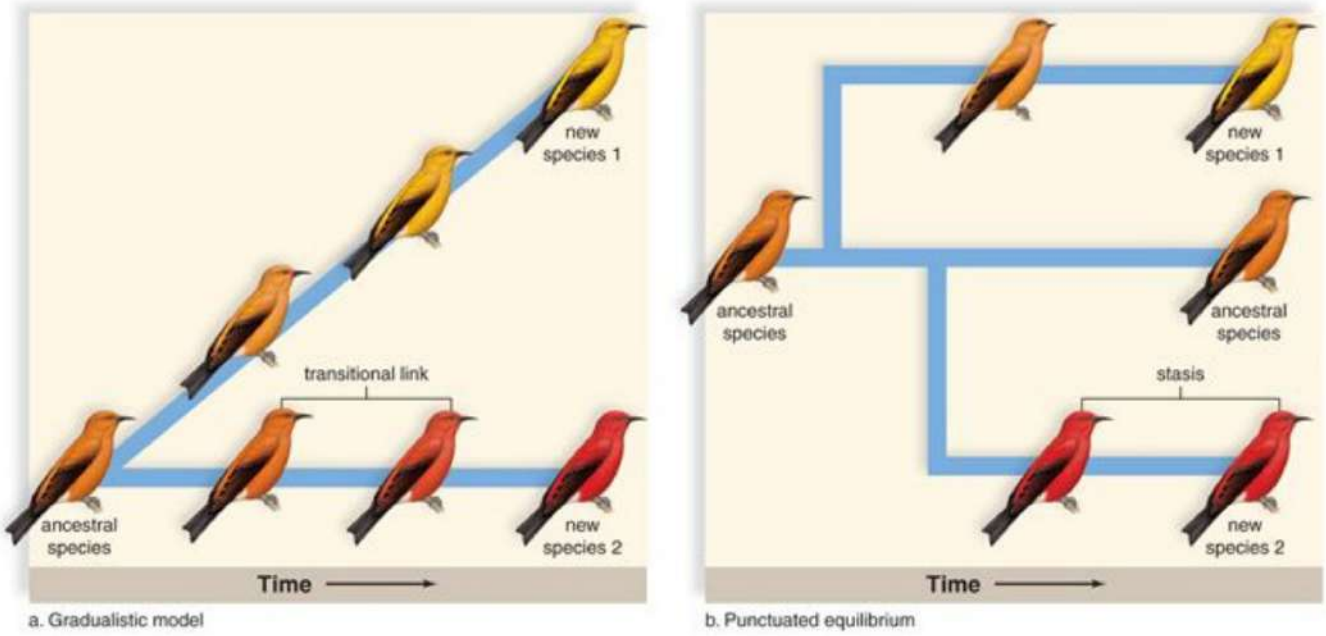
17-3 Principles of Macroevolution

Rate of Evolution: 2 Models

1. gradualistic model - speciation occurs after pops become isolated
   - each group continues changing slowly
   - difficult to pinpoint speciation b/c many transitional forms
2. punctuated equilibrium model - species appear suddenly and then go through a period of stasis until extinction or evolution
   - periods of *equilibrium*; *punctuated* by rapid/abrupt speciation

You don't have to choose!

Models of Evolution

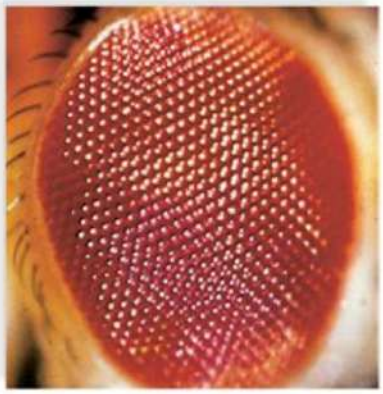


Developmental Genes and Macroevolution

- all animals appear to share certain genes that are believed to have developed more than 600 MYA
- control timing and location in body where proteins are synth
- cause differences in body shape and organs
- act as control switches

Development of Eye

- eyes in all animals are controlled by *Pax6* gene

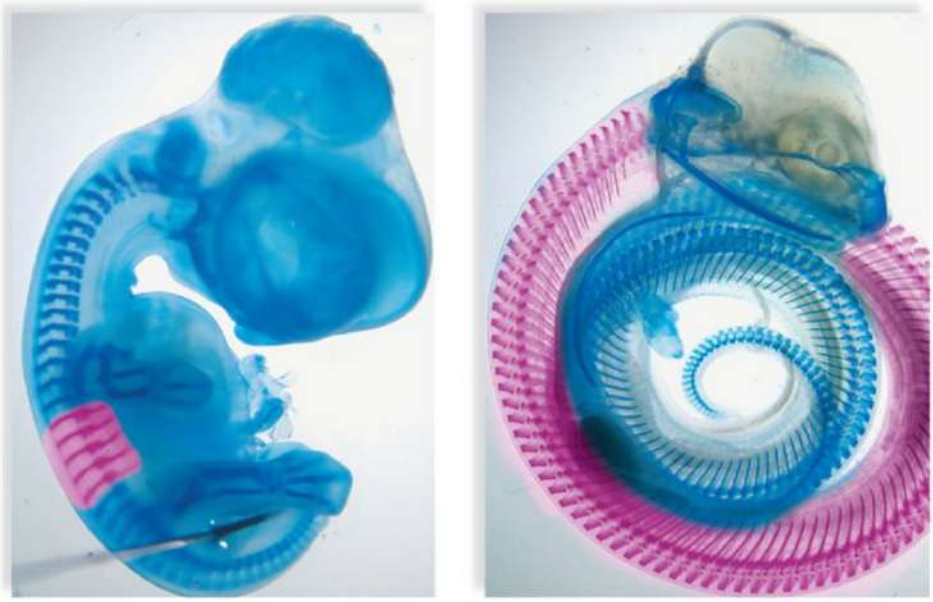


Development of Limbs

- *Tbx5* gene regulates expression of limb-forming genes in limb buds of humans and birds
- "turns on" different genes in each
- subtle changes in gene control and timing can affect body shape

Development of Overall Shape

- *Hox* genes control expression of repeating segments in animals
- changes in expression during development explain large number of vertebrae in some species and number of legs in diff insects
- Changes are not always result of new genes...can be changes in expression of old genes



Macroevolution is Not Goal-Oriented