Chapter 16

Origin of species

What is a species?

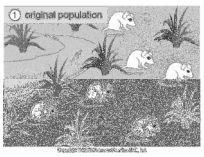
- Biological species concept (Mayr)
  - **A species is a group of populations whose individuals interbreed with each other (or at least are capable of interbreeding), but not with members of other such groups.**
    - Interbreeding: Includes both mating and production of fertile offspring
  - **Problems with definition:**
    - Can't always tell whether members of different groups can/do interbreed.
    - Doesn't help define species that reproduce asexually (i.e. bacteria)

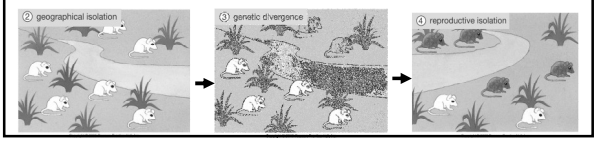
How do new species form?

- For speciation to occur for a pair of populations, two factors are necessary:
  - Isolation of populations
    - No gene flow between them!
  - Genetic divergence of populations
    - Become different enough genetically that they could no longer interbreed/produce vigorous, fertile offspring if reunited

Allopatric speciation

- Geographic isolation
  - Impassible physical barrier
- Genetic divergence
  - Natural selection
  - Genetic drift
  - Founder effect
- Reproductive isolation
  - Due to accumulated genetic differences



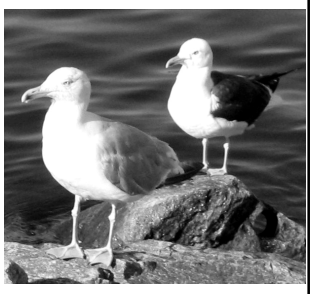


A case of allopatric speciation?

- Kaibab squirrel and Abert squirrel live on opposite rims of the Grand Canyon.
  - Are they really different species?
    - Molecular data says they're really subspecies.

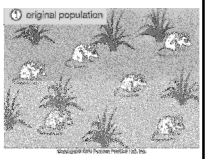
Allopatric speciation

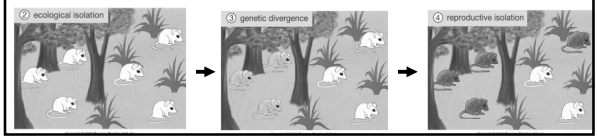
- Known example
  - Herring gulls (UK) & lesser blackbacked gulls (Continental Europe)
  - No longer interbreed, even when the two species meet.



Sympatric speciation

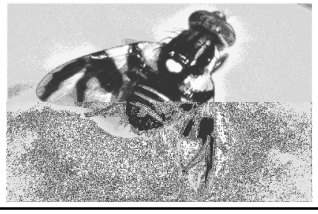
- Ecological isolation
  - ❖Distinct niches
- Genetic divergence
  - ❖Natural selection (best-fit to niche)
  - ❖Assortative mating
- Reproductive isolation
  - ❖Due to accumulated genetic differences





A case of sympatric speciation?

- Apple-flies and hawthorn-flies (genus *Rhagoletis*) show assortative mating.
  - ❖Are they really different species?
  - ❖Molecular data indicates that they are speciation in process since 1800 (incipient speciation).



Changes in chromosome number lead to sympatric speciation

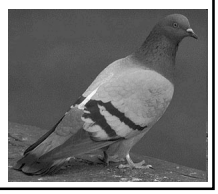
- Specific to plants
- Plants can double their chromosome number and become new species.
  - ❖Plant breeders take advantage of this using colchicine.
  - ❖colchicine causes plants to double their chromosome number.

Adaptive radiation

- Many species may evolve from an ancestral species over a short period of time.
- Can occur if a species moves into an area with a variety of unoccupied niches with differing selective pressures.
  - ❖Example 1: Darwin's finches (Galapagos)
  - ❖Example 2: Over 300 species of cichlid fish in lake Malawi
    - ➢In both examples, species differences reflect adaptations to different food resources.

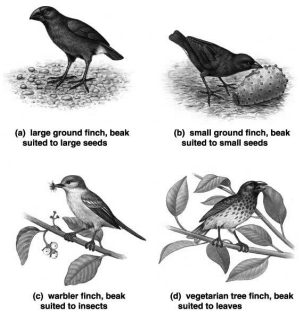
Adaptive radiation is often seen in islands

- Islands, due to natural disasters like volcanoes and hurricanes, are often "cleared" of species.
  - ❖Species from nearby mainlands arrive
  - ❖Speciate to fill empty niches on islands.



Adaptive radiation: Darwin's finches (Galapagos)

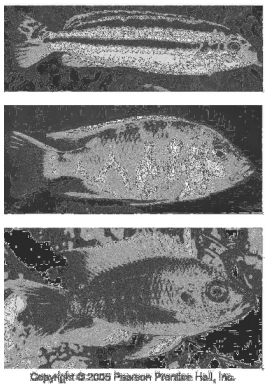
- Beak size and shape were related to food type
- Other aspects were similar, suggesting the birds were related
- Explanation
  - Ancestral species arrived in the Galapagos.
  - Unoccupied niches were exploited
  - ❖ Sympatric speciation occurred.



Adaptive radiation:

Cichlid fishes (Lake Malawi)

- These are three of over 300 cichlid species!
- Body shape, mouth size and coloration reflect differences in feeding strategies and habitat
- Explanation:
  - ❖ Ancestral species arrived at the lake
  - ❖ Unoccupied niches were exploited
  - ❖ Sympatric speciation occurred.



Maintenance of reproductive isolation

- Pre-mating isolation
  - ❖Geographic isolation
    - ➢Geographic barriers prevent mating.
  - ❖Ecological isolation
    - ➢Ecological barriers prevent mating
  - ❖Temporal isolation
    - ➢Different species mate at different times of the year.
  - ❖Behavioral isolation
    - ➢Different species use different courtship signals
  - ❖Physiological barriers
    - ➢Different species don't fit.
    - ➢Known as a "lock & key" physiology.

Maintenance of reproductive isolation

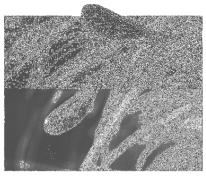
- Pre-mating isolation
  - ❖Different habitats prevent cross-breeding
    - ➢Example: Each species of fig wasps mates and lays eggs within a particular fig species.

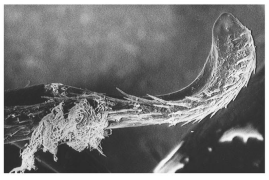
Maintenance of reproductive isolation

- Pre-mating isolation (cont.)
  - ❖Different species breed at different times of year.
    - ➢Example: Bishop pines (in photo) release pollen in the summer, while Monterey pines release pollen in the spring

Maintenance of reproductive isolation

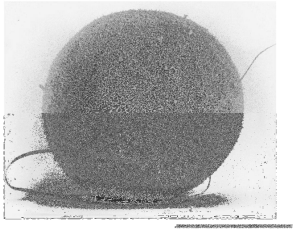
- Pre-mating isolation (cont.)
  - ❖Different species may have different reproductive organs.
    - ➢Example: Complex sex organs of insects such as damselflies
    - ➢Very common in invertebrates.





Maintenance of reproductive isolation

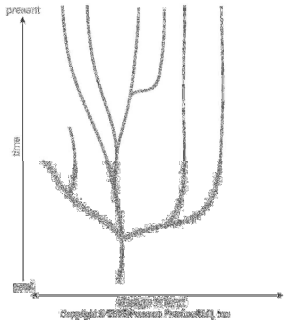
- Post-mating isolation
  - ❖Sperm may fail to fertilize female's egg.



Maintenance of reproductive isolation

- Post-mating isolation (cont.)
  - ❖Hybrid offspring may be poor survivors.
    - ➢Particular genetic combination may give rise to intermediate characteristics not well-adapted to the environment.
  - ❖Hybrid offspring may be infertile.
    - ➢Classic example: Mules, crosses between horses and donkeys, are infertile.

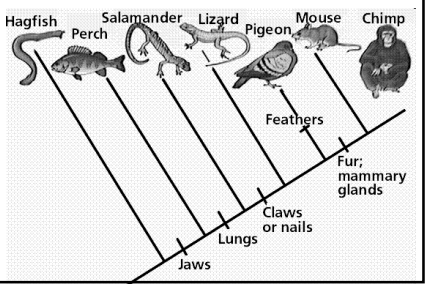
Evolutionary trees



Evolutionary trees

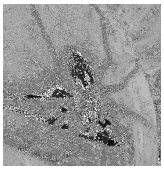
- Based on shared characteristics or DNA sequence data.
  - ❖The more shared traits/DNA, the closer related the two species are.

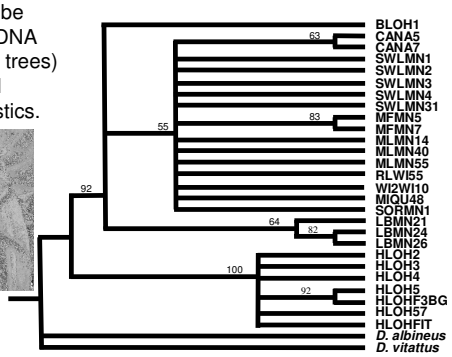
Each node represents an evolutionary change in traits



Evolutionary tree

- Trees can be based on DNA (molecular trees) or physical characteristics.





Extinction

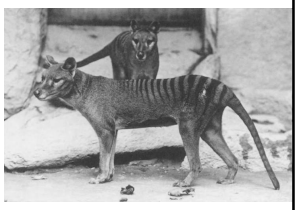
- Extinction is the death of all members of a species or subspecies.
- Causes:
  - ❖Very limited habitats
  - ❖Habitat change
  - ❖Overpredation
  - ❖Overhunting

Extinction

- Great Auk
  - ❖Breeding colonies once widespread through North Atlantic
  - ❖Population fragmentation by hunting for food/bait
  - ❖Scarcity → high-price trade in skins & eggs
  - ❖Last auk: Iceland, 1844
    - ➢Breeding pair and egg destroyed

Extinction: Tasmanian wolf

- Tasmanian Wolf
  - ❖Marsupial predator
  - ❖Extinction caused by overhunting by sheep farmers



- Movie link

Extinction

- Heath hen
  - ❖Eastern species of prairie chicken.
  - ❖Overhunting reduced population.
  - ❖Catastrophic fire killed most of females and eggs.
  - ❖Last male died 1932.

Last male heath hen looking for a mate in their traditional lek

Near Extinctions

- California Condors
  - ❖ Population reduced to 22 individuals.
    - ➢ Causes include:
      1. Habitat fragmentation
      2. Lead poisoning from eating hunting kills.
      3. poaching
  - ❖ Captive breeding and other conservation efforts have increased the population to 326 currently.

Near extinctions

- **Przewalski's Horse** or Takhi
  - ❖Population reduced to 31 individuals.
  - ❖Near extinction due to:
    - ➢1. habitat loss: grasslands
    - ➢2. habitat fragmentation limited access to water.
  - ❖Conservation efforts have increased population to 1,500 currently.