

## Chapter 16

### Origin of species

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### 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)

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### 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

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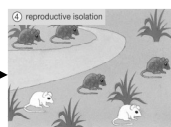
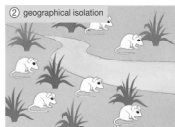
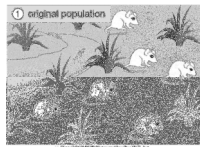
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## Allopatric speciation

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




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## 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.




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## Allopatric speciation

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




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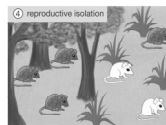
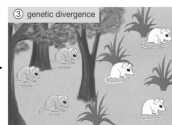
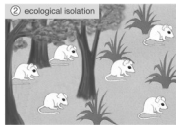
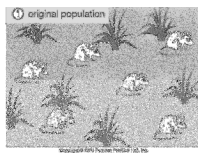
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## Sympatric speciation

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




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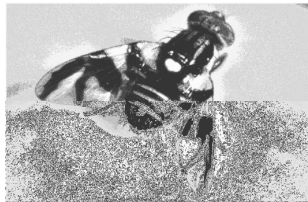
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## A case of sympatric speciation?

- 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).




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## 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.




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## 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.

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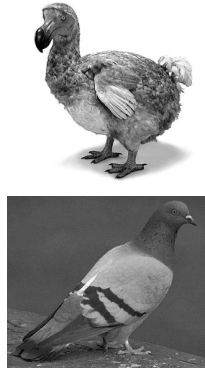
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## Adaptive radiation is often seen in islands

- 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.




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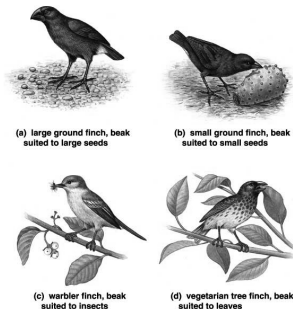
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## Adaptive radiation: Darwin's finches (Galapagos)

- 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.




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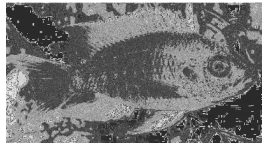
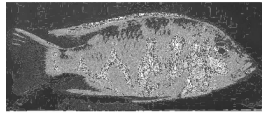
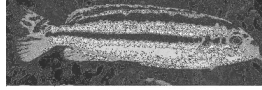
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### Adaptive radiation:

#### 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.



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### 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.

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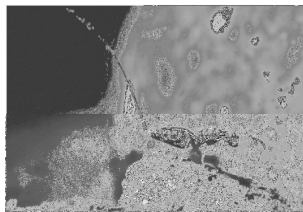
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### Maintenance of reproductive isolation

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



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### 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



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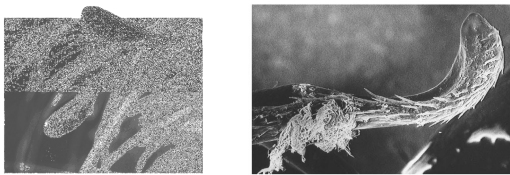
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### Maintenance of reproductive isolation

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



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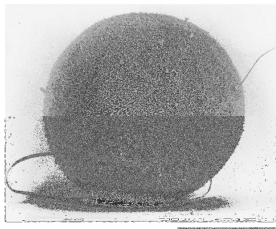
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### Maintenance of reproductive isolation

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



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## 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.

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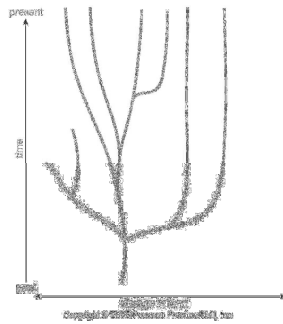
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## Evolutionary trees




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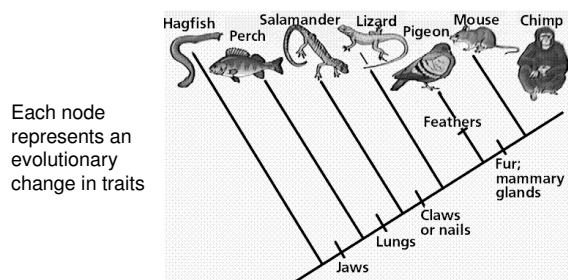
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## Evolutionary trees

- Based on shared characteristics or DNA sequence data.

- ❖ The more shared traits/DNA, the closer related the two species are.




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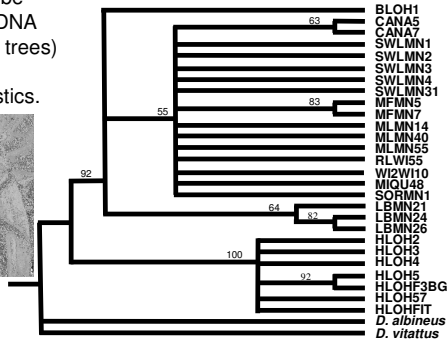
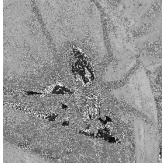
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## Evolutionary tree

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




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## Extinction

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

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## 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




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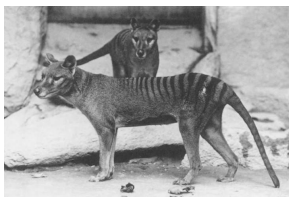
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## Extinction: Tasmanian wolf

- Tasmanian Wolf
  - ❖ Marsupial predator
  - ❖ Extinction caused by overhunting by sheep farmers
- [Movie link](#)



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## 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

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## 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.



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## 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.



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