Speciation

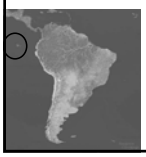
Reading: Chap. 26

I. Intro
- A. Motivating question
- B. What is a species?
  1. Biological
  2. Morphospecies
  3. Phylogenetic

II. Modes of speciation
- A. Allopatric speciation
- B. Sympatric speciation
- C. Contact between diverging populations

I. Introduction

A. Motivating Question:
Darwin's finches



C&R Fig. 1.17 Galapagos finches

Know: mechanisms for genetic shifts within populations

Q: How do these genetic shifts (adaptations) lead to new species?

Q: How do these genetic shifts lead to formation of major new taxa (genus, family, order, class, etc.)?

Macroevolution

The evolution of species and larger taxa

Evolutionary theory must also explain **macroevolution**

Speciation is the keystone process in the origination of diversity of higher taxa.

Galapagos tortoise

IB. What is a "Species"?

Latin meaning "kind" or "appearance"

Traditionally distinguished by morphological differences

Today distinguished in addition by differences in body function, biochemistry, behavior, and genetic makeup

1. Biological species concept

- Reproductive isolation between species.
- Individuals within a species can potentially interbreed to produce viable, fertile offspring.

C&R Fig. 24.2a Similar morphology, but hybrids infertile.

C&R Fig. 24.2b Diversity within species

How are biological species isolated?

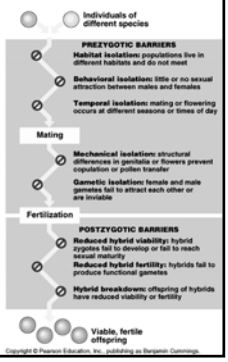
Horse — Donkey

1. Prezygotic barrier: behavioral isolation

2. Postzygotic barrier: reduced hybrid fertility

How are biological species isolated?

1. Prezygotic barriers – impede mating and fertilization:
   a. Impede coupling of different species
      habitat, behavioral, and temporal isolation
   b. If mating, impede fertilization



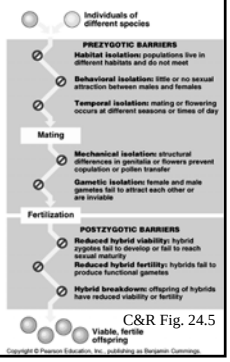
C&R Fig. 24.5

How are biological species isolated?

1. Prezygotic barriers – impede mating and fertilization:
   b. If mating, impede fertilization:
   mechanical and gametic isolation

Seed beetle, male genitalia

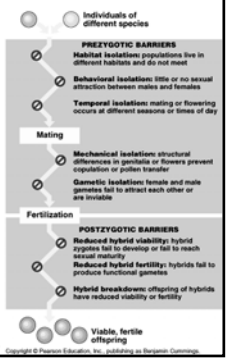
http://www.cosmosmagazine.com/node/1380



C&R Fig. 24.5

How are biological species isolated?

2. Postzygotic barriers – prevent development
   - reduced hybrid viability
   - reduced hybrid fertility
   - hybrid breakdown

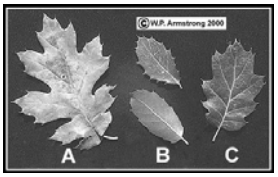


C&R Fig. 24.5

Limitations of the biological species concept

Impractical or impossible to assess:

- Fossils
- Asexual species (bacteria, fungi, protists)
- Many living sexual species (e.g., plants)



A - California black oak (Q. kellogii)
B - Interior live oak (Q. wislizenii var. frutescens)
C - Oracle Oak (Q. x morehus)

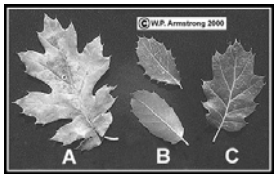
http://waynesword.palomar.edu/hybrids1.htm

2. Morphospecies

Distinguishing physical characteristics.

Widely applicable – sexual, asexual, fossil species

Disadvantage: which traits, and how much difference is enough?



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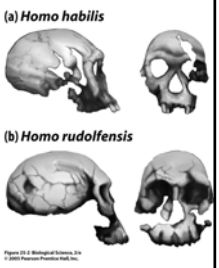


3. Phylogenetic Species

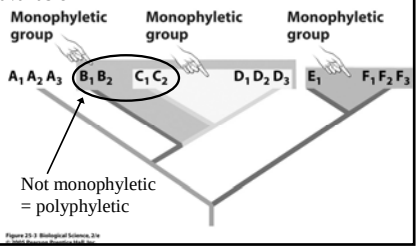
Smallest monophyletic group in a tree that compares populations.

Advantages:

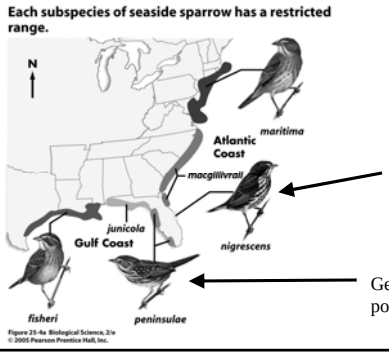
- logical
- broadly applicable, at least theoretically

Disadvantage:

- data not widely available
- more species?



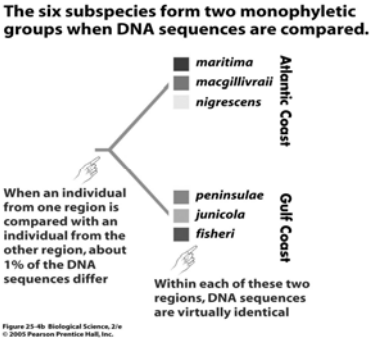
Case study: Seaside Dusky Sparrow conservation



Only 6 males left – taken for captive breeding

Geographically closest population

Seaside sparrow phylogeny



Types of Speciation

Anagenesis: Transformation of one species into another

C&R Fig. 24.1a

Speciation: Cladogenesis

Creation of one or more new species from a "parent" species

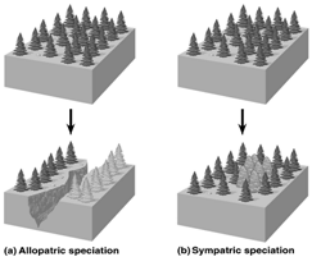
Promotes biological diversity by increasing the number of species

C&R Fig. 24.1b

II. Modes of Speciation

A. Allopatric speciation - geographic separation restricts gene flow

B. Sympatric speciation - biological factors reduce gene flow



C&R Fig. 24.6

Key point:

Gene flow among populations is key to possibility of speciation.

- high gene flow: populations remain homogenous in terms of allelic composition
- low gene flow: populations may diverge due to mutation, selection, & drift, but may not become reproductively isolated.
- No gene flow: populations free to diverge.

A. Allopatric speciation – geographic isolation

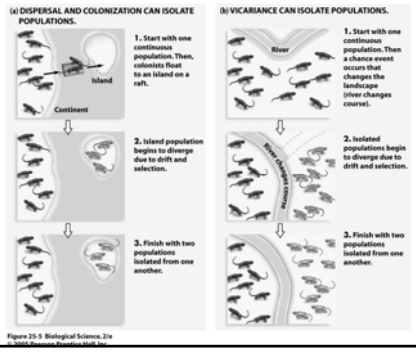
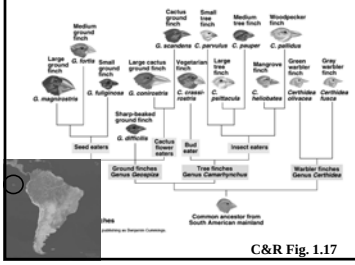


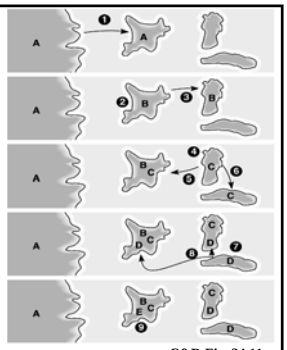
Figure 25-5 Biological Science, 2/e

1. Dispersal and colonization: Island Radiations

The evolution of many diversely-adapted species from a common ancestor.



C&R Fig. 1.17



C&R Fig. 24.11

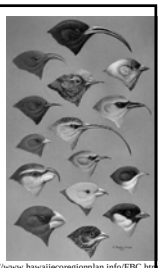
Seen in some island chains: (Hawai'i, Galapagos)

Cool Hawai'ian examples

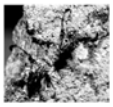
Honeycreepers

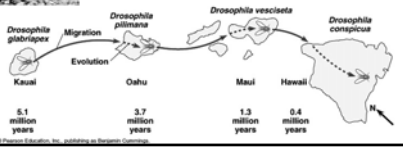
Euphorbia's - arborescence

Drosophila



http://www.hawaiiecoregionplan.info/FBC.htm





C&R Fig. 22.16

2. Ring species

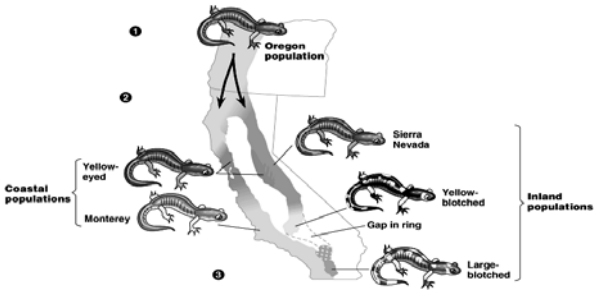
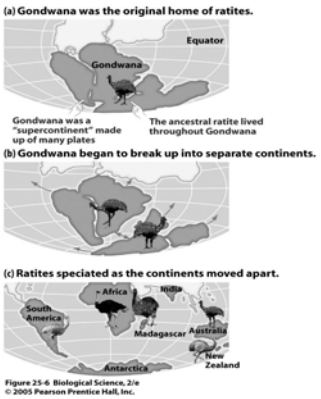


Fig. 24.9 ***Ensatina eschscholtzii*** **salamanders**

Emphasizes gradient in gene flow.

3. Vicariance

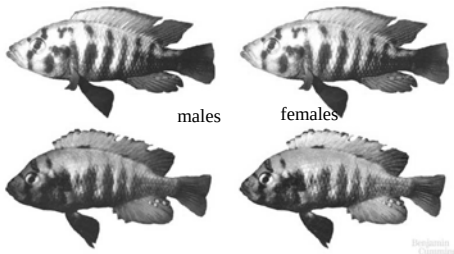
Ratites: giant, flightless birds
Ostrich - Africa
Emu - Australia
Rheas – S. America
Kiwis, moas (extinct) – N.Z.
Cassowaries – Australia, New Guinea
Elephant bird (extinct) - Madagascar



B. Sympatric speciation

In animals, sympatric speciation may result from gene-based shifts in habitat or mate preference

Cichlid fishes in Lake Victoria, East Africa



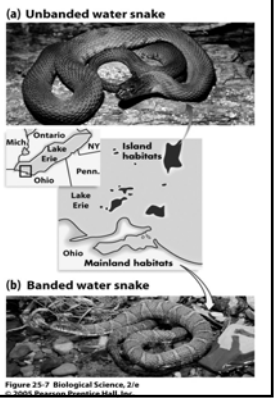
C&R Fig. 24.16

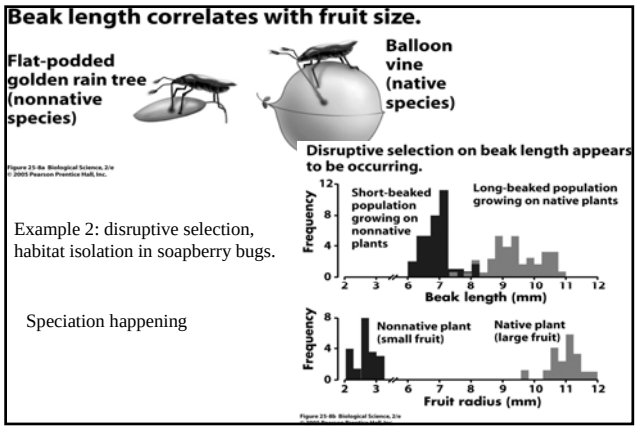
Reproductive barriers must evolve between sympatric populations

Example 1: different selective pressures, but continued gene flow.

Water snakes:
selection for unbanded on islands, banded on mainland (substrate color).

But, gene flow keep population intact.





Example 2: disruptive selection, habitat isolation in soapberry bugs.

Speciation happening

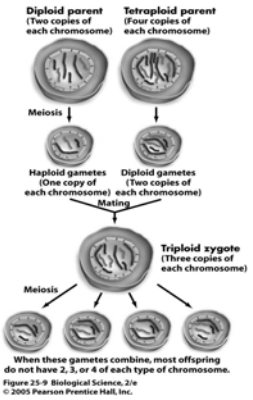
Example 3: Reproductive isolation first - Polyploidy

In plants, sympatric speciation often results from **polyploidy**

2 steps:

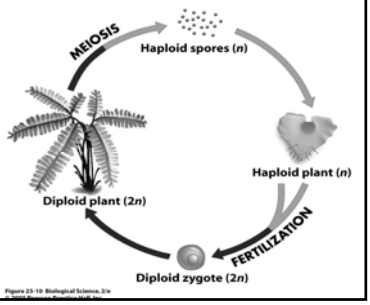
1. Mistake in mitosis or meiosis → chromosome doubling
2. Polyploid individual can't cross with 2n individuals.

(Fig. 26.8)



How do plants become polyploid?

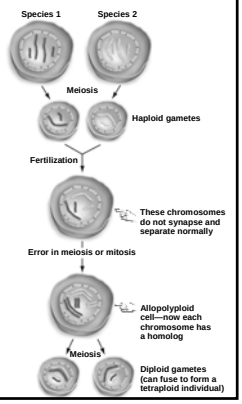
1. Autopolyploidy – self-generated



Maidenhair fern

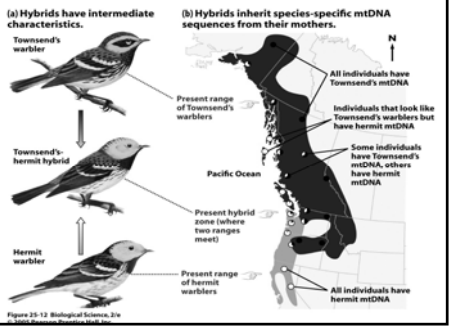
2. Allopolyploidy – generated by "other" species

- May Occur after Two Species Hybridize



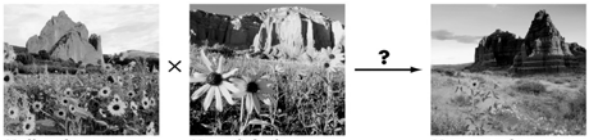
C. What Happens When Isolated Populations Come into Contact?

Hybrid Zones



New Species through Hybridization

Hybridization hypothesis for the origin of a new species:



Helianthus annuus × *H. petiolaris* → ? → *H. anomalus*

Figure 25-13 Biological Science, 2/e
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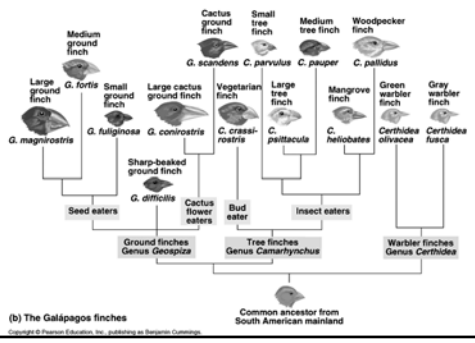
Motivating Question: Darwin's finches



KEY CONCEPTS

Populations can be recognized as distinct species if they are reproductively isolated from each other, if they have distinct morphological characteristics, or if they form independent branches on a phylogenetic tree.

KEY CONCEPTS

Speciation occurs when populations of the same species become genetically isolated by lack of gene flow and then diverge from each other due to selection, genetic drift, or mutation.

KEY CONCEPTS

Populations can become genetically isolated from each other if they occupy different geographic areas, if they use different habitats within the same area, or if one population is polyploid and cannot breed with the other.

KEY CONCEPTS

When populations that have diverged come back into contact, several outcomes are possible:

- Reinforcement of evolved differences
- Hybrid zones
- New species from hybrids