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

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.)?

Macrolevelation
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.

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.

How are biological species isolated?
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

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

How are biological species isolated?
1. Prezygotic barriers – impede mating and fertilization:
   b. If mating, impede fertilization: mechanical and gametic isolation

Limitations of the biological species concept
Impractical or impossible to assess:
Fossils
Asexual species (bacteria, fungi, protists)
Many living sexual species (e.g., plants)

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Limitations of the biological species concept
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Many living sexual species (e.g., plants)
2. Morphospecies
Distinguishing physical characteristics.
Widely applicable – sexual, asexual, fossil species
Disadvantage: which traits, and how much difference is enough?

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

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?

Not monophyletic = polyphyletic

Case study: Seaside Dusky Sparrow conservation
Each subspecies of seaside sparrow has a restricted range.

Only 6 males left – taken for captive breeding
Geographically closest population

Seaside sparrow phylogeny
The six subspecies form two monophyletic groups when DNA sequences are compared.

Types of Speciation
Anagenesis: Transformation of one species into another

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. 24.1a
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

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

1. Dispersal and colonization: Island Radiations
The evolution of many diversely-adapted species from a common ancestor.

C&R Fig. 24.11

Cool Hawai‘ian examples

Honeycreepers  
*Euphorbia*’s - arborescence  
*Drosophila*

2. Ring species
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

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.

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)

Beak length correlates with fruit size.

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

Speciation happening
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?

New Species through Hybridization

Hybridization hypothesis for the origin of a new species:

Helianthus annuus × H. petiolaris → H. anomalous

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.

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.

When populations that have diverged come back into contact, several outcomes are possible:
  - Reinforcement of evolved differences
  - Hybrid zones
  - New species from hybrids