Ch 24: origin of species

• What is a species?
• Species Concepts
  - Morphological
  - Biological
  - Isolating mechanisms and hybridization
  - Other Species Concepts
• How do new species arise?
  - Allopatric vs. sympatric speciation
• What is the tempo of speciation?
  - Punctuated equilibrium model and fossil record
• How can new, complex structures evolve?

What is a species?

Species

• A Latin word meaning “kind” or “type”
• There are many kinds of living thing!
• Biologists mean something special by the word species

Morphological Species Concept

• morphology = shape or appearance
  - Collect a type specimen
  - Others that are similar to the type are the same species
  - Very widely used (e.g., insects)
  - Problem - doesn’t take intraspecific variation into account - how similar is similar enough? Are the similarities we notice the important ones?

Biological Species Concept

• Formulated by Ernst Mayr: Ornithologist; one of the contributors to the Modern Evolutionary Synthesis
  - Species are populations or groups of populations whose members have the potential to interbreed in the wild and produce viable, fertile offspring (1942)
• Rationale: hybridization implies mixing - species are distinct because they don’t mix
• Advantage: the organisms decide themselves how different is different enough
Reproductive isolation

What keeps different species from interbreeding? (not counting geography)

- Prezygotic barriers
  - Before mating or fertilization
- Postzygotic barriers
  - After mating or fertilization
- What's a zygote?

Prezygotic barriers (1)

- Habitat isolation: species occupy different habitats in the same geographic area

Three-spined stickleback species differ by lake habitat: benthic vs. pelagic zones

Prezygotic barriers (2)

- Breeding behavior →

Prezygotic barriers (3)

- Temporal isolation: species reproduce at different times in the same geographic area

Prezygotic barriers (4)

- Mechanical isolation: species have incompatible anatomy

Different insects pollinating black sage and white sage

Prezygotic barriers (5)

- Gametic isolation: species have gametes that recognize only their own species
**Postzygotic barriers**
- Reduced viability: embryos die or fail to develop
- Hybrid offspring born, but have reduced viability or fertility
- Hybrid breakdown: offspring of hybrids have reduced survival or fertility

Horse + donkey = sterile mule

**Problems with Biological Species Concept**
- The Biological Species Concept works very well with some taxa (birds, for instance) but...
- Information on hybridization lacking for most species

? X

**Problems with Biological Species Concept (2)**
- In some groups (oak trees, for instance, and many other plants) hybridization between what seem to be quite different species is common.

**Problems with Biological Species Concept (3)**
- In other groups (some birds), hybridization at least happens occasionally - a little mixing doesn't always break down differences between species

**Alternative species concepts**
- Phylogenetic species concept - minimum diagnosable unit
- Ecological Species Concept - a set of organisms adapted to a particular set of resources, called a niche, in the environment
- All these species concepts agree most of the time - they differ mostly when applied to borderline or poorly understood cases.
Speciation

• Speciation - when one species splits into two (aka cladogenesis)
• How does it happen?
• Allopatric vs. sympatric speciation

Allopatric Speciation

• Allopatry - “different fatherlands”
  – 1. One species is divided into two isolated populations in two geographic regions
  – 2. The two populations evolve in different directions while apart
  – 3. Isolating mechanisms evolve in the two groups
  – 4. The two populations are unable to breed with each other when they reconnect - they are now two separate species

Sympatric Speciation

• Sympatry = living in the same place
• How could individuals evolve reproductive barriers to others in a local, interbreeding population?
• Theoretically possible, but evidence suggests it’s rare at best
• Organisms can undergo sympatric speciation by producing polyploid offspring

Modes of speciation

Fig. 24.6

Allopatric speciation in ground squirrels

Speciation by production of tetraploids
**Sympatric Speciation (1)**

*Tree Frogs*

*Hyla chrysocelis*  
*Hyla versicolor*

**Sympatric Speciation (2)**

- Mate choice by cichlids

![Fig. 24.16](https://example.com/image)

**Adaptive radiation**

- Example?

![Fig. 24.11](https://example.com/image)

**Is speciation gradual or sudden?**

- Paleontologists have a hard time seeing gradual change in the fossil record. More often, a form appears suddenly, then, after persisting for some eons, disappears from the fossil record just as suddenly.
- Why is this?
Evolutionary Novelties

- So for novel complex structures to arise by natural selection
  - 1. Each step must be a plausible small minor modification of the one before it
  - 2. Each step must be an improvement on the one before it

A simple patch of pigmented cells detects light

If a depression forms with the pigment cells in it, can detect direction of light source

A depression with a small opening allows formation of images on the light-sensing cells
A lens within the eye allows better focussing and allows more light to enter.

A lens that can change shape allows near and far focussing.

Is it plausible?
- Could these different stages have existed?
- Would they each give their owners an advantage?