Chapter 24.

The Origin of Species

“Both in space and time, we seem to be brought somewhat near to that great fact—that mystery of mysteries—the first appearance of new beings on this Earth.”

— Darwin

Essential Questions

- How and why do new species originate?

Biological species concept

- Eastern Meadowlark
- Western Meadowlark

Similar body & colorations, but are distinct biological species because their songs & other behaviors are different enough to prevent interbreeding.
**Diversity & Taxonomy**
- **The Tree of Life**
  - species are the smallest unit at the ends of branches
  - basic unit for organizing & categorizing living things
  - smallest unit by which we measure diversity

**Reproductive isolation**
- **Species concept hinges on reproductive isolation**
  - biological barriers that impede members from producing viable offspring
  - before vs. after fertilization
    - pre-zygotic barriers (before the zygote)
    - post-zygotic barriers (after the zygote)

**Prezygotic barriers**
- Impede mating or hinder fertilization if mating occurs
  - habitat isolation
  - temporal isolation
  - behavioral isolation
  - mechanical isolation
  - gametic isolation

**Habitat isolation**
- Two species may occupy different habitats within the same area so may encounter each other rarely

2 species of garter snakes, Thamnophis, occur in the same area, but one lives in water & the other is terrestrial
Temporal isolation
- Species that breed during different times of day, different seasons, or different years cannot mix gametes

Eastern spotted skunk (L) & western spotted skunk (R) overlap in range but eastern mates in late winter & western mates in late summer

Behavioral isolation
- Courtship rituals that attract mates & other unique behaviors to a species are effective reproductive barriers

Blue-footed boobies mate only after a courtship display unique to their species

Mechanical isolation
- Morphological differences can prevent successful mating

Even in closely related species of plants, the flowers often have distinct appearances that attract different pollinators. These 2 species of monkey flower differ greatly in shape & color, therefore cross-pollination does not happen.
Mechanical isolation

- For many insects, male & female sex organs of closely related species do not fit together, preventing sperm transfer
  - lack of "fit" between sexual organs
  - hard to imagine for us, but a big issue for insects with different shaped genitals!

Gametic isolation

- Sperm of 1 species may not be able to fertilize eggs of another species
  - variety of mechanisms
    - chemical incompatibility
    - sperm cannot survive in female reproductive tract
    - biochemical barrier so sperm cannot penetrate egg

Postzygotic barriers

- prevent hybrid zygote from developing into a viable, fertile adult
  - reduced hybrid viability
  - reduced hybrid fertility
  - hybrid breakdown

Reduced hybrid viability

- Genes of different parent species may interact & impair the hybrid's development

Species of salamander genus, Ensatina, may interbreed, but most hybrids do not complete development & those that do are frail.
Reduced hybrid fertility

- Even if hybrids are vigorous they may be sterile
- Chromosomes of parents may differ in number or structure & meiosis in hybrids may fail to produce normal gametes

Habitat breakdown

- Hybrids may be fertile & viable in first generation, but when they mate offspring are feeble or sterile

Strains of cultivated rice have accumulated recessive alleles. Hybrids are vigorous but plants in next generation are small & sterile.

On path to separate species.
Speciation

- Species are created by a series of evolutionary processes
  - populations become isolated
    - reproductively isolated
    - geographically isolated
    - isolated populations evolve independently

Isolation

- allopatric
- sympatric

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Allopatric speciation

- Allopatric = “other country”
  - geographic separation
    - migration
    - physical barrier

Harría’s antelope squirrel inhabits the canyon’s south rim (L). Just a few miles away on the north rim (R) lives the closely related white-tailed antelope squirrel.

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Sympatric speciation

- Sympatric = “same country”
  - isolation even though members of population remain in contact
  - what causes this isolation?
    - chromosomal changes
      - polyploidy
      - mostly in plants
      - oats, cotton, potatoes, tobacco, wheat
    - non-random mating

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Adaptive radiation

- Evolution of many diversely adapted species when introduced to various new environmental challenges & opportunities

Drosophila
Geospiza

([Additional diagrams as needed])
Adaptive radiation in plants

Silversword alliance

- All descended from a common ancestor

Adaptive radiation

- Many ecological niches open
- Evolution of many diversely-adapted species from a common ancestor to fill niches
  - Darwin's finches
  - Mammals

Review

- Speciation is a process
  - Populations become isolated
  - Geographic isolation
    - Different environmental conditions: food, predators, disease, habitat
    - Different selection pressures
    - Genetic drift
  - Reproductive isolation
    - Different selection pressures: sexual selection
  - Isolated populations evolve independently

Current debate

- Does speciation happen gradually or rapidly perhaps in response to environmental change
  - Gradualism
    - Charles Darwin
    - Charles Lyell
  - Punctuated equilibrium
    - Stephen Jay Gould
    - Niles Eldredge

Niles Eldredge
Curator
American Museum of Natural History
Gradualism
- Gradual divergence over long spans of time
  - assume that big changes occur as the accumulation of many small ones

Punctuated Equilibrium
- Rate of speciation is not constant
  - species undergo most change when they 1st bud from parent population
  - as separate species, remain static for long periods of time

- Harvard paleontologist & evolutionary biologist
- prolific author
  - popularized evolutionary thought
**Evolution is not goal-oriented**

An evolutionary trend does not mean that evolution is goal-oriented. The modern horse is the only surviving twig of an evolutionary bush with many divergent trends.

**Convergent evolution**

- Flight evolved 3 separate times
  - evolving similar solutions to similar "problems"

**Parallel Evolution**

- parallel paths
- filling similar niches therefore exhibit similar adaptations
  - but are not closely related

**Coevolution**

- Predator-prey relationships
- Parasite-host relationships
- Flowers & pollinators
Darwin Awards

Named in honor of Charles Darwin, the father of evolution, the Darwin Awards commemorate those who improve our gene pool by removing themselves from it. The Darwin Awards salute the improvement of the human genome by honoring those who accidentally kill themselves in really stupid ways. Of necessity, this honor is generally bestowed posthumously.

www.DarwinAwards.com