Speciation and Macroevolution

Problems with defining species:

- Can’t be done on basis of morphology: two different species can appear identical
- A single species can exhibit great diversity of form

Biological Species concept

- A population or group of populations whose members have the potential to interbreed and produce fertile offspring
- Problems with this definition:
  - Applies only to sexually reproducing organisms
  - Can’t be applied to fossil organisms
Evolutionary species concept

• Based on recognition of clusters of organisms that share a common lineage. Recognition of these clusters depends on finding unique genotypic or phenotypic characteristics.
• Can be applied to both sexually and asexually reproducing organisms, and to both extant and extinct species

Speciation defined:

The evolution of new species from preexisting parent species, or attainment of reproductive isolation

How do new species arise? (theoretical scenario)

• A population of interbreeding organisms becomes fragmented
• The subgroups no longer intermingle and interbreed
• Different environmental pressures exert different selective forces
• Random effects of mutation, migration and genetic drift operate; non-random effects of natural selection
• Genetic divergence
• Reproductive isolation
• New species arise
• If species are reintroduced, are no longer capable of interbreeding
Mechanisms of Reproductive Isolation (AKA Reproductive Barriers)

- any heritable trait that prevents interbreeding among divergent populations.

• Prezygotic Barriers: mechanisms of isolation that prevent mating or fertilization. These prevent the formation of embryo.
• Postzygotic Barriers: mechanisms of isolation that take effect after fertilization, during embryonic development. These prevent the development of fertile adults.

Temporal isolation:

• Occurs when two species breed at different times (seasons, time of day, different years)
• Examples: spotted skunks, cicadas
Behavioral isolation

- Occurs when there is little/no sexual attraction between females and males of different species
- Exs: fireflies, gypsy moths, birds with different courtship rituals
Habitat isolation

- Occurs when populations have become adapted to different microenvironments
- Examples: garter snakes, white-crowned and white-throated sparrows

Temporal, behavioral, and habitat isolation are all prezygotic barriers that are due to the ecology of the organisms, and so are sometimes classified as ecological isolation mechanisms.

Mechanical isolation

- Occurs when structural differences between species prevent fertilization
- Examples: Female and male organs may not fit together; in plants, attraction of different pollinators
Gametic isolation

- Occurs when male and female gametes of the two species cannot fuse, or die before they unite.
- Also called gametic incompatibility.
- Fluids of female reproductive tract may weaken or kill sperm of another species

Postzygotic barriers

- Mechanisms of reproductive isolation that take effect after fertilization, during embryonic development, and prevent the development of fertile adults
Hybrid inviability

- Hybrids do not live
- Ex: certain frogs
- Hybrid is hopelessly uncoordinated
- Ex: lovebird hybrid

Hybrid sterility

- Hybrids are not fertile
- Ex: mules

Hybrid breakdown:

- Progressive weakening of successive generations of interbreeding hybrids
- The first generation of hybrids is fertile, but in subsequent generations hybrid fitness declines.
- Example: some cotton plants
Modes of Speciation

Allopatric Speciation

Sympatric Speciation

Allopatric Speciation

• Occurs when two populations are geographically separated from one another
• allo = “different”, patria = “fatherland”
• It is isolation from gene flow with geographic separation
• Changes in the populations occur by microevolutionary processes (mutation, genetic drift, and natural selection).

Geographical isolation...
Sympatric Speciation

• (sym = "together")
• Occurs when different species arise within the area occupied by parent species
• It is isolation from gene flow without geographic separation
• Sympatric speciation rare among animal species; has been important in plant evolution
• Most common type of sympatric speciation occurs when an accident during cell division results in an extra set of chromosomes (polyploidy)

When is speciation likely to occur? Horseshoe crabs and Galapagos finches

Specialists vs generalists

• Horseshoe crabs are generalists: their diet is extremely diverse (will eat plants, small animals, debris)

• By contrast, many of the Galapagos finches are very specialized in their feeding; they are specialists
New environments

Adaptive radiation

- Sudden appearance of several new species from a common ancestor introduced into a new and diverse environment
- Commonly results from two causes:
  - A species encounters an unoccupied habitat
  - Examples: Galapagos, mass extinctions (ultimate example!)
  - A species develops superior adaptations that enable it to displace less well-adapted species from a variety of habitats

Cichlids in Lake Victoria