# Chapter 24- The Origin of Species

(Key Concepts are Underlined)

**Macroevolution**- origin of new taxonomic groups
**Speciation**- origin of new species
**Anagenesis (phyletic evolution)**- the transformation of one species into another
**Cladogenesis (branching evolution)**- budding of one or more new species from a parent species

## What is a species?

**Species**- discrete, distinct biological units; similar in morphology, physiology, behavior, and genetics

The biological species concept emphasizes reproductive isolation

**Biological species concept**- designates species via *reproductive isolation*, which species are isolated by factors (barriers) that prevent interbreeding (but have the potential to interbreed)

Prezygotic and postzygotic barriers isolate the gene pools of biological species

**Prezygotic barriers**- impede mating between species or hinder fertilization of different species

1) **Habitat isolation**- species living in different habitats within the same area may rarely encounter each other
2) **Behavioral isolation**- different mating rituals or elaborate behaviors unique to a species
3) **Temporal isolation**- different breeding times
4) **Mechanical isolation**- anatomically incompatible
5) **Gametic isolation**- selective gamete recognition

**Postzygotic barriers**- prevent the hybrid zygote from developing into viable, fertile adult

1) **Reduced hybrid viability**- embryonic development aborted
2) **Reduced hybrid fertility**- sterile offspring (e.g. mule)
3) **Hybrid breakdown**- 1st generation is viable and fertile, but the next generation offspring are feeble or sterile

<u>The biological species concept does not work in all situations</u>

- asexual organisms must be grouped according to chemical and biochemical characteristics (interbreeding is meaningless)
- wolves, dogs, and coyotes can interbreed, but are distinct
- members of the same species do not interbreed

<u>Other species concepts emphasize features and processes that identify and unite species members</u>

1) ***Morphological*** **species concept**- species separated by measurable physical features
2) ***Recognition*** **species concept**- emphasizes mating adaptations (e.g. displays, behavior, etc.)
3) ***Cohesion*** **species concept**- focuses on the mechanisms/adaptations which maintain species as discrete entities; *cohesion* of phenotype and adaptations
4) ***Ecological*** **species concept**- emphasizes their ecological roles (i.e. position and function)
5) ***Evolutionary*** **species concept**- emphasizes evolutionary lineages and ecological roles (i.e. species are subject to unique sets of selective pressures)

## Modes of Speciation

**Allopatric speciation**- geographical barrier physically isolates populations, initially preventing gene flow

**Sympatric speciation**- intrinsically, genetically isolated, while ranges overlap

<u>Geographical isolation can lead to the origin of species: allopatric speciation</u>

- e.g. the various species of desert pupfish found within springs in southern California deserts
- the gene pools of small allopatric populations change more than larger populations (see "Conditions …" #2)

*Conditions favoring allopatric speciation* (in regards to peripheral isolates)

1) The gene pool of a *peripheral isolate* (isolated peripheral population) probably differs from the parent population from the outset (i.e. extreme genotypes).
2) A small peripheral isolate will be significantly affected by genetic drift causing genotypic and phenotypic divergence from the parental population.
3) Evolution by natural selection may take a different direction in the peripheral isolate (i.e. different selecting factors- generally more severe since the environment is somewhat different).

**Adaptive radiation**- the evolution of many diversely adapted species from a common ancestor (e.g. island chains- resulting from multiple invasions and allopatric speciation)

A new species can originate in the geographical midst of the parent species: sympatric speciation

**Polyploidy**- a mutant condition resulting in extra sets of chromosomes; accounts for 25% to 50% of plant species

*In plants…*

1) **Autopolyploid**- individuals having more than 2 chromosomes sets resulting from meiosis failure: these mutants are able to interbreed, but not with the original population
2) **Allopolyploid**- occurs when 2 different species interbreed producing infertile hybrids able to asexually propagate and eventually transform into fertile offspring (reproductively isolated from parents); most common form of polyploidy

*In animals…*

1) They may become reproductively isolated by becoming fixed on resources not used by the parent population.
2) *Polymorphism* and *assortative mating* could lead to speciation

Genetic change in populations can account for speciation

**Adaptive divergence**- when two populations adapt to disparate environments, they accumulate differences in their gene pool

- there is no drive toward speciation for its own sake- reproductive isolation (prezygotic and postzygotic barriers) is usually a secondary result of the divergence of two populations as they adapt to separate environments

**Hybrid zone**- region where two related divergent populations become geographically isolated, make secondary contact, and interbreed where their ranges

overlap; outside the hybrid zones, populations remain distinct (fits the *cohesive species concept* since the two species can maintain their taxonomic identity, even though they hybridize)
- **many** to **few** gene loci may separate species

The punctuated equilibrium model has stimulated research on the tempo of speciation

*Gradualism*- species gradually descend from a common ancestor (note: paleontologists rarely find these gradual transitions in the fossil record)

**Punctuated equilibrium**- species diverge in spurts of relatively rapid change (long periods of stasis punctuated by episodes of speciation); in terms of change, "sudden" may be thousands of years (on average, successful species last a few million years!)

## The Origin of Evolutionary Novelty

Most evolutionary *novelties* (features defining taxonomic groups) are modified versions of older structures

**Exaptation**- refers to a structure which evolved in one context and become co-opted for another function

Genes controlling development play a major role in evolutionary novelty

- temporal and spatial changes in development can cause great differences in appearance, with little change in genetics

1) **Allometric growth**- a difference in the relative rates of growth of various parts of the body during development; helps shape an organism (a subtle

alteration of development becomes compounded in its effects on the adult)

2) **Paedomorphosis**- result of changes in the development timing of an organism, where sexually mature adults retain juvenile structures from their ancestors
3) **Heterochrony**- a general term for changes in timing or rate of development (e.g. allometry and paedomorphosis)
4) **Homeosis**- alteration of basic body design, or spatial arrangement of body design: homeotic genes initiate the development and placement of basic body features

<u>An evolutionary trend does not mean evolution is goal oriented</u>

"Evolution is a response to interactions between organisms and their current environments."

"If (environmental) conditions change, an evolutionary trend may cease or even reverse itself."