Chapter 24 - The Origin of Species

Overview: That “Mystery of Mysteries”

* In the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Darwin discovered plants and animals found nowhere else on Earth
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, the origin of new species, is at the focal point of evolutionary theory
* Evolutionary theory must explain how new species \_\_\_\_\_\_\_\_\_\_\_\_ and how populations \_\_\_\_\_\_\_\_\_\_\_\_\_\_
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** consists of adaptations that evolve within a population, confined to one gene pool
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** refers to evolutionary change above the species level

Concept 24.1: The biological species concept emphasizes reproductive isolation

* *Species* is a Latin word meaning “\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_” or “\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_”
* Biologists compare morphology, physiology, biochemistry, and DNA sequences when grouping organisms

The Biological Species Concept

* The **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** states that a **\_\_\_\_\_\_\_\_\_\_\_\_** is a group of populations whose members have the potential to interbreed in nature and produce viable, fertile offspring; they do not breed successfully with other populations
* Gene flow between populations holds the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of a population together

*Reproductive Isolation*is the existence of biological factors (barriers) that impede two species from producing viable, fertile offspring

* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** are the offspring of crosses between different species
* Reproductive isolation can be classified by whether factors act before or after \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ barriers** block fertilization from occurring by:
  + Impeding \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ species from attempting to mate
  + Preventing the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ completion of mating
  + Hindering \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ if mating is successful
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ isolation**: Two species encounter each other rarely, or not at all, because they occupy different habitats, even though not isolated by physical barriers
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ isolation**: Species that breed at different times of the day, different seasons, or different years cannot mix their gametes
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_ isolation**: Courtship rituals and other behaviors unique to a species are effective barriers
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ isolation**: Morphological differences can prevent successful mating
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ isolation**: Sperm of one species may not be able to fertilize eggs of another species
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ barriers** prevent the hybrid zygote from developing into a viable, fertile adult:
  + Reduced hybrid \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Reduced hybrid \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Hybrid \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**: Genes of the different parent species may interact and impair the hybrid’s development
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**: Even if hybrids are vigorous, they may be sterile
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**: Some first-generation hybrids are fertile, but when they mate with another species or with either parent species, offspring of the next generation are feeble or sterile

*Limitations of the Biological Species Concept*

* The biological species concept \_\_\_\_\_ be applied to fossils or asexual organisms (including all prokaryotes)

Other Definitions of Species

* Other species concepts emphasize the \_\_\_\_\_\_\_\_ within a species rather than the separateness of different species
* The **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ concept** defines a species by structural features
  + It applies to sexual and asexual species but relies on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* The **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ concept** views a species in terms of its ecological niche
  + It applies to sexual and asexual species and emphasizes the role of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* The **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ concept**: defines a species as the smallest group of individuals on a phylogenetic tree
  + It applies to sexual and asexual species, but it can be difficult to determine the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ required for separate species

Concept 24.2: Speciation can take place with or without geographic separation

* Speciation can occur in \_\_\_\_\_\_\_ ways:
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ speciation
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ speciation

Allopatric (“Other Country”) Speciation

* In **allopatric speciation**, gene flow is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ when a population is divided into geographically isolated subpopulations

*The Process of Allopatric Speciation*

* The definition of *barrier* depends on the ability of a population to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Separate populations may evolve independently through \_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*Evidence of Allopatric Speciation*

* Regions with \_\_\_\_\_\_ geographic barriers typically have \_\_\_\_\_ species than do regions with fewer barriers
* Reproductive isolation between populations generally \_\_ as the distance between them \_\_ (use arrows)
* Barriers to reproduction are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; separation itself is not a biological barrier

Sympatric (“Same Country”) Speciation

* In **sympatric speciation**, speciation takes place in geographically \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ populations

*Polyploidy-* is the presence of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of chromosomes due to accidents during cell division

* An **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** is an individual with more than two chromosome sets, derived from one species
* An **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** is a species with multiple sets of chromosomes derived from different species
* Polyploidy is much more common in \_\_\_\_\_\_\_\_\_\_\_\_\_ than in animals
* Many important \_\_\_\_\_\_\_\_\_\_ (oats, cotton, potatoes, tobacco, and wheat) are polyploids

*Habitat Differentiation*

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ can also result from the appearance of new ecological niches
* For example, the North American maggot fly can live on native hawthorn trees as well as more recently introduced apple trees

*Sexual Selection*

* Sexual selection can drive \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ speciation
* Sexual selection for mates of different colors has likely contributed to the speciation in cichlid fish in Lake Victoria

Allopatric and Sympatric Speciation: *A Review*

* In allopatric speciation, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ restricts gene flow between populations
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ may then arise by natural selection, genetic drift, or sexual selection in the isolated populations
* Even if contact is restored between populations, interbreeding is prevented
* In sympatric speciation, a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ isolates a subset of a population without geographic separation from the parent species
* Sympatric speciation can result from polyploidy, natural selection, or sexual selection

Concept 24.3: Hybrid zones provide opportunities to study factors that cause reproductive isolation

* A**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** is a region in which members of different species mate and produce hybrids

Patterns Within Hybrid Zones

* A hybrid zone can occur in a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ where adjacent species meet
* Hybrids often have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ compared with parent species
* The distribution of hybrid zones can be more complex if parent species are found in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ within the same region

Hybrid Zones over Time

* When closely related species meet in a hybrid zone, there are three possible outcomes:
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of reproductive barriers
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of reproductive barriers
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of hybrid individuals

*Reinforcement: Strengthening Reproductive Barriers*

* The **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** of barriers occurs when hybrids are less fit than the parent species
* Over time, the rate of hybridization \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Where reinforcement occurs, reproductive barriers should be \_\_\_\_\_\_\_\_\_\_ for sympatric than allopatric species

*Fusion: Weakening Reproductive Barriers*

* If hybrids are as fit as parents, there can be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ between species
* If gene flow is great enough, the parent species can fuse into a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*Stability: Continued Formation of Hybrid Individuals*

* Extensive gene flow from outside the hybrid zone can overwhelm selection for \_\_\_ reproductive isolation inside the hybrid zone
* In cases where hybrids have increased fitness, local extinctions of parent species within the hybrid zone can \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the breakdown of reproductive barriers

Concept 24.4: Speciation can occur rapidly or slowly and can result from changes in few or many genes

* Many questions remain concerning how \_\_\_\_\_\_\_ it takes for new species to form, or how \_\_\_\_\_\_\_ genes need to differ between species

The Time Course of Speciation

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in speciation can be studied using the fossil record, morphological data, or molecular data

*Patterns in the Fossil Record*

* The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ includes examples of species that appear suddenly, persist essentially unchanged for some time, and then apparently disappear
* Niles Eldredge and Stephen Jay Gould coined the term **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** to describe periods of apparent stasis punctuated by sudden change
* The punctuated equilibrium model \_\_\_\_\_\_\_\_\_\_\_\_\_ with a model of gradual change in a species’ existence

*Speciation Rates*

* The punctuated pattern in the fossil record and evidence from lab studies suggests that speciation can be \_\_\_\_\_\_\_\_\_\_\_\_\_
* The interval between speciation events can range from 4,000 years (some cichlids) to 40,000,000 years (some beetles), with an average of 6,500,000 years

Studying the Genetics of Speciation

* The explosion of genomics is enabling researchers to identify \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ involved in some cases of speciation
* Depending on the species in question, speciation might require the \_\_\_\_\_\_\_\_ of only a single allele or many alleles

From Speciation to Macroevolution

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is the cumulative effect of many speciation and extinction events