

The Origin of Species

Microevolutionary changes show us how populations change over time. When do we know that distinctly new species have evolved?

•Critical to determining the limits of a species is understanding if two populations are truly reproductively isolated. For example, some populations of western and eastern spotted skunks overlap in the center of the United States.

Eastern



Western



1. In eastern spotted skunks, mating occurs in late winter, and the young are born between April and July.

2. In western spotted skunks, mating occurs in late summer; development is arrested at an early stage during winter and begins again in spring, so that young are born in May or June.

3. Thus, their individual reproductive behavior is such that it would be impossible for gene flow to occur between the species.

What is a species?

•**Taxonomy** is the science of naming and classifying organisms. These names are in the form of **binomials**, the forms first used by Linnaeus in the 1700s. The binomial for the human species is *Homo sapiens*.

•A **biological species** is defined as a population or group of populations whose members have the potential to interbreed and produce fertile offspring.

•Two different species can appear to be almost identical (for example, the eastern and western spotted skunks or the eastern and western meadowlarks).

Eastern

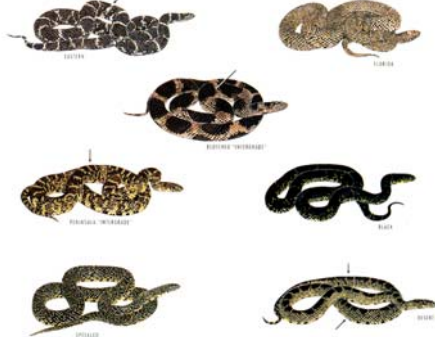


Western



- A single species can exhibit considerable diversity of form.

i.e. - Kingsnakes



The biological species concept does not work in all situations

- The **biological species** concept cannot be applied to asexually reproducing organisms, nor can it be applied to the fossil record. In these cases similarity of appearance, biochemical features, are used to distinguish among species.

- When there may be a chance for a flow of genes between to quite different populations, it is difficult to apply the biological species concept to distinguish the populations.

i.e. - deer mice

- In this case, **subspecies** designations are used for a situation that appears to show a large population in the middle of evolution to two isolated species.

- An alternative to the biological species concept is the **evolutionary species** concept. This concept is based on the recognition of clusters of organisms that share a common lineage. The recognition of these clusters depends on finding unique genotypic or phenotypic characteristics.

- The evolutionary species concept can be applied to both sexually and asexually reproducing organisms.

Reproductive barriers keep species separate

Prezygotic barriers prevent mating or fertilization:

- (a) differential timing of mating (**temporal isolation**), such as the skunk example, or the case with many plants that reproduce at different times.
- (b) reproductive habitat differences (**habitat isolation**), such as the differences between two related species of toad.

- (c) **behavioral isolation** may involve differences in display (*i.e.* - fireflies) or pheromones.



- (d) **mechanical isolation** concerns structural differences that prevent copulation or the transfer of gametes (*i.e.* - the unique structures of copulatory organs of many insects).

- (e) **gametic isolation** occurs when gametes fail to unite, such as different species of sea urchin all releasing their gametes into the oceans with only specific gametic pairing occurring.

Postzygotic barriers prevent the development of fertile adults

- (a) **hybrid inviability**: the hybrids do not live, for example, when two different species of frog mate but the hybrid does not survive.
- (b) **hybrid sterility**: the hybrids are not fertile, such as when a female horse and a male donkey mate to produce a sterile mule.
- (c) **hybrid breakdown**: there is progressive weakening of successive generations of interbreeding hybrids; the first generation of hybrids is fertile, but in subsequent generations hybrid fitness declines.

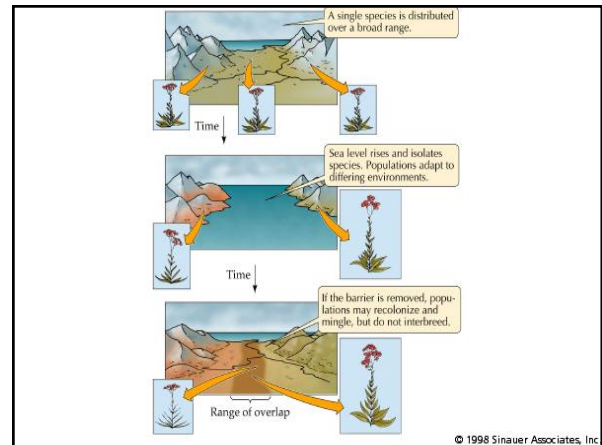
Geographical isolation can lead to speciation

- **Allopatric speciation** involves changes in allele frequencies in two or more geographically isolated populations stemming from one initial population, and it is most likely a small isolated population.

- Changes occur by microevolutionary processes (mutation, genetic drift, and natural selection)

- Many factors can create geographical isolation: mountain building, deep canyons, the removal of land bridges between continents, continental drift.

Allopatric Speciation of Squirrels in Grand Canyon



- The effectiveness of barriers depends on how effective dispersal is in the organisms that might speciate. Large mammals may find it easy to cross mountain ranges, while small mammals may be stopped by a wide river.

- Geographical isolation does not necessarily lead to speciation. Speciation occurs only after barriers to reproduction are established.

Islands are living laboratories of speciation

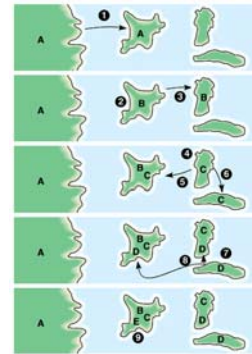
- Islands must be close enough together or to the mainland to allow for occasional dispersal but far enough apart to provide isolation most of the time.

- Darwin's finches (13 closely related species, distinguished by morphology and habitat) of the Galapagos Island chain are excellent examples the results of island speciation.

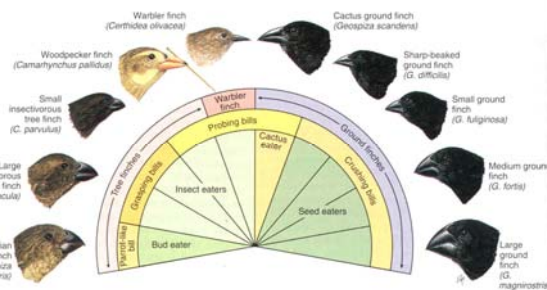
- A contrasting situation occurs on a more isolated island (Cocos), which has just a single unique species of finch.

- The emergence of numerous species from a common ancestor in one diverse environment (such as the Galapagos) is known as **adaptive radiation**.

Adaptive Radiation



Galapagos Finch - Adaptive Radiation



New species can also arise within the same geographic area as the parent species

- Such **sympatric speciation** seems to be rare among animal species, but has played an important role in plant evolution.

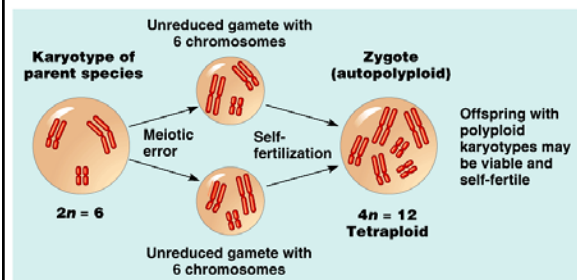
- The most common type of sympatric speciation occurs when an accident during cell division (cells dividing by mitosis rather than meiosis) results in an extra set of chromosomes (**polyploidy**).

- Tetraploid plants can form by self-fertilization of diploid gametes in a flower where meiosis has not reduced the chromosome set.

- The plants that grow from a tetraploid zygote can reproduce by self-fertilization but cannot produce fertile offspring by mating with its fertile ancestors because these offspring would be triploid.

- Most polyploidy species are the result of hybridization of two species.

Sympatric speciation by autopolyploidy in plants



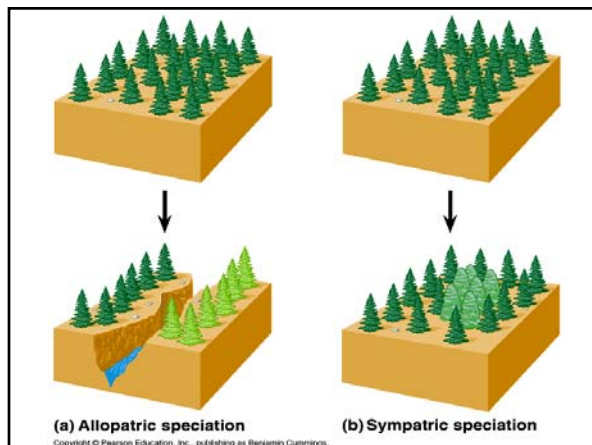
Polyploid plants clothe and feed us

•Scientists estimate 25-50% of all plants are polyploidy. Most commercially grown food and fiber plants are polyploidy hybrids: oats, potatoes, bananas, peanuts, barley, plums, coffee, wheat, and cotton.

NOTE: It has been natural for humans to select, for practical purpose, the better strains from among the offspring of chance matings.

•The genetic diversity of polyploidy hybrids is often advantageous.

•The recent evolutionary history of bread wheat (*Triticum aestivum*) is believed to have occurred by a series of steps involving hybridization, a failure of meiosis, an additional hybridization, and nondisjunction.

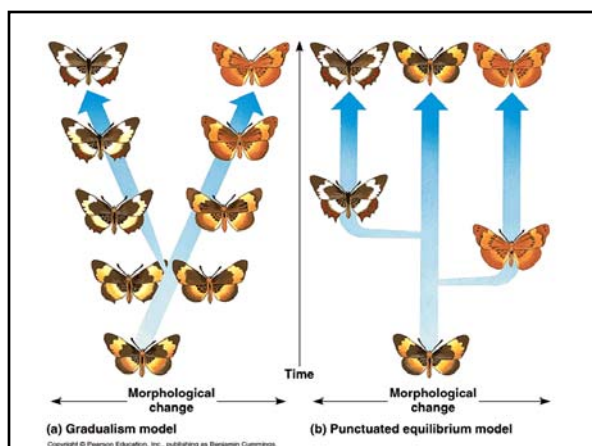


The tempo of speciation can appear steady or jumpy

•In the **gradualist model**, populations isolated from the ancestral stock change slowly as their allele frequencies shift during adaptation by natural selection. Darwin's proposal incorporated this model.

•Most of the fossil record does not support the gradualist model because most new species seem to appear suddenly in rock strata, without intermediary transitional forms.

•In the **punctuated equilibrium model**, periods of rapid evolutionary change (punctuation) and speciation are interrupted by long periods of little or no change (equilibrium; stasis).



Talking About Science: Evolutionary biologist Richard Dawkins expounds on the power of natural selection

•Dr. Dawkins is the author of several books that make evolutionary concepts accessible to the general public.

•In his book, *The Selfish Gene*, Dawkins argues for a gene-centered view of natural selection. The gene is what is passed from generation to generation; thus natural selection is best understood when viewed from the perspective of the gene.

•In *The Blind Watchmaker*, Dawkins makes an analogy between natural selection and a "blind watchmaker." The key is that natural selection does not predict the future but acts on the alternative that are most fit for the current environment.