

# Evolution III

## The Origin of Species



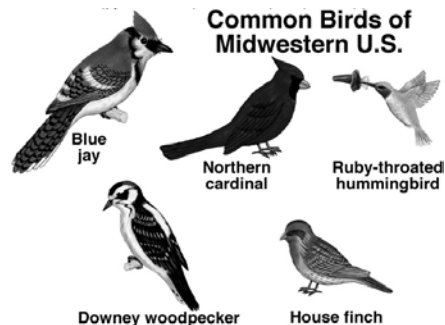
New species are formed when one species becomes two. Different populations of the same species can evolve independently and become so different that they can no longer be considered the same species. The biological species concept gives us a criterion for evaluating species.

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**Cladogenesis** - the origin of new genetic lineages - the formation of new species - **speciation**

What is a species?

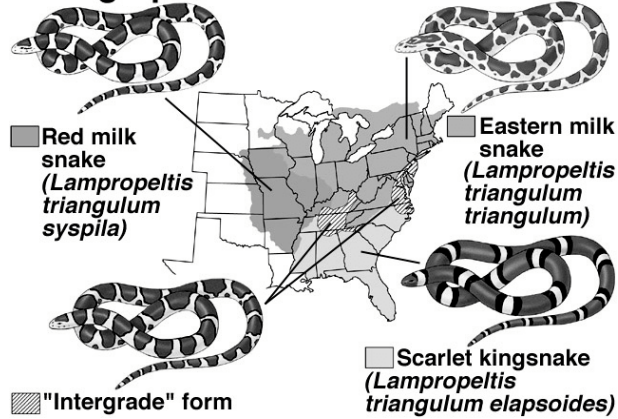
Whether two organisms are the same species or not, for most species, is not a difficult decision - house cats vs. dogs, groupers vs. tarpon, oaks vs pines. The difference between species reflects many generations of independent evolution and divergence from a common ancestor.



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The question is sometimes more difficult - when closely related forms are compared. The similarity is due to each only diverging slightly from their common ancestor.

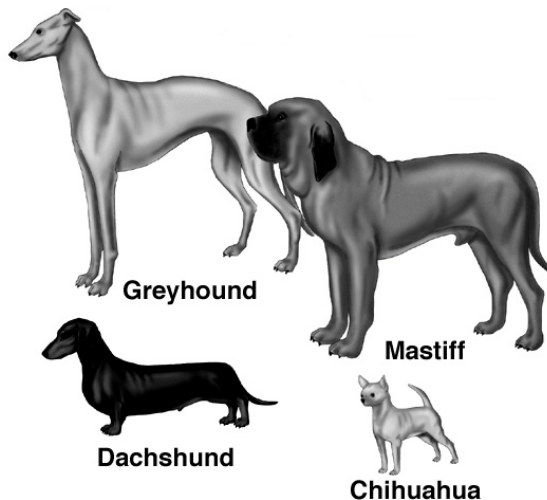
### Geographic Variation—Milk Snake



These snakes are all thought to be the same species, having different coloration, and living in different areas of the country. They are classified as **subspecies** of the same species.

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Difference in body form, coloration, etc., often characterizes different species but many times a single species can be highly variable.



Humans have produced divergent forms from a single ancestor through generations of artificial selection that are so different that they might be thought to be different species if they were found in nature.

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The **biological species concept** - a species is a population or a group of populations that are reproductively isolated from all other populations.

**Reproductive isolation** - the inability to exchange genetic information. Two types of organism are reproductively isolated if they lack the ability to mate and produce healthy fertile offspring under natural conditions.

Whether two organisms are reproductively isolated or not is often difficult to evaluate, most commonly because they live in different regions of the world. In such cases, their phenotypic similarity or differences, are commonly used as a criterion for placing them in the same or different species.

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Reproductive isolation can be classified into two categories:

**Prezygotic Reproductive Isolation** - the inability to exchange genes, even when the two forms live in the same geographic area.

**Postzygotic Reproductive Isolation** - the inability to produce healthy fertile offspring, even though the two forms can mate and produce a zygote.

Within each category there are several modes or mechanisms of reproductive isolation.

Prezygotic isolation includes ecological isolation, behavioral isolation, temporal isolation, mechanical isolation, and gamete incompatibility

Postzygotic isolation includes zygotic inviability and hybrid sterility.

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**Ecological isolation** occurs when two species live in the same area but do not encounter each other because they exploit different portions of the same habitat.

Until recently lions and tigers had overlapping ranges in India. They did not mate, in part, because lions live in open areas, and tigers prefer forests. They can, and will mate, and produce offspring in zoos. In nature, they are good biological species.



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**Behavioral isolation** occurs when two species live in the same area but do not recognize each other as mates because of behavioral differences.

Many species of birds, reptiles, fish, and arthropods, have elaborate courtship rituals where each potential mate must exhibit the proper sequence of behaviors before mating can occur.



Lions and tigers exhibit behavioral isolation as well as ecological isolation. Lions are social animals, living in prides. Tigers are solitary animals and associate as pairs only for mating.

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**Temporal isolation** occurs when two species, living in the same area, don't mate because of differences in their reproductive timing. Locally, our white and brown shrimp spawn at different times of the year. They lack the opportunity to mate.

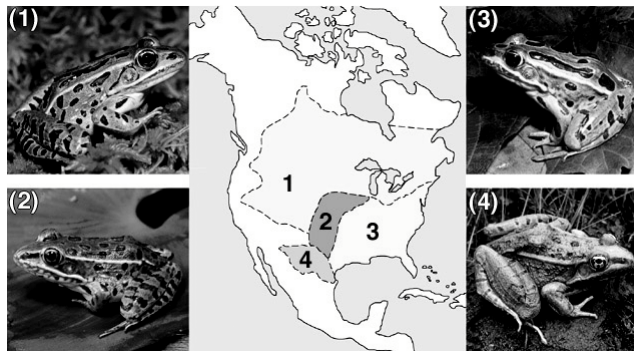
**Mechanical isolation** occurs when two species can't mate because their genitalia or some other aspect of their anatomy does not allow them to mate. Many insects have elaborate and species specific genitalia - when mating they form a lock and key like relationship. If the key doesn't fit the lock, no mating is possible.

**Gamete incompatibility** occurs when two species mate, but for various reasons, syngamy doesn't occur. Sometimes the sperm lack appropriate receptors for finding the egg. Sometimes the sperm lack the proper enzymes for digesting the jelly coat surrounding the egg.

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**Postzygotic Reproductive Isolation** - the inability to produce healthy fertile offspring, even though the two forms can mate and produce a zygote.

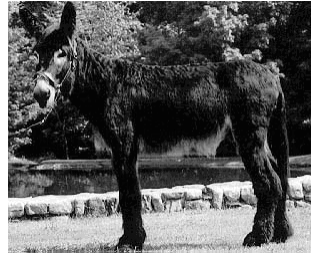
**Hybrid or zygotic inviability** is a common result of mating between two species. Fertilization occurs, but the zygote fails to develop, or if it develops, the hybrid is not healthy and does not survive.



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**Hybrid sterility** isolates species. The two species can mate and produce a sterile but otherwise healthy offspring. The sterility of the hybrid keeps the gene pools of the two species separate. When horses and donkeys are mated they produce mules. Mules are completely sterile. The sterility results from problems in meiosis. Horses have fewer chromosomes than donkeys and their genes are distributed differently among the chromosomes. In the mule, sterility is the result of inability to form viable eggs.

Horses and donkeys are good biological species.



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## How does reproductive isolation evolve?

The most common mode of speciation is **allopatric speciation**. In allopatric speciation, one species becomes distributed into two or more populations occupying different geographic areas and exchanging few or no individuals with other populations. The populations become **geographically isolated**.

In isolation, the two populations evolve independently. They become different ecologically, behaviorally, develop reproductive timing differences, or develop some other difference that would keep them reproductively isolated if they were brought back together.

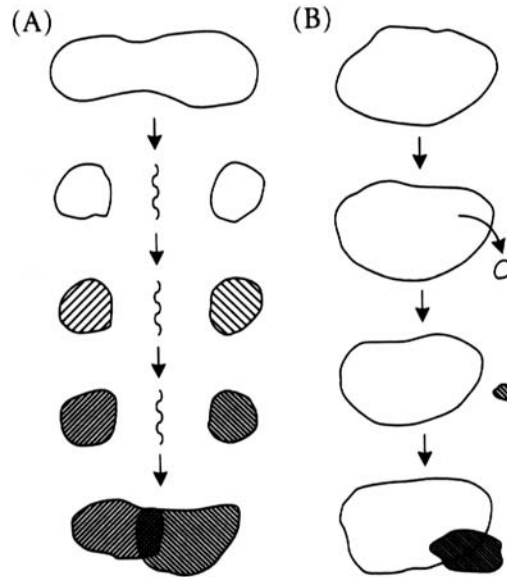
Often the evolution of the allopatric populations is associated with adaptation to different environments. But, the evolution can also involve chance changes in chromosome number, or arrangement, that results in postzygotic isolation.

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The geographic isolation may involve two populations separated by geological changes, or one or more small populations colonizing island habitats.

Independent evolution in isolation results in the evolution of some type of difference that keeps the two forms from mating when they come into contact again.

Allopatric speciation is a chance event.

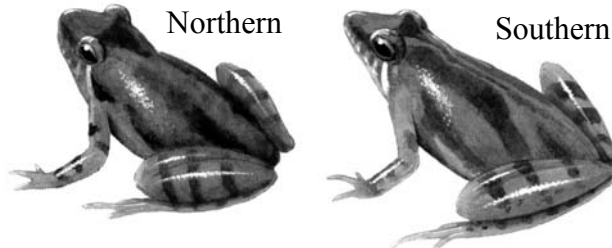


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### Speciation in cricket frogs (a hypothesis).

Two very similar species of small frogs, are reproductively isolated in the areas where they overlap by a slight difference in their calls. Females of one species don't recognize males of the other.

Before the last ice age, a single species of cricket frog may have inhabited much of southern N. America.



During glacial melting, a 200 mile river separated two populations of the cricket frog in southeastern and southwestern N. America. After the retreat of the glaciers, the two populations came together again in Louisiana and Mississippi. A call difference that evolved during separation, keeps the two species from exchanging genes today.

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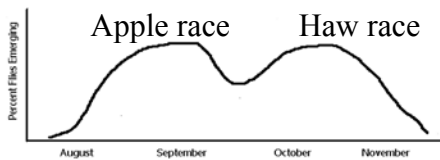
Speciation can also occur within the range of a single species, but this probably only happens rarely.

**Sympatric speciation** can occur through disruptive selection. First, a single species evolves two varieties each adapted to different portions of the same habitat. The two varieties can mate but mating between them produces poorly adapted offspring because there is no intermediate habitat. If there are any tendencies in the two varieties that cause them choose only members of the same variety for mating, those tendencies will be favored. Those who are not choosy will sometimes mate with the other variety and produce offspring with low fitness. The tendency to mate within a variety eventually becomes perfected as a prezygotic isolating mechanism.

Apple maggot flies may be a case of the beginning stages of sympatric speciation.

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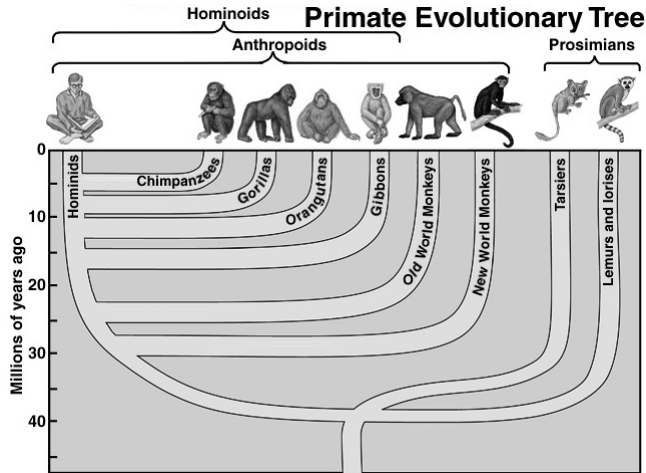
The apple race emerges early and parasitizes apples. The Haw race emerges late and parasitizes haws. Any mating between a late apple fly and an early haw fly will produce hybrids with an intermediate emergence time with few opportunities for parasitism.

Those that avoid mating with the other race will produce offspring with emergence times appropriate for apples or haws.

The two races already show some preferences in mating for members of their own race.

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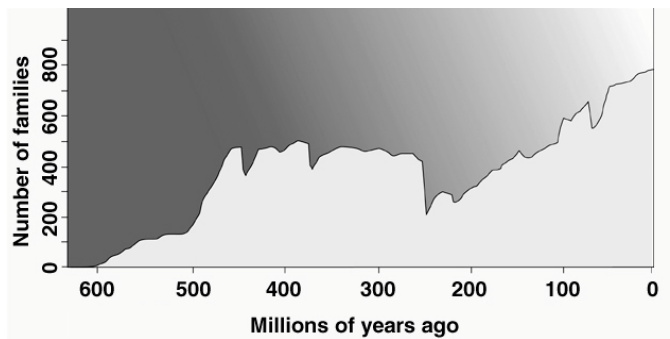
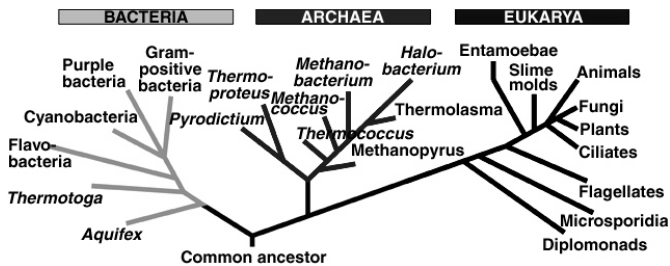
Anagenesis and cladogenesis combine to produce the diversity of life. Selection, mutation, genetic drift, etc. cause change within a lineage. Isolated populations can become separate evolutionary lineages with their own novelties, and evolutionary future.



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Like a growing oak tree, producing more and more branches through time, so does the tree of life.

The record of diversity found in fossils shows that life has gradually increased in diversity through time.



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“Nothing in biology makes sense  
except in light of evolution.”

Theodosius Dobzhansky 1973