Biology – Chapters 16 & 17

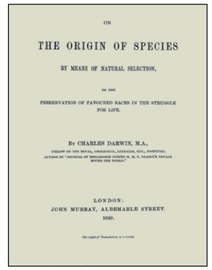
Evolution & Natural Selection

Honors Biology – Chapters 13 & 14

How Populations Evolve

The Origin of Species

Ridgefield Memorial High School


ON

THE ORIGIN OF SPECIES

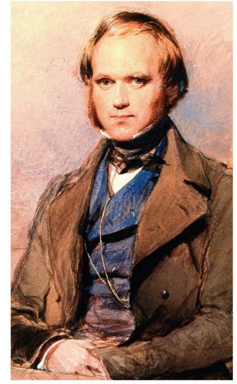
BY MEANS OF NATURAL SELECTION,

OR THE

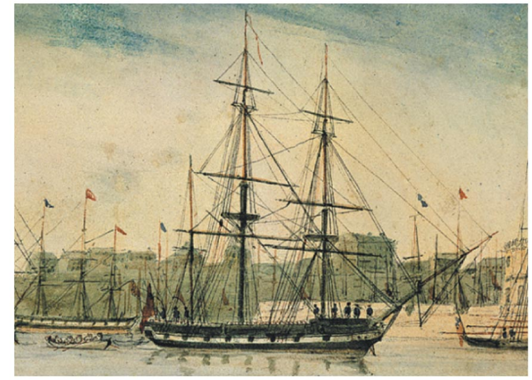
PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

BY CHARLES DARWIN, M.A.,

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.



Charles Darwin, the father of evolution, was only 22...



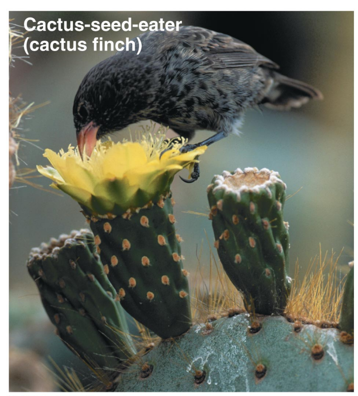
...when he went on the voyage of the Beagle in 1831...

...and sailed around the world.
Darwin did his research nearly 30 years before Gregor Mendel discovered dominant and recessive traits and 123 years before Watson and Crick discovered DNA.

Most of Darwin's research took place in the Galápagos Islands, which are located nearly 900 miles off the west coast of Ecuador.

The giant tortoise is one of the unique inhabitants of the Galápagos Islands.

Much of Darwin's knowledge came from studying the finches in Ecuador and on the islands.
In particular, he observed patterns between their diet and the shape of their beak.



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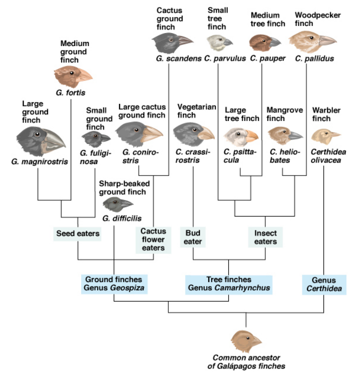
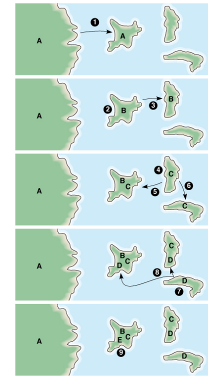


This is a phylogenetic tree of Darwin's finches.
The common ancestor lived in Ecuador.



The finches on the islands all evolved from a common ancestor in Ecuador. As birds migrate to the different islands, the environment naturally selects for favorable traits.

Jean Baptiste de Lamarck

- first major theory of evolution

- based on 3 principles:

- a desire to change = if an animal wants or needs to change its body, then it does
- use and disuse = if a part of an animal isn't used, then it shrinks and disappears; if it is used a lot, then it grows bigger, stronger, or more numerous
- acquired traits = traits that an animal receives during its lifetime will be passed to its offspring

What is wrong with LaMarck's theory?

5 Steps of Natural Selection

1. GENETIC VARIATION
   Every species contains differences in DNA
   EX: Some giraffes have longer necks and some have shorter necks.

2. OVERPRODUCTION OF OFFSPRING
   Organisms often produce more offspring than can survive.
   EX: The giraffes produce a lot of offspring.

3. FITNESS
   Only some individuals survive and reproduce.
   EX: Tall giraffes could reach the food. They survived and reproduced.
   Short giraffes could not reach the food. They died and did not reproduce.

4. GENETIC CHANGE
   Natural selection changes the % of genes in the population.
   EX: The "tall" gene becomes more common.
   The "short" gene becomes less common.

5. ADAPTATION
   Species adapt to the environment. Some genes are more favored than others.
   EX: Most of the giraffes in the population are taller.
   The shorter ones were unable to survive.

This model can be used to explain nearly all examples of natural selection.

5 Steps of Natural Selection – DARWIN'S FINCHES (The only food sources are nuts, fruits, and seeds.)

1. GENETIC VARIATION
   Every species contains differences in DNA
   EX: There are finches with short, fat beaks and other finches with long, thin beaks.

2. OVERPRODUCTION OF OFFSPRING
   Organisms often produce more offspring than can survive.
   EX: The finches produce a lot of offspring.

3. FITNESS
   Only some individuals survive and reproduce.
   EX: The birds with the short, fat beaks got the food, survived, and reproduced.
   The birds with the long, thin beaks couldn't get the food and died.

4. GENETIC CHANGE
   Natural selection changes the % of genes in the population.
   EX: The "short, fat beak" gene became more common.
   The "long, thin beak" gene became less common.

5. ADAPTATION
   Species adapt to the environment. Some genes are more favored than others.
   EX: The finches with the short, fat beaks are more likely to survive.
   The finches with the long, thin beaks are unable to survive.

This model can be used to explain nearly all examples of natural selection.

5 Steps of Natural Selection

1. GENETIC VARIATION
   Every species contains differences in DNA

2. OVERPRODUCTION OF OFFSPRING
   Organisms often produce more offspring than can survive.

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   Only some individuals survive and reproduce.

4. GENETIC CHANGE
   Natural selection changes the % of genes in the population.

5. ADAPTATION
   Species adapt to the environment. Some genes are more favored than others.

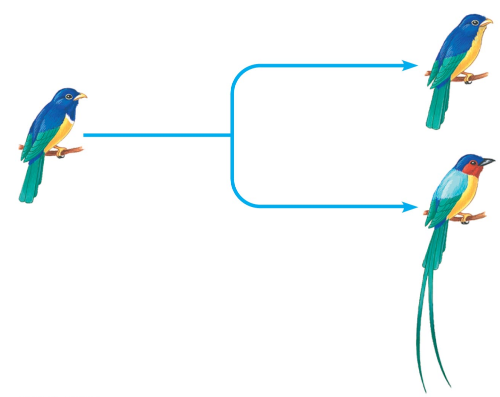
EX: DRUG-RESISTANT BACTERIA – Some bacteria are killed by antibiotics and some are not.

EX: PESTICIDE-RESISTANT INSECTS – Some insects are killed by pesticides and some are not.

EX: THE PEPPERED MOTH – There are light and dark peppered moths.
(The trees have been covered with soot.)

This model can be used to explain nearly all examples of natural selection.

Genetic variation is the first step in evolution.



Speciation (the origin of new species) leads to increased genetic variation.

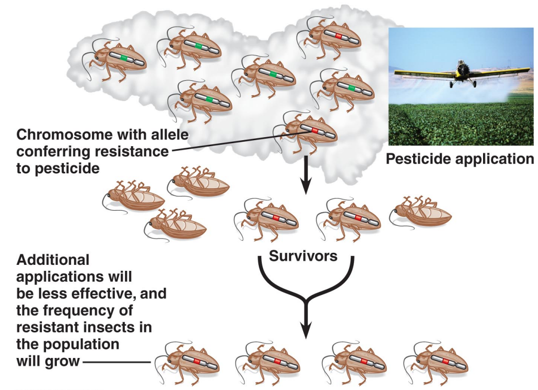
Fish overproduce their offspring because reproduction
is the ONLY important thing in life.

The peacock tries to attract the peahen by showing his beautiful feathers.
The colorful feathers are an indication of good health and "strong" genes.

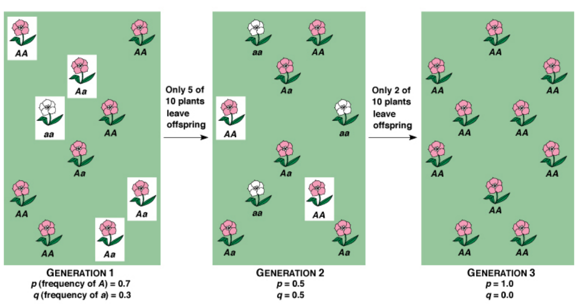
This is another view of the male peacock trying to attract the female.

Two males fight over a female.

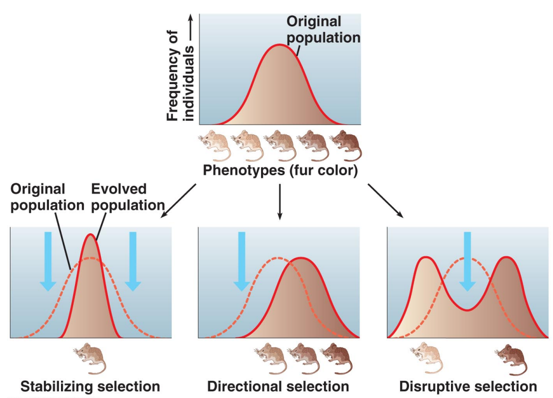
The male gray tree frogs sings a long mating call to attract a female.



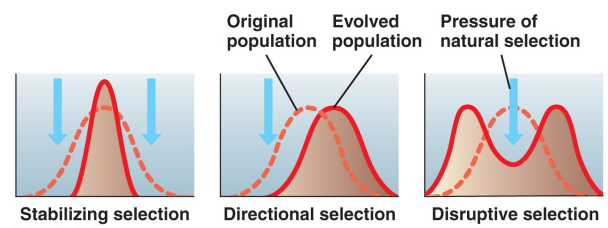
Evolution works because those with unfavorable traits do not survive to reproduce.
This is one of the simplest explanations of natural selection.



These flowers evolved to become pink because the white ones were selected against.
Notice the relationship between genetics and evolution.



Natural selection can be stabilizing, directional, or diversifying (disruptive). Natural
selection can favor the "middle" trait, one "extreme" trait, or two "extreme" traits.



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selection can favor the "middle" trait, one "extreme" trait, or two "extreme" traits.

Directional Selection (one extreme trait is favored)

EX: - Trait: speed of wolves

- Evolution favors faster wolves
- Graph is shifted to the left or right

The 3 modes of natural selection are directional, stabilizing, and diversifying selection.

Stabilizing Selection (the middle form of the trait is favored)

EX: - Trait: human birth weight

- Evolution favors medium birth weight
- Graph produces a thinner bell curve

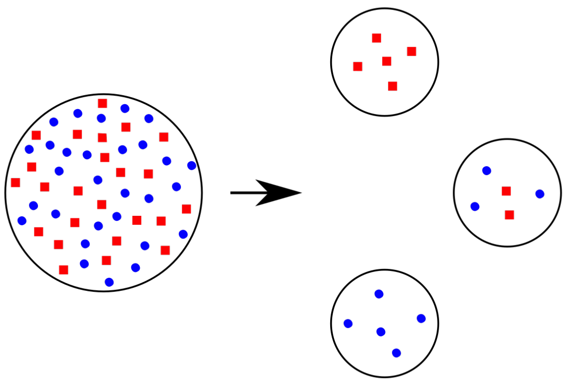
The 3 modes of natural selection are directional, stabilizing, and diversifying selection.

Diversifying Selection (both extreme traits are equally favorable, but not the middle trait)

EX: - Trait: type of beak (Darwin's finches)

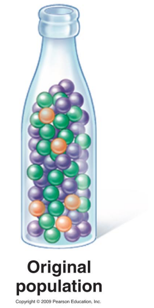
- Evolution favors short/fat beaks (for eating nuts and fruit) as well as long/thin beaks (for eating worms and insects), but not medium-sized beaks
- Graph produces an upside-down bell curve

The 3 modes of natural selection are directional, stabilizing, and diversifying selection.

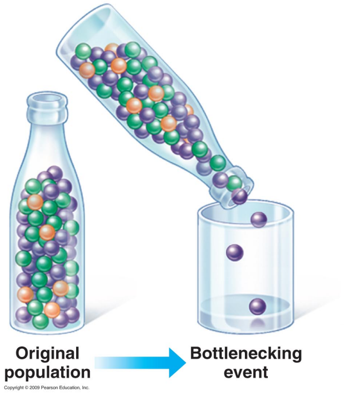


When a small group is separated from a large population, the small group will have a different % of genes than the original (larger) group. This is called the founder effect.

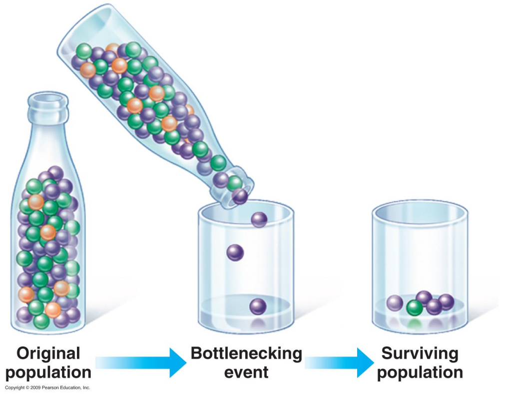
Ellis-van Creveld Syndrome is much more common among the Amish than the rest of the human population. One or two of their "founders" had the faulty alleles on chromosome 4.



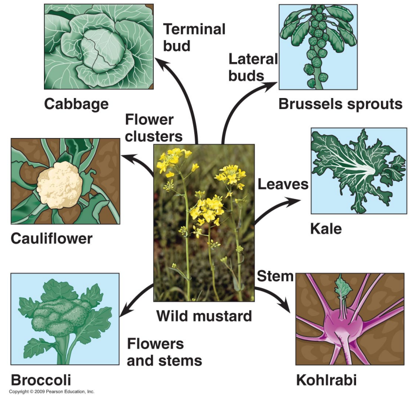
The bottleneck effect is when a disaster kills most of a population, leaving just a few organisms behind. ...



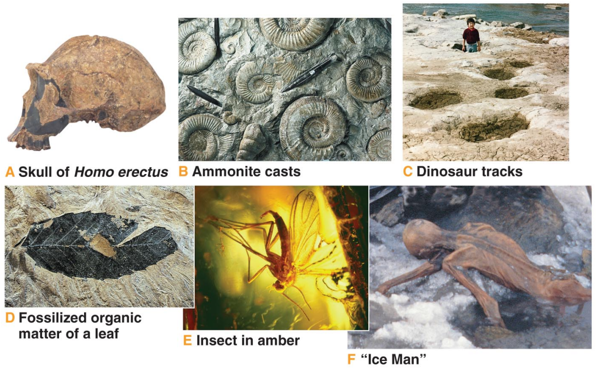
... Since the organisms that died were determined randomly, the bottleneck effect would not be considered to be a form of natural selection. ...



... However, the percentage of gene frequencies did change, so the bottleneck effect would be considered to be a form of natural selection.



Farmers experience artificial selection when they choose certain crops to grow. They select for certain traits, causing the percentage of gene frequencies to change throughout the generations.



Fossils provide a lot of evidence for evolution.

A Skull of *Homo erectus*

A skull is an example of an original remain.

B Ammonite casts

A cast is made when the original fossil is weathered and eroded.
A new material, such as sediment, fills in the empty areas to produce a cast.

C Dinosaur tracks

A dinosaur track is an example of a trace fossil.

D Fossilized organic matter of a leaf

A dinosaur track is an example of a trace fossil.

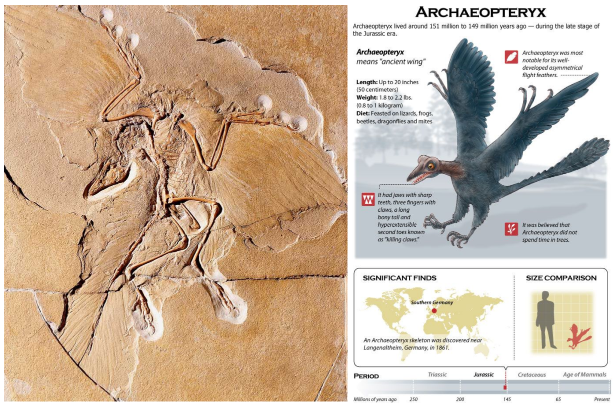
E Insect in amber

An insect fully preserved in amber is an example of an original remain.

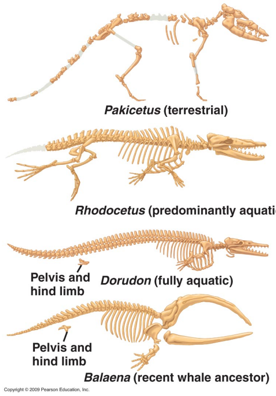
F "Ice Man"

A caveman preserved in ice is an example of an original remain.

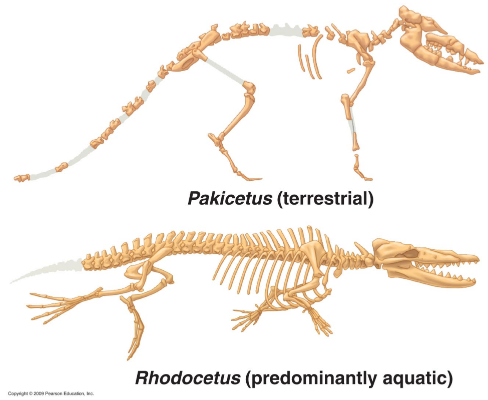
Layers of rock help identify the age of fossils using the principle of superposition. The oldest rocks are always at the bottom, unless they have been disturbed in some way.



Archaeopteryx is considered the "missing link" between dinosaurs and birds.



Fossils show how the ancestors of whales used to live on land.



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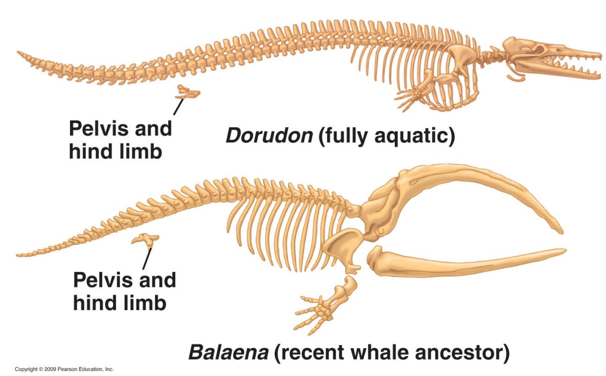

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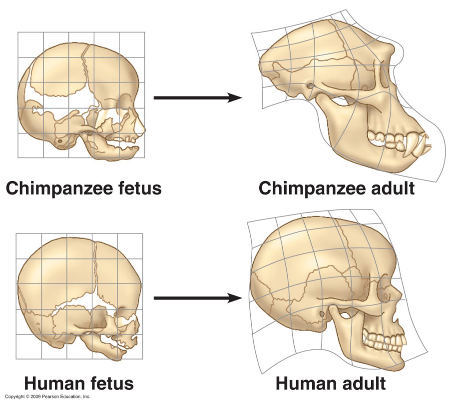
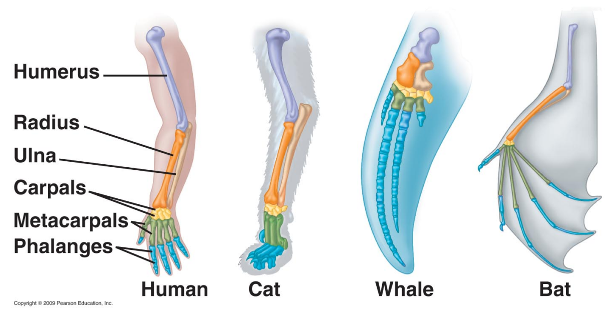
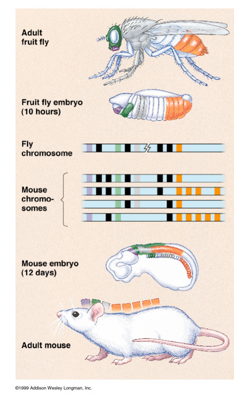


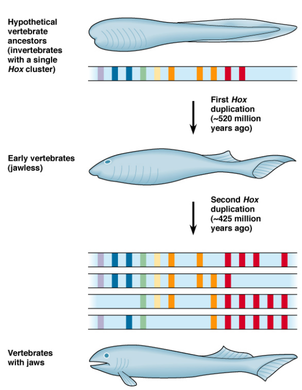
Skull structures are used to help determine the evolution of humans from other primates.



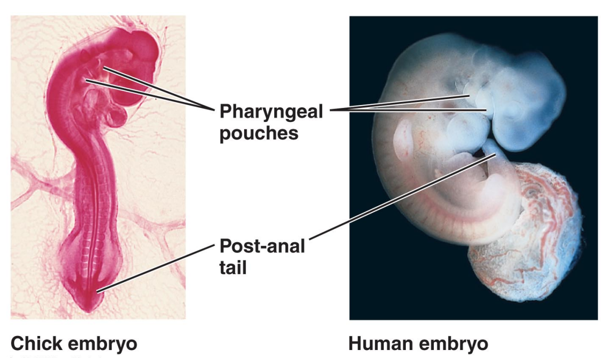
Homologous structures have similar structures but may have different functions. Structures, not functions, evolve. Remember that structure always determines function.



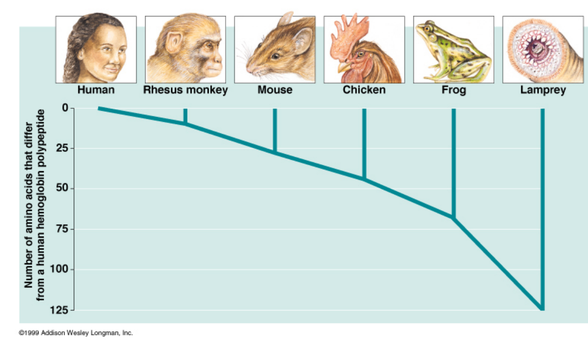
Molecular data shows the genetic similarities between species. Phylogenetic trees can be made with great accuracy by comparing DNA or protein sequences of different species.



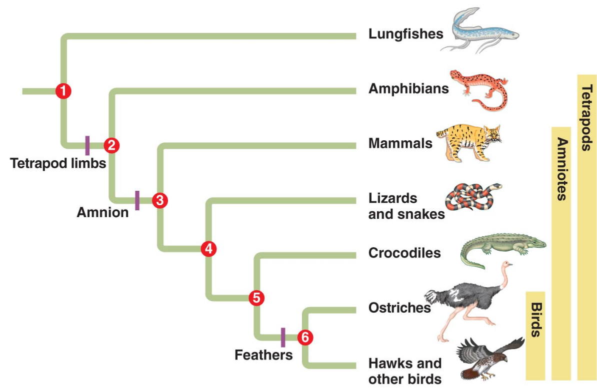
In this example, molecular data shows the relationship between early fish and modern fish.



As we develop as an embryo, we have features similar to other animals including gill-like slits and a "tail".

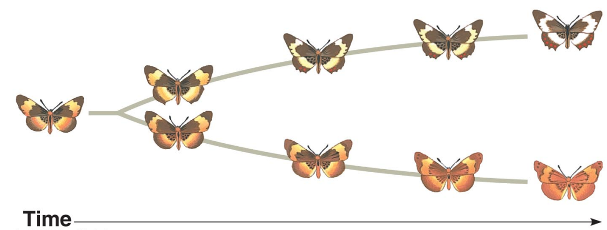


This is an example of a phylogenetic tree based on molecular data.



This phylogenetic tree shows the origin of 3 important homologies.

Evolution can occur in short, quick bursts (often due to catastrophic events)...

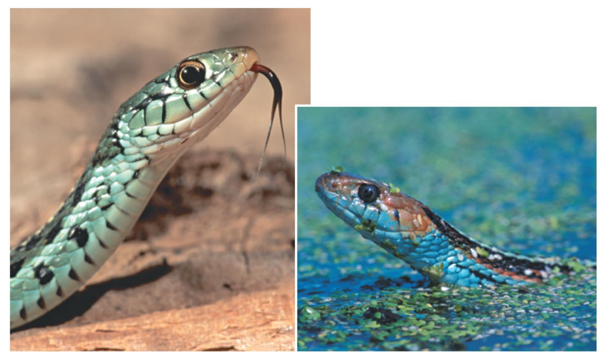


...or be a very gradual process (usually the result of natural selection).

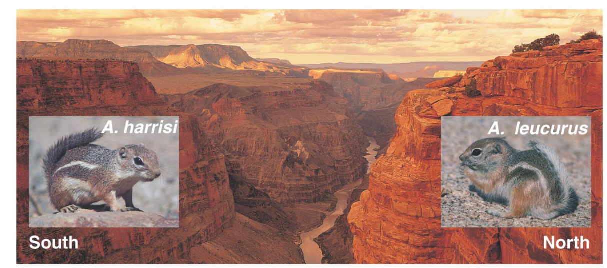
TABLE 14.3 REPRODUCTIVE BARRIERS BETWEEN SPECIES

Prezygotic Barriers: Prevent Mating or Fertilization	
Temporal isolation:	Mating or flowering occurs at different seasons or times of day.
Habitat isolation:	Populations live in different habitats and do not meet.
Behavioral isolation:	There is little or no sexual attraction between different species.
Mechanical isolation:	Structural differences in genitalia or flowers prevent copulation or pollen transfer.
Gametic isolation:	Male and/or female gametes die before uniting or fail to unite.
Postzygotic Barriers: Prevent the Development of Fertile Adults	
Reduced hybrid viability:	Hybrids fail to develop or to reach sexual maturity.
Reduced hybrid fertility:	Hybrids fail to produce functional gametes.
Hybrid breakdown:	Offspring of hybrids are weak or infertile.

There are 8 reproductive barriers that keep species separate from each other. Pre-zygotic barriers prevent two different species from mating. Post-zygotic barriers prevent hybrids from mating.

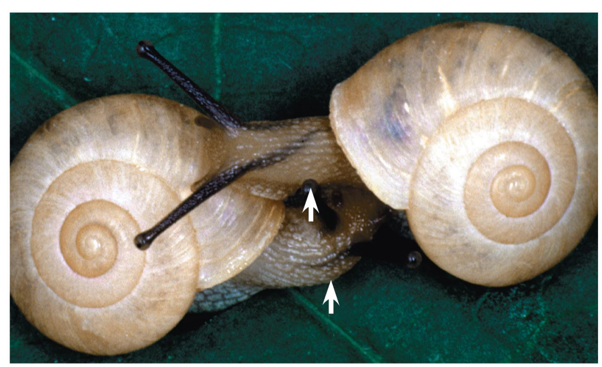


Habitat isolation is when species are separated based on where they live.



This is another example of habitat isolation.
One day, these will become 2 different species.

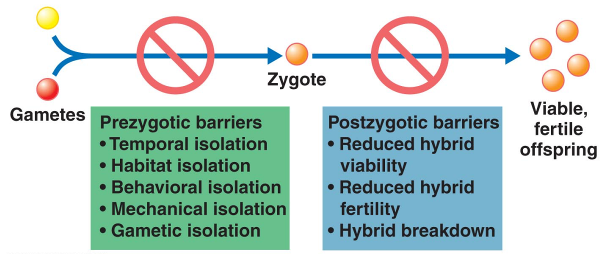
Behavioral isolation is when animals can't mate because they have different mating rituals.



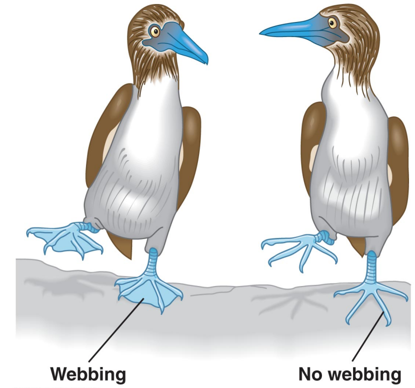
Mechanical isolation is when animals cannot mate because of physical limitations.
These snails cannot mate because their opposite shell shapes prevent copulation.

These sea urchins experience gametic isolation.
The sperm and egg don't make a lock-and-key fit.

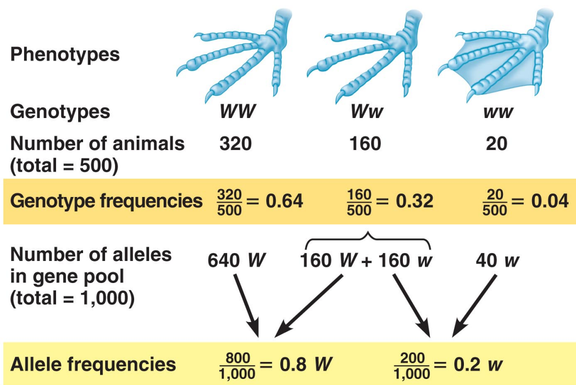
A mule (bottom) is not a species because it is a hybrid of a horse (left) and donkey (right).



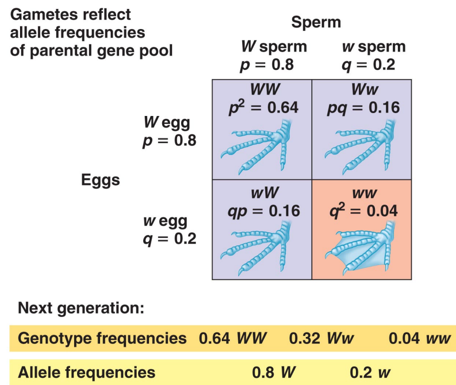
This is a review of the 5 pre-zygotic and 3 post-zygotic barriers to reproduction.



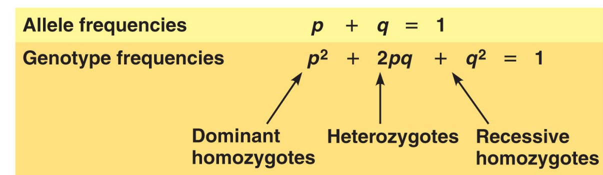
These imaginary birds can have feet with or without webbing.



This shows the gene pool of the original population of birds.



This shows the gene pool of the next generation of birds.



This is the Hardy-Weinberg equation for determining equilibrium in a population. Remember that a population experiencing equilibrium is NOT evolving!

Hardy-Weinberg Shortcuts:

1. Find q^2.
2. Take the square root of q^2 to find q.
3. Subtract: $1 - q$ to get p.
4. Square p to get p^2.
5. Multiply $2 \cdot p \cdot q$ to get $2pq$.
6. Reread the question and answer it using the answers you have calculated!