

Discussion and debate is essential to science.

When Charles Darwin proposed his theory of evolution 150 years ago it was deeply controversial. Many people - including other scientists - were shocked or bitterly hostile to the idea.

1. It undermined the religious belief in creation
2. Most scientists thought the earth was only tens of millions of years old at most.
3. People's instinctive assumption that organisms had always been the way they are now

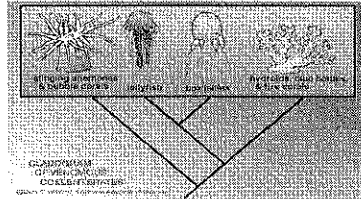
REMEMBER:

- Always keep an open mind to new possibilities
 - even when they seem to fly in the face of reason
- Use the scientific method:
 - first look objectively at ALL the evidence
 - then develop a theory that explains it as completely as possible

<http://www.edmentix.com/teachers/grade/level/subject/units/101>

KEY POINTS OF EVOLUTION

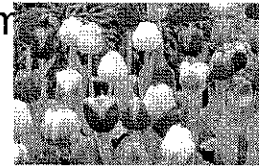
- 1. Process of evolution occurs in populations of organisms as generation follows generation through long periods of time
- 2. Single individuals do not go through evolution



Review: 5 Proofs of Evolution

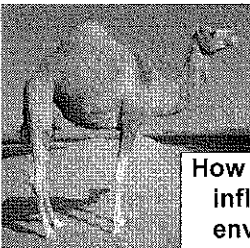
1. Homologous Structures
2. Embryonic Similarities
3. Universal Genetic Code (A, T, C, G) & DNA similarities
4. Fossil Record
5. Vestigial Organs

What is an Adaptation?
An adaptation is a characteristic that helps an organism reproduce



- What adaptations do tulips have?
- What adaptations did Darwin's finches have?

Bactrian Camel



How are adaptations influenced by an organisms environment?

- **Special Adaptations**
- Camel's hump serves as a reservoir for energy-rich fat, which the camel can metabolize for energy when food is scarce.
 - Bactrian camels can go for months without drinking water.
 - When they do drink, they can consume 30 gallons of water at one sitting!
- Long eyelashes, ears lined with hair and nostrils that can be pinched shut all help shield the Bactrian camel from the blowing sand of its dry environment.

Natural selection

(video: darwins dangerous ideas - hummingbirds)

- **Organisms that are best suited to their environment will survive and reproduce; this can lead to a change over time**
- What is speciation?
- What are the four key components of natural selection?
- What kinds of variable traits within the hummingbird population has natural selection acted upon?

Breeding Bunnies Lab

Day III

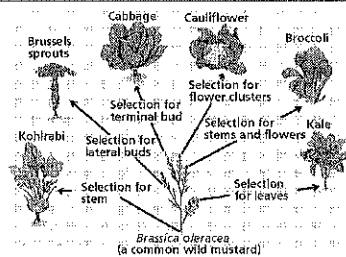
Review:

Adaptations are characteristics that give an organism an advantage in survival

Survival =

living to reproduce

- Reproductive success



Evolving Ideas: How Does Evolution Really Work?

Factors are needed for evolution:

1. **Variation**
 - you need to have variation for Natural Selection
 - Variation → Isolation → Natural Selection → Divergence → New Species
2. **Change in environment**

These bring: Competition among individuals in a population

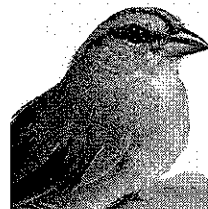
Think: what if all organisms were identical and the environment changed? Malaria example? Bird peak example???

Example of how variation can lead to evolution of a species: Peppered moths



- Varied population of moths: white and peppered color moths
- Originally the lighter color moths were the majority and were favored because they could blend in better with the environment
- Industrial revolution caused the environment to change
- Peppered moths had an advantage in the new environment
 - Overtime peppered moths outnumbered the lighter colored moths

How do we get variation in a population?



- Sources of Variation
 1. Recombination of genes during meiosis and fertilization
 2. Mutations (in gametes)
- Variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions

1. Mutations (from Secret Life - Accidents of Creation - Sickle Cell Anemia)

- Mutation = an unpredictable change in DNA
- Video: ~5mins

- In West Africa Malaria is very common
- For most the disease is not fatal
- This is because they have a resistance

A mutation in the hemoglobin sickle cell gene changes the shape of the hemoglobin it makes. People that have this mutation have an **ADVANTAGE!**

Mutations of Chromosomes

How has natural selection favored sickle cell anemia?

- In West Africa Malaria is very common
- For most the disease is not fatal
- This is because they have a resistance
- A mutation in the hemoglobin sickle cell gene changes the shape of the hemoglobin it makes. People that have this mutation have an **ADVANTAGE!**

How do different species form? (cont)

2. Genetic Recombinations (Evolution: Why Sex – minnows) (~5mins)

- resulting from meiosis and sexual reproduction
- increase the genetic variability
- contributes to the **GENE POOL** (the sum of all the alleles of a population)

Synapsis: Pairing of homologous chromosomes

Crossing over

How do different species form? (cont)

1. Variations in Population due to Mutation and Genetic Recombination
2. Environmental Change
3. Migration (leaving) and Immigration (arriving)
4. Random change leading to **genetic drift**
5. Artificial or natural selection
 - **Artificial selection** = selective breeding to obtain the optimal offspring (milk or beef production in cows, etc)
 - **Natural selection** = survival of the fittest
6. Nonrandom mating – **sexual selection**
 - Animals choose mate based on desired traits (size, appearance, etc)

Factors that bring about evolution

1. Environmental change:

- **Genetic Drift** = when a population is affected by a chance event
- Usually decreases variation in a population
 - Chance events
 - Fire, earthquakes, tornadoes, floods.... All can change an environment
 - These things affect what food/shelter is available to the organism
- **Gene Pool:** genes available within a reproducing population
- **Gene Flow:** Immigration and emigration
 - If a population moves to a new environment
 - Example. An organism gets brought to an island

Examples Genetic Drift causing a change in animal populations...

- Example: (p433 of Bio Book)
 - little genetic variation in the cheetah population
 - This is consistent with a reduction in the size of the population to only a few individuals - an event that probably occurred several thousand years ago.
- Another observed example is the northern elephant seal
 - hunted almost to extinction
 - By 1890 there were fewer than 20 animals but the population now numbers more than 30,000.
 - NOW there is very little genetic variation in the elephant seal population and it is likely that the twenty animals that survived the slaughter were more "lucky" than "fit".

Theory: How does our environment relate to Lactose Tolerance?

- Human ancestry comes from a lactose intolerance background
 - Most mammals develop lactose intolerance after a certain time in infancy
- Since milk is such a staple food, at one point in time it probably became advantageous to be able to drink milk
 - The trait for lactose tolerance was advantageous and was passed on to later generations
 - Now the majority of humans are lactose tolerant

When speciation occurs, why is it maintained?

1. Barriers

- Behavioral
 - Organisms mate at different times of the year, organisms use different courtship rituals like songs that only attract certain species as mates
- Geographical
 - Mountains, oceans, rivers, space, etc
- Physical
 - Elephant and mouse won't mate



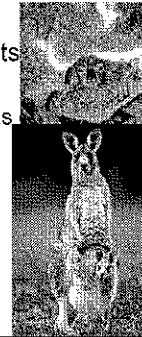
Example of Geographic Isolation: Abert & Kaibab Squirrels (p438)

- 10,000 yrs ago only Abert squirrel lived in Arizona forests
- Small group became isolated on north side of Grand Canyon
- Evolved into the Kaibab squirrel



Continental Drift

- After Pangaea species could no longer walk around the world
- Some became isolated on continents and evolved independently
 - Australia - species isolated for millions years
 - Species are very unique (many



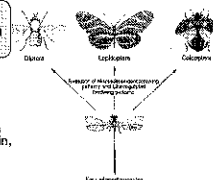
Distinctness of Species (speciation) is Maintained in 3 Ways (cont.)

2. offspring do not live to reproduce
 - organisms mate but offspring do not develop to be born
3. offspring are sterile and cannot reproduce
 - a. ex. Mules are sterile and the offspring of a horse and a donkey mating



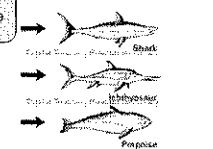
Divergence v. convergence

Divergence = when organisms within a species become so different that they can no longer interbreed



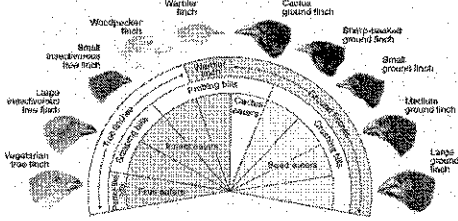
- Species → subspecies → new species
- HOMOLOGOUS STRUCTURES
 - For example, the vertebrate limb is one example of divergent evolution. The limb in many different species has a common origin, but has diverged somewhat in overall structure and function

Convergence = different groups have developed the same adaptations because they live in the same type of environment



- ANALOGOUS STRUCTURES
 - Insect wings and birds wings
 - Whales fins and sharks fins

Darwin's finches is an example of adaptive radiation...."speciation event"

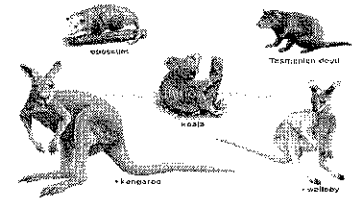


- Adaptive radiation=diversification of a species as it adapts to different ecological niches.

Another example of adaptive radiation..

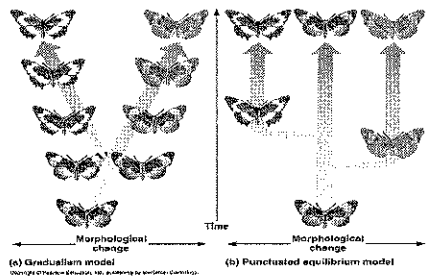
The Marsupials

- All the marsupials in present day Australia would have evolved from one common ancestor. However, over time and via natural selection, the many marsupial species (i.e. kangaroo and koala) have occupied their own ecological niche and adapted accordingly. Kangaroo's have long powerful legs to cover the wide area of land that they occupy while the koala's smaller structure and more centralised centre of gravity allow them to climb trees and obtain the eucalyptus that they feed on.



Rates of Speciation

- Gradualism- changes in species is slow and gradual, occurring in small periodic changes in the gene pool
 - Punctuated Equilibrium- evolution occurs in spurts of relatively rapid change with long periods of non-change.
- this theory is commonly found in the fossil record.



Coevolution

PBS: Toxic Newt



- When two or more organisms develop specialized traits together
 - They directly influence each others survival
 - predator and prey
 - competitors
 - organisms linked by mutually beneficial symbiosis.

What were the adaptations?

- Over time, some genetic variants of the snake that are resistant to the toxin have emerged
 - Snakes with resistance had an adaptation
- AND variants of the newt have become more poisonous
 - Newts that were VERY toxic were at an advantage

Coevolution → when two unrelated groups become uniquely adapted to one another

- Evolving Ideas: Why Does Evolution Matter Now?
- http://www.pbs.org/wgbh/evolution/library/11/2/e_s_6.html
- Evolution continues to have an impact on our lives -- the food we eat, our environment, and our health. Through the story of a multi-drug resistant strain of tuberculosis in the prisons of Russia, we see evolution in action today. This video illustrates how evolution is important to our understanding of disease prevention and treatment in Russia and around the world.
- Credits: ©2001 WGBH Educational Foundation and Clear Blue Sky Productions, Inc. All rights reserved.

Honors cont....

Speciation – creation of a new species

- There are different types of speciation events

TYPES OF SPECIATION

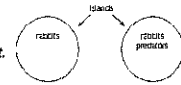
- **Allopatric**
(allo = other, patric = place)
geographically isolated populations
Example: Finches in the Galapagos Islands
- **Peripatric**
(peri = near, patric = place)
a type of allopatric speciation, but in this scenario one of the isolated populations has only a few individuals
• a small population isolated at the edge of a larger population
- **Parapatric**
(para = beside, patric = place)
a continuously distributed population (not geographically isolated)
• But the pop. Doesn't mate randomly = reduced gene flow
- **Sympatric**
(sym = same, patric = place)
within the range of the ancestral population
• Some of the individuals are exploiting a new niche which results in those individuals evolving differently over time

Hypothetical Example of Allopatric Speciation

SCENARIO 1

Suppose that there are two populations of rabbits, each on an island in the ocean. One island has predators that eat rabbits and the other does not.

- How might natural selection change the rabbit populations after several thousand years?



SCENARIO 2

Suppose that the rabbit food is different on one island than it is on the other.

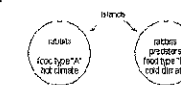
- How might natural selection change the rabbit populations with regard to their food requirements after several thousand years?



SCENARIO 3

Suppose that the climate of one island is hot but the climate of the other is cold.

- How might the rabbits become adapted to the different climates?

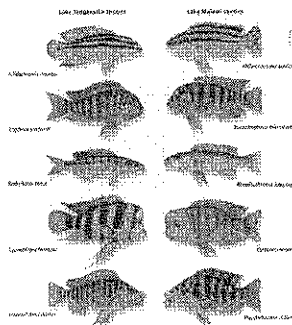


Eventually, the two populations will become so different, that they will be different species.

• http://www.pbs.org/hgbh/evolution/library/05/27_052_02.html

Example of variation can lead to speciation:

- **African cichlid fishes**
= case of "explosive speciation"
– there is very little sequence divergence between species: confirms short time span.



Assumptions of the Hardy-Weinberg Equilibrium Theory (Evolutionary Mechanisms)

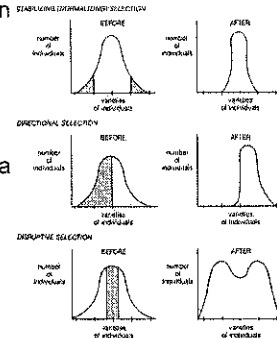
IF populations disobey these assumptions EVOLUTION WILL OCCUR.

- POPULATIONS WILL BE LARGE IN SIZE (i.e., no genetic drift). Random chance can alter allele frequencies through mating processes and death within small populations.
- INDIVIDUALS WILL RANDOMLY MATE which means that the choice of mates by individuals in the population is determined by chance, and not influenced by the genotypes of the individuals in question.
- THERE ARE NO MUTATIONS: No difference in the mutation rates between alleles at the same locus.
- THERE IS NO GENE FLOW: Reproductive isolation from other populations (i.e., no gene flow or migration).
- NO NATURAL SELECTION: No differential survival or reproduction among phenotypes (i.e., no natural selection).

Natural Selection affects populations and often creates 3 patterns:

Natural Selection affects populations and often creates 3 patterns:

- Stabilizing selection- favors the norm, the common, average traits in a population.



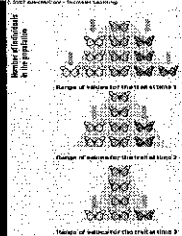
- Directional selection- favors those individuals who have extreme variations in traits within a population.

- Disruptive selection- the extremes traits in a population.

Example of Stabilizing selection- favors the norm, the common, average traits in a population.

Stabilizing Selection

- Intermediate forms are favored and extremes are eliminated

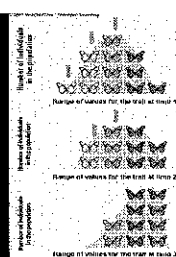


- Siberian Husky, a dog breed for working in the snow.
- These dogs have strong pectoral and leg muscles, allowing it to move through dense snow.
 - The Siberian Husky is well designed for working in the snow.
 - If the Siberian Husky had heavier muscles, it would sink deeper into the snow, so they would move slower or would sink and get stuck in the snow.
 - Yet if the Siberian Husky had lighter muscles, it would not be strong enough to pull sleds and equipment, so the dog would have little value as a working dog.
 - So stabilizing selection has chosen a norm for the size of the Siberian Husky.

Directional selection- favors those individuals who have extreme variations in traits within a population.

Directional Selection

- Allele frequencies shift in one direction

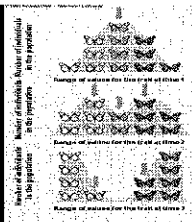


- Ex. breeding of the greyhound dog.
 - Early breeders were interested in dog with the greatest speed. They carefully selected from a group of hounds those who ran the fastest. From their offspring, the greyhound breeders again selected those dogs who ran the fastest.
 - By continuing this selection for those dogs who ran faster than most of the hound dog population, they gradually produced a dog who could run up to 64km/h (40mph).

Disruptive selection- the extremes traits in a population.

Disruptive Selection

- Forms at both ends of the range of variation are favored
- Intermediate forms are selected against



- African butterfly *Pseudacraea eurytus*
 - Variation in coloration: reddish yellow to blue.
- The lightest color butterfly and the brightest color butterfly, look like (mimic) other species of butterflies that are not normally the prey of other the local predator group of birds and other insects.
- The most colorful extremes are favored