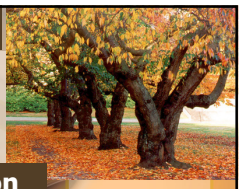
# The Theory of Evolution

## What is Evolution?



- The process of change over time.

## How is Biological Evolution Different?

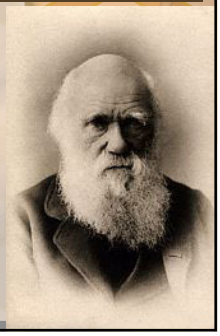
- All organisms on Earth descended from ancestral species & share a common ancestor (genetic inheritance).
- Species modify or adapt to different ways of life.
- A process called *descent with modification*.

## What People Thought Before Charles Darwin

- Species do not ever change over time.
- Earth is only several thousands of years old & doesn't change.

These ideas were challenged because of the great diversity seen in life!

## Charles Darwin 1809-1882

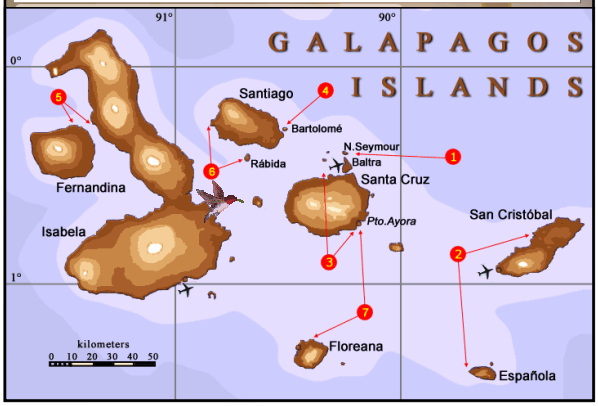


## HMS Beagle

## Darwin's 5 Year Voyage

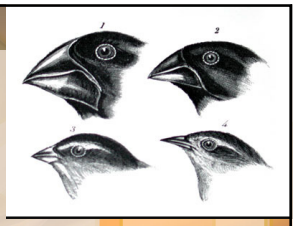
aboard the *HMS Beagle*

## Charles Darwin's Voyage




## Galapagos Islands

Finches

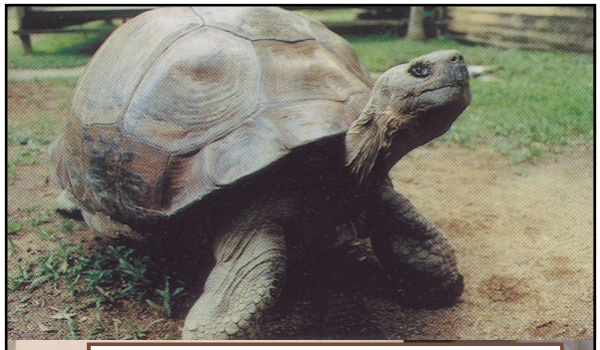


- Noticed the islands had some differences in species than on the mainland.
- Species adapted to their new environment

Iguanas

Tortoises


## Galapagos Finches



**Harriet-Galapagos Tortoise 176 years old (approximate birthday: around Nov. 15, 1830)**

## Darwin's Observations

- **Diversity of life**
  - enormous number of different species on planet
- **Fossils**
  - many ancient organisms no longer existed **(Living species have ancestors!)**
- **Galapagos Islands**
  - different traits among similar organisms that lived on different islands

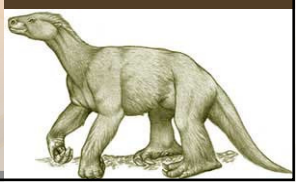
## A fossil found in South America

*(Megatherium, ground sloth)*

- **Hypothesized:**

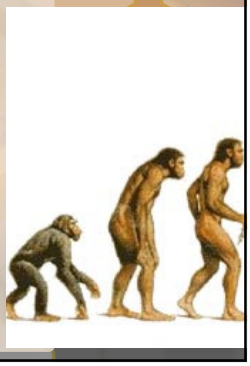
**"Existing animals have a close relation in form to extinct species."**

**Called "Descent with Modification"**



## Descent with Modification

- Over long periods of time, natural selection will produce organisms with different structures.



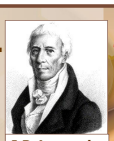
## Summary On Darwin's Theory of Evolution

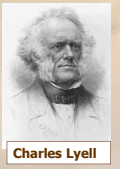
✓Species change & adapt over time to their environment.

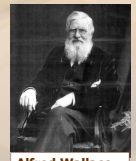
## The People Who Shaped Darwin's Ideas

1. 
James Hutton

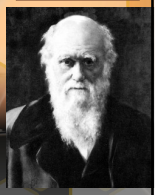
2. 
Thomas Malthus

3. 
J.B. Lamarck

4. 
Charles Lyell

5. 
Alfred Wallace

Charles Darwin



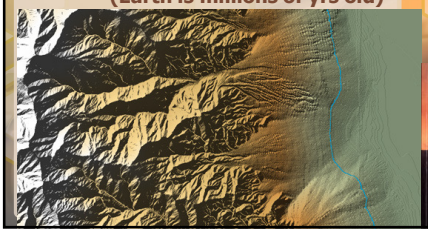
## Hutton

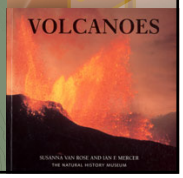

James Hutton

1785

Geological forces & features have shaped the Earth for a long time.

(Earth is millions of yrs old)






## Malthus

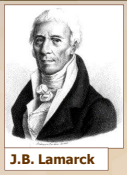

Thomas Malthus

1798

Species produce lots of offspring, competition, most die.

Space / food / disease / war = controls population

## Lamarck 1809


J.B. Lamarck

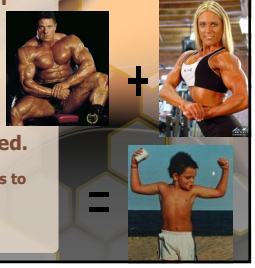
1. "Tendency towards Perfection"

Organisms change & acquire features to live successfully in their environment.

2. *"Use & Disuse"*

Structures used became better developed. Not used, disappeared.

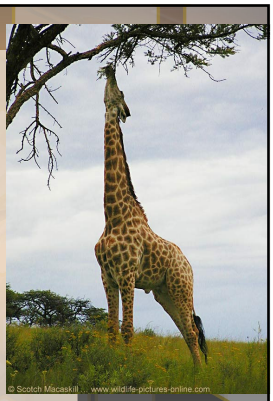
Ex: if wanted to transform limbs into wings to fly then it can because it used it.



### *3. "Inheritance of Acquired Characteristics"*

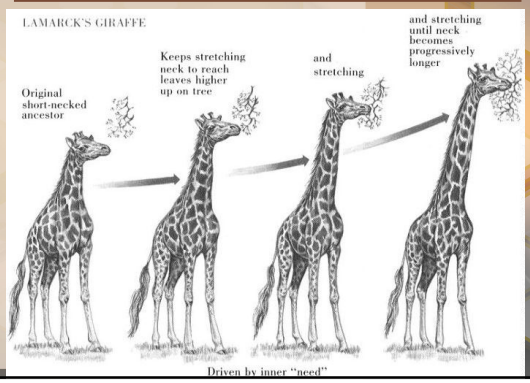
**Traits could be passed on & so organisms change over time, adaptation.**

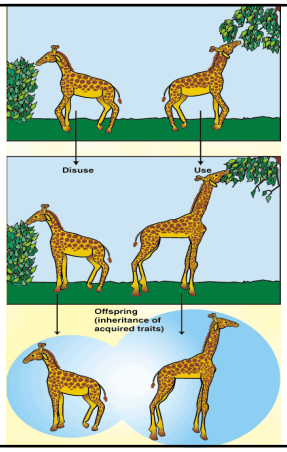
Ex: A neck stretched (body structure changed) would pass to offspring.

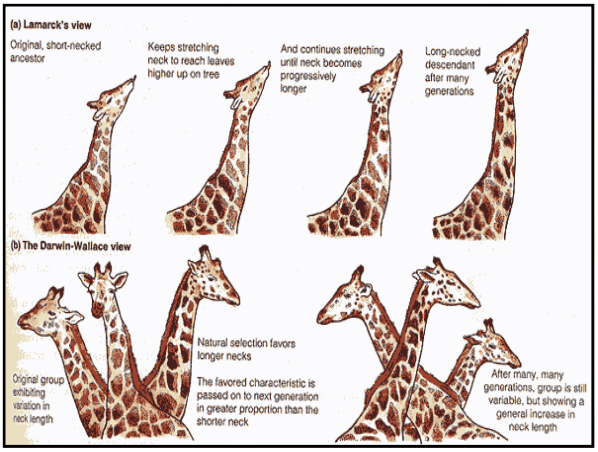



***There is no evidence this*** **happens because an acquired characteristic would have to somehow modify the DNA of specific genes in order to be inherited.**

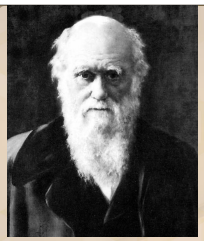
## Lamark's Giraffes



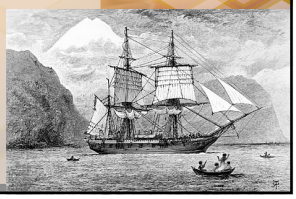




## Charles Darwin



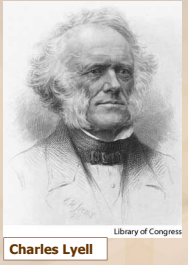
**1831**



**Sails the Beagle.**

**Develops his theory of evolution.**

## Lyell



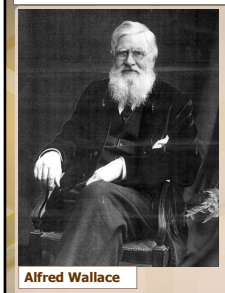

**1833**

Charles Lyell

**Geologist.**

**Believes the Earth's shape has changed over a long time.**

## Wallace

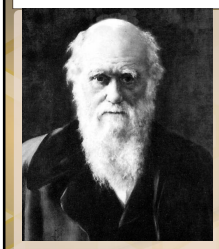


1858

Alfred Wallace

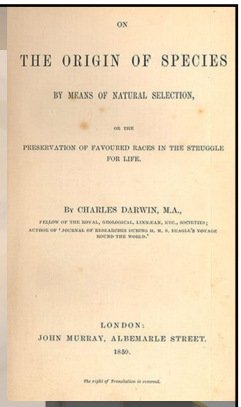
Thinks about the idea of natural selection.

## Charles Darwin



1859

Published his book,
*On the Origin of Species.*

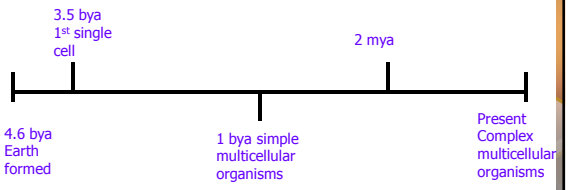



## The Supporting Evidence For Darwin's Theory

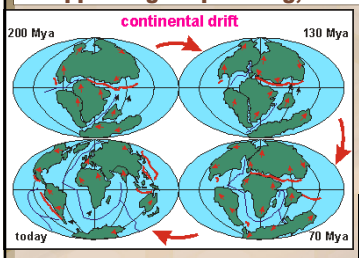
1. Geologic Time
2. Fossil Record
3. Comparative Anatomy
4. Comparative Embryology
5. Comparative Biochemistry

## 1. Geologic Time

- Earth formed 4.6 billion yrs ago (bya)
- This allows species to change.




## Tectonic Plates- seafloor is disappearing & spreading, continents moving

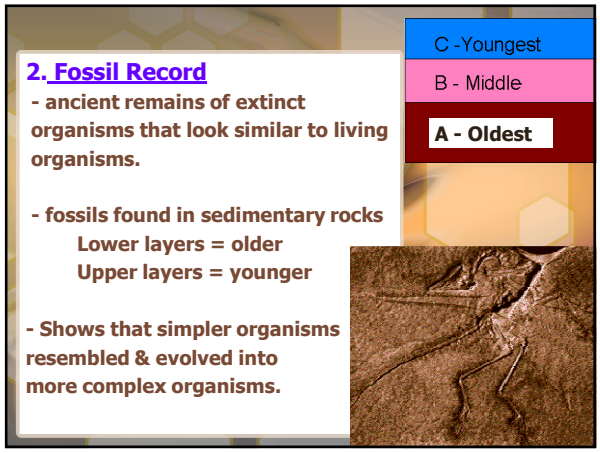



## 2. Fossil Record

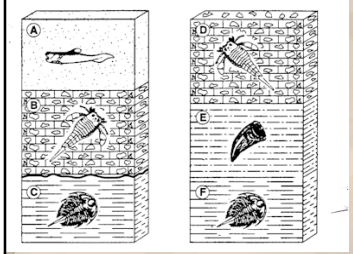
- ancient remains of extinct organisms that look similar to living organisms.

- fossils found in sedimentary rocks
  - Lower layers = older
  - Upper layers = younger

- Shows that simpler organisms resembled & evolved into more complex organisms.

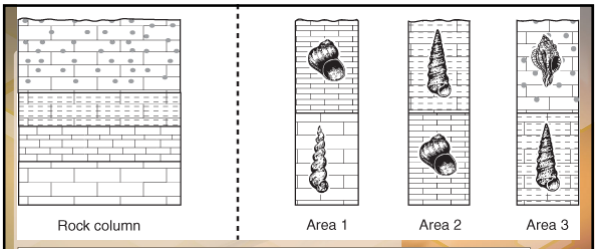


## Using the graph below, answer questions.




In which sequence are the rock layers listed in order from oldest to youngest?

A) F, B, E, D
B) C, A, F, D
C) F, E, C, A
D) C, E, D, A

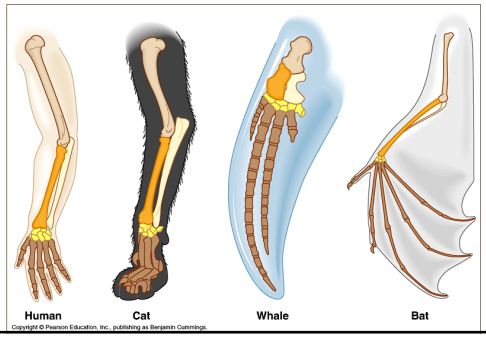


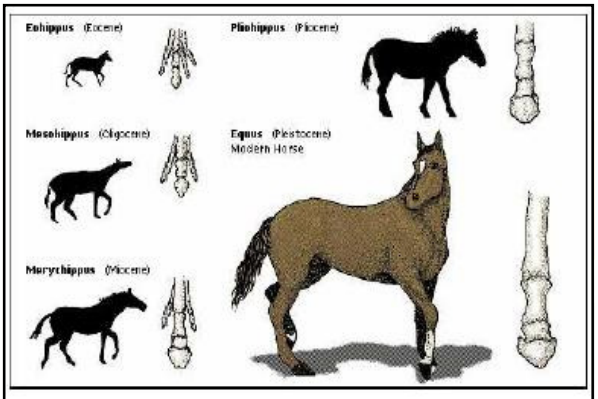

The rock column above shows the layers in a rock formation. The three diagrams above show the positions of fossils in different rock layers. According to this information, which fossil is the youngest?

A. 
B. 
C. 
D. 

3. Comparative Anatomy
- similarities of basic structures exist between different organisms *(homologous structures)*

* Similar # & arrangement of bones in arm bones of vertebrates.




The Evolutionary Changes of the Horse's Skeleton

## Vestigial Structures

- Structures found in living organisms that no longer functioned in ancestors.

Ex: Humans
- appendix, tail bone, wisdom teeth

Ex: Whales & Snakes
- have small pelvic bones & hind limbs

## Vestigial Structure: Pelvic Bones in Whales

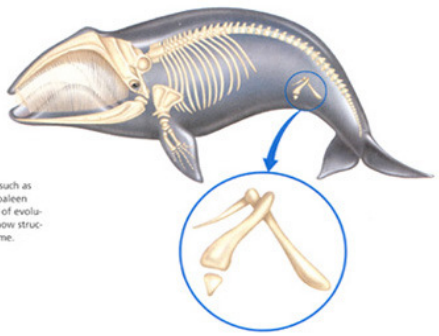
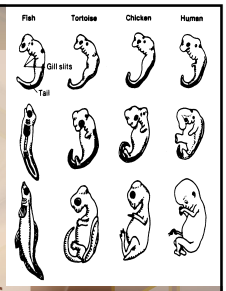


Figure 15.8
Vestigial structures, such as pelvic bones in the baleen whale, are evidence of evolution because they show structural change over time.

## 4. Comparative Embryology

- early stages of embryo development show similarities suggesting a common ancestor.

- Vertebrates (animals with a backbone) have similar structure & patterns of development.



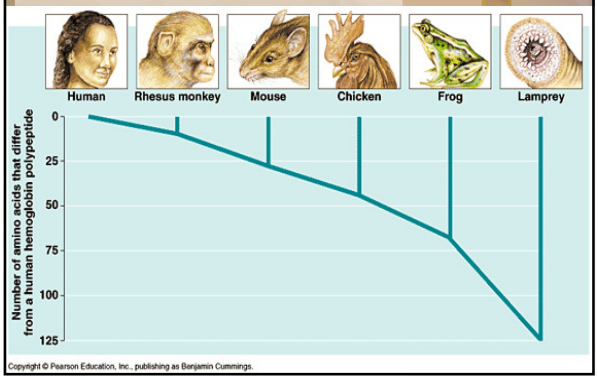

## 5. Comparative Biochemistry

Similar organisms have similar

- DNA (similar base sequence)
- Protein (similar amino acid sequence)

* This helps determine that the species are closely related.

## Similar Amino Acid Sequence In The Protein- Hemoglobin




## Farmers

Selection of *best traits* occurs in nature.

• *Artificial selection* – means nature provides the variation, then humans select those variations that are useful to create better offspring.

## What Is Natural Selection?

- Favorable traits are selected by nature because it contributes to the survival of an organism in its environment.
- Examples of selecting agents by nature: predators, climate, amount/type of food.
- Changed inherited traits within a population will not be seen till after many successive generations.

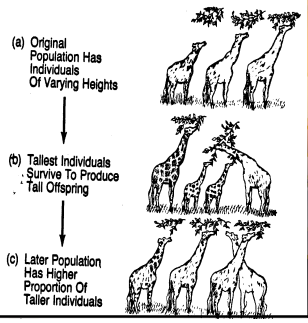
## Darwin's Idea of Natural Selection Theory

4 Parts

## 4 Parts of Natural Selection

- **Genetic variations**- different inherited traits of species (the unique combination of traits).
  **Ex:** body shape, strength size, running speed, structure, behavior, functions, resistance to disease
- **Overproduction**- more offspring produced than can survive.
- **Struggle for Survival** (Competition) - natural resources are limited (water, food, space) & competes for survival. Successful = Survival
- **Reproduction** – organisms that survive pass their variations to offspring.

- **Survival of the Fittest**
  - The best adapted for the environment will survive.
  - The most favorable inherited genetic variations (traits) will be passed to offspring during reproduction.




## Summary

✓Nature selects good traits.

✓Good traits survive then organism reproduces & passes it to offsprings.

## Check Point: Key Facts on Evolution

- ✓Species change over time.
- ✓Species give rise to new species.
- ✓Organisms through modification descend from ancestors.
- ✓Species are related in *tree of life*.
- ✓Biodiversity through evolution results in different species.
- ✓Evolution occurs in changing environment, not stable ones.
- ✓Inherited traits help organisms survive, called adaptation.
- ✓New adaptations come from inherited traits through genetic variations.
- ✓Nature selects the best inherited traits that are favorable.
- ✓Only organisms with favorable traits survive & reproduce; others die.
- ✓Organisms with favorable traits increase in # (frequency, proportion).
- ✓Population of species changes & adapts to the environment (evolution).

## 3 Weaknesses of Charles Darwin's Theory

1. Theory based on evidence.
   Not a lot of fossil records
2. Did not explain how variations arose.
   No proposed mechanism for the inheritance of traits.
3. Did not distinguish between hereditary & environmental variations.

## An Example of Natural Selection

Darwin's Finches

## Darwin's Finches: Galapagos Islands

- Adaptive Radiation- "Different species" developed because of successful adaptation through natural selection.
- Adapted to different ecological niche's (habitat, how organism makes a living) by feeding on different food sources.
- Gene pool – the combination of all heritable genes in a species within a population. Results in great diversity (increased variation/variability in species).

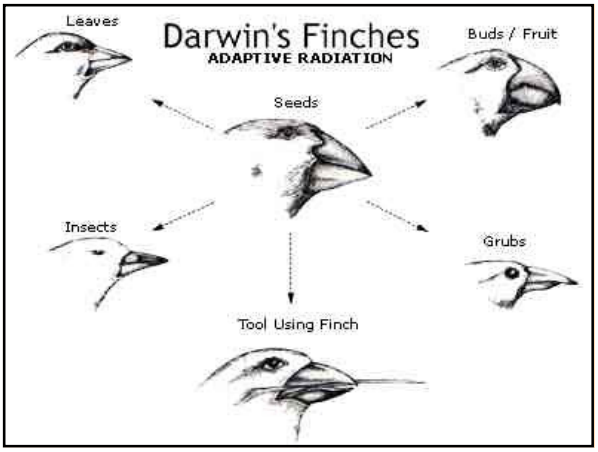
## Why Is Variation Important Within Species?

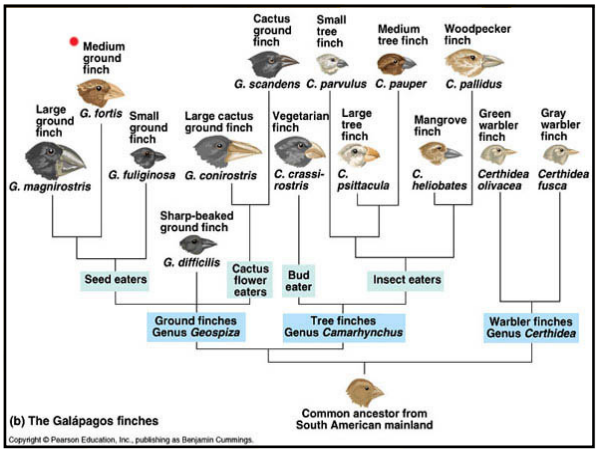
A. Decreases survival of species

B. Increases survival of species

C. No effect on species

**Answer: B**




## Modern Natural Selection Theory

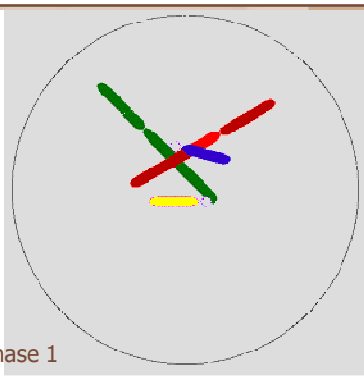
## Mutations During Meiosis

Gametes = **Sex Cells** (sperm, egg)

1. Variations occur through spontaneous **mutations** during sexual reproduction.

- ***Mutations*** may occur when
  - Cross over (chromosome exchange parts)
  - Chromosome shuffling
- **Results**: ***Genetic Recombination*** (new gene combination after fertilization that will become the stuff of evolution)

## Crossing Over Shuffles Ancestral Genes To Have Both Mother & Father Genes



Prophase 1

## Modern Examples of Natural Selection

1. Industrial Melanism: Peppered Moth
2. Antibiotic Resistant Bacteria
3. Pesticide Resistant Insects

## Industrial Melanism: Peppered Moth

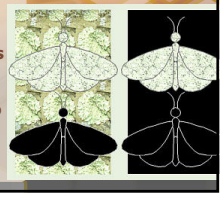
- Industrial Revolution (England) caused pollution
- Birds preyed (ate) on white moths & was responsible for dark moths survival.

**Why?**

- **Dark colored moths** blended into the trees & increased in numbers.
- **Light colored moths** was less adapted & decreased in numbers.

**Results:**

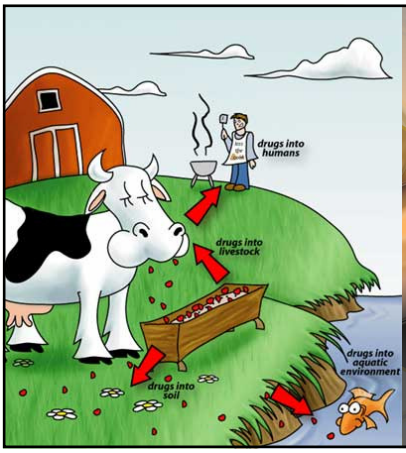
- Dark colored moths evolved due to birds preying more on white moths.
- Birds ate the moths that were easiest to find!



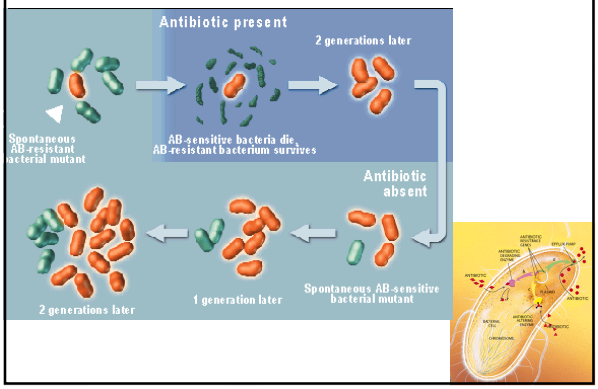
Industrial Melanism

1. Genetic Variation
   - Light colored moths (mostly)
   - Dark colored moths (few)
2. Gene Mutation
   -Random mutation in dark colored moths happened. Not due to environmental change (pollution).
3. Natural Selection
   -Nature are the Predatory birds & dark tree bark. These select the dark moths to survive & reproduce.
   -White moths are eaten.
4. Survival of the Fittest
   -A changed environment (**darkened tree barks** from pollution) allowed darker moths to camouflage better & survive. Then reproduced more!

## Antibiotic Resistance



**Example of Natural Selection: Selection for Resistant Bacteria**




1. Genetic Variation
- Bacteria with no resistance
- Bacteria with resistance

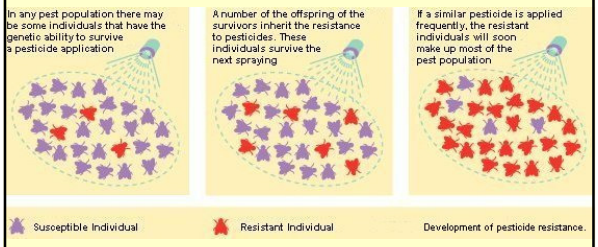
2. Gene Mutation
- Mutation occurred in the genes, not the environment. (Resistance happened before antibiotic was given)

Antibiotic Resistant Bacteria

3. Natural Selection
- Nature is the environment that has antibiotic. So resistant bacteria survive & reproduced.
-Non-resistant bacteria are killed.

4. Survival of the Fittest
-A changed environment (antibiotic given) allowed resistant bacteria to survive. Then increased in number through reproduction!

## Pesticide Resistant Insects




1. Genetic Variation
- Resistant insects &
Non resistant insects

2. Gene Mutation
- Mutation occurred in the gene not caused by the pesticide.

Pesticide Resistant Insects

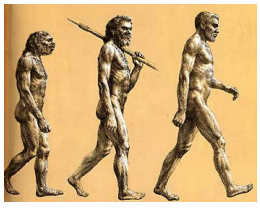
3. Natural Selection
- Nature is the environment that has pesticide. So resistant insects survived & reproduced.
- Non-resistant insects were killed.

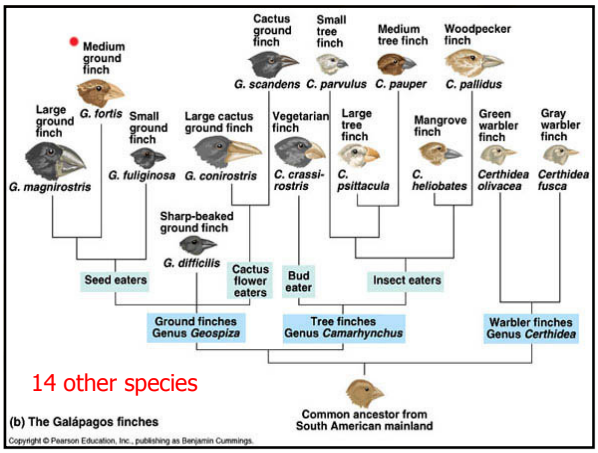
4. Survival of the Fittest
- A changed environment (pesticide used) allowed resistant insects to survive. Then increased in number through reproduction!

## Charles Darwin's Belief About

## Speciation

| Speciation | Adaptive Radiation |
|---|---|
| ➢One species **Evolves** into **Another** species.<br>Ex: caveman → present man | ➢One species **Evolves** into **Many** species.<br>Ex: Darwin's Finches (Galapagos Island) |



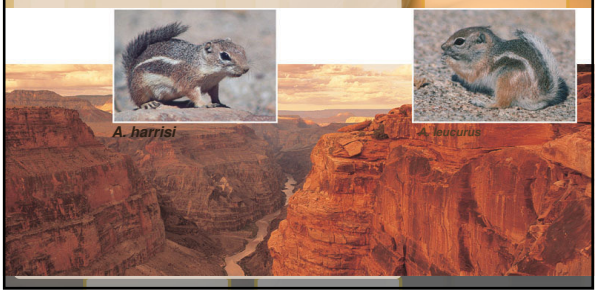



## Speciation & Adaptive Radiation

- Both can be caused by **GEOGRAPHIC ISOLATION**.
- Geographic isolation can lead to **REPRODUCTIVE ISOLATION**.

| Geographic Isolation | Reproductive Isolation |
|---|---|
| • A population of 1 species becomes separated by a physical barrier (geographically isolated).<br><br>Ex: canyons, mountains, islands, rivers<br><br>• Causes **genetic variations** to evolve into different species because of different selecting agents from nature. | • New species is so different it's unable to mate & produce offspring with its ancestor species resulting in *Different Species* . |

## Geographic isolation of antelope squirrels on opposite rims of the Grand Canyon



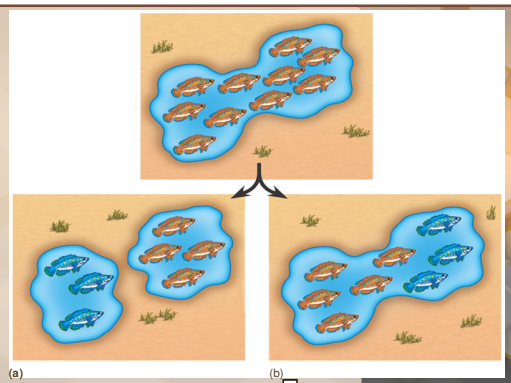

## Geographic Isolation & Reproductive Isolation


**The Western meadowlark (left) and the Eastern meadowlark (right) appear to be identical, and their ranges overlap, but their distinct songs prevent interbreeding.**

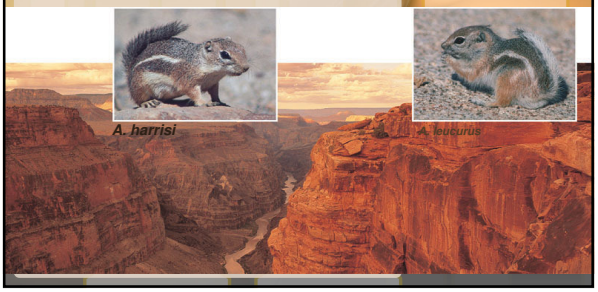
**Allopatric speciation**
**A population forms a new species when geographically isolated from its parent population.**

**Sympatric speciation**
**A small population becomes a new species without geographic separation.**

## Two main modes of speciation



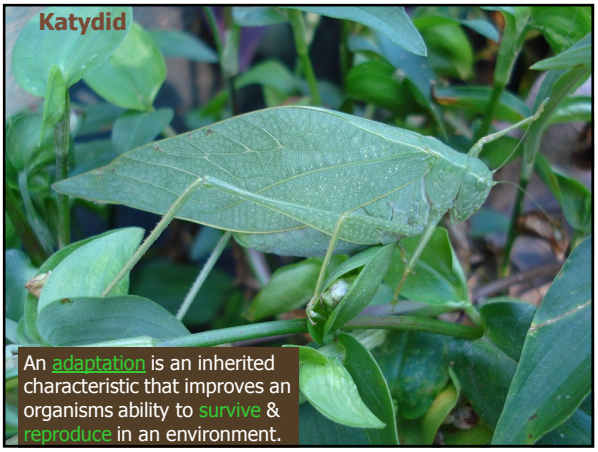

## Allopatric speciation of antelope squirrels on opposite rims of the Grand Canyon




## What Does Having A High Adaptive Value Mean?

- Means an organism's variation in inherited traits were responsible for its survival in the environment.

## Katydid



An adaptation is an inherited characteristic that improves an organisms ability to survive & reproduce in an environment.

## Summary On Evolution of Species

✓New species develop due to the accumulation of traits (genetic variations) in a population over many generations & adapts well in its environment to survive.

## Evolutionary Tree

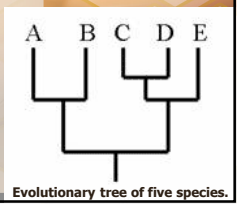
Ancestral Tree

## How Do Scientists Figure Relatedness?

- Collect data based on structural & molecular similarities.
- Use:
  - Fossils
  - Anatomical bones
  - Compare amino acid sequences of species

## An Evolutionary Tree Tells.....

- Relatedness
  - a common ancestor exists
- Different Species
  - some species evolve into other species
- Extinction
  - some species no longer exist



Evolutionary tree of five species.

## Extinction

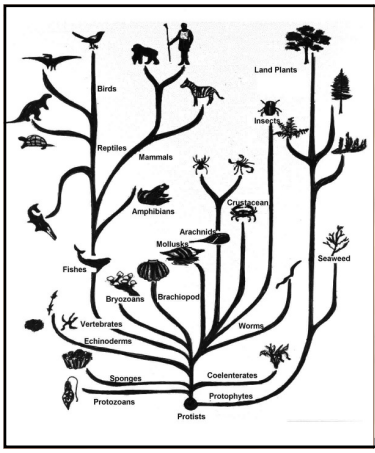
- Disappearance of an entire species.
- Death rate > birth rate

Causes

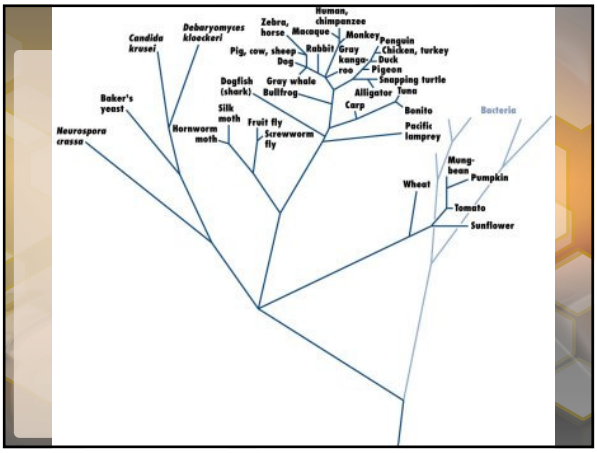
- Temperature change ex: Sea level increase, grassland became desert
- Not enough adaptive characteristics for survival

## How To Interpret An Evolutionary Tree

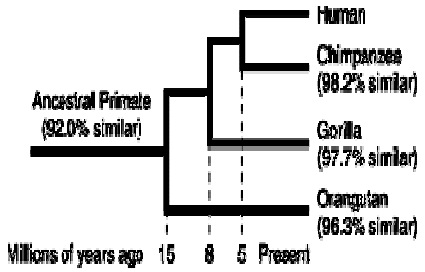
1. Where lines intersect indicates a common ancestor.
2. Lines ending before present time means species extinct.
3. Lines intersecting closer means the closer the species are related.
4. Species up to present exist today.




Tree of Life: Evolution means we're all distant cousins (humans, oak trees, hummingbirds, & whales).



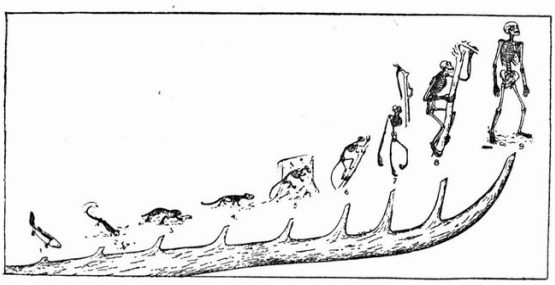
## DNA Sequence Similarities in Some Primates



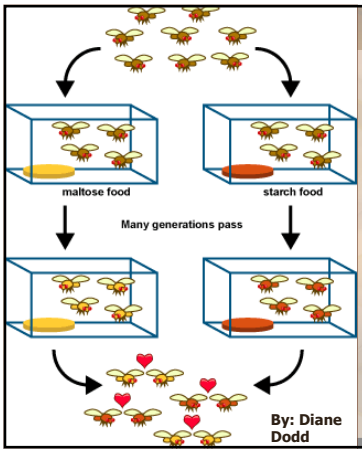

✓ What Do These Primates Have in Common? **Same Ancestor**

✓ Which 2 have the closest evolutionary relationship as their DNA is the most similar? And Why? **Humans & Chimpanzees**

## Do You Think A Human's Coccyx Bone Was Once The Caudal Fin (tail) Of A Fish?

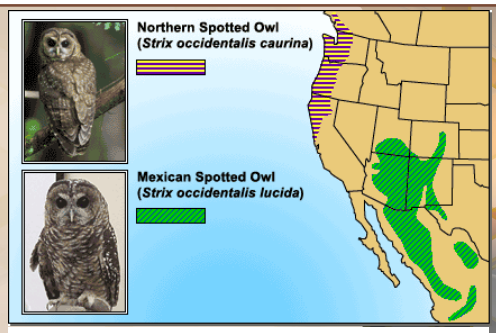


## Experimental Design: Geographic Isolation & Speciation



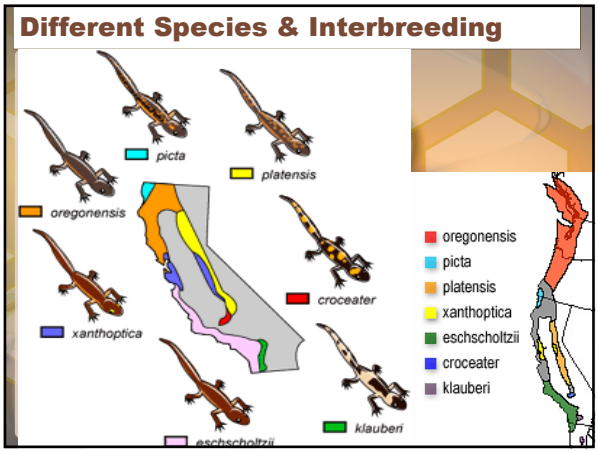

**Results**: Did Geographic Isolation (different food source) lead to Reproductive Isolation?

## Geographic Isolation & New Species




Spotted owl subspecies living in different geographic locations show some genetic and morphological differences.
This observation is consistent with the idea that new species form through geographic isolation.

## Different Species & Interbreeding




## *The Skink – a Pet Lizard*

## Which One Leads To Greater Genetic Variation?

a. Sexual reproduction
b. Asexual reproduction

**Answer: A**

**Why?**
**Genetic shuffling & cross over allows for greater gene variation & better able to Survive due to adaptation.**