# THE THEORY OF EVOLUTION

**Evolution**

Very slow change in a species
over vast periods of timem

**Charles Darwin**: father of evolution

"Origin of the Species thru
Natural Selection"


**Why did some species survive and flourish and others become extinct?**

**Is evolution fact or theory?**
Both!

FACT: things change over time, documented in fossil record

THEORY: evolution is a collection of carefully reasoned and tested hypotheses about how evolutionary change occurs

## HISTORY OF EVOLUTIONARY THEORY

1801: **Jean Lamarck** (French)

1. **Theory of desire**
   - organisms change due to inborn desire to change to become more fit for environment
     ex: ant eaters develop long snouts

2. **Theory of use and disuse**
   - organs that are being used get large and strong
   - organs that are not used shrink and eventually disappear
     ex: snakes- didn't use legs so disappeared
     whales- used to be land creatures, legs became fins

3. **Theory of inheritance**
   - acquired traits were passed on to offspring
     ex: snakes that lost legs passed trait

1859: **Charles Darwin** (English)

**Influences in Darwin's theory of evolution.**

1. **Geology**
   Lyell (geologist) said earth changed over time

2. **Artificial selection**
   Process whereby with human intervention superior specimens are bred to produce superior offspring with desired traits
   ex: larger bulls cows that produce more milk
   larger ears of corn

3. **Population controls**
   Malthusian Doctrine (human population is controlled by famine, disease, and war)
   - applied even more to plants and animals

What factor determines which individuals survive and reproduce?

## Darwin's Theory of Natural Selection

**Natural selection**

Individuals that have physical or behavioral **traits** that better **suit their environment** are **more likely to survive** and will **reproduce more successfully** than those without traits.

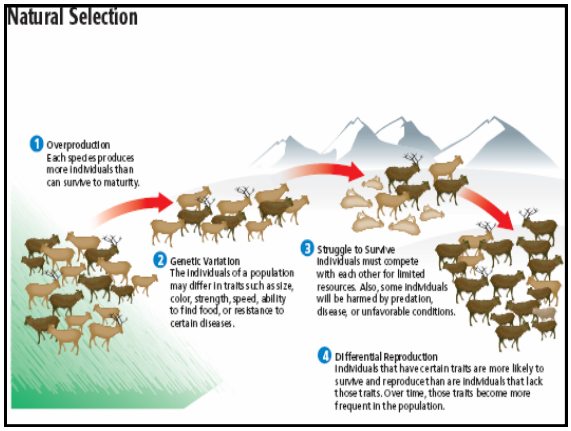
**Parts of Theory**

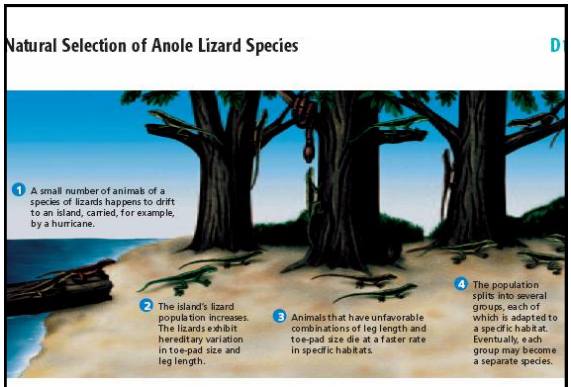
1. **Overproduction**
   - organisms produce more offspring than can survive

2. **Genetic variation**
   - individuals in a given species vary by chance (due to gene recombination)……. this is normal.
   exception: identical twins

3. **Struggle to survive**
   - all organisms face constant struggle to survive (limited resources)
   ex: pond ecosystem – cattails compete with duckweed for surface of lake water

4. **Survival of the fittest**
   - Individuals best adapted to environment are more likely to survive and reproduce




## DIFFERENCE IN THEORIES

**Lamarck**: organisms change in order to survive in environment

- **occurs in the organism's lifetime**

**Darwin**: environment determines which organisms survive through natural selection

- **occurs over many generations**

## Examples of Natural Selection

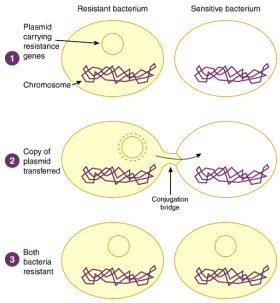
1. Industrial Melanism: Peppered Moths


Show moths

natural selection video

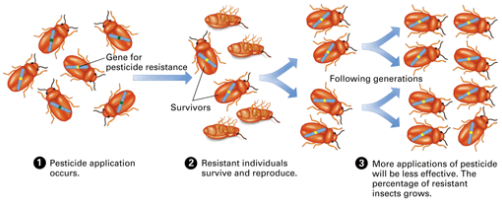
## Examples of Natural Selection, cont.

2. Antibiotic Resistance: T.B. and other bacteria




## Examples of Natural Selection, cont.

3. Pesticide resistance




By spraying crops with poisons to kill insect pests, humans have favored the reproduction of insects with inherited resistance to the poisons over those with no resistance

Nov. 1859: Darwin published book

**"Origin of the Species through Natural Selection"**

## UPDATES ON DARWIN'S THEORY

1. **Genes** are carriers of characteristics and source of random variation.
   (caused by mutations)

2. **Variation** is the raw material for natural selection.
   - Natural selection can operate only thru **phenotypic variations.**

   (physical and behavioral characteristics produced by genotype and environment)

3. Evolutionary change involves change in **allele frequency** in the gene pool of a population

   **Population**: collection of individual of same species in specific area that can successfully breed.
   - offspring share same gene pool

   **Gene pool**: common group of genes

   **Relative frequency**: how often alleles show up
   - Since genes come in pairs (alleles), some occur more frequently
   - As relative frequency changes, distribution of traits changes

4. Evolutionary fitness and adaptation depends on success of organism passing its genes (traits) to its offspring

- **adaptation**:
  - genetically controlled characteristics (physical or behavioral traits)
  - increase an organisms fitness for its environment

## Examples of Adaptations



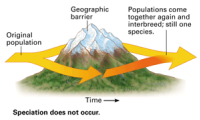


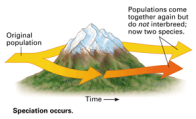
5. Formation of species

- **species**: group of organisms that breed and produce fertile offspring
  - normal
  - members share a common gene pool
  - if beneficial gene- increases fitness members of a species can evolve together
- **speciation**: development of a new species through evolution

## FACTORS IN SPECIATION

**1. Reproductive Isolation**: two populations of same species do not breed with each other due to geographic separation




-Gene pools change thru natural selection to the point where same species becomes different over time and can no longer breed

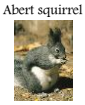
-Two populations now considered to be two different species

- Can occur thru rivers, mts., roads, courtship behavior, fertile periods

ex: isolation by grand canyon

Kaibob squirrel

Abert squirrel



2. **Migration (gene flow)**

movement of large numbers of organisms of same species from one environment to another (immigration or emigration)

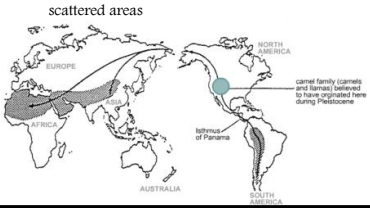
- eventually leads to adaptation from natural selection to environment
- results in change in gene frequency
- if population breeds with existing population there is a change in gene pool

Ex: camels: originated in N America but migrated around the world, ice age destroyed most except those in scattered areas


Asian


African


Llama

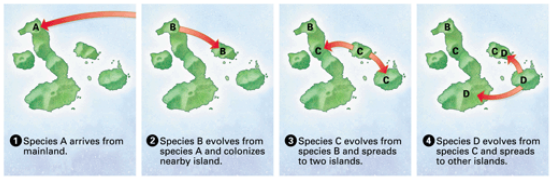



3. **Adaptive radiation (divergent evolution)**: process by which different species arise from one common ancestor

- organisms evolve new characteristics that enable them to survive in different environments
- over time it is difficult to tell which species are related

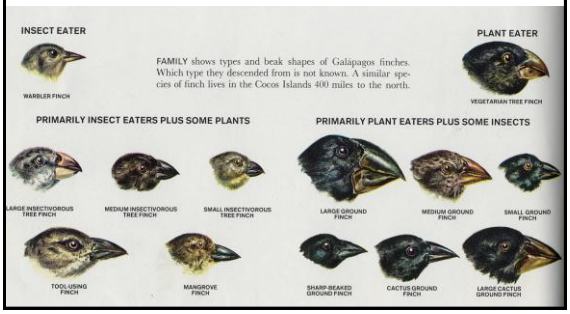
ex: **Darwin's finches**

## How Adaptive Radiation Occurs



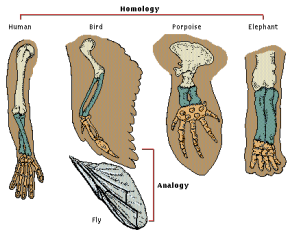

**Adaptive radiation on an island chain may lead to several new bird species evolving from one founding population.**

- Darwin visited Galapogos Islands (620 mi. off Equador)
  - noticed 14 species of finches
  - evolved from common ancestor in S.A.
  - each of 14 species had traits to allow them to survive in different **niche**




## Examples of adaptive radiation, cont.

**Homologous structures**: structures which developed from a common ancestor, but have changed over time due to different purposes




**similar structures → less similar structures**

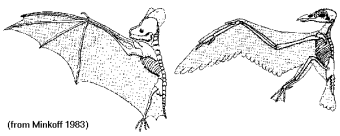
## Examples of adaptive radiation, cont.

platypus

kangaroo

anteater

4. **Convergent evolution**: process whereby organisms not closely related, independently evolve similar traits as a result of having to adapt to similar environments or ecological niches.
   - organisms with different ancestors become more alike because they share same environment
   - result in:
     **analogous structures**: similar in appearance and function, but different origins with different internal structures (each evolved independently)



(from Minkoff 1983)

**bat wing v.s. bird wing**

**dissimilar structures → more similar structures**

## EVOLUTION OF EVOLUTIONARY THEORIES

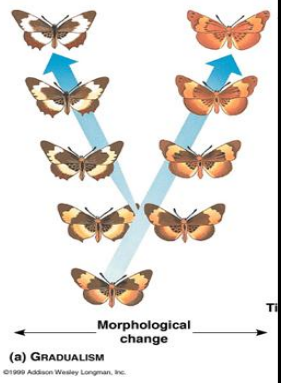
1. **Genetic Drift**: chance changes in gene pool from generation to without natural selection
   - causes random change in frequency of a gene

   - unlike natural selection
   - doesn't work to produce adaptations since random

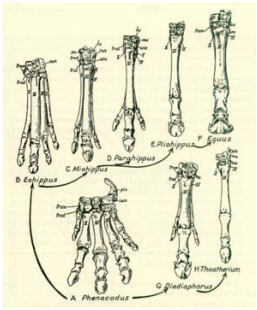
2. **Unchanging gene pools**: if species is very well adapted to environment and there is no competition, no change occurs

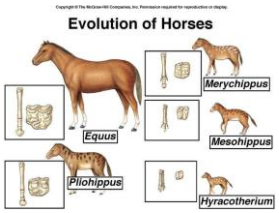
ex: horseshoe crabs (living fossils)

3. **Gradualism**:
evolutionary change occurs slowly and gradually over time

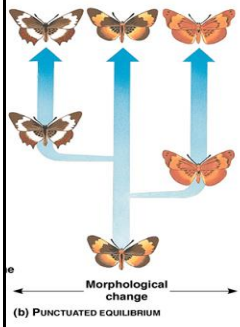



Horse Fossil Record – gradualism
(60 million years)





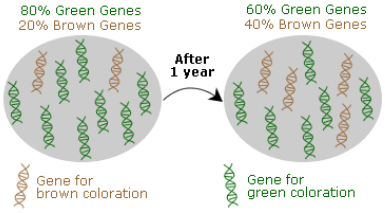

4. **Equilibrium**: organism does not change every much over time
** explains gaps in the fossil record **




- **punctuated equilibrium**:
  long stable period interrupted by brief periods of change
  (sometimes events occur to disturb equilibrium)
- causes rapid change in small groups of organisms
- usually fills new niche
- could cause mass extinctions

## Microevolution

- Evolution on a small scale within a single population
- Changes gene frequency within that population



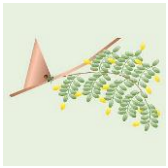

## Co-evolution

- The mutual evolutionary influence between two species (the evolution of two species totally dependent on each other)
- Each of the species involved exerts selective pressure on the other, so they evolve together
- Extreme example of mutualism

## Examples of Co-evolution

**Acacia ants and acacia trees**

- trees have large hollow thorns
- ants live in thorns
- leaves make substance that ants eat
- ants defend tree from herbivores



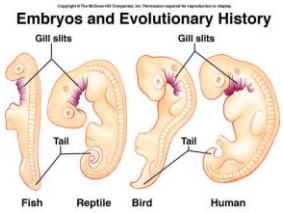
**Pollination**

- bumblebees use nectar from pollen
- flowers become cross pollinated from bees

## EVIDENCES OF EVOLUTION

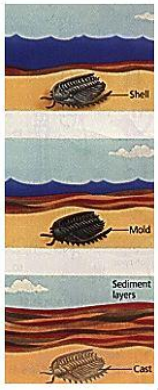
1. **Embryologic similarities**: evidence of a common ancestor

- dorsal, hollow nerve cord, notochord (stiffening rod of cartilage) in the back
- similar membranes in the embryos, yolk sac that produces the first blood cells and germ cells
- similar development of many organs

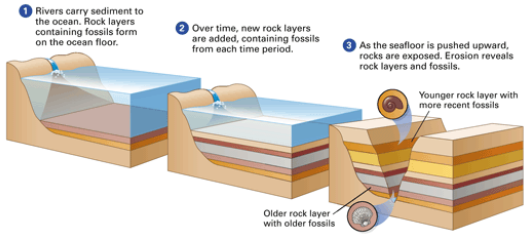



2. **Fossil record**

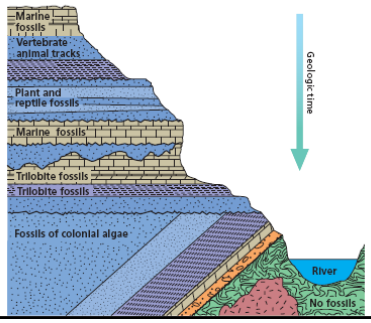
- Most occur in layers of rock, with the youngest usually on top, and the oldest in deeper layers (sedimentary rock)
- Some found in amber (fossilized tree sap)
- Record incomplete due to soft outer coverings on organisms not leaving imprints
- 99% of all species that lived on Earth are now extinct.




**Each layer of sedimentary rock represents a particular time period. Fossils reveal organisms that lived when the layer formed.**

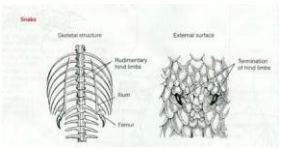



**Distribution of Fossils** D12




3. **Comparative anatomy**

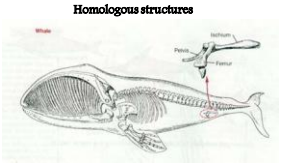
**Vestigial structures (organs)**



Snake

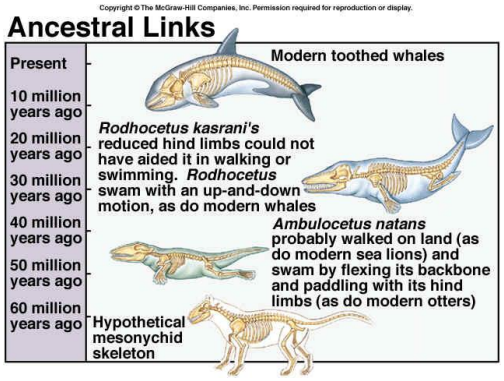
Vestiges of pelvic girdle and leg bones of walking ancestors

**Homologous structures**



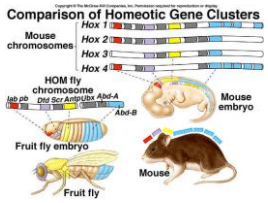
Whale

Set of bones that are clearly homologous with the pelvis of any four-limbed vertebrate




4. **Biochemical similarities**

- DNA, RNA, amino acids, and serology (comparison of blood chemistry)

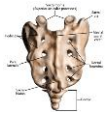



| Species | Amino Acid Differences from Human Hemoglobin Protein |
|---|---|
| Gorilla | 1 |
| Rhesus monkey | 8 |
| Mouse | 27 |
| Chicken | 45 |
| Frog | 67 |
| Lamprey | 125 |

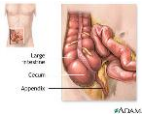
5. **Vestigial structures:**

- Structures which have lost all or most of their original function in a species through evolution.
- Degenerated, atrophied, or rudimentary condition
- Largely or entirely functionless, may retain lesser functions or develop new ones

coccyx



appendix



muscles behind ears

## MECHANISMS OF EVOLUTION

1. **Natural selection**
2. **Mutation**
3. **Migration (gene flow)**
4. **Genetic drift**

What is the significance of evolutionary theory?

Allows us to:

- discuss universal characteristics of life
- study other animals to learn how our bodies work
- understand how organisms interact with each other and their environment
- appreciate diversity of all the earths organisms