Evolution Notes – Part II
Theories of Modern Evolution

Charles Darwin's Theory of Natural Selection

1. ***Based on variation and natural selection.***
2. Although Darwin was given credit for the theory of natural selection, another scientist, **Alfred Wallace**, proposed a theory of evolution that was quite similar to Darwin during the same time period.
3. The only problem with Darwin's theory is that he did not explain the source of the variations among organisms of the same species.
4. Darwin's theory of evolution was based on the following concepts:

Overpopulation: within a population, more offspring are born than can possibly survive due to carrying capacity of the given environment.

Competition: individual in each species, within each generation, compete for limited resources such as food, space, water, light, opportunities to reproduce.

Variations: members of the same generation show variations in traits that provide a competitive advantage for survival.

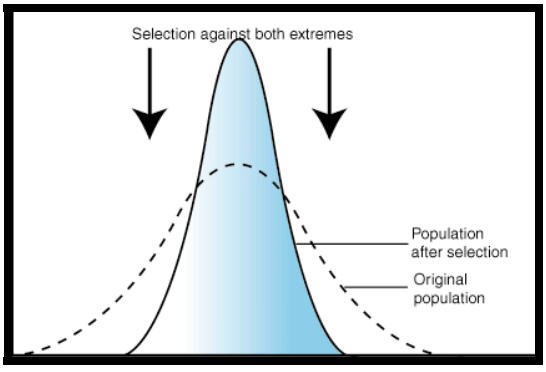
Survival of the Fittest: those individual in the generation that survive are those that are best adapted to their environment. They have the necessary variations to survive. The individuals that survive are considered to be the **best adapted** for their particular environment.

Reproduction: Individuals that survive and reproduce pass these variations to the next generation.

Speciation: the offspring of the fittest will inherit the variations that are necessary for survival in that environment. These traits pass from generation to generation. In some cases, because of variations from generation to generation, a new species may result that is better adapted to their environment.

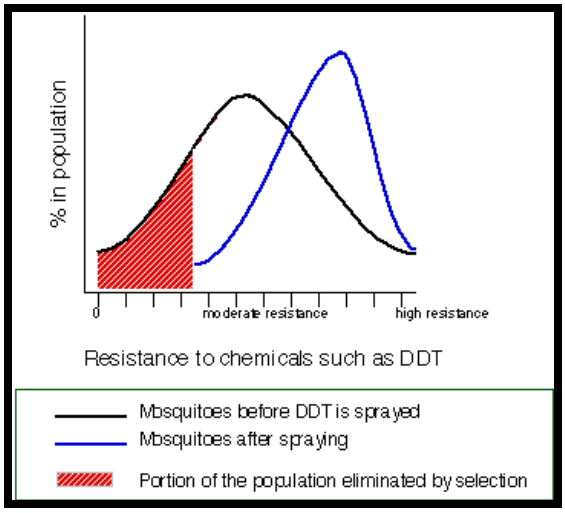
Types of Natural Selection

1. Stabilizing Selection: selection in the population supports the more common intermediate forms and selects AGAINST organisms with traits from either extreme (if you remember your genetics, the heterozygous form is more common than homozygous dominant or recessive).

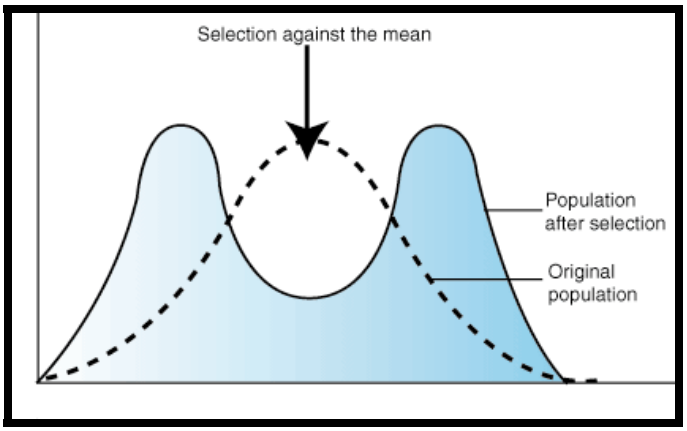


2. Directional Selection: When individuals at one end of the curve have higher fitness and are favored more than individuals in the middle or at the other end.

Example: Environmentalists spray pesticide DDT on mosquitoes to stop the spread of malaria and the West Nile virus. Those mosquitoes with a high resistance to DDT will be favored over those who have little or no resistance to DDT.



3. **Disruptive Selection:** When individuals at both extremes of the (upper and lower ends) of a trait are both more fit and are favored over the average individuals in the population.



Modern Evolutionary Theory

The evolutionary theory we embrace today combines the **concepts of Darwin's theory of natural selection with the understanding that variations are the result of random mutations and the shuffling of genes during sexual reproduction.**

- ✓ Genes of inherited variations that have better **adaptive value**, give an organism a better chance of survival and are passed from parents to offspring.
- ✓ These favorable genes tend to increase in frequency in a population over time.
- ✓ Genes with low survival value decrease in numbers from generation to generation.
- ✓ If the environment changes, genes that were previously neutral or had low survival value may become favorable, and as a result, may increase in frequency over time.

What are Variations?

1. What Darwin did not know was that variations or differences among offspring are due to **GENETIC VARIATIONS**, which result for the unique combination of traits each organism inherits from its parents.
2. **Adaptive Value**: any trait that helps an organism survive and reproduce in a given environment.
3. **Selecting Agent**: the environment acts as a selecting agent in the sense that organisms with traits that have the best adaptive value for that environment will have a competitive advantage, a greater chance of survival with increased opportunities to mate and pass their genes to the next generation.

Sources of Variations

1. **Mutations:** random changes in the nitrogenous base sequence of the DNA.
    a. mutations can be random errors that occur when DNA makes copies of itself during normal cell functioning
    b. some mutations can occur from exposure to certain chemicals (Agent Orange, asbestos, benzene) and radiation (ultraviolet rays, X-rays, nuclear radioactivity)
    c. If a mutation occurs in a **body (somatic) cell**, it **ONLY affects that organism**.
    d. If a **mutation occurs in a sex cell** (sperm or egg) **then that mutation can be passed to the offspring.**
    e. Most mutations are harmful and may affect the offspring so severely that it cannot survive.
    f. A few mutations, however, may be beneficial and increase the organism's chance for survival.
    g. In a ***changing environment***, mutations may be a source of variations that increase the organism's chance of survival. **These mutations, if they are in the sex cells, can be passed to the offspring and may lead to the evolution of a new species.**

2. **Genetic Shuffling:** the sorting of recombination of genes during **meiosis** (the making of sperm and egg that have ½ the normal number of chromosomes than the parent cells) and **fertilization** result in offspring with new and different combination of genes.
    a. **genetic shuffling through sexual reproduction is the main source of variation in sexually reproducing species.**

A changing environment is the driving force for evolutionary change.

Variations are necessary for a species to continue to survive in a changing environment.

Species with short reproductive cycles that produce many offspring tend to evolve more quickly than species with long life spans and few offspring.

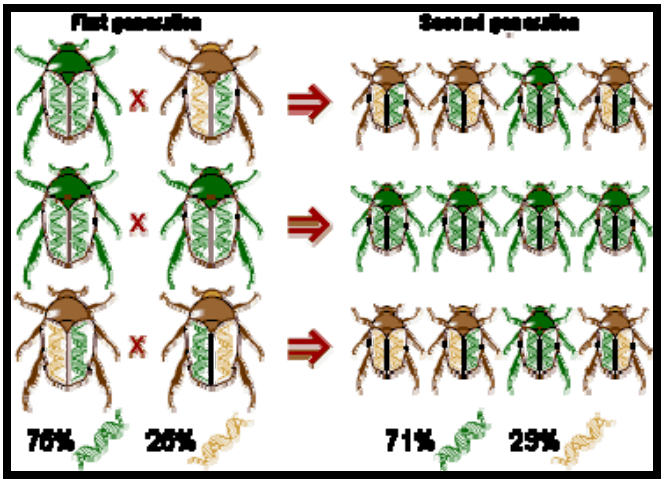
The failure to adapt to a changing environment may result in the death of a species (extinction).

2. Genetic Drift

-- occurs in small populations

-- certain alleles may be more common in the small population simply due to chance

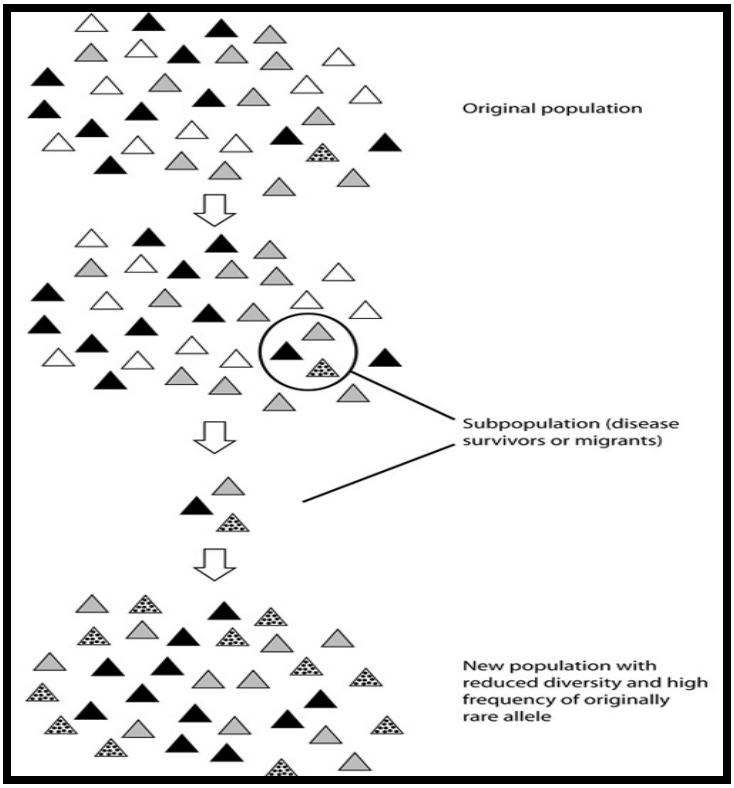
--over time, this can result in a particular allele to have a higher frequency in the descendents of the original small population



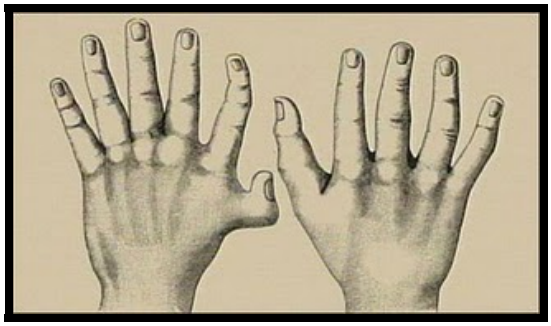
Examples of genetic drift include:

A. **Founder's Effect:**

1. A small population breaks away from a larger one to colonize a new area –this population most likely is **NOT** genetically representative of the original larger population.
2. Rare alleles may be overrepresented in the smaller population and traits that are not usually seen in the larger population may have a higher frequency of appearance in this smaller population.

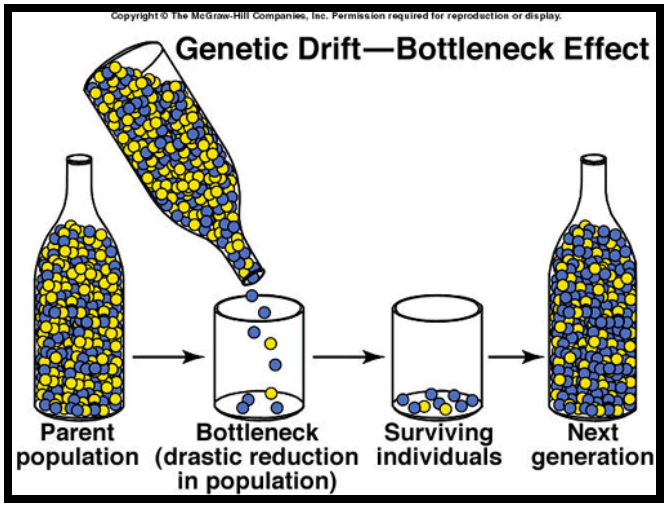


3. For example, the Old Order of Amish of Lancaster Pennsylvania, all of whom descended from a small group settlers who migrated from Germany to the US in the 1770s. One or more of these settlers carried the rare but dominant gene for polydactyly (having a extra finger or toe). Due to extreme isolation and intermarriage of the close-knit community, this population evidences a high incidence of polydactyly.



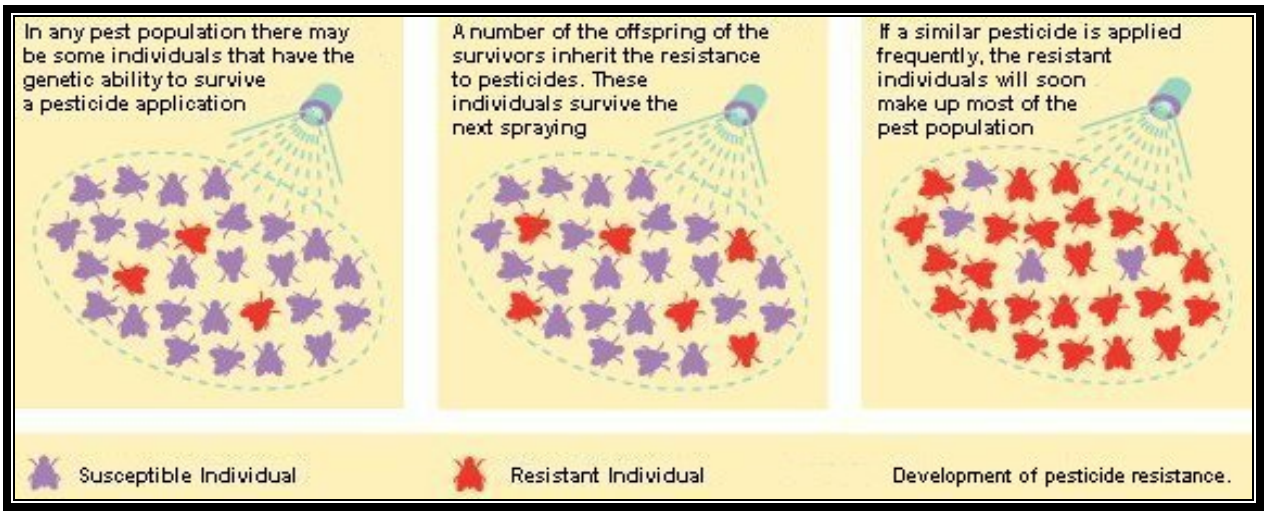
B. **Bottleneck Effect**

1. Natural disasters such as fire, earthquake, and flood reduce the size of a population nonselectively.
2. The resulting population is smaller and not representative of the original population.
3. Certain alleles may be overrepresented or underrepresented in the new population resulting in the occurrence or nonoccurrence of traits typical of the original population.



Evolution in a Changing Environment

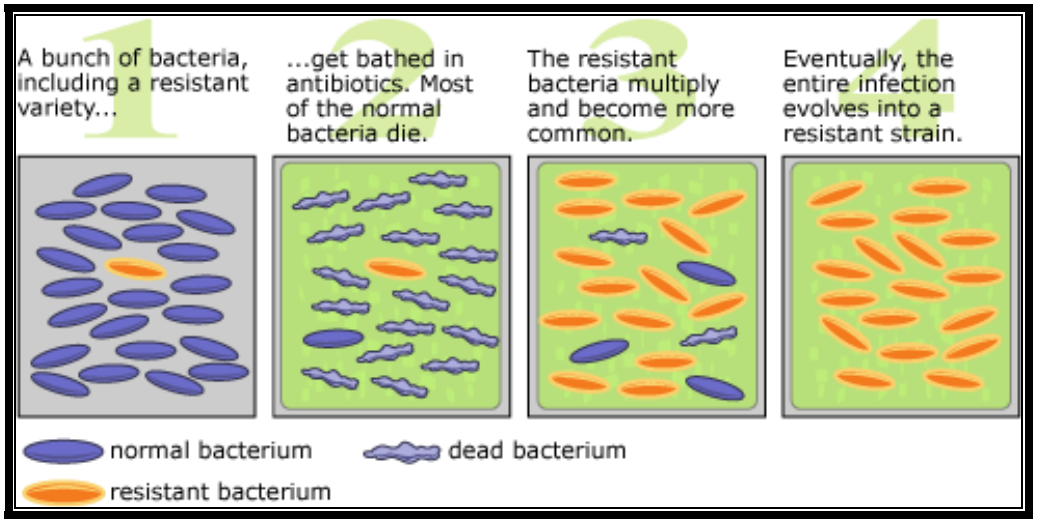
1. **Pesticide resistance**: refers to the ability of a pest to survive applications of pesticides at rates that once killed most of that species. These pests already possess the inherited variation to survive the pesticide. This variation is passed from generation to generation, eventually rendering the pesticide useless against these pests. Resistance most often develops when pesticides are applied at lower-than-recommended rates and when either the same pesticide or pesticides with the same mode of action are repeatedly used.



Resistance Management

- ✓ Use pesticides only when needed.
- ✓ Avoid pesticide residues. Alternate pesticides with different modes of action.
- ✓ Use recommended rates of pesticide.
- ✓ Use other controls where possible
- ✓ Time pesticide sprays for the most vulnerable stage

2. Antibiotic Resistance



Why did antibiotic resistance occur?

- ✓ Over prescription of antibiotics. (antibiotics do **NOT** work on viral infections)
- ✓ Prescribing the same antibiotic over and over again
- ✓ Patients frequently misused prescribed antibiotics by not finishing their medications
- ✓ Pharmaceutical companies stopped developing new drugs to fight bacterial infections.

What can we do now?

- ✓ Doctors prescribe antibiotics only when necessary
- ✓ Patients finish their antibiotics, even if they feel better
- ✓ Vary the antibiotics used to kill bacterial infections
- ✓ Scientists step up the development of new antibiotics

Isolation and New Species Formation

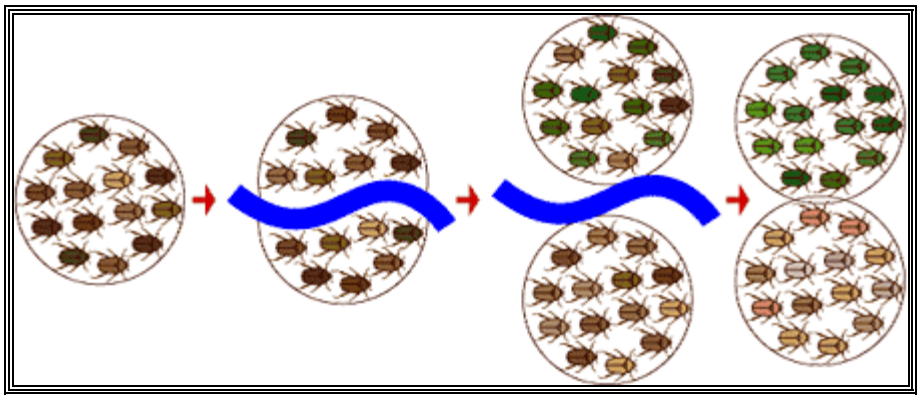
1. **Geographic Isolation**
   a. **Occurs when a population is separated into smaller populations by geographic barriers** such as mountain ranges, deserts, oceans, rivers or other bodies of water. Human can separate populations by building shopping malls or large expressways.
   b. **Scientists think that geographic isolation is a common way for the process of speciation to begin**: rivers change course, mountains rise, continents drift, organisms migrate, and what was once a continuous population is divided into two or more smaller populations.

2. **Reproductive Isolation and Speciation**
   a. Through spontaneous mutations and sexual reproduction, the two populations may become so genetically different that organisms from the two separate populations no longer can successfully interbreed.
   b. ***Unable to produce fertile offspring, the two populations have now evolved into separate species***.

Reminder!

A **species** is a population of organisms sharing the most common characteristics or traits that are capable of mating and producing fertile offspring.

In the illustration below, a large body of water separates a population of fruit flies. Those traits that enable the fruit flies to survive in their separate environments are passed on to future generations. Over time, the two populations of fruit flies may genetically be so different from each other that they have evolved into two separate species.



   c. **Habitat Isolation:** two organisms live in the same area but rarely encounter each other. For example, two species that are members of the same genus can be found in the same geographic area but one inhabits the water and the other is terrestrial so they rarely come into contact with one another.
   d. **Temporal Isolation:** isolation occurs due to timing. For example, different plants of the same species living in the same area become functionally separated into 2 populations because some plants mature earlier and begin to flower in the cooler part of the season while other plants mature during the warmer part of growing season.
   e. **Behavioral Isolation:** two animals of the same species become isolated from each other because of some change in behavior by one member of the group.

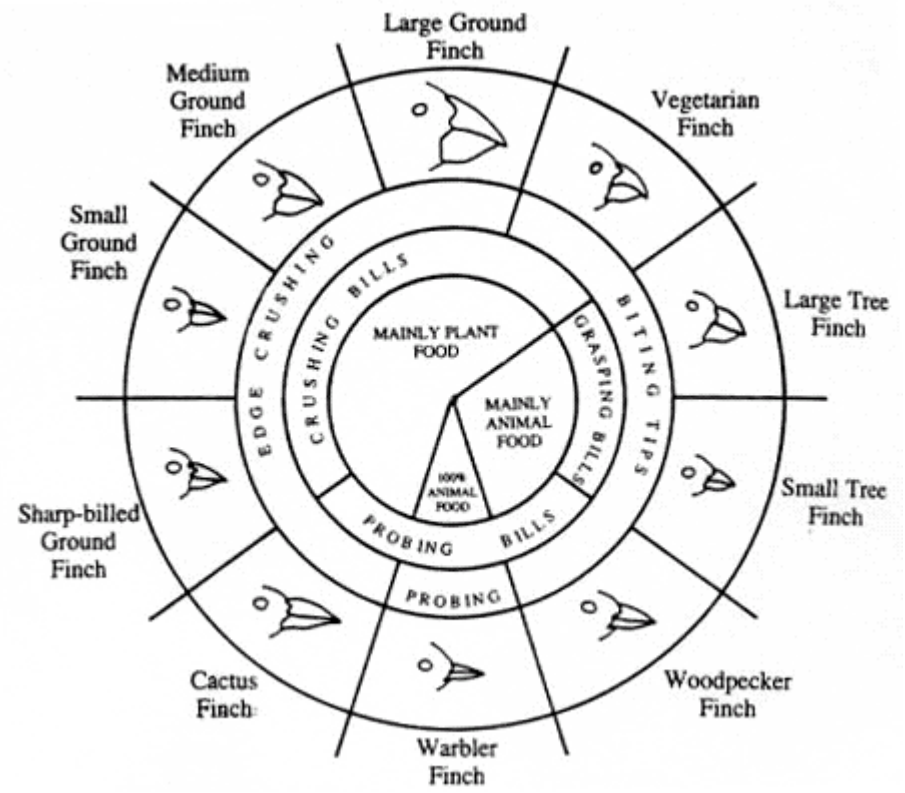
Darwin's Finches and Adaptive Radiation

1. **Adaptive Radiation:** process by which many new species of organisms evolve from one common ancestor.
   - ✓ In a changing environment, different variations may become more important for survival.
   - ✓ As a result of random mutations and genetic shuffling that variations that have positive adaptive value will be passed on to offspring.
   - ✓ **In adaptive radiation,** species evolve to fill different ***niches*** where there is less
   - ✓ competition.

Remember!

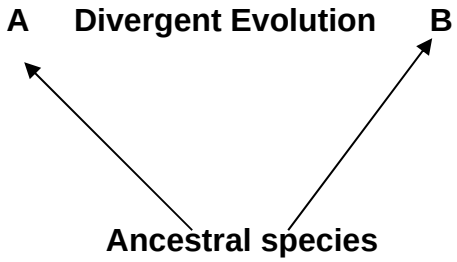
A ***niche*** is a role an organism fills in its environment. A niche includes the organism's feeding habits, how it reproduces, and other life activities. It also determines it relationships with other organisms in the environment and enhances its chances for survival.

Example: During his travels to the Galapagos Islands, Darwin observed that there were 13 different finch species living on the various islands. He noted that their beak shapes were very different. The beak differences enabled the birds to live in different niches based on the type of food they ate. Darwin suspected that the finches had evolved from one common ancestor. Although he did not know why offspring would have different beaks than their parents, but he guessed that these new beaks gave the finches new feeding niches that would reduce the competition for food. For example, he saw a large ground finch with a blunt, powerful beak used to break open hard seeds. Because it could eat bigger seeds than other ground finches, it was not in direct competition with smaller birds and both could exist together without competing for food.



Patterns of Evolution

1. **Divergent Evolution:** occurs when a population becomes isolated from the rest of the species and becomes exposed to selective pressures, leading to the evolution of a new species. Homologous structures are evidence of divergent evolution.



2. **Convergent Evolution:** when unrelated species occupy the same environment, they are subjected to similar pressures and show similar adaptations. The classic example of convergent evolution is a whale and a fish. They have analogous structures due to the ocean environment but the whale's structure is entirely different than that of a fish.

3. **Parallel Evolution:** two related species that have made similar evolutionary adaptations after their divergence from a common ancestor.

4. **Coevolution:** the mutual evolutionary set of adaptation of two interacting species. Coevolution is likely to happen when different species have close ecological interactions with one another. These ecological relationships include:
   - ✓ Predator/prey and parasite/host
   - ✓ Competitive species
   - ✓ Mutualistic species

5. **Adaptive Radiation:** (see above for description)