Chapter 15: Theories of Evolution

Evolution is considered a scientific fact supported by scientific data. Exactly how organisms evolved was first presented by Lamarck and Darwin.

A. Lamarck's Theory

a. If an organism did not "use it" then it would "lose it."

b. Inheritance of "acquired characteristics".

i. Ex: Giraffes needed a long neck to reach the tall leaves in the trees. They acquired the trait for the long neck by stretching it and passed this "stretched neck" down to their offspring.

c. His theory could not be supported by the majority of the scientific community so it has very few who accept it today.

B. Darwin's Theory

a. Charles Darwin was a British naturalist who presented his theory on evolution 50 years after Lamarck. He wrote "Origin of the Species". He stated in this book that environmental factors like climate, food supplies, and natural enemies determine which organisms survive and can reproduce. The characteristics of those organisms that survive would be transmitted to the next generation.

b. Principles His Theory Was Based On

i. Variation exists within any species

ii. All organisms compete for limited natural resources

iii. Organisms produce more offspring than can survive

iv. Environment selects individuals with beneficial traits to survive and reproduce. This is called "natural selection" and is the vehicle for change within a population.

c. Darwin believed that animals that were able to adapt to their environment would be able to survive and pass those useful traits on to their offspring. ("*Survival of the Fittest*")

d. Today we consider Darwin's theory in defining evolution as: **Descent with modification from a common ancestor as a result of natural selection.** Natural selection is a theory that Darwin proposed to explain HOW evolution occurred.

i. **Modern Synthesis** theory merges theories of Darwin with Lamark due to our understanding of epigenetics (the role of our "genetic switches" due to our experiences influencing the traits we can pass on to our future generations)

e. What are the Mechanisms of Evolution?

i. Populations evolve not individuals. A species is defined as a group of like individuals that are able to interbreed and produce fertile offspring. A population is defined as members of the same species living in the same geographical location. (i.e., all the rabbits in a forest.)

ii. *When populations change genetically, EVOLUTION HAS OCCURRED!*

iii. All of the alleles of all of the genes within a population are called the "**gene pool**". The percentage of the presence of any given allele in a gene pool is called "**allelic frequency**."

iv. If the frequency of alleles within a population remains the same over many generations, that population is said to be in "genetic equilibrium" and is not evolving.

1. Hardy and Weinberg proposed a theory called the "**Hardy-Weinberg Principle**" which measures the gene frequency (measurement of the occurrence of an allele) within a population. Hardy determined that under certain conditions, the frequencies of genes stay the same for many generations in a sexually reproducing population. This stability is called "**genetic equilibrium**".

    a. Evolution only occurs if gene frequency is altered

    b. When allelic frequencies remain constant, a population is in genetic equilibrium ("Hardy Weinberg Equilibrium")

2. They found for a population to be in genetic equilibrium they must have:

    a. No Natural Selection

    b. No Net Mutations

    c. No Migration

    d. Random Mating

    e. Very Large Population

3. Hardy Weinberg Principle involves mathematical formulas where…

    p = frequency of the dominant allele in the population
    q = frequency of the recessive allele in the population

    p^2 = percentage of homozygous dominant individuals
    q^2 = percentage of homozygous recessive individuals
    2pq = percentage of heterozygous individuals

v. <u>How Can Genetic Equilibrium be Disrupted</u>? (what are the mechanisms that lead to microevolution?)

1. Natural Selection

2. Mutation

3. Migration (gene flow)

4. Nonrandom mating

5. Genetic Drift

vi. <u>How Can We Define These</u>?

1. **Natural Selection** allows the fittest to survive and reproduce more than those less fit.

a. **directional selection** proceeds in a given direction like long necks of the giraffe. Where one extreme of phenotype range has the advantage.

b. **stabilizing selection** eliminates extremes of a trait and reduces variation. Where the mean/average of phenotype range has the advantage.

c. **disruption selection** eliminates average and favors extremes. Where both extremes fo the phenotype range have advantage over the mean/average.

2. **Mutation** refers to the random DNA changes that are passed down to offspring

3. **Migration (AKA Gene Flow)** refers to the movement of genes into and out of a population.

   a. **emigration** moves individuals and their genes out of a population

   b. **immigration** moves individuals and their genes into a population

4. **Genetic Drift** is a change in gene frequency of a small population due to <u>chance</u>.

   a. **Founder's Effect** is when a small [portion] of a population leaves the rest therefore reducing their gene pool

   b. **Bottleneck** Effect is when a natural disaster reduces the size of a population to a very small number, therefore reducing their gene pool

5. **Nonrandom Mating** is the preference (by females usually) for those with certain traits or lack of ability for females to access males with certain traits

   a. Ex. Associative mating (preference for those who look like you) and inbreeding (easy access to those related to and therefore often near you).

6. **Sexual Selection** (considered to be a type of natural selection by some) results change in frequency of a trait is based on the ability to attract a mate.

   a. Drives dramatic phenotypes in one sex that can be a detriment to an individual's survival but enhance reproductive success.

      i. Peacock tail: hard to hide and run through forest (not so fit for survival) but peahens choose to mate with males with the flashiest tail (need it to contribute to gene pool)

C. The main theme for change, and ultimately speciation (macroevolution) is <u>Reproductive isolation to prevent gene flow</u>:

   a. <u>Pre-zygotic isolation</u>: isolated from making a zygote

      i. *Example*: **geographical isolation** is when members of a population become separated by rivers, roads, rivers, etc.

   b. <u>Post-zygotic isolation</u>: can make a zygote (fertilization happens), but offspring cannot develop or cannot reproduce if does develop into self-sustaining individual and are therefore isolated from survival and/or reproduction (isolated from being a part of the population's gene pool).

D. <u>Speciation Processes:</u>

a. A population must diverge and then be reproductively isolated for speciation to occur. Two ways:

b. Allopatric speciation: separation by a physical barrier (mountain ranges, gullies, lava flows, etc.). The separate populations, over time (generations) will no longer be able to successfully breed with each other.

    i. Thought to be the most common form of speciation

c. Sympatric speciation: no physical barrier; perhaps more behavioral (feeding, activity timing, etc.) barriers to separate the population so that they diverge into two separate breeding populations and then eventually become separate species (experience speciation) where they would not interbreed (not capable and/or not by choice).

E. What are the Patterns of Evolution?

a. Increased variation comes about when isolated populations adapt to their surroundings.

b. Speciation is a long process; we look for patterns. Three main patterns of evolution are:

    i. **Divergent evolution** is the overall process of producing a greater number of different species from one ancestral species. (i.e., brown bear >> polar bear)

        1. Divergent evolution leads to the creation of a new species or "**speciation**" and "**adaptive radiation**" which occurs when members of a species adapt to a variety of habitats like Darwin's finches.

        2. The difference among the species comes from the adaptions of each to its own surroundings, preventing mating between the different groups.

    ii. **Convergent evolution** is when two species live in similar surroundings and by each adapting to its own, they begin to resemble one another. (i.e., whale and shark)

        1. Convergent evolution can lead to mimicry which is when one species begins to resemble another for one reason or another. (i.e., the Monarch butterfly resembles the Viceroy for protection.)

    iii. **Coevolution**: When two species evolve in close relationship where the adaptations of pone species affects the other

        1. Examples: predator and prey (predation), pollinator and plant (a form of "mutualism"), parasites and hosts (a form of "parasitism")

F. Rate of Speciation:

a. Evolution is a dynamic process. Does change come about rapidly or gradually? We are limited in our data as the fossil record is incomplete and only provides some data about an organisms genetics. Two theories:

    i. **Gradualism**: evolution proceeds in small, gradual steps

    ii. **Punctuated Equilibrium**: rapid spurts of genetic change cause species to quickly diverge

        1. Attempts to explain what we see in the fossil record