**Evolution**

What is a scientific theory?

A **scientific theory** is a well-substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment. Such fact-supported **theories** are not "guesses" but reliable accounts of the real world.

*Evolution*: Decent with modification; transformation of a species through time, including both changes that occur within species, as well as the origin of new species.

*Gradualism*: Change can happen slowly over a long period of time.

**Jean Baptiste Lamarck** was one of the first to recognize that **living things have changed over time.**

**Charles Darwin (1809-1882)**

Research began when he traveled as a naturalist aboard the H.M.S. Beagle. One stop was to an isolated set of islands called the Galapagos where he made key observations that would later support his theory.

**Darwin’s Observations** from his trip to the Galapagos

* Organisms native to the islands had specific adaptations suited to their environment (Example: beaks of finches to match food source)
* Animals living on different islands had once been members of the same species
* Organisms better adapted to their environment were more likely to survive and pass on their traits. (Better *fitness*)

**Darwin’s 3 Main Inferences**

1. Not all offspring survive and reproduce because of a struggle for resources.
2. Some individuals are more likely to survive and reproduce due to heritable characteristics.
3. Difference in survival is non-random

*Adaptation*: A change or the process of change by which an organism or species becomes better suited to its environment.

*Fitness*: the genetic contribution of an individual to the next generation's gene pool relative to the average for the population, usually measured by the number of offspring or close kin that survive to reproductive age.

*Artificial selection*: The breeding of plants and animals to produce desirable traits.

**Natural Selection –** primary mechanism of change in populations over time.

*Natural Selection*: The process in which individuals with a particular trait tend to leave more offspring in the next generation than do individuals with a different trait.

Three conditions for natural selection (adapted from Darwin’s 3 inferences)

1. Struggle for existence: Individuals and species compete for limited resources and only some are successful.
2. Survival of the fittest: only those species best adapted for their environment survive and pass on genetic traits
3. Descent with modification: all living species have descended (with changes) from other species

How can natural selection lead to evolution?

1. Genetic mutations can increase variations that may become successful
2. Environments change so genes in populations shift with the need to adapt to different conditions

**Evidence for Evolution**

Fossil Records

Homologous structures: structures that are the same between different organism even though the functions may differ based on adaptations to the environment (Supports the idea of a **common ancestor)**

Analogous structures: structures that are formed differently for different organism even though the function may be the same

(Supports the idea that environmental factors can shape the evolution of a species)

Vestigial Structures: anatomical structures that appear to have no present day use but may have been used in ancestral species

Embryology: the study of similarities in organisms during embryonic stages of development

Biochemistry

DNA bases (ATCG) are used in all life forms

DNA sequences differ based on evolutionary relationships

Predator-Prey Relationships Examples: camouflage, mimicry

Structural Adaptations Examples: long necks in giraffes, webbed feet in a duck

**Modern Synthesis of Evolution**

1. Populations as the unit of evolution.
2. Natural selection as the most important mechanism of evolution.
3. Gradualism explains how large changes can evolve as an accumulation of small changes occurring over long periods of time.

**Evolution of Populations**

Evolution and Natural Selection are changes in populations NOT individuals.

*Variation:* inheritable differences in DNA within a population

*Gene Pool:* all of the genes for a trait that are present in a population (represented by alleles)

*Microevolution:* the change in the frequencies of alleles within a population over time

***Variation*** in a population occurs when organisms within a population have traits that set them apart. Within the ***gene pool*** alleles for each variation are present but some may be more successful than others. Through ***microevolution***, eventually the alleles in the population favor the trait that is more successful.

**Sources of Genetic variation**

1. *Mutations:* a change in DNA
2. *Genetic drift:* random changes due to small population sizes
3. *Migration / Gene Flow*: individuals move into and out of a population such that genes come and go
4. *Non-random mating*: individuals choose their mates based on specific traits (think about a peacock); this a type of natural selection called ***sexual selection.***
5. *Natural Selection*

**Equalibrium**

The opposite of evolution is **equilibrium** – (life is static, and nothing changes)

*Genetic equilibrium*: allele frequency stays the same.

5 Conditions Required to maintain equilibrium

1. Random Mating
2. Large Population
3. No movement in or out of population
4. No mutations
5. No Natural Selection

**Patterns of Natural Selection**



Changes in Populations

*Polygenic trait*: a trait controlled by two or more genes.

A single polygenic trait often has many possible genotypes and even more different phenotypes. Changes in traits within a population can cause a genetic drift towards a specific appearance or adaptation.

**Three types of natural selection within populations**

1. Stabilizing Selection: the average individual is favored.
2. Directional Selection: one of the extreme forms is favored.
3. Disruptive Selection: both extreme forms are favored.

*Speciation*: changes leading to formation of a new species.

**Reproductive isolating mechanisms that can lead to speciation:**

**Prezygotic**

1. Geographic Isolation – individuals of different cannot mate due to a physical barrier
2. Behavioral Isolation – individuals of different species ignore mating cues from other species
3. Temporal (time) Isolation – individuals of different species reproduce at different times

**Postzygotic** – individuals of different species can mate but offspring are less likely to survive and or reproduce

* Reduced hybrid viability – extra or missing genes reduce survival
* Reduced hybrid fertility – robust but sterile offspring

*Allopatric speciation – a physical barrier arises and ends the gene flow between populations*

*Sympatric speciation – new species arise in the absence of a physical barrier*

**Macroscopic Patterns of Evolution**

*Divergent Evolution:* The pattern where many different species are linked to one common ancestor.

*Convergent Evolution:* The process by which unrelated species evolve similar physical characteristics because they have similar environmental circumstances.