Natural Selection - How do traits get selected?

- Natural selection is the differences in survival and reproduction among individuals in a population as a result of their interaction with the environment. Some individuals possess alleles (genotypes) that generate traits (phenotypes) that enable them to cope more successfully in their environment than other individuals. The more successful individuals produce more offspring.
- Superior inherited traits are adaptations to the environment and increase an individual's fitness, or relative ability to survive and leave offspring. When the environment favors a trait, that is, when a trait increases the survival of its bearer, selection is said to act for that trait. In contrast, selection is said to act against unfavorable traits. Favorable traits are adaptive, while unfavorable traits are maladaptive.
- The Process of Natural Selection
    - Populations possess an enormous reproductive potential. For example, Darwin calculated that two elephants would produce a population of 19 million individuals after 750 years if all offspring survived to reproductive maturity and fostered their normal number of offspring.
    - Population sizes remain stable. Darwin observed that populations generally fluctuate around a constant size.
    - Resources are limited. Resources, such as food,water, or light, do not increase as populations grow larger.
    - Individuals compete for survival. Eventually, the needs of a growing population will exceed the available resources. As a result, individuals must compete for resources.
    - There is variation among individuals in a population. Most traits reveal considerable variety in their form. In humans, skin, hair, and eye color occur as continuous variation from very dark to very light.
    - Much variation is heritable. Most traits are produced by the action of enzymes that are coded by DNA. DNA is the hereditary information that is passed from generation to generation. This contrasts with characteristics acquired during the life of an organism. The amputation of a limb, for example, is not heritable.
    - Only the most fit individuals survive. Survival of the fittest occurs because individuals with traits best adapted for survival and reproduction are able to outcompete with other individuals for resources and mates.
    - Evolution occurs as favorable traits accumulate in the population. The best adapted individuals survive and leave offspring who inherit the traits of their parents. In turn, the best adapted of these offspring leave the most offspring. Over time, traits best adapted for survival and reproduction and the alleles that generate them accumulate in the population.
- Natural selection may act upon a population in a variety of ways:
    - Directional selection - One extreme trait is favored and selected
    - Disruptive selection - Two extreme traits are favored and selected
    - Stabilizing selection - One average trait is favored and selected

- Sexual selection

Genetic Equilibrium

- Five Main Agents of Evolution
  - Gene flow
  - Mutation
  - Nonrandom mating
  - Selection
  - Genetic drift
- Populations and Gene Pools
  - A population is a localized group of interbreeding individuals
  - A gene pool is a collection of alleles in the population
    - Remember difference between alleles and genes
  - Allele frequency is how common is that allele in the population
    - How many A (dominant) vs. a (recessive) in whole population
- Evolution of Populations
  - Evolution - change in allele frequencies in a population
    - Hypothetical - what conditions would cause allele frequencies to not change? (remove all agents of evolutionary change)
  - Overall, when the allele frequencies in a population remain constant from generation to generation, the population is said to be in genetic equilibrium, or Hardy-Weinberg equilibrium. At genetic equilibrium, there is no evolution. In order for equilibrium to occur, the factors that normally change gene frequencies do not occur.
- Non-Evolving Population Requirements
  - 1. Large population size (no genetic drift)
  - 2. Random mating (no sexual selection)
  - 3. No migration (no gene flow in or out)
  - 4. No mutation (no genetic change)
  - 5. No natural selection (everyone is equally fit)
- Basic Ideas of H-W Equilibrium
  - This hypothetical, non-evolving population preserves allele frequencies
  - Serves as a model
  - However, natural populations are rarely in H-W equilibrium
  - Can be a useful model to measure if forces are acting on a population measuring evolutionary change
- Math/Science Interconnected
    - It's all about counting Alleles
      - Assume 2 alleles - B, b
      - Frequency of dominant allele (B) = p
      - Frequency of recessive allele (b) = q
      - Frequencies must add to 1 (100%), so p+q=1

- It's all about counting Individuals
  - Frequency of homozygous dominant: p x p = p2
  - Frequency of homozygous recessive: q x q = q2
  - Frequency of heterozygotes: (p x q) + (q x p) = 2pq
  - Frequencies must add to 1 (100%), so p2 + 2pq + q2 = 1

Origin of Life

- Setting the Scenery
  - Earth was bombarded continuously by the remnants of the dust and debris, like asteroids, meteors, and comets, until it formed into a solid sphere, pulled into orbit around the sun and began to cool down
  - The atmosphere was poisonous: formed mostly from water vapor, carbon monoxide, methane, ammonia, nitrogen, carbon dioxide, nitrogen, hydrochloric acid and sulfur produced by the constant volcanic eruptions
  - It had no free oxygen
  - About 4.1 billion years ago, the Earth's surface began to cool and stabilize, creating the solid surface with its rocky terrain
- How does a cell, or life, exist in these conditions?
  - It appears that life first emerged at least 3.8 billion years ago
  - How life originated and how the first cell came into being are just ideas, since these events can't be reproduced in the lab
  - Several types of experiments provide important evidence bearing on some steps of the process
- Brief History: Landmarks
  - Earth - 4.6 bya
  - Life - 3.5 to 4 bya
  - Prokaryotes - 3.5 bya
  - Oxygen - 2.7 bya
  - Eukaryotes - 2.1 bya
  - Multicellular Eukaryotes - 1.2 bya
  - Animal Diversity - 543 mya
  - Land Colonized - 500 mya
- Experiments: Origins of Life
  - Spontaneous Generation: Life could come from nonliving things, such as maggots from rotting meat, mice from corn, etc. Francesco Redi and Louis Pasteur disproved this.
- Stromatolites
  - Stromatolites have been found amongst fossils
  - Stromatolites are a byproduct of microbial life, such as cyanobacteria. This is a similar process of how coral reefs are made.
- Forming Macromolecules
  - Life is made from organic compounds, known as molecules

- These are covalently bonded nonmetals
- Miller-Urey Experiment
  - Showed that abiotic synthesis of organic molecules in a reducing atmosphere is possible
  - They performed lab experiments that simulated the earth and its pre-life environment
  - They were able to synthesize molecules from gases, electric charges, and manipulating the temperature

Organizing and Classifying: Phylogeny and Systematics

- Making sense of what we already know
  - Phylogeny
    - Evolutionary history of a species
    - Based on common ancestries inferred from
      - Fossil record
      - Morphological and biochemical resemblances
      - Molecular evidence
  - Systematics
    - Connects classification system to phylogeny by categorizing and naming organisms
  - Fossil Record
    - Sedimentary rock are riches source of fossils
    - Fossil record is a substantial, but incomplete, chronicle of evolutionary history
      - Incomplete historical documents of biology
    - History of life on Earth is punctuated by mass extinctions
- Paleontology
  - Study of fossils
  - Fossils provide the strongest evidence of change links past and current organisms
  - Morphological and molecular homologies - similarities based on shared ancestries
    - Bone structure
    - DNA sequences
  - Evaluating molecular homologies
    - Aligning DNA sequences
    - More bases in common = more closely related
    - Analyzed by software
- Systematics
  - Connecting classification to phylogeny
    - Hierarchical system
    - Carolus Linnaeus
    - Latin binomial
      - *Genus species*

        - The first letter of the genus is capitalized, and the entire species name is italicized or underlined
        - Both parts together name the species
    - Building Trees
        - Connection between classification and phylogeny
    - Cladograms
        - Patterns of shared characteristics
        - Classify organisms according to the order in time at which branches arise along a phylogenetic tree
- Taxonomy
    - Science of classifying and naming organisms
    - Branching diagram that shows evolutionary history of a group of organisms
    - Linnaeus introduced a system for grouping species in increasingly broad categories
    - The taxonomic groups from broad to narrow are: domain, kingdom, phylum, class, order, family, genus, and species
    - A taxonomic unit at any level of hierarchy is called a taxon