Unit 7: Evolution
Content Outline: Evolution of Populations (7.2) – Part 1

I.   Natural Selection & Evolution
  A. *Populations evolve;* <u>not</u> individuals.
      This is because we "are" what we "are" because of the genetics *we inherited*. You can't change your somatic cells' DNA by choice, only by random mutation. If a mutation occurs in the DNA that located in the gametes (sperm and eggs), then those changes *may* affect the *next* generation of offspring and therefore a change in traits has occurred. In other words, the "population" is evolving from generation to generation. "Evolve" just means "change over time" and that is what has occurred.
  B. Individuals "suffer" or "benefit" as a result of the traits they inherited or mutations they acquire during their life.
      1. "Weak" vs. "strong" genes is the way it is usually communicated. "Weak" are considered detrimental traits and "strong" are considered favorable traits in terms of survival and reproduction.

Please ask students for examples of favorable genetic traits and unfavorable genetic traits for humans to possess in terms of our survival as a species.

II.   **Population Genetics**
  A. The science that studies the *trait variation rates over time* within a population.
  B. It basically is following *allele frequency rates* in a gene pool. (A.K.A. a population.)

III.   **Population** is defined by four criteria:
  A.   *Same species* of organism.
  B. Located in the *same location.*
  C. At the *same time.*
  D. And showing *signs of reproduction.* (Offspring are present within the group.)

IV.   **Species**
  A. Mostly defined as organisms that are so genetically similar in genome that there exists the *potential to breed* and produce *viable* (living) *fertile* (able to reproduce eventually themselves) *offspring.*
      Please make sure the students understand the significance of offspring that can reproduce… keep the species going over time.
  B. Genetics are *very similar* is important to defining a species since it is the "blueprint" for "constructing" an organism. The "plans" must be very similar or there will be confusion in "construction" and problems will arise during development. Problems are a terrible thing to encounter since we are discussing the making of a *living* organism.
  C. **Geographic range** vs. population
      1. A population is in one *specific* given area; but in the case of organisms that are quite common (For example, grey squirrels or humans.); we may have several populations that cover a wider expanse of territory. In the case of humans, as a species we are global in our range; but we have millions of different populations, such as the population of Montgomery or the population of Birmingham. "Range" refers to *everywhere* where that species *may* be found.
      2. Gene pools may or may not interact; it depends on the species and if any geographic barriers (such as large mountains or large bodies of water) interfere with the ability to interact.
      3. **Allele frequency** (Remember, an allele is a *version* of a gene, such as blue or brown for eye color.)
          a. "Frequency" refers to "how many" are present at that time within the population (gene pool).
          b. Is considered *fixed*, if there is <u>no</u> change in frequency—<u>no</u> evolution is present. (A state of *equilibrium* is occurring.)
          c. Is considered *evolving*, if frequency is changing— evolution <u>is</u> occurring. (A state of *change* is occurring over time.)

Evolution of Populations (7.2) – Part 2

I. **Hardy-Weinberg Theorem**
   A. This *set of equations* is used to follow allele frequency within a population (also considered a gene pool)
      1. If the numbers (rates) *change* from generation to generation, the population is evolving over time.
      2. If the numbers (rates) <u>do not</u> change from generation to generation, the population is not evolving over time and is then said to be in a state of equilibrium.
   B. Equation #1: $p + q = 1$ (This equation is for **alleles**.) "p" refers to the "dominant" allele percentage and "q" refers to the recessive allele percentage. Together p + q percentages must equal 100% of the gene pool or 1.
   C. Equation #2: $p^2 + 2pq + q^2 = 1$ (This equation refers to the percent composition/number of organisms within the population (gene pool) at that time.) It is essentially a Punnett square, but in math format.
      1. p^2 = the homozygous dominant percentage of organisms within the population at that time.
      2. 2pq = the heterozygous percentage of organisms within the population at that time.
      3. q^2 = the homozygous recessive percentage of organisms within the population at that time.
      4. All three <u>must</u> add up to 100% (1) of the population.

Please make sure that students understand the difference between the two equations and can see the need for having two different equations… each is referring to different sets of information; but are related as genes create traits within individuals within a population.

   D. These equations are mainly used in health sciences to explain the frequency of genetic conditions.
   E. These equations can be used to show how or if variation is preserved over time.
   F. Five conditions <u>must</u> be met for a population to be in *Equilibrium* (Frequency *not* changing):
      1. Large population must exist. (This dilutes any non-random processes that are occurring.)
      2. No migration in or out of the population is occurring at that time. (The population is not being influenced by *outside* environmental factors.)
      3. No mutations are occurring within the genome. (No random, unforeseen change due to an environmental stress.)
      4. Random mating is occurring (No preferences are being displayed for one trait over another trait…everyone is *equal* in fitness.)
      5. No natural selection is occurring on the population at this time. (Nature favors all equally in terms of fitness.)

Students must know all 5. They also need to understand how that condition promotes change if it is not met.

Evolution of Populations (7.2) – Part 3

I. **Variation** (Different traits exist within a given species or population.)

   A. Variation is key to surviving in a changing environment. (This is because you have *options*.) Perhaps some of the members of that species or population will survive and reproduce.

   B. These *options* are the raw building materials of evolution to utilize. If there is no variation or "option" from which to utilize, a species is confined to what is available; even if it is weak or unfavorable. Variation, on the most basic level, will only come into existence with a change in the DNA nucleotide sequence, what we refer to as a mutation. Some mutations are favorable, but *most* are harmful.

   C. Variation exists between individuals and populations unless the population is composed of clones.

II. "Creating" Variation for evolution to build upon:

   A. Through mutations

      1. These changes are *rare and random in gametes*. (Because these cells are normally not exposed to the environmental stresses an organism may encounter in their existence.)

      2. Mutations mostly occur in somatic cells because these cells are exposed to the environmental stresses.

      3. Most mutations, unfortunately, are harmful to the cell or organism, so it usually dies.

   B. Through sexual reproduction

      1. The *process of crossover*, during Prophase I of meiosis, "swaps genes from one chromosome to another, its equal "mate" usually, during gamete formation. (This is so that each sperm or egg is unique in it's genetic composition.)

      2. The *Segregation (means "separation") of Chromosomes* during Anaphase I and II of meiosis so as to reduce the genetic content (number of chromosomes) found within a sperm or egg to one-half (referred to as "haploid") the normal content (referred to as "diploid").

      3. The *random fertilization* of a sperm by an egg increases variety. (Each sperm and egg are different remember… so each coming together between egg and sperm (what is referred to as fertilization) will be different too.)

Please make sure students understand and know these three processes as these are often questions on high stakes exams.

III. **Microevolution** (Evolution/change on a small scale.)

      A. This term usually refers to changes in allele frequency within a population of a species.

      B. Microevolution *can eventually* lead to **macroevolution** - The evolution of a new species or higher taxon in the classification system from a *pre-existing* species.

      C. *Remember*: Change over time is referred to as evolution. Evolution is a scientific *law*… the environment changes from minute to minute, hour to hour, day to day; just as a genome may. Please do not confuse this "change over time" with the belief of creationism. These are two different concepts that are confused with each other because of misconceptions of the definition.

IV. Natural Selection

      A. *Always* has a *positive* effect on variation because "nature" favors those traits that make a population or species more able to survive within an environment and increases their ability to reproduce and keep the species viable. The weak traits perish over time.

Evolution of Populations (7.2) – Part 4

I. **Phenotypic Polymorphism** (A.K.A. **Discrete Characters**.)
    A. These are referred to as *single gene traits* for the "discrete" phenotypic outcome.
    B. They are also called *either – or – traits* (You either have the gene or you don't, which in turn means you either produce the trait or you don't.)
    C. Phenotypic (means "the physical outcome of a gene); polymorphisms (means "many versions or types")
        1. This basically means that there may exist *multiple versions* of the same basic gene trait simply because of a different sequence of nucleotides that make that gene.
            1. A, B, AB, and O Blood types for example. (These are all blood; but different versions or types of the same main gene being expressed.)

II. **Genotypic Polymorphisms** (A.K.A. **Quantitative Characters**.)
        1. These are traits for which there may exist several phenotypic outcomes based on the fact that these traits are the cumulative interaction of several genes interacting with one another.
        2. The fact that there are several genes involved is why they are also referred to as Quantitative (how many alleles) characters.
            1. Skin color is basically based upon how many dominant alleles you inherit from your parents. The dominant allele makes the protein pigment found in skin called melanin. *Every* human makes this protein pigment, except people suffering from Albinism (a genetic condition where the individual inherited *zero* dominant alleles and therefore does not have a single DNA blueprint for making the protein pigment; so they "appear" white because they have zero pigment in their cells. In those individuals who did inherit at least one dominant allele they will have skin pigmentation. So basically, the more dominant alleles that are inherited; the darker the skin will be. Race is a man made construct that tries to group individuals based on geographic origin or degree of skin pigmentation, but we are <u>all</u> human (*Homo sapiens)*. We now recognize the direct relationship between the environment and the degree of pigmentation. Populations around the Equator are darker (in an attempt to counteract the harmful effects of the sunlight) and as we move away from the equator the amount of pigmentation decreases generally.

Recipe cards and blank index cards work well with this discussion. The recipe cards represent Dominant genes… we can make that protein because we have information. Blank cards represent recessive genes… can't make a protein because there is no information. Both are paper; therefore, both are DNA.

III. Evolutionary **flow** (Modes or ways of selection "affecting" phenotypic outcomes.)
    A. **Directional** – the "bell curve" for a trait flows in *one direction only*.
    B. **Diversifying** (Disruptive) - the "bell curve" for a trait *separates in opposite directions at the <u>same</u> time*.
    C. **Stabilizing** – the "bell curve" moves to the *"stable"* center.
    D. These are <u>all</u> related to some trait that is beneficial for survival within that changing environment.

IV. **Neutral Variation**
        1. No survival benefit or harm (Why we call it neutral.) from the trait. For example, Fingerprints … everyone's is different but it doesn't help us or hurt us in survival and reproduction. Only helps in crime solving.

V. **Sexual Dimorphism** ("di" means "two"; "morph" means "structures/versions")
        1. The two "versions" (male or female) are the direct result of the secondary sexual characteristics associated with estrogen versus testosterone production.
    B. This difference leads to **sexual selection** among the populations organisms.
        1. **Intrasexual selection** ("intra" means "*within* one same sex")
            a. Males mainly "fight" for reproductive rights. (It becomes "Survival of the fittest", basically.)
        2. **Intersexual selection** ("Inter" means "*between* the two sexes")
            a. Males strut to attract the females attention. (Mostly seen in birds with bright coloration.)
            b. Females choose based on "fittest" looks. (This indicates good health.)
    C. The competition between individuals makes sure that the "best or most fit" genes get passed to the next generation.