AP BIOLOGY

LECTURE NOTES: CHAPTER 23
THE EVOLUTION OF POPULATIONS

Name: _____ Date: _____

Microevolution – a change in allele frequencies in a population over generations.

Concept 23.1 – Mutation and sexual reproduction produce the genetic variation that make evolution possible.

1. ***Genetic Variation*** within a population may be discrete or quantitative.
    a. ***Discrete characters*** – can be classified on an either-or basis; many are determined by a single gene locus with different alleles that produce distinct phenotypes – i.e. white or purple flowers
    b. ***Quantitative characters*** – traits that vary along a continuum within a population; usally results from the influence of two or more genes on a single phenotypic character

2. ***Geographic Variation*** – differences in genetic composition of separate populations living in different geographic locations

3. ***Mutation*** – the ultimate source of new alleles – is a change in the nucleotide sequence of an organism's DNA

4. ***Sexual Reproduction*** – most of the genetic variation in a population results from the unique combination of alleles that each individual receives
    a. Three mechanisms contribute to the shuffling of alleles
        i. Crossing over
        ii. Independent assortment of chromosomes
        iii. Fertilization

Concept 23.2 – The Hardy-Weinberg equation can be used to test whether a population is evolving.

1. ***Population*** – a group of individuals of the same species that live in the same area and interbreed, producing fertile offspring

2. We can describe a populations makeup by describing its ***gene pool***

3. ***Hardy-Weinberg Principle*** can be used to determine if a population is evolving or not
    a. Hardy-Weinberg used to determine what the genetic makeup for a particular locus would be for a population if it was NOT evolving
    b. We can than compare these numbers with the actual numbers of the real population
        i. If there is NO difference in the numbers = NO evolution taking palce
        ii. If there is a difference in the numbers = evolution is taking place
    c. ***Hardy-Weinberg Equilibrium*** – population's gene pool remains constant from generation to generation – provided Mendelian segregation and recombination of alleles are the only factors at work
    d. ***Hardy-Weinberg Equation*** – $p^2 + 2pq + q^2 = 1$
        i. p^2 = frequency of homozygous for allele #1
        ii. q^2 = frequency of homozygous for allele #2
        iii. $2pq$ = frequency of heterozygous for allele #1 & #2

4. FIVE Conditions for Hardy-Weinberg equilibrium

    Condition #1 – **No Mutations** – mutations would modify the gene pool
    Condition #2 – **Random Mating** – without random mating you would not have random mixing of gametes
    Condition #3 – **No Natural Selection** – this would alter allele frequencies
    Condition #4 – **Extremely Large Population Size** – smaller populations more likely allele frequency fluctuates
    Condition #5 – **No Gene Flow** – moving genes in or out of population will change allele frequencies

Concept 23.3 – Natural selection, genetic drift, and gene flow can alter allele frequencies in a population.

Three mechanisms that later allele frequencies directly and cause MOST evolutionary change:

1. Natural Selection
    a. Selection will result in alleles being passed to the next generation in proportions different from their proportions in the present generation
    b. Natural selection is NOT coincidental – it leads to ***adaptive evolution*** – evolution that results in a better match between organisms and their environment

2. Genetic Drift
    a. ***Genetic drift*** – chance events can cause allele frequencies to fluctuate from on e generation to the next, especially in small populations
        i. ***Founder Effect*** – a few individuals become isolated from a larger population, this small group may establish a new population whose gene pool differs from the source population
        ii. ***Bottleneck Effect*** – a sudden change in the environment – such as a fire or flood – may drastically reduce the size of the population – a severe drop in population may lead to the bottle neck effect – by chance certain alleles may be overrepresented among the survivors, others may be underrepresented, some may be absent altogether
            1. ***Human actions*** sometimes create severe bottlenecks for other species
                a. For example the Illinois prairie chicken

    b. ***SUMMARY*** of the Effects of Genetic Drift
        i. Genetic drift is significant in small populations – alleles can become overrepresented, underrepresented, or lost
        ii. Genetic drift can cause allele frequencies to change at random – it is NOT predictable from year to year
        iii. Genetic drift can lead to a loss of genetic variation within a population – alleles can be eliminated from a population
        iv. Genetic drift can cause harmful alleles to become fixed – especially in very small populations, it can threaten the population's survival

3. Gene Flow
    a. ***Gene flow*** – the transfer of alleles into or out of a population due to the movement of fertile individuals or their gametes
    b. Gene flow tends to <u>reduce</u> the genetic differences between populations – if it is extensive enough – neighboring populations could combine into a single population with a single gene pool
    c. Gene flow, like mutations, can introduce new alleles into a population –gene flow happens at a higher rate than mutations and therefore gene flow is more likely to alter allele frequencies
    d. Once gene flow introduces a new allele into a population – natural selection may either increase or decrease its frequency

Concept 23.4 – Natural selection is the only mechanism that consistently causes adaptive evolution.

1. Evolution by natural selection is a blend of chance and "sorting" – chance is the creation of new genetic variations and sorting as natural selection favors some alleles over others.
    a. Because of this sorting effect – ONLY natural selection consistently increases the frequencies of alleles that provide reproductive advantage and thus leads to adaptive evolution

2. ***Relative Fitness*** – the contribution an individual makes to the gene pool of the next generation, *relative* to the contributions of the other individuals
    a. Relative fitness conferred by a particular allele depends on the entire genetic and environmental context in which it is expressed

3. ***Three Modes of Selection***

    a. ***Directional Selection*** – occurs when conditions favor individuals exhibiting one extreme of a phenotype range – thus shifting the frequency curve in one direction of the other

    b. ***Disruptive Selection*** – occurs when conditions favor individuals at both extremes of a phenotypic range over individuals with intermediate phenotypes

    c. ***Stabilizing Selection*** – acts against both extreme phenotypes and favors intermediate variants

4. **Key role of natural selection in adaptive evolution**
    a. natural selection increases the frequencies of alleles that enhance survival and reproduction, thus improving the match between organisms and their environment
    b. The physical and biological components of an organism's environment may change over time. As a result , what constitutes a "good match" between an organism and its environment can be a moving target, <u>making adaptive evolution a continuous, dynamic process</u>

5. **Sexual Selection**
    a. *Sexual selection* – a form of natural selection in which individuals with certain inherited characteristics are more likely than other individuals to obtain mates
    b. ***Sexual dimorphism*** – a result of sexual selection; a marked differences between the two sexes in secondary sexual characteristics
    c. ***Intrasexual selection***
        i. Means selection within the same sex – typically males
        ii. Individuals of one sex compete directly for mates of the opposite sex
            1. Often it is based on rituals and displays that don't risk injury
    d. ***Intersexual selection***
        i. Also called "mate choice" – typically females
        ii. Females choice typically based on showiness of the male's appearance and/or behavior
        iii. Males will often weight the attraction of predators versus the attraction of mates

6. **The Preservation of Genetic Variation**
    a. Tendency for directional and stabilizing selection to reduce variation is countered by mechanisms that preserve or restore it
        i. ***Diploidy*** – organisms carrying genes in pairs
            1. recessive traits can be preserved in heterozygotes – this maintains a large pool of genes that may not be useful today – but could be in the future
        ii. ***Balancing Selection*** – maintains two or more forms in a population
            1. ***Heterozygote advantage*** – sometimes a heterozygote has an advantage to a homozygote and survives – for example sickle cell genes in areas of Africa afflicted with malaria
            2. ***Frequency dependent selection*** – the fitness of a phenotype declines if it becomes too common in a population – for example right – and left- mouthed fish
        iii. ***Neutral variations*** – changes in the DNA (typically non-coding) that provide no selective advantage or disadvantage

7. **Why Natural Selection Cannot Fashion Perfect Organisms**

    a. **Selection can act only on existing variations** – new advantageous alleles do NOT arise on demand
    b. **Evolution is limited by historical constraints** – evolution can only modify what already exists
    c. **Adaptations are often compromises** – for example humans took flexibility in their joints versus stability
    d. **Chance, natural selection, and the environment interact** – for example a storm may blow organisms (insects, birds) to another island, but they don't necessarily blow the most fit organisms to that new environment