AP Biology
Unit 7 - Natural Selection

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1. Introduction to Natural Selection:

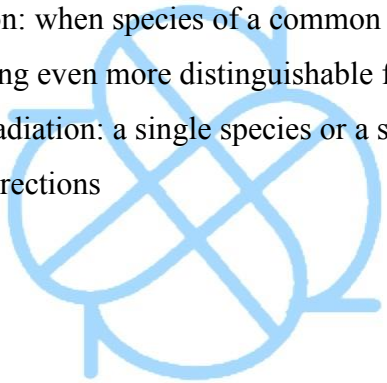
- Frequency dependent selection: a phenotype's fitness is dependent on how common it is in the population
    - Negative frequency dependent selection:selection favors the less common trait
    - Positive frequency dependent selection: selection favors the more common trait.
- Oscillating selection: where at one time, selection favors one phenotype, and then another time, selection favors the other (happens often with changing seasons)
- Industrial melanism: event where selection favors darker individuals over lighter individuals. (Ex: peppered moths due to pollution)
- Heterozygote advantage: more chances of reproductive success for heterozygotes
- Types of Selection
    - Directional selection: one extreme of a variation is favored
    - Disruptive selection: both extremes of a variation are favored
    - Stabilizing selection: where extremes are not favored, but rather intermediates have the selection advantage.
- Relative fitness:how likely an organism is to reproduce in comparison to other organisms
- Natural selection: where the environment favors certain traits, allowing organisms with these traits to have a selective advantage
- Adaptation: characteristic that a species overtime develops as natural selection wipes out a less favorable trait

2. Natural Selection:

- Results in a group of organisms that have traits the environment favors; the most fit individuals survive
- Variation of Traits: the varied alleles and traits that parents have and that they pass on to their offspring
- Over-reproduction: too much offspring
- Competition:
    - Survival of the fittest: natural process that leaves the most fit individuals in the population, and wipes out individuals with unfavorable traits
- Evolutionary Trends/Changes
    - Adaptive radiation: An evolutionary pattern in which many species evolve from a single ancestral species
    - Genetic Drift: gene pool of a population changes due to chance
    - Bottleneck Effect: gene pool of a population changes due to the dramatic decrease in population; often a result of disaster or disturbance to the ecosystem
    - Founder's Effect: genetic drift, but in the case where a certain group of organisms migrate to an uninhabited area, and thus change the proportions of alleles in the gene pool
    - Gene Flow: Mixture of genes between populations
    - Mutation: changes that occur in a gene's DNA sequence

3. Artificial Selection:

- Artificial Selection: Selection brought about by humans (ex: breeding)
- Genetic Engineering: intention and direct manipulation traits in DNA
- Selective Breeding: artificial selection; breeding is done deliberately and selectively to produce desired traits.
- GMOs: Genetically modified organisms
- Convergent evolution:unrelated, independent organisms in the same environment evolve similar traits in relation one another, only because of the environment and not because of evolutionary origin
    - Analogous structures: structures in unrelated species that are similar in function and appearance; result of undergoing similar environmental pressures, not a result of evolutionary origin
- Divergent evolution: when species of a common ancestor evolve in different directions, becoming even more distinguishable from each other overtime
    - Adaptive radiation: a single species or a small group of species evolve in different directions



4. Population Genetics:

- Charles Darwin
  - The differential survival and reproduction of individuals in a population based on variations in their traits
  - Adaptation was a product of natural selection
  - Divergent species have a common ancestor, from which they evolved due to descent with modification
- Jean Baptiste Lamarck
  - Use and Disuse (Lamarckism): in a single organism's lifetime, its less utilized body parts will shrink and disappear. More utilized body parts will be maintained and will change to become more beneficial. These traits are then passed down
  - Very different from Darwin's theory
- Natural selection occurs between individuals and their environment, but *individuals* do not evolve. Evolution occurs in a species or group of organisms where individuals with less favorable traits die off, while those with a specific favorable trait survive and reproduce. Thus, the species evolves to have favorable traits, not the individual itself.
- Hardy Weinberg Theorem: shuffling of alleles due to meiosis and random fertilization have no effect on overall gene pool. (ex: Just mixing marbles in a sack)
  - For a population to be considered in Hardy-Weinberg equilibrium there can be NO "outside factors" that affect allele frequencies. But this equilibrium is hardly ever achieved in reality. These five factors are
    1. No genetic drift: must have very large population
    2. No gene flow: no migration or transfer of alleles with other populations
    3. No net mutations: no changing alleles in another
    4. Random mating
    5. No natural selection: differential survival and reproduction will alter genotypic frequency

    What is the Hardy Weinberg equation?

p = dominant

q = recessive

$p^2 + 2pq + q^2 = 1$

p+q = 1 (1 = 100%)

p = freq of dominant allele = 1 - q

q = freq of recessive allele

- heterozygous individuals: 2pq.
- Microevolution refers to specific changes in gene pool on the small scale e.g. changes in frequency of allele in the population from generation to generation. Change occurs constantly through mutation, natural selection, genetic drift, gene flow. If one allele at specific locus is changing from gen to gen, then pop is said to be evolving even if in H-W eq for all other loci
  - Caused often by genetic drift and natural selection
- Genetic drift cannot increase genetic diversity, but will actually decrease genetic diversity as alleles disappear and reappear overtime in smaller populations. The only way to truly increase genetic diversity is by introducing new traits and alleles e.g. via mutation.
- Genetic drift is a direct result of independent assortment. The chromosomes that align randomly during meiosis create great variations in resulting offspring, and even more variation hidden behind carrier organisms (heterozygous). IN smaller populations, it is clear to see how there would be fluctuations in alleles, and then sudden surges in allele frequencies. The drift is a result of this.
- Geographic variations are differences in variation between population subgroups in different areas. A graded change in a trait along a geographic axis: cline
  In contrast to cline, geographic variation between isolated pops often consist of discrete differences
- Balanced polymorphism is when 2 or more phenotypes of the same locus maintain stable frequency in the population. Two mechanisms for preserving this are heterozygous advantage e.g. sickle cell anemia AND frequency dependent selection.

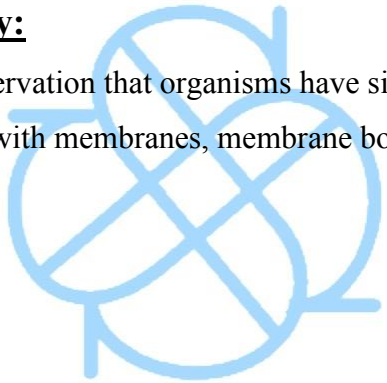
- What does macroevolution refer to?
  - evolution above species level; such as appearance of a pelvis in tetrapods
  - think of it as "the big picture", which includes patterns of macroevolution i.e. gradualism vs. punctuated equilibrium...how speciation occurs, etc.
- Prezygotic Barriers = factors that prevent mating between organisms
- Postzygotic barriers = advance past prezygotic barriers; prevents the proper fusion of gametes and the proper development of viable zygotes.
- Allopatric Speciation (means "other - homeland") occurs when gene flow is disturbed when population is divided into geographically (physical barrier) isolated subpopulations?
- Sympatric Speciation - speciate even without a physical barrier
- Parapatric speciation is when ranges do not significantly overlap but are immediately adjacent to each other e.g. "ring species" in which populations that overlap interbreed but end populations are too distantly related to breed
- Punctuated equilibrium: Pattern of evolutionary change over time; describes periods of apparent stasis punctuated by sudden change in species caused by shift in gene pool.
- Allometric Growth: Proportional growth that helps the body get its specific form. e.g. fetal skulls of human & chimp are similar, but allometric growth transforms rounded skull of newborn chimp into ape skull with ↑ jaw growth and downward sloping brow
- Evolution of morphology that arises by modification of allometric growth is an example of heterochrony = evolution of morphology that arises by modification of allometric growth. e.g. salamanders evolved to vertical climbing developed larger, webbed feet
- Homeotic Genes: Genes that control how body parts are organized and placed in the phenotypic expression
  - Hox Genes = class of homeotic genes that provide positional information in animal embryo. Prompts structures to develop into structures appropriate for a particular location.

5. **Evidence of Evolution:**

- Fossil Record: Can show the changes that occurred over time for a specific type of creature. Older fossils are found deeper than more recent fossils.
- Biogeography: the study of the past and present geological distribution of species and the patterns that emerge from such analysis
- Embryo: a developing, unborn offspring
- Embryology: scientific branch that compares/studies embryos and various developmental stages
- Molecular Homology: Comparing DNA molecules or protein sequence between organisms to show how closely related they are

6. **Common Ancestry:**

- Proven by the observation that organisms have similar life processes: glycolysis, DNA/RNA, cells with membranes, membrane bound organelles.



7. Continuing Evolution:

- Proven with genetic changes and changes in fossils overtime
- Evolution is constant in this never-ending cycle, along with that of pesticides, herbicides, and even chemotherapy drugs that drive that cycle
- Speciation: The formation of a new, distinct species through evolution
- Morphology: The study of the forms of living organisms and the relationships between their structures
- Fossils: The remains of a prehistoric organism in stone or amber
- Monophyletic: descended from a common ancestor or ancestral group that is not shared with any other group
- Phylogenetics: The study of evolutionary relationships between groups of organisms
- Phylogenetic tree: A diagram showing the hypothesized evolutionary relationships between species
- Analogous structures: Structures that have the same use but have different evolutionary history
- Cladogram: A diagram showing the cladistic relationship between different species
- DNA sequence alignment: A way of arranging the DNA sequences to identify similarities that may be a result of evolutionary relationships
- Homologous Structures: Structures that have anatomical similarities demonstrating descent from a common ancestor

8. Speciation:

- Speciation: the origin of new species is at the focal point of evolutionary theory
    - New species occur due to many of the following factors
- Barriers: Mechanisms preventing interbreeding (gene flow) are central to speciation
- Extrinsic Barriers: Physical barriers (mountains, rivers) are isolating mechanisms
- Intrinsic barriers are isolating mechanisms
    - Habitat Isolation
        - two species occupy different habitats and meet rarely
        - Not isolated by physical barriers
        - Differentiation of niches
    - Temporal Isolation: Species that breed at different times
    - Behavioral Isolation: Courtship rituals and other behaviors unique to a species are effective barriers to mating
    - Mechanical Isolation: reproductive organs are not compatible for mating
    - Gametic Isolation: sperm and egg cannot fuse due to their incompatibility
- Hybrid: Offspring from an interspecific cross, normally of parents from the same genus
    - Reduced hybrid viability: Genes of the different parent species may interact and impair the hybrid's development or survival in its environment
    - Reduced hybrid fertility
    - Even if hybrids are vigorous, they may be sterile

9. Extinction:

- Extinction: When an entire species dies out
- Mass Extinction: Many species going extinct at once
- Background Extinction: The "normal" extinction rate
- Biodiversity: extinction leaves empty niches that many species are free to

takeover, giving space for biodiversity and speciation

10. Variations in Populations:

- Essential for survival. If all individuals in a population had the same set of genes, the entire population is vulnerable to complete wipeout by a single disastrous event. Variation is like a safeguard that allows for some individual to survive and pass on their genes in the case of a disaster.

11. Origin of Life on Earth:

- LUCA: Last Universal Common Ancestor
- Stromatolites: Fossilized mats of cyanobacteria
- All living things have Right-handed spiral DNA (double helix), Universal genetic code, DNA, RNA, Protein. 400 genes that code for same proteins
- Miller-Urey Experiment: Experiment that replicated conditions from early earth
- RNA was most likely the first genetic model

Sources: www.khanacademy.org