UNIT NINE: POPULATION GENETICS, ADAPTATION, SPECIATION AND EVOLUTION

Upon completion of this unit you will be able to:

1. Define and discuss the gene pool.
2. State the conditions under which the Hardy-Weinberg Law is applicable.
3. Apply the Hardy-Weinberg Law to the prediction of the frequency of alleles in a population.
4. Define evolution and explain the two step process of evolution.
5. Describe and explain with examples mechanisms that increase genetic variability.
6. Describe and explain using examples manners in which variability can be reduced.
7. Compare and contrast genetic drift and the founder effect.
8. Describe how genetic drift and natural selection can affect gene frequencies in a population.
9. Define a species.
10. Explain how a species may be seperated into distinct groups by geographical isolation, mutation and natural selection.
11. Explain how a subspecies differs from a species.
12. Describe and give examples of each of the following prezygotic isolating mechanisms: Mechanical isolation, temporal isolation, behavioral isolation, gamete incompatability and ecological isolation.
13. Describe and give examples of each of the following postzygotic isolating mechanisms: Hybrid inviability, hybrid infertility and hybrid breakdown.
14. Discuss the competitive exclusion principle.
15. Provide the definition and examples of ecological equivalents.
16. Contrast the views of Lamarck with those of Darwin and Wallace.
17. Relate natural selection to survival of the fittest.
18. Relate the experiments of Miller in 1953 to the origin of life.
19. List and discuss some examples of present day evolution.
20. Compare and contrast evolutionary gradualism and punctuated equilibrium.
21. Provide examples of convergent and divergent evolution.
22. Define adaptive radiation.
23. Explain how common origin can be established in various groups of living organisms.
24. Discuss possible reasons for the extinction of a species.

Unit References: Text Chapters 12, 13, 14, 19, 20
http://www.mhhe.com/enger13

An Online Biology Text Book

Unit 9: Adaptation, Speciation and Evolution

Population genetics (Objective #1) text pgs 248

Population- a group of organisms inhabiting an area. Includes individuals of the same type that are capable of breeding and producing viable offspring (human pop.; cat pop; etc.)

gene pool- all the genes (alleles) available to a population

Statistical studies- employ known rates to predict future outcomes. Need large #s to be most accurate

-studies help determine changes in population, changes in allele frequency

Check Out: **Population Genetics**

Hardy-Weinberg Equilibrium (Objectives #2, 3) Text pgs 281-288 - under certain conditions, gene frequencies and genotype frequencies remain the same from one generation to the next in sexually reproducing animals.

Conditions: 1. no selection
2. no migration in or out
3. no mutations, lethals
4. large population so as not to be affected by random chance.

*****Conditions required for Hardy Weinberg Equilibrium rarely exist, all of the above conditions do contribute to changes in allele frequencies over time.**

**if the cross between two heterozygous carriers of albanism (a) produce 25% albino offspring, why isn't the population of humans 25% albino? How many heterozygous carriers are there? Is it likely that two heterozygotes mate with each other?

	A	a
A		
a		

Key terms: gene pool, inbreeding, allele frequency, population

Hardy- Weinberg: endeavored to link inheritance to predictable mathematical models.

let p = frequency of dominant allele
let q = frequency of recessive allele

p + q = 1 (or 100%) All individuals have two alleles for any trait, p + q = all alleles in pop

Binomial Expansion- statistical method to fit general population characteristics

$(p + q)^2 = 1$; $(p + q)^2 = p^2 + 2pq + q^2 = 1$ *notice 1:2:1 ratio (genotype)

p^2 or p X p = frequency of homozygous dominant
2pq or 2 X p X q = frequency of heterozygotes
q^2 or q X q = frequency of homozygous recessive

Check Out: Hardy-Weinberg

Hardy-Weinberg Equilibrium

Production of variation: frequencies of genes in the gene pool stay constant unless change (evolution) occurs

Hardy-Weinberg implies no change, however, Hardy-Weinberg conditions rarely exist

Evolutionary process requires two steps (Objective #4):

1. Production of genotype and therefore phenotype variations (adaptations)
2. Sorting out and reduction of variations passed on to next generation (field test)

**Evolution can be defined as changes in allele frequency within a population over time

Variations Produced by (Objective #5) text pgs. 251-253:

1. **Mutation** - 1/100,00 to 1/10,000,000 per generation, likely to be neutral or harmful (non adaptive). Replacement of one allele with another.

2. **Gene flow** - change of allele frequency due to migration into or out of a population.
-removing alleles from one group and introducing them to another

Ex. Africanized Killer bees; Hybrid production; "Melting Pot", introduced species

Check out: Carl Hayden Bee Research Center

3. **Recombination** - gene mixing during meiosis (sexual reproduction)

4. **Non Random mating-** sexual selection (Bower birds; Humans- tall X tall etc.)
Speciation

Variations Reduced (Objective #6, 7) by:

1. **Genetic drift** **text pgs. 253-255**- movement of genes out of the pop

(effects greatest on small pops)
Population bottleneck - cheetahs, black footed ferret
Just as a small amount of liquid can get through a narrow neck bottle, only a small pop may survive a disaster, leaving depleated gene pool.

Founder effect- a few individuals separate from a large pop and establish a new one
Amish- recessive alleles for short forearms and lower legs. As a result, Amish in Penn. have a freq. for these alleles of 1/14 when other pops have a freq of 1/1000

Check Out:

Genetic Drift Simulation

Genetic Drift and the Founder Effect

Bottlenecks and Founder Effects

Small Population Effects

Natural Selection (Objective #8, 17) text pgs 269-273, 276-279

Adaptations resulting from changes in allele frequencies due to differential reproduction and survival

-what do cactuses, brown stone plants, poison ivy and Thompson's gazelles have in common?

"Survival of the Fittest"- surviving to reproductive age and pass favorable genes on to the next generation, favorable genes enhance survival, therefore, survivors leave more offspring and favorable genes are passed on.

-natural selection chooses parents with most suitable phenotypes (coded by genotypes)

Result: **Adaptations**- accumulation of structural, physiological or behavioral traits that increase an organisms fitness. (peppered moth, insecticide resistance)

Check Out: **Theory of Natural Selection**

Maintaining Variation- Speciation (Objective #9) pgs 291-293

Species- group of organisms that interbreed naturally to produce fertile offspring

Speciation- portion of gene pool becomes isolated; process of generating new species

*Accumulation of changes may separate a population into distinct groups (Obj #10)

Speciation: three step process

1. **Geographic isolation-** prevents free flow of genes
2. **Selection**- field test determines which combos are valuable (selection pressure)
3. **Accumulation** of genetic differences and time to develop differences sufficient to prevent reproduction

Examples: Tassel eared squirrels, snails (pg 241)

?What if after a period of time the barriers are removed?

-pops interact but no gene flow: different mutations, different adaptations, different gene recombinations

Subspecies (races) (Objective #11)- groups significantly different in appearance behavior and physiology but may interbreed
-geographic variants differ but DNA changes not dramatic enough to prevent interbreeding

Check Out: **Observed Instances of Speciation**

Maintaining Genetic (Reproductive) Isolation (Objective #12) text pgs 291-295

- reproductive isolating mechanisms
-prevent cross-species mating (why can't a dog and a cat have an offspring together?

Check Out: **Insect Opera**

1. **Prezygotic (Objective #12)- prevent mating or fertilization**
   a. **Habitat Preference** (Ecological isolation)
   -pops in different habitats do not meet (garter snakes, parasites, etc)

   b. **Temporal Isolation**- mating or flowering occur at different seasons or times of day

   -Brown Trout, fall; Rainbow Trout, spring

   c. **Behavioral Isolation**- little or no sexual attraction between males and females
   -fireflies (blinking); insects (pheromones); meadowlarks (song)

   d. **Mechanical Isolation**- structural differences in genetalia (dragon flies)

   e. **Gametic Isolation**- male and female gametes fail to attract each other or are inviable (gametic recognition) dog X cat ---> NOT!!

2. **Postzygotic (Objective #13)- prevent development of viable, fertile adult**
   a. **Hybrid Inviability** - hybrid zygotes fail to develop or fail to reach reproductive maturity

   b. **Hybrid sterility**- hybrids fail to produce functional gametes; mules (failure of meiosis)

   c. **Hybrid breakdown**- offspring of hybrids have reduced viability or fertility
   -Cotton, radish/cabbage; usually hybrids have to give up something

Development of Evolutionary Thought/ Origin of Species chapters 19, 20

Check out:

History of Evolutionary Thought

PBS Evolution

Evolution (Objective #4)- Genetic and phenotypic changes occurring in a pop. over time, resulting in increased adaptations of organisms to the prevailing environment.

Species- group of reproductively isolated individuals or populations

George Cuvier- Catastrophism
Charles Lyall- geologic changes slow, therefore, earth old

Thomas Malthus (1798)- death and famine are inevitable because human pops. tend to increase faster than the supply of food. Necessitates struggle to survive.

Lamark (1744-1829)- Inheritance of Acquired Characteristics (Objective #16)
"Changes in individual body over its life could be passed to offspring"

-believed evolution responded to "felt needs"
2 principles: 1. use and disuse
2. Inheritance of acquired characteristics
Giraffes neck; blacksmith's sons

**wrong mechanism of change: Muscle cell enlargement due to lifting weights has no effect on gene for muscle development

Darwin/ Wallace (~1869)- Natural Selection; "Survival of the Fittest" (Objective #16)
-all species have great biotic potential

-no two organisms are alike, variations occur constantly, at random

-natural resources are limited

-individuals with advantageous variations most likely to survive (acquire resource)

-individuals best suited to survive will be best suited to leave most offspring.

-genes of individuals producing most offspring will be found most frequently in future generations

**Darwin, Wallace, Lamarck had no knowledge of Mendel

Natural Selection (Objective #14, 15, 17)- guiding force of evolution, environmental selection of individuals that are well adapted to their environment and fit to reproduce.

Competitive Exclusion Principle- two species, same environmental requirements, cannot live together; competition forces one to leave, adapt differently or become extinct

ecological equivalents- organisms performing similar activities in widely separated biomes (kangaroo/antelope)

Artificial Selection- outside forces guiding selection of desired traits

Check out : **Artificial and Natural Selection**

Evolutionary Applications (Objective #19, 20, 21, 22) **text pgs. 296-299**

1. **Convergent Evolution**- different organisms similar due to common environment
   Ex. water ---> seals, penguins, turtles
2. **Divergent Evolution**- speciation events cause many branches in evolution of group
   -**Adaptive Radiation**- Darwins Finches (competitive exclusion ---> adaptation ---> speciation)

3. **Coevolution-** bee pollinated flowers; parasites; disease

Chemical Evolution (Objective #18) - Could this have all begun from scratch?

Chemical evolution of life- primordial soup
Simple molecules + Simple molecules ---> complex molecules (carbo, fat, protein, etc)

Extinction (Objective #26) text pg 296 - 99%+ of species that have existed, exist no more (baseball)

-changing environments, unable to adapt

-Dinosaurs, asteroid/volcanoes

Habitat Destruction - animals forced to leave habitat, are unable to adapt or compete in new one

Isolation - line dies out because gene pool not diverse. Not enough individuals to maintain hybrid vigor (black footed ferret, virtually all endangered species)

Specialization - yucca moth is only pollinator of yucca plant. Moth dies . . . .

Check Out : **Extinction**

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