CONCEPT 1 – EVOLUTION

1. <u>Natural Selection</u>
    a. Major mechanism of change over time – Darwin's theory of evolution
    b. There is variation among phenotypes – genetic <u>mutations</u> play a role in increasing variation
    c. <u>Competition</u> for resources results in differential survival, with individuals with the most favorable traits surviving to reproduce offspring
    d. An <u>adaptation</u> is a genetic variation that is favored by selection and is manifested as a trait that provides an advantage to an organism in a particular environment.
    e. Fitness is the ability to <u>survive and reproduce</u>

2. <u>Hardy-Weinberg Equilibrium</u>
    a. A mathematical model used to calculate changes in <u>allele frequency</u>, providing evidence for the occurrence of evolution in a population.
    b. 5 conditions must be met for a population to be in HW equilibrium – conditions are seldom met
        (1) <u>Large population</u>
        (2) No migration
        (3) <u>No mutations</u>
        (4) Random mating
        (5) <u>No natural selection</u>
    c. Equations
        (1) p = the frequency of <u>dominant alleles</u> in a population
        (2) q = the frequency of <u>recessive alleles</u> in a population
        (3) p^2 = the frequency of homozygous dominant individuals in a population
        (4) q^2 = the frequency of homozygous recessive individuals in a population
        (5) 2pq=the frequency of <u>heterozygous individuals</u> in a population
        (6) p + q = 1
        (7) $p^2 + 2pq + q^2 = 1$

3. <u>Speciation</u>
    a. An evolutionary process by which 2 or more species arise from 1 species and 2 new species can no longer breed and reproduce successfully
    b. Many mechanisms by which it can occur
        (1) Geographic isolation
            • Species separated by physical barrier
        (2) Reproductive isolation
            • Different <u>behaviors</u> limit mating
            • Different habitats limit mating
            • Different <u>mating seasons</u> limit mating
            • Different anatomical structures limit mating
    c. Can take place over millions of years or rapidly (after extinction events, for example)

4. <u>Evidence for Evolution</u>
    a. Fossils can be dated by a variety of methods that provide evidence for evolution. These include the age of the rocks where a fossil is found, the rate of decay of isotopes including carbon-14, the relationships within phylogenetic trees, and the mathematical calculations that take into account information from chemical properties and/or geographical data.

     b. Morphological homologies represent features shared by common ancestry. Vestigial structures are remnants of functional structures, which can be compared to fossils and provide evidence for evolution.

     c. Biochemical and genetic similarities, in particular DNA nucleotide and protein sequences, provide evidence for evolution and ancestry.

5. Origin of Life
   a. Primitive Earth provided inorganic precursors from which organic molecules could have been synthesized due to the presence of available free energy and the absence of a significant quantity of oxygen.
   b. Chemical experiments have shown that it is possible to form complex <u>organic</u> molecules from <u>inorganic</u> molecules in the absence of life.
   c. These complex reaction sets could have occurred in solution (organic soup model) or as reactions on solid reactive surfaces.
   d. The RNA World hypothesis proposes that <u>RNA could have been the earliest genetic material.</u>

6. Phylogenetic Trees
   a. Phylogenetic trees and cladograms can represent traits that are either derived or lost due to evolution.
   b. Phylogenetic trees and cladograms illustrate speciation that has occurred, in that relatedness of any two groups on the tree is shown by how recently two groups had a common ancestor.
   c. Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species, and from DNA and protein sequence similarities.
   d. Phylogenetic trees and cladograms are dynamic, constantly changing due to current and emerging knowledge.

Vocabulary

Adaptation	Gene Pool	Morphology
Bottleneck Effect	Genetic Drift	Phylogenetic Tree
Common Ancestor	Geographic Isolation	Reproductive Isolation
Cladogram	Fitness	Speciation
Evolution	Hardy-Weinberg Equilibrium	Variatiion
Gene Flow	Natural Selection	

Thinking Questions

1. As a field researcher you are sent to the Arizona desert to study the prairie dog species C. ludivincianus to determine if the population is in Hardy-Weinberg equilibrium. Specifically, you are studying this population with respect to the gene that determines the coat color in C. ludivincianus. This trait is coded for by a single gene (the NDY6 gene) with two alleles (N, n) and is passed down from one generation to the next. After sampling 170 of these prairie dogs, you find that 36% of the C. ludivincianus population is homozygous recessive for coat color. Assuming that the population is in Hardy-Weinberg equilibrium…
   a. What is the allele frequency of the N allele? .4
   b. What is the frequency of homozygous dominant prairie dogs? .16
   c. What is the frequency of heterozygous prairie dogs? .48
   d. What conditions must be being satisfied? Large Population, No Migration, No Mutation, No Natural Selection, No Sexual Selection

2. ~~Sixty flowering plants are planted in a flowerbed. Forty of the plants are red-flowering homozygous dominant. Twenty of the plants are white-flowering homozygous recessive. The plants naturally pollinate and reseed themselves for several years. In a subsequent year, 178 red-flowered plants, 190 pink-flowered plants, and 52 white-flowered plants are found in the flowerbed. Use a chi-square analysis to determine if the population is in Hardy-Weinberg equilibrium.~~

3. For the past 10 to 25 years, farmers have planted crop seeds that have been genetically modified to withstand treatment with a common weed killer called Roundup®. This allows the farmers to spray their fields to get rid of weeds without harming their crops. Recently, more and more farmers have discovered that their fields have Roundup-resistant pigweed growing along with their crop. Describe what has most likely happened over time to lead to this. Over time the naturally resistant pigweed survived the Roundup treatments and reproduced. Over time, this led to a population of resistant pigweed.

4. Peppered moths have wings that vary in color, ranging from white to dark gray. During the Industrial Revolution through the mid-20th century, factories and power plants, which burned coal, produced large quantities of soot and smog. Near industrialized areas, black powder covered surfaces, including the moth habitat.
   a. Use this information to explain the changes seen in light and dark peppered moths from 1800-1950, as shown in the graph below. After industrial revolution, dark had an advantage on the sooty trees.

   b. Propose an explanation for the return of the peppered moth population to more light than dark moths by the year 2000.
   Better environmental procedures and clean up
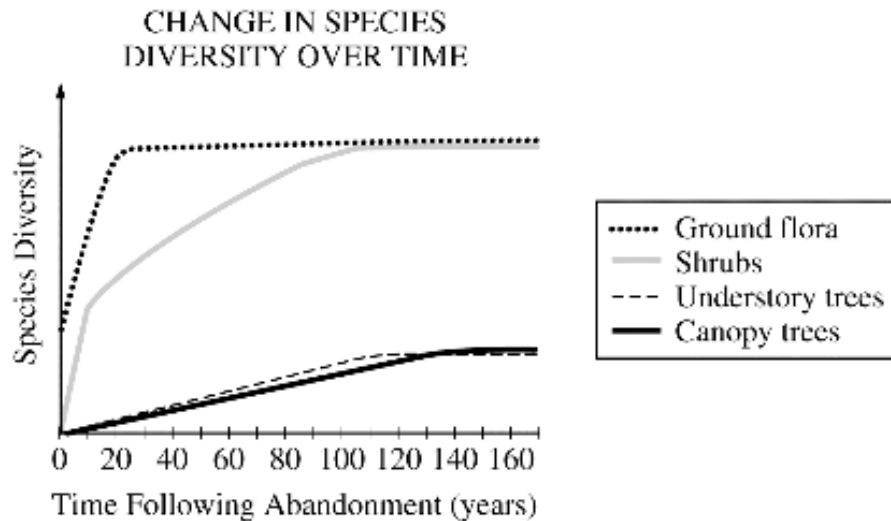

Peppered Moth Frequency
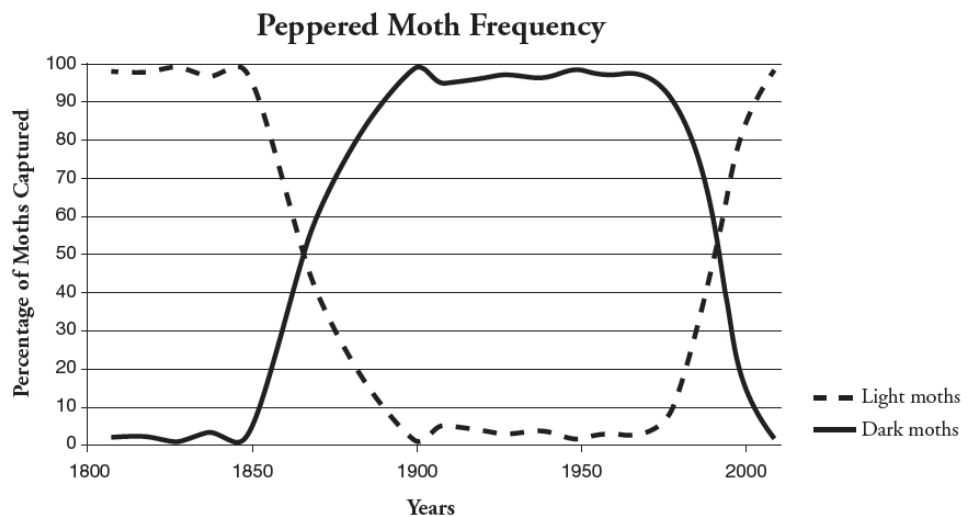
5. Five new species of bacteria were discovered in Antarctic ice core samples. The nucleotide (base) sequences of rRNA subunits were determined for the new species. The table below shows the number of nucleotide differences between the species. Draw a phylogenetic tree indicating the relatedness of these 5 species.

Species	1	2	3	4	5
1	-	2	23	19	17
2		-	24	19	18
3			-	23	23
4				-	1
5					-

3   4   5 1   2
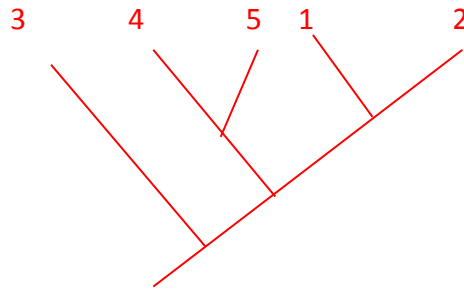
6.

Ecological succession describes the pattern of changes in communities over time. The graph below shows changes in plant diversity following the abandonment of an agricultural field in a temperate biome.

CHANGE IN SPECIES
DIVERSITY OVER TIME

Species Diversity

0   20 40 60 80 100 120 140 160
Time Following Abandonment (years)

- ...... Ground flora
- ——— Shrubs
- – – – Understory trees
- —— Canopy trees

a. Discuss the differences in diversity among the plants shown in the graph.
The ground flora and shrubs have the most diversity and reached high diversity very quickly. The understory and canopy trees have the least diversity and it took a lot longer to reach that level of diversity.

b. If a scientist wanted to determine if two understory trees in the field were the same species, what pieces of evidence would she gather and how would these inform her conclusion? DNA evidence or look at homologous structures

Evolution Long Free Response (10 points)

Evolution is one of the unifying themes of biology. Evolution involves change in the frequencies of alleles in a population. For a particular genetic locus in a population, the frequency of the recessive allele (a) is 0.4 and the frequency of the dominant allele (A) is 0.6.

(a) What is the frequency of each genotype (AA, Aa, aa) in this population? What is the frequency of the <u>dominant</u> <u>phenotype</u>?

(b) How can the Hardy-Weinberg principle of genetic equilibrium be used to determine whether this population is evolving?

(c) Identify a particular environmental change and describe how it might alter allelic frequencies in this population. Explain which condition of the Hardy-Weinberg principle would not be met.

Evolution Free Response Answer

(a) What is the frequency of each genotype (AA, Aa, aa) in this population? What is the frequency of the <u>dominant phenotype</u>?

  Calculations **(4 points maximum)**
  - Frequency AA = .36
  - Frequency Aa = .48
  - Frequency aa = .16
  - Frequency dominant phenotype = .84
  (Correct equation needed for credit if one of calculated numbers is wrong.)

(b) How can the Hardy-Weinberg principle of genetic equilibrium be used to determine whether this population is evolving?

  Evolving population **(2 points maximum)**
  - Allelic frequency changes <u>or</u> five conditions that <u>do not</u> change if population is not evolving
  - Means of measurement/detection

(c) Identify a particular environmental change and describe how it might alter allelic frequencies in this population.

  Explain which condition of the Hardy-Weinberg principle would not be met. **(4 points maximum)**
  - Environmental change identified **(1 point)** (first one scored)
  - Explanation of how allelic frequency changed **(1–2 points)**
  - Which Hardy-Weinberg condition not met **(1 point)**