Concept 7: Evolution

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?

$q^2 = .36$
$q = \sqrt{.36} = .6$
$p = 1 - q$
$p = 1 - .6$
$p = .4$
$\boxed{p = N = 0.4}$

   b. What is the frequency of homozygous dominant prairie dogs?

$p^2 = 0.4^2 = \boxed{0.16}$

   c. What is the frequency of heterozygous prairie dogs?

$2pq = 2(0.4)(0.6) = \boxed{0.48}$

   d. What conditions must be being satisfied?

Large population
No natural selection
No immigration/emigration
No mutations
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.

1/ $p^2 = 0.66$
$q^2 = 0.33$

$\chi^2 = \sum \frac{(o-e)^2}{e}$

Later: $q^2 = 52/420$
$q = 0.35$ X
$p = 0.65$

$0.04 + 0.06 = 0.10$

p-value = 1

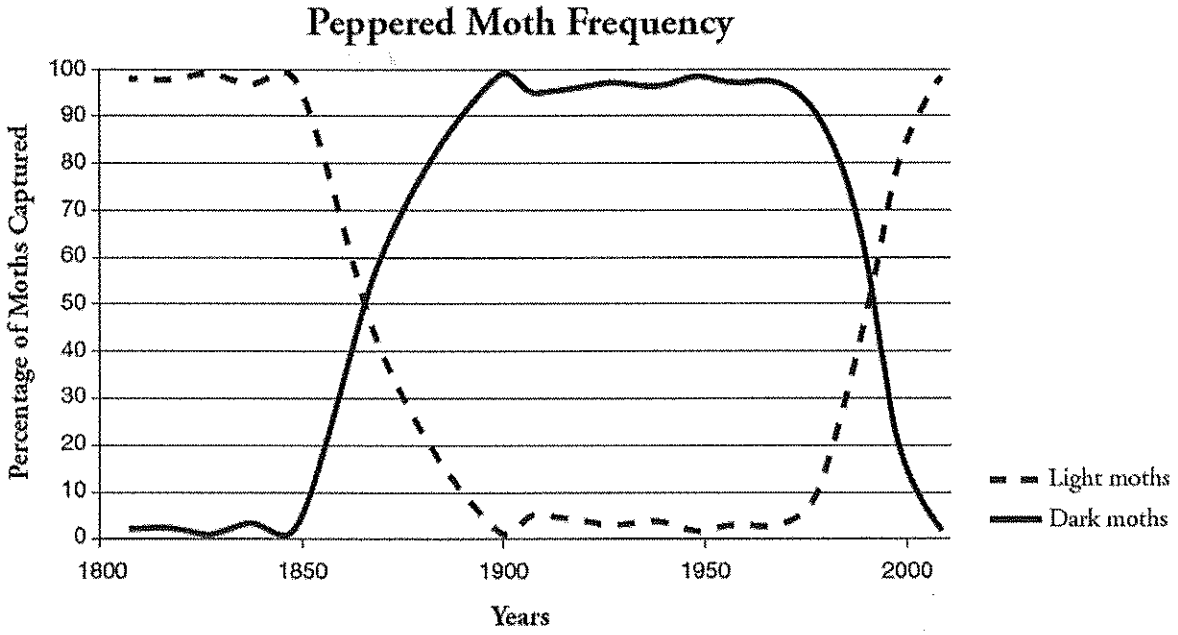
Since $0.10 < 3.84$ we can say that the difference from expected may be explained by chance.

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.

In the starting population there was variation in the susceptibility to Roundup®. More resistant weeds survived better in the presence of Roundup®. Since resistance is genetically determined this trait was passed on and became more prevalen

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.



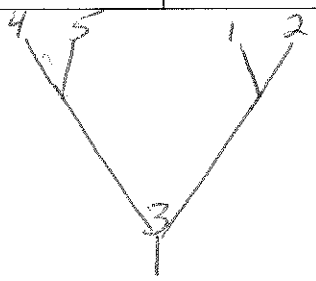
   b. Propose an explanation for the return of the peppered moth population to more light than dark moths by the year 2000.

With the advent of cleaner forms of energy the amount of soot and smog decreased. Surfaces of the moth's habitat returned to its original shade which offered better camouflage for lighter moths. Over several generations, the frequency of light colored moths in the population increased.

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

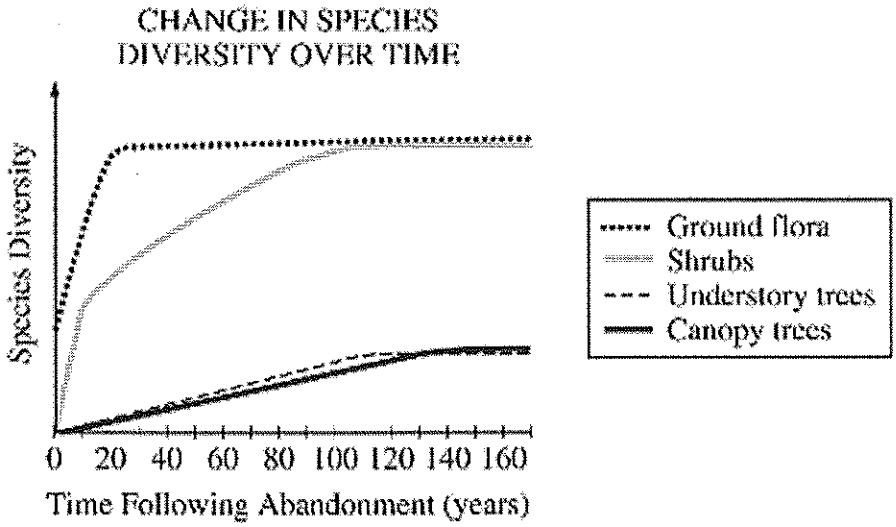
1	-	2	23	19	17
2		-	24	19	18
3			-	23	23
4				-	1
5					-



Answers will vary

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.



a. Discuss the differences in diversity among the plants shown in the graph.

shrubs and grasses show the greatest diversity. These diversified rapidly while trees are taking longer. Grasses and shrubs are shorter-lived than trees

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?

She should gather DNA data to look for similarities in sequences but most importantly, she should determine if the two trees are able to mate and produce offspring.

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 dominant phenotype?

(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.

Scoring Guide

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

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 or five conditions that do not 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)**