Assignment: Alleles, Genotypes, and Hardy Weinberg Equilibrium
Introduction to Evolution and Scientific Inquiry, Fall 2018
Instructor: Dr. Spielman

Name:_____

Instructions:
Complete each question *by hand on this paper*, showing all of your work. Clearly indicate your final answer by circling it (including conclusions, when applicable). This assignment is due Monday 10/15/18 at the beginning of class. Please directly hand in this sheet with your work and answers in the spaces provided.

Question 1
You are studying differences in whisker length in a population of manatees in the Gulf of Mexico. This trait shows *incomplete dominance*, where **WW**=long whiskers, **Ww**=intermediate whiskers, and **ww**=short whiskers. You have found, in a population of 75 manatees, that 45 have long whiskers, 7 have intermediate whiskers, and the remaining 23 have short whiskers.

a. If natural selection is responsible for this distribution of whiskers in the manatees, which *mode* of selection do you think is acting? Why? Write 1-2 sentences for this answer.

Disruptive selection - homozygotes are more frequent than heterozygotes.

b. Determine if this population of manatees is in Hardy-Weinberg equilibrium or if there is evidence of evolution. You must ultimately calculate a p-value *and* state your final conclusion in the form of a sentence.

① Calculate p, q

$p: \frac{45}{75} + \frac{1}{2}\left(\frac{7}{75}\right) = 0.65$

$q: \frac{23}{75} + \frac{1}{2}\left(\frac{7}{75}\right) = 0.35$

② Calculate HWE - expected genotypes w/ $p^2 + 2pq + q^2$ (WW, Ww, ww)

	× N = number of individuals
$p^2 = 0.65^2 = 0.4225$	31.69
$2pq = 2(0.65)0.35 = 0.455$	34.125
$q^2 = 0.35^2 = 0.1225$ (ww)	9.19
$\Sigma \approx 1$!	

Since $\chi^2 > 3.841$, $p < 0.05$. We reject HWE and find evidence for evolution

③ χ^2 test

$\chi^2 = \Sigma \frac{(O-E)^2}{E}$

$= \frac{(45-31.69)^2}{31.69} + \frac{(7-34.125)^2}{34.125} + \frac{(23-9.19)^2}{9.19} = 47.919$ ← χ^2 test statistic

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Question 2

You are studying a population of "rodents of unusual size" (ROUS's) in the Fire Swamp, specifically their teeth characteristics. You find that genotype **SS** individuals have pointy teeth, genotype **Ss** individuals have serrated teeth, and genotype **ss** individuals have no teeth but jaws strong enough to crush you (either way, don't get bitten). In a population of 60 ROUS's, 30% of individuals are SS, 60% of individuals are Ss, and 10% of individuals are ss. → 6 → 18 → 36

a. If natural selection is responsible for this distribution of teeth types in ROUS's, which *mode* of selection do you think is acting? Why? Write 1-2 sentences for this answer.

Balancing: heterozygotes are most frequent.

b. Determine if this population of ROUS's is in Hardy-Weinberg equilibrium or if there is evidence of evolution. You must ultimately calculate a p-value *and* state your final conclusion in the form of a sentence.

① Calculate p, q

$p: 0.3 + \frac{0.6}{2} = 0.6$

$q: 0.1 + \frac{0.6}{2} = 0.4$

② Calculate HWE expected genotypes

$p^2 \times N = 0.6^2 \times 60 = 21.6$

$2pq \times N = 2(0.6)0.4 \times 60 = 28.8$

$q^2 \times N = 0.4^2 \times 60 = 9.6$

③ χ^2 test

$\chi^2 = \frac{(O-E)^2}{E}$

$= \frac{(18-21.6)^2}{21.6} + \frac{(36-28.8)^2}{28.8} + \frac{(6-9.6)^2}{9.6} = 3.75$

$3.75 < 3.841$, so **$P > 0.05$**.

No evidence for evolution in this population. It may be in HWE.

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Question 3

Intrigued by the bizarre teeth styles of ROUS's, you decide to set up an assay to compare fitnesses of the different genotypes/phenotypes. You randomly select 20 individuals with each tooth phenotype, and you give each ROUS (they are vicious carnivores!) a small goat to eat. You measure fitness by asking how quickly each ROUS fully devours the goat. You assume that individuals who are able to consume their food the ~~fastest~~ SLOWEST have the highest fitness. You found these results, on average:

- SS (pointy teeth) take an average 355 seconds to eat the goat
- Ss (serrated teeth) take an average 315 seconds to eat the goat
- ss (no teeth but strong jaws) take an average 410 seconds to eat the goat

Assuming "time to eat" is a proxy for fitness, calculate the following quantities:

1. The relative fitness for each genotype
2. The selection coefficients for each genotype
3. The mean fitness of the population

① Relative Fitness ② Coefficients

SS: $\frac{355}{410} = 0.86$ → 0.14

Ss: $\frac{315}{410} = 0.77$ → 0.23

ss: $\frac{410}{410} = 1$ → 0

③ mean fitness. Since no information about # individuals given, assume all in equal proportions:

$\frac{0.86 + 0.77 + 1}{3} = 0.876$

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Question 4

Corn kernels can be either purple (**PP** or **Pp**) or yellow (**pp**). A random sample of 750 corn kernel was sampled from a field of corn known to be in Hardy-Weinberg Equilibrium. Of these 750, you determined that 244 have a genotype of PP.

a. Determine the *number of kernels* from this sample that have genotypes Pp and pp.

$PP \rightarrow p^2 \rightarrow \frac{244}{750} = 0.325 = p^2$, so $p = \sqrt{0.325} = 0.57$

$q = 1 - 0.57 = 0.43$

$\#Pp = 2pq \times N = 2(0.57)(0.43)(750) = \approx 367$

$\#pp = q^2 \times N = 0.43^2 (750) = \approx 139$

b. Assume the relative fitness of purple kernels is 0.82, and the relative fitness of yellow kernels is 1.0. Calculate the mean fitness of your sample of kernels.

total purple: $PP + Pp = \frac{244 + 367}{750} = 0.81$ frequency in pop.

total yellow: $pp = \frac{139}{750} = 0.19$ frequency

$W = 0.81(0.82) + (0.19)(1.0) = 0.852$

(0.81: frequency of purple; 0.82: fitness of purple; 0.19: freq of yellow; 1.0: fitness of yellow)

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