

(x) [25 points] Inbreeding Questions. Suppose you see the following genotypes

Genotype	AA	Aa	aa
Frequency	0.432	0.336	0.232

(a) What is freq(A)? freq(a)?

$$f(A) = 0.432 + (1/2)*0.336 = 0.6, f(a) = 0.4$$

(b) What is the expected frequency of Aa heterozygotes under random mating?

$$2*f(A)*f(a) = 2*0.6*0.4 = 0.48$$

(c) What is the level F of inbreeding in this population?

$$\begin{aligned} \text{Freq}(Aa) &= (1-F)*2*f(A)*f(a) \\ 0.336 &= (1-F)*0.48 \rightarrow 1-F = 0.336 / 0.48 = 0.7 \\ \text{or } F &= 1 - 0.336 / 0.48 = 0.3 \end{aligned}$$

(d) Assuming this level of inbreeding, now consider a locus with a lethal recessive (allele q), so that qq = dead. Suppose freq(q) = 10^{-3} . What is the expected frequency of qq individuals?

$$\begin{aligned} \text{freq}(qq) &= F*\text{freq}(q) + (1-F)*\text{freq}(q)^2 \\ &= 0.3*0.001 + 0.7*0.001^2 = 0.0003007 \end{aligned}$$

(e) How much more frequent are qq individuals under inbreeding relative to their expected frequency under random mating?

$$[0.3*0.001 + 0.7*0.001^2] / [0.001^2] = 301$$

(x) [25 points] Consider one locus with two alleles, A and a. You observe the following number of genotypes and the average number of offspring for each genotype:

Genotype	AA	Aa	aa
Number of Genotypes	400	100	500
Offspring per genotype	20	0	10

(a) Compute W_A , W_a , and \bar{W} .

$$\text{let } p = \text{freq}(A) = 0.4 + (1/2)(0.1) = 0.45$$

$$W_A = W_{AA} * p + W_{Aa} * (1-p) = 20 * p = 9$$

$$W_a = W_{Aa} * p + W_{aa} * (1-p) = 10 * (1-p) = 5.5$$

$$\bar{W} = pW_A + (1-p)W_a = 0.45 * 9 + 0.55 * 5.5 = 7.075$$

(b) What is the frequency of A after one generation of selection?

$$p' = p * W_A / \bar{W} = 0.45 * 9 / 7.075 = 0.573$$

(c) Let $p = \text{freq}(A)$. What is the equilibrium value of p (for what value of p , excluding 0 and 1, does p remain unchanged after selection)?

When $W_A = \bar{W}$, or $W_A = W_a$ p is at an equilibrium

Hence, at equilibrium $20 * p = 10 * (1-p)$, or $20p = 10 - 10p$ or $30p = 10$, or $p = 1/3$

(d) Suppose $\text{freq}(A) = 0.1$. Which allele is ultimately fixed (and why)?

a is fixed, as $\text{freq}(A) < 1/3$

(e) Suppose $\text{freq}(A) = 0.9$. Which allele is ultimately fixed (and why)?

A is fixed, as $\text{freq}(A) > 1/3$

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(x) [10 points] Consider a cross between two parents: **AaBbCCdd** and **AaBbCcDd** where all loci are unlinked.

(a) What is the probability of an **aabbCcdd** offspring?

$$(1/4)(1/4)((1/2)((1/2)) = 1/64 = 0.015625$$

(b) How many offspring do you need to sample to ensure a 90 percent probability that at least one is **aabbCcdd**?

$$\text{Prob(none in } n) = (63/64)^n = 0.10, \text{ solving } n \log(63/64) = \ln(0.10) \\ \text{or } n = \ln(0.10) / \log(63/64) = 147$$

(x) [15 points] Short answer, i.e., one or two SHORT sentences (5 points each).

(a) Why are males more likely to be color blind than females?

Green/Red gene located on X, and recessive. Males have only a single X, female must be a homozygote

(b) Why is an XO fly (a single X, no Y) a male?

Sex determined by X:autosome ratio in flies

(c) Why is an XO human female?

Sex determined by presence/absence of Y in humans

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(x) [10 points] Consider one locus with four alleles, with the following allele frequencies and marginal fitnesses:

	A1	A2	A3	A4
Allele frequency	0.3	0.1	0.4	0.2
Marginal fitness	2	5	4	3

- (a) What is the mean population fitness?
- (b) What is the frequency of allele A2 after one generation of selection

(x) [10 points] Recall the genetics of coiling in the snail *Linnaea*, which is normally right-handed, but does show some left-handed coiling. Sturtevant showed coiling result from a single locus with alleles s and s^+ , where the recessive allele s gives left-handed coiling. Suppose a female is right-handed coiled, but produces left-handed offspring.

- (a) What is the genotype of this female? Why?
- (b) What is the genotype of the mother of this female? Why