Will Blondes Go Extinct?

Name _____

Name _____ Name _____

To answer this question, we need to consider how alleles in a population are passed from one generation to the next. Let's assume:

- *A* and *a* are alleles for hair color, with *aa* individuals having blonde hair.
- In the current US population, the frequency of *A* is 0.8 and the frequency of *a* is 0.2. In other words, when you consider the entire population at large, 80% of all alleles (and remember that each individual has two!) are *A*.
- Individuals of each genotype all produce the same number of gametes. This means that the proportion of eggs and sperm that are *A* is 0.8 and that the proportion that are *a* is 0.2. You can also think of these as the probabilities that a randomly selected egg or sperm will be *A* (or *a*).

Q1a What is the probability that an *A* sperm and an *A* egg will combine to produce an offspring with genotype *AA*?

fr(AA) = _____**0.64**_____

Q1b What is the probability that an *A* sperm and an *a* egg will combine to produce an offspring with genotype *Aa*?

___0.16___

Q1c What is the probability that an *a* sperm and an *A* egg will combine to produce an offspring with genotype *Aa*?

___0.16___

Q1d What is the TOTAL probability of getting an offspring with genotype *Aa*? fr(*Aa*) = _____**0.32**_____

Q1e What is the probability that an *a* sperm and an *a* egg will combine to produce an offspring with genotype *aa*?

fr(aa) = _____**0.04**_____

Now the question is: What are the frequencies of alleles *A* and *a* in the F_1 generation? (If you have trouble with Q2, imagine there are 100 F_1 individuals in the population. The genotype frequency of *AA* tells you what proportion of those 100 individuals are *AA*. For example, if the genotype frequency is 20%, then 20 individuals of the 100 total are *AA*. Thus, 40 of the 200 alleles in the population (20%) are *A* from *AA* individuals.)

Q2a Of all the alleles in the F_1 generation, what proportion are *A* alleles from *AA* individuals? fr(*A*) = **__0.64____**

Q2b Of all the alleles in the F_1 generation, what proportion are *A* alleles from *Aa* individuals? fr(*A*) = **__0.16____**

Q2c Of all the alleles in the F_1 generation, what proportion are *a* alleles from *Aa* individuals? fr(*a*) = **__0.16____**

Q2d Of all the alleles in the F_1 generation, what proportion are *a* alleles from *aa* individuals? fr(*a*) = **___0.04___**

Q3a What is the TOTAL frequency of the *A* allele in the F_1s (from both *AA* and *Aa* individuals)? **____0.80_____**

Q3b What is the TOTAL frequency of the *a* allele in the F_1s (from both *Aa* and *aa* individuals)? **_____0.20_____**
REMEMBER: the frequency of allele *A* and the frequency of allele *a* have to sum to 1.

Q4a Are allele frequencies in the F_1 generation the same or different from allele frequencies in the parental generation?

___same_____

Q4b Is the frequency of the *a* allele for blonde hair changing over time?

____no_____

Is your result for Q4 correct for *any* allele frequencies—or just when *a* is relatively rare? To answer this question, let's say that the frequency of A is *p* and the frequency of a is *q*. Note that *p* and *q* could be anything, but that *p* + *q* = 1. You could figure out the genotype frequencies in F_1s the same way you did in Q1, but let's try another approach: Setting up a Punnett square that simulates all possible matings, among all parents in the population, as follows:

Q11a Fill in the genotypes that occur in the F_1 generation.

Q11b Based on what we know about the probability of each gamete from the parent generation being *A* and *a* (see above), quantify the frequency of each genotype in the Punnett square.

Q11c Note that the genotype frequencies must sum to 1. Write this expression below:

$p^2 + 2pq + q^2 = 1.0$

Sperm: \ Eggs:	*A*	*a*
A	***AA*** p^2	***aA*** ***qp***
a	***Aa*** ***pq***	***aa*** q^2

Q12 In Question 11, were you predicting F_1 offspring genotypes from male and female parents with known genotypes, the way you do with a normal Punnett square? Explain why or why not.

No—we were getting F_1 genotypes by saying that any sperm and any egg (all the gametes in the population) can combine at random. We simulated all possible matings between all parents with all genotypes.

Now the question is: What are the frequencies of alleles *A* and *a* in the F_1 generation?

Q13a Of all the alleles in the F_1 generation, what proportion are *A* alleles from *AA* individuals?

fr(*A*) = ___ p^2 ____

Q13b Of all the alleles in the F_1 generation, what proportion are *A* alleles from *Aa* individuals?

fr(*A*) = ___ ***pq*** _____

Q13c Of all the alleles in the F_1 generation, what proportion are *a* alleles from *Aa* individuals?

fr(*a*) = ___ ***pq*** ____

Q13d Of all the alleles in the F_1 generation, what proportion are *a* alleles from *aa* individuals?

fr(*a*) = ___ q^2 ____

Q14a What is the TOTAL frequency of the *A* allele in the F_1s (from both *AA* and *Aa* individuals)? _ $p^2 + pq = p$ ____

Because $p^2 + pq = p\,(p + q) = p * 1 = p$

Q14b What is the TOTAL frequency of the *a* allele in the F_1s (from both *Aa* and *aa* individuals)? _ $q^2 + pq = q$ ____

REMEMBER: The frequency of allele *A* and the frequency of allele *a* have to sum to 1.

Because $q^2 + pq = q\,(p + q) = q * 1 = q$

Q14a Are allele frequencies in the F_1 generation the same or different from allele frequencies in the parental generation?

_____same_____

Q14b Is the frequency of the *a* allele for blonde hair changing over time?

_____no_____

Last question: What happens when there are more than two alleles of the gene affecting hair color? To figure this out, add a third row and a third column to your Punnett square, above. Label the new row and new column with allele *a′*, and suppose that the frequency of this third allele is *r* (so *p* + *q* + *r* = 1).

Q15a Add the new genotypes and their frequencies to the new cells.

Q15b Note that the genotype frequencies must still sum to 1. Write this expression below:

= 1.0

	A	*a*	***a′***
A	***AA*** p^2	***aA*** ***qp***	***a′A*** ***rp***
a	***Aa*** ***pq***	***aa*** q^2	***a′a*** ***qr***
a′	***a′A*** ***rp***	***a′a*** ***qr***	***a′ a′*** r^2

********** Please hand your completed worksheet to your TA **********