Hardy-Weinberg problems

(BTW, These are all fictitious examples using fictitious characters and traits.)

1) Suppose you are looking at a population of humans living near Hobbiton, and you notice that out of 500 randomly sampled individuals in the human community, about 70 of them have the big hairy hobbit-type feet. Remember, we said in our genetics problems that big, hairy Hobbit-like feet was caused by a single recessive gene (*h*). Clearly, there has been some gene flow between the human and hobbit populations in the past (and maybe still.) **Assuming that the population is in Hardy-Weinberg equilibrium, compute the number of heterozygous individuals that currently exist in the population of humans.**

2) In looking at a population of elves, living in a nearby forest, it is observed that 205 of the population of 295 elves have pointy ears. (Remember how elf ears are inherited? haha. Pointy elf-like ears are caused by a single locus, and pointy ears are dominant. *E* = pointy ears, *e* = rounded ears.) **Assuming that this population is at Hardy-Weinberg equilibrium, compute the allele frequencies and the numbers of homozygous and heterozygous individuals.**

3) Suppose you do some testing on the hobbit population of Hobbiton. You sample 600 hobbits and are able to determine that of these hobbits, 125 are homozygous dominant for pointy ears (*EE*), 265 are heterozygous (*Ee*) and 210 have rounded ears (*ee*). **Determine the allele frequencies and expected genotypic frequencies if the population were at Hardy-Weinberg equilibrium. Is the population at Hardy-Weinberg equilibrium? explain.**

Critical values of the Chi-square distribution with *d* degrees of freedom

	Probability of exceeding the critical value						
d	0.05	0.01	0.001	*d*	0.05	0.01	0.001
1	3.841	6.635	10.828	11	19.675	24.725	31.264
2	5.991	9.210	13.816	12	21.026	26.217	32.910
3	7.815	11.345	16.266	13	22.362	27.688	34.528
4	9.488	13.277	18.467	14	23.685	29.141	36.123
5	11.070	15.086	20.515	15	24.996	30.578	37.697
6	12.592	16.812	22.458	16	26.296	32.000	39.252
7	14.067	18.475	24.322	17	27.587	33.409	40.790
8	15.507	20.090	26.125	18	28.869	34.805	42.312
9	16.919	21.666	27.877	19	30.144	36.191	43.820
10	18.307	23.209	29.588	20	31.410	37.566	45.315

INTRODUCTION TO POPULATION GENETICS, Table D.1

4) For the human population in question #1, suppose that you do a similar sampling. You test 700 of the humans and find that for the pointy-ear gene, 525 of them are homozygous for round ears (*ee*). Of the ones that have pointy ears, 11 of them are homozygous (*EE*) and 164 of them are heterozygous (*Ee*). **Determine the allele frequencies and the expected genotypic frequencies if the population were at equilibrium. Is this population at Hardy-Weinberg equilibrium? explain.**

ANSWERS:

(1) Here, the frequency of homozygous recessive individuals is 70 out of 500, or 14%, or 0.14. This is q^2.

We can take the square root of q^2 to get q. In this case, $q = 0.374$.
We can then use q to get p, since $p+q=1$.
You can rearrange that to get $1-q = p$. So, $p = 0.626$.
If you square p, you get $p^2 = 0.392$.
Then we can multiply that times 500 to get the number of individuals with that condition (196).
Now that we know that 196/500 individuals have the homozygous dominant condition and 70/500 are homozygous recessive, the rest should be heterozygous. Just to double-check though, we can multiply out 2pq to get the frequency. $2 \times p \times q = 0.468$.
If we multiply this frequency times 500, ***we get 234. That is the number of heterozygous individuals.***

(2) Here, there are 205/295 individuals with the dominant phenotype. That means the rest are recessive. So, 90/205 have the recessive phenotype. If we multiply that out, it gives us 0.3051, which is q^2. just like in the last problem, we take the square root of q^2 to get q.

In this case, ***$q = 0.5523$.*** $1-q = p$, SO, ***$p = 0.448$***.
$p^2 = 0.201$ If we multiply that times 295, we get 59. SO, ***59/295 are homozygous dominant.***
$2pq = 0.495$ If we multiply that times 295, we get 146. SO, ***146/295 are heterozygous.***

(3) genotypic ratios:
600 hobbits
125/600 = EE = 0.208 = 20.8%
265/600 = Ee = 0.442 = 44.2%
210/600 = ee = 0.350 = 35%

phenotypic ratios:
600 hobbits
390/600 = pointy ears
210/600 = round ears

Here we are not assuming HWE, so to get p, we need to use the following formula: $p = p^2 + ½(2pq)$
To get q, we need to use: $q = q^2 + ½(2pq)$
SO, $p = 0.429$, $q = 0.571$ (those should add up to 1, and they do.)
SO, if those are our allele frequencies, we would expect $p^2 = 0.1840$, $2pq = 0.4899$, $q^2 = 0.3260$.
SO, our expected genotypic frequencies are:

110.4/600 (EE)
293.94/600 (Ee)
195.62/600 (ee)

Our *chi-square* for these data ends up being 5.8372, which is significant with a $p<0.05$. ***In other words, this population deviates significantly from Hardy-Weinberg Equilibrium.***

(4) genotypic frequencies:
525/700 (ee) = 0.75 = q^2
164/700 (Ee) = 0.234 = $2pq$
11/700 (EE) = 0.016 = p^2
SO:
p $= p^2 + 0.5(pq) =$ **0.133**
q $= q^2 + 0.5(pq) =$ **0.867**

p^2(expected) = 0.018 = 12.6/700
q^2(expected) = 0.752 = 526.4/700
2pq(expected) = 0.231 = 161.4/700

Our *chi-squared* ends up being 0.24787, which is not significant. **Therefore, this population is not significantly different from HWE.**