Population Genetics Problem Set Answers
Conservation Biology
Spring 2009

1. Suppose that you study the genetics of a locus that controls flower color (C). Assume that individuals who are homozygous C^R always have red flowers, homozygous C^W have white flowers and the heterozygotes are pink. You go out and write down the phenotypes of a number of plants and get the following:

red = 70
pink = 120
white = 110

(a) What are the allele frequencies in the study population?

Let the frequency of allele C^R = **p** and
the frequency of allele C^W = **q**

p = (total num. of C^R alleles)/ total num. of alleles in pop.
= ((2 * # homozygotes) + heterozygotes) / 2 * (total pop size)
= (2 * 70 + 120) / 2 * (70+120+110) = 260 / 600 = **0.433**

and since q = 1-p = 1.0 - 0.433 = **0.567**

Using the same concept to calculate phenotypes frequencies:

freq. = # of a certain phenotype / total number of individuals

freq. (red) = 70/(70+120+110) = 0.233
freq. (pink) = 120 / 300 = 0.40
freq. (white) = 1.0 - freq.(red) - freq.(pink) = 1.0 - 0.233 - 0.4
= 0.367

Check for freq.(white) --- 110/300 = 0.367

(b) Is this population at Hardy-Weinberg Equilibrium?

We know the actual allele frequencies in the entire population from the calculation we did in #1(a).
We need to use the Hardy-Weinberg expression to generate a series of expected genotypic frequencies. These are the frequencies that would exist given the allele frequencies we just worked out IF THE POPULATION IS AT H-W EQUILIBRIUM.

freq. of red = freq. $C^R C^R = p^2 = 0.433*0.433$
freq. of white = freq. $C^W C^W = q^2 = 0.567 * 0.567$
freq. of pink = freq. $C^R C^W = 2pq = 2 * *0.433 * 0.567$

NOTE THAT THESE MUST SUM TO 1.0 SINCE
$p^2 + 2pq + q^2 = 1.0$
However, summing to one does not show whether or not the population is at equilibrium (note: unfortunately, many high school classes teach students that equilibrium occurs when they sum to 1 – the frequencies always must sum to one since they make up a whole!
Back to it:
WE SUBSTITUTE IN THE APPROPRIATE ALLELE FREQ.:

$0.433^2 + 2*0.433*0.567 + 0.567^2$ = **0.1875 + 0.491 + 0.3215**

(Notice that these DO all add to 1.0, **as they must** regardless of whether or not the pop is at H-W equilibrium. IF THEY DON'T YOU HAVE MADE A MATH ERROR – NOTHING MORE, NOTHING LESS)

Now, lets compare these expected frequencies to the frequencies in the actual population (last page):

observed red flowers = 0.233
predicted reds (H-W) = 0.433^2 = 0.1875
We need go no further because these are not equal. The observed does not come close to the expected and so the population is not at H-W equilibrium. For practice sake, let's go ahead anyway.

observed white flowers = 0.367
predicted reds (H-W) = 0.3215
(not very close to predicted by H-W)

observed pink flowers = 0.40
predicted pinks (H-W) = 0.491
(not even close)

The observed values do not reflect the values predicted from the allele frequencies in the observed population. Thus the population is <u>not at equilibrium</u> -- one of more of the H-W assumptions has been violated.

2. Suppose that the following frequencies are observed for blood type alleles in a human population:

I^A = 0.40

I^B = 0.05

I^C = 0.55

(a) Write and expand an equation to predict the frequency of each genotype at Hardy-Weinberg equilibrium. (this is not as hard as it might seem – just apply the principles that we went over in class that explained how the Hardy-Weinberg model was constructed.

let freq.(I^A) = p

let freq.(I^B) = q
let freq.(I^c) = r

so: $p + q + r = 1.0$

Since human folk, like most organisms, are diploid, all possible combinations of alleles are derived by squaring this binomial:

$(p + q + r)^2 = 1.0^2$

$$\mathbf{p^2 + 2pq + 2pr + q^2 + 2qr + r^2 = 1.0}$$

(b) If the population is at Hardy-Weinberg equilibrium, give the frequency of each of the following:

(i) $I^C I^C$

This is $r^2 = 0.55^2 = 0.3025$

(ii) $I^A I^C$

From the expanded equation in bold few lines up, we see that the frequency of I^AI^C is $2pr = 2*0.4*0.55 = 0.44$

(iii) $I^A I^A$

These are homozygous recessive (earlier in the course) and therefore if the population is at H-W equilibrium:

freq. (I^AI^A) = $p^2 = 0.4^2$ = **0.16**