Homework 2: Hardy-Weinberg problems

# What genetic factors must be occurring for a Hardy-Weinberg equilibrium to exist? **(1 pts)**

No natural selection, no migration, no genetic drift, no mutation.

# Cystic fibrosis is a genetic disorder in homozygous recessives that causes death during the teenage years. If 4 in 10,000 newborn babies have the disease, what are the expected frequencies of the three genotypes in newborns, assuming the population is at Hardy- Weinberg equilibrium? Why is this assumption not strictly correct? **(2 pts)**

In a population of 10,000 newborn babies, the expected proportion of babies having the disease is 4/10,000 = 0.0004, which is q2. The frequency of the allele q that causes the

0.0004

disease if the square root of this number,

= 0.02. You know that p + q = 1,

therefore p = 1 – 0.02 = 0.98. Now, you can calculate the expected frequency of the three genotypes:

p2 (homozygote, normal) = 0.9604

2pq (heterozygote, normal) = 0.0392 q2 (recessive, cystic fibrosis) = 0.0004

Assuming Hardy-Weinberg in this case is not correct because there is natural selection acting against the allele that causes the disease, given that children with the disease die before they reproduce (Remember that Natural Selection is defined as differential reproduction and/or survival among the individuals in a population).

# The allele **y** occurs with a frequency of 0.8 in a population of clams. Give the frequency of genotypes **YY**, **Yy**, and **yy**. Show your work! **(1 pts)**

The allele **y** has a frequency q = 0.8.

You know that p + q = 1, then p = 1 – 0.8 = 0.2. Now you can estimate the frequency of each genotype:

YY genotype frequency = p2 = 0.04 Yy genotype frequency = 2pq = 0.32 yy genotype frequency = q2 = 0.64.



# In the year 2374, humans finally developed the technology necessary for time travels. You are a

scientist interested in the population genetics of extinct animals. Taking advantage of this technological advance, you decide to go to the past 8 million years to conduct a field work in **Venezuela** to study a population of *Phoberomys pattersoni\**, the world’s largest extinct rodent weighing approximately 700 kg (1500 lb) and looking vaguely like a giant guinea pig. The coat color of this rodent varies between tan (dominant) and brown (recessive). Assume the population is in Hardy-Weinberg equilibrium. You observed 336 tan *Phoberomys* and 64 brown *Phoberomys* during your study. **(4 pts)**

1. What is the frequency of the homozygous recessive genotype?

There are 336 + 64 = 400 animals in the population. 64 are homozygous recessive (brown)

Frequency of homozygous recessive = q2 = 64/400 = 0.16

# What is the allelic frequency of the dominant (tan) allele in the population?

Since q2 = 0.16, take the square root to get q = 0.4 Remember that p + q = 1 (formula for allele frequencies)

Frequency of the dominant allele p = 0.6

# Of the animals you observed, how many were heterozygous?

Frequency of heterozygote genotypes = 2pq 2pq = (2)\*(0.6)\*(0.4) = 0.48

Multiply the frequency by the total population size to get the number of animals: (0.48)\*(400) = 192

# You make another trip to **Venezuela** and this time you observe 650 animals.

1. How many of the 650 animals would you expect to be tan, assuming the population is still in Hardy-Weinberg equilibrium?

If the population is still in H-W equilibrium, then the allele frequencies would be the same: p = 0.6, q = 0.4

The tan phenotype is produced by 2 genotypes, homozygous dominant and heterozygous Frequency of these genotypes is p2 and 2pq

p2 = (0.6)2 = 0.36 and 2pq = (2)\*(0.6)\*(0.4) = 0.48

Multiple each of these frequencies by the total population size (0.36)\*(650) = 234, and (0.48)\*(650) = 312. Then, 234 + 312 = 546 tan

# How many of these tan animals are homozygous for the dominant allele?

We calculated this in the previous problem:

p2 = (0.6)2 = 0.36, and then we multiply the genotypic frequency by the total population: (0.36)\*(650) = 234

# How many of these 650 animals would you expect to be brown, assuming the population is still in Hardy-Weinberg equilibrium?

Brown animals are homozygous recessive Frequency of brown is q2 = (0.4)2 = 0.16 Multiply the frequency by the total population size (0.16)\*(650) = 104

NOTE: You can check your math. Brown + tan should equal 650!

# As you observe the animals, you count 200 brown *Phoberomys* and 450 tan. Conduct a chi-square test to determine if your observations are significantly different from what you expect.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Observed | Expected | (O-E)2 | (O-E)2/E |
| Tan | 450 | 546 | 9216 | 16.88 |
| Brown | 200 | 104 | 9216 | 88.62 |
|  |  |  | Total: | 105.5 |

The calculated X2 is 105.5

There are 2 phenotypes (brown and tan), so there is 1 degree of freedom (2 – 1 = 1) The theoretical X2 for 1 degree of freedom is 3.841, which is much smaller than our calculated one. Therefore, we reject the null hypothesis that the population of 650 is in H-W equilibrium. Our observations are significantly different from our espectation, assuming H-W equilibrium.

# What does your result in #7 mean in terms of the genetic composition of this population of

Phoberomys?

The chi-square test tells us that this population is not in H-W equilibrium with the population that we first observed. This means that evolution has been occurring – at least one of the assumptions of H-W equilibrium is not being met. Perhaps natural selection is occurring, or perhaps there has been some gene flow. We don’t know how the H-W equilibrium has been violated, but we do know that the genetic composition of this population is different from that of the original population of 400.

# \**Phoberomys pattersoni* is the world’s largest extinct rodent. It lived in South America about 8 million years ago. It is related to modern guinea pigs. If you would like to know more about this species, go to this link: <http://www.aaas.org/news/releases/2003/0918rodent.shtml>