Date: _____

Calculating Allele Frequency

Definitions:

- **Allele frequency** is a measure of the relative frequency of an allele in a population.
- **Microevolution** is defined as the change in the frequency of alleles that occurs over generations.

For a particular allele N, its frequency in a population is calculated using the formula:

$$\text{allele frequency of N} = \frac{\text{\# of N alleles}}{\text{Total \# of alleles at that locus}}$$

Example 1: Two alleles (brown, B and white, b) exist for mouse coat colour. In a population of mice whose gene pool consists of 500 alleles, 301 of these alleles are brown. Calculate the allele frequencies for:

a. the brown allele _____ b. the white allele _____ [Ans: B = 0.60, b=0.40]

Calculating allele frequencies from genotypes

Example 2: In a different population of mice, 290 mice are homozygous BB, 425 are hybrid Bb, and 270 are homozygous bb. Calculate the allele frequencies:

B = _____ b = _____

Solution:

Genotypes 290 BB 425 Bb 270 bb

Alleles (2 × 290) B + 425 B = 1005 B 425 b + (2 × 270) b = 965 b

Total alleles = B + b = 1005 + 965 = 1970

$$\text{allele frequency of B} = \frac{1005}{1970} \qquad \text{allele frequency of b} = \frac{965}{1970}$$

B = 0.51 b = 0.49

Example 3: In centaurs, the allele for curly tails (T) is incompletely dominant to the allele for straight tails (t). The hybrid genotype results in wavy tails. In a population of 1500 centaurs, 315 have curly tails, 820 have wavy tails, and the remainder has straight tails.

a. How many total alleles are in this gene pool? _____

b. Determine the allele frequencies of: T = _____ t = _____ [Ans: T = 0.48, t=0.52]

The Hardy-Weinberg Model

The Hardy-Weinberg model describes, for a population, the relations hip between the occurrence of genotypes and the frequency of alleles. Hardy and Weinberg independently concluded that allele frequencies are inherently stable in populations, if certain assumptions are met. *(See box)*

Assumptions:

1. Population size is infinitely large
2. No mutation occurs
3. No migration occurs
4. All members of the population breed, and mating is random
5. Natural selection does not occur

A population that meets these assumptions is said to be in **Hardy-Weinberg equilibrium,** because allele frequencies do not change from generation to generation.

The Hardy-Weinberg model was an important step to defining the mechanisms for evolution. Through recognizing that no population can ever meet these five assumptions, it identified situations that would lead to changes in allele frequency. Recall that these changes are the definition of ~~macroevolution~~. microevolution

Description: For a character that has only two alleles (R and r), the frequency of all the dominant R and recessive r alleles adds up to 1.0.

$$p + q = 1$$

The equation: $(p + q)^2 = p^2 + 2pq + q^2 = 1$

Frequency of alleles
p = frequency of dominant allele A
q = frequency of recessive allele a

Frequency of allele combinations (genotypes)
p^2 = frequency of AA (homozygous dominant)
q^2 = frequency of aa (homozygous recessive)
2pq = frequency of Aa (heterozygous)

To solve Hardy-Weinberg Problems follow these steps:

1. Examine the information to determine what piece of information you have been given about the population.
2. Find out the value of p or q. If this is achieved, then every other value in the equation can be determined by simple calculation.
3. Take the square root of q^2 to find q.
4. Determine p by subtracting q from 1 (i.e. p= 1-q).
5. Determine p^2 by multiplying p by itself (i.e. $p^2 = p \times p$)
6. Determine 2 pq by multiplying p times q times 2.
7. Check that your calculations are correct by adding up the values for $p^2 + q^2 + 2pq = 1$.

Practice Problem: In the American Caucasian population approximately 70% of people can taste the chemical phenylthiocarbamide (PTC) (the dominant phenotype), while 30% are non-tasters (the recessive phenotype). Determine the expected frequency of:

a) homozygous recessive phenotype (q^2) _____

b) the recessive allele (q) _____

c) the dominant allele (p) _____

d) homozygous tasters (p^2) _____

e) heterozygous tasters (2pq) _____

If a population's genotype distribution does not match those predicted by the H-W model, then at least one of the assumptions of H-W equilibrium is being violated.

Answer:

a) The recessive phenotype q^2 = 30% or 0.30
b) Therefore: q = 0.5477 (square root of 0.30)
c) Therefore: p = 0.4522 (1 – q = p so 1- 0.5477 = 0.4523)
d) Then use p and q in the Hardy-Weinberg equation to solve:
e) Homozygous dominant: p^2 = 0.2046 (p x p = 0.4523 x 0.4523)
f) Heterozygous: 2pq = 0.4953