TOPIC: THE HARDY-WEINBERG PRINCIPLE

Introduction to Hardy-Weinberg

- Hardy-Weinberg equation: predicts genotype frequencies for gene with __ alleles in a diploid population.
  - Assumes _________ mating & no changes to _________ frequency.
  - Populations that match this prediction are said to be in Hardy-Weinberg _____________.

- *Recall*: p = the frequency of the _____ allele (*A*). q = the frequency of the _________ allele (*a*).
  - Because there are only 2 alleles: $p + q = 1$

- Predicting expected genotypes using p and q:
  - Chance of being a *AA* homozygote: ___________________________________.
  - Chance of being a *Aa* heterozygote: ___________________________________.
  - Chance of being a *aa* homozygote: ___________________________________.

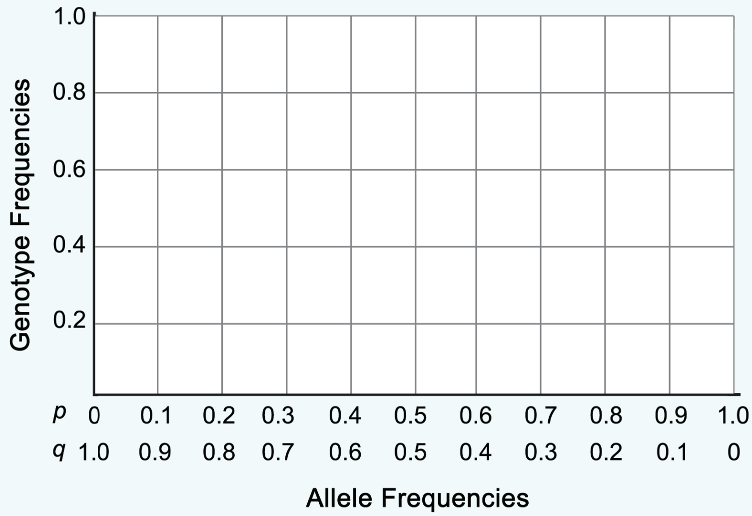
We pick alleles out of the "gene pool".

- **Hardy-Weinberg Equation:** $p^2 + 2pq + q^2 =$ ___

EXAMPLE

The table below gives the allele frequencies (p & q) for 4 populations (A, B, C, D) in Hardy-Weinberg equilibrium. Based on the information in the table, fill in the values for p^2, q^2, and $2pq$ for each population. Then, using the graph provided, plot the genotype frequencies for populations A, B, C, & D.

	Allele Frequencies		Genotype Frequencies		
	p	q	p^2	$2pq$	q^2
A	0	1			
B	0.2	0.8			
C	0.4	0.6			
D	0.5	0.5			



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PRACTICE

In the Hardy-Weinberg equation, what does the term $2pq$ represent?

a) The probability of being a homozygote for the first allele.

b) The probability of being a homozygote for the second allele.

c) The probability of being a heterozygote.

d) The combined probability of all genotypes.

PRACTICE

Which of the following statements about the Hardy-Weinberg equation are true?

I) For a gene with two alleles, q^2 represents the frequency of one of the homozygotes.

II) If p and q both equal 0.5, you expect 50% of the population to be heterozygous.

III) The p^2 and q^2 terms will be equal as they both represent the probability of being a homozygote.

a) I & II only. b) II & III only. c) I & III only. d) I, II, & III.

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Predicting Allele or Genotype Frequencies Using Hardy-Weinberg

- HW can be used to predict _______ or __________ frequencies for populations.
  - Assumes the population is in HW _________.
- Use the following generalized steps:

Steps to solve:

1. Remember your equations:

Allele Frequencies	Genotype Frequencies
$p + q = 1.$	$p^2 + 2pq + q^2 = 1$

2. Identify which variables are given.

3. Identify which variable or variables the problem is asking for.

4. Solve for the missing variable(s).

- *Recall*: If the traits have a simple dominance relationship:
  - *AA* & *Aa* genotypes will display the dominant trait.
  - *aa* genotypes will display the recessive trait.

A. Calculating Genotype Frequency from Allele Frequency

- Plug p & q into the HW (__________ freq.) equation.

- Find the predicted genotype frequencies if the frequency of the *A* allele = 0.2 and the frequency of the *a* allele = 0.8.

Steps to solve:

1. Remember your equations:

Allele Frequencies	Genotype Frequencies
$p + q = 1.$	$p^2 + 2pq + q^2 = 1$

2. Identify which variables are given.

3. Identify which variable or variables the problem is asking for.

4. Solve for the missing variable(s).

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B. Calculating Allele Frequency from a Genotype Frequency

- Work backward from genotype to find the ______ freq.

- Predict the allele frequency for both alleles if the population is 1% *aa* homozygotes.

Steps to solve:

1. Remember your equations:

Allele Frequencies	Genotype Frequencies
$p + q = 1.$	$p^2 + 2pq + q^2 = 1$

2. Identify which variables are given.
3. Identify which variable or variables the problem is asking for.
4. Solve for the missing variable(s).

C. Calculating Allele Frequency from Phenotype Frequency

- When given a phenotype freq. convert to _________ freq.
  - For simple dominance:

	Dominant Trait		Recessive Trait
Genotypes:	*AA*	*Aa*	*aa*
Genotype frequencies:	____ +	____	____

- In a population, 64% of individuals display the dominant trait. What percent of the population do you predict to be heterozygous?

Steps to solve:

1. Remember your equations:

Allele Frequencies	Genotype Frequencies
$p + q = 1.$	$p^2 + 2pq + q^2 = 1$

2. Identify which variables are given.
3. Identify which variable or variables the problem is asking for.
4. Solve for the missing variable(s).

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PRACTICE

Imagine a population of cats where one gene codes for eye color. The *E* allele codes for yellow eyes and is dominant. The *e* allele codes for green eyes and is recessive. The frequency of the *E* allele is 0.6, and the frequency of the *e* allele is 0.4. Assuming the population is in Hardy-Weinberg equilibrium, what percent of the population will have green eyes?

a) 36%
b) 24%
c) 16%
d) 48%

PRACTICE

Sickle cell anemia is a recessive trait. In Nigeria, it is estimated that 2.4% of the population is born with sickle cell anemia. Heterozygotes for the sickle cell allele are said to have the sickle cell trait and have few sickle cell symptoms. Assuming that the population is in Hardy Weinberg equilibrium for the sickle cell gene, what percentage of the population would you expect to have the sickle cell trait?

a) ~71.4%
b) ~13%
c) ~15.5%
d) ~26%

PRACTICE

PTC is a chemical that elicits a bitter taste response in some people. The ability to taste PTC depends on the presence of the PTC-tasting allele. Individuals with at least one copy of the PTC-tasting allele taste PTC as bitter. It is estimated that about 70% of the population taste PTC. Assuming that the population is in Hardy-Weinberg equilibrium for this trait, what percent of the population would you expect to be heterozygous for this trait?

a) ~42%
b) ~49%
c) ~45%
d) ~54%

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Testing if a Population is in Hardy-Weinberg Equilibrium

- To test if a population is in HW equilibrium, compare _______ genotype frequencies to HW ___________:
- HW equilibrium is sometimes used as a *null model*. If the population is ____ in HW, we assume one of two things:

_______________ mating OR _______________.

A sample from a particular population has:

250 *AA* 100 *Aa* 150 *aa*

Is this population in Hardy-Weinberg equilibrium? ______

Step 1		**Allele Frequency**
Actual	p	
	q	
	Total	

Steps 2+3		**Genotype Freq.**	**# of Individuals**
Expected	***AA***		
	Aa		
	aa		
	Total		

Steps to solve:

1. Calculate allele frequencies:

$$p = \frac{2(\#AA) + \#Aa}{2(\#\text{individuals})} \qquad q = \frac{\#Aa + 2(\#aa)}{2(\#\text{individuals})}$$

2. Plug p & q into HW equation to calculate *expected* genotype frequencies.

$$AA = p^2 \qquad Aa = 2pq \qquad aa = q^2$$

3. Multiply expected genotype frequencies by the number of individuals in the sample.

4. Compare to the original data.

PRACTICE

In a population of glass frogs (*Hyalinobatrachium munozorum*) you collect 200 individuals. Of those, you determine that 160 are homozygous for the *H* allele, 10 are homozygous for the *h* allele, and 30 are heterozygous. Is this population in Hardy-Weinberg equilibrium? If not, why not?

a) Yes. The population is in Hardy-Weinberg equilibrium.

b) No. There are more heterozygotes than predicted by the Hardy-Weinberg equation.

c) No. There are fewer *HH* homozygotes than predicted by the Hardy-Weinberg equation.

d) No. There are more *HH* homozygotes than predicted by the Hardy-Weinberg equation.

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PRACTICE

Jorge and Claire are given the following data on fur density in red pandas at zoos in the United States. Is the following population in Hardy-Weinberg equilibrium?

160 homozygous for the *F* allele, 137 heterozygotes, and 29 homozygous for the *f* allele.

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a) Yes, the population is in Hardy-Weinberg equilibrium.

b) No, we would expect there to be more heterozygotes in the population.

c) No, we would expect there to be more *ff* homozygotes in the population.

d) No, we would expect there to be more *FF* homozygotes in the population.