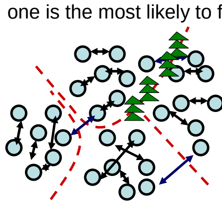
Population genetics

Breeding population – a group of randomly mating individuals relatively isolated from the other members of the same species.

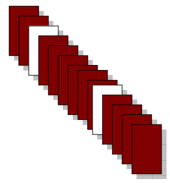
Breeding population – a group of individuals where one is the most likely to find a mate



barrier: geographic, ecological, behavioral (cultural)

Population genetics is the study of the allele and genotype frequency distribution and change in a population

frequency - **how often something occurs**



I have 80 cards,
8 white,
72 red

What is the frequency of white cards?

fr(w) = 8/80 = 0.1

fr(R) = 72/80 = 0.9

fr(R) + fr(w) = 1   **fr(R) = 1 – fr(w)**

Genotype frequencies

In a population of 75 individuals:

#RR =20

#RW= 10

#WW = 45

Find genotype frequencies:

fr(RR) = ***#RR/total =20/75= = 0.27***

fr(RW) = ***#RW/total =10/75= = 0.13***

fr(WW) = ***#WW/total =45/75= = 0.6***

fr(RR) + fr(RW) + fr(WW) = 1

Allele frequencies

In a population of 75 individuals:

#RR =20

#RW= 10

#WW = 45

Find allele frequencies:

$$\text{fr (R)} = \frac{2 \times \#RR + \#RW}{2 \times \text{(total number of people)}}$$

$$= \frac{2 \times 20 + 10}{2 \times 75} = \frac{50}{150} = 0.33$$

fr (W) = 1 – 0.33 = 0.67

Finding Allele frequencies from the genotype frequencies

$$\text{fr (A)} = \frac{2 \times \#AA + \#Aa}{2 \times N} =$$

$$= \frac{2\ \#AA}{2\ N} + \frac{\#Aa}{2\ N} = \text{fr(AA)} + 0.5\text{fr(Aa)}$$

$$\text{fr (a)} = \frac{2 \times \#aa + \#Aa}{2 \times N} =$$

$$= \text{fr(aa)} + 0.5\text{fr(Aa)}$$

Find allele frequencies for each of the following sets of numbers:

1. #AA = 20
 # Aa = 40
 # aa = 140

2. fr(AA) = 0.5
fr (Aa) = 0.4

3. fr (bb) = 0.7
fr (Bb) = 0.2

True or False about a randomly mating population?

~~1. In a randomly mating population everyone is heterozygous~~

~~2. Dominant alleles are more common than recessive alleles in a randomly mating population~~

~~3. Frequency of heterozygotes tends to increase over time in a randomly mating population~~

~~4. Dominant phenotypes are more common than recessive phenotypes~~

5. Allele frequencies do not change from generation to generation

6. Genotype frequencies can be found from allele frequencies

Godfrey Hardy
and
Wilhelm Weinberg

Hardy-Weinberg theorem

p + q = 1 $0 \le p \le 1$ $0 \le q \le 1$

If fr(A) = p; fr(a) = q

1. population is infinitely large
2. population is randomly mating
3. there is no migration
4. no mutations
5. no selection

Then

fr (AA) = p^2

fr (aa) = q^2

fr (Aa) = 2pq

	fr(A) = p	fr(a) = q
fr(A) p	AA p x p = $= p^2$	Aa p x q = = pq
fr(a) q	Aa p x q = = pq	aa q x q = $= q^2$

2pq

p + q = 1

Hardy-Weinberg theorem: applications

1. Knowing frequency of one allele/genotype, *estimate* frequencies of the other alleles and genotypes

fr (B) = 0.7 = p   fr (b) = q = 1 - p = 1 – 0.7 = 0.3

fr (BB) = p^2 = 0.7^2 = 0.49

fr (Bb) = 2pq = 2x0.7x0.3 = 0.42

fr (bb) = q^2 = 0.3^2 = 0.09

2. Testing if a population is a Hardy-Weinberg population (randomly mating, not affected by migration, selection, etc.)

3. Modeling evolutionary change

Test whether a population is at Hardy-Weinberg equilibrium (randomly mating, is not affected by migration, selection, etc.)

	RR	RW	WW	total
observed numbers	10	8	2	20

1) find allele frequencies

$$fr(R) = \frac{2 \times \#RR + \#RW}{20 \times 2} = \frac{2 \times 10 + 8}{40} = 0.7$$

fr (W) = 1 - 0.7 = 0.3

Test whether a population is at Hardy-Weinberg equilibrium (randomly mating, is not affected by migration, selection, etc.)

	RR	RW	WW	total
observed numbers	10	8	2	20
expected frequencies	$fr(RR)_e = p^2$ $= 0.7^2 = 0.49$	$fr(RW)_e = 2pq$ = 2 x 0.3x0.7 = = 0.42	$fr(WW)_e = q^2$ $= 0.3^2 = 0.09$	1

2) find EXPECTED genotype frequencies for given allele frequencies fr (R) = 0.7 = p, fr (W) = 0.3 = q

Test whether a population is at Hardy-Weinberg equilibrium (randomly mating, is not affected by migration, selection, etc.)

	RR	RW	WW	total
observed numbers	10	8	2	20
expected frequencies	$fr(RR)_e = 0.49$	$fr(RW)_e = 0.42$	$fr(WW)_e = 0.09$	1
expected numbers	$\#(RR)_e$ = fr(RR) x total = 0.49 x 20 = 9.8	$\#(RW)_e$ = fr(RW) x total = 0.42 x 20 = 8.4	$\#(RR)_e$ = fr(WW) x total = 0.09 x 20 = 1.8	20

3) find EXPECTED number of individuals with each genotype

Test whether a population is at Hardy-Weinberg equilibrium (randomly mating, is not affected by migration, selection, etc.)

	RR	RW	WW	total
observed numbers	10	8	2	20
expected frequencies	$fr(RR)_e = 0.09$	$fr(RW)_e = 0.42$	$fr(WW)_e = 0.49$	1
expected numbers	9.8	8.4	1.8	20

4) compare OBSERVED and EXPECTED numbers