**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**

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## Hardy-Weinberg theorem

**p + q = 1**   **0 ≤ p ≤ 1**
**0 ≤ q ≤ 1**

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

**Then**
**fr (AA) = $p^2$**
**fr (aa) = $q^2$**
**fr (Aa) = 2pq**

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

| | fr(A) = p | fr(a) = q |
|---|---|---|
| fr(A) p | AA<br>p x p =<br>= $p^2$ | Aa<br>p x q =<br>= pq |
| fr(a) q | Aa<br>p x q =<br>= pq | aa<br>q x q =<br>= $q^2$ |

2pq

---

## Hitchhiker thumb


**hh**   **HH or Hh**

fr (H) = 0.2
fr (h) = 0.8

*How many people with hitchhiker thumbs do we expect to find among 200 members of this population?*

**# hh = fr(hh) x total =**
**= 0.64 x 200 =**
**= 128**

how many are expected to have no hitchhiker thumb?
**#HH + #Hh = 200 – 128 =**
**= 72**

| | fr(H)=0.2 | fr(h)=0.8 |
|---|---|---|
| fr(H) 0.2 | HH<br>0.2x0.2 =<br>$0.2^2$ = 0.04 | Hh<br>0.8x0.2 =<br>= 0.16 |
| fr(h) 0.8 | Hh<br>0.8x0.2 =<br>= 0.16 | hh<br>0.8x0.8 =<br>$0.8^2$ = 0.64 |

0.32

---

**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**

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**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 | $fr(RR)_e = p^2$<br>= $0.7^2$= 0.49 | $fr(RW)_e$ = 2pq<br>= 2 x 0.3x0.7 =<br>= 0.42 | $fr(WW)_e = q^2$<br>= $0.3^2$= 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***

$$\chi^2 = \sum \frac{(E - O)^2}{E}$$

**compare with 3.84**

$$\frac{(10 - 9.8)^2}{9.8} + \frac{(8 - 8.4)^2}{8.4} + \frac{(2 - 1.8)^2}{1.8} =$$

**= 0.004 +0.02 +0.02 = 0.044 < 3.84**

**(1 df, p<0.05, not significant)**

**➔ the population is at Hardy-Weinberg equilibrium**