

Hardy–Weinberg Equilibrium

Name: _____

Date: _____ Score: ____ / 22

Key ideas

Allele frequencies: p = frequency of the dominant allele, q = frequency of the recessive allele. Genotype frequencies: $p^2 = AA$, $2pq = Aa$, $q^2 = aa$.

$p + q = 1$ $p^2 + 2pq + q^2 = 1$

Strategy: start from the recessive phenotype, because only aa individuals show it: $q^2 \rightarrow q = \sqrt{q^2} \rightarrow p = 1 - q$.

Equilibrium conditions: no mutation, random mating, no natural selection, a very large population and no gene flow. If any are broken, allele frequencies change and the population **evolves**.

A Which condition is broken?2 marks

Each population is **not** in Hardy–Weinberg equilibrium. Name the condition that is broken (½ mark each).

Scenario	Condition that is broken
1. Birds from a neighbouring valley fly in and breed with the population.	
2. Peahens choose to mate with the males that have the brightest tails.	
3. A storm kills all but 40 beetles, and by chance most survivors carry the same allele.	
4. Moths whose colour matches the tree bark are eaten less by birds.	

B Calculate the frequencies8 marks

The shaded value is given. Fill in the rest of each row (½ mark per blank). Round to two decimal places.

	q^2 (aa)	q	p	p^2 (AA)	$2pq$ (Aa)
5. Population 1	0.16				
6. Population 2	0.09				
7. Population 3	0.25				
8. Population 4			0.8		

Show your work

Show your work

C Word problems

6 marks

Show your work. 2 marks each.

9. Cystic fibrosis is a recessive disorder that affects about 1 in 2500 newborns in some populations. Find the frequency of carriers (heterozygotes). About 1 in how many people is a carrier? (2 marks)

10. A population of 1000 mice has 840 brown mice (dominant, B) and 160 white mice (bb). Assuming Hardy-Weinberg equilibrium, how many mice are heterozygous, and how many are homozygous dominant? (2 marks)

11. A population of 200 plants has 90 AA, 80 Aa and 30 aa. Calculate p and q by counting alleles. Then find how many aa plants you would expect if the population were in equilibrium. (2 marks)

D Is the population evolving?

2 marks

12. Before a new predator arrived, the frequency of a recessive allele in a lizard population was 0.30. Ten generations later it is 0.42. Is the population in Hardy-Weinberg equilibrium? Which condition is most likely being broken? (2 marks)

E Understanding the equations

2 marks

13. Why must $p + q$ always equal 1?

14. What does each term in $p^2 + 2pq + q^2 = 1$ represent?

F Spot the mistake

2 marks

15. A student finds $q^2 = 0.36$ and writes $q = 0.36 \div 2 = 0.18$. Explain the error and correct it.

16. A student writes: "A rare recessive allele will soon disappear from a population." Explain the error and correct it.

Hardy–Weinberg Equilibrium

ANSWER KEY

Key ideas

Allele frequencies: p = frequency of the dominant allele, q = frequency of the recessive allele. **Genotype frequencies:** $p^2 = AA$, $2pq = Aa$, $q^2 = aa$.

$$p + q = 1 \quad p^2 + 2pq + q^2 = 1$$

Strategy: start from the recessive phenotype, because only aa individuals show it: $q^2 \rightarrow q = \sqrt{q^2} \rightarrow p = 1 - q$.

Equilibrium conditions: no mutation, random mating, no natural selection, a very large population and no gene flow. If any are broken, allele frequencies change and the population **evolves**.

A Which condition is broken?

2 marks

Each population is **not** in Hardy–Weinberg equilibrium. Name the condition that is broken (½ mark each).

Scenario	Condition that is broken
1. Birds from a neighbouring valley fly in and breed with the population.	No gene flow (no migration)
2. Peahens choose to mate with the males that have the brightest tails.	Random mating
3. A storm kills all but 40 beetles, and by chance most survivors carry the same allele.	Very large population (genetic drift)
4. Moths whose colour matches the tree bark are eaten less by birds.	No natural selection

B Calculate the frequencies

8 marks

The shaded value is given. Fill in the rest of each row (½ mark per blank). Round to two decimal places.

		q^2 (aa)	q	p	p^2 (AA)	$2pq$ (Aa)
5.	Population 1	0.16	0.4	0.6	0.36	0.48
6.	Population 2	0.09	0.3	0.7	0.49	0.42
7.	Population 3	0.25	0.5	0.5	0.25	0.5
8.	Population 4	0.04	0.2	0.8	0.64	0.32

C Word problems

6 marks

Show your work. 2 marks each.

9. Cystic fibrosis is a recessive disorder that affects about 1 in 2500 newborns in some populations. Find the frequency of carriers (heterozygotes). About 1 in how many people is a carrier? (2 marks)

$q^2 = 1/2500 = 0.0004$, so $q = 0.02$ and $p = 0.98$. $2pq = 2(0.98)(0.02) = 0.0392 \approx 3.9\%$, about 1 in 26 people.

10. A population of 1000 mice has 840 brown mice (dominant, B) and 160 white mice (bb). Assuming Hardy–Weinberg equilibrium, how many mice are heterozygous, and how many are homozygous dominant? (2 marks)

$q^2 = 160/1000 = 0.16 \rightarrow q = 0.4$, $p = 0.6$. Heterozygous: $2pq \times 1000 = 480$; homozygous dominant: $p^2 \times 1000 = 360$ (check: $480 + 360 = 840$ brown).

11. A population of 200 plants has 90 AA, 80 Aa and 30 aa. Calculate p and q by counting alleles. Then find how many aa plants you would expect if the population were in equilibrium. (2 marks)

$p = (2 \times 90 + 80) \div 400 = 0.65$; $q = 0.35$. Expected aa = $q^2 \times 200 = 0.1225 \times 200 = 24.5$. There are more aa plants (30) than expected, so the population may not be in equilibrium.

D Is the population evolving?

2 marks

12. Before a new predator arrived, the frequency of a recessive allele in a lizard population was 0.30. Ten generations later it is 0.42. Is the population in Hardy–Weinberg equilibrium? Which condition is most likely being broken? (2 marks)

No: the allele frequency changed, so the population is evolving. The predator suggests natural selection is favouring the recessive phenotype.

E Understanding the equations

2 marks

13. Why must $p + q$ always equal 1?
There are only two alleles for this gene, so their frequencies must add up to 100% of the gene pool.

F Spot the mistake

2 marks

15. A student finds $q^2 = 0.36$ and writes $q = 0.36 \div 2 = 0.18$. Explain the error and correct it.
To find q from q^2 , take the square root: $q = \sqrt{0.36} = 0.6$.
14. What does each term in $p^2 + 2pq + q^2 = 1$ represent?
 p^2 = frequency of homozygous dominant, $2pq$ = heterozygous, q^2 = homozygous recessive individuals.
16. A student writes: "A rare recessive allele will soon disappear from a population." Explain the error and correct it.
Without evolutionary forces, allele frequencies stay the same. Rare recessive alleles hide in heterozygotes ($2pq$), where selection can't act on them.