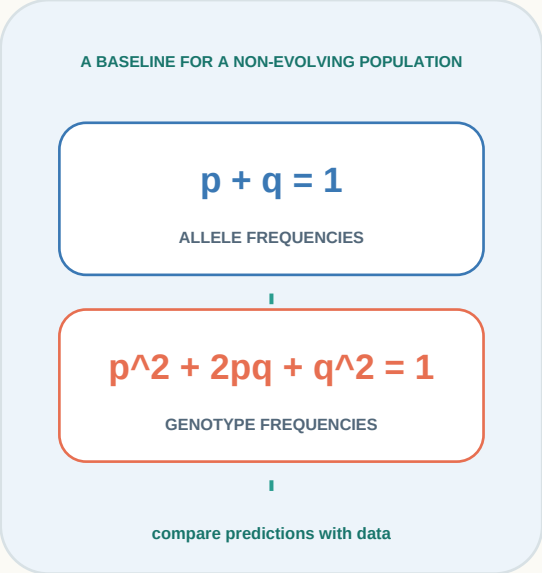
AP BIOLOGY | UNIT 7

TOPIC 7.5

Hardy-Weinberg Equilibrium

A null model predicts allele and genotype frequencies when evolutionary forces are absent, giving scientists a baseline for comparison.



THE CORE CAUSAL CHAIN

ALLELES → measure p and q

ASSUMPTIONS → remove evolution

EXPECTED → predict genotypes

COMPARE → test the null model

BY THE END, YOU SHOULD BE ABLE TO...

1. Define p and q as allele frequencies in a two-allele model.
2. Calculate expected homozygote and heterozygote frequencies.
3. Interpret a mismatch between observed and expected data.

CENTRAL IDEA

Hardy-Weinberg equilibrium is a baseline, not a claim that real populations meet every assumption. Evidence is evaluated by comparing data with the model.

1 Assumptions create the null model

When all five conditions hold, allele frequencies stay constant and genotype frequencies follow the Hardy-Weinberg equation.

THE FIVE CONDITIONS

1 LARGE POPULATION

Random sampling error is negligible, so genetic drift is weak.

2 NO NATURAL SELECTION

Genotypes have equal survival and reproductive success.

3 NO MUTATION

Alleles do not change into new sequence variants.

4 NO MIGRATION

No gene flow adds or removes alleles from the population.

5 RANDOM MATING

Mate choice is unrelated to the genotype or phenotype being studied.

WORKED EXAMPLE: START WITH THE RECESSIVE PHENOTYPE

16% of a population shows a recessive phenotype (aa). Population size = 500.

STEP 1

$q^2 = 0.16 \rightarrow q = 0.40$

The recessive phenotype directly gives the aa frequency.

STEP 2

$p = 1 - q = 0.60$

The two allele frequencies must add to one.

AA

$p^2 = 0.36$

0.36 x 500 = 180

Aa

$2pq = 0.48$

0.48 x 500 = 240

aa

$q^2 = 0.16$

0.16 x 500 = 80

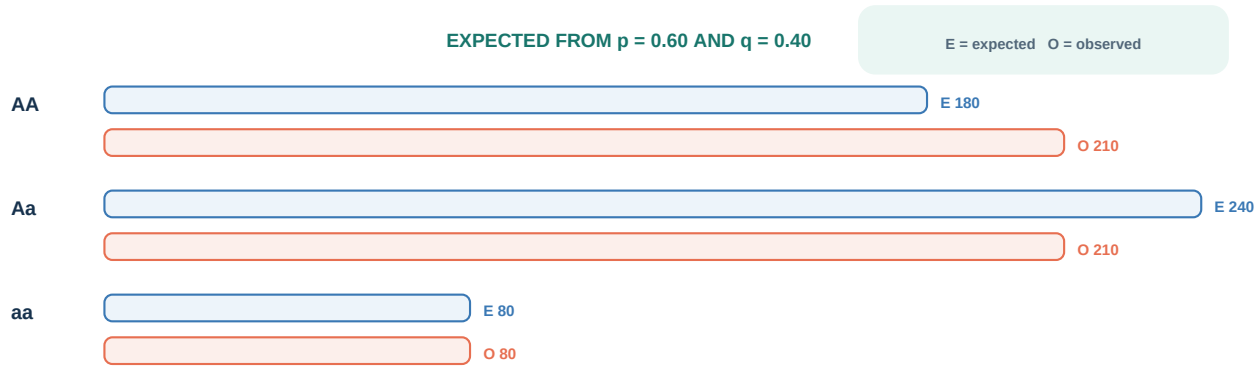
Check: 0.36 + 0.48 + 0.16 = 1.00, and 180 + 240 + 80 = 500.

2

Observed data test the model's prediction

A mismatch means at least one assumption may be violated. The comparison alone does not identify which evolutionary process caused it.

EXPECTED VS OBSERVED GENOTYPE COUNTS (N = 500)



INTERPRETATION

The observed counts differ from the null-model prediction, so one or more Hardy-Weinberg conditions may not hold. More evidence is needed to identify the cause.

WHAT COULD BREAK EQUILIBRIUM?

NATURAL SELECTION

Genotypes differ in survival or reproduction.

GENETIC DRIFT

Chance has a strong effect in a small population.

MUTATION OR GENE FLOW

Alleles are created, enter, or leave the population.

NONRANDOM MATING

Mate choice changes genotype proportions.

COMMON ERROR

The heterozygote frequency is 2pq, not pq. Either allele can come from either parent, producing two equivalent combinations.

FINAL MAP

Calculate the prediction -> compare with observations -> reject or retain the null model -> investigate the mechanism.