Hardy-Weinberg Equilibrium (HWE)

Introduction to Evolution and Scientific Inquiry

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Major question: Is a population evolving?

- We say populations are in equilibrium when they do not change over time

- One option: Monitor the population over multiple generations and directly ask if allele frequencies and/or "average trait values" have changed

- Other option: Ask if the population is in **Hardy-Weinberg Equilibrium**
  - A "null hypothesis" of evolution

Hardy-Weinberg Equilibrium (HWE): A null model

- When a population is in HWE, allele frequencies DO NOT CHANGE over generations, and hence the population is not evolving.

- A population is in *HWE* if:
  - There is **random mating**
  - There is **no selection**
  - There is **no mutation**
  - There is **no genetic drift**
  - There is **no migration**

- **Key point:** If a population is in HWE, we can directly predict genotype frequencies from allele frequencies!
  - We only need a "snapshot" in time of the population to ask if it is evolving

Is my population evolving or in HWE?

- If **HWE-expected** genotype frequencies **match** the **observed frequencies** (actual given data), the population is in HWE

- If **HWE-expected** frequencies are **very different** from **observed frequencies**, the population is evolving

Testing for HWE with the χ^2 test ("keye - squared")

- Calculate the *allele frequencies* observed in a population

***p* + *q* = 1**
p = observed frequency of "A"
q = observed frequency of "a"

- Calculate the *HWE-expected genotype frequencies*

$p^2 + 2pq + q^2 = 1$
p^2 = HWE genotype AA frequency
2pq = HWE genotype Aa frequency
q^2 = HWE genotype aa frequency

- Compare what is expected under HWE to what we actually see, using *genotype COUNTS*

$$X^2 = \sum \frac{(o-e)^2}{e}$$

Calculating the test statistic, χ^2

$$X^2 = \sum \frac{(o-e)^2}{e}$$

- Calculate χ^2 using ***genotype COUNTS (not frequencies!!!)***
  - **o = observed value**
  - **e = expected value**
- Add up $(o-e)^2/e$ for each p^2, $2pq$, q^2 (three things to add!)

- Determine the P-value from the calculated χ^2 (*This P is NOT the same as* "p+q=1")

- If the P-value = 0.05, there is a 5% chance the genotypes in the population are caused by HWE. Since 5% is pretty low, we make the logical leap that probably HWE is not the cause, and something else is. That "something else" is evolution.

How to make your statistical conclusions. You should use these EXACT WORDS

- **$p > 0.05 \rightarrow$ not significant**
  - **$\chi^2 < 3.841$**
  - There is no evidence that the population is evolving. The population may be under Hardy-Weinberg equilibrium.

- **$p <= 0.05 \rightarrow$ significant**
  - **$\chi^2 > 3.841$**
  - There is evidence that the population is evolving. We reject the null hypothesis that the population is under Hardy-Weinberg equilibrium.