

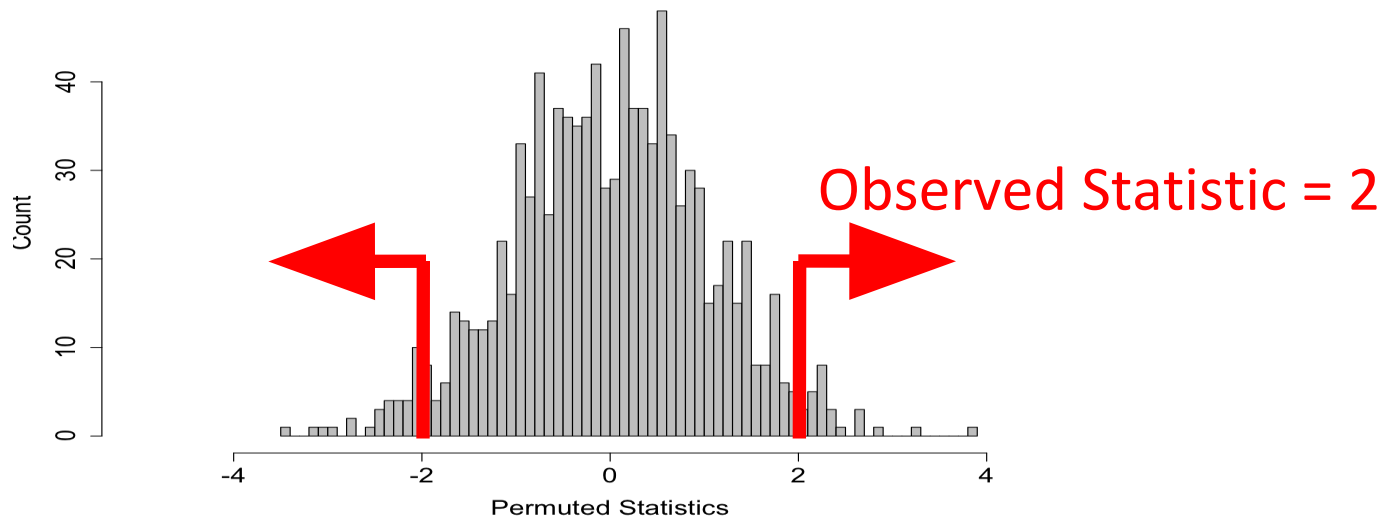
# Multiple testing

Jeff Leek

@jtleek

P-values

# how to calculate

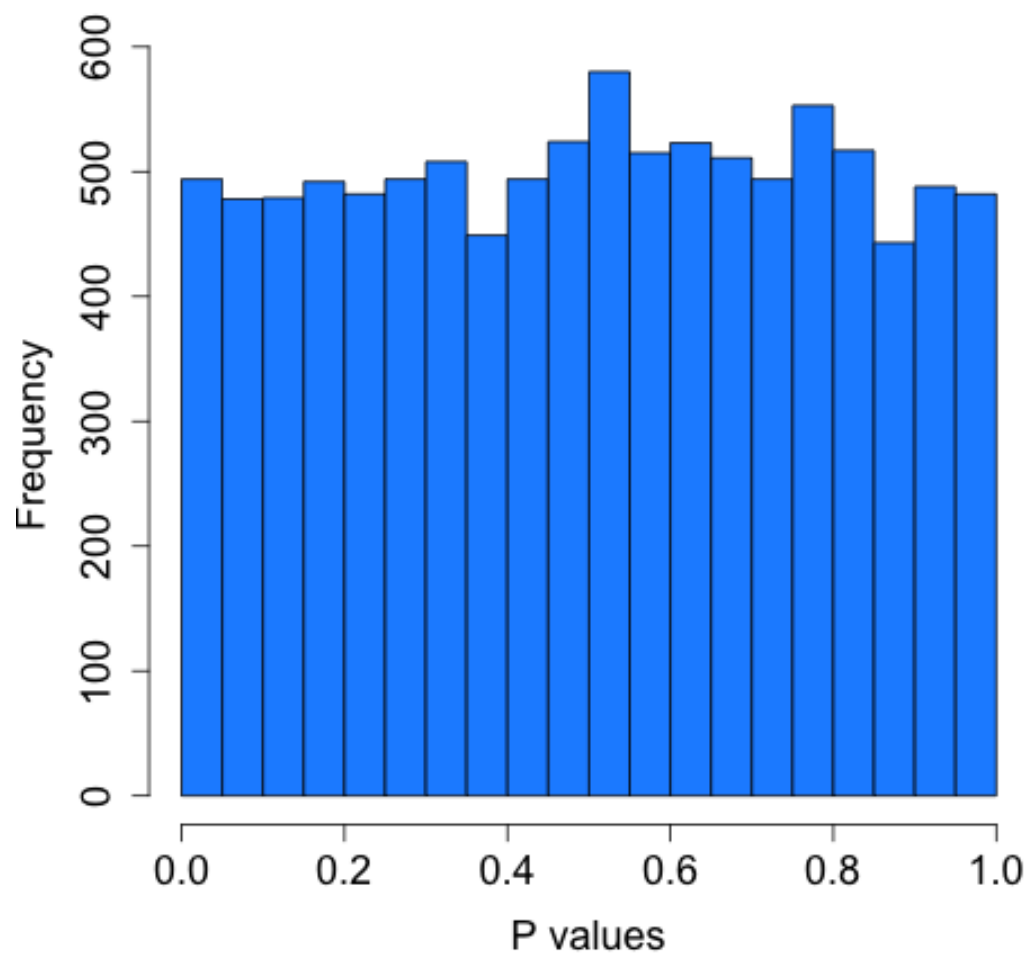


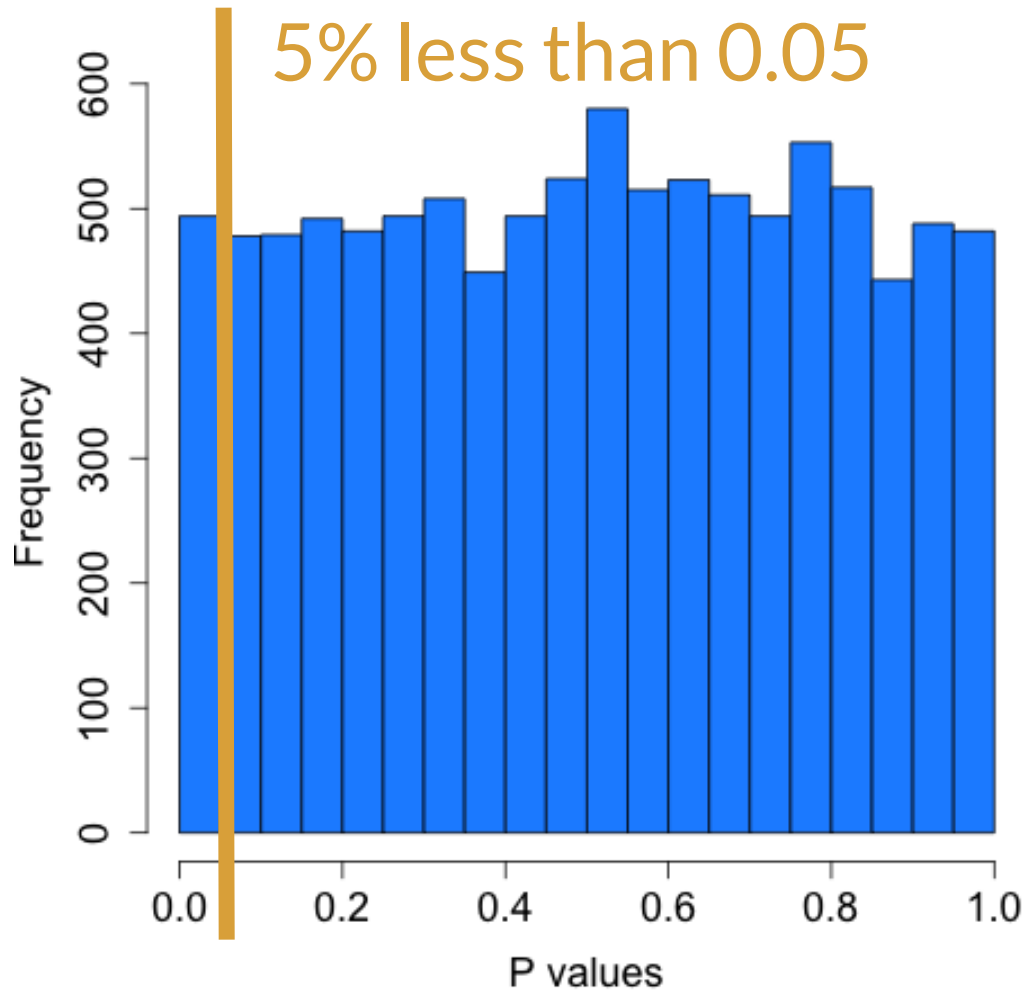
$$\frac{\{ \# \mid S^{perm} \mid \geq \mid S^{obs} \mid \}}{\text{# of Permutations}}$$

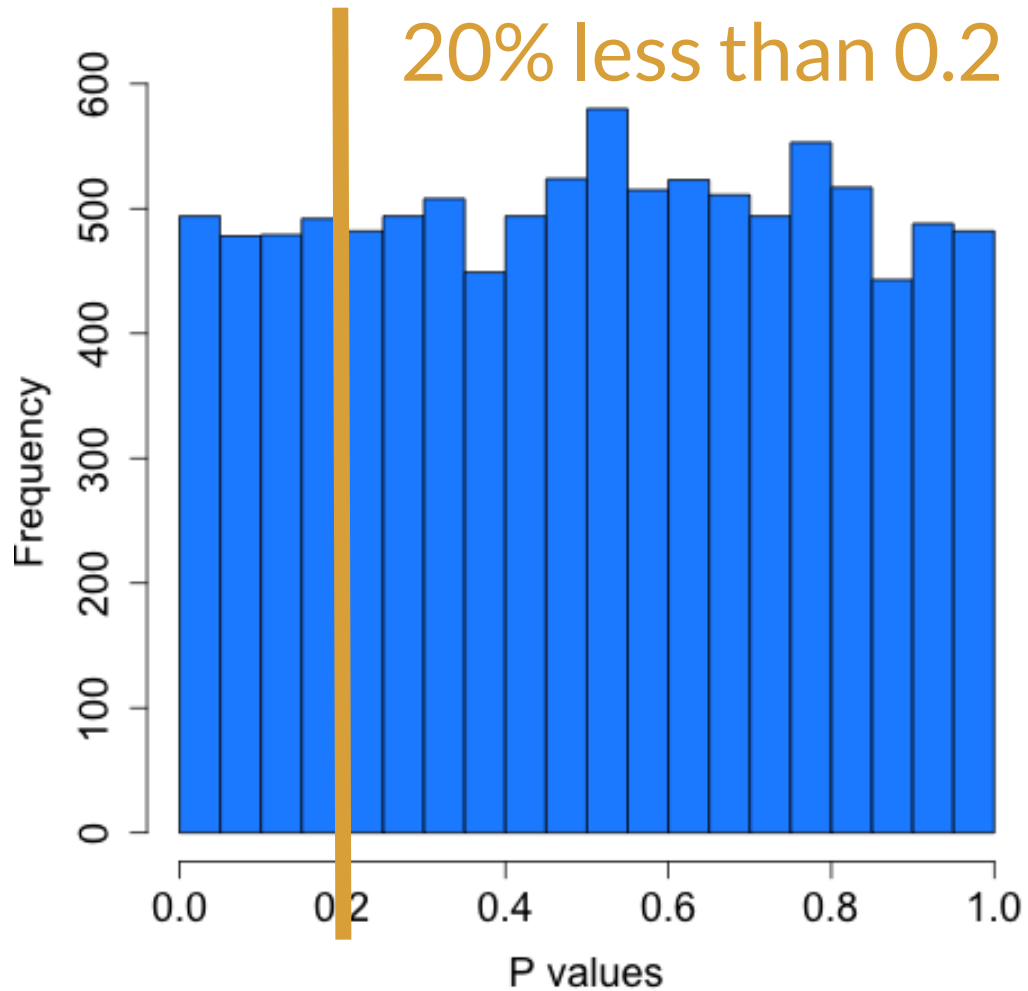
P-value =

# of Permutations

P-values are uniformly distributed  
when nothing is happening “the null”







What is the problem with multiple testing?

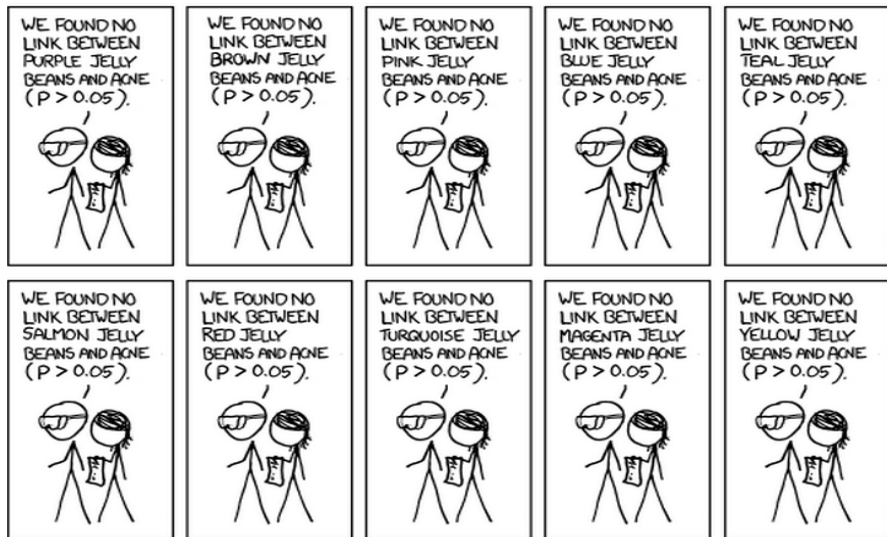
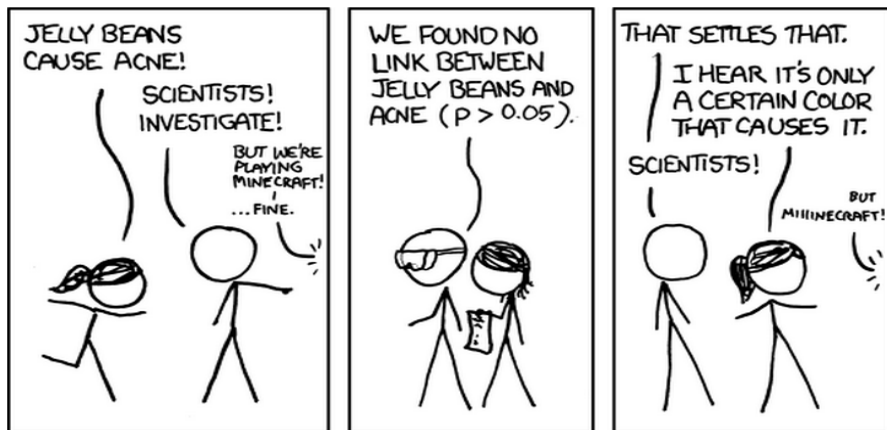


JELLY BEANS  
CAUSE ACNE!

SCIENTISTS!  
INVESTIGATE!

BUT WE'RE  
PLAYING  
MINECRAFT!  
... FINE.





# News

## GREEN JELLY BEANS LINKED TO ACNE!

95% CONFIDENCE

ONLY 5% CHANCE  
OF COINCIDENCE!



SCIENTISTS...

# Error rates

- Family wise error rate:

$$\Pr(\# \text{ False Positives} \geq 1)$$

- False discovery rate:

$$E \left[ \frac{\# \text{ False positives}}{\# \text{ Total Discoveries}} \right]$$

# Interpretation

Suppose 550 out of 10,000 genes are significant at 0.05 level

P-value < 0.05

Expect  $0.05 * 10,000 = 500$  false positives

False Discovery Rate < 0.05

Expect  $0.05 * 550 = 27.5$  false positives

Family Wise Error Rate < 0.05

The probability of at least 1 false positive  $\leq 0.05$

**The inevitable**



**$P > 0.05$**

**GAME OVER, TRY AGAIN**

## **Subject: A curse on you and your progeny!!!**

Ingo:

Curse you, Ingo! Yet another disappearing act!

The association between flame broiled food consumption and breast cancer disappears in the imputed dataset (see below). I'm beginning to hate this imputation stuff! I much prefer biased data. The findings are more interesting (and more publishable).

**Beware of statistics “hacking”**

# **False-Positive Psychology: Undisclosed Flexibility in Data Collection and Analysis Allows Presenting Anything as Significant**

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