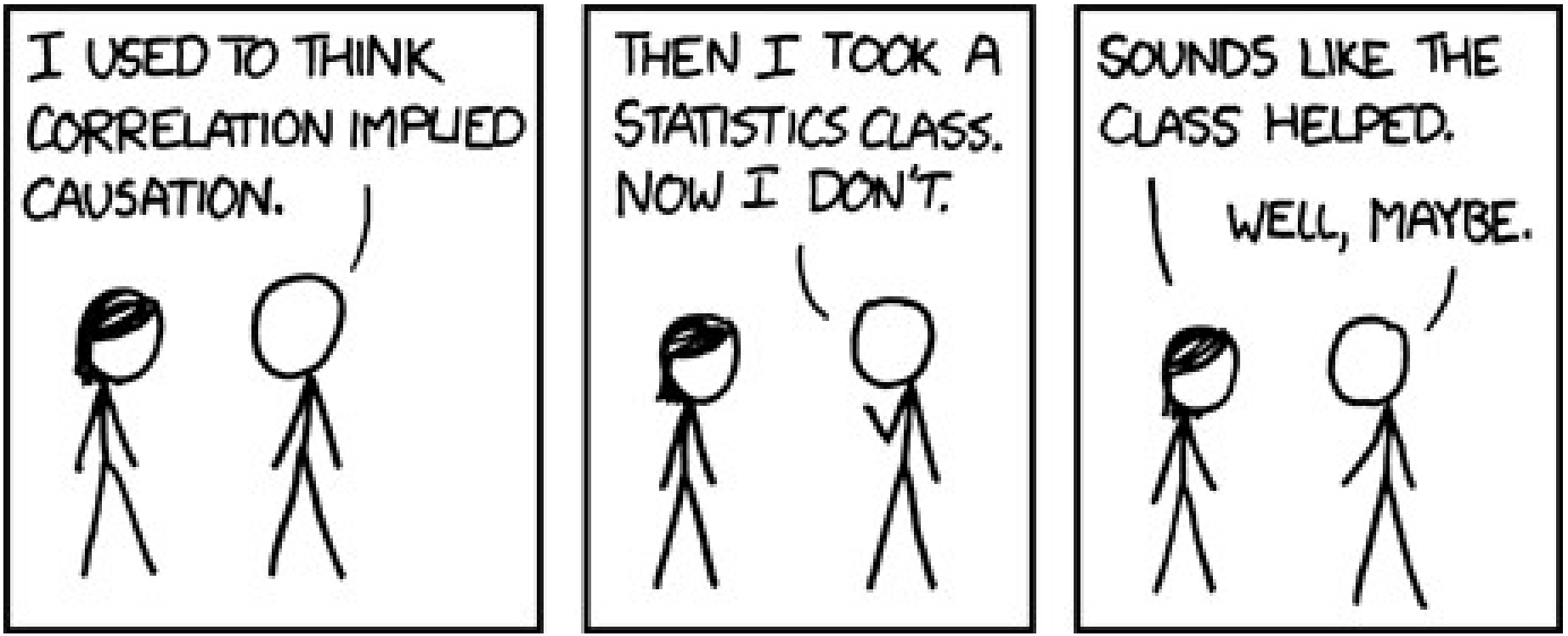
Analyzing Data and Statistics



xkcd.com

Most statistical work can be done, and more easily done, by computer using programs such as:

MS Excel

Open Office

SPSS

SAS

Most statistical work can be done, and more easily done, by computer using programs such as:

MS Excel is the most common.

Available from UT for cheap, ~$30.

If you have not used it, start practicing now.

Most statistical work can be done, and more easily done, by computer using programs such as:

Open Office is a free alternative.

If you have not used it, start practicing now.

The Basics:
Mean, median, and mode

Mean- aka the average.

Sum of all numbers divided by the number of data points.

$(14+17+7+6+4+11+8)/7 = 9.57$

Median- the middle number of a group of ordered numbers

1 17 7 6 4 11 8

4 6 7 8 11 14 17 median is 8

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2 6 7 8 11 14 17 median is 8

What about 4 6 7 11 14 17?

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1 17 7 6 4 11 8

2 6 7 8 11 14 17 median is 8

What about 4 6 7 11 14 17?

Median is 9.

Mode- the most common value in a group.

9, 8, 3, 4, 5, 2, 4, 5, 2, 3, 6, 1, 6, 2, 3, 9, 2, 6

Mode is 2

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The mean is the most common form of analysis.

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The mean is the most common form of analysis.
2, 3, 2, 4, 2, 7, 2, 5, 3, 2, 5, 4, 3, 5, 6, 121, 130

Mean = 18

Why are there 3 ways to analyze a group of numbers?

2, 3, 2, 4, 2, 7, 2, 5, 3, 2, 5, 4, 3, 5, 6, 121, 130

Mean = 18

Is this an accurate representation of these numbers?

Why are there 3 ways to analyze a group of numbers?

2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7, 121, 130

Median = 4

Mean = 18

Median can be more accurate when there are a few especially large or small numbers.

What is your favorite color?

What is your favorite color?

Mode can be used with non-numerical data.

Is there a numerical way to determine the accuracy of our analysis?

2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7, 121, 130

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Mean = 18

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Standard Deviation is a measure of variability.

Standard deviation is a measure of variability. The standard deviation is the root mean square (RMS) deviation of the values from their arithmetic mean.

$$s = \sqrt{\frac{\sum (X - M)^2}{n - 1}}$$

where $\sum$ = Sum of
X = Individual score
M = Mean of all scores
N = Sample size (Number of scores)

(Do not memorize this formula; you will do these calculations via spreadsheet.)

Is there a numerical way to determine the accuracy of our analysis?

2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7, 121, 130

Mean = 18

Standard deviation = 40.5

Standard deviation is a measure of variability.

Is there a numerical way to determine the accuracy of our analysis?

2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7

Mean = 3.67

Standard deviation = 1.6

Standard deviation is a measure of variability.

Is there a numerical way to determine the accuracy of our analysis?

2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7
(121, 130)

Mean = 3.67

Median was 4

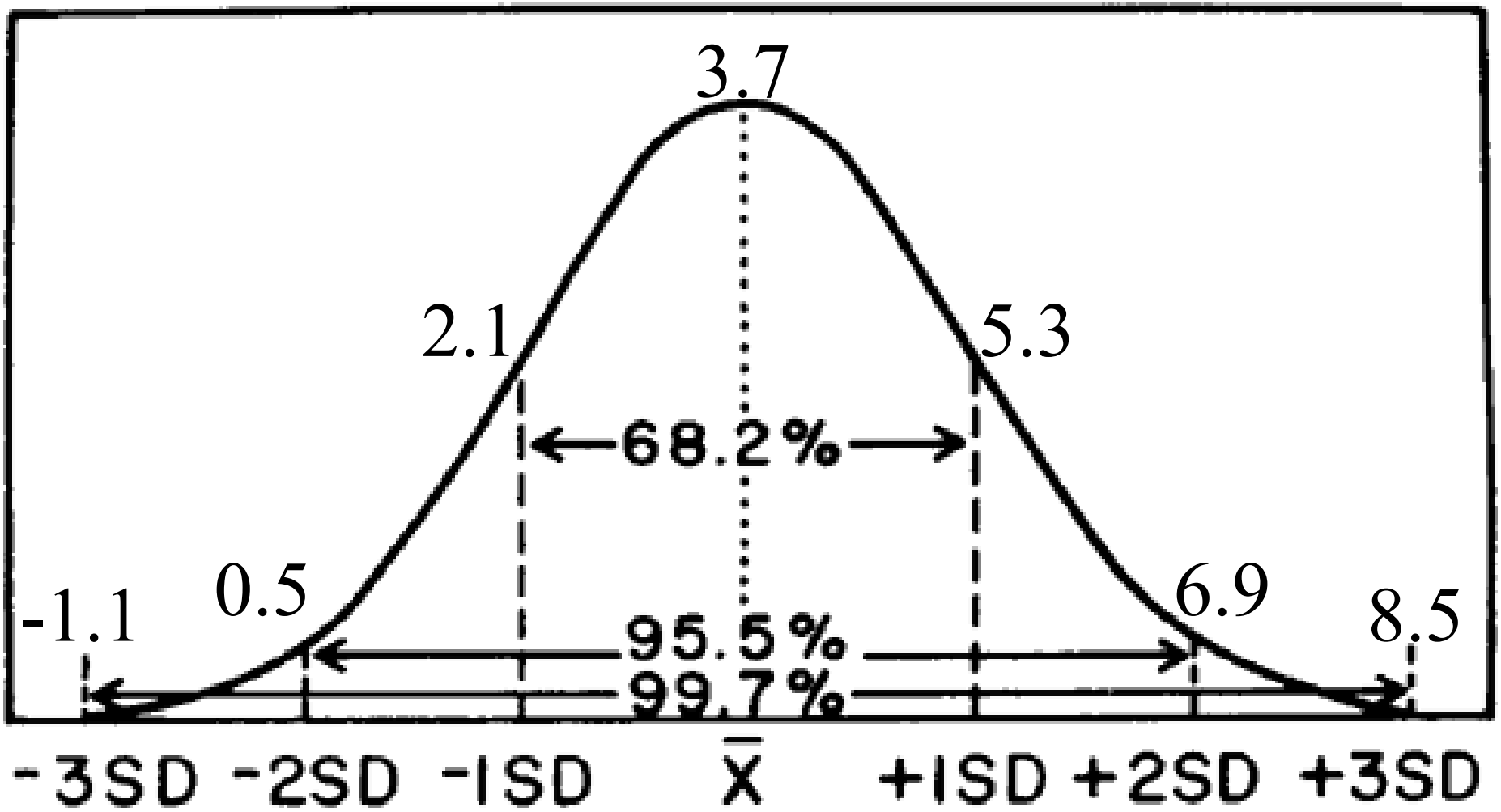
Is there a numerical way to determine the accuracy of our analysis?

2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7

Mean = 3.67 ±1.6

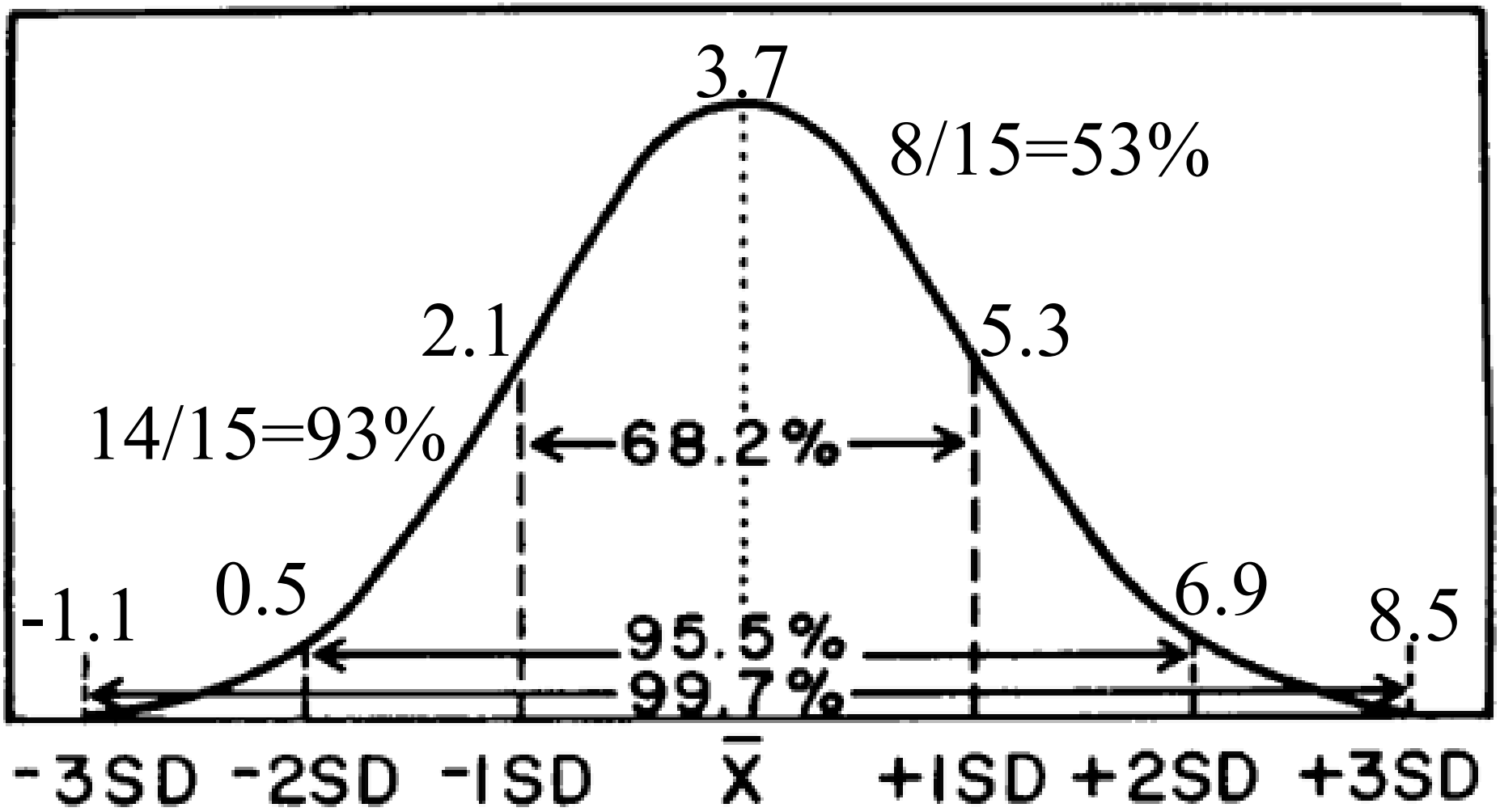
Standard deviation is a measure of variability.

Percent of data at 1, 2, or 3 standard deviations from the mean



http://www.westgard.com/lesson34.htm

2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7



15/15=100%

http://www.westgard.com/lesson34.htm

How significant of a difference is this?

Set 1= 2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7

Mean = 3.67 ±1.6 range = 2.07 to 5.27

And

Set 2= 8, 6, 7, 8, 9, 5, 6, 7, 9, 8, 9, 5

Mean = 7.25 ± 1.48 range = 5.77 to 8.73

The ‘Students’ T-test is a method to assign a numerical value of statistical difference.

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$$T = \frac{|X_1 - X_2|}{\sqrt{\left(\frac{Sx_1}{\sqrt{n_1}}\right)^2 + \left(\frac{Sx_2}{\sqrt{n_2}}\right)^2}}$$

(Do not memorize this formula; you will do these calculations via spreadsheet.)

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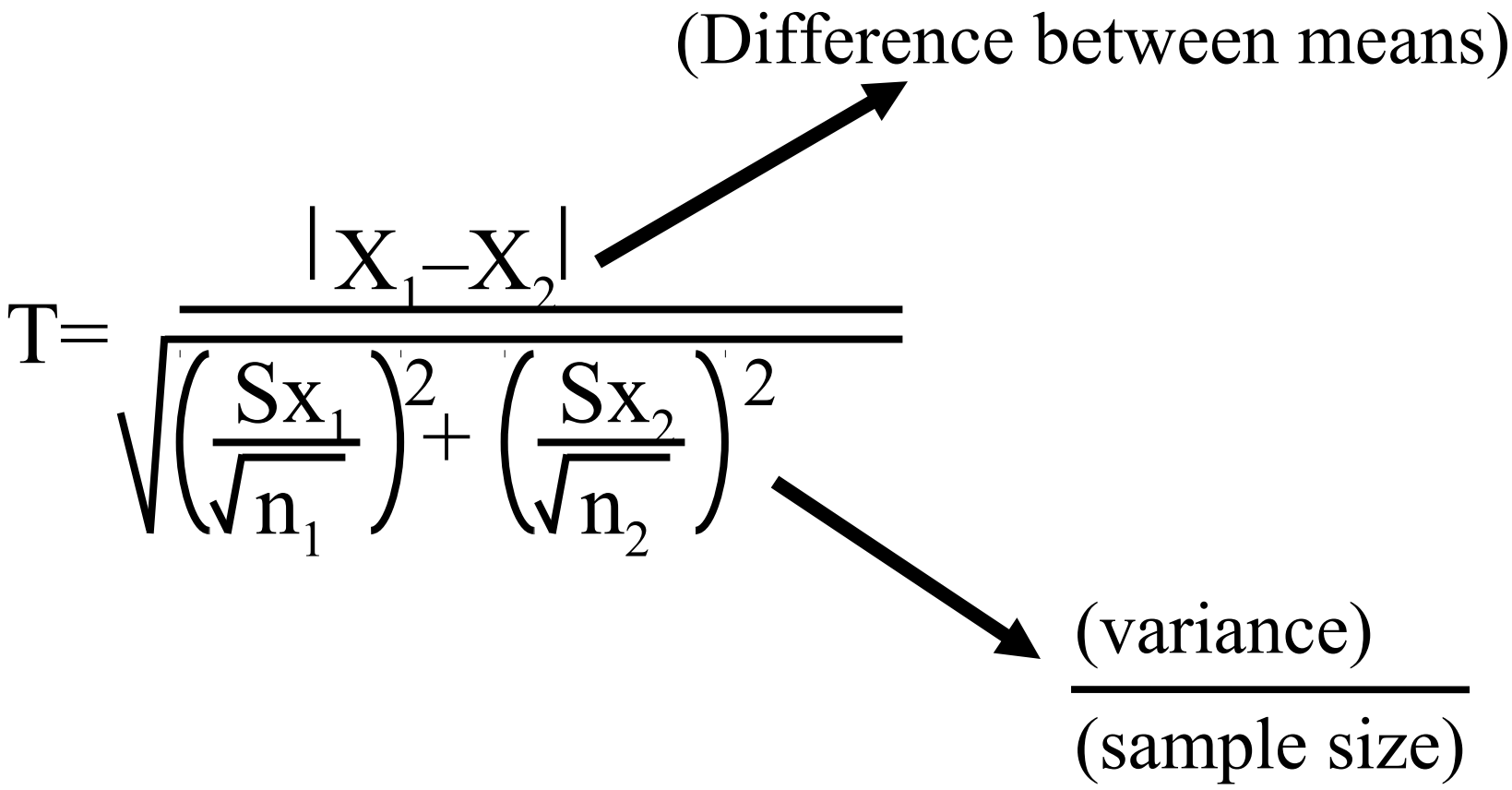

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T is then used to look up the P-value from a table. Also need ‘degrees of freedom’ $= (n_1+n_2)-1$.

Partial table for determining P from T

	P-value		
Df	**0.05**	**0.02**	**0.01**
1	12.71	31.82	63.66
2	4.303	6.965	9.925
3	3.182	4.541	5.841

T

How significant of a difference is this? Using a speadsheet to get a P value = 3.44×10^{-6}.

Set 1= 2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7

Mean = 3.67 ±1.6

And

Set 2= 8, 6, 7, 8, 9, 5, 6, 7, 9, 8, 9, 5

Mean = 7.25 ± 1.48

How significant of a difference is this?

P value = 3.44×10^{-6}. So the chance that these 2 sets of data are **not** significantly different is 3.44×10^{-6}

Set 1= 2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7

Mean = 3.67 ± 1.6

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Set 2= 8, 6, 7, 8, 9, 5, 6, 7, 9, 8, 9, 5

Mean = 7.25 ± 1.48

How significant of a difference is this?

P value = 3.44×10^{-6}. So the chance that these 2 sets of data are significantly different is

$1 - 3.44 \times 10^{-6}$ or 0.999996559

We can be 99.9996559% certain that the difference is statistically significant.

Set 1= 2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7

Mean = 3.67 ±1.6

Set 2= 8, 6, 7, 8, 9, 5, 6, 7, 9, 8, 9, 5

Mean = 7.25 ± 1.48

In this data set, the range of +/- one standard deviation overlaps, but the T-test shows a very significant difference between these sets of numbers.

Set 1= 2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7

Mean = 3.67 ±1.6 range = 2.07 to 5.27

Set 2= 8, 6, 7, 8, 9, 5, 6, 7, 9, 8, 4, 5

Mean = 6.83 ± 1.64 range = 5.19 to 8.47

P-value = 4.41×10^{-5}

Generally a P-value of 0.05 or less is considered a statistically significant difference.

20% random difference : 80% confidence

10% random difference : 90% confidence

5% random difference : 95% confidence

1% random difference : 99% confidence

0.1% random difference : 99.9% confidence

T-test is one valid and accurate method for determining if 2 means have a statistically significant difference, or if the difference is merely by chance.

Outliers…

2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 7, 121, 130

Median = 4

Mean = 18

Outliers: When is data invalid?

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Not simply when you want it to be.

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Not simply when you want it to be.

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$$Q = \frac{|(\text{suspect value} - \text{nearest value})|}{|(\text{largest value} - \text{smallest value})|}$$

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Example: results from a blood test…
789, 700, 772, 766, 777

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$$Q = |(700 - 766)| \div |(789 - 700)|$$

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Example: results from a blood test…
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$$Q = |(700 - 766)| \div |(789 - 700)| = 0.742$$

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Dixon's Q test can determine if a value is statistically an outlier.

Example: results from a blood test…
789, 700, 772, 766, 777

$$Q = |(700 - 766)| \div |(789 - 700)| = 0.742$$ **So?**

$$Q = \frac{|(\text{suspect value} - \text{nearest value})|}{|(\text{largest value} - \text{smallest value})|}$$

You need the critical values for Q table:

Sample #	Q critical value
3	**0.970**
4	**0.831**
5	**0.717**

If Q calc > Q crit rejected

From: E.P. King, J. Am. Statist. Assoc. 48: 531 (1958)

You need the critical values for Q table:

Sample #	Q critical value
3	**0.970**
4	**0.831**
5	**0.717**

If Q calc > Q crit than the outlier can be rejected

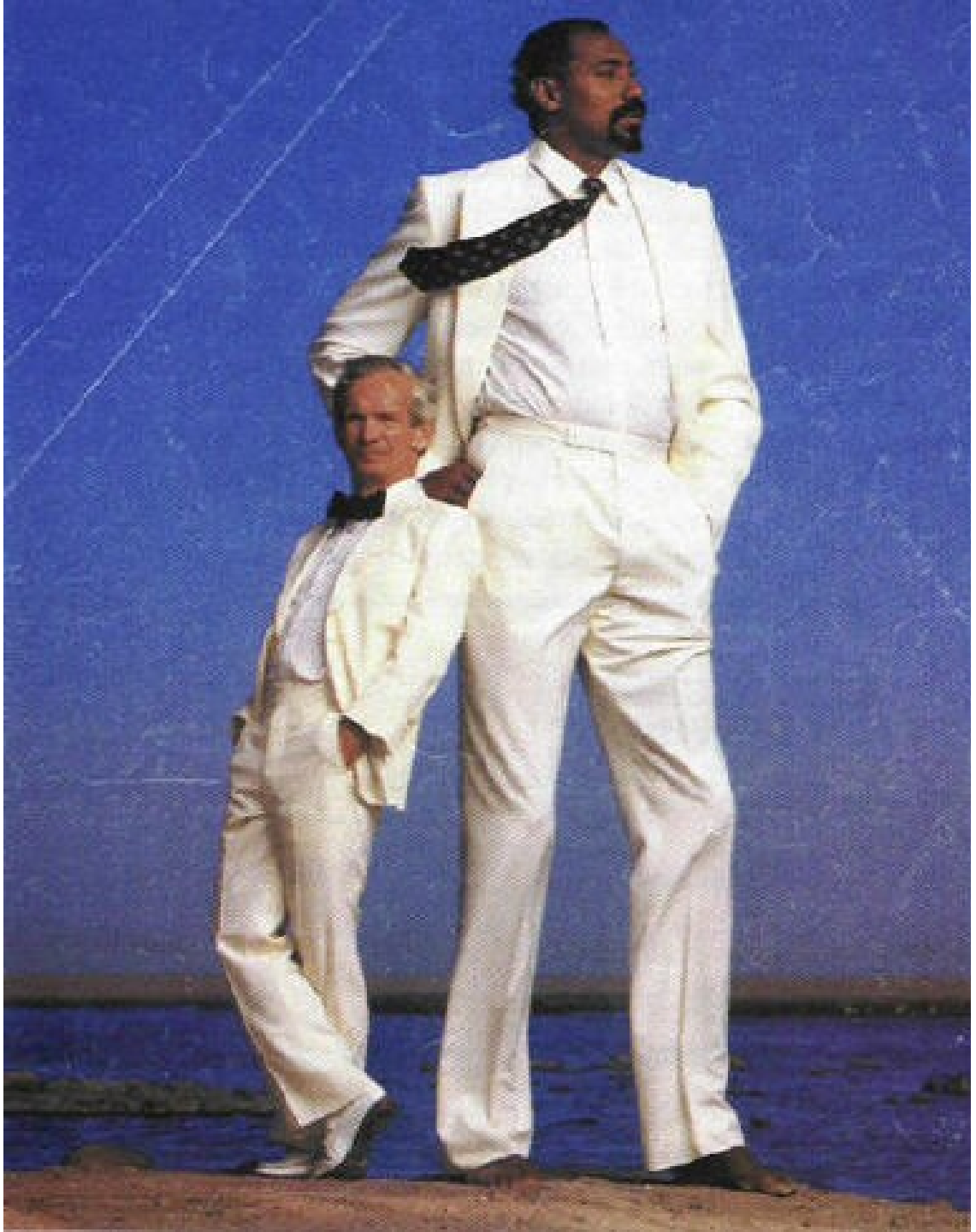
Q calc = 0.742

Q crit = 0.717

= rejection

From: E.P. King, J. Am. Statist. Assoc. 48: 531 (1958)

What can outliers tell us?

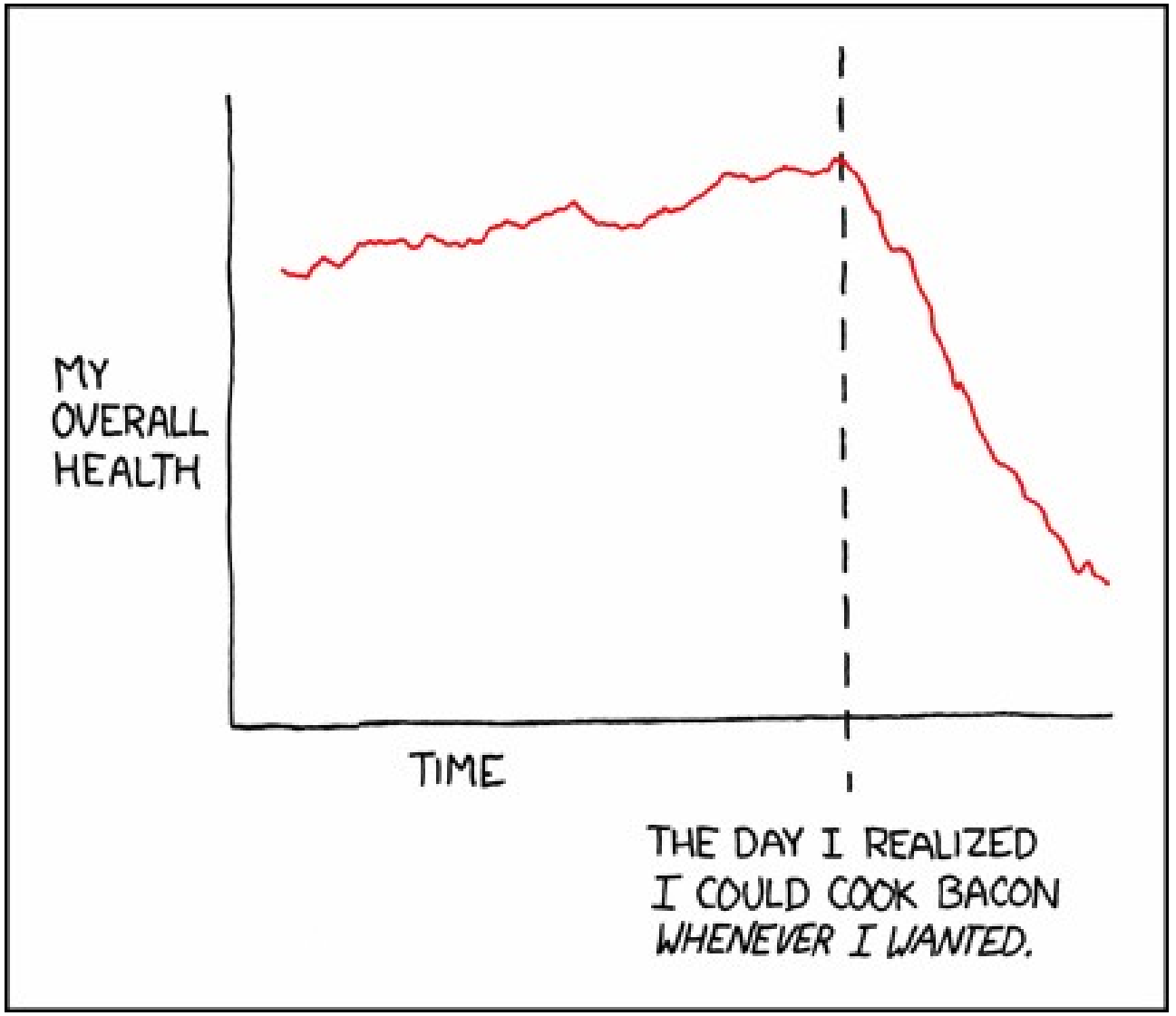


If you made a mistake, you <u>should have</u> already accounted for that.

Outliers can lead to important and fascinating discoveries.

Transposons "jumping genes" were discovered because they did not fit known modes of inheritance.

What about relating 2 variables?



XKCD.com

What about relating 2 variables?

R^2 gives a measure of fit to a line.

If $R^2 = 1$ the data fits perfectly to a straight line

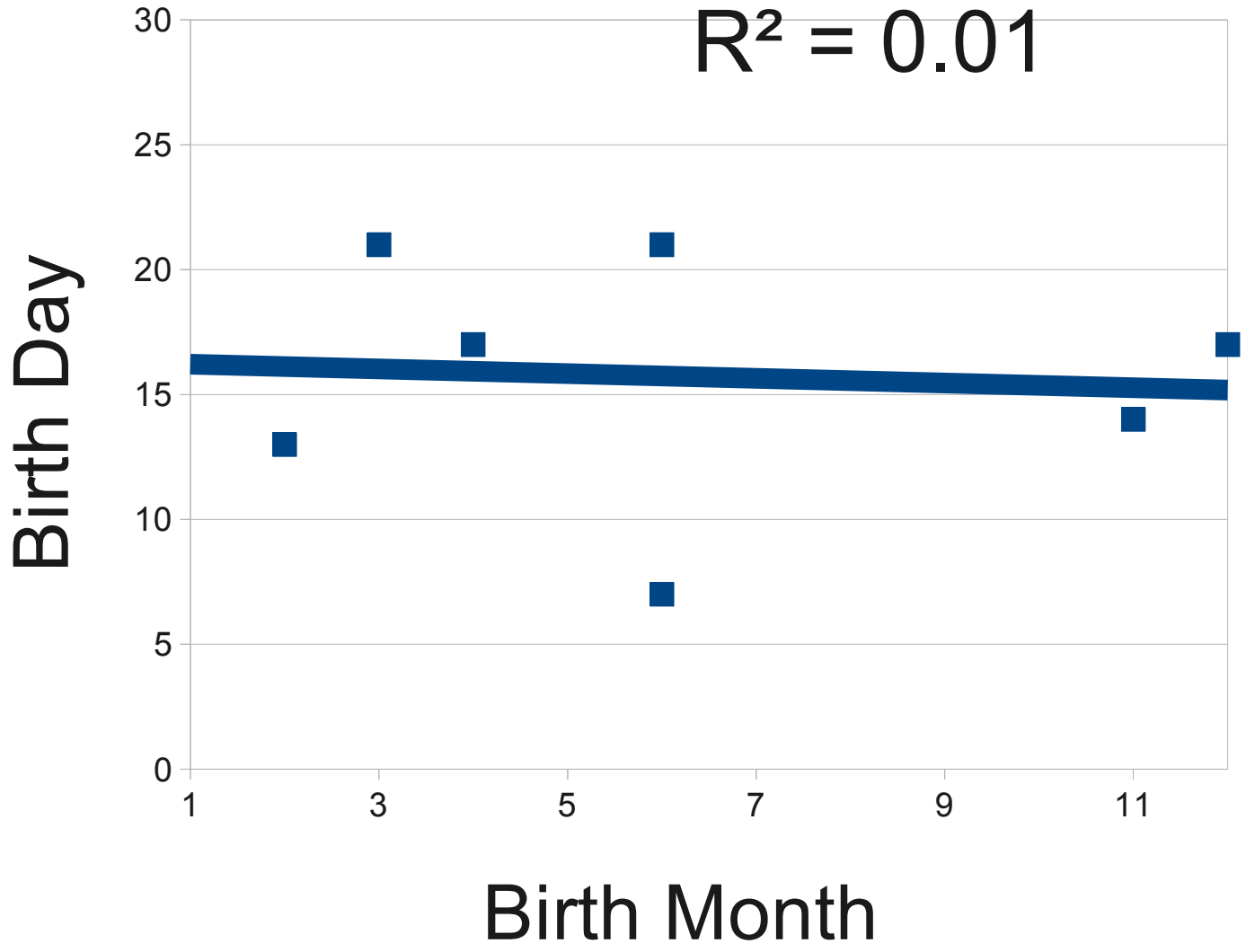
If $R^2 = 0$ there is no correlation between the data

R^2 gives a measure of fit to a line.

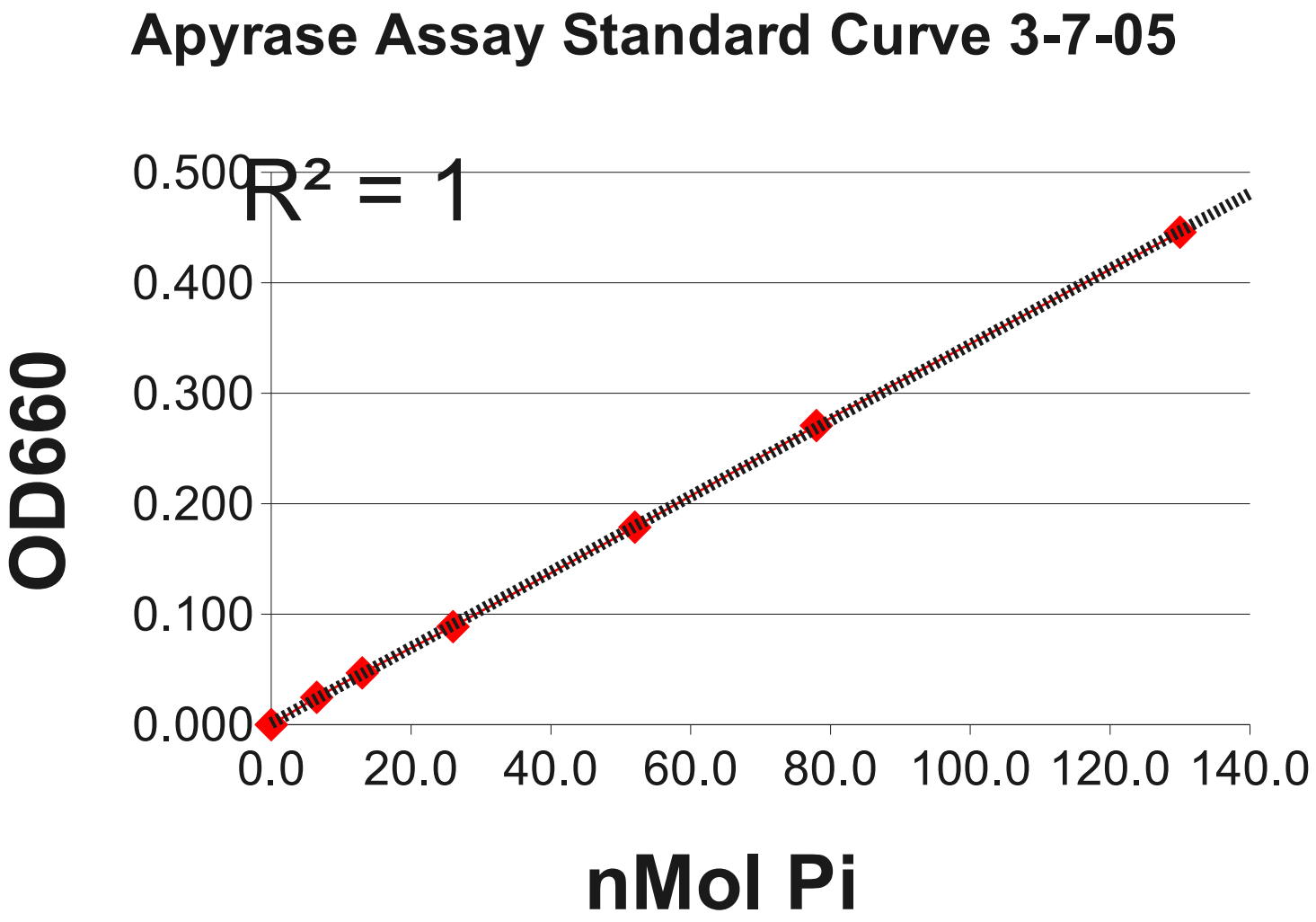
birth month vs birth day

4	17
11	14
6	7
12	17
2	13
6	21
3	21

birth month vs birth day



phosphate quantity vs absorbance



What about relating 2 variables?

- **To use R^2 the data must be continually variable...**

R^2 gives a measure of fit to a line.

If $R^2 = 1$ the data fits perfectly to a straight line

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Samples vs populations

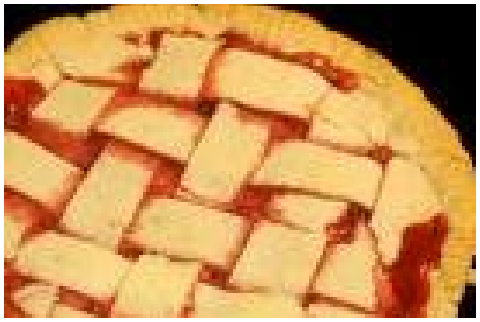








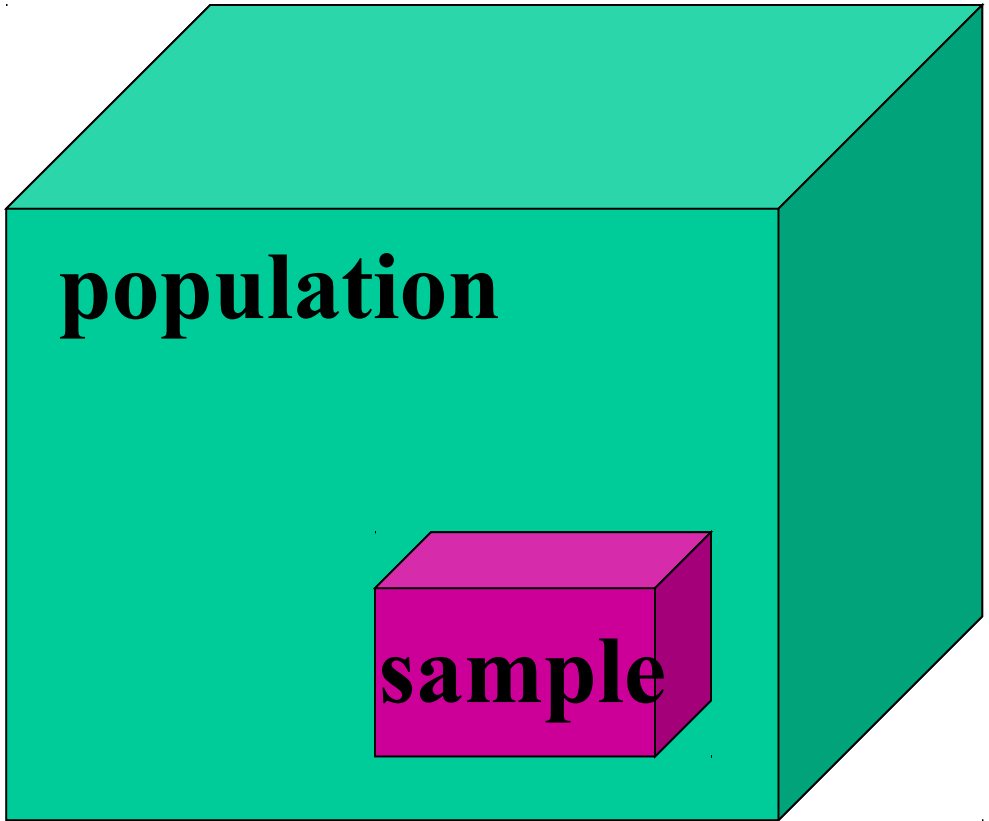





Samples vs populations

Population- everything or everyone about which information is sought

Sample- a subset of a population (that is hopefully representative of the population)



Population-

- U.S. census
- Dogs
- 1 – infinity

Sample-

- Travis county
- Poodles
- Prime numbers

Why use a sample instead of a population?

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- Logistics

Why use a sample instead of a population?

- Logistics
- Cost

Why use a sample instead of a population?

- Logistics
- Cost
- Time

Samples:

Random- each member of population has an equal chance of being part of the sample.

or

Representative- ensuring that certain parameters of your sample match the population.

Replicates:

Technical vs Experimental

Technical replicate- one treatment is divided into multiple samples.

Experimental replicate- different, replicate, treatments are done to different samples.

Testing blood sugar levels after eating a Snickers:

Testing blood sugar levels after eating a Snickers:

Divide a participants blood into 3 samples and test blood sugar in each sample.

Technical or Experimental replicate?

Testing blood sugar levels after eating a Snickers:

Test 3 different people.

Technical or Experimental replicate?

Testing blood sugar levels after eating a Snickers:

Test the same person on 3 different days.

Technical or Experimental replicate?

What sample size do you need?

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It depends on the error you expect.

To determine an appropriate sample size, you need to estimate a few parameters.

- Means
- Standard Deviation

- Power:

The probability that an experiment will have a significant (positive) result, that is have a p-value of less than the specified significance level (usually 5%).

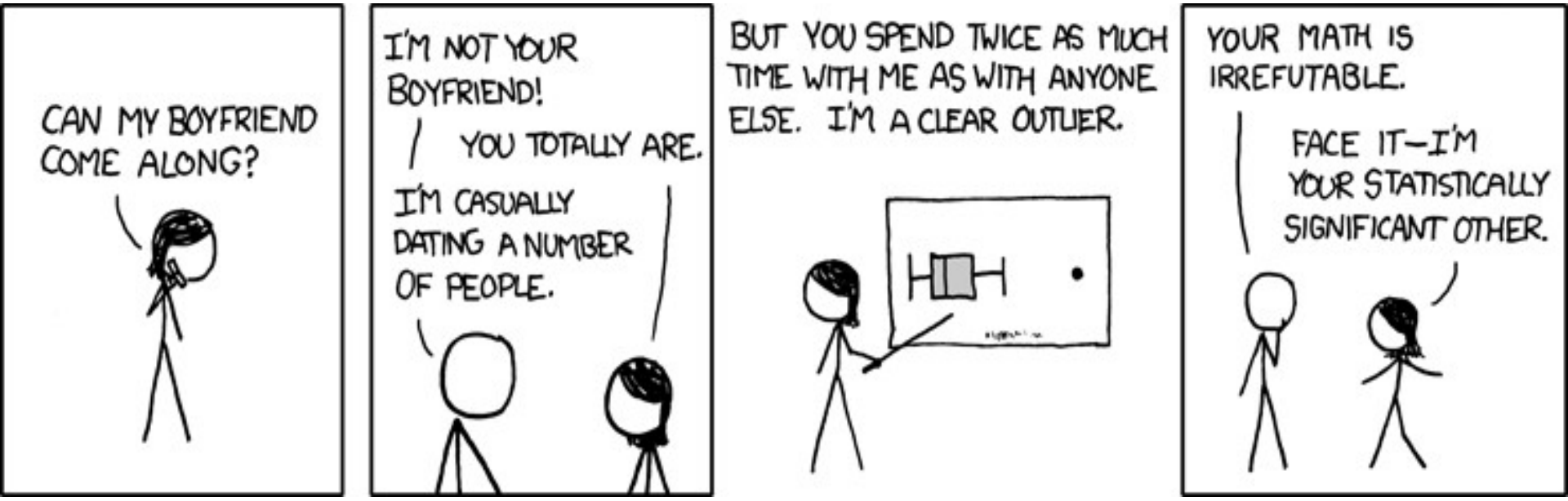
This calculator will help you determine the appropriate sample size:

http://www.stat.ubc.ca/~rollin/stats/ssize/n2.html

What sample size do you need?

It depends on the error you expect.

(So it is impossible to predict with 100% accuracy before the experiment is carried out.)


CAN MY BOYFRIEND COME ALONG?
I'M NOT YOUR BOYFRIEND!
YOU TOTALLY ARE.
I'M CASUALLY DATING A NUMBER OF PEOPLE.
BUT YOU SPEND TWICE AS MUCH TIME WITH ME AS WITH ANYONE ELSE. I'M A CLEAR OUTLIER.
YOUR MATH IS IRREFUTABLE.
FACE IT—I'M YOUR STATISTICALLY SIGNIFICANT OTHER.

xkcd.com