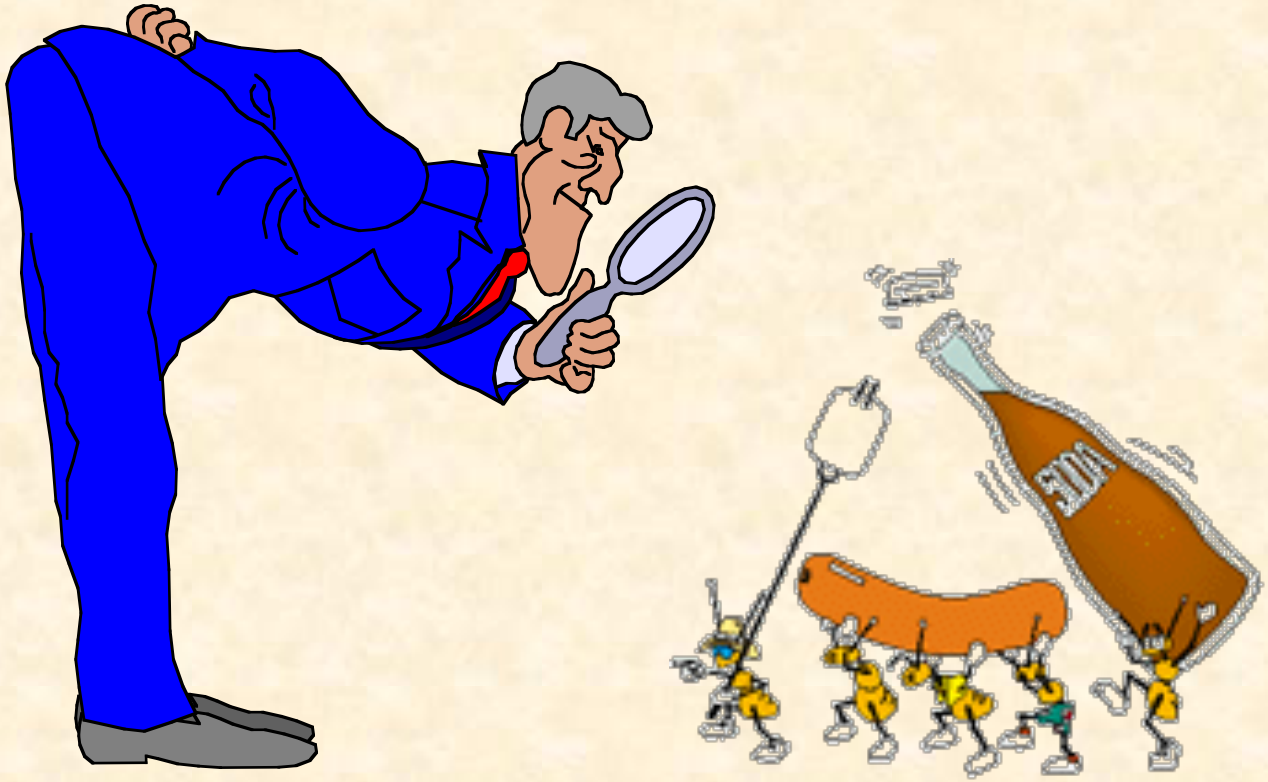
STATISTICS
For Research

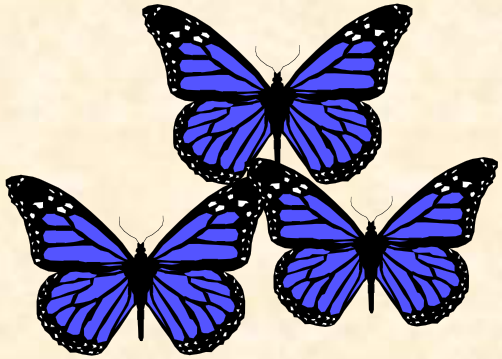
A Researcher Can:

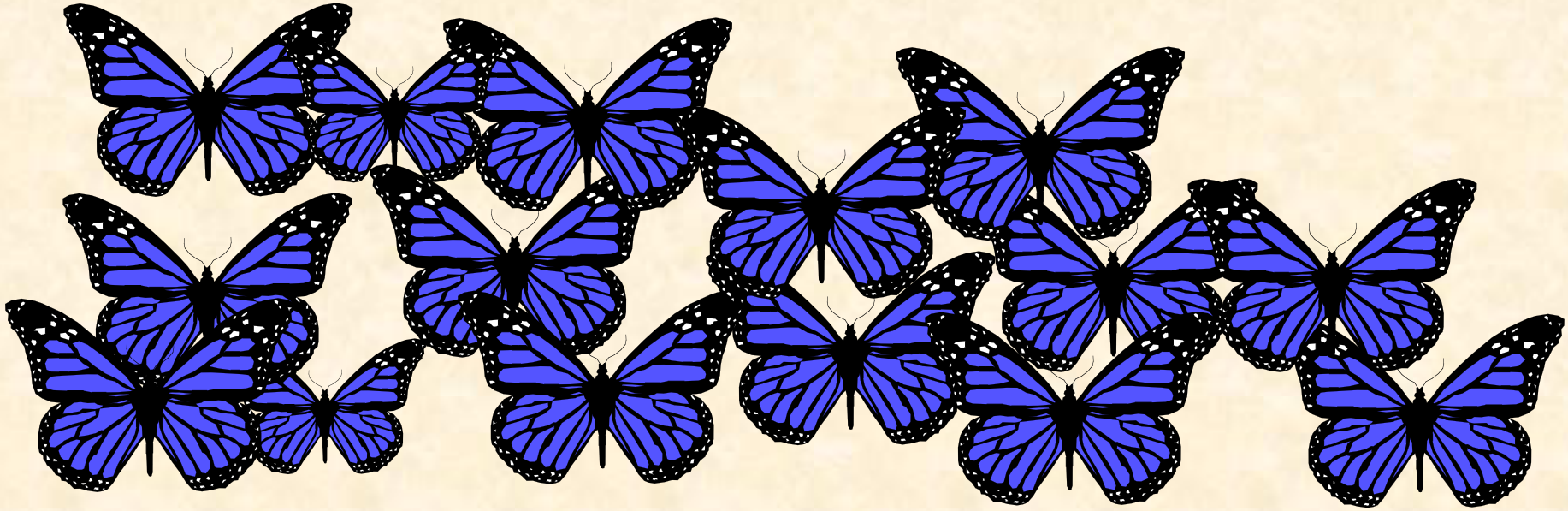
1. *Quantitatively* describe and summarize data



A Researcher Can:

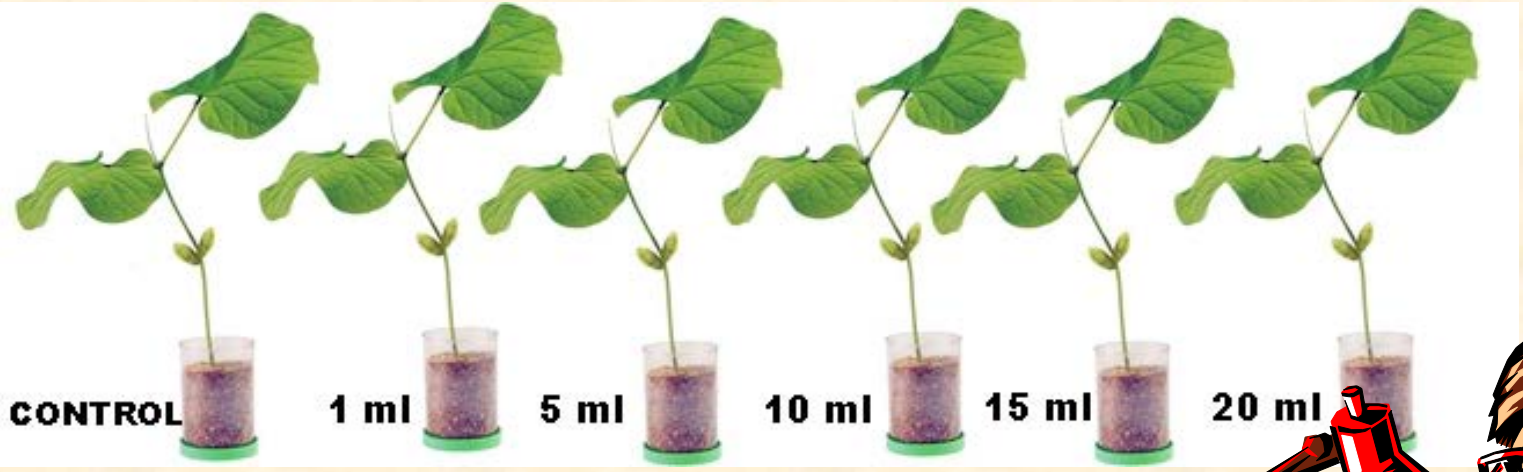
2. Draw conclusions about large sets of data by sampling only *small portions of them*

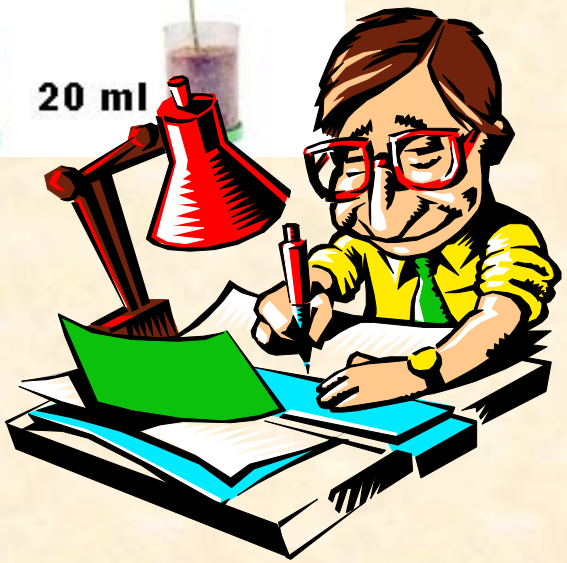




A Researcher Can:

3. *Objectively* **measure differences** and relationships between sets of data.





Random Sampling

- Samples should be taken at ***random***
- Each measurement has an ***equal opportunity*** of being selected
- Otherwise, sampling procedures may be ***biased***

Sampling Replication

- A characteristic CANNOT be estimated from a single data point

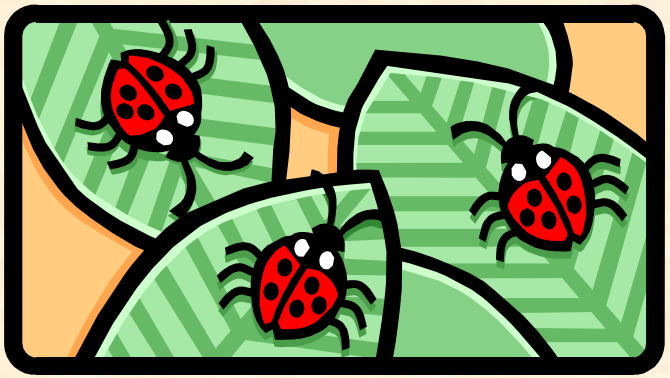
- ***Replicated*** measurements should be taken, at least 10.

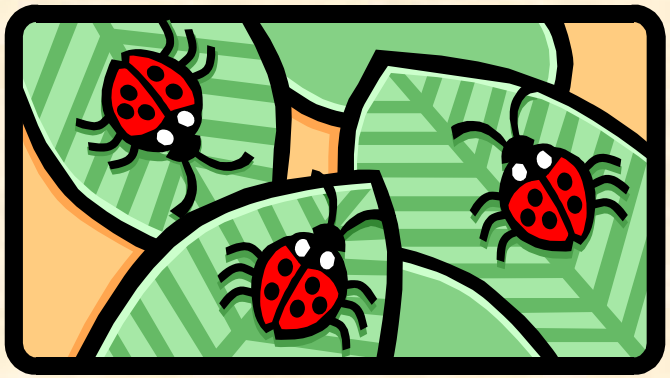
Mechanics

1. ***Write down a formula***
2. ***Substitute numbers into the formula***
3. ***Solve for the <u>unknown</u>.***

The Null Hypothesis

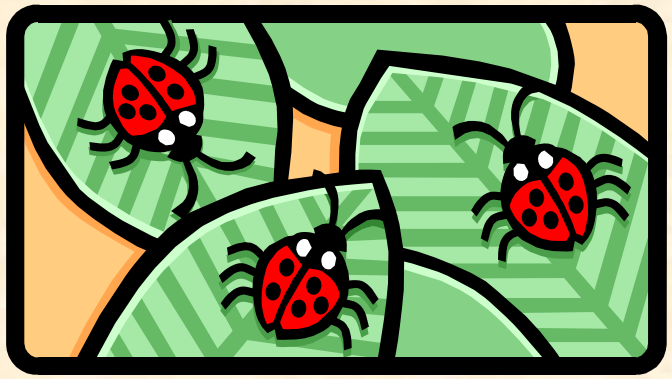
- H_o = There is no difference between 2 or more sets of data
  - any difference is due to chance alone
  - Commonly set at a probability of 95% ($P \leq .05$)

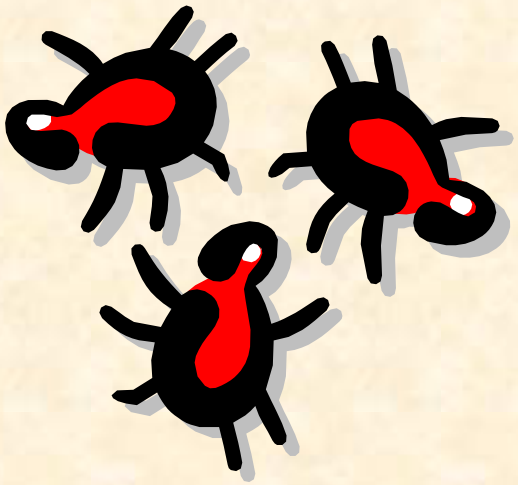




The Alternative Hypothesis

- H_A = There <u>is</u> a difference between 2 or more sets of data
  - the difference is due to more than just chance
  - Commonly set at a probability of 95% ($P \leq .05$)





Perform Comparative Tests

- **Averages/ Population Means** — Jr. Div
- **Standard Deviation** — Jr. Div
  - Deviation of data *from their mean.*
- **% Error** — Jr. Div
  - Deviation from a predicted result
- **T-test**
  - For data sets that follow normal distribution
- **Chi Square**
  - Comparing data in % form in 2+ categories
- **Diversity Indices**
  - Compares species diversity and dominance between different communities
- **Mann-Whitney U test**
  - Differences in two sets of data by examining a sample of data from each population

Averages/ Means

- **Population Average = mean (x)**
- **<u>Population *mean*</u> = (χ)**
  - **take the mean of a *random sample* from the population (n)**

"Add the numbers, divide by how many numbers you've added and there you have it-the average amount of minutes you sleep in class each day."

Population Means

To find the population mean (χ),

- add up (Σ) the values

  (x = grasshopper mass, tree height)

- divide by the number of values

  (n):

$$\chi = \frac{\Sigma x}{n}$$

Measures of Variability

- Calculating a mean gives only a *partial* description of a set of data
  - Set A = 1, 6, 11, 16, 21
  - Set B = 10, 11, 11, 11, 12
    - Means for A & B ??????

- *Need a measure of how variable the data are.*

Range

- <u>Difference</u> between the largest and smallest values
  - Set A = 1, 6, 11, 16, 21
    - Range = ???
  - Set B = 10, 11, 11, 11, 12
    - Range = ???

Standard Deviation

Standard Deviation

- **A measure of the deviation of data *<u>from their mean.</u>***

The Formula

$$SD = \sqrt{\frac{N \sum X^2 - (\sum X)^2}{N(N-1)}}$$

SD Symbols

SD = Standard Dev

$\sqrt{}$ = Square Root

$\sum X^2$ = Sum of x^2' d

$\sum (X)^2$ = Sum of x's, then squared

N = # of samples

The Formula

$$SD = \sqrt{\frac{N \sum X^2 - (\sum X)^2}{N(N-1)}}$$

X	X^2
297	88,209
301	90,601
306	93,636
312	97,344
314	98,596
317	100,489
325	105,625
329	108,241
334	111,556
350	122,500
$\Sigma X = 3{,}185$	$\Sigma X^2 = 1{,}016{,}797$

$$\text{standard deviation} = \sqrt{\frac{N\sum X^2 - (\sum X)^2}{N(N-1)}} = \sqrt{\frac{10(1{,}093{,}597) - (3185)^2}{10(10-1)}}$$

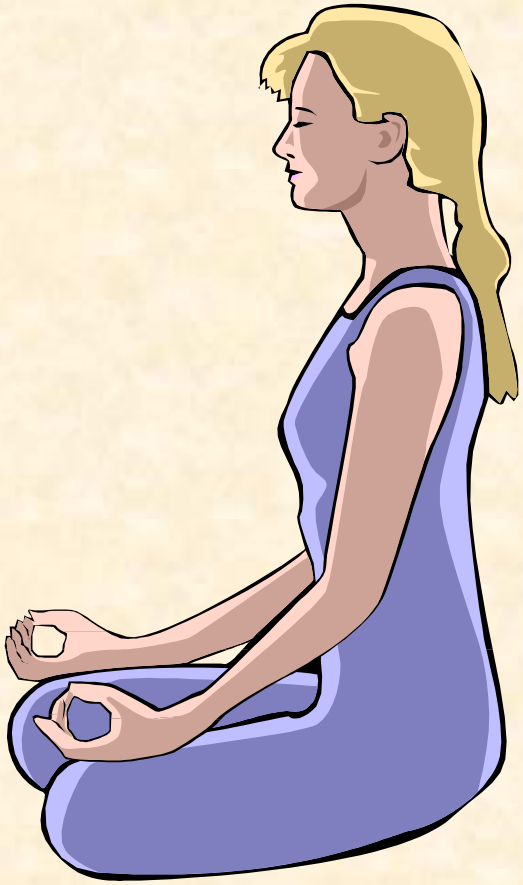
$$= \sqrt{\frac{10{,}935{,}970 - 10{,}144{,}225}{10(9)}} = \sqrt{\frac{781{,}645}{90}}$$

$$= \sqrt{8684.944} = 93.19$$

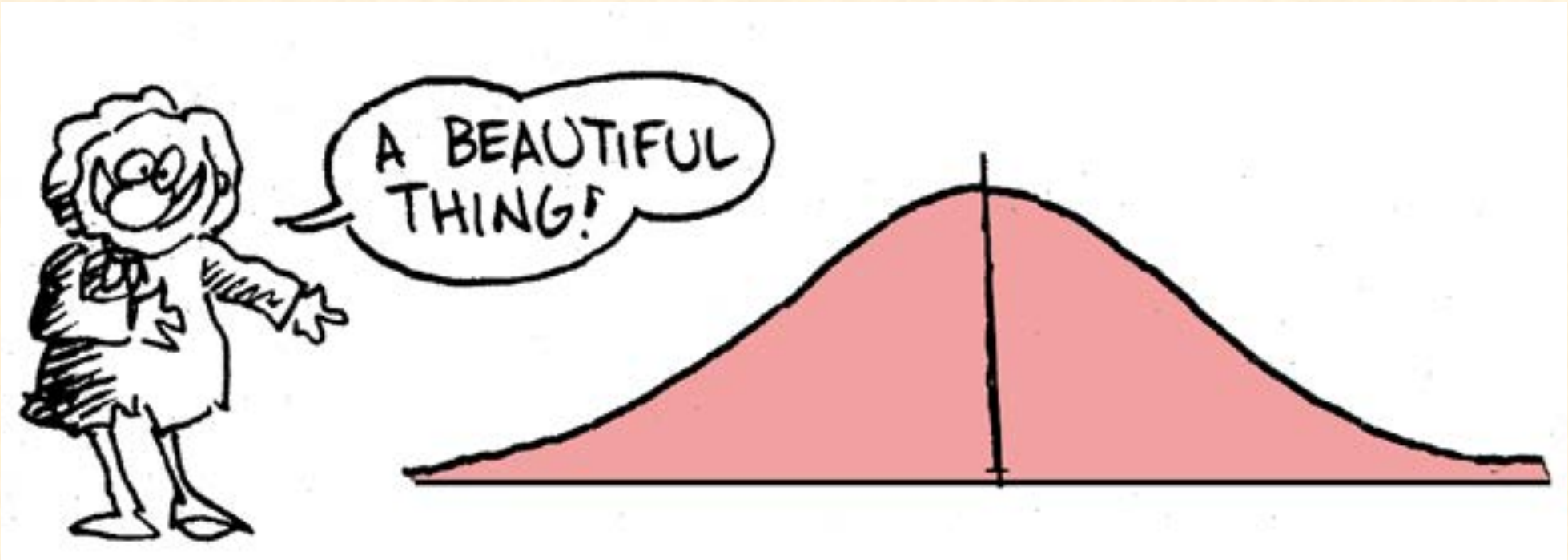
Once You've got the Idea:

You can use your calculator to find SD!

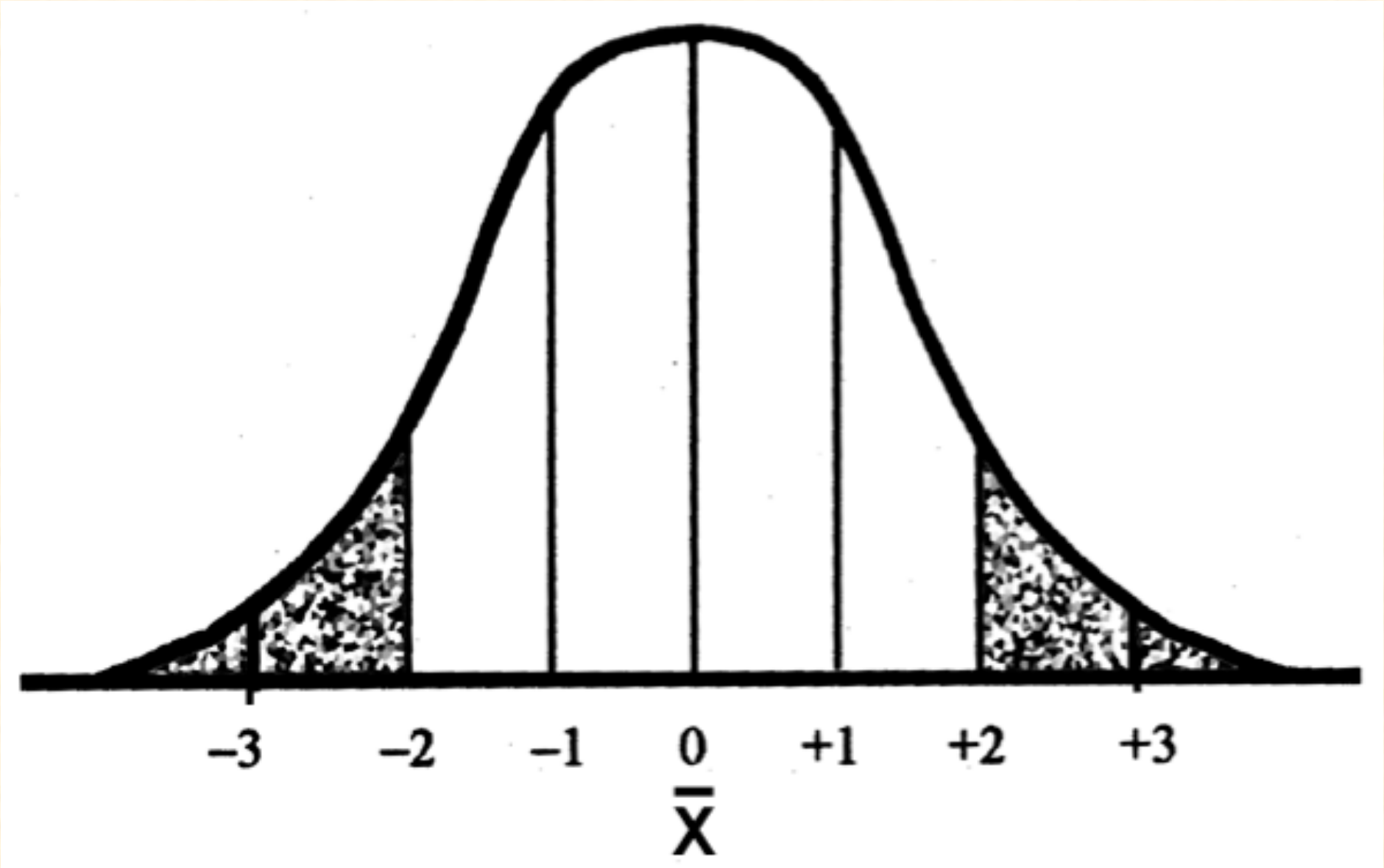
The Normal Curve



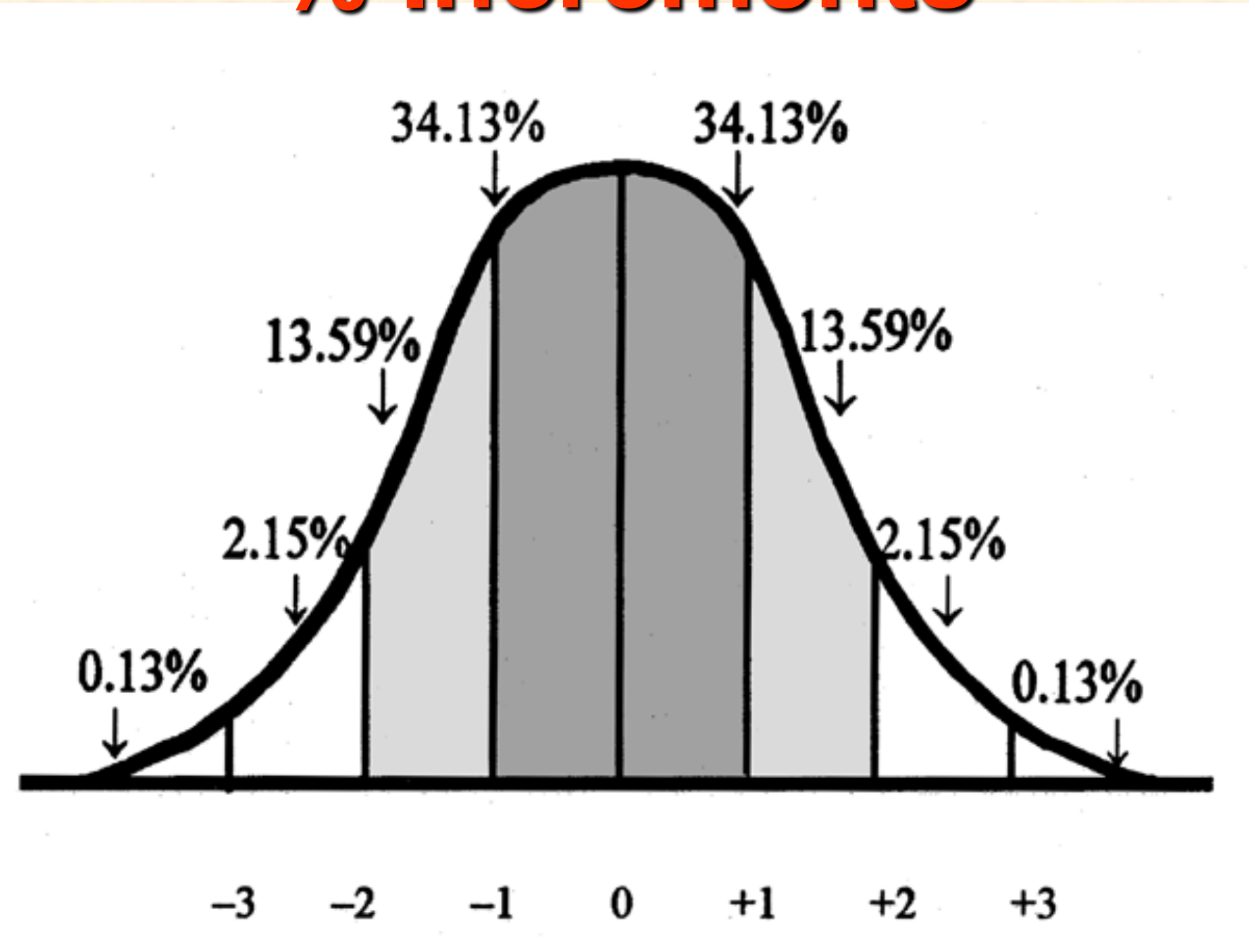
The Normal Curve

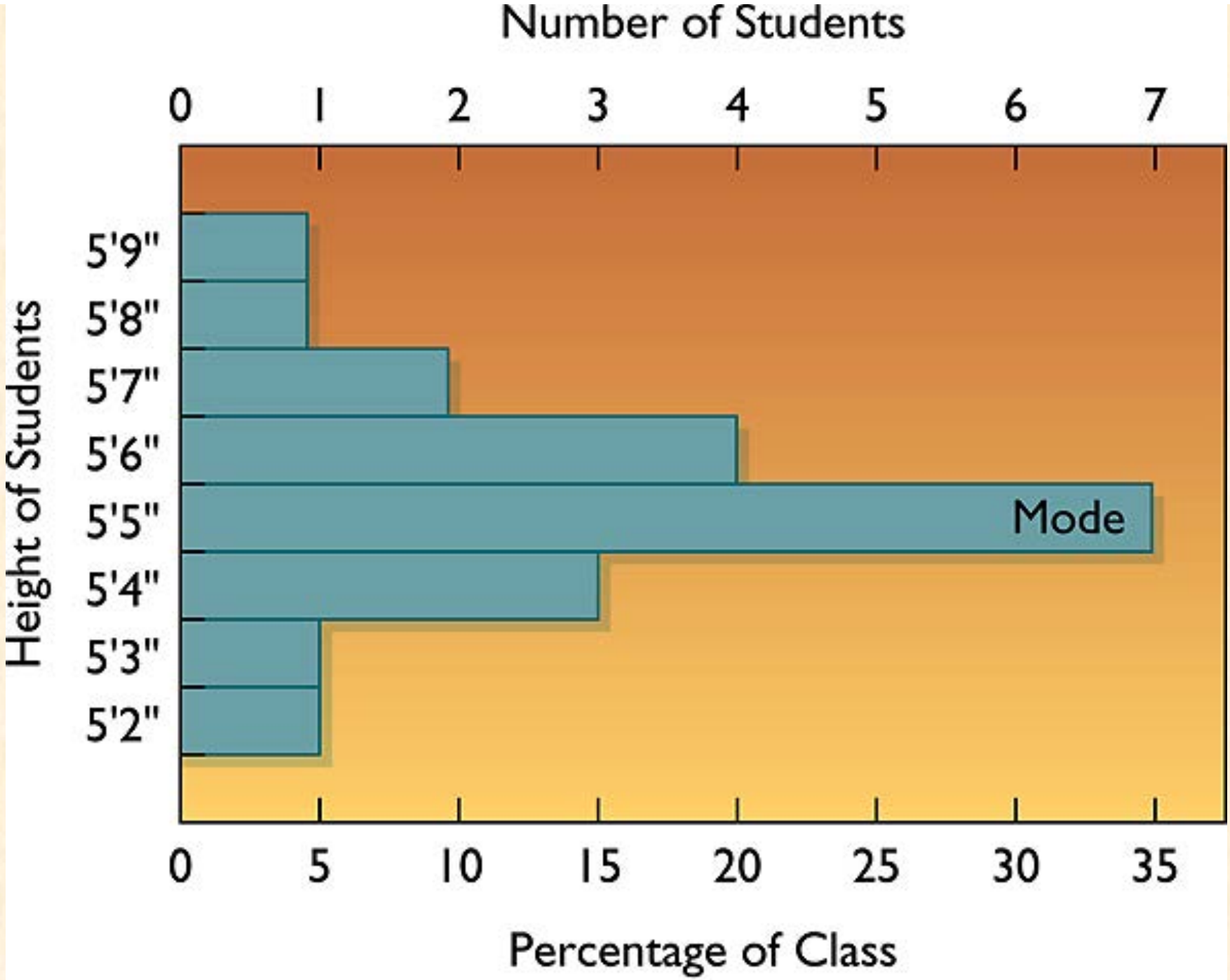


SD & the Bell Curve



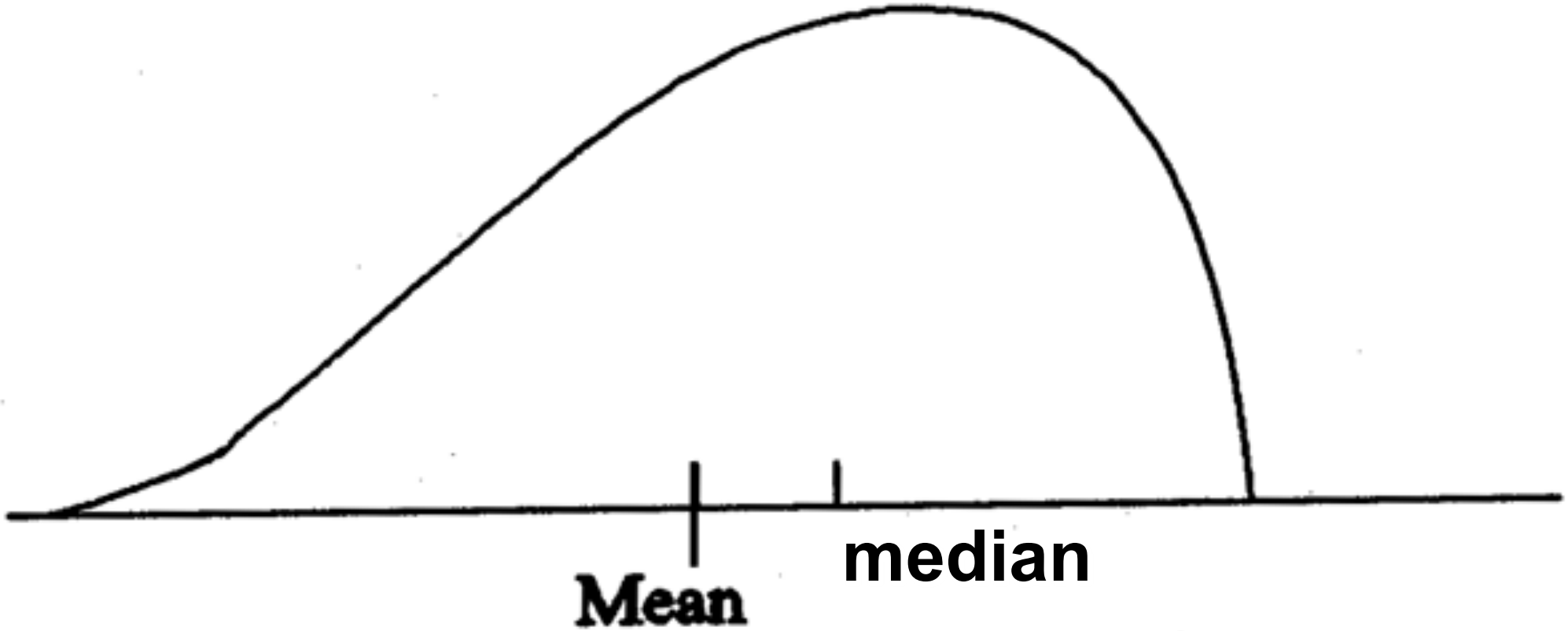
% Increments





FREQUENCY OF THE HEIGHT OF CLASSMATES

Skewed Curves



Critical Values

Standard Deviations $\geq$ 2 SD above or below the mean =

"due to more than chance alone."

THIS MEANS: The data lies *outside* the 95% confidence limits for probability. ***Your research shows there is something significant going on...***

Chi-Square

χ^2

Chi-Square Test Requirements

- Quantitative data
- Simple random sample
- One or more categories
- Data in frequency (%) form
- Independent observations
- All observations must be used
- Adequate sample size ($\geq$10)

Example

Table 1 - Color Preference for 150 Customers for Thai's Car Dealership

Category Color	Observed Frequencies	Expected Frequencies
YELLOW	35	30
RED	50	45
GREEN	30	15
BLUE	10	15
WHITE	25	45

Chi-Square Symbols

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

O = Observed Frequency

E = Expected Frequency

Σ = sum of

df = degrees of freedom (n -1)

χ^2 = Chi Square

Chi-Square Worksheet

CATAGORY	*O*	*E*	*(O - E)*	$(O - E)^2$	$\frac{(O - E)^2}{E}$
YELLOW	35	30	5	25	0.83
RED	50	45	5	25	0.56
GREEN	30	15	15	225	15
BLUE	10	15	-5	25	1.67
WHITE	25	45	-20	400	8.89

χ^2 = 26.95

Chi-Square Analysis

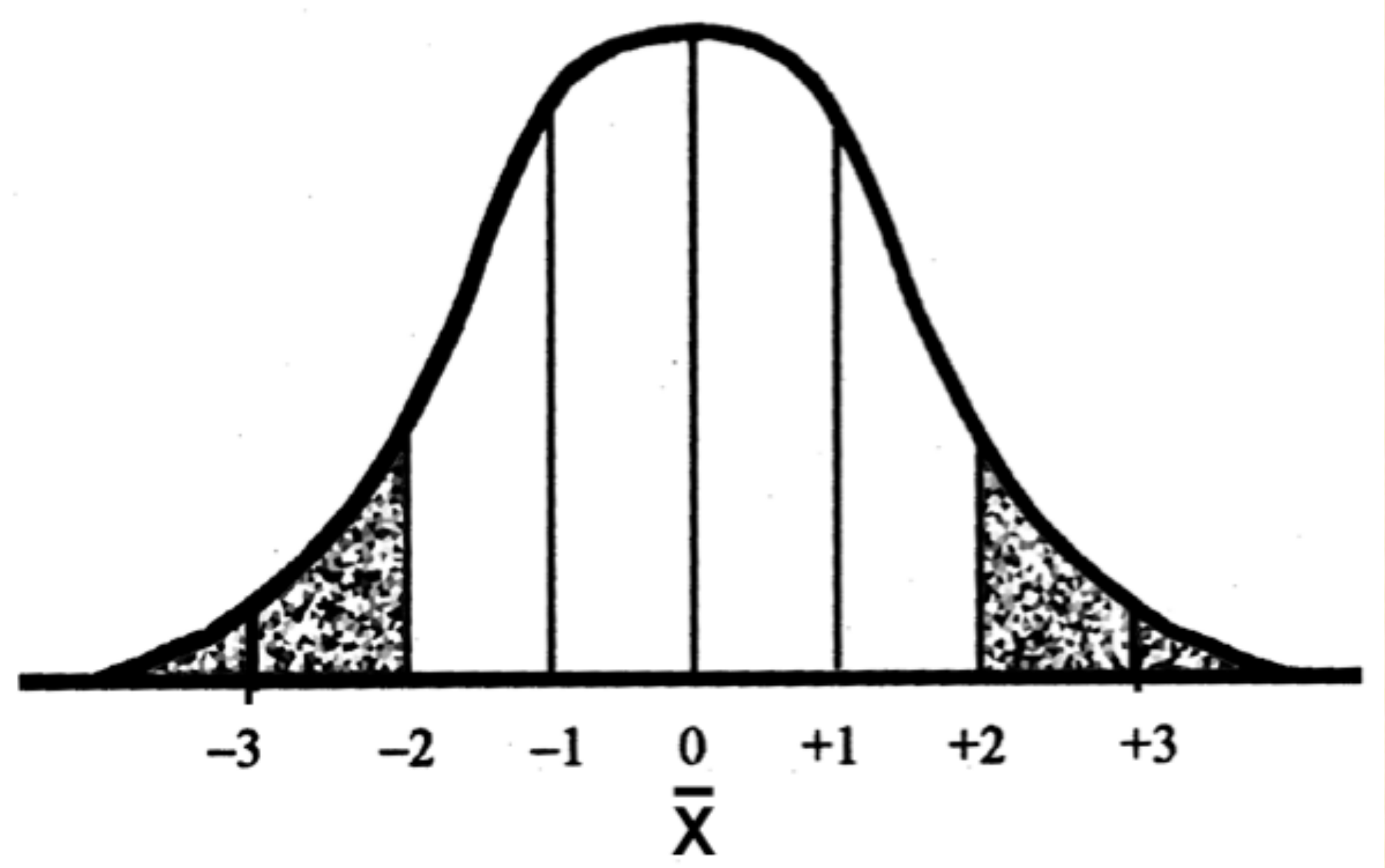
Table value for Chi Square = 9.49

4 df

P = .05 **level of significance**

Is there a significant difference in car preference????

SD & the Bell Curve



T-Tests

T-Tests

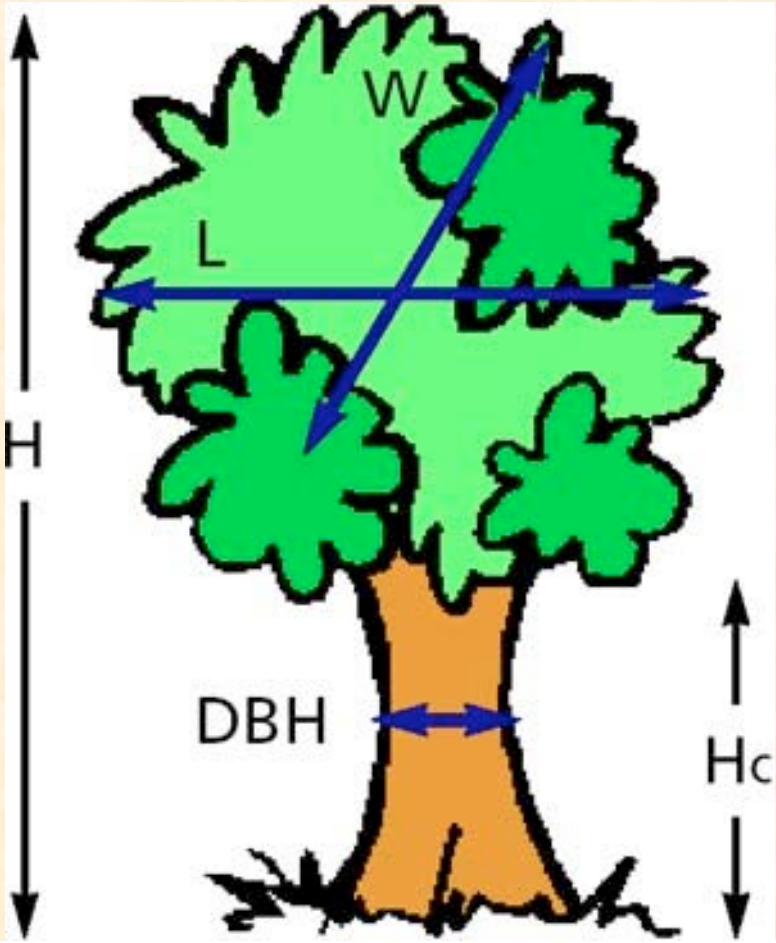
For populations that *do* follow a <u>normal</u> distribution

T-Tests

- **To draw conclusions about similarities or differences between *population means* (χ)**
- **Is average plant biomass the same in**
  - ***two different geographical areas ???***
  - ***two different seasons ???***

T-Tests

- ***<u>To be COMPLETELY</u>*** **confident you would have to measure *<u>all</u>* plant biomass in each area.**
  - ***Is this PRACTICAL?????***



Instead:

- **Take one sample from <u>each</u> population.**
- ***<u>Infer</u>* from the sample means and standard deviation (SD) whether the populations have the same or different means.**

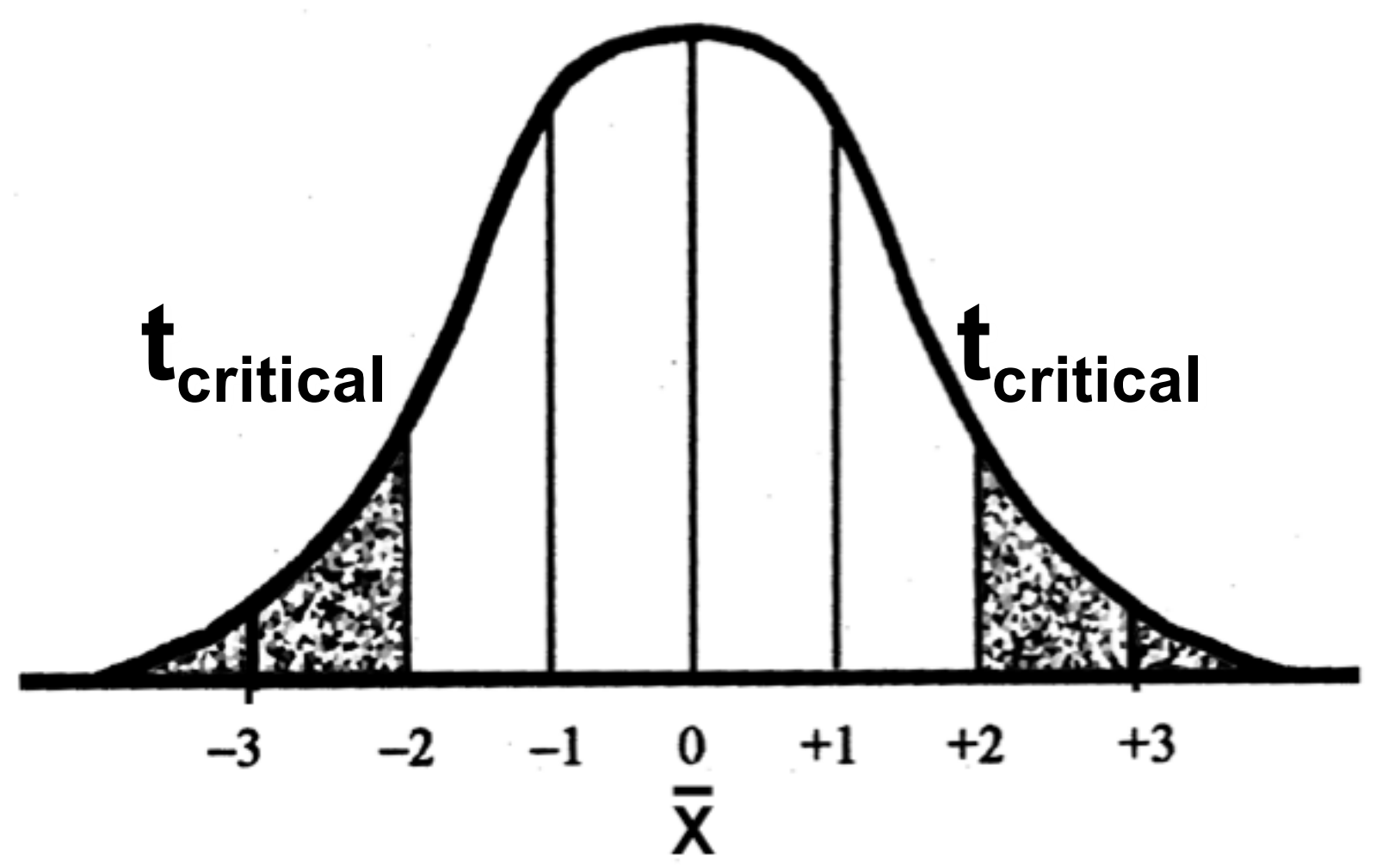
Analysis

- **SMALL *t* values = high probability that the two population means are the <u>same</u>**

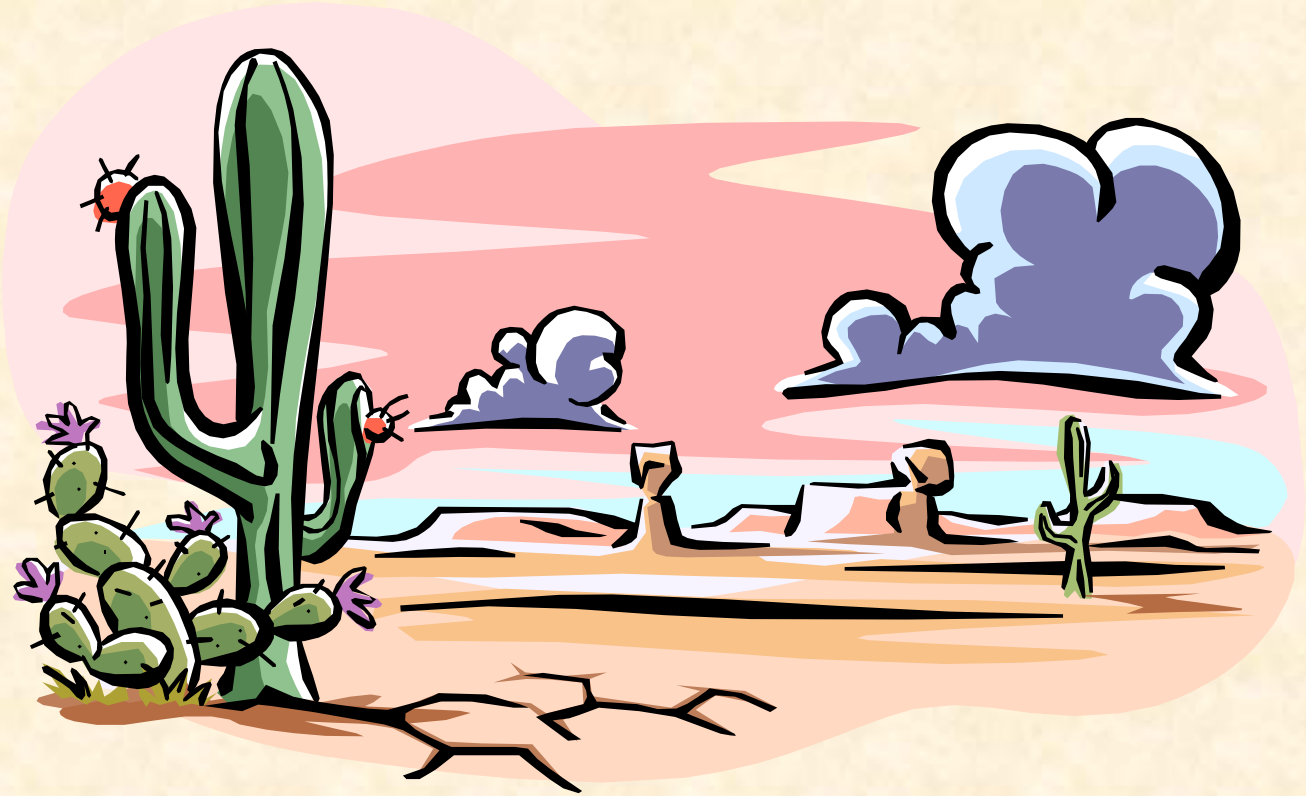
- **LARGE *t* values = low probability (the means are different)**

Analysis

$T_{calculated} > t_{critical}$ = reject H_o



Simpson's Diversity Index

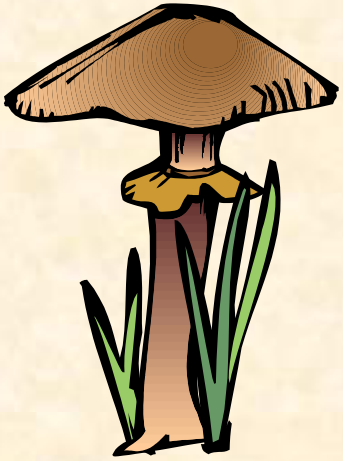


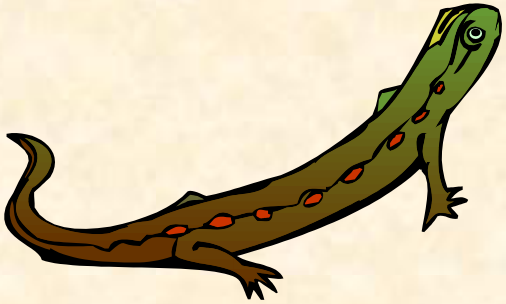
Nonparametric Testing

- For populations that *do NOT* follow a <u>normal</u> distribution
  - includes most wild populations

Answers the Question

- **If 2 indiv are taken at RANDOM from a community, what is the probability that they will be the <u>SAME species</u>????**





The Formula

$$D = 1 - \frac{\sum n_i (n_i - 1)}{N (N-1)}$$

Example

Species, N	Abundance, n_i	Relative Abundance, P_i
1	50	50/85 = 0.588
2	25	25/85 = 0.294
3	10	10/85 = 0.118
N = 3	n = 85	

Example

$$D = 1 - \frac{50(49)+25(24)+10(9)}{85(84)}$$

D = 0.56

(medium diversity)

Analysis

- **Closer to 1.0 =**
  - **more Homogeneous community *(low diversity)***

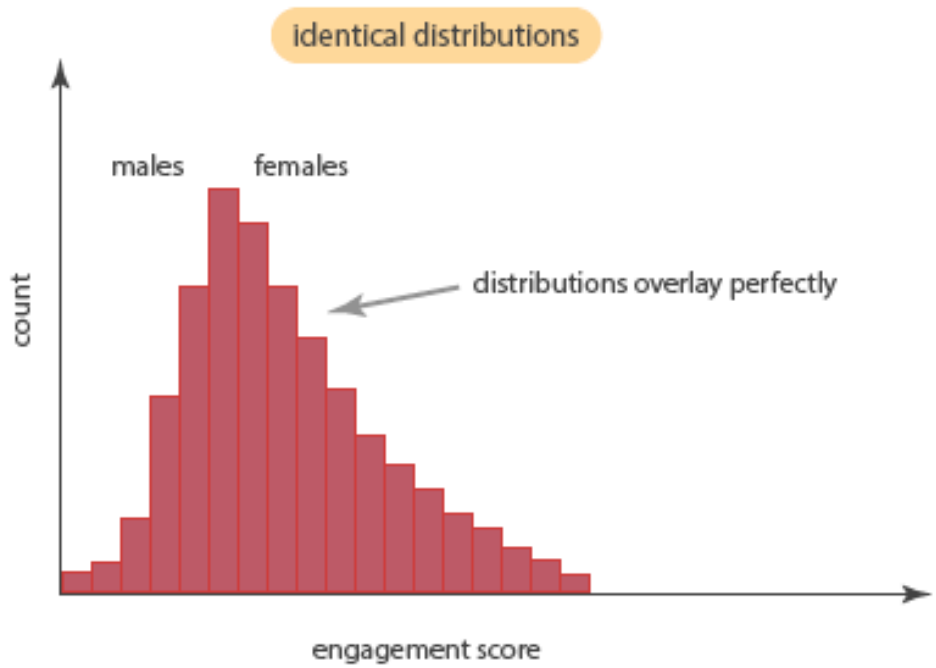
- **Farther away from 1.0 =**
  - **more Heterogeneous community *(high diversity)***

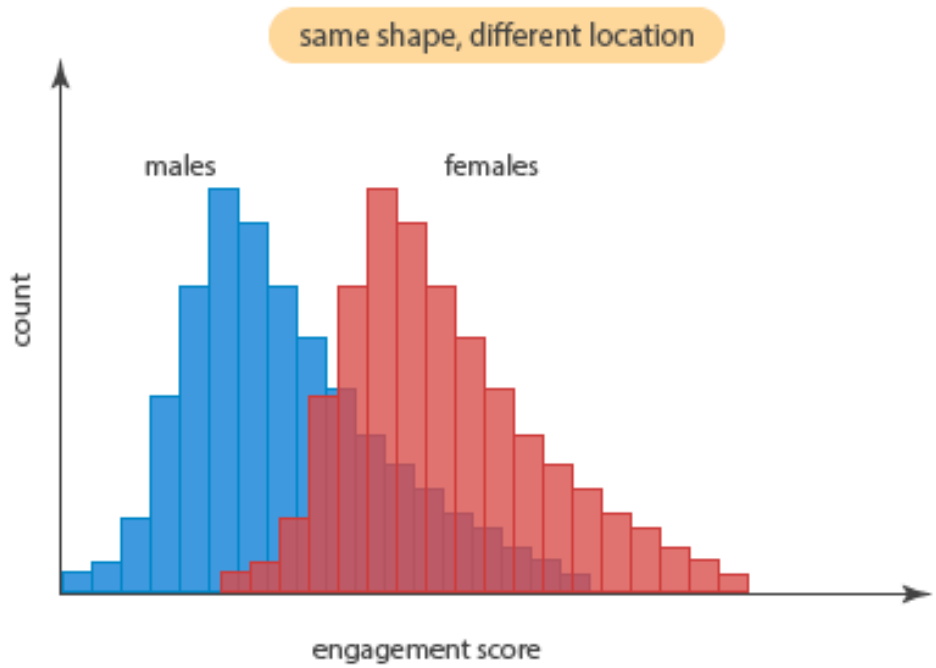
- You can calculate by hand to find "D"

- School Stats package ***MAY*** calculate it.

Mann-Whitney U Test

- **Non-Parametric Test**
  - **Differences in two sets of data by examining a <u>sample</u> of data from <u>each</u> population**





Students will be using computer analysis to perform T-tests and Non-parametric tests

Designed by

Anne Maben

Science Consultant, UCLA Science Project

For the

Orange County Science & Engineering Fair

http://www.ocsef.org/