The I.A.

Formulation of a Question

- This stage involves personal research of a topic
    - library search -U.of W.
    - scientific journal article as a guide and reference
    - web searches

- What have others done before you?

- Requires you to read other scientific work to guide you to your question and REFERENCE

- Determining a good question can sometimes be difficult and may affect the outcome of your investigation

The Hypothesis

- **The hypothesis is a conjecture.**
    - Today —> Hypothesis. There is a difference in size between males and females in of *Tenebrio molitor*
    - Null Hypothesis. There is no difference

Testing

- Exhaust list of **controls** to identify
    - ensure the right species (*T. molitor)*
    - same experiment procedure
    - same methods of measurement
    - consistent examiner
    - only healthy ones chosen

Testing

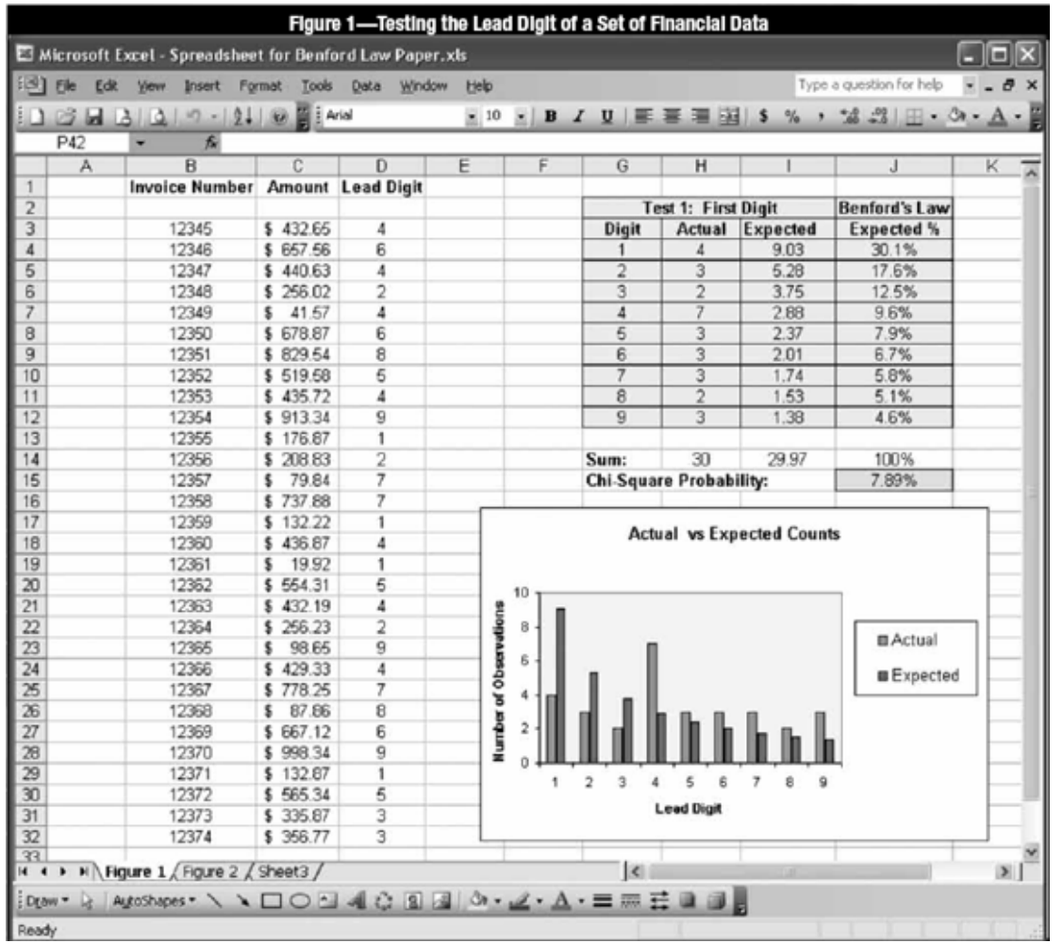
- *Seek advice from others*
  - *Professionals*
  - *Teachers*
  - *Professors*

Testing

- Strategic planning and the design of the experiment.
    - how to measure accurately
    - how to collect data
    - use consistent methodology
    - document everything- how you did something and why
    - errors are recording, problems are documented, changes noted and reason

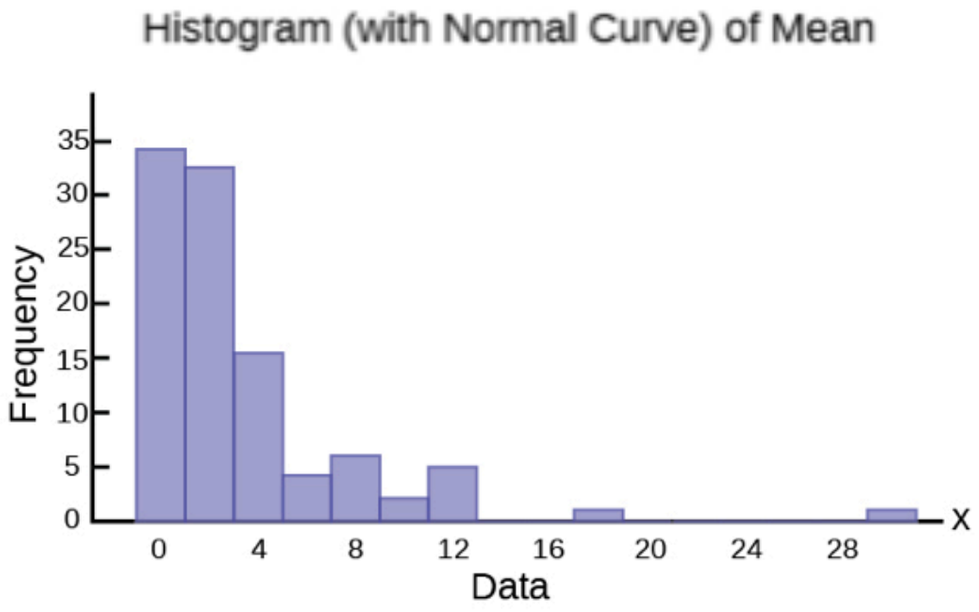
Data

- Collect and organize on it spreadsheets
- label everything, save everything
- **CONDUCT STATISTICAL TESTING**
- finding means
- calculating standard deviation
- Calculation T-Tests- a test the confirms that your results significant to confirm your hypothesis or reject your hypothesis

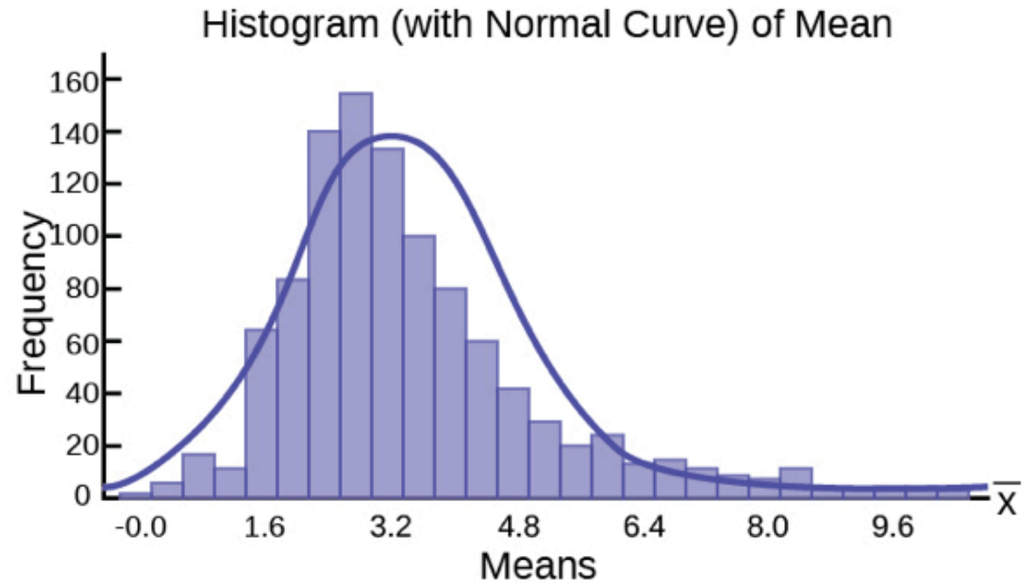


Appropriate Sample size

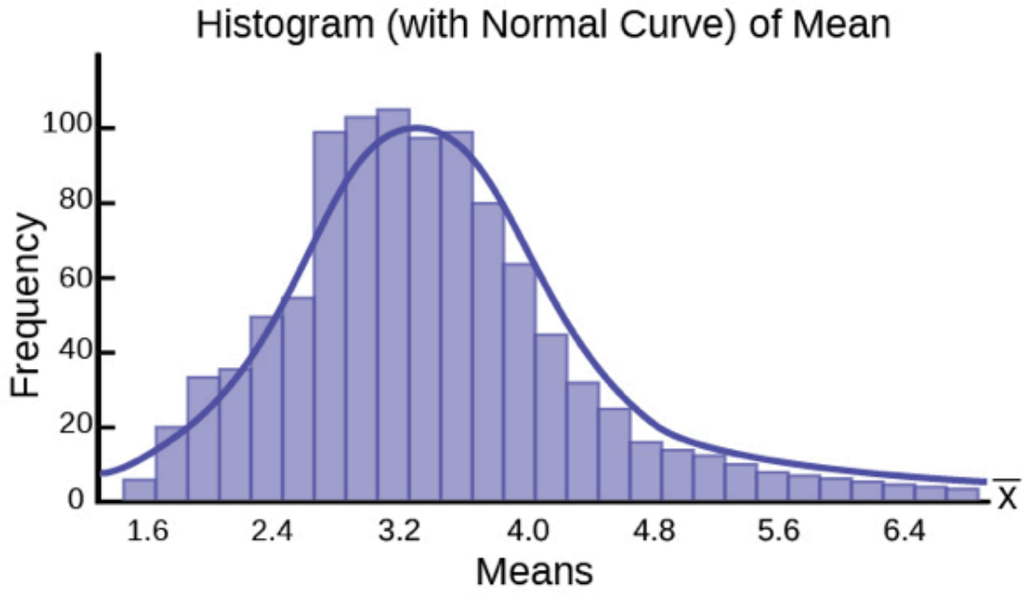
- more is better



Distribution of Sample means with $n = 10$



Distribution of Sample means with $n = 25$



Distribution of Sample means with $n = 50$

Calculate Means

$$\bar{x} = \frac{\sum x}{n}$$

$\bar{x}$ **is the mean**

n **sample size**

$\sum x$ **sum of the data you measured**

Standard Deviation

- Averages don’t tell everything.

- Samples can be very uniform with the data all bunched around the mean (Figure 1)

- Samples can be spread out a long way from the mean (Figure 2).

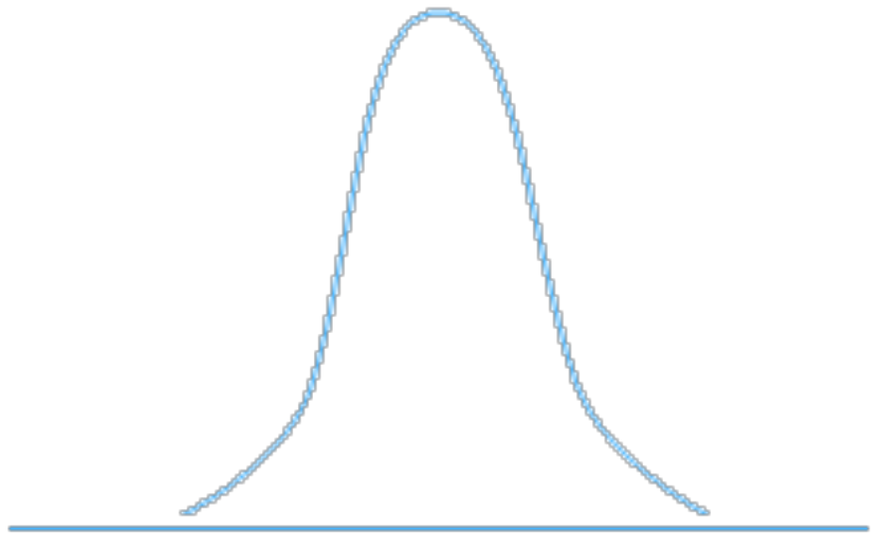


Figure (1)

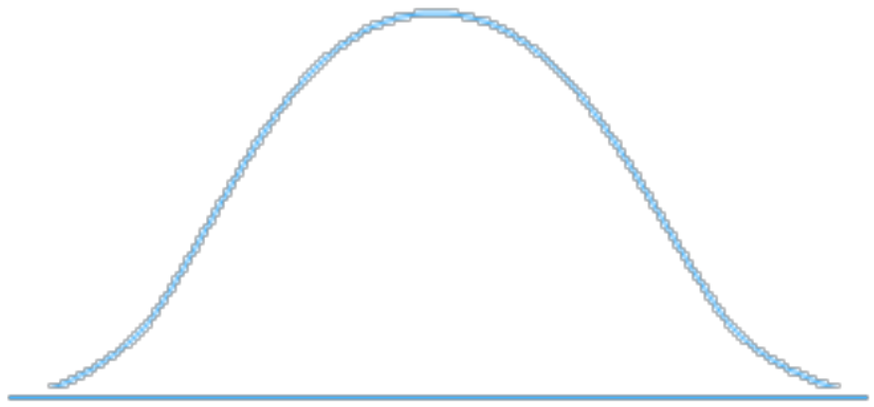
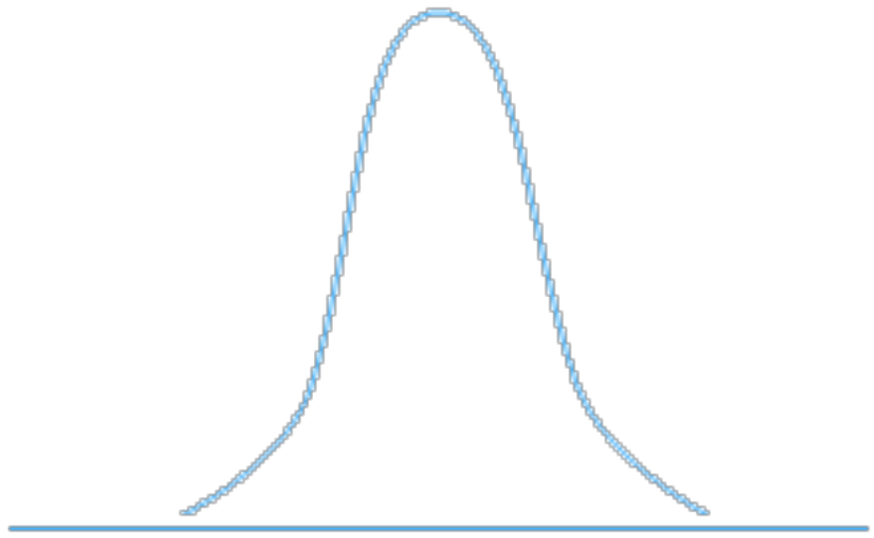


Figure (2)

Standard Deviation

• The statistic that measures this spread is called the standard deviation. The wider the spread of measurements, the larger the standard deviation.



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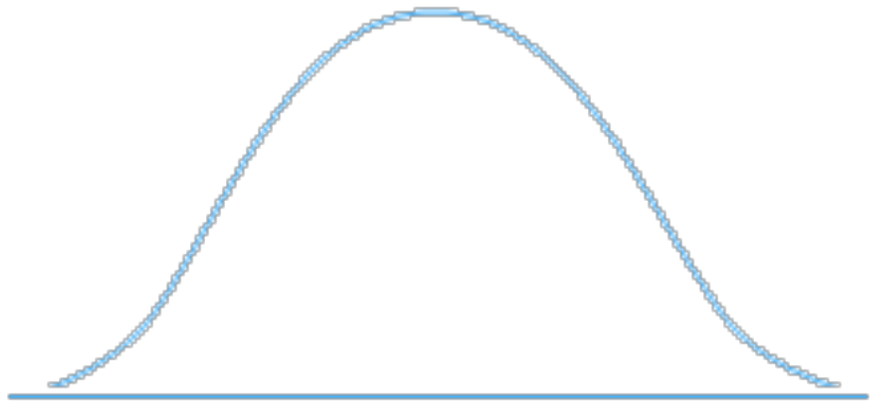
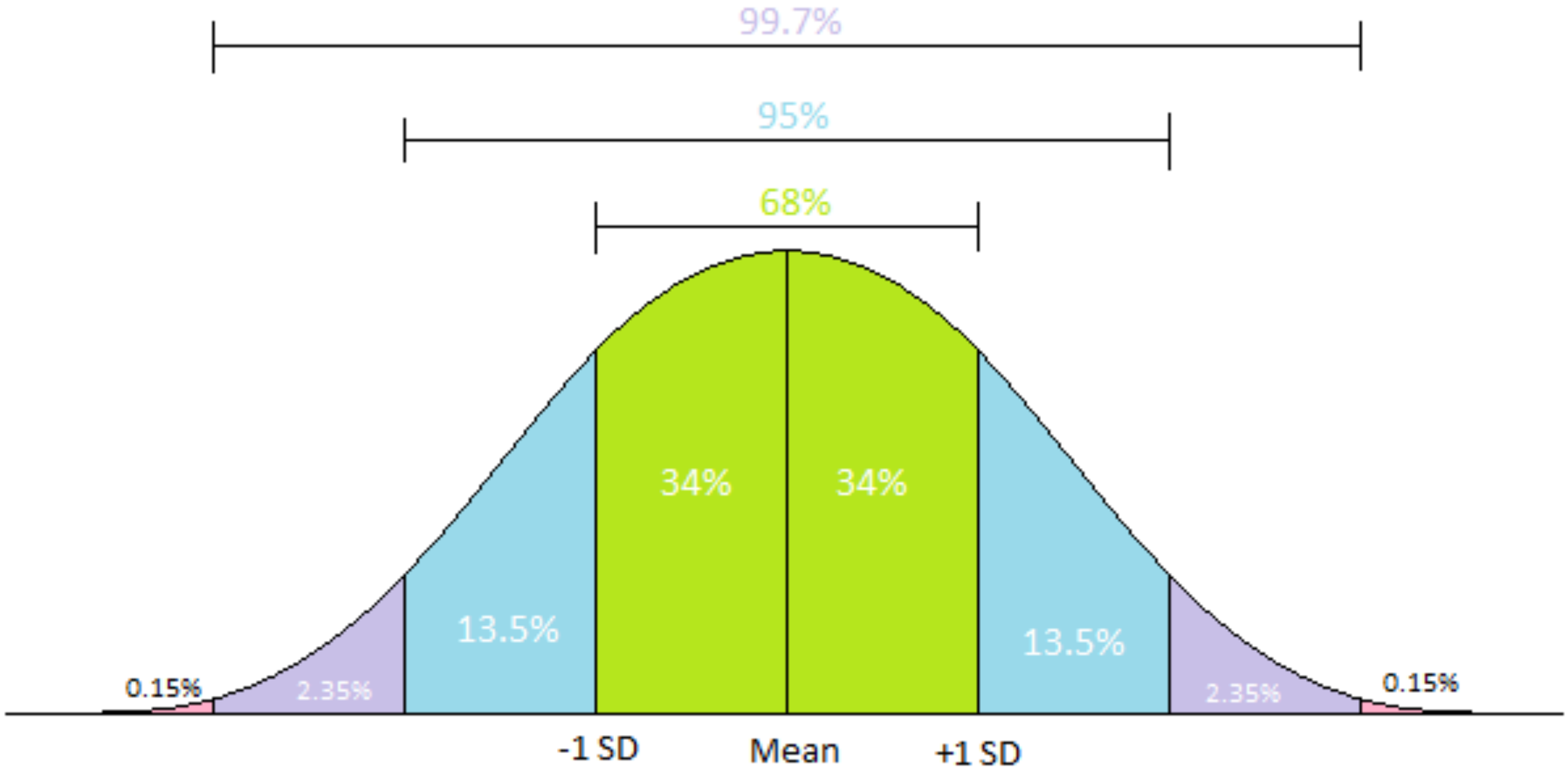


Figure (2)

Standard Deviation



Standard Deviation

1. Calculate the mean ($\bar{x}$) of a set of data. (using a spreadsheet)
2. Subtract the mean from each point of data to determine ($x-\bar{x}$). You'll do this for each data point, so you'll have multiple ($x-\bar{x}$).
3. Square each of the resulting numbers to determine $(x-\bar{x})^2$. As in step 2, you'll do this for each data point, so you'll have multiple $(x-\bar{x})^2$.
4. Add the values from the previous step together to get $\sum(x-\bar{x})^2$. Now you should be working with a single value.
5. Calculate (n-1) by subtracting 1 from your sample size. Your sample size is the total number of data points you collected.
6. Divide the answer from step 4 by the answer from step 5
7. Calculate the square root of your previous answer to determine the standard deviation.
8. The standard deviation should have the same unit as the raw data you collected. For example, SD = +/- 0.5 cm.

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

Conducting a T-test

- The Student's t-test is a statistical test that compares the mean and standard deviation of two samples to see if there is a significant difference between them.

    - typically control VS experimental data
    - eg Male size vs Female size in *T. molitor*

Conducting a T-test

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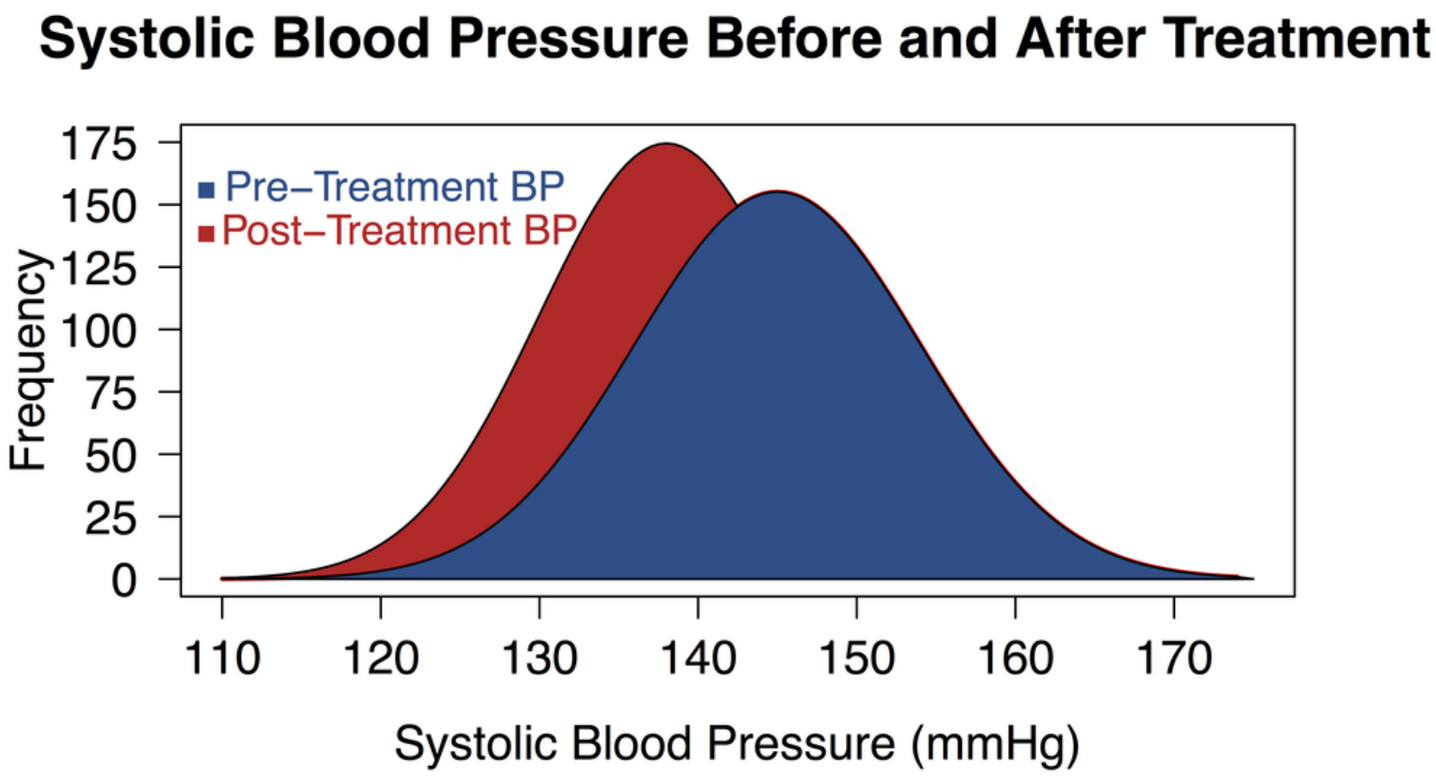

Conducting a T-test

- The T-test is a test of a **statistical significant difference between two groups.**

    - Results may be as a result of your manipulated test or
    - A result of chance.

How to do a T-Test

Where:

- $\bar{x}_1$ is the mean of sample 1 (*control*)
- s_1 is the standard deviation of sample 1
- n_1 is the sample size of sample 1
- $\bar{x}_2$ is the mean of sample 2 (*Test group*)
- s_2 is the standard deviation of sample 2
- n_2 is the sample size in sample 2

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

How to do a T-Test

How to Calculate T:

1. Calculate the mean ($\overline{X}$) of each sample
2. Find the absolute value of the difference between the means
3. Calculate the standard deviation for each sample
4. Square the standard deviation for each sample
5. Divide each squared standard deviations by the sample size of that group.
6. Add these two values
7. Take the square root of the number to find the "standard error of the difference.
8. Divide the difference in the means (step 2) by the standard error of the difference (step 7). The answer is your "calculated T-value."

$$t = \frac{(\overline{x_1} - \overline{x_2})}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

How to do a T-Test

9. Determine the degrees of freedom (df) for the test. In the t-test, the degrees of freedom is the sum of the sample sizes of both groups minus 2. $(n_1 + n_2 - 2)$

10. Determine the "Critical T-value" in a table by triangulating your **df** and the "p value" of 0.05.

Degrees of freedom	Significance level					
	20% (0.20)	10% (0.10)	5% (0.05)	2% (0.02)	1% (0.01)	0.1% (0.001)
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.598
3	1.638	2.353	3.182	4.541	5.841	12.941
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.859
6	1.440	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.405
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140

How to do a T-Test

11. Draw your conclusion:

- If your calculated t value is greater than the critical T-value from the table, —> there is a significantly different.

- We reject the null hypothesis and conclude that the alternative hypothesis is correct. *ie. your prediction was right you're onto something*

- If your calculated t value is lower than the critical T-value
  —> NOT significantly different. We accept the null hypothesis. *ie. your hunch was incorrect.*