AP Biology **Name** _____ **Block** _____

Properties of Water Lab with Stats!

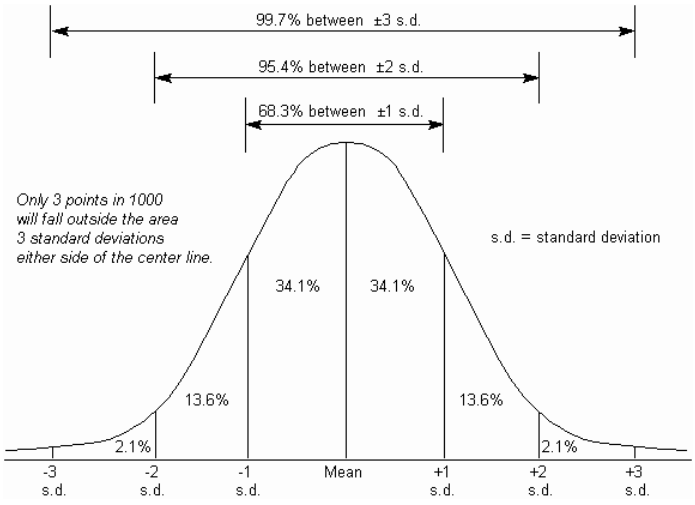
Background Information:

Water is a ***polar*** molecule. The oxygen atom in water has a greater ***electronegativity***, or a stronger "pull," on the electrons that it shares with the two hydrogen atoms it is covalently bonded to. As a result, the molecule ends up having a **partially negatively charged end**, near the **oxygen atom**, and a **partially positively charged end** near the **hydrogen atoms**. Much like a magnet, opposite charges will attract and similar ones will repel so that the slightly negatively charged oxygen of one water molecule will be attracted to the slightly positively charged hydrogen of a neighboring water molecule. This weak attraction and "sticking together" of polar molecules is called ***hydrogen bonding***.

Water is an extremely important molecule in biology. Life came from the earliest watery environments, and thus all life depends upon the unique features of water which result from its polar nature and 'stickiness.' Some of the unique properties of water that allow life to exist are:

- It is less dense as a solid than as a liquid.
- It sticks to itself –***cohesion***– cohesion is also related to surface tension.
- It sticks to other polar or charged molecules –***adhesion***– adhesion results in phenomena such as capillary action.
- It is a great ***solvent*** for other polar or charged molecules.
- It has a very ***high specific heat*** –that is, it can absorb a great deal of heat energy while displaying only small increases in temperature.
- It has a neutral pH of 7, which means the concentrations of H^+ and OH^- ions are equal.

Introduction to Statistics:



Statistical analysis is used to collect a sample size of data which can infer what is occurring in the general population**. *Standard deviation*** (often reported as ±) shows how much variation there is in the data from the average (mean). **If data points are *close* together, the standard deviation will be *small*. If data points are *spread out*, the standard deviation will be *larger.*** Typical data will show a ***normal distribution*** (bell-shaped curve). In normal distribution, about 68% of values are within one standard deviation of the mean, 95% of values are within two standard deviations of the mean, and 99% of the values are within three standard deviations of the mean. The formula for standard deviation is shown on the following page.

Standard Deviation

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

Consider the following sample problem:

Grades on a recent AP Biology quiz were as follows: 96, 96, 93, 90, 88, 86, 86, 84, 80, 70.

Step 1: Find the **Mean (x)**_____

Step 2: Calculate the **Standard Deviation (*s*)** _____ (Show your work in the space below)

In the problem above, the mean is 86.9 and the standard deviation is 7.9. So one standard deviation would be (86.9-7.9) through (86.9+7.9), or 79-95 (68% of the data should fall between these numbers). Two standard deviations would be (86.9-15.8) through (86.9+15.8), or 71-103 (95% of the data should fall between these numbers). Three standard deviations would be (86.9-23.7) through (86.9+23.7), or 63-111 (99% of the data should fall between these numbers).

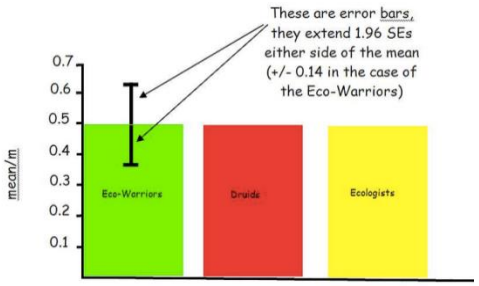
Standard Error of the Mean is used to represent uncertainty in an estimation of mean and accounts for both sample size and variability. The formula used to calculate standard error of the mean is shown below. **As standard error grows smaller, the likelihood that the sample mean is an accurate estimation of the population increases.**

Using the data from the **Standard Deviation (*s*)** example above and a sample size (n) of 10, calculate the **Standard Error of the Mean**: _____

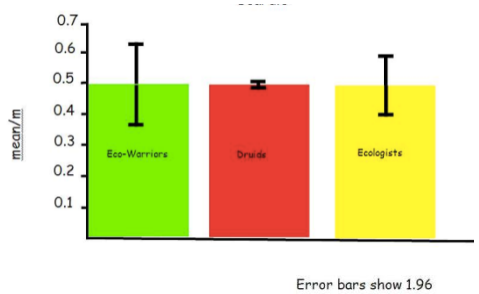
Standard Error

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

It is common practice to add standard error bars to graphs, marking one or two standard error(s) above and below the sample mean (see figure to the right). Such bars give an impression of the ***precision*** of estimation of the mean in each sample. Typically, the length of the bars above and below the mean and the overlap of the bars as compared to one another is analyzed (see figures to the right). The ***length*** of the bars shows the spread around the mean. **Shorter bars indicate less variability from the mean**. If two or more error bars are the *same* size, they have *similar* spreads around their means. If a bar is longer than others, it has a larger spread around its mean.



When the ***range*** of bars ***overlaps***, this indicates that there is ***NOT*** a significant difference in averages and data sets. If the range of bars does not overlap, there *may* be a significant difference in averages and data sets. Notice that in the last image, the error bars tell us that we can be 95% confident (± 2 SEM) that the Greenies mean IQ is significantly different from either the Reddies or the Yellowies. Things are not nearly so clear-cut between the Reddies and the Yellowies. Notice how the error bars of the Reddies and Yellowies overlap, but there is clearly no overlap between both of them and the Greenies.



Pre-Lab Questions: Use the above background information and your textbook to answer the following questions.

1. Why is water considered to be a polar molecule?

2. Sketch a molecule of water (include the partial charges).

3. Which type of bonds form between the oxygen and hydrogen atoms of ***TWO DIFFERENT*** water molecules?

4. Which type of bonds form between the oxygen and hydrogen atoms ***WITHIN*** *a* water molecule?

Question: How does soap affect hydrogen bonds between different water molecules?

Null Hypothesis:

Alternative Hypothesis:

Materials: Penny, distilled water, soap, pipette, paper towel

Safety: Soap can be an irritant. Take caution to avoid contact between soap and eyes.

Procedure:

1. Obtain a DRY penny and place it on a DRY paper towel.
2. Using a clean pipette, add distilled water to the penny drop by drop until it overflows. **Be sure to count the drops!** Record the number of drops for Trial 1 in Data Table 1 below.
3. Repeat steps 1-2 for a total of five trials.
4. Obtain a DRY penny and place it on a DRY paper towel.
5. Spread a thin layer of soap on the penny.
6. Using a clean pipette, add distilled water to the penny drop by drop until it overflows. **Be sure to count the drops!** Record the number of drops for Trial 1 in Data Table 1 below.
7. Repeat steps 4-6 for a total of five trials. **Be sure to add a new layer of soap between trials**

Data Collection:

Data Table 1: Number of Drops of Distilled Water Contained on the Surface of a Penny

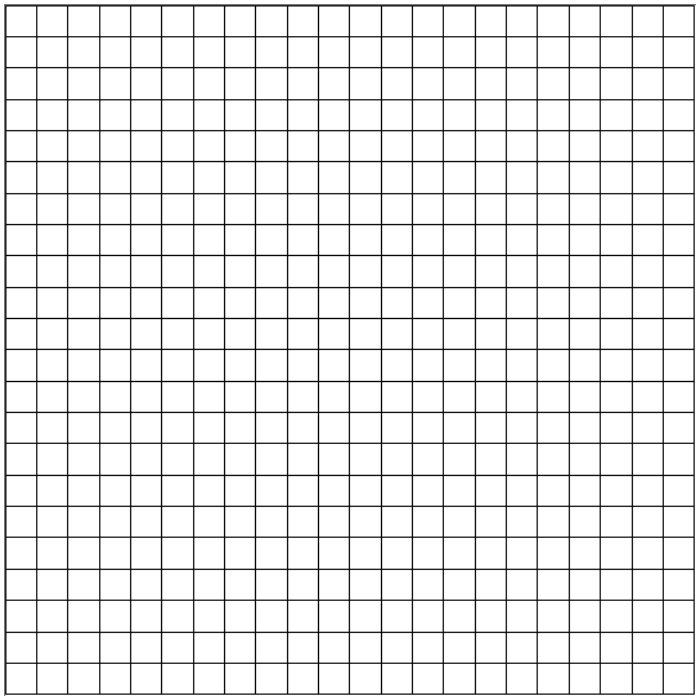
Trial	# Drops Distilled Water	# Drops Distilled Water + Soap
1		
2		
3		
4		
5		
Mean		

Data Analysis: Complete the appropriate calculations in Data Table 2 below. **Show your work for Standard Deviation and Standard Error in the space below Data Table 2.**

Data Table 2: Statistical Analysis of the Number of Drops of Distilled Water Contained on the Surface of a Penny

Calculation	# Drops Distilled Water	# Drops Distilled Water + Soap
Mean		
Standard Deviation		
Standard Error		
± 2 SEM		

Create an appropriately labeled bar graph to illustrate the sample means for the penny with and without soap within 95% confidence (± 2 SEM). **Don't forget a title that includes the independent and dependent variables and axes labels with units.**



1. Make a **claim** about how soap affects hydrogen bonds between water molecules.

2. **Justify** your claim by using the data as **evidence**.

3. Provide **reasoning** to support the claim. (discuss scientific principles)