

# Solving Mystery Molarities Using Principles of Osmosis

## Background

Mrs. Simpson made six different solutions, each containing various concentrations of sucrose, but she forgot to label each one! It is your group's task to solve the mystery of which solution represents each of the possible molar concentrations: 0.0 M sucrose, 0.2 M sucrose, 0.4 M sucrose, 0.6 M sucrose, 0.8 M sucrose, and 1.0 M sucrose.

Water moves through membranes by diffusion; this process is called osmosis. Like solutes, water moves down its concentration gradient. Water moves from areas of high potential (high water concentration) and low solute concentration to areas of low potential (low water concentration) and high solute concentration. In walled cells, osmosis is affected not only by the solute concentration but also by the resistance to water movement in the cell by the cell wall. This resistance is called turgor pressure (the physical pressure exerted on the cell).

## Materials

6 dialysis bags or semi-permeable membranes  
20 mL of each colored mystery solution  
Graduated cylinders – 50 mL  
Electronic balance  
6 plastic cups  
Thread

## Procedure

1. Obtain 6 semi-permeable pieces of dialysis tubing. **Note that the membrane is permeable to water, but not to sucrose.**
2. Using graduated cylinders, measure 20 mL of each colored mystery solution.
3. Pour 20 mL of each of the colored mystery solutions into separate bags: red, orange, yellow, green, blue, and purple.
4. Remove some of the excess air from each bag before securing the "cell" with thread. Leave room for expansion. Rinse each bag if necessary to remove sucrose from the outside surface.
5. Carefully blot the outside of each bag, and then mass it and record the initial mass in Table 1.
6. Fill up each cup half-way with distilled water.
7. At the same time, place each bag into a cup so that it is submerged. Label each cup with your group's initials. Cover with plastic wrap to prevent evaporation, and let the cups stand overnight.
8. The next day, remove the bags from the cups and carefully blot each with a paper towel to remove excess water on the surface.
9. Determine the final mass and record in Table 1.
10. Record data of percent change in mass for each bag in Table 1.

**Table 1: Individual Group Data**

Contents of Bag	Initial Mass	Final Mass	Mass Difference	% Change in Mass*
Red				
Orange				
Yellow				
Green				
Blue				
Purple				

$$*\text{Percent Change in Mass} = \frac{(\text{Final Mass}) - (\text{Initial Mass})}{\text{Initial Mass}} \times 100$$

11. Next, determine which mystery solution color represents each of the possible molar concentrations of sucrose: 0.0 M sucrose, 0.2 M sucrose, 0.4 M sucrose, 0.6 M sucrose, 0.8 M sucrose, and 1.0 M sucrose. There is only one of each! Record the values of the % change in mass for each solution in Table 2.

**Table 2: Solving the “Mystery”**

Molar Concentration of Solution	Color	Corresponding % Change in Mass
0.0 M Sucrose		
0.2 M Sucrose		
0.4 M Sucrose		
0.6 M Sucrose		
0.8 M Sucrose		
1.0 M Sucrose		

12. Gather class data for percent change in mass for each bag placed in the varying molar concentration solutions of sucrose. Record these values in Table 3.

**Table 3: Class Data**

	Percent Change in Mass of Bags						Mean	Standard Deviation	Standard Error of the Mean
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6			
0.0 M Sucrose									
0.2 M Sucrose									
0.4 M Sucrose									
0.6 M Sucrose									
0.8 M Sucrose									
1.0 M Sucrose									

13. Using Excel or Google Sheets, create a graph depicting each solution's mean percent change and corresponding standard error from the class data. Add this chart to your conclusion as question #1.

**Instructions for Google Sheets**

- In one column, put all molar concentrations. NOTE: Do NOT include the "M" for molarity – it will not recognize this as a numerical value. Instead, put 0.2, 0.4, etc.
- In the next column, put the corresponding mean percent changes in mass (from class data).
- Highlight both columns, and click Insert → Chart. Under the "Chart Types" tab, choose "Column."
- Make sure that "Switch rows/columns" AND "Use column \_\_\_ as headers" are checked.
- Under the "Customize" tab, change the Title, and the titles of each Axis. T
- Scroll down to "Series" and click the drop-down button. Under "Apply to" you should see each of your molarities. Click on each one, and change the COLOR to correspond to the mystery color of the solution. Then, for each molarity, under "error bars" change the drop-down button to "Constant" and add in the corresponding standard error in the box (this should be the standard error you calculated in Table 3).

**Each student is responsible for generating a graph. Analysis questions will be answered in teams.**

## Analysis

1. Attach your graph you created in #13 of the procedure. One graph per student.
2. Explain **in detail** how your group determined which solution color signified each molarity. Use the principles of osmosis to explain your reasoning.
3. What are some sources of error in this experiment?
4. Analyze the means in terms of the standard error. Are there any points (solutions) that have statistically significant differences in the means? Are there points that suggest there are no statistically significant differences in the means?
5. How are dialysis tubing membranes different from living animal cell membranes? How might this limit the accuracy of the data obtained?

## Statistics Review

- **Standard Deviation** measures how spread out the data is from the mean.
  - A lower standard deviation means that the data is closer to the mean, and that there is a greater likelihood that the independent variable is causing the changes in the dependent variable.
  - A higher standard deviation means that the data is more spread out from the mean, and most likely other factors other than the independent variable are influencing the dependent variable.

$$s_x = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}}$$

$n$  = The number of data points

$\bar{x}$  = The mean of the  $x_i$

$x_i$  = Each of the values of the data

- **Standard Error** indicates how well the mean of a sample estimates the true mean of a population.

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

1. Calculate standard deviation
2. Divide standard deviation by square root of sample size

- After standard error bars have been plotted, look for overlap!
  - If they overlap, the difference is not significant.
  - If they don't overlap, the difference may be significant.

**Using Google Sheets to calculate the mean, standard deviation, and standard error for each concentration.**

a. Set up your Sheets table like Table 3. It should look something like this:

	A	B	C	D	E	F	G	H	I
1	CONCENTRATIONS	Group 1	Group 2	Group 3	Group 4	Group 5	Mean	Standard Deviat	Standard Error
2	0.0 M	0	0	1.09	-0.54	-0.55	0	0.6674953183	0.2985129813
3	0.2 M	0.5	0	2.73	0	0.55	0.756	1.134429372	0.5073322383
4	0.4 M	-0.5	0	-0.5	0	0	-0.2	0.2738612788	0.1224744871
5	0.6 M	11.6	0	0.99	-0.48	0	2.422	5.158490089	2.3069469
6	0.8M	0	0	0	-1.4	0.49	-0.182	0.7131759951	0.318942001
7	1.0 M	-0.4	2.73	3.77	0.47	0	1.314	1.831237287	0.8189542112
8									
9									
10							2.236067977		
11									

- To calculate mean, use =average( ) and then enter. \*\*\*You can highlight the cells necessary in between your parentheses.
- To calculate standard deviation, use =stdev( ) and then enter. \*\*\*You can highlight the cells necessary in between your parentheses.
- To calculate standard error, find the square root of your sample size, n (i.e. the number of groups) by using =sqrt(n) and then enter in cell G10. Then use the formula for standard error to calculate it – and click on the cells for your standard deviation and the square root of n when solving. For example: =H2/G10 and then enter.