Name _____ Period _____ Date _____

Lab: Determining the Water Potential of Potato Cells

Section		Points Possible	Points Received
Exploration	Format / Communication	2	
	Purpose • Levels of manipulation • Personal interest	3	
	Hypothesis	3	
	Variables (independent, dependent, standardized variables, control, and hidden variables)	3	
	Methods • Brief description of materials, methods and procedures • Labeled sketch / photograph of lab setup	3	
	Pre-Lab Questions	2	
Lab Data & Analysis	Data Tables (title, units and organization)	3	
	Graph • Title and labeled axes with units • Proper type of graph utilized • Data plotted properly with error bars	3	
	Calculations • Fully worked exemplar for each type of calculation with units • Uncertainties are noted	3	
Evaluation	Post Lab Questions	2	
	Analysis • Summary of purpose • Conclusion statement • Summary of lab data • Comparison of lab data to accepted values / results from literature • Strengths and weaknesses of experimental design	10	
	Reference • At least one scholarly resource (not from the text)	3	
Total Points Earned		40	

BACKGROUND

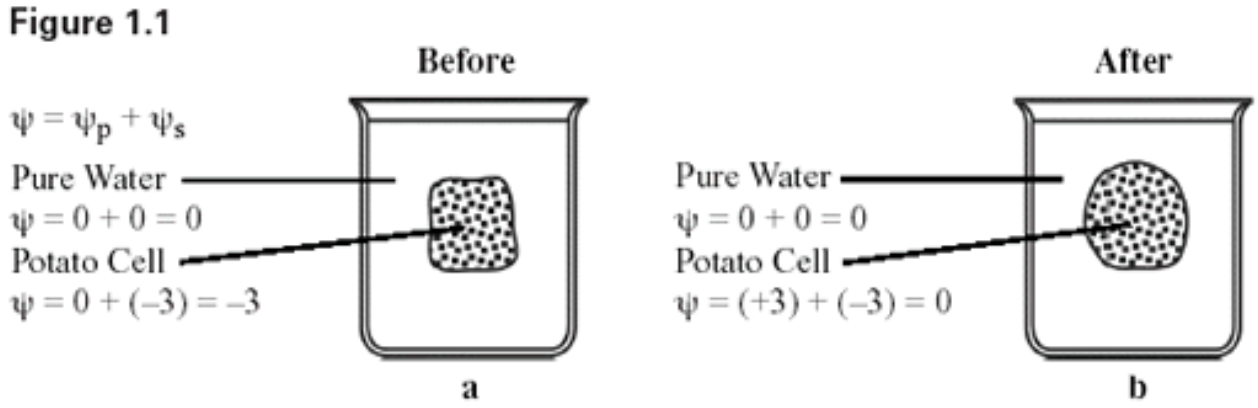
In animal cells, the movement of water into and out of the cell is influenced by the relative concentration of solute on either side of the cell membrane. If water moves out of the cell, the cell will shrink. If water moves into the cell, the cell may swell or even bursts. In plant cells, the presence of a cell wall prevents the cells from bursting, but pressure does eventually build up inside the cell and affects the process of osmosis. When the pressure inside the cell becomes large enough, no additional water will accumulate in the cell even though the cell still has a higher solute concentration than does pure water. So movement of water through the plant tissue cannot be predicted simply through knowing the relative solute concentrations on either side of the plant cell wall. Instead, the concept of water potential is used to predict the direction in which water will diffuse through living plant tissues.

In a general sense, the water potential is the tendency of water to diffuse from one area to another under a given set of perimeters. Water potential is expressed in bars, a metric unit of pressure equal to about 1 atmosphere and measured with a barometer. Water potential is abbreviated by the Greek letter psi (ψ) and has two major components: solute potential (ψ_S), which is dependent on solute concentration and pressure potential, (ψ_P) which results from the exertion of pressure - either positive or negative - on a solution. We express this as:

$$\psi = \psi_p + \psi_S$$

$$\text{Water Potential} = \text{Pressure Potential} + \text{Solute Potential}$$

Figure 1.1 A potato cell is placed in pure water. Initially the water potential outside the cell is 0 and is higher than the water potential inside the cell (-3). Under these conditions there will be a net movement of water into the cell. The pressure potential inside the cell will increase until the cell reaches a state of equilibrium.



PRE-LAB QUESTIONS

1. What would happen if you applied saltwater to the roots of a plant? Why?
2. Will water move into or out of a plant cell if the cell has a higher water potential than the surrounding environment?

VARIABLES

- Independent variable is the solute concentrations you will use to determine the water potential of the Russet potato. It is recommended that you have at least five treatment levels between 0.0 M and 1.0 M (Example: 0.0M, 0.2M, 0.4M, 0.6M, 0.8M and 1.0M). You will also need five trials (pieces of potato) for each treatment (Example: 6 treatments equals 30 pieces of potato needed). The purpose of multiple trials is to help with minimizing the effects of errors when gathering data.
- Dependent variable is either the change in mass –OR– change in volume of the Russet potato pieces after being soaked in a solute solution.
- The standard variables will be room temperature (recorded in degrees Celsius), length of time for the potato pieces too soak (approximately 24 hours), and volume of solution used.

MATERIALS

Containers
Mass balance
Metric ruler
Russet potato
Scalpel
Various sucrose or sodium chloride solutions

PART 1: RAW DATA COLLECTION PROCEDURE

Each group will try to determine the concentration of starch in a Russet potato using various one of several methods:

- Sucrose solutions of increasing molarity by change in mass –OR– by change in volume
- Sodium chloride solutions of increasing molarity by change in mass –OR– by change in volume

A possible set of procedures is given below. **NOTE**: Your procedures may differ!

1. Determine how many treatments are needed to find the concentration of starch in a Russet potato.
2. Label the containers with your table number and one of the solution concentrations.
3. Pour 50 mL of the corresponding solution into the appropriate container.
4. Using the scalpel, slice the potato into five equally sized pieces.
5. Determine the individual masses of the potato pieces and record the data into the table in your lab notebook (see Table 1 below as an example).

Table 1: Change in Mass of Russet Potato in Varying Concentrations of Solution

Solution (M)	Final Mass (g, +/- 0.05 g)	$\bar{x}$ Initial Mass (g, +/- 0.05 g)	Final Mass (g, +/- 0.05 g)	$\bar{x}$ Final Mass (g, +/- 0.05 g)	$\bar{x}$ Change in Mass (g, +/- 0.05 g)	% Change in Mass
	1. 2. 3. 4. 5.		1. 2. 3. 4. 5.			

Remember: *You must include all solution used on the table.*

6. Place the pieces into the beakers with solution and cover with plastic wrap. Leave overnight.
7. Record the room temperature in Celsius.
8. On the next class day, remove the piece of potato from the containers and carefully blot of any excess solution.
9. Record **qualitative data** for each treatment group into your lab notebook.
10. Determine the new individual masses of the potato pieces and record the data into the table in your lab notebook.

PART 2: DATA ANALYSIS (use Table 1 above to finalize your calculations)

1. Calculate the mean ($\bar{x}$) initial mass and mean final mass –OR– mean ($\bar{x}$) initial volume and mean final volume of your potato pieces.
2. Calculate the change in mass –OR– volume of your potato pieces:

   Δ mass = mass $_{final}$ – mass $_{initial}$
3. Calculate the percent change in mass –OR– volume of your potato pieces:

   % Δ mass = (mass $_{final}$ – mass $_{initial}$) / mass $_{initial}$

Remember*: You must show one example calculation for each type of calculation made. It may be easier to select one treatment and show all the calculation for that treatment. In addition, in a calculation you can round to one decimal place beyond the original measurement precision.*

PART 3: STATISTICAL ANALYSIS

1. Calculate the standard deviation (SD) for each mean final mass for each solution. The best way to calculate this is by using a table. See Table 2 below:

Table 2: Calculation of Standard Deviation for Final Mass of Potato

Solution (M)	Final Mass (x) (g, +/- 0.05 g)	$\bar{x}$ Final Mass (g, +/- 0.05 g)	$(x - \bar{x})$	$(x - \bar{x})^2$	$\frac{(x - \bar{x})^2}{n-1}$	SE	95% CI
	1. 2. 3. 4. 5.		1. 2. 3. 4. 5.	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.		
Σ (sum)							

***Remember**: This table must be made for each solution used!*

Complete the SD by taking the value in by the arrow and taking the square root. Report this value in your notebook.

2. Calculate the standard error (SE) for each mean initial mass for each solution **AND** the standard error (SE) for each mean final mass for each solution (n = number of data points collected)

   Standard error (SE) $= \frac{SD}{\sqrt{n}}$

   Report this value in the appropriate table.
3. Calculate the 95% confidence interval (95% CI) by using the SE and the critical values table below ($t_{P(n-1)}$ is the value on the critical table based on the degrees of freedom (df) = the number of data points collected minus one):

   95% CI = SE x $t_{P(n-1)}$
4. Record this value in the appropriate table. The 95% confidence interval value will be used to draw error bars on your graph in Part 4.

Critical values of Student's t distribution at P = 0.05

df	P / 0.05
1	12.71
2	4.303
3	3.182
4	2.776
5	2.571

PART 4: GRAPHING RESULTS

1. In order to graph the results, the zero axis line should actually be in the middle of your graph.
2. The y-axis above this line should be labeled as % increase in mass while the y-axis below this line should be labeled % decrease.
3. The x-axis is the solution molarity within the container.
4. Create an appropriate title with both independent and dependent variables.
5. Plot your points from the percent change in mass.
6. Add standard deviation bars to each point on the graph.

PART 5: CALCULATION OF WATER POTENTIAL

1. To determine the molar concentration of the potato pieces we will need to determine the molarity of the solution in which the mass of the potato pieces does not change.
2. To find this, draw the straight line on your graph that best fits your data. **The point at which this line crosses the x-axis represents the molar concentration of the solution with a water potential that is equal to the potato tissue water potential.** At this concentration, there is no net gain or loss of water from the tissue.
3. What is the molar concentration of the solution?
4. Calculate the solute potential for the sucrose solution:

***Remember**: You must show one example calculation for each type of calculation made. It may be easier to select one treatment and show all the calculation for that treatment. In addition, in a calculation you can round to one decimal place beyond the original measurement precision.*

The solute potential of a solution can be calculated using the following formula:

Ψ_S = – iCRT

where

i = Ionization constant (sucrose = 1 because sucrose does not form ions in water, while sodium chloride = 2 because sodium chloride forms sodium and chloride ions in water)

C = molar concentration at equilibrium determined above

R = pressure constant (R = 0.0831 liter • bar / mole • K

T = temperature in Kelvin (K) = (273 + °C of room temperature)

POST-LAB QUESTIONS:

1. If a potato core is allowed to dehydrate by sitting in the open air, would the water potential of the potato cells decrease or increase? Why?
2. If a plant cell has a lower water potential than its surrounding environment and if pressure is equal to zero, is the cell hypertonic (in terms of solute concentration) or hypotonic to its environment? Will the cell gain or lose water? Explain.
3. If the water potential for a sucrose solution in a dialysis bag is -6.25 bars and it is immersed in a cup of sucrose solution having a water potential of -3.25 bars, and if the water potential inside and outside the bag is zero, will the bag gain or lose mass? Explain your answer.

CONCLUSION: Write a 3 paragraph **Evaluation** (see Lab Notebook Guidelines).

WATER POTENTIAL OF POTATO CELLS

POST-LAB QUESTIONS

1. If a potato core is allowed to dehydrate by sitting in the open air, would the water potential of the potato cells decrease or increase? Why?

The potato will lose water and there will be a decrease in water potential. There would be an increase in solute potential.

2. If a plant cell has a lower water potential than its surrounding environment and if pressure is equal to zero, is the cell hypertonic (in terms of solute concentration) or hypotonic to its environment? Will the cell gain or lose water? Explain.

The cell is hypertonic and will gain water (a low water potential = more solute)

3. If the water potential for a sucrose solution in a dialysis bag is -6.25 bars and it is immersed in a cup of sucrose solution having a water potential of -3.25 bars, and if the water potential inside and outside the bag is zero, will the bag gain or lose mass? Explain your answer.

There will be no movement. The two solutions will be at equilibrium when the water potential is equal (zero); the solute concentrations do not have to be the same.