AP BIOLOGY

Lab: Determining the Water Potential of Potato Cells

Background

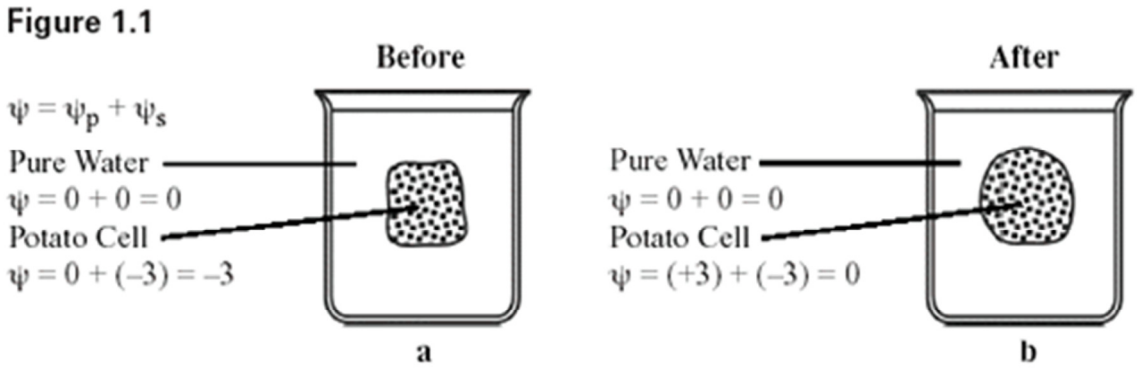
In animal cells, the movement of water into and out of the cell is influenced by the relative concentration of solute on either side of the cell membrane. If water moves out of the cell, the cell will shrink. If water moves into the cell, the cell may swell or even bursts. In plant cells, the presence 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:

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

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

In 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

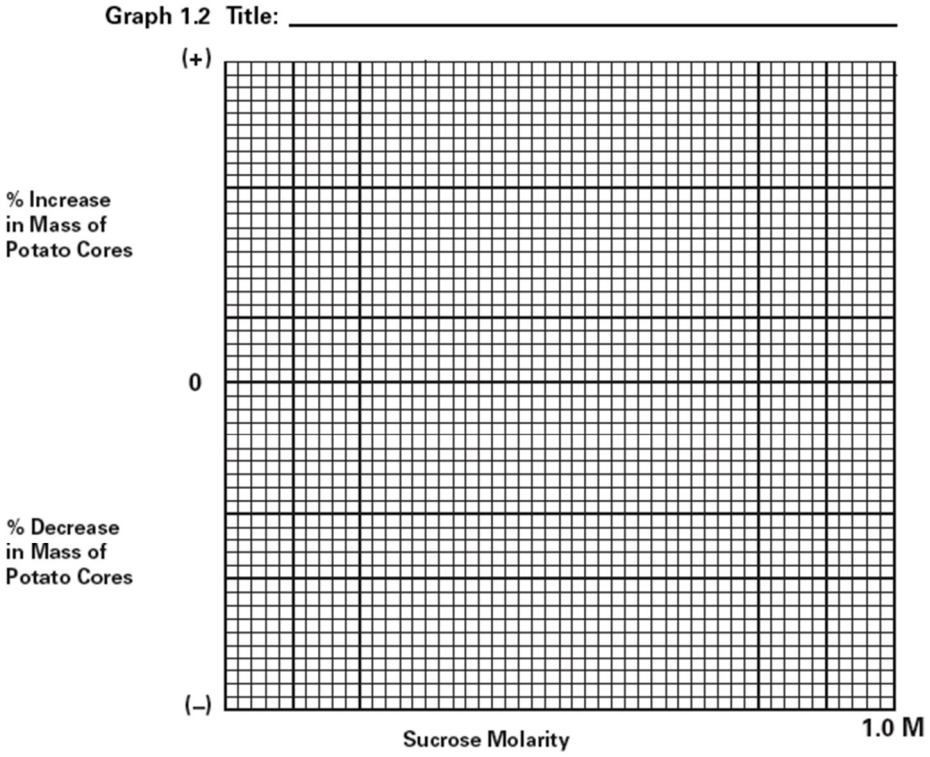
1. What would happen if you applied saltwater to the roots of a plant? Why?
2. Will water move into or out of a plant cell if the cell has a higher water potential than the surrounding environment?

Directions:

1. You will be provided with 5 sucrose solutions of unknown molarity (Each unknown is one of the following: 0.2 M, 0.4 M, 0.6 M, 0.8 M, 1.0M).
2. Pour 100 mL of each unknown solution into a beaker. Slice a potato into 5 equal cylinders.
3. Determine the mass of the 5 potato cylinders and record.
4. Place the cylinders into the beakers with solution and cover with plastic wrap. Leave overnight.
5. Remove the cylinders from the beakers and carefully blot of any excess solution. Record the room temperature in Celsius.
6. Determine the mass of the potato cylinders and record.
7. Calculate the % change.

Unknown Solution	Initial Mass	Final Mass	Mass difference	% Change in Mass

8. Determine the molarity of the unknown solutions. *This step will require some thought.*
9. Graph the results. In order to do so, the 0 axis line should actually be in the middle of your graph. The y axis above this line should be labeled % increase in mass while the y axis below this line should be labeled % decrease. The x axis is the sucrose molarity within the beaker.



10. Determine the molar concentration of the potato cores. This would be the sucrose molarity in which the mass of the potato core does not change. 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 sucrose 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.

11. What is the Molar concentration of sucrose? _____

12. Calculate the solute potential for the sucrose solution: _____

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

$\psi_S = -iCRT$

where

i	=	ionization constant (for sucrose this is 1 because sucrose does not ionize in water)
C	=	molar sucrose concentration at equilibrium (determined above)
R	=	pressure constant (handbook value R = 0.0831 liter bar/mole°K)
T	=	temperature °K (273 + °C of solution)

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.