Estimating the Osmolarity of Plant Cells by Change in Weight

Foreword:

Osmosis is a type of diffusion, the diffusion of water through a semi-permeable membrane, from an area of low solute concentration to an area of high solute concentration. For example, if a membrane that is impermeable to sucrose separates a solution of sucrose from distilled water, water will move from the distilled water, through the membrane into the sucrose solution. In this example, sucrose is the osmotically active substance (OAS).

Three terms, hypertonic, hypotonic, and isotonic, are used when referring to two solutions separated by a selectively permeable membrane. The hypertonic solution has a greater concentration of OAS than the solution on the other side of the membrane. It is described, therefore, as having a greater osmolarity (solute concentration expressed as molarity). The hypotonic solution has a lower concentration of OAS, or a lower osmolarity, than the solution on the other side of the membrane. When the two solutions are in equilibrium, the concentration of OAS being equal on both sides of the membrane, the osmolarities are equal and the substances are said to be isotonic. The net flow of water is from the hypotonic to the hypertonic solution. When the solutions are isotonic, there is no net flow of water across the membrane.

Fig. 1: The effect of solute concentration on osmosis in plant cells.
https://upload.wikimedia.org/wikipedia/commons/thumb/a/ab/Turgor_pressure_on_plant_cells_diagram.svg/2000px-Turgor_pressure_on_plant_cells_diagram.svg.png

Frequently, plant scientists need to determine the optimum water content for normal physiological processes in plants. They know that for normal activities to take place, the amount of water relative to osmotically active substances in cells must be maintained within a reasonable range. If plant cells have reduced water content, all vital functions slow down.

In the following experiments, you will estimate the osmolarity of potato tuber cells. You will incubate pieces of potato tuber in sucrose solutions of known molarity. The object is to find the molarity at which weight of the potato tuber tissue does not change, indicating that there has been no net loss or gain of water. This molarity is an indirect measure of the osmolarity of the potato tuber.
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Purpose:
In this experiment, you will determine the weight of several potato tuber cylinders and immerse them in a series of sucrose solutions overnight. You will then measure the mass of the cylinders and determine if they have gained or lost mass. This information will enable you to estimate the osmolarity of the potato tuber tissue.

Hypothesis
In a hypertonic solution the potato cylinders will lose mass, in a hypotonic solution they will gain mass and in an isotonic sucrose solution cylinders will not change mass. The osmolarity of the potato can therefore be determined by analyzing the change in mass of the potato cylinders.

Materials
1 large potato tuber
6 test tubes
10 ml graduated cylinder
paper towels

sucrose solutions: 0.10, 0.20, 0.30, 0.40, 0.50 M
balance
scalpel
weighing paper
metric ruler

forceps
cork borer
deionized (DI) water (0 molar)

Procedure
1. Label 6 test tubes as follows: 0.00M, 0.10M, 0.20M, 0.30M, 0.40M, and 0.50M.
2. Add 10.0 mL of the sucrose solutions to the correct test tube. (Note: DI water is 0.00M).
3. Use a sharp cork borer to obtain cylinders of potato. Push the borer through the length of the potato, twisting it back and forth. When the borer is filled, remove from the potato and push the potato cylinder out of the borer.
4. Line up the potato cylinders and, using a scalpel, cut all cylinders to a uniform length, about 3.0 cm, removing the peel from the ends. A minimum of 12 of these cylinders are required.
5. Use paper towel to blot excess fluid from the cylinders.
6. Measure and record the mass of a cylinder to nearest 0.1 g. Repeat for a second cylinder.
7. Transfer the two potato cylinders to the test tube containing deionized water.
8. Repeat steps 5 to 7 for each sugar solution from 0.10 to 0.50 M.
9. Leave the cylinders in the test tubes overnight.
10. The next day, remove the potato cylinders from the first sample. Blot the potato cylinders on a paper towel, removing excess solution only.
11. Measure the mass of the 2 potato cylinders and record the final masses.
12. Repeat this procedure for each test tube until all samples have been massed.
13. Calculate the percentage change in the mass of the pair of cylinders in each test tube using the following formula:

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\text{Percentage change in mass} = \left(\frac{\text{initial mass of the cylinders} - \text{final mass of the cylinders}}{\text{initial mass of the cylinders}}\right) \times 100\%
\]

14. Make a scatterplot of sucrose concentration against percentage change in mass (do not perform error analysis). Draw a line of best fit (no error bars are required). Use your graph to estimate the osmolarity of the potato (estimate to the hundredth of a molar unit).

This lab is NOT being marked using IB criteria

Raw Data Table (4) Calculations (2) Processed Data Table (4) Scatterplot (5)

Be sure to clearly state your estimate of potato osmolarity