Investigation

13

Solute Concentration of Potatoes

Introduction

A solution is a *solute* (dissolved substances, including charged particles) suspended in a *solvent* (which in living systems is water). When two solutions of different solute concentrations are separated by a selectively or semipermeable membrane, such as a cell membrane, the natural tendency would be for these two solutions to reach a concentration equilibrium, that is, an *isotonic* state. This might be accomplished by the movement of molecules through the membrane in both directions until a concentration equilibrium was reached between the two solutions. However, the attainment of this equilibrium is partially dependent upon the membrane separating the two solutions.

It is known that living cell membranes can and do restrict the passage of many types of molecules. For example, water molecules, because of their small size, electrical neutrality, and abundance in intracellular and extracellular fluids, tend to pass through cell membranes much faster than do other molecules or ions. This movement of water molecules through membranes is called *osmosis*. Furthermore, water diffuses very rapidly down its concentration gradient from a more dilute (*hypotonic*) solution, to a less dilute (*hypertonic*) solution.

Osmotic pressure is the pressure associated with osmosis and can be simply considered as a measure of a solution's tendency to draw water into it. The osmotic pressure of a solution is proportional to the total number of solute particles dissolved in it. Therefore, a hypertonic solution will draw more water from a hypotonic solution because it has a higher osmotic pressure. If some of the solutes in the hypertonic solution do not leave, as is the normal situation, it will tend to increase in volume because of the inflow of water. This increased volume usually resists more net water movement into this solution. Finally, an equilibrim may be reached in which the number of water molecules moving into the solution will equal the number moving out. Solutions which have the same osmotic pressure are said to be *iso-osmotic*.

Purpose

To determine the concentration of solute in potato cytoplasm.

Materials and Equipment

Materials
- potato
- 1 mol/L sucrose stock solution
- distilled water

Equipment
- 11 test tubes
- 10 mL graduated cylinder
- 100 mL beaker
- 10 mL pipette
- test tube holder
- #5 cork borer
- single edge razor blade
- ruler
- Centigram balance

Procedure

A. Preparation of sucrose solutions

Label the test tubes from 1 to 11. Prepare 10 mL of each concentration of sucrose solution shown in column A in the table below. Use the information in the table to mix the solutions as follows: add the amount of 1.0 mol/L sucrose solution (mL) indicated in column B to the amount of distilled water (mL) indicated in column C to make a solution of the concentration shown in column A. Place each solution as it is prepared into the numbered test tubes as indicated in column D.

A	B	C	D
Concentration of sucrose solution required (mol/L)	Amount of 1.0 mol/L sucrose solution required (mL)	Amount of distilled water required (mL)	Pour into test tube number shown below
1.0	10	0	1
0.9	9	1	2
0.8	8	2	3
0.7	7	3	4
0.6	6	4	5
0.5	5	5	6
0.4	4	6	7
0.3	3	7	8
0.2	2	8	9
0.1	1	9	10
0.0	0	10	11

B. Preparation of potato sections

Using a #5 cork borer, remove a section of potato. Using a razor blade cut a 5-cm length (excluding the skin) of potato section. Rinse the section in distilled water. Blot the section on a dry paper towel. Weigh the section to the nearest 0.1 g. Record this mass in a table similar to the one shown below under "Initial mass" for test tube 1. Place this potato section in test tube 1.

Remove and cut 10 more 5-cm lengths of potato section following the procedure above. Carefully record the initial mass of each section before placing it in its respective test tube. Allow each section to remain in its solution for approximately 24 hours.

Observations

Record your result in a chart similar to the one shown.

Test tube #	Concentration of sucrose solution (mol/L)	Initial mass (g)	Final mass (g)	Change in mass (g)	Percentage change in mass (%)
1	1.0				
2	0.9				
3	0.8				
4	0.7				
11	0.0				

After 24 hours, remove each potato section, blot dry and weigh to the nearest 0.1 g as before. Record each mass in the table as "Final mass." Calculate if a gain or loss of potato mass occurred for each potato section by subtracting the "Final mass" from the "Initial mass." A positive (+) value will indicate a gain in mass, a negative (−) value will indicate a loss. Record the final result by using a + or − sign before the numerical value to indicate a loss or gain in the mass of each section of potato. Calculate the percentage change in mass for each potato section by using the following formula:

$$\frac{\text{Change in mass (g)}}{\text{Initial mass (g)}} \times 100$$

Graph the *group* and *class* percentage changes in mass of the potato sections versus the concentration of the sugar solutions on the same graph. Connect the points with a smooth line. Label the graph appropriately.

Questions

1. In terms of tonicity, explain why some potato sections increased in mass, why some decreased in mass, and why some changed very little in mass.
2. At approximately what concentration is potato cytoplasm and the sucrose solution isotonic? Explain. What can you conclude about the solute concentration of potato cytoplasm?
3. If potato cells were suspended in a 1.0 mol/L sodium chloride solution instead of the 1.0 mol/L sucrose solution, what would you expect to happen to the mass of the potato cells? Explain.
4. From this exercise, what can you conclude about the permeability of potato cytoplasm with respect to sucrose and water molecules?
5. Explain why salt can be used as a weed killer.
6. In order to keep vegetables "crisp", grocery stores use cool water or ice. Which would keep vegetables crisper, tap water or distilled water? Explain.
7. When chemicals are added into the human body intravenously (directly into the bloodstream), they are added in solution. Why is it important that this solution be of the same concentration as that of blood plasma (liquid portion of the blood)?
8. What was the purpose of using distilled water as a solution in this exercise?
9. Name the responding and manipulative variables in this investigation.