Example of diffusion and osmosis report

Technology, Development

Introduction

Osmosis refers to the net water movement across a membrane, which is selectively permeable and the movement is driven by a difference in the concentration of the solutes on the opposite sides of the membrane. A selectively permeable membrane allows water to pass through without allowing ions or solute molecules to pass through. Other small molecules that are not charged are also allowed to pass through the membrane. Diffusion, on the other hand, refers to the movement of molecules in a random motion as a result of the kinetic energy and causes the molecules to have a net movement from areas where the particles are highly concentrated to areas where they are at low concentration. Osmosis and diffusion processes are very essential in a living organism since they enable the cell to take in the necessary nutrients and liquids in and take out waste that is needed. In human, diffusion is used to transfer oxygen from the capillaries into the cells and carbon dioxide from the cells into the capillaries. Osmosis is used in the human body in maintaining the appropriate concentration in the cells (Wright, 2000).

Animal and plant cells respond differently when they are put in solutions with a different water concentration. When placed in a solution that has a lower solute concentration (hypotonic) than the fluid in the cell, an animal cell tends to gain water from the surrounding. Failure to eliminate the excess water may cause the animal cell to burst, a process known as lysis. A plant cell, on the other hand, gains water in a hypotonic solution but does not burst due to the presence of the cell wall. The cell only becomes rigid and cannot take in more water. In a solution that has a higher solute concentration than the cytosol (hypertonic solution), an animal cell tends to lose its water content causing the cell to shrink. The plant cell also loses water when in a hypertonic solution causing the cell to be flaccid. Both the animal and plant cell do not change in shape when placed in a solution that has an equal solute concentration as their cytosol (Kent, 2000).

The cell membrane of an animal cell is highly permeable to water molecules and processes such as osmosis are necessary in making sure that cell content is constantly maintained. The amount of the osmotically active substances in a cell, as well as the extracellular tonicity, determines the amount of water in the cell and the volume of the cell. Although the osmotic water permeability is higher in most animal cells than the permeability towards ions such as Na^+, K^+, and Cl^-, high water permeability in these cells is a reflection of the presence of aquaporins (Hoffmann, Lambert, & Pedersen, 2009).

The rate of taking up materials through diffusion is greatly affected by the surface area to volume ratio of the cell. Small cells enable diffusion process of oxygen and nutrients into the cell to be quick and at the same time allowing excretion process to be quick. A big cell means that the nutrients will take too long to diffuse into the cell lowering the chances for the cell or the organism to survive. Most single celled organisms have a surface area that is big enough for oxygen and other nutrients to diffuse through. However, multicellular organisms lack this large surface area and thus require specialized organs to perform some cellular functions such as respiration (Miller & Stein, 2013).

This experiment aimed to investigate diffusion and osmosis in intestine and potato by investigating the osmolality of potato tissue by a change in weight. The experiment also aimed to investigate the effect of surface area to volume ratio on the amount of water that can diffuse across the plasma membrane. The experiment also aimed to determine the permeability of sausage casing.

Methods

Part I: Estimating Osmolarity by a change in Weight

Four large plastic tubes were placed in a test tube rack and labeled 0, 0. 3, 0. 5 and 0. 7 using masking tape and lab marker. Two rectangular pieces of potato that were prepared using a vegetable chopper were obtained using a piece of wax paper. Using a single-edged razor blade, any peel that was left on the potato was cut out. The potato pieces were cut into four cubes of equal size using a ruler and the razor blade. The dimensions of each cube were recorded. Each potato cube was weighed. This was done by placing a clean piece of wax paper on the balance pan and pressing down on the tare button to zero the machine. A potato cube was placed onto the wax paper and the weight. The cube was transferred to the first tube. Each of the remaining potato section was weighed and transferred to a different tube. Into each tube, 10mL of the appropriate solution was added to cover the potato cubes completely. The tubes were incubated in the solution for one hour. After incubation, the tubes were taken to balance and the final weight obtained. The percentage change in weight was calculated using the formula below.

Percentage weight change= Final Weight-Initial WeightInitial Weigth×100

Part II: The effect of Surface to Volume Ratio

Two rectangular potatoes, one large and one small, were obtained and placed on a piece of wax paper. Using a single-edged razor blade, any peel was cut from the potato pieces and the potatoes cut into a small cube of about 1cm and a large cube of about 2cm. The dimensions, area, volume and the weight of the two cubes were measured and recorded before and after the experiment. The potato sections were taken to the balance and weighted individually. This was done by placing a clean piece of wax paper on the balance pan and pressing down on the tare button to zero the machine. The first potato section was placed onto the balance and the initial weight recorded. The procedure was repeated for the other potato section. Both potato sections were transferred to a 50mL beaker and covered with distilled water for one hour. After incubation, the potato sections were weighted and the final weight recorded. The surface area of the two cubes was calculated using the formula L×W×6 while the volume was calculated using the formula L×W×H. The surface area to volume ratio was calculated using the formula Surface area of the cubeVolume of the cube.

Part III: IKI Test for the Presence of Starch

A 15cm piece of sausage casing was obtained and a plastic, 50mL piece of tripour beaker filled with 40mL of distilled water. A tight knot was tied carefully in one end of the sausage casing and using a 5mL pipette 2mL of a 45% glucose solution transferred into the sausage casing. Using a different 5mL pipette, 2mL of a 1. 5% starch solution to the sausage casing and the contents mixed completely by inverting the casing three times. After 30 minutes, the color of the solution in the sausage casing and the color of the solution in the beaker were observed and recorded. Using a clean 1mL pipette, 1mL of IKI was added to the water in the beaker and the color of the beaker contents and IKI solution recorded. One clean cuvette was labeled with SI (sausage casing (S) and IKI (I)) using a masking tape and a marker, and 1mL of solution from the sausage casing were placed into the cuvette using a clean 1mL pipette. The color of the solution in the cuvette was recorded.

Part IV: Benedict’s test for the Presence of Sugar

Three clean cuvettes were labeled with C (for control), S (for sausage casing), and B (for beaker) using masking tape and marker pen. Using a clean 1mL pipette, 1mL of solution from the beaker was removed and put in the cuvette labeled B. Using a clean 1mL pipette, 1mL of solution from the sausage casing was removed and put in the cuvette labeled S. In cuvette labeled C, 1mL of distilled water was added and the color of the contents in cuvettes C, B, and S was recorded prior to Benedict’s test. To each of the cuvettes, 5 drops of Benedict’s solution were added and the cuvettes placed in a test tube rack. The test tube rack was placed in the 60OC water bath for 5 minutes. The color of the solutions in the cuvettes was recorded.

Results

Part I: Estimating Osmolarity by a change in Weight

The percentage weight changes at different sucrose concentration by the different groups gave different values with 0M of sucrose giving the highest weight gain and 0. 7M sucrose gave the highest weight loss (Table 3). On average at 0M, percentage weight change was 10. 53%, 6. 8% weight change at 0. 3M, -7. 2% weight change at 0. 5M and -12. 93% at 0. 7M sucrose.

A graph of the average percentage change in weight against sucrose molarity was plotted as shown in Figure 1 below. Weight change decreased as the concentration of the sucrose solution increased. The point where there were no net gain or loss of water was at point y= 0 and using the equation of the line y = -35. 751x + 12. 704 giving 0. 36M to be the osmolarity of the potato cells.

Figure 1: Relationship between sucrose concentration and percentage weight change

Part II: Effect of Surface to Volume Ratio

The measurements of the small and large potatoes were recorded in Table 1 below. The calculated surface area was 24cm2 for the large potato cube and 6cm2 for the small potato cube. The calculated volumes gave 8cm3 for the large potato cube and 1cm3 for the small potato cube.

The percentage weight changes observed by the different groups after the two potato cubes were placed in a hypotonic solution were recorded in Table 2 below. On average, the large potatoes increased in weight by 5. 16% and 12. 06% respectively.

Part III and IV: IKI Test for the Presence of Starch and Benedict’s test for the Presence of Sugar

The original colors of the content, the color before and after IKI and Benedict’s test were recorded as shown (Table 4). For the IKI test, the color prior to the test was clear both in the beaker and the sausage casing. However, after the IKI test, the color in the beaker was dark purple while that of the sausage casing was dark blue. In the case of Benedict's test, cuvette C and S were clear in color before the test and cuvette B had a purple color. After the Benedict's test, the colors in cuvette C, S and B were light blue, light orange and dark orange respectively.

Discussion

This experiment aimed to investigate diffusion and osmosis in intestine and potato by investigating the osmolality of potato tissue by a change in weight. From the results, the potato sections had the highest weight gain at 0M sucrose since this represented a solution that was hypotonic to the cells of the potato. This caused water to enter into the potato cells increasing their weight. The 0. 3M sucrose solution was also hypotonic to the potato cells, and this caused the slight increase in weight. However, 0. 5M and 0. 7M sucrose solutions were both hypertonic to the potato cells, and this caused them to lose water to the solution resulting to a reduction in weight. The osmolarity of the potato cells was thus less than 0. 5M but higher than 0. 3M. This was confirmed by the results from the graph, which indicated the osmolality to be 0. 36M.

The experiment also aimed to investigate the effect of surface area to volume ratio on the amount of water that can diffuse across the plasma membrane. The small potato cube had a higher weight gain than the large potato cube. This means that the high surface area to volume ratio of the small potato cube enabled it to take in more water compared to the large potato cube, which had a less surface area to volume ratio. This indicates that surface are to volume ratio has an effect on the amount of content that a cell can diffuse across the membrane within a given time.

The experiment also aimed to determine the permeability of sausage casing. IKI turns the solution purple or black if starch is present and retains the color of IKI, which is pale yellow, when there is no starch in the solution. The solution, in the sausage casing, was dark blue after the IKI test indicating that starch was present in the solution. In the solution, in the beaker, the color turned dark purple also an indication that starch was present. This shows that sausage casing was permeable to starch molecules. Adding Benedict's reagent into a solution and then heating turns orange or orange-red if sugar is present. If no sugar is present, the solution remains blue, the characteristic color of Benedict's reagent. From the test, both cuvettes B and S changed color to purple while cuvette C had a blue color. This indicated that sugar was present in cuvette B and S while absent in cuvette C. The sausage casing was, therefore, permeable to sugar molecules.

In conclusion, the experiment successfully determined the osmolarity of potato cells to be 0. 36M. The surface area to volume ratio was also shown to have an effect on the amount of content that can diffuse across the plasma membrane. Finally, the experiment determined that sausage casing is permeable to both starch and sugar.

Reference List

Hoffmann, E. K., Lambert, I. H., & Pedersen, S. F. (2009). Physiology of cell volume regulation in vertebrates. Physiological reviews, 89(1), 193-277.

Kent, M. (2000). Advanced Biology. Oxford: Oxford University Press.

Miller, K., & Stein, J. (2013). Surface Area/Volume Relationships. Providence: Brown University.

Wright, D. B. (2000). Human Physiology and Health. London: Heinemann.