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Testing for Passive Transport of Water in Solanum Tuberosum within Saline Solutions

Introduction:

Diffusion and osmosis are two important mechanisms of passive transport. The concept behind these processes are very simple; molecules move from high concentration to low concentration (Khan, 2016). This is shown prominently in the human body, they allow for most transport into cells, and ensure sustainability of metabolic processes. These two mechanisms are common in plant and animal cells, which is why this lab explores whether or not it is possible to demonstrate the effects of osmosis and diffusion on plant cells by using common vegetables, in this case, a solanum tuberosum commonly known as a potato. This will occur through a series of observations of small pieces of the solanum tuberosum placed into slightly saline solutions. The solanum tuberosum is ideal for this experiment because of two features. First, it is composed of cells that are with semi permeable membranes. Second, the cells have salt water solutions inside their semipermeable membranes. These two features make them ideal for showing the effects of osmosis. This paper hypothesises that the solanum tuberosum, depending on the salinity of the solution, is expected to decrease in weight as a result of water loss, increase in weight due to water gain, or stay the same. It is further hypothesised that these occurrences would occur because the concentration of salt on the inside of the cell is greater, less than, or equal to the concentration of salt outside of the cell indicating that passive transport did occur.

Materials

The following materials were required in the experiment:
- 1 – 2 large solanum tuberosum
- knife
- salt
- hot water
- ruler
- food scale
- cups
- saran wrap
- paper towel
- Measuring beakers/graduated cylinder

Procedure:

The procedure for the experiment was made with two criteria in mind. First, the effects of osmosis and diffusion, assuming that the solanum tuberosum can exhibit these forms of passive transport, are evident, measurable, and repeatable. This is a main requirement for all labs, and will help confirm or contradict the hypothesis. Second, the experiment will be as free from as many external factors that can affect results as reasonably possible given the lack of precise measuring materials, and lack of a perfect lab environment.

The steps are as follows. First, the solanum tuberosum is cut into equal size slices. 3cm x 3 cm x 8 cm slices. The exact weights are then recorded. Next, 4 salt water solutions of

200ml each are made with the salt content at 0% (control), 1%, 2%, and 5% respectively. Then, a piece of solanum tuberosum is placed into each cup. The cup is then covered with saran wrap and placed in a cool dark area. After 24 hours, the solanum tuberosum is removed, and gently blotted with a paper towel to rid of excess water not absorbed by the solanum tuberosum. Finally, their exact weights are recorded.

1. Cut the solanum tuberosum into 3cm x 3 cm x 8 cm slices. Record the exact weights.
2. Make 4 salt water solutions with the salt content at 0% (control), 1%, 2%, and 5% respectively.
3. Place a slice into each cup.
4. Cover the cup with saran wrap and place in a cool dark area.
5. Remove the slices after 24 hours.
6. Gently blot each of them with a paper towel to rid of excess solution not absorbed by the solanum tuberosum, and record their final weights.

Results:

Figure 1: A depiction of the lab setup moments before it was commenced. The four cups have 200ml of respective salt solution and are ready to receive their solanum tuberosum piece.

Test Cases	Initial Mass (grams)	Final Mass (grams)	Change in mass (grams)	% Change in mass	Texture of the potato
Control: potato in tap water	12.4	15.1	2.7	22%	Puffy and bloated
Potato in 1% salt water	13.0	11.0	-2	-15%	shriveled
Potato in 2.5% salt water	12.2	8.2	-4	-33%	shriveled
Potato in 5% salt water	10.4	6.4	-4	-38%	shriveled

Table 1: Measurements of the mass of the potato before and after the experiment along with change in mass of potato, percent change in mass of potato, and texture of potato after the experiment for all 4 test cases. The % change in mass is calculated as the percent change in mass from the initial mass.

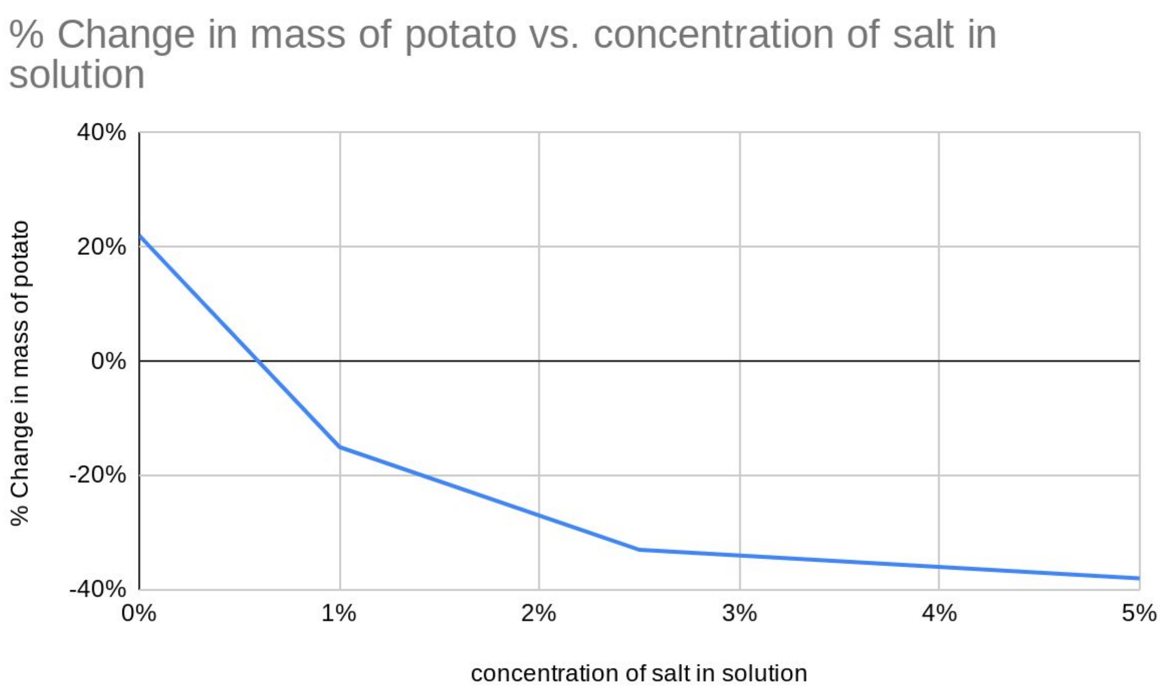

Figure 2: A representation of the relationship between concentration of salt in a solution with the change in mass of potato.

Analysis:

1. Analyze and interpret your results. What happened to the solanum tuberosum slices overnight (over the course of your experiment)? Why did it happen?

    Over the course of the experiment, the mass of the solanum tuberosum slices had changed. The 0% solution of saltwater caused a 22% increase in mass of the solanum tuberosum slice, the 1% solution of saltwater caused a 15% decrease in mass of a solanum tuberosum slice, the 2.5% solution of saltwater caused 33% decrease in mass of a solanum tuberosum slice, and the 5% solution of saltwater caused a 38% decrease in mass of a solanum tuberosum slice. Moreover, there was a drastic change in the texture of the solanum tuberosum slices. The solanum tuberosum slice in the 0% solution became puffy and bloated, while the slices in the 1%, 2.5%, and 5% salt water solutions shriveled.

    The change in mass and texture can be explained by osmosis, the net movement of solvent molecules through a semipermeable membrane to tend to equalize the concentrations. In this experiment, the solvent is water and the semipermeable membrane is made up of the cell walls of the solanum tuberosum cells. When placed in a solution less concentrated than its own, the solanum tuberosum cells had a lower concentration of solvent (water) than the solution. To equalize the concentrations of the solution and the solanum tuberosum cells, water rushed into the solanum tuberosum cells, increasing the solanum tuberosum slice's mass and causing the slice to swell. This mirrors what was observed in the control (0% solution). When placed in solutions more concentrated than its own, the solanum tuberosum cells had a higher concentration of solvent(water) than the solution. To equalize the concentrations of the solution and the solanum tuberosum cells, water within the solanum tuberosum cells moved out of the cells and into the solution, decreasing the solanum tuberosum slice's mass and causing the slice to shrivel.

2. Is diffusion or osmosis responsible for the changes? If so, what did we observe that would be evidence of osmosis and diffusion? (2T)

    Osmosis is responsible for the movement of water either into or out of the solanum tuberosum cells. While both processes equalize the concentration of two solutions, only solvent particles move in osmosis and do so through a semipermeable membrane. In the experiment, it was observed that only water (solvent) moved between the solanum tuberosum cells and the solution. Moreover, the cell walls of the solanum tuberosum cells of the slice make up the semipermeable membrane.

3. What are some sources of experimental errors in your experiment? (1T)

    Experimental error could arise in a variety of forms, and a possible source of experimental error is the volume of solution absorbed by the paper towel. The paper towel cannot absorb all the excess solution on a solanum tuberosum slice, and the mass of residual solution on the solanum tuberosum slice affects the measured final mass of the solanum tuberosum slice.

4. Does your result/interpretation agree with the literature? Does it open up new questions? (1T)

   The observations made in this experiment support existing literature that describes the processes of osmosis. Existing literature describes osmosis as the net movement of solvent molecules through a semipermeable membrane into a region of higher solute concentration (Haynie). In this experiment, it was observed that the solvent moved through the semipermeable membrane made of the cell walls of the solanum tuberosum cells of the solanum tuberosum slice. The observations (and result) support the literature.

5. Use your findings to explain: (3T)
   a. Why road salt cause damage to street plants

      Road salt is designed to reduce the freezing point of water and acts as a very concentrated solute. Street plants suffer when solutions of road salt and water splash onto them and when salted snow melts into their roots. Solutions of road salt and some water would have very low relative solvent concentrations, causing water from plant cells to rush out to equalize the concentrations inside and outside the plant cells. This would result in street plants suffering intense dehydration as road salt bounds up water and prevents the plant from receiving water and nutrients.

   b. Why wilted celery will become crisp when placed in a glass of pure water

      Wilted celery becomes crisp when placed in a glass of pure water due to a lower solvent concentration within the cells of the celery. The pure water rushes into the cells of the celery, restoring its rigidity with turgor pressure.
   c. Why would a sailor die more quickly drinking saltwater than not drinking at all

      Like plants, humans have water in their cells and desperately need their cells to have water in them. Drinking saltwater causes water to exit our cells to equalize concentrations inside and outside the cell. When a sailor needs to quench his/her thirst, drinking salt water would have the opposite effect - causing water to exit their cells, leaving them even thirstier than if they hadn't drunk the saltwater.

Conclusion

This experiment explored the relationships between the concentration of solute within a saltwater solution and the change in mass of a solanum tuberosum slice over an extended period of time. It was found that a 0% solution of saltwater caused a 22% increase in mass of the solanum tuberosum slice, a 1% solution of saltwater caused a 15% decrease in mass of a solanum tuberosum slice, a 2.5% solution of saltwater caused 33% decrease in mass of a solanum tuberosum slice, and a 5% solution of saltwater caused a 38% decrease in mass of a solanum tuberosum slice. The observations from this experiment support existing literature of osmosis (Haynie), the net movement of solvent through a semipermeable membrane tends toward equalizing concentrations of solvent on either side of a semipermeable membrane. The sources of error in this experiment include: residual saltwater solution that paper napkins were unable to absorb that affect the final measurements of slice mass and variation in the mass density of solanum tuberosum slices.

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