Jonathan Nisner

Investigate the use of Osmosis in potatoes

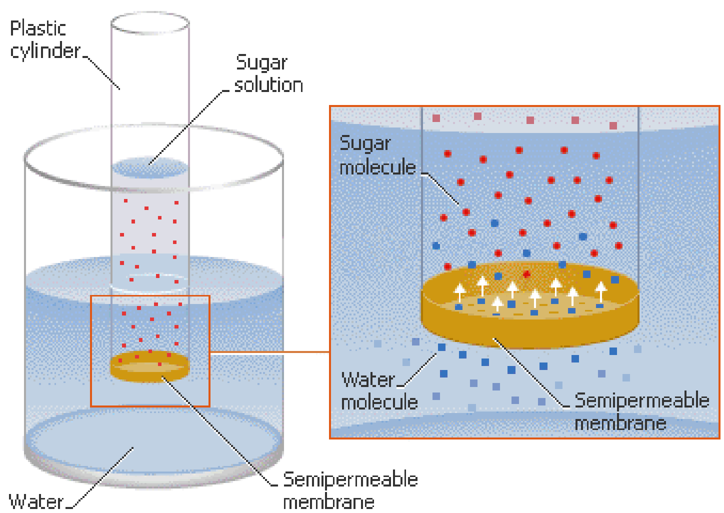
Aim: I will investigate how osmosis occurs and the effect of osmosis and the diffusion of salt to water and how the rate of osmosis changes. I will want to check the independent variables and independent variables and finally I will need to check the mass of the potato before and after the experiment.

Equipment needed: 2/3 potatoes, cork borer, ruler, beaker, thermometer, potato cuttings, scales/TBP, measuring cylinder, pure water, timer, and a calculator.

Prediction:

I predict that the potato will take in more water when put in a high concentration of water. I think this because the theory of osmosis states that water will pass from a dilute solution i.e. a high concentration of water, to a more concentrated solution i.e. a low concentration of water through a partially permeable membrane.

A partially permeable membrane is a cell membrane that only allows some molecules that are small enough to fit through the tiny holes e.g. water, through. It therefore prevents the passing through of molecules that are too big e.g. sucrose.



The water can pass through the cell membrane in both directions but is likely to balance the amount of water in the container with the amount in the potato cell. Therefore when the potato is put in a high concentration of water, the potato takes more water in, to balance it.

If the concentration of water in the potato cell is lower than the concentration in the solution, this is called a hypotonic solution. When the potato cell takes water in, it doesn't burst due to its very strong cell wall. The water enters the cell because the water potential of the cell is bigger than the water potential of the solution. These two water potentials work against each other pulling the water like a tug-of-war between the cell and solution. Since the water potential of the cell is larger, it sucks the water in to the cell, making it turgid from the amount of water. This water increases the mass of the potato.

If the plant cell is placed in an isotonic solution, a solution that has an equal concentration of water to the plant cell, the two water potentials have the same value so there is no movement of water. We call this incipient plasmolysis since the cell doesn't become turgid but doesn't become flaccid either.

When plant cells are put in a hypertonic solution, a solution that has a lower concentration of water to the concentration in the cell, the water potential of the cell is smaller then the water potential of the solution. The loss of water from the cell occurs because the water potential of the cell is smaller than the water potential of the solution therefore allowing the solution to win the tug-of-war so sucks water in from the cell making it shrink and become flaccid and plasmolysed. This causes a decrease in the mass of the potato.

The water potential is the total of the two pressures working on the cell and the solution. The cell has pressure being exerted onto its cell wall from the inside. This is called pressure potential. The cell also has pressure inside it from all its solutes called solute potential.

The solution that the cell is put in also has a water potential made up in the same way. The solute potential is from the actual solution, but since the solution has no cell wall, the pressure potential is always zero.

The solute potential is always negative, and the pressure potential is always positive. Depending on how high the potentials are the water potential can be positive or negative. Water potential that is negative always sucks water in, and water potential that is positive always pushes water out. The solution's water potential will always be negative since the solute potential is negative and the pressure potential is always zero.

Water potential = pressure potential + solute potential (negative plus positive becomes negative)
For example:

Solution: (▯▯▯-150 = 0 –150
Cell: (▯) -50 = 150 – 200 (this is just an example)

The solution's water potential is larger than the cell's water potential and since it is a negative, the solution sucks the water in from the cell.
If the cell's water potential had been larger than the solution's and would have been negative, then the cell would have sucked water in from the solution. If the cell's water potential is positive, the water would still leave the cell and enter the solution because positive pushes water out, and negative sucks in.

<u>Constants</u>:

- I will be keeping the volume of the solution to $10cm^3$.
- The length of the potato chips will be kept the same at 30mm.
- The potatoes will be peeled since the peel may affect how permeable the potato is.
- The same type of potato will be used because the environment in which it was grown may have affected its characteristics of permeability and water content.
- The environmental conditions of the potatoes will be kept the same to prevent any affects on the rate of evaporation of the water.
- The only variable is the concentration of the solutions.

<u>Safety</u>: to ensure that the experiment is carried out safely I will remove any objects that may be tripped over and any spilt solutions will be cleared up. I will be careful when cutting the potato so as not to cut myself.

<u>Method</u>:

- Cut 12 potato chips to the same size.
- Group them into 6pairs and weigh each pair noting the average mass down to 2 decimal points.
- Put each pair in separate containers.
- Measure out $6cm^3$ of 0.0molar glucose concentration i.e. water and pour it into a container with a pair of cuttings, ensuring that the cuttings are completely covered by the solution.
- Label the container with the amount of glucose concentration.
- Then measure out $6cm^3$ of 0.2m of glucose concentration and put it in a container with a pair of potato cutting and label it.
- Do the same for 0.4m, 0.6m, 0.8m, and 1.0m.
- Leave the containers for 24 hours and then re-measure the size and mass of each potato cutting, noting the average of each pair to see if they have changed.
- Measure how much liquid is left in the containers.

- Repeat the whole experiment 3 times to ensure that it is a fair test and to ensure that accurate averages will be used in the graphs.

<u>Preliminary Experiment</u>

Concentration of Sucrose	Vol. cm^3	Average mass of cutting before experiment (g)	Average length of cutting before experiment	Average mass after experiment (g)	Average length after experiment	Liquid left in tube after experiment
0.0m	6	0.84	1cm	0.97	1.2cm	$5.5cm^3$
0.2m	6	0.84	1cm	0.87	1cm	$5.7cm^3$
0.4m	6	0.84	1cm	0.8	0.9cm	$6cm^3$
0.6m	6	0.84	1cm	0.63	0.8cm	$6cm^3$
0.8m	6	0.84	1cm	0.67	0.7cm	$6.1cm^3$
1.0m	6	0.84	1cm	0.65	0.7cm	$6cm^3$

For the real experiment, I will make a number of improvements to my method in order to make my results more accurate. I will make my potato cuttings slightly larger to 3cm in length because it would be easier to measure the size of them at the end of the experiment, since they decrease in size. Since I will make the cuttings larger I will need to increase the volume of the solution to ensure that the cuttings are completely covered. So I will use $10cm^3$ of solution.

I will now do the real experiment.

Here are my results:

	Before experiment			After experiment		
Sucrose Concn. (mole)	Vol of Soln. (cm^3)	Avge. Mass (g)	Avge. Length (mm)	Avge. Mass (g)	Avge. Length (mm)	Vol of Soln. (cm^3)
0.0	10	5.39	30	5.88	33.0	8.0
0.2	10	5.39	30	5.56	31.0	9.1
0.4	10	5.24	30	4.93	29.5	10.0
0.6	10	5.36	30	4.34	28.3	10.7
0.8	10	5.42	30	4.06	26.8	11.3
1.0	10	5.14	30	3.66	26.8	11.0
All results are the average of 3 experiments						

Here is a table showing the percentage change:

Concentration of sucrose (molar)	Average original mass (g)	Average change in mass (g)	Percentage change in mass
0.0	5.39	0.49	8.3
0.2	5.39	0.17	3.06
0.4	5.24	-0.31	-6.29
0.6	5.36	-1.02	-23.5
0.8	5.42	-1.36	-33.5
1.0	5.14	-1.48	-40.44

<u>Analysis</u>

From the results plotted on the graph I can see that the potatoes have increased in mass when put in a high concentration of water i.e. 0.0m and 0.2m of sucrose, but when put in a lower concentration of water i.e. 0.4m, 0.6m, 0.8m, 1.0m of sucrose, the potato cells decreased in mass.

At 0.0m of sucrose, the potato chip increased in mass by 8.3%. This occurred due to osmosis. There was a higher concentration of water in the solution (0.0m is distilled water) than in the potato cells. This meant that water flowed from the cell into the solution. It moved because of the pressures acting on the cell and on the solution. The solution's water potential was lower than the cell's, so the cell sucked in water from the solution because of its higher negative water potential causing the cell to swell up and become turgid. This increased the mass of the potato.

The line of best fit follows a negativ e pattern showing that as the concentration of sucrose increased, the potato gradually lost more water causing the potato to decrease in mass.

At 1.0m of sucrose, the potato decreased in mass by 40.44%. This occurred because the concentration of water in the potato cells was higher than the concentration of water in the solution. This meant that the water potential of the cell was smaller than the solution's causing the solution to suck in water from the cell. This caused the potato to become flaccid an d plasmolysed and so decrease in mass.

From my graph I can see that when the concentration of sucrose was 0.17m, there was no change in mass of the potato. This was the point at which the solution and the cell had an equal concentration of water and was at a state of incipient plasmolysis. It was at this state that the water potential's of the solution and the cell were equal. The solution at this point was isotonic.

The above analysis shows that the results of my experiment confirm my prediction.

<u>Evaluation</u>
The results of my experiment follow my prediction but many factors may have affected the quality of the results.
The results are quite accurate since I repeated the experiment 3 times and I found the average of those results to 2 decimal places. My graph is accurate because I have drawn it to a precise scale. The points on the graph are fairly close together and aren't too scattered. The line of best fit is therefore quite accurate and there is an even number of points along each side of it.
I found no anomalies and my results follow quite a smooth pattern. I could have improved my method of carrying the experiment in a number of ways. I could have measured more accurately by having a larger scale on my measuring cylinders. Also, I could ha ve found a

way of drying the potatoes without losing too much of the solution, so that there would be an accurate amount of liquid remaining in the container after the experiment.

I could have done more experiments in order to have a more precise average p lotted on my graph. I could also have timed the experiment more accurately since each of the repeats may not have been exactly 24hours. Using two potato cuttings in each container was slightly inefficient as they weren't identical causing inaccuracies.

The containers were moved around. This may have affected the rate at which the water diffused in and out of the cells and may have affected any evaporation. The movement of the containers could also have changed the environmental conditions causing inac curacies.

All these factors may have affected the quality of my results and could be improved on.

So, although the results were fairly accurate, there were more considerations that should have been thought of to add to the result's reliability. Ther efore my conclusion is that there is sufficient evidence to say that the results show correct osmosis in action yet, the results seen by osmosis could have been more accurate