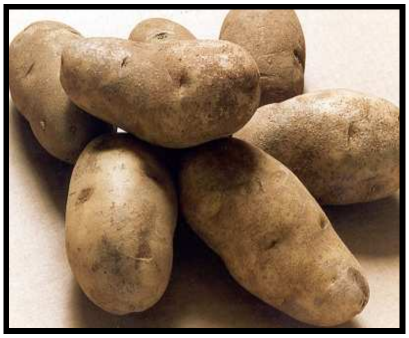
Investigation into the affect of Osmosis in Potato Tissue.



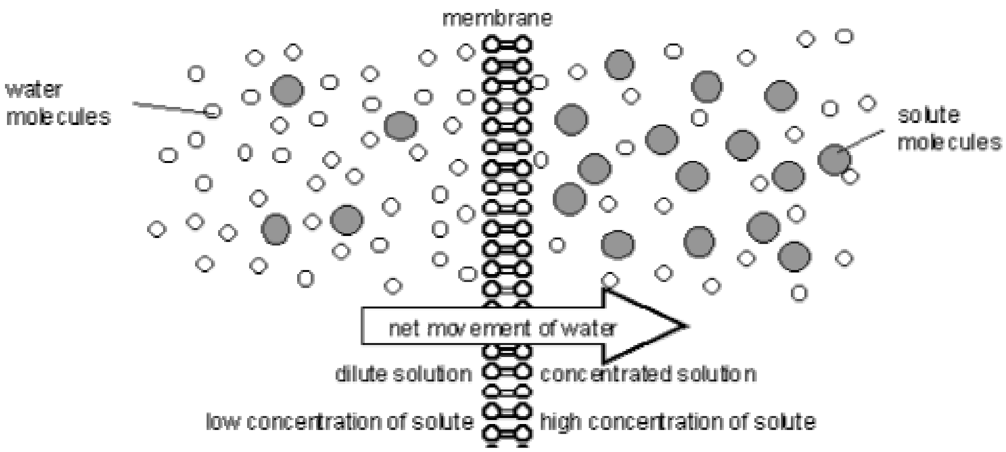
Introduction.

Water potential, Ψ_w, 'is a measure of the ability of water molecules to move from one region to another'. [1]

The more water molecules there are per volume of the cell the more likely that, by random movement, they will collide with the cell's plasma membrane, and travel out of it. Pure water has a Ψ_w of 0. As all solutions have less water molecules per volume than pure water they have a lower Ψ_w; therefore all solutions have negative water potentials.

The movement of water molecules is not totally random, the net movement of water is known as Osmosis.

Osmosis is a special form of diffusion, which involves the movement of water. Osmosis can be defined as: The movement of water, through a semi-permeable membrane, from an area where it is highly concentrated to an area where its concentration is lower. The water molecules move down a water potential gradient until equilibrium is reached. Equilibrium is reached when the water potentials on both sides of the plasma membrane are the same.

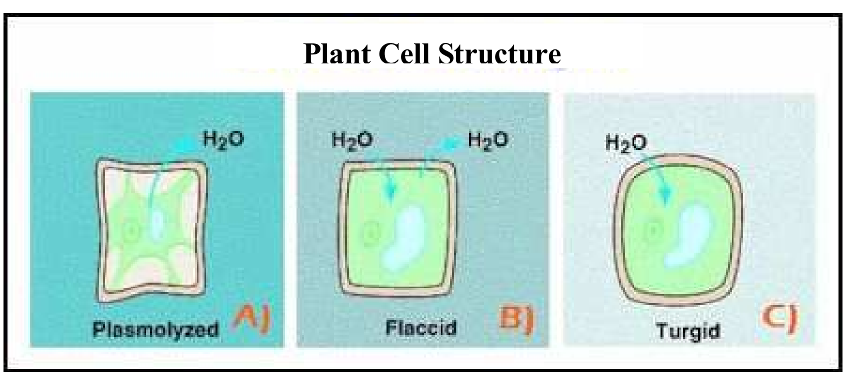


Water potential, Ψ_w, is equal to the solute potential, Ψ_s, plus the pressure potential, Ψ_p.

Therefore: $\Psi_w = \Psi_s + \Psi_p$

Potato and celeriac are both tubers, 'a thick rounded part of a stem or rhizome, usually found underground and covered with modified buds'. The root vegetables potato and celeriac were used because there structure is sufficiently similar so they will react in the same way when immersed in hypertonic and hypotonic solutions.

Knowing that osmosis will occur across a semi-permeable membrane whenever there is a difference between the water concentrations on either side of the membrane, and when this happens the cells will either become: turgid if water flows into the cell, or flaccid or possibly plasmolysed if water flows out of them. Water will flow into the cell if the solution is pure water or a hypotonic solution and will flow out if the solution is hypertonic.



(A) Plasmolysis occurs when a plant cells membrane shrinks away from its cell wall. This phenomenon occurs when water is drawn out of the cell and into the extra cellular *(*outside cell*)* fluid. The movement of water occurs across the membrane moving from an area of high water concentration to an area of lower water concentration outside the cell.

(B) Plant cells where the water flows into the cell and out of the cell are in equilibrium are not capable of providing the cell with support. Flaccid is a term used to indicate that the cell; although it contains water, does not have enough internal turgor pressure to provide structural support.

(C) Turgor pressure is the build-up of water within the plant cell. *B*ecause of the rigidity of the cell wall, the cell does not rupture, but instead the internal pressure increases. This increased internal pressure gives the plant cells structure that can support the plant.

*A*im:

To investigate the affect caused by varying the concentration of a sucrose solution on the amount of osmotic activity between; the solution, the potato/*C*eleriac cylinder. *A*nd to measure the water potential, Ψ_w, of the two root vegetables and compare them.

Variables:

To create a fair test certain aspects of the experiment will have to be kept the same whilst one variable is changed. The key variables are:

- The concentration of the solution.
- The volume of the potato/celeriac cylinders.
- The amount of solution used.
- Time the vegetable is left in the solution.

The concentration of the sugar solution will be varied. The factors that I will keep constant are; the volume of the potato/celeriac cylinders, the amount of solution used, and the time the vegetable is left in the solution.

Prediction

I think that the lower the concentration of the sugar solution in the test tube the larger the mass of the potato will be. This is because the water molecules pass from a high concentration, i.e. in the water itself, to a low concentration, i.e. in the potato chip. Therefore, the chips in higher water concentrations will have a larger mass than in higher sugar concentrations.

This hypothesis can be seen in living cells. The cell membrane in plant cells is semi-permeable and the vacuole contains a sugar/salt solution. So when a cell is placed in distilled water (high water concentration) water will move across the semi-permeable membrane into the cell (lower water concentration) by osmosis, making the cell swell. This cell is now referred to as turgid.

If done with potato cells, the cells would increase in length volume and mass because of the extra water. If these potato cells were placed in a solution with a low water concentration, then the opposite would happen. Water would move out of the cell into the solution. In extreme cases the cell membrane breaks away from the cell wall and the cell is referred to as plasmolysed. The potato cells will have decreased in length, volume and mass. The greater the concentration of water in the external solution the greater the amount of water that enters the cell by osmosis. The smaller the concentration of water in the external solution the greater the amount of water that leaves the cell.

However, there will be a point where the concentrations of water inside and outside will be at the same concentration. At this point the length, volume and mass of the potato will not change any further, the process will be in equilibrium.

<u>The Experiment.</u>

The apparatus that are needed for this experiment are:

- Petri Dishes (x 22)
- Cylinders of Potato (x 33) and Celeriac (x 33)
- Ruler: to measure length of cylinders.
- Top Pan Balance
- 50 ml Syringe (x 2)
- Beaker 250 cm3 (x 2)
- Distilled water: the reason for using distilled water instead of regular tap water is that the impurities such as; chlorine, fluoride, sulphur, salts and minerals, that make the water hard are extracted this should give more accurate results.
- 1.0 mol.dm^{-3} Sucrose solution: this is the stock solution from which all the serial dilutions will be made.
- Blotting Paper: to dry excess solution off the cylinders
- Cork Borer: to ensure uniformity to the size of the cylinders, which will increase the accuracy of the results.
- Scalpel
- Cutting tile
- Sticky Labels

<u>Method</u>

1.) Label the 2 sets of Petri dishes, from 0, 0.05, 0.1 to 0.5 cm^3

2.) Make up the serial dilutions of Sucrose, a separate 50ml syringe for the Distilled water and Sucrose to prevent contamination.

3.) Put the dilute solutions into its correct ensure that the solution covers the cylinders of potato.

4.) Prepare enough celeriac and potato cylinders using the cork b orer (about 8mm diameter). Cut the 33 potato cylinders to 5cm in length using the scalpel and the tile.

5.) Weigh and record the initial mass of the potato and celeriac cylinders.

6.) Put three potato cylinders in each dilution, of the first set of petri dishes . Then leave for 24 hours.

7.) Remove the cylinders from the solutions and dry with blotting paper (To ensure no excess solution is being weighed as this would bring errors to the recording.)

8.) Weigh and Record the final mass of the cylinders.

9.) Calculate the average change in mass for each sucrose solution and plot a graph of water potential of sucrose solution, shown in the table below, against average change in mass.

Water Potentials of the Sucrose Solution.

Concentration of the Sucrose Solution ($Mol.dm^{-3}$)	Water Potential KPa
0.0	0
0.05	-130
0.10	-260
0.15	-410
0.20	-540
0.25	-680
0.30	-860
0.35	-970
0.40	-1120
0.45	-1280
0.50	-1450

Serial Dilutions.

These are the measurements that are needed to make the serial dilutions.

Concentration of solution (mol)	Amount of Water (ml)	Amount of Sucrose (ml)
0	100	0
0.05	95	5
0.1	90	10
0.15	85	15
0.2	80	20
0.25	75	25
0.3	70	30
0.35	65	35
0.4	60	40
0.45	55	45
0.50	50	50

Risk Assessment.

Some simple safety precautions that must be taken whilst carrying out this experiment are: -

- Ensure all walkways are clear.
- Stand up whilst carrying out experiment.
- Be careful with the cork borer. Keep hands clear.
- Use the tile for all cutting.
- Cut the potato away from the body.
- Be careful with the glassware, If breakages occur ensure the glass is cleaned up immediately. Caution must be taken with the broken glass.

Average Results.

Potato.

Concentration ($Mol.dm^{-3}$)	Water Potential KPa	Initial Mass (g)	Time (Hrs)	Final Mass (g)	Mass Gain (g)	% Increase	Length (cm)
0	0	7.866	24	9.363	1.497	+ 19.03	5
0.05	-130	7.925	24	8.974	1.049	+ 12.88	5
0.1	-260	7.980	24	8.520	0.54	+ 6.77	5

0.15	-410	7.804	24	8.219	0.415	+ 5.32	5
0.2	-540	7.872	24	8.058	0.186	+ 2.36	5
0.25	-680	7.813	24	7.833	0.02	+0.25	5
0.3	-860	7.995	24	7.696	-0.299	- 3.74	5
0.35	-970	7.783	24	7.570	-0.213	- 2.74	5
0.4	-1120	7.750	24	7.421	-0.329	- 4.26	5
0.45	-1280	7.797	24	7.252	-0.545	- 5.99	5
0.50	-1450	7.745	24	7.061	-0.684	- 8.83	5

These results are the average masses from the three potato cylinders that were used for each concentration. The percentage weight gain is used to eradicate any errors due to the density of the potato used, as the weight from each piece of potato can vary.

The variation of the results is significant as it shows that the water potential of each potato cylinder was different. This is due to the fact potato tissue stores substances' for the plant and the water potential of the tissue, even in the same region, will vary.

The result obtained is an average and therefore using the mean or percentage water potential for the tissue sampled will reduce the inaccuracy results due to the variation of the plant tissue.

<u>Conclusion.</u>

Form the results and graphs it can be seen that in the more hyper tonic solutions the potato lost mass, in the 0.50 mol.dm-3 sucrose solution, -1450 KPa, the potato cylinders lost an average of 0.684 g. In hypotonic solutions and distilled water it gained mass, in water, 0 KPa, he potato chips gained an average of 1.497 g.

These results were predicted in the hypothesis and the results demonstrates the movement of water molecules by osmosis, described in the hypothesis to be 'the net movement of water molecules from a region of higher water potential to a region of lower water potential, down a water potential gradient, through a partially permeable membrane.

It was stated in the hypothesis that when the potato cylinders in a hypotonic solution (closer to 0 KPa than that of the potato tissue), the potato will gain mass and will lose mass in a hypertonic solution. And that equilibrium is reached when the potato tissue has the same water potential as its surrounding environment. This has been shown to be true by the results of the experiment.

The water potential of the potato can be calculated from the intercept on the x-axis of the graph, this is because, this is the point where there is no mass change so the water potential inside the tissue is the same as the surrounding solution.

According to the trend-line on the average percentage change graph the water potential of potato is -800 KPa, according to the results the water potential should be between 0.25 and 0.30 mol.dm-3, so these link in fairly close so I believe that the results are accurate. According to the trend-line of the mass gained graph it is also -810 KPa. So this shows the results are fairly accurate as the difference between the two values is only 10 KPa. So this shows that the mean value is -805 KPa.

Evaluation.

The results obtained follow a smooth sigmoid curve on the graph except for the result on –860 KPa, which was anomalous.

There are many possible explanations for this anomaly:

The equipment used places restrictions on precision and accuracy:

- Syringes: Syringes can only be read to 0.1 of a cm3 and therefore there is a high degree of imprecision that will affect the overall accuracy of the results. I would improve this aspect of the experiment by using more accurate syringes or pipettes.

- Ruler: It is hard to read a ruler more accurately than to the nearest mm. This is quite a large error in terms of the length of the celeriac chips and is imprecise. This aspect could be improved by using a constant measurement on a Vernier scale.

- Cork Borer: It is impossible to ensure that the cork borer enters the celeriac tissue at exactly the same angle. This means that if the cells are considered to be running in a similar direction a different number will be damaged each time. The more diagonally the cork borer enters the celeriac the more cell walls and membranes will be damaged making the results more inaccurate. There is no real way to correct this anomaly so in this aspect of the experiment, there will always be variances in the results.

- Petri Dishes. Petri dishes may not be deep enough to cover the entire cylinder of potato with solution, this would cause anomalies as some cylinder would not have the chance to take in as much water as others.

Environmental problems

Within the environment the experiment was carried out and left to stand over-night the temperature would fluctuate greatly. This is due to the heating system and the drop in temperature during the night.

This drop in temperature would cause the cells in the plant to take in less water. Also the temperature of the heating could cause some water to evaporate leaving a more concentrated solution.

A way to improve this would be to leave the experiment in a temperature stable environment, such as a thermostatically controlled room.