Asma Khan **Biology**

Determine the Water Potential of Potato tissue

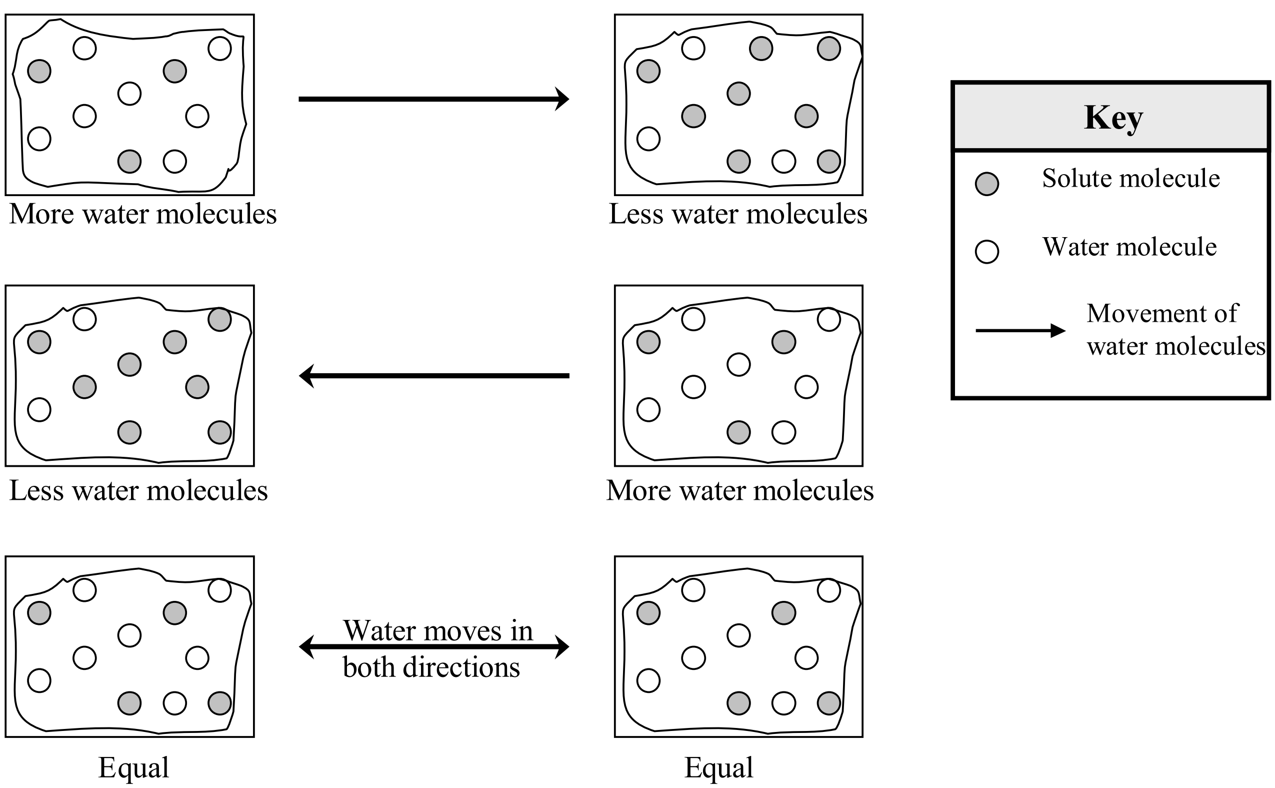
The aim of this experiment is to determine the water potential of potato tissue, using different concentrations of sucrose solution.

If plant cells are placed in pure water, water will initially move into the cells. After a period of time the cells will become turgid. Turgor pressure is the pressure exerted against the cell wall by contents of the cell. At first most water movement is into the cell. As the turgor pressure increases water will begin to diffuse out of the cell at a greater rate, eventually equilibrium will be reached and water will enter and leave the cell at the same rate. This stage is used to find the water potential of a particular cell.
Potato cells contain polysaccharides starch and glycogen they are good for storage. The potato cell is surrounded by plasma membrane it is a fluid mosaic model, which is a mosaic of phospholipids and proteins moving around they are not solid. This is why plant cell can become turgid and flaccid because their walls (plasma membrane) can stretch.
The plasma membrane is a selectively permeable barrier between the cell and the extra cellular environment. Water enters in the cell through phospholipids.

Water moves into and out of the cell by osmosis. This is a passive process which does not require any energy.

- Water always moves from high water potential to low water potential.
- Water potential is a measure of the tendency of water to move from high free energy to lower free energy.
- Distilled water in an open beaker has a water potential of 0(zero).
- The addition of solute decreases water potential.
- The addition of pressure increases water potential.

<u>Diagram</u> showing direction of water moving at different stages



Solvent molecules don't move in and out of the cell because their particles are too big, only water molecules can diffuse in and out of the cell.

Water potential is a measure of the ability of water molecules to move from one region to another. 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 water potential of 0. As all solutions have less water molecules per volume than pure water they have a lower water potential therefore all solutions have negative water potentials. The movement of water molecules is not totally random it is fixed.
Pressure potential helps plant cells from exploding when it is turgid.

Water potential, solute potential and pressure potential are related and linked by this formula:

Water potential (Ψ_W) = Solute potential (Ψ_S) + Pressure potential (Ψ_P)

In this experiment we have to determine the water potential of potato tissue. Water potential equals to solute potential because pressure potential is zero. This is because there is no pressure added or taken away in this experiment, pressure does not vary in this experiment we are leaving it natural. Therefore we now don't need to use the formula above for this reaction we will only need to find solute potential which will equal to water potential.

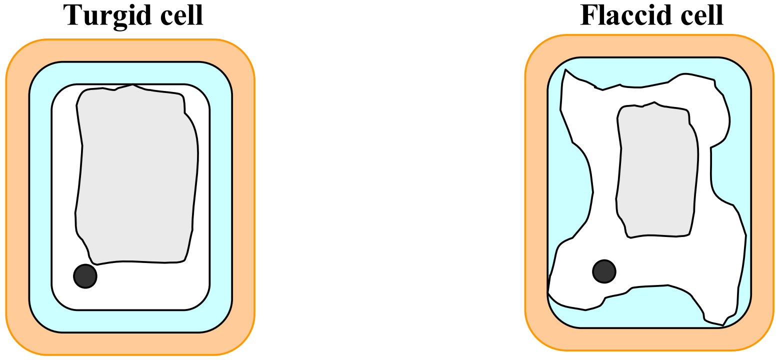
Water potential (Ψ_W) = Solute potential (Ψ_S)

In a free standing solution there is no turgor pressure ($\Psi p = 0$), so Ψw of the solution is equal to the Ψs of the solution. At equilibrium, the water potential of the tissue is equal to the water potential of the solution.

All plant tissues are composed of cells containing the same organelles in varying proportions.
Plant cells, would be bound by a cell wall and plasma membrane, have a nucleus containing chromatin granules, bounded by a nuclear membrane, cytoplasm, rough and smooth endoplasmic reticulum (ER), ribosomes, mitochondria, Golgi apparatus and a large, permanent vacuole.

Plant cells always have a strong cell wall surrounding them. When they take up water by osmosis they start to swell, but the cell wall prevents them from bursting. Plant cells become **"turgid"** when they are put in dilute solutions. Turgid means swollen and hard. The pressure inside the cell rises, eventually the internal pressure of the cell is so high that no more water can enter the cell.
When plant cells are placed in concentrated sugar solutions they lose water by osmosis and they become **"flaccid"**; this is the exact opposite of "turgid". The cell shrinks.
Diagram:

Turgid cell **Flaccid cell**



Potato Cell

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Results:

Result 1					
concentration of sucrose	**Original weight of potato**	**final weight of potato**	**change in weight**	**% change**	**% change - 100**
1	2.45	2.17	-0.28	88.57	-11.43
0.75	2.47	2.23	-0.24	90.28	-9.72
0.5	2.48	2.26	-0.22	91.13	-8.77
0.25	2.39	2.31	-0.08	96.65	-3.35
0	2.38	2.63	0.25	110.50	10.50
Concentration (M)	**water potential (K Pa)**				
0.35	**-970**				

Result 2					
concentration of sucrose	**original weight of potato**	**final weight of potato**	**change in weight**	**% change**	**% change - 100**
1	2.95	2.53	-0.42	85.76	-14.24
0.75	2.72	2.38	-0.34	90.49	-9.51
0.5	2.45	2.32	-0.13	94.69	-5.31
0.25	2.28	2.24	-0.04	98.25	-1.75
0	2.41	2.79	0.38	115.77	15.77
Concentration (M)	**water potential (K Pa)**				
0.41	**-1150**				

Average result for 1 & 2					
concentration of sucrose	**original weight of potato**	**final weight of potato**	**change in weight**	**% change**	**% change - 100**
1	2.70	2.35	-0.35	87.04	-12.96
0.75	2.60	2.31	-0.29	90.59	-9.41
0.5	2.47	2.29	-0.18	92.71	-7.29
0.25	2.34	2.28	-0.06	97.46	-2.54
0	2.40	2.71	0.32	112.92	12.92
Concentration (M)	**water potential (K Pa)**				
0.38	**-1070**				

CALCULATIONS

Subtract the initial weights from the final weights. Divide the difference by the initial weight and multiply by 100 to get the percent weight change.

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Interpreting results

The first observation I made was after the potato cylinders were placed in their solutions. I could see a difference. The potato in the 0.0M and 0.25M solutions were floating and the potatoes in the 0.5M, 0.75M and 1.0M solutions were at the bottom of the test tube.

The equilibrium where water enters and leaves the cell at the same rate is shown in my graph I have marked the point with dotted lines, this is where the line of best fit touches the x-axis at zero line and the concentration is found such as for graph 1 it is 0.35M. This demonstrates the movement of water molecules by osmosis, described in the plan as 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.
Looking at the results the physical condition of potato after the result the positive number of change in weight represents that the cell is turgid. The negative number of change in weight shows that the cell is flaccid.
All solute potential numbers are a negative because water has a solute potential of zero therefore solutions will have a negative solute potential because they contain less water molecules.

Graphs 1, 2 and 3 are S-shaped, sigmoid. Even though the concentration of sucrose solution increases in steady increments the graph is not a straight line. This is because as the concentration of sucrose solution increases the water potential does not increase proportionally. This is evident on the graph as the changing gradient of the line.

The graphs 1,2 and 3 shows that at 0M (water) the potato cell is turgid and the weight of potato is very high. This is because the potato cell is gaining water molecules, potato has less concentration of water molecules therefore water enters the potato through osmosis from high concentration of water to low concentration. This is a passive process which does not require energy.

Graph 1 shows that as you increase the concentration the weight of potato decreases even more because the potato cell is loosing water. Result 1 shows that as you go down concentration from 1 molar to 0.25 molar, change in weight has decreased therefore the potato cell has become flaccid. Water has moved out of the cell into the sucrose solution by diffusion of Osmosis (water molecules). At 0 Molar (only water) change in weight has increased therefore the potato cell has become turgid. Water has moved inside of cell by osmosis.
This also applies to graph/result 2 and 3.

Comparing result 1 and 2, you can see that at 1.0 Molar concentration of sucrose solution more water has been lost by potato tissue in result 1 when compare with result 2. But as you go down concentration more water is lost by potato tissue in result 2 than in result 1. At 0 Molar (water~) more water has been uptake by potato tissue in both tables. Result 2 shows that the potato cell was more turgid than the potato tissue in result 1.

Graph 4 shows solute potential of graph1, 2 and 3. You can see that result 3 lies in the middle of result 1 and 2 in graph 4. This is because result 3 is the average of result 1 and 2.
Graph 4 shows solute potentials and therefore shows water potential of experiment 1 and 2.

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<u>Evaluation</u>.

Results look fairly accurate I followed my method quite accurately, but when plotted the results in a graph you can see that the graph 2 result is not quite accurate, there is an anomalous result at 0.75 M concentration of sucrose solution. This is spotted because the pattern of the graph should be s-shaped but this is not shown by graph 2 and the anomalous result is where the result does not fit into the pattern.
Anomalous result might have occurred while weighing the potato before or after the experiment this must have changed the change in weight results which gave us an anomalous result.
The first and third graphs look accurate the pattern of the graph is s-shaped. As you increase the concentration the change in weight of potato tissue decreases becomes flaccid.

Graph 3 shows average result of result 1 and 2. This is much accurate graph that graphs 1 and 2, as it is the average. You can see that there are no anomalous results as the graph is a smooth s-shape.

Graph 4 shows solute potential of given sucrose solution. Graph 1, 2 and 3 show us the concentration at which the water potential is equal (water potential outside cell and inside are equal).
Graph 4 helps us to determine the solute potential therefore the water potential of potato tissue. By looking at the concentration at x-axis e.g. for graph 1 it is 0.35 then you go up and when it touches the line of best fit you go across and that reading is your solute potential (water potential) in this case it is -970.

When I compared my results with other members of pupils in my class I noticed that the result did vary a little this could be caused by:

- The length of potato
- How much the potato weighed before experiment. Therefore the weight of potato after the experiment would be affected by this.
- How long the potato had been in the sucrose solution

Reasons for anomalous result:
When I dried off the excess water on the potato cylinders after the experiment and before I weighed them, I used a paper towel. This might have either taken some water out of the potato or it might have left some excess water on the potato. This part of the experiment is difficult to come up with an accurate and fair method, as other ways would also lead to some slight mistakes.

The use of tap water was mentioned in the plan. It was impossible to use distilled or deionised water, as this is expensive and there was insufficient supply. Tap water often contains chlorine, fluoride, sulphur, minerals, salts, and heavy metals such as copper, lead and iron. However the majority of the contaminants in tap water are large, and often insoluble, molecules which have a lesser effect on Ψ_w than small soluble molecules. The use of tap water may well have had an effect on the accuracy of the results. The contaminants each volume of tap water contains will not be constant so the effect will vary from sample to sample, which in turn may have caused errors in the results obtained.

Improvements
It would have been beneficial to have repeated the experiment more times to make certain that the results were not gained through chance or by an external factor.
Ideally all samples should have come from the same part of the potato, as this would have decreased the chances of variations in texture.
I should have got a friend to help me see if I am recording the weight of the potato accurately.
The size of the potato cores were more than likely to be inconsistent in shape as they were cut by hand using a ruler for measurement. It may have been more appropriate to use a template of some sort.
It was also unlikely that room temperature and pressure remained consistent throughout the experiment conduction, and changes in temperature may have altered the rate of diffusion.

I think the conclusion reached is quite accurate. Although there was an anomalous result the rest lay on a smooth curve. The exact value of this point may not be exactly accurate as it is calculated from a freehand curve of best fit.
I can say that my results were successful at which the conditions I had, I managed to find water potential of potato tissue which is on average -1070 KPa.
If I had to do the experiment again I would make sure that all of the accuracy listed about is same each time. This is because there will be less difference in my final results and I will therefore get an accurate and reliable reading. I will use same equipments and weighing machine so I get similar readings.

Further investigation

I can extend my experiment by further investigation. I could find water potential of different types of potatoes and compare their results and find out which potato has the highest and lowest water potential.
I could extend the experiment to a more exact level by looking at the potato cylinders under a microscope, then I would be able to see the cells in greater detail and draw some more observational results.
I can also change my variables such as length of potato and see how the water potential changes as the length of potato increases.
I can also use some other source of food such as an apple to find its water potential in similar way.

References:

Class notes

Internet sites:

- www.learn.co.uk
- http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..ShowTOC&rid=mcb.TOC

Books:

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