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Biology Coursework

Investigating the Water Potential of Root Vegetables.

Introduction

For my experiment I will be investigating the water potential of root vegetables. The vegetable I am going to use is turnip. I am going to use turnip because it is a uniform vegetable.

This investigation is about osmosis. "Osmosis is the net movement of water molecules from an area of high water potential to an area of low water potential. This takes place through a partially permeable membrane."
Water potential is the potential energy of the water molecules on either side of the partially permeable membrane to move. Where the water molecules are more concentrated the potential energy of the water molecules is higher.
If a solution has a high water potential it has a higher concentration of water molecules and a lower concentration of solute molecules. The solution is said to be hypotonic. Low water potential is the opposite of this; the solution would have a low concentration of water molecules and a higher concentration of solute molecules, and is referred to as hypertonic.
If a plant cell is placed in a solution that has lower water potential than the cell (hypertonic solution) it becomes turgid. When a cell becomes turgid it swells, water enters the vacuole by osmosis, its protoplast expands and its turgidity increases. The cell does not burst because of its cellulose wall, when the cell wall is fully stretched it resists any further expansion of the cell. But if the cell were placed into a solution that has a higher water potential than the cell (hypotonic solution) the cell would become flaccid and then will would no longer exert a pressure on the cell wall. If water loss continues it will reach a point where the cell would completely detach itself from the cell wall. This is called plasmolysis and the cell would be referred to as plasmolysed. "Plasmolysis is the process by which water leaves the vacuole by osmosis, its protoplast shrinks and turgidity decreases. For the cell to remain in its normal state in a solution, the solution must be of the same concentration as the cell (isotonic solution). When this happens it is said to be in a state of equilibrium.
Water is important to the structural support of a plant, thus a lack of water can cause wilting, discolouration or even death. Water is taken into the plant from the soil by specialized root hairs, which are each about "200-250 mm" across. On a single root branch there are hundreds maybe thousands of these root hairs, this provides the plant with a large surface area for absorption of water from the soil. The water then moves across the root into the xylem in the center of the stem. It travels up through the xylem in the stem, and into the leaves; where it is transpired through open stomata into air.
Another important factor that must be taken into consideration is the tissue cells taken from the turnip must contain cells such as parenchyma and not xylem vessels. This is important because xylem vessels do not carry out osmosis. This means that in my results, depending on how much of the sample was xylem vessel; there would be a lower percentage weight gain or loss to the turnip that had xylem vessels in them.

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Prediction.

I predict that the swede that is put in low concentrations of sucrose solution will gain some weight. For example, swede placed in concentrations like 0.5mol dm^{-3} and 1mol dm^{-3} will gain the most weight. As the concentrations increase the weight gain decreases to a point where the swede starts to loose weight, this will happen at 2mol dm^{-3}, 2.5mol dm^{-3} concentrations.

This happens because of osmosis. Water molecules move from an area of high water potential to an area of lower water potential. The solutions with a low concentration of solute molecules have a high concentration of water molecules. So a concentration of 0.5mol dm^{-3} would have high water potential and therefore the water molecules would move through a partially permeable membrane and into the turnip, which has lower water potential thus increasing its weight.

The effects above would be the opposite for solutions with low water potential. But if the water potential of the solution was close to or equal to that of the turnip there would be little or no water movement therefore no weight change.

Variables

In any experiment there are three different variables, the independent, dependant, and fixed variables.
One of the independent variables is the morality of the different solutions in which the turnip would be placed. This factor is important because it affects the rate at which osmosis takes place. Different molarities mean different water potentials, which would suggest that osmosis is going to take place.
The dependant variable is the mass changes. I will record the masses in grams using a top pan balance. I will also make sure that the sizes of the discs are all the same by using a ruler.
The fixed variables are:

- The masses of the turnip tissue sample. They all have to be of the same weight or else the weight changes cannot be graphed against each other to show clear correlation.
- The size of the discs, to ensure there is the same surface area in each sample.
- The core borer, So that all the tubes are the same diameter.
- The amount of solution in each test tube, in order to allow for consistency.
- Keeping the same turnip throughout the experiment as different ones have different water content.
- The top pan balance, so there is no discrepancy between results.

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Preliminary Work.

Myself and two other classmates did preliminary experiments. I wanted to carry out a preliminary experiment to make sure that my method was suitable and that there weren't any other factors that might affect the experiment, which I hadn't already thought of. I used a book called "Biology, a functional approach" to help me develop a method I could use for my preliminary experiment.

I had already decided that I was going to use a swede for this experiment but as I found out it was incredibly difficult to work with because it is really stiff. So instead I'm going to use a turnip.

In my preliminary experiment I used two tubes of swede, one of which I cut into smaller equally sized discs. The two tubes were of equal mass. I cut one of the tubes into smaller discs because I wanted to see if there would be a major difference between the two. To observe the idea that a greater surface area allows faster diffusion. From my results, I gathered that the tube that had been cut into smaller discs had a greater rate of osmosis because it had gained more weight. I want to complete the experiment in one lesson so I am going to use the method of cutting the tubes into discs, so the experiment happens faster.

I put the swede in to the 2-test tube containing 20cm of 1mol dm^{-3} sucrose solution. When I reached this point of the experiment I felt that my method was working very well. After 20 minutes I emptied the test tubes and wiped the surface water of the swede. I then weighed the tube and then all the discs at once. These were my results…

Original weight (g)	**Weight after (g)**		**Weight diff. (g)**		**% Change**	
	Tube	Discs	Tube	Discs	Tube	Discs
2.73	2.84	2.87	0.11	0.14	4%	5%

There was some weight change but it wasn't great. So in my experiment I am going to increase the time that the turnip is in the solutions, to see if there is more of a change.

After I finished this preliminary experiment I wanted to do another 3 experiments using all the concentrations to make sure that I wouldn't get any anomalous results. At the end of the 3rd experiment I wanted to find the average weight and then the % change. The results can be seen on the results table.

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Method.

Equipment;
Boiling tubes x5,
Glass rods x5
Cork borer,
Test tube rack,
Razor blade,
Top pan balance,
Measuring cylinder,
Sticky labels and pen,
Ruler,

Sucrose solutions (0.5, 1, 1.5, 2, 2.5 mol dm^{-3})

Turnip tuber

1. Place the 5 test tubes in order in the test tube rack and give them a label so you don't get them mixed up.
2. Using cork borer, razor blade and top pan balance prepare 5 solid cylinders of turnip. Each cylinder must weigh 2 grams; this must be accurate because I am going to be calculating the weight change. Cut each cylinder into 4 equally sized discs.
3. Weigh each group of discs and record their masses.
4. In each of the boiling tubes put 20cm of the different concentrations of sucrose solutions, measured out using a measuring cylinder. E.g. in the first test tube put 20cm of 0.5mol dm^{-3} and label it.
5. Place the groups of discs in each of the boiling tubes and leave for 40minutes. During their time in the solutions give them a stir with a glass rod. This is to make sure that osmosis is occurring on all surfaces of the turnip. Do not use the same rod for all the boiling tube, as this will mix the solutions.
6. After 40 minutes empty the boiling tubes by using your thumb as a stopper to allow the solution out. Make sure that whilst emptying the boiling tubes you don't let the turnip fall out.
7. Weigh each group of discs again; making sure that when you put them on the balance you place them in the middle of the pan as this can affect the overall weight. Record the weight and do this for the other boiling tubes.

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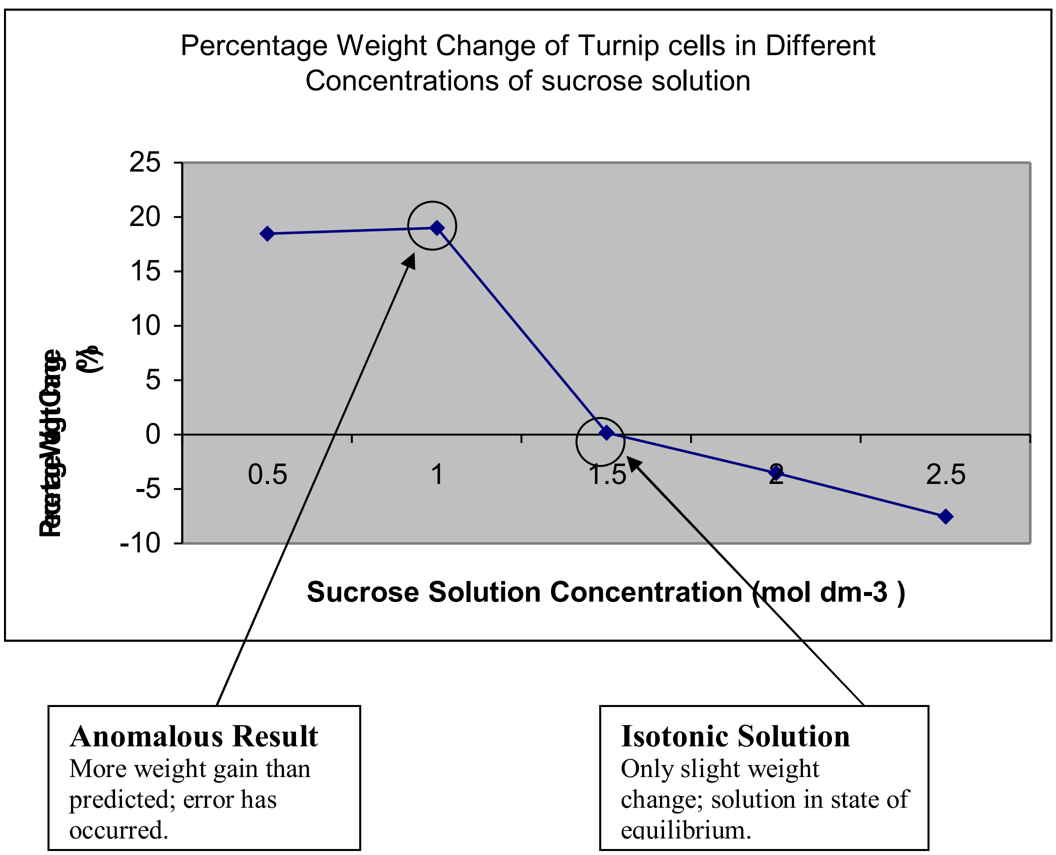
Results.

Concentration (mol dm^{-3})	Weight Before (g)			Weight After (g)			Average Weight Diff. (g)	Percentage Change (%)
	1	2	3	1	2	3		
0.5	2	2	2	2.35	2.34	2.41	0.37	18.5
1	2	2	2	2.18	2.34	2.64	0.38	19
1.5	2	2	2	2	1.98	2.03	0.003*	0.15
2	2	2	2	1.89	1.93	1.97	-0.01	-3.5
2.5	2	2	2	1.75	1.82	1.97	-0.15	-7.5



My results are quite significant as they show the trend that at lower concentrations there is more weight gain than there is at higher concentrations, which is a reflection of osmosis.

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Conclusion and Interpretation.

I predicted that turnip put into different concentrations of sucrose solution would change weight. Turnip put into low concentrations of sucrose solution would gain weight but those put into higher concentrations would loose weight. This is because of osmosis. Water molecules move from an area of high water potential to an area of lower water potential. If the solution has a high concentration of solute molecules then it will have low water potential, this is called a concentration gradient.

I can conclude that my original prediction was correct with the exception of one anomalous result. The lower concentrations gained more weight and the higher concentrations lost weight. My results show a trend that I expected to see.

The 2-gram cylinder of turnip placed in a boiling tube along with 20cm of 0.5mol dm^{-3} Sucrose solution gained an average weight of 0.37g, which is an 18.5% change (it is a hypertonic solution), compared to the turnip placed in a concentration of 2.5mol dm^{-3}, which lost 0.15g, which is a –7.5% change (this is a hypotonic solution). As the concentrations increased the weight gain generally decreased, this was shown in the concentrations of 0.5, 1, 1.5mol dm^{-3}; although, the turnip placed in a 1mol dm gained more weight than that in the0.5mol dm which was not what I expected. This is called an anomalous result. When the concentrations reached 2, 2.5mol dm^{-3} there was weight loss. The turnip placed in the concentration 2mol dm^{-3} lost 0.01g but when the concentration increased so did the weight loss to 0.15g. At 2mol dm^{-3} the solution is almost isotonic, as the net movement of water molecules is little.

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Evaluation.

My experiment is limited by the accuracy of the top pan balance, which is accurate to one decimal place. It is also likely that during my experiment there was some temperature change or pressure change, which may have influenced the rate of diffusion.
I have one anomalous result, which arose from the solution with the concentration of 1mol dm-3. The disks of turnip that were placed in this solution gained more weight than the disks in the lower concentration 0.5mol dm-3. I know this is an anomalous result because if a solution has a low concentration of solute molecules there is a high concentration of water molecules; it has high water potential. Osmosis describes the movement of water molecules from an area of high water potential to an area of lower water potential. This means that the 0.5mol dm-3 concentrated solution has the highest water potential and therefore the turnip placed in that solution should gain the most weight. However this is not the case, the turnip placed in the 1mol dm-3 concentrated solution gained more weight. This anomalous result may have occurred from an error in my practical work. I could have done a number of mistakes; I may have measured the weight wrongly in the initial stages or after the experiment had finished. Before I weighed the disks after the experiment I removed the excess water by lightly rolling the disks on a paper towel, I could have pressed harder on the other samples and absorbed some of the water making them all lighter than these disks or I may have just missed them out by accident, having the excess water could make them heavier.
Apart from my single anomalous result I would say that my results are very reliable, they show a trend that I predicted to see; the lower concentration gaining more weight than the higher concentration. I did my experiment three times; the preliminary experiments all had close results.
I could improve the reliability of my results by using more concentrations, so that I would have a wider range to view, although I don’t think that there would be much of a difference in what I have already seen but using a greater range of molarities over smaller increments would show more accurate results. I don’t need to repeat my experiment because I carried out preliminary experiments so I know that my results weren’t gained through chance or influenced by outside influences. I took the samples of tissue for one experiment from the same turnip, even though I tried not to cut through the xylem/phloem there would probably still be differences in texture between the different sample which could have influenced the results so ideally all samples would come from the same part of the turnip. The last improvement would be that during the experiment handle the turnip tubes with tongs or forceps to allow minimum contact with cell surface membranes.

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