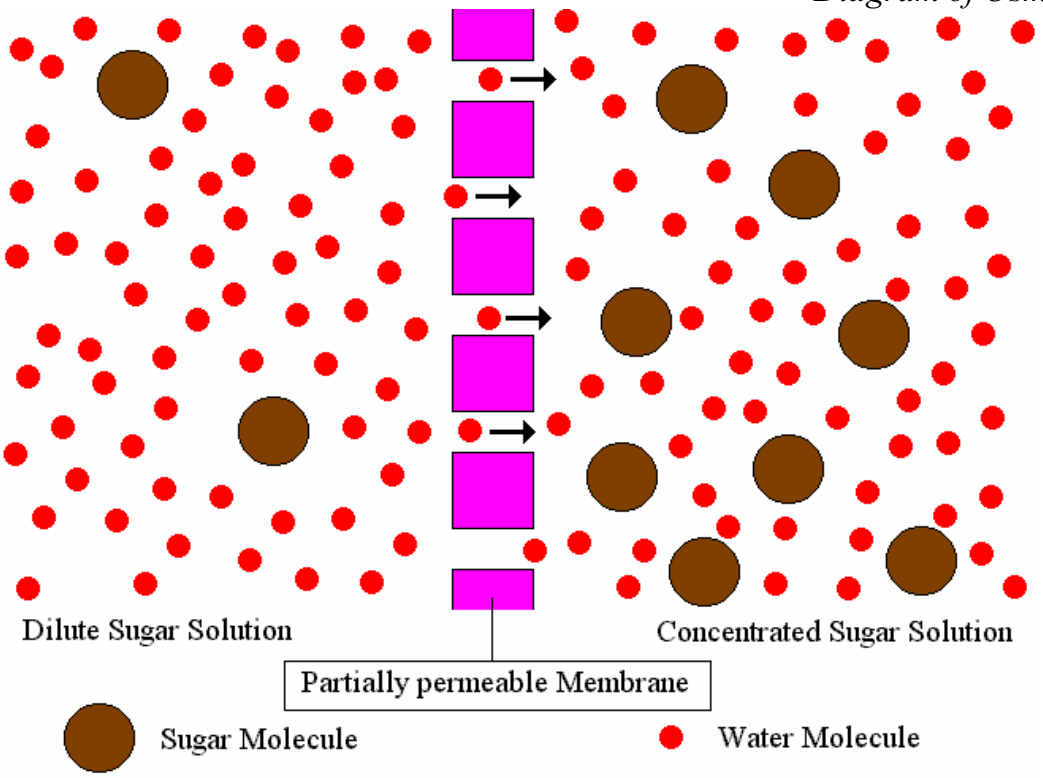
Introduction

The water molecules move in and out of the cell through the partially permeable cell membrane by the process of **Osmosis**. The definition of osmosis as given in "Understanding Biology For A-level, Fourth Edition" by "Susan and Glenn Toole" is as follows, *"the passage of water from a region where it is highly concentrated to a region where its concentration is lower, through a partially permeable membrane."*

Diagram of Osmosis



This investigation is to establish the exact water potential of apple tissue. The definition of water potential, as written in "Biology 1" endorsed by OCR

"Water potential is the tendency of a solution to lose water; water moves from a solution with high water potential to one with low water potential. Water potential is decreased by the addition of a solute, and increased by the application of pressure. Symbol is ψ"

This is called moving down a water potential gradient. When the water potential in both regions is equal both areas are in equilibrium and there is not further net movement of molecules. The water potential of a cell is

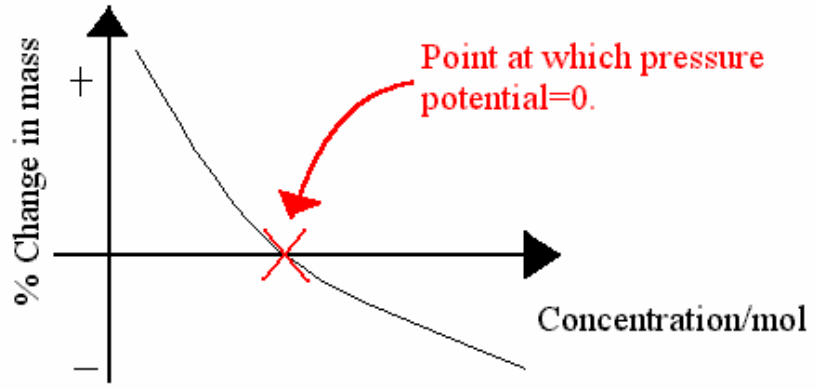
determined by two factors: the solute potential in the cell (ψ_s), and the pressure potential (ψ_p).

- The solute potential (ψ_s) is a measure of the reduction in water potential due to the presence of solute molecules. It is the **negative** component of water potential, sometimes referred to as the osmotic potential or osmotic pressure.
- The pressure potential (ψ_p) is the hydrostatic pressure to which water is subjected. The pressure potential is usually **positive**. It is sometimes called turgor or wall pressure. Therefore:

$$\psi_{cell} = \psi_s + \psi_p$$

When the environment water potential and the cell water potential are the same the two systems are said to be **isotonic**. If the external water potential is more negative than the cell water potential the solution is **hypertonic**. This means the water leaves the cell and becomes **flaccid** ($\psi_p=0$) and the cell membrane pulls away from the cell wall. This is called **plasmolysis**. If full plasmolysis occurs the cell can never recover, even if more water is taken on. If the external water potential is less negative than the water potential of the cell or the cell is placed in a **hypotonic** solution, then water begins to move into the cell, causing it to swell and increasing the ψ_p. ψ_p continues to rise until it offsets ψ_s and the water potential equals zero. This also stops water from entering the cell, which is now said to be **turgid**.

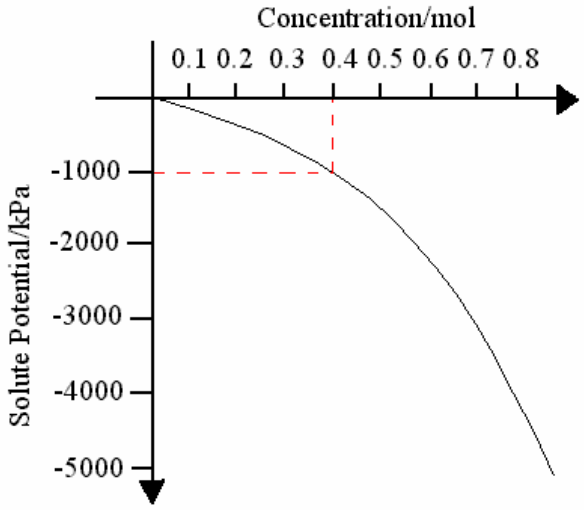
If I can determine the point at which the pressure potential equals zero then I can find the water potential be knowing the solute potential. During previous questions done in class, I know that by drawing a concentration against percentage change in mass and length graph and find the point at which the curve crosses the x-axis I can determine the solute potential of the tissue being tested. The graph usually looks like this:



The concentration at which the curve crosses the axis is the concentration of the solute in the tissue being tested. By using a calibration curve it is possible to find out the pressure in kPa of that concentration and hence find the solute potential for the tissue. Since the pressure potential = 0 at this point the solute potential will also be the value for the water potential. For example, if the

concentration was read to 0.4M, by using the graph below the p ressure would come to a value of –1000kPa (this is not an exact representation of a calibration curve).

Example of a Calibration Curve



I obtain some true figures from Table 13.4 in
which show the solute potentials of given sucrose solutions at 20ºC. The graph is shown on the next page.

Concentration of sucrose solution (molarity)	Solute potential/kPa
0.05	-13
0.10	-260
0.15	-410
0.20	-540
0.25	-680
0.30	-820
0.35	-970
0.40	-1120
0.45	-1280
0.50	-1450
0.55	-1620
0.60	-1800
0.65	-1980
0.70	-2180
0.75	-2370
0.80	-2580
0.85	-2790
0.90	-3010
0.95	-3250
1.00	-3510
1.50	-6670
2.00	-11810

Preliminary Test 1: to find Range of concentrations

1. Using cork borer cut 12 cylinders from apple flesh and cut to 50mm long, ensuring the skin is cut off at both ends because it may interfere with the process of osmosis.
2. Check length and find mass of each cylinder and place in petri dishes with their labels on the bottom of the dishes.
3. Make up $20cm^3$ of 0.0M, 0.2M, 0.4M, 0.6M, 0.8M and 1.0M sucrose solution and place each into a different petri dish, making sure that all the apple is submerged.
4. Leave for 12 hours and then retake mass and length for each cylinder and make a note of results.
5. I also need to find the percentage change by dividing the change in b y the initial and multiplying by 100 for both length and mass.

Results for Preliminary Test 1

Concentration	Mass before/g			Mass after/g			Change in mass/g			% Change in mass		
/Mol	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
0.0	0.87	0.87	0.87	0.85	0.82	0.835	-0.020	-0.050	-0.035	-2.30	-5.75	-4.02
0.2	0.92	0.92	0.92	0.87	0.90	0.885	-0.050	-0.020	-0.035	-5.43	-2.17	-3.80
0.4	0.92	0.90	0.91	0.90	0.94	0.92	-0.020	0.040	0.010	-2.17	4.44	1.10
0.6	0.86	0.83	0.845	0.90	0.85	0.875	0.040	0.020	0.030	4.65	2.41	3.55
0.8	0.91	0.88	0.895	0.87	0.83	0.85	-0.040	-0.050	-0.045	-4.40	-5.68	-5.03
1.0	0.93	0.90	0.915	0.78	0.75	0.765	-1.150	-0.150	-0.150	-16.13	-16.67	-16.39

Concentration	Length before/mm			Length after/mm			Change in Length/mm			% Change in Length		
/Mol	1	2	Mean	1	2	Mean	1	2	Mean	1	2	Mean
0.0	50	50	50	50	51	50.5	0	1	0.5	0	2	1
0.2	50	50	50	51	50	50.5	1	0	0.5	2	0	1
0.4	50	50	50	51	52	51.5	1	2	1.5	2	4	3
0.6	50	50	50	51	51	51	1	1	1	2	2	2
0.8	50	50	50	48	49	48.5	-2	-1	-1.5	-4	-2	-3
1.0	50	50	50	47	46	46.5	-3	-4	-3.5	-6	-8	-7

Preliminary Test 2: to find what shape to use

I also needed to establish what shape I should make my samples of apple in order to ensure a fair test and to obtain the optimum results from the experiment. I cut two different shapes of apple, one w as in the shape of a slice and tried to make the dimensions 5mm x 50mm x 2mm and the other was using a 5mm cork borer which I used to obtain cylinders of apple, which I then cut to 50mm long. I placed two pieces of each shape into petri dishes containing 1M sucrose solution, from my previous experiment I knew that this high molarity would give the most noticeable results and so making it easier to notice any differences between the two shapes. The results were as follows:

Results of Preliminary Test 2

Shape of Apple Piece	Core 5mm x 50mm			Strip 5mm x 50mm x 2mm		
	1	2	Mean	1	2	Mean
Mass Before/g	0.85	0.92	0.885	0.56	0.53	0.545
Mass After/g	0.72	0.78	0.745	0.52	0.50	0.51
Change in Mass/g	-0.130	-0.140	-0.135	-0.040	-0.030	-0.035
% Change in Mass	-15.29	-15.22	-15.25	-7.14	-5.66	-6.42

Shape of Apple Piece	Core 5mm x 50mm			Strip 5mm x 50mm x 2mm		
	1	2	Mean	1	2	Mean
Length Before/mm	50	50	50	50	50	50
Length After/mm	46	46	46	49	49	49
Change in Length/mm	-4	-4	-4	-1	-1	-1
% Change in Length	-8	-8	-8	-2	-2	-2

Apple tissue, as most people can tell just by tasting, is very sugary but to prove this I looked at results from a previous question we had answered during class, which was taken from the March 1998 exam paper. The results from this experiment showed that potato tissue had a molarity of sucrose solution of around 0.1 Mol dm^{-3}, which converts to give a solute potential of about -250 kPa. However, apple tissue had a molarity of sucrose solution of 0.94 Mol dm^{-3}, which gives a solute potential of -3200 kPa. This shows that apple tissue is more sugary than potato. I also performed a Benedict's Test to get some idea of the sugar content of apple compared with that of potato.

Preliminary Test 3: to prove apple is highly sugary

1. Label two test tubes 'potato' and 'apple'.
2. Crush a small amount of potato and a small amount of apple and put into appropriate tubes.
3. Using a pipette, add water and equal amount of Benedict's Reagent to each tube. NOTE Copper solutions are poisonous.
4. Place both tubes into water bath and leave to boil, making sure they are clearly labelled. NOTE Benedict's solution must be boiled in a water bath, it should not be heated directly.
5. Remove after about 30min and observe and record and colour changes.

Results of Preliminary Test 3

From my test I found that the apple solution turned an orange colour and the potato solution turned a murky yellow. However, from observing a number of my schoolmates experiments I found that the majority of their potato solutions had turned a green colour, which is the result I was looking for since it shows that potato is less sweet that, or contains less sugar that apple.

Conclusions

From my preliminary results I can conclude that the best shape to cut my apple is into cores as it is more accurate and seems to show greater percentage change in mass and in length. It was also very difficult to cut the strips into exactly the right thickness and the masses were much less than the cores. By using a cork borer, it ensures the diameter of each piece of apple is always the same and the only measurement I have to cut by hand is the length, this reduces risk of inaccuracy within the results.

From the preliminary tests I can tell that apple tissue has a very high sugar content so the solute concentration will be higher than the one demonstrated. I can also conclude that I will use a range of concentrations around 0.2M and 0.8M concentrations. This is because I am trying to find the exact point at which the molarity of the solution causes the percentage change = 0. If the results were drawn on the graph, this would be the point at which the curve crossed the x-axis, thus showing the concentration of sucrose within the apple tissue. I will also use four pieces of apple instead of two to allow a greater range of results to get a much more accurate mean average. This would also make it easier to see any anomalies.

Prediction

Using my preliminary tests I can estimate the sucrose concentration of apple tissue to be between 0.4M and 0.8M, and therefore the water potential will also be between 0.4M and 0.8M. The results of the main experiment will conclude whether this hypothesis is accurate or not.