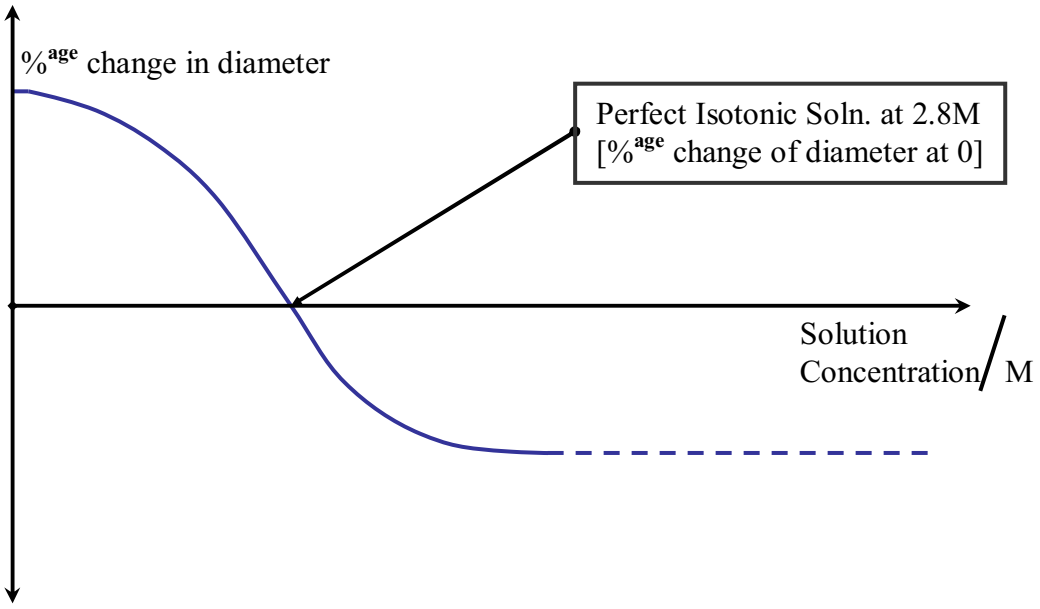
Key Stage 4 - Assessment Bi1 – Osmosis in Plant Cells

i) Investigation into Length-Changes when Varying Concentration of Water

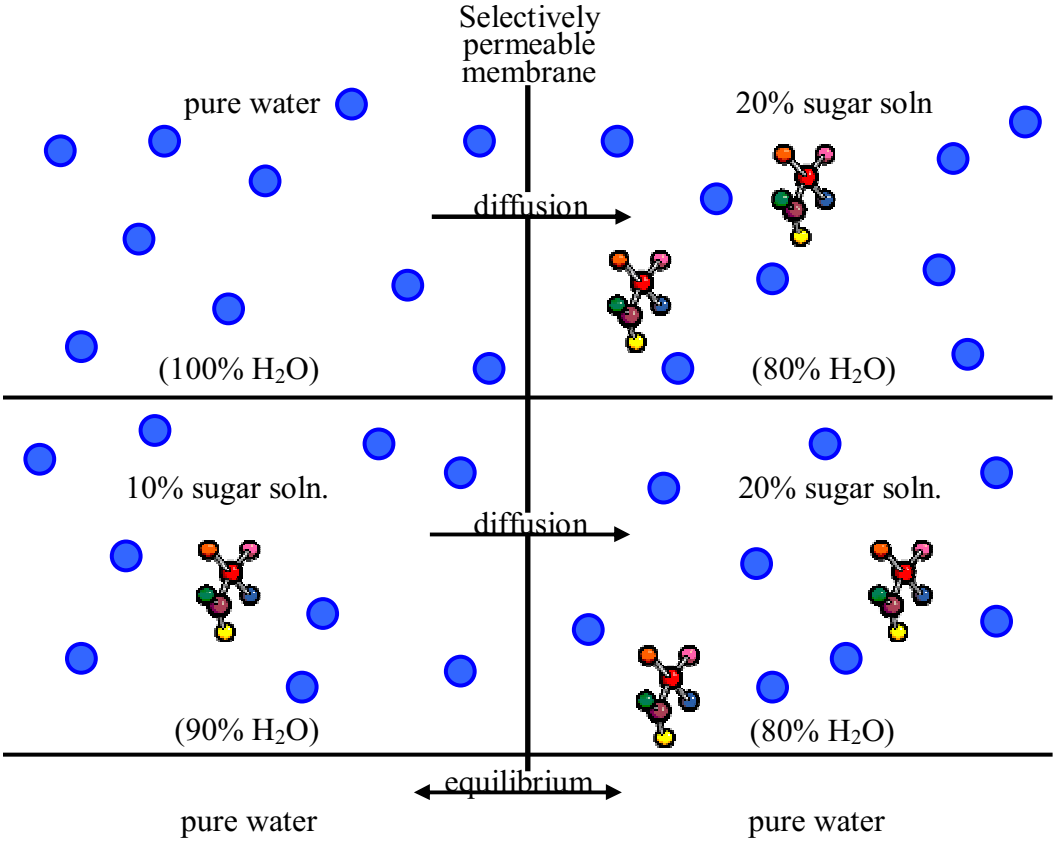
My AIM, in this experiment, is to find the correct concentration (conc.) of water at which uncooked potato chips remain unchanged in size, i.e. the perfect isotonic solution (soln.), having the same water concentration, and therefore same water potential, with a theoretically `flat` concentration gradient.

The THEORY behind this is, that to find the isotonic soln., we must achieve results telling us that the mass, length, or other dimensions have remained constant throughout the duration of immersion in that certain soln. of conc. xM (moles per cubic decimetre or litre), which I predict to be between 0.2 and 0.4M. I have chosen this range as my hypothesis for the final result, because of a preliminary experiment carried out six months ago using beetroot slices, instead of potato chips. Here, my result was confirmed as 0.28M.

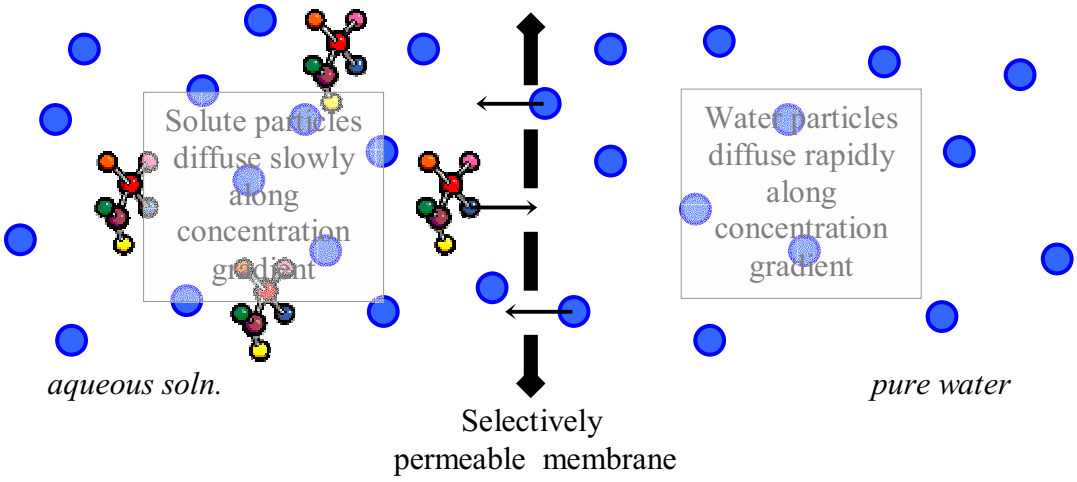


So what causes this effect?…..This effect is called **osmosis** and can be defined as the movement of water, through **diffusion**. Starting with basics, diffusion is the way in which `fluid` particles spread from a source through the space available. For example, if a gas with a distinct odour (such as H_2S, Hydrogen Sulphide) is released in the corner of a room it takes very little time before people all over the room will be able to smell it. However, diffusion in liquids, like water, is not as fast as in gases, because the particles move at slower speeds and collide more often. Diffusion is also part of the evidence for the kinetic model of matter, with its particles always moving. Osmosis, however, concentrates on the diffusion of a solvent (usually water), as aforementioned, through a selectively (partially) permeable membrane from a region of high solvent concentration to a region of lower solvent concentration. Another example, other than this experiment, would be the visking tubing similar to that used in dialysis, or in kidney-dialysis machines. Selectively (partially) permeable membranes are thought to have tiny pores

which allow the rapid passage of small water molecules but restrict the passage of larger solute molecules.



Since the cell membrane is selectively or partially permeable, osmosis is important in the passage of water into and out of cells and organisms. The pressure exerted by the movement of water due to osmosis is called *osmotic pressure*.



As Osmosis occurs and water diffuses out from the vacuole of a cell, due to a high water potential outside of it, making a steep conc. gradient, the cell begins to lose its

shape, increasing in flaccidity. The name of the solution surrounding the cell has a special name and is called a `hypertonic` solution. In extreme cases, when the cell decreases in turgor pressure very much, the cell is said to be plasmolysed and therefore irrecoverable, and will die, after losing most, if not all, its shape and rigidity. I expect the range of this outcome to be > 0.28, 0.28 being my predicted isotonic soln.

However, if the opposite occurs and…..water diffuses into the vacuole, from the surrounding soln., this time called a `hypotonic` soln., the cell expands due to the steep conc. gradient the only difference being that it is in the opposite direction, with the surrounding water having the greater water potential. The cell then has a increased turgor pressure, giving more rigidity and less flexibility, with us ending up with a longer, thicker, and wider chip. I expect the range for this outcome as 0M ≤ 0.28M, the range being definite because of the highest water potential being pure water.

So, we are left with 0.28, as the expected value for an `isotonic` soln., that does not let net osmosis occur, through a semi-permeable membrane, with the same conc. of water or water potential on both sides of the vacuole, giving rise to no increase in size, flaccidity, rigidity, i.e. turgor pressure.

METHOD

1] There is a simple list of apparatus we need to start off this experiment. Obviously, we will need the 18 potato chips, whose dimensions I will describe later. Apart from these we will need our 6 concs. of sugar solns.; also a measuring cylinder and boiling-tubes; a razor-blade or scalpel; a small cutting tile; and a small ruler.

2] The fixed variables will be the temp. of the soln.; the length of the potato chips, and its other dimensions, of those which we will be using in the experiment; the volume of the water or soln., 40ml; the number of chips, fifteen; the number of chips per soln., three; time in soln., ½ hour; type of container, boiling-tube(; type of chip, King Edward's , etc…). And, of course, the changed variable will be the conc. of the soln.

3] Firstly, the chips need to be cut into equal dimensions, in terms of their length, width, and depth; for my experiment, they will be 5x5x70mm, measured by a ruler to the nearest ½ mm.

4] The boiling-tubes will then be filled with 0.8, 0.6, 0.4, 0.3 (I have chosen this odd value because it corresponds with my hypothesis), 0.2,and 0.0 ~M sugar solns.

For the :-

- 0.8M – 40ml [100%] 0.8M soln.
- 0.6M – 30ml [75%] 0.8ml w/ 10ml [25%] pure water solns.
- 0.4M – 20ml [50%] " " 20ml [50%] " " "
- 0.3M – 15ml [37.5%] " " 25ml [62.5%] " " "
- 0.2M – 10ml [25%] " " 30ml [75%] " " "
- 0.0M – 40ml [100%] pure water.

5] 3 chips will be in each boiling-tube, left there for 30mins., at room temperature and pressure (RTP), measured by a thermometer to be around 20°C.

6] After the ½ hour, I will obtain the results for the 18 chips, by measuring their length with a ruler to the nearest ½ mm. And by plotting a graph I will be able to find the isotonic soln. to a suitable degree of accuracy.

On the next page is the RESULTS TABLE (graph on page after), containing the results in pure form for the experiment above, with all measurements taken and sub-stages made, shown……

My results start off with a high differential, +6.19%, as the first soln. used was 0M, i.e. pure water, the soln. with the highest water conc. or water potential, so I expected this value to be very high in relation to the rest of the graph, with it giving a very turgid, bent chip; the next two points fell close to the trend line; and these two, 0.2M and 0.3M, were also the last to be positive increases in percentage change of length. The next point is that of the 0.4M soln., but this value may not be reliable as seen on the graph and so I believe it is anomalous. My results then, however, become less steep, i.e. a lesser gradient on the graph, and I believe that, this happens at this point because there is only a certain extent to which the chips can become flaccid and, eventually plasmolysed. As some tension is retained within the molecules of the cells, so that, at least a minimum amount of shape is held.

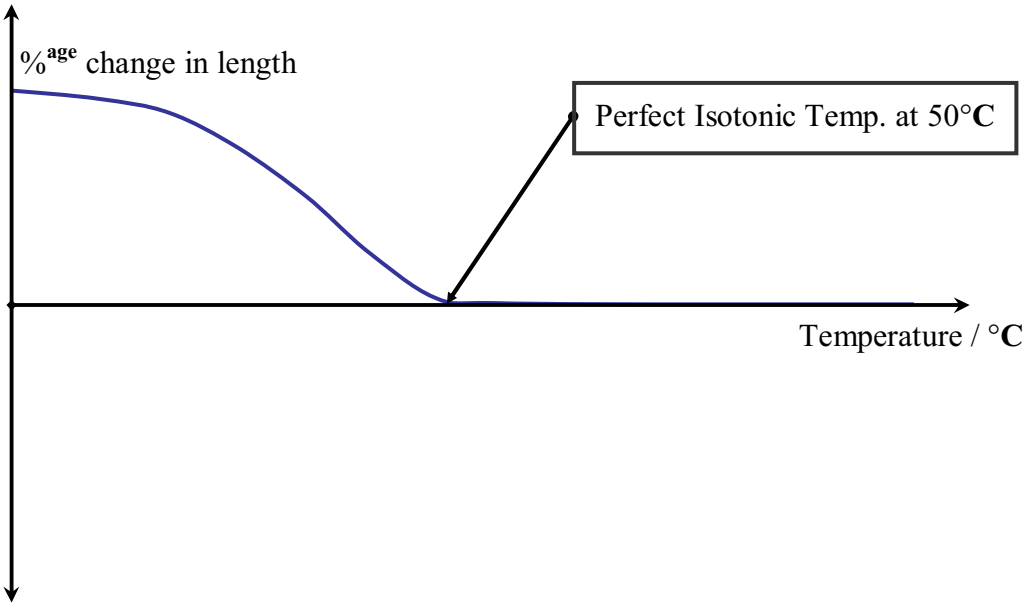
The description above only touches on single points, so I think its best that I describe, compare, and explain the graph as a whole. Although my graph was not the same shape as the one hypothesised. The data I collected followed a definite negative correlation as was expected, with only one anomalous result, which was accountable for. My graph describes the isotonic soln. of potato chips as 0.285, but this value could be slightly put off by the factor that some error could have been involved, which I will expand on in the Evaluation. My most anomalous result occurs in the 0.4M soln. where there is a –1% miscalculation in comparison to the major trend line, i.e. my point falls –1% below the line.

Nevertheless, my hypothesis, in my eyes, has proved a complete success, even with my preliminary experiment being based on beetroot slices, where my isotonic soln. was 0.28M, only -0.005M off.

ii) Investigation into How Exposition to Different Temperatures Affects the Changes Made by Water Concentration

My AIM, in this experiment is to find out how the temperature a potato chip is exposed to, affects the alterations made by water concentration, therefore my water conc. shall stay constant while the temperatures change.

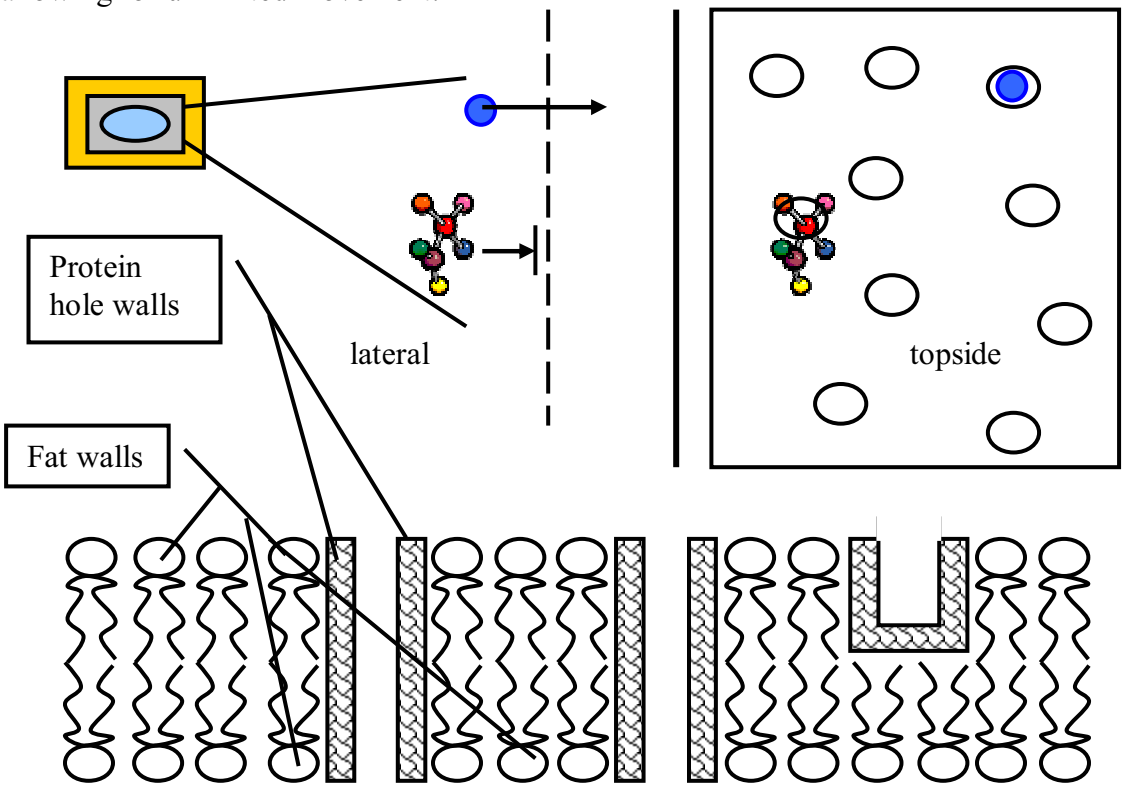
My HYPOTHESIS is that as the temperature increases the amount the chips alter will decrease, however it may not be an exactly inversely proportional relationship. As, for reasons that I will disclose in the next paragraph, I believe that the temperatures around body temperature, i.e. 30-40°C, will be the most effective at altering the potato chip's dimensions; and that at around 50-60°C, the chips will be unchanged when inserted into a non-isotonic soln.



The reasons for choosing this set of temperatures can be easily shown. I believe that as the temperature increases above 40°C, the protein lined walls of the holes in the semi-permeable cell membrane deteriorate, bringing the net flow of molecules through them to the unlimited, with everything from water molecules to sugar molecules travelling through the holes. So that the environment on the inside of the cell is the same as the environment on the outside, like an isotonic soln. as the graph suggests.

This takes place because of the definite structure of the cell membrane. It is infact mostly impermeable due to its major composition of fat, but the semi-permeability is brought in due to tiny holes lined with protein, embedded in the fat walls of the membrane. Although proteins are also impermeable, they are used to create the little

tunnels, because of their reliability for holding their shapes in constant environments, of ranges from approximately 10°C to 40°C, outside of these boundaries, and more importantly above 40°C the protein is denatured and so does not have a definite shape, allowing for unlimited movement.



I have used this in my hypothesis because of another past experiment, in which I found out the relationship between salivary amylase and starch, when temperature expositions of the enzymes were altered, again in which I found 50°C to be the temp. at which no starch was broken down. This was because the amylase, used to break down starch in the digestive system, was constructed from various proteins. The temp. 50°C was significant because this was where the enzyme proteins became denatured, losing all shape, therefore not being able to breakdown starch.

METHOD

1] There is again a simple list of apparatus we need to start off this experiment. Firstly, the 12 potato chips(I only used 12 this time as I had 6 diff. temp.'s and as demand outstripped supply, I was left with 2 chips in each soln.),heated in ovens to the prescribed temperatures – 4, 30, 40, 50, 60, 70°C, and cut to the prescribed dimensions 5x5x70mm, accurately, with a ruler, scalpel, and cutting tile, for safety. Secondly, I need the 6 boiling-tubes of pure water, used because it is the easiest source of a non-isotonic soln.

2] The fixed variables will be the temp. of the soln., itself, obviously not the pre-exposed temp. of the chips; the length of the potato chips, and its other dimensions, of

those which we will be using in the experiment; the volume of the water or soln., 40ml; the number of chips, twelve; the number of chips per soln., two; time in soln., ½ hour; type of container, boiling-tube(; type of chip, King Edward's , etc…). And, of course, the changed variable will be the pre-exposed temp. of the chip, before the experiment, in an oven.

3] The boiling-tubes will, first, need to be filled with 40ml each of pure water, my non-isotonic soln.

4] The pre-cut chips will then need to be placed, carefully, 2 each, into each boiling-tube, left there for ½ hour, at RTP.

5] When the ½ hour expires, I will obtain the results for the 12 chips, by measuring their length with a ruler to the nearest ½ mm. And by plotting a graph I will be able to find the isotonic temperature range to a suitable degree of accuracy.

N.B.: I have included my result for 0M conc. from the previous experiment, because all of them were kept at RTP and so I get an extra value, 22°C, to increase the accuracy of my results and so my graph.

On the next page is the RESULTS TABLE (graph on page after), containing the results in pure form for the experiment above, with all measurements taken and sub-stages made, shown……

This is an EVALUATION, combining both experiments, for both sections of this coursework and assessment.

I found that in both experiments, my points fitted well to neat curve or major trend line; with the exception of one value on each. These anomalous results, I considered, to be not so important or major, because of their position on the graph – in the middle and because of their magnitude, both around 1%. Also I did not have any results that stood out before taking averages, as all my results for specific variables were quite close together, with only a maximum of 1.5mm difference between two results, like 72.5mm and 74mm; of which the ave. is 73.75mm.

I believe that the best way, overall, to get more accurate results would have been to take more concentrations or temperatures (depending on exp.), as then my number of averages would be increased, honing in on the perfect isotonic soln. or temp. exposition, using a more powerful graph. The same would be true if more readings were taken of specific conc.'s or temp.'s, as then the average would be more accurate. If both techniques were then used, a very precise reading could have been obtained.

There were also flaws in the physical method, as discrepancies in length could be encountered, as well as miscalculations with volumes of soln., the conc./temp. of the soln., and also the overall time immersed in the soln. could have been increased considerably, especially in my case from 30min.'s in both experiments to at least 1 hour, letting diffusion and osmosis finish before anything else. Even dirty boiling-tubes could prevent the obtaining of the best results. Also, the increasing in size of the original dimensions would mean an increase in the change, which would make it easier to measure, as big things are easier to measure than smaller things.

So I have discovered repetition is very important in an experiment like this, because it increases accuracy. Even repeating the whole experiment again would do us some good because, comparing results always paves the way to improving them, even if this is time-consuming or money-wasting, or even practical and easy.

A good way to bring all these improvements together would be to rewrite my method. So here it is…..

METHOD 2

1] Cut 5 chips to the dimensions 20x20x100mm.

2] Prepare 1 litre solutions of the following conc.'s of soln. – 0.200M, 0.225M, 0.250M, 0.275M, 0.300M, 0.325M, 0.350M, 0.400M – because we know the rough range of the isotonic soln. and so can pinpoint it with more accuracy, with these soln.'s.

3] Immerse chips in soln.'s, each for 1½ hours, leaving time for net osmosis to slow down and halt.

4] Measure chip weight quickly, but carefully, straight after removal from soln.'s, on electric balances, because of their extra accuracy, then proceed to measure length by callipers (e.g. Vernier Callipers), giving extra accuracy to ¼'s of a mm.

So I have succeeded partially in the investigation into osmosis; all that is left to do now is try out the method above and also hope that someone else will eventually try it for their real, own coursework, too!

Thank YOU for reading this and taking your time with it!