Biology Coursework: Potato and Osmosis Investigation.

PLANNING: (P)

Some background Information: Water Potential and Living Plant Cells

Plant Cells in Pure Water: If plant cells are placed in pure water (a hypotonic solution) 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.

Free Energy and Water Potential: Free energy can be simply defined as the energy available (without temperature change) to do work. Chemical potential of a substance is the free energy per mole of that substance. Water potential is the chemical potential of water and is a measure of the energy available for reaction or movement (Bidwell 1974:59). Water potential is important when studying osmosis because it measures the ability of water to move, water always moves from areas of high potential to areas of low water potential.

The formula for calculating water potential is:

Water Potential = Osmotic Potential + Pressure Potential

Water Potential in Plant Cells: Water will move by osmosis into and out of cells due to differences in water potential between the cell and its surroundings. Remember that water always moves from areas of high potential to areas of low water potential.

Some Basic Principles:

- 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.

- In cells, water moves by osmosis to areas where water potential is lower.
- A hypertonic solution has lower water potential.
- A hypotonic solution has higher water potential.

References: Bidwell, R.G.S. 1974. Plant Physiology. MacMillan Publ. Co. New York.643pp.

Weier, T. E., C.R. Stocking and M.G. Barbour.1974. Botany: An Introduction to Plant Biology. 5th ed. John Wiley & Sons. New York. 693pp.

What is Sucrose and what is it made up of?
Sucrose is made up of three elements which can be found in the periodic table, they are: Oxygen, Hydrogen and Carbon. But how many components are found with each element?
Oxygen contains: 11, 16 x 11 = 176g
Hydrogen has: 22, 1 x 22 = 22g
Carbon holds 12, 12 x 12 = 144g
= 342g in $100dm^3$
That means there is 342g of sucrose in $1000cm^3$ of distilled water in a 1 molar solution, however we must divide this equation by ten so we get 34.2g in $100cm^3$ of water.

Preliminary Experiment: Before we begin our main experiment to this coursework, we conducted a preliminary experiment, this involved testing the rigidity of five separate 'evenly cut' pieces of potato chips from the same potato, we left the chips to infuse individually in five separate beakers, each with a different concentration (varying from 1 molar – 34.2g of sugar to 0 molar – 0g of sugar) we shall go down by 25 molar each time to get clear results, the whole procedure of the preliminary test was successful with the result of each potato chip being revealed as being different to the other. Below is a table of the results we found, plus a scatter diagram* to show how different sugar solute concentrations affect the rigidity of a potato chip.

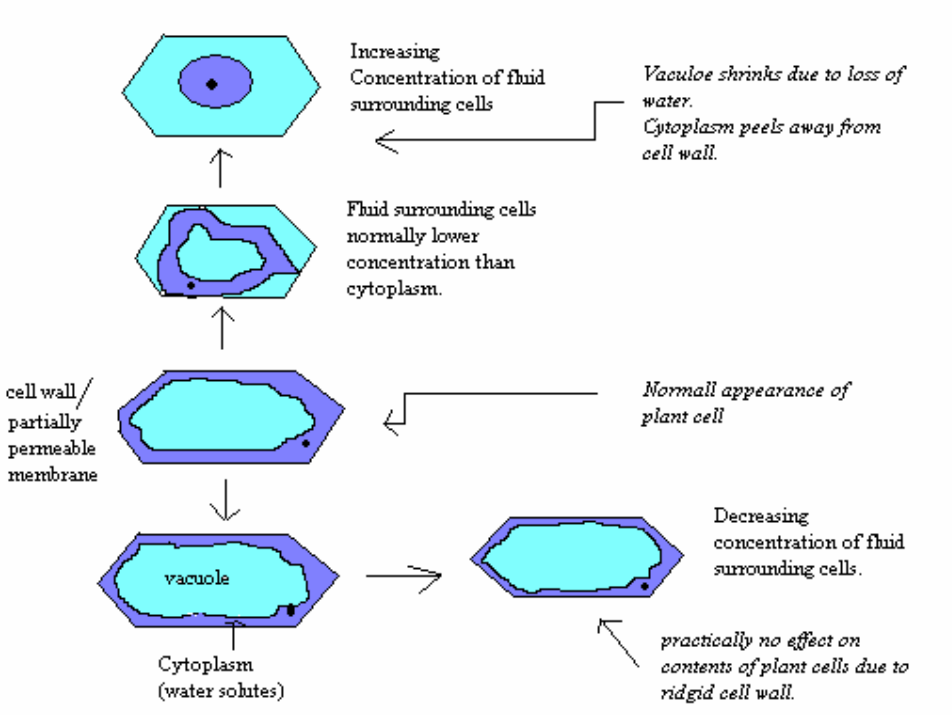
Sucrose solution con.	Sugar (g)	Angle (˚)
1	34.2	160
0.75	25.6	150
0.5	17.1	140
0.25	8.55	50
Raw Potato Chip	N/A	40
0	0	25

As we can see from pg 3, there are three isolated results at the top of the chart, (thus being: 1 Molar, 0.75 Molar and 0.5 Molar), I shall now rule two of these possible concentrations which I could use for my main experiment, I shall now not use these and concentrate on my main solutions and add a few more Molar concentrations varying from 0.5 Molar and 0 Molar to get a more accurate set of results, this should conclude what I have already acknowledged before, which was, as the general decline of concentration decreases then so shall the water potential (Ψ) increase and cause the potato chip to shrink and become flaccid.

MAIN INVESTIGATION:

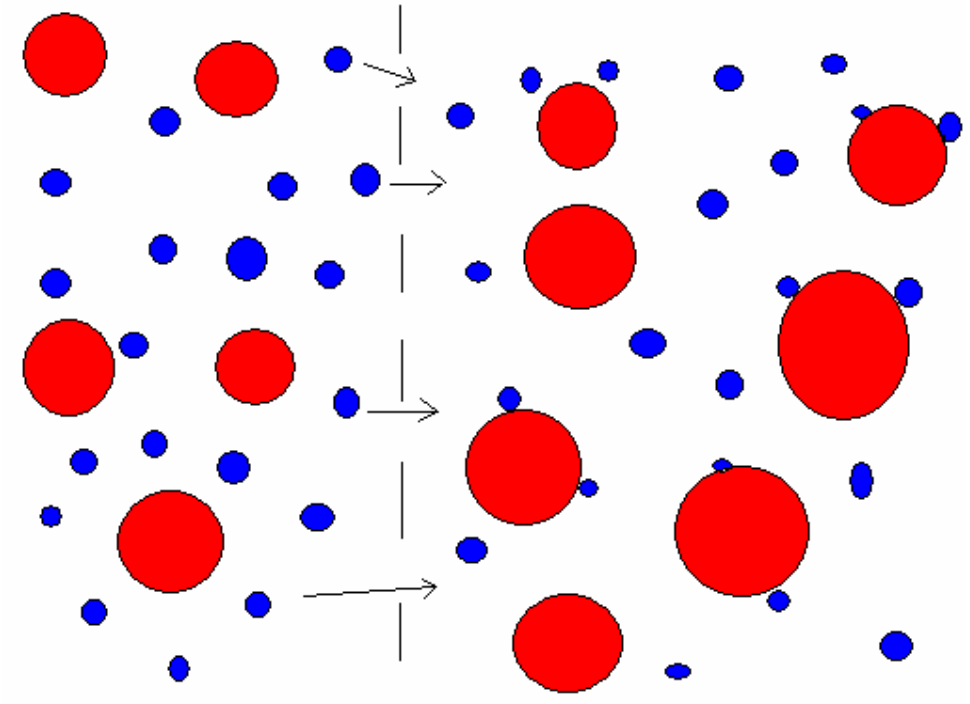
Aim: To investigate the effect of varying concentration of a sugar solution on the amount of osmotic activity between the solution and a potato chip at a given size.

Hypothesis: Osmosis is defined as the net movement of water molecules from a region of high concentration to a region of lower concentration; the way osmosis diffuses is through a semi-permeable membrane which allows only small molecules (e.g. water molecules) to pass through its partially permeable membrane. The molecules will continue to diffuse until they have reached the state of equilibrium, the balance between molecules on either side of the cell wall, the semi-permeable membrane. The idea for this experiment is to find the water potential of a potato tissue. Water potential of a cell is the measure of occurrence of water molecules passing in and out of the cell. It is known that pure water has the highest potential (zero) and the effect of dissolved substances into the pure water will actually lower the water potential of the sugar solution. Water diffuses from regions of high concentration to regions of lower water concentration to create the balance of equilibrium.



Prediction: I think as the molecules pass through the membrane from the high water potential (Ψ) to a lower water potential (Ψ) then the water potential will decrease. This will cause the cytoplasm to collapse and press up against the cell wall, which is able to withstand this because it is made from cellulose which is strong and capable of such pressures. The reason why the cytoplasm collapses and is forced to be pushed against the wall is because the vacuole has obtained so much water and has swelled up. Thus, being that the water potential started out as being greater outside the cell rather than inside it. After the vacuole has increased it's mass it should therefore swell and become 'rigid' and reach the stage known as 'equilibrium' where the Ψ , both inside and outside the cell are equal However, should the opposite occur (which is likely due to testing with different solute waters) then the cytoplasm will grow smaller and peel away from the cell wall because the water is leaving the cell, this would be caused by an increase of concentration of fluid surrounding cells and so making the vacuole shrink to water being passed out of the membrane. The result of this means therefore – the membrane will shrink and cause a loss in Ψ and cause the potato chip to become flaccid. I predict that in a pure water solution the water potential (Ψ) will be greater than one that has 35.5g of sugar in its solution; this should conclude that the potato chip should soak-

up more water therefore meaning that it may become rigid and the vacuole will increase and the cytoplasm will be pushed up against the cell wall. When I conduct my test for potato chips in 1 molar (35.5g of sugar solutes in 100ml of water) it should be confirmed that the potato chip will be come flaccid due to a high water potential (Ψ) being contained inside the chip rather than outside due to a higher region of concentration, the net movement of molecules should flow from the cell to outside the cell and so the vacuole will decrease and the vacuole will peel away from the cell wall.



Diffusion of molecules from a high water potential (Ψ) to a region of lower concentration.

Method: For our main test we will be determining how mass of potato chips can be affected by different levels of sucrose solutions and a given period of time (which we will set as being 48 hours). I think by then we shall see how the mass of each potato chip differs and also see how the water concentration affects the vacuole and cytoplasm of the chip, which can be seen on pg. 3 of the 'Planning Section'. As mention before the increase of water potential will cause the vacuole to increase and the cytoplasm to be compresses and the result being the chip should increase, there should be a clear indication of mass increase when this happens. After the 48 hours we will re-weigh our chips and produce a conclusion and analysis section complete with tables and graphs to state clearly what has happened. For this main experiment we have to make sure our results

are completely fair and accurate or else our entire test will be ruined because of uncontrolled variables and inaccurate measurements of sucrose or uneven sized potato chips. We must also be careful when using the scalpel, when we cut our chips so we don't accidentally cut ourselves and also wear goggles when our solutions are being stirred by the 'electronic heat stirring' machine. We will use five different sucrose solutions, the table below show the precise measurements of sugar to use, plus the molar mass we will use.

Molar concentration	Mass of Sugar (g)
0.5 Molar	17.1
0.4 Molar	13.68
0.3 Molar	10.944
0.2 Molar	8.7552
0.1 Molar	4.3776

Apparatus: Below is a list of the apparatus we will use when conducting our main experiment:

- Potato
- Core borer (diameter of 10mm)
- Scalpel
- Sugar (at 5 differently weighed measurements)
- Water (5 x 100ml of water)
- 5 beakers
- Weighing machines
- Electronic heat stirring machine
- Goggles
- Paper towels

Method: Below is a bullet point format of our investigation will be set out.

- Collecting our beakers, filling each one with the volume of $100cm^3$ of distilled water.
- Next we will be collecting our sugar, measured to the most accurate measurements to the nearest 0.01g, we can get in relation to be required, and this ensures a fair experiment.
- After weighing our sugar we will cut our potatoes using a core borer, we have to ensure that all our potato chips have precisely the right length and diameter this should enable us to have a fair experiment.
- Next, we will be able to add our sucrose to the water and with an electronic heat stirring machine place our beakers with the sucrose

solution in it and stir it up so we can dissolve the sucrose to create a n equilibrium in the solution (if this didn't happen the sugar would just dissolve to the bottom of the beaker and there would be a greater water potential at the top and not at the bottom).

- After this, we will now be able to note our start weigh in of our chips and place them into their chosen beakers
- We will cover our beakers will cling film and place them on the window sill (being covered with cling film means no loss of evaporation).

48 Hours Later...

- Still continuing with our experiment we shall return to the lab and conduct our final test to the experiment, this will include disposing of our sucrose solution and drying of our chips, this will remove excess water and any unnecessary water will be gone to give us a fair test, now we can weigh our chips again and accurately plot on graph paper a scatter diagram showing the gradual decline/incline in weight mass of each chip.

Controlled Variables:

- Size of potato chips (accurately measured each time to ensure fair experiment, approximately 65mm long to the nearest tenth, with a diameter of 10mm).
- Volume of distilled water used (100ml of distilled water in each beaker.
- The weight of each potato chip before being placed in the beakers.
- Time potato chips are left in sucrose solution (48 hrs).
- Type of potato used (white potato).
- It was made sure that the scales were reading "0" before the potatoes were placed on them to take the weight.
- The potatoes to be dried after the experiment so the mass of residue water on the potato was not included in the final weight
- Temperature. We shall conduct our test with the account of room temperature; the room temperature at the time of experiment was approximately 19.3˚c at the time.
- Removing any excess water so each chip and no extra water will be affecting our final results.

Independent Variables:

- The change from a high concentration of sucrose solution to a region of lower concentration.

Dependant Variables:

- The mass of each potato chip after being placed in the beakers.

ANALYSIS, RESULTS AND CONCLUSION:

Test Results of Experiment: Below are the results of our test we conducted last week, included with this piece is a scatter graph diagram of the mass percentage change, the mass before and after the test and finally the molar mass number indicated to the left.

Sucrose solution concentration (M)	Sugar used (g) per 100ml of distilled water	Mass before the experiment (g)	Mass after the experiment (g)	% change difference (to 1dp)
0.1	4.4	7.2g	8.5g	15.3
0.2	8.8	7.2g	7.7g	6.5
0.3	10.9	7.2g	7.2g	0
0.4	13.7	7.2g	6.4g	-12.5
0.5	17.1	7.2g	5.7g	-26.3

*please note: we did not use a raw potato chip sample in our main investigation, because we would not get a mass percentage change from a raw potato chip not placed in a concentrated solution.

After completing our tests I found there was a noticeable difference in the mass of the potato chips (as can be seen in the table above), listed along with the mass of potato chips are the percentage changes of each chip that was placed in the separate sucrose solutions.

As stated in my prediction, I said: 'I predict that in a pure water solution the water potential (Ψ) will be greater than one that has 35.5g of sugar in its solution;' this was a correct statement I think as to how my experiment was played out. As the Sucrose solution concentration increased in (M) there was a significant change in mass before and after the test was conducted. Using simple conclusions I think it is most obvious that we can see a trend in our results, thus being; as the water potential decreases the mass of the potato chip decreases along with it. A reason for this can be: Less water potential means that the potato chip will have a great water potential than the sucrose solution will, so the molecules in the potato chip will pass through the membrane of the cell to the solution to try and create

a balanced equilibrium between the potato chip and the solution. However if the sucrose solution becomes too weak and there is more distilled water in the solution than there is in the potato chip, the water molecules in the solution will move in the opposite direction and actually move across into the potato chip to create a balanced equilibrium between the chip and the sucrose solution. These examples can be seen on pages 4 and 5 (the diagrams of cells being affected by water potential and on pg. 5 the water molecules passing through the partially permeable membrane of the potato chip wall into the sucrose solution).

Using basic knowledge of osmosis I know:

Osmosis is the passage of water from a region of high water concentration through a semi-permeable membrane to a region of low water concentration.

The definition contains three important statements:

1. Osmosis is the passage of water from a region of high water concentration through a semi-permeable membrane to a region of low water concentration.
2. Osmosis is the passage of water from a region of high water concentration through a semi-permeable membrane to a region of low water concentration.
3. Osmosis is the passage of water from a region of high water concentration through a semi-permeable membrane to a region of low water concentration.

Judging by my results I can finally conclude that theses definitions do match my results, for example if the water potential is greater outside the cell, water molecules will pass through the membrane into the chip and if the water potential is greater inside the cell, the molecules will pass out of the cell.

From the evidence I have obtained during my experiment I can conclude that the point of equilibrium for our group was at 0.3 molar, where the concentration of sucrose solutions was equal both inside and outside of the potato chip. From evidence concluded in the table above (pg.8) I can now make deductions from my chart and add in some new points that I can use if I was to conduct for this experiment again. For example, if I was to conduct my test again I would use some new points, here is a selection below of the concentrations I would consider using:

- 0.25 molar

- 0.275 molar
- 0.3 molar
- 0.325 molar
- 0.35 molar

The reason why I have selected these points of sucrose solution is because they make give me a chance to make the experiment more accurate and more reliable in terms of how the concentration of may be affected by new concentration levels.

In conclusion I think our experiment went as well as we could expect to gain as regards to knowledge and how the osmosis can affect the potato cells, especially at different concentrations of sucrose solution. The test was fairly conducted with accurate measurements of weight and length of the potato chips. I would say the length of time would definitely have had an influence on our results. The time period of 48 hours was sufficient time for the concentration of sucrose solution to affect the chips. Especially with the different concentration levels, time can have an effect because it does take time for net movement to pass through a semi-permeable membrane and it would be useful to conduct a test in the future to see what the affects would be if we increased or decreased the time period. I think what would be interesting would be one test that was 24 hours long and one that was 72 hours long. I think our test overall was fair and accurate.

EVALUATION:

The effect of anomaly results means that some areas of my test may be unreliable as regards to how the change in mass was affected by different concentration levels. For example the mass of potato chip left in a molar concentration of 0.5 is vastly different from one that was left in 0.4 M, why though? I thought when the experiment was complete I would be able to draw a graph that had an angle of 45˚however there is a much steeper drop between 0.4 M and 0.5M on my graph. I think I'd have to say 0.5M would be one point I would rule out for the next experiment. I think overall my prediction did work well because from my prediction and test I was able to match my ideas and theories with the experiment, so that part was a success, I did obtain anomalies as mentioned above and some improvements which could be made are more accurate measurements with weight and length of chips, make some changes with concentration levels of our sucrose solution, this has been mention previously on pages 9 and 10 and more time and care taken to improve on drying our potato chips; this my reduce the weight of our chips and give more accurate weight measurements when we do our final weigh in.

I think was experiment was a good for obtaining evidence and therefore had no need to do a re-test of our potato chips, on a photocopied sheet of my graph I have circled my anomaly results (sucrose concentration level of 0.5M)