BIOLOGY INTERNAL ASSESSMENT

STANDARD LEVEL

OSMOSIS

OSMOSIS IN POTATO STRIPS

i. Aim

To investigate the change in the mass of potato strips as a result of the process of osmosis in potato strips over varying periods of time.

ii. Research Question

How does time affect the mass of potato strips (measured in grams) when immersed in distilled water (H_20) over a period of five hours at one hour intervals: 1 hour, 2 hours, 3 hours, 4 hours, and 5 hours?

iii. Introduction

Osmosis is the passive movement of water molecules from a region of high water concentration to a region of lower water concentration (lower solute concentration to higher solute concentration), across a partially permeable membrane.[1] The plasma membrane is selectively permeable, and it controls the movement of substances in and out of cells, but water is able to move freely in and out of the cell, allowing osmosis to occur.[2] Potato cells have selectively permeable membranes and therefore can be used to show the process of osmosis.

As plant cells generally have a higher solute concentration than their surroundings (lower water concentration), when immersed in H_20, the potato strips will be surrounded by a region of high water concentration since water has a solute concentration of 0.[3] This would mean that the distilled water is hypotonic whereby it has a higher concentration of water than the potato cells, causing water to flow from the area of higher water concentration (water solution) to the area of lower water concentration (potato cell).

However, as the duration given for osmosis to occur increases, the volume of fluid in the cell will increase as water continually enters the cell, increasing its turgidity (when pressure inside the cell increases as the volume of its contents increases). Eventually, the cell wall will be stretched to the maximum, achieving full turgor, which will then force water back out of the cell due to the high pressure within the cell. [4] Thus, it is likely that over a long period of time, the water solution will become isotonic: where the water concentration within the cell increases until it is the same as the surrounding solution and water particles move both in and out of the cell, causing the cell to remain the same size. [5]

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[1] Andrew Allot. *IB Study Guide: Biology Standard and Higher Level (2nd edition).* UK: Oxford University Press, 2007.

[2] Alberts B, Johnson A, Lewis J. *Molecular Biology of the Cell (4th edition).* New York: Garland Science, 2002.

[3] M B V Roberts. *Biology, A functional approach (4th edition).* UK: Thomson Nelson and Sons Ltd, 1986.

[4] Ibid.

[5] Regina Bailey. *"Diffusion and Passive Transport"* About.com Guide. Biology. 11 May 2011. <http://biology.about.com/od/cellularprocesses/ss/diffusion_3.htm>.

iv. Variables

Type of Variable	Variables	Units	Range
Independent	Time given for osmosis to occur	Hours ± 1 second	5hours, at one hour intervals (1, 2, 3, 4, 5)
Dependent	Percent change in the mass of the potato strips	Percent (%)	-

Formula used to measure dependent variable:

$$\frac{Final\ mass - Initial\ mass}{Initial\ mass} x100\%$$

Controlled Variables	How it is controlled
Type/ concentration of solution	The same solution is used throughout the experiment: distilled water (H_20), obtained from the lab technician (same source) and dispensed from the same bottle
Volume of distilled water (H_20) used	Each potato strip is immersed in 10ml of distilled water measured from the same 10ml measuring cylinder
How the potato strips are immersed in the distilled water	Each potato strip is fully immersed in the distilled water in the test tube.
Temperature of distilled water	All test tubes containing the potato strips immersed in distilled water are left in an air-conditioned room over the period of five hours set at the temperature 23º Celsius, which is monitored every hour to ensure that it remains constant
Exposure to surrounding environment	All of the test tubes are covered with aluminum foil cut from the same box and left in the same room under the same circumstances (same exposure to light – under the window)
Size and shape of potato strip	Each potato strip is bored out of the potato using the same cylindrical borer (1cm in diameter), and cut to a length of 4cm (measured using the same ruler) then weighed (on the same weighing scale with fresh pieces of paper towel replaced each time) to ensure they weigh 3 grams, with any excess trimmed off using the same scalpel
Source of Potato	All potatoes used are from the same bag, of similar size, skin colour and shape

v. Materials and Apparatus

Materials	Quantity	Uncertainty
Distilled Water (H_20)	300ml	±1ml
Potatoes (Medium Sized)	4	-

Apparatus	Quantity	Uncertainty
Electronic Weighing Scale	1	±0.1gram
Stopwatch	5	±0.1second
Forcep	1	-
Scalpel	1	-
Ruler	1	±1mm
Cylindrical food borer (1cm diameter)	1	±0.1cm
10ml Measuring Cylinder	1	±1ml
Cutting Mat	1	-
Test tube racks	5	-
3cmx3cm pieces of Aluminium Foil	25	±1mm
Test Tubes	25	-
Paper Towels	100	-

vi. Procedure

1. Pour 10ml of distilled water (H_20) into the 10ml measuring cylinder. Pour the 10ml of distilled water into a test tube.
2. Repeat *step 1* 24 times such that there are 25 test tubes (5 to every test tube rack) each containing 10ml of distilled water (H_20).
3. Using a cylindrical borer, bore 5 cylindrical strips (1cm in diameter) out of a Potato.
4. Using the ruler, measure each strip and cut into pieces that are 4 cm long.
5. Place each potato strip on a fresh paper towel to drain off excess juices.
6. Place a fresh paper towel on the electronic weighing scale, set the scale to zero, then weigh each potato strip on the fresh paper towel, ensuring each weighs 3 grams. Cut off any excess with a scalpel if necessary.
7. Place each of the 5 potato strips into a test tube containing 10ml of distilled water on the same test rube rack.

8. Immediately cover the test tubes with a 3cm by 3cm piece of aluminium foil. Start the stopwatch.
9. Label the test tube rack: “immersion duration of 5 hours”.
10. Repeat *steps 3 to 9* 4 times with a label for 4 hours, 3 hours, 2 hours, and 1 hour accordingly, in descending order (label the first repeat 4 hours, the second repeat 3 hours, the third repeat 2 hours, and the final repeat 1 hour).
11. After 1 hour from the starting time, using forceps, remove the potato strips labelled “immersion duration of 1 hour” from the respective 5 test tubes. Place them on fresh paper towels to allow excess juices to be drained.
12. Place a fresh paper towel on the electronic weighing scale, set the scale to zero, then weigh each potato strip on the fresh paper towel, record their respective weights.
13. Repeat steps 11 to 12 for the potato strips labelled “immersion duration of 2 hours”, followed by those labelled 3 hours, 4 hours, and lastly, 5 hours.
14. Dispose of all used material appropriately.

vii. Results

Table 1. Initial and final mass of the potato strips after immersion in distilled water (H_2O) over a period of five hours at one hour intervals

Duration given for osmosis to occur (hours ± 1min)	Initial and final mass of potato strips ±0.1g									
	Trial 1		Trial 2		Trial 3		Trial 4		Trial 5	
	Initial Mass	Final Mass	Initial Mass	Final Mass	Initial Mass	Final Mass	Initial Mass	Final Mass	Initial Mass	Final Mass
1.0	3.0	3.0	3.0	3.0	3.0	3.1	3.0	3.2	3.0	3.0
2.0	3.0	3.2	3.0	3.3	3.0	3.3	3.0	3.2	3.0	3.1
3.0	3.0	3.4	3.0	3.4	3.0	3.6	3.0	3.5	3.0	3.4
4.0	3.0	3.5	3.0	3.6	3.0	3.5	3.0	3.7	3.0	3.7
5.0	3.0	3.6	3.0	3.6	3.0	3.6	3.0	3.7	3.0	3.6

*Note that the initial mass of all the potato strips are the same

Table 2. Mean, standard deviation, and 33.33% of the mean for the final mass of potato strips immersed in distilled water (H_2O)

Duration given for osmosis to occur (hours ± 1min)	Mean, S.D, and 33.33% of mean of final mass of potato strips ±0.1g		
	Mean	S.D.	33.33% of mean
1.0	3.1	0.09	1.02
2.0	3.3	0.08	1.09
3.0	3.5	0.09	1.16
4.0	3.6	0.10	1.19
5.0	3.6	0.04	1.19

*As the Standard Deviation is less than 33.33% of the mean for all the values of final mass of the potato strips, it can be seen that these mean values are accurate.

Graph 1. Mean and Standard Deviation for the final mass of potato strips immersed in Distilled Water (H_2O)

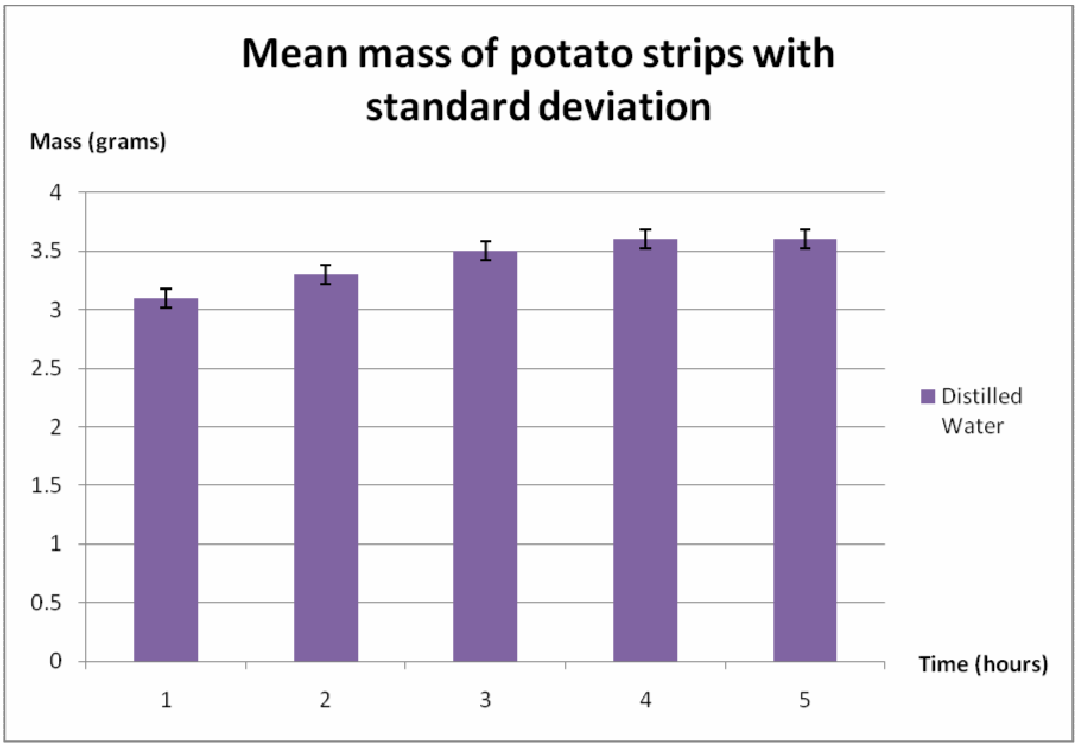


Table 3. Change in mass of potato strips immersed in distilled water (H_2O) with mean ±0.1g, standard deviation, and 33.33% of mean

Duration given for osmosis to occur (hours ± 1min)	**Change in mass of potato strips with mean ±0.1g, standard deviation, and 33.33% of the mean**							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Standard Deviation	33.33% of Mean
1.0	+0.0	+0.1	+0.1	+0.2	+0.0	+0.1	0.08	0.30
2.0	+0.2	+0.3	+0.3	+0.2	+0.1	+0.2	0.08	0.61
3.0	+0.4	+0.4	+0.6	+0.5	+0.4	+0.5	0.09	1.52
4.0	+0.5	+0.6	+0.5	+0.7	+0.7	+0.6	0.10	1.82
5.0	+0.6	+0.6	+0.6	+0.7	+0.6	+0.6	0.04	1.82

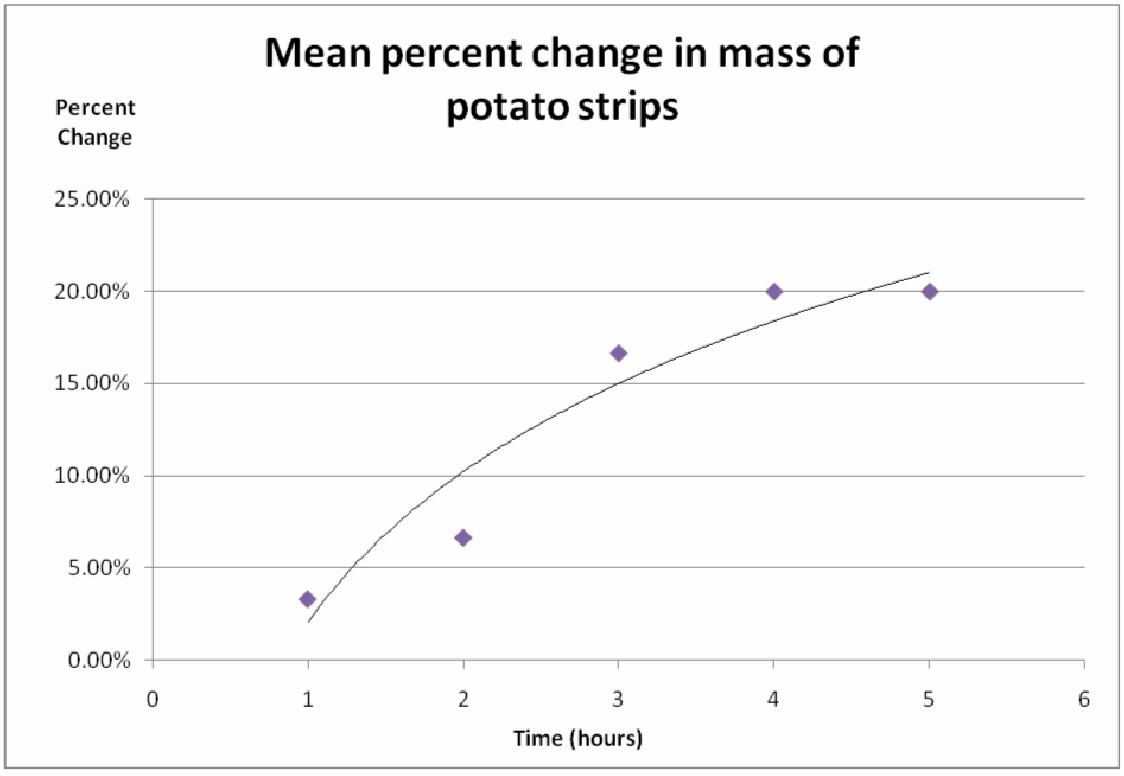
*The + and – signs indicate increase and decrease in weight respectively

*As the Standard Deviation is less than 33.33% of the mean for all the values of final mass of the potato strips, it can be seen that these mean values are accurate.

Table 4. Percent change in mass and mean percent change in mass of potato strips immersed in distilled water (H_2O)

Duration given for osmosis to occur (hours ± 1min)	Percent change in mass and mean percent change in mass of potato strips					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
1.0	0.00%	3.33%	3.33%	6.66%	0.00%	3.33%
2.0	6.66%	10.00%	10.00%	6.66%	3.33%	6.66%
3.0	13.33%	13.33%	20.00%	16.66%	13.33%	16.66%
4.0	16.66%	20.00%	16.66%	23.33%	23.33%	20.00%
5.0	20.00%	20.00%	20.00%	23.33%	20.00%	20.00%

Graph 2. Mean percent change in mass of potato strips immersed in distilled water (H_2O)



viii. Calculations Involved

$$Change\ in\ mass = Final\ mass - Initial\ mass$$

Eg. $3.1g - 3.0g = 0.1g$

$$Average\ change\ in\ mass = \frac{(Change\ in\ mass\ of\ Trial\ 1 + Trial\ 2 + Trial\ 3 + Trial\ 4 + Trial\ 5)}{5}$$

Eg. $\frac{(0.0g + 0.1g + 0.1g + 0.2g + 0.0g)}{5} = 0.1g$

$$Standard\ Deviation = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n}}$$

Eg. $\sqrt{\frac{(0-0.1)^2+(0.1-0.1)^2+(0.1-0.1)^2+(0.2-0.1)^2+(0-0.1)^2}{5}} = 0.08$

$$33.33\%\ of\ mean = \bar{x} \times \frac{33.33}{100}$$

Eg. $3.1g \times \frac{33.33}{100} = 1.02$

$$Percent\ Change\ in\ mass = \frac{change\ in\ mass}{original\ mass} \times 100\%$$

Eg. $\frac{0.6g}{3.0g} \times 100\% = 20\%$

ix. Conclusion

As seen in graph 1, as the duration of the immersion of potato strips in the solution increased, the mass of the potato strips generally increased. This was in line with my predictions because the distilled water had a higher water concentration than the potato strip, thus making it hypotonic, and allowing water to travel from the region of higher water concentration (water solution) to the region of lower water concentration (potato strip). When a longer period of time was given for osmosis to occur, a plateau in the mass of the potato strips could be seen whereby most of the potato strips stopped increasing in mass at 3.6 grams, indicating that after 4 hours of immersion in the distilled water, the potato cells had become turgid and that the net movement of water molecules was equal to zero. Here, the water solution had turned isotonic and the movement of water into the cell equaled the movement of water out of the cell, resulting in a general trend where no further changes in the mass of the potato strips were observed after 4 hours.[6]

For all of the values for which standard deviation and 33.33% of the mean were calculated, the standard deviation was less than 33% of the mean, indicating that the results were accurate and reliable. Therefore, no anamolous results were removed from the processing of the raw data. However, there was a noticeable difference in the change in mass of the potato strips between those that has been left in the distilled water for 2 hours and 3 hours. The difference between the two was 0.3 grams while the differences between the one hour intervals for all the other time intervals was only 0.1 grams, and after processsing the raw data, mean percent change of the mass of the potato strip at 2 hours did not fit in graph 2 as well as the other values did, this is to be discused in the evaluation.*

[6] Alberts B, Johnson A, Lewis J. *Molecular Biology of the Cell (4th edition)*. New York: Garland Science, 2002.

x. Evaluation

Limiations and Weaknesses	Effect on Investigation	Suggestions for improvement
Human error	It was not possible for all of the potato strips to be put in the test tubes at the same time, thus the actual duration given for osmosis to occur would differ between individual test tubes, affecting the accuracy of the results.	Staggering the time for each test tube by amount 1 minute would allow for greater precision in data collection.
How the potato strips were cut and stored	By leaving the potato strips on the cutting mat while cutting them, they were exposed to the external environment, causing oxidation of some potato strips to occur before immersion.	Covering the potato strips with ceran wrap while cutting the others would minimise exposure to the outside environment and allow the potato strips to remain fresh.
Which part of the potato was used	As different parts of the potato may have different consistency and density, this could affect the potato strips' water concentration, and thus, its ability to take in water from its surroundings.	Ensure that all potato strips are cut from the same part of the potato.
Temperature of the distilled water	As the temperature was only monitored with the air conditioning, when students left or entered the room for periods of time, this could potentially have changed the temperature as the room was very big.	Using a thermometer to measure the temperature of the water in the test tube before the potato strips are immersed and after they are removed would ensure that temperature remained fairly constant.
Way in which mass was measured	The mass of the potato strips were recorded using an electronic weighing scale up to only one decimal place, thus resulting in minimal differences in data collection, making conclusions more general and vague.	Using a weighing scale with up to two decimal places will allow the data collected to be more accurate.
Frequency of data collection*	The mass of the potato strips were recorded after immersion in distilled water for 1 hour, 2 hours, 3 hours, 4 hours, and 5 hours, meaning large gaps between the data points, causing conclusions to be less accurate as the data was less reliable, and trends were more general and rather vague.	Collection of data should occur at half an hour intervals over a period of six hours, providing ample data to make detailed conclusions.