

Osmosis in potatoes

Investigate osmosis in potatoes

For Edexcel GCSE Biology 1BI0 and Combined Science 1SC0. Teacher answers start on a new page.

Name

Date

Aim

To investigate how the concentration of a sugar solution affects the percentage change in mass of potato cylinders, and to estimate the concentration of the potato cell contents.

Background

Osmosis is the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane. Potato cells have a partially permeable cell membrane, so they gain or lose water by osmosis depending on the concentration of the solution around them.

If the surrounding solution is more dilute than the cell contents, water moves into the cells and the mass of the potato increases. If the surrounding solution is more concentrated, water moves out of the cells and the mass decreases. If the concentrations are the same, there is no net movement of water and the mass does not change.

Because the starting mass of each cylinder is slightly different, the change in mass is compared as a **percentage change**: $\text{percentage change in mass} = (\text{final mass} - \text{initial mass}) \div \text{initial mass} \times 100$. A positive value is a gain in mass and a negative value is a loss in mass.

The concentration of the sucrose solution is given in mol/dm^3 . 0.0 mol/dm^3 is pure water.

Hypothesis

As the concentration of the sucrose solution increases, the percentage change in mass of the potato cylinders will decrease, because water will move out of the potato cells by osmosis when the solution is more concentrated than the cell contents.

Variables

Independent	Concentration of sucrose solution (mol/dm^3)
Dependent	Percentage change in mass of the potato cylinder (%)
Control	• Same potato (and same variety) for all cylinders • Same diameter and length of cylinder (cork borer size and trimming to 3 cm) • Same volume of solution (20 cm^3) • Same time in solution • Same temperature (room temperature) • Cylinders blotted in the same way before weighing

Equipment

- Large potato (peeled)
- Cutting tile and scalpel (or knife)
- Cork borer (about 1 cm diameter)
- Ruler

- Sucrose solutions of 0.2, 0.4, 0.6, 0.8 and 1.0 mol/dm³, and distilled water (0.0 mol/dm³)
- Six boiling tubes (or beakers) and a rack
- Measuring cylinder (25 cm³)
- Balance reading to 0.01 g
- Paper towel
- Stopwatch or clock
- Marker pen for labelling
- Eye protection

Risk assessment

Hazard	Risk	Precaution
Cork borer and scalpel	Cuts to hands and fingers.	Cut on a tile. Push the borer into the potato placed flat on the tile, not held in the hand. Cut away from the body. Use the scalpel only for trimming.
Spilt sugar solution	Slippery floor or bench.	Mop up spills at once.
Glass boiling tubes	Broken glass can cause cuts.	Stand tubes in a rack and tell the teacher if any break.
Potatoes and sugar solutions used as laboratory materials	Food used in a laboratory may be contaminated with chemicals or microorganisms.	Do not eat the potato or taste the solutions. Wash hands at the end.

Method

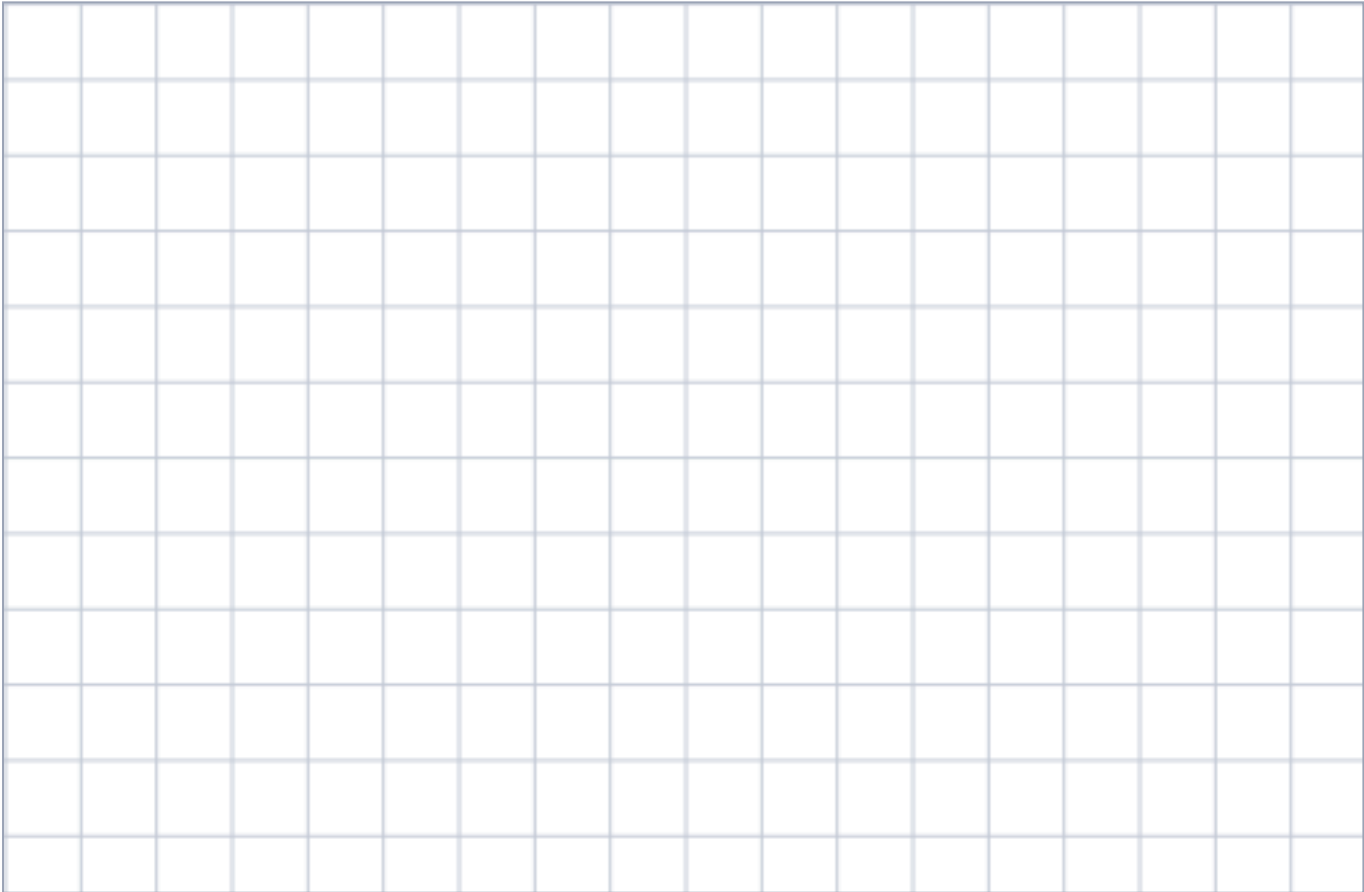
1. Put on eye protection. Label six boiling tubes with the concentrations 0.0, 0.2, 0.4, 0.6, 0.8 and 1.0 mol/dm³.
2. Use a measuring cylinder to put 20 cm³ of the correct solution into each tube.
3. Use a cork borer to cut at least six cylinders from the same potato. Remove any skin.
4. Trim every cylinder to exactly 3 cm long with a scalpel on a tile.
5. Blot each cylinder with paper towel and measure its mass on the balance. Record the initial mass of each cylinder.
6. Put one cylinder into each tube, making sure the cylinder is fully covered by the solution.
7. Start the stopwatch. Leave the tubes at room temperature for the same time: at least 60 minutes, or overnight if your teacher allows, which gives larger and easier-to-measure changes in mass.
8. Take each cylinder out of its tube, one at a time, in the order they went in.
9. Blot each cylinder gently with paper towel until it is dry on the surface.
10. Measure the final mass of each cylinder and record it.
11. Calculate the change in mass: final mass – initial mass.
12. Calculate the percentage change in mass: change in mass ÷ initial mass × 100. Include the + or – sign.
13. Repeat the experiment at least twice more (or collect results from other groups) and calculate a mean percentage change for each concentration.
14. Plot a graph of mean percentage change in mass against concentration. Draw a smooth line of best fit.

Results

Change in mass of potato cylinders in different concentrations of sucrose solution				
Concentration of sucrose solution (mol/dm ³)	Initial mass (g)	Final mass (g)	Change in mass (g)	Percentage change in mass (%)
0.0				
0.2				
0.4				
0.6				
0.8				
1.0				

Graph

Plot a line graph with concentration of sucrose solution (mol/dm³) on the x-axis (0.0 to 1.0) and percentage change in mass (%) on the y-axis. The y-axis must extend below zero to show negative values, and the x-axis crosses at 0%. Plot each mean point with a small cross and draw a smooth line of best fit. Read off the concentration at which the line crosses the x-axis (0% change): this is the concentration of the potato cell contents.



Exam questions 10 questions · 28 marks

1 A student investigates the effect of sucrose concentration on the mass of potato cylinders. State the independent variable and the dependent variable. **[2 marks]**

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2 The student blotted each potato cylinder with paper towel before measuring its mass. Explain why. **[2 marks]**

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3 A potato cylinder had an initial mass of 2.60 g. After a day in a sucrose solution, its mass was 2.34 g. Calculate the percentage change in mass. **[3 marks]**

Answer =

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4 Explain why the student calculated the percentage change in mass and not just the change in mass. **[2 marks]**

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5 The mass of a potato cylinder increased when it was left in pure water. Explain why, using the term osmosis. **[3 marks]**

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6 A potato cylinder in 0.8 mol/dm^3 sucrose solution decreased in mass. Explain why. **[2 marks]**

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7 The table shows a student's results. Use the data to estimate the concentration of the potato cell contents. Explain your answer. **[3 marks]**

Percentage change in mass of potato cylinders	
Concentration of sucrose solution (mol/dm^3)	Percentage change in mass (%)
0.0	+15.0
0.2	+5.6
0.4	-4.1
0.6	-9.7

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8 Name three variables that should be controlled in this investigation. **[3 marks]**

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9 Suggest two ways the student could make the results more reliable. **[2 marks]**

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10 Describe a method to find the concentration of the solution inside potato cells. You should include how you would obtain and process your results. **[6 marks]**

[illegible]

Teacher answers

Core practical 4: Osmosis in potatoes. The example results are practice data, not real measurements.

Example results

Example results (practice data). Cylinders 1 cm diameter and 3 cm long, left overnight (about 18 hours) at room temperature.

Concentration of sucrose solution (mol/dm ³)	Initial mass (g)	Final mass (g)	Change in mass (g)	Percentage change in mass (%)
0.0	2.40	2.76	+0.36	+15.0
0.2	2.50	2.64	+0.14	+5.6
0.4	2.44	2.34	−0.10	−4.1
0.6	2.48	2.24	−0.24	−9.7
0.8	2.40	2.08	−0.32	−13.3
1.0	2.44	2.06	−0.38	−15.6

Conclusion

As the concentration of the sucrose solution increased, the percentage change in mass decreased, from a gain of 15.0% in pure water to a loss of 15.6% in 1.0 mol/dm³ sucrose solution. In pure water and the dilute solution, the solution was more dilute than the potato cell contents, so water moved into the cells by osmosis and the mass increased. In the more concentrated solutions, water moved out of the cells by osmosis and the mass decreased. The line of best fit crosses 0% change at about 0.3 mol/dm³, between 0.2 (+5.6%) and 0.4 (−4.1%). At this concentration there is no net movement of water, so the concentration of the solution equals the concentration of the potato cell contents. The results support the hypothesis. Example working for 0.4 mol/dm³: $(2.34 - 2.44) \div 2.44 \times 100 = -4.1\%$.

Errors and improvements

Error	Effect on the results	Improvement
Surface liquid left on the cylinders, or the cylinders blotted too hard or for different lengths of time (random error).	Final masses are too high (extra liquid) or too low (water squeezed out), so the percentage change is wrong.	Blot each cylinder gently, in the same way and for the same time, before weighing.
Different cylinders having different cell contents because they come from different potatoes, or from different parts of the same potato.	Some cylinders gain or lose water more than others for reasons not linked to the solution.	Cut all the cylinders from the same potato, and use more than one cylinder for each concentration.
Cylinders not exactly the same length or diameter.	Cylinders have different surface areas, so water moves in or out at different rates and the percentage changes are not fully comparable.	Use the same cork borer for every cylinder and trim each to the same length against a ruler. Using percentage change also allows for small differences in starting mass.
Only one cylinder at each concentration, and a short time in the solution.	An anomalous result cannot be spotted, and small changes in mass give a large percentage error from the balance.	Use three or more cylinders at each concentration and calculate a mean, ignoring anomalies. Leave the cylinders for longer, for example overnight.
Only six concentrations tested.	The concentration at which there is no mass change can only be estimated roughly.	Test more concentrations near the point where the line crosses 0%, for example 0.25, 0.30, 0.35 mol/dm ³ .

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [2]

- independent variable: concentration of sucrose solution (1)
- dependent variable: (percentage) change in mass of the potato cylinder (1)

2. [2]

- to remove the solution / water from the surface of the cylinder (1)
- so the mass measured is only due to water that has moved in or out by osmosis / surface liquid would add extra mass (1)
- ignore 'to dry it' alone

3. [3]

- change in mass = $2.34 - 2.60 = -0.26$ g (1)
- percentage change = change $\div$ initial mass $\times 100$, or $-0.26 \div 2.60 \times 100$ (1)
- -10(%) (1) allow 10% decrease / loss; do not accept +10% or 10% with no indication of a loss
- Correct answer with no working gains 3 marks
- Allow 1 mark for -11.1% (divided by final mass)

4. [2]

- the cylinders had different starting masses (1)
- so percentage change allows a fair comparison between cylinders / makes the results comparable (1)

5. [3]

- the (pure) water is more dilute than the potato cell contents / the cell contents are more concentrated (1)
- water moves into the cells by osmosis (1)
- through the partially permeable (cell) membrane (1)
- do not accept 'sucrose / sugar moves out' or 'the solution moves in'

6. [2]

- the sucrose solution is more concentrated than the cell contents (1)
- water moves out of the potato cells by osmosis (1)

7. [3]

- about 0.3 mol/dm³ (1) accept 0.25 to 0.35
- where the percentage change in mass is 0 / between the gain at 0.2 and the loss at 0.4 (1)
- so there is no net movement of water / the solution has the same concentration as the cell contents (1)

8. [3]

- volume of solution (1)
- time left in solution (1)
- temperature (1)
- size / length / diameter / mass (surface area) of the cylinder (1)
- same potato / same type of potato (1)
- Max 3

9. [2]

- repeat the experiment / use more than one cylinder for each concentration (1)
- calculate a mean (and ignore anomalous results) (1)
- Max 2

10. [6]

Level 3 5-6	A clear, logical method that could be followed. It includes preparing solutions of different concentrations, cylinders of equal size, equal volumes, time and temperature, blotting and measuring mass before and after, calculating percentage change, and plotting a graph to find where it crosses 0%. Repeats are included.
Level 2 3-4	A method with most of the main stages, but missing some detail, for example no control variables, no blotting or no explanation of how the concentration is found.
Level 1 1-2	A basic method with a few relevant points and little order.

Indicative content

- cut cylinders of equal size from the same potato; measure initial mass; place in solutions of different concentrations including pure water, using the same volume; leave for the same time at the same temperature; remove, blot dry, measure final mass; calculate percentage change in mass; plot percentage change against concentration; the concentration where the line crosses 0% is the concentration of the cell contents; repeat and calculate a mean.

Exam tips

- Always say the direction of water movement, for example 'water moves into the potato by osmosis from a dilute solution to a more concentrated solution'. Do not say 'the solution moves'.

- Percentage change = $(\text{final} - \text{initial}) \div \text{initial} \times 100$. Keep the negative sign when there is a loss, and always divide by the initial mass.
- When you read a concentration off a graph, state that this is where there is no net movement of water and the concentrations are equal.
- Say 'blot dry to remove surface solution'. 'To dry it' alone does not get the mark.
- A line of best fit is a smooth line or curve through the points. Do not join the points with ruled lines.