

# Osmosis in potato cylinders

Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.

For AQA GCSE Biology 8461 and Combined Science: Trilogy 8464. Teacher answers start on a new page.

Name .....

Date .....

## Aim

To find how the concentration of a sugar solution affects the mass of potato tissue, and to estimate the concentration inside the potato cells.

## Background

**Osmosis** is the diffusion of water from a dilute solution to a concentrated solution through a **partially permeable membrane**. The cell membrane of a plant cell is partially permeable. It lets small water molecules through but not larger sugar molecules.

If a plant cell is in a solution that is more dilute than its cytoplasm, water moves into the cell by osmosis and the tissue gains mass. If the solution is more concentrated than the cytoplasm, water moves out of the cell and the tissue loses mass. If the solution is the same concentration as the cytoplasm, there is no net movement of water and the mass does not change.

Because the starting masses of the cylinders are never exactly the same, the change in mass is given as a **percentage change**. The concentration of the sugar solution is measured in  $\text{mol/dm}^3$ .

## Hypothesis

As the concentration of the sugar solution increases, the percentage change in mass of the potato cylinders will decrease, because less water moves into the cells by osmosis and more water moves out.

## Variables

|                    |                                                                                                                                                                                                                                                                                                    |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Independent</b> | The concentration of the sucrose solution ( $\text{mol/dm}^3$ )                                                                                                                                                                                                                                    |
| <b>Dependent</b>   | The percentage change in mass of the potato cylinder (%)                                                                                                                                                                                                                                           |
| <b>Control</b>     | <ul style="list-style-type: none"><li>• Type of potato (same potato if possible) and size and shape of the cylinders</li><li>• Volume of solution in each tube</li><li>• Temperature</li><li>• Time left in the solution</li><li>• The way the cylinders are blotted dry before weighing</li></ul> |

## Equipment

- Large potato
- Cork borer (about 8 mm across), white tile and ruler
- Knife or scalpel (used by the teacher or with care on the tile)
- 6 boiling tubes (or large test tubes) and a rack
- $1.0 \text{ mol/dm}^3$  sucrose solution and distilled water
- 2 measuring cylinders or syringes ( $10 \text{ cm}^3$  and  $25 \text{ cm}^3$ )
- Top-pan balance (accurate to 0.01 g)
- Paper towels, forceps and a marker pen
- Stopwatch or clock

- Eye protection

## Risk assessment

| Hazard                       | Risk                                | Precaution                                                                                                                                |
|------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Cork borer, knife or scalpel | Cuts to the hand from sharp blades. | Cut on a white tile, push the borer away from your body and never hold the potato in your hand while cutting. Cut away from your fingers. |
| Spilt solution on the floor  | Slipping.                           | Wipe up spills at once with paper towels.                                                                                                 |

## Method

1. Label six boiling tubes 0.0, 0.2, 0.4, 0.6, 0.8 and 1.0 (the concentration in mol/dm<sup>3</sup>).
2. Use the 1.0 mol/dm<sup>3</sup> sucrose solution and distilled water to make 20 cm<sup>3</sup> of each concentration (for example 0.4 mol/dm<sup>3</sup> is 8 cm<sup>3</sup> of sucrose solution and 12 cm<sup>3</sup> of distilled water). Put each into the correct tube.
3. Push the cork borer through the potato to cut six cylinders. Cut the skin off the ends.
4. Cut each cylinder to the same length (for example 3.0 cm) using a ruler and a knife on the tile.
5. Blot each cylinder gently with a paper towel to remove the surface liquid. Weigh each cylinder one at a time and record its initial mass in the table.
6. Put one cylinder into each tube so that it is completely covered by the solution. Note the time.
7. Leave the tubes in a rack at room temperature for the same length of time, ideally overnight (about 24 hours). If the practical must fit in one lesson, leave them for at least 30 minutes; the changes in mass will be smaller but the pattern is the same.
8. Use forceps to take out each cylinder. Blot each one dry in the same way as before and weigh it again. Record the final mass.
9. Calculate the change in mass for each cylinder: final mass – initial mass.
10. Calculate the percentage change in mass for each cylinder: (change in mass ÷ initial mass) × 100. A loss in mass has a negative sign.
11. Repeat the whole experiment at least twice more (or use three cylinders for each concentration) and calculate a mean percentage change for each concentration.
12. Plot a graph of mean percentage change in mass against the concentration of sucrose solution.
13. Draw a line of best fit through the points. Find the concentration where the line crosses the x-axis, because this is where the mass does not change.

Results

| Change in mass of potato cylinders                       |                  |                |                    |                               |
|----------------------------------------------------------|------------------|----------------|--------------------|-------------------------------|
| Concentration of sucrose solution (mol/dm <sup>3</sup> ) | 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. Put the concentration of sucrose solution (mol/dm<sup>3</sup>) on the x-axis and the percentage change in mass (%) on the y-axis. The y-axis must go below zero to include negative values, and the x-axis crosses at 0 on the y-axis. Plot each point with a small cross and draw a smooth line of best fit. Read off the concentration where the line crosses the x-axis: here there is no change in mass.



Exam questions 10 questions · 25 marks

1

State the independent variable in this investigation.

[1 mark]

.....

.....

**2** Each potato cylinder is blotted dry with a paper towel before it is weighed. Explain why. **[2 marks]**

.....

.....

.....

.....

**3** The student calculated the percentage change in mass rather than just the change in mass. Explain why. **[2 marks]**

.....

.....

.....

.....

**4** A potato cylinder has a mass of 2.50 g at the start and 2.15 g at the end. Calculate the percentage change in mass. Show your working. **[3 marks]**

Answer = .....

.....

.....

.....

.....

.....

.....

.....

.....

**5** A potato cylinder placed in distilled water gains mass. Explain why. **[3 marks]**

.....

.....

.....

.....

.....

.....

.....

.....

- 6** A student plots a graph using the results in the table. Use the data to estimate the concentration of sucrose solution that has no effect on the mass of the potato. Explain what this concentration shows. **[2 marks]**

| Percentage change in mass of potato cylinders            |                               |
|----------------------------------------------------------|-------------------------------|
| Concentration of sucrose solution (mol/dm <sup>3</sup> ) | Percentage change in mass (%) |
| 0.0                                                      | +12                           |
| 0.2                                                      | +4                            |
| 0.4                                                      | -6                            |
| 0.6                                                      | -11                           |

.....

.....

.....

- 7** A potato cylinder in a concentrated solution loses 0.45 g in 30 minutes. Calculate the rate of change of mass in g per minute. **[2 marks]**

Answer = .....

.....

.....

.....

- 8** Name two control variables in this investigation. **[2 marks]**

.....

.....

.....

- 9** Suggest two ways of making the results more repeatable. **[2 marks]**

.....

.....

.....

**10** Describe a method to find out how the concentration of a sugar solution affects the mass of potato tissue. In your answer, explain how you would process your results. **[6 marks]**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

## Teacher answers

Required practical 3: Osmosis in potato cylinders. The example results are practice data, not real measurements.

### Example results

**Example results (practice data): cylinders left in the solutions for 24 hours at room temperature**

| Concentration of sucrose solution (mol/dm <sup>3</sup> ) | Initial mass (g) | Final mass (g) | Change in mass (g) | Percentage change in mass (%) |
|----------------------------------------------------------|------------------|----------------|--------------------|-------------------------------|
| 0.0                                                      | 2.45             | 2.84           | +0.39              | +15.9                         |
| 0.2                                                      | 2.38             | 2.52           | +0.14              | +5.9                          |
| 0.4                                                      | 2.51             | 2.42           | -0.09              | -3.6                          |
| 0.6                                                      | 2.40             | 2.11           | -0.29              | -12.1                         |
| 0.8                                                      | 2.47             | 2.03           | -0.44              | -17.8                         |
| 1.0                                                      | 2.36             | 1.84           | -0.52              | -22.0                         |

### Conclusion

As the concentration of sucrose solution increases, the percentage change in mass goes down from a gain of 15.9% in distilled water to a loss of 22.0% in 1.0 mol/dm<sup>3</sup> sucrose. In dilute solutions, water moves into the potato cells by osmosis, because the cytoplasm is more concentrated than the solution, and the cylinder gains mass. In concentrated solutions, water moves out of the cells by osmosis and the cylinder loses mass. The line of best fit crosses the x-axis at about 0.3 mol/dm<sup>3</sup>. At this concentration there is no net movement of water, so the sucrose solution is the same concentration as the contents of the potato cells.

### Errors and improvements

| Error                                                                  | Effect on the results                                                                                         | Improvement                                                                                                                      |
|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Surface liquid is not blotted off equally from each cylinder.          | Extra water on a cylinder makes its mass look too high, so the change in mass is wrong (random error).        | Blot each cylinder for the same time in the same way, before both weighings.                                                     |
| The cylinders are different in length or come from different potatoes. | Different surface areas and different cell contents change how fast water moves, so the results are not fair. | Cut all cylinders from the same potato to the same length, using the same borer.                                                 |
| Only one cylinder is used for each concentration.                      | An anomalous result cannot be spotted, so the line of best fit may be wrong.                                  | Use at least three cylinders for each concentration and calculate a mean percentage change.                                      |
| Only a few concentrations are tested.                                  | The point where there is no change in mass can only be estimated roughly.                                     | Use more concentrations close to where the line crosses zero, for example 0.1 mol/dm <sup>3</sup> intervals between 0.2 and 0.4. |

### Mark scheme

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

#### 1. [1]

- concentration of the sucrose / sugar solution (1)

**2. [2]**

- to remove surface water / liquid (1)
- because this water would add to the mass / would give an inaccurate mass of the potato tissue (1)

**3. [2]**

- the cylinders did not all have the same starting mass (1)
- percentage change allows a fair comparison between the cylinders (1)

**4. [3]**

- change in mass =  $2.15 - 2.50 = -0.35$  g (1)
- $(-0.35 \div 2.50) \times 100$  (1)
- -14% (1) allow 14% loss; allow 14.0

**5. [3]**

- water moves into the cells by osmosis (1)
- from the dilute solution / distilled water to the more concentrated cytoplasm (1)
- through the partially permeable cell membrane (1)

**6. [2]**

- $0.28 \text{ mol/dm}^3$  (1) allow 0.25 to 0.30
- the solution has the same concentration as the potato cells / no net movement of water (1)

**7. [2]**

- $-0.45 \div 30$  (1)
- $-0.015$  g/min (1) allow 0.015 g/min loss

**8. [2]**

- volume of solution (1)
- temperature (1)
- time left in the solution (1)
- type / size / length of potato cylinder, or same potato (1)
- Max 2

**9. [2]**

- repeat the experiment / use more than one cylinder at each concentration (1)
- calculate a mean (and ignore any anomalous results) (1)
- blot the cylinders in the same way each time / use the same potato (1)
- Max 2

## 10. [6]

|                        |                                                                                                                                                                                                                                                                                            |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Level 3<br/>5-6</b> | A clear and logical method including the preparation of identical cylinders, a range of concentrations including pure water, the measurement of mass before and after, and the control of at least two variables. The calculation of percentage change and a suitable graph are described. |
| <b>Level 2<br/>3-4</b> | A method with most of the main steps (cylinders, range of concentrations, mass before and after) and at least one control. The processing of results is mentioned but may lack detail.                                                                                                     |
| <b>Level 1<br/>1-2</b> | A few relevant points such as putting potato in different solutions and weighing it, with little detail or control.                                                                                                                                                                        |

### Indicative content

- cut identical potato cylinders using a cork borer and cut them to the same length
- make up a range of sugar concentrations (for example 0 to 1.0 mol/dm<sup>3</sup>) with the same volume of solution in each tube, including pure water
- blot each cylinder dry and weigh it before putting it in the solution
- leave for the same time at the same temperature
- remove, blot dry in the same way and weigh again
- calculate the percentage change in mass:  $(\text{final} - \text{initial}) \div \text{initial} \times 100$
- plot percentage change in mass against concentration, draw a line of best fit
- read the concentration where the line crosses the x-axis, because that is where the mass does not change

### Exam tips

- Describe osmosis using the spec definition: the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane. Always write 'partially permeable'.
- Percentage change uses the initial mass as the denominator, and a loss is negative. Show the sign in your answer.
- For the graph, include negative values on the y-axis and read the concentration where the line crosses the x-axis. At this point there is no net movement of water.
- Explain mass changes in terms of water moving, not 'sugar going into the potato'. Sugar does not pass through the membrane.
- A control variable is something you keep the same, such as volume of solution, temperature, time or size of the cylinder.