

Plant tissue in solutions of different concentration

Investigate and describe the effects on plant tissues of immersing them in solutions of different concentrations

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). Teacher answers start on a new page.

Name

Date

Aim

To investigate the effect of the concentration of a sucrose solution on the mass of potato cylinders, and to find the concentration of solution that has the same concentration as the potato cell contents.

Background

Water diffuses through partially permeable membranes by **osmosis**, and water moves into and out of cells by osmosis through the cell membrane. In Extended terms, osmosis is the net movement of water molecules from a region of higher water potential (dilute solution) to a region of lower water potential (concentrated solution), through a **partially permeable membrane**. The cell membrane of a plant cell is partially permeable.

When potato tissue is placed in a solution that is more dilute than the cell contents, there is a net movement of water into the cells by osmosis, so the cells swell, become firm (turgid) and the tissue gains mass. When it is placed in a solution that is more concentrated than the cell contents, water leaves the cells, so the cells become soft (flaccid) and the tissue loses mass.

There is a concentration of solution at which the mass does not change. At this concentration there is no net movement of water, so the solution has the same concentration (and water potential) as the cell contents. You can find it from a graph where the line crosses the x-axis.

Hypothesis

Potato cylinders will gain mass in dilute sucrose solutions and lose mass in concentrated solutions, because water moves into the cells from a dilute solution and out of the cells into a concentrated solution by osmosis.

Variables

Independent	Concentration of the sucrose solution / mol/dm ³
Dependent	Percentage change in mass of the potato cylinders / %
Control	• Same potato and same length and diameter of each cylinder • Same number of cylinders in each tube • Same volume of solution in each tube • Same time in the solution and same temperature • Same method of blotting dry

Equipment

- Large potato; cork borer (about 1 cm diameter); white tile; scalpel or sharp knife; ruler graduated in mm
- Sucrose solutions of 0.0 (distilled water), 0.2, 0.4, 0.6 and 0.8 mol/dm³, 20 cm³ of each
- 5 large test-tubes (150 mm × 25 mm), labelled, in a rack; measuring cylinder, 25 cm³
- Balance reading to 0.1 g or better; paper towels; forceps
- Stop-clock; marker pen

Risk assessment

Hazard	Risk	Precaution
Cork borer and scalpel	Cuts to the hand or fingers	Cut on a tile, push the cork borer through the potato with a twisting motion and away from your hand, and do not hold the potato in your hand while cutting.
Spilt solutions on the floor	Slips	Wipe up spills at once.

Method

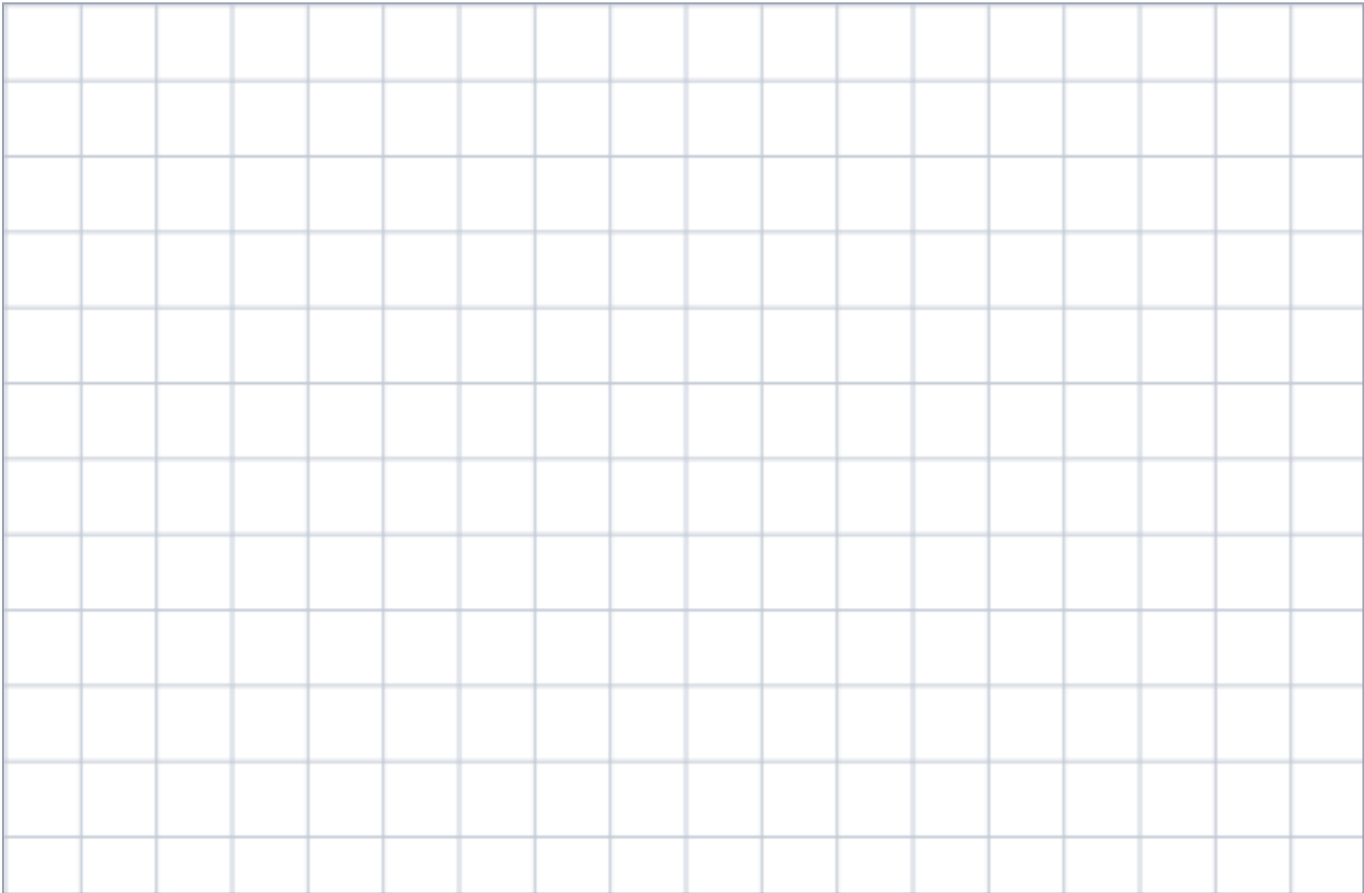
1. Label five large test-tubes 0.0, 0.2, 0.4, 0.6 and 0.8 and use a measuring cylinder to put 20 cm³ of the matching sucrose solution in each.
2. Use a cork borer to cut 15 cylinders from the same potato. Push the borer into the potato on a tile, and push the cylinder out with a clean rod.
3. Using a scalpel and ruler, trim all the cylinders to the same length, for example 4.0 cm, and remove any potato skin.
4. Divide the cylinders into five groups of three. Blot each group dry with a paper towel.
5. Measure the mass of each group of three cylinders to 0.1 g and record it as the initial mass.
6. Put one group into each test-tube, making sure the cylinders are covered by the solution. Start the stop-clock.
7. Leave the tubes in a rack at room temperature for 60 minutes.
8. After 60 minutes, remove the cylinders from one tube, blot them dry in the same way, and measure their mass. Record it as the final mass. Repeat for each tube in the order they were started.
9. Feel the cylinders and bend one gently. Record whether they are firm, slightly soft or floppy.
10. Calculate the change in mass and the percentage change in mass: $(\text{final mass} - \text{initial mass}) \div \text{initial mass} \times 100$.
11. Plot a graph of percentage change in mass against concentration. Use the graph to find the concentration at which there is no change in mass.

Results

Change in mass of potato cylinders in sucrose solutions				
concentration of sucrose solution / mol/dm ³	initial mass / g	final mass / g	change in mass / g	change in mass / %
0.0				
0.2				
0.4				
0.6				
0.8				

Graph

Plot change in mass / % (y-axis, with positive and negative values) against concentration of sucrose solution / mol/dm³ (x-axis). Mark points with crosses (x) and draw a single smooth best-fit curve. Read the value where the curve crosses the x-axis (0% change): this is the concentration of the solution with the same concentration as the potato cell contents. Read the value to the nearest half small square.



Exam questions 10 questions · 30 marks

1 A student investigates the effect of the concentration of sucrose solution on the mass of potato cylinders. (a) State the independent variable and the dependent variable. [2] (b) State two variables that must be kept constant. [2] **[4 marks]**

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2 Describe two safety precautions the student should take when cutting the potato cylinders. **[2 marks]**

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3 The student blots the cylinders dry with a paper towel before measuring their mass. Explain why. **[2 marks]**

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4 In 0.6 mol/dm³ sucrose solution, three potato cylinders had an initial mass of 9.5 g. After 60 minutes their mass was 8.7 g. Calculate the percentage change in mass. Give your answer to 1 decimal place. Show your working. **[3 marks]**

Answer =

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- 5** The student plots a graph of the results in the table. (a) State what should be written on the x-axis and on the y-axis. [2] (b) The y-axis values range from -12.4 to $+9.4$. State how the student should choose the scale on the y-axis. [1] (c) State how the points and the line should be drawn. [1] **[4 marks]**

Results	
concentration of sucrose solution / mol/dm ³	change in mass / %
0.0	+9.4
0.2	+4.2
0.4	-2.1
0.6	-8.4
0.8	-12.4

[illegible]

- 6** The line on the graph crosses the x-axis at 0.33 mol/dm^3 . (a) Explain what this shows. [2] **[3 marks]**
(b) State what would happen to the mass of a potato cylinder placed in a 0.1 mol/dm^3 solution. [1]

[illegible]

- 7** Explain the results for the potato cylinders in distilled water (+9.4%) and in 0.8 mol/dm³ sucrose solution (-12.4%). **[4 marks]**

[illegible]

8 Describe how the cylinders from distilled water and from 0.8 mol/dm^3 sucrose solution would feel when they are bent. Explain the difference. **[2 marks]**

9 Suggest four improvements to the method to improve the accuracy and reliability of the investigation. **[4 marks]**

10 Explain why the percentage change in mass is calculated instead of just the change in mass. **[2 marks]**

Teacher answers

Practical skill 3: Plant tissue in solutions of different concentration. The example results are practice data, not real measurements.

Example results

Example results (practice data), after 60 minutes				
concentration of sucrose solution / mol/dm ³	initial mass / g	final mass / g	change in mass / g	change in mass / %
0.0	9.6	10.5	+0.9	+9.4
0.2	9.5	9.9	+0.4	+4.2
0.4	9.6	9.4	-0.2	-2.1
0.6	9.5	8.7	-0.8	-8.4
0.8	9.7	8.5	-1.2	-12.4

Conclusion

The potato cylinders gained mass in the most dilute solutions (+9.4% in distilled water, +4.2% in 0.2 mol/dm³) and lost mass in the more concentrated solutions (-2.1% in 0.4 mol/dm³ and -12.4% in 0.8 mol/dm³). In dilute solutions the water potential outside the cells is higher than inside, so water moved into the cells by **osmosis** through the partially permeable cell membranes; the cells became turgid and the mass increased. In concentrated solutions water moved out of the cells, which became flaccid, and the mass fell. The best-fit curve crosses 0% change at about 0.33 mol/dm³ (accept 0.31-0.35 mol/dm³). At this concentration there is no net movement of water, so the solution has the same concentration as the cell contents of the potato. In practice the cylinders from 0.0 mol/dm³ were firm and hard to bend, those from 0.4 mol/dm³ were slightly soft, and those from 0.8 mol/dm³ were floppy and bent easily.

Errors and improvements

Error	Effect on the results	Improvement
Water left on the surface of the cylinders when they are weighed	The final mass is too high, so the percentage change is overestimated	Blot all the cylinders in the same way for the same time before every mass measurement.
Cylinders from different potatoes or from different parts of one potato	Cell sap concentration varies, so the point where there is no change in mass is not reliable	Cut every cylinder from the same potato, preferably from the same part, and repeat each concentration to calculate a mean.
Different lengths and initial masses of the cylinders	The change in mass cannot be compared fairly between tubes	Trim all the cylinders to the same length and calculate the percentage change in mass.
Balance reads only to 0.1 g	Small changes in mass, such as those near the 'no change' concentration, cannot be measured accurately	Use a balance that reads to 0.01 g and use more cylinders per tube.
Too few concentrations near the point where the line crosses 0%	The concentration of the cell contents can only be estimated roughly	Add solutions at smaller steps between 0.2 and 0.4 mol/dm ³ , such as 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. [4]

- (a) independent: concentration of the sucrose solution (1); dependent: (percentage) change in mass of the potato cylinders (1)
- (b) any two from: length / diameter / size / mass of cylinder; same potato / type of potato; volume of solution; time (in the solution); temperature; number of cylinders (2) ignore amount / time of experiment

2. [2]

- cut on a tile / a hard flat surface (1)
- cut away from the hands / fingers (1)
- do not hold the potato in the hand while cutting (1)
- use a sharp cork borer / scalpel with care (1)
- Max 2; ignore 'wear gloves' / 'be careful'

3. [2]

- to remove water / solution from the surface (1)
- because this would add to the mass / would give an inaccurate (higher) mass that is not due to osmosis (1)

4. [3]

- $8.7 - 9.5 = -0.8$ (g) (1)
- $-0.8 \div 9.5 \times 100$ (1)
- -8.4 (%) (1) allow 8.4% decrease / loss; award 3 marks for the correct answer with no working; ignore a missing minus sign if 'loss / decrease' is stated

5. [4]

- (a) x-axis: concentration of sucrose solution / mol/dm^3 (1); y-axis: change in mass / % (1) quantity and unit with a solidus needed for each mark
- (b) the scale should use more than half of the grid and be a sensible ratio, e.g. 2 cm = 2% or 5%, and include both positive and negative values (1)
- (c) points marked with crosses (x) or encircled dots and a single smooth best-fit curve (1) reject straight lines joining each point

6. [3]

- (a) there is no change in mass / no net movement of water (1)
- the solution has the same concentration as the potato cell contents / same water potential (1)
- (b) the mass increases / gains mass (1)

7. [4]

- in distilled water, water moves into the cells (1)
- by osmosis (1)
- because the water outside has a higher water potential / is more dilute than the cell contents (1) allow down a water potential gradient
- in 0.8 mol/dm^3 solution, water moves out of the cells because the solution is more concentrated than the cell contents / has a lower water potential (1)
- through the partially permeable cell membrane (1)
- Max 4

8. [2]

- distilled water: firm / hard / stiff / hard to bend; 0.8 mol/dm³: soft / floppy / flexible / easy to bend (1) both needed
- water has entered the cells in distilled water, making them turgid, but water has left the cells in the sucrose solution, making them flaccid (1) allow cells pressing on the cell walls / lose turgor

9. [4]

- repeat each concentration and calculate a mean (1)
- use a balance that reads to 0.01 g (1)
- use more concentrations / smaller steps near the concentration where the line crosses the x-axis (1)
- cut all cylinders from the same potato / part of the potato (1)
- blot all cylinders for the same length of time / in the same way (1)
- control the temperature using a water bath (1)
- Max 4; ignore 'be more careful'; ignore 'use a bigger potato'

10. [2]

- the cylinders may have different starting / initial masses (1)
- percentage change allows a fair comparison between the tubes (1)

Exam tips

- Use the initial mass as the divisor in percentage change and show the sign: a loss in mass is negative.
- Always describe osmosis as the movement of water: from a dilute solution (higher water potential) to a more concentrated solution (lower water potential) through a partially permeable membrane.
- The point where the line crosses the x-axis is where there is no net movement of water, so the solution has the same concentration as the cell contents. Say both parts.
- Describe plant tissue as turgid (firm, gained water) or flaccid (soft, lost water) when you are asked about texture.
- Axes: independent variable on the x-axis, each labelled with the quantity and unit using a solidus, and a smooth best-fit curve through the points.