

Osmosis using dialysis tubing

Investigate osmosis using materials such as dialysis tubing

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

Name

Date

Aim

To investigate how the concentration of a sucrose solution inside dialysis tubing affects the movement of water into the tubing by osmosis.

Background

Water diffuses through partially permeable membranes by **osmosis**. 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**. A partially permeable membrane lets small molecules such as water through but not larger molecules such as sucrose.

Dialysis tubing (also called Visking tubing) is a model of a cell membrane. It has tiny pores. Water molecules pass through the pores easily. Sucrose molecules pass through very much more slowly (a little may leak out over many hours), so during a 30-minute experiment the tubing behaves as if sucrose cannot cross it. This lets us see the effect of osmosis on the mass of a tubing 'bag' without using living cells.

If the solution inside the bag is more concentrated than the water outside, there is a net movement of water into the bag and its mass increases. If the solution outside is more concentrated, water leaves the bag and its mass decreases. If both have the same concentration, there is no net movement and the mass stays the same.

Hypothesis

The more concentrated the sucrose solution inside the tubing, the greater the percentage increase in mass of the bag, because there will be a greater net movement of water into the bag by osmosis.

Variables

Independent	Concentration of the sucrose solution inside the bag / mol/dm ³
Dependent	Percentage change in mass of the bag / %
Control	• Volume of sucrose solution put in each bag • Length and type of dialysis tubing • Volume of distilled water in the beaker • Time in the water and temperature • How the bags are dried before weighing

Equipment

- Dialysis (Visking) tubing, 5 pieces each about 15 cm long, soaked in water
- Thread or tubing clips; scissors

- Sucrose solutions of 0.0 (distilled water), 0.2, 0.4, 0.6 and 0.8 mol/dm³, about 50 cm³ of each (enough for three repeats)
- 5 beakers, 250 cm³, each with 150 cm³ distilled water, labelled
- 2 syringes, 10 cm³ (or 5 cm³), or a funnel, for filling the bags
- Balance reading to 0.1 g or better; paper towels; stop-clock; marker pen
- Extension: glucose and starch solution mixed; Benedict's solution, iodine solution, test-tubes, hot water bath, eye protection

Risk assessment

Hazard	Risk	Precaution
Spilt water and solutions on the floor and bench	Slips and falls; wet balance	Wipe up spills at once and keep the balance dry by drying each bag before it is placed on it.
Scissors	Minor cuts	Cut the tubing on the bench, pointing the blades away from you.
Benedict's solution, iodine solution and the hot water bath (extension only)	Irritation to the eyes; scalds from hot water	Wear eye protection, use a water bath (not a flame) at about 80 °C and hold hot tubes with a holder.

Method

1. Soak five pieces of dialysis tubing in water for a few minutes until they are soft and can be opened by rubbing the end between your fingers.
2. Tie a tight knot (or fix a clip) at one end of each piece so that it makes a bag with a closed end.
3. Label five beakers 0.0, 0.2, 0.4, 0.6 and 0.8 and put 150 cm³ distilled water in each.
4. Use a syringe to put 15 cm³ of sucrose solution into each bag, using a different solution for each bag. Use clean syringes or rinse between solutions, working from 0.0 upwards.
5. Squeeze out most of the air and tie the open end tightly (or fix a clip), leaving a short length of empty tubing.
6. Rinse each bag under the tap and blot it dry gently with a paper towel. Use the same method on every bag.
7. Measure the mass of each bag to 0.1 g and record it as the initial mass.
8. Put each bag in its labelled beaker, making sure it is covered by water. Start the stop-clock.
9. Leave the bags for 30 minutes at room temperature.
10. Remove each bag in the same order as it went in. Blot each dry in the same way and measure its mass to 0.1 g. Record it as the final mass.
11. Calculate the change in mass and the percentage change in mass: (final mass – initial mass) ÷ initial mass × 100.
12. Extension: fill a bag with glucose and starch solution and place it in distilled water for 20 minutes. Test samples of the water outside with Benedict's solution (heat in a water bath) and with iodine solution.

Results

Change in mass of dialysis tubing bags in distilled water				
concentration of sucrose solution in bag / 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) against concentration of sucrose solution in bag / mol/dm³ (x-axis). Mark each point with a cross (×), use more than half of the grid in both directions, and draw a single smooth best-fit curve. Use a line graph because the concentration of sucrose is a continuous variable.



Exam questions 10 questions · 28 marks

- 1** A student investigates osmosis by putting bags of dialysis tubing, filled with sucrose solutions of different concentrations, in distilled water. (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** One bag contained distilled water instead of sucrose solution. Explain why this bag is included. **[2 marks]**

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- 3** A bag had an initial mass of 16.4 g. After 30 minutes in distilled water its mass was 17.5 g. Calculate the percentage change in mass. Give your answer to 1 decimal place. Show your working. **[3 marks]**

Answer =

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- 4** The table shows the percentage change in mass of the bags. Describe the pattern in the results. Use data from the table in your answer. **[3 marks]**

Change in mass of bags in distilled water	
concentration of sucrose solution in bag / mol/dm ³	change in mass / %
0.0	0.0
0.2	+3.7
0.4	+6.7
0.6	+8.9
0.8	+9.9

- 5** The student plots a line graph of change in mass / % against concentration of sucrose solution in bag / mol/dm³. Suggest why a line graph is more suitable than a bar chart. **[2 marks]**

- 6** Explain why the mass of the bags containing sucrose solution increased. **[3 marks]**

- 7** Another bag containing distilled water is placed in a beaker of 0.8 mol/dm³ sucrose solution for 30 minutes. Predict what happens to the mass of the bag, and explain your prediction. **[2 marks]**

- 8** The student rinses each bag under the tap and blots it dry before measuring the initial mass, and again before measuring the final mass. (a) Explain why the bags are rinsed before the first measurement. [1] (b) Explain why the bags are blotted dry before each measurement. [2] **[3 marks]**

- 9** In an extension, a bag containing a mixture of glucose solution and starch solution is placed in distilled water for 20 minutes. Samples of the water outside the bag are then tested with Benedict's solution and with iodine solution. Predict the results of the two tests, and explain the results. **[3 marks]**

- 10** Suggest three ways in which the reliability or accuracy of this investigation could be improved. **[3 marks]**

Teacher answers

Practical skill 2: Osmosis using dialysis tubing. The example results are practice data, not real measurements.

Example results

Example results (practice data), after 30 minutes in distilled water				
concentration of sucrose solution in bag / mol/dm^3	initial mass / g	final mass / g	change in mass / g	change in mass / %
0.0	15.6	15.6	0.0	0.0
0.2	16.1	16.7	+0.6	+3.7
0.4	16.4	17.5	+1.1	+6.7
0.6	16.8	18.3	+1.5	+8.9
0.8	17.1	18.8	+1.7	+9.9

Conclusion

The bag containing distilled water showed no change in mass (0.0%). The bags containing sucrose solution all gained mass, and the more concentrated the sucrose solution, the greater the percentage increase in mass: +3.7% at 0.2 mol/dm^3 up to +9.9% at 0.8 mol/dm^3 . The solution inside the bag had a lower water potential than the distilled water outside, so water moved into the bag by **osmosis** through the **partially permeable** dialysis tubing. The sucrose molecules were too large to pass through the pores, so they stayed inside, and the mass of the bag rose. The initial masses are higher for the more concentrated solutions because a sucrose solution is denser than water. The increases get smaller as the concentration rises, because the water that enters dilutes the solution inside, and the bag becomes full and tight, so less water can enter. The 0.0 bag acts as a control: with no sucrose there is no water potential difference, so there is no net movement of water. In the extension, glucose passed out into the water (positive Benedict's test) but starch did not (iodine stays orange-brown), showing that the tubing allows small molecules through but not large ones.

Errors and improvements

Error	Effect on the results	Improvement
Water left on the outside of a bag when it is weighed	The final mass is too high, so the percentage increase is overestimated	Blot every bag in the same way and for the same time before weighing, and handle the bags with dry hands.
A bag leaks at a knot, or sucrose is spilt on the outside	The mass changes for a reason that is not osmosis, so the point is anomalous	Tie the knots tightly, test each bag by squeezing it over the sink, and rinse the outside before the first weighing.
Balance reads only to 0.1 g and the changes are small	Percentage changes are not very precise, especially at low concentrations	Use a balance reading to 0.01 g, use bigger bags, or leave the bags longer.
Bags are not filled with exactly the same volume, or not left for exactly the same time	The starting mass and the amount of osmosis differ from bag to bag	Measure each volume with a syringe, start the bags at set intervals, and remove them in the same order after the same time.
Only one bag at each concentration	An anomalous result cannot be identified	Repeat each concentration at least three times and calculate a mean.

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 in the bag (1); dependent: (percentage) change in mass of the bag (1) allow final mass of the bag
- (b) any two from: volume of solution in the bag; (size / length of) dialysis tubing; volume of water in the beaker; time (left in the water); temperature; same way of drying the bag (2) ignore amount of water / sucrose / time of the experiment

2. [2]

- it is a control (1)
- to show that the change in mass in the other bags is due to the sucrose / to show there is no net movement of water when there is no difference in concentration (1) allow to compare with the other bags

3. [3]

- $17.5 - 16.4 = 1.1$ (g) (1)
- $1.1 \div 16.4 \times 100$ (1)
- 6.7 (%) (1) allow +6.7; award 3 marks for the correct answer with no working; 6.71 / 6.707 (not given to 1 decimal place) scores 2 marks

4. [3]

- as the concentration increases, the percentage increase in mass increases (1)
- quotes figures, e.g. from 0.0% at 0.0 mol/dm³ to +9.9% at 0.8 mol/dm³ (1) units not needed for this mark
- the rate of increase gets smaller / curve levels off at higher concentrations (1) allow the increase from 0.6 to 0.8 mol/dm³ (1.0%) is less than from 0.0 to 0.2 mol/dm³ (3.7%)

5. [2]

- the independent variable / concentration is continuous (numerical) data (1) allow concentration can have any value
- a line graph shows the trend / pattern and allows values to be read between the points (interpolation) (1) reject 'it is neater'

6. [3]

- water moves into the bag by osmosis (1) reject 'sucrose moves'
- through the partially permeable membrane / pores in the dialysis tubing (1) allow semi-permeable
- from a higher water potential / dilute solution outside to a lower water potential / more concentrated solution inside (1) allow down the water potential gradient
- sucrose molecules are too large to pass out through the tubing (1)
- Max 3

7. [2]

- the mass decreases (1)
- water leaves the bag / moves out by osmosis into the more concentrated solution (1) allow water moves from higher to lower water potential

8. [3]

- (a) to remove any sucrose solution on the outside of the bag / that has spilt (1) allow so the initial mass is correct
- (b) to remove water from the outside (1)
- because this would add to / change the mass, giving an inaccurate result / mass would not be due to osmosis (1) allow so each bag is treated the same way

9. [3]

- Benedict's solution: positive / turns green, yellow, orange or brick-red (precipitate) (1) allow orange-red
- iodine solution: negative / stays orange-brown / no blue-black colour (1)
- glucose molecules are small enough to pass through the pores of the tubing but starch molecules are too large (1)

10. [3]

- repeat for each concentration and calculate a mean (1)
- use a balance that reads to 0.01 g / use larger bags (1)
- dry all bags in the same way / for the same time (1)
- leave the bags for a longer time (1)
- check each bag for leaks before the experiment (1)
- use a range of concentrations with smaller steps / more concentrations (1)
- Max 3; ignore 'be more careful'; ignore 'do it again' without a mean

Exam tips

- Osmosis is about water only: 'water moves from a dilute solution to a concentrated solution through a partially permeable membrane'. Do not write that sucrose or sugar moves by osmosis.
- For percentage change use $(\text{final} - \text{initial}) \div \text{initial} \times 100$ and show the sign. A gain is positive and a loss is negative.
- Dialysis tubing has pores that let small molecules (water, glucose) through but not large molecules (starch, sucrose). Name which molecules do and do not pass.

- A control tube or bag with no solute shows that the change in mass is caused by the solute and not by something else. Say this when asked why a control is used.
- Table headings and axis labels use a solidus, such as change in mass / %, and the unit is not repeated in the body of the table.