RSC | Advancing the Chemical Sciences

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Rate of osmosis

Student worksheet

Uptake of water by plant tissues

The uptake of water by plant cells or loss of water from them is due to osmosis. Water passes from a more dilute solution to a more concentrated solution through the partially permeable cell membrane.

Water potential (Ψ) is a measure of the tendency of water molecules to move from one place to another. The more dilute a solution, the higher its water potential. Increasing the concentration of solutes in a solution lowers its water potential.

Water moves from high to low water potential. To some extent, plant cells control this process by the active transport of solutes (molecules or ions) through cell membranes. In a root, active transport of ions from the soil into the centre of the root:

- increases the concentration of the cell solutions;
- lowers water potential below that of the cells in the periphery of the root;
- causes water to move by osmosis from root hairs, through the root to the xylem vessels to be transported up to the leaves by the transpiration stream.

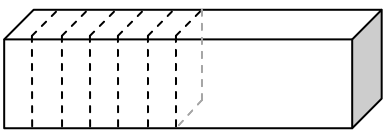
In this experiment you will determine how the rate of osmosis depends on the concentration of solutes.

Equipment and materials

- Potatoes
- Sharp knife
- Cutting board or white tile
- Test tubes x 5
- Test tube rack
- 1 mol dm^{-3} sucrose solution
- 100 cm^3 beaker
- 10 cm^3 graduated syringes or pipettes
- Filter paper
- Balance (to 0.01 g)
- Marker pen
- Paper towels

Method

1. Make up 10 cm^3 samples of 0.8, 0.4, 0.2, 0.1 and 0.05 mol dm^{-3} sucrose solutions in suitably labelled test tubes.
2. Remove the peel from the potato and cut a chip about 6-7 cm long and 1 cm x 1 cm. Slice into pieces about 2 mm thick. You need 20 pieces.



3. Blot the potato pieces with a paper towel to remove moisture.
4. Place a piece of filter paper on the balance pan and zero the balance. Put four pieces of blotted potato on the paper and measure the mass of potato tissue to the nearest 0.01 g. Record this in the 'Initial mass' column of the table on the next page.
5. Put the potato pieces in a test tube. Pour 1 mol dm^{-3} sucrose solution into the tube until it comes to about 1 cm above the top of the potato pieces. Leave for 15 minutes, agitating each tube occasionally.

6. Remove the potato from the test tube, blot dry and weigh accurately, recording the result (the 'Final mass' of potato tissue).
7. Repeat steps 4-6 for the other sucrose solutions.

Results

Concentration of sucrose solution / mol dm^{-3}	Initial mass of potato tissue / g	Final mass of potato tissue / g	$\frac{\text{Final mass}}{\text{Initial mass}}$
0.80			
0.40			
0.20			
0.10			
0.05			

Calculations

1. Calculate the ratio of final mass to initial mass for each concentration. Record the values in the table.
2. Plot a graph of $\frac{Final\ Mass}{Initial\ Mass}$ against sucrose concentration.
3. Use the graph to determine the concentration of sucrose which is in equilibrium with the potato tissue (zero osmosis).
4. Use the table below to find the water potential of the potato tissue (MPa).

Sucrose concentration / mol dm^{-3}	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Water potential / MPa	−0.27	−0.55	−0.83	−1.13	−1.46	−1.82	−2.20	−2.61	−3.05	−3.56

Conclusions

1. Explain why the rate of uptake or loss of water from the potato tissue varied according to the concentration of the solution in which it was immersed.
2. Suggest factors which might affect the results that you obtain for different potato samples.