DP Biology – D2.3 (HL extension)

Water potential

- What affects whether water moves into or out of a cell?
- In what ways do plant cells and animal cells control water movement differently?

HL statements D2.3.8–11. Textbook pp. 690–692.

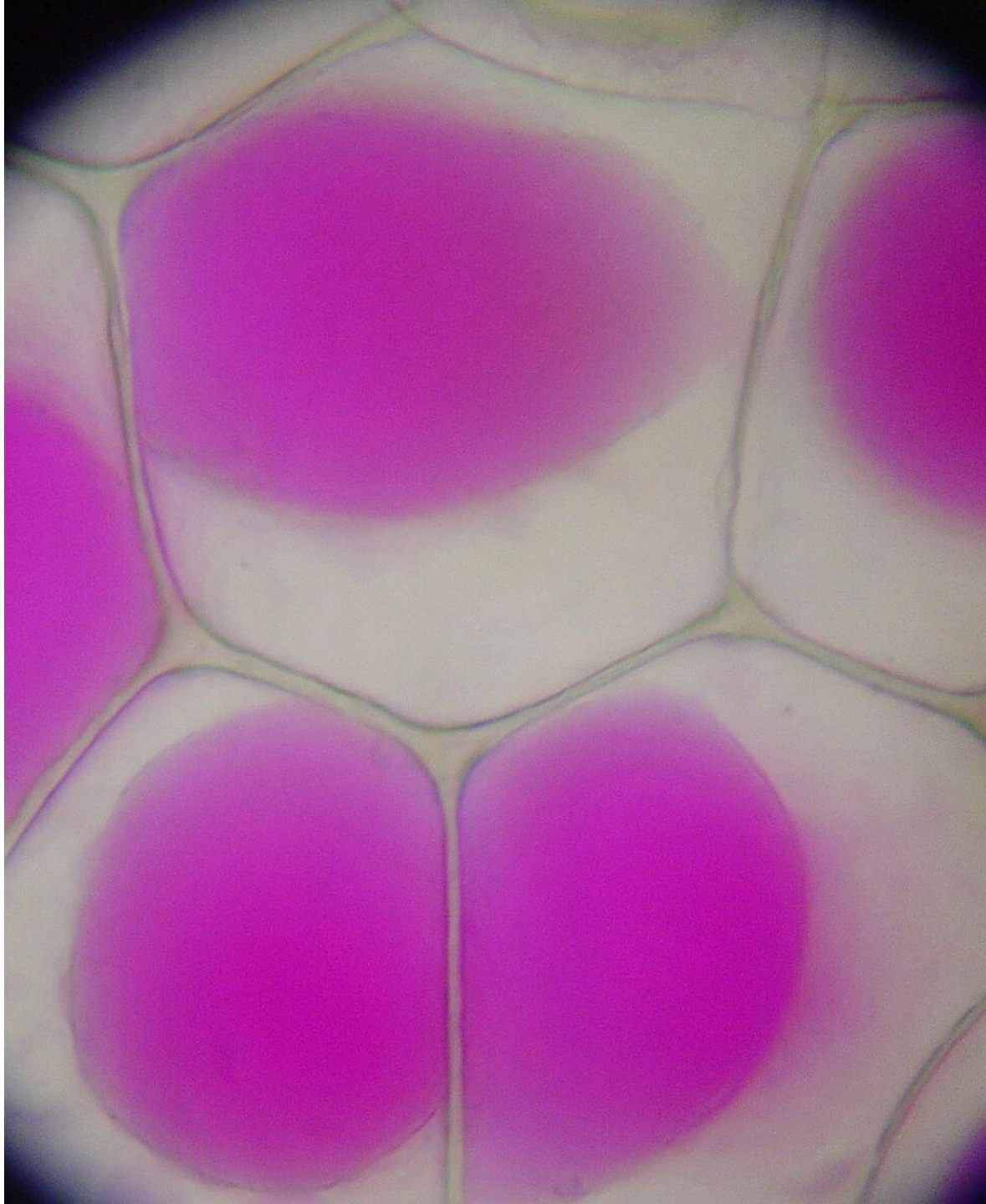


Image: plasmolysed cells of a leaf epidermis. Mnolf, CC BY-SA 3.0.

Objectives for each class

Class	Statements	By the end of the class, you can...
1	D2.3.8–9	Define water potential and predict the direction of water movement
2	D2.3.10–11	Use solute and pressure potential to explain water movement in plant tissue

What is water potential?

D2.3.8

- **Water potential** measures the stored energy held by a given volume of water
- Symbol: the Greek letter psi; unit: kPa
- It is measured relative to pure water at standard pressure, which is set at **0 kPa**
- Dissolving a solute lowers water potential: solutions have **negative** values
- The more concentrated the solution, the more negative its water potential

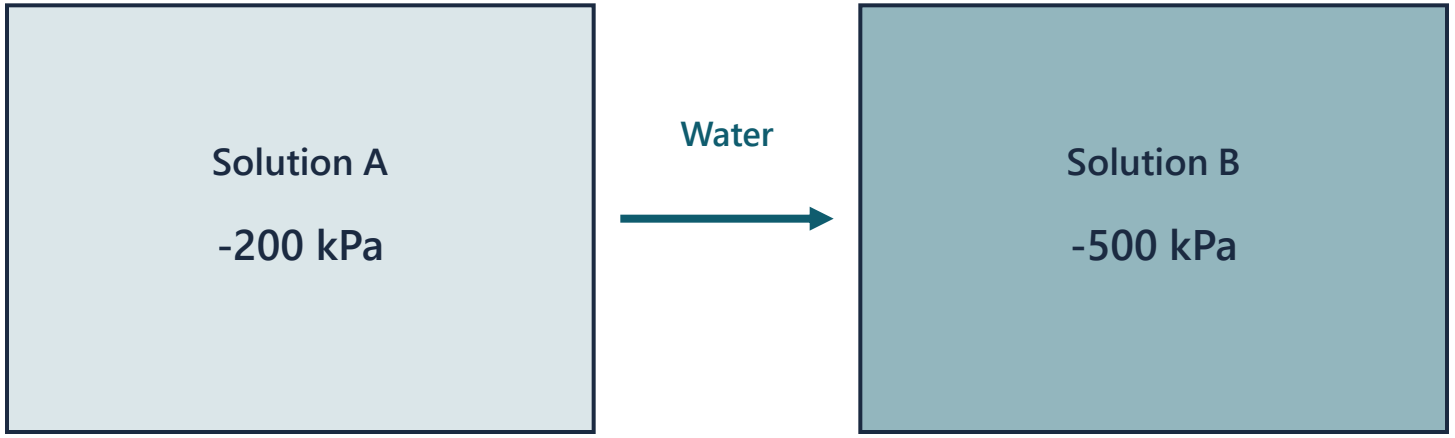
Liquid	Water potential / kPa
Pure water	0
Dilute solution	about -100
Cell sap of a leaf	about -1000
Sea water	about -2500

Why solutes lower it

Water molecules form hydrogen bonds with solute particles, so they are less free to move: their potential energy falls.

Water moves down a water potential gradient

D2.3.9



Separated by a partially permeable membrane. Darker: more solute.

- Water moves from **higher** (less negative) to **lower** (more negative) water potential
- So water moves from A to B
- Movement stops when the water potentials are equal

Try it

Three cells touch in a row: X at -300 kPa, Y at -500 kPa and Z at -400 kPa. Draw arrows to show the net movement of water between each pair.

Solute potential and pressure potential

D2.3.10

$$\text{water potential} = \text{solute potential} + \text{pressure potential}$$

	Solute potential	Pressure potential
Caused by	Dissolved solutes	Pressure of the cell contents on the cell wall
Usual sign	Zero or negative	Positive in turgid cells
Gets lower when	More solute dissolves	The cell loses water
Note	Pure water has 0 kPa	Negative in xylem, where sap is under tension

Key idea

A cell wall lets pressure build up, so pressure potential matters most in plants, fungi and bacteria.

Using the equation

D2.3.10

Cell	Solute potential / kPa	Pressure potential / kPa	Water potential / kPa
Turgid cell in pure water	−700	+700	0
Cell in a leaf on a sunny day	-1000	+400	-600
Flaccid cell	-900	0	-900
Plasmolysed cell	-1200	0	-1200

Try it

A cell has a solute potential of -800 kPa and a pressure potential of +300 kPa. Calculate its water potential.

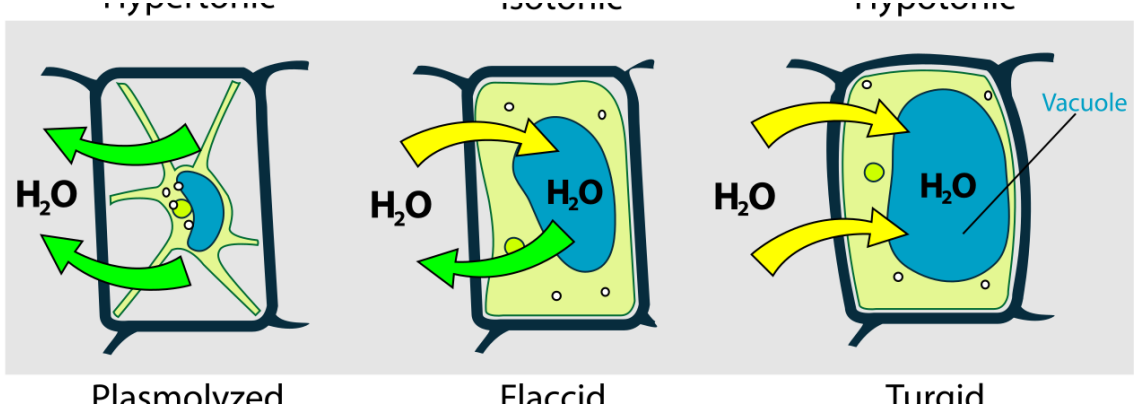
Then

It is placed in a solution at -400 kPa. Does it gain or lose water?

Plant tissue in a hypotonic solution

D2.3.11

Solution has a higher water potential than the cells → Water enters by osmosis → Cell sap becomes more dilute: solute potential less negative → **Protoplast presses on the wall: pressure potential rises** → Water potential rises until it equals the solution



Plant cells in hypertonic, isotonic and hypotonic solutions. LadyofHats, public domain.

Result

The cell becomes turgid. The wall stops it bursting. Turgid cells hold up leaves and young stems.

Plant tissue in a hypertonic solution

D2.3.11

Solution has a lower water potential than the cells → Water leaves by osmosis → Cell sap becomes more concentrated: solute potential more negative → Pressure potential falls to zero: cell is flaccid → Protoplast shrinks from the wall: plasmolysis

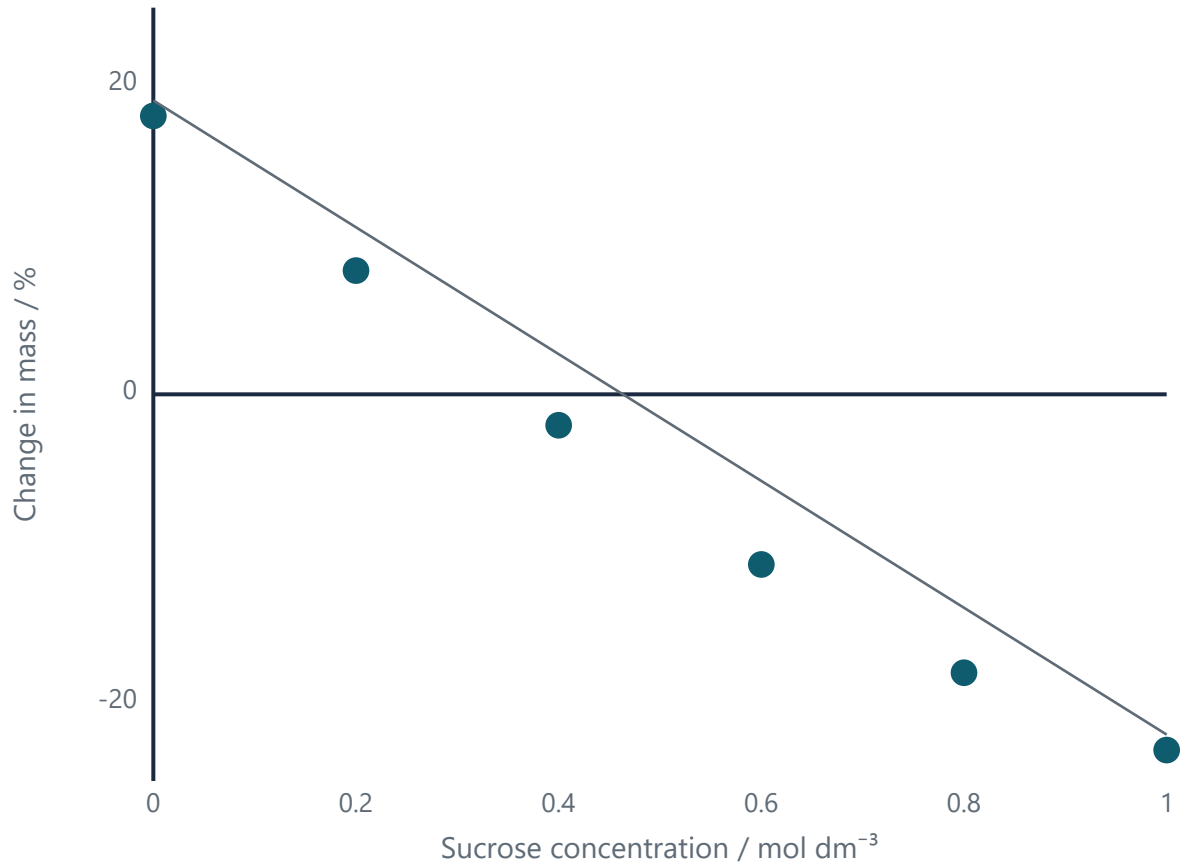


Plasmolysed epidermis cells. Mnolf, CC BY-SA 3.0.

Why plants wilt

In drought or salty soil, cells lose water, pressure potential falls and leaves droop. Few plants survive in sea water: its water potential is far lower than that of most plant cells.

Estimating the water potential of a tissue



Invented results for potato cylinders after 24 h.

- Weigh tissue samples, leave them in a range of sucrose solutions, then reweigh
- Plot percentage change in mass against concentration
- Where the line crosses zero, there is no net water movement
- So the tissue has the same water potential as that solution

Try it

Read the concentration where the line crosses zero, then look up its water potential in a table.

Check that you can explain

1. What water potential is, and why pure water is 0 kPa
2. Why solutes make water potential negative
3. Which way water moves between two solutions or cells
4. How to use: water potential = solute potential + pressure potential
5. What happens to each potential in hypotonic and hypertonic solutions
6. How to estimate the water potential of a plant tissue

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. State the water potential of pure water.

2. A cell has a solute potential of -900 kPa and a pressure potential of +500 kPa. Calculate its water potential.

3. Explain what happens to the pressure potential of a cell placed in a hypertonic solution.

Image credits

Rhoeo Discolor – Plasmolysis.jpg – Mnolf – CC BY-SA 3.0

Turgor pressure on plant cells diagram.svg – LadyofHats – Public domain

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