DP Biology – D2.3

Water movement

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

SL statements D2.3.1–7. Textbook pp. 681–690. Water potential itself is at HL.

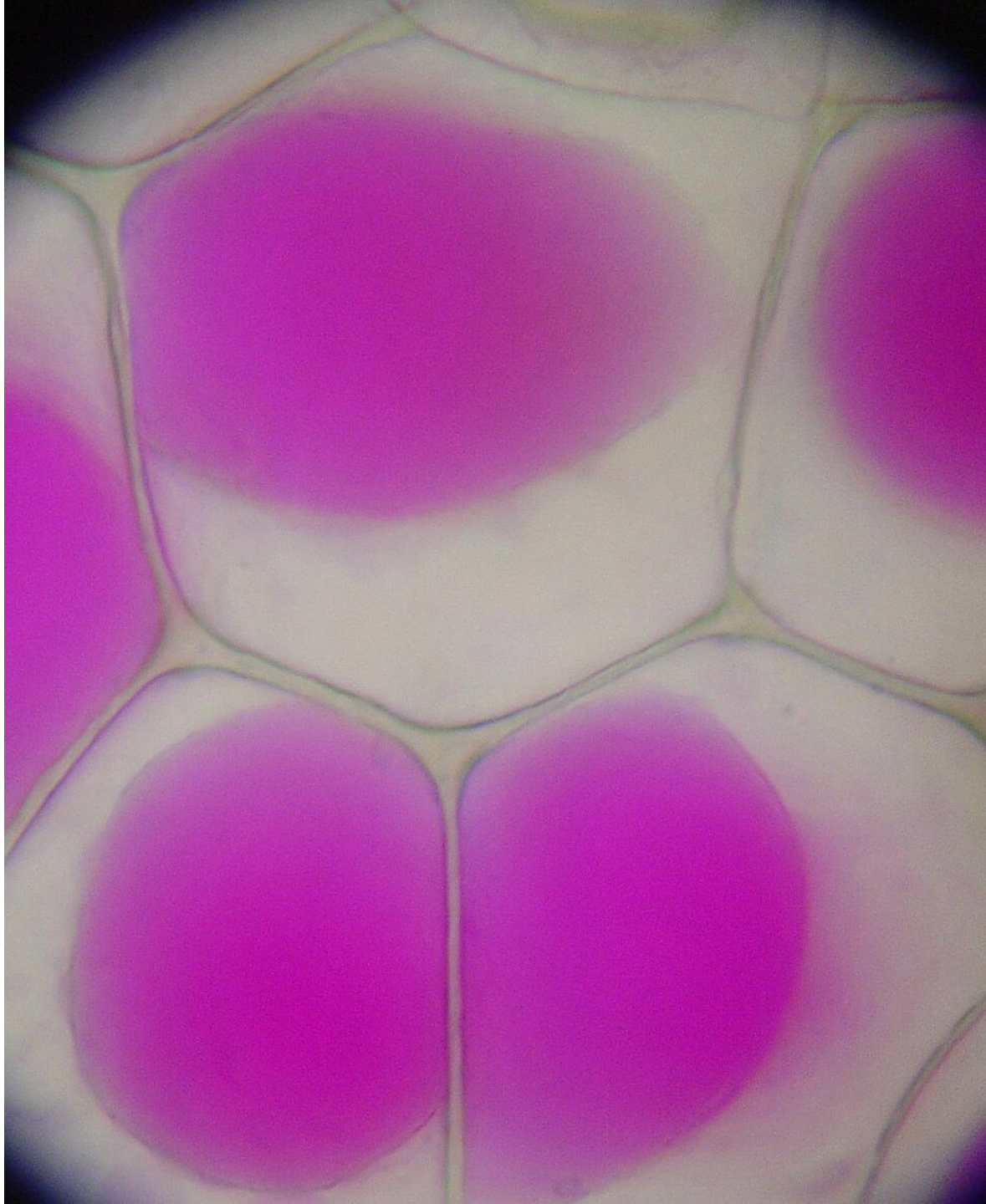


Image: plasmolysed cells of Rhoeo. Mnolf, CC BY-SA 3.0.

Objectives for each class

Class	Statements	By the end of the class, you can...
1	D2.3.1–4	Explain solvation and osmosis using hypotonic, hypertonic and isotonic, and analyse data from plant tissue
2	D2.3.5–7	Explain what water movement does to cells with and without walls, and why isotonic solutions are used in medicine

Water as a solvent

D2.3.1

- A **solute** dissolves in a **solvent** to form a **solution**
- **Solvation** is the attraction of solvent molecules around a solute
- Water is polar, with partial charges on hydrogen and oxygen
- Positive ions attract the partially negative oxygen; negative ions attract the partially positive hydrogen
- Polar solutes such as glucose form **hydrogen bonds** with water

Key idea

Water molecules surround each dissolved particle in a shell, which keeps the particles apart and in solution.

Activity

Draw a sodium ion, a chloride ion and a glucose molecule in water. Show which end of each water molecule faces each particle.

Comparing solutions

D2.3.2

Term	Meaning, compared with another solution	Net movement of water
Hypotonic	Lower solute concentration	Out of this solution
Hypertonic	Higher solute concentration	Into this solution
Isotonic	Same solute concentration	None

Common mistake

These terms always compare two solutions. Describe direction using solute concentration, not water concentration.

Memory aid

Water moves towards the **hyper**tonic solution, the one with more solute.

Water entering and leaving cells

D2.3.3

Surroundings	Net water movement	What happens to the solution inside
Hypotonic	Into the cell	Solute becomes more dilute
Hypertonic	Out of the cell	Solute becomes more concentrated
Isotonic	No net movement	No overall change

Common mistake

Isotonic does not mean that water stops moving. Water molecules keep crossing in both directions at the same rate. This is called dynamic equilibrium, and it is why we say no net movement.

Practical: potato tissue in sucrose

D2.3.4

1. Cut equal cylinders of potato and blot them
2. Record the mass or length of each
3. Place them in sucrose solutions, such as 0 to 1.0 mol dm^{-3}
4. After a set time, blot and measure again
5. Calculate the percentage change, as starting sizes differ

Why percentage change?

It allows a fair comparison between pieces that started at different masses.

Finding the isotonic concentration

Plot percentage change against concentration. Where the line crosses zero, there is no net gain or loss. That concentration is the same as inside the tissue. Use repeats, standard deviation and standard error to judge how reliable the means are.

Reading osmosis data

D2.3.4

Sucrose / mol dm^{-3}	Mean mass change / %
0.0	+18
0.2	+9
0.4	+1
0.6	-8
0.8	-15

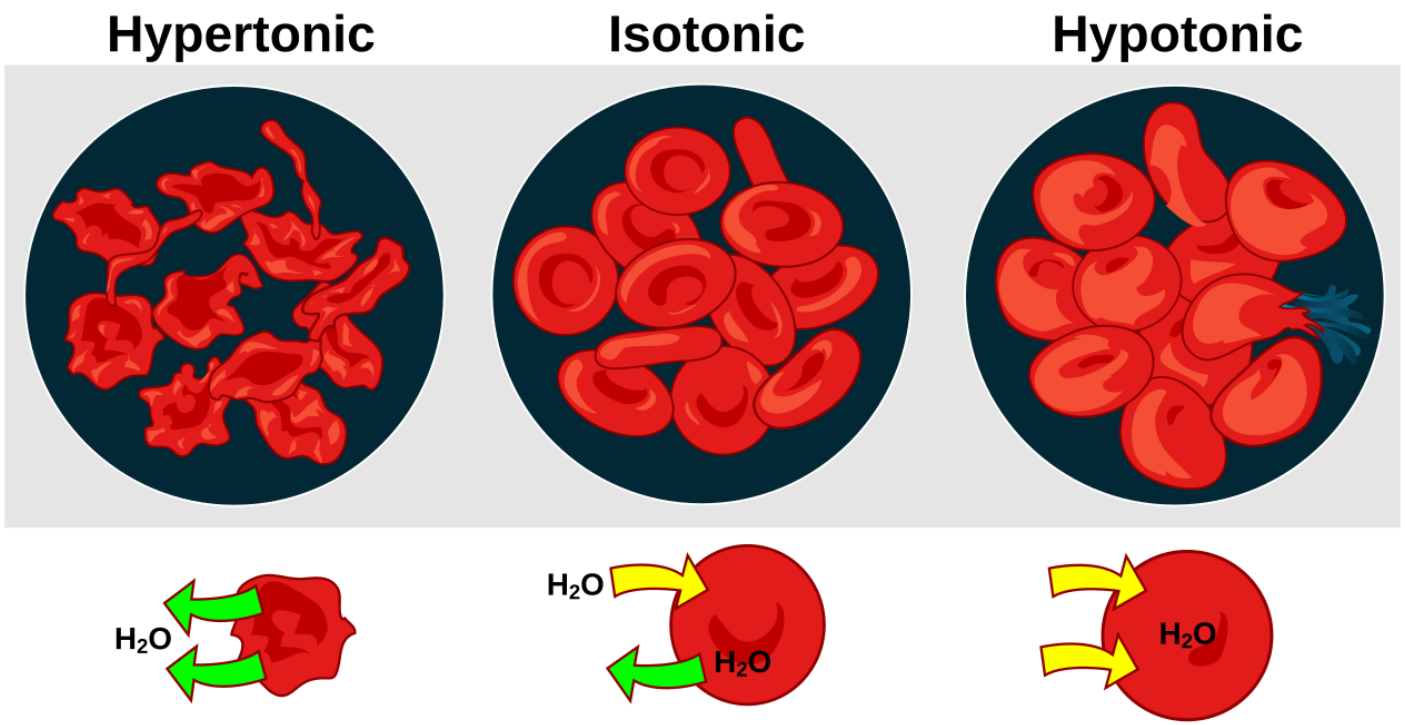
- Hypotonic solutions: tissue gains water
- Hypertonic solutions: tissue loses water
- Isotonic point: just above 0.4 mol dm^{-3}
- These figures are invented for practice

Activity

Plot these values, draw a line of best fit and read off the isotonic concentration. Suggest why tissue from a different potato could give a different value.

Cells without a cell wall

D2.3.5



Blood cells in different solutions. LadyofHats, public domain.

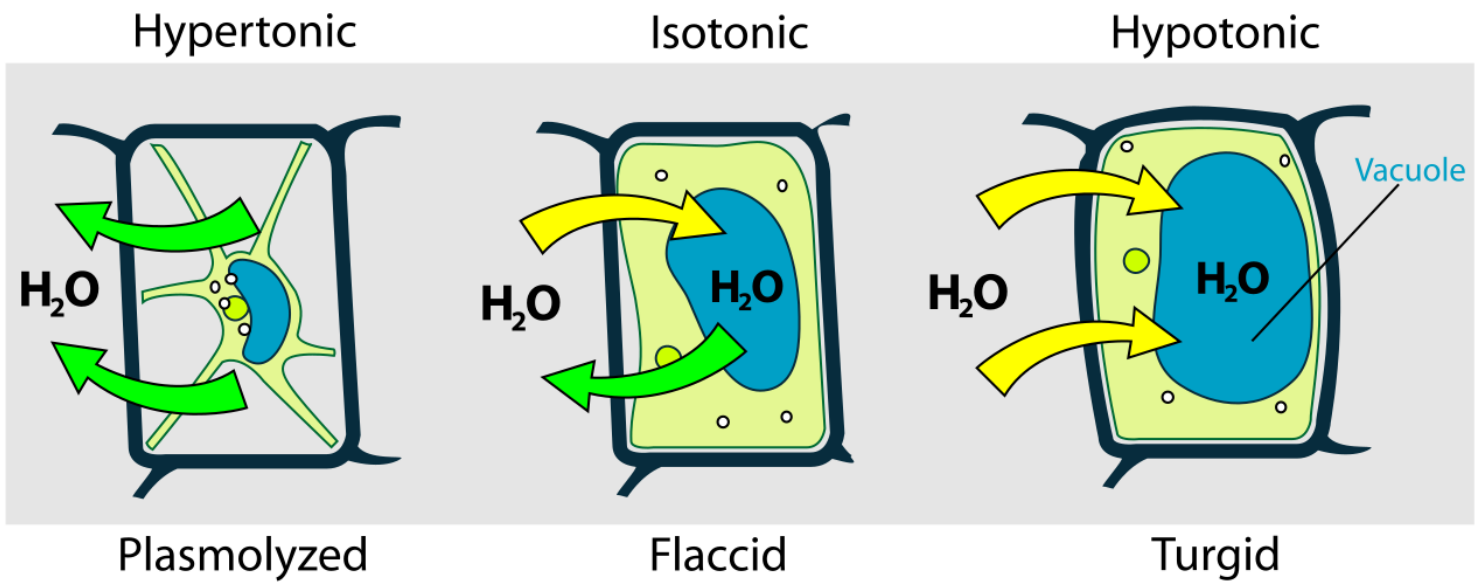
Solution	Effect
Hypotonic	Swells and may burst
Hypertonic	Shrinks; crenation
Isotonic	Stays the same

Keeping water balance

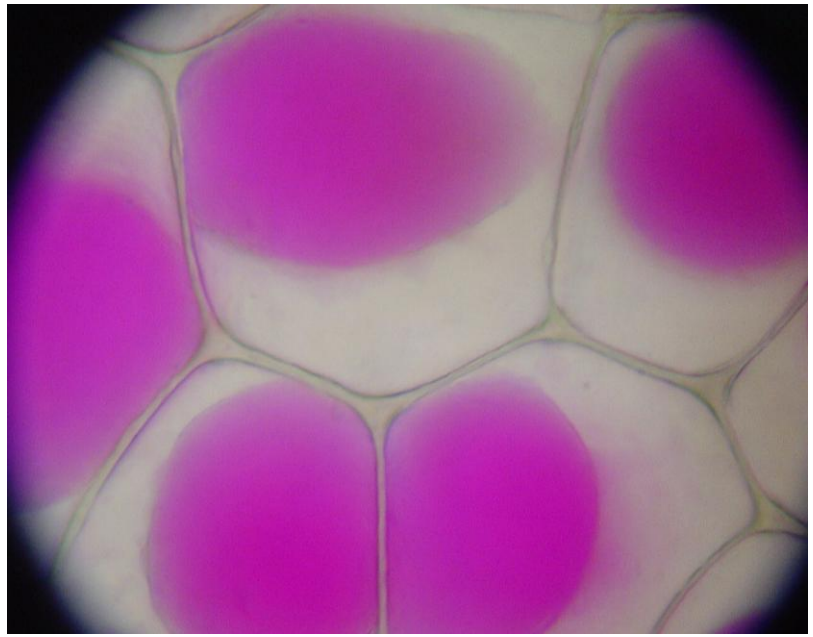
Many animals keep their tissue fluid isotonic with their cells. Freshwater unicellular organisms such as Paramecium live in a hypotonic medium, so they use contractile vacuoles to pump out water that enters.

Cells with a cell wall

D2.3.6



Plant cells in different solutions. LadyofHats, public domain.



Plasmolysis in Rhoeo. Mnolf, CC BY-SA 3.0.

Solution	What happens	Name
Hypotonic	Water enters; pressure rises; the wall stops the cell bursting	Turgor pressure
Hypertonic	Water leaves; membrane pulls away from the wall	Plasmolysis

Comparing plant and animal cells

D2.3.5–6

In a…	Animal cell	Plant cell
Hypotonic solution	Swells and bursts	Becomes firm, or turgid
Hypertonic solution	Shrinks and crenates	Plasmolyses

Key idea

A cell wall resists the pressure of water entering. This answers the second guiding question: walled cells build up pressure, while unwalled cells must keep their surroundings isotonic or remove water.

Discussion

Why does a plant wilt when it is short of water? Why can salting a path kill the plants along it?

Isotonic solutions in medicine

D2.3.7

- **Intravenous fluids**: normal saline, 0.9% sodium chloride, replaces fluid without harming blood cells
- **Organs for transplant** are bathed in isotonic solution, often kept as a cold slush
- **Eye drops and wound rinses** avoid damage to exposed cells

Why isotonic?

If the solution were hypotonic, cells would take up water, swell and burst. If it were hypertonic, cells would lose water and shrink. An isotonic solution prevents any net movement of water, so cells keep their shape and go on working.

Check that you can explain

1. How water surrounds ions and polar molecules
2. Hypotonic, hypertonic and isotonic
3. Why isotonic does not mean no water movement
4. How to find the isotonic concentration of a tissue
5. Bursting, crenation, contractile vacuoles
6. Turgor pressure and plasmolysis
7. Why isotonic solutions are used in medicine

Exit activity: 5 minutes

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

1. A cell is placed in a hypertonic solution. State the direction of net water movement.
2. Explain why an animal cell can burst in pure water when a plant cell does not.
3. State one medical use of an isotonic solution, and explain why it must be isotonic.

Image credits

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

Osmotic pressure on blood cells diagram.svg – LadyofHats – Public domain

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

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