IB BIOLOGY | D2.3 | SL AND HL

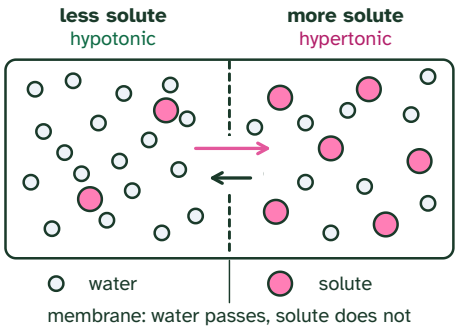
REVISION ON TWO PAGES

Water follows the *solute*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

Water moves by osmosis towards the more concentrated solution. Whether a cell has a wall decides if it bursts or turns turgid.



Read it like this. Water crosses both ways; more crosses into the more concentrated side.

D2.3.2 and 3 START HERE

Water goes to the *higher* solute concentration

- **Osmosis:** the net movement of water across a **partially permeable membrane**, which lets water through but not the solute.
- Water crosses both ways all the time. More crosses **from the less concentrated solution to the more concentrated** one, so that is the net direction.
- A cell in a **hypotonic** solution **gains water**; in a **hypertonic** one it **loses water**.
- **Isotonic:** water still crosses, as fast each way. This is a **dynamic equilibrium**, with no net change, not no movement.

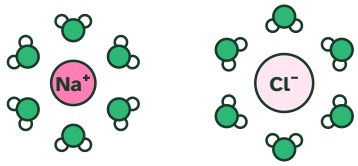
COMPARE BY SOLUTE CONCENTRATION — *never by "water concentration"*

Hypertonic	Hypotonic	Isotonic
more solute than the other solution	less solute than the other solution	the same solute concentration

D2.3.1

Solvation in water

- Water is polar: a δ− oxygen and two δ+ hydrogens.
- **Ions:** water is **attracted to both positive and negative ions** and wraps each in a shell: solvation.
- **Polar molecules** such as glucose form **hydrogen bonds** with water through their −OH groups.



oxygens (δ−) face in — hydrogens (δ+) face in

D2.3.5

No wall, *no limit*

- **Hypotonic:** the cell **swells and can burst**. **Hypertonic:** it shrinks; a red blood cell puckers: **crenation**.
- **Freshwater unicells** such as *Paramecium*: a **contractile vacuole** pumps out the water that keeps entering, using ATP.
- **Multicellular animals** keep blood plasma and **tissue fluid isotonic** with their cells.



swells, bursts — no net change — crenated

D2.3.6

The wall *pushes back*

- **Hypotonic:** the membrane presses on the wall, which presses back: **turgor pressure**. No bursting.
- **Isotonic: flaccid**, the membrane just touching the wall.
- **Hypertonic:** the membrane **pulls away from the wall**: **plasmolysis**. Outside solution fills the gap.

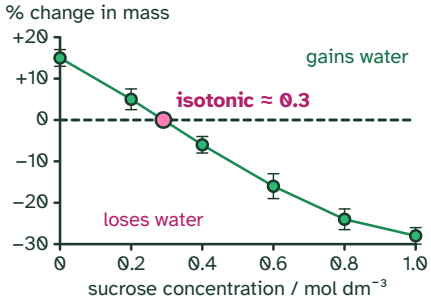


turgid — flaccid — plasmolysed

D2.3.4 APPLICATION OF SKILLS

Potato cores in *sucrose*

- Weigh and measure cores, soak them in a range of sucrose solutions, then **blot** and weigh again.
- **Hypotonic:** cores gain mass, lengthen, go firm. **Hypertonic:** they lose mass, shorten, go floppy.
- Use **percentage change**, so cores of different sizes compare fairly.
- Where the mean line **crosses zero** is the isotonic concentration, usually between two tested points.



Repeats reliability
Give a **standard deviation** for each set and a **standard error** of the mean, drawn as error bars. No formulae to learn.

Mass or length which to trust
Mass changes are **larger** and measured **more precisely**, so they usually give the clearer result.

Isotonic solutions and *water potential*

D2.3.7

Isotonic in medicine

- Isotonic solutions cause **no net water movement**, so cells keep their size and shape.
- Isotonic means the same **solute concentration** as the cells, not the same substance.
- Some drips carry **glucose** at a strength that keeps them close to isotonic too.

EXAMPLE 1

Intravenous fluids

A drip runs straight into the blood. Normal saline, 0.9% NaCl, replaces water and salts; pure water would burst red blood cells.

EXAMPLE 2

Donor organs

A kidney for transplant is flushed and bathed in a cold isotonic solution. The cold slows its metabolism.

D2.3.8 and 9 HIGHER LEVEL

Water runs *downhill*

- **Water potential, ψ:** the **potential energy of water per unit volume**, in **kilopascals (kPa)**.
- It cannot be measured absolutely, so it is given **relative to pure water** at atmospheric pressure and 20 °C, set at zero.
- Water moves from **higher to lower water potential**, from higher to lower potential energy, as a ball rolls downhill.
- Solutes lower ψ, so any solution is negative. Pressure raises it.

0 kPa
pure water: the reference

−800 < −300
more negative is lower

D2.3.10 and 11 HIGHER LEVEL

$\psi = \psi s + \psi p$ in cells with walls

PART	WHAT IT IS	VALUES
ψs solute potential	Set by the dissolved solutes	**Zero** for pure water, **negative** for any solution: more solute, more negative
ψp pressure potential	The pressure of the contents on the wall	**Positive** in turgid cells, **zero** when flaccid, **negative** in xylem under tension

Into pure water hypotonic

Flaccid cell: ψ = −800 + 0 = −800 kPa, below 0, so water enters. ψp rises until ψ = 0: **turgid**, ψp about equal and opposite to ψs.

Into −1200 kPa hypertonic

The cell (−800) is higher, so water leaves. ψp falls to zero, the membrane pulls away, and water leaves until ψs = −1200: **plasmolysed**.

WATCH OUT

Six mistakes that *cost marks*

- ✕ **Say "towards the higher solute concentration".** The IB wants solute concentration, never "water concentration".
- ✕ **Isotonic is not no movement.** Water crosses both ways at the same rate: a dynamic equilibrium.
- ✕ **Hypotonic and hypertonic compare two solutions.** Say what the solution is hypotonic to: "hypotonic to the cell".
- ✕ **A turgid plant cell does not burst.** The wall presses back; only cells with no wall burst.
- ✕ **The gap in a plasmolysed cell is not empty.** It fills with outside solution, which passes freely through the wall.
- ✕ **−800 kPa is lower than −300 kPa.** Water moves to the more negative ψ; a turgid cell in pure water has ψ = 0.

COVER THE SHEET

Can you *answer these?*

1. Describe how a sodium ion and a chloride ion are each surrounded by water.
2. State the direction of net water movement between a hypotonic and a hypertonic solution.
3. Explain why water still crosses the membrane of a cell in an isotonic solution.
4. Outline how to find the isotonic sucrose concentration of potato tissue.
5. Compare what happens to a red blood cell and a plant cell in pure water.
6. Explain why intravenous fluids and organ storage solutions are isotonic.
7. State the reference point for water potential and its units. HL
8. Explain, using ψs and ψp, why a plant cell becomes turgid in pure water. HL

IN THE EXAM

Name the solutions by solute concentration ("the solution is hypertonic to the cell"), then **give the net direction** and its effect on the cell. With water potentials, **add ψs and ψp before comparing**: ψs alone gives the wrong answer.

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.