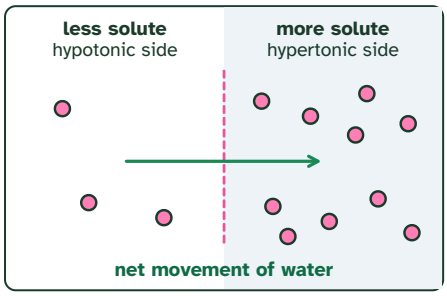
# Water goes where the *solute* is

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

**THE ONE IDEA**

**Water moves by osmosis toward more solute: from higher water potential to lower. A wall turns that into pressure.**




**Always say "to what".** A solution is hypertonic only compared with another, such as a cell's cytoplasm.

2.7.A START HERE

## *Osmosis* and tonicity

- **Osmosis** is the diffusion of water across a selectively permeable membrane: one that lets water through but not the solute.
- Water crosses both ways all the time. Where there is more solute, more of the water is held around the dissolved particles and is less free to move, so the **net movement** is from lower solute concentration to higher.
- Tonicity compares two solutions. Water moves from the **hypotonic** side to the **hypertonic** side. Between isotonic solutions it crosses as fast each way: a dynamic equilibrium.

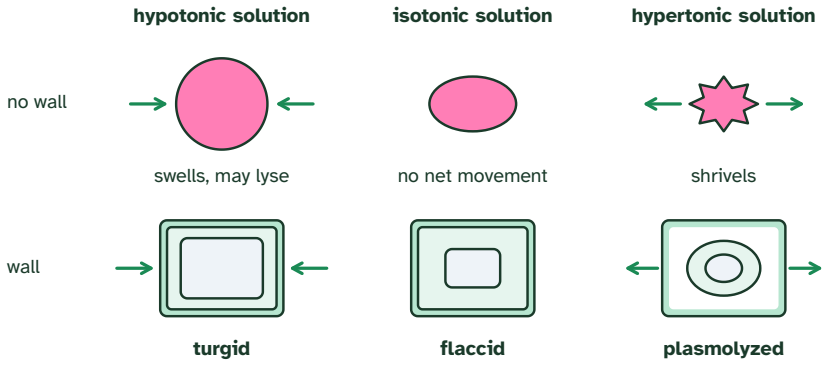
THREE WORDS THAT COMPARE TWO SOLUTIONS

| | | |
|---|---|---|
| − **Hypotonic** less solute | = **Isotonic** the same | + **Hypertonic** more solute |

2.7.A

## Cells in *three solutions*

- **No wall** (animal cells, many protists). In a hypotonic solution the cell swells and can **lyse**: burst. In a hypertonic one it loses water and shrivels.
- **With a wall** (plants, fungi, bacteria). In a hypotonic solution water enters until **turgor pressure**, the wall pressing back, stops it. The cell is turgid, and turgid cells hold a plant up.
- Isotonic: the plant cell is **flaccid**. Hypertonic: the membrane pulls away from the wall, **plasmolysis**, and the plant wilts.




2.7.A STAYING IN BALANCE

## *Osmoregulation*

- **Osmoregulation** keeps an organism's water and solutes in balance, whatever its surroundings.
- A plant cell stores solutes in its **central vacuole**. That lowers its water potential, so it keeps drawing water in and stays turgid.

**Contractile vacuole** freshwater protists
Collects the water that keeps entering a *Paramecium* and expels it, using ATP.

**Kidneys or gills** animals
Adjust the water and salt that leave, so body fluids stay isotonic with the cells.

2.7.A IN MEDICINE

## Keeping cells *as they are*

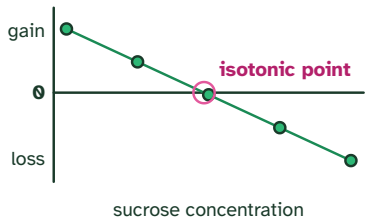
- Fluid run into a vein must be **isotonic** with the blood cells. Pure water would make red blood cells swell and lyse; strong salt solution would shrivel them.
- A donor organ is flushed and bathed in a **cold isotonic solution**: its cells neither gain nor lose water, and the cold slows their metabolism.
- Isotonic means the same total solute concentration, not the same substance.

**0.9%**
sodium chloride: normal saline, isotonic with blood cells

2.7.A THE POTATO LAB

## Cores in *sugar*

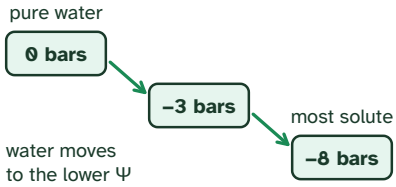
- Potato cores are weighed, soaked in a range of sucrose solutions, blotted and reweighed.
- In a hypotonic solution they gain mass; in a hypertonic one they lose it. Use **percentage change in mass**, as cores start at different sizes.
- Where the line crosses zero, the solution is isotonic with the cells.



2.7.B

## Water runs *downhill*: Ψ = Ψp + Ψs

- **Water potential**, Ψ (psi), measures how free water is to move. Its unit is a unit of pressure: **bars**.
- Pure water in an open container is the reference: **Ψ = 0**. Solute lowers Ψ; pressure raises it.
- Water moves from **higher Ψ to lower Ψ**: toward the more negative value.
- Two things set it. Add them before comparing: Ψs alone can give the wrong direction.



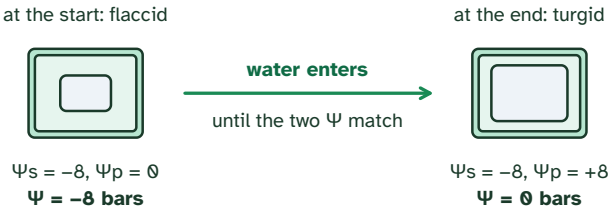

**Ψs** solute potential
Zero for pure water, negative for any solution. The more solute, the more negative.

**Ψp** pressure potential
Zero in an open container. Positive in a turgid cell pressing on its wall.

2.7.B

## A cell in *pure water*

- A flaccid cell with Ψs = −8 bars goes into pure water. Its Ψ is 0 + (−8) = **−8 bars**, lower than the water's 0, so water enters.
- The cell presses on its wall, and Ψp rises until the cell's Ψ reaches 0. Ψp is then about **+8 bars**: the cell is turgid.
- In a solution of −12 bars instead, water leaves the cell and it plasmolyzes.




2.7.B CALCULATE A SOLUTE POTENTIAL

## $\Psi s = -iCRT$

| | STANDS FOR | USE |
|---|---|---|
| **i** | Ionization constant | Particles per unit in water: 1 for sucrose, 2 for NaCl. |
| **C** | Molar concentration | In mol/L. |
| **R** | Pressure constant | 0.0831 L·bar/(mol·K). |
| **T** | Temperature in kelvin | °C + 273. |

Particles count, not their kind: 0.1 M NaCl has the same Ψs as 0.2 M sucrose.

WORKED EXAMPLE

**0.20 M sucrose at 22 °C**
Ψs = −(1)(0.20)(0.0831)(295) = −4.9 bars.

THEN

**In an open beaker**
Ψp = 0, so Ψ = Ψs = −4.9 bars.

WATCH OUT

## Five mistakes that *cost points*

- ✕ **Water does not stop at isotonic.** It crosses equally both ways.
- ✕ **A plasmolyzed cell's gap is not empty.** The outside solution fills it, passing freely through the wall.
- ✕ **−8 bars is lower than −3 bars.** Water moves toward the more negative value.
- ✕ **A turgid cell in pure water has Ψ = 0.** Its Ψp just cancels its Ψs.
- ✕ **T is in kelvin.** At 22 °C use 295, never 22.

COVER THE SHEET

## Can you *answer these?*

1. Describe osmosis in terms of solute concentration.
2. Predict the fate of a red blood cell in pure water.
3. Explain why a plant cell in pure water does not burst.
4. Describe how a *Paramecium* osmoregulates.
5. Explain why percentage change in mass is used.
6. Calculate Ψ for a cell: Ψs = −7 bars, Ψp = +2 bars.
7. Predict where water moves if it sits in a −4 bar solution.
8. Calculate Ψs of 0.30 M sucrose at 27 °C.

IN THE EXAM

**Show the working:** write the equation, substitute with T in kelvin, then state the direction: "from −4 to −6.5 bars, higher water potential to lower".

GO FURTHER

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