

Hypotonic, isotonic and hypertonic: the table, the cells and the examples

Osmosis: water moves across a partially permeable membrane from the more dilute solution (higher water concentration) to the more concentrated one. The three words describe the SOLUTION compared with the cell. Hypo = under (less solute): water into the cell. Hyper = over (more solute): water out. Iso = same: no net movement.

	Hypotonic solution	Isotonic solution	Hypertonic solution
Solute concentration (vs the cell)	lower	equal	higher
Water concentration	higher	equal	lower
Net water movement	into the cell	none (equal both ways)	out of the cell
Animal cell (red blood cell)	swells, may burst (lysis, haemolysis)	normal	shrinks, puckers (crenation)
Plant cell	turgid: swollen against the wall, firm	flaccid: limp	plasmolysed: membrane pulls from the wall
Examples	pure water, 0.45% saline	0.9% saline, Ringer's lactate, isotonic drinks	3% saline, sea water, syrup

Medical and everyday

Situation	Tonicity to human cells	What happens
Normal saline 0.9% NaCl	isotonic	standard IV fluid, wound wash, lens solution: cells unchanged
Half-normal saline 0.45%; 5% dextrose once used	hypotonic	water into cells; rehydrates them, with care
3% saline; 10% and 50% dextrose	hypertonic	pulls water out of cells into the blood; monitored use
Sea water, about 3.5% salt	hypertonic	drinking it dehydrates: water leaves the cells
Salting meat; sugar in jam	hypertonic	draws water from bacteria: preservation
Wilted lettuce in cold water	hypotonic to the cells	cells turgid again, leaves crisp

The words

- [] The word describes the solution, not the cell: 'the solution is hypotonic TO the cell'
- [] Compare solute, not water: water moves toward the higher solute concentration
- [] Isotonic is not 'nothing moves': water crosses both ways at equal rates; the NET movement is zero
- [] Osmosis is water only, across a membrane; diffusion is any particle down its own gradient

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The potato experiment, the curriculum, and a practice set

The potato (osmosis) practical

- [] Cut equal potato cylinders; blot and weigh each
- [] One cylinder in each sugar (or salt) solution from pure water to 1 mol/dm³, same time, same temperature
- [] Blot, reweigh; percentage change = (final - initial) / initial x 100
- [] Plot % change against concentration; gain = hypotonic to the potato, loss = hypertonic; where the line crosses zero the solution is isotonic with the cell sap (about 0.25-0.3 mol/dm³ sucrose)
- [] Marks: blot before weighing; use percentage change (cylinders differ in mass); read the isotonic point from the graph

Curriculum	Where
US NGSS	MS-LS1-2 cell structure and function; HS-LS1-3 homeostasis; AP Biology Unit 2 water potential
England	GCSE Biology, Cell biology: osmosis and the potato required practical
Australia	Year 8 cells; Year 11 Biology Unit 1 membranes and transport
CBSE	Class 9 The Fundamental Unit of Life: hypotonic, isotonic, hypertonic, plasmolysis
Ontario	Grade 11 Biology SBI3U; nursing and health programmes (IV fluids)

Practice

- A red blood cell is placed in distilled water. Describe and explain what happens.
- A plant cell is placed in concentrated salt solution. Name its state and describe the membrane.
- Why is 0.9% saline used for drips rather than pure water?
- A potato cylinder of 2.40 g becomes 2.64 g. Percentage change? Was the solution hypotonic, isotonic or hypertonic to the potato?
- Why does salt draw water out of a slice of aubergine?
- Solutions A (0.2 mol/dm³ sucrose) and B (0.6 mol/dm³) are separated by a partially permeable membrane. Which way does water move? Which is hypertonic to the other?
- A cylinder loses 8% of its mass in 0.5 mol/dm³ sucrose and gains 4% in 0.1 mol/dm³. Estimate the isotonic concentration.
- Explain why a plant cell does not burst in pure water.

Answers

- Water enters by osmosis (the water is hypotonic to the cell); the cell swells and bursts (haemolysis), having no cell wall.
- Plasmolysed; the membrane pulls away from the cell wall as the vacuole shrinks.
- It is isotonic with blood cells, so there is no net water movement; pure water would make them swell and burst.
- +10%; hypotonic.
- The salt makes the surface solution hypertonic to the cells, so water leaves them by osmosis.
- From A to B; B is hypertonic to A.
- About 0.23 mol/dm³ (where the straight line between the two points crosses zero).
- The cell wall resists the swelling; the cell becomes turgid instead.