REVISION GUIDE

Which way will the *water* go?

Tonicity and water potential

Drop a potato core into sugar solution and it swells or shrinks, depending on which side holds more solute. Find out why, what it does to cells with and without a wall, how cells and patients are kept in balance, and how water potential and Ψs = −iCRT put a number on it.

8 chapters · a dry lab

The interactive guide, with every animation:

biologybybradford.com/guides/ap-biology-unit-2-tonicity-and-water-potential

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	Answers	24

By the end you can

- [ ] Explain which way water moves by osmosis between solutions, using hypotonic, isotonic and hypertonic 2.7.A
- [ ] Predict what hypotonic and hypertonic surroundings do to cells with and without a wall, including turgor and plasmolysis 2.7.A
- [ ] Explain how organisms osmoregulate, with contractile vacuoles and central vacuoles as examples, and why medical fluids are isotonic 2.7.A
- [ ] Explain that water moves from higher to lower water potential, and use Ψ = Ψp + Ψs 2.7.B
- [ ] Calculate solute potential with Ψs = −iCRT, and use it to predict water movement 2.7.B

Tick each one when you can do it without the book.

2.7.A TONICITY AND OSMOREGULATION

01 Water goes where the *solute* is

Osmosis is the diffusion of water across a selectively permeable membrane, one that lets water through but not the solute. Water molecules cross both ways all the time. On the side with more solute, more of the water is held around the dissolved particles and is less free to move, so more water crosses into that side than comes back. The net movement is from **lower** solute concentration to **higher**.

Tonicity compares two solutions by their solutes. The one with more solute is **hypertonic**, the one with less is **hypotonic**, and two with the same concentration are **isotonic**. Water moves from the hypotonic side to the hypertonic side. In an isotonic pair water still crosses, but as fast each way: a dynamic equilibrium.

The words only make sense in pairs. Say what is hypertonic **to** what: a solution can be hypertonic to a red blood cell and hypotonic to a seawater fish's cells.

KEY POINTS

- Osmosis: net water movement from lower to higher solute concentration.
- Hypertonic: more solute. Hypotonic: less. Isotonic: the same.
- Isotonic: water still moves, equally both ways.

KEY TERMS

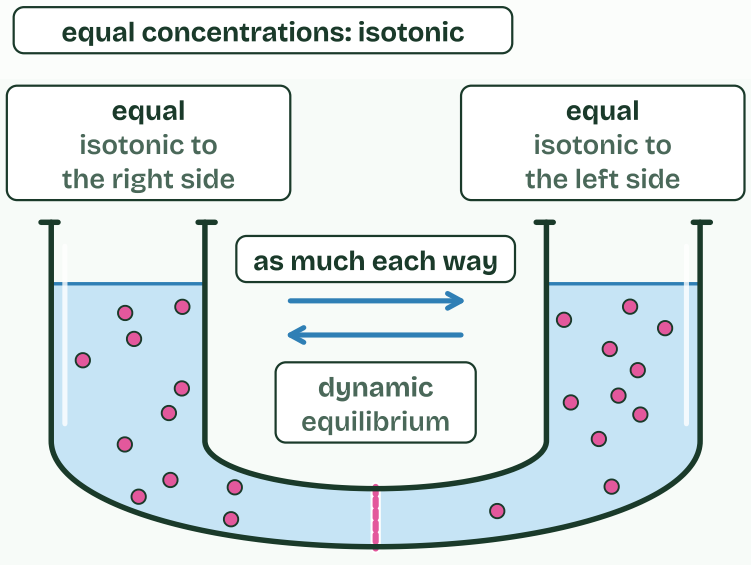
osmosis
The net movement of water across a selectively permeable membrane, from a region of lower solute concentration to one of higher solute concentration.

tonicity
The relative concentration of solutes in two solutions, which decides which way water moves between them by osmosis.

hypertonic
Having a higher solute concentration than the solution it is compared with. Water moves into a hypertonic solution.

hypotonic
Having a lower solute concentration than the solution it is compared with. Water moves out of a hypotonic solution.

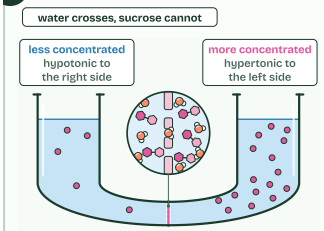
isotonic
Having the same solute concentration as the solution it is compared with, so there is no net movement of water.



STEP BY STEP

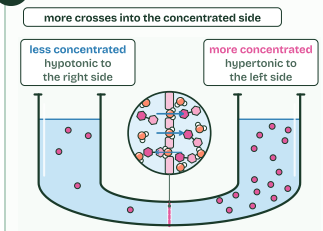
4 STEPS

1



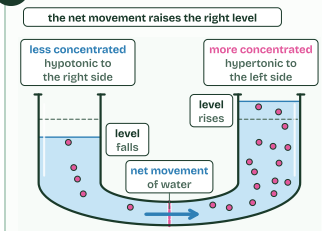
Two solutions, split by a **partially permeable membrane**. The solute cannot cross.

2



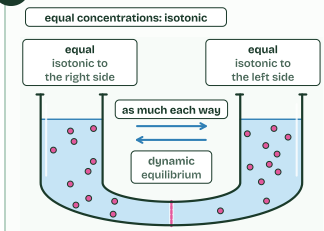
Water crosses **both ways**, but more crosses into the more concentrated side.

3



The **net** movement raises the level on the more concentrated side.

4



Equal concentrations, **isotonic**: water still crosses, as much each way.

WATCH OUT

Tonicity describes the solution compared with the cell, not the cell itself. "The cell is hypertonic" needs a "to what".

PREDICT

A cell's cytoplasm is more concentrated than the solution around it. Which is true?

(A) The solution is hypertonic to the cell, so there is a net movement of water out of it

(B) The solution is hypotonic to the cell, so there is a net movement of water into the cell

(C) Water stops crossing the membrane until both sides reach the same solute concentration

Decide before you look. Answer on page 24.

02

2.7.A TONICITY AND OSMOREGULATION

Cores in *sugar*

Cut cores from a potato, weigh them, and soak them in a range of sucrose solutions. Where the solution is hypotonic to the potato's cells, water enters them: the core gains mass and goes firm. Where it is hypertonic, water leaves: the core loses mass and goes floppy. Blot each core before weighing again, so only its own water counts.

The cores start at different masses, so compare their **percentage change**: (final − initial) ÷ initial × 100. Plot the mean for each concentration. Where the line crosses zero, the tissue neither gains nor loses water: that concentration is isotonic with its cells, which tells you their solute concentration.

The same test works on red blood cells, with no wall to hold them. Switch the film to them and compare what a hypotonic solution does.

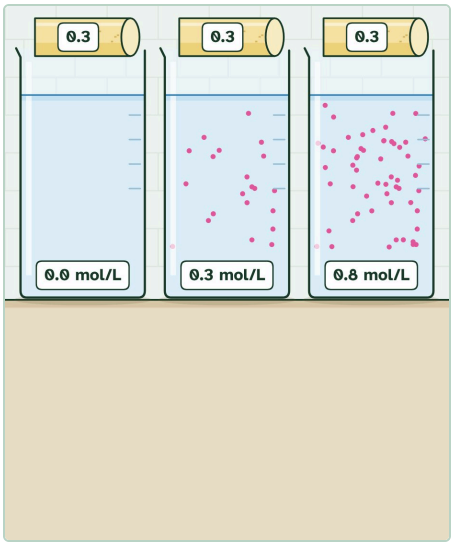
KEY POINTS

- Hypotonic solution: cores gain mass. Hypertonic: they lose mass.
- Use percentage change, so cores of different sizes compare fairly.
- The isotonic point is where the mean change crosses zero.

ANIMATION · INTO THE BEAKER

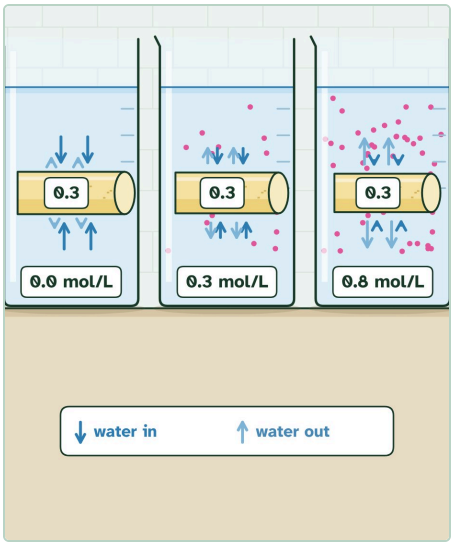
6 MOMENTS

1 CORES



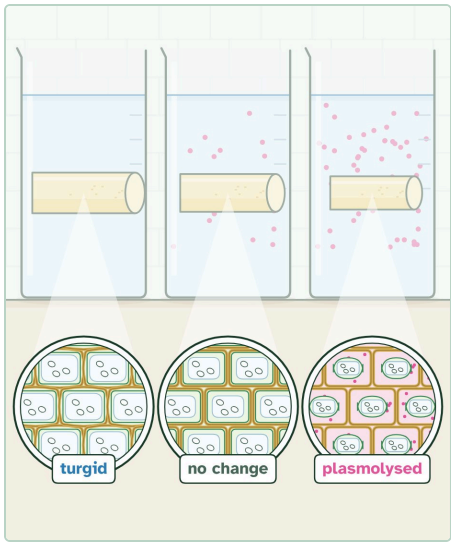
Three cores cut from one potato, 2.00 g each. Its cells hold solutes at about **0.3 mol/L**, written on each core.

2 OSMOSIS



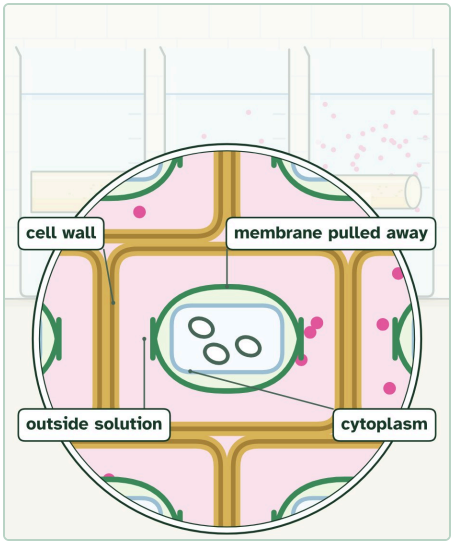
In 0.0 more water enters than leaves: the outside is **hypotonic**. In 0.8 more leaves: **hypertonic**.

3 CLOSE UP



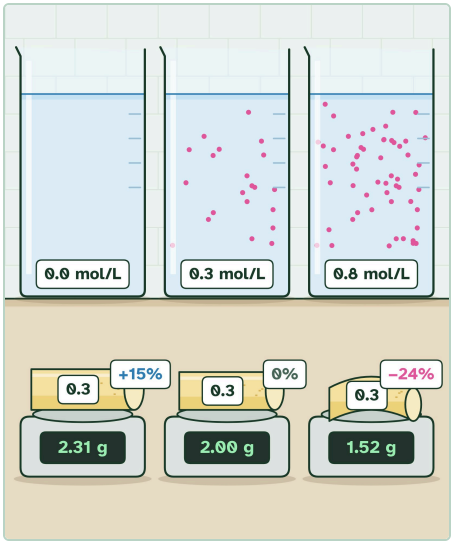
Close up: in 0.0 the cells are **turgid**, pressed against their walls. In 0.8 they are **plasmolysed**.

4 CLOSE UP



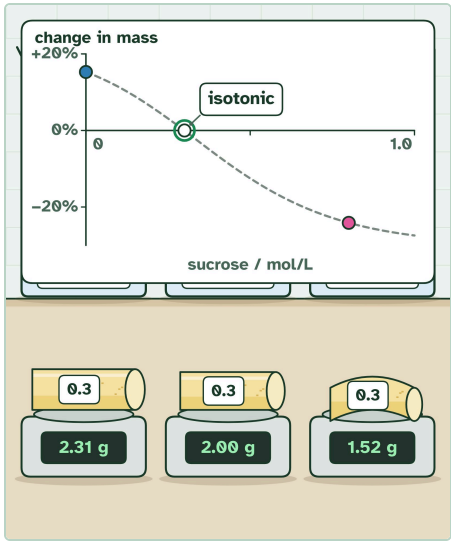
Plasmolysed: the membrane has pulled away from the wall, and the outside solution fills the gap.

5 WEIGHED



Out, blotted and weighed. The core in 0.8 has lost water and is floppy.

6 THE RESULTS



Water moves by osmosis toward the more concentrated solution. The line crosses 0% at the **isotonic** concentration. (Sizes are drawn bigger than life.)

Watch it move, and change it as it runs: biologybybradford.com/guides/ap-biology-unit-2-tonicity-and-water-potential#cores

WATCH OUT

The isotonic point is rarely one of the concentrations you tested. Read it from where the line crosses zero, between two points.

PREDICT

Potato cores soaked in pure water gain 15% of their mass, then no more however long they are left. Why do they stop?

(A) The water around the cores has run out of the free water molecules able to cross into them

(B) The cell walls push back on the swelling cells, and that pressure stops any more net water entering

(C) The cells all burst when they reach 15% more mass, so they cannot hold any more of the water

Decide before you look. Answer on page 24.

03 No wall, no *limit*

2.7.A TONICITY AND OSMOREGULATION

Animal cells and many single-celled organisms have only a plasma membrane around them. In a hypotonic solution they take in water and swell, and with nothing to stop them they can **lyse**, burst; red blood cells in pure water do so within seconds. In a hypertonic solution they lose water and shrivel, a red blood cell's surface puckering into points.

Freshwater protists such as *Paramecium* live in a hypotonic world, and water enters them all the time. A **contractile vacuole** collects it and expels it, using ATP. This is **osmoregulation**: keeping water and solutes in balance whatever the surroundings.

Multicellular animals do it on a larger scale. Their kidneys or gills adjust how much water and salt leaves the body, so the blood and tissue fluid around their cells stay isotonic with the cells.

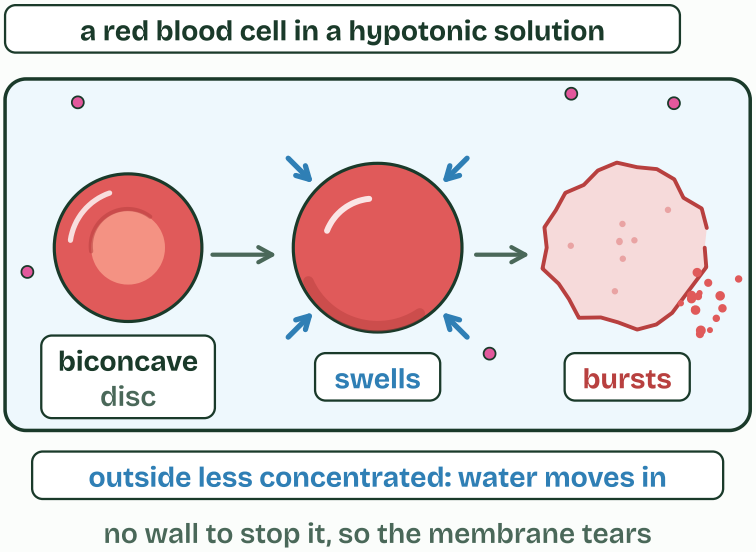
KEY POINTS

- Hypotonic: an animal cell swells and may lyse. Hypertonic: it shrivels.
- A contractile vacuole expels the water that enters a freshwater protist.
- Osmoregulation keeps an organism's water and solutes in balance.

KEY TERMS

contractile vacuole
An organelle of freshwater protists that collects the water entering by osmosis and expels it from the cell, using energy.

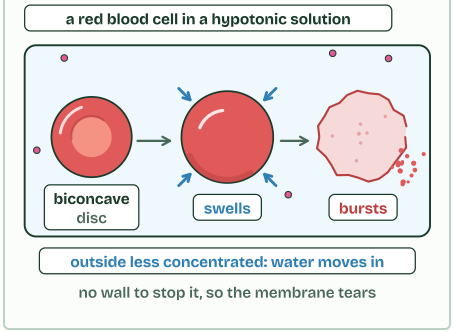
osmoregulation
The control of water and solute balance in an organism, keeping its internal water potential and solute composition steady.



SWITCH IT

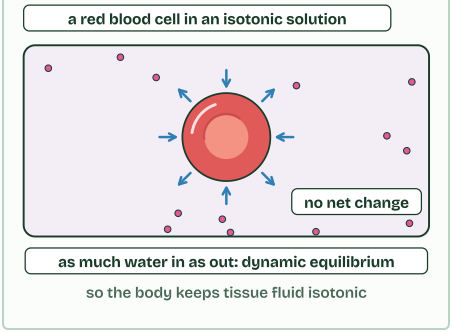
4 SETTINGS

1



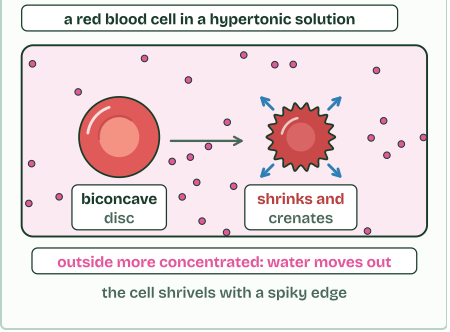
Hypotonic

2



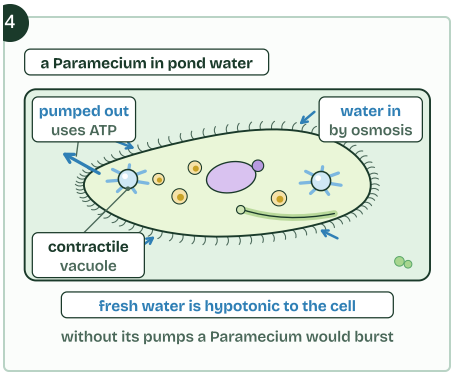
Isotonic

3



Hypertonic

4



Pond water

WATCH OUT

A contractile vacuole does not stop water coming in. It removes it as fast as it enters, and needs energy to do so.

PREDICT

A *Paramecium* is moved from pond water into a solution isotonic with its cytoplasm. What happens to its contractile vacuole?

(A) It fills and empties faster, because there is now more water around the cell for it to deal with

(B) It fills and empties much more slowly, because water no longer enters the cell by osmosis

(C) It goes on at the same rate, because a contractile vacuole always works at one fixed pace

Decide before you look. Answer on page 24.

04 The wall *pushes back*

2.7.A TONICITY AND OSMOREGULATION

Plant cells, fungi and bacteria have a cell wall outside the membrane. In a hypotonic solution water enters, the large **central vacuole** swells, and the membrane presses against the wall. The wall hardly stretches, so it presses back. That pressure, **turgor pressure**, stops more water entering long before the cell could burst. A plant cell is healthiest this way, **turgid**, and turgid cells pressing on each other hold stems and leaves up.

In an isotonic solution the cell is **flaccid**: the membrane just touches the wall, with no pressure. In a hypertonic solution water leaves, the vacuole shrinks, and the membrane pulls away from the wall: **plasmolysis**. A plant whose cells lose turgor wilts.

The central vacuole is how a plant osmoregulates. By storing solutes in it, a cell lowers its own water potential and keeps drawing water in from the soil.

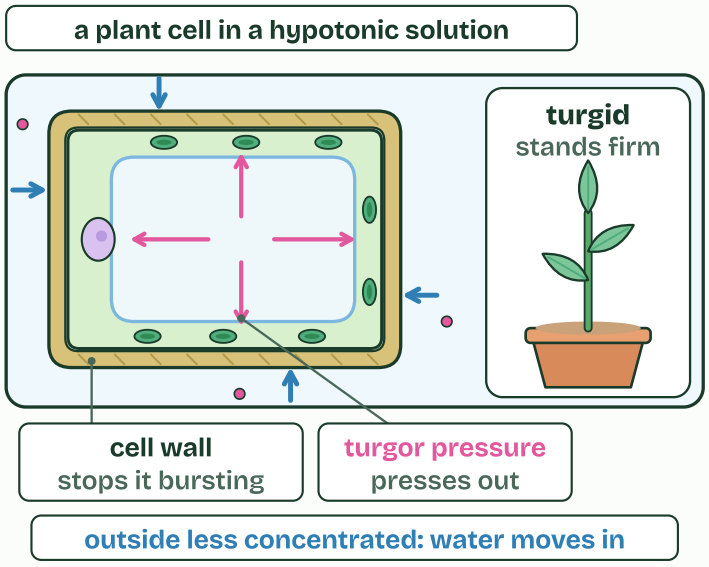
KEY POINTS

- Hypotonic: turgid; the wall resists, so the cell does not burst.
- Isotonic: flaccid. Hypertonic: plasmolyzed, the membrane pulled from the wall.
- The central vacuole stores water and solutes and keeps the cell turgid.

KEY TERMS

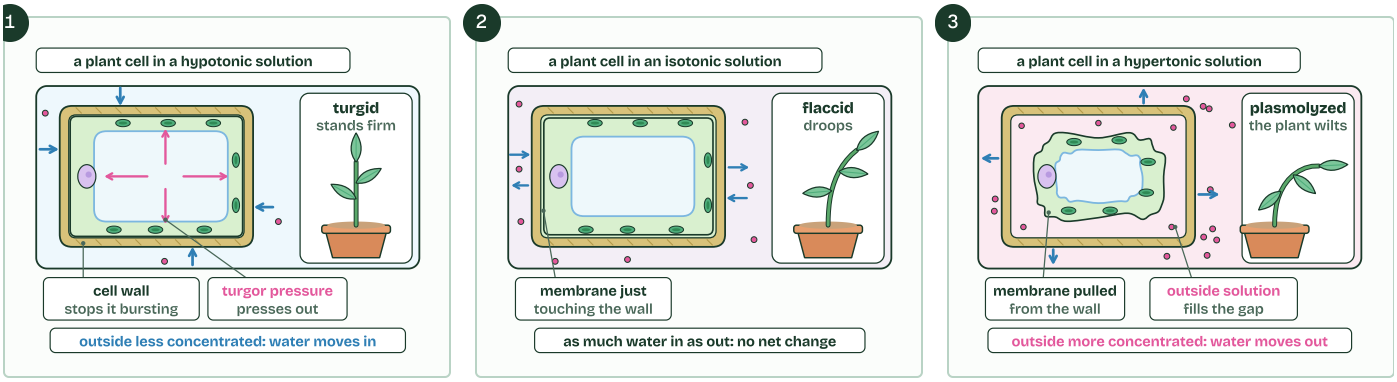
turgor pressure
The pressure of a plant cell's contents pushing out against its cell wall, built up as water enters by osmosis.

plasmolysis
The shrinking of a plant cell's contents away from its cell wall, as water leaves in a hypertonic solution.



SWITCH IT

3 SETTINGS



Hypotonic **Isotonic** **Hypertonic**

WATCH OUT

In a plasmolyzed cell the gap between membrane and wall is not empty. It is filled with the outside solution, which passes freely through the wall.

PREDICT

Lettuce leaves left in a bowl of salty dressing go limp. Why?

(A) Salt enters the leaf cells and breaks down their cell walls, so the cells can no longer keep their shape

(B) The dressing is hypertonic to the cells, so they lose water, turgor pressure falls and they plasmolyze

(C) The dressing is hypotonic to the cells, so they take in so much water that they all burst open

Decide before you look. Answer on page 24.

05 Keeping cells *as they are*

2.7.A TONICITY AND OSMOREGULATION

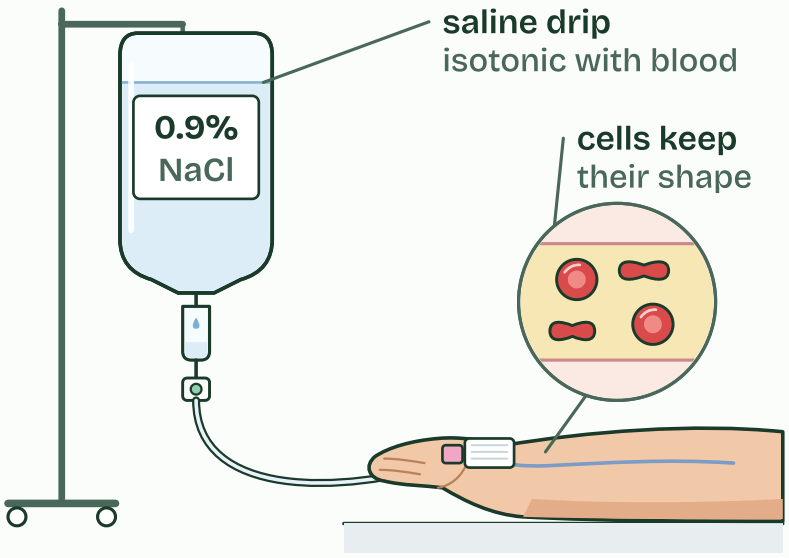
Fluid put into a patient's vein runs straight into the blood, so it must be isotonic with the blood cells. **Intravenous fluids** such as normal saline, 0.9% sodium chloride, replace lost water and salts without making red blood cells swell and lyse, as pure water would, or shrivel, as a strong salt solution would.

An **organ for transplant**, such as a kidney, is kept until the patient is ready, sometimes for many hours. It is flushed and bathed in a cold isotonic solution, so its cells neither take in nor lose water, and the cold slows their metabolism while they receive no blood.

Both are osmoregulation done for the body, from outside it.

KEY POINTS

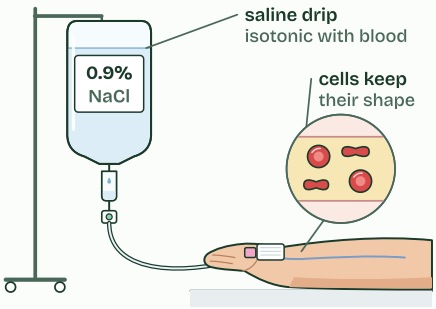
- Intravenous fluids are isotonic with blood, such as 0.9% saline.
- Donor organs are bathed in cold isotonic solution.
- Isotonic: no net water movement, so cells keep their size and shape.



SWITCH IT

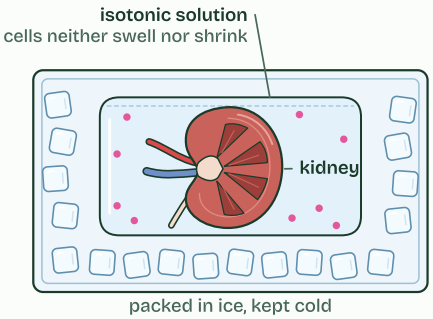
2 SETTINGS

1



Intravenous drip

2



Donor organ

WATCH OUT

Isotonic means the same total solute concentration as the cells, not the same substance. Saline and a glucose drip can both be isotonic.

PREDICT

What would happen if a large volume of pure water were run into a patient's vein?

(A) Red blood cells would lose water and shrivel, because pure water draws water out of the cells

(B) Red blood cells would take in water by osmosis and could swell and lyse

(C) Nothing would happen, because the salts in the blood would mix in with the pure water at once

Decide before you look. Answer on page 24.

06 Water runs *downhill*

2.7.B TONICITY AND OSMOREGULATION

Water potential, Ψ (the Greek letter psi), measures how free water is to move. Pure water in an open container is the reference, Ψ = 0, and it is measured in units of pressure: in AP Biology, **bars**.

Adding solute lowers the water potential, so any solution has a negative Ψ. Adding pressure raises it. Water moves from higher water potential to lower, as a ball rolls downhill. So high water potential goes with low solute concentration, and low water potential with high solute concentration: the same direction tonicity gives, now with a number.

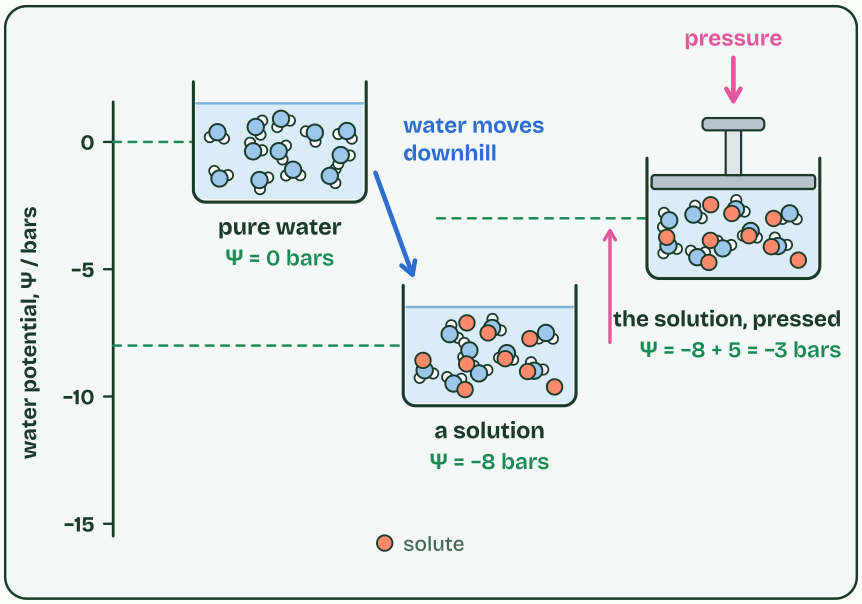
Read the scale carefully: −8 bars is **lower** than −3 bars.

KEY POINTS

- Water potential, Ψ: pure water is 0; measured in bars.
- Solutes lower Ψ; pressure raises it.
- Water moves from higher Ψ to lower Ψ.

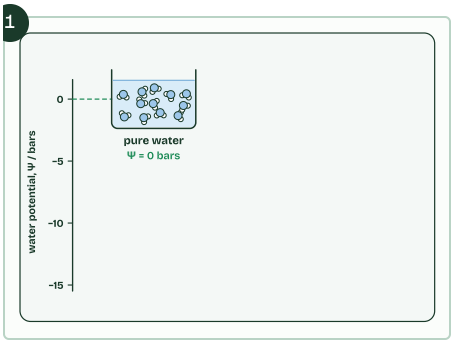
KEY TERMS

water potential
The potential energy of water, relative to pure water at atmospheric pressure, which is set at zero. Symbol Ψ, measured in bars.



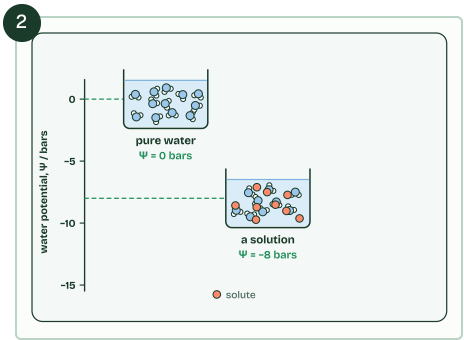
STEP BY STEP
4 STEPS

1



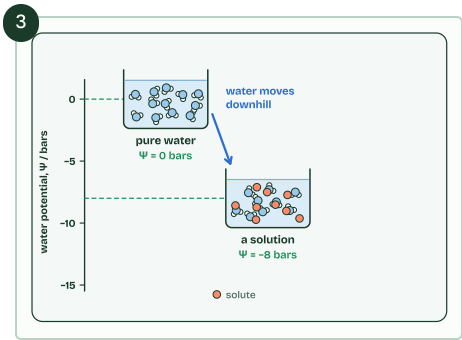
The reference: **pure water** at atmospheric pressure and 20 °C has Ψ = 0.

2



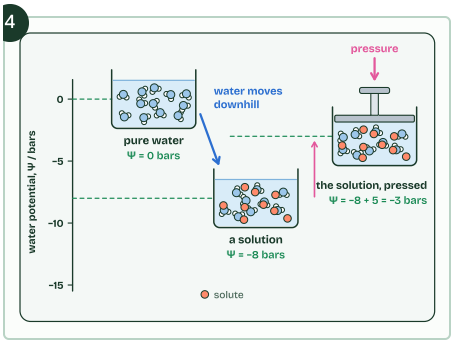
Dissolve solutes in it and its water potential falls below zero: **negative**.

3



Water moves **downhill**, from higher water potential to lower.

4



Pressure on a solution **raises** its water potential.

WATCH OUT

The more negative the number, the lower the water potential. Water moves toward the more negative value.

PREDICT

Cell A has a water potential of −4 bars and cell B, next to it, −6.5 bars. Which way does water move?

(A) From B to A, because 6.5 is the bigger number of the two water potentials

(B) From A to B, from the higher water potential to the lower

(C) Not at all, because both of the cells have negative water potentials

Decide before you look. Answer on page 24.

07 2.7.B TONICITY AND OSMOREGULATION

$\Psi = \Psi_p + \Psi_s$

Two things set a water potential. The **solute potential**, Ψ_s, is zero for pure water and negative for any solution: the more solute, the more negative. The **pressure potential**, Ψ_p, is zero in an open container and positive in a turgid cell pressing on its wall. Together: $\Psi = \Psi_p + \Psi_s$.

Put a flaccid cell with Ψ_s = −8 bars 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 Ψ_p rises until the cell's Ψ reaches 0, with Ψ_p about +8 bars: turgid. In a solution of −12 bars instead, water leaves, Ψ_p falls to zero and the cell plasmolyzes.

The film runs these numbers. Set the cell and the solution, and watch which way water goes.

KEY POINTS

- $\Psi = \Psi_p + \Psi_s$.
- Ψ_s: zero or negative. Ψ_p: zero in an open beaker, positive in a turgid cell.
- Water enters until Ψ_p rises enough to match Ψ outside.

KEY TERMS

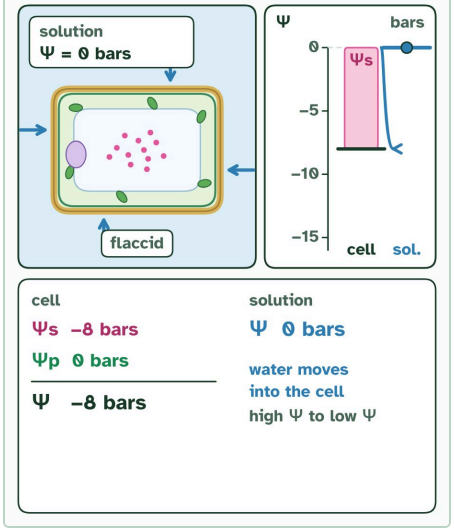
solute potential
The part of water potential due to dissolved solutes. Zero for pure water and negative for any solution.

pressure potential
The part of water potential due to physical pressure. Zero in an open container, positive in a turgid plant cell.

ANIMATION · WATER POTENTIAL

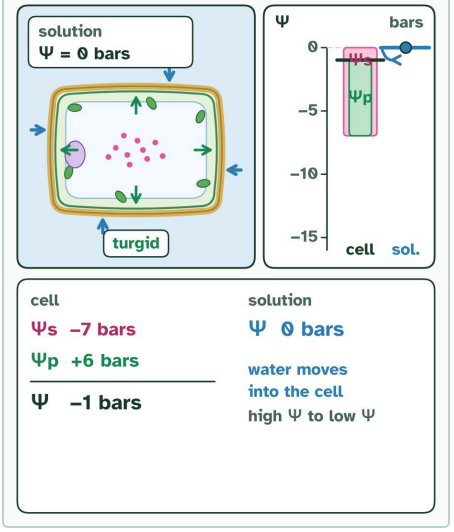
3 MOMENTS

1 START



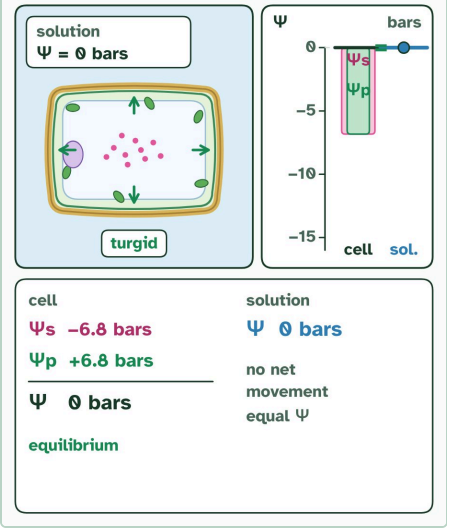
The cell: Ψ = Ψs + Ψp = −8 + 0 = **−8 bars**. The solution: **0 bars**. The solution's Ψ is higher, so water moves **into the cell**, from higher to lower Ψ.

2 WATER MOVING



As water enters, the protoplast pushes on the wall and Ψp rises; the solutes are diluted, so Ψs rises a little too.

3 EQUILIBRIUM



The wall pushes back: Ψp has risen to +6.8 bars, so Ψ = −6.8 + 6.8 = 0 bars, equal to the solution.

Watch it move, and change it as it runs: biologybybradford.com/guides/ap-biology-unit-2-tonicity-and-water-potential#components

WATCH OUT

A turgid cell in pure water has a water potential of zero, not a positive one. Its pressure potential just cancels its negative solute potential.

PREDICT

A cell has Ψ_s = −9 bars and Ψ_p = +3 bars. It is put in a solution with Ψ = −7.5 bars. Which way does water move?

(A) Into the cell, because its solute potential of −9 bars is lower than the solution's value

(B) Out of the cell, because its water potential, −6 bars, is higher than the solution's

(C) Neither way, because the pressure potential stops any more water crossing the membrane

Decide before you look. Answer on page 24.

08 $\Psi_s = -iCRT$

2.7.B TONICITY AND OSMOREGULATION

The solute potential of a solution can be calculated. The AP equation sheet gives **$\Psi_s = -iCRT$**, where **i** is the ionization constant, **C** the molar concentration, **R** the pressure constant, 0.0831 L·bar/(mol·K), and **T** the temperature in kelvin (°C + 273).

The ionization constant counts the particles each unit gives in water. Sucrose and glucose do not ionize, so i = 1. NaCl splits into Na^+ and Cl^-, so i = 2. Water potential depends on the number of solute particles, not their kind, so 0.1 M NaCl has the same solute potential as 0.2 M sucrose.

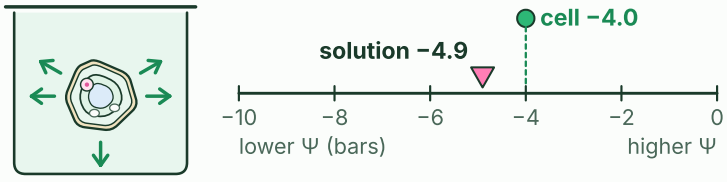
Worked through for 0.20 M sucrose at 22 °C: $\Psi_s = -(1)(0.20)(0.0831)(295) = -4.9$ bars. In an open beaker $\Psi_p = 0$, so the solution's Ψ is −4.9 bars too. Try your own in the calculator.

KEY POINTS

- $\Psi_s = -iCRT$, with R = 0.0831 L·bar/(mol·K) and T in kelvin.
- i: the particles per unit, 1 for sucrose, 2 for NaCl.
- Open container: $\Psi_p = 0$, so $\Psi = \Psi_s$.

0.20 M sucrose at 22 °C, in an open beaker

i	1 (sucrose does not ionize)
C	0.20 mol/L
R	0.0831 L·bar/(mol·K)
T	22 + 273 = 295 K
Ψs	−iCRT = −(1)(0.20)(0.0831)(295) = −4.90 bars
Ψ	Ψp + Ψs = 0.0 + (−4.90) = −4.90 bars



Water moves from higher Ψ to lower Ψ.

Pick a solute, set its concentration and temperature, and follow the working. Then tick the cell to see which way water would go.

STEP BY STEP 2 STEPS

1

0.20 M sucrose at 22 °C, in an open beaker

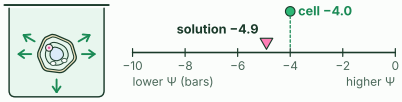
i	1 (sucrose does not ionize)
C	0.20 mol/L
R	0.0831 L·bar/(mol·K)
T	22 + 273 = 295 K
Ψs	−iCRT = −(1)(0.20)(0.0831)(295) = −4.90 bars
Ψ	Ψp + Ψs = 0.0 + (−4.90) = −4.90 bars

Solute potential from the equation sheet: **Ψs = −iCRT**. Here 0.20 M sucrose at 22 °C gives Ψs = −4.90 bars.

2

0.20 M sucrose at 22 °C, in an open beaker

i	1 (sucrose does not ionize)
C	0.20 mol/L
R	0.0831 L·bar/(mol·K)
T	22 + 273 = 295 K
Ψs	−iCRT = −(1)(0.20)(0.0831)(295) = −4.90 bars
Ψ	Ψp + Ψs = 0.0 + (−4.90) = −4.90 bars



Water moves from higher Ψ to lower Ψ.

A plant cell here has Ψ of −4.0 bars. The solution's water potential is lower than the cell's, so water moves out of the cell into the solution. The solution is hypertonic to the cell.

WATCH OUT

T goes in as kelvin, not degrees Celsius. At 22 °C, T is 295 K; using 22 gives an answer more than ten times too small.

PREDICT

What is the solute potential of 0.1 M NaCl at 27 °C?

(A) −0.25 bars, from −(1)(0.1)(0.0831)(30), using i = 1 and the temperature in degrees Celsius

(B) −2.5 bars, from −(1)(0.1)(0.0831)(300), because NaCl is one compound, so i is just 1

(C) −5.0 bars, from −(2)(0.1)(0.0831)(300), because NaCl gives two ions

Decide before you look. Answer on page 24.

Key terms

Every term this guide defines, A to Z, with the chapter it is in. Cover the right-hand side and test yourself.

contractile vacuole 03
An organelle of freshwater protists that collects the water entering by osmosis and expels it from the cell, using energy.

hypertonic 01
Having a higher solute concentration than the solution it is compared with. Water moves into a hypertonic solution.

hypotonic 01
Having a lower solute concentration than the solution it is compared with. Water moves out of a hypotonic solution.

isotonic 01
Having the same solute concentration as the solution it is compared with, so there is no net movement of water.

osmoregulation 03
The control of water and solute balance in an organism, keeping its internal water potential and solute composition steady.

osmosis 01
The net movement of water across a selectively permeable membrane, from a region of lower solute concentration to one of higher solute concentration.

plasmolysis 04
The shrinking of a plant cell's contents away from its cell wall, as water leaves in a hypertonic solution.

pressure potential 07
The part of water potential due to physical pressure. Zero in an open container, positive in a turgid plant cell.

solute potential 07
The part of water potential due to dissolved solutes. Zero for pure water and negative for any solution.

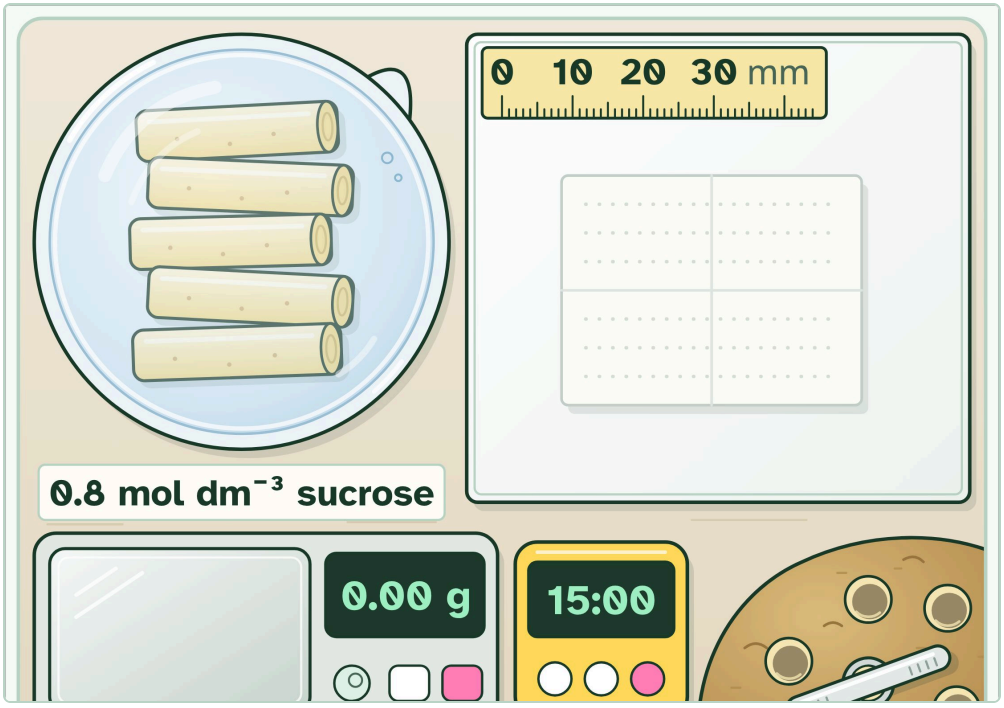
tonicity 01
The relative concentration of solutes in two solutions, which decides which way water moves between them by osmosis.

turgor pressure 04
The pressure of a plant cell's contents pushing out against its cell wall, built up as water enters by osmosis.

water potential 06
The potential energy of water, relative to pure water at atmospheric pressure, which is set at zero. Symbol Ψ, measured in bars.

Dry lab: *Cores in sugar*

Cut cores of potato, sweet potato or carrot, weigh them, soak them in sucrose solutions and weigh them again. Plot the percentage change, add error bars, find the concentration where the tissue neither gains nor loses mass, and turn it into a water potential.



Run it online: change the variables, run the trials, and the table and graph fill in as you go. `biologybybradford.com/guides/ap-biology-unit-2-tonicity-and-water-potential#lab`

Your question

At what concentration of sucrose does the tissue neither gain nor lose mass? That isotonic point gives the water potential of its cells. Predict first: will a potato core gain mass in 0.2 M sucrose?

What you can change

The tissue, the sucrose concentration (0.0 to 1.0 M), and whether the cores are blotted dry before they are weighed again. Each solution gets five cores, so you have repeats for the standard deviation and standard error. Mystery colors gives six solutions of unknown concentration to rank.

What to record

The mass (to 0.01 g) and length (to 1 mm) of each core before and after 30 minutes, the percentage change in each, and for each solution the mean, standard deviation and standard error. The cores are modeled on real class results, with real scatter.

Find out

- **The potato first.** Soak cores in all six solutions, 0.0 to 1.0 M. In which do they gain mass, and in which do they lose it?
- **Find the isotonic point.** Read where the line joining the means crosses 0%, type it in and check it. Then do the same for sweet potato and carrot. Which has the most concentrated cells?
- **Mass or length?** Switch on Length too. Compare the standard deviations of the two. Which measurement would you trust to find the isotonic point, and why?
- **Forget to blot.** Switch off blotting and repeat one solution. Which way does it move the result, and is the error random or systematic?

Record

- For each core: the mass and length before and after, and the percentage change: (after − before) ÷ before × 100.
- For each solution: the mean percentage change, its standard deviation and its standard error (the SD divided by the square root of the number of cores).
- A graph of mean percentage change in mass against concentration, with error bars, and the isotonic point read from it.
- From the isotonic point, the solute potential of the cells: $\Psi s = -iCRT$ with $i = 1$ for sucrose and T in kelvin.
- In Mystery colors, the order of the six solutions from least to most concentrated, before you reveal them. Download the CSV to keep every core.

Your question At what concentration of sucrose does the tissue neither gain nor lose mass? That isotonic point gives the water potential of its cells. Predict first: will a potato core gain mass in 0.2 M sucrose?**What you can change**The tissue, the sucrose concentration (0.0 to 1.0 M), and whether the cores are blotted dry before they are weighed again. Each solution gets five cores, so you have repeats for the standard deviation and standard error. Mystery colors gives six solutions of unknown concentration to rank.**What to record**The mass (to 0.01 g) and length (to 1 mm) of each core before and after 30 minutes, the percentage change in each, and for each solution the mean, standard deviation and standard error. The cores are modeled on real class results, with real scatter.

Back to cells

Potato cores gain mass in 0.0 M sucrose and lose it in 1.0 M. Explain both changes using water potential, and what the isotonic point tells you about the cells.

QUESTIONS ON THE LAB

QUESTION 1

Potato cores gain 6% of their mass in 0.2 M sucrose and lose 7% in 0.4 M. What is the best estimate of the isotonic point?

(A) 0.20 M, because the cores still gained mass there and so the cells must be close to it

(B) About 0.29 M, where a straight line between the two points crosses zero

(C) 0.40 M, because it is the first solution in which the cores lost mass overall

Answer on page 25.

QUESTION 2

Why is a percentage change in mass used rather than the change in grams?

(A) Percentages are always more precise than masses read from a balance to two decimal places

(B) The cores start at different masses, and a percentage lets them be compared fairly

(C) A percentage change cancels out any surface solution left on the cores when they are reweighed

Answer on page 25.

QUESTION 3

The error bars for 0.0 and 0.2 M overlap when they show one standard error. What can you conclude?

(A) The two solutions had exactly the same effect on the cores, so one of them can be left out

(B) The data are wrong, because bars for different concentrations should never overlap at all

(C) The difference between the two means may not be significant; more cores would help decide

Answer on page 25.

QUESTION 4

The isotonic point for potato is 0.29 M sucrose, at a room temperature of 22 °C. What is the water potential of the potato cells, taking them as flaccid?

(A) About −0.6 bars, from −(1)(0.29)(0.0831)(22), with the temperature in degrees Celsius

(B) About −7.1 bars, from −(1)(0.29)(0.0831)(295), the same as the isotonic solution's

(C) About −14.2 bars, from −(2)(0.29)(0.0831)(295), because sucrose splits into two sugars

Answer on page 25.

Check yourself

The check for this guide is online: a fresh paper of past-paper style questions from the exam bank on 2.7 each time, marked as you go, and saved to your Exam practice progress when you are signed in. Scan the code, or type the link.

biologybybradford.com/exam-maker/sit?program=ap&units=U2&ced=2.7&paper=quiz&marks=15&src=ep

Answers

PREDICTIONS IN THE CHAPTERS

01 A cell's cytoplasm is more concentrated than the solution around it. Which is true?

B **The solution is hypotonic to the cell, so there is a net movement of water into the cell**

The solution has less solute than the cell, so it is hypotonic to it. Water moves toward the more concentrated side, into the cell. It crosses both ways throughout; only the net direction is inward.

02 Potato cores soaked in pure water gain 15% of their mass, then no more however long they are left. Why do they stop?

B **The cell walls push back on the swelling cells, and that pressure stops any more net water entering**

Plant cells have walls. As water enters, the cells press on them and the walls press back. When that pressure balances the pull of the solutes, net movement in stops. The cells are turgid, not burst.

03 A *Paramecium* is moved from pond water into a solution isotonic with its cytoplasm. What happens to its contractile vacuole?

B **It fills and empties much more slowly, because water no longer enters the cell by osmosis**

With no net water entering by osmosis there is little to expel, so the vacuole slows down or nearly stops. In pond water, which is hypotonic, it has to work all the time.

04 Lettuce leaves left in a bowl of salty dressing go limp. Why?

B **The dressing is hypertonic to the cells, so they lose water, turgor pressure falls and they plasmolyze**

Salty dressing is more concentrated than the cells. Water leaves them by osmosis, turgor pressure is lost and the cells pull away from their walls. Without turgor, nothing holds the leaf stiff.

05 What would happen if a large volume of pure water were run into a patient's vein?

B **Red blood cells would take in water by osmosis and could swell and lyse**

Pure water would make the plasma hypotonic to the red blood cells. Water would enter them by osmosis, and with no wall to stop it they could burst. This is why fluids for a vein are made isotonic.

06 Cell A has a water potential of −4 bars and cell B, next to it, −6.5 bars. Which way does water move?

B **From A to B, from the higher water potential to the lower**

−4 bars is higher than −6.5 bars, closer to zero. Water moves down the gradient, from A to B.

07 A cell has Ψ_s = −9 bars and Ψ_p = +3 bars. It is put in a solution with Ψ = −7.5 bars. Which way does water move?

B **Out of the cell, because its water potential, −6 bars, is higher than the solution's**

Add the two: Ψ = 3 + (−9) = −6 bars, which is higher than −7.5 bars. Water moves out of the cell, and Ψ_p falls as it goes. Looking at Ψ_s alone gives the wrong answer.

08 What is the solute potential of 0.1 M NaCl at 27 °C?

C **−5.0 bars, from −(2)(0.1)(0.0831)(300), because NaCl gives two ions**

NaCl gives Na^+ and Cl^-, so i = 2, and T = 27 + 273 = 300 K. Ψs = −(2)(0.1)(0.0831)(300) = −4.99, about −5.0 bars.

QUESTIONS ON THE DRY LAB

Q1 Potato cores gain 6% of their mass in 0.2 M sucrose and lose 7% in 0.4 M. What is the best estimate of the isotonic point?

B **About 0.29 M, where a straight line between the two points crosses zero**

The change goes from +6 to −7 across 0.2 M, a fall of 13 percentage points. It reaches zero 6/13 of the way along: 0.2 + 0.2 × 6/13 ≈ 0.29 M. That is where the tissue neither gains nor loses water, so its cells hold solutes equal to about 0.29 M of sucrose.

Q2 Why is a percentage change in mass used rather than the change in grams?

B **The cores start at different masses, and a percentage lets them be compared fairly**

A 2.2 g core and a 1.7 g core in the same solution gain different numbers of grams but about the same fraction of their mass. Dividing by the starting mass puts every core on the same scale, so the repeats can be averaged.

Q3 The error bars for 0.0 and 0.2 M overlap when they show one standard error. What can you conclude?

C **The difference between the two means may not be significant; more cores would help decide**

Overlapping standard error bars mean the difference between the means could be due to chance variation between cores. It does not show that the effects are the same. More repeats shrink the standard error and make a real difference easier to see.

Q4 The isotonic point for potato is 0.29 M sucrose, at a room temperature of 22 °C. What is the water potential of the potato cells, taking them as flaccid?

B **About −7.1 bars, from −(1)(0.29)(0.0831)(295), the same as the isotonic solution's**

At the isotonic point there is no net water movement, so the cells' water potential equals the solution's. Sucrose does not ionize (i = 1) and T = 22 + 273 = 295 K: Ψs = −(1)(0.29)(0.0831)(295) = −7.1 bars. With Ψp = 0 in an open beaker, that is the solution's Ψ, and so the cells'.

How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.

Written and drawn for Biology by Bradford, biologybybradford.com. Free to print and share with a class.