D2.3 Water Potential (HL)

Water Potential (Ψ_w)

Ψ_w — Potential, Water

The measure of the potential energy (potential movement) of water in a particular environment or system in comparison to **pure water**. The units of water potential are kilo pascals: kPa (or sometimes MPa where 1,000 kPa = 1 MPa)

At atmospheric pressure and 20°C, the water potential of pure water (no solutes) is **ZERO** kPa.

Two components can affect water potential: **SOLUTES** and **PRESSURE**.

$$\Psi_w = \Psi_s + \Psi_p$$

(Ψ_w = Water, Ψ_s = Solute, Ψ_p = Pressure)

- Water (Ψ_w) **ALWAYS NEGATIVE** −
- Solutes (Ψ_s) – More solutes, less movement **ALWAYS NEGATIVE** −
- Pressure (Ψ_p) – More pressure, more movement **POSITIVE** or **NEGATIVE** + −

Water moves from HIGHER water potential to LOWER water potential.

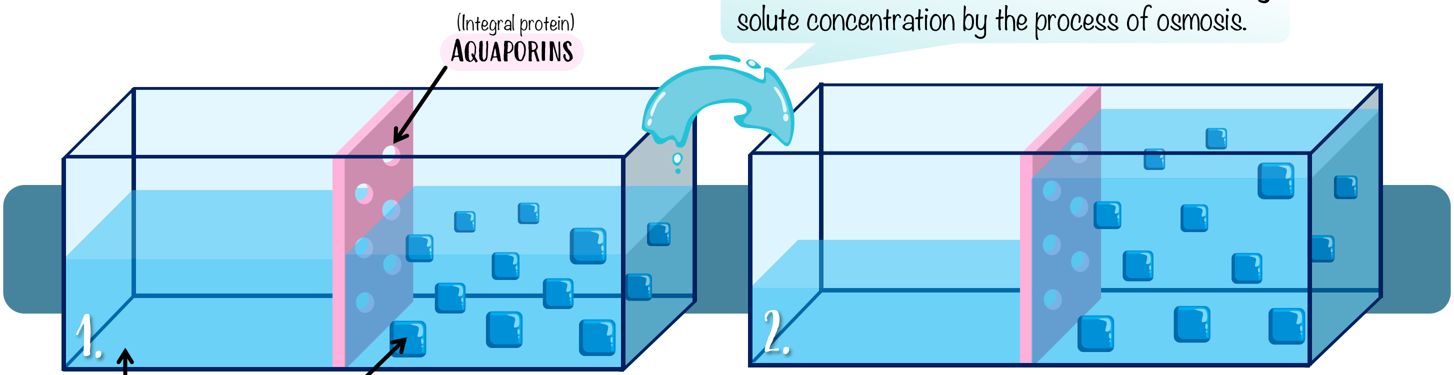
The Effect of Solutes

The presence of solutes **DECREASES** the water potential. Therefore Ψ_s is always **NEGATIVE**. −

Example

A large container is seperated into two by a membrane with AQUAPORINS (permeable to water). The left side contains pure water and the right side contains pure water with solutes. As we know, the Ψ_w of pure water is **ZERO**, but the Ψ_w of the righthand container will be lower (a negative Ψ_w) due to the presence of solutes. Water will therefore move from the left to the right container **FROM HIGHER TO LOWER WATER POTENTIAL**.

Water moves from **low** solute concentration to **high** solute concentration by the process of osmosis.



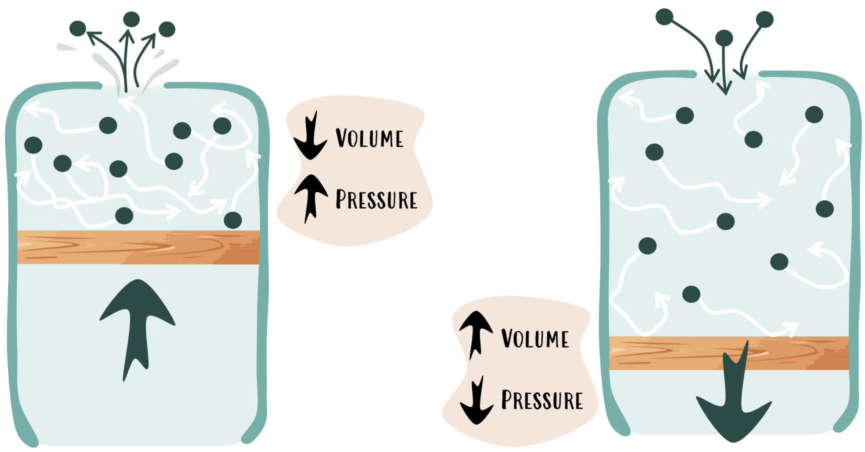
PURE WATER

SOLUTE
Solutes attract water molecules and make it difficult for them to move away.

Pure water has **HIGHER WATER POTENTIAL** compared to right container; hence water will move to the right.

To understand the effect of pressure on water potential, we must first understand Boyle's law:

By reducing the space (volume) within a confined space [by pushing on the , it causes the pressure inside to increase, thus expelling out some of the particles (●).



Inversely, by increasing the volume within a confined space [by pulling on the , it causes the pressure inside to decrease, thus pulling in some particles (●).

Teach Me

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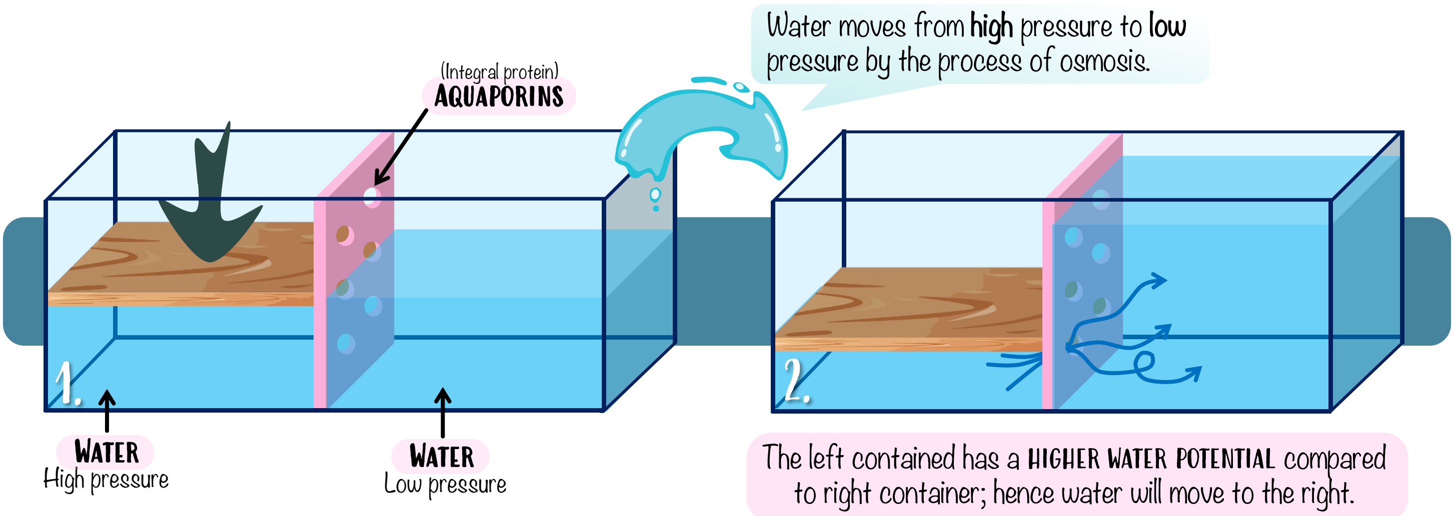
The Effect of Pressure

Higher pressure **INCREASES** the water potential and lower pressure **DECREASES** the water potential. Therefore Ψ_p is either **POSITIVE** or **NEGATIVE** depending on the pressure.

Example

A large container is seperated into two by a membrane with AQUAPORINS (permeable to water). The both sides contain pure water, but pressure is exerted on the left container (illustrated as the arrow pushing down), and not on the right one. Thus, the Ψ_w of the lefthand container will be higher due to the higher hydrostatic pressure*. Water will therefore move from the left to the right container **FROM HIGHER TO LOWER HYDROSTATIC PRESSURE.**

*Hydrostatic pressure is the pressure exerted by water.



The left contained has a **HIGHER WATER POTENTIAL** compared to right container; hence water will move to the right.

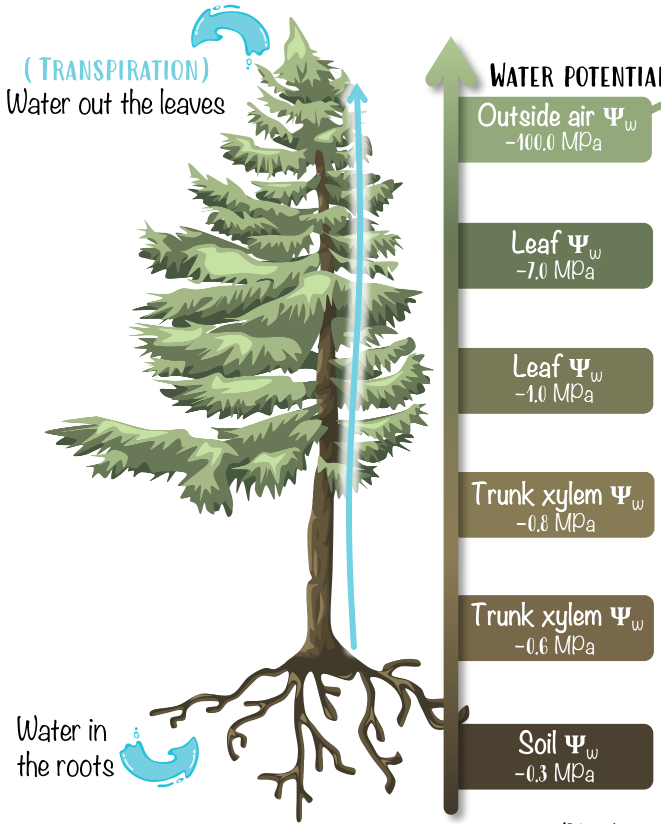
Summary

$$\Psi_w = \Psi_s + \Psi_p$$

Now that you understand the individual effects of both solutes Ψ_s and pressure Ψ_p on water potential, remember that they comulatively affect Ψ_w. It is a combination of solute concentration and pressure differences.

Water Potential in Plants

Water potential **DECREASES** from the roots to the leaves, which allows for water to move from the roots to the leaves.



Notice the Ψ_w is **ALWAYS** negative!

During TRANSPIRATION, negative pressure is created causing the water potential to be reduced.

BIG BRAIN TIP!
Transpiration allows for water to climb up a plant much like how we can suck water up a straw.

$$\Psi_w = \Psi_s + \Psi_p$$

Water potential is a combination of solute concentration and pressure differences.

Higher water potential at the roots causes the water to move from higher to lower Ψ_w: towards the leaves.

You do not need to remember the values of water potential at different heights in a plant.

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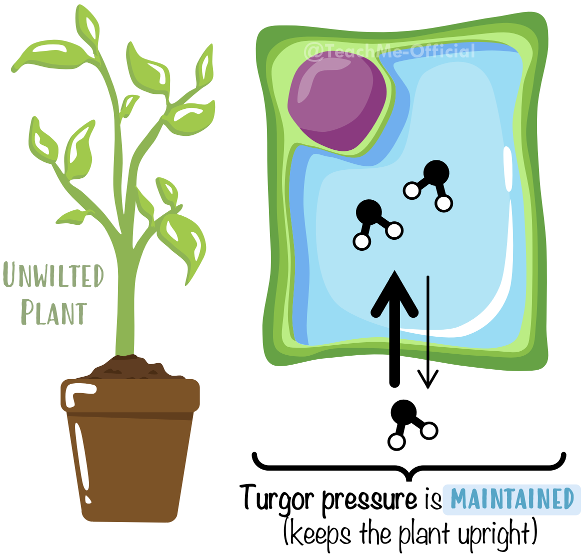
HYPOTONIC environment

When in a hypotonic environment, **water will move from lower to higher solute concentrations** (from outside to inside the cell). This causes the plant cell to swell → the turgor pressure (pressure potential) increases.

Ψ_w Extracellular fluid > Ψ_w Intracellular fluid



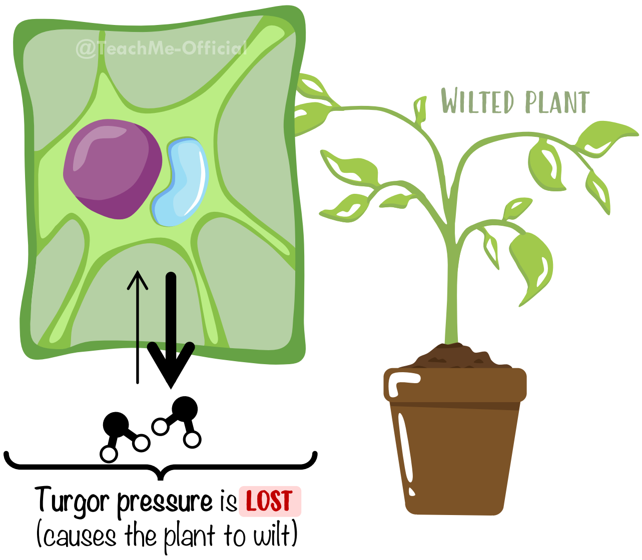
Once both the extracellular and intracellular water potentials equalise, water stops entering the cell and turgor pressure stops increasing.

Ψ_w Extracellular fluid = Ψ_w Intracellular fluid

HYPERTONIC environment

When in a hypertonic environment, **water will move from lower to higher solute concentrations** (from inside to outside the cell). This causes the plant cell to shrink → the turgor pressure (pressure potential) decreases (until it is lost).

Ψ_w Extracellular fluid < Ψ_w Intracellular fluid



Once both the extracellular and intracellular water potentials equalise, water stops leaving the cell and turgor pressure stops decreasing.

Ψ_w Extracellular fluid = Ψ_w Intracellular fluid

notes