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Fun with Water Potential!

Botanists use the term water potential when predicting the movement of water into and out of plant cells. Remember, the movement of water across a semi-permeable membrane as it follows its own concentration gradient is osmosis. But plants are a unique case because they have a cell wall which prevents a plant cell from bursting if it takes on too much water. If a plant cell is placed in a hypotonic environment, it will take on water UNTIL water pressure inside the cell builds up to a point that it cannot take on any more. This increase in water pressure will actually push water molecules back out of the cell against water's concentration gradient until the amount of water moving *in* due to solute difference is equal to the water moving *out* due to water pressure—this is a dynamic equilibrium!

Water potential is a measure of how likely water is to move from one location (say outside the cell) to another (inside the cell). For example, in the case above....a plant cell placed in a hypotonic solution.....water has a higher potential (tendency) to move INTO the cell than it does to move OUT of it. Therefore, water potential is GREATER outside the cell than inside the cell because the water outside the cell has the GREATER POTENTIAL TO MOVE. Just like any solute will diffuse DOWN its concentration gradient—from high to low concentration, water will always move from an area of greater water potential to an area of lesser water potential.

Water potential is made up of 2 parts---solute potential and pressure potential. Add both together to get the total water potential. See below.

Note: (we use the greek letter “psi” or “ Ψ ” to represent water potential.)

$$\text{Solute potential} + \text{Pressure potential} = \text{Water potential}$$
$$\Psi_s + \Psi_p = \Psi$$

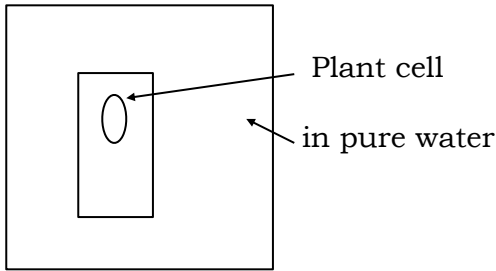
- ∞ **Solute potential**—(Ψ_s)—the greater the concentration of a solute, the lower the water potential.—an inverse relationship. Think of it this way: if you place a plant cell in very salty water, water will leave the cell for the environment it's in. Water had a greater tendency to move OUT than in (the cell). Therefore, water potential was lower in the environment than in the cell. This means that the water in the environment had low tendency to move (into the cell) than the other way around. Said another way, water that was in the cell had a greater potential to move (OUT) than the other way around. In summary, solute potential is the effect that solutes have on a solution's overall water potential.
- ∞ **Pressure potential**—(Ψ_p)—physical pressure increases water potential—a direct relationship. If you have a syringe filled with water and you press down on the plunger (increasing pressure), water will leave the syringe through the needle (the only opening). Plant cells work the same way, if water pressure increases inside the cell, that pressure will drive water back out. The cell wall will not break, but it is a little bit elastic and will bulge outward. This is called TURGOR. The water pressure that causes turgor is called TURGOR PRESSURE. Lack of turgor is called WILTING!

Now let's add some numbers to this:

- ∞ Pure water has a water potential of ZERO.
- ∞ Solutes added to pure water decrease water potential—negative numbers.
- ∞ Pressure increases water potential.

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Example:



Problems:

1. The solute potential of pure water is _____.
2. The solute potential of the plant cell is (greater/less than) pure water. Therefore the greater water potential is (in the cell/in the solution). Circle your choice.
3. If solute potential in the plant cell above is -6.25 bars and pressure potential is 0 , what is water potential of the plant cell? _____ What does this indicate in terms of water movement?

4. If solute potential in the plant cell above is -6.25 bars and pressure potential is 6.25 bars, what is water potential of the plant cell? _____ What does this indicate in terms of water movement?

5. A plant cell has a solute potential of -4.0 and a pressure potential of 1.0 . It is then placed in a solution with a water potential of -5.0 . What will happen to this plant cell?

6. A plant cell has a solute potential of -2.0 and a pressure potential of 0.0 . It is placed in a solution with a water potential of -1.0 . What will happen to this plant cell?
