Explaining H_2O Movement

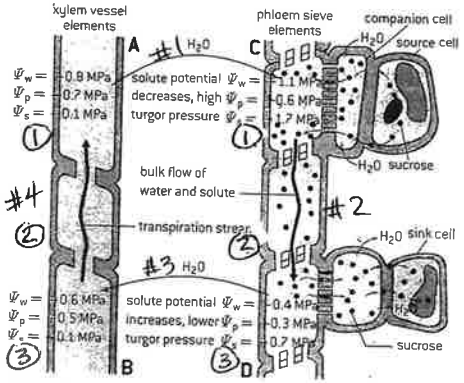
MPa = Megapascal

Data-based questions: Explaining water movement

Water potential is a measure of the tendency of water to move from one area to another. It is represented by the variable Ψ_w. It is defined as the sum of solute potential and pressure potential.

Pure water has a solute potential, Ψ_s, of zero. Once solute is added, the value of the solute potential becomes more negative. The more negative the solute potential, the more likely water will be drawn from another area with higher solute potential; i.e., lower solute concentration.

Pressure potential (Ψ_p) in a plant cell is the pressure exerted by the rigid cell wall that limits further intake of water. In a plant cell, pressure exerted by the rigid cell wall limits further water uptake despite solute potential differences.



▲ Figure 5

1 Explain the movement of water from point A to point C. [3]

due to: Water Potential?
Xylem cell ① Phloem cell ①
$\Psi = -0.8$ $\Psi = -1.1$
$-0.8 > -1.1$
H_2O flow YES!

2 Explain the movement of water from point C to point D. [3]

due to: ~~H_2O Potential~~?
Phloem Cell ① Phloem Cell ③
$\Psi = -1.1$ $\Psi = -0.4$
$-0.4 > -1.1$
H_2O flow No!
∴ gravity

3 Explain the movement of water from point D to point B. [3]

due to: Water Potential?
Phloem Cell ③ Xylem Cell ③
$\Psi = -0.4$ $\Psi = -0.6$
$-0.4 > -0.6$
H_2O Flow YES!

4 Explain the movement of water from point B to point A. [3]

due to: Water Potential?
Xylem Cell ③ Xylem Cell ①
$\Psi = -0.6$ $\Psi = -0.8$
$-0.6 > -0.8$
H_2O Flow YES!

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Osmoregulation & Eukaryotic Cells

30's

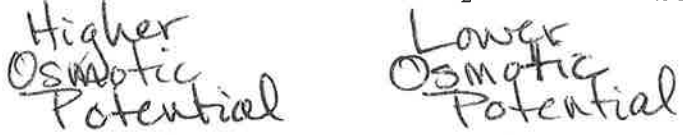
Summary/reflection

Osmoregulation & Eukaryotic Cells

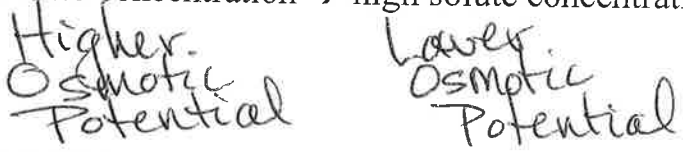
I. Ways to describe the potential for water to move across a membrane:

A. Osmotic Potential - OP (animal cells & others with no cell wall)

1. definition: measure of the tendency of a solution outside of a cell to either cause the withdraw or movement of water into a cell
2. Osmotic Potential values:
   a. pure H_2O has an Osmotic Potential = 0
   b. add solutes, and the Osmotic Potential becomes **negative**... the more solutes, the more negative the value
3. Compare the relative solute concentration on either side of the membrane
   c. Isotonic = equal solute concentrations ∴ Osmotic Potential equal
   d. Hypertonic = higher solute concentration ∴ Osmotic Potential **more** negative
   e. Hypotonic = lower solute concentration ∴ Osmotic Potential **less** negative (unless it is pure H_2O, and then it is 0)
4. Water moves from a higher Osmotic Potential to a lower Osmotic Potential
   a. water moves down a water concentration gradient
      high H_2O concentration → low H_2O concentration



   b. water moves up a solute concentration gradient
      low solute concentration → high solute concentration

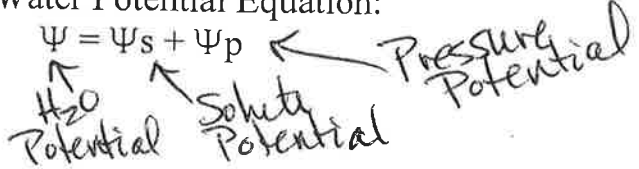


5. Animal cell response:
   a. environmental solution with a higher Osmotic Potential = net gain H_2O ∴ cell expands in size (may lyse)
   b. environmental solution with a lower Osmotic Potential = net loss H_2O ∴ cell shrinks in size (shrivels)
   c. environmental solution with an equal Osmotic Potential = dynamic equilibrium of H_2O in and out of the cell

B. Water Potential - Ψ (plant cells & other cells with a cell wall)

1. definition: the free energy per mole of water, calculated from two major components:
   a. solute potential(Ψs): depends on the solute concentration (also called the osmotic potential)
   b. pressure potential (Ψp): results from the exertion of pressure on the solution
2. Water Potential Equation:

$$\Psi = \Psi s + \Psi p$$



3. Solute Potential calculation:
   $\Psi s = -iCRT$
   - i = ionization constant (# of parts compound breaks into in water)
   - C = molar concentration
   - R = pressure constant (R = 0.0831 litre bars/mole K)
   - T = temperature in Kelvin (°C + 273)
4. Pressure Potential:
   a. Initial Ψp value = 0 (atmospheric pressure)
   b. Final Ψp value is caused by the turgor pressure, to compensate for flow of water into the cell
5. Water Potential values:
   a. pure water $\Psi = 0$
   b. add solutes changes the Ψ
      1) addition of solutes makes the Ψs value drop ∴ Ψ value drops (become more negative)
6. Water moves from a higher water potential to a lower water potential →
7. Water Potential Practice Problem:

①What is the water potential of a cell that has a molar concentration of 0.15M sucrose at 27 °C?

stays in 1 piece when dissolved in H_2O ∴ i = 1

calculate solute potential 1st

$\Psi_s = -(1)(0.15\,M)(0.0831\,\frac{\text{litre bars}}{M \cdot K})(27+273\,K)$

$\Psi_s = -(1)(0.15)(0.0831)(300)$

$\Psi_s = -3.7395 \approx -3.7$

$\Psi_p = 0$ & $\Psi = \Psi_s + \Psi_p$

$\Psi = -3.7 + 0$

$\Psi = -3.7$ litre bars

②What is the water potential of a solution that has a molar concentration of 0.15M NaCl at -5 °C?

splits into 2 ions when dissolved in H_2O ∴ i = 2

$\Psi_s = -(2)(0.15\,M)(0.0831\,\frac{\text{litre bars}}{M \cdot K})(-5+273\,K)$

$\Psi_s = -(2)(0.15)(0.0831)(268)$

$\Psi_s = -6.68124 \approx -6.7$

$\Psi_p = 0$ & $\Psi = \Psi_s + \Psi_p$

$\Psi = -6.7 + 0$

$\Psi = -6.7$ litre bars