PLANT PHYSIOLOGY Lecture 18 - Water Potential and Xylem Transport

I. Measuring water potential

A. Water potential (Ψ)

1. $\Psi = \Psi_p + \Psi_s$ (water potential = pressure + osmotic potentials)
2. When water moves it causes a $\Delta\Psi$ (note ΔG)
   a) Water moves from high to low (low ΔG - high ΔG = negative ΔG)
3. Why is water potential important?
   a) It is the chemical potential of water in a system
   b) It is the indirect determinant of water movement
4. How is water potential measured?
   a) Thermocouple psychrometry - based on relative humidity of equilibrated sample
   b) Pressure bomb - leaf placed in a chamber with pressure (assume osmotic potential is negligible)
   c) Chardakov's Method (assume Ψ_p[solute for assay] = 0; so, $\Psi = \Psi_s$)
      1) Line up tubes of known solute concentration and add some dye
      2) Immerse tissue in duplicate samples of solute and allow to equilibrate
      3) Remove tissue and the add one drop of colored solution to each corresponding tube
         a)) If drop rises, water potential of tissue is lower
         b)) If drop sinks, water potential of tissue is higher
      4) Then calculate Ψ assuming $\Psi = \Psi_s$
         Ψ_s = -miRT, where m = molality, i = ionization constant, R is a constant, and T is temperature
5. What are units of water potential?
   a) Bars (1 bar = 0.98 atmospheres or 0.10 MPa)

B. Other potentials - destroy pressure potential by freezing (rupturing) cells

II. How does water move (remember apoplast, xylem, tracheids, vessels, water, dead)?

A. Mechanism of xylem transport (cohesion-adhesion-tension hypothesis)

1. Tracheids and vessels usually dead, empty cells
2. Transport by bulk flow - driven by transpiration
   a) Transpiration causes "suction" and negative pressure on water in xylem
3. Important characteristics of water
   a) Cohesion - attraction of water molecules to each other
   b) Adhesion - attraction of water to other molecules (like cell walls)
   c) Tension - ability of water to withstand negative pressure

B. Example of flow from soil to air (from Oosterhuis, Univ. Arkansas)

Units are in bars

Soil:	$\Psi_p = 0$, $\Psi_s = -1$, $\Psi = -1$
Root surface:	$\Psi_p = 12$, $\Psi_s = -14$ $\Psi = -2$
Inside root:	$\Psi_p = -2$, $\Psi_s = -1$ $\Psi = -3$
Xylem:	$\Psi_p = -3$, $\Psi_s = -1$, $\Psi = -4$
Leaf:	$\Psi_p = 15$, $\Psi_s = -20$ $\Psi = -5$
Stem meristem:	$\Psi_p = 17$, $\Psi_s = -22$ $\Psi = -5$
Air:	$\Psi = -270$