Biology 325/425 **Answers – Fifth Question Set** Feb. 9, 2004

1. The Ψ of the root cell must be sufficiently negative so that water will diffuse from the outside solution to the root cells. If the roots are in water, the Ψ is 0 or close to it, with the result that the root cells do not have to have a very negative water potential. But in soil, where the soil particles hold the water, the water potential of the root cells must be more negative, as they can only take up the water from the soil held by a Ψ less negative than that of the root cell.

2. Plants dying due to lack of sufficient water are either losing water too fast, or failing to get sufficient water by the roots to replace the water lost in transpiration. The plant can increase the amount of water taken up by the roots in two ways. The first is to contact more soil particles, since the root can only take up water from particles that it actually contacts. It does this by producing branch roots and/or root hairs. The bean plant may have a more extensive root system. The second way is to make the osmotic potential, and thus the water potential of the root cells more negative. This will mean that the root cells can take more water off of each soil particle. The bean root cells may have had a more negative water potential than the radish roots. Finally, the bean plant may be losing less water than the radish plant. This could be due to the bean plant having a lower density of stomates in the leaves, less leaves from which to lose water, or stomates that do not open as wide during the day.

3. a) When you get flowers from the store, and transport them home, due to water transpiration from the flowers air enters the bottom of the xylem. If you then put the flowers in water, there will be a bubble in each water column, and the flower will not be able to take up water. The result is that the flower will die from water stress. If you recut the flower stalks under water when you get the flowers home, you will remove the air bubbles from the water column and the flower will still be able to take up water, and survive for a longer period of time.

   b) In the arctic, the freezing temperatures cause bubbles to appear in the xylem. The bubbles break the water columns. A bubble in a tracheid causes the loss of that single tracheid, while a bubble in vessels causes the loss of a stack of vessel cells. Thus the loss to the water column of a bubble is larger with vessels than with tracheids.

   c) One heavy rain will cause water to penetrate deeper into the soil than a series of light rains. Plants with tap roots, that reach down into the soil, can get more water if there is water deeper in the soil, but can't use water near the surface as efficiently because their roots go downwards. Grass, whose roots are always close to the surface, could not use this deeper water, but can use the water close to the surface.

   d) When ions are secreted into the xylem vessels, this make the Ψ_s more negative. If the water potenial of the vessels remains the same, the Ψ_p must become more positive, which will decrease the tension in the xylem.

   e) You cannot answer this question on the basis of the information that you have been given. In order for xylem sap to exude out upon cutting the stem, there must be a positive pressure in the xylem. This means that the Ψ_s of the xylem must be slightly more negative than the Ψ of the xylem. If you know the Ψ of the xylem, you can use that value as the minimum Ψ_s in the xylem, and calculate the minimum OC in the xylem to cause any pressure. The problem is that you need to know the water potential of the root cells. You are given the osmotic potential, but you also need the pressure potential in the root cells in order to calculate the Ψ of these cells.

f) Clay holds much more water than sand, when at field capacity. When water is removed from clay to give 10% water left, it will have required a much more negative root water potential to get the water down to this level. With sand, 10% water is quite a lot, and it will have taken a let less negative root water potential to get to that value.

g) In foggy areas, quite a bit of the water needed for the leaves comes from the fog, resulting in a lowered rate of water movement up the stem. In the sun, when water loss from the leaves is greater, the rate of water movement would have to be much greater. The faster the rate of water movement, the greater the tension in the xylem, and the greater the potential for breakage of the water columns.

h) Bubbles occur in the xylem because of breakage of the water columns when under tension, as well as in response to gasses coming out of solution when the plants are warmed. In the phloem, no bubbles are formed because of breakage of water columns, since the water in the phloem is under pressure, not tension.

i) Mature vessels and tracheids are dead cells, and therefore no longer have nuclei. Mature sieve cells have no nuclei, because nuclei would get swept from cell to cell as the cell contents move by mass flow in the phloem.

j) Water could move downwards in the xylem if the water potential of the root cells was more negative than the water potential of the cells in the leaves. This could occur is the roots were in very dry soil, while the leaves were in fog.

4. The source end of the phloem would have a greater OC and pressure, because of the uptake of sucrose in this region. The cell wall pH would be lower here, because of the active PM ATPase, which exports the H^+ needed for cotransport of H^+/sucrose back into companion cells and sieve cells. The sink end would have less OC and thus pressure, because the sucrose was being unloaded from the phloem at this end. The wall pH would be higher, because the PM ATPase is not activated at this end.

5. Water crosses membranes by diffusion, from less negative to more negative water potentials. The entry of water at the source end is due to the more negative water potential, caused by the uptake of sugars, while the loss of water across the PM at the sink end is due to the less negative water potential, caused by the loss of sugars at this end. But the movement of the contents of the sieve cells from source to sink is by bulk flow, and this is driven solely by differences in pressure. Since the pressure is greater at the source end, bulk flow will move water from the source end to the sink end.

6. Plants require all the macro- and micronutrients. They all are required. The difference is in the amounts that are required. Plants need far more of the macronutrients than the micronutrients. Not all the essential elements for plants are required for animals; an example is boron. Not all essential elements for animals are requried for plants. An example is nickel.