Bio Factsheet

Number 54

Water Potential

Water potential strikes fear into many students. However, in reality there are only five typical questions:
1. Here are two cells with different water potentials. Which way will water move?
2. Use water potential theory to explain why water enters and moves across roots.
3. Explain each part of the equation $\Psi = \Psi s + \Psi p$.
4. How can water potential theory be used to explain turgor and plasmolysis?
5. Interpret the water potential graph.

Water potential is defined as **"the tendency of water to enter or leave a cell".** Water moves from a region of high water potential to a region of lower water potential. A crucial point to learn is that the highest water potential is 0. All other water potential values are negative numbers and water moves towards the region with the more negative water potential. Water potential is measured in kilopascals (kPa).

Imagine two cells A and B (In reality, the numbers in the diagram are ridiculous – water potential would never be this low, but they illustrate the point).

A	B
-110kPa	-111kPa

Cell B (-111kPa) is more negative than cell A. Since water always moves to the cell with lower water potential, water would move from cell A to cell B. Usually in exam questions, the numbers are a bit trickier.

A	B
-110.4kPa	-110.5kPa

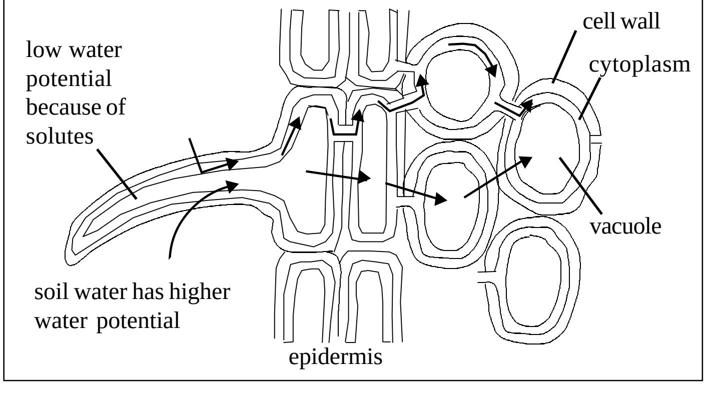
Some students find that the decimal points confuse things. Keep calm -110.5 is more negative than –110.4 (110.5 is further away from 0) so, again, water would move from cell A to B.

Water potential explains why water enters roots and how water moves across roots.

The movement of water into roots

Roots absorb water through their root hairs. Root hairs consist of a single cell (Fig 1). Root cells contain solutes and this lowers their water potential.

Fig 1. Movement of water into and across the root



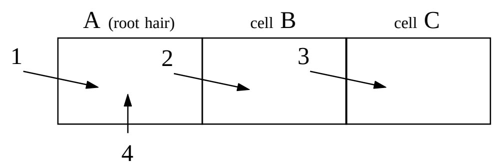
The water in the soil outside the root hair also contains some solutes, but not as many as the cell sap. So the water potential of the sap vacuole (of the root hair) is much lower than the water potential of the soil solution. Since water moves to areas of lower water potential, water moves from the soil solution into the vacuolar sap of the root hair.

Water potential also explains how water moves from cell to cell across the root. Remember that water moves from region of high water potential (soil) to region of low water potential (root hair cell). The water then has to move across the root from cell to cell.

The movement of water across the root

1. Water enters the root hair cell. This increases the water potential of that cell i.e. it becomes less negative (Fig 2).

Fig 2. Movement of water across the root



2. Cell A now has a higher water potential than cell B, so water moves from cell A to cell B
3. When cell B takes this water, its own water potential now increases, so its water potential is higher than C. Now water moves from B to C and so on across the cells of the root.
4. When A loses some water to B, the water potential of A decreases (because the solutes are now in less water and therefore more concentrated), so more water from the soil moves in, etc.

> ***Exam Hint*** *- Many candidates really struggle to explain what is going on in plant cells purely and simply because they are unsure about the structure of a typical cell. Make sure you can draw a plant cell and label the cell wall, cell membrane and vacuole.*

In order for water to enter the vacuole of a plant cell it must cross:
1. the cell wall
2. the cytoplasm
3. the tonoplast (Fig 3.)

When water enters the vacuole the volume of the vacuole increases. This pushes the cytoplasm against the cell wall, which stretches. The pressure of the cell contents pushing against the cell wall is called the **turgor pressure**. In turn, the cell wall is said to be pushing back against the cytoplasm with opposing force. When a cell has taken in as much water as it possibly can and the cell contents are being pushed against the cell wall with maximum force, the cell is said to be **turgid**.

Imagine a cell which is now placed in a solution which has a high concentration of solutes. Since solutes lower water potential the solution will have a low water potential. Water will be drawn out of the plant cell and the vacuole will begin to shrink. Eventually a point will be reached when the protoplast (the living part of the cell) is about to become detached from the cell wall (Fig 4), this point is known as **incipient plasmolysis**. When the protoplast becomes detached the cell is said to be **plasmolysed**

Fig 3. A turgid plant cell

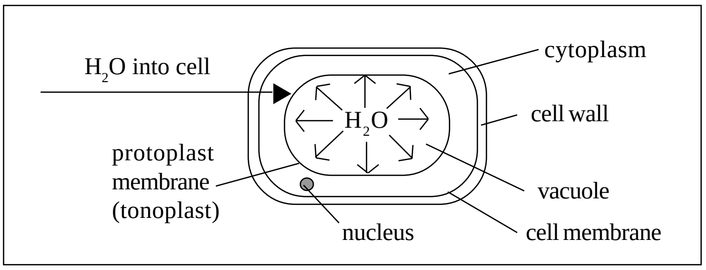


Fig 4. Incipient plasmolysis

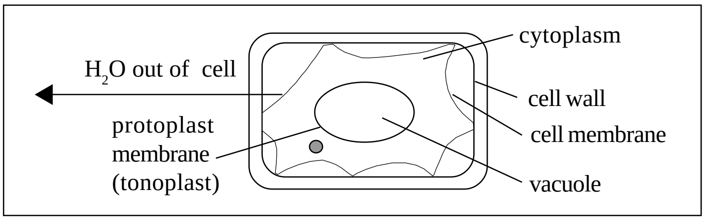
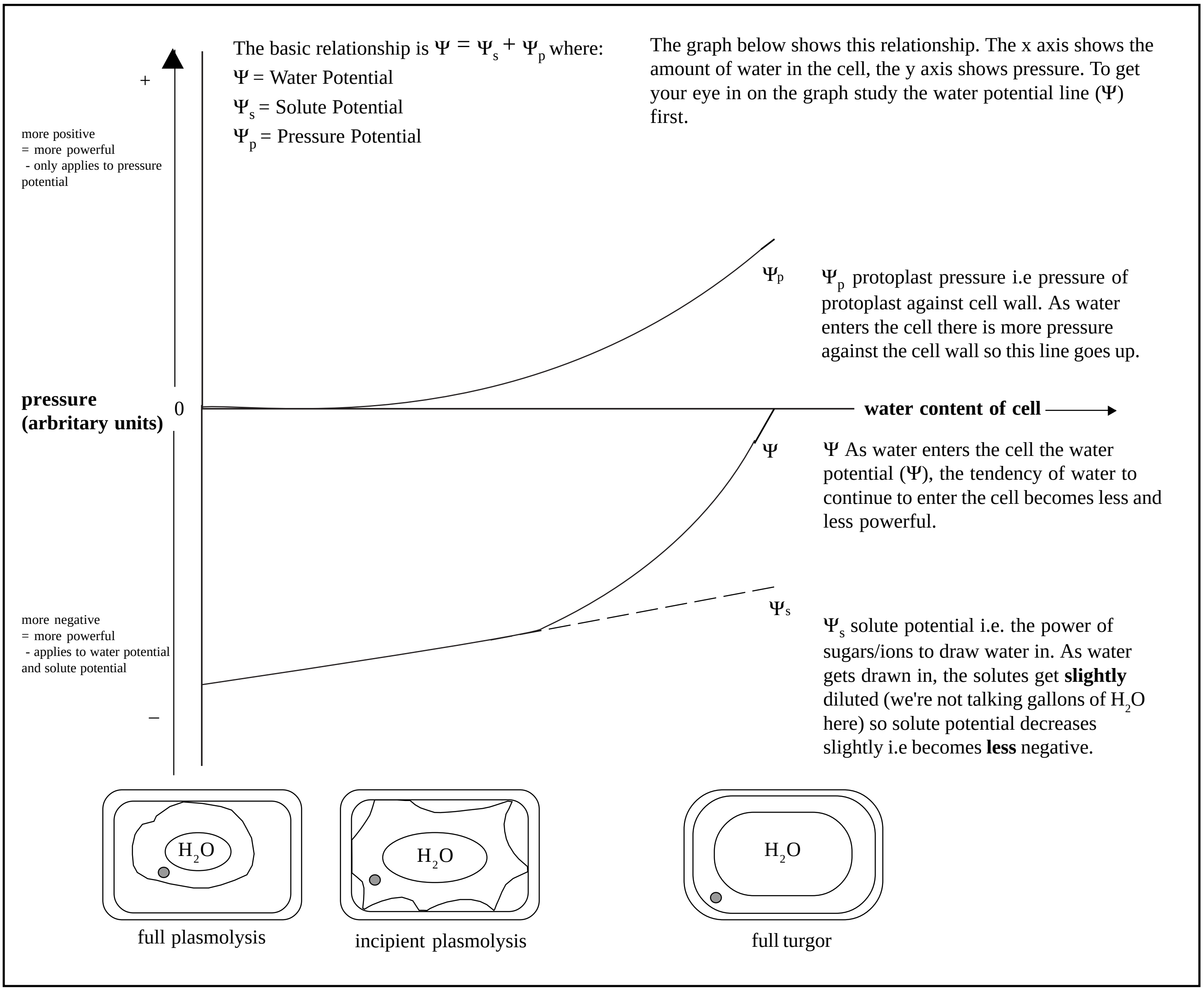


Fig 5. The water potential graph



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