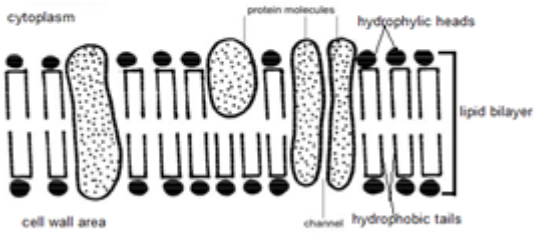
ION UPTAKE

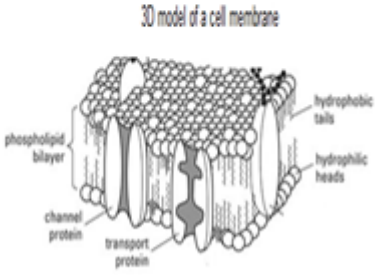
With the exception of O_2, CO_2 which is taken up in a gaseous form by all plants and N_2 which is utilized by the symbiotic association between legumes and rhizobia, **all the essential elements are taken from the soil by plant roots**. Inorganic ions are taken up into plants via the **epidermis of the younger portion of the roots where secondary growth has not yet initiated**. Ions enter the epidermal cells of the plant and passes into the internal cells (cortex) until they are secreted into the transport tissue – xylem.

- **It has been observed that the concentration of ions in the root cells (sap) is several times higher than that in the soil solution** eg. Root cells of pea (*Pisum sativum*) were found to contain 75 times more K+ than nutrient solutions in which they were growing.
- **The normal movement of ions is from high to lower concentration**.
- The question then arises why the ions in the roots do not move back to the soil since the soil solution is less concentrated than the sap in the root tissues.
- This is due to the semi permeable nature of the cell membrane that prevents the movement of ions from the cell back into the soil solution.

The cell membrane/plasma membrane

- The membrane consists of a lipid bilayer with interspersed proteins.
- The bilayer is made up of a hydrophilic heads (water loving) and hydrophobic tails (water avoiding).
- The arrangement of the bilayer is such that the hydrophobic tails face each other towards the inner side and the hydrophilic heads are on the outer surface facing the cytoplasm.



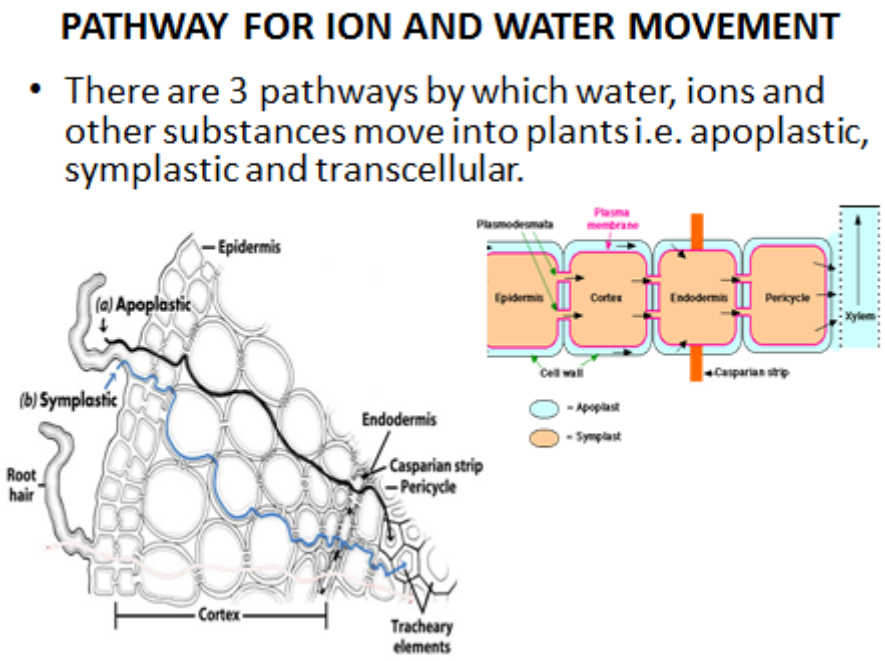


- The lipid bilayer does not allow polar molecules (the molecules which carry charge eg K^+ and NO_3^{--}) to pass through but allows only non polar molecules (the molecules which do not carry charge eg Methane CH_4 & Benzene C_6H_6) to pass through.
- The protein molecules in the membrane either go across the bilayer or are in one half of the bilayer.

- **Those proteins that go across the membrane acts as transport proteins moving ions from the soil solution into the cell**.

- These proteins show specificity for ions i.e. specific protein moves a particular ion into the cell. They act as channels, carriers and pumps.

    - The channel proteins have a passage way through which ions move.
    - The carrier proteins pickup ions rotate within the membrane and release the ions into the cytoplasm.
    - The pump proteins use energy from ATP to pump ions across the membrane.



Apoplastic Pathway:

- **This is a movement within the cell walls and the intercellular spaces of the plant**.

The cell walls of cells making up various tissues are thought to be a continuous structure across the root or stem. In the root however this continuum is broken in the **exodermis – hypodermis with casparian strips** (right beneath the epidermis) and the **endodermis** (just outside the pericycle). Both these tissues have cells with impermeable substances (suberin) in their radial walls – **casparian strips –** which prevent substances moving across them.

In those plants having exodermis, after water or ions enter the epidermis they cannot progress through the cell wall at the exodermis and therefore at this particular point substances or ions have to find an alternative pathway by which it can continue the movement to the xylem. In plants lacking an exodermis, water and ion movement continues apoplastically until it reaches endodermis at which an alternative pathway is used.

Symplastic Pathway:

The protoplast of plant cells are interconnected through narrow strands of cytoplasm – plasmodesmata – spanning the cell wall. Thus the cytoplasm of the cells within any organ of the plant form a continuum and substances can move through this continuous cytoplasm from one point of the plant to the other. This is called the symplastic pathway. Water and ions can move through the symplast until they get to the xylem, where they enter the apoplast.