MINERAL NUTRITION

All living organisms require food for the accomplishment of their life processes. The food is used as a source of

1. Energy required in various biochemical reactions – ATP
2. Simple biomolecules that are the building blocks for more complex biomolecules that makes up the structure of the plants. Eg glucose in cell wall, phospholipids in cell membranes, various amino acids which are part of enzymes and coenzymes required for biochemical reactions.

The foods that animals take in normally are energy rich complex biomolecules either from plants or other sources. Some fungi and bacteria that are saprophytic also obtain their food by breaking down animal and plant remains.

In contrast plants manufacture their food from simple elements in the environment. The presence of chlorophyll in plants enables them to utilize the sun's energy for synthesizing energy rich biomolecules like glucose and amino acids.

Studies on the nutrition of plants began in 1800 with analysis of plants by both botanists and chemists. These analyses showed that plants contained certain inorganic elements which could only come from the environment. Towards the end of 1800's it was demonstrated that some 10 of these inorganic elements were required for plant growth. In their absence plants grew abnormally and their reproductive process was also abnormal. These elements were then referred to as **essential inorganic nutrients.**

Currently more than 16 elements are known to be essential for the plant's nutrition. The concentration of various elements that have been estimated during plant analyses separated these elements into two groups.

a. Macronutrients – These elements are required in large amounts by plants and also occur in relatively high concentrations in plants.
b. Micronutrients – These elements are required in very low concentrations. Micronutrients are also called trace elements in older literature.

For example in maize, the percentage concentrations of various macro and micronutrients were as follows:

Macronutrients in % :

Nitrogen	2.81
Potassium	1.86
Calcium	0.40
Phosphorus	0.28
Magnesium	0.27
Sulphur	0.18
Oxygen	large proportion
Carbon	large proportion
Hydrogen	large proportion

Micronutrients in %

Iron	0.000110
Chloride	0.003100
Copper	0.000006
Manganese	0.000080
Zinc	0.000027
Molybdenum	0.000001
Boron	0.000014

The studies on nutritional requirements of plants have also established that some elements seem to be required by only a limited group of plants. Eg legumes seem to have improved growth when **cobalt** is added to their rooting medium. It is now known that the cobalt is used by bacteria that are in a symbiotic relationship with legumes. These bacteria are found in the roots of legumes and they convert gaseous atmospheric nitrogen to nitrogenous compounds for the plant.

Although sodium can be tolerated by halophytes it has not been demonstrated to be essential for the plants' metabolism in general. Still some people maintain that sodium is an essential element for C4 plants and some halophytes.

Soyabeans also appear to require nickel. In absence of nickel, plants often accumulate urea which is toxic at high concentrations. This results in necrosis at leaf tips and reduction in the overall growth rate of the plant. Necrosis is a disease symptom which shows as browning because of death of cells in a particular area.

Functions of elements

The functions of elements can be specific or non-specific when other elements can substitute for each other.

Non Specific function

i. Maintenance of osmotic pressure necessary for water uptake into plant can be performed by inorganic ions eg. sodium, potassium or chlorine

Specific functions

Specific functions for elements span the entire range of the plant's life processes. Some elements also have more than one function in the plant. The functions may be

a. Structural – i.e. the elements be part of structures that make up the plant cell.
examples
    1. Calcium combines with pectic acid to form the middle lamella of the plant cell.
    2. Phosphorus is a constituent of phospholipids, a part of plasma membrane.
    3. Carbon, oxygen and hydrogen are constituents of glucose chains that make up the cell wall.

b. Non Structural - Components of various biomolecules that are not part of the cell structure
    1. Phosphorus – component of nucleic acid which make up the genes, energy carrying compound (ATP, ADP) and several coenzymes (non protein organic compounds that require enzymes for activity eg. pyridoxal phosphate).
    2. Magnesium – part of the chlorophyll molecule.

3. Nitrogen – component of amino acids and hence proteins(proteins are made up of amino acid chains), nucleic acids, chlorophylls and coenzymes eg NAD
4. Carbon, oxygen, hydrogen – components of
   i. Carbohydrates - eg glucose, sucrose, starch
   ii. Lipids - eg oleic acid, linoleic acids, oils, waxes
   iii. Proteins - components of amino acids eg. Glycine, alanine, proline
5. Sulphur – component of some amino acids and hence proteins eg. coenzyme A

c. Metabolic reactions - Photosynthesis
   Cl and Mn – are involved in the light reaction of photosynthesis – specifically reaction leading to release of oxygen

d. Catalysis
   1. Components of enzymes
      Most micronutrients are components of enzymes that are required for the activity of these enzymes
         Fe – cytochrome oxidase (transfers electrons to oxygen during the respiration process) and nitrogenase(converts atmospheric nitrogen to ammonia)

   2. Activators or regulators of enzymes - Other essential elements are activators or regulators of enzymes. They might change the shape of the enzyme such that the catalytic site is exposed or obstructed
      i. Mg 2+ → ATPase (ATPase is an enzyme which requires Mg for its activity)

e. Osmotic activity
   Some essential elements are involved in the maintenance of osmotic potential and ionic balance in plant cells
   1. K – stomatal opening and closure is dependent on osmotic potential in the guard cells. The osmotic potential is generated by influx (inward movement) of potassium ion into the guard cells. This leads to uptake of water by the guard cells which swell and the stomata open. During the efflux (outward movement) of potassium ion from the guard cells, the osmotic potential is reduced and water moves out of the guard cells into the surrounding cells. The guard cells then lose their turgidity and shrink closing the stomata.

f. Cell Permeability
   1. Ca – directly affects the physical structure of cell membranes. Membrane integrity is maintained only in the presence of calcium. Thus Ca affects the function of the cell membrane which is selective uptake of substances into the cell.