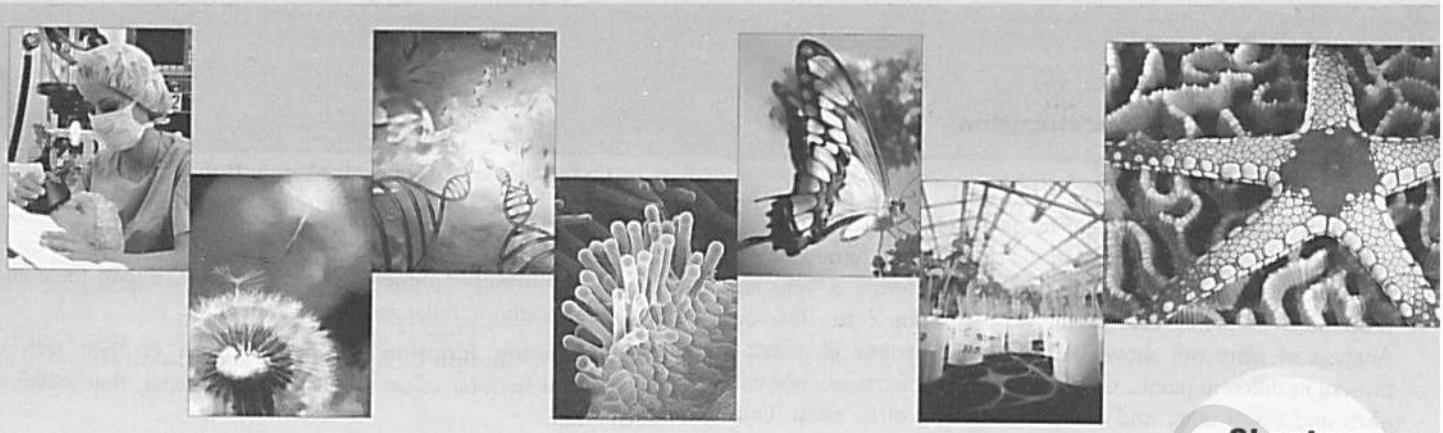


Chapter

4.2

Mineral Nutrition

Organisms require many organic and inorganic substances to complete their life cycle. All such substances which they take from outside constitute their nutrition. On the basis of their nutritional requirements, organisms can be classified into heterotrophs and autotrophs.

All non-green plants and animals, including human beings, are heterotrophs. Autotrophic green plants obtain their nutrition from inorganic substances which are present in soil in the form of minerals, which are known as mineral elements or mineral nutrients and this nutrition is called mineral nutrition.

Essential mineral elements

An essential element is defined as 'one without which the plant cannot complete its life cycle, or one that has a clear physiological role'. Therefore, in 1939 Arnon and Stout proposed the following characters for judging the criteria of essentiality of an element in the plant :

(1) The element must be essential for normal growth and reproduction, which cannot proceed without it.

(2) The requirement of the element must be specific and cannot be replaced by another element.

(3) The requirement must be direct that is, not the result of any indirect effect *e.g.*, for relieving toxicity caused by some other substance.

Essential elements are divided into two broad categories, based on the quantity in which they are required by plants. Macro-elements and micro-elements. Their ionic forms are respectively called macronutrients and micronutrients. Mineral salts dissolved in soil solution are constantly passing downwards along with percolating (gravitational) water. The phenomenon is called leaching. Leaching is more in case of anions.

Macronutrients (Macroelements or major elements) : Which are required by plants in larger amounts (Generally present in the plant tissues in concentrations of 1 to 10 *mg per* gram of dry matter). Of the non-essential functional elements, silicon and sodium often occur in the range of macroelements. Macroelements are usually involved in the synthesis of organic molecules and development of osmotic potential.

Micronutrients (Microelements or minor elements or trace elements) : Which are required by plants in very small amounts, *i.e.*, in traces (equal to or less than 0.1 *mg* per gram dry matter). Cobalt, vanadium, aluminium and nickel, may be essential for certain plants. Microelements are mostly involved in the functioning of enzymes, as cofactors or metal activators. The usual concentration of essential elements in higher plants according to D.W. Rains (1976) based on the data of Stout are as follows :

Table : 4.2-1

Elements	% of dry weight
Macronutrients	
Carbon	45
Oxygen	45
Hydrogen	6
Nitrogen	1.5
Potassium	1.0
Calcium	0.5
Magnesium	0.2
Phosphorus	0.2
Sulphur	0.1
Micronutrients	
Chlorine	0.01
Iron	0.01
Manganese	0.005
Boron	0.002
Zinc	0.002
Copper	0.0001
Molybdenum	0.0001

Plant analysis

Ash analysis : The plant tissue is subjected to a very high temperature (550-600°C) in an electric muffle furnace and is reduced to ash. The plant ash left behind forms a very small proportion of plants dry weight ranging from 2 to 10% only. Analysis of plant ash shows that about 92 mineral elements are present in different plants. Out of these, 30 elements are present in each and every plant and rest are in one or other plant. Out of these 30 elements, 16 elements are necessary for plants and are called essential elements.

Solution culture (Hydroponics) : In this method plants are grown in nutrient solutions containing only desired elements. To determine the essentiality of an element for a particular plant, it is grown in a nutrient medium that lacks or is deficient in this element.

The growing of plants with their roots in dilute solutions of mineral salts instead of soil led to increased understanding of plant nutrition. This cultivation of plants by placing the roots in nutrient solution is called hydroponics. Probably the first recorded use of soilless culture was by Woodward in 1699. By 1860, the culture solution technique was modernized by Sachs and he showed the essentiality of nitrogen for plant growth.

Another significant worker for studying the essentiality of elements was Knop (1865). The method of growing plants in aqueous nutrient solutions as employed by Sachs and Knop is used experimentally and commercially today and known as hydroponic culture. Now a days a chelating agent Na^2-EDTA (Disodium salt of ethylene diamine tetra acetic acid. EDTA (Ethylene diamine tetra-acetic acid) is a buffer which is used in tissue cultures is added.

Sand culture : Here plants are grown in inert sand + nutrient solution. Main advantage is that roots get natural environment and proper aeration.

Aeroponics : In this practice, plants are grown with their roots bathed in nutrients mist. This method has been successfully used in growing *Citrus* and olive.

Major role of nutrients

Various elements perform the following major roles in the plants :

Construction of the plant body : The elements particularly *C, H* and *O* construct the plant body by entering into the constitution of cell wall and protoplasm. They are, therefore, referred to as framework elements. Besides, these (*C, H* and *O*) *N, P* and *S, Mg* and *Fe* also enter in the constitution of protoplasm. They are described as protoplasmic elements.

Maintenance of osmotic pressure : Various minerals present in the cell sap in organic or inorganic form maintain the osmotic pressure of the cell.

Maintenance of permeability of cytomembranes : The minerals, particularly Ca^{++}, K^+ and Na^+ maintain the permeability of cytomembranes.

Influence the pH of the cell sap : Different cations and anions influence on the *pH* of the cell sap.

Catalysis of biochemical reaction : Several elements particularly *Fe, Ca, Mg, Mn, Zn, Cu, Cl* act as metallic catalyst in biochemical reactions.

Toxic effects : Minerals like *Cu, As,* etc. impart toxic effect on the protoplasm under specific conditions.

Balancing function : Some minerals or their salts act against the harmful effect of the other nutrients, thus balancing each other.

Specific role of macronutrients

The role of different elements is described below :

(1) **Carbon, hydrogen and oxygen :** These three elements, though can not be categorised as mineral elements, are indispensible for plant growth. Carbon, hydrogen and oxygen together constitute about 94% of the total dry weight of the plant. Carbon is obtained from the carbon dioxide present in the atmosphere. It is essential for carbohydrate and fat synthesis. Hydrogen and oxygen would be obtained from water which is absorbed by the plants from the soil. Some amount of oxygen is also absorbed from the atmosphere.

(2) **Nitrogen**

Source : The chief source of nitrogen for green plants is the soil. It is absorbed mainly in the form of nitrate ions (NO_3^-). The major sources of nitrate for the plants are sodium nitrate, potassium nitrate, ammonium nitrate and calcium nitrate.

Functions : Nitrogen is an essential constituent of proteins, nucleic acids, vitamins and many other organic molecules as chlorophyll. Nitrogen is also present in various hormones, coenzymes and ATP etc. It plays an important role in protein synthesis, respiration, growth and in almost all metabolic reactions. It also intensifies colouration in apple.

Deficiency symptoms

(i) Impaired growth

(ii) Yellowing of leaves (appearing first in older leaves) due to loss of chlorophyll, *i.e.*, chlorosis.

(iii) Development of anthocyanin pigmentation in veins, sometimes in petioles and stems.

(iv) Delayed or complete suppression of flowering and fruiting.

Excessive supply of nitrogen produces following symptoms :

(i) Increased formation of dark green leaves.

(ii) Poor development of root system.

(iii) Delayed flowering and seed formation.

(3) **Phosphorus**

Source : Phosphorus is present in the soil in two general forms, organic and inorganic. Organic compounds are decomposed and phosphorus is made available to plants in inorganic form. Soil solution contains phosphorus in inorganic forms as the phosphate ions obtained as $H_2PO_4^-$ and HPO_4^{2-}. When *pH* is low phosphate ions are present in the form of $H_2PO_4^-$. When *pH* is high, phosphate ions are represented in HPO_4^{2-}.

Functions

(i) Phosphorous is present abundantly in the growing and storage organs such as fruits and seeds. It promotes healthy root growth and fruit ripening by helping translocation of carbohydrates.

(ii) It is present in plasma membrane, nucleic acid, nucleotides, many coenzymes and organic molecules as ATP.

(iii) Phosphorus plays an indispensable role in energy metabolism *i.e.*, hydrolysis of pyrophosphate. Thus it is required for all phosphorylation reactions.

Deficiency symptoms

(i) Leaves become dark green or purplish.

(ii) Sometimes development of anthocyanin pigmentation occurs in veins which may become necrotic (Necrosis is defined as localised death of cells).

(iii) Premature fall of leaves.

(iv) Decreased cambial activity resulting in poor development of vascular bundles.

(v) Sickle leaf disease.

(4) **Sulphur**

Source : Sulphur is present as sulphate SO_4^{2-} in mineral fraction of soil. In industrialized areas, atmospheric sulphur dioxide (SO_2) and sulphur trioxide (SO_3; in low concentration) may be important sources of sulphur nutrition.

Functions

(i) Sulphur is a constituent of amino-acids like cystine, cysteine and methionine; vitamins like biotin and thiamine, and coenzyme A.

(ii) It increases the nodule formation in the roots of leguminous plants. It favours soluble organic nitrogen and there is decrease in the quantity of soluble nitrogen with its increase.

(iii) The characteristic smell of mustard, onion and garlic is due to the presence of sulphur in their volatile oils.

(iv) Sulphur in plants is required in stem and root tips and young leaves. It is remobilised during senescence.

Deficiency symptoms

(i) Leaves remain small and turn pale green *i.e.*, symptoms of chlorosis. Chlorosis affects young leaves more because of immobile property of the sulphur. The young leaves develop orange, red or purple pigment.

(ii) Leaf tips and margins roll downwards and inwards *e.g.*, tobacco, tea and tomato.

(iii) Delayed flowering and fruiting.

(iv) Apical growth is retarded whereas premature development of lateral buds starts.

(v) The tea yellow disease is caused in tea plants.

(vi) Decrease in stroma lamellae and increase in grana stacking.

(vii) Increase in starch and sucrose accumulation, and decrease in reducing sugars.

(5) **Potassium**

Source : Source of K^+ to the plants is inorganic compounds like potassium sulphate, potassium nitrate, etc. Potassium is usually present in sufficient amount in clay soils. It contains approximately 0.3 to 6.0 percent of whole plant. In seeds, it is found in less amount.

Functions

(i) It differs from all other macronutrients in not being a constituent of any metabolically important compound.

(ii) It is the only monovalent cation essential for the plants.

(iii) It acts as an activator of several enzymes including DNA polymerase.

(iv) It is essential for the translocation of photosynthates, opening and closing of stomata, phosphorylation, synthesis of nucleic acid and chlorophyll.

It takes part in the formation of cell membrane and it is also responsible for maintenance of turgidity of cells.

Deficiency symptoms

(i) Mottled chlorosis followed by the development of necrotic areas at the tips and margins of the leaves.

(ii) K^+ deficiency inhibits proteins synthesis and photosynthesis. At the same time, it increases the rate of respiration.

(iii) The internodes become shorter and root system is adversely affected.

(iv) The colour of leaves may turn bluish green.

(v) Widespread blackening or scorching of leaves may occur as a result of increased tyrosinase activity.

(vi) Rosette or bushy habit of growth may be seen in plants.

Destruction of pith cells of tomato and increased differentiation of phloem elements.

(6) **Calcium**

Source : It is absorbed by the plants in the form of Ca^{2+} from calcium carbonate etc. It occurs abundantly in a non-exchangeable form such as anorthite ($CaAl_2.Si_2O_8$). Much of the exchangeable calcium of the soil is absorbed on to the surface of clay micelle.

Functions

(i) It is necessary for formation of middle lamella of plants where it occurs as calcium pectate.

(ii) It is necessary for the growth of apical meristem and root hair formation.

(iii) It acts as activator of several enzymes, *e.g.*, ATPase, succinic dehydrogenase, adenylate kinase, etc.

(iv) Along with Na^+ and K^+ it maintains the permeability of plasma membrane.

(v) It is involved in the organisation of spindle fibres during mitosis.

(vi) It antagonises the toxic effects of Na^+ and Mg^{++}.

It is essential for fat metabolism, carbohydrate metabolism, nitrate assimilation and binding of nucleic acids with proteins.

Deficiency symptoms

(i) Ultimate death of meristems which are found in shoot, leaf and root tips.

(ii) Chlorosis along the margins of young leaves, later on they become necrotic.

(iii) Distortion in leaf shape.

(iv) Roots poorly developed or may become gelatinous.

(v) Young leaves show malformation and leaf tips becomes hooked.

(vi) Its deficiency checks flowering and causes the flowers to fall early.

(vii) Potato tubers become small and malformed.

(7) **Magnesium**

Source : Magnesium occurs in the soil in the form of magnesite ($MgCO_3$), dolomite ($MgCO_3$, $CaCO_3$), magnesium sulphate ($MgSO_4$) and as silicates. It is absorbed from the soil in the form of (Exchangeable cation) ions (Mg^{++}). It is easily leached and thus become deficient in sandy soils during rainy season.

Functions

(i) It is an important constituent of chlorophyll.

(ii) It is present in the middle lamella in the form of magnesium pectate.

(iii) It plays an important role in the metabolism of carbohydrates, lipids and phosphorus.

(iv) It acts as activator of several enzymes.

(v) It is required for binding the larger and smaller subunits of ribosomes during protein synthesis.

Deficiency symptoms

(i) Interveinal chlorosis followed by anthocyanin pigmentation, eventually necrotic spots appear on the leaves. As magnesium is easily transported within the plant body, the deficiency symptoms first appear in the mature leaves followed by the younger leaves at a later stage.

(ii) Stems become hard and woody, and turn yellowish green.

(iii) Depression of internal phloem and extensive development of chlorenchyma.

Specific role of micronutrients

(1) **Iron**

Source : It is present in the form of oxides in the soil. It is absorbed by the plants in ferric (Fe^{3+}) as well as ferrous (Fe^{2+}) state but metabolically it is active in ferrous state. Its requirement is intermediate between macro and micro-nutrients.

Functions

(i) Iron is a structural component of ferredoxin, flavoproteins, iron prophyrin proteins (Cytochromes, peroxidases, catalases, etc.)

(ii) It plays important roles in energy conversion reactions of photosynthesis (phosphorylation) and respiration.

(iii) It acts as activator of nitrate reductase and aconitase.

(iv) It is essential for the synthesis of chlorophyll.

Deficiency symptoms

(i) Interveinal chlorosis particularly in younger leaves, the mature leaves remain unaffected.

(ii) It inhibits chloroplast formation due to inhibition of protein synthesis.

(iii) Stalks remain short and slender.

(iv) Extensive interveinal white chlorosis in leaves.

(v) It may develop necrosis aerobic respiration severely affected.

(vi) In extreme deficiency scorching of leaf margins and tips may occur.

(2) **Manganese**

Source : Like iron, the oxide forms of manganese are common in soil. However, manganese dioxide (highly oxidised form) is not easily available to plants. It is absorbed from the soil in bivalent form (Mn^{++}). Oxidising bacteria in soils render manganese unavailable to plants at *pH* ranging from 6.5 to 7.8.

Functions

(i) It acts as activator of enzymes of respiration (malic dehydrogenase and oxalosuccinic decarboxylase) and nitrogen metabolism (nitrite reductase).

(ii) It is required in photosynthesis during photolysis of water.

(iii) It decreases the solubility of iron by oxidation. Hence, abundance of manganese can lead to iron deficiency in plants.

Deficiency symptoms

(i) Chlorosis (interveinal) and necrosis of leaves.

(ii) Chloroplasts lose chlorophyll, turn yellow green, vacuolated and finally perish.

(iii) 'Grey speck disease' in oat appears due to the deficiency of manganese, which leads to total failure of crop.

(iv) 'Marsh spot's in seeds of pea.

(v) Deficiency symptoms develop in older leaves.

(3) **Copper**

Source : Copper occurs in almost every type of soil in the form of complex organic compounds. A very small amount of copper is found dissolved in the soil solution. It is found in natural deposits of chalcopyrite ($CuFeS_2$).

Functions

(i) It activates many enzymes and is a component of phenolases, ascorbic acid oxidase, tyrosinase, cytochrome oxidase.

(ii) Copper is a constituent of plastocyanin, hence plays a role in photophosphorylation.

(iii) It also maintains carbohydrate nitrogen balance.

Deficiency symptoms

(i) Both vegetative and reproductive growth are reduced.

(ii) The most common symptoms of copper deficiency include a disease of fruit trees called 'exanthema' in which trees start yielding gums on bark and 'reclamation of crop plants', found in cereals and legumes.

(iii) It also causes necrosis of the tip of the young leaves (*e.g., Citrus*). The disease is called 'die back'.

(iv) Carbon dioxide absorption is decreased in copper deficient trees.

(v) Wilting of entire plant occurs under acute shortage.

(vi) Grain formation is more severely restricted than vegetative growth.

(4) **Molybdenum**

Source : It is available to the plants mostly as molybdate ions. It is required in extremely small quantities by plants.

Functions

(i) Its most important function is in nitrogen fixation because it is an activator of nitrate reductase.

(ii) It is required for the synthesis of ascorbic acid.

(iii) It acts as activator of some dehydrogenases and phosphatases.

Deficiency symptoms

(i) Mottled chlorosis is caused in the older leaves as in nitrogen deficiency, but unlike nitrogen-deficient plants, the cotyledons stay healthy and green.

(ii) It is also known to inhibit flowering, if they develop, they fall before fruit setting.

(iii) It leads to drop in concentration of ascorbic acid.

(iv) Its deficiency causes 'whiptail disease' in cauliflower and cabbage. The leaves first show an interveinal mottling and the leaf margins may become gray and flaccid and finally brown.

(5) **Zinc**

Source : Zinc occurs in the soil in the form of ferromagnesian minerals like magnetite, biotite and hornblende. Increase in soil *pH* decreases the availability of zinc.

Bivalent form of zinc (Zn^{++}) is exchangeable and is readily available in the soil. Plants require this mineral only in traces and its higher concentrations are highly toxic.

Functions

(i) It is required for the synthesis of tryptophan which is a precursor of indole acetic acid-an auxin.

(ii) It is a constituent of enzymes like carbonic anhydrase, hexokinase, alcohol dehydrogenase, lactic dehydrogenase and carboxypeptidase.

(iii) It is required for metabolism of phosphorus and carbohydrates.

(iv) Zinc also appears to play an important role in protein synthesis because in its absence there is substantial increase in soluble nitrogenous compounds.

Deficiency symptoms

(i) The first symptom appears in the form of interveinal chlorosis of the older leaves, starting at the tips and the margins.

(ii) Growth becomes stunted due to formation of smaller leaves and shortened internodes. Reduced stem growth is due to less synthesis of auxin.

(iii) The leaves become distorted and sickle shaped and get clustered to form rosettes. This effect is known as 'little leaf disease'.

(iv) In maize, zinc deficiency produces 'white bud disease' which leads to greatly reduced flowering and fruiting as well as poorly differentiated root growth.

(v) Its deficiency causes khaira disease of rice and mottled leaf of apple, *Citrus* and walnut.

(6) **Boron**

Source : Boron is present in the soil in very small amounts. It appears in exchangeable soluble and nonexchangeable forms in the soil BO_3^{3-} or $B_4O_7^2$. It is absorbed from the soil as boric acid (H_3BO_3) and tetraborate anions.

Functions

(i) It facilitates the translocation of sugars.

(ii) It is involved in the formation of pectin.

(iii) It is also required for flowering, fruiting, photosynthesis and nitrogen metabolism.

(iv) Boron is required for uptake and utilisation of Ca^{2+}, pollen germination, seed germination and cell differentiation.

(v) It regulates cellular differentiation and development.

Deficiency symptoms

(i) The first major symptom of boron deficiency is the death of shoot tip because boron is needed for DNA synthesis.

(ii) Generally flowers are not formed and the root growth is stunted.

(iii) The leaves develop a thick coppery texture, they curve and become brittle.

(iv) Some of the physiological diseases caused due to boron deficiency are internal cork of apple, top rot of tobacco, cracked stem of celery, browning of cauliflower, water core of turnip, hard fruit of Citrus and heart rot of sugar beets and marigold. These diseases can be cured by application of small doses of sodium tetraborate in the soil.

(v) Its deficiency checks the cell division of cambium but continues cell elongation.

(7) **Chlorine**

Source : It is absorbed from the soil as chloride ions. Hence, it is rarely supplied as fertilizer.

Functions

(i) It is required for photolysis of water during photosynthesis in photosystem-II.

(ii) In tobacco, it increases water volume inside the cell and also regulates carbohydrate metabolism.

(iii) With Na^+ and K^+, chlorine helps in determining solute concentration and anion cation balance in the cells.

(iv) It is essential for oxygen evolution in photosynthesis.

Deficiency symptoms

(i) The deficiency symptoms of chlorine consist of wilted leaves which later become chlorotic and finally attain a bronze colour.

(ii) Roots become stunted or thickened and club shaped and fruiting is reduced.

(iii) Photosynthesis is also inhibited.

Critical elements : Macroelements which become commonly deficient in the soils are called critical elements. They are in number–N, P and K most fertilisers contain critical elements. They are called complete fertilisers.

Mechanism of absorption of mineral elements

Plants obtain minerals from soil where these are dissolved in soil solution or are present adsorbed to colloidal clay particles.

- Mineral salt absorption is **independent** of water absorption.
- Maximum mineral salt absorption occurs by **zone of elongation.** No mineral salt absorption occurs by root hair zone. Mineral salt absorption occurs directly by cells of epiblema and not by root hair.
- Mineral salts are absorbed mostly in form of ions, *i.e.*, anions and cations.

Various theories have been proposed to explain the mechanism of mineral salt absorption and can be placed under the following two categories.

(1) **Passive absorption :** Absorption of ions without the use of metabolic energy is known as passive absorption. This type of absorption is carried out by purely physical forces.

Briggs and Robertson (1957) demonstrated the passive absorption of ions by root system. They showed :

(i) Mineral salt absorption is not affected by temperature and metabolic inhibitors.

(ii) Rapid uptake of ions occurs when plant tissues are transferred from a medium of low concentration to high concentration.

Some of the important theories explaining the mechanism of passive absorption of minerals are given below :

Mass flow hypothesis : According to Hylmo (1953, 1955), the ion absorption increases with increase in transpiration. The ions have been considered to move in a mass flow with water from the soil solution through the root and eventually to the shoot. The theory was supported by Kramer (1956), Russel and Barber (1960), etc. Later, Lopushinsky (1960) using radioactive P^{32} and Ca^{45}, has supported this experiment.

Simple diffusion hypothesis : According to this hypothesis, if the concentration of solutes inside the plant is lower than the soil, the mineral ions are thought to migrate into the root by simple diffusion. As a result, a state of equilibrium is reached. The part of plant cell or tissue that permits free diffusion is sometimes called outer space. The apparent volume that accomodates these ions has been referred to by some workers as apparent free space. The accumulation of ions in the cell against concentration gradient can not be explained by this concept.

Facilitated diffusion hypothesis : According to this concept, the ions are transported across the membrane by a carrier protein. When the ions enter the cell through protein channels and not through the lipid layer the phenomenon is called facilitated diffusion.

Ion exchange hypothesis : According to this view the ions adsorbed to the cell surface are exchanged from the external medium. A cation is exchanged for a cation and anion for anion. If a particular ion is absorbed by the plant, in exchange it offers H^+ or OH^- ions which are made available by the dissociation of water molecule.

There are two theories to explain the mechanism of ion exchange.

(i) **Contact exchange theory :** According to this theory, ions are not completely static, they are always oscillating around their absorption surface and when the oscillation volume of the ions on the roots and on the colloidal particles overlap each other, ion exchange occurs. An equilibrium is maintained between the dissolved fractions as any depletion in the soil solution is covered by movement of ions.

(ii) **Carbonic acid exchange theory :** In this case, CO_2 released by roots during respiration reacts with water to produce carbonic acid which dissociates into hydrogen ions and bicarbonate ions. Hydrogen ion exchanges itself with the cations adsorbed on the colloidal particles and the bicarbonate ions release the adsorbed anions to supply both anions and cations nearby.

$$H_2O + CO_2 \qquad H_2CO_3 \qquad H^+ + HCO_3^-$$

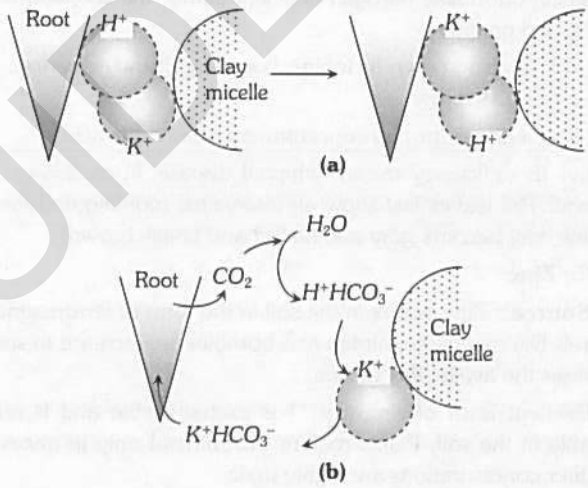


Fig : 4.2-1 Diagrammatic representation of (a) The contact-exchange theory and (b) The carbonic acid exchange theory

Donnan equilibrium : This mechanism, given by F.G. Donnan (1927), takes into account the effect of non-diffusible ions, which may be present on one side of the membrane. Unlike diffusible ions, the membrane is not permeable to non-diffusible ions. Such ions are termed as fixed ions. They may be anions or cations. In a system, in which there are no fixed ions, there are equal number of anions and cations on both sides of the membrane at equilibrium. But in Donnan equilibrium, in order to balance the charge of the fixed ions (say anions), more ions of the other charge (say cations) would be required.

Mathematically, the Donnan equilibrium may be represented by following equation :

$$[C_i^+][A_i^-] = [C_o^+][A_o^-]$$

Here : C_i^+ = Cations inside; C_o^+ = Cations outside

A_i^- = Anions inside; A_o^- = Anions outside

$$\frac{\text{Positive ions inside}}{\text{Positive ions outside}} = \frac{\text{Negative ions outside}}{\text{Negative ions inside}}$$

(2) **Active absorption :** Generally, the lipid-protein membrane of a cell is largely permeable to free ions. The energy is considered to be involved in the transport of such free ions across the membrane. The absorption of ions, involving use of metabolic energy, is called active absorption. Energy used in these mechanisms comes from metabolic activities, especially respiration. Mineral absorption is mainly active process. Hoagland (1944) indicated active ion absorption and their (ions) accumulation against concentration gradient in green algae *Nitella* and *Valonia*.

Following evidences show the involvement of metabolic energy in the absorption of mineral salts :

(i) Higher rate of respiration increases the salt accumulation inside the cell.

(ii) Respiratory inhibitors check the process of salt uptake.

(iii) By decreasing oxygen content in the medium, the salt absorption is also decreased.

Active transport is necessary for living cells because certain substances must be concentrated and others must be excluded. Active uptake of minerals by roots mainly depends on availability of oxygen. Some of these are discussed below :

Carrier concept : This concept was proposed by Van den Honert (1937). The space in a cell or tissue where mineral ions enter by the usage of metabolic energy is called inner space. According to this concept there are separate carriers for cations and anions. A carrier forms an ion-carrier complex on the outer surface of the membrane. This complex breaks up and releases the ion into the inner space and this release is perhaps mediated by the enzyme *phosphatase*. The inactivated carrier is again activated by the enzyme *kinase* and in this process an ATP is used up. ATP molecule combine with carrier molecules and allow passage of substances against concentration gradient. The activated carrier again accepts new ions and the entire cycle is repeated.

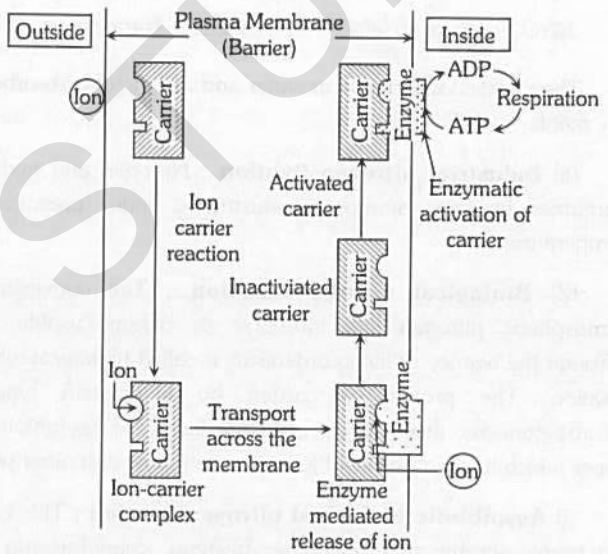


Fig : 4.2-2 The ion-carrier hypothesis

Cytochrome – pump hypothesis : This theory was proposed by Lundegardh (1950, 1954). According to this explanation only anions are absorbed actively, *i.e.*, anion uptake requires energy and the absorption of cations does not require energy, (*i.e.*, they are absorbed passively). At the outer surface of the membrane, the cytochrome undergoes oxidation and loses one electron and in exchange picks up an anion. This is then transported to the inner side of the membrane through to the cytochrome chain and on the inner surface of the membrane the anion is released and the cytochrome gets reduced by the action of dehydrogenase involved in respiration.

The cations move passively along the electrical gradient created by the accumulation of anions at the inner surface of the membrane.

The evidence in favour of Lundegardh's hypothesis is that the respiration increases when a plant is transferred from water to salt solution. The increased respiration is called salt respiration or anion respiration.

Criticism

(i) It is applicable to absorption of anions only.

(ii) It fails to explain selective absorption of ions.

(iii) It has been observed that even cations can stimulate respiration.

(iv) ETS is poorly developed in anaerobically respiring forms.

Protein-lecithin carrier concept : Bennet-Clark (1956)

proposed that the carrier could be some amphoteric molecule which can carry anions as well as cations. He suggested it to be a membrane-bound protein which is conjugated with a phosphatide called as lecithin. Lecithin functions as a carrier. According to this theory, the phosphate group in the phosphatide acts as the cation binding site and choline acts as the anion binding site. During transport, ions are picked up by lecithin to form an ion-lecithin-complex. The ions are released on the inner surface of the membrane due to hydrolysis of lecithin by the enzyme lecithinase into phosphatidic acid and choline.

Lecithin is resynthesised from these components in the presence of enzyme choline acetylase and choline esterase which requires ATP.

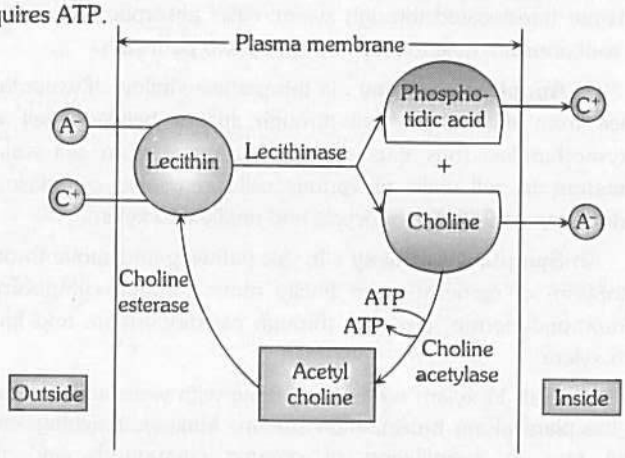


Fig : 4.2-3 The protein-lecithin carrier concept

Goldacre, 1952 proposed a mechanism of ion transport where contractile proteins act as ion carrier. They bind ions in unfolded condition on the outer face of the membrane and then contract releasing the ion into the cell and again become unfolded. The energy for this folding and unfolding is provided by ATP.

In hydrophytic plants, water and salts are absorbed by outer layer of plants.

Factors affecting mineral absorption

The process of mineral absorption is influenced by the following factors :

Temperature : The rate of absorption of salts and minerals is directly proportional to temperature.

The absorption of mineral ions is inhibited when the temperature has reached its maximum limit, perhaps due to denaturation of enzymes.

Light : When there is sufficient light, more photosynthesis occurs. As a result more food energy becomes available and salt uptake increases.

Oxygen : A deficiency of O_2 always causes a corresponding decrease in the rate of mineral absorption. It is probably due to unavailability of ATP. The increased oxygen tension helps in increased uptake of salts.

***pH* :** It affects the rate of mineral absorption by regulating the availability of ions in the medium. At normal physiological *pH* monovalent ions are absorbed more rapidly whereas alkaline *pH* favours the absorption of bivalent and trivalent ions.

Interaction with other minerals : The absorption of one type of ions is affected by other type. The absorption of K^+ is affected by Ca^{++}, Mg^{++} and other polyvalent ions. It is probably due to competition for binding sites on the carrier. However, the uptake of K^+ and Br^- becomes possible in presence of Ca^{++} ions. There is mutual competition in the absorption of *K, Rb* and *Cs* ions.

Growth : Due to proper development surface area, no. of cells and no. of binding sites for mineral ions are increased. From that mineral absorption is also increased.

Mineral translocation

P.R. Stout and D.R. Hoagland (1939) proved that mineral salts are translocated through xylem. After absorption of minerals by root, ions are able to reach xylem by two pathways.

(1) **Apoplast pathway :** In this pathway inflow of water takes place from the cell to cell through spaces between cell wall polysaccharides. Ions thus are able to move from cell wall of epidermis to cell walls of various cells in cortex, cytoplasm of endodermis, cell wall of pericycle and finally into xylem.

(2) **Symplast pathway :** In this pathway ions move through cytoplasm of epidermis and finally move through cytoplasm of cortex, endodermis, pericycle through plasmodesmata and finally into xylem.

Minerals in xylem are carried along with water to other parts of the plant along transpiration stream. Minerals reaching leaves take part in assimilation of organic compounds and then transported to other parts of the plant through phloem.

Nitrogen nutrition in plants

Higher plants generally utilize the oxidized forms such as nitrate (NO_3^-) and nitrite (NO_2^-) or the reduced form (NH_4^+) of nitrogen which is made available by a variety of nitrogen fixers. Nitrogen can be fixed by three methods :

Process of Nitrogen fixation

On the basis of agency through which the nitrogen is fixed the process is divided into two types abiological and biological.

(1) **Abiological :** They are two types :

(i) **Natural or Atmospheric nitrogen fixation :** By photochemical and electrochemical reactions, oxygen combines with nitrogen to form oxides of nitrogen. Now they get dissolved in water and combine with other salts to produce nitrates.

Physical nitrogen fixation out of total nitrogen fixed by natural agencies approximately 10% of this occurs due to physical processes such as lightening (*i.e.*, electric discharge), thunder storms and atmospheric pollution.

Due to lightening and thundering of clouds, N_2 and O_2 of the air react to form nitric oxide (NO). The nitric oxide is further oxidised with the help of O_2 to form nitrogen dioxide (NO_2).

$$N_2 + O_2 \xrightarrow{\text{Lightening}} 2NO$$

$$2NO + O_2 \xrightarrow{\text{Oxidation}} 2NO_2$$

NO_2 combines with H_2O to form nitrous acid (HNO_2) and nitric acid (HNO_3). The acid falls along with rain water. Now it acts with alkaline radicals to form water soluble NO_3^- (nitrates) and NO_2^- (nitrites).

$$2NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$$

$$HNO_3 + Ca \text{ or } K \text{ salts} \longrightarrow Ca \text{ or } K \text{ Nitrates}$$

The nitrates are soluble in water and are directly absorbed by the plants.

(ii) **Industrial nitrogen fixation :** Nitrogen and hydrogen combines to form ammonia industrially, under pressure and temperature.

(2) **Biological nitrogen fixation :** The conversion of atmospheric nitrogen into inorganic or organic usable forms through the agency of living organisms is called biological nitrogen fixation. The process is carried by two main types of microorganisms, those which are "free living" or asymbiotic and those which live in close symbiotic association of with other plants.

(i) **Asymbiotic biological nitrogen fixation :** This is done by many aerobic and anaerobic bacteria, cyanobacteria (blue green algae) and some fungi *e.g.* :

Free living bacteria : Free living N_2 fixing bacteria add 10–25 *kg* of nitrogen /ha/annum.

Aerobic	–	*Azotobacter*
Anerobic	–	*Clostridium*
Photosynthetic	–	*Chlorobium*
Chemosynthetic	–	*Thiobacillis*

Cyanobacteria (blue-green algae) *e.g., Anabaena, Nostoc, Tolypothrix cylindrospermum, Calotherix and Aulosira* etc. They add 20–30 *kg* of N_2 per hactare of soil and water bodies.

Free living fungi *e.g.*, Yeast cells and *Pullularia*.

(ii) **Symbiotic biological nitrogen fixation :** Symbiotic bacteria are found in the root nodules of the members of family Leguminosae. The best known nitrogen fixing symbiotic bacterium is *Rhizobium leguminosarum* (*Bacillus radicicola*).

Rhizobium penetrates to the cortex of root through infection thread. Simultaneously cortical cells or root are stimulated to divide more vigorously to form nodules on the root. Neither bacterium nor plant alone can fix nitrogen in such cases. Nitrogen fixation is actually the outcome of symbiotic relationship between the two. When a section of root nodules is observed the presence of a pigment, leghaemoglobin is seen to impart pinkish colour to it. This pigment is closely related to haemoglobin and helpful in creating optimal condition for nitrogen fixation. Like haemoglobin, leghaemoglobin is an oxygen scavenger. Fixation of nitrogen is done with the help of enzyme nitrogenase, which functions under anaerobic conditions. Leghaemoglobin combines with oxygen and protects nitrogenase.

Symbiotic bacteria (*Frankia*) have also been found to occur in root nodules of non-leguminous plants *e.g., Casuarina, Cycas, Alnus*, etc. Leaf nodules develop in some members of family Rubiaceae, the bacteria being *Mycobacterium*. Some cyanobacteria also have symbiotic association with plants *e.g.*, Lichens; *Anthoceros* (a liverwort) and *Azolla* (a water fern).

Mechanism of biological nitrogen fixation : Several schemes incorporating such idea have been proposed and Burris (1966) accepts that the total reduction of nitrogen occurs on an enzyme complex (Nitrogenase) without release of intermediates less reduced than ammonia.

The enzyme complex nitrogenase consists of two sub-units

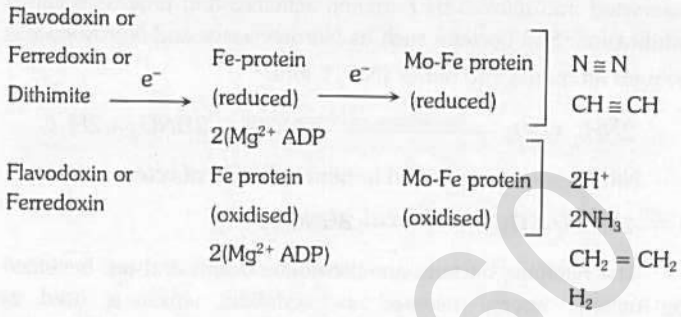
(i) A non-heme iron protein commonly called *Fe* protein (or dinitrogen reductase, component I).

(ii) An iron molybdenum protein called *MoFe* protein (or dinitrogenase, component II).

According to Burris (1966) hypothesis for nitrogen fixation suggesting the function of ATP and ferredoxin at each step in the reduction of nitrogen. The pretty function of ATP donor is furnished by pyruvate which also acts as electron donor for N_2 reduction as well.

Pyruvate on one hand acts as ATP donor while on other hand it supplies hydrogen ions and electrons for nitrogen reduction via $NADH_2$ and ferredoxin. The nitrogenase enzyme require 16 ATP molecules, 8 hydrogen ions and 8 electrons to reduce one molecule of nitrogen to $2NH_3$ molecules.

$$N_2 + 8e^- + 8H^+ + 16ATP \rightarrow 2NH_3 + H_2^+ + 16ADP + 16Pi$$



Explaining the mechanism of nitrogenase activity, its now believed that electrons are transferred from the reducing agent (Ferredoxin, Flavoprotein or Dithionite) to complex of *Mg*-ATP and Fe-protein (component II). From here electrons flow to *Mo-Fe* protein (component I) and then to substrate (nitrogen) which is finally reduced (to NH_3).

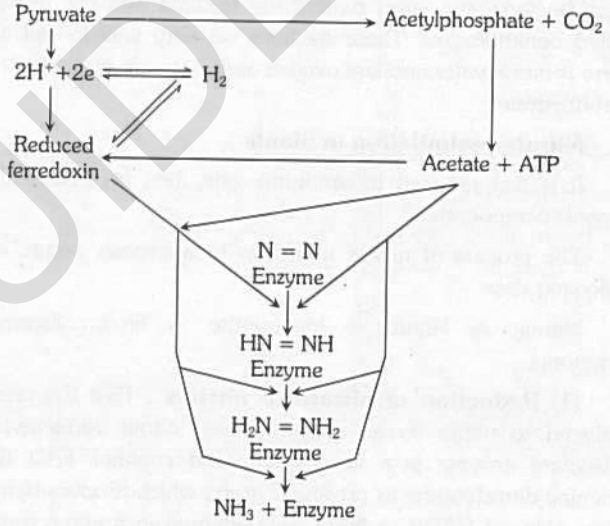


Fig : 4.2-4 Scheme suggesting the role of ATP and ferredoxin at each step in the reduction of nitrogen. Enzymes is nitrogenase (Burris, 1966)

The ammonia formed in biological nitrogen fixation is not liberated. It is highly toxic and is immediately converted into amino acids.

Ammonia + α-ketoglutarate + NADH $\xrightarrow{\text{Dehydrogenase}}$ Glutamate + NAD^+ + H_2O.

The amino acids are transported through phloem to other parts of the plant.

Ammonification and nitrification

The free living nonsymbiotic nitrogen fixing organisms do not enrich the soil immediately. It is only after organism death that the fixed nitrogen enters the cyclic pool by the two steps namely the ammonification and nitrification.

Ammonification : The nitrogenous organic compounds in the dead bodies of plants and animals are converted into ammonia or ammonium ions in the soil. This is carried out by ammonifying bacteria. Ammonia is toxic to the plants but ammonium ions can be safely absorbed by the higher plants.

Nitrification : Once ammonia has been produced it is converted into nitrates by nitrifying activities and process is called nitrification. Soil bacteria such as *Nitrosomonas* and *Nitrosococcus* convert ammonia into nitrite (NO_2^-) ions.

$$2NH_3 + 3O_2 \xrightarrow{\text{Nitrosomonas and Nitrosococcus}} 2HNO_2 + 2H_2O$$

Nitrites are then oxidised to nitrates by *Nitrobacter*.

$$2HNO_2 + O_2 \xrightarrow{\text{Nitrobacter}} 2HNO_3$$

The nitrifying bacteria are chemoautotrophs and are benefited by utilising energy released in oxidation, which is used in chemosynthesis. At soil temperatures 30°C – 35°C in alkaline soils and with sufficient moisture and aeration, the activity of ammonifying and nitrifying bacteria is found to be maximum.

Some bacteria such as *Thiobacillus denitrificans* and *Micrococcus denitrificans* also occur in the soil which convert the nitrate and ammonia into atmospheric free elemental nitrogen. Such bacteria are called denitrifying bacteria and the process is called denitrification. These bacteria act very well in soil where there is more water and less oxygen and there are high level of the carbohydrate.

Nitrate assimilation in plants

It is first reduced to ammonia and then incorporated into organic compounds.

The process of nitrate reduction to ammonia occurs in the following steps :

Nitrate → Nitrite → Hyponitrite → Hydroxylamine → Ammonia

(1) **Reduction of nitrate to nitrites :** First the nitrate is reduced to nitrite by an enzyme called nitrate reductase. The reductase enzyme is a flavoprotein and contains FAD (Flavin adenine dinucleotide) as prosthetic group which receives hydrogen from reduced NADP or NAD. Molybdenum in enzyme serves as electron carrier.

$$NO_3 + NADPH + H^+ \xrightarrow[FAD/FMN]{\text{Nitrate reductase}} NO_2^- + H_2O + NADP^+$$

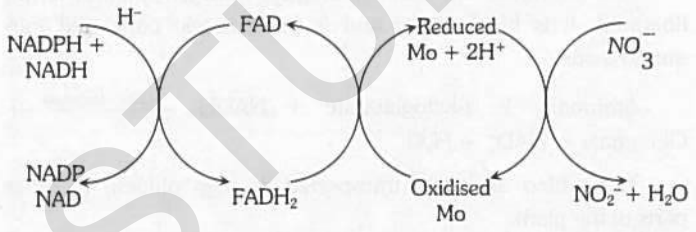


Fig : 4.2-5 Steps for nitrate reduction

(2) **Reduction of nitrites :** The nitrite ions are reduced to ammonia by an enzyme called nitrite reductase. This change occurs in leaves in the presence of light more rapidly and in dark with lesser speed. This is due to the reducing power of reaction from photochemical splitting of water.

$$2HNO_2 + 2H_2O \rightarrow 2NH_3 + 3O_2$$

Nitrite reductase does not need molybdenum but may require the presence of iron and copper. NADH and NADPH act as hydrogen donors.

Application of fertilizers : Most of the soil usually contain sufficient amounts of essential mineral elements for the better crop production. Some of them are, however, deficient in certain elements. These elements are required to be supplemented externally by adding the appropriate fertilizers. Moreover, constant agricultural cultivation in field may also cause depletion of certain elements which must be replenished in order to improve the fertility of soil. The important elements need to be replenished in crop fields are nitrogen, phosphorus and potassium. These are grouped as nitrogenous fertilizers, phosphate fertilizers and potash fertilizers. These are abbreviated as NPK. Common sources of NPK are ammonium chloride, ammonium sulphate, ammonium nitrate, bone meal, calcium magnesium phosphate and nitrate of soda.

Special modes of nutrition

The method of taking in and synthesis of various types of foods by different plants and animals is called nutrition.

Generally plants are autotrophic in their mode of nutrition, but there are some examples which are heterotrophic in their mode of nutrition. These plants are unable to manufacture their own food due to lack of chlorophyll or some other reasons.

(1) **Parasites :** These plants obtain either their organic food prepared by other organisms or depend upon other plants only for water and minerals with the help of which they can synthesize their own food. The living organism from which the parasite obtains its organic food or water and minerals is called host. Any part of the body of parasite is modified into a special organ called haustorium which enters into the cells of host and absorbs food or water and minerals from the host.

Parasites can be classified into two categories :

(i) Total parasites. (ii) Semiparasites or partial parasites.

(i) **Total parasites :** These plants never possess chlorophyll, hence they always obtain their food from the host. They may be attached to branches, stem (stem parasites) or roots (root parasites) of the host plants.

Total stem parasite : *Cuscuta* is a rootless, yellow coloured, slender stem with small scale leaves, which twines around the host. The parasite develops haustoria (Small adventitious sucking roots) which enter the host plant forming contact with xylem and phloem of the host. It absorbs prepared food, water and minerals from the host plant.

Total root parasite : Total root parasites are common in the families like Orobanchaceae, Rafflesiaceae, Balanophoraceae, etc. *Orobanche, Rafflesia* and *Balanophora* are some of the common root parasites.

Orobanche is commonly known as broom rape. It has scale leaves and pinkish or bluish flowers. The tip of the root of parasite makes haustorial contact with the root of host and absorbs food from the host. *Orobanche* is usually parasitic upon brinjal, tobacco. In *Rafflesia* (stinking corpse lily) another root parasite, vegetative parts of the plant are highly reduced and represented by cellular filaments resembling fungal mycelium. These filaments get embedded in the soft tissue of the host while the flowers emerge out in the forms of buds.

Balanophora occurs as a total root parasite in the roots of forest trees.

(ii) **Semiparasite or partial parasite :** Such parasitic plants have chlorophyll and, therefore, synthesize their organic food themselves. But they fulfil their mineral and water requirements from their host plants. These are of two types :

Partial stem parasites : The well known example of partial stem parasite is *Viscum album* (mistletoe) which parasitizes a number of shrubs and trees. The mature plant of *Viscum* is dichotomously branched with green leaves born in pairs attached on each node of stem. The shoots are attached to the host by means of haustoria. The primary haustoria reaches upto cortex of the host which runs longitudinally. It sends secondary haustoria which make connection with the xylem of the host and absorb water and minerals, *Loranthus* is another partial stem parasite.

Partial root parasites : The common example of partial (semi-parasite) root parasite is *Santalum album* (Sandal wood tree) which is an evergreen partial root parasite which grows in South India. It grows on the roots of *Dalbergia sisso, Eucalyptus*. Like other partial parasites, it also has green leaves and absorbs only minerals and water from the host plants.

Similarly, *Striga* on roots of sugarcane and *Thesium* on the roots of grasses are other partial root parasites.

(2) **Saprophyte :** These plants live upon dead organic matter and are responsible for conversion of complex organic substances into simple inorganic substances (minerals), *e.g.*, some bacteria, some fungi (*Yeast, Mucors, Penicillium, Agaricus*), few algae (*Polytoma*), few bryophytes (*Buxbaumia, Hypnum* and *Splanchnum*), few pteridophytes (like *Botrychium*) and some angiosperms (*Monotropa* and *Neottia*) also.

Monotropa, commonly known as Indian pipe, lacks chlorophyll and is colourless or ivory white. It is found in Khasi hills and in the dense forests of Shimla. *Monotropa*, though usually referred to as a saprophyte, actually gets its nourishment from fungal mycelium which surround its roots. Such association between roots of higher plants and fungi is known as mycorrhiza. *Neottia* (Bird's nest orchid) grows in the humus rich soil of the forests. It has very few reduced leaves and thick pale yellow stem. The roots lack root hairs and the nutrients are absorbed by mycorrhiza.

(3) **Symbiotic plant :** Sometimes two different species of organisms spend much or all of their lives in close physical association, deriving mutual benefit. Such an association is known as symbiosis and each organism is known as symbiont. Symbiotic association is so close that symbionts appear to be different parts of the same plant.

Symbiotic association may be between two higher plants or between a higher plant and a lower plant. Some common examples of symbiosis are described below.

Lichens : Lichens is a special group of plants, when an alga and fungus live together and are mutually benefitted (alga provides food and fungus provides water minerals and protection of alga).

The fungus component of the lichens, called mycobiont, is generally a member of Ascomycetae or occasionally a Basidiomycetae. The algal component of the lichen is known as phycobiont and is generally a member of Chlorophyceae (*e.g., Trebouxia*) or Cyanophyceae (*e.g., Nostoc, Gloeocapsa*).

Mycorrhiza : It is a mutually beneficial association between a fungus and the root of higher plant. In such association the fungal mycelium forms a mantle over the root surface and some of the hyphae penetrate between cortical cells and metabolites are transferred in both directions (*i.e.*, from fungus to the root cells and vice-versa).

Root nodules of leguminosae : Members of the sub-family Papilionaceae of the Leguminosae (*e.g.*, pea, beans, trifolium) harbour species of *Rhizobium*, a nitrogen fixing bacteria. The bacteria form nodules in the roots. They fix elemental nitrogen of the atmosphere and make it available to the plant in forms that can be utilized. In turn they derive food and shelter from the leguminous plant.

Myrmecophily : It is the symbiotic relationship between ants and some higher plants. The ants obtain food and shelter from the plant. They protect the plant (*e.g.*, Mango) from other animals. In *Acacia sphaerocephala* the stipules are hollowed to function as ant shelter. Leaflet tips (Belt's corpuscles) and rachis (extrafloral nectaries) possess feeding materials. A higher plant which is benefitted by association with ants is called myrmecophyte. The term myrmecophily is also used for pollination by ants.

(4) **Carnivorous or Insectivorous plants :** These plants are autotrophic in their mode of nutrition but they grow in marshy or muddy soils, which are generally deficient in nitrogen and in order to fulfil their nitrogen requirement, these plants catch small insects. The organs and specially leaves of these plants are modified variously to catch the insects. These plants have glands secreting proteolytic enzymes which breakdown complex proteins into simple nitrogenous substances, which inturn are absorbed by these plants. Some of these plants are as follows :

Drosera (Sundew) : It is a herbaceous plant having spathulate or lunate leaves. The leaves are covered by glandular hair with a swollen tip. The glands secretes a sticky purple juice which shines like a dew drop in bright light sunshine, hence the name sundew. These long special hair are generally referred to as 'tentacles'. When an insect alights on the leaf, the tentacles curve due to thigmonasty. The insect is killed and its proteins are digested by pepsin hydrochloride. Similar tentacles are also found in *Drosophyllum*.

Utricularia (Bladderwort) : It is submerged floating aquatic herb which lacks roots. Some of the species of *Utricularia* also occur in moist soil. The leaves are dissected into fine segments and appear like roots. Some of the leaf segments are modified into pear-shaped sacs called bladders or utricles.

The bladders are triangular or semicircular structures having a single opening guarded by a valve. There are numerous bristles near the mouth and digestive glands inside. The bladders show special trap mechanism. The valve of the bladder opens on the inner side. When small aquatic animalcules enter the bladder along with water current, they get trapped inside. Their proteins are digested enzymatically. When a bladder is full of undigested matter, it degenerasis.

Nepenthes (Pitcher plant) : They are commonly found in tropical areas like Assam and Meghalaya (*i.e., N. Khasiana*). It is an endangered species. In this plant the leaf base is winged, petiole is tendrillar and the lamina is modified into pitcher. The pitcher has a distinct collar at the mouth and the apex is modified into the lid. The undersurface of the lid has alluring glands whereas the inner surface of pitcher is lined by numerous digestive glands and several downward directed hair. The lid attracts insects which slide down into the pitcher. The downward directed hair check their escape. The insect is killed and its proteins are digested by pepsin hydrochloride. Other insectivorous plants having leaf pitchers are *Sarracenia, Cephalotus, Heliamphora*, etc.

Dionaea (Venus fly trap) : It is a small herbaceous plant found mainly in America. The plant has a rosette of radiating leaves. The petiole is winged and photosynthetic. The lamina is bilobed and the midrib acts like a hinge between the two lobes of the lamina. Each lobe has 15-20 trigger hairs or bristles. These hairs are very sensitive to nitrogenous substances. When an insect alights on the leaf and touches the sensitive hairs, the two lobes of lamina fold along the midrib. Thus the insect is trapped in between the lobes. Pepsin hydrochloride secreted by the digestive glands, present in the upper part of the lobes digests the insect.

Sarracenia (Pitcher plant; Devil's boot) : This pitcher plant is found in the temperate regions. It has a very reduced stem which bears a rosette of leaves. The leaves are modified into pitchers. It can easily be distinguished from *Nepenthes* on the basis of its trumpet-shaped sessile pitchers. The pitchers of *Sarracenia* lack digestive enzymes and here the insects are decomposed by bacteria.

Pinguicula (Butterwort) : It is a herbaceous plant having a basal rosette of ovate leaves. The leaf margins are slightly curved in upward direction. The dorsal (upper) surface of leaf has two types of glands stalked and sessile. The stalked glands secrete mucilage while the sessile glands secrete digestive enzymes.

Aldrovanda (Water flea trap) : It is also a rootless, submerged aquatic plant (bog plant) recalling the habit of *Utricularia*. The leaves are bilobed with long petioles. There are five bristle like outgrowths associated with the lamina. The leaf surface is covered by visid stalked glands. The proteins of the insect are digested enzymatically.

Tips & Tricks

- Woodward (1699) reported that plants grow better in muddy water as compared to fresh rain water.
- De Saussure (1804) first of all demonstrated that plants obtain minerals from soil through root system.
- Liebig for the first time discovered the presence of elements in plant ash.
- Tracer elements : These are radioactive isotopes of elements, which are used to detect various metabolic pathways in plants, *e.g.*, C^{14}, N^{15}, P^{32}, S^{35}, etc.).
- Hydroponics developed by Geriche.
- Venedium (*V*) is required by alga *Scenedesmus*.
- Selenium (*Se*) is required by *Atriplex* and *Astragalus*.
- Iodine is required by marine alga *Polysiphonia*.
- The elements taken in the form of gas by prokaryotes only is nitrogen.
- Critical elements are the elements in which soil is generally deficient *e.g., N, P* and *K*. These are given in form of fertilizers.
- Silica : Found in grasses and diatoms.
- Sodium : Found in halophytes.
- Cobalt : Found in ferns (*e.g., Lycopodium*) taking part in growth.
- Nickel : Enzyme urease uses it to hydrolyse urea by living organisms.
- *Dischidia* is the pitcher plant, which is without lid and it is used only for storing rain water.
- Haber-Bosch method is considered to be the best chemical method of fixing atmospheric nitrogen.
- In *Rhizobium* cobalt play an important role in nitrogen fixation and is an essential constituents of vitamin B_{12}. It is used in 'cancer therapy'
- Cytozyme is a water soluble commercial preparation which contains essential mineral element for use as foliar spray.
- The symptoms produced by the deficiency of mineral substances are called 'hunger sign'.
- Cytochromes act as anion carriers.
- Phytotron is the place or laboratory where plants can be maintained and studied under wide range of controlled conditions.
- Winogradsky (1891). Discovered biological nitrogen fixation.
- *Rafflessia* (largest flower in the world) was discovered by Sir Stamford Raffles from Java. Flower measures about a meter in diameter, about 11 *kg* in weight, smell is like rotten fish, pollination by elephants and found on roots of Vitis and Cissus.
- *Sapria himalayensis* (largest flower in India), measures 15 *cm* – 30 *cm* in diameter.
- *Cephalotus* (Fly Catcher). A deep rooted carnivorous herb with a rosette of pitchers for trapping small animals.
- Cuscuta/Amarbel/Akashbel/Dodder : A dicot with no cotyledon (some workers consider it to have a single cotyledon). It is a total stem parasite but initially grows on soil.
- Bird of paradise flower is Sterilitzia reginae.
- Certain plants require very high doses of nitrogen. They are called heavy feeders, *e.g.*, Zea mays.
- Arceuthobium is the smallest dic of angiospermic parasite. It is total parasite that grows on a number of forest trees including Pinus and Juniper.

Ordinary Thinking

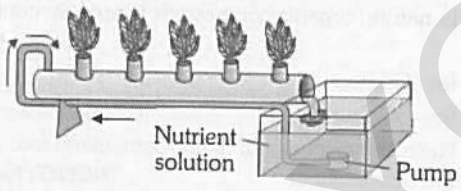
Objective Questions

General

1. Which one of the following is not an essential mineral element for plants while the remaining three are **[NCERT; MP PMT 1992; CBSE PMT (Mains) 2011]**
   (a) Cadmium (b) Phosphorus
   (c) Iron (d) Manganese

2. In plant nutrition elements are classified as major or minor depending on
   (a) Their availability in the soil
   (b) Their relative production in the ash obtained after burning the plants
   (c) The relative amounts required by the plants
   (d) Their relative importance in plant growth

3. The given figure shows hydrophonic / soil less plant production. Plants are grown in a tube or through placed on a slight incline. The arrows indicate the direction of flow of nutrient solution.
   Nutrient solution is sent to the elevated end of the tube from the reservoir by _____ and it flows back into reservoir due to _____ **[NCERT]**



   (a) Pump, Gravity (b) Gravity, Pump
   (c) Gravity, Gravity (d) Pump, Pump

4. Inorganic nutrients are present in the soil in the form of **[MP PMT 1999; BHU 2008]**
   (a) Molecules (b) Atoms
   (c) Electrically charged ions (d) Parasite

5. Sulphur is an important nutrient for optimum growth and productivity in **[CBSE PMT 2006]**
   (a) Fibre crops (b) Oilseed crops
   (c) Pulse crops (d) Cereals

6. An essential element is one **[NCERT]**
   (a) Improve plant growth
   (b) Present in plant ash
   (c) Is indispensable for growth and is irreplaceable
   (d) Available in soil

7. Hydroponics are **[NCERT; MP PMT 1992; KCET 1994; EAMCET 1995; CPMT 1998; Pb. PMT 1999; KCET 1999; AMU (Med.) 2005]**
   (a) Growing of aquatic plants
   (b) Growing of floating aquatic plants
   (c) Growing of plants in sand
   (d) Growing of plants aqueous balanced nutrient

8. Which of the following ions of heavy metals participate in process of photosynthesis in higher plants **[AMU (Med.) 2005]**
   (a) *Pb, Fe, Ni, Co* (b) *Mg, Zn, Cu, Hg*
   (c) *Mg, Mn, Co, Fe* (d) *Mg, Cu, Mn, Fe*

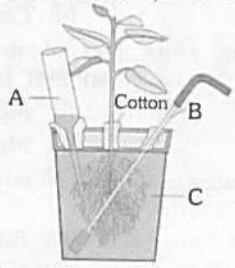
9. Necrosis means
   (a) Yellow spots on the leaves
   (b) Death of tissue and decomposition
   (c) Darkening of green colour in leaves
   (d) None of the above

10. Tracer elements are **[MP PMT 2002]**
    (a) Micro elements (b) Macro-elements
    (c) Radio isotopes (d) Vitamins

11. Essential elements for plants are **[MP PMT 2005; KCET 2007]**
    (a) Life cycle incomplete without it
    (b) Non replaceable
    (c) Metabolism (necessary for it)
    (d) All above

12. In hydrophytic plants, water and salts are absorbed by **[MP PMT 1992]**
    (a) Roots (b) Leaves
    (c) Stem (d) Outer layer of plants

13. The given figure shows a typical setup for hydrophonic technique. Choose the option which gives correct set of words for all the three blanks A, B and C **[NCERT]**



    (a) A - Funnel for adding water and nutrients, B - Aerating tube, C - Water
    (b) A - Funnel for adding nutrients only, B - Aerating tube, C - Nutrient solution
    (c) A - Funnel for adding water only, B - Aerating tube, C - Nutrient solution
    (d) A - Funnel for adding water and nutrients, B - Aerating tube, C - Nutrient solution

14. The number of essential elements required for normal growth of plant is **[BHU 2003]**
    (a) 10 (b) 16
    (c) 20 (d) 25

15. Aeroponic is also called as
    (a) Soilless cultivation of plants
    (b) Parthenocarpy
    (c) Vivipary
    (d) Phytotron

16. Who gave the criteria of essentiality
    (a) R. Hill (b) F.F. Blackman
    (c) M.P. Kaushik (d) D.L. Arnon

17. Which one of the following scientists used the nutrient culture solution in hydroponic cultures **[MP PMT 1995]**
(a) Sachs (b) Webster
(c) Wallace (d) Knop

18. Which group of element is not essential for a normal plant **[CBSE PMT 1996; AFMC 2009]**
(a) Potassium, calcium, magnesium
(b) Iron, zinc, manganese, boron
(c) Lead, nickel, iodine, sodium, barium
(d) Magnesium, iron, molybdenum

19. The charcoal culture experiment is better than water culture experiment because
(a) Plants get support
(b) Problem of aeration is removed
(c) Charcoal is an inert substance
(d) All the above

20. Which of the following is not caused by deficiency of mineral nutrition **[CBSE PMT 1997; MP PMT 2007]**
(a) Necrosis (b) Chlorosis
(c) Etiolation (d) Shortening internode

21. Cultivation by sand culture is also called **[MP PMT 1999]**
(a) Soilless cultivation (b) Green house effect
(c) Photorespiration (d) None of these

Macro-Nutrients

1. Which of the following is associated with electron transport in photosynthesis **[MP PMT 2012]**
(a) Sodium (b) Potassium
(c) Iron (d) Cobalt

2. Which element forms part of structure of chlorophyll molecule **[MP PMT 1995; CBSE PMT 2003]**
(a) *Fe* (b) *Mg*
(c) *K* (d) *Mn*

3. Deficiency symptoms of nitrogen and potassium are visible first in **[CBSE PMT 2014]**
(a) Roots (b) Buds
(c) Senescent leaves (d) Young leaves

4. In which of the following, all three are macronutrients **[NEET (Phase-I) 2016]**
(a) Boron, zinc, manganese
(b) Iron, copper, molybdenum
(c) Molybdenum, magnesium, manganese
(d) Nitrogen, carbon, phosphorus

5. Plants requiring two metallic compounds (minerals) for chlorophyll synthesis, are **[NCERT; CPMT 1994; Odisha JEE 2008]**

Or

One mineral activates the enzyme catalase and the other is a constituent of the ring structure of chlorophyll. These minerals are respectively **[Kerala PMT 2012]**
(a) *Fe* and *Ca* (b) *Fe* and *Mg*
(c) *Cu* and *Ca* (d) *Ca* and *K*

6. Which of the following is essential mineral element and is not a constituent of any enzyme but stimulate the activity of many enzymes **[BHU 1994]**
(a) *Zn* (b) *Mg*
(c) *Mn* (d) *K*

7. Interveinal chlorosis of leaves is caused by the deficiency of **[Kashmir MEE 1995]**
(a) Nitrogen (b) Calcium
(c) Potassium (d) Magnesium

8. Chlorosis occurs when plants are grown in
(a) Dark
(b) Shade
(c) Strong light
(d) *Fe* free medium or (due to lack of iron or magnesium)

9. *K, N, Ca, Mg* deficiency causes **[AFMC 2008; J & K CET 2010]**
(a) Chlorosis (b) Leaf curl
(c) Exanthema (d) Little leaf

10. The possible resource of phosphorus ions and nitrogen ions in soil generally get depleted because they are usually found as **[CBSE PMT 1994]**
(a) Positively charged ions
(b) Negatively charged ions
(c) A disproportionate mixture of negatively charged ions
(d) Particles carrying no charge

11. Which of the following does NPK (Critical element) denote **[NCERT]**
(a) Nitrogen, potassium, kinetin
(b) Nitrogen, protein, kinetin
(c) Nitrogen, protein, potassium
(d) Nitrogen, phosphorus, potassium

12. In nature, organic compounds invariably contain **[MP PMT 1996]**
(a) Carbon (b) Phosphorus
(c) Sulphur (d) Magnesium

13. Necrosis, or death of tissue particularly leaf tissue, is due to the deficiency of **[NCERT; Kerala PMT 2010]**
(a) *N, K, S* (b) *N, K, Mg* and *Fe*
(c) Mn, *Zn* and *Mo* (d) *Ca, Mg, Cu* and *K*
(e) *N, K, Mg, Fe, Mn, Zn* and *Mo*

14. Which element is require for the germination of pollen grain **[GUJCET 2007]**

Or

Which of the following element is very essential for uptake and utilization of Ca^{2+} and membrane function **[NCERT; Kerala PMT 2007]**
(a) Boron (b) Calcium
(c) Chlorine (d) Potassium

15. The appearance of yellow edges to leaves is due to deficiency of this mineral element **[Kerala PMT 2004]**
(a) Calcium (b) Magnesium
(c) Potassium (d) Sulphur
(e) Molybdenum

16. The most abundant element present in the plants is **[CBSE PMT 2004; CPMT 2010]**

Or

Which of the following is not absorbed through soil
(a) Manganese (b) Iron
(c) Carbon (d) Nitrogen

17. The major portion of the dry weight of plants comprises of **[CBSE PMT 2003]**

Or

Frame work elements in plants are

(a) Carbon, hydrogen and oxygen
(b) Nitrogen, Phosphorus and potassium
(c) Calcium, magnesium and sulphur
(d) Carbon, nitrogen and hydrogen

18. Those fertilizers, which provide all the essential elements such as *N*, *P* and *K* *etc.* required for plant growth, are called **[BHU 2001]**

(a) Direct fertilizers (b) Indirect fertilizers
(c) Complete fertilizers (d) Incomplete fertilizers

19. Which of the following element is used up in phosphorylation **[AFMC 2000, 12]**

(a) Calcium and sulphur
(b) Chlorine and maganese
(c) Iron and phosphorous
(d) Magnesium and phosphate

20. Which of the following is not an essential macro-element for the growth of plants **[CPMT 1993, 96, 1999]**

(a) *N* (b) *Zn*
(c) *Ca* (d) *K*

21. Most common free ion in a cell is

(a) *P* (b) *K*
(c) *Fe* (d) *B*

22. The major role of phosphorus in plant metabolism is **[MP PMT 1994]**

(a) To generate metabolic energy
(b) To evolve oxygen during photosynthesis
(c) To evolve carbon dioxide during respiration
(d) To create anaerobic conditions

23. In plants sulphur is found as

(a) Fast moving (b) Moving
(c) About non-moving (d) None of the above

24. Which one is not related with plant ash **[MP PMT 1997]**

(a) Trace elements (b) Essential elements
(c) Nitrogen (d) Mineral elements

25. Plants absorb phosphates as

(a) Soluble phosphate (b) All phosphates
(c) Phosphoric acid (d) As element

26. Which of the following is a macro nutrient **[CPMT 1994]**

(a) *Ca* and *Mg* (b) *Mo*
(c) *Mn* (d) *Zn*

27. Deficiency of which of the following element cause weakening of pedicel and petiole

Or

Which of the following is required for binding protein with nucleic acid

(a) Magnesium (b) Zinc
(c) Nitrogen (d) Calcium

28. Magnesium is mainly present in the form of

(a) Citrate (b) Bicarbonate
(c) Carbonate (d) Phosphate

29. The constant *pH* of body fluid is maintained by buffer salts like

(a) Potassium phosphates
(b) Sodium phosphates
(c) Adenosine monophosphate
(d) Sodium and potassium phosphates

30. Premature leaf fall is caused due to the deficiency of **[AFMC 1997]**

(a) Molybdenum (b) Sulphur
(c) Sodium (d) Phosphorus

31. Which of the following is considered to be the elements between macro-nutrients and micro-nutrients

(a) Iron (b) Nitrogen
(c) Phosphorus (d) Manganese

32. The cause of special flavour in onion and garlic is due to the presence of

Or

Yellowing of tea leaf takes place by the deficiency of

(a) Sulphur (b) Phosphorus
(c) Potassium (d) Nitrogen

33. Which is essential for root hair growth **[BHU 2005]**

Or

The mineral present in cell wall is **[MP PMT 2007]**

(a) *Zn* (b) *Ca*
(c) *Mo* (d) *S*

34. Rapid deterioration of root and shoot tip occurs due to the deficiency of **[DPMT 2004]**

(a) Calcium (b) Phosphorus
(c) Nitrogen (d) Carbon

35. About 98 percent of the mass of every living organism is composed of just six elements including carbon, hydrogen, nitrogen, oxygen and **[CBSE PMT 2007]**

(a) Phosphorus and sulphur (b) Sulphur and magnesium
(c) Magnesium and sodium (d) Calcium and phosphorus

36. Phosphorus is a structural element in **[Pb. PMT 1999]**

(a) Fat (b) Starch
(c) Nucleotide (d) Carbohydrate

37. Which of the following is not a macro-nutrient **[CPMT 1994]**

Or

Which is essential for the growth of root tip **[NEET (Phase-II) 2016]**

(a) *Mn* (b) *Ca*
(c) *Mg* (d) Phosphorus

38. Presence of phosphorus in a plant

(a) Brings about healthy root growth
(b) Retards fruit ripening
(c) Retards protein formation
(d) None of the above

39. Essential macroelements are **[MP PMT 1993]**

(a) Absorbed from soil
(b) Manufactured during photosynthesis
(c) Produced by enzymes
(d) Produced by growth hormones

Micro-Nutrients

1. A trace element is an element which **[NCERT]**
(a) Is a radioactive and can be traced by Geiger counter
(b) Is required in very minute amounts
(c) Draws other element out of protoplasm
(d) Was one of the first to be discovered in protoplasm

2. Micro-nutrients are **[CPMT 2002]**
(a) Less important in nutrition than macro-nutrients
(b) As important in nutrition as macro-nutrients
(c) May be omitted from culture media without any detrimental effect on the plant
(d) Called micro because they play only minor role in nutrition

3. Deficiency of molybdenum cause
(a) Poor development of vasculature
(b) Bending of leaf tip
(c) Yellowing of leaves
(d) Mottling and necrosis of leaves

4. Find out the correctly matched pair **[Kerala PMT 2012]**

Nutrients		Functions
(a) Zinc	–	Helps to maintain the ribosome structure
(b) Magnesium	–	Needed during the formation of mitotic spindle
(c) Calcium	–	Plays a role in the opening and closing of stomata
(d) Manganese	–	Needed in the splitting of water to liberate oxygen during photosynthesis
(e) Potassium	–	Needed in the synthesis of auxin

5. In a *Citrus* plantation, all the plants were found to be suffering from the die-back disease, spraying of fungicides was of no help. This problem was due to the deficiency of
(a) Copper (b) Gibberellic acid
(c) Zinc (d) Auxins

6. Appearance of brown spots surrounded by chlorotic veins is a prominent toxicity symptom of **[AMU (Med.) 2009]**
(a) *Mn* (b) *Mo*
(c) *Mg* (d) *Zn*

7. Which of the following is widely used metal cofactor **[CBSE PMT 2003]**
(a) Ca^{2+} (b) Al^{3+}
(c) Ni^{2+} (d) Mg^{3+}

8. For its activity, carboxypeptidase requires **[NCERT; CBSE PMT (Mains) 2012]**

Or

Which one is the co-factor of carbonic anhydrase **[WB JEE 2010]**
(a) Zinc (b) Iron
(c) Niacin (d) Copper

9. Apple fruit develop internal cork due to deficiency of

Or

'*Petiole crack*' is caused by the deficiency of
(a) Magnesium (b) Iron
(c) Manganese (d) Boron

10. Micronutrients are needed in amounts equivalent to **[AMU (Med.) 2010]**
(a) 8m mole/kg of dry matter (b) 18m mole/kg of dry matter
(c) 25m mole/kg of dry matter (d) 30m mole/kg of dry matter

11. Mottle leaf in citrus plants is due to deficiency of **[MP PMT 1997]**

Or

One of the causes of littles leaf disease is due to deficiency of **[J & K CET 2008]**
(a) Boron (b) Magnesium
(c) Zinc (d) None of these

12. The deficiency of molybdenum induces
(a) Citrus die back disease
(b) Pea rossete disease
(c) Cauliflower whip tail disease
(d) White bud of maize

13. Boron in green plants assists in **[CBSE PMT 2003]**
(a) Sugar transport (b) Activation of enzymes
(c) Acting as enzyme cofactor (d) Photosynthesis

14. Study the following lists

List-I		List-II	
(A)	Photolysis of water	(I)	Zinc
(B)	Diazotrophy	(II)	Copper
(C)	Cytochrome 'c' oxidase	(III)	Manganese
(D)	Biosynthesis of IAA	(IV)	Molybdenum
		(V)	Boron

The correct match is **[MP PMT 1992; EAMCET 2009]**

	A	B	C	D
(a)	III	II	I	V
(b)	III	IV	II	I
(c)	V	II	III	IV
(d)	IV	I	III	II

15. The deficiencies of micronutrients, not only affects growth of plants but also vital functions such as photosynthetic and mitochondrial electron flow. Among the list given below, which group of three elements shall affect most, both photosynthetic and mitochondrial electron transport **[NCERT; CBSE PMT 2005]**
(a) *Cu, Mn, Fe* (b) *Co, Ni, Mo*
(c) *Mn, Co, Ca* (d) *Ca, K, Na*

16. The elements arsenic, copper and murcury have which of the following effect
(a) Catalytic effect (b) *pH* effect
(c) Toxic effect (d) Antagonastic action

17. Deficiency of iron causes **[MP PMT 1995]**
(a) Bending of leaf tip
(b) Interveinal chlorosis first on young leaves
(c) Decrease of protein synthesis
(d) Reduced leaves and stunted growth

18. *Zn, Mo, Fe, Cu* are **[DPMT 2007]**
(a) Trace elements (b) Non-essential elements
(c) Macro nutrients (d) None of these

19. Gray speck disease in oats takes place by the deficiency of **[CBSE PMT 2003]**
(a) Zinc (b) Copper
(c) Potassium (d) Manganese

20. Which of the following is not a micro or trace element for plant growth **[MP PMT 1992, 2003; CBSE PMT 2007]**
(a) Boron (b) Molybdenum
(c) Manganese (d) Calcium

21. Which one of the following is not a micronutrient **[CBSE PMT (Pre.) 2010]**
(a) Boron (b) Molybdenum
(c) Magnesium (d) Zinc

22. The micronutrient least required by plants is **[DPMT 1992]**
(a) Calcium (b) Nickel
(c) Manganese (d) Boron

23. The plants accept *Zn* as **[CBSE PMT 2000]**
(a) *Zn* (b) Zn^{2+}
(c) *ZnO* (d) $ZnSO_4$

24. Major role of minor essential elements is to act as **[AIEEE Pharmacy 2004]**
(a) Co-factors of enzymes
(b) Building blocks of important amino acids
(c) Constituents of hormones
(d) Binders of cell structure

25. Which one of the following elements plays an important role in biological nitrogen fixation **[MP PMT 1992; CBSE PMT 1995, 2003; AFMC 2002; AIEEE Pharmacy 2004; DUMET 2009; CBSE PMT (Pre.) 2010]**

Or

Browning of cauliflower takes place due to deficiency of which one of the following elements
(a) Molybdenum (b) Manganese
(c) Copper (d) Zinc

26. Which one of the following nutrient serves as micro elements for plant growth **[MP PMT 1995; RPMT 1995; AMU (Med.) 2012]**
(a) Manganese, copper, calcium, zinc
(b) Sodium, potassium, boron, chlorine
(c) Sodium, nickel, chlorine, copper
(d) Copper, molybdenum, zinc, nickel

27. Which of the following is micro-element in plant **[CBSE PMT 1996; HP PMT 2005]**
(a) Manganese (b) Nitrogen
(c) Magnesium (d) Calcium

28. Which of the following is the importance of molybdenum in plants metabolism **[Pb. PMT 1999; BHU 2012]**
(a) Carbon assimilation
(b) Nitrate reduction
(c) Plant breeding
(d) Chromosome contraction

29. Which of the following element is a component of ferredoxin
(a) *Cu* (b) *Mn*
(c) *Zn* (d) *Fe*

Mineral absorption

1. Conduction of inorganic materials in plants occur mainly through **or** Minerals absorbed by roots move to the leaf through **[Manipal 1995]**
(a) Xylem (b) Phloem
(c) Sieve tube (d) None

2. Active transport from outside to inside of molecules across a membrane requires
(a) Cyclic AMP (b) Acetyl chlorine
(c) ATP (d) Phloroglucinol

3. Ion uptake is called active because
(a) Ions are active (b) Energy is expended
(c) Ions move freely (d) Ions move passively

4. Plants absorb mineral salts from the soil solution through
(a) A semipermeable membrane into the cytoplasm
(b) Perforation at the apex of root hair cells
(c) The cell wall which is semipermeable
(d) None of these

5. The theory which suggest that the CO_2 produced in respiration plays an important role in mineral absorption
(a) Contact exchange theory
(b) Carbonic acid exchange theory
(c) Active absorption theory
(d) None the above

6. All mineral salts are absorbed in cells as **[RPMT 1991, 95]**
(a) Ions (b) Atoms
(c) Molecules (d) All the above

7. Carrier proteins are involved in **[MP PMT 1998; BVP 2003]**
(a) Active transport of ions (b) Passive transport of ions
(c) Water transport (d) Water evaporation

8. Which statement is incorrect for ion–channels **[WB JEE 2008]**
(a) They are proteins
(b) Movement through them is simple diffusion
(c) Movement through them is from high to low concentration
(d) All ions pass through the same type of channel

9. Entry of mineral ions in plant root cells by diffusion is **[CBSE PMT 1996]**
(a) Passive absorption (b) Active absorption
(c) Osmosis (d) Endocytosis

10. Active uptake of minerals by roots mainly depends on the **[AIEEE Pharmacy 2003]**
(a) Availability of oxygen
(b) Light
(c) Temperature
(d) Availability of carbon dioxide

11. The plant ash is an indication of **[CPMT 2004]**
(a) Organic matter of plant
(b) Waste product
(c) Mineral salts absorbed by plants
(d) None of these

12. Minerals are absorbed by a plant from the soil by a process
(a) Independent of water absorption
(b) Dependent on water absorption
(c) Dependent on strength of solutions
(d) Dependent on osmosis

13. By which method ions are absorbed by plants **[RPMT 1992]**
(a) By difference in DPD
(b) By difference in water potential
(c) By carriers and pumps
(d) By molecular diffusion

14. Nobel prize of 1991 for discovering the single ion channels in cell was awarded to
(a) Waston and Hargobind Khorana
(b) Erwin Neher and Bert Stakmann
(c) Nirenberg and Kornberg
(d) Holley and Matthaei

15. In the light of carrier concept, the transport of ion across the membrane is
(a) Passive process (b) Non-osmotic process
(c) Osmotic process (d) Active process

16. If the amount of an ion absorbed by a root hair cell at 0° *C* is 5 *gm* and at 20° *C* is 20 *gm*. The amount of this ion absorbed actively should be
(a) 25 *gm* (b) 20 *gm*
(c) 15 *gm* (d) 5 *gm*

17. Solutes are absorbed by a plant cell through
(a) Osmosis (b) Diffusion
(c) Active absorption (d) Passive absorption

Nitrogen nutrition

1. Most of the plants obtain or absorb nitrogen from soil in the form of **[NCERT; Odisha PMT 2002; MP PMT 2005; AFMC 2010]**
(a) Free nitrogen gas
(b) Nitric acid
(c) Nitrite
(d) Nitrates and ammonium salt

2. In root nodules of legumes, leg-haemoglobin is important because **[NCERT; AMU (Med.) 2006; DUMET 2009]**
(a) It transports oxygen to the root nodule
(b) It acts as an oxygen scavenger
(c) It provides energy to the nitrogen fixing bacterium
(d) It acts as a catalyst in trans-amination

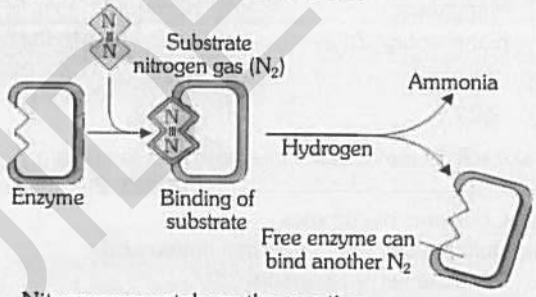
3. The possibility of increase of infectious disease become more due to more supply of
(a) Potassium (b) Magnesium
(c) Copper (d) Nitrogen

4. Cell elongation is adversely affected by
Or
Element required by plant in large quantity is **[DPMT 1992]**
(a) Sodium (b) Cobalt
(c) Manganese (d) Nitrogen

5. The enzyme responsible for the reduction of molecular nitrogen to the level of ammonia in leguminous root nodule is **[Kerala PMT 2009; AIIMS 2013]**
Or
The enzyme responsible for atmospheric nitrogen fixation is **[AIIMS 2000; CBSE PMT 2001]**
(a) Nitrogenase (b) Nitrate reductase
(c) Nitrite reductase (d) Hydrogenase
(e) Carboxylase

6. An important essential element is necessary in plants for protein synthesis
Or
The most important element associated with protoplasm and proteinaceous materials of plant is **[MP PMT 2010]**
(a) Calcium (b) Phosphorus
(c) Magnesium (d) Nitrogen

7. The given figure represents the Nitrogen fixation. See the diagram and select the correct option



I. Nitrogenase catalyses the reaction
II. The formation of ammonia is a reductive process
III. One molecule of nitrogen produces two molecules of ammonia
IV. Nitrate reductase catalyse the reaction
V. Formation of ammonia is an oxidative process
VI. One molecule of nitrogen produces one molecule of ammonia **[NCERT]**
(a) III, IV and V are correct (b) I, V and VI are correct
(c) IV, V and VI are correct (d) I, II and III are correct

8. Nitrogen is an important constituent of **[MP PMT 1994, 2002]**
(a) Proteins (b) Lipids
(c) Carbohydrates (d) Polyphosphates

9. Which one of the following is an amide involved in nitrogen assimilation by plants **[NCERT; Kerala PMT 2009]**
(a) Glutamate (b) Alanine
(c) Asparagine (d) Serine
(e) Glycine

10. $N_2 + 8_{e^-} + 8H^+ + 16ATP \rightarrow 2NH + H_2 + 16ADP + 16Pi$
The above equation refers to **[NCERT; Kerala PMT 2007]**
(a) Ammonification (b) Nitrification
(c) Nitrogen fixation (d) Denitrification
(e) Reductive amination

11. For its action, nitrogenase requires **[NCERT; CBSE PMT (Mains) 2012]**
(a) High input of energy (b) Light
(c) Mn^{2+} (d) Super oxygen radicals

12. Which one of the following can fix atmospheric nitrogen directly
(a) Pea (b) *Brassica*
(c) Castor (d) *Petunia*

13. N_2 fixation is **[CPMT 1996; MHCET 2003; Odisha JEE 2005]**
(a) $N_2 \rightarrow NH_3$ (b) $N_2 \rightarrow NO_3$
(c) $N_2 \rightarrow$ Amino acid (d) Both (a) and (b)

14. Nodules with nitrogen fixing bacteria are present in **[AFMC 2001; CPMT 2003]**
(a) Cotton (b) Gram
(c) Wheat (d) Mustard

15. Legume plants are important because they **[CPMT 2002]**
(a) Help in NO_2 fixation (b) Not help in NO_2 fixation
(c) Increased soil fertility (d) All of these

16. Knot like bodies known as 'nodules' found in the roots of groundnut plant are produced by **[BHU 2003]**
(a) *Azospirillum* (b) *Azotobacter*
(c) *Pseudomonas* (d) *Rhizobium*

17. The limiting factor in nitrification of soil is **[CPMT 2010]**
(a) Soil nature (*pH*) (b) Light
(c) Temperature (d) Air

18. Which of the following pigments is essential for nitrogen fixation by leguminous plants **[HP PMT 2005; AIIMS 2012]**
(a) Anthocyanin (b) Phycocyanin
(c) Phycoerythrin (d) Leghaemoglobin

19. Fertilizers have a formula written in a set of three figures 8 – 10 – 22. What for does it stand
(a) % of *Ca, Mg, P* (b) % of *N, S, P*
(c) % of *N, P, K* (d) % of *Fe, Mg, K*

20. The conversion of ammonia into nitrites and nitrates is called **[MP PMT 1996; J & K CET 2005]**
(a) Ammonification (b) Nitrification
(c) Denitrification (d) All of these

21. Nif genes occur in **[MP PMT 1996; CPMT 2004]**
(a) *Rhizobium* (b) *Aspergillus*
(c) *Penicillium* (d) *Streptococcus*

22. Nitrates are converted to nitrogen by **[Pb. PMT 2004]**
(a) Nitrogen fixing bacteria (b) Ammonification bacteria
(c) Denitrifying bacteria (d) Nitrifying bacteria

23. Symbiotic nitrogen fixation in non-leguminous plant is carried out by **[BHU 1994; Odisha JEE 2005]**
(a) *Azotobacter* (b) *Brodyrhizobiun*
(c) *Clostridium* (d) *Frankia*

24. Leguminous plants are able to fix atmospheric nitrogen through the process of symbiotic nitrogen fixation. Which one of the following statements is not correct during this process of nitrogen fixation **[CBSE PMT (Mains) 2010]**
(a) Leg haemoglobin scavenges oxygen and is pinkish in colour
(b) Nodules act as sites for nitrogen fixation
(c) The enzyme nitrogenase catalyses the conversion of atmospheric N_2 to NH_3
(d) Nitrogenase is insensitive to oxygen

25. Higher plants obtain nitrogen from soil that has **[MP PMT 2013]**
(a) Six forms (NO_3, NO_2, N_2O_2, N_2, NH_2OH, NH_3) of nitrogen with oxidation number ranging from +5 to –3
(b) Six forms (NO_3, NO_2, N_2O_2, N_2, NH_2OH, NH_3) of nitrogen with oxidation number ranging from +6 to –3
(c) Five forms (NO_3, NO_2, N_2, NH_2OH, NH_3) of nitrogen with oxidation number ranging from +5 to –3
(d) Five forms (NO_3, NO_2, N_2, NH_2OH, NH_3) of nitrogen with oxidation number ranging from +6 to –3

26. The first stable product of fixation of atmospheric nitrogen in leguminous plants is **[NEET 2013]**
(a) Glutamate (b) NO_2^-
(c) Ammonia (d) NO_3^-

27. Which two distinct microbial processes are responsible for the release of fixed nitrogen as dinitrogen gas (N_2) to the atmosphere **[NEET (Karnataka) 2013]**
(a) Aerobic nitrate oxidation and nitrite reduction
(b) Decomposition of organic nitrogen and conversion of dinitrogen to ammonium compounds
(c) Enteric fermentation in cattle and nitrogen fixation by *Rhizobium* in root nodules of legumes
(d) Anaerobic ammonium oxidation and denitrification

Special modes of nutrition

1. A plant that manufactures its own food is
(a) Autotroph (b) Parasite
(c) Epiphyte (d) Saprophyte

2. Plants which are unable to manufacture their food wholly or partially are
(a) Autophytes (b) Heterophytes
(c) Halophytes (d) Holophytes

3. In *Nepenthes* (Pitcher plant), the pitcher is formed due to modification of **[KCET 2004; Odisha JEE 2010]**
(a) Leaf petiole (b) Leaf lamina
(c) Tendril (d) Leaflet

4. Epiphytes are the plants which are dependent on other plants **[BHU 1996]**
(a) Only for water (b) For water and food
(c) Only for food (d) Only for shelter (support)

5. Partial parasite is dependent upon the host for
(a) Support (b) Food at times
(c) Water (d) Water and minerals

6. *Cuscuta* is an example of **[CPMT 1994, 2003; BVP 2000; CBSE PMT (Mains) 2012]**
(a) Ectoparasitism (b) Brood parasitism
(c) Predation (d) Endoparasitism

7. *Viscum album* grows on trees. This is an example of **[DPMT 2006]**
(a) Symbiosis (b) Parasitism
(c) Commensalism (d) Predation

8. Biotrophic nutrition is shown by **[CPMT 2010]**
(a) Humans (b) Saprophytic plants
(c) Invertebrates (d) Insectivorous plants

9. Insectivorous plants usually grow in soils which are deficient in **[BHU 1997, 2004; Pb. PMT 1999, 2001, 04; JIPMER 2000, 02; BVP 2001; Kerala CET 2002; AFMC 2003; Odisha JEE 2005; CPMT 2009]**
(a) Nitrogen (b) Water
(c) Organic matter (d) *Ca/Mg*

10. *Viscum* and loranthus are **[AFMC 2004]**
(a) Partial root parasite (b) Partial stem parasite
(c) Total root parasite (d) Total stem parasite

11. *Drosera* catches insects by means of
(a) Bladder
(b) Pitcher
(c) Tentacles secreting shining liquid
(d) Adhesive disc

12. *Balanophora/Orobanche* is a **[CPMT 1992; Bih. PMT 1994, 2002; BHU 1996]**

Or

Biggest flower belongs to a plant which is **[CBSE PMT 1999]**
(a) Total root parasite (b) Partial root parasite
(c) Partial stem parasite (d) Total stem parasite

13. *Santalum album is* **[DPMT 2002]**
(a) Partial root parasite (b) Partial stem parasite
(c) Total stem parasite (d) Total root parasite

14. Select the one, which is pitcher plant **[DPMT 1997; Chd. CET 1997]**
(a) *Drosera* (b) *Utricularia*
(c) *Sarracenia* (d) *Aldrovanda*

15. Bird of Paradise flower is **[JIPMER 2002]**
(a) *Ravenea madagascariensis*
(b) *Sterilitzia reginae*
(c) *Heliconia schlideana*
(d) *Musa chinensis*

16. Majority of the orchids are

Or

A plant growing on another plant without drawing any nourishment is
(a) Epizoics (b) Epiphytes
(c) Saprophytes (d) Parasites

17. Botanical name of Venus Fly trap is **[JIPMER 2000; Chd. CET 2002]**

Or

Insectivorous plant with rosette of spiny margined bilobed hinged and winged leaves for catching the prey is **[CPMT 1992]**
(a) *Aldrovanda* (b) *Dionaea muscipula*
(c) *Utricularia* (d) *Nepenthes*

18. One of the following in an insectivorous plant **[AFMC 1996]**
(a) *Balanophora* (b) *Orobanche*
(c) *Rafflesia* (d) *Drosera*

19. Which one is the largest root parasite **[BHU 1996, 98; CPMT 1998; MP PMT 2009]**
(a) *Rafflesia* (b) *Monotropa*
(c) *Arceuthobium* (d) All of these

20. *Nepenthes khasiana* is a/an **[AIIMS 1999; MP PMT 2012]**
(a) Fungicidal and wet land plant
(b) Insectivorous and endangered/endemic plant
(c) Fungicidal and endangered plant
(d) Insectivorous and wet land plant

21. Botanical generic name of bladderwort is **[MP PMT 2010]**

Or

A rootless aquatic in which a portion of leaf is modified to form a bladder for catching small aquatic animals is **[CPMT 1998; DUMET 2009]**
(a) *Drocera* (b) *Nepenthes*
(c) *Utricularia* (d) *Dionaea*

22. Plants obtaining food from other plants by means of haustoria are **[CPMT 1995; AFMC 2002; J & K CET 2010]**
(a) Symbionts (b) Parasites
(c) Hydrophytes (d) Saprophytes

23. Insects captured by carnivorous plants partially meet their requirement of **[CPMT 1996; Odisha JEE 1997; Pb PMT 1997]**
(a) Organic matter (b) Enzymes
(c) Water (d) Nitrogen

24. *Nepenthes* is **[MP PMT 1995]**
(a) Both producer and primary carnivore
(b) Producer
(c) Consumer
(d) None of these

25. *Rhizophora* is an example of **[RPMT 1995]**

Or

The plants that grow on saline soils with high concentration of NaCl, $MgSO_4$ and $MgCl_2$ are called **[Kerala CET 2003]**
(a) Lithophyte (b) Fresh water aquatic
(c) Mesophyte (d) Halophyte

26. A plant living symbiotically inside another plant is **[AFMC 1994]**
(a) Saprophyte (b) Endophyte
(c) Semiparasite (d) Parasite

27. Which is not an insectivorous plant **[Chd. CET 1997]**

Or

A pitcher plant without lid
(a) *Dionaea* (b) *Dischidia*
(c) *Drosera* (d) *Pinguicula*

28. A pair of insectivorous plants is **[CBSE PMT 1999; Odisha JEE 2009]**
(a) *Drosera* and *Rafflesia*
(b) *Nepenthes* and Bladderwort
(c) *Dionaea* and *Viscum*
(d) Venus fly trap and *Rafflesia*

29. Match the following with correct combination

Column I		Column II	
A.	Cuscuta	1.	Saprophyte
B.	Eichornia	2.	Pneumatophore
C.	Monotropa	3.	Insectivorous plant
D.	Rhizophora	4.	Parasite
E.	Utricularia	5.	Root pocket

[BHU 1999; KCET 2001; HP PMT 2001; Kerala PMT 2002, 08]
(a) A – 4, B – 3, C – 1, D – 5, E – 2
(b) A – 4, B – 5, C – 1, D – 2, E – 3
(c) A – 2, B – 3, C – 1, D – 5, E – 4
(d) A – 3, B – 1, C – 5, D – 4, E – 2
(e) A – 2, B – 5, C – 4, D – 3, E – 1

30. Pitcher plant is **[KCET 1998]**

Or

Drosera and *Sarracenia* are

(a) Herbivorous (b) Carnivorous
(c) Saprotroph (d) All of these

31. Which of the following is not an insectivorous plant **[AFMC 2004; J & K CET 2010]**

(a) *Drosera* (b) *Nepenthes*
(c) *Monotropa* (d) *Utricularia*

NCERT Exemplar Questions

1. When a plant undergoes senescence, the nutrients may be **[NCERT]**

(a) Exported (b) Withdrawn
(c) Translocated (d) None of the above

2. Choose the correct option mycorrhiza is a symbiotic association of fungus with root system which helps in

(A) Absorption of water (B) Mineral nutrition
(C) Translocation (D) Gaseous exchange

Options: **[NCERT]**

(a) Only (A) (b) Only (B)
(c) Both (A) and (B) (d) Both (B) and (C)

3. Which one of the following roles is not characteristic of an essential element **[NCERT]**

(a) Being a component of biomolecules
(b) Changing the chemistry of soil
(c) Being a structural component of energy related chemical compounds
(d) Activation or inhibition of enzymes

4. Which one of the following statements can best explain the term critical concentration of an essential element **[NCERT]**

(a) Essential element concentration below which plant growth is retarded
(b) Essential element concentration below which plant growth becomes stunted
(c) Essential element concentration below which plant remains in the vegetative phase
(d) None of the above

5. Deficiency symptoms of an element tend to appear first in young leaves. It indicates that the element is relatively immobile. Which one of the following elemental deficiency would show such symptoms **[NCERT]**

(a) Sulphur (b) Magnesium
(c) Nitrogen (d) Potassium

6. Which one of the following symptoms is not due to manganese toxicity in plants **[NCERT]**

(a) Calcium translocation in shoot apex is inhibited
(b) Deficiency in both Iron and Nitrogen is induced
(c) Appearance of brown spot surrounded by chlorotic veins
(d) None of the above

7. Reaction carried out by N_2 fixing microbes include **[NCERT]**

(a) $2NH_3 + 3O_2 \rightarrow 2NO_2^- + 2H^+ + 2H_2O$ (i)
(b) $2NO_2^- + O_2 \rightarrow 2NO_3^-$ (ii)

Which of the following statements about these equations is not true

(a) Step (i) is carried out by *Nitrosomonas* or *Nitrococcus*
(b) Step (ii) is carried out by *Nitrobacter*
(c) Both steps (i) and (ii) can be called nitrification
(d) Bacteria carrying out these steps are usually photoautotrophs

8. With regard to the Biological Nitrogen Fixation by *Rhizobium* in association with soyabean, which one of the following statement/statements does not hold true **[NCERT]**

(a) Nitrogenase may require oxygen for its functioning
(b) Nitrogenase is MO-Fe protein
(c) Leg-haemoglobin is a pink coloured pigment
(d) Nitrogenase helps to convert N_2 gas into two molecules of ammonia

9. Match the element with its associated functions/roles and choose the correct option among given below

A. Boron	i. Splitting of H_2O to liberate O_2 during photosynthesis
B. Manganese	ii. Needed for synthesis of auxins
C. Molybdenum	iii. Component of nitrogenase
D. Zinc	iv. Pollen germination
E. Iron	v. Component of ferredoxin

Options **[NCERT]**

(a) A-i, B-ii, C-iii, D-iv, E-v
(b) A-iv, B-i, C-iii, D-ii, E-v
(c) A-iii, B-ii, C-iv, D-v, E-i
(d) A-ii, B-iii, C-v, D-i, E-iv

10. Plants can be grown in (Tick the incorrect option) **[NCERT]**

(a) Soil with essential nutrients
(b) Water with essential nutrients
(c) Either water or soil with essential nutrients
(d) Water or soil without essential nutrients

Critical Thinking Objective Questions

1. Which of the following deficiency may cause leaf tip bending **[BVP 2003]**

(a) Sulphur (b) Nitrogen
(c) Phosphorus (d) Calcium

2. EDTA is much used in tissue cultures, it is a

(a) Hormone (b) Vitamin
(c) Buffer (d) Nutrient

3. Match the following and choose the correct combination from the options given

	Column I		Column II
A.	Potassium	1.	Constituent of ferredoxin
B.	Sulphur	2.	Involved in stomatal movement
C.	Molybdenum	3.	Needed in the synthesis of auxin
D.	Zinc	4.	Component of nitrogenase

[CBSE PMT 2003; Kerala PMT 2006, 10]

(a) A – 2, B – 1, C – 4, D – 3 (b) A – 1, B – 2, C – 3, D – 4
(c) A – 4, B – 3, C – 2, D – 1 (d) A – 1, B – 3, C –4, D –2
(e) A – 3, B – 4, C – 1, D – 2

4. Minerals known to be required in large amounts for plant growth include **[AIPMT (Cancelled) 2015]**

(a) Calcium, magnesium, manganese, copper

(b) Potassium, phosphorus, selenium, boron

(c) Magnesium, sulphur, iron, zinc

(d) Phosphorus, potassium, sulphur, calcium

5. Match the following mineral element with their deficiency symptom and choose the correct option

Column I		Column II	
A.	Calcium	1.	Chlorotic veins
B.	Potassium	2.	Delayed germination of seeds
C.	Zinc	3.	Necrosis of young leaves
D.	Iron	4.	Scorched leaf tips
E.	Phosphorous	5.	Malformed leaves

[Kerala PMT 2008]

(a) A – 3, B – 1, C – 5, D – 2, E – 4

(b) A – 1, B – 4, C – 5, D – 3, E – 2

(c) A – 3, B – 4, C – 5, D – 1, E – 2

(d) A – 2, B – 3, C – 4, D – 1, E – 5

(e) A – 4, B – 2, C – 1, D – 3, E – 5

6. Which of the following is considered to be the best chemical method of fixing atmospheric nitrogen **[BHU 2004]**

(a) Fisher method

(b) Decan method

(c) Haber-Bosch method

(d) Paranas-Meyerhoff method

7. Fly-ash is a/an **[BHU 2004]**

(a) Insectivorous plant

(b) Light airborne particulate matter

(c) New name of orchid plant

(d) Causal organism of various diseases

8. Which one of the following is correctly matched **[CBSE PMT (Pre.) 2012]**

(a) Passive transport of nutrients – ATP

(b) Apoplast – Plasmodesmata

(c) Potassium – Readily immobilisation

(d) Bakane of rice seedlings – F. Skoog

9. On the basis of symptoms of chlorosis in leaves, a student inferred that this was due to the deficiency of nitrogen. This inference could be correct only if yellowing of leaves appeared first in **[AIIMS 2007]**

(a) Young leaves

(b) Old leaves

(c) Young leaves followed by old leaves

(d) Old leaves followed by young leaves

10. *Aldrovanda* is

(a) Fly catcher plant (b) Water flea trap

(c) Devil's foot (d) None of these

11. Which of the following shows that metabolic energy is required in the absorption of ions

(a) More ions absorption in presence of oxygen

(b) Less absorption of ions in presence of oxygen

(c) More ions absorption in presence of ATP

(d) More ions absorption in presence of NAD

12. According to the well known theory of transport of solutes across a cell membrane, what happens when sugar is passed through it **[CBSE PMT 1992]**

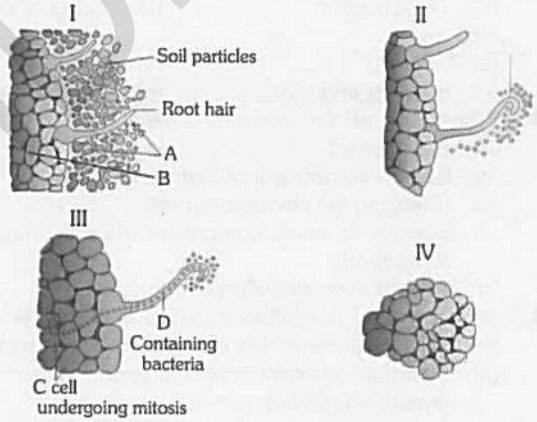
(a) Na^+ flows in the direction of the sugar

(b) Na^+ flows independent of sugar molecules

(c) Na^+ flows against the sugar molecules

(d) Na^+ ions do not flow at all

13. The given figure indicates the development of root nodule in soyabean



Identify A, B, C and D respectively **[NCERT]**

(a) A - *Nitrosomonas* bacteria; B - Cortex cell; C - Inner cortex; D - Infection thread

(b) A - *Rhizobial* bacteria; B - Endodermal cell; C - Inner Endodermis; D - Infection thread

(c) A - *Rhizobial* bacteria; B - Cortex cell; C - Inner cortex; D - Infection thread

(d) A - *Rhizobial* bacteria; B - Cortex cell; C - Outer cortex; D - Infection thread

14. The smallest angiospermic/dicot parasite is **[JIPMER 1997]**

(a) *Arceuthobium* (b) *Wolffia*

(c) *Cassytha* (d) *Rafflesia*

15. Fertility of the soil in rice fields can be improved by **[MP PMT 1992]**

(a) Gypsum (b) Sodium chloride

(c) Blue-green algae (d) *Rhizobium*

A/R Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : Plants lack excretory organs.
Reason : Plant usually absorb essential nutrients and lead a passive life. **[AIIMS 1997]**

2. Assertion : Leguminous plants are nitrogen fixers.
Reason : Leguminous plants have *Rhizobium* in their root nodules. **[AIIMS 1997]**

3. Assertion : Insectivorous habitat of plants is to cope up O_2 deficiency.
Reason : Insectivorous plants are partly autotrophic and partly heterotrophic. **[AIIMS 1998]**

4. Assertion : Use of fertilizers greatly enhances crop productivity.
Reason : Irrigation is very important in increasing crop productivity. **[AIIMS 2003]**

5. Assertion : Hydroponics is used for solution culture.
Reason : A balanced nutrient solution contains both essential and nonessential elements.

6. Assertion : The leaves of cauliflower become flaccid and brown in molybdenum deficiency.
Reason : Cauliflower plant is affected by whiptail disease in molybdenum deficiency.

7. Assertion : In *Dionaea*, each lamina has marginal teeth.
Reason : Marginal teeth of *Dionaea* help in prey capturing.

8. Assertion : Plants absorb nitrogen in the form of nitrate only.
Reason : Nitrogen is the most critical element.

9. Assertion : Magnesium is important in photosynthesis and carbohydrate metabolism.
Reason : Mg^{++} is involved in the synthesis of nucleic acids.

10. Assertion : Manganese is an activator of enzyme nitrite reductase.
Reason : Manganese deficient cells prefer ammonia over nitrate.

11. Assertion : Nitrogen-fixing bacteria in legume root nodules survive in oxygen-depleted cells of nodules.
Reason : Leghaemoglobin completely removes oxygen from the nodule cells. **[AIIMS 2004]**

12. Assertion : Deficiency of sulphur causes chlorosis in plants.
Reason : Sulphur is a constituent of chlorophyll, proteins and nucleic acids. **[AIIMS 2004]**

13. Assertion : Exanthema disease occurs due to deficiency of manganese.
Reason : Reclamation is a disease of cereals.

14. Assertion : Iron is a microelement.
Reason : Microelements are required in traces only, less than 1mg/gm of dry matter.

15. Assertion : In solution culture of plants, iron is added in the form of Fe-EDTA.
Reason : Hydroponics set-up is costly.

Answers

General

1	a	2	c	3	a	4	c	5	b
6	c	7	d	8	d	9	b	10	c
11	d	12	d	13	d	14	b	15	a
16	d	17	d	18	c	19	d	20	c
21	a								

Macro-Nutrients

1	c	2	b	3	c	4	d	5	b
6	d	7	d	8	d	9	a	10	b
11	d	12	a	13	d	14	a	15	c
16	c	17	a	18	c	19	d	20	b
21	b	22	a	23	c	24	c	25	b
26	a	27	d	28	c	29	d	30	d
31	a	32	a	33	b	34	a	35	d
36	c	37	a	38	a	39	a		

Micro-Nutrients

1	b	2	b	3	d	4	d	5	a
6	a	7	c	8	a	9	d	10	a
11	c	12	c	13	a	14	b	15	a
16	c	17	b	18	a	19	d	20	d
21	c	22	b	23	b	24	a	25	a
26	d	27	a	28	b	29	d		

Mineral absorption

1	a	2	c	3	b	4	a	5	b
6	a	7	a	8	d	9	a	10	a
11	c	12	a	13	b	14	b	15	d
16	c	17	c						

Nitrogen nutrition

1	d	2	b	3	d	4	d	5	a
6	d	7	d	8	a	9	c	10	c
11	a	12	a	13	d	14	b	15	c
16	d	17	a	18	d	19	c	20	b
21	a	22	c	23	d	24	d	25	a
26	c	27	d						

Special modes of nutrition

1	a	2	b	3	b	4	d	5	d
6	a	7	b	8	d	9	a	10	b
11	c	12	a	13	a	14	c	15	b
16	b	17	b	18	d	19	a	20	b
21	c	22	b	23	d	24	a	25	d
26	b	27	b	28	b	29	b	30	b
31	c								

NCERT Exemplar Questions

1	b	2	c	3	b	4	a	5	a
6	b	7	d	8	a	9	b	10	c

Critical Thinking Questions

1	a	2	c	3	a	4	d	5	c
6	c	7	b	8	c	9	c	10	b
11	c	12	a	13	c	14	a	15	c

Assertion and Reason

1	a	2	a	3	e	4	b	5	c
6	a	7	a	8	e	9	b	10	a
11	c	12	c	13	e	14	a	15	b

Answers and Solutions

General

2. (c) Major elements are required by plants in quantity of more than 1 milligram/gram dry matter and minor elements are required in quantity of less than 1 milligram/gram of dry matter.

6. (c) An essential element is the one which has a specific structural or physiological role and without which plants cannot complete their life cycle.

7. (d) Soilless production of plants is called hydroponics. A solution having all the essential elements in proper proportion is called normal or balanced nutrient solution.

9. (b) Necrosis is death of cells of an area which therefore, becomes discoloured.

10. (c) Tracer elements are radioactive isotopes of elements, which are used to detect various metabolic pathways in plants *e.g.*, $C^{14}, N^{15}, P^{32}, S^{35}$ etc.

15. (a) Aeroponic plants are grown with their roots bathed in nutrient mist. This method has been successfully used in growing *Citrus* and olive plants.

16. (d) Criteria for essentiality of elements were first of all given by Arnon.

17. (d) The nutrient solution composition proposed by Knop (1865) and Arnon and Hoagland's (1940) are commonly used.

20. (c) Etiolation is a type of growth exhibited by plants grown in darkness, usually in seed. They lack chlorophyll and therefore appears white or yellow.

21. (a) Sand culture plants are grown in inert sand + nutrient solution. Main advantage is that roots get natural environment and proper aeration.

Macro-Nutrients

2. (b) *Mg* is present in centre of chlorophyll molecule head.

3. (c) N and K are mobile elements.

5. (b) *Mg* is an important constituent of chlorophyll molecule where it occupies a central position and essential for photosynthesis and *Fe* plays an important role in ETS, photosynthesis and respiration because iron is the part of cytochromes. It is also essential for chlorophyll synthesis.

6. (d) According to Webster (1953) potassium is activator of more than 40 enzymes connected with phosphorylation, photosynthesis, starch synthesis, respiration, synthesis of chlorophyll, DNA and proteins.

7. (d) *Mg* is chief element of chlorophyll molecule.

9. (a) Magnesium is a component of porphyrin part of chlorophyll molecule.

10. (b) Phosphorus is absorbed by the plants from the soil in the form of phosphate ions $H_2PO_4^-$ and HPO_4^{2-} and nitrogen is absorbed by the plants in the form of nitrate ions (NO_3^-).

11. (d) Nitrogen, phosphorus and potassium are three critical elements which are essential for proper growth of plants *e.g.*, crop plants.

12. (a) Natural organic compounds are generally made up of carbon, hydrogen and oxygen.

14. (a) Boron has some role in the osmoregulation during the in vitro pollen fermination. Boron is responsible for maintaining the solubility of calcium in cells.

15. (c) The foliage leaves are the first to suffer from its deficiency. Their tips become scorched and margins become dull yellow in colour.

16. (c) Carbon is absorbed in the form of carbon dioxide.

17. (a) Carbon, hydrogen and oxygen together constitute about 94% of the total dry weight of the plant. *Frame work elements* : *C, H, N, O, P, S*; these six elements are called as frame work elements which constitute the body of plants.

18. (c) Fertilizers providing *N, P, K* and minerals is called complete fertilizer. Nitrogen is necessary for dividing tissues, phosphorus is required for development of young tissue, growth of them, potassium is required in meristematic tissue, growing tips, leaves etc. The deficiency of *N, P, K* cause yellowing of leaves and premature death.

21. (b) Potassium is the commonest free in the cell and help to keep the cell electrically neutral and perphaps stabilises emulsions.

22. (a) Phosphorus plays an indispensable role in energy metabolism *i.e.*, hydrolysis of pyrophosphate and various organic phosphate bonds being used to drive chemical reactions. Thus it is required for all phosphorylation reactions.

23. (c) Sulphur is relatively immobile and therefore, deficiency symptoms appear first in young leaves.

24. (c) In plant ash, nitrogen is not present because it releases out as its oxide when heated upto 600° *C* to obtain plant ash, however it is an essential element.

25. (b) Phosphorus is absorbed by the plants from the soil in the form of phosphate ions $H_2PO_4^-$ and HPO_4^{2-}.

26. (a) *Mo, Mn* and *Zn* are microelements.

27. (d) Calcium is essential for fat metabolism, carbohydrate metabolism, nitrate assimilation and binding of nucleic acid with proteins.

28. (c) Magnesium occurs in the soil in the form of magnesite ($MgCO_3$), dolomite ($MgCO_3, CaCO_3$), magnesium sulphate ($MgSO_4$) and as silicates. It is absorbed from the soil in form of ions (Mg^{++}).

30. (d) Phosphorus deficiency causes premature leaf fall and leaves become dark to blue-green in colour.

31. (a) Iron occurs in the concentration of less than 1 *mg/gm*. However, its essentiality was discovered along with other macroelements long before microelements were found to be required. Therefore, it is often regarded to be macroelement.

32. (a) Onion and its relatives also possess antimicrobial sulphur containing compounds allicin and diallylsulphide. Tear promoting substance is also a sulphur compound propanethial sulphenic oxide. Reduced meristematic activity and chlorotic leaves produce tea yellow disease of tea plants.

33. (b) Calcium stimulates development of root hairs.

34. (a) Meristematic regions found is stem, leaf and root tips are greatly affected by the absence of calcium because it is not rapidly translocated to these regions. Ultimately they die and thus stop the growth of these organs. Calcium involved in selective permeability of cell membranes. It activates certain enzymes required for development of stem and root apex and as calcium pectate in the middle lamella of the cell wall

36. (c) Nucleotide is made up by nitrogen base + sugar (ribose or deoxyribose) + phosphate.

38. (a) Phosphorus promotes healthy root growth and fruit ripening by helping translocation of carbohydrates.

Micro-Nutrients

1. (b) They are those essential elements which are required by plants in traces only, equal or less than 0.1 *mg/gm* of dry matter. They are eight in number – *Fe, Zn, Mn, B, Cu, Mo, Cl* and *Ni*.

2. (b) Micro-nutrients are present in less amount in plants but they are as important as macro-nutrients.

3. (d) Mottled chlorosis with marginal necrosis and infolding, lamina or upper half of lamina falls down (whiptail disease) due to the deficiency of molybdenum.

5. (a) *Cu* deficiency causes necrosis of the tip of the young leaves (*e.g.*, Citrus). The disease is called 'die back'.

7. (c) Some minerals are either components of enzymes, their cofactors or activators. *e.g.*, Ni_{2+}.

8. (a) Zinc is a cofactor for carboxypeptidases.

9. (d) Some of the physiological diseases caused due to boron deficiency are internal cork of apple, top rot of tobacco. These diseases can be cured by application of small doses of sodium tetraborate in the soil.

11. (c) The leaves become distorted and sickle shaped and get clustered to form rosettes. This effect is known as 'little leaf disease'.

12. (c) Its deficiency causes 'whiptail disease' in cauliflower and cabbage. The leaves first show an interveinal mottling and the leaf margins may become gray and flaccid and finally brown.

13. (a) Boron is absorbed by the plants as borate it is involved in the transport of carbohydrates (Sugar).

15. (a) *Cu*-Copper takes part in electron transport as plastocyanin (between PS II and PSI) and cytochrome to oxygen.

Mg–Manganese is activator of a number of enzymes like reductases, oxidases, etc. taking part in respiration and photosynthesis.

Fe – Iron is component of e^- transferring biomolecules like cytochromes and ferredoxin. They are essential components of photosynthesis.

16. (c) Many elements become toxic in higher concentration than the normal *e.g., Cu*. Others are toxic even in smaller concentration *e.g., Hg*.

17. (b) Iron deficient plants develop pronounced interveinal chlorosis similar to that caused by *Mg* deficiency. Whereas in iron chlorosis the young leaves may become yellow or white with prominent green veins.

19. (d) "Grey speck disease" in oat appears due to the deficiency of manganese, which leads to total failure of crop.

20. (d) Calcium is required by plants in larger amounts hence it is called macro or tracer element.

22. (b) Recent research has shown that some elements, such as cobalt, vanadium and nickel, may be essential for certain plants in very small amounts.

23. (b) Zinc is absorbed by the plants in ionic form.

24. (a) Micro-elements are mostly involved in the functioning of enzymes, as cofactors or metal activators.

25. (a) Molybdenum is required for nitrogen fixation. Nitrate metabolism depends upon enzyme nitrate reductase. It is an activator of nitrate reductase. Therefore, the element is important for nitrogen fixation.

26. (d) *Cu* (6 $\mu m/gm$), *Zn* (20 $\mu m/gm$) and *Mo* (.1 $\mu m/gm$) are required for plant growth.

28. (b) Molybdenum is component of nitrogenase and it also acts as enzyme activator for nitrate reductase.

29. (d) *Ferredoxin* is *Fe* having electron carrier which participates in photosynthesis. It plays an important role in ETS, photosynthesis and respiration because iron is the part of cytochromes.

Mineral absorption

1. (a) Because inorganic materials move with water.

2. (c) The use of energy of ATP in transferring solutes across membrane may be through an ATPase which creates a *pH* gradient across the membrane.

3. (b) It is mode of mineral absorption which involves expenditure of metabolic energy. Energy is generally obtained from ATP.

4. (a) The semipermeable membrane is responsible for absorption of mineral salts.

6. (a) Mineral salts are absorbed mostly in form of ions, *i.e.*, anions and cations. Ions are accumulated by the plants against their concentration in the soil.

7. (a) The carrier proteins usually transport solutes against their electrochemical gradient. Energy for transport is provided by ATP, electron transport chain and light.

9. (a) This type of absorption is carried out by purely physical forces.

11. (c) The ash that is left after burning any dry part of the plant in a crucible, contains only mineral elements and is called plant ash.

12. (a) Maximum mineral salt absorption occurs by zone of elongation. No mineral salt absorption occurs by root hair zone. Mineral salt absorption occurs directly by cells of epiblema and not by root hair.

15. (d) In this process an ATP is used up. ATP molecule combine with carrier molecules and allow passage of substances against concentration gradient.

16. (c) At 0° *C*, 5 *gm* ions are absorbed and at 20°*C*, 20*gm* ions are absorbed.

Energy is increased from 0°*C* to 20° *C*, then the increase in ion absorption amount = 20 – 5 =15 *gm*.

Nitrogen nutrition

1. (d) Chief source of nitrogen for plants are the nitrates of calcium and potassium.

3. (d) Nitrogen excess in soil cause susceptibility towards pathogen like fungi, bacteria.

4. (d) The deficiency of nitrogen causes chlorosis in leaves of the plants and the cell division as well as cell elongation is stopped, due to which plants remain dwarf and production of flowers, fruits and seeds is decreased.

6. (d) Nitrogen is absolutely essential for the synthesis of protein. In addition nitrogen is found in such important molecules as aminoacids, purines, pyrimidines etc. Purines, pyrimidines, RNA and DNA which are essential for protein synthesis.

11. (a) Nitrogenase require high input of energy and anaerobic condition.

12. (a) The bacterium *Rhizobium leguminosarum* lives symbiotically in the root of pea. This bacteria are responsible for the nitrogen fixation.

14. (b) Nitrogen fixing bacteria as *Rhizobium* have symbiotic relationship with the roots of gram (leguminous) plants. This association produce nodules on roots.

15. (c) The bacteria (*Rhizobium* sps.) associated with the root nodules of legumes fix atmospheric nitrogen. It helps in increase of soil fertility because they are rich in nitrogen and adds nitrates in the soil.

16. (d) The bacterium *Rhizobium* infects the roots through the root hairs of groundnut plant and reproduce in the cells of cortex of roots. Simultaneously the division of cortex cells take place due to which the nodules are formed in the root.

19. (c) The important elements need to be replenished in crop fields are nitrogen, phosphorus and potassium. These are grouped as nitrogenous fertilizers, phosphate fertilizers and potash fertilizers. These are abbreviated as NPK.

21. (a) Nif gene is present in *Rhizobium*. It is responsible for the synthesis of enzyme nitrogenase which can fix atmospheric nitrogen. *Rhizobium leguminosarum* bacteria is found symbiotically associated in the root nodules of leguminous plant.

22. (c) Some bacteria such as *Thiobacillus denitrificans*, *Pseudomonas aeruginosa* and *Micrococcus* denitrificans also occur in the soil which convert the nitrate and ammonia into atmospheric free elemental nitrogen.

23. (d) Frankia is symbiont in root nodules of several nonlegume plants like *Casuarina* and *Alnus* (Alder).

24. (d) Nitrogenase is sensitive against O_2.

Special modes of nutrition

1. (a) Autotrophs are green plants capable of synthesizing their own food from raw material (CO_2, water and sunlight). Thus they are independent and self nourishing.

2. (b) The heterotrophs, require both organic and inorganic substances from outside. All nongreen plants and animals, including human beings are heterotrophs.

4. (d) Epiphytes are plants which live on other plants for space (shelter/support) only. They are therefore, called space parasites.

5. (d) Partial parasite plants have chlorophyll and therefore, synthesize their organic food themselves. But they fulfil their mineral and water requirements from their host plants *e.g.*, *Viscum*.

6. (a) *Cuscuta* is found on outer side of the host and are total stem parasite.

7. (b) *Viscum album* is a partial stem parasite that grows on silverfish, poplar, apple, walnut, oak etc. The parasite sends a primary haustorium into the host for sucking food.

9. (a) Insectivorous plants usually grow in water logged and swampy soil deficient in nitrogen compounds. These plants leaves trap and digest the insects and other small animals to get their nitrogen requirements.

10. (b) *Loranthus* is another partial stem parasite. *Loranthus* is similar to viscum growing on Acacia, Mango, *Dalbergia*, *Albizzia* etc.

11. (c) *Drosera* is a herbaceous plant. These long special hair are generally referred to as tentacles. The glandular heads of the tentacles secrete sticky juice. Insect is attracted by the sticky fluid and tries to sit on the leaf, it becomes entangled in the sticky fluid.

12. (a) *Orobanche* is usually parasitic upon brinjal, tobacco. *Balanophora* occurs as a total root parasite in the roots of forest trees. *Rafflesia* is a total root parasite plant on Fig, *Cissus* and several other forest trees. They are largest with a diameter of $1m$ and weight of $11kg$.

13. (a) The common example of partial root parasite is *Santalum album*. Which is an evergreen partial root parasite. It grows on the roots of *Dalbergia sisso*, *Eucalyptus*.

14. (c) The leaves are modified into pitchers. The pitchers of *Sarracenia* lack digestive enzymes and here the insects are decomposed by bacteria.

16. (b) Epiphytic roots develop in some orchids which grow as epiphytes upon the trunk or branches of trees. They absorb moisture with the help of special sponge like tissue called velamen.

17. (b) Dionaea (Venus Flay Trap) is an American herb that possesses a rosette of long-petioled leaves.

19. (a) It is a total root parasite. The plant body consists of fine threads resembling hyphae of fungal mycelia. It lies completely inside the root of the host. It grows directly on the roots of *Cissus* and Figs.

21. (c) These insects die in the bladder and are decomposed in due course of time. After decomposition the nitrogenous substances are absorbed through the hair of bladder.

22. (b) A heterotrophic plant which obtains its food from other living organism without killing it, is called a parasite. The parasite sucks its food from the host with the help of specialized absorbing organs called haustoria.

23. (d) Because they grow in marshy or muddy soils, which are generally deficient in nitrogen. Plants usually grow in nitrogen deficient soils and fulfil their nitrogen requirement by digesting insects.

24. (a) *Nepenthes khasiana* is a green plant (photosynthetic plant) but shows heterotrophic nature for nitrogen supply, therefore, is called as carnivorous.

25. (d) Halophytes are those plants which grow in saline habitats, *i.e.*, in salty marshes, alkaline soil etc. In halophytes the water is present in sufficient amount but due to high osmotic concentrations it is physiologically not available to normal plants. Such conditions are said to be physiologically dry e.g. *Spartina*, *Atriplex*, *Portulaca*.

27. (b) *Dischidia* : The pitcher is without lid and is used only for storing rain water with some mud.

30. (b) Carnivorous plants (Pitcher plant) are green plants. They manufacture their food themselves. Hence are autotrophic in nature. They behave like heterotrophic organisms for supplementing their nitrogen supply only through catching and digesting small animals like insects. Insect captured by carnivorous plants (*Drosera* and *Sarracenia*) partially meet their requirement of nitrogen.

31. (c) *Monotropa*, though usually referred to as a saprophyte, actually gets its nourishment from fungal mycelium, which surround its roots. Such association between roots of higher plants and fungi is known as mycorrhiza.

Critical Thinking Questions

1. (a) Sulphur deficiency causes chlorosis in young leaves. Leaf tips and margins roll downwards and inwards. *e.g.*, Tomato, Tea etc.

2. (c) EDTA is buffer solution and it maintains the *pH* of culture medium.

6. (c) Haber-bosch method is the best chemical method for fixing of nitrogen.

7. (b) Fly-ash is a light airborne particulate matter. Coal also produces mineral ash. Some of which is discharged as fly ash.

9. (c) Chlorosis is the main symptom of nitrogen deficiency. As a result, the leaves gradually become pale or yellow. These symptoms first appear in old leaves and later in young leaves.

10. (b) *Aldrovanda* (Water flea trap) is an aquatic free floating rootless insectivorous plant which possesses leaves similar to those of *Dionaea*.

11. (c) The absorption of ions, involving use of metabolic energy is called active absorption. Energy is generally obtained from ATP. Therefore, active absorption is linked to hydrolysis of ATP.

14. (a) *Arceuthobium* is the smallest angiospermic parasite. It is total parasite that grows on a number of forest trees including *Pinus* and Juniper.

15. (c) *Aulosira fertilissima* (Blue-green algae) is an important nitrogen fixer of rice fields.

Assertion and Reason

1. (a) Plants absorb essential nutrients from soil hence they lack excretory organs. Particulate matter is not taken as these lack mouth.

2. (a) Leguminous plants have nodulated roots in which *Rhizobium* is present. So, these are able to fix nitrogen.

3. (e) Insectivorous plants are autotrophic and heterotrophic as they capture insects to overcome their N_2 deficiency.

4. (b) Among the sixteen essential plant nutrients nitrogen, phosphorus and potash are the most common nutrients found deficient in Indian soil. Supply of these nutrients to soil artificially through fertilizers is necessary to keep the soil rich in plant nutrients for achieving maximum yield. Irrigation practices also helpful in enhancing the crop yield. In this way both fertilizers and irrigation are equally important for high crop yield.

5. (c) Solution culture is being used for raising flowers and vegetables at home. This soilless production of plants is called hydroponics. A solution having all the essential elements in proper proportion is called normal or balanced nutrient solution.

6. (a) Cauliflower plants very commonly show whiptail disease. The leaves first shown an interveinal mottling and the leaf margins may become gray and flaccid and finally brown.

7. (a) The upper surface of each lamina lobe of *Dionaea* contains 3 sensitive spines. The leaf margin bears 12-20 curved spiny teeth. The marginal teeth get interlocked. So the prey cannot escape. It is digested by the secretion of reddish glands.

8. (e) Plants absorb nitrogen in the form of NO_3^- (nitrate) or NH_4^+ (ammonium ion). They can absorb NO_2^- (nitrite) as well but the same does not accumulate in the soil. Only a small quantity of nitrate or ammonium is available in the lithosphere. Therefore, nitrogen is the most critical element. Other critical elements are phosphorus and potassium.

9. (b) Magnesium is a constituent of the chlorophyll molecule, without which photosynthesis would not occur. Many of the enzymes involved in carbohydrate metabolism require magnesium as an activator. Magnesium is also an activator for those enzymes involved in the synthesis of nucleic acids (DNA, RNA) from nucleotide polyphosphate.

10. (a) Manganese plays an important role in nitrate reduction. Manganese acts as an activator for the enzymes nitrite reductase and hydroxylamine reductase. The preference of ammonia over nitrate as a nitrogen source by the manganese – deficient cells supports the above mentioned analysis of the role of manganese.

11. (c) *Rhizobium* species (*e.g.*, *Leguminosarum*, *R.lupini* etc) live in symbiotic association in the root nodules of leguminous plants like, pea, gram etc. In the soil the bacteria cannot fix nitrogen. After entering the legume root, the bacterium induces cell membrane. A pink-red pigment called leghaemoglobin lines the membrane and protects the bacteriods from the oxygen.

12. (c) Due to deficiency of sulphur plant shows chlorosis (*i.e.*, yellowing due to degradation of chlorophyll) followed by anthocyanin development. The younger leaves show chlorosis before older ones. Sulphur is not the constituent of chlorophyll. The main constituent of chlorophyll is magnesium.

13. (e) The most important diseases due to copper deficiency are exanthema and reclamation. Exanthema is a disease of fruit tree. Reclamation is disease of cereals that occurs chiefly on newly reclaimed peat land.

14. (a) Micro elements are those essential elements which are required by plants in traces only, less than 1 mg/gm of dry matter. Iron occurs in the concentration of less than 1 *mg/gm*.

15. (b) In solution culture, iron is added as Fe-EDTA. The agent which keeps metals in the soluble state is called chelating agent or ligand. Fe-EDTA complex is called chelate. The soilless production of plants is called solution culture or hydroponics. The cost of setting up a hydroponic system is very high.

Mineral Nutrition

SET Self Evaluation Test

1. The element which is required by the sea plants is
   (a) Cobalt (b) Zinc
   (c) Copper (d) Sodium
2. The ability of the venus fly trap of capture insects is due to **[CBSE PMT 2005]**
   (a) Chemical stimulation by the prey
   (b) A passive process requiring no special ability on the part of the plant
   (c) Specialized "muscle-like" cells
   (d) Rapid turgor pressure changes
3. It is possible to determine whether an element is essential by observing growth of plants **[AIEEE Pharmacy 2004]**
   (a) On soil form which the particular element is removed
   (b) On soil in which only the particular element is present
   (c) On an inert medium to which solution of only the particular element is added
   (d) On an inert medium to which a nutrient solution excluding that particular element, is added
4. Which statement is wrong
   (a) Plants take very little amount of mineral elements from soil
   (b) Plants absorb one thing at a time either water or mineral salt
   (c) Root hair absorb water and minerals together
   (d) Mineral absorption primarily takes place by active method
5. Chlorosis, etiolation and albinism are caused by the deficiency of **[JIPMER 1994]**
   (a) Iron, light and certain genes
   (b) Zinc, iron and magnesium
   (c) Magnesium, iron, zinc, light and certain genes
   (d) Magnesium, zinc and light
6. The association between ants and members of family rubiaceae is **[AMU (Med.) 1997; MP PMT 2013]**
   (a) Ornithophily (b) Entomophily
   (c) Myrmecophily (d) Anemophily
7. A trace element essential for plant growth and radioactive isotope which is used in cancer therapy is known as
   (a) Cobalt (b) Iron
   (c) Calcium (d) Sodium
8. The enzyme commonly presents in insectivorous plants to fulfil the need of their specific habit
   (a) *Trypsin* (b) *Pepsin*
   (c) *Pectinase* (d) *Cellulase*
9. An example of a parasitic plant that is also strictly epiphytic is
   (a) *Cuscuta* (dodder) (b) *Viscum* (mistletoe)
   (c) *Rafflesia* (d) *Orobanche*

AS Answers and Solutions

1	d	2	d	3	d	4	b	5	c
6	c	7	a	8	b	9	b		

2. (d) In *Dionaea* (Venus Fly Trap) an insect that happens to alight over the lamina and touch a sensitive spine twice in quick succession, causes the folding of the lamina. The curved marginal spines get interlocked and the insect gets trapped.
6. (c) The ants obtain food and shelter from the plant and they protect the plant from other animals.
8. (b) The insect is killed and its proteins are digested by pepsin.
9. (b) *Viscum* is a partial stem parasite with edible berries having sticky pulp.

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