CHAPTER 12

Mineral Nutrition

12.2 Essential Mineral Elements

1. Match the following concerning essential elements and their functions in plants.

	Column-I		Column-II
(A)	Iron	(i)	Photolysis of water
(B)	Zinc	(ii)	Pollen germination
(C)	Boron	(iii)	Required for chlorophyll biosynthesis
(D)	Manganese	(iv)	IAA biosynthesis

Select the correct option.

	(A)	(B)	(C)	(D)
(a)	(ii)	(i)	(iv)	(iii)
(b)	(iv)	(iii)	(ii)	(i)
(c)	(iii)	(iv)	(ii)	(i)
(d)	(iv)	(i)	(ii)	(iii)

(NEET 2020)

2. Which of the following elements is responsible for maintaining turgor in cells?
(a) Magnesium (b) Sodium
(c) Potassium (d) Calcium *(NEET 2018)*

3. In which of the following forms is iron absorbed by plants?
(a) Ferric
(b) Ferrous
(c) Free element
(d) Both ferric and ferrous *(NEET 2018)*

4. Which is essential for the growth of root tip?
(a) Zn (b) Fe
(c) Ca (d) Mn *(NEET-II 2016)*

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

6. The oxygen evolved during photosynthesis, comes from water molecules. Which one of the following pairs of elements is involved in this reaction?
(a) Magnesium and Molybdenum
(b) Magnesium and Chlorine
(c) Manganese and Chlorine
(d) Manganese and Potassium *(2015)*

7. Minerals known to be required in large amounts for plant growth include
(a) potassium, phosphorus, selenium, boron
(b) magnesium, sulphur, iron, zinc
(c) phosphorus, potassium, sulphur, calcium
(d) calcium, magnesium, manganese, copper.
(2015 Cancelled)

8. Deficiency symptoms of nitrogen and potassium are visible first in
(a) senescent leaves
(b) young leaves
(c) roots
(d) buds. *(2014)*

9. A few normal seedlings of tomato were kept in a dark room. After a few days they were found to have become white-coloured like albinos. Which of the following terms will you use to describe them?
(a) Mutated (b) Embolised
(c) Etiolated (d) Defoliated *(2014)*

10. Which of the following elements is a constituent of biotin?
(a) Magnesium
(b) Calcium
(c) Phosphorus
(d) Sulphur *(Karnataka NEET 2013)*

11. Best defined function of manganese in green plants is
(a) photolysis of water
(b) Calvin cycle
(c) nitrogen fixation
(d) water absorption. *(2012)*

12. Which one of the following elements in plants is not remobilised?
(a) Phosphorus (b) Calcium
(c) Potassium (d) Sulphur *(2011)*

13. Which one of the following is not an essential mineral element for plants while the remaining three are?
(a) Iron (b) Manganese
(c) Cadmium (d) Phosphorus
(Mains 2011)

14. An element playing important role in nitrogen fixation is
(a) molybdenum (b) copper
(c) manganese (d) zinc. *(2010)*

15. Which one of the following is not a micronutrient?
(a) Molybdenum (b) Magnesium
(c) Zinc (d) Boron *(2010)*

16. Manganese is required in
(a) plant cell wall formation
(b) photolysis of water during photosynthesis
(c) chlorophyll synthesis
(d) nucleic acid synthesis. *(2009)*

17. Which one of the following elements is not an essential micronutrient for plant growth?
(a) Zn (b) Cu
(c) Ca (d) Mn *(2007)*

18. A plant requires magnesium for
(a) protein synthesis
(b) chlorophyll synthesis
(c) cell wall development
(d) holding cells together. *(2007)*

19. Sulphur is an important nutrient for optimum growth and productivity in
(a) oilseed crops (b) pulse crops
(c) cereals (d) fibre crops. *(2006)*

20. Farmers in a particular region were concerned that pre-mature yellowing of leaves of a pulse crop might cause decrease in the yield. Which treatment could be most beneficial to obtain maximum seed yield?
(a) Application of iron and magnesium to promote synthesis of chlorophyll
(b) Frequent irrigation of the crop
(c) Treatment of the plants with cytokinins along with a small dose of nitrogenous fertilizer
(d) Removal of all yellow leaves and spraying the remaining green leaves with 2, 4, 5-trichlorophenoxy acetic acid *(2006)*

21. The deficiencies of micronutrients, not only affect 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?
(a) Co, Ni, Mo (b) Ca, K, Na
(c) Mn, Co, Ca (d) Cu, Mn, Fe *(2005)*

22. Gray spots of oat are caused by deficiency of
(a) Cu (b) Zn
(c) Mn (d) Fe. *(2003)*

23. Boron in green plants assists in
(a) activation of enzymes
(b) acting as enzyme co-factor
(c) photosynthesis
(d) sugar transport. *(2003)*

24. Mg is a component of
(a) chlorophyll (b) cytochrome
(c) haemoglobin (d) haemocyanin. *(2000)*

25. Plants take zinc in the form of
(a) $ZnSO_4$ (b) Zn^{++}
(c) ZnO (d) Zn. *(2000)*

26. When the plants are grown in magnesium deficient but urea rich soil, the symptoms expressed are
(a) yellowish leaves (b) colourless petiole
(c) dark green leaves (d) shoot apex die. *(2000)*

27. Which of the following is not caused by deficiency of mineral nutrition?
(a) Etiolation
(b) Shortening of internode
(c) Necrosis
(d) Chlorosis *(1997)*

28. Which one of the following elements is almost non-essential for plants?
(a) Zn (b) Na (c) Ca (d) Mo
(1996)

29. Which of the following elements plays an important role in biological nitrogen fixation?
(a) Copper (b) Molybdenum
(c) Zinc (d) Manganese *(1995)*

30. Mineral associated with cytochrome is
(a) Cu (b) Mg
(c) Cu and Mg (d) Fe. *(1991)*

31. Which one is an essential mineral, not constituent of any enzyme but stimulates the activity of many enzymes?
(a) Zn (b) Mn (c) K (d) Mg
(1989)

32. Phosphorus and nitrogen ions generally get depleted in soil because they usually occur as
(a) neutral ions
(b) negatively charged ions
(c) positively charged ions
(d) both positively and negatively charged but disproportionate mixture. *(1989)*

12.3 Mechanism of Absorption of Elements

33. Passive absorption of minerals depends on
(a) temperature
(b) temperature and metabolic inhibitor
(c) metabolic inhibitor
(d) humidity. *(2001)*

12.6 Metabolism of Nitrogen

34. The product(s) of reaction catalysed by nitrogenase in root nodules of leguminous plants is/are
(a) ammonia alone
(b) nitrate alone
(c) ammonia and oxygen
(d) ammonia and hydrogen. *(NEET 2020)*

35. *Thiobacillus* is a group of bacteria helpful in carrying out
(a) denitrification
(b) nitrogen fixation
(c) chemoautotrophic fixation
(d) nitrification. *(NEET 2019)*

36. Which of the following bacteria reduce nitrate in soil into nitrogen?
(a) *Nitrobacter* (b) *Nitrococcus*
(c) *Thiobacillus* (d) *Nitrosomonas*
(Odisha NEET 2019)

37. During biological nitrogen fixation, inactivation of nitrogenase by oxygen poisoning is prevented by
(a) carotene (b) cytochrome
(c) leghaemoglobin (d) xanthophyll. *(2015)*

38. The first stable product of fixation of atmospheric nitrogen in leguminous plants is
(a) NO_3^-
(b) glutamate
(c) NO_2^-
(d) ammonia. *(NEET 2013)*

39. Which two distinct microbial processes are responsible for the release of fixed nitrogen as dinitrogen gas (N_2) to the atmosphere?
(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 *(Karnataka NEET 2013)*

40. Which one of the following is wrong statement?
(a) *Anabaena* and *Nostoc* are capable of fixing nitrogen in free-living state also.
(b) Root nodule forming nitrogen fixers live as aerobes under free-living conditions.
(c) Phosphorus is a constituent of cell membranes, certain nucleic acids and all proteins.
(d) *Nitrosomonas* and *Nitrobacter* are chemo-autotrophs. *(2012)*

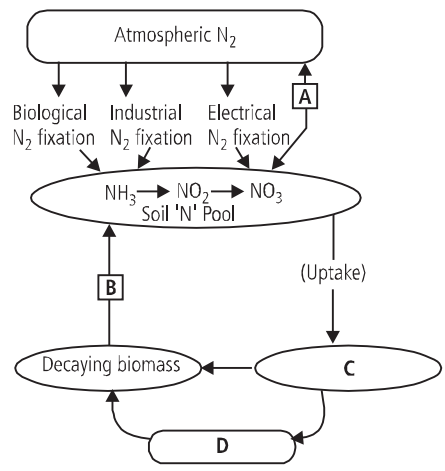
41. For its action, nitrogenase requires
(a) high input of energy
(b) light
(c) Mn^{2+}
(d) super oxygen radicals. *(Mains 2012)*

42. Nitrifying bacteria
(a) oxidise ammonia to nitrates
(b) convert free nitrogen to nitrogen compounds
(c) convert proteins into ammonia
(d) reduce nitrates to free nitrogen. *(2011)*

43. The function of leghaemoglobin in the root nodules of legumes is
(a) inhibition of nitrogenase activity
(b) oxygen removal
(c) nodule differentiation
(d) expression of *nif* gene. *(2011)*

44. 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?
(a) Leghaemoglobin 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.
(Mains 2010)

45. Study the cycle shown below and select the option which gives correct words for all the four blanks A, B, C and D.



	A	B	C	D
(a)	Nitrification	Ammoni-fication	Animals	Plants
(b)	Denitrification	Ammoni-fication	Plants	Animals
(c)	Nitrification	Denitri-fication	Animals	Plants
(d)	Denitrification	Nitrification	Plants	Animals

(Mains 2010)

46. One of the free-living, anaerobic nitrogen-fixer is
(a) *Beijerinckia* (b) *Rhodospirillum*
(c) *Rhizobium* (d) *Azotobacter*. *(2010)*

47. Which of the following is a flowering plant with nodules containing filamentous nitrogen-fixing microorganism?
(a) *Crotalaria juncea*
(b) *Cycas revoluta*
(c) *Cicer arietinum*
(d) *Casuarina equisetifolia* *(2007)*

48. If by radiation all nitrogenase enzyme are inactivated, then there will be no
(a) fixation of nitrogen in legumes
(b) fixation of atmospheric nitrogen
(c) conversion from nitrate to nitrite in legumes
(d) conversion from ammonium to nitrate in soil. *(2004)*

49. Roots of which plant contains a red pigment which have affinity for oxygen?
(a) Carrot (b) Soybean
(c) Mustard (d) Radish *(2001)*

50. What is true for cyanobacteria?
(a) Oxygenic with nitrogenase
(b) Oxygenic without nitrogenase
(c) Non oxygenic with nitrogenase
(d) Non oxygenic without nitrogenase *(2001)*

51. Which aquatic fern performs nitrogen fixation?
(a) *Azolla* (b) *Nostoc*
(c) *Salvia* (d) *Salvinia* *(2001)*

52. Enzyme first used for nitrogen fixation
(a) nitrogenase (b) nitroreductase
(c) transferase (d) transaminase. *(2001)*

53. Which of the following is free-living aerobic non-photosynthetic nitrogen-fixing bacterium?
(a) *Nostoc* (b) *Azospirillum*
(c) *Rhizobium* (d) *Azotobacter* *(1997)*

54. A non-photosynthetic aerobic nitrogen fixing soil bacterium is
(a) *Rhizobium* (b) *Clostridium*
(c) *Azotobacter* (d) *Klebsiella*.
(1994, 1990)

ANSWER KEY

1.	(c)	**2.**	(c)	**3.**	(a)	**4.**	(c)	**5.**	(*)	**6.**	(c)	**7.**	(c)	**8.**	(a)	**9.**	(c)	**10.**	(d)
11.	(a)	**12.**	(b)	**13.**	(c)	**14.**	(a)	**15.**	(*)	**16.**	(b)	**17.**	(c)	**18.**	(b)	**19.**	(a)	**20.**	(a)
21.	(d)	**22.**	(c)	**23.**	(d)	**24.**	(a)	**25.**	(b)	**26.**	(a)	**27.**	(a)	**28.**	(b)	**29.**	(b)	**30.**	(d)
31.	(c)	**32.**	(b)	**33.**	(a)	**34.**	(d)	**35.**	(a)	**36.**	(c)	**37.**	(c)	**38.**	(d)	**39.**	(d)	**40.**	(c)
41.	(a)	**42.**	(a)	**43.**	(b)	**44.**	(d)	**45.**	(b)	**46.**	(b)	**47.**	(d)	**48.**	(a)	**49.**	(b)	**50.**	(a)
51.	(a)	**52.**	(a)	**53.**	(d)	**54.**	(c)												

*None of the options is correct.

Hints & Explanations

1. (c)

2. (c) : Potassium helps in the maintenance of cell turgidity and opening and closing of stomata.

3. (a) : Iron is absorbed by plants in the form of ferric ions.

4. (c) : Calcium (Ca) is necessary for the proper growth and functioning of root tips and meristems.

5. None of the options is correct.
Macronutrients are essential elements which are present in easily detectable quantities, 1-10 mg per gram of dry weight. The macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, potassium, calcium and magnesium. Micronutrients or trace elements, are needed in very small amounts (equal or less than 0.1 mg/gm of dry matter). These include iron, manganese, copper, molybdenum, zinc, boron, chlorine and nickel.

6. (c) : Oxygen is evolved during photosynthesis by the process of photolysis of water taking place in

the membranes of grana thylakoids. The phenomenon of breaking up of water into hydrogen and oxygen in the illuminated chloroplasts is called photolysis or photocatalytic splitting of water. Light energy, an oxygen evolving complex (OEC) and electron carrier are required for this process. Oxygen evolving complex is attached to the inner surface of thylakoid membrane and the enzyme has four Mn ions. Light energised changes in Mn (Mn^{2+}, Mn^{3+}, Mn^{4+}) remove electrons from OH^- component of water forming oxygen. Liberation of O^2 also requires two other ions, Ca^{2+} and Cl^-.

$$4H_2O \rightleftharpoons 4H^+ + 4OH^-$$

$$4OH^- \xrightarrow[Mn^{2+},Ca^{2+},Cl^-]{\text{Oxygen evolving complex}} 2H_2O + O_2\uparrow + 4e^-$$

7. (c) : Minerals known to be required in large amounts for plant growth are called macroelements. Macroelements (macronutrients) are present in easily detectable quantities, *i.e.*, 1-10 mg per gram of dry matter. They are usually involved in the synthesis of organic molecules and development of osmotic potential. They are nine in number – C, H, O, N, P, K, S, Mg and Ca.

8. (a) : Deficiency symptoms appear first in young leaves and young tissues in case of elements which are relatively immobile inside the plant, *e.g.*, Ca, S. For mobile elements like N and K, deficiency symptoms first appear in old and senescent leaves as the elements are mobilised from senescing regions for supply to young tissues.

9. (c) : Etiolation is a process in which flowering plants are grown in the partial or complete absence of light. It is mainly characterised by long and weak stems and smaller, sparse pale yellow colour leaves due to longer internodes. Hence, because of lack of chlorophyll pigments due to deficiency of sunlight, tomato seedings become white-coloured like albinos.

10. (d) : Sulphur is present in two vitamins of B complex, thiamine and biotin. Biotin is important to hair. It is normally found in protein foods, such as eggs, lettuce, sprouts, etc.

11. (a) : Manganese (Mn^{2+}) is used for photolysis of water to produce oxygen and electrons during light reaction of photosynthesis. It is the phenomenon of breaking up of water into hydrogen and oxygen in the illuminated chloroplast. It acts as an essential cofactor.

12. (b)

13. (c) : C, H, O, N, P, K, S, Mg, Ca, Fe, B, Mn, Cu, Zn, Mo, Cl, Ni are essential elements, which has a specific structural or physiological role and without which plant cannot complete their life cycle.

14. (a) : Molybdenum is a micronutrient which is required in very minute amount by the plants. It is responsible for nodulation in legumes. It is part of nitrate reductase enzyme which helps in nitrogen fixation.

15. None of the options is correct.

Macronutrients are essential elements which are present in easily detectable quantities, 1-10 mg per gram of dry weight. The macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, potassium, calcium and magnesium. Micronutrients or trace elements, are needed in very small amounts (equal or less than 0.1 mg/gm of dry matter). These include iron, manganese, copper, molybdenum, zinc, boron, chlorine and nickel.

16. (b) : *Refer to answer 11.*

17. (c) : Calcium is an essential macronutrient for plant growth. Calcium is used as a calcium pectinate for the formation of middle lamella in cell wall for lipid metabolism, for cell division and cell enlargement. It helps in translocation of carbohydrates and also activates enzyme activity in plants. All other like Zn, Cu and Mn are micronutrients of plants.

18. (b) : Magnesium is an important constituent of chlorophyll, found in all green plants and essential for photosynthesis. The chlorophyll molecule has a tetrapyrolic or porphyrin head and a phytol tail. Mg atom is present in the centre of porphyrin head.

19. (a) : Sulphur is present in all the cells of the body in association with proteins made of sulphur containing amino acids, *viz.*, cystine, cysteine and methionine. Members of Family Brassicaceae and animal proteins are rich sources of sulphur. Other vegetable proteins (*e.g.*, pulses) have only little sulphur. Plants absorb sulphur from soil in the form of sulphate ions. It is a constituent of ferredoxin and some of the lipids present in chloroplasts. Pungent odour of mustard, cabbage, turnip, etc. of Family Brassicaceae is due to the presence of sulphur containing oils.

20. (a)

21. (d) : Iron is mainly available in the ferrous form and it is absorbed in the ferric form also. It is a part of catalases, peroxidases, cytochromes, etc., and plays a role in electron transport system in photosynthesis.

Manganese is absorbed by the plants when it is in the bivalent form. Manganese participates in the photolysis of water in pigment system II during photosynthesis and thus it helps in the electron transport from water to chlorophyll. Copper is absorbed on the clay particles as divalent cations, from where it can be absorbed by the plants by exchange mechanism. It is constituent of plastocyanin which takes part in electron transport during photosynthetic phosphorylation.

22. (c) : Gray spot diseases of oat is caused due to deficiency of manganese. Its symptoms include greyish-brown elongated specks and streaks, empty panicles, interveinal chlorosis on stem and leaves. The symptoms that occur only on leaves are irregular, greyish brown

lesions which coalesce and bring about collapse of leaf. This is called grey speck symptom.

23. (d) : Boron occurs in the soil as a part of silicates, boric acid, calcium borate and magnesium borate. It is available to the plants as boric acid and borates of calcium and magnesium. It plays a role in carbohydrate metabolism and translocation of sugar is facilitated through the cell membrane through the agency of borate ion as it forms complexes with the carbohydrates.

24. (a) : *Refer to answer 18.*

25. (b) : Zinc is available to the plants for absorption in the divalent form. The availability of zinc in soil decreases when the pH of soil shifts towards alkaline side. Zinc may form zinc phosphate in the soil which is insoluble and in that case, it is not available to the plants. It is essential for synthesis of tryptophan, amino acid which forms IAA (Indole Acetic Acid). Its deficiency causes chlorosis of older leaves.

26. (a) : Magnesium is important constituent of chlorophyll, thus it is found in all green plants and is essential for photosynthesis. It also helps in binding of ribosomal particles where protein synthesis occurs. It is also a part of many enzymes used in respiration. The deficiency symptoms of magnesium includes interveinal chlorosis in leaves and yellowing of leaves starting from basal to younger ones.

27. (a) : When the plants are kept in dark, they become pale yellow in colour and also become abnormally long with considerable internodal elongation, it is called etiolation. It is because 'flavonoids', which are inhibitors of GA are not formed in dark and hence in absence of flavonoids, GA show their full effect, i.e., elongation (etiolation).

28. (b)

29. (b) : *Refer to answer 14.*

30. (d) : Cytochromes are generally membrane-bound hemoproteins that contain heme groups and carry out electron transport. The heme group is a highly conjugated ring system (which means its electrons are very mobile) surrounding a metal ion, which readily interconverts between the oxidation states. For many cytochromes the metal ion present is that of iron, which interconverts between Fe^{2+} (reduced) and Fe^{3+} (oxidized) states (electron-transfer processes) or between Fe^{2+} (reduced) and Fe^{3+} (formal, oxidized) states (oxidative processes). Cytochromes are thus capable of performing oxidation and reduction.

31. (c) : Potassium is an essential mineral. It is not a constituent of any enzyme but accelerates the rate of activity of many enzymes. Potassium is rich in actively dividing cells of buds, young leaves and root tips. It is needed for proper growth and development. It regulates movement of stomata. A high amount of potassium is required in the process of protein synthesis.

32. (b) : Phosphorus and nitrogen ions generally get depleted in soil because they usually occur as negatively charged ions. Both the elements are essential for plants and act as macromolecules which are required in large quantities.

33. (a) : Rate of salt absorption increases when temperature increases but to a certain limit as salt absorption is inhibited at higher temperature because certain enzymes are not active at higher temperature and carriers are not synthesised. These carriers are required for active transport of salts from outer space in inner space. Rate of diffusion of ions and molecules increases at enhanced temperature due to their increased kinetic activity. Thus passive salt absorption will increase.

34. (d) : The enzyme nitrogenase is a Mo – Fe protein and catalyses the conversion of atmospheric nitrogen to ammonia. The reaction is as follows :

$$N_2 + 8e^- + 8H^+ + 16\ ATP \xrightarrow{\text{Nitrogenase}} \underset{\text{(Ammonia)}}{2NH_3} + \underset{\text{(Hydrogen)}}{2H^+} + 16ADP + 16\ Pi$$

35. (a) : Denitrification is the process opposite to nitrogen fixation in which nitrates (NO^-_3) get converted into N_2 gas by bacteria *Pseudomonas denitrificans* and *Thiobacillus denitrificans.*

36. (c)

37. (c) : Leghaemoglobin is a pinkish colour pigment present in the root nodules of leguminous plants. It acts as oxygen scavenger and prevents the inactivation of nitrogenase enzyme by oxygen poisoning.

38. (d) : Nitrogen fixation is the conversion of inert atmospheric nitrogen or dinitrogen (N_2) into utilisable compounds of nitrogen like nitrate, ammonia, amino acids, etc. There are two methods of nitrogen fixation - abiological and biological. Biological nitrogen fixation is performed by both free living and symbiotic forms. Symbiotic nitrogen fixing organisms hand over a part of their nitrogen to the host in return for shelter and food. The nodule of leguminous plants contains all the necessary biochemical components, such as the enzyme nitrogenase and leghaemoglobin, for nitrogen fixation. The enzyme nitrogenase is a Mo-Fe protein and catalyses the conversion of atmospheric nitrogen to ammonia, the first stable product of nitrogen fixation.

39. (d) : Denitrification is a chemical process in which nitrates in the soil are reduced to molecular nitrogen (N_2) which is released into the atmosphere. It is done by denitrifying bacteria like *Pseudomonas denitrificans.* Anaerobic oxidation of ammonium (NH_4) also releases nitrogen in the atmosphere.

40. (c) : Phosphorus is present in plasma membrane in the form of phospholipid bilayer. It is an essential component of all nucleic acids not 'certain' nucleic acids.

41. (a) : Nitrogenase enzyme is present in prokaryotic nitrogen fixers. The enzyme nitrogenase requires a high input of energy to carry out biological nitrogen fixation. This can be illustrated by the following equation :

$$N_2 + 8e^- + 8H^+ + 16\,ATP \xrightarrow{\text{Nitrogenase}} 2NH_3 + H_2 + 16ADP + 16\,Pi$$

42. (a) : Nitrifying bacteria involves the oxidation of ammonia to nitrates through nitrites called nitrification. Nitrite bacteria (*Nitrosomonas* and *Nitrococcus*) convert ammonia to nitrites whereas, nitrate bacteria (*Nitrobacter* and *Nitrocystis*) convert nitrite to soluble nitrates.

43. (b) : The root nodule of legume contains enzyme nitrogenase and leghaemoglobin. Nitrogenase catalyses the conversion of atmospheric nitrogen to ammonia. It is highly sensitive to the molecular oxygen and requires anaerobic conditions. The nodules have adaptations to ensure that the enzyme is protected from oxygen. To protect these enzymes, the nodule contains an oxygen scavenger called leghaemoglobin.

44. (d) : The enzyme nitrogenase is highly sensitive to the molecular oxygen.

45. (b) : A – Denitrification
B – Ammonification
C – Plants
D – Animals

46. (b) : Many free living bacteria and blue green algae are capable to fix atmospheric nitrogen *Rhodospirillum* is a free living photosynthetic anaerobic nitrogen fixing non-sulphur bacteria. It is capable of synthesizing its organic food in presence of light and in absence of O_2 by a process known as bacterial photosynthesis. *Beijerinckia* and *Azotobacter* are free living but aerobic nitrogen fixing bacteria. *Rhizobium* is a symbiotic nitrogen fixing bacteria.

47. (d) : Casuarinaceae is the family of dicotyledonous flowering plants placed in the Order Fagales. *Casuarina* is a member of the family, characterised by drooping equisteoid twigs, are evergreen, and monoecious or dioecious. The roots have nitrogen fixing nodules that contain the soil actinomycetes called *Frankia* which is filamentous bacteria.

48. (a) : The process by which N_2 is reduced to NH_4^+ is called nitrogen fixation. Nitrogenase enzyme catalyses this reduction. It is only carried out by prokaryotic microorganisms. Principal N_2-fixers include certain free living cyanobacteria in symbiotic associations with fungi in lichens or with ferns, mosses and liverworts; and by bacteria or other microbes associated symbiotically with roots, especially those of legumes. About 15 percent of the nearly 20,000 species in the Family Fabaceae (Leguminosae) have been examined for N_2 fixation and approximately 90 percent of these have root nodules in which fixation occurs. So without active nitrogenase enzyme there will be no N_2 fixation in legumes.

49. (b) : Leghaemoglobin is a red respiratory pigment found in the root nodules of leguminous plant if *Rhizobium* is present. It has affinity for oxygen. Soybean is a legume plant so it contains leghaemoglobin in its root nodules.

50. (a) : Cyanobacteria are gram negative prokaryotes which are popularly known as blue-green algae. Although cyanobacteria are true prokaryotes, but their photosynthetic system closely resembles with that of eukaryotes because they have chlorophyll *a* and photosystem II and they carry out oxygenic photosynthesis. Like the red algae, cyanobacteria use phycobiliproteins as accessory pigments. Photosynthetic pigments and electron transport chain components are located in thylakoid membranes lined with particles called phycobilisomes, which contain phycobilin pigments, particularly phycocyanin and transfer energy to photosystem II. They contain nitrogenase enzyme for nitrogen fixation. This enzyme becomes inactive in the presence of oxygen but the thick walled heterocysts provide suitable anaerobic enviornment for nitrogenase activity even in aerobic conditions.

51. (a) : *Azolla* is an aquatic fern which is inoculated in the rice field to increase the yield. *Azolla* contains *Nostoc* and *Anabaena* (BGA) in its leaf cavities which perform nitrogen fixation.

52. (a) : Nitrogen fixation involves conversion of atmospheric nitrogen to ammonia. It is done with the help of nitrogenase enzyme which occurs inside thick walled heterocysts of the blue green algae. These provide suitable anaerobic environment for nitrogenase activity even in aerobic conditions.

53. (d) : All plants need nitrogen to synthesize proteins, but for this purpose they are unable to utilize atmospheric nitrogen. Nitrogen fixation is brought about by two types of bacteria which are known as nitrogen fixing bacteria. One type is symbiotic nitrogen fixers that are associated with plants, *e.g.*, *Rhizobium* and *Azospirillum*. The other type of these bacteria are free living in the soil, *e.g.*, *Azotobacter* and *Nostoc*. *Nostoc* is photosynthetic and *Azotobacter* is non-photosynthetic. So that, the free living aerobic non-photosynthetic nitrogen fixing bacterium is *Azotobacter*.

54. (c) : *Refer to answer 53.*

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