Frequently asked questions:

1) What are the different forms of thiamine? Explain the role of thiamine in the human body.

Ans: The different forms of thiamin are free thiamin, thiamine monophosphate and thiamine pyrophosphate or thiamine diphosphate, thiamine triphosphate, adenosine thiamine triphosphate and adenosine thiamine diphosphate. Thiamin pyrophosphate is the active form. Their activation requires phosphorylation by kinases into the diphosphate and triphosphate esters. Thiamin pyrophosphate is essential for the conversion of pyruvate to acetyl CoA to generate energy. It is a co-enzyme for transketolase in the oxidation of glucose by the hexose monophosphate shunt.

2) Write the functions of Pantothenic acid.

Ans: Pantothenic acid is essential in the intermediary metabolism of carbohydrate, fat and protein. It is an integral part of co-enzyme A (CoA) which is involved in energy production from the macronutrients and acyl carrier protein (ACP) which is used in synthesis reactions. CoA is important in energy metabolism for pyruvate to enter the tricarboxylic acid cycle (TCA cycle) as acetyl-CoA, and for α-ketoglutarate to be transformed to succinyl-CoA in the cycle. The CoA and ACP forms are found in foods and their absorption requires hydrolysis to phosphopantetheine and later the conversion to pantothenic acid. It is absorbed by passive diffusion and active transport in the jejunum.

3) What is the role of niacin in the human body?

Ans: Niacin is essential in glycolysis, fat synthesis and tissue respiration. The different forms of niacin are nicotinic acid and nicotinamide. It is very essential for energy production and metabolism of cells. It is part of the pyridine nucleotide coenzymes nicotinamide adenine dinucleotide (NADH) and nicotinamide adenine dinucleotide phosphate (NADPH) which facilitate transport of hydrogen. These molecules are co-substrates for more than 200 enzymes involved in metabolism of carbohydrates, amino acids and fatty acids. It can be synthesized from tryptophan.

4) Which water soluble vitamin has a role in metabolism of proteins? Explain.

Ans: Pyridoxine in the form of pyridoxal phosphate are bound to protein and act as prosthetic group or co enzyme of enzymes which are involved in transamination, decarboxylation, transsulfuration, desulfuration and non-oxidative deamination reactions, primarily in the metabolism of proteins. Pyridoxal phosphate is also coenzyme for enzymes that are involved in the synthesis of heme, neurotransmitters, catecholamines and coenzyme A synthesis. It is essential in the biosynthesis of niacin from tryptophan and unsaturated fatty acids from essential fatty acids.

5) Which water soluble vitamin is essential during early fetal development? Explain its role.
Ans: Folate is essential during early fetal development due to its role in the biosynthesis of DNA and RNA as single carbon atom donors or acceptors. They also play a role as enzyme co-substrates in synthesis reactions in the metabolism of methionine and; formation and maturation of red and white blood cells

6) Which water soluble vitamin functions as an antioxidant? Explain its role.
Ans: Ascorbic acid or vitamin C are involved in oxidation-reduction reaction and act as antioxidants. Humans receive ascorbic acid from their diet which is absorbed by active transport and passive diffusion. Other roles of vitamin C are synthesis and production of collagen, neurotransmitters serotonin and norepinephrine, interferons conferring immunologic potential and carnitine. It converts ferric to ferrous state of iron thus facilitating iron absorption overall especially from the non-heme sources. It is also important in wound healing.

7) Write a note on vitamin like compounds present in the body.
Ans: Compounds such as choline, carnitine, myo-inositol, ubiquinone and bioflavonoids are classified under vitamin like compounds as the name suggests they have characteristics of vitamins and are essential. Few of them such as carnitine can be biosynthesized and few such as choline have to be provided in the diet. Choline is a structural component in the membrane phospholipids as phosphatidylcholine and in the neurotransmitter acetylcholine. Carnitine helps in energy production by the transport of long chain fatty acids into the mitochondria for oxidation in a process called carnitine transport shuttle. Myo-inositol in the form of phosphatidylinositol serves as an anchor for membrane proteins by covalent bonding. It is

essential for the biosynthesis of eicosanoids. They are important sources of intracellular signals and act as secondary cell messengers in response to hormonal stimuli. Ubiquinones are essential for the reversible redox reactions in the mitochondrial electron transport chain. Bioflavonoids help in reducing the risk of cardiovascular diseases and cancers.

8) What is bioavailability? What are the factors affecting bioavailability of water soluble vitamins?

Ans: Bioavailability refers to the degree to which an ingested nutrient undergoes intestinal absorption and metabolic function or utilization within the body. Bioavailability depends on the concentration of the vitamin present during consumption, composition of the diet, intestinal transit time, efficiency of the intestine to absorb nutrients, enzyme concentration, rate of conversion of vitamins to its active form and interaction of vitamins with other food components such as proteins, carbohydrates, fat.

9) Explain the structure of Vitamin $B_{12.}$

Ans: The molecular formula of Vitamin B_{12} is $C_{63}H_{88}CoN_{14}O_{14}P$. The structure of B_{12} is based on a corrin ring. The ring consists of 4 pyrrole subunits, joined on opposite sides by a C-CH_3 methylene link, on one side by a C-H methylene link, and with the two of the pyrroles joined directly. It is thus like a porphyrin, but with one of the bridging methylene groups removed. The nitrogen of each pyrrole is coordinated to the central cobalt atom. The central metal ion is cobalt. Four of the six coordination sites are provided by the corrin ring, and a fifth by a dimethylbenzimidazole group. The sixth coordination site, the center of reactivity, is variable, being a cyano group (-CN), a hydroxyl group (-OH), a methyl group (-CH_3) or a 5'-deoxyadenosyl group (here the C5' atom of the deoxyribose forms the covalent bond with Co), respectively, to yield the four B_{12} forms; cyanocobalamin, hydroxocobalamin, methylcobalamin and adenosylcobalamin respectively. The structure of B_{12} is the most complex of all vitamins

10) Explain the structure of folate.

Ans: The molecular formula of folate is $C_{19}H_{19}N_7O_{6.}$ Folic acid consists of pteridine nucleus, p-aminobenzoic acid and glutamate. In their reduced form cellular folates function conjugated to a polyglutamate chain. These folates are a mixture of unsubstituted polyglutamyl tetrahydrofolates

and various substituted one-carbon forms of tetrahydrofolate (e.g., 10-formyl, 5,10-methylene, and 5-methyl). The reduced forms of the vitamin, particularly the unsubstituted dihydro and tetrahydro forms, are unstable chemically. They are easily split between the C-9 and N-10 bond to yield a substituted pteridine and *p*-aminobenzoylglutamate, which have no biologic activity.

11) Explain the structure of biotin.

Ans: Biotin in nature appears as white crystalline needles. It is composed of an ureido (tetrahydroimidizalone) ring fused to a tetrahydrothiophene ring with a valeric acid side chain. Tetrahydrothiophene is a five membered ring containing four carbon atoms and one sulphur atom. The molecular formula is $C_{10}H_{16}N_2O_3S$

12) Explain the structure of thiamine, riboflavin and niacin.

Ans: Thiamin is named as the thio-vitamine or sulphur containing vitamin. It is a colorless organosulphur compound with the chemical formula $C_{12}H_{17}N_4OS$. Its structure consists of an amino pyrimidine and a thiazole ring linked by a methylene bridge. The thiazole is substituted with methyl and hydroxy ethyl side chains. Riboflavin is derived from ribose which is a sugar and flavus which means yellow. The ring moiety flavin imparts yellow color. Riboflavin appears as yellow orange crystals. The molecular formula is $C_{17}H_{20}N_4O_6$. Riboflavin has 3 benzene rings and 6 tetrahedron bond shapes. Niacin is a colorless compound which is a derivative of pyridine with a carboxylic acid at C-3 position. The molecular formula of niacin is $C_6 H_5NO_2$.

13) Explain the structure of Vitamin C

Ans: L-ascorbic acid is a carbohydrate like compound whose acidic and reducing properties are contributed by the 2,3-enediol moiety. It is highly polar and readily soluble in aqueous solution. Ascorbic acid contains two optically active isomeric forms, C-4 optical isomer D-ascorbic acid and C-5 optical isomer L-isoascorbic acid which is also known as erythorbic acid. The molecular formula is $C_6H_8O_6$.

14) Explain the structure of pantothenic acid and pyridoxine.

Ans: The molecular formula of pantothenic acid is $C_9H_{17}NO_5$ It is the amide between pantoic acid and β-alanine. The molecular formula of pyridoxine is $C_8H_{11}NO_3$. By replacing the hydroxymethyl ($-CH_2OH$) group on position 4 of the pyridoxine molecule with an amine (-

CH_2NH_2) and aldehyde (-CHO) respectively, two related compounds, pyridoxamine and pyridoxal can be formed which are also vitamin active.

15) What factors affect the stability of water soluble vitamins?

Ans: *Physical methods*: Processing such as milling and refining has shown decrease in water soluble vitamins such as pantothenic acid, riboflavin, biotin, niacin, thiamin, folic acid and vitamin B_6 which are concentrated in the germ and bran of the grain. Polishing of grains significantly reduce B-vitamins. They are easily washed out during food storage and processing. Refrigeration can minimize the loss of water soluble vitamins. Preliminary treatments such as trimming and washing of fruits and vegetables cause loss of vitamins present in the peel, skin or the discarded unedible part of the food. Cuts, damage, washing and cooking will leach water soluble vitamins.

Temperature: Thermal processes such as blanching which is an essential step during processing of fruits and vegetables to inactivate enzymes and to reduce microbial load on the surface has shown larger losses of water soluble vitamins. Canning which involves blanching as the preliminary step has shown loss of folate, pantothenic acid, thiamin, vitamin C, riboflavin and niacin. Thiamin is heat sensitive in neutral and alkaline foods and is unstable in air. High temperature short time retains vitamins than low temperature long time. Microwave heating has the potential for a greater retention of heat-labile vitamins compared with other more conventional methods because the heating time is shorter. Retention of vitamin C, B_1, B_2 and B_6 is higher in microwave heating than in conventional heating method. Freezing does not cause loss of vitamins.

Moisture: Water activity (a_w) greatly influences the stability of vitamins. Higher the water activity greater is the degradation rate. The process, temperature and exposure time decides the extent of loss of water soluble vitamins in dehydrated foods. Direct contact of the food material to the heated surface causes higher loss of water soluble vitamins than indirect methods such as spray drying.

Oxygen: Vitamins sensitive to oxidation such as ascorbic acid, folate and thiamin are lost during drying of foods.

Chemicals: Chemicals such as chlorine, sulphites, nitrites interact with vitamins by oxidation and reduction to inactivate water soluble vitamins. Sulfite ions directly react with thiamin causing inactivation. Sulfites also react with carbonyl groups and convert active vitamin B_6 aldehydes to their inactive sulfonated derivatives. Ascorbic acid prevents formation of N-nitrosamine in nitrite treated meat. The stability of ascorbic acid and thiamin is higher at lower pH and higher pH decreases the stability of ascorbic acid, thiamin, pantothenic acid and folates.

Light: Vitamin C, riboflavin, pyridoxine, folic acid and vitamin B_{12} become unstable when exposed to light.

Irradiation: Irradiation causes loss of thiamin whereas riboflavin and vitamin C shows better stability.