

Vitamins and Coenzymes

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Vitamins

- Vitamins are organic compounds which are needed in small quantities to sustain life.
- Get from food, because the human body either does not produce enough of them, or none at all
- Vitamins are organic molecules needed for variety of biological function within the body.
- The most important function of the vitamins is to serve as cofactors (co-enzymes) for enzymatic reactions
- protein + coenzyme (vitamin)= enzyme
- protein + cofactor (metal ion)= enzyme
- The vitamins cannot be synthesized by mammalian cells and, therefore, must be supplied in the diet in small quantities (microgram or milligram per day).

- **Enzyme:** a protein that is a catalyst
- **cofactor:** a small, inorganic or organic substance that facilitates enzyme action; includes both organic coenzymes made from vitamins and inorganic substances such as minerals
- **Coenzymes** are non-protein organic molecules that are mostly derivatives of vitamins soluble in water by phosphorylation; they bind apoenzyme to proteins to produce an active holoenzyme.
- **prosthetic group:** a cofactor permanently associated with the protein, often covalently bound.
- **Holoenzyme:** catalytically active enzyme-cofactor complex.
- **Apoenzyme:** an enzyme without its cofactor enzymatically inactive protein
- **free radicals:** unstable and highly reactive atoms or molecules that have one or more unpaired electrons in the outer orbital

Water - Soluble Vitamins

- **Vitamin B1 - thiamine**

- Converted to thiamine pyrophosphate coenzyme.
- Thiamine the water soluble vitamin of B complex, exist in tissues in the active form of Thiamine Pyrophosphate (TPP), Thiamine Pyrophosphate (TPP) is essential co-enzyme involve in energy extraction and cellular process in catabolism of sugar and amino acid.
- It is necessary for decarboxylation of pyruvic acid and α -ketoglutaric acid in citric acid cycle.
- It is necessary for transketolase reaction in HMPshunt of glucose metabolism
- It is obtained from unpolished rice,wheat germ,cereals,pulses,nuts,oils, meat,fish,milk and vegetables
- DEFICIENCY of vitamin B1 :
- Deficiency of vitamin B1 leads to disorder BERIBERI which is manifested by gastrointestinal,cardiovascular and neurological problem
- Gastrointestinal problem associated with anorexia and diarrhea
- Cardiovascular problem associated with palpitation.enlargement of heart and edema
- Neurological disorder associated with peripheral neuritis

Vitamin B2 – riboflavin (lactoflavin)

- Incorporated in FMN (Flavin MonoNucleotide) and FAD (Flavin Adenine Dinucleotide) coenzymes
- Active form of riboflavin is Riboflavin Phosphate• It is the central component of the cofactor FAD and FMN, and therefore required for energy metabolism• vitamin B2 is required for a wide variety of cellular processes transferring oxygen from plasma to the tissues.• It plays a key role in energy metabolism, and for the metabolism of fats, ketone bodies, carbohydrates and proteins.
- Obtained from milk,egg,liver,leafy vegetable.
- Deficiency of **vitaminB2** leads to cheliosis,glossitis and photophobia

Vitamin B3(niacin)

- Obtained from nicotinic acid
- It contains pyridine 3-carboxylic acid group
- Sources are liver,milk,tomato
- It forms two phosphorylated molecule NAD and NADP
- Deficiency leads to disorder *PELLAGRA* manifested by dermatitis,diarrhea and dementia.
- Sources are liver,milk,tomato,fish etc

Pantothenic Acid(vitamin B5)

- Pantothenic acid is used in the synthesis of co- enzyme A (CoA). And the coenzyme is formed when the vitamin combines with a derivative of ADP and the amino acid cysteine. Coenzyme A may act as an acyl group carrier to form acetyl-CoA and other related compound.
- CoA is also important in the biosynthesis of many important compounds such as fatty acids, cholesterol. • CoA is important in energy metabolism for pyruvate to enter the Kerbs cycle or tricarboxylic acid cycle (TCA cycle) as acetyl- CoA, • and for transformation of α -ketoglutarate to be transformed to succinyl-CoA in the cycle.
- Deficiency of pantothenic acid results in graying of hair,growth failure and loss of hair.

Vitamin B6 - pyridoxal (-ol, -amine)(pyridoxine)

- Derivative of pyridine molecule
- Permits cleavage of C - C, C - O, C - S, C - H, and C - N bonds in area of attachment, Very versatile, but amino group needed in substrate
- Pyridoxal,pyridoxol and pyridoxamine are collectively known as vitamin B6
- Pyridoxal phosphate(phosphorylated form of pyridoxine) is responsible for decarboxylation of Dopa to Dopamine,transamination of glutamic acid to α -ketoglutaric acid
- Deficiency of this vitamin leads to epileptiform convulsion in infants,peripheral neuritis in tuberculosis patient,microcytic hypochromic anaemia

Biotin (vitamin H/vitamin B7)

- Sulfur containing vitamin...obtained from egg yolk,liver,kidney,yeast,milk,tomatoes
- Biotin acts as Coenzyme for carboxylase enzyme and incorporate carboxylation reaction and CO₂ fixation.
- Biotin acts as coenzyme in fatty acid synthesis,carbohydrate metabolism,amino acid metabolism and purine synthesis
- Deficiency leads to nausea,anorexia,anemia,muscular pain.

Vitamin B9 (Folic acid)

- Folic acid is synthesized from pteridine,glutamic acid and p-amino benzoic acid(PABA)
- Active form of folic acid is tetra hydro folate(THF),acts as coenzyme for transferase enzyme.
- Folic acid acts as coenzyme in single carbon transfer reaction,helps in transmethylation reaction,helps in purine, pyrimidine,nucleic acid synthesis,necessary for maturation of RBC
- Deficiency of this vitamin leads to megaloblastic anemia.

Vitamin B12 (cyanocobalamin)

- It contains corin ring which is connected to(5,6 dimethyl benzimidazole nucleotide).
- A cobalt atom is attached to corin ring
- Obtained from all leafy vegetables,kidney,liver,meat and milk.
- Absorbed in intestine for which it needs intrinsic factor.in absence of intrinsic factor it is not absorbed in intestine

- It is necessary for maturity and development and maturation of RBC.acts as co-enzyme to transfer methyl group.converts RNA to DNA.
- Deficiency of this vitamin leads to Pernicious anemia.atrophy of mucous membrane of mouth and tongue and lesions in the central nervous system.

Lipoic Acid

It is a sulfur containing fatty acid.acts as coenzyme in the oxidative decarboxylation of pyruvic acid to Acetyl co-A and α -ketoglutaric acid to succinyl co-A.

Vitamin C - ascorbic acid ("antiscorbutic") ("anti-scurvy")

- Derivative of glucose.chemically it is enediol lactone of gluconic acid.it is oxidized to dehydroascorbic acid .it is a good reducing agent.both oxidized and reduced forms of Ascorbic acid is biologically active.
- Obtained from citrus fruits(lemon,oranges),berries,cabbage and tomatoes
- Necessary for functional activity of fibroblast and osteoclast.synthesizes collagen,operates oxidation and reduction reaction,helps in absorption of iron,converts folic acid to THF.
- Deficiency of this vitamin leads to Scurvy manifested by painful swelled joints,defective teeth and bone formation and haemorrhage.

Lipid-Soluble Vitamins

Vitamin A (antixerophthalmic factor)

- Fat soluble ,exist in three forms Retinol,Retinal and Retinoic acid.
- It is derived from carotenoids(provitaminA)
- Obtained from shark liver oil,cod liver oil
- It is necessary for growth and reproduction,bone teeth formation.maintenance of epithelium of normal skin and mucus membrane,
- It has antioxidant effect(neutralises free radical formation) thus reduces the risk of heart attack and cancer.it synthesizes Rhodopsin present in Rods(in retina) for vision in bright light and Iodopsin present in cones(in Retina) for vision in dim light.
- Deficiency leads to night blindness,xerophthalmia,keratomalacia(destruction of cornea),roughening of skin.

Vitamin D - 7-dehydrocholesterol

- Exist in 3 forms D2(ergocalciferol),D3(cholecalciferol)
- Obtained from shark liver oil,cod liver oil and egg yolk.
- Facilitates absorption of calcium and phosphorous in the intestine,development of bone and teeth,improves calcification of bones and hydrolyse phyllate to reduce risk of Rickets
- Deficiency leads to Rickets in childrens and osteomalacia in adults
- Excess of vitamin D leads to calcification of tissue and form renal calculi,

Vitamin E - tocopherol(α,β,γ forms)(α -active form)

- Antioxidant, Prevents sterility
- Obtained from sunflower oil, wheat germ oil, soyabean, egg, meat, fish
- It has antioxidant (prevent damage of vit-A and fatty acid) as well as anti-sterility function (growth and maintenance of ovary and seminiferous tubule).
- Deficiency leads to sterility, intrauterine death of foetus, muscle dystrophy, weakness, paralysis.
- Vitamin E is an antioxidant a substance that stops chain reactions caused by free radicals that can damage cells and affect its normal physiological function.
 - free radicals: is an unstable and highly reactive atoms or molecules that have one or more unpaired electrons in the outer orbital
 - Vitamin E acts primarily in lipid-rich areas of the body, where free radicals can initiate a chain of reactions known as peroxidation.

Vitamin K - phyloquinone in plants; menaquinone in animals and bacteria

- Exist in 3 forms (k1/k2/k3)
- K1(phyloquinone), k2(menaquinone), k3(menadione), k3 is potent among the three types.
- Necessary for blood coagulation, activating factors prothrombin factors II, VII, IX and X.
- Necessary for oxidative phosphorylation, acts as antidote for anticoagulant drugs.
- Deficiency leads to bleeding and haemorrhage.
- Deficiency occurs due to administration of antibiotic and malabsorption due to pancreatic disease.