

VITAMINS

➤ Definition

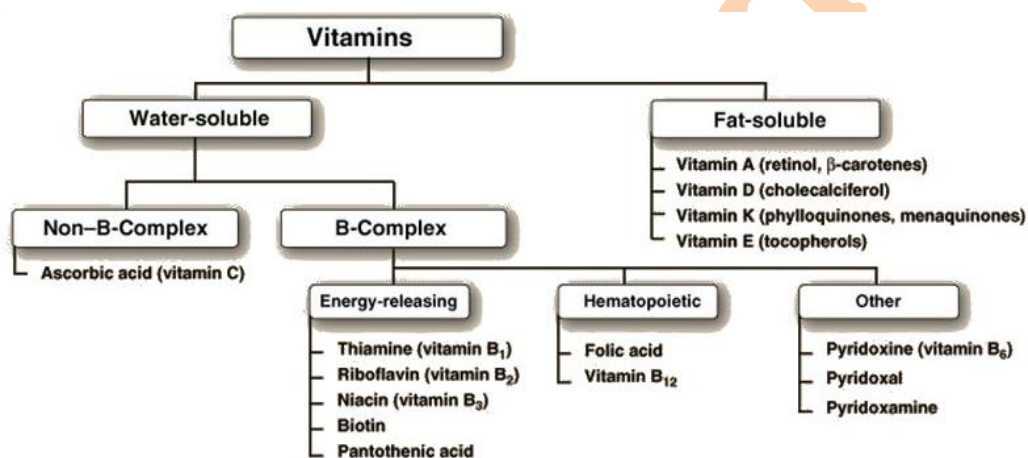
- A **vitamin** is an organic molecule that is an essential micronutrient that an organism needs in small quantities for the proper functioning of its metabolism.

or

The vitamins are natural and essential nutrients, required in small quantities and play a major role in growth and development, repair and healing wounds, maintaining healthy bones and tissues, for the proper functioning of an immune system, and other biological functions. These essential organic compounds have diverse biochemical functions.

- There are thirteen different types of vitamins and all are required for the metabolic processes. The discovery of the vitamins was begun in the year 1912 by a Polish American biochemist Casimir Funk. Based on his research and discoveries on vitamins, their sources, functions and deficiency disorders, he is considered as the father of vitamins and vitamin therapy.
- Similar to minerals, vitamins cannot be synthesized by our body. Therefore, we need to get them from the food we consume or in extreme cases supplements to keep ourselves healthy.

➤ Classification of vitamins



1. Vitamin A (Retinol, β-Carotene)

- Source- Fish liver oil, carrots, butter and milk
- Function- growth and maintenance of skin, bone development, maintenance of retina and vision.
- Dietary requirement – 750 µg
- Deficiency disease-

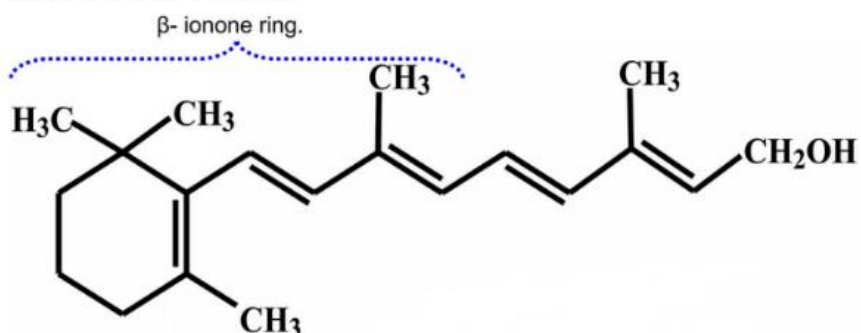
Xerophthalmia (Hardening of cornea of eye)

- Coenzyme form- retinal

vi) Chemical nature →

- Natural form: A1 (retinol), A2 (3-dehydroretinol)
- Active form : retinol, retinal, retinoic acid
- Provitamin-A : β-Carotene

- Vitamin A (Retinol) is a cyclic polyene alcohol which resembles the structure of Diterpenoid.
- The structure of vitamin A consists of a β-ionone ring.
- Four conjugated double bonds in the side chain of vitamin A.
- They are in trans arrangement.
- Synthetic retinol is a trans isomer. It exists in 8 stereoisomeric forms.
- β-ionone ring and conjugated double bonds are essential for the biological activity of vitamin A.

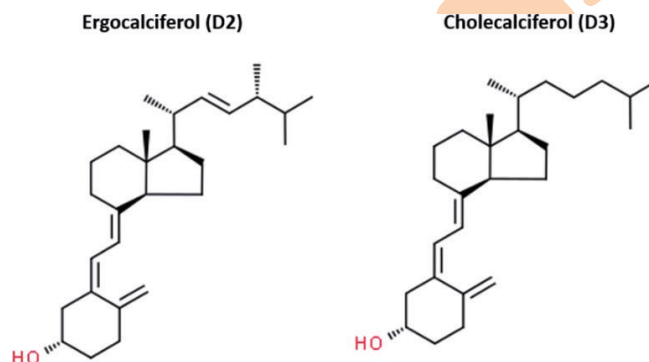


2. Vitamin D (Cholecalciferol)

- i) Source- exposure to sunlight, fish and egg yolk
- ii) Function- Normal growth, Ca and P absorption, maintain serum calcium and phosphorus level
- iii) Dietary requirement – 2.5 μg
- iv) Deficiency disease- Rickets, osteomalacia
- v) Coenzyme form- Nil

vi) Chemical nature

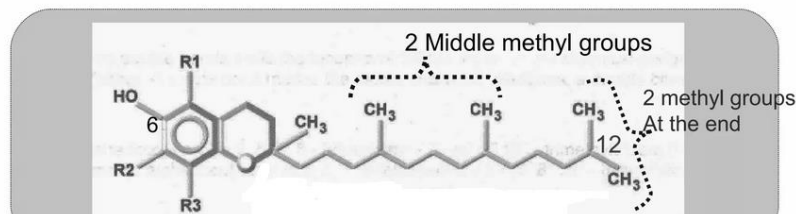
- Two main forms of the vitamin D were discovered
- 1. Ergocalciferol vitamin D₂ is formed from ergosterol, present in plants
- 2. Cholecalciferol (vitamin D₃) is found in animals, and is formed by irradiating the animal sterol, 7- dehydrocholesterol.
- Both the sterols are similar in structure except that ergocalciferol has an additional methyl group and double bond.
- Both these compounds are sources for vitamin D activity and are referred to as provitamins.
- The synthesis of vitamin D₃ in the skin is proportional to the exposure to sunlight. Dark skin pigment (melanin) adversely influences the synthesis of vitamin D₃.



3. Vitamin E (Tocopherol)

- i) Source- vegetable oils like wheat germ oil, sunflower oil etc
- ii) Function- Antioxidant, maintain muscular metabolism, aids absorption of unsaturated fatty acid
- iii) Dietary requirement- 8-10mg
- iv) Deficiency disease- increased fragility of RBCs and muscular weakness
- v) Coenzyme form- nil
- vi) Chemical nature

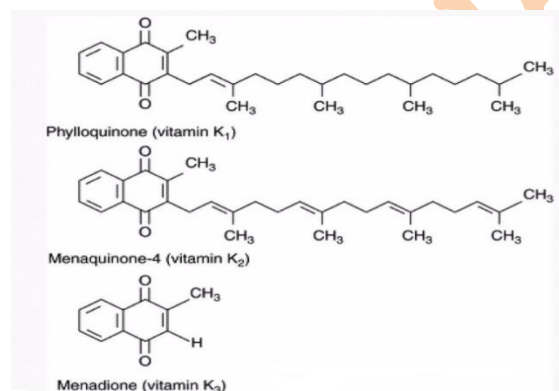
- **Vitamin E** refers to a family of **eight** molecules having a **chromanol ring (chroman ring with an alcoholic hydroxyl group)** and a 12-carbon aliphatic side chain containing two methyl groups in the middle and two more methyl groups at the end.
- For the four **tocopherols the side chain is saturated**, whereas for the four **tocotrienols the side chain contains three double-bonds**, all of which adjoin a methyl group.
- The four tocopherols and the four tocotrienols have an alpha, beta, gamma and delta form — named on the basis of the number and position of the methyl groups on the chromanol ring.
- The **alpha** form has three methyl groups, the **beta & gamma** forms have two methyl groups and the **delta** form has only one methyl group.



4. Vitamin K(Phylloquinones)

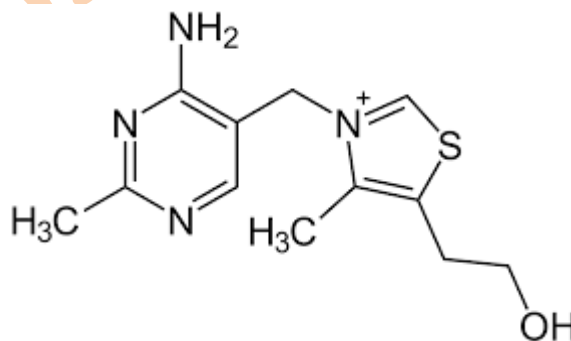
- i) Source- green leafy vegetables
- ii) Function- Blood clotting mechanism, prothrombin synthesis in liver, electron transport mechanism
- iii) Dietary requirement – 70-140 mg
- iv) Deficiency disease- increased blood clotting time
- v) Coenzyme form- nil
- vi) **Chemical nature**

- ☐ Vitamin K family are naphthoquinone derivatives .
- ☐ Phylloquinone and menaquinones, both have a long isoprenoid side chain.
- ☐ The length of the side chain differs.
- ☐ Phylloquinone have a 20 C side chain , whereas menaquinones have a 30 C side chain.
- ☐ The isoprenoid chain makes these vitamin hydrophobic or lipophilic.
- ☐ The synthetic vitamin K (menadione, menadiol diacetate) have only hydrogen in place of isoprenoid side chain that makes these vitamin water-soluble.



5. Vitamin B1 (Thiamine)

- i) Source- yeast, milk, green vegetables and cereals
- ii) Function- growth, appetite, digestion, nerve activity, energy production
- iii) Dietary requirement – 1-1.5 mg
- iv) Deficiency disease- Beri-Beri(loss of appetite, retarded growth)
- v) Coenzyme form- Thiamine Pyrophosphate(TPP)
- vi) Chemical nature-
 - Thiamine consists of a **thiazole** and **pyrimidine** ring that are linked through a **methylene** group.
 - Thiamine is the only natural compound (apart from penicillin) that contains a thiazole ring.



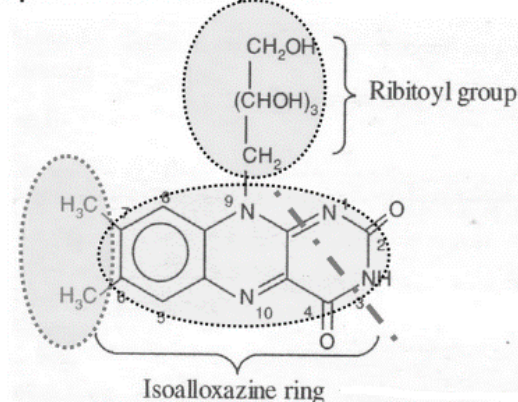
6. Vitamin B2 (Riboflavin)

- i) Source- milk, egg white, liver
- ii) Function- growth and development of foetus, redox system, maintenance of mucosal, epithelial and eye tissues
- iii) Dietary requirement – 1.5-2 mg
- iv) Deficiency disease- Cheilosis, digestive disorders and burning sensation of skin
- v) Coenzyme form- Flavin Mononucleotide (FMN), Flavin Adenine dinucleotide(FAD)

vi) Chemical nature

- Stable to heat, oxidation and acid.
- Light and alkali destroy it
- It should be noted that bottled milk (which has large amount of B2) loses a significant amount of B2 if left in the sun light

The structure of Riboflavin consists of **6,7-dimethyl-isoalloxazine** (heterocyclic three ring system) to which a sugar alcohol group called ribityl group is attached at **9th** position.



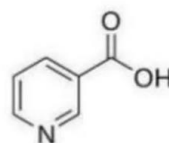
7. Vitamin B3 (Niacin)

- Source- Yeast, fish, pulses, cereals
- Function- converting carbohydrates into glucose, metabolizing fats and proteins, and keeping the nervous system working properly.
- Dietary requirement – 10-20 mg
- Deficiency disease- Pellagra includes the triad of dermatitis, dementia, and diarrhea and can result in death
- Coenzyme form- Nicotinamide adenine dinucleotide (NAD⁺), Nicotinamide adenine dinucleotide phosphate (NADP⁺)

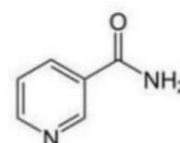
vi) Chemical nature

- Niacin is the generic term for nicotinamide and nicotinic acid.
- Also known as Niacinamide / Nicotinamide / Vitamin PP (pellagra preventive) / Vitamin G (after Goldberger).
- is an organic compound with the formula $C_6H_5NO_2$
- Simple derivative of pyridine.
- **Pyridine 3 carboxylic acid.**
- White crystalline substance.
- Water soluble.
- Resistant to heat, oxidation & alkalis.
- Nicotinamide is an important component of **NAD** and **NADP**.

- Niacin has a carboxyl group (COOH) at the 3-position, whereas, in Nicotinamide the carboxyl group is replaced by a Carboxamide group (CONH₂).



Niacin

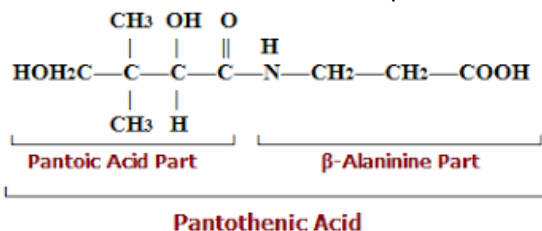


Nicotinamide

8. Vitamin B5 (Pantothenic acid)

- Source- liver, yeast, egg yolk, mushroom avacados
- Function- **breakdown of fats and carbohydrates for energy**, manufacture of red blood cells, sex and stress-related hormones produced in the adrenal glands
- Dietary requirement – 6 mg
- Deficiency disease- Paresthesia, Dermatitis and adrenal insufficiency
- Coenzyme form- Co-enzyme A
- Chemical nature

Pantothenic acid is formed from β -alanine and pantoic acid joined by a peptide bond.



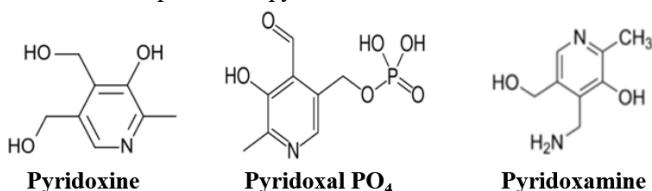
9. Vitamin B6 (Pyridoxine)

- Source- yeast, milk, egg yolk, cereals and grams
- Function- growth, Protein, CHO and lipid metabolism, coenzyme in amino acid metabolism
- Dietary requirement : 1-2 mg
- Deficiency disease- Convulsions
- Coenzyme form-Pyridoxal Phosphate
- Chemical nature

VITAMIN B₆ is used to collectively represent the three compounds namely pyridoxine, pyridoxal and pyridoxamine (the vitamers of B₆).

Chemistry

Vitamin B6 compounds are pyridine derivatives.



They differ from each other in the structure of a functional group attached to 4th carbon in the pyridine ring. Pyridoxine is a primary alcohol, pyridoxal is an aldehyde form while pyridoxamine is an amine. Pyridoxamine is mostly present in plants while pyridoxal and pyridoxamine are found in animal foods. Pyridoxine can be converted to pyridoxal and pyridoxamine, but the latter two cannot form pyridoxine.

10. Vitamin B7 (Biotin or Vit-H)

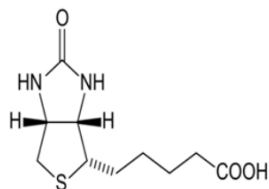
- Source- Egg, nuts, avocado, sweet potato
- Function- metabolize carbohydrates, fats, and amino acids
- Dietary requirement : 100-300µg
- Deficiency disease- Dermatitis and conjunctivitis
- Coenzyme form- Biotin Carboxyl carrier protein
- Chemical nature

BIOTIN (vitamin B7 or vitamin H)

Biotin (formally known as anti-egg white injury factor) is a sulfur containing B-complex vitamin. It directly participates as a coenzyme in the Carboxylation reactions.

Chemistry

Biotin is a heterocyclic sulfur containing monocarboxylic acid.



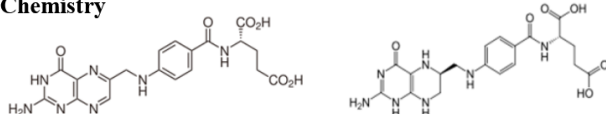
The structure is formed by fusion of **imidazole** and **thiophene** rings with a **valeric acid** side chain. Biotin is co-valently bound to amino group of lysine to form **biocytin** in the enzymes. Biocytin may be regarded as the coenzyme of biotin.

11. Vitamin B9 (Folic acid)

- i) Source- Dark green vegetables, beans, pea nut, sunflower seed
- ii) Function- formation of RBC
- iii) Dietary requirement: 200 gm
- iv) Deficiency disease- Megaloblastic anemia and diarrhea
- v) Coenzyme form- Tetrahydrofolic acid
- vi) **Chemical nature**

Folic Acid (Vitamin-B9)

Folic acid or folacin is abundantly found in green leafy vegetables. It is important for one carbon metabolism and is required for the synthesis of certain amino acids, purines, pyrimidine and thymine.

Chemistry

Folic acid consists of three components pteridine ring, p-amino benzoic acid (PABA) and glutamic acid (1 to 7 residues). Folic acid mostly has one glutamic acid residues and is known as pteroyl-glutamic acid (PGA).

The active form of folic acid is tetrahydrofolate (THF or FH4). It is synthesized from folic acid by the enzyme Dihydrofolate reductase.



12. Vitamin B12 (Cobalamin)

- i) Source- Meat, fish, egg and curd
- ii) Function- development, myelination and function of the central nervous system; healthy red blood cell formation; and DNA synthesis
- iii) Dietary requirement: 2-3 gm
- iv) Deficiency disease- Pernicious anemia
- v) Coenzyme form- Cobamide
- vi) **Chemical nature**

- **Vitamin B12, is also called cobalamin, cyanocobalamin and hydroxycobalamin.**

- It is built from :

1. A nucleotide and
2. A complex tetrapyrrol ring structure (corrin ring)
3. A cobalt ion in the center.
4. A R- group

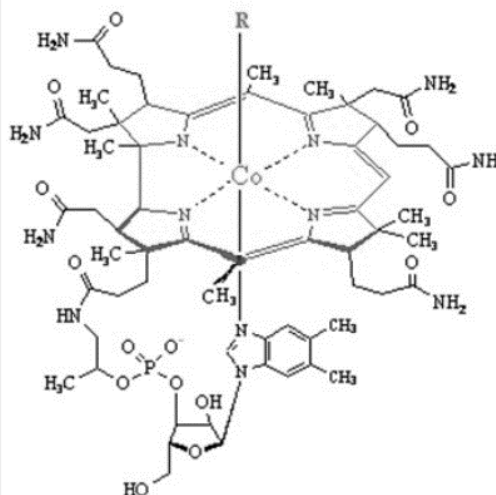
- **When R is cyanide (CN), vitamin B12 takes the form of cyanocobalamin.**

- **In hydroxycobalamin, R equals the hydroxyl group (-OH).**

- **In the coenzyme forms of vitamin B12,**

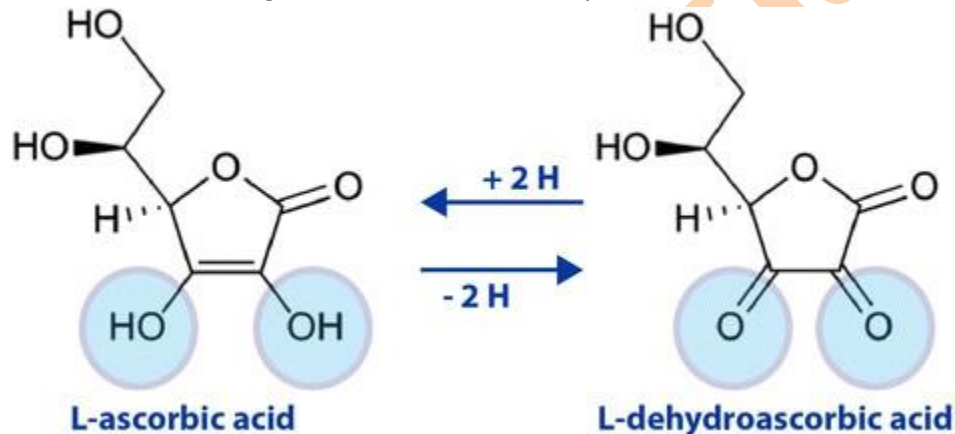
- R equals an adenosyl group in adenosylcobalamin.
- R equals a methyl (-CH₃) group in methylcobalamin.

- Vitamin B12 is synthesized exclusively by microorganisms (bacteria, fungi and algae) and not by animals and is found in the liver of animals bound to protein as methylcobalamin or 5'-deoxyadenosylcobalamin.



13. Vitamin C (Ascorbic acid)

- i) Source- citrus fruit, amla and green leafy vegetables
- ii) Function- Absorption of iron, antioxidants, growth, wound healing, formation of cartilage, dentine bone and teeth, maintenance of capillaries
- iii) Dietary requirement: 30-45 mg
- iv) Deficiency disease- Scurvy (bleeding gums)
- v) Coenzyme form-
- vi) Chemical nature
 - Chemically it is known as ascorbic acid
 - Ascorbic acid is hexose derivative and closely resembles monosaccharides in structure
 - It exist in two forms
 - i) L-Ascorbic acid (Reduces form)
 - ii) L-dehydroascorbic acid(oxidized form)
 - The acidic property of vitamin C is due to enolic hydroxyl group
 - L-ascorbic acid undergoes oxidation to form dehydro ascorbic acid and it is reversible reaction



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