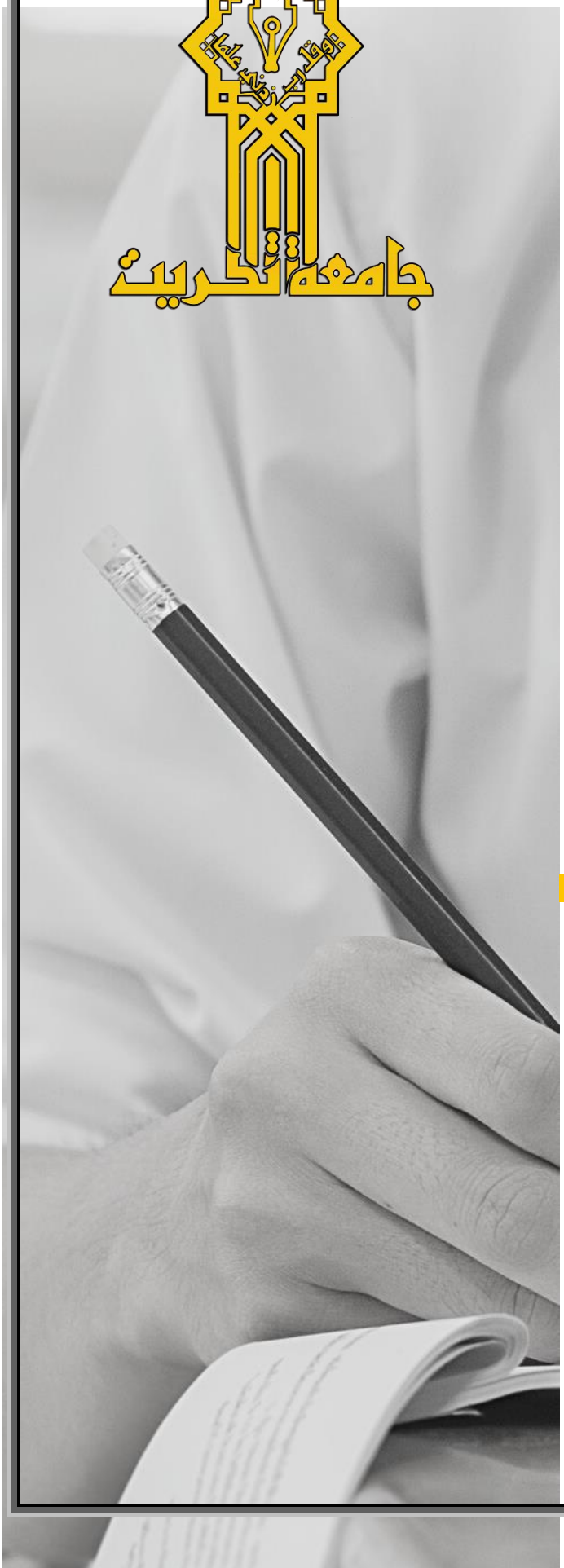

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vitamins

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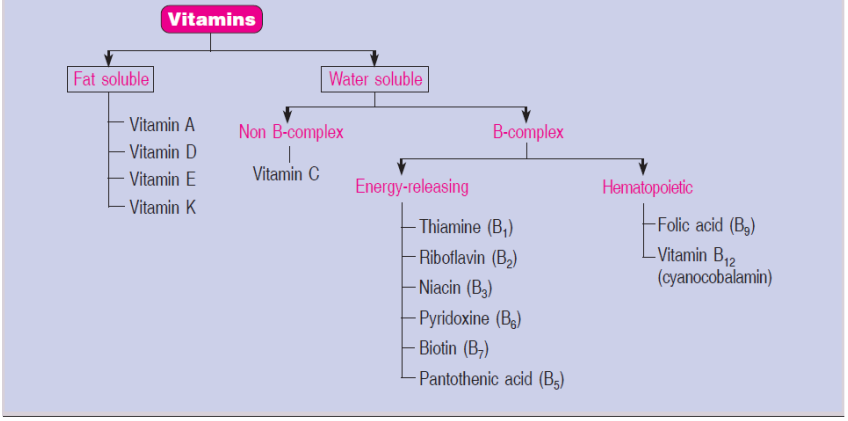
VITAMINES

Vitamins may be regarded as organic compounds required in the diet in small amounts to perform specific biological functions for normal maintenance of optimum growth and health of the organism. The word Vitamin comes from the Greek word "VITAMINE" which means '' Vital for Life."

Classification of vitamins

There are about 15 vitamins, essential for humans. They are classified as fat soluble (A, D, E and K) and water soluble (C and B-group) vitamins as shown in the Table 7.1. The B-complex vitamins may be sub-divided into energy-releasing (B1, B2, B6, biotin etc.) and hematopoietic (folic acid and B12).

TABLE 7.1 Classification of vitamins



Fat soluble vitamins (General)

The four vitamins, namely vitamin A, D, E, and K are known as fat or lipid soluble. Their availability in the diet, absorption and transport are associated with fat. They are soluble in fats and oils and also the fat solvents (alcohol, acetone etc.). Fat soluble vitamins can be stored in liver and adipose tissue. They are not readily excreted in urine. Excess consumption of these vitamins (particularly A and D) leads to their accumulation and toxic effects.

Water soluble vitamins(General)

The water soluble vitamins are a heterogenous group of compounds since they differ chemically from each other. The only common character shared by them is their solubility in water. Most of these vitamins are readily excreted in urine and they are not toxic to the body. Water soluble vitamins are not stored in the body in large quantities (except B12). For this reason, they must be continuously supplied in the diet. The water soluble vitamins form coenzymes , that participate in a variety of biochemical reactions, related to either energy generation or haematopoiesis.

VITAMIN A

the term vitamin A is collectively used to represent many structurally related and biologically active molecules (Fig.7.1). The term retinoids is often used to include the natural and synthetic forms of vitamin A. Retinol (vitamin A alcohol) , retinal(vitamin A aldehyde) , β-Carotene (provitamin A) This is found in plant foods . and retinoic acid are all regarded as vitamers of vitamin A.

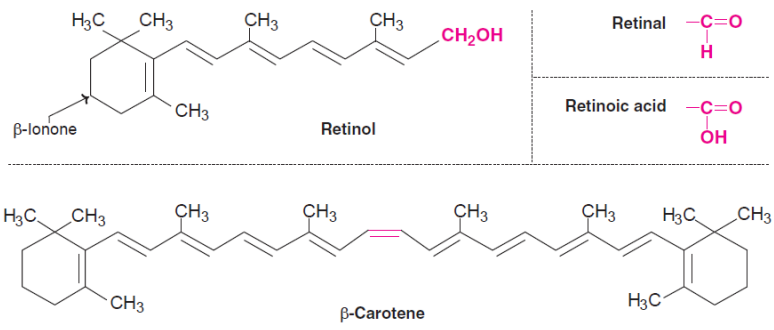
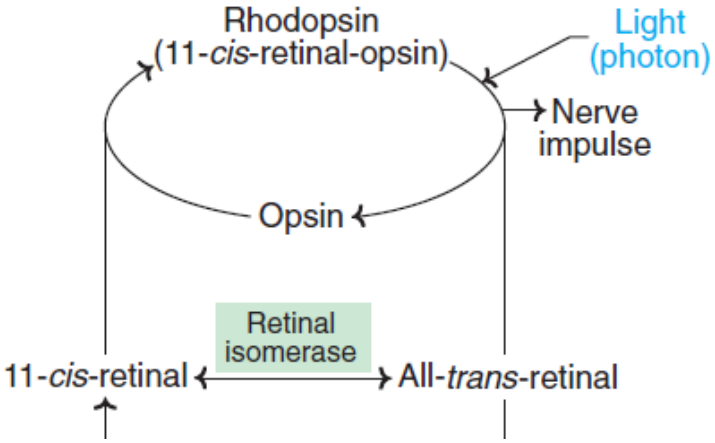


Fig. 7.1 : Structures of vitamin A and related compounds (Red colour represents the substituent groups in the respective compounds).

1. Visual cycle (Vision and the Role of Vitamin A):
   The retina of the eye possesses two types of cells—rods and cones. Rods are involved in dim light vision whereas cones are responsible for bright light and colour vision The primary event in visual cycle, on **exposure to light**, is the isomerization of 11-cisretinal to all-trans retinal. This leads to a **conformational change in opsin** which is responsible for the generation of nerve impulse. The all-trans-retinal is immediately isomerized by retinal isomerase to 11-cis-retinal. This combines with opsin to regenerate rhodopsin and complete the visual cycle (**Fig.7.4**).



2. Growth: Vitamin A deficiency results in a decreased growth rate in children. Bone development is also slowed.

3. Reproduction: Retinol and retinal are essential for normal reproduction.

Retinoic acid is inactive in maintaining reproduction and in the visual cycle, but promote growth and differentiation of epithelial cells.

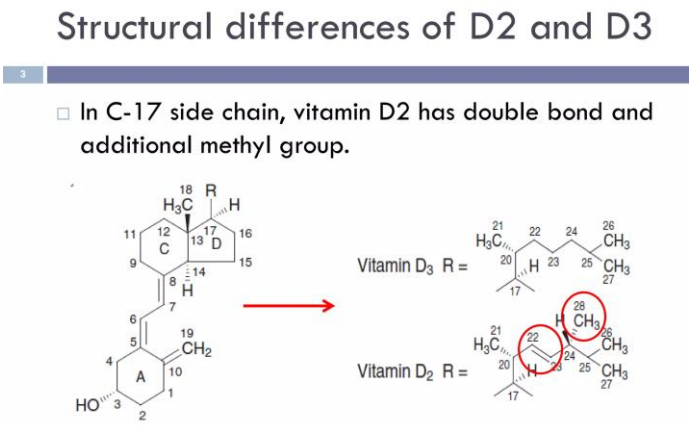
4. Maintenance of epithelial cells: Vitamin A is essential for normal differentiation of epithelial tissues and mucus secretion.

5. As antioxidant Beta carotene an antioxidant protects body against disease

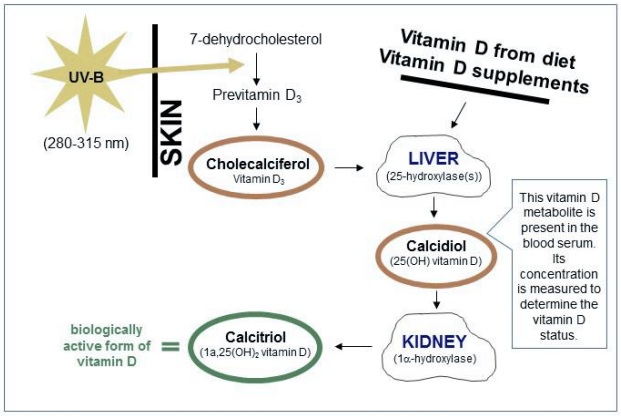
Clinical Significances of Vitamin A Deficiency :

• Vitamin A is stored in the liver and deficiency of the vitamin occurs only after prolonged lack of dietary intake. The earliest symptoms of vitamin A deficiency are night blindness, which is poor vision in dim light.

VITAMIN D



Vitamin D is a fat soluble vitamin. Vitamin D, also known as the **sunshine vitamin**, is produced by the body as a response to sun exposure;, It resembles sterols in structure and functions like a hormone. Ergocalciferol (vitamin D2) is formed from ergosterol and is present in plants , Cholecalciferol (vitamin D3) is found in animals**. Calcitriol (1,25-(OH)2D3, also termed 1,25-Dihydroxycholecalciferol) The biologically active form of vit D.**



DISEASES CAUSED BY VITAMIN D DEFICIENCY

Vitamin D deficiency causes several bone diseases, including:

1. Rickets: a childhood disease characterized by failure of growth and deformity of long bones.
2. Osteomalacia: (adult version of Rickets) is a case of softening of bones due to defective bone mineralization and characterised by proximal weakness and bone fragility.
3. Osteoporosis: a condition characterized by :fragile bones, easily fractured due to decreased bone density.

VITAMIN E

Vitamin E (tocopherol) is a naturally occurring antioxidant. Vitamin E is absorbed along with fat in the small intestine. It is essential for normal reproduction in many animals, hence known as **anti-sterility vitamin**. Bile salts are necessary for the absorption. In the liver, it is incorporated into lipoproteins (VLDL and LDL) and transported. Vitamin E is stored in adipose tissue, liver and muscle.

VITAMIN K

Vitamin K is the only fat soluble vitamin with a specific coenzyme function. It is required for the production of blood clotting factors, essential for coagulation, Vitamin K exists in different forms (Fig.7.11). Vitamin K1 (phylloquinone) is present in plants.

Vitamin K2 (menaquinone) is produced by the intestinal bacteria and also found in animals. Vitamin K3 (menadione) is a synthetic form.

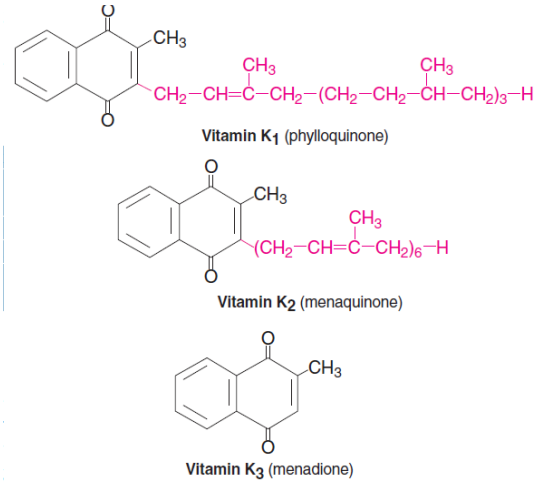


Fig. 7.11 : Structures of vitamin K.

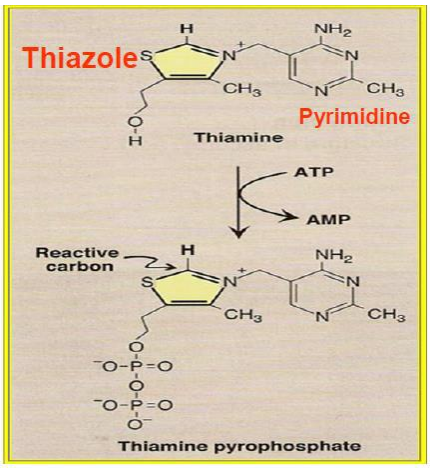
Vitamin K is taken in the diet or synthesized by the intestinal bacteria. Its absorption takes place along with fat (chylomicrons) and is dependent on bile salts. Vitamin K is transported along with LDL and is stored mainly in liver and, to a lesser extent, in other tissues. Deficiency of vitamin K leads to the lack of active prothrombin in the circulation. The result is that blood coagulation is adversely affected. The individual bleeds profusely even for minor injuries.

THIAMINE (VITAMIN B1)

Thiamine (anti-beri-beri or antineurotic vitamin) is water soluble. It has a specific coenzyme, **thiamine pyrophosphate (TPP)** which is mostly associated with carbohydrate metabolism.

Chemistry

Thiamine contains a pyrimidine ring and a thiazole ring held by a methylene bridge The alcohol (OH) group of thiamine reacted with phosphate (2 moles) from ATP to form the **coenzyme**, **thiamine pyrophosphate** (TPP).



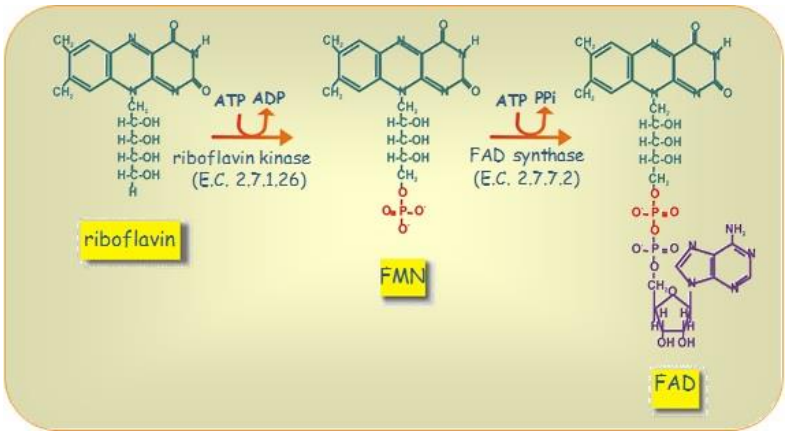
Thiamin diphosphate(pyrophosphate) is an important coenzyme in carbohydrate metabolism , being necessary for 2 types of reaction:

1. oxidative decarboxylation reactions (e.g. conversion of pyrovate to acetyl CoA)
2. Transketolation reactions e.g. transketolase catalyzed reactions of the pentose phosphate pathway.

- Deficiency of thiamin causes Beri Beri. loss of appetite (anorexia), weakness, constipation, nausea, mental depression, peripheral neuropathy.

RIBOFLAVIN (VITAMIN B2)

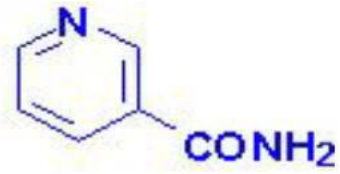
Riboflavin is the precursor for the coenzymes, flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD). Both classes (FMN and FAD) are involved in a wide range of oxidation reduction reactions . Riboflavin deficiency a such is uncommon. It is mostly seen along with other vitamin deficiencies.



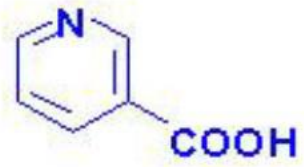
NIACIN (VITAMIN B3)

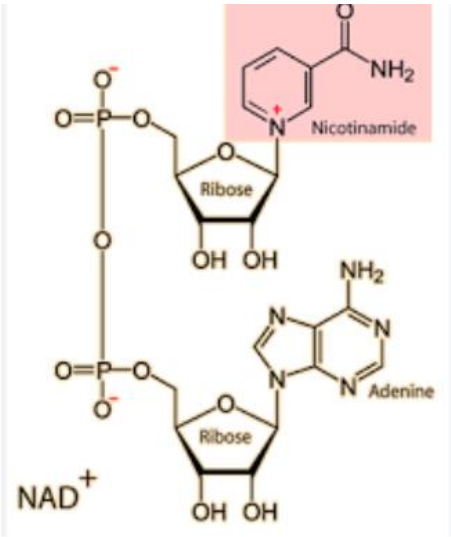
Niacin is required for the synthesis of the active forms of vitamin B3,which are nicotinamide adenine dinucleotide (NAD+) and nicotinamide adenine dinucleotide phosphate (NADP+). Both NAD+ and NADP+ function as cofactors (coenzyme) in numerous oxidation –reduction reaction **Deficiency of Niacin leads to the clinical condition called pellagra (rough skin).**

Nicotinamide



Nicotinic Acid





COBALAMIN (VITAMIN B12)

Vitamin B12 is also known as anti-pernicious anemia vitamin. It is a unique vitamin, synthesized by only microorganisms and not by animals and plants. Vitamin B12 is the only vitamin with a complex structure. The empirical formula of vitamin B12 (cyanocobalamin) is C63H90N14 O14PCo. The structure of vitamin B12 consists of a corrin ring with a **central cobalt atom**.

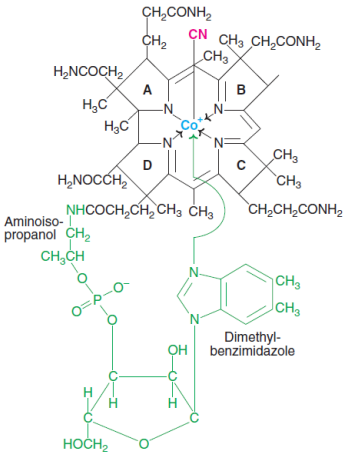
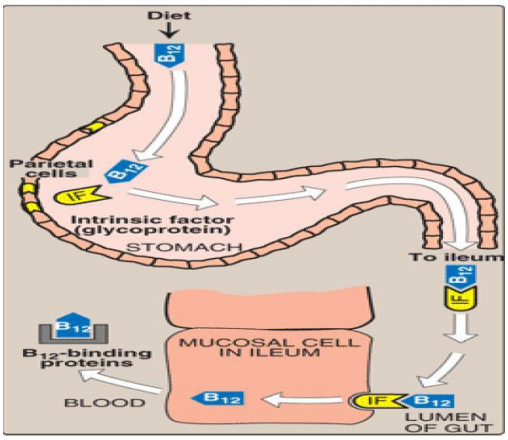


Fig. 7.35 : Structure of vitamin B_{12} (cyanocobalamin).

The corrin ring has four pyrrole units, Two of the pyrrole units (A and D) are directly bound to each other whereas the other two (B and C) are held by methene bridges. Cobalt present at the centre of the corrin ring is bonded to the four pyrrole nitrogens.

Metabolism of vitamin B12:Normally, vitamin B12 obtained from the diet binds to a glycoprotein called **intrinsic factor** (gastric parietal cells are responsible for the synthesis of intrinsic factor) . The cobalamin–intrinsic factor complex travels through the gut and eventually binds to specific receptors on the surface of mucosal cells of the ileum. The bound cobalamin is transported into the mucosal cell and subsequently, into the general circulation, where it is carried by B12-binding proteins which is called transcobalamin II.



Pernicious anemia is a megaloblastic anemia resulting from vitamin B12 deficiency that develops as a result a lack of intrinsic factor in the stomach leading to malabsorption of the vitamin. It is an autoimmune disease.