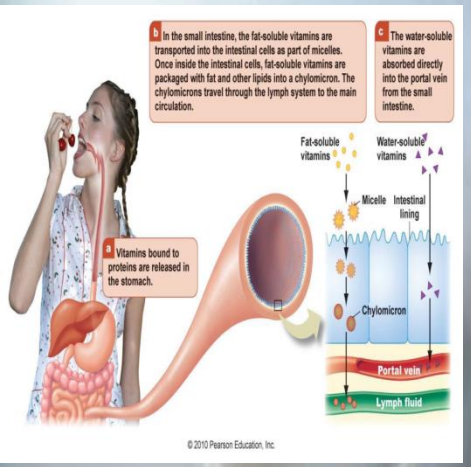
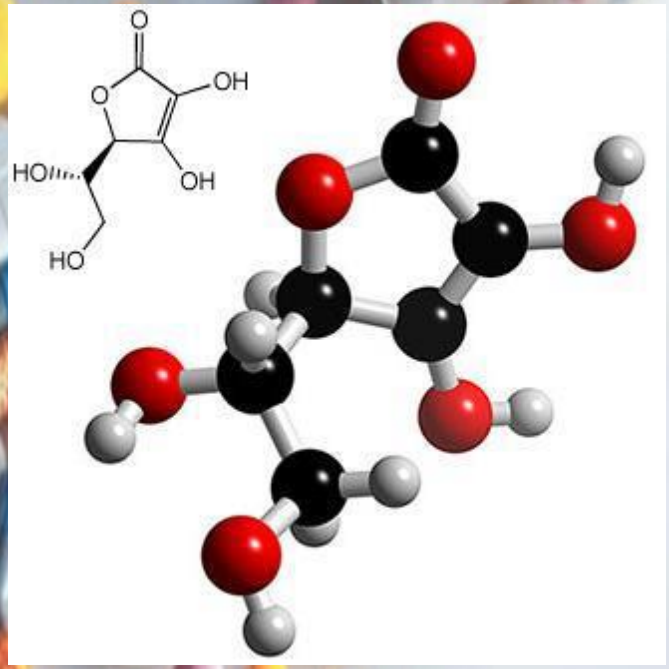




Vitamins,as coenzymes and cofactors

STRUCTUREAND FUNCTION

المحاضرة الثالثة

لطلاب المرحلة الثانية

D.Ehssan Alobaidy

Introduction:

- **Primarily organic molecules**
- **May have inorganic component or cofactor**
- **Some work with/are part of an enzyme**
- **Promote or catalyze biochemical reactions**
- **Most cannot be made by human body Nutrients that our body does not make on its own.**
- **Water-soluble = all B vitamins, vitamin C**
- **Vitamins A, D, E, K are lipid-soluble**
- **Most of B vitamins used in 2o metabolism**

- **Coenzymes** :Non-protein conjugated with enzyme(**apoenzyme**) as **Haloenzyme** to help transfer groups in biochemical reactions.
- And if not strongly conjugated with enzyme and easy to separate and if conjugated strongly then called **Prosthetic group** coenzymes as Only Vitamins soluble in water.
- **Cofactors:** Is the differ from coenzyme its only cation and as not organic Fe+3in Cytochromes Mg+2 in ATP , Zn+2 in LDH ,Mo+6 in Xanthic oxide,
- Cu+2 in cytochrome oxidase.

What are vitamins ?

- Thus we must obtain them from the foods we eat, or via vitamin supplements.
- Several vitamins are synthesized in the intestines by bacteriums.
- They are essential for providing good health and are necessary for many life functions.
- *Vitamins are:
- •Tasteless, organic compounds
- •Required in small amounts
- •Functions:
- Regulate metabolism.
- Help convert energy in fat, carbohydrate, and protein into ATP
- Promote growth and reproduction
- Deficiencies can result in potentially serious consequences

History of Vitamins

- **Disease related to deficiency and foods that help were recognized long before the vitamin was discovered.**

- **Scientists are now focusing on prevention of disease with vitamin research.**

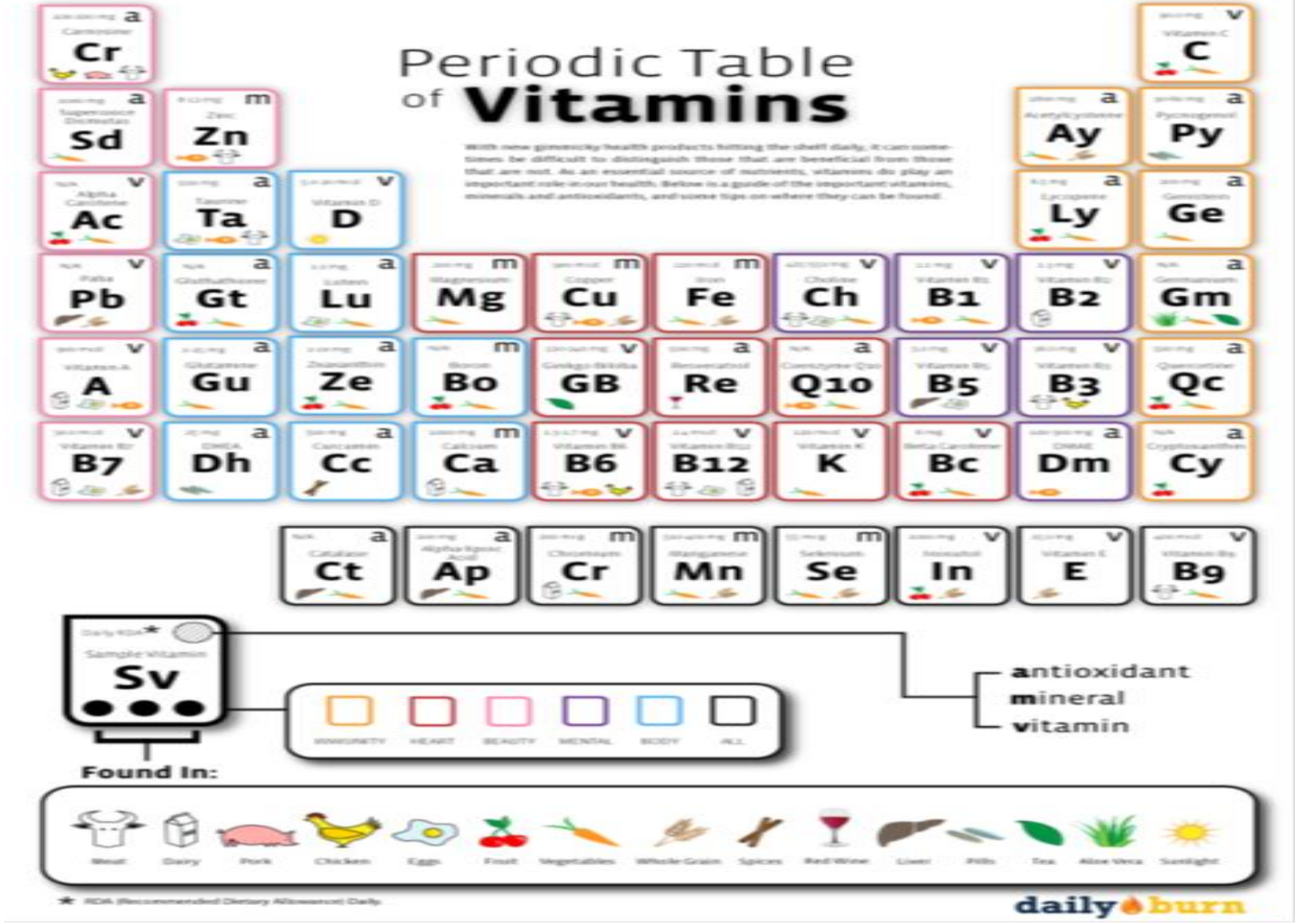
- **The naming of vitamins follows the letters of the alphabet, starting with A; we are up to the letter K**
- **A, B, C, D, E, and K**

- **Rickets:**
- **Is defective mineralization of bones before epiphyseal closure in immature mammals due to deficiency or impaired metabolism of vitamin D, phosphorus or calcium, potentially leading to fractures and deformity.**

- **Scurvy**
- **Is a disease resulting from a deficiency of vitamin C, which is required for the synthesis of collagen in humans. The chemical name for vitaminC, ascorbic acid, is derived from the Latin name of scurvy, scorbutus, which also provides the adjective scorbutic**

Criteria for Vitamins

- •Cannot be synthesized in ample amounts in the body
- •Chronic deficiency is likely to cause physical symptoms
- •Symptoms will disappear once the vitamin level in the body is restored
- •Deficiency can cause permanent damage
- •15compounds meet the above criteria:


Periodic Table
of Vitamins
With new gimmicky health products hitting the shelf daily, it can sometimes be difficult to distinguish those that are beneficial from those that are not. As an essential source of nutrients, vitamins do play an important role in our health. Below is a guide of the important vitamins, minerals and antioxidants, and some tips on where they can be found.
Cr
Sd
Zn
Ac
Ta
D
C
Ay
Py
Ly
Ge
Pb
Gt
Lu
Mg
Cu
Fe
Ch
B1
B2
Gm
A
Gu
Ze
Bo
GB
Re
Q10
B5
B3
Qc
B7
Dh
Cc
Ca
B6
B12
K
Bc
Dm
Cy
Ct
Ap
Cr
Mn
Se
In
E
B9
Sv
antioxidant
mineral
vitamin
Found In:
Meat
Dairy
Pork
Chicken
Eggs
Fruit
Vegetables
Whole Grain
Spices
Red Wine
Liver
Pills
Tea
Aloe Vera
Sunlight
★ RDA (Recommended Dietary Allowance) Daily
daily burn

Vitamin B1	thiamine
Vitamin B2	riboflavin
Vitamin B3	niacin
Vitamin B5	pantothenic acid
Vitamin B6	pyridoxine
Vitamin B7/H	biotin
Vitamin B9	folic acid
Vitamin B12	cobalamin
Vitamin C	ascorbic acid
Vitamin A	retinol
Vitamin E	tocopherol
Vitamin F	fatty acids

- **Classification is based on solubility:**

- Eight water-soluble: B vitamin complex and vitamin C
- Four fat-soluble: vitamins A, D, E, and K
- Solubility influences a vitamin's: Digestion; Absorption; Transportation; Storage; Excretion

Mean Roles of Vitamins

Table 9.1

The Many Roles of Vitamins in Promoting Health

Metabolic Function	Vitamins That Play a Role
Antioxidants	Vitamin C, vitamin E
Blood clotting and red blood cell synthesis	Folate, vitamin B_6, vitamin B_{12}, vitamin K
Bone health	Vitamin A, vitamin C, vitamin D, vitamin K
Energy	Biotin, niacin (B_3), pantothenic acid, riboflavin (B_2), thiamin (B_1), vitamin B_6, vitamin B_{12}
Growth and reproduction	Vitamin A, vitamin D
Immune function	Vitamin A, vitamin C, vitamin D
Protein metabolism	Folate, vitamin B_6, vitamin B_{12}

- All vitamins contain carbon, hydrogen, and oxygen
- Some vitamins contain nitrogen and sulfur
- Chemical structure of each vitamin is unique
- Each vitamin is a singular unit
- Vitamins are absorbed intact
- Vitamins perform numerous essential functions

Vitamin Absorption and Storage

- All absorption takes place in the small intestine
- Fat-soluble vitamins Are absorbed in the duodenum

  Storage

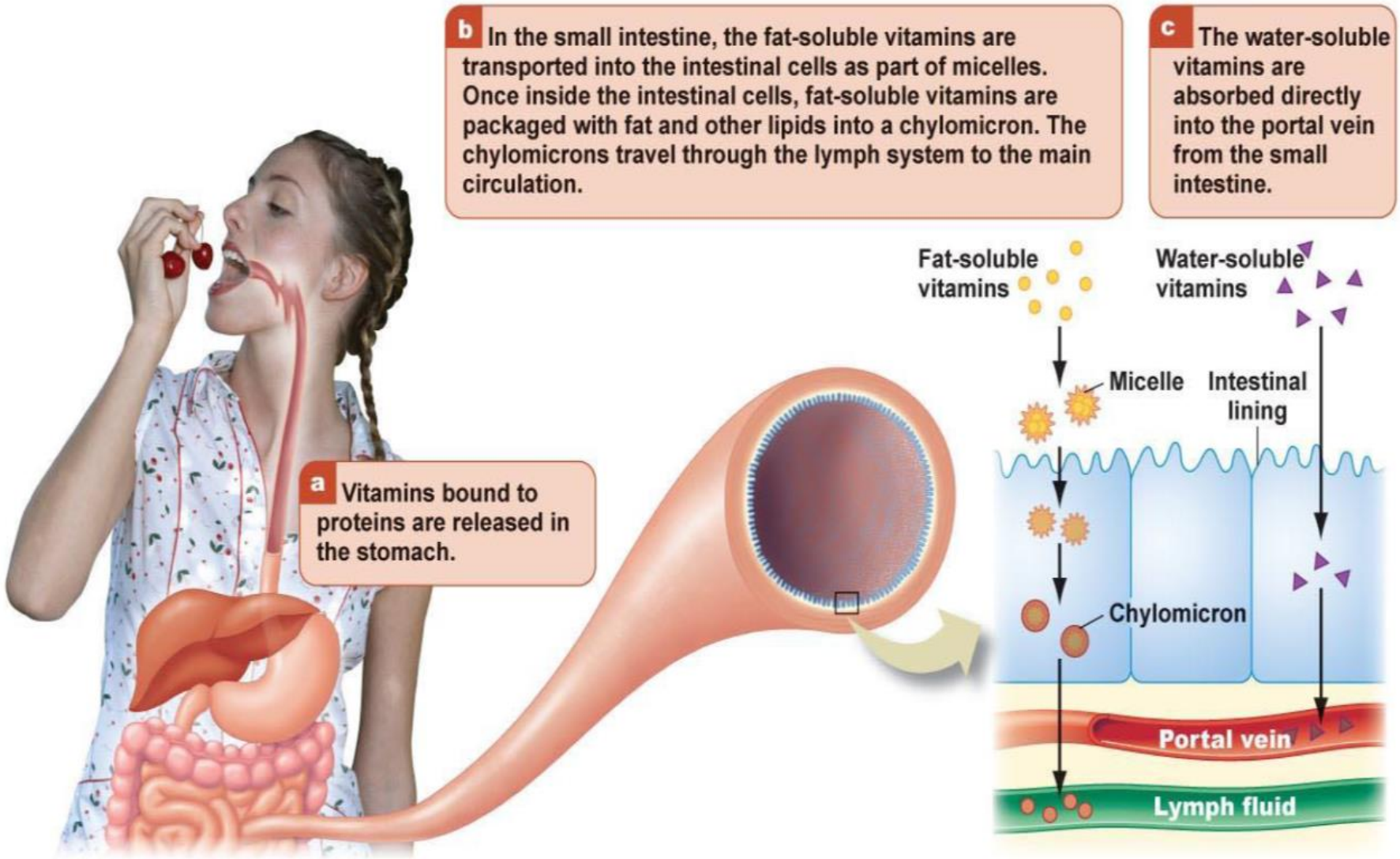
  Vitamin A is mainly stored in the liver

  Vitamins K and E are partially stored in the liver

  Vitamin D is mainly stored in the fat and muscle tissue

- Water-soluble vitamins:
  - Absorbed with water and enter directly into the blood stream
  - Most absorbed in the duodenum and jejunum
  - Most are not stored in the body
  - Excess intake excreted through the urine
  - Important to consume adequate amounts daily
  - Dietary excesses can be harmful

Digesting and Absorbing Vitamins



Comparison

	Water-Soluble Vitamins	Fat-SolubleVitamins
Absorbed in the	Small Intestine	Small Intestine
Hydrophobic or Hydrophilic	Hydrophilic	Hydrophobic
Absorbed into the	Blood	Lymph
Stored in the body	Not Generally	Yes
Can build up and become toxic	Not Generally	Yes
Need to consume daily	Yes	No

Bioavailability and destruction of vitamins

Fat-soluble vitamins are generally less bioavailable than water-soluble vitamins.

Vitamins from animal foods are generally more bioavailable than those in plant foods.

Water-soluble vitamins can be destroyed by

- Exposure to air
- Exposure to ultraviolet light
- Water
- Changes in pH
- Heat
- Food preparation techniques

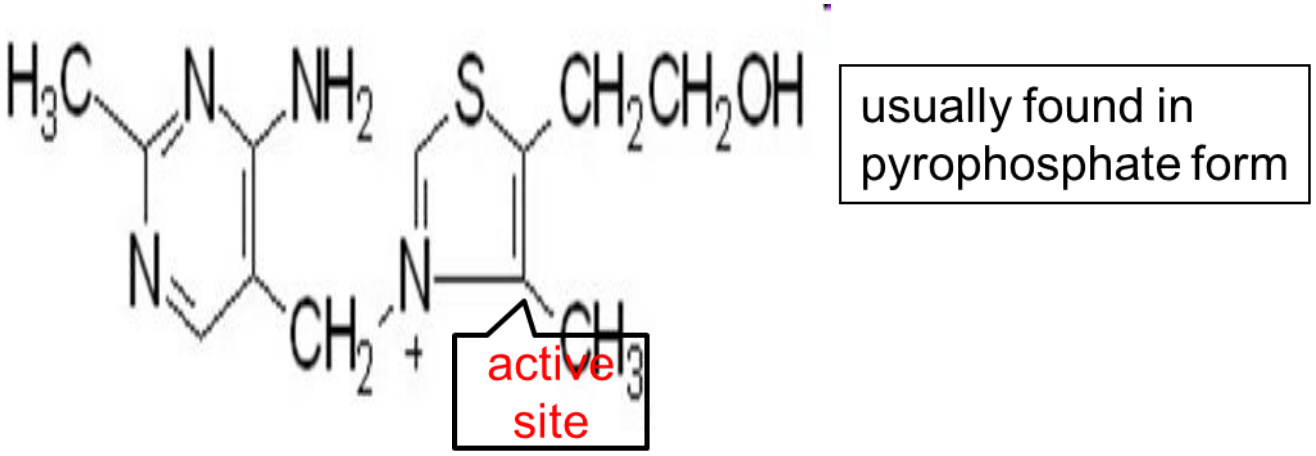
Fat-soluble vitamins tend to be more stable

Thiamine (Vitamin B1)

- **Human need 1-1.4g/daily. Its called TPP Thiamin pyrophosphate**

--Importance: Role it as coenzyme with Lipoic acid(decarboxylation)

- **Catalyzes decarboxylation of a-keto acids, a feature of primary metabolism**
- **e.g. pyruvic acid ----------→ acetaldehyde in glycolysis**
- **pyruvic acid ----------→ acetyl-CoA**
- **Helps metabolize carbohydrates**
- **Supports nervous system.**
- **Deficiency causes beri-beri (neurological disorder)**
- **Found in cereals, wheat germ, beans, nuts, eggs, yeast and vegetables**



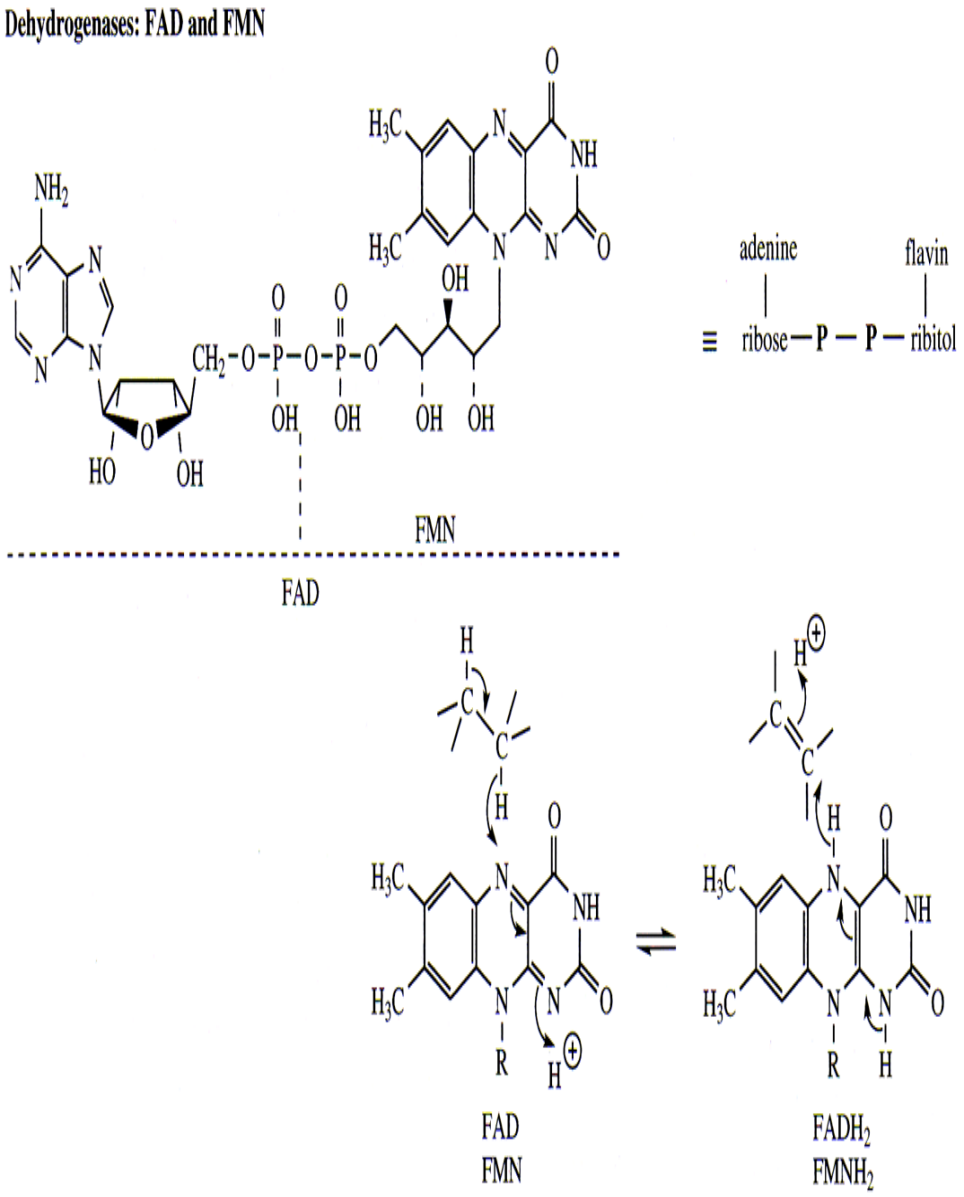
Riboflavin (Vitamin B2) catalyzes dehydrogenation

***It's important for growth**

***deficiency caused **Chellosis**disease

As FMN .FAD (Flavin mono nucleeotide) and (Flavin adinen dinucleotide. And function to transfer **Aldehyde

- Involved in **redox** rxns of C-C bonds
- Metabolism of carbs, fat, protein
- B2 is widely available in foods, including liver, kidney, dairy products, eggs, yeast,meat, and fresh vegetables
- Promotes healthy skin & vision
- Deficiency causes eye problems and skin disorders



Vitamin B3 Niacin (nicotinic acid+nicotinamide+)

***Nicotinamide adienine Dinuleotide NAD+**

***Nicotinamide adienine Dinuleotide phosphate NADP+**

***To transfer Hydrogen atoms**

***As part of NAD+ system, catalyzes redox rxns of alcohols/carbonyl compounds**

***Ethanol-----alcohol dehydrogenas------aceta aldehyde**

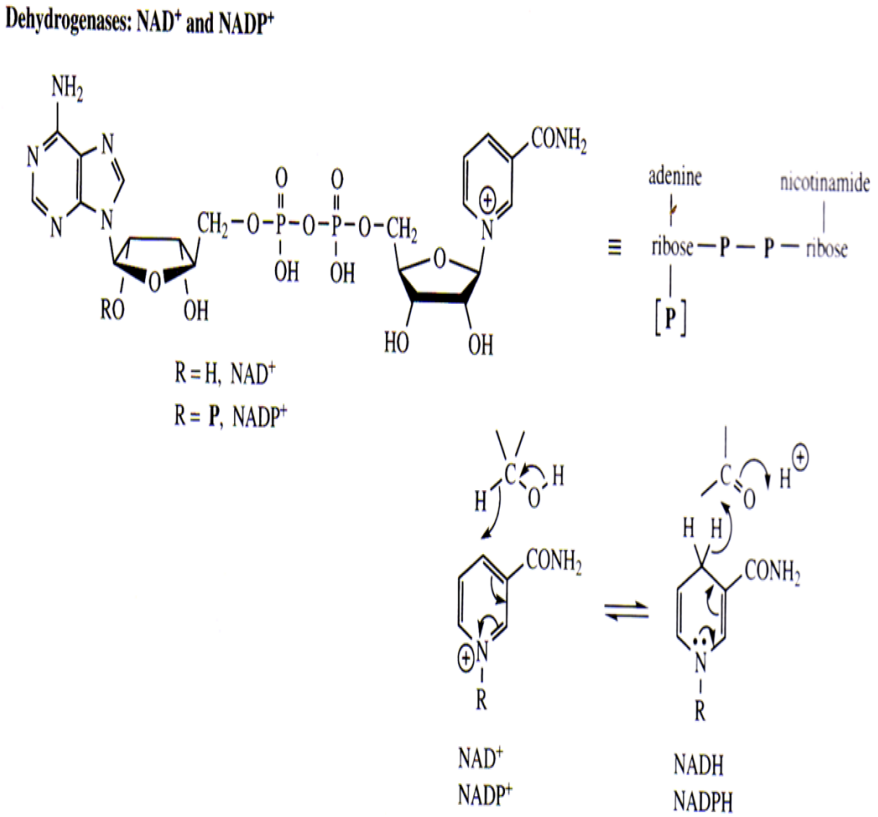
***Degradation of L-Trp----→niacin**

Needed for general metabolism, health of skin, nervous & digestive system

***Found in meats, fish, yeast, eggs, dairy, grains, nuts, legumes, roasted coffee**

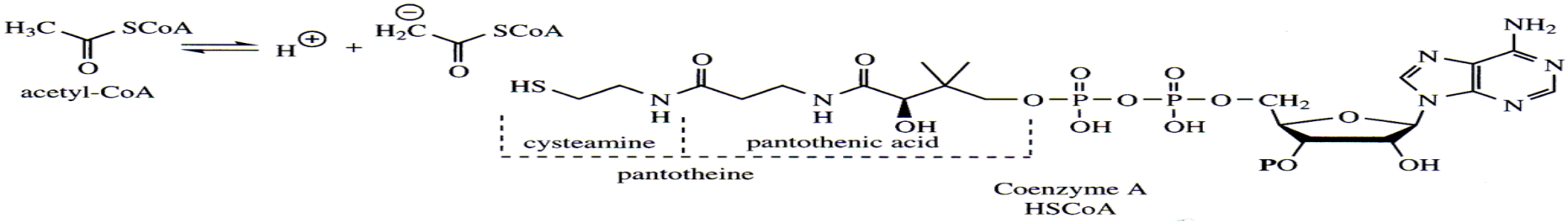
-Deficiency causes pellagra

oral lesions, diarrhea, dermatitis, and dementia



Panthothenic acid (Vitamin B5) is part of Coenzyme A acyle carrier protein(ATC)

***acyl group transfer**



***as coenzyme CoA-SH in Kribs cycle to convert Pyruvic----in TCA**
***Synthesis of fatty acids (acetate pathway), some peptides, phenylpropanoids, isoprenoids**

****Fat, carbs and protein metabolism**
******Very widely distributed throughout foods,yeast, liver, and cereals provide rich sources.**

****Deficiency is rare**
****Vitamins B3, B5, B6 and biotin are thought to promote healthy hair and prevent hair loss**

Vitamin B6 (pyridoxamine, pyridoxal phosphate & pyridoxine)

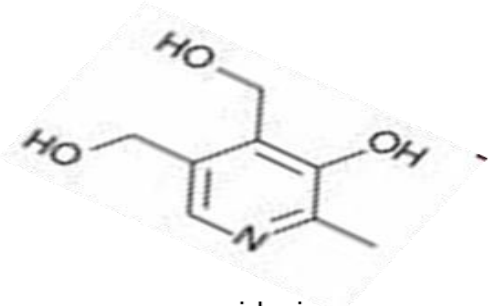
Pyridoxal 5-Phosphat(PLP) And transfer amino groups

*Catalyzes transaminations & Alanin------to pyruvate (decarboxylations of amino acids

*Metabolism → energy
*In plants, used in biosynthesis of phenylpropanoids from amino acids
*Meat, salmon, nuts, potatoes, bananas, and cereals
*Can be lost through cooking, though deficiency usually caused by poor absorption
*Deficiency causes nervous disorders, skin rash, muscle weakness, anemia

pyridoxal P
(PLP)

pyridoxamine P



pyridoxine

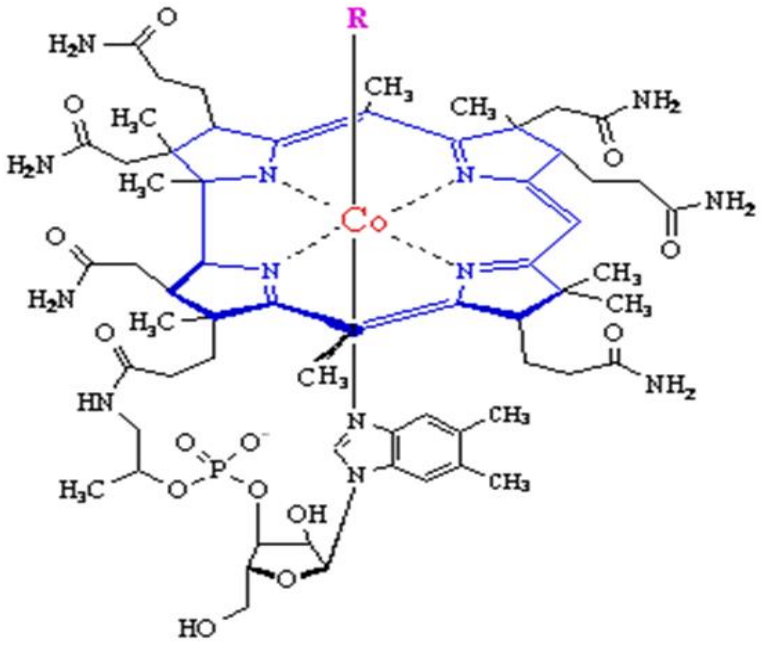
Vitamin B12 (cobalamins)

Its complex composition and found only in Micro organs and not in plant only

***5-deoxyadenosylcobalamin**

****act transfer alkyl groups, hydrogen groupsin بقوليات**

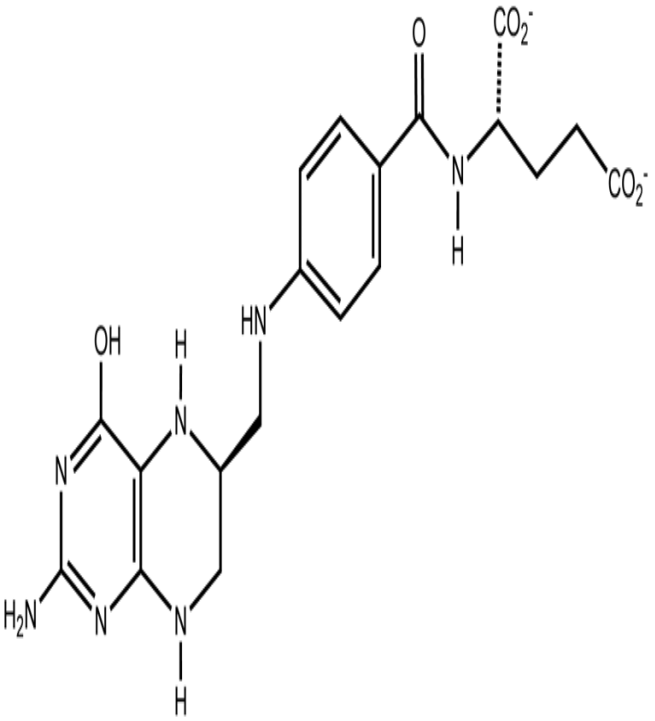
- Involved in synthesis,of DNA, amino acids, fatty acids, one-C metabolism (methylations)
- Needed to maintain nerve cells, RBC, genes
- Microbial in origin; intestinal flora contribute towards human dietary needs.
- Stored in the liver
- Found in meat, shellfish, liver, dairy products and eggs
- Deficiency causes pernicious anemia
- Poor absorption of B12 is thought to be a complication of aging
- Methylations such as the conversion of homocysteine to methionine require B12
- Contains Co(III) coordinated to a corrin ring (R = CN is cyanocobalamin, most common form)



R groups vary:
CN, OH, H_2O, NO_2, Me

Fig 2.29 p 32 Dewick

Vitamin B9 (folate)Tetra hydro folate THF
Folic acid=Pteroylglutamic acid
Glutamic+Amino benzoic+pteridine

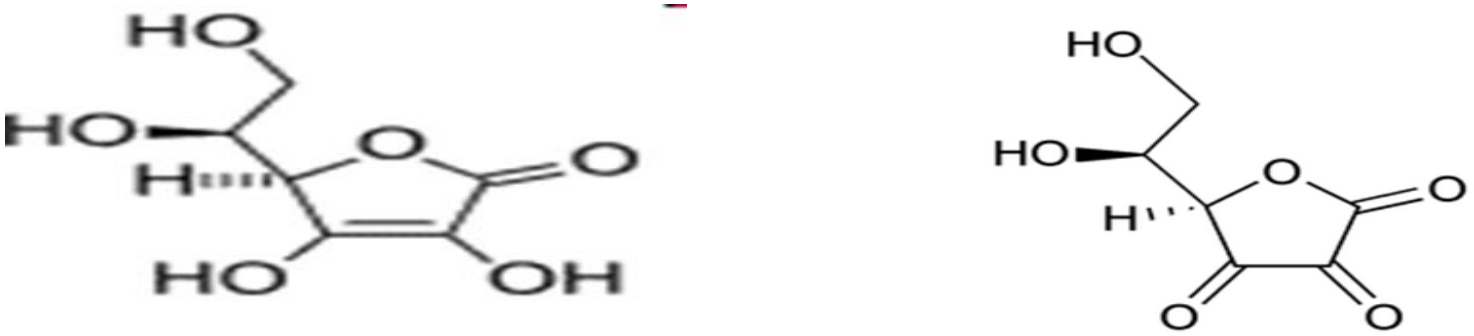


- Role: Tetrahydrofolate functions in one-C metabolism as a carrier of methyl, methylene or formyl groups
- Involved in amino acid and nucleotide metabolism, red blood cell formation
- Found in green veggies, yeast, liver, legumes, whole grains, some fruits
- Deficiency can cause anemia, neural tube defects in a fetus, cardiovascular problems in adults
- Folate intake linked to reduced CVD, colon cancer in women and depression in men

Folate analyses:

- Microbiological assay
- HPLC on C18 column with fluorescence detection at 350 nm.

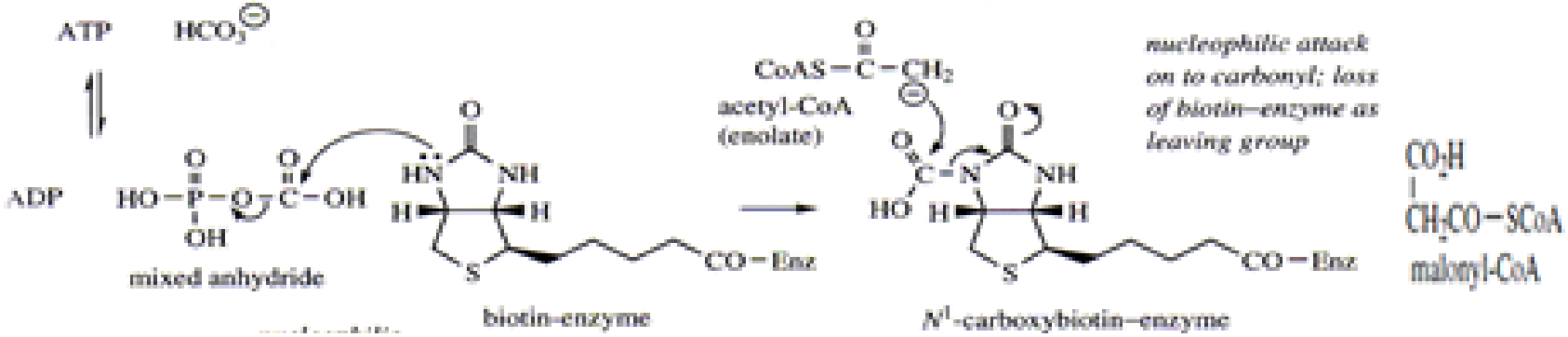
Vitamin C (ascorbic acid)



L-dehydroascorbic acid

- Antioxidant, strong reducing agent
- Collagen synthesis, tissue repair, bones & teeth, immune system, iron absorption
- Cannot be made by human body though animals can biosynthesize from glucose
- Found in citrus fruits, cruciferous veggies, tomatoes, dark green leafy, berries, mangos, melons
- Degraded by cooking
- Deficiency causes scurvy, anemia, depression, infection, tooth/gum problems, muscle deterioration, fragile bones, poor wound healing

Biotin (Vitamin H)):



- **Importance**: act to enter Carboxyle group to substance.
- Ex: transforms acetyl-CoA to malonyl-CoA (acetate pathway)
- functions as a carboxyl group carrier
- Found in eggs, liver, kidney, yeast, cereals, milk
- Also produced by intestinal microflora
- Deficiency is rare, but could lead to dermatitis and hair loss

Fat –Soluble Vitamins E,D,A,K

- **Only 4 fat soluble-vitamins and there are many kinds of vitamins involved process that accrue in**
  - **Cell membranes**
- **It contain non-polar to enhances their solubility in cell membrane.**
- **Vitamin A:-Dietary intake provide *present in both forms *Preformed and precursor* forms as provitamin .**
- ***Preformed active (retinoids) as Retinal ,retinol,retinic acid***
- ***Sources from egg yolks, and datary products and provide retinyl compound esters that easy hydrolyzed to retinoids in the intestine.***

Vitamin D

- Tow must important members of the Vit D family D3 cholecalciferol and VitD2 ergocalciferol,
- Vit D3 produced in the skin of human and animls by sunlight (UV) to its procures molecule(7-dehydrocholesterol) and absorbed of light energy.
- 7-Dehydrochlesterol---UV→ Pre-vitaminD3→D3 (cholecaliferol)
- And its called sun shine vit because syntheses in the skin by sun light radiation.
- **The principle function: maintain normal blood levels Ca and P in bones.**

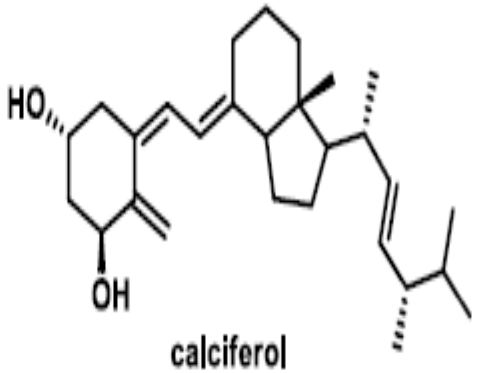
Chemical name and provitamins: Cholecalciferol, Ergocalciferol

Solubility: fat

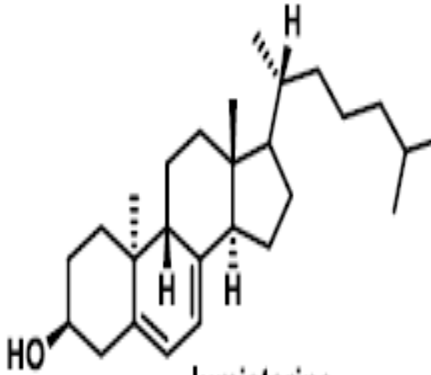
Deficiency disease: Rickets and Osteomalacia

Overdose disease: Hypervitaminosis D

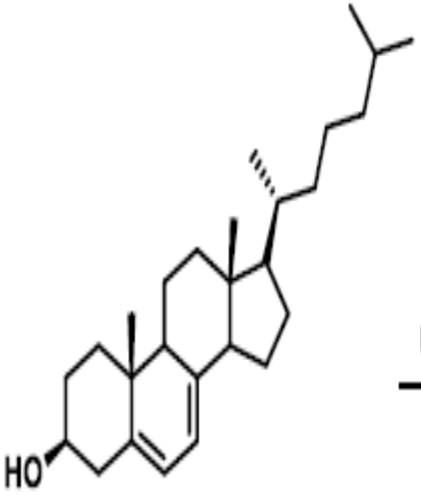
Food sources: Fish, eggs, liver, mushrooms



calciferol

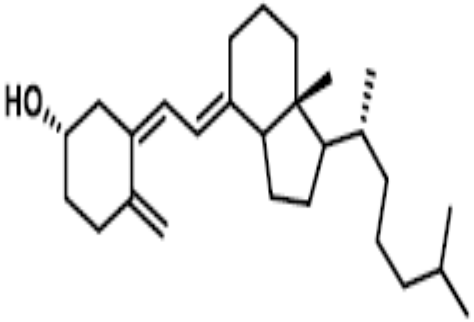


lumisterine

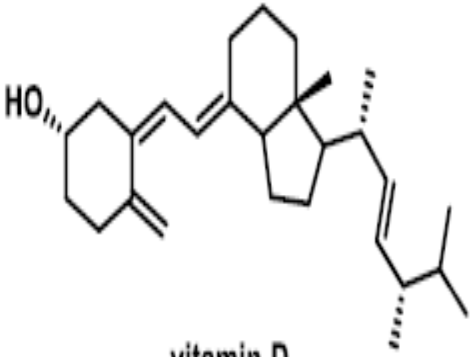


7-dehydrocholeseterine

UV light



vitamin-D_3



vitamin-D_2

Vitamin E

- **There are 4 forms of it Vitamin Alpha,Beta,delta, gamma Tocopherol**
- **The greatest for alpha-Tochopherol .in plant oil,salad,green vegetable, as sourses .**
- **The primary functions:**
- **As antioxidnt in the body.as compound that protect the compound in body from oxidation by bieng oxidied itsef**
- **Important in preventing the oxidation of polyunsaturated fatty acids in membrane lipids.**
- **And act also been found to conversion of Arachidonic acid to prostoglandins.**

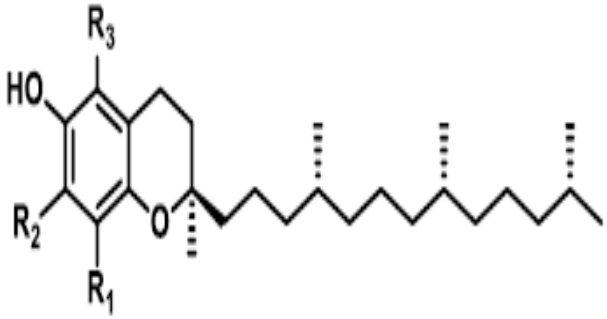
Chemical name and provitamins: Tocopherols, tocotrienols

Solubility: fat

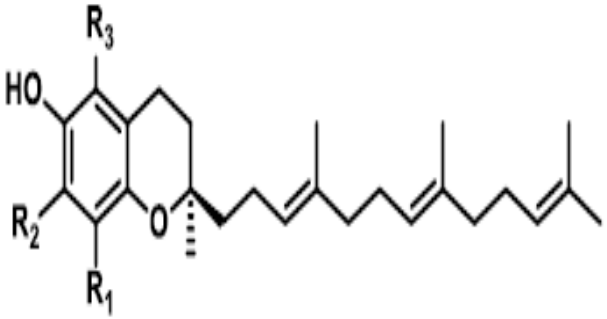
Deficiency disease: Deficiency is very rare; sterility in males and abortions in females, mild hemolytic anemia in newborn infants

Overdose disease: Increased congestive heart failure

Food sources: Many fruits and vegetables, nuts and seeds

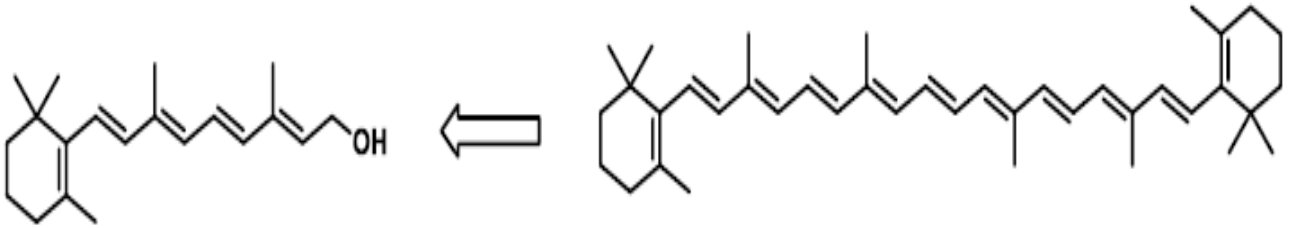


α-tocopherol: $R_1 = R_2 = R_3 = CH_3$
β-tocopherol: $R_1 = R_3 = H$; $R_2 = CH_3$
γ-tocopherol: $R_1 = R_2 = H$; $R_3 = CH_3$
δ-tocopherol: $R_1 = R_2 = R_3 = H$



α-tocotrienol: $R_1 = R_2 = R_3 = CH_3$
β-tocotrienol: $R_1 = R_3 = H$; $R_2 = CH_3$
γ-tocotrienol: $R_1 = R_2 = H$; $R_3 = CH_3$
δ-tocotrienol: $R_1 = R_2 = R_3 = H$

Vitamin A



Chemical name and provitamins: Retinol, retinal, and four carotenoids including β-carotene

Solubility: fat

Deficiency disease: night-blindness; hyperkeratosis; keratomalicia

Overdose disease: Hypervitaminosis A

Food sources: Liver, orange, ripe yellow fruits, leafy vegetables, carrots, pumpkin, squash, spinach, fish, soy milk, milk

Vitamin A is a group of unsaturated nutritional organic compounds, that includes retinol, retinal, retinoic acid, and several provitamin A carotenoids, among which beta-carotene is the most important.

Vitamin A has multiple functions: it is important for growth and development, for the maintenance of the immune system and good vision. Vitamin A is needed by the retina of the eye in the form of retinal, which combines with protein opsin to form rhodopsin, the light-absorbing molecule necessary for both low-light (scotopic vision) and color vision. Vitamin A also functions in a very different role as retinoic acid (an irreversibly oxidized form of retinol), which is an important hormone-like growth factor for epithelial and other cells.

Vitamin K

- Has more than one forms K1.K2.K3.K4
- Called phyllo quinone
- Essential to the blood clooting process and essential for the formation of **Prothombin**
- Five other proteins involved in the requlation of blood clotting.
- Vitamin K: is also requierd for the biosynthsis of several other proteins found in the plasma,bone and kidneys.

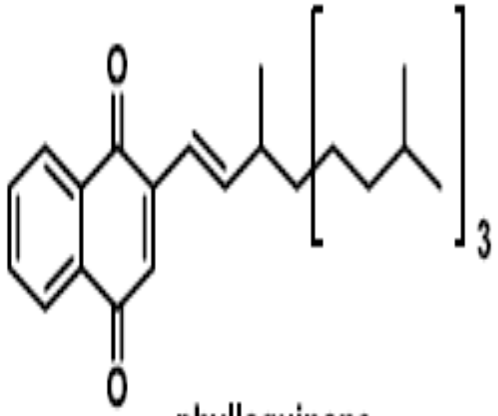
Chemical name and provitamins: phylloquinone (K_1), menaquinones (K_2)

Solubility: fat

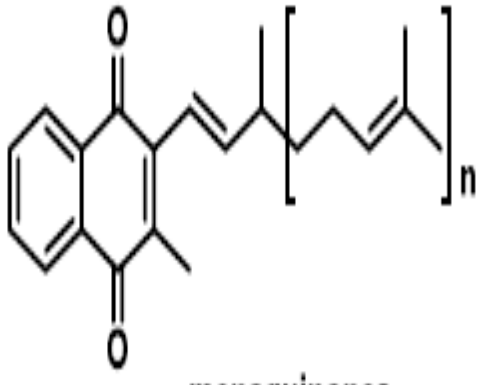
Deficiency disease: Bleeding diathesis

Overdose disease: Increases coagulation in patients

Food sources: Leafy green vegetables such as spinach, egg yolks, liver



phylloquinone



menaquinones

Vitamin K is a group of structurally similar, fat-soluble vitamins that the human body needs for modificat