

VITAMINS



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INTRODUCTION

- ❖ The word "**vitamin**" comes from the Latin word "**vita**", means "**life**".
- ❖ **Vitamins are organic components in food that are needed in very small amounts for growth and for maintaining good health.**



FEATURES AND CHARACTERISTICS

- ❖ Vitamins are required in small quantities in the diet because they cannot be synthesized by the body.
- ❖ Water soluble vitamins cannot be stored in human tissues. Their excess is excreted with urine.
- ❖ Significant amounts of fat soluble vitamins can be stored in adipose tissue and the liver.
- ❖ Synthetic vitamins are identical to natural vitamins.
- ❖ Once growth and development are completed, vitamins remain essential nutrients for the healthy maintenance of the cells, tissues, and organs.

FUNCTIONS

- ❖ They build up the **immunity** of the body.
- ❖ Prevent and cure various diseases caused by deficiency.
- ❖ Helps in body's metabolism.
- ❖ Stimulate and give strength to digestive and nervous system.
- ❖ Help maintenance of proper health and normal growth.

CLASSIFICATION

- On the basis of their **solubility** vitamins are mainly 2 types:

Fat soluble vitamins



Water soluble vitamins



vitamins

FAT SOLUBLE VITAMIN

- VITAMIN A (RETINOIDS)
- VITAMIN D (CALCITRIOL)
- VITAMIN E (TOCOPHEROL)
- VITAMIN K (NAPHTHOQUINONE)

WATER SOLUBLE VITAMIN

VITAMIN B COMPLEX

VITAMIN C (ASCORBIC ACID)

ENERGY RELEASING VITAMIN

HEMATOPOIETIC

OTHERS

- THIAMINE (B1)
- RIBOFLAVIN (B2)
- NIACIN (B3)
- PANTOTHENIC ACID (B5)
- BIOTIN (B7)

- FOLIC ACID (B9)
- CYNOCOBALAMIN (VIT-B12)

- PYRIDOXINE
- PYRIDOXAL
- PYRIDOXAMINE (VIT-B6)



Vitamin D
The body makes vitamin D when it is exposed to Ultraviolet (UV) rays from the sun.

FOOD SOURCES:

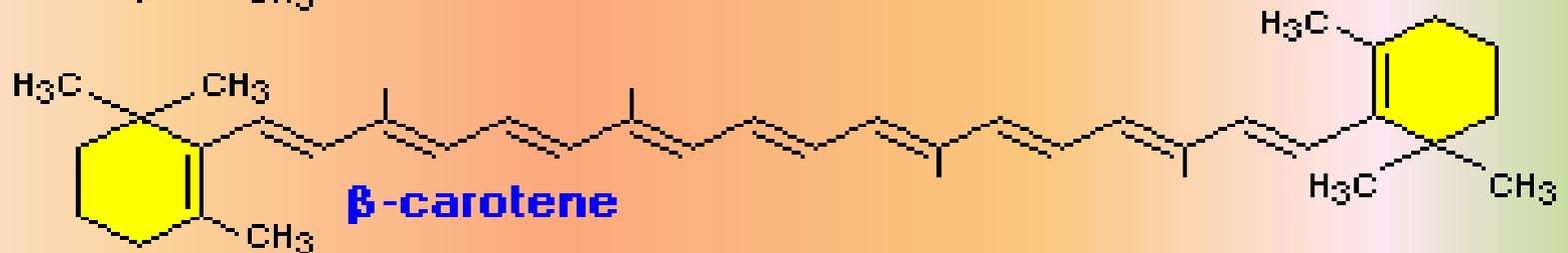
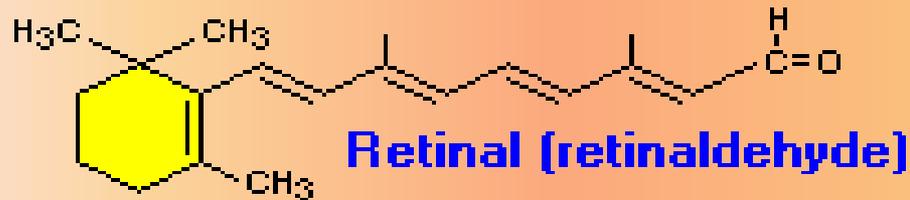
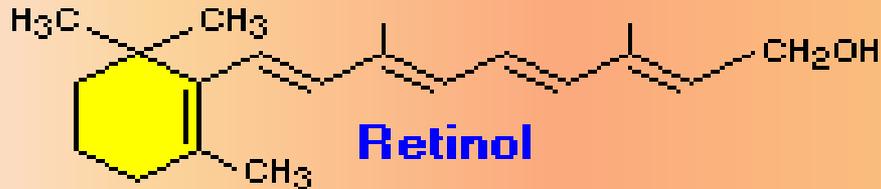
- Cheese
- Margarine
- Butter
- Fortified Milk
- Healthy Cereals
- Fatty Fish

VITAMIN –A

(ANTI-NIGHT BLINDNESS FACTOR)

- Vitamin A is a group of unsaturated nutritional organic compounds and Its active form is present only in Animal Tissue.
- Provitamin A carotenoids, among which **beta-carotene** is present in plants.
- **Retinol** (vitamin A alcohol), **Retinal** (vitamin A aldehyde) and **Retinoic acid** (vitamin A acid) are vitamers of vitamin A.
- Non Provitamins:
 - **lutein & zea-xantheine**: protect against macular degeneration
 - **lycopene**: protects against prostate cancer.

CHEMICAL STRUCTURE OF VITAMIN -A



FUNCTIONS

- ❖ Vitamin A plays a role in a variety of functions throughout the body, such as:
- ❖ Vision
- ❖ Gene transcription
- ❖ Immune function
- ❖ Embryonic development and reproduction
- ❖ Bone metabolism
- ❖ Hematopoiesis (the production of blood cells and platelets)
- ❖ Skin and cellular health
- ❖ Antioxidant activity

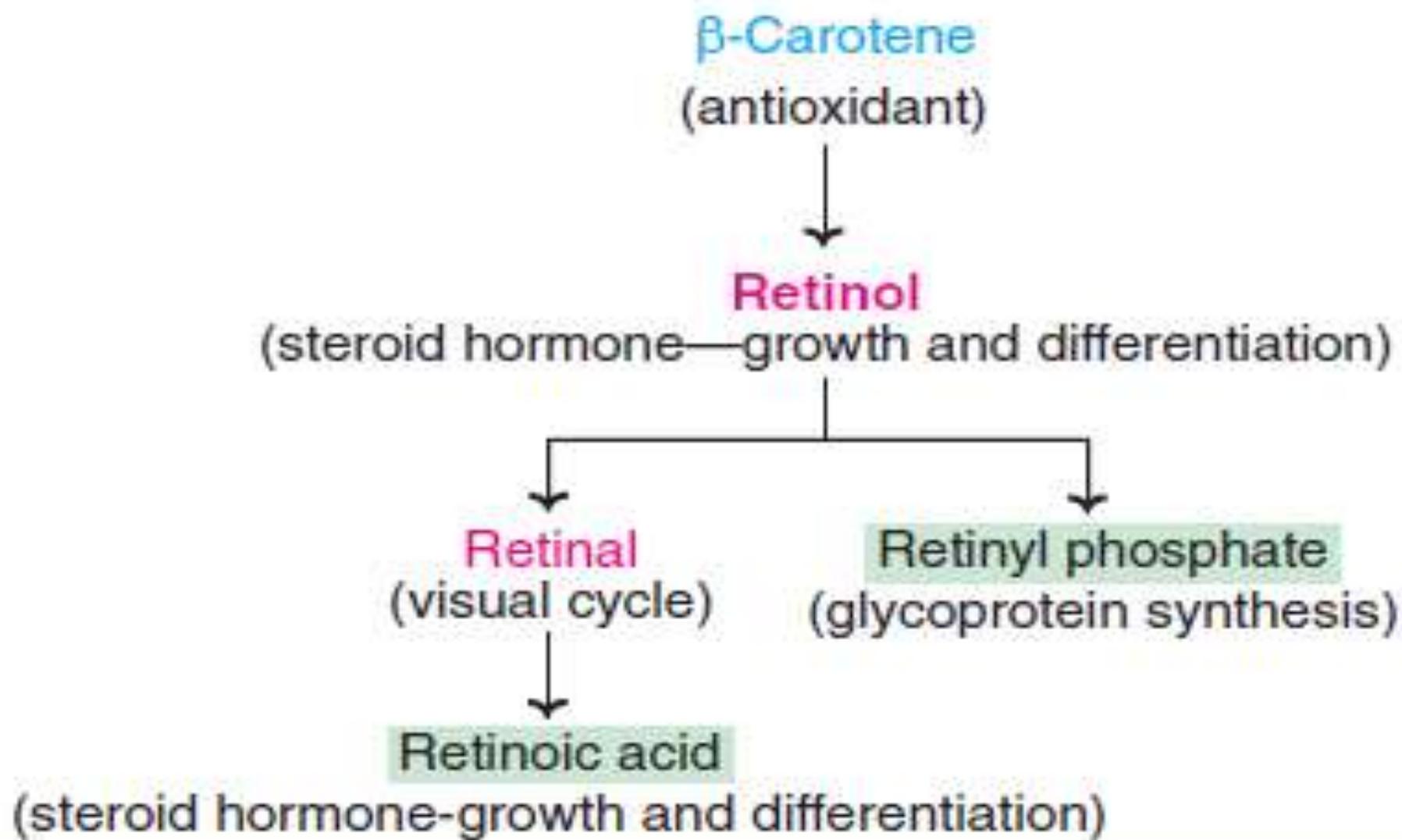
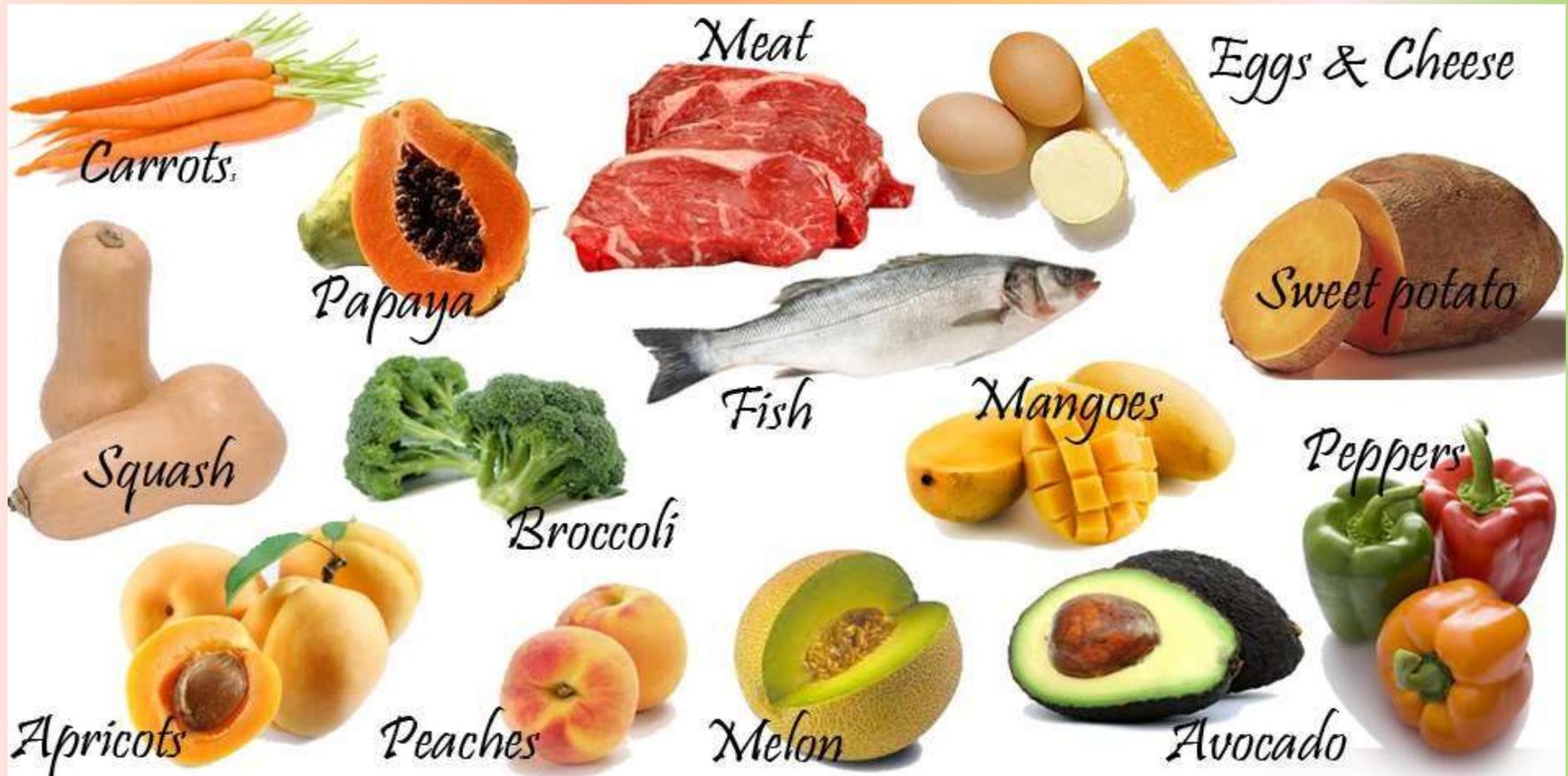


Fig. 7.3 : Summary of the functions of vitamin A compounds.

DIETARY SOURCES OF VITAMIN A



Animal sources contain (preformed) vitamin A. The best sources are **liver, kidney, egg yolk, milk, cheese, butter. Fish (cod or shark) liver oils** are very rich in vitamin A. **Vegetable sources contain the provitamin A-carotenes. Yellow and dark green vegetables** and fruits are good sources of carotenes e.g. carrots, spinach, pumpkins, mango, papaya etc.

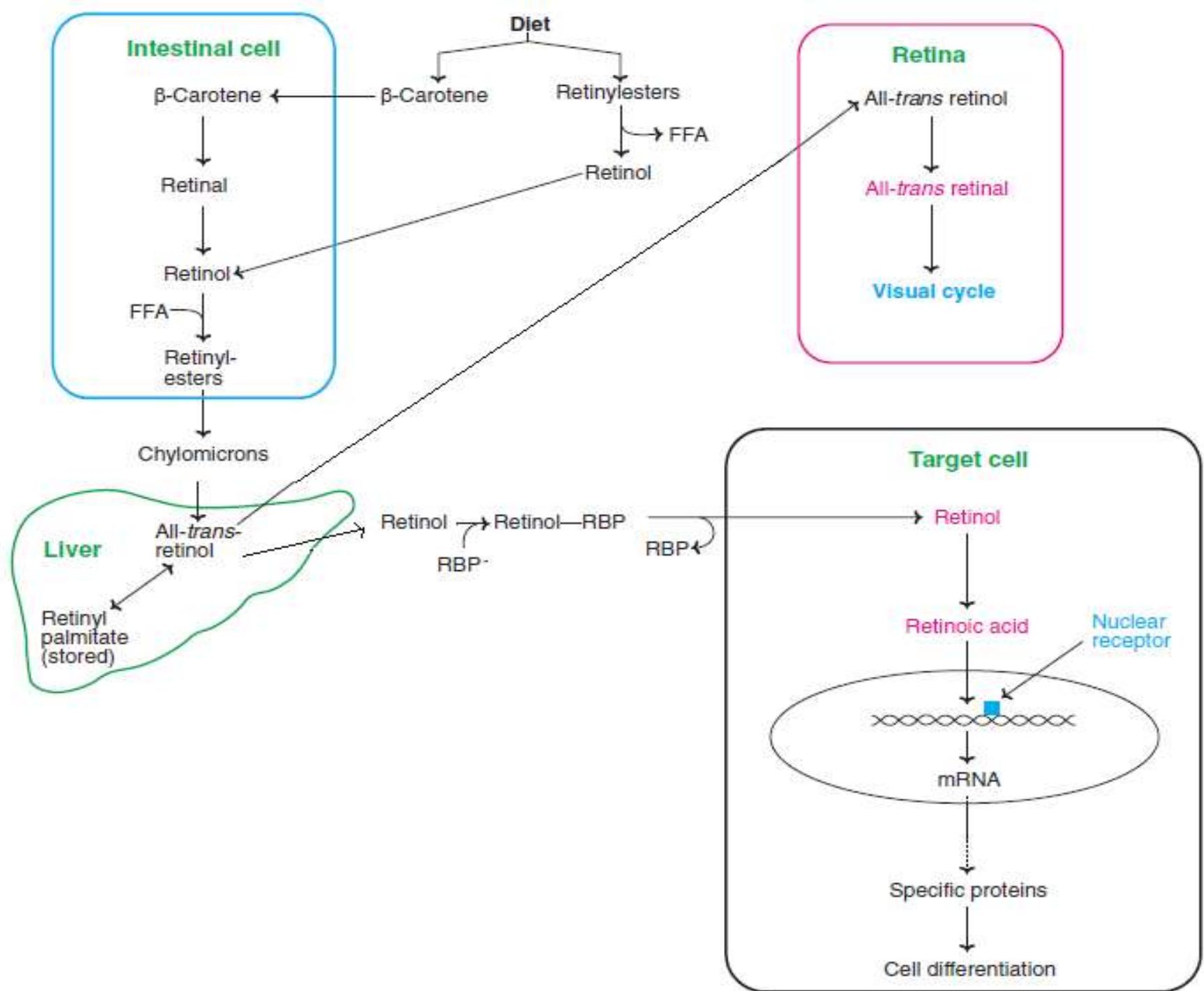
Recommended dietary allowance (RDA)

- The daily requirement of vitamin A is expressed as **retinol equivalents (RE) rather than** International Units (IU).
- 1 retinol equivalent = 1 μ g retinol
 - = 6 μ g β -carotene
 - = 12 μ g other carotenoids
 - = 3.33 IU of vitamin A activity from retinol
 - = 10 IU of vitamin A activity from β -carotene

The RDA of vitamin A for adults is around **1,000 retinol equivalents (3,500 IU) for man and 800 retinol equivalents (2,500 IU) for woman.**

MOBILIZATION AND ABSORPTION OF VITAMIN A

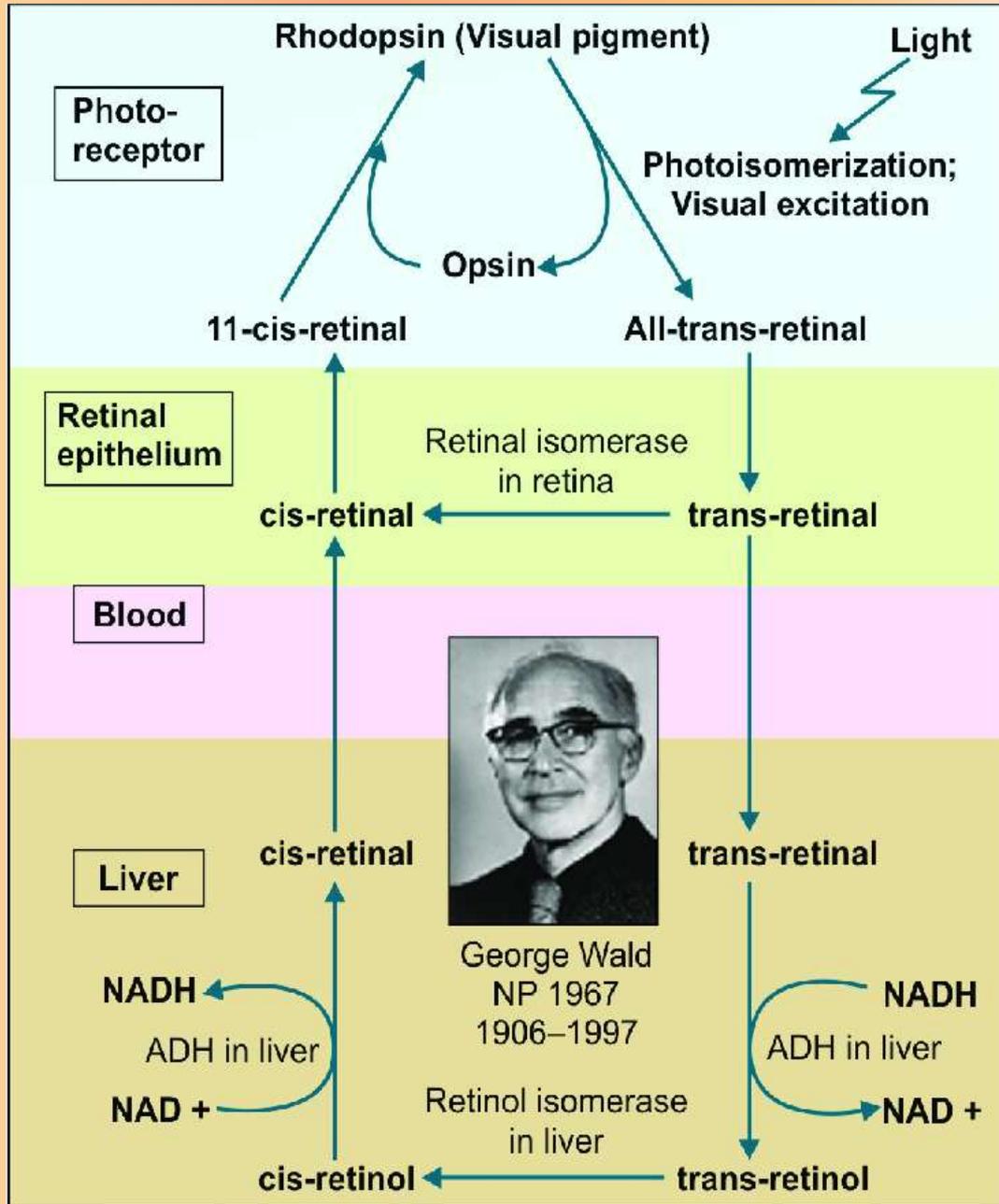
- Dietary retinyl esters are hydrolyzed by pancreatic and intestinal hydrolyses in intestine releasing retinol & free fatty acids.
- Carotenes are hydrolyzed by β -carotene 15-15' dioxygenase of intestinal cells to release 2 moles of retinal which is reduced to retinol.
- In intestinal mucosal cells, retinol is re-esterified to LCFA incorporated into chylomicrons & transferred to lymph.
- Retinol esters of chylomicrons are taken up by liver & stored.
- When required Vitamin A is released from liver as free retinol.



MOBILIZATION AND ABSORPTION OF VITAMIN A

- Retinol is transported in circulation by Plasma Retinol Binding Protein in association with albumin(transthyretin).
- Retinol-RBP complex binds to specific receptors on cell membrane of peripheral tissues & enters cells.
- Carry retinol by Cellular Retinol Binding Protein(CRBP)and Cellular Retinoic Acid Binding Protein(CRABP-I, CRABP-II) to nucleus & binds to chromatin(DNA).

WALD'S VISUAL CYCLE



DARK ADAPTATION TIME:

When a person shifts from a bright light to dim light (e.g. entry into a dim cine theatre), rhodopsin stores are depleted and vision is impaired. However, within few minutes, known as dark adaptation time, rhodopsin is resynthesized and vision is improved. Dark adaptation time is increased in Vitamin A deficient individuals.

LIGHT CYCLE

- **When the G protein** transducin binds to light-activated rhodopsin **A, on the structure of the complex**; it leads to the GDP that is bound to the transducin being exchanged for GTP.
- In transducin that has been activated in this way, the GTP-containing α -subunit breaks off from the rest of the molecule and in turn activates a membrane *cGMP phosphodiesterase*.
- This hydrolyzes cGMP to GMP and thus reduces the level of free cGMP within milliseconds.
- As a consequence, the cGMP bound at the ion channel dissociates off and the channel closes.
- As cations are constantly being pumped out of the cell, the membrane potential falls and **hyperpolarization of the cell** occurs, which interrupts glutamate release.

REGENERATION

After exposure to light, several processes restore the initial conditions:

1. The **α -subunit of transducin** inactivates itself by GTP hydrolysis and thus terminates the activation of **cGMP esterase**.
2. The reduced Ca^{++} concentration causes activation of **guanylate cyclase**, which increases the **cGMP** level until the cation channels reopen.
3. An **isomerase** transfers *all-trans-retinal* to the *11-cis-form*, in which it is available for the next cycle. A dehydrogenase can also allow retinal to be supplied from vitamin A (retinol).

CAUSES OF VITAMIN A DEFICIENCY

- Inadequate intake
- Impaired absorption
- Impaired storage & transport
- Increased excretion [RBP]
- Alcoholism

FEATURES OF VITAMIN A DEFICIENCY

- Night blindness
- Xerophthalmia
- Bitot spots
- Keratomalacia
- Infections
- Hyperkeratinization of skin
- Growth retardation
- Anemia

Xerophthalmia-

characterized by

- dryness (**xerosis**) in conjunctiva and cornea, **bitot's** spot-white patches of keratinised epithelium appearing on sclera.
- If Xerophthalmia persists for a long time, corneal ulceration and degeneration occur.



Bitot spot, Keratomalacia, Xerophthalmia

Effect on Growth:

Vitamin A deficiency results in growth retardation due to impairment in skeletal formation.

Effect on Reproduction :

The reproductive system is adversely affected in Vitamin A deficiency. Degeneration of germinal epithelium leads to sterility in males.

Effect on Skin and epithelial cells (phrynoderma):

The skins becomes rough and dry. Keratinization of cells of GIT, Respiratory Tract, Genito-UrinaryTract leads to increased bacterial infections.



VITAMIN D (SUNSHINE VITAMIN)

- ❖ Vitamin D refers to a group of fat-soluble secosteroids (a type of steroid with a "broken" ring) found in liver and fish oils, or obtained by irradiating provitamin D with ultraviolet light and are responsible for enhancing intestinal absorption of calcium, iron, magnesium, phosphate and zinc. It is also called ***SUNSHINE VITAMIN***.

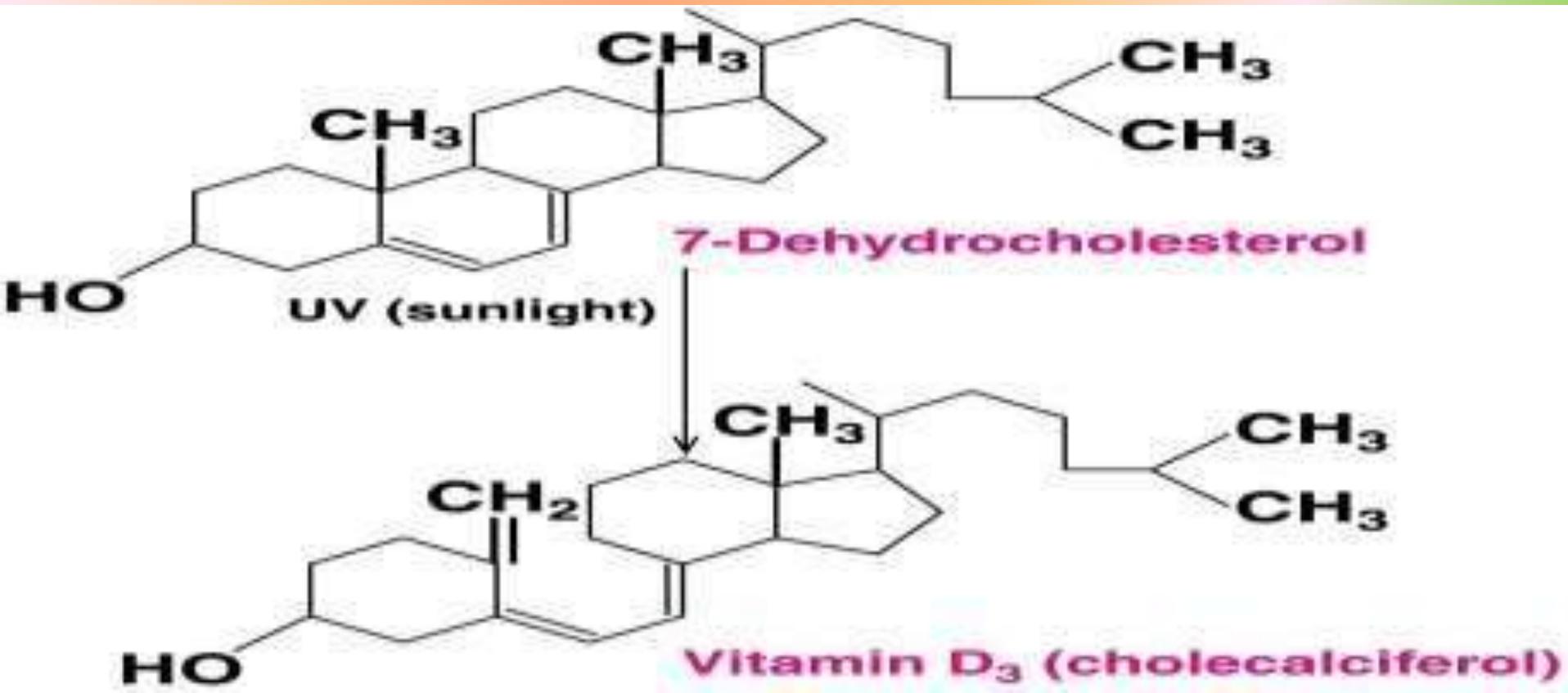
It is available in 2 forms-

Cholecalciferol (vitamin D3)

is made from 7-dehydrocholesterol in the skin of animals and humans.

Calciferol - D2

is obtained artificially by irradiation of ergo- sterol and is called ergocalciferol.



DIETARY SOURCES OF VITAMIN D

Vitamin D

The body makes vitamin D when it is exposed to Ultraviolet (UV) rays from the sun.

FOOD SOURCES:

Cheese
Margarine
Butter
Fortified Milk
Healthy Cereals
Fatty Fish



RDA

- Children - 10 gm/day or 400 IU/day —
- Adults - 5 gm/day or 200 IU/day —
- Pregnancy/lactation -10 gm/day or 400 IU/day —
- Above the age of 60 yrs - 600 IU /day

FUNCTIONS OF VITAMIN D

Calcium and Phosphorus Homeostasis

- Calcium and Phosphorus absorption (small intestine)
- Calcium resorption (bone and kidney)
- Maintain blood calcium levels

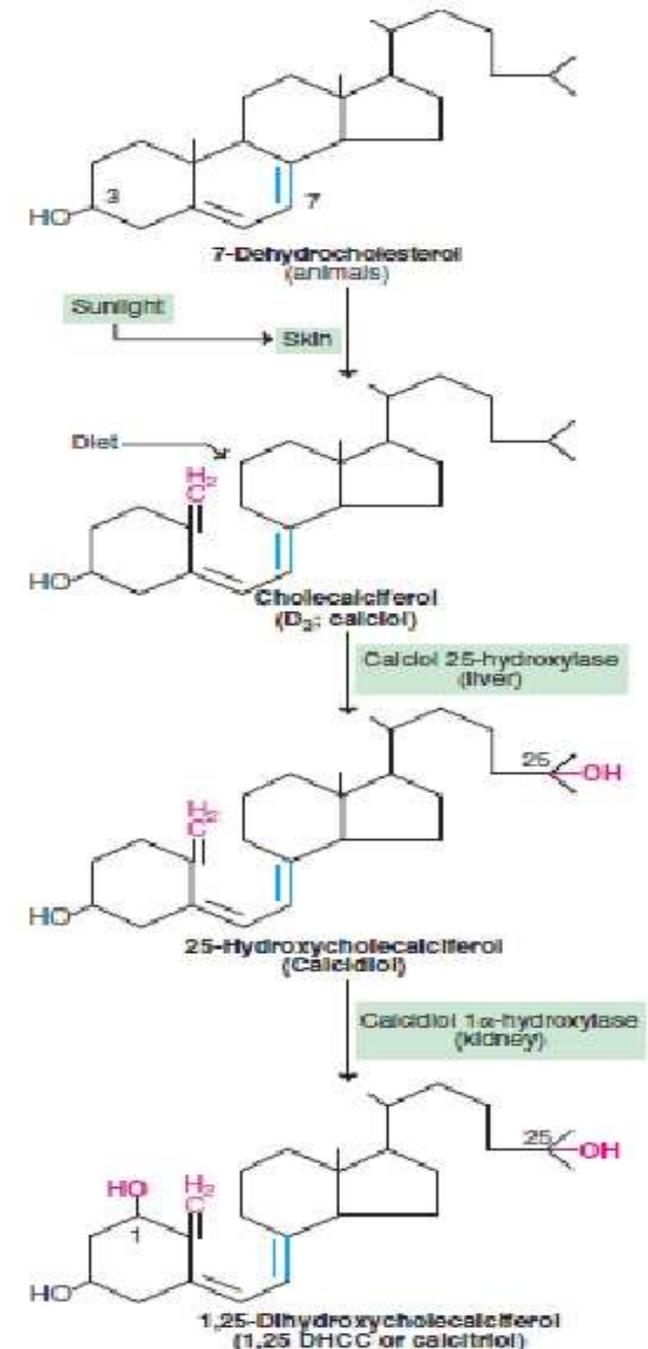
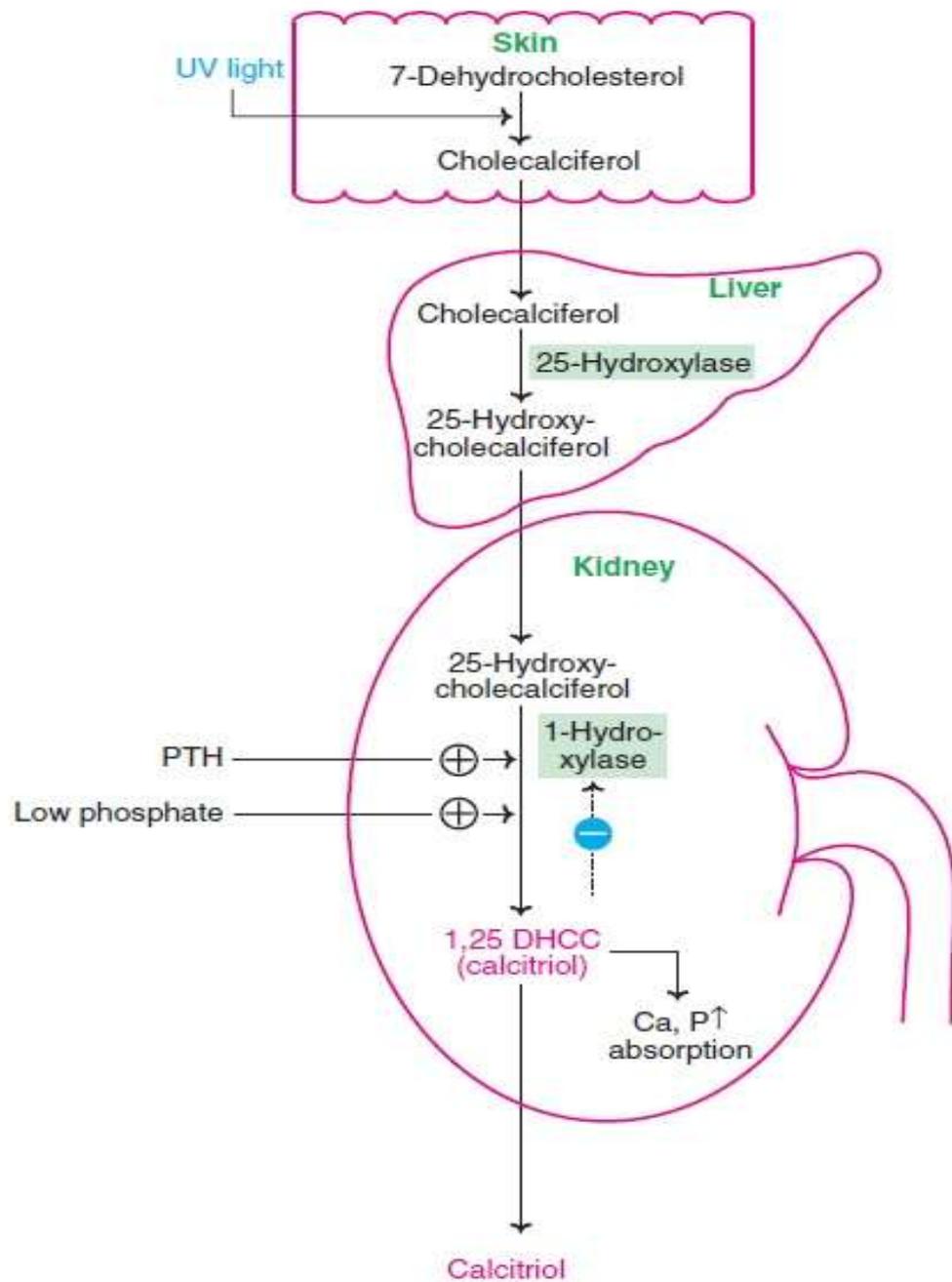
Bone formation

- Stimulate calcium uptake for deposition as calcium phosphate (Osteoblasts: bone-forming cells)

FUNCTIONS OF VITAMIN D

Other effects-it acts like steroid hormone, binding to nuclear receptors and enhance gene expression

- Is involved in insulin secretion
- Synthesis & secretion PTH & thyroid hormones
- Inhibition of production interleukins by activated T -lymphocytes
- Modulation of cell proliferation



BIOSYNTHESIS & FUNCTIONS OF VITAMIN D

Fig. 7.7 : Biosynthesis of active form of vitamin D-calcitriol (1,25 DHCC).

Transport absorption & storage

- vitamin D is transported from intestine to the liver by binding to **vitamin D binding globulin**.
- **25 – Hydroxy D3** and **1,25 – dihydroxy D3** are also transported in the blood by binding to vitamin D binding globulin. —
- **25 – hydroxycholecalciferol** is the major storage and circulatory form of vitamin D.

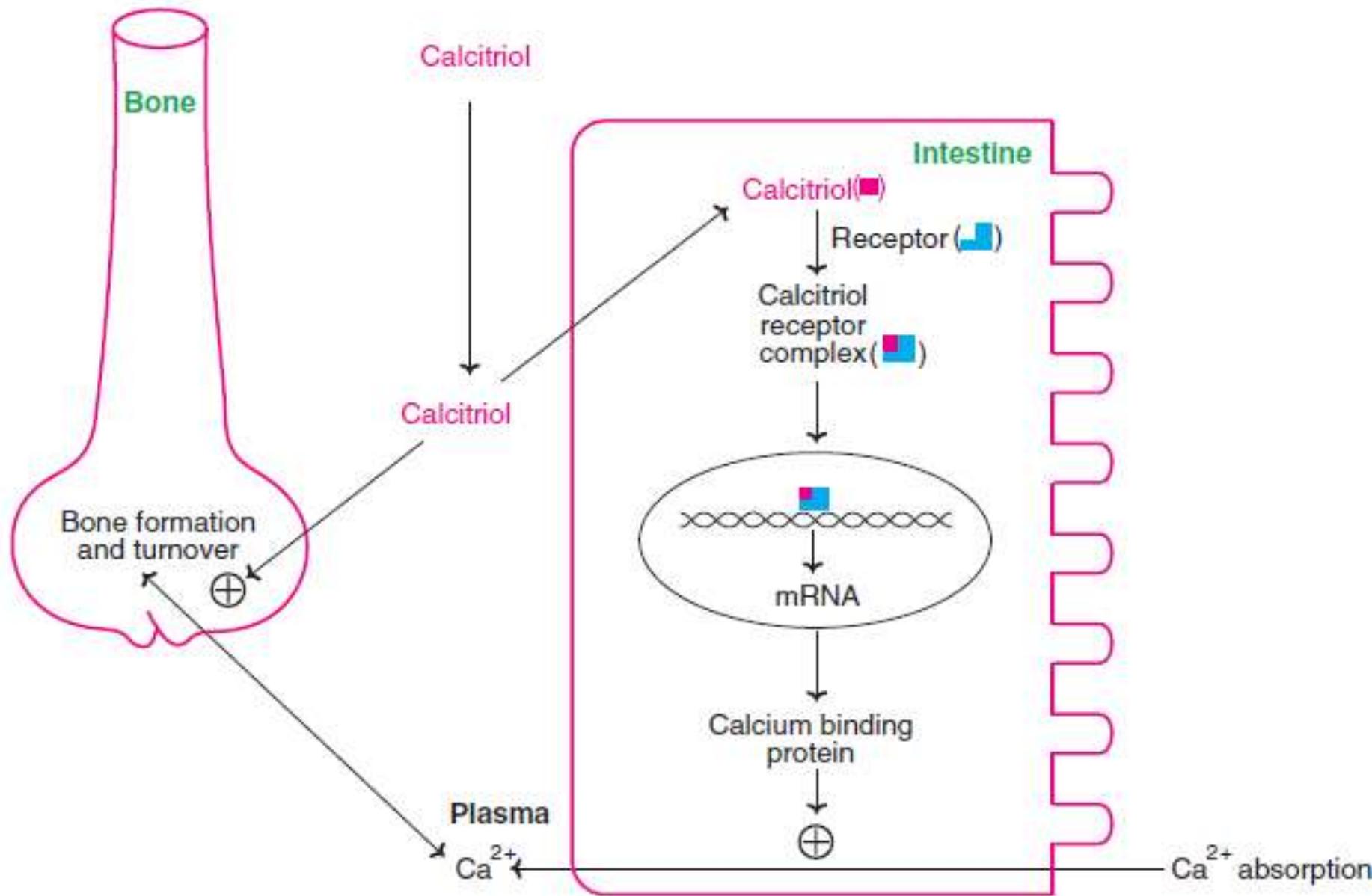


Fig. 7.8 : Metabolism and biochemical functions of vitamin D (1, 25 DHCC-1, 25-Dihydroxycholecalciferol, also called as calcitriol is the active form of vitamin D; PTH-Parathyroid hormone).

Vitamin D is a hormone not a vitamin- a justification.

- Calcitriol is now considered as an important calcitropic hormone, while cholecalciferol is the prehormone.
- Cholecalciferol (vitamin D₃) is synthesized in the skin by ultra violet rays of sunlight.
- The biologically active form of vitamin D, calcitriol is produced in the kidney.
- Calcitriol has target organs- **intestine, bone and kidney**, where it specifically acts.
- other tissues-PT glands, Pancreas, immune system, musculoskeletal system

- Calcitriol synthesis is self regulated by a feedback mechanism i.e., calcitriol decreases its own synthesis by **inducing 24-hydroxylase and repressing 1-hydroxylase in kidneys.**
- Calcitriol action is similar to steroid hormones.

DEFICIENCY OF VIT-D

- ✓ **Insufficient exposure to sunlight.**
- ✓ **higher melanin content (darker skin)**
- ✓ **breast-fed infants**
- ✓ **body covering/use of sunscreen**
- ✓ **fat malabsorption syndrome**
- ✓ **inadequate dietary intake**
- ✓ **liver and renal diseases**
- ✓ **genetic susceptibility**



Deficiency of vitamin D

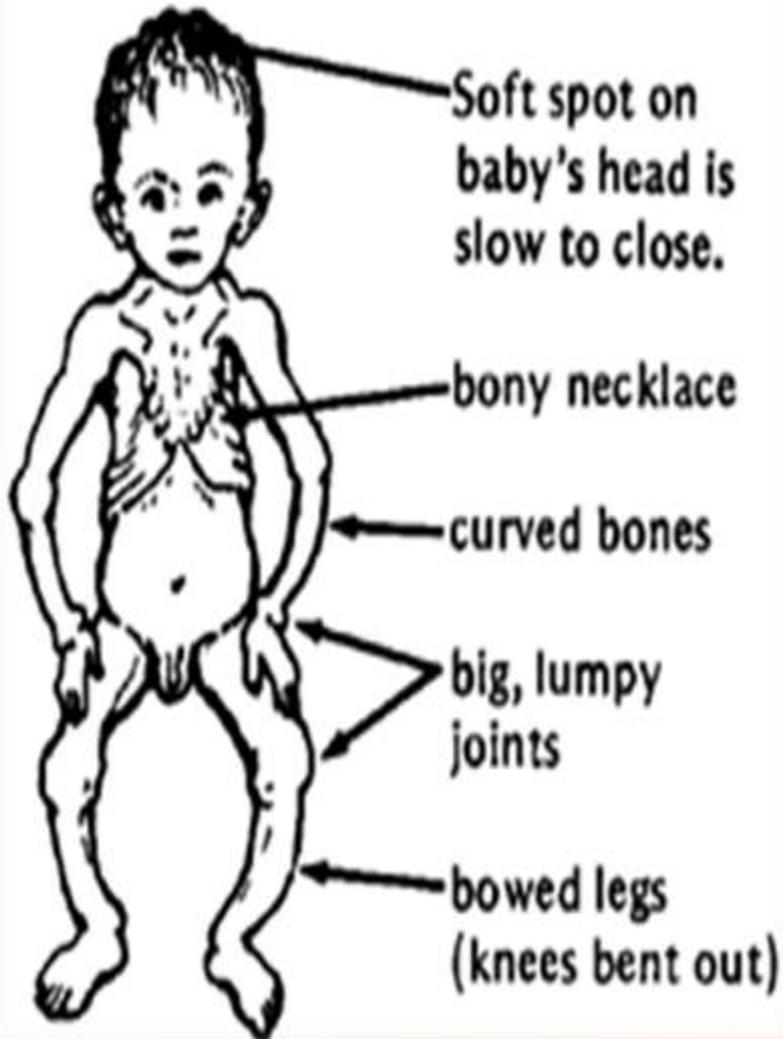
- **RICKETS:** ~~It~~ is a vitamin D deficiency state in children. —
- Causes: Dietary deficiency and non-exposure to sunlight. —
- Rickets in children and is characterized by bone deformities due to incomplete mineralization.

SIGNS & SYMPTOMS

- ❖ inadequate calcification of bones.
- ❖ Growth retardation.
- ❖ Frontal bone becomes prominent-**frontal bossing**
- ❖ Misshapen bones- **bowing of the legs.**
- ❖ Enlargement of the ends of long bones.
- ❖ Deformities of ribs-enlargement of epiphyseal ends of ribs and costchondral junctions lead to swelling ,**bead like appearance-ricket rosary.**
- ❖ **Chest cage expands become barrel shaped – pigeon chest**
- ❖ Lax muscles (resulting in a protruding abdomen) and muscle spasms -**pot belly**

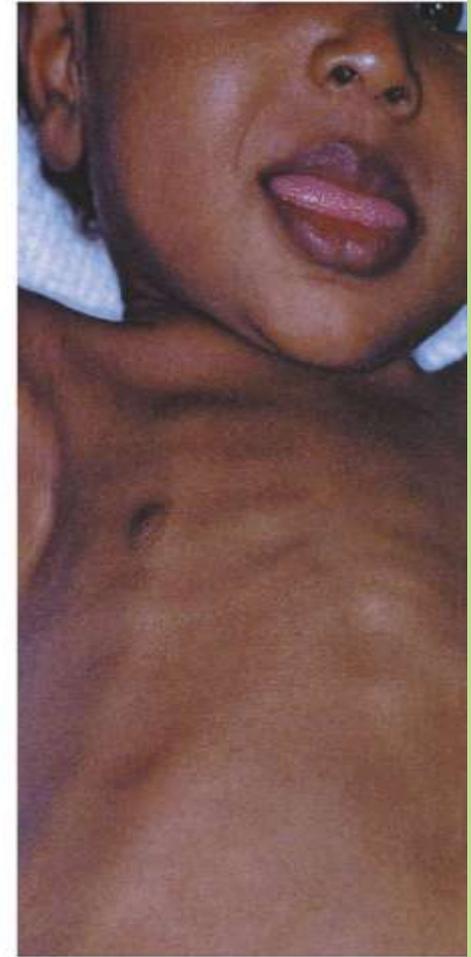
SIGNS & SYMPTOMS

SIGNS OF RICKETS



Bowed legs. In rickets, the poorly formed long bones of the legs bend outward as weight-bearing activities such as walking begin.

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Beaded ribs. In rickets, a series of "beads" develop where the cartilages and bones attach.

OSTEOMALACIA

(Greek: osteon-bone, malakia-softness):

- Adult form of rickets
- Soft, flexible, brittle, deformed bones
- Progressive weakness
- Pain in pelvis, lower back, and legs

on X-ray- cortical thinning & reduced opacity of bones (due to poor mineralization)



Figure 28.25

Bowed legs of middle-aged man with osteomalacia, a nutritional vitamin D deficiency that results in malformation of the skeleton.

RENAL RICKETS

- This seen in patients with chronic renal failure.
- Renal rickets is mainly due to **decreased enzyme activity of 1 α hydroxylase** present in kidneys, so synthesis of 1,25 di hydroxy D3 (calcitriol) does not occur.
- It can be treated by the administration of calcitriol.

Hypervitaminosis D

Vitamin D is stored mostly in liver and slowly metabolized.

Toxic effects- demineralization of bone (resorption) and increased calcium absorption from the intestine, hypercalcemia, loss of appetite, nausea, increased thirst, loss of weight.

Calcification of soft tissue

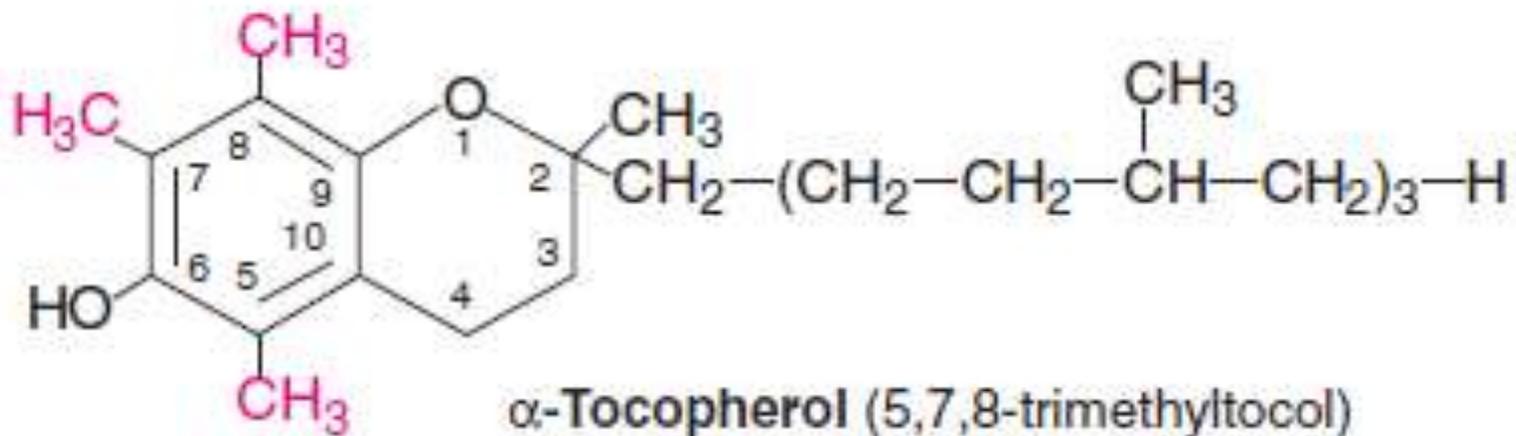
- Lungs, heart, blood vessels
- Hardening of arteries, stone formation in kidneys



VITAMIN E

- ❑ Vitamin E refers to a group of compounds that include both *tocopherols* and *tocotrienols*. They are naturally occurring **anti-oxidant**.
- The word tocopherol is derived from the word **toco** meaning child birth and **pheros** meaning to bear.
- It is also called **anti-aging** factor.
- It is essential for normal reproduction in many animals, hence known as **anti-sterility vitamin**.
- It is yellow oily liquid freely soluble in fat solvent.
- Tocopherol **$\alpha, \beta, \gamma, \delta$** have been obtained from the natural sources.

VITAMIN E

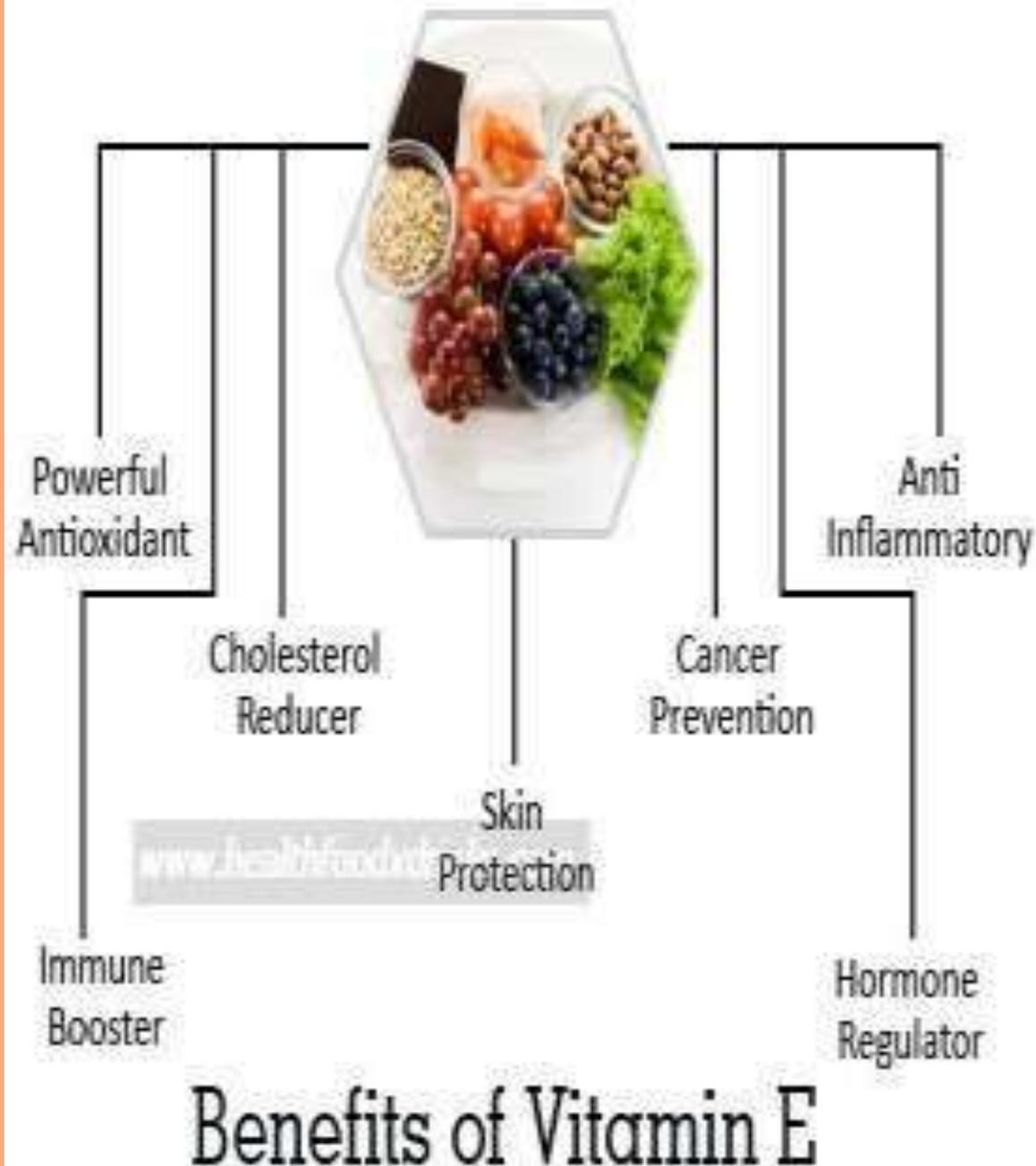


α -Tocopherol (5,7,8-trimethyltolcol)
 β -Tocopherol (5,8-dimethyltolcol)
 γ -Tocopherol (7,8-dimethyltolcol)

Fig. 7.10 : Structure of α -tocopherol (Note : The tocopherols differ in the substitution of methyl groups, represented in red).

FUNCTIONS

- Powerful natural Antioxidant
- Free radical scavenger
- Protects cell membranes
- Protects LDL from oxidation
- Protection of double bonds in polyunsaturated fatty acids
- Prevention of rancidity
- Vitamin E also plays a role in neurological functions.
- Inhibition of platelet aggregation.
- The element **selenium** helps in **these functions**.



DIETARY SOURCES OF VITAMIN E

In nature 8 isoforms of vitamin E exist. These 8 forms exist for important reasons as nature knows best that both tocotrienols and tocopherols work together synergistically to confer a higher beneficial effect from vitamin E.



almonds



bell peppers



butternut squash



dried apricots



leafy greens



green olives



papaya



pine nuts



cooked spinach

**cold-pressed
plant oils**



avocado



tomatoes



RDA OF VITAMIN E

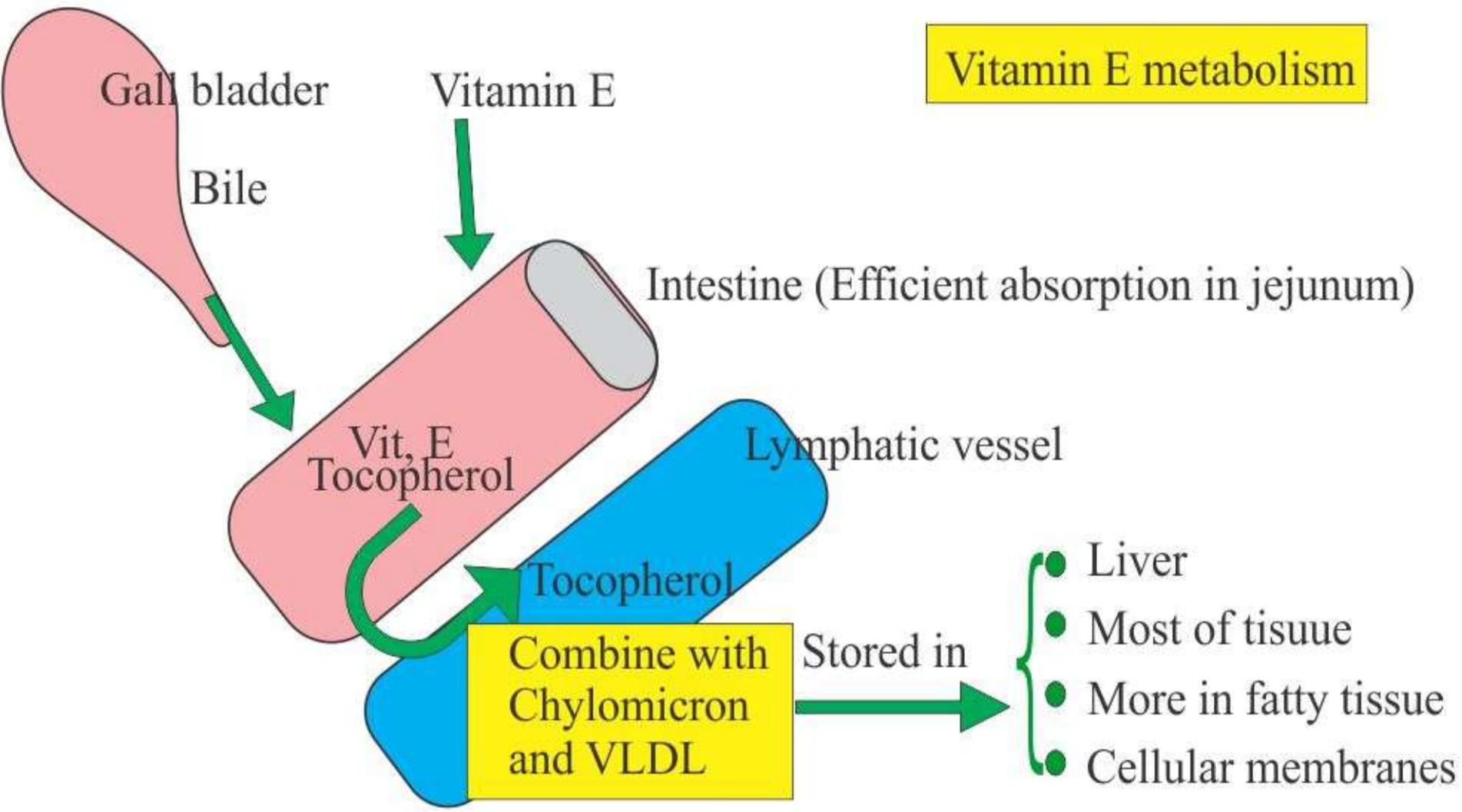
- A daily consumption of about **10 mg (15 IU)** of **α -tocopherol for man and 8 mg (12 IU)** for woman is recommended. One mg of **α -tocopherol** is equal to 1.5 IU.
- Vitamin E supplemented diet is advised for pregnant and lactating women.

TRANSPORT, ABSORPTION & STORAGE

- Vitamin E is absorbed along with fat in the small intestine.
- 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.
- The normal plasma level of tocopherol is less than 1 mg/dl.

TRANSPORT, ABSORPTION & STORAGE

Vitamin E metabolism



Deficiency Manifestations of Vitamin E

- In many animals, the deficiency is associated with sterility.
- Degenerative changes in muscle.
- Megaloblastic anaemia and changes in central nervous system.
- Severe symptoms of vitamin E deficiency are not seen in humans except increased fragility of erythrocytes and minor neurological symptoms.

Deficiency Manifestations of Vitamin E

Therapeutic Uses of vitamin E

Disease

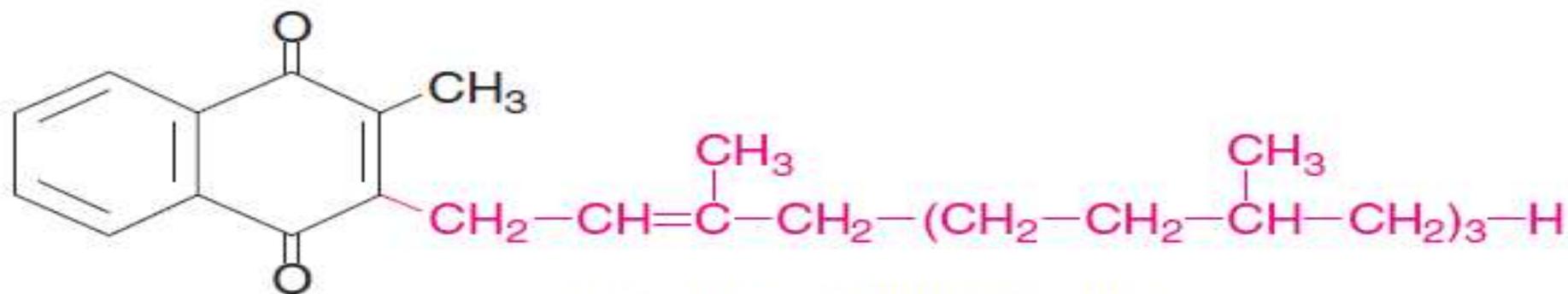
Mechanism of action of Vitamin E

- | <i>Disease</i> | <i>Mechanism of action of Vitamin E</i> |
|-------------------------------------|--|
| 1. Nocturnal muscle cramp (NMC) | The precise mechanism not known. By virtue of its antioxidant property, vit. E prevents oxidation of certain radicals and ensures better utilisation of oxygen in muscle tissue, thereby improving muscle metabolism. |
| 2. Intermittent claudication (IC) | Same as above. In addition: <ul style="list-style-type: none">• A decrease in circulating lactate level and increase in pyruvate level noted after therapy• Improvement in blood supply due to opening of new vessels, improving circulation |
| 3. Fibrocystic breast disease (FBD) | Precise mechanism of action in FBD remains obscure
It has been suggested that vit. E probably acts by correcting the deranged progesterone/estrogen ratio in women of FBD |
| 4. Atherosclerosis | Beneficial effects of vit. E in atherosclerosis are due to: <ul style="list-style-type: none">• Inhibits the formation of lipid peroxides and restores PG-I₂ synthesis• Inhibits platelets aggregation• Elevates HDL-cholesterol level ↑ (increased scavenging action). |



VITAMIN K

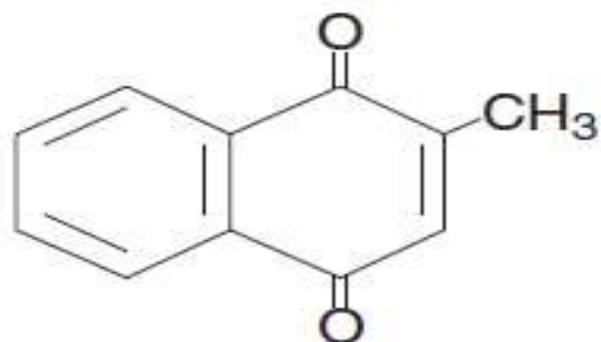
- Vitamin K is the only fat soluble vitamin with a specific coenzyme function.
- Vitamin K exists in different forms
 - Vitamin K1 (**phylloquinone**) is present in plants.
 - Vitamin K2 (**menaquinone**) is produced by the intestinal bacteria and also found in animals.
 - Vitamin K3 (**menadione**) is a synthetic form.



Vitamin K₁ (phylloquinone)



Vitamin K₂ (menaquinone)



Vitamin K₃ (menadione)

Fig. 7.11 : Structures of vitamin K.

FUNCTIONS OF VITAMIN K

- It is essential for the hepatic synthesis of coagulation factor **II, V, VII, IX, X**.
- **CLOTTING** – it prevents hemorrhage only in cases when there is defective production of prothrombin
- **OXIDATIVE PHOSPHORYLATION** – it acts as a co- factor in oxidative phosphorylation associated with lipid
- Vitamin-K is needed for carboxylation of glutamyl residue of Ca^{++} binding transport between the flavin coenzyme and the cytochrome system.

VITAMIN K

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- Vitamin K helps blood clotting, essential to stop bleeding from wounds.

- People with vitamin K deficiency may experience easy bruising, nosebleeds, etc., although the deficit of this vitamin is rare to occur.

- The sources of vitamin K are animal fats (egg yolks, whole milk, red meat, ...) and dark green vegetables (spinach, asparagus, ...)



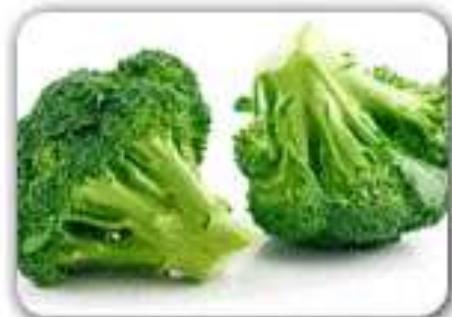
DIETARY SOURCES OF VITAMIN K



Spinach



Asparagus



Broccoli



Beans



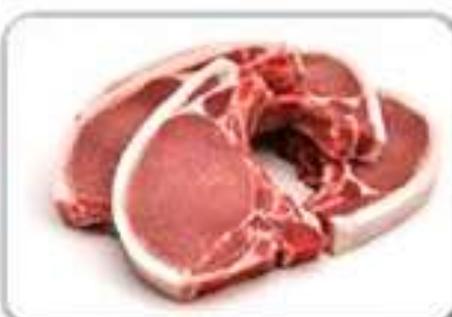
Soybeans



Eggs



Berries



Meat



Fish oils



RDA of VITAMIN K

- Strictly speaking, there is no RDA for vitamin K, gut.
- It is however, recommended that half of the body requirement is provided in the diet, while the other half is met from the bacterial synthesis.
- Accordingly, the suggested RDA for an adult is **70-140 µg/day**. since it can be adequately synthesized in the

ABSORPTION, TRANSPORTATION AND STORAGE

- Absorption takes place in intestine in the presence of bile salts.
- The transportation from intestine is carried out through chylomicrons.
- Storage occurs in liver and from liver transportation to peripheral cells is carried out bound with beta lipoproteins

IMPAIRED ABSORPTION OF VITAMIN K

- Impaired absorption of vitamin K Fat malabsorption is associated with impaired absorption of vitamin K and other fat soluble vitamins.
- Absorption of vitamin K may also be decreased by mineral oil, bile acid sequestrants (Cholestyramine, Colestipol) and Orlistat (weight loss medication).

DEFICIENCY SYMPTOMS

- Vitamin K deficiency may occur due to its faulty absorption (lack of bile salts), loss of vitamin into feces (diarrheal diseases) and administration of antibiotics (killing of intestinal flora).
- 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. **The blood clotting time is increased.**

HYPERVITAMINOSIS K

- Administration of large doses of vitamin K produces hemolytic anaemia and jaundice, particularly in infants. The toxic effect is due to increased breakdown of RBC.

