This booklet is dedicated to :

Done by :

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We did our best to make this chapter easy and more clear ; we also explained some important points in the figures and we included some important questions at the end of this booklet.

We Hope you find it helpful **J**

NOW... Let's make the Vitamins more soluble.

Fat Soluble Vitamins
(A - D - K - E)

VITAMIN A (Retinol) :

Vitamin A is often used as a collective term for several related biologically active molecules.

The retinoids are a family of molecules that are related to retinol.

Retinoids includes both natural and synthetic forms of vitamin A that may or may not show vitamin A activity. (synthetic forms = drugs)

Retenoids are essential for :

1- Vision

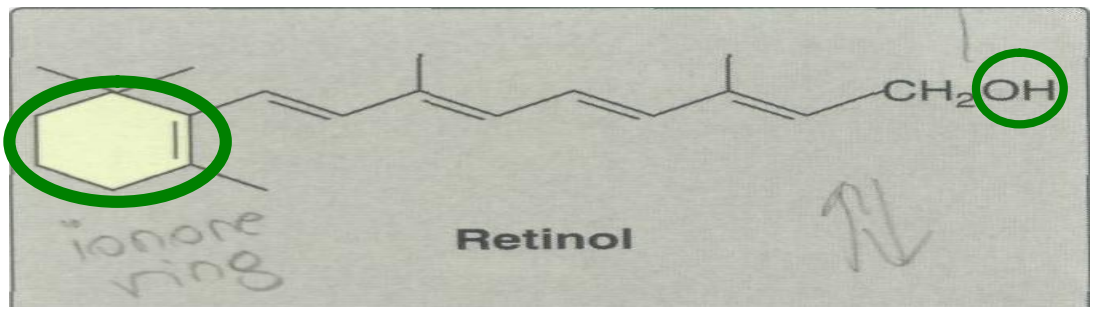
2- Reproduction

3- Growth

4- Maintenance of epithelial tissues.

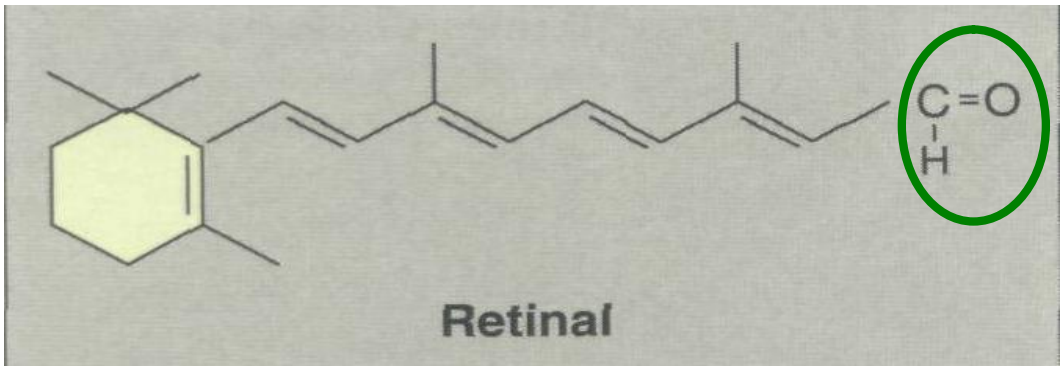
A. Active forms of vitamin A :

1. **Retinol: A primary alcohol containing a β-ionone ring with an unsaturated side chain, retinol is found in animal tissues as a retinyl ester with long-chain fatty acids.**



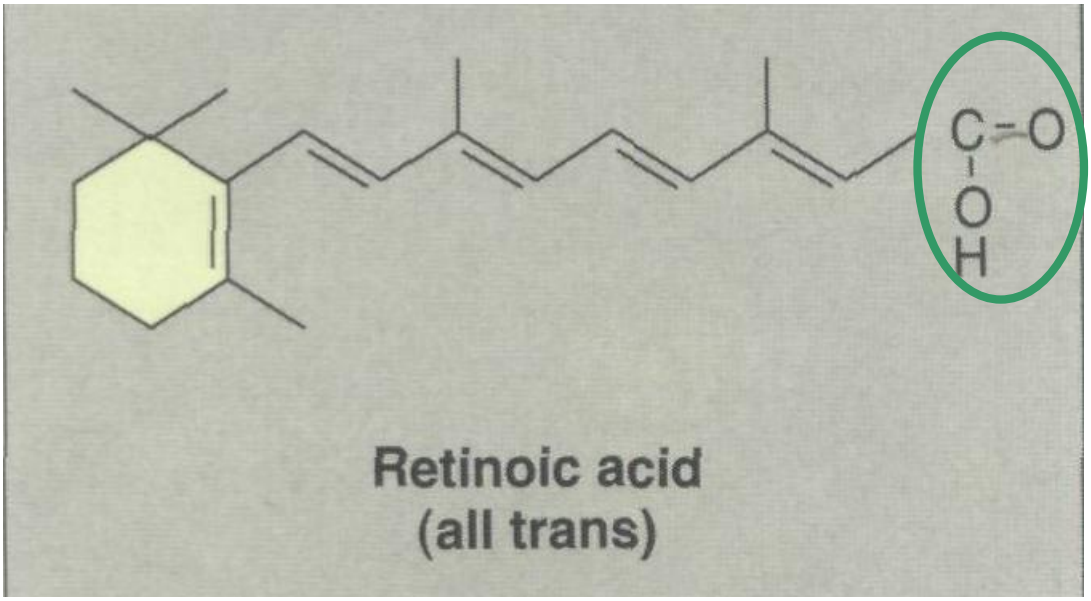
Alcohol group

2. Retinal: This is the aldehyde derived from the oxidation of retinol. Retinal and retinol can readily be interconverted.



Aldehyde group

3. **Retinoic acid:** This is the acid derived from the oxidation of retinal. Retinoic acid cannot be reduced in the body, and, therefore, cannot give rise to either retinal or retinol (MCQ)



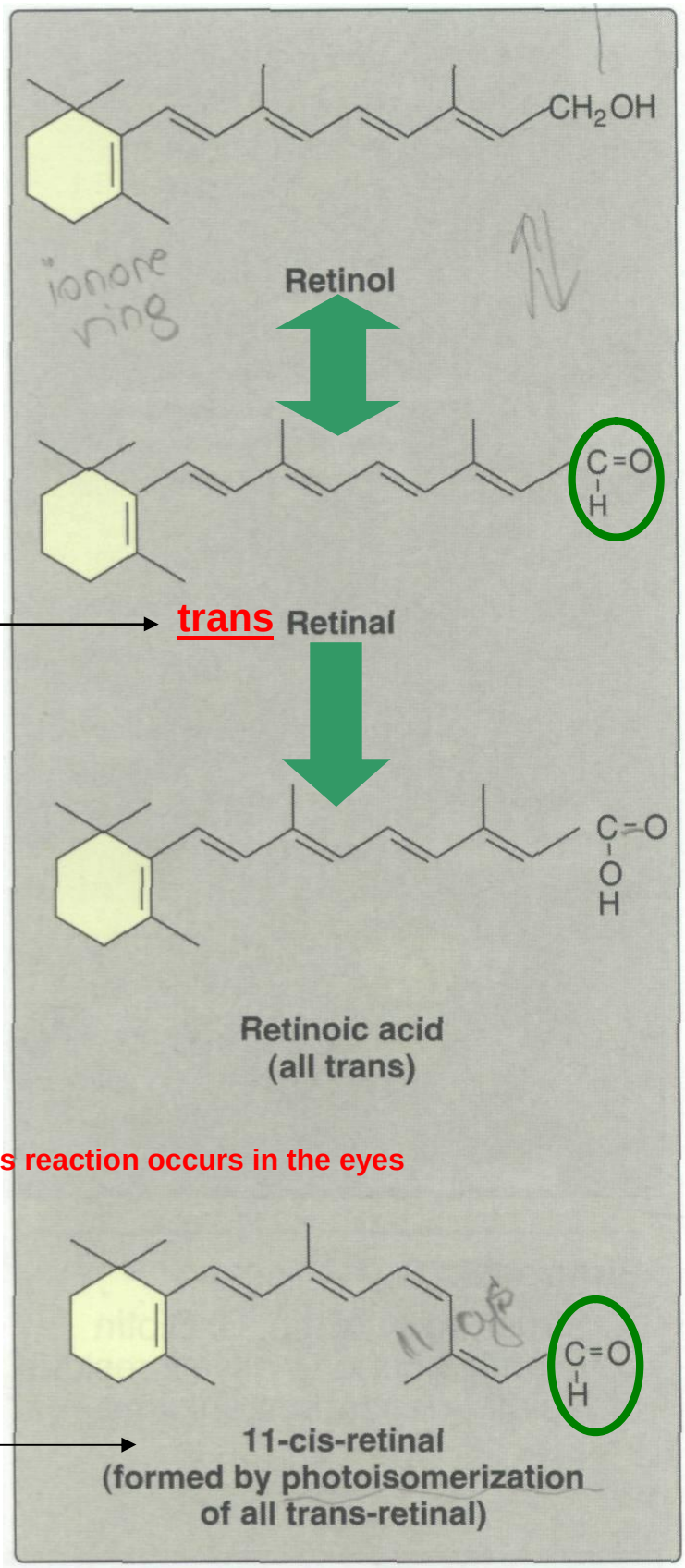
Acidic group

4. **β-carotene**: Plant foods contain β-carotene, which can be oxidatively cleaved in the intestine to yield two molecules of retinal.

β-carotene → 2 retinal

In humans, the conversion is inefficient (MCQ), because vitamin A activity of β-carotene is only about one sixth that of retinol.

This means that the activity of 1 molecule of retinol is equal to the activity of 6 molecules of β-carotene



oxidation

Aldehyde group

Don't forget : retinoic acid can't be reduced in the body to retinal or retinol

This means that the reaction from retinal to retinoic acid is irreversible (MCQ)

Reduction

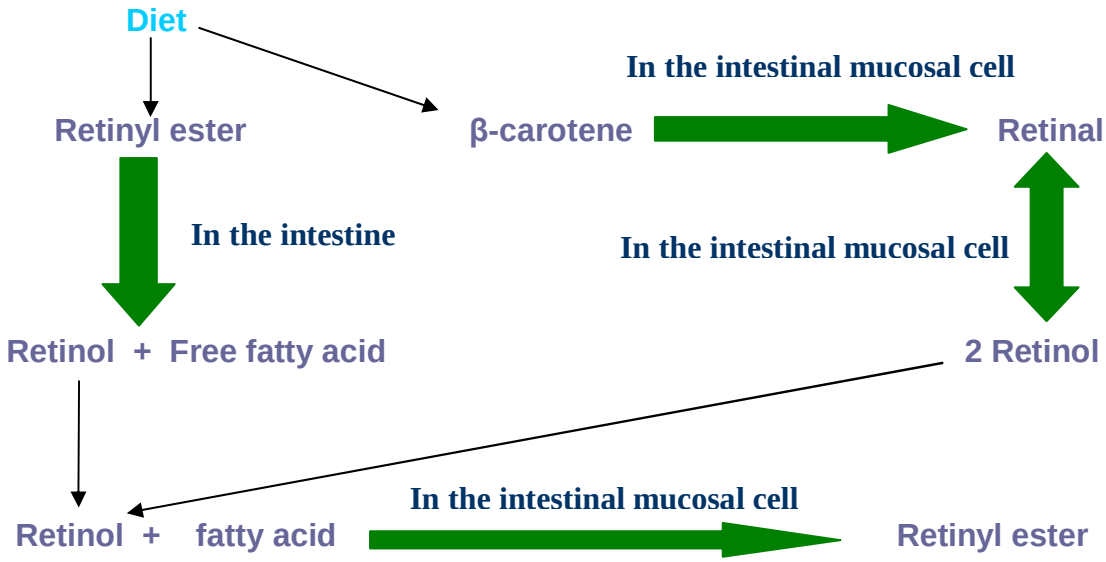
Aldehyde group

This compound is 11-cis retinal
Not retinoic acid
Please don't be confused about this

Figure 28.18
Structure of the retinoids.

B. Absorption and transport of vitamin A

1. Transport to the liver:



Retinyl ester is then secreted as component of chylomicron (MCQ)

The chylomicron is secreted from the intestine then it travels in the lymph and blood vessels and ends in the liver where it is stored there in the Retinyl ester form (Retinyl palmitate)

[Important note from the figure : retinyl ester is stored in the liver and adipose tissue (MCQ)]

2. Release from the liver:

When needed, retinol is released from the liver and is transported to extrahepatic tissues by the plasma retinol-binding protein (RBP).

The complex attaches to specific receptors on the surface of the cells of peripheral tissues, permitting retinol to enter.

Many tissues contain a cellular retinol-binding protein that carries retinol to sites in the nucleus where the vitamin acts in a manner analogous to steroid hormones.

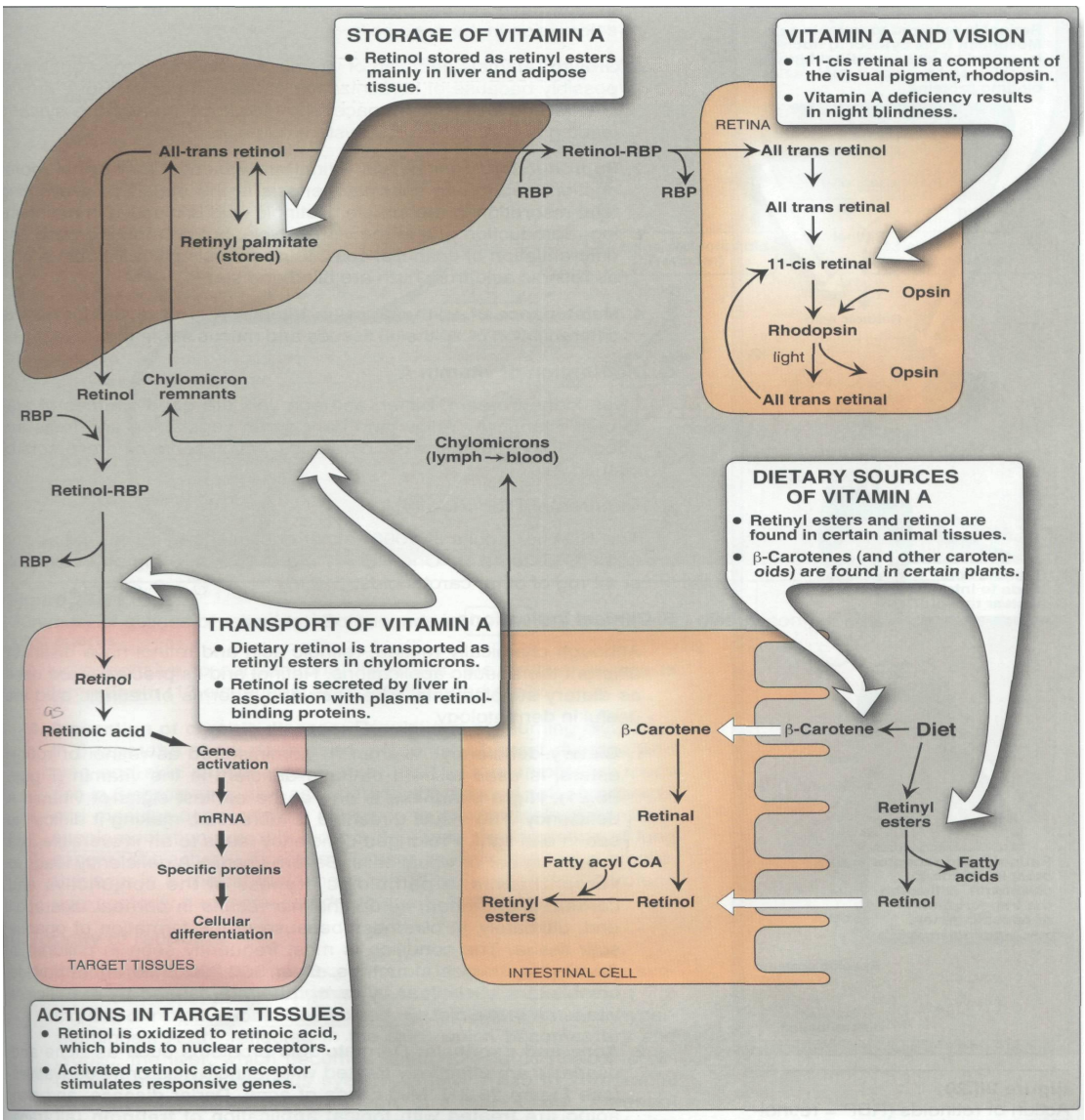


Figure 28.19
Absorption, transport, and storage of vitamin A and its derivatives. RBP = retinol-binding protein.

C. Mechanism of action of vitamin A :

- **Retinoic acid binds with high-affinity to specific receptor proteins present in the nucleus of target tissues, such as epithelial cells.**

- **The activated retinoic acid-receptor complex interacts with nuclear chromatin to stimulate retinoid-specific RNA synthesis, resulting in the production of specific proteins that mediate several physiologic functions.**

- **For example, retinoids control the expression of the keratin gene in most epithelial tissues of the body.**

- **The specific retinoic acid-receptor proteins are part of the superfamily of transcriptional regulators that includes the *steroid and thyroid hormones* and all of which function in a similar way.**

This is a brief summary regarding the transport of vitamin A :

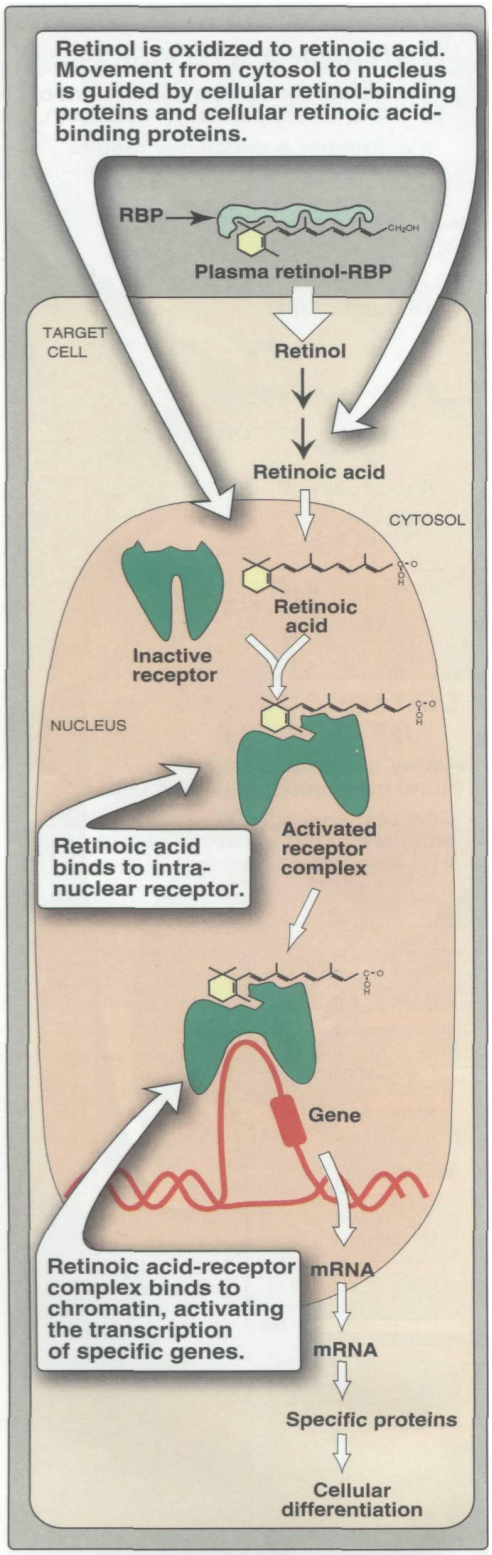


Figure 28.20
Action of retinoids (RBP = retinol-binding protein).

Step 1 :
When needed, retinol is released from the liver and is transported to extrahepatic tissues by the plasma retinol-binding protein (RBP).

Step 2 :
The complex attaches to specific receptors on the surface of the cells of peripheral tissues, permitting retinol to enter.

Step 3 :
Retinol binds to cellular retinol binding protein

Step 4 :
Retinol is oxidized to retinoic acid

Step 5 :
Retinoic acid enters the nucleus

Step 6 :
Retinoic acid binds with high affinity to an intranuclear receptor.(MCQ)

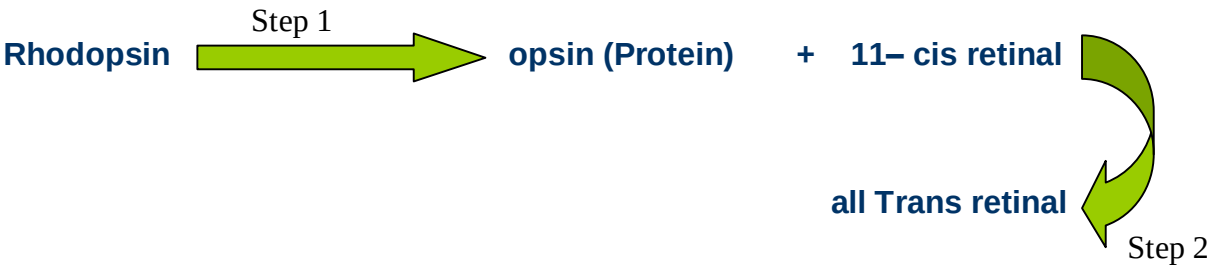
Step 7 :
The activated retinoic acid-receptor complex interacts with nuclear chromatin to stimulate retinoid-specific RNA synthesis, resulting in the production of specific proteins that mediate several physiologic functions

D. Functions of vitamin A

1. Visual cycle:

Vitamin A is a component of the visual pigments of rod and cone cells. Rhodopsin, the visual pigment of the rod cells in the retina, consists of 11- cis retinal specifically bound to the protein opsin.

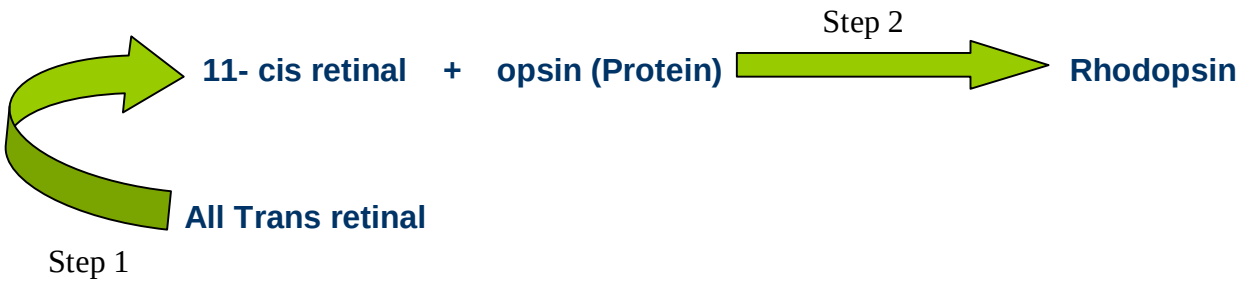
In the presence of light (bleaching phase) :



When rhodopsin is exposed to light, a series of photochemical isomaration occurs, which results in the bleaching of the visual pigment (Rhodopsin) and release of all trans retinal and opsin

This process triggers a nerve impulse that is transmitted by the optic nerve to the brain.

In the absence of light (regeneration phase) :



Regeneration of rhodopsin requires isomerization of all trans retinal back to 11- cis retinal.

Trans retinal, after being released from rhodopsin, is isomarized to 11-cis retinal, which spontaneously combines with opsin to form rhodopsin, thus completing the cycle.

Similar reactions are responsible for color vision in the cone cells.

2. Growth:

Animals deprived of vitamin A suffer from :

- **Lose of appetites, possibly because of keratinization of the taste buds.**
- **Growth retardation**
- **Central nervous system damage because Bone growth fails to keep pace with growth of the nervous system**

3. Reproduction:

Retinol and retinal are essential for normal reproduction, supporting spermatogenesis in the male and preventing fetal resorption in the female. (deficiency of retinol or retinal causes impotence)

Retinoic acid is inactive in maintaining reproduction and in the visual cycle (MCQ) but promotes growth and differentiation of epithelial cells.

Thus, animals given vitamin A only as retinoic acid from birth are blind and sterile.

4. Maintenance of epithelial cells:

Vitamin A is essential for normal differentiation of epithelial tissues and mucus secretion.

D. Distribution of vitamin A

Liver, kidney, cream, butter, and egg yolk are good sources of preformed vitamin A
[Note : preformed vitamin A source means vitamin A which is in the retinol form]

Yellow and dark green vegetables and fruits are good dietary sources of the carotenes, which serve as precursors of vitamin A.

In summary :
Retinol is found in certain animal tissues
β-carotene is fond in certain plants

E. Requirement for vitamin A

The RDA (Recommended Dietary Allowance) for adults is 1000 retinol equivalents (RE) for males and 800 RE for females.

One RE = 1 µg of retinol
= 6 µg of β-carotin
= 12 µg of other carotenoids.

[Note : There is a mistake in the book please change it.
It is on p. 382: replace all mg (milligram) units with µg (microgram) units]

F. Clinical indications

Although chemically related, retinoic acid and retinol have distinctly different therapeutic applications.
Retinol and its precursor are used as dietary supplements, whereas various forms of retinoic acid are useful in dermatology (MCQ)

1. Dietary deficiency :

Vitamin A, administered as retinol or retinyl esters, is used to treat patients deficient in the vitamin (Very important MCQ)

Night blindness is one of the earliest signs of vitamin A deficiency(MCQ)

The visual threshold is increased, making it difficult to see in dim light.

Prolonged deficiency leads to an irreversible loss in the number of visual cells.
Severe vitamin A deficiency leads to xerophthalmia, a pathologic dryness of the conjunctiva and cornea.

If untreated, xerophthalmia results in *corneal ulceration* and, ultimately, in blindness because of the formation of opaque scar tissue.

The condition is most frequently seen in children (MCQ) in developing tropical countries. Over 500,000 children worldwide are blinded each year by xerophthalmia caused by insufficient vitamin A in the diet.

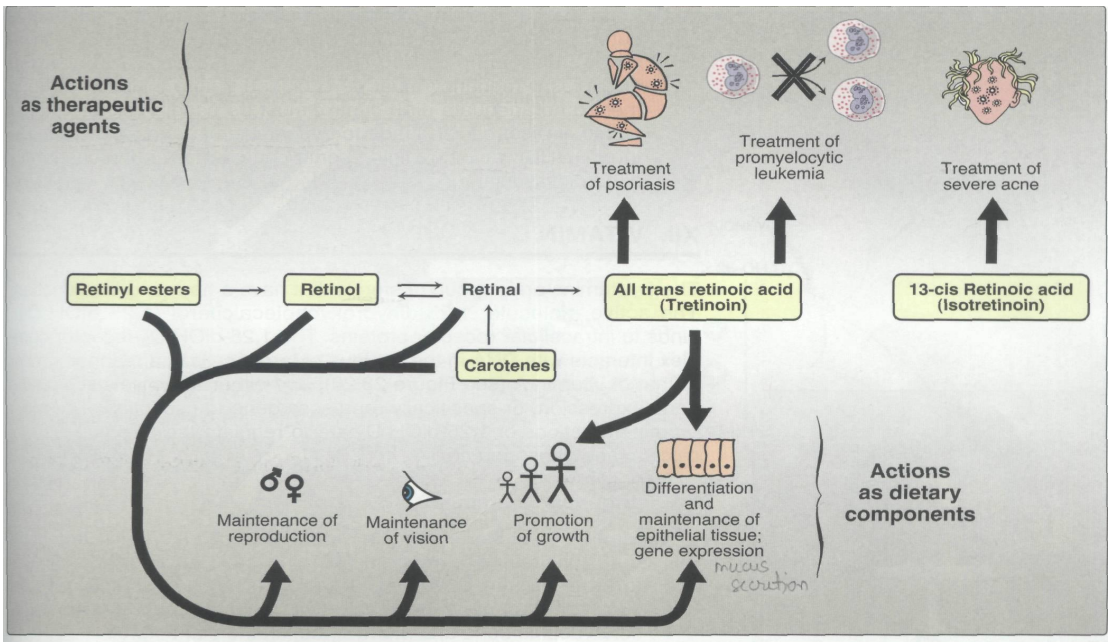


Figure 28.21
Summary of actions of retinoids. Compounds in boxes are available as dietary components or as pharmacologic agents.

2. Acne and psoriasis : (very very important MCQ)

Problems such as acne and psoriasis are effectively treated with retinoic acid or its derivatives .

***Tretinoin* (all *trans* retinoic acid), *benzoyl peroxide*, and *antibiotics* are applied in case of :**

- **Mild cases of acne**
- **Darier disease (genetic disorder characterized by dark crusty patches on the skin, sometimes containing pus)**
- **skin aging**

[Note: Tretinoin is too toxic for systemic administration and is confined to topical application]

{ Important note from the figure : we can use trans retinoic acid to treat promyelocytic leukemia, because in promyelocytic leukemia we have undifferentiated cells, and trans retinoic acid (tretinoin) helps in promoting the differentiation of leukocytes }

In patients with severe recalcitrant cystic acne unresponsive to conventional therapies, the drug of choice is isotretinoin (13- cis retinoic acid) administered orally (MCQ)

[recalcitrant means difficult to manage]

3. Prevention of chronic disease:

Populations consuming diets high in β-carotene show :

a. **Decreased incidence of heart disease**

b. **Decreased incidence of lung and skin cancer**

c. **Reduced risk of cataracts and macular degeneration.**

However, in clinical trials, β-carotene supplementation not only did not decrease the incidence of lung cancer, but actually increased cancer in individuals who smoke.

Subjects in a clinical trial who received high doses of β-carotene unexpectedly had increased death due to heart disease.

Self Quiz :

Q) Tretinoin is a trans retinoic acid drug that is always used topically (T)

Q) Tretinoin is used in case of sever acne (F)

Q) Isotretionin is used is to treat promyelocytic leukemia (F)

Q) retinol and retinyl ester are used in case of dietery deficiency (T)

G. Toxicity of retinoids :

1. Vitamin A:

Excessive intake of vitamin A produces a toxic syndrome called hypervitaminosis A .

Amounts exceeding 7.5 mg /day of retinol should be avoided (MCQ)

Early signs of chronic hypervitaminosis A are :

- **in the *skin*, which becomes dry and pruritic (pruritic means itchy)**
- **in the *liver*, which becomes enlarged and can become cirrhotic**
- **in the *nervous system*, where a rise in intracranial pressure may mimic the symptoms of a brain tumor.**

Pregnant women particularly should not ingest excessive quantities of vitamin A because of its potential for causing congenital malformations in the developing fetus (very important MCQ)

2. Isotretinoin :

The drug is teratogenic (teratogenic means it interferes with the fetus development)

It is absolutely contraindicated in women with childbearing potential unless they have severe, disfiguring cystic acne that is unresponsive to standard therapies (MCQ)

Pregnancy must be excluded before initiation of treatment, and adequate birth control must be used.

Prolonged treatment with Isotretinoin leads to:

1) **Hyperlipidemia**
2) **increase in LDL/HDL ratio, providing some concern for an increased risk of cardiovascular disease**

Self Quiz :

Q) Isotretinoin is given in oral doses (T)

Q) In pregnant woman, Isotretinoin might be used to treat sever disfiguring cystic acne (T)

Q) Retinol :

A. Can be formed from retinoic acid.

B. Is transported from the intestine to the liver in chylomicrons.

C. Is the light-absorbing portion of rhodopsin.

D. Is phosphorylated and dephosphorylated during the visual cycle.

E. Mediates most of the actions of the retinoids

The Correct answer is B.

- **retinyl esters are incorporated into chylomicrons.**
- **Retinoic acid cannot be reduced to retinol.**
- **Retinal, the aldehyde form of retinol, is the for chromophore for rhodopsin.**
- **Retinal is photoisomarized during the visual cycle.**
- **Retinoic acid, not retinol, is the most important retinoid.**

Summary of vitamin A :

Other names	Active form	function
Retinol Retinal Retinoic acid β-carotene	Retinole Retinal Retinoic acid	Maintenance of reproduction Vision Promotion of growth Differentiation and maintenance of epithelial tissue Gene expression

Deficiency	Signs and symptoms	Toxicity	notes
Impotence Night blindness Retardation of growth Xerophthalmis	Increased visual threshold Dryness of cornea	yes	β-carotene not acutely toxic but supplementation is not recommended excess vitamin A can increase the incidence of fracture

Vitamin D :

Are group of sterols that have a hormone like function.
The active molecule is 1,25 dihydroxycholecalciferol (1,25 diOH D3) bind to intracellular receptor protein .

Its most prominent action is to regulate the plasma level of Ca++ and phosphorus.

The complex of the molecule and receptor interact with DNA for either selectively stimulate gene expression OR, specifically represses gene transcription .

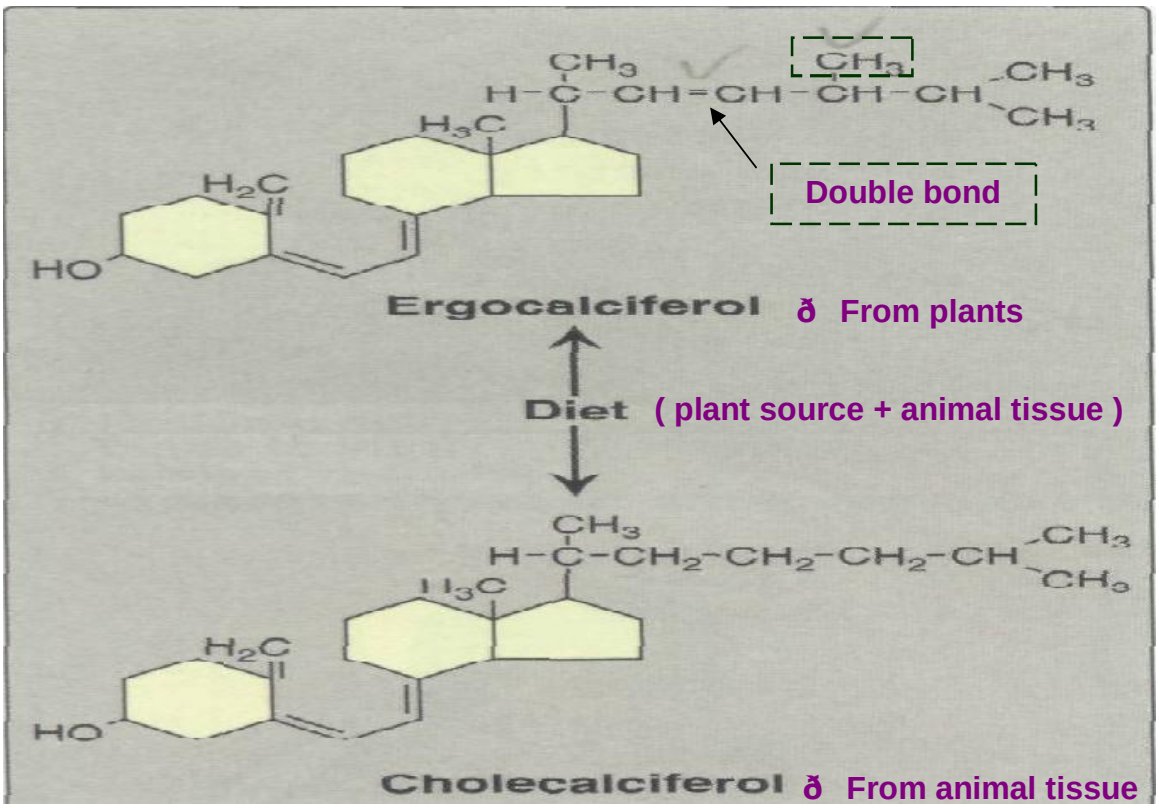
A. Forms of Vitamin D :

1. Forms obtained from Diet :

Ergocalciferol **è (Vit.D_2) found in plants.**

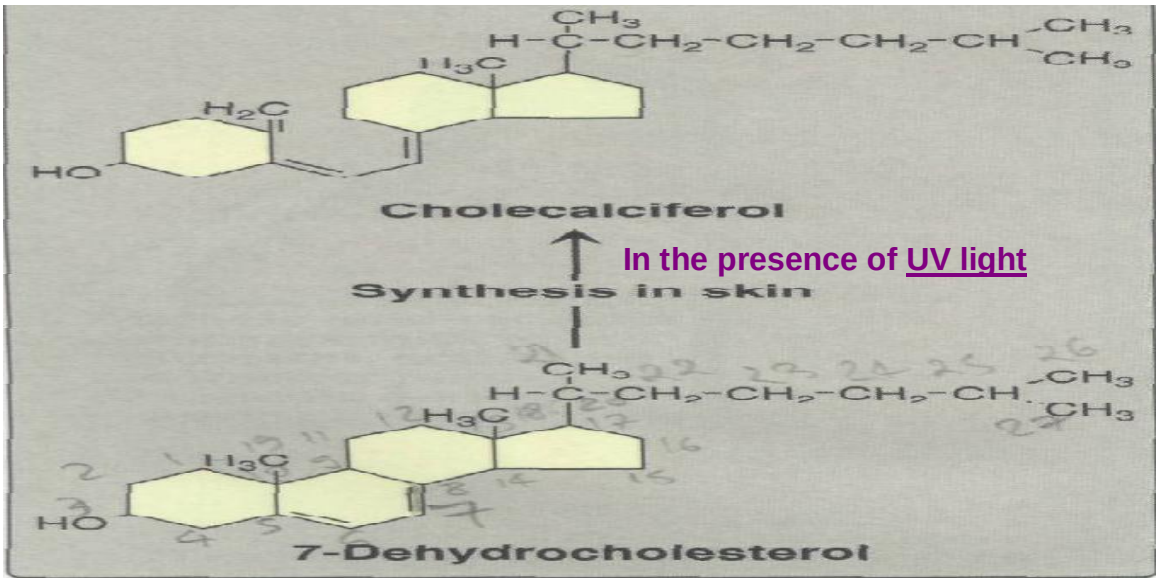
Cholecalciferol **è (Vit.D_3) found in animal tissue.**

They are sources of preformed vitamin D activity and they differ chemically only in the presence of an additional double bond and methyl group in the plant sterol (plant sterol = *Ergocalciferol*)



2. Endogenous vitamin precursor :

7-Dehydrocholestrol (an intermediate in cholesterol synthesis) is converted to cholecalciferol in the dermis and epidermis of human exposed to sunlight.
[NOTE: preformed vitamin D is a dietary requirement only in individuals with limited exposure to sunlight]



B. Metabolism of vit.D :

1. Formation of 1,25 diOH D_3 :

Vitamin D_2 and vitamin D_3 are biologically inactive, but are converted In vivo to the active form of the vitamin D by two sequential hydroxylation reactions .

The first hydroxylation occurs at the 25-postion , and is catalyzed by a 25-hydroxylase in the liver .
The result is 25- hydroxycholecalciferol (25-OH D_3) .

It is the predominant form of vitamin in the plasma and is the major storage form .

The second hydroxylation occurs in 25-OH D_3 at the first-position by specific 25-hydroxycholecalciferol 1-hydroxylase found in kidney

The result is (1,25-dihydroxycholecalciferol) or (1,25-diOH D_3)
è active molecule .

both *25-hydroxycholecalciferol 1-hydroxylase* (the kidney's hydroxylase) and *25- hydroxylase* (the liver's hydroxylase) employ :

cytochrome P450 molecular oxygen and NADPH

2.Regulation of 25-hyroxycholecalciferol 1-hyroxylase:

1.25-diOH D_3 is the most potent vitamin D metabolite,so its formation is tightly regulated by level of plasma phosphate and *calcium ions* .

25-hydroxycholecalciferol 1-hydroxylase activity is :

- **increase directly by low plasma phosphate .**
- **increase indirectly by low plasma calcium which trigger the release of PTH.**

Hypocalcaemia caused by insufficient dietary Ca^{++} will lead to an elevation in the levels of plasma 1.25 diOH D_3 resulting in a decrease in the activity of *1-hydroxylase* (negative feedback)

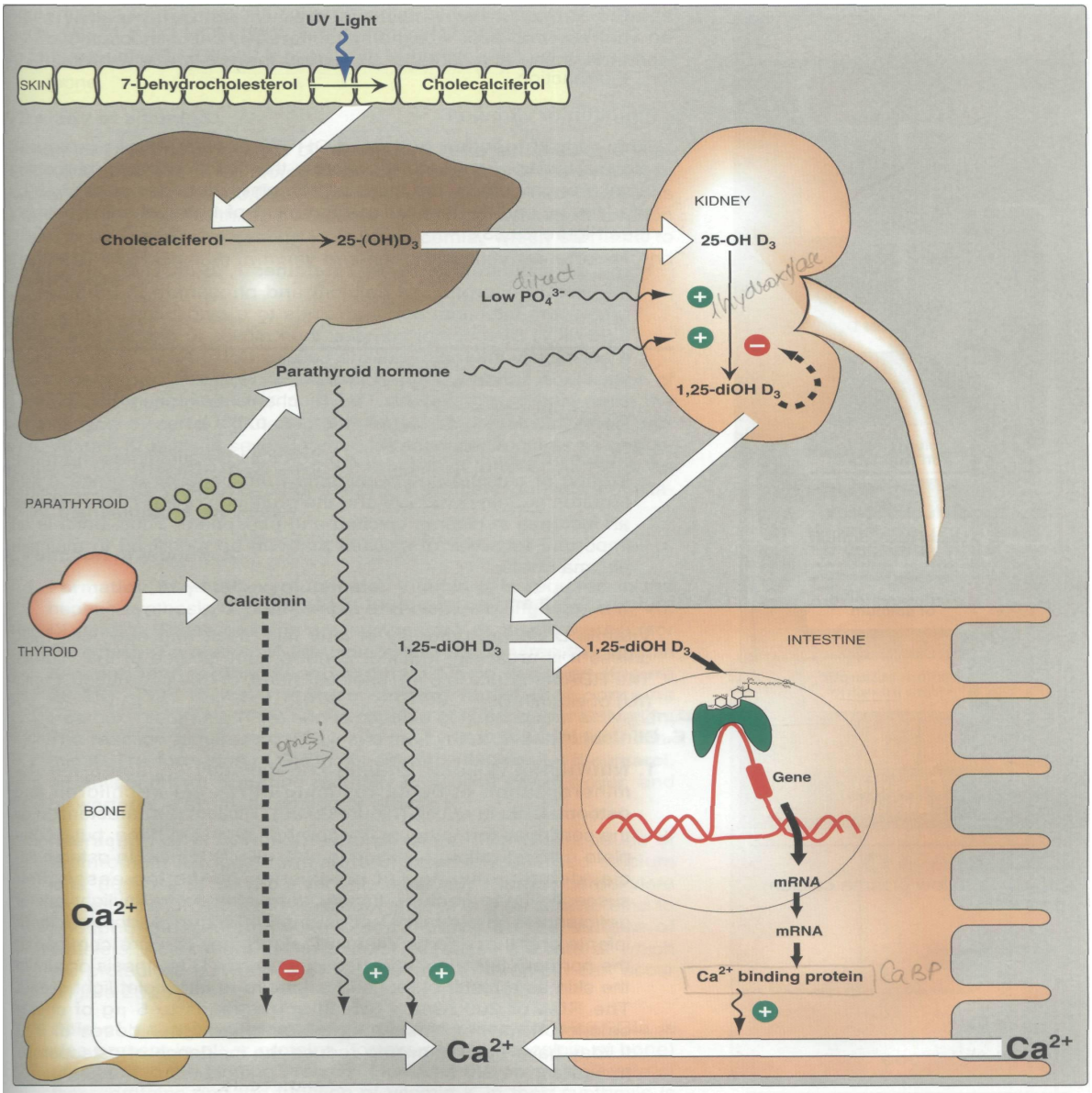


Figure 28.23
Metabolism and actions of vitamin D.

C. Function OF Vit. D :

It functions in maintaining adequate plasma level of calcium .

It performs this function by :

1) **Increasing the uptake of Ca^{++} by the intestine.**
2) **Minimizing loss of Ca^{++} by Kidney.**
3) **Stimulating resorption of bone when necessary.**

- **Effect of vitamin D on the intestine :**

1,25 diOH D_3 stimulates intestinal absorption of Ca^{++} and phosphate .

- **1,25 diOH D_3 enter the intestinal cell and bind to a cytosolic receptor .**
- **Molecule-receptor complex moves to the nucleus where it selectively interact with DNA.**
- **Ca^{++} uptake enhanced by an increasing synthesis of a specific calcium-binding protein.**

- **Effect of vitamin D on bone :**

1,25 diOH D_3 stimulate the mobilization of Ca^{++} and phosphate from bone by process that requires :

1. **proteins synthesis**
2. **parathyroid hormone.**

The result is an increase in plasma level of Ca^{++} and phosphate.

D. Distribution and requirement of vit.D :

Vit.D occurs naturally in fatty fish , liver and egg yolk.

Milk unless it's artificially fortified , is not a good source for the vitamin.

The RDA for adults is 5 µg cholecalciferol , or 200 IU of Vit. D

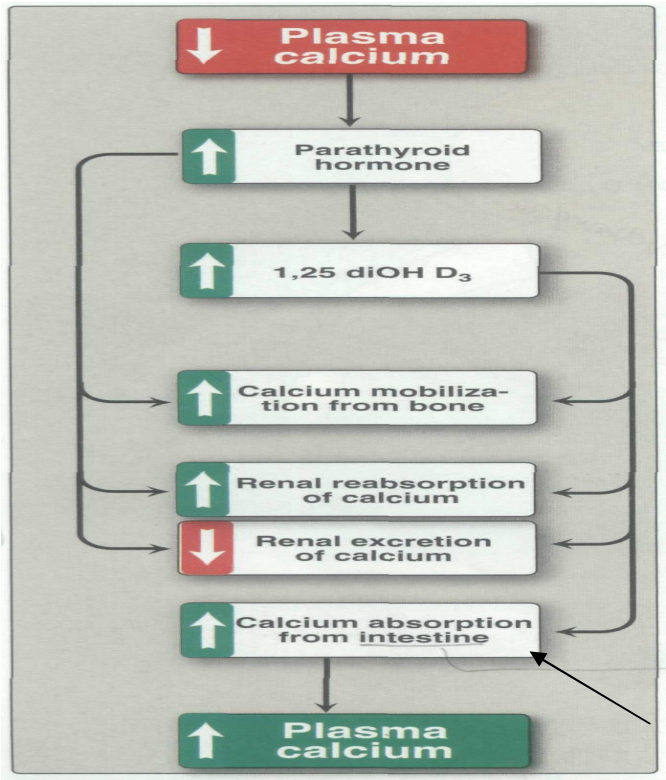


Figure 28.24
Response to low plasma calcium.

Important note from the figure:
PTH does not increase the absorption of calcium from the intestine.
(Only vitamin D does this)

E. Clinical indication :

§ Nutritional rickets :

Vitamin D deficiency causes a net demineralization of bone , resulting in rickets in children and osteomalacia in adults .

Rickets characterized by the continued formation of collagen matrix of bone , but INCOMPLETE mineralization , resulting in soft , pliable bones.

Osteomalacia characterized by demineralization of pre-existing bones increases their susceptibility to fracture . It may caused by insufficient exposure to daylight and/or deficiency of Vit.D consumption occur in in infant and elderly.

[Note : Vit.D deficincey is more common in the northern latitudes , because less vitamin D synthesis occur in the skin as a result of reduced exposure to the UV light]

§ Renal rickets (renal osteodystrophy) :

Result from chronic renal failure and , thus, decrease the ability to form the active form of the vitamin .

1-25 diOH cholecalciferol (calcitriol) administration is effective replacement therapy (MCQ)

§ Hypoparathyrodism :

Lack of parathyroid hormone è hypocalcaemia + hyperphosphatemia

Patient are treated with any form of Vit.D together with PTH.

F. Toxicity of vit.D :

Vit.D is the most toxic of all Vitamins (Very Important MCQ)

High doses (100,00 IU for weeks or months) can cause loss of appetite, nausea, thirst, and stupor.

(stupor : a condition of near unconsciousness with apparent mental inactivity and reduced ability to respond to stimulus)

Excess vit.D will promote :

1. absorption of Ca^{++} from the intestine

2. resorption of Ca^{++} from bone

These 2 factors will lead to hypercalcaemia

This will result in the deposition of Ca^{++} in many organs particularly arteries and kidneys

(Note : Deposition of Ca^{++} the kidneys will lead to the formation of uretric stones)

Vitamin D is stored in the body, and is only slowly metabolized (this happens because vitamin D it is a fat soluble vitamin)

Summary for vitamin D :

Other names	Active form	function
Cholecalciferol ***Ergocalciferol***	**1,25 dihydroxycholecalciferol**	**Calcium uptake**

Deficiency	Signs and symptoms	toxicity	Notes
Rickets in children **Osteomalacia in adults**	**Soft pliable bones**	**Yes**	**Vit.D is not a true vitamin because it can be synthesized in skin.** **Application of sunscreen lotions or presence of dark skin color decreases its synthesis.**

Vitamin K

The principal role of vitamin K is in the post-translational modification of various blood clotting factors.

Vitamin K serves as a coenzyme in the carboxylation of certain glutamic acid residues present in these proteins.

Vitamin K exists in several forms, for example :

a. phylloquinone (or vitamin K_1) in plants

b. menaquinone (or vitamin K_2) in intestinal bacterial flora

c. menadione (a synthetic derivative of vitamin K) used in therapy

A. Function of vitamin K

1. Formation of γ-carboxyglutamate :

Vitamin K is required in therapeutic synthesis of prothrombin and blood clotting factors II, VII, IX , and X (MCQ)

These proteins are synthesized as inactive precursormolecules (MCQ)

Formation of the clotting factors requires :

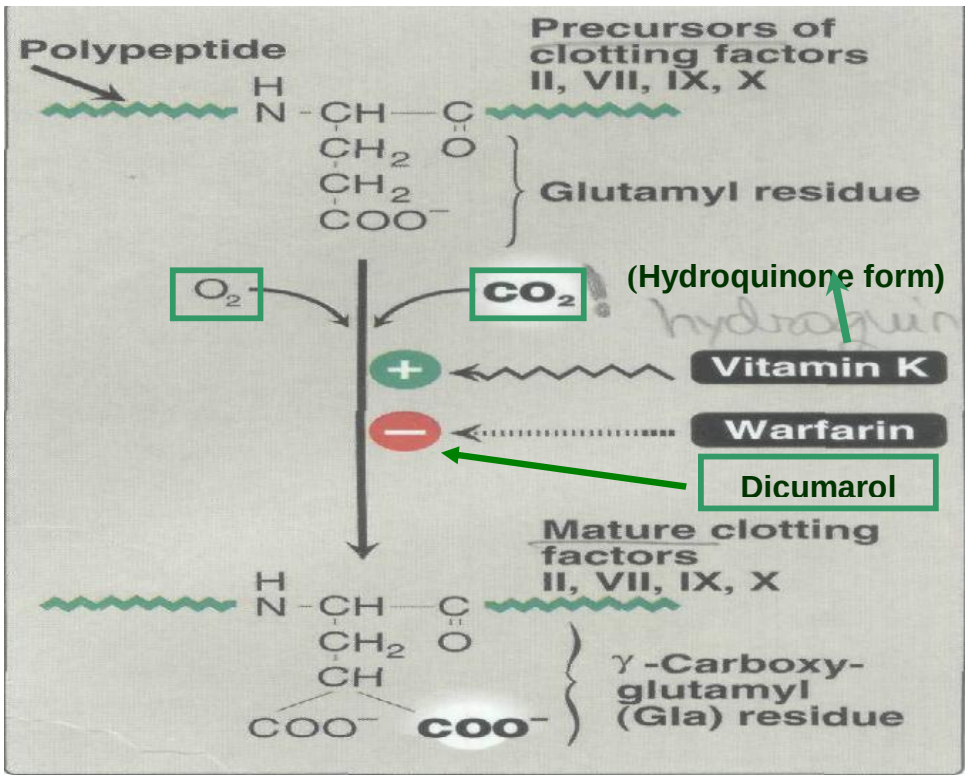
- **The hydroquinone form of vitamin K.**
- **O_2**
- **CO_2**

This forms a mature clotting factor that contains γ-carboxyglutamate (Gla) and is capable of subsequent activation .

The formation of Gla is sensitive to inhibition by :

i. **dicumarol ,an anticoagulant occurring naturally in spoiled sweet clover.**

ii. **warfarin, a synthetic analog of vitamin K.**



2. Interaction of prothrombin with platelets :

The Gla residues of prothrombin are good chelators of positively charged calcium ions, because of the two adjacent, negatively charged carboxylategroups.

The prothrombin-calcium complex is then able to bind to Phospholipids essential for blood clotting on the surface of platelets.

Attachment to the platelet increases the rate at which the proteolytic conversion of prothrombin to thrombin can occur.

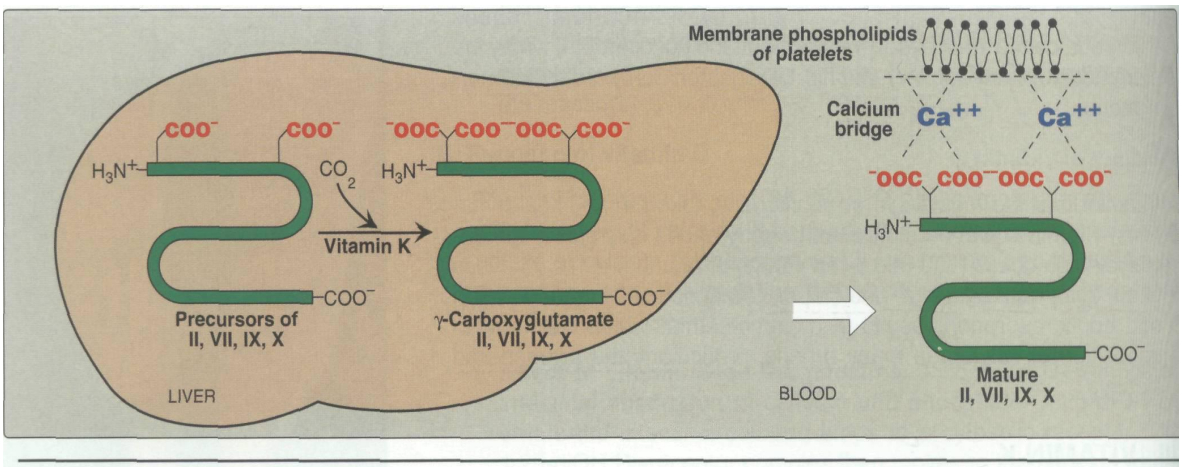


Figure 28.27
Role of vitamin K in blood coagulation.

3. Role of γ-carboxyglutamate residues in other proteins

Gla is also present in other proteins (for example, osteocalcin of bone) unrelated to the clotting process. However, the physiologic role of these proteins and the function of vitamin K in their synthesis is not yet understood.

B. Distribution and requirement of vitamin K

Vitamin K is found in cabbage, cauliflower, spinach, egg yolk, and liver.

There is also extensive synthesis of the vitamin by the bacteria in the gut.

There is no RDA for vitamin K , but 70 to 140 mg/day is recommended as an adequate level.

The lower level assumes one half of the estimated requirement comes from bacterial synthesis, whereas the upper figure assumes no bacterial synthesis.

C. Clinical indications

1. Deficiency of vitamin K:

A true vitamin K deficiency is unusual because adequate amounts are generally produced by intestinal bacteria or obtained from the diet.

If the bacterial population in the gut is decreased, for example by antibiotics, the amount of endogenously formed vitamin is depressed, and can lead to hypoprothrombinemia in the marginally malnourished individual (for example, a debilitated geriatric patient).

This condition may require supplementation with vitamin K to correct the bleeding tendency.

Certain second generation cephalosporins (for example, cefoperazone, cefamandole, and moxalactam) cause hypoprothrombinemia, apparently by a warfarin-like mechanism.

Consequently, their use in treatment is usually supplemented with vitamin K. (MCQ)

(Note : cephalosporins are groups of antibiotics)

2. Deficiency of vitamin K in the newborn :

Newborns have sterile intestines and cannot initially synthesize vit.K .

Because human milk provides only about one fifth of the daily requirement for vitamin K, it is recommended that all newborns receive a single intramuscular dose of vitamin K as prophylaxis against hemorrhagic disease.

D. Toxicity of vitamin K

Prolonged administration of large doses of vitamin K can produce hemolytic anemia and jaundice in the infant, due to toxic effects on the membrane of red blood cells.

Summary of vitamin K

Other names	*Active form*	*Function*
phylloquinone *menaquinone* *menadione*	*phylloquinone* *menaquinone* *menadione*	*γ-carboxylation of glutamate residue in clotting and other protins.*

Deficiency	Signs and symptoms	Toxicity	Notes
New born Rare in adults	Bleeding	Rare	Vitamin K is produced by intestinal bacteria Vitamin K deficiency is common in newborns Parental treatment with vitamin k is recommended at birth

VITAMIN E :

The E vitamins consist of *eight* naturally occurring tocopherols, of which α-tocopherol is the most active .

The primary function of vitamin E is as an antioxidant in prevention of the nonenzymatic oxidation of cell components (for example, polyunsaturated fatty acids) by molecular oxygen and free radicals.

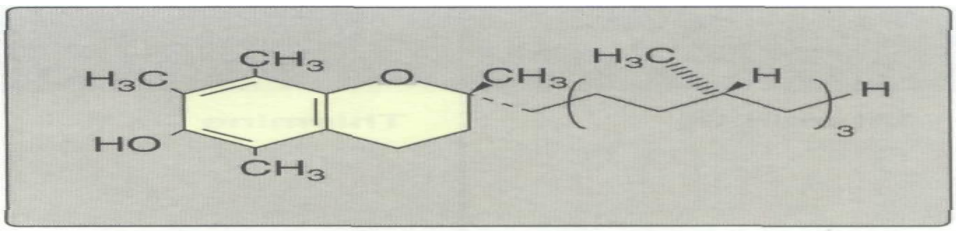


Figure 28.28
Structure of vitamin E.

A. Distribution and requirements of vitamin E

Vegetable oils contain rich sources of vitamin E

liver and eggs contain moderate amounts.

The RDA for α-tocopherol is 10 mg for men and 8 mg for women.

Vitamin E requirement *increases* as the intake of polyunsaturated fatty acid increases. (MCQ)

B. Deficiency of vitamin E

Vitamin E deficiency is almost entirely restricted to premature infants.

When observed in adults, it is usually associated with defective lipid absorption or transport.

The signs of human vitamin E deficiency include :

1- Sensitivity of erythrocytes to peroxide

2- Appearance of abnormal cellular membranes.

C. Clinical indications

Vitamin E is not recommended for the prevention of chronic disease, such as coronary heart disease or cancer.

Clinical trials using vitamin E supplementation have been uniformly disappointing.

For example, subjects in the Alpha-Tocopherol Beta Carotene Cancer Prevention Study trial who received high doses of vitamin E, not only lacked cardiovascular benefit but also had an increased incidence of stroke.

D. Toxicity of vitamin E

Vitamin E is the least toxic of the fat-soluble vitamins, and no toxicity has been observed at doses of 300 mg/day.

Summary for vitamin E :

Other names	Active form	Function
α-tocopherol	Any of several tocopherol derivatives	Antioxidant

Deficiency	Signs and symptoms	Toxicity	Notes
rare	Red blood cell fragility leads to hemolytic anemia	None	Benefits of supplementation not established in controlled trails

Self Quiz :

Multiple Choice :

1. Vitamin D helps:

a. maintaining Ca^{++} level in the blood
b. Blood clotting
c. Protect the body from damage
d. The health of the skin

2. Egg yolks have :

a. Vitamin A
b. Vitamin D
c. Vitamin E
d. vitamin K
e. All the above

3. The only vitamin that the cells can produce is:

a. Vitamin A
b. Vitamin E
c. Vitamin D
d. vitamin K

4. Which one of the following statements concerning vitamin D is correct?

A. Chronic renal failure requires the oral administration of 1,25-dihydroxycholecalcifrol

B. it is required in the diet of individuals exposed to sunlight.

C. 25-Hydroxycholecalciferol is the active form of the vitamin.

D. Vitamin D opposes the effect of parathyroid hormone

E. A deficiency in vitamin D results in an increased secretion of calcitonin.

5. Vitamin K:

A. plays an essential role in preventing thrombosis.

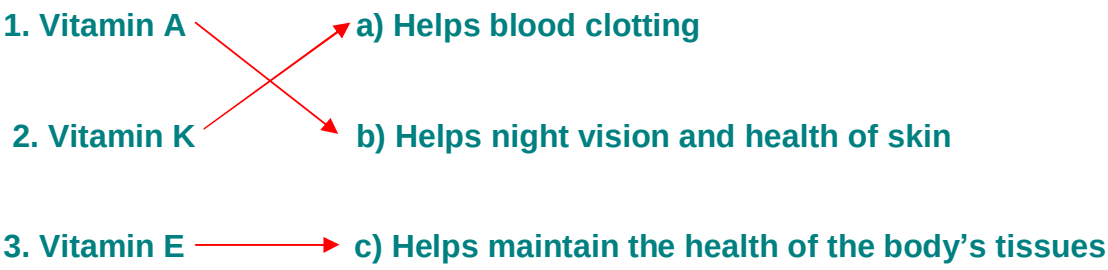
B. increases the coagulation time in newborn infants with hemorrhagic disease

C. is present in high concentration in cow or breast milk.

D. is synthesized by intestinal bacteria.

E. is a water-soluble vitamin.

Matching:



True or False:

1. Fat-soluble vitamins can be stored in the body (T)

2. Vitamin D is a water-soluble vitamin. (F)

3. Vitamin E deficiency is almost entirely restricted to children (F)

4. Vitamin A deficiency is most frequently seen in children (T)

5. Vitamin K deficiency is most frequently seen in newborns (T)