

Vitamins

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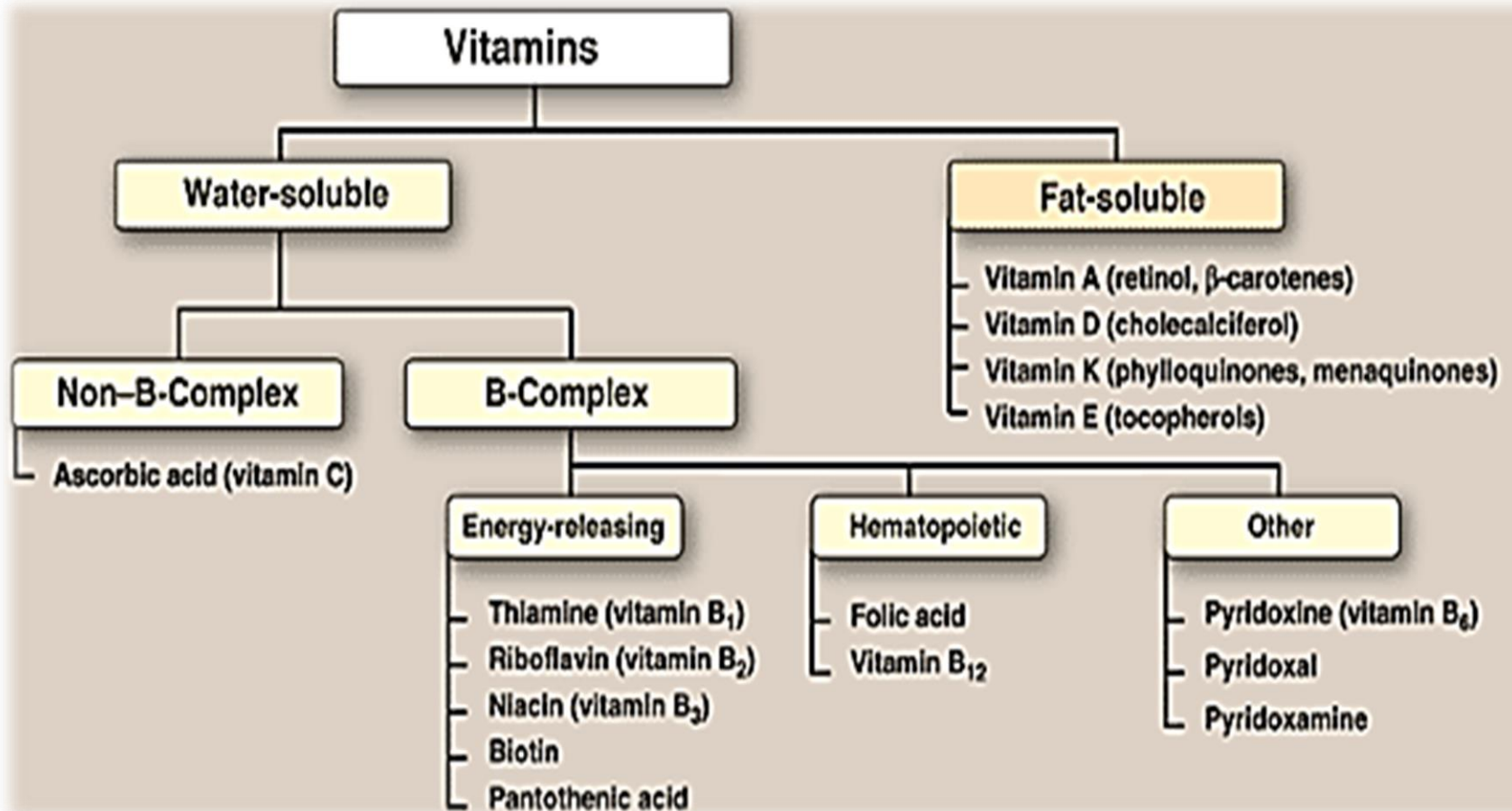
Vitamins

- ❖ Organic compounds required by an organism in tiny amounts as a vital nutrient
- ❖ Cannot be synthesized in sufficient quantities, & mostly is obtained from the diet
- ❖ The term is conditional both on the circumstances & on the particular organism (ascorbic acid, humans, other animals) (vitamin D, human diet)
- ❖ Thirteen vitamins are universally recognized at present
- ❖ Vitimers are compounds that are convertible to the active form of the vitamin in the body

Vitamins

- ❖ Vitamins have diverse biochemical functions:
 - ❖ Hormone-like functions (regulators): regulators of mineral metabolism (e.g., vitamin D), or regulators of cell & tissue growth & differentiation (e.g., vitamin A)
 - ❖ Anti-oxidants (e.g., vitamins E & C)
 - ❖ Precursors for enzyme cofactors (vitamin B subclasses)

Classification



Water soluble vitamins

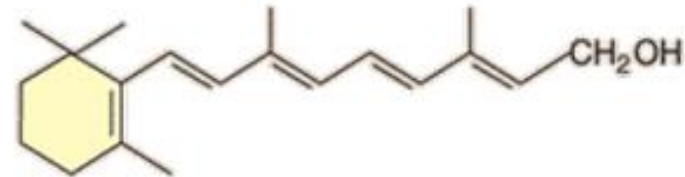
Vitamin	Coenzyme	Consequences of deficiency
Thiamine (B ₁)	TPP	
Riboflavin (B ₂)	FAD	Angular stomatitis (mouth lesions)
Nicotinic acid (niacin) (B ₃)	NAD ⁺	
Pantothenic acid (B ₅)	CoA	
Pyridoxine (B ₆)	PLP	
Biotin (B ₇)		
Folic acid (B ₉)	TH ₄	Megaloblastic anemia
Cobalamin (B ₁₂)	5'-Deoxyadenosyl cobalamin	Megaloblastic anemia
Ascorbic acid (C)		Scurvy

Fat soluble vitamins

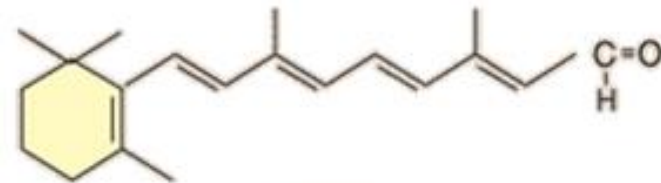
Vitamin	Main function	Deficiency
A	Roles in vision, growth, reproduction	Night blindness, cornea damage
D	Regulation of Ca^{+2} & phosphate metabolism	Rickets (children), Osteomalacia (adults)
E	Antioxidant	RBCs fragility
K	Blood coagulation	Subdermal hemorrhaging

Vitamin A

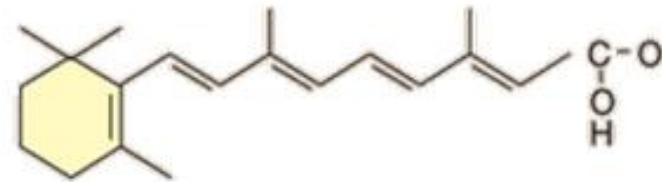
- ✓ The retinoids, a family of molecules related to retinol (vitamin A), are essential for vision, reproduction, growth, & maintenance of epithelial tissues
- ✓ Retinoic acid, mediates most of the actions of the retinoids, except for vision and spermatogenesis



Retinol



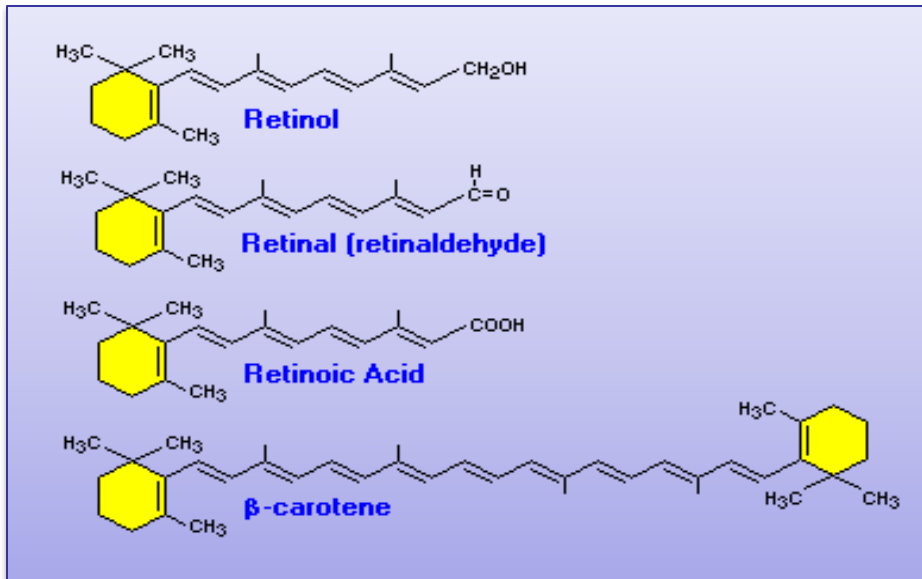
Retinal



Retinoic acid

Vitamin A - structure

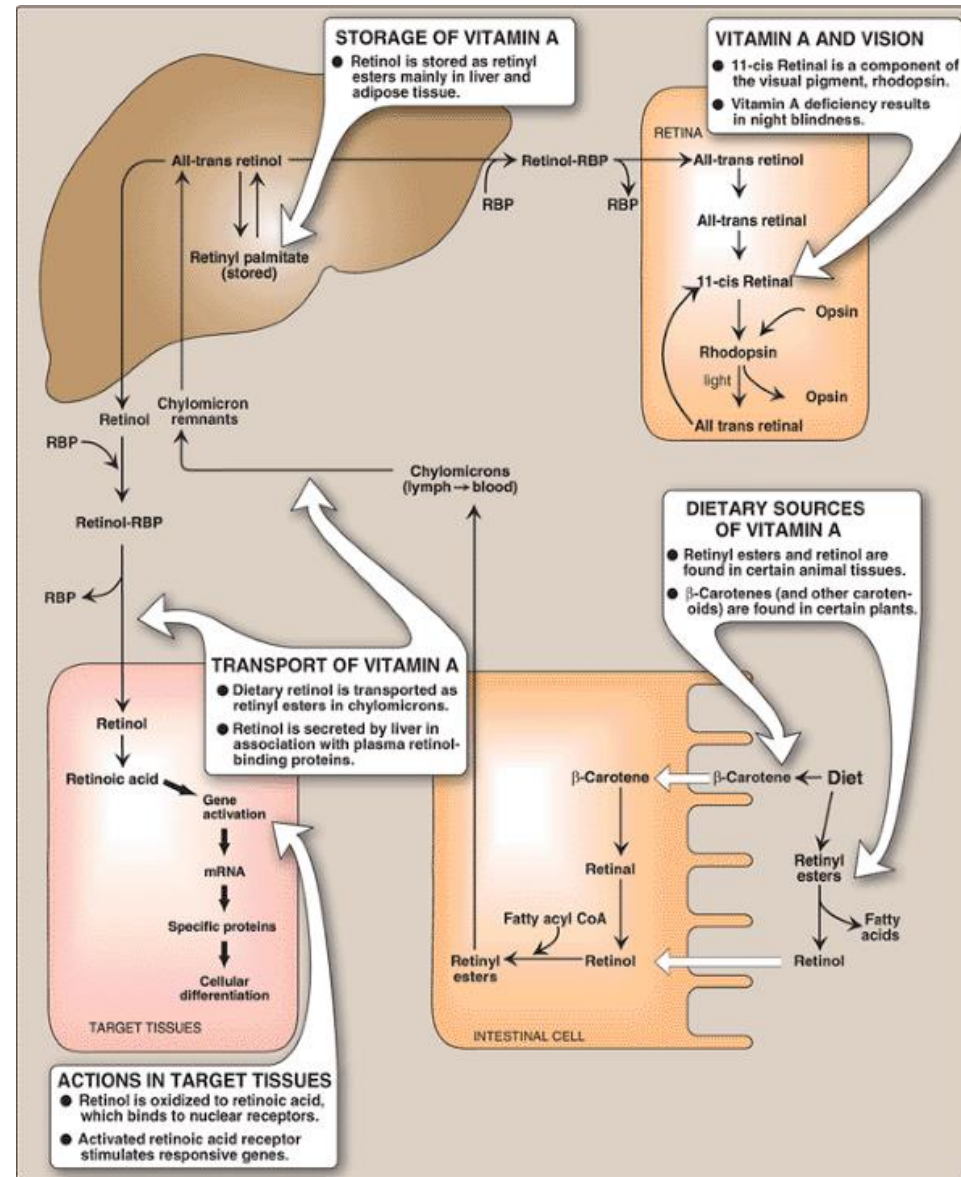
- ✓ Retinol: a primary alcohol, unsaturated side chain
- ✓ Retinal: an aldehyde, derived by oxidation of retinol, retinal and retinol are inter-convertible



- ✓ Retinoic acid: an acid, derived by oxidation of retinal, cannot be reduced in the body
- ✓ β-Carotene: oxidatively cleaved in the intestines to yield 2 molecules of retinal

Absorption & transport of vitamin A

- ✓ Retinol esters, intestinal mucosa, retinol
- ✓ Carotenes, retinal, retinol
- ✓ Chylomicrons, lymphatic system, liver (storage)
- ✓ Release from the liver: retinol binds the plasma retinol-binding protein (RBP)
- ✓ Cellular RBP → nuclear receptors (steroids), RNA, proteins (keratin expression)

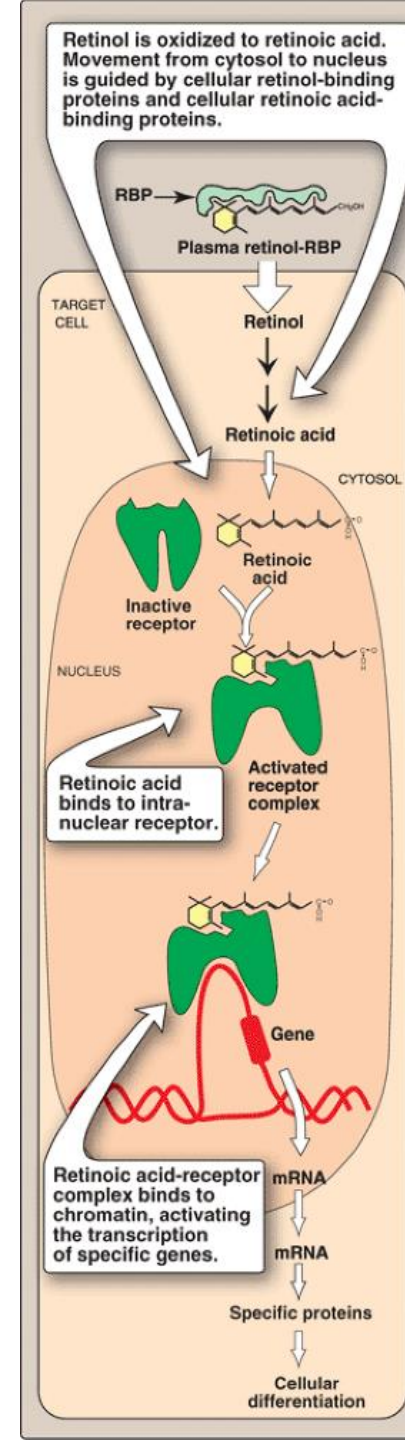


Functions of vitamin A

- ✓ Visual cycle: 11-cis retinal specifically binds the protein opsin (rhodopsin)
- ✓ Reproduction: Retinol and retinal (not retinoic acid) are essential for spermatogenesis in the male and preventing fetal resorption in the female
- ✓ Growth (retinoic acid): Vitamin A deficiency results in a decreased (growth rate & bone development) in children
- ✓ Maintenance of epithelial cells (retinoic acid): Vitamin A is essential for normal differentiation of epithelial tissues & mucus secretion
- ✓ Animals given vitamin A only as retinoic acid from birth are blind and sterile

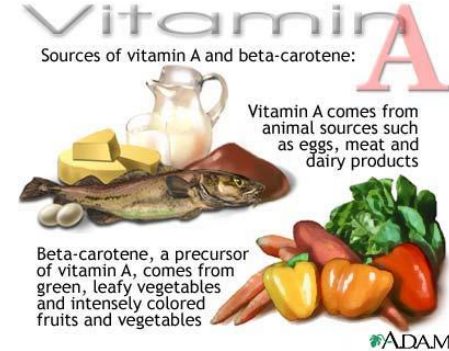
Mechanism of action of vitamin A

- ✓ Retinoic acid binds with high affinity to specific receptors (epithelial cells)
- ✓ The complex interacts with nuclear chromatin to stimulate retinoid-specific RNA synthesis
- ✓ Production of specific proteins that mediate several physiologic functions (keratin)



Sources & indications

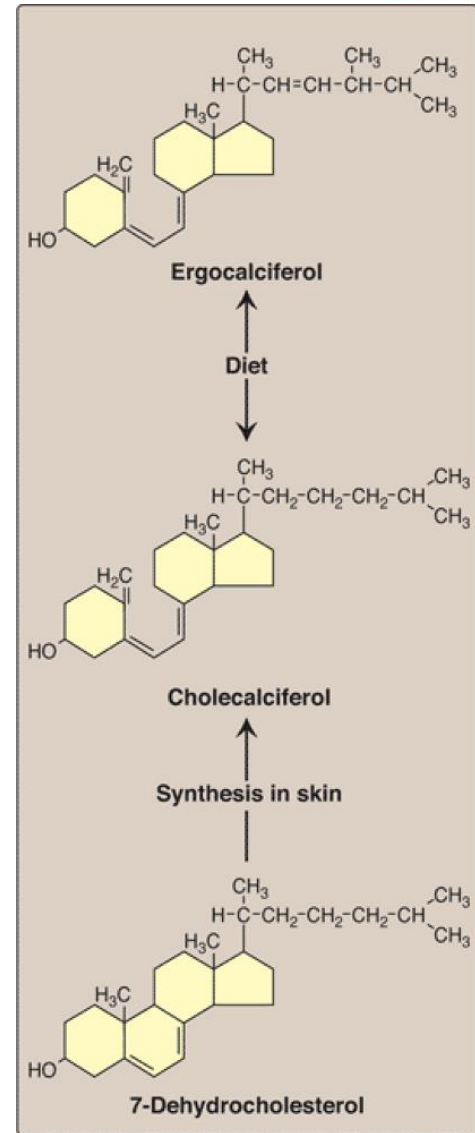
- ✓ Sources: excess cause hypervitaminosis A
- ✓ Clinical indications:
 - ✓ Dietary deficiency: mild (night blindness), prolonged (irreversible loss for some visual cells), severe (xerophthalmia)
 - ✓ Xerophthalmia: ulceration & dryness of conjunctiva & cornea, followed by scar & blindness (affecting over 500,000 children worldwide every year)
 - ✓ Acne and psoriasis: effectively treated with retinoic acid



Vitamin D



- ✓ Is a group of sterols that have a hormone-like function
- ✓ The active molecule, 1,25-dihydroxycholecalciferol (1,25-diOH-D3), binds to intracellular receptor proteins
- ✓ The most prominent actions are to regulate the plasma levels of calcium & phosphorus
- ✓ Sources:
 - ✓ Diet: Ergocalciferol (vitamin D₂, plants)
 - ✓ Cholecalciferol (vitamin D₃, animals)
 - ✓ Endogenous: 7-Dehydrocholesterol is converted to cholecalciferol in the skin

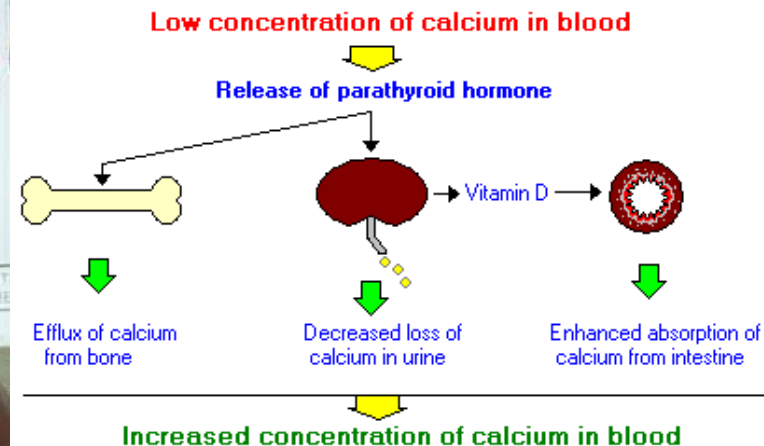
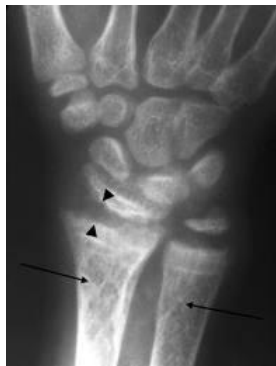
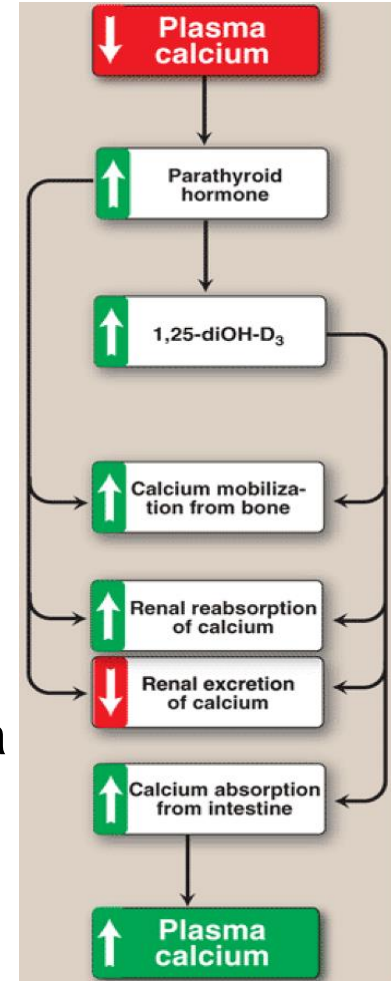


Metabolism of vitamin D

- ✓ Vitamins D₂ and D₃ are not biologically active
- ✓ Converted by two sequential hydroxylation reactions to the active 1,25-diOH-D₃
 - ✓ The first occurs in liver (25-hydroxycholecalciferol)
 - ✓ The predominant form of vitamin D in plasma
 - ✓ The major storage form
 - ✓ The second occurs in kidneys (25-hydroxycholecalciferol 1-hydroxylase)
- ✓ Regulation of 25-hydroxycholecalciferol 1-hydroxylase:
 - ✓ Increased directly by low plasma phosphate
 - ✓ Increased indirectly by low plasma calcium (PTH)
 - ✓ Decreased by excess 1,25-diOH-D₃, the product of the reaction

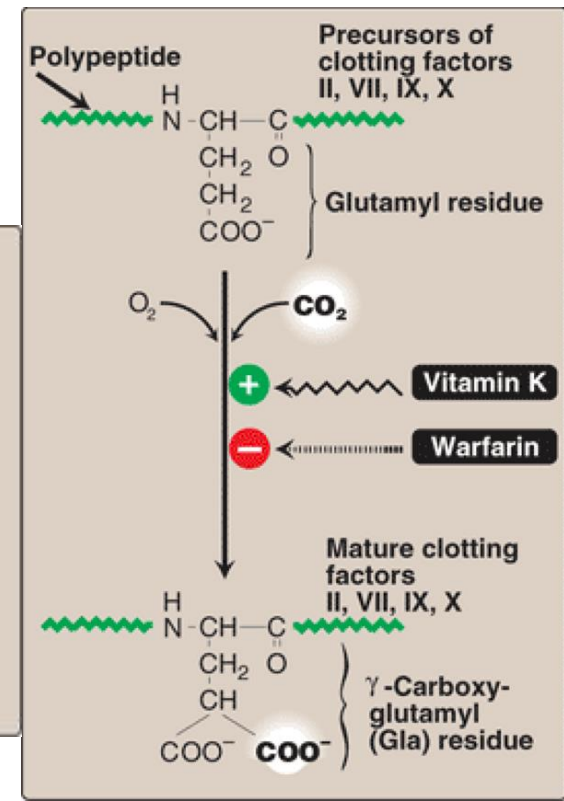
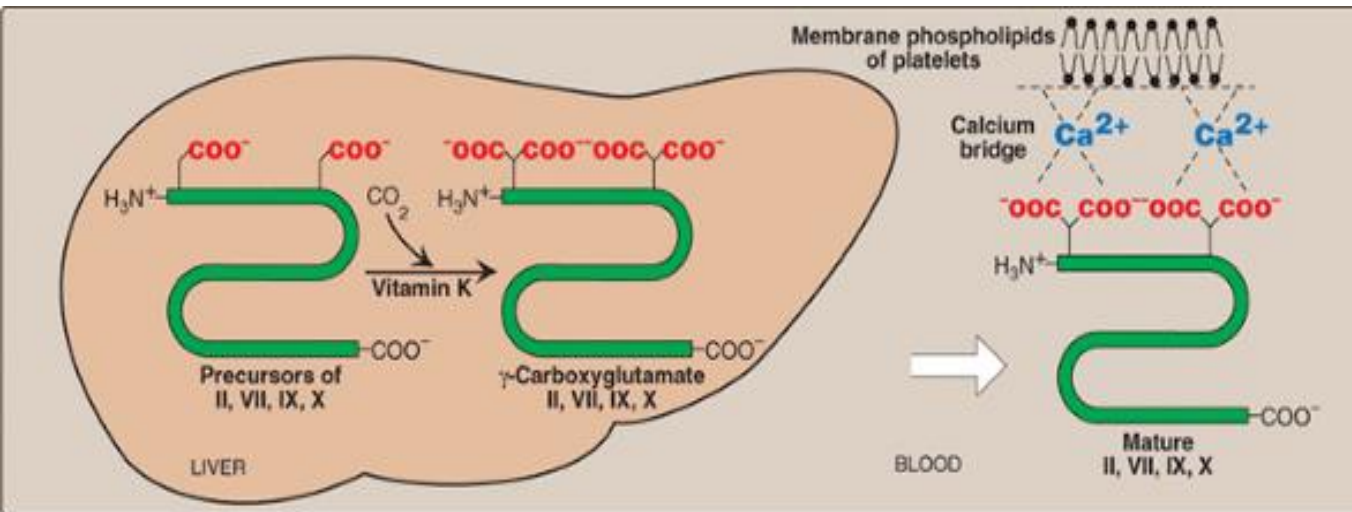
Functions & indications

- ✓ The overall function is to maintain adequate plasma levels of calcium
 - ✓ 1) Increasing calcium uptake by intestines (the mechanism is typical of steroid hormones)
 - ✓ 2) Minimizing calcium loss by kidneys
 - ✓ 3) Stimulating resorption of bone when necessary
- ✓ Indications:
 - ✓ Nutritional rickets: rickets in children & osteomalacia in adults
 - ✓ Renal rickets (renal osteodystrophy): chronic renal failure



Vitamin K

- ✓ Exists in several forms:
 - ✓ In plants: phylloquinone (vitamin K₁)
 - ✓ Intestinal bacterial flora: menaquinone (vitamin K₂)
- ✓ The principal role: posttranslational modification of various blood clotting factors: hepatic synthesis of clotting factors II (prothrombin), VII, IX, and X
- ✓ Present in low concentration in milk





Vitamin K

- ✓ Clinical indications:
 - ✓ Deficiency of vitamin K: unusual (intestinal bacteria), antibiotics
 - ✓ Deficiency of vitamin K in the newborn (sterile intestines). Human milk (20%) of the need, so it is recommended that all newborns receive a single intramuscular dose of vitamin K as prophylaxis against hemorrhagic disease

Vitamin E



- ✓ 8 naturally occurring tocopherols
- ✓ α-tocopherol is the most active form
- ✓ The primary function is as an antioxidant
- ✓ Vitamin E deficiency is almost entirely restricted to premature infants
- ✓ When observed in adults, it is usually associated with defective lipid absorption or transport

