# VITAMINS

## lipid soluble vitamins

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# Vitamin - definition

- An organic compound required as a nutrient in tiny amounts by an organisms.
- It cannot be synthesized in sufficient quantities by an organism, and must be obtained from the diet.
- Vitamins have diverse biological function:
  - hormone-like functions as regulators of mineral metabolism (vit. D),
  - regulators of cell and tissue growth and differentiation (some forms of vit. A)
  - antioxidants (vit. E, C)
  - enzyme cofactors (bound to enzyme as a part of coenzymes)

# History

- Polish biochemist Casimir Funk discovered vitamin B1 in 1912 in rice bran.

- He proposed the complex be named "Vitamin" (vital amines).

- By the time it was shown that not all vitamins were *amines*, the word was already ubiquitous.

# Vitamin classification

**Lipid-soluble vitamins** (A, D, E and K)

- hydrophobic compounds, absorbed efficiently with lipids,
- transport in the blood in lipoproteins or attached to *specific binding proteins,*
- more likely to accumulate in the body,
- more likely to lead to *hypervitaminosis*

# Vitamin classification

**Water-soluble vitamins** - 8 B vitamins and vitamin C

- Function: mainly as enzyme cofactors,
- hydrophilic compounds dissolve easily in water,
- not readily stored, excreted from the body,
- their consistent daily intake is important.

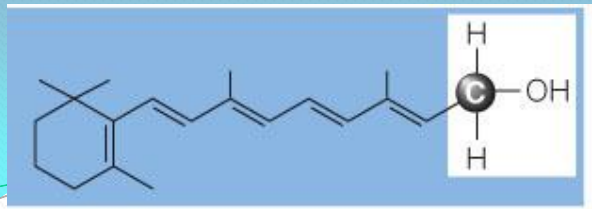
Many types of water-soluble vitamins are synthesized by bacteria.

# Vitamin A and Beta-Carotene

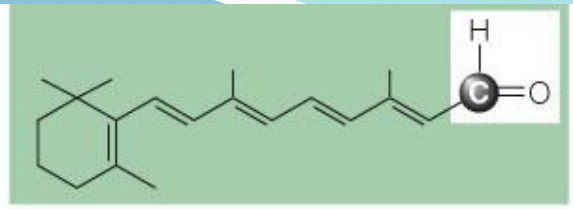
- Also known as retinol, retinal, retinoic acid
- Vitamin A is found in the body in compounds known as retinoids: retinol, retinal, and retinoic acid.
- **These have functional roles in vision, healthy epithelial cells, and growth.**

# Vitamin A and Beta-Carotene

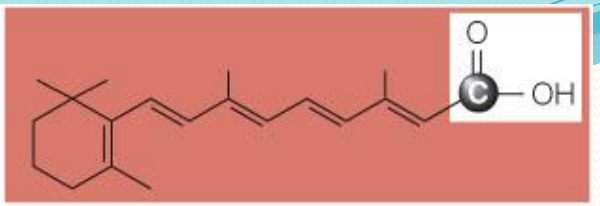
- **Vitamin A deficiency is a major health problem in the world.**
- Toxicity is often associated with abuse of supplements.
- Plant foods provide carotenoids, such as **beta-carotene**, some of which have vitamin A activity.
- Animal foods provide compounds that are easily converted to retinol.
- Retinol binding protein (RBP) allows vitamin A to be transported throughout the body.



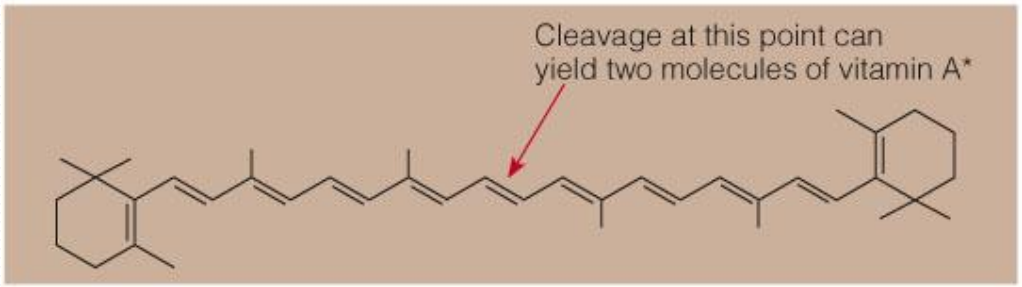

Retinol, the alcohol form




Retinal, the aldehyde form



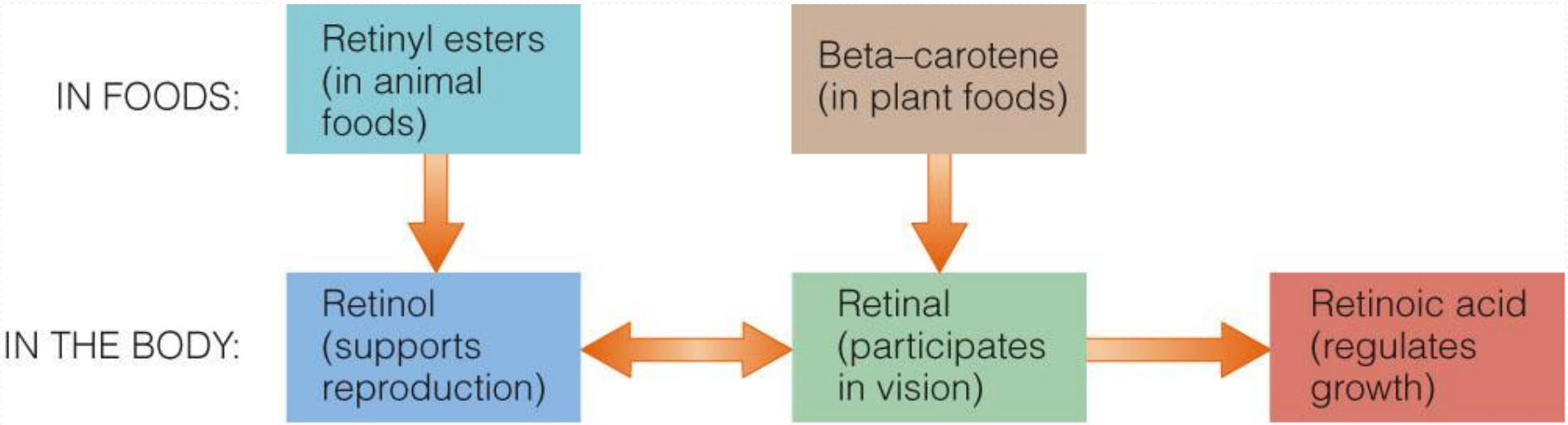

Retinoic acid, the acid form




Beta-carotene, a precursor

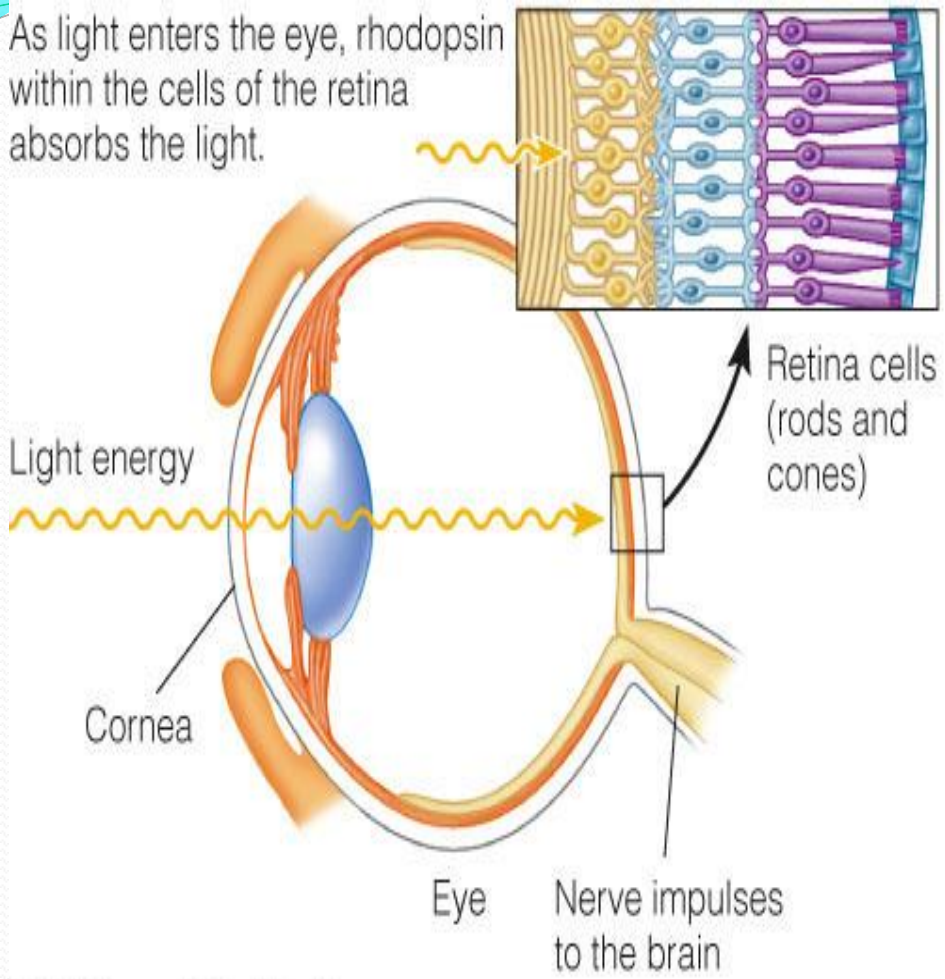
*Sometimes cleavage occurs at other points as well, so that one molecule of beta-carotene may yield only one molecule of vitamin A. Furthermore, not all beta-carotene is converted to vitamin A, and absorption of beta-carotene is not as efficient as that of vitamin A. For these reasons, 12 µg of beta-carotene are equivalent to 1 µg of vitamin A. Conversion of other carotenoids to vitamin A is even less efficient.





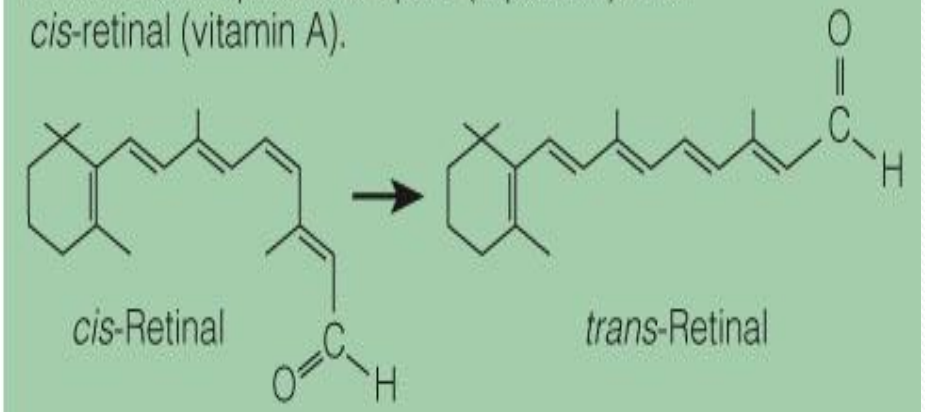
# Vitamin A and Beta-Carotene

- Roles in the Body
  - **Vitamin A in Vision**
    - Helps to maintain the cornea
    - Conversion of light energy into nerve impulses at the retina
    - Rhodopsin is a light-sensitive pigment of the retina that contains a protein called opsin.






The cells of the retina contain rhodopsin, a molecule composed of opsin (a protein) and *cis*-retinal (vitamin A).



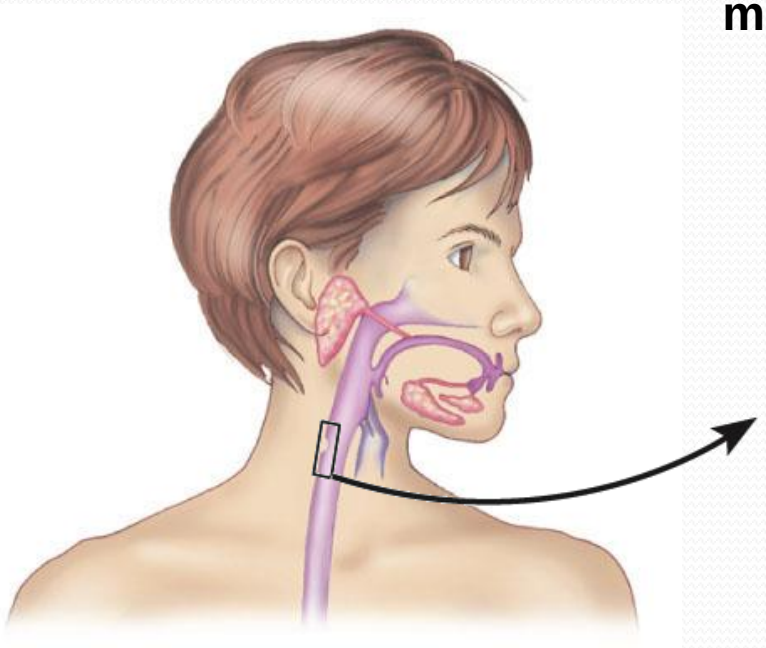

As rhodopsin absorbs light, retinal changes from *cis* to *trans*, which triggers a nerve impulse that carries visual information to the brain.

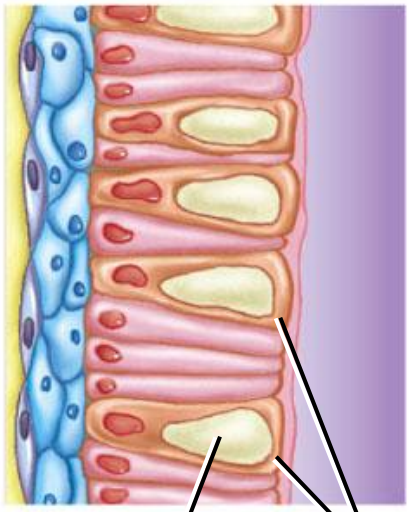
# Vitamin A and Beta-Carotene

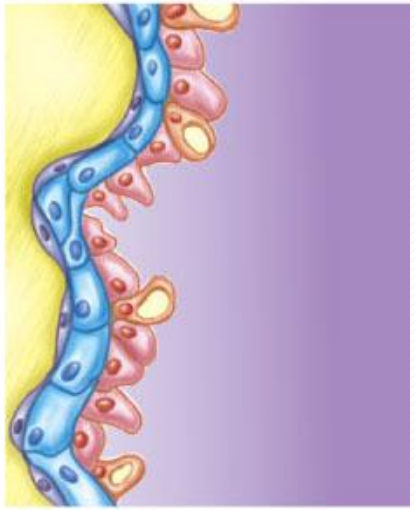
- Roles in the Body
  - **Vitamin A in Protein Synthesis and Cell Differentiation**
    - Through cell differentiation, vitamin A allows cells to perform specific functions.
    - Epithelial cells
      - Epithelial tissues on the outside of the body form the skin.
      - Epithelial tissues on the inside of the body form the mucous membranes.

**Vitamin A maintains healthy cells in the mucous membranes.**

**Without vitamin A, the normal structure and function of the cells in the mucous membranes are impaired.**







**Mucus**

**Goblet cells**

**Stepped Art**

**Fig. 11-4, p. 372**

# Vitamin A and Beta-Carotene

- Roles in the Body
  - **Vitamin A in Reproduction and Growth**
    - Sperm development in men
    - Normal fetal development in women
    - Growth in children
    - Remodeling of the bone involves osteclasts, osteoblasts, and lysosomes.
      - Osteoclasts are cells that destroy bone growth.
      - Osteoblasts are cells that build bones.
      - Lysosomes are sacs of degradative enzymes that destroy bones.

# Vitamin A and Beta-Carotene

- Roles in the Body
  - **Beta-Carotene as an Antioxidant**
    - Beta-carotene helps protect the body from diseases, including cancer.

# Vitamin A and Beta-Carotene

- **Vitamin A Deficiency**
  - **Because vitamin A is stored in the body, it would take a year or more to develop a deficiency in the presence of inadequate intake.**
  - **Infectious Diseases**
    - Impaired immunity correlates with vitamin A deficiency in children.
    - The goals of worldwide health organizations include vitamin A supplementation.
  - **Night Blindness**
    - First detectable sign of vitamin A deficiency
    - Inability to see in dim light or inability to recover sight after a flash of bright light

In dim light, you can make out the details in this room. You are using your rods for vision.

A flash of bright light momentarily blinds you as the pigment in the rods is bleached.

You quickly recover and can see the details again in a few seconds.

With inadequate vitamin A, you do not recover but remain blinded for many seconds.

# Vitamin A and Beta-Carotene

- **Vitamin A Deficiency**
  - **Blindness**
    - **Xerophthalmia**
    - Xerosis is the first stage where the cornea becomes dry and hard.
    - Keratomalacia is the softening of the cornea.
  - **Keratinization**
    - Epithelial cells secrete a protein called keratin—the hard, inflexible protein of hair and nails.
    - Changes in epithelial cells results in keratinization, rough, dry and scaly skin.
  - Deficiency disease is called hypovitaminosis A

# Xer

In vitamin A deficiency, the epithelial cells secrete the protein keratin in a process known as *keratinization*. (Keratinization doesn't occur in the GI tract, but mucus-producing cells dwindle and mucus production declines.) The extreme of this condition is *hyperkeratinization* or *hyperkeratosis*. When keratin accumulates around hair follicles, the condition is known as *follicular hyperkeratosis*.

# Vitamin A and Beta-Carotene

- **Vitamin A Toxicity**
  - **Can occur with concentrated amounts of the preformed vitamin A from animal foods, fortified foods, or supplements.**
  - Consuming excessive amounts of beta-carotene from supplements can be harmful.
  - Bone Defects
    - Increased activity of osteoclasts causes weakened bones and contributes to osteoporosis and fractures.

# Vitamin A and Beta-Carotene

- **Vitamin A Toxicity**
  - **Birth Defects**
    - **Teratogenic** risk is possible, resulting in abnormal fetal development and birth defects.
    - Vitamin A supplements are not recommended the first trimester of pregnancy.
  - **Not for Acne**
    - Massive doses for teens are not effective on acne.
    - Accutane is made from vitamin A, but is chemically different. It is toxic during growth and can cause birth defects.
    - Retin-A fights acne, the wrinkles of aging, and other skin disorders.

# Vitamin A and Beta-Carotene

- Vitamin A Toxicity
  - Toxicity is called **hypervitaminosis A**
  - Chronic toxicity symptoms include liver abnormalities.
  - Acute toxicity symptoms include blurred vision, nausea, vomiting, vertigo, headaches, and pressure in the skull.
  - Upper level for adults: 3000 µg/day

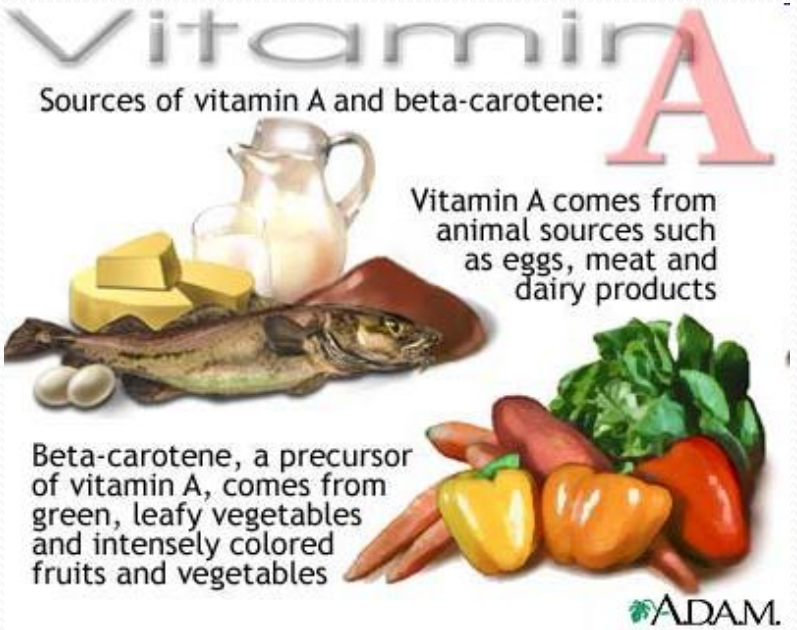
# Vitamin A and Beta-Carotene

- Vitamin A Recommendations (2001 RDA)
  - Expressed as **retinal activity equivalents** (RAE) because sources include all forms of retinoids and beta-carotene
  - RDA men: 900 µg RAE/day
  - RDA women: 700 µg RAE/day

# Sources of vitamin A

- cod liver oil
- meat
- egg
- milk
- dairy products

- carrot
- broccoli
- spinach
- papaya
- apricots



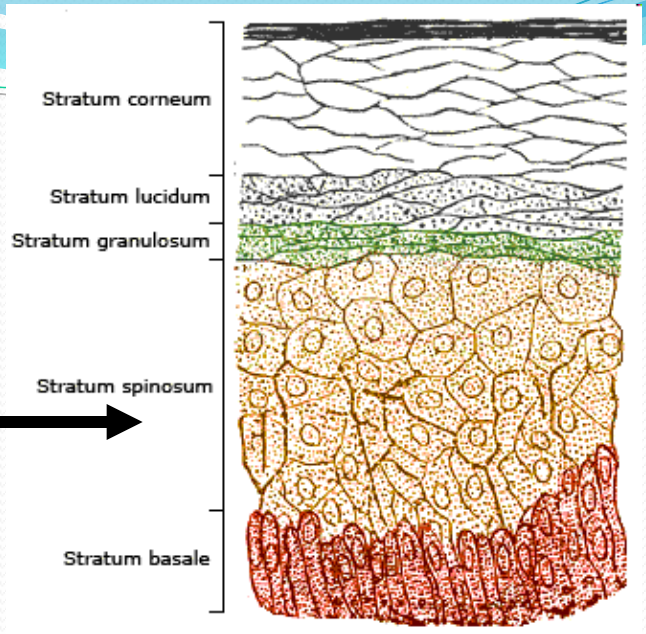

 http://health.allrefer.com/health/nutrition.html

# Vitamin D

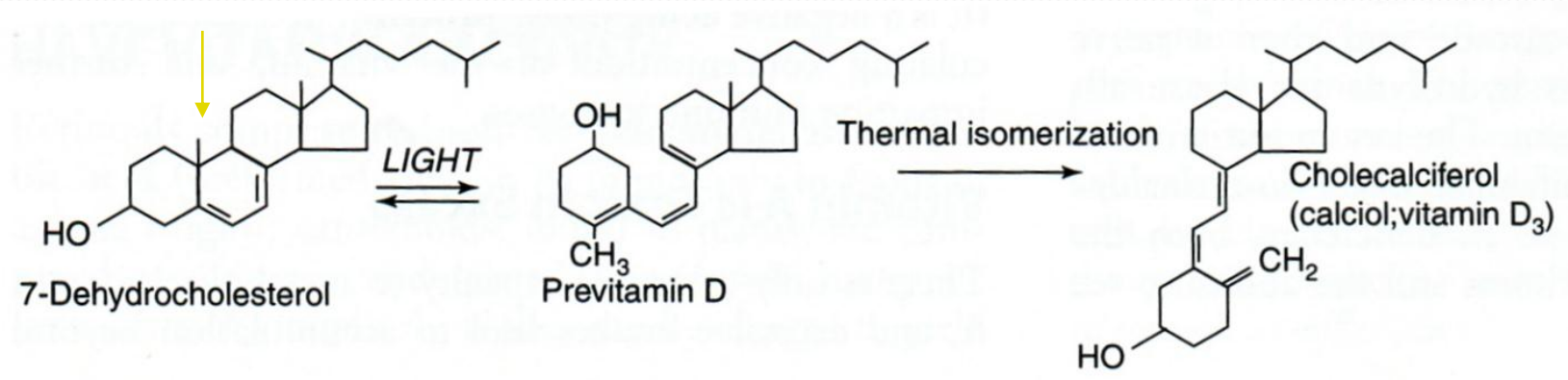
- Calciol, vitamin $D_2$ (cholecalciferol) → precursor of calcitriol, $D_3$ (1,25-dihydroxycalciferol).
- Regulates with PTH calcium and phosphate level (absorption, reabsorption, excretion).
- Synthesis in the skin (7-dehydrocholesterol) UV → further transformation in the liver and kidneys .

# Synthesis

UV irradiation 270 – 300 nm




*Photolysis*

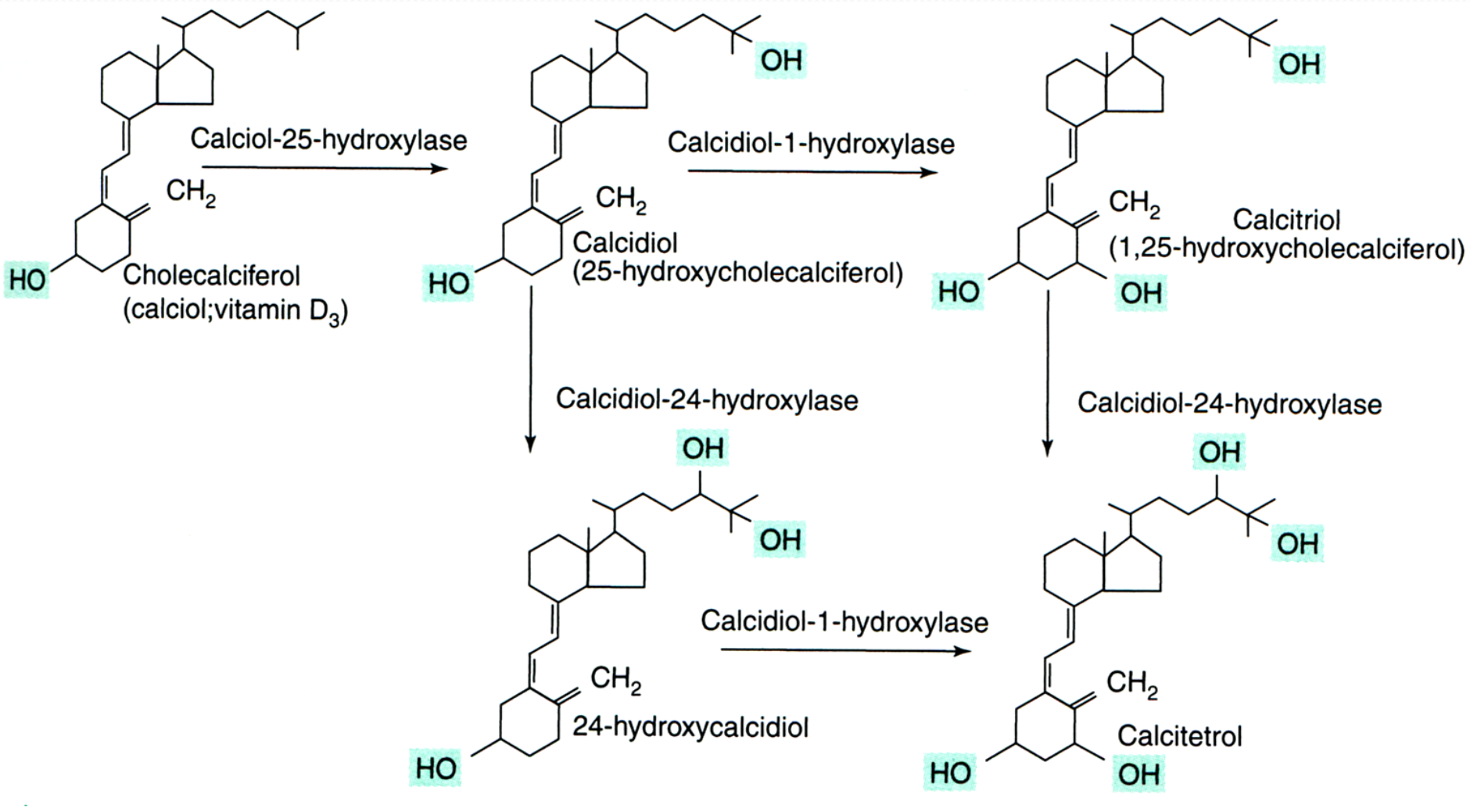



Non-enzymatic reaction in the skin

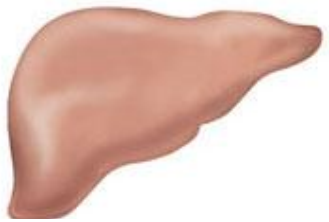
Transport to the liver

Liver

Kidneys




Inactive form



In the skin:
7-dehydrocholesterol
(a precursor made in the liver from cholesterol)

Ultraviolet light from the sun

Previtamin $D_3$

Foods

Vitamin $D_3$
(an inactive form)

In the liver: Hydroxylation

25-hydroxy vitamin $D_3$

In the kidneys: Hydroxylation

1,25-dihydroxy vitamin $D_3$ (active form)



Stepped Art

Fig. 11-9, p. 377

# Effects of vitamin D

- Transported in the blood on a carrier (vitamin-D binding protein, VDBP).
- $1,25(OH)_2D$ binds to intracellular receptors (intestine, bone, kidney).
- The main function is to maintain plasma levels of calcium (essential for neuromuscular activity) and phosphate levels:
  - increase Ca absorption in the intestine,
  - reduce the excretion of calcium (stimulates parathyroid hormone-dependent Ca reabsorption in the distal tubule),
  - mobilizing bone mineral, together with parathyroid hormone

# Vitamin D and imunity

- It increases the activity of natural killer cells (cytotoxic lymphocytes).
- Increases the phagocytic ability of macrophages .
- Reduces the risk of virus diseases (colds, flu).
- Reduces the risk of many cancers (colon, breast and ovarian cancer).
- Reduces the risk of cardiovascular disease → have a positive impact on the composition of plasma lipids.

# Vitamin D - deficincy

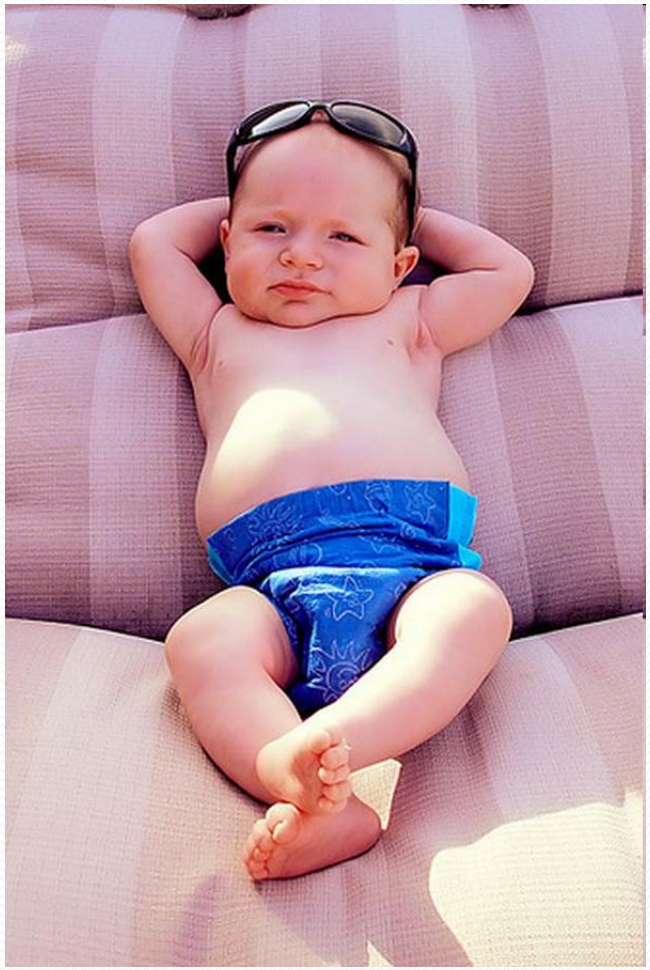
- Failure of absorption in the intestine.
- The lack of the liver and the renal hydroxylation of vit. D (congenital deficiency of 1-hydroxylase).

- The lack of UV irradiation.

- The main manifestation - impaired ossification of the newly created osteiod, abundance of non mineralized matrix.
- Vit. D is necessary for the prevention of skeletal changes (rickets in growing individuals, osteomalacia in adults).

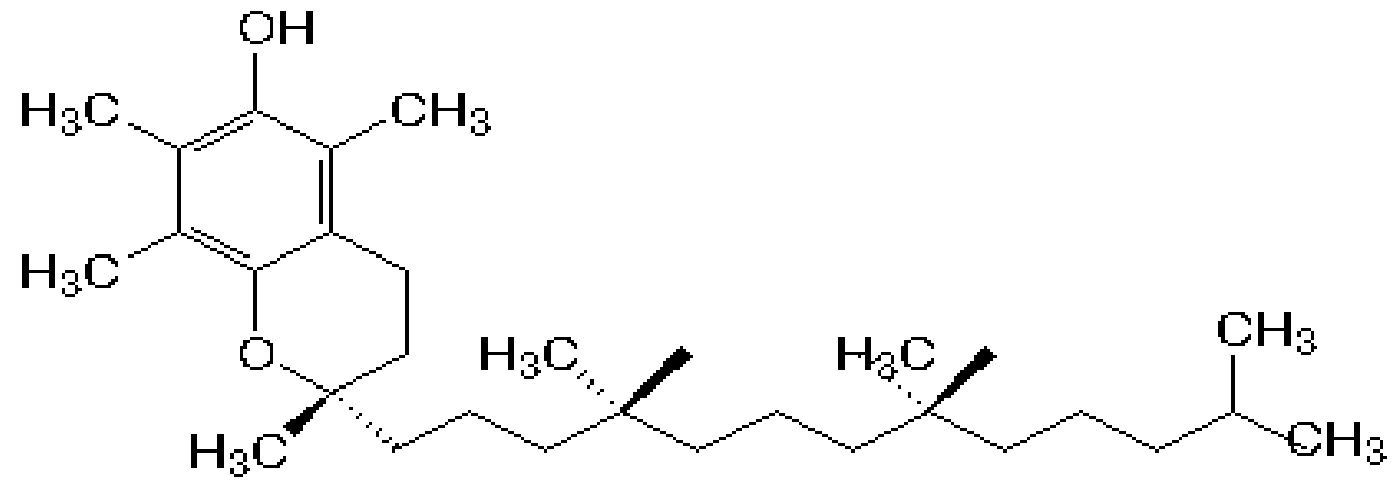
# Sources of vitamin D

- In addition to sunbathing:
- various fish species (salmon, sardines and mackerel, tuna, catfish, eel), fish oil, cod liver
- eggs, beef liver, mushrooms



# Vitamin E

- Vitamin E is a family of α–, β–, γ–, δ– tocopherols and corresponding tocotrienols izomers.
- The highest biological activity has α- tocopherol .



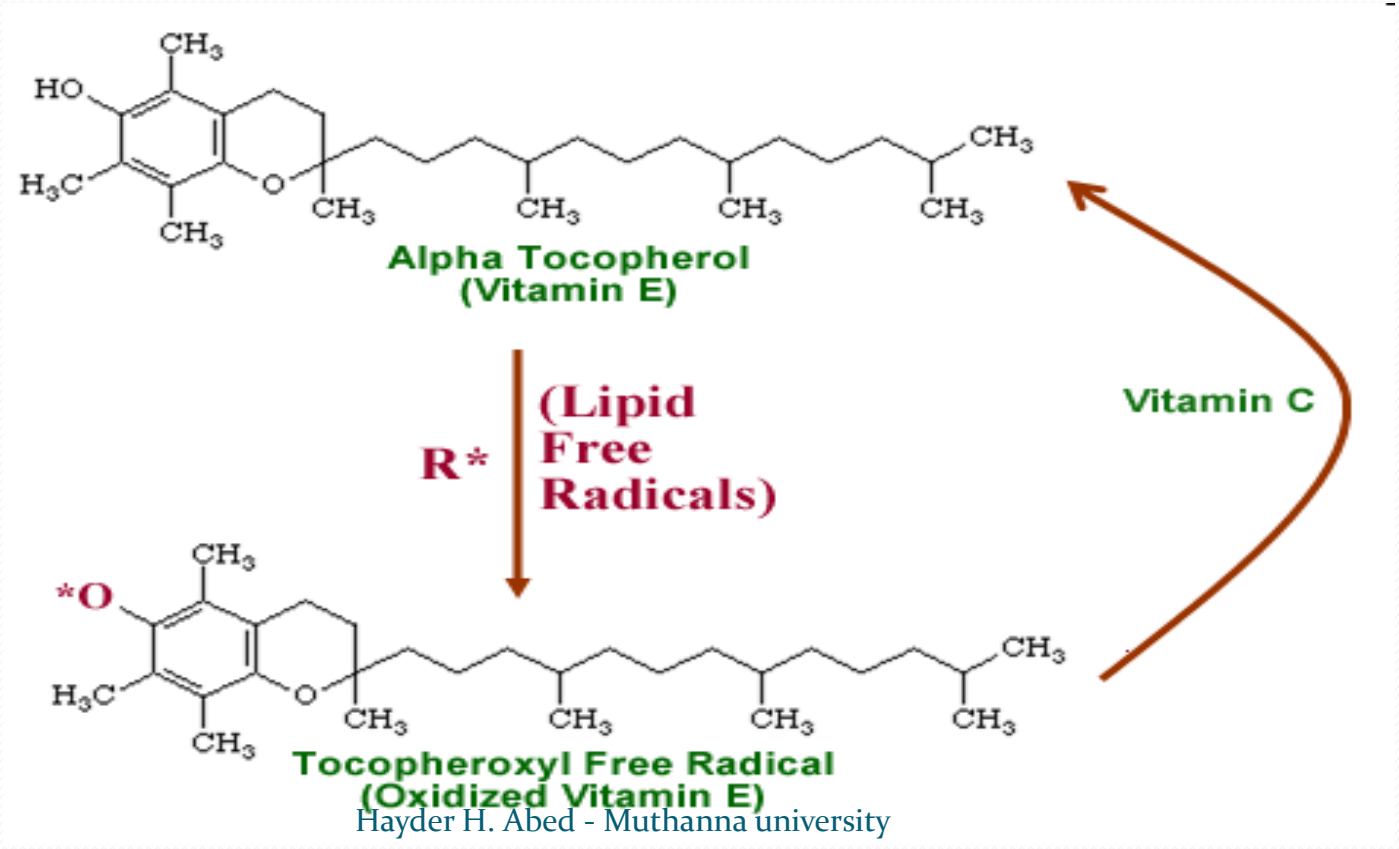

Vitamin E (α-tocopherol)

# Vitamin E

- There are four different tocopherol compounds, but only the alpha-tocopherol has vitamin E activity in human beings.
- Vitamin E as an **Antioxidant**
  - **Stops the chain reaction of free radicals**
  - **Protection of polyunsaturated fatty acids and vitamin A**
  - **Protects the oxidation of LDLs**

# Vitamin E as antioxidant

- Stops free radical reactions (peroxyl radicals ROO• , oxygen radicals HO•, lipoperoxid radicals LOO•). Chroman ring with OH group → uptake radicals.



# Vitamin E

- Adsorbtion from the small intestine.
- Its absorption is dependent on the presence of lipids in the diet.
- Associated with plasma lipoproteins → liver uptake through receptors for apolipoprotein E.
- α–tocopherol is bind to *α-tocopherol transport protein* (α-TTP) → transported to the target organs (the excess is stored in adipocytes, in muscle, liver).
- β–, γ– a δ–tocopherols are transferred into the bile and degraded.

# Vitamin E Deficiency

- Vitamin E Deficiency - Symptoms
  - Loss of muscle coordination and reflexes
  - Impaired vision and speech
  - Nerve damage
  - Erythrocyte hemolysis (breaking open of red blood cells)
- Supplements do not prevent or cure muscular dystrophy.
- Fibrocystic breast disease responds to vitamin E treatment.
- Intermittent claudication responds to vitamin E treatment.

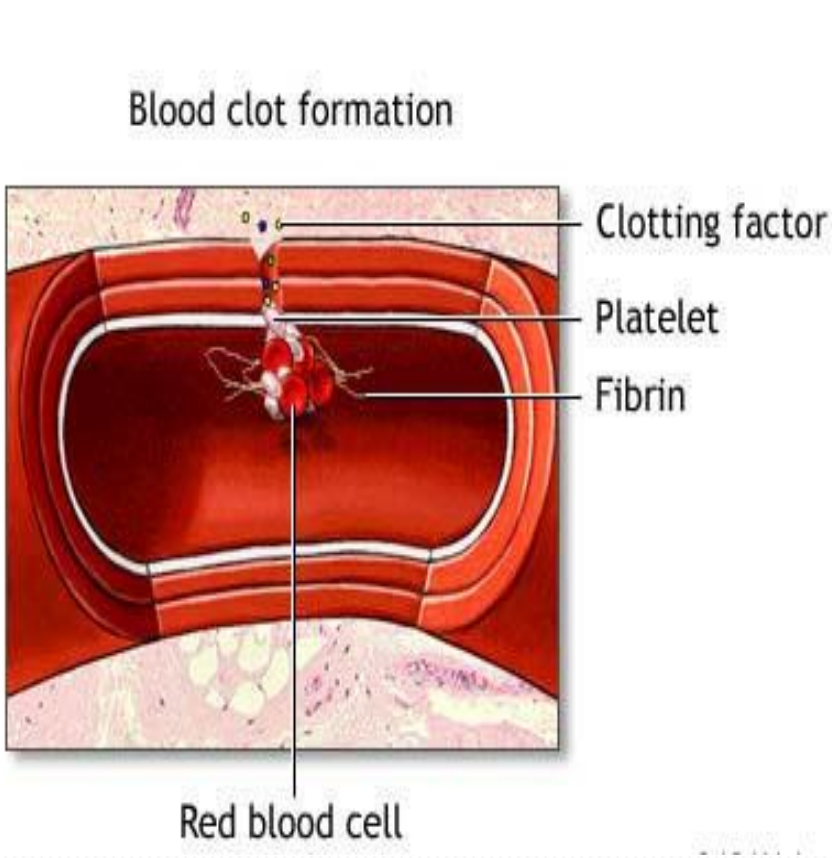
# Sources of vitamin E

- fortified cereals
- seeds and seed oils, like sunflower
- nuts and nut oils, like almonds and hazelnuts
- green leafy vegetables,
- broccoli
- cabbage
- celery

Vitamin E is found in corn, nuts, olives, green, leafy vegetables, vegetable oils and wheat germ

# Vitamin K

**Vitamin K is a fat-soluble vitamin. The "K" is derived from the German word "koagulation." Coagulation refers to the process of blood clot formation.**




**Vitamin K is essential for the functioning of several proteins involved in blood clotting.**

**When an injury occurs, the protein molecules (with names like Factor II or prothrombin, Factor VII, Factor IX, and Factor X) rapidly assemble and form the blood clot.**

**The term thrombus or thrombosis refers to a blood clot.**

# Vitamin K

- Also known as phylloquinone, menaquinone and menadione,
- Vitamin K is unique in that half of human needs are met through the action of intestinal bacteria.

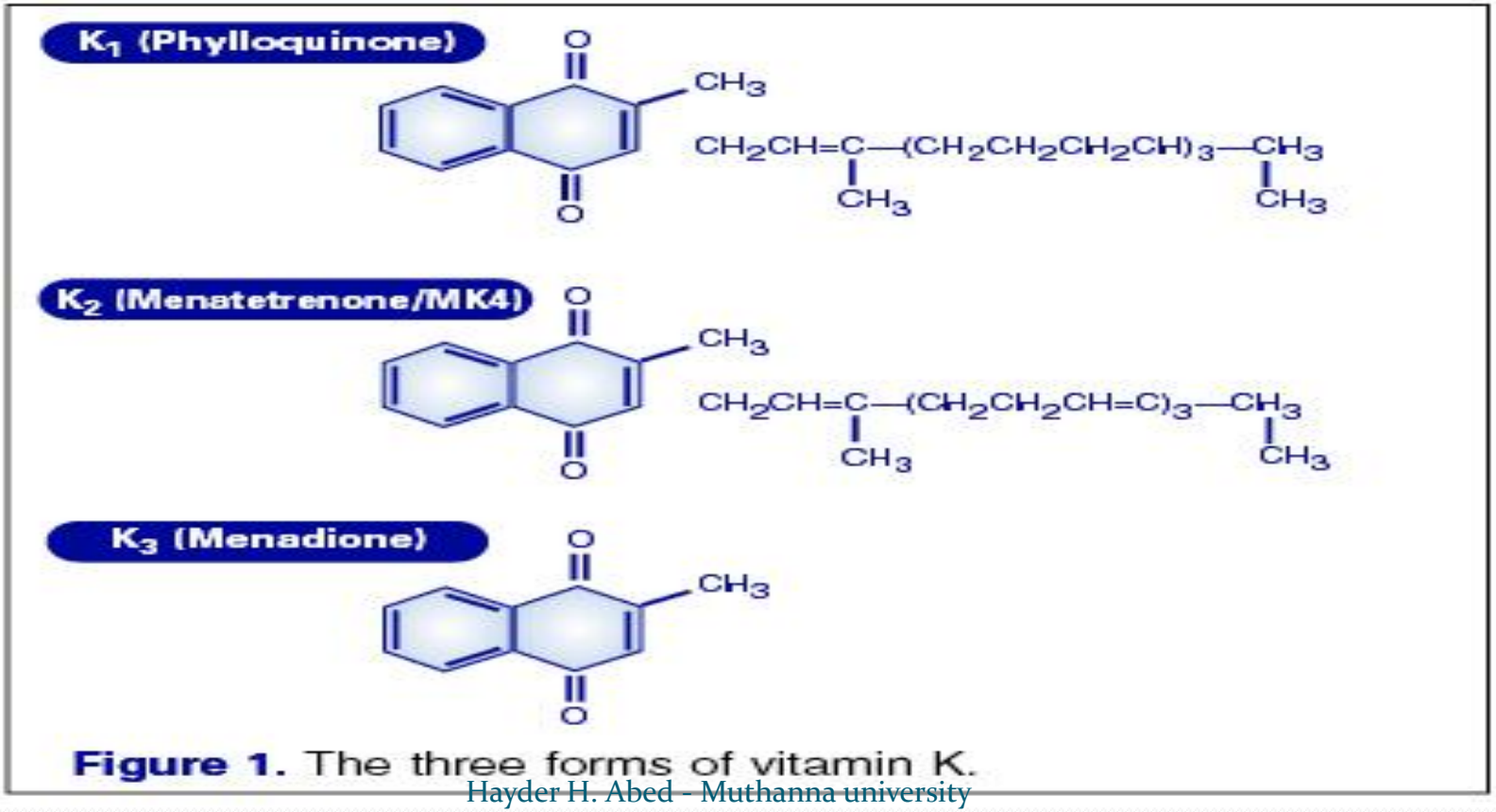
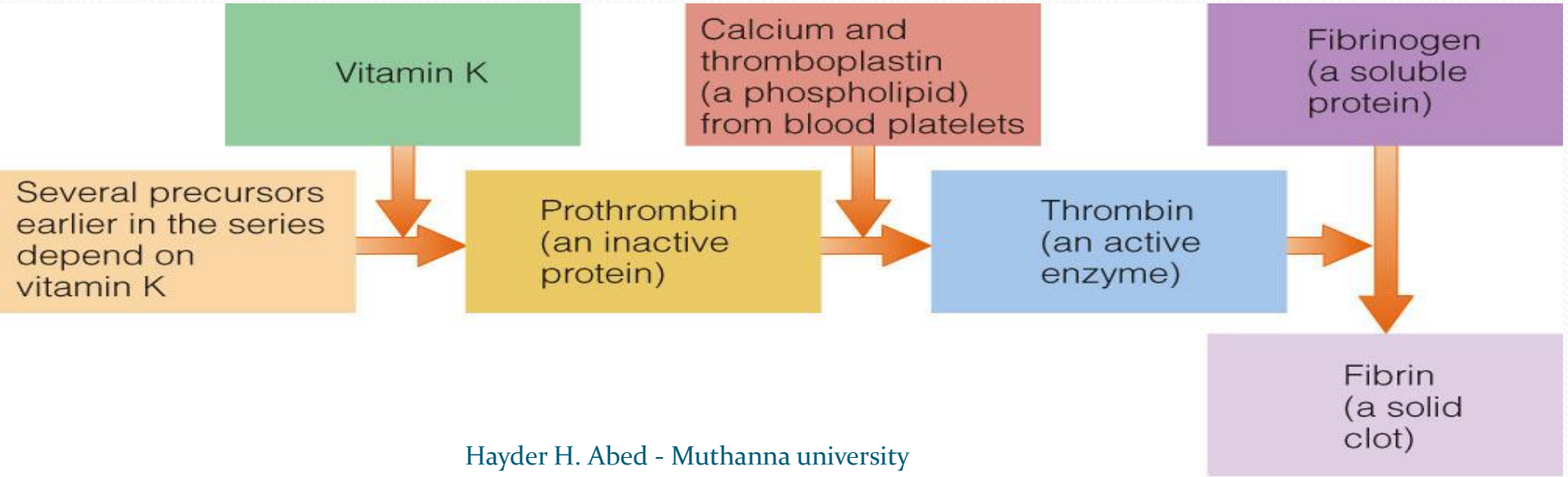



**Figure 1.** The three forms of vitamin K.

# Vitamin K

- Roles in the Body
  - Synthesis of blood-clotting proteins
  - Synthesis of bone proteins that regulate blood calcium
  - Without vitamin K, a hemorrhagic disease may develop.
  - Hemophilia is a hereditary disorder and is not cured with vitamin K.



# Vitamin K


- Vitamin K Deficiency
  - Symptoms include hemorrhaging
  - Secondary deficiencies may occur with use of antibiotics.
  - Newborn infants receive a single dose of vitamin K at birth because of a sterile intestinal tract.
- Vitamin K Toxicity
  - Uncommon
  - No known toxicities
  - High doses can decrease the effectiveness of anti-clotting medications.

# Sources of vitamin K

- Green leafy vegetables
- vegetable oil
- broccoli
- cereals

# Thank you for listening