Biochemistry
Team 434

Vitamin A

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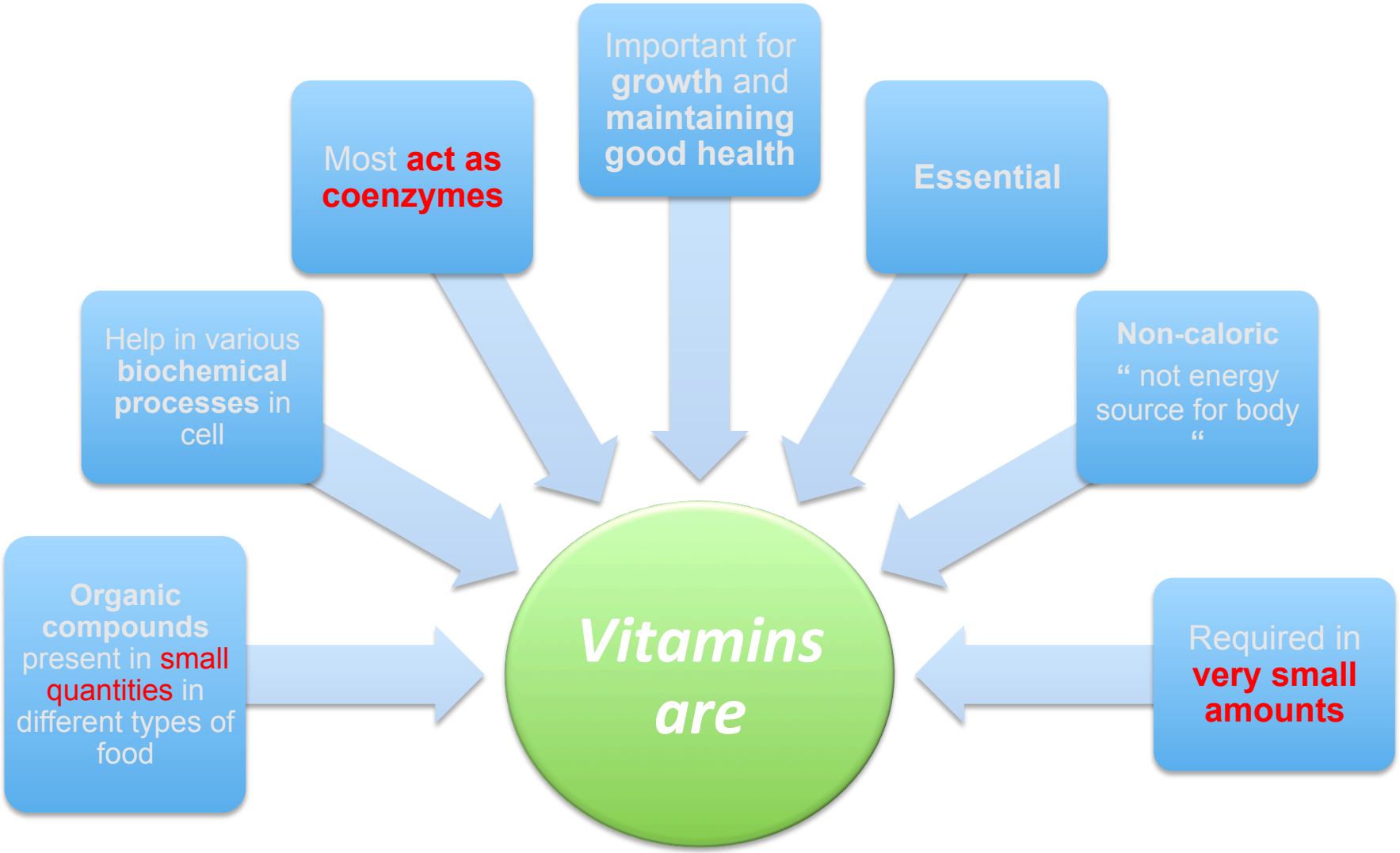
Overview

- Fat-soluble vitamins
- Biochemistry and types of vitamin A
- Absorption and transport
- Functions
- Functions in the visual cycle
- Deficiency and diseases


Most act as coenzymes
Important for growth and maintaining good health
Essential
Help in various biochemical processes in cell
Non-caloric " not energy source for body "
Organic compounds present in small quantities in different types of food
Vitamins are
Required in very small amounts

Vitamins - Classified Based on Solubility:

Fat Soluble

- A, D, E, and K

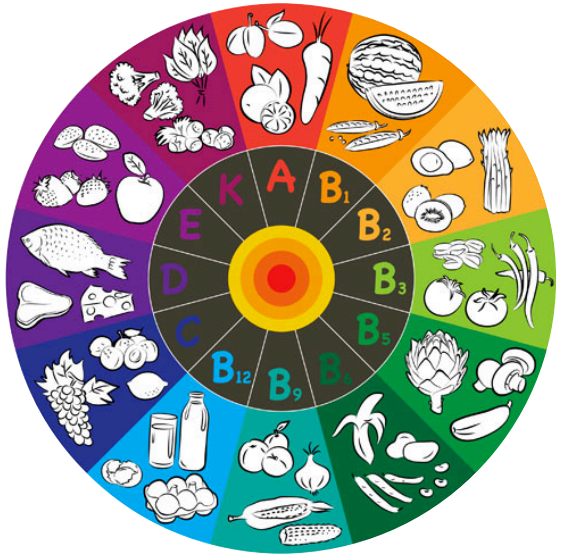
"AKED" اكيد

Water Soluble

- ascorbic acid (vitamin C)
- thiamin (vitamin B_1)
- riboflavin (vitamin B_2)
- niacin
- biotin
- pantothenic acid
- **pyridoxine** (vitamin B_6)
- folate
- **cobalamin** (vitamin B_{12})

Almost all water soluble acts as coenzyme.

Vitamin K is the fat soluble that acts as coenzyme.



Fat-soluble Vitamins

- Stored in the liver and adipose tissue.
- Excess may accumulate and cause toxicity .
- Cases of toxicity with vitamin A and D have been reported.
- Do not need to be consumed each day due to storage in the body.
- Absorbed slowly with fats.
- Diseases due to deficiency are rare as large amounts are stored in the body.

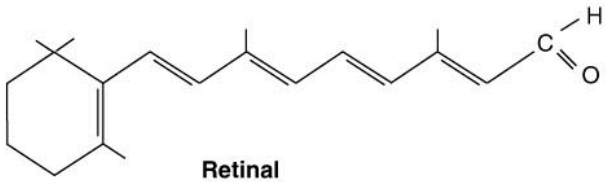
Vitamin A from animal sources (Preformed):

- Three preformed compounds called **retinoids** that are metabolically active and found in animal products:

Retinol — **alcohol form** (can be converted to other forms)- ACTIVE

Retinal — **aldehyde form** (essential in vision)

Retinoic acid — **acid form** (for skin and bone growth)

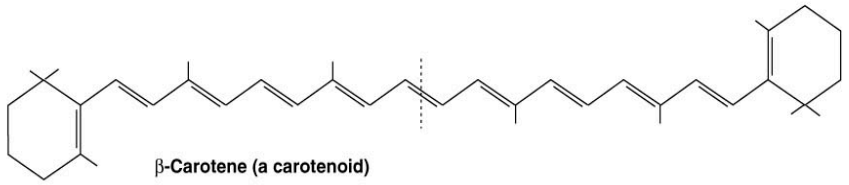


Retinal

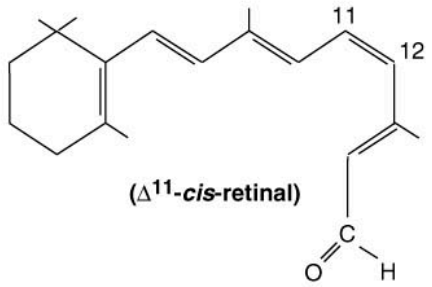
(All-*trans*-retinal)

Vitamin A from plant sources (Provitamin):

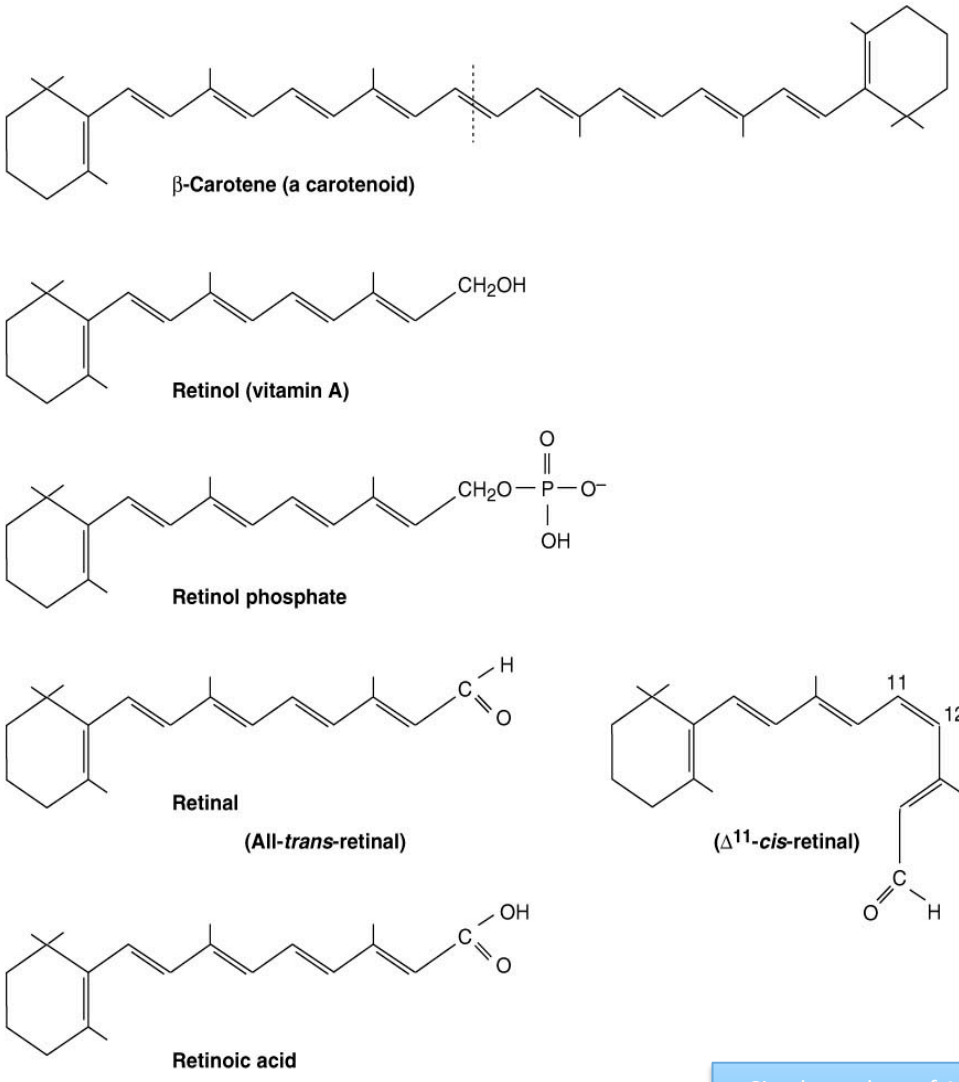
- **Carotenoids (**b-carotene**)** and cryptoxanthin can yield retinoids when metabolized in the body.
- These are from plant sources.
- One molecule of b-carotene can be cleaved into two molecules of **retinal** in the intestine.

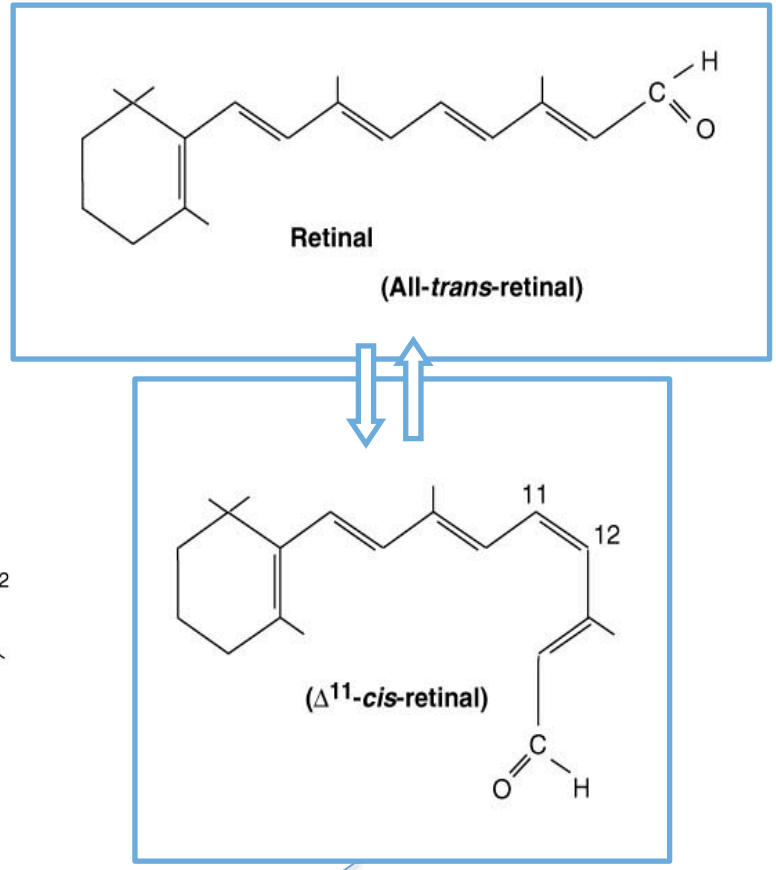


β-Carotene (a carotenoid)



(Δ^{11}-*cis*-retinal)

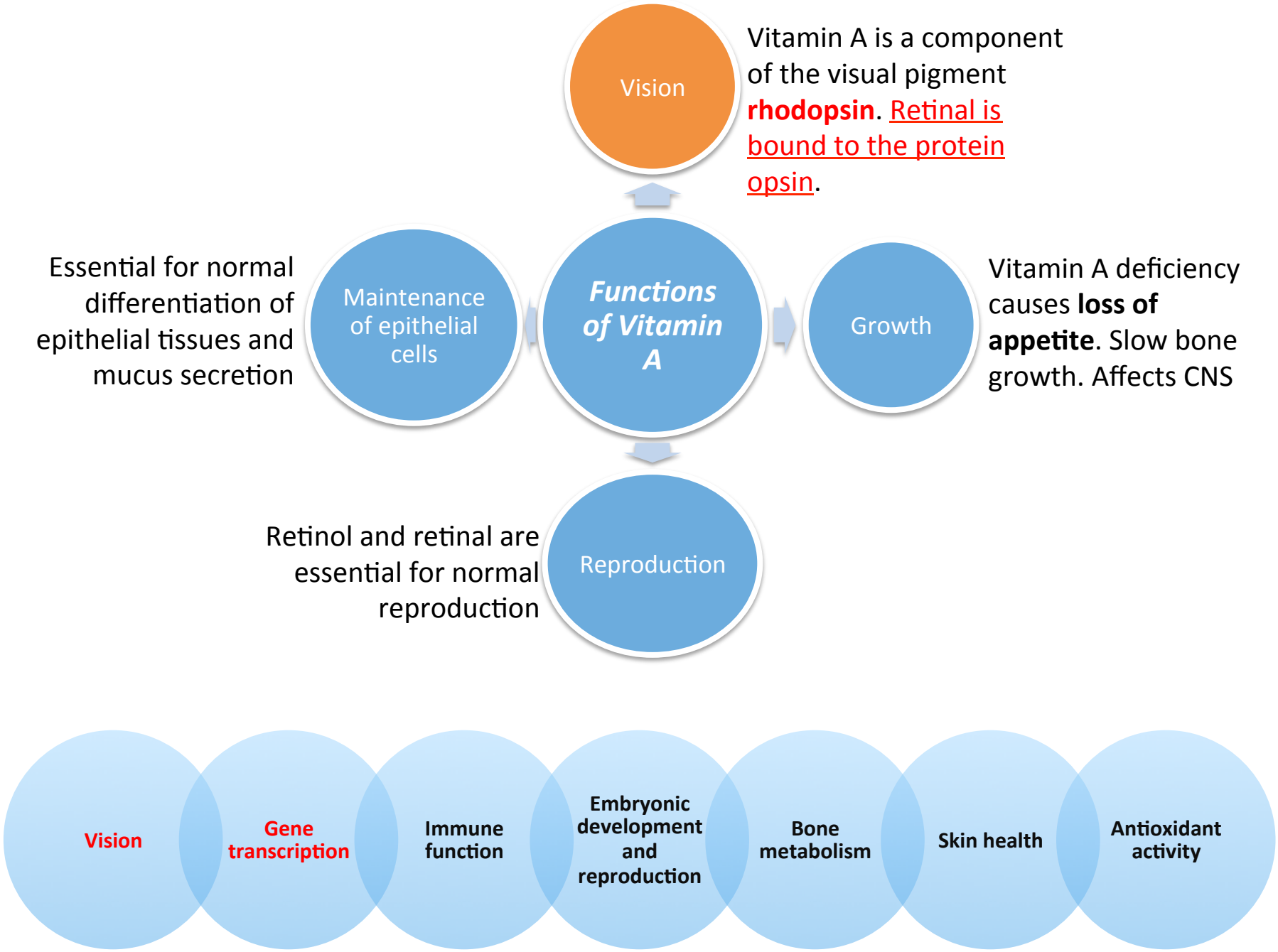




Cis: the carbon of 11 and 12 are on the same side.
Trans: Carbons are on the opposite to each other.

Figure 28.2. Structures of vitamin A and relate

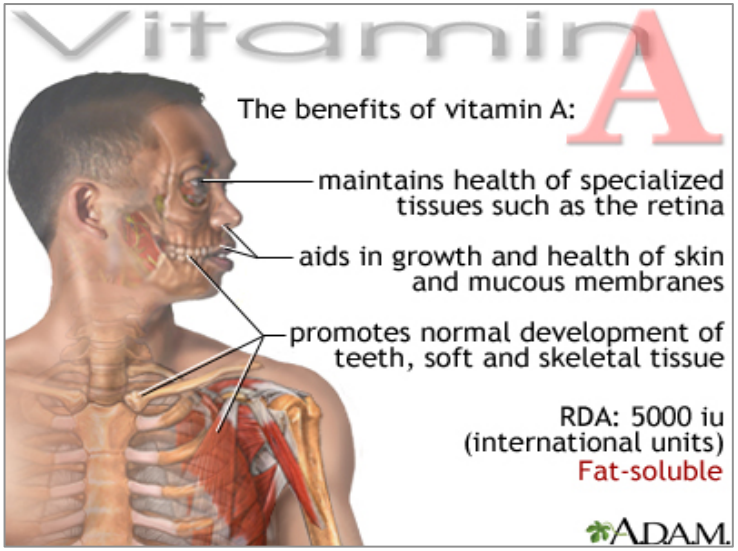
Textbook of Biochemistry With Clinical Correlations, Sixth Edition, Edited by Thomas M. Devli


Vision
Vitamin A is a component of the visual pigment **rhodopsin**. Retinal is bound to the protein opsin.
Essential for normal differentiation of epithelial tissues and mucus secretion
Maintenance of epithelial cells
Functions of Vitamin A
Growth
Vitamin A deficiency causes **loss of appetite**. Slow bone growth. Affects CNS
Retinol and retinal are essential for normal reproduction
Reproduction
Vision
Gene transcription
Immune function
Embryonic development and reproduction
Bone metabolism
Skin health
Antioxidant activity

Vitamin A

- Essential role in vision and normal cell differentiation
- Deficiency is the most significant cause of blindness in the developing world
- Large doses over a prolonged period of time can produce intoxication and eventually lead to liver disease
- Excessive carotenoids intake can result in yellowing of the skin, but appears to be harmless

Additional:



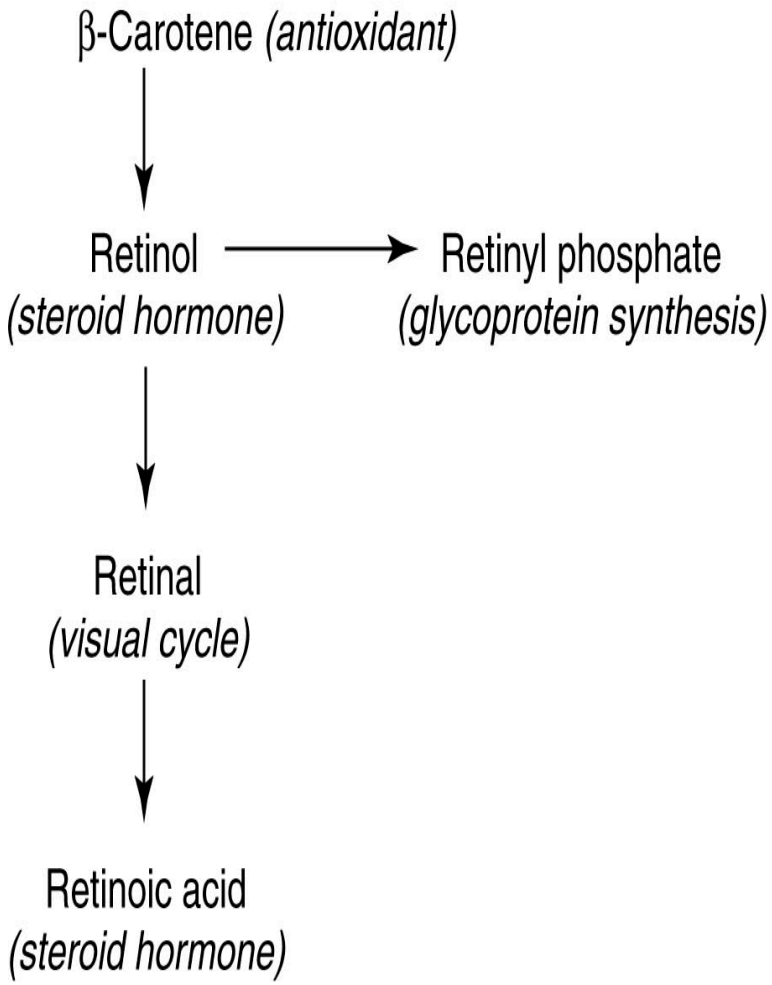
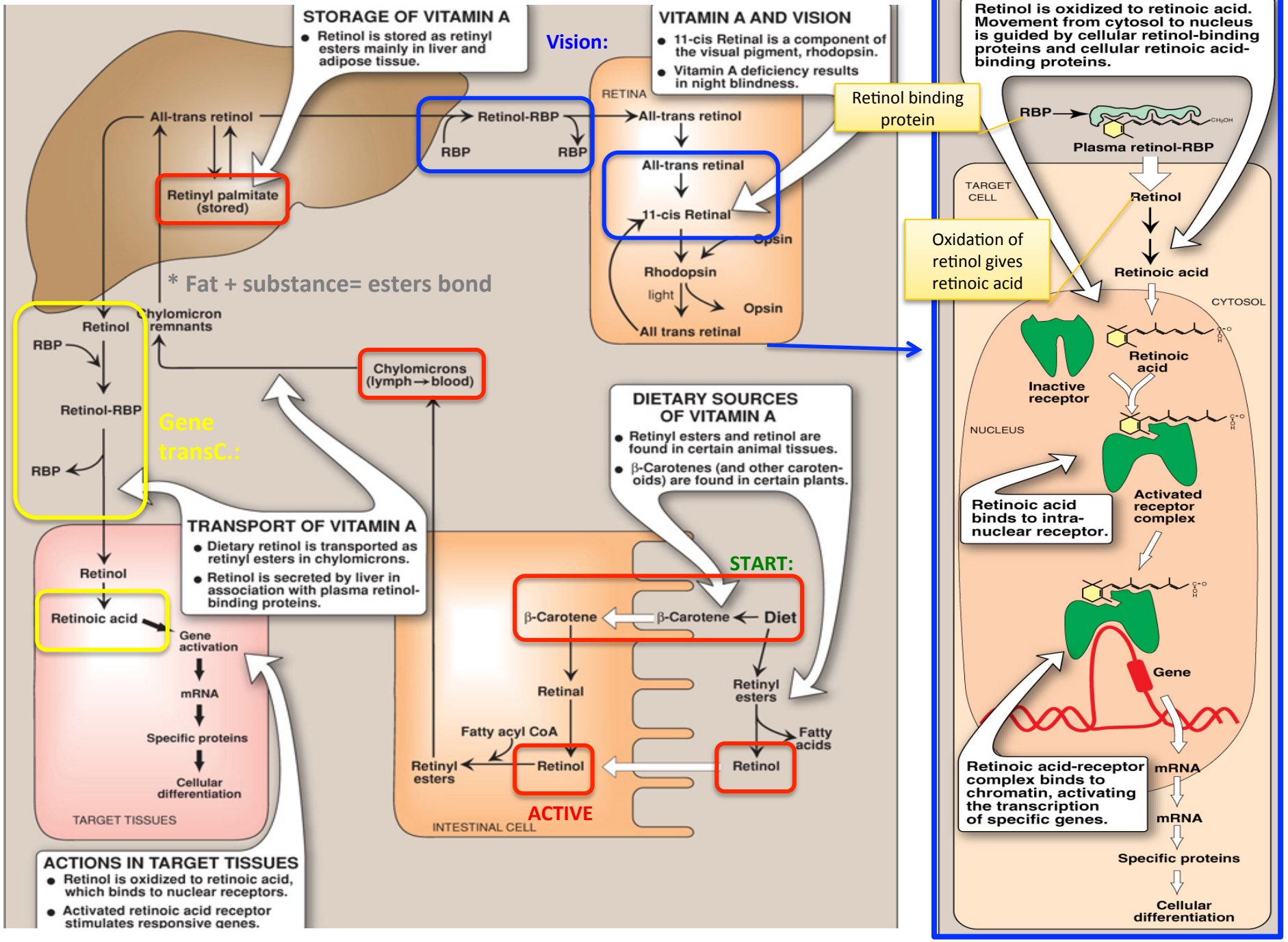
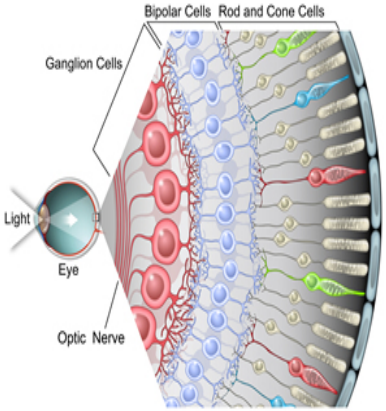


Figure 28.3. Vitamin A metabolism and function.


STORAGE OF VITAMIN A
Retinol is stored as retinyl esters mainly in liver and adipose tissue.
Vision:
VITAMIN A AND VISION
11-cis Retinal is a component of the visual pigment, rhodopsin.
Vitamin A deficiency results in night blindness.
RETINA
All-trans retinol
Retinol-RBP
RBP
RBP
All-trans retinol
All-trans retinal
11-cis Retinal
Opsin
Rhodopsin
light
Opsin
All trans retinal
Retinyl palmitate (stored)
Retinol binding protein
* Fat + substance= esters bond
Chylomicron remnants
Retinol
RBP
Retinol-RBP
RBP
Chylomicrons (lymph → blood)
Gene transC.:
TRANSPORT OF VITAMIN A
Dietary retinol is transported as retinyl esters in chylomicrons.
Retinol is secreted by liver in association with plasma retinol-binding proteins.
DIETARY SOURCES OF VITAMIN A
Retinyl esters and retinol are found in certain animal tissues.
β-Carotenes (and other carotenoids) are found in certain plants.
START:
β-Carotene
β-Carotene
Diet
Retinal
Retinyl esters
Fatty acyl CoA
Fatty acids
Retinyl esters
Retinol
Retinol
ACTIVE
INTESTINAL CELL
Retinol
Retinoic acid
Gene activation
mRNA
Specific proteins
Cellular differentiation
TARGET TISSUES
ACTIONS IN TARGET TISSUES
Retinol is oxidized to retinoic acid, which binds to nuclear receptors.
Activated retinoic acid receptor stimulates responsive genes.
Retinol is oxidized to retinoic acid. Movement from cytosol to nucleus is guided by cellular retinol-binding proteins and cellular retinoic acid-binding proteins.
RBP
Plasma retinol-RBP
TARGET CELL
Retinol
Retinoic acid
Oxidation of retinol gives retinoic acid
CYTOSOL
Inactive receptor
Retinoic acid
NUCLEUS
Retinoic acid binds to intra-nuclear receptor.
Activated receptor complex
Gene
Retinoic acid-receptor complex binds to chromatin, activating the transcription of specific genes.
mRNA
mRNA
Specific proteins
Cellular differentiation

Visual cycle

Light impacting on the retina → Converted to electrical signals → The optic nerve carries these signals to the brain (nerve impulses) → The signals are processed in the brain to images



- Retina is a light-sensitive layer of cells at the back of the eye where an image is formed. Which composed of **photosensitive cells**:
- **Rods** (for black & white image)
- **Cons** (for Colors)
- Normal vision depends on the retina and on adequate vitamin A.
- Vitamin A in the retina is found in the form of ritnal.

Retinal binds to a protein called **opsin** forming light sensitive structures:
Rhodopsin (in Rod cells) and
iodopsin (in cone cells)

Recommended Dietary Allowance (RDA) of Vitamin A for Adults

Women: 700 µg or 2,330 IU

Men: 900 µg or 3,000 IU

Upper Limit (UL) for Men or Women: 3,000 µg or 10,000 IU

IU= International unit

Role of Vitamin A in Vision

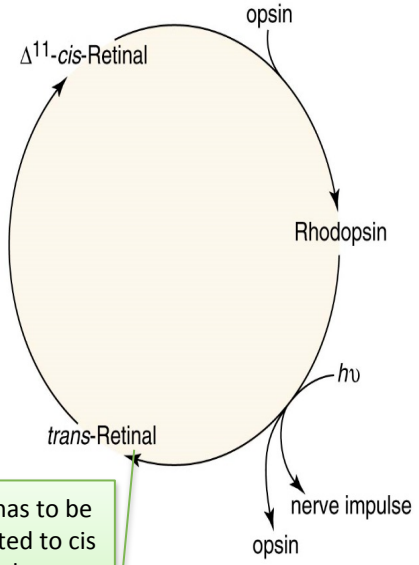
Rhodopsin contains retinal in cis form (bent). When stimulated by light vitamin A isomerizes* from its cis form to trans form (straight) then it detaches from opsin, after opsin detaches from trans-Retinal it changes its shape and that causes sending of a signal to the brain via optic nerve and the image is formed (when opsin changes its shape it helps in the production of metarhodopsin II and a lot of reactions resulting in sending the signal).. Most of the trans-retinal are converted to trans-retinol and then to cis-retinal and it binds to opsin to form rhodopsin all over again.

isomerization: is the process by which one molecule is transformed into another molecule which has exactly the same atoms, but the atoms have a different arrangement

Dark Adaptation time

- Bright light depletes rhodopsin this process is called **photobleaching**. **The time required to synthesize rhodopsin in the dark is called dark adaptation time.**
- It is increased in vitamin A deficiency.
- Sudden shift from bright light to darkness causes difficulty in seeing.
- Rhodopsin is synthesized in a few minutes and vision is improved in the dark.

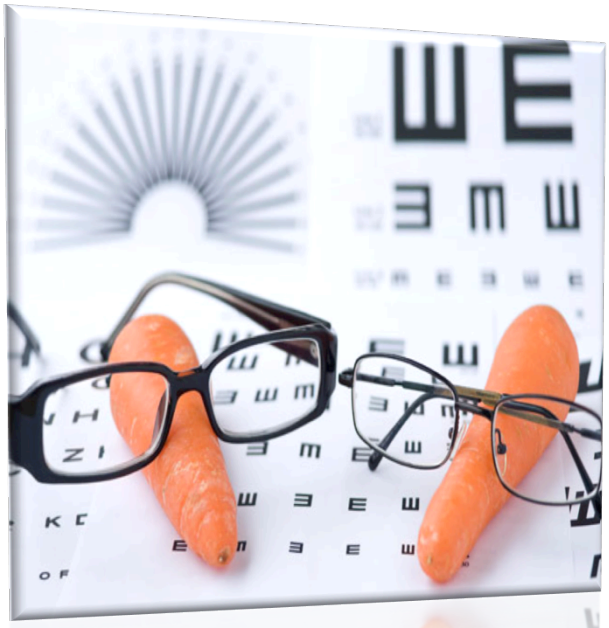
عشان كذا اذا سكرت النور فجأه ماتقدر تشوف شي لكن بعد فترة تبدا تشوف بشكل خفيف



Trans has to be converted to cis again by an enzyme found in the liver

ure 28.4. Role of vitamin A in vision.

Vitamin A Deficiency and Diseases



- **Nyctalopia (night blindness):** patient cannot see in low light or near darkness conditions.
- **Xerophthalmia:** dryness of the conjunctiva and cornea.
- **Keratomalacia:** prolonged xerophthalmia leads to drying and clouding of cornea.
- **Bitot's spots:** localized increased thickness of the conjunctiva.
- **Complete blindness (in severe deficiency)**

MCQs

1. **Which one is fat soluble vitamins :**
   - A. Vitamin C.
   - B. Vitamin D.
   - C. Vitamin B.
   - D. Non of them.

2. **Retinoci acid for :**
   - A. Skin & Bone groth.
   - B. Vision.
   - C. Both.
   - D. Non of them.

3. **Plant source vitamins is Carotenoids :**
   - A. True.
   - B. False.

4. **A patient appear with yellowing in the skin, which one of them could be true :**
   - A. Liver disease.
   - B. Deficiency in vitamins A.
   - C. Excessive carotenoids intake.
   - D. Large doses of vitamins.

5. **In which form dose the vitamin A store in the liver:**
   - A. Retinol .
   - B. Retinyl palmitate .
   - C. Retionic acid.
   - D. Retinyl phosphate.

6. **Vitamins A bind to protein called opsin in the retina, which will make ..... In cone cells**
   - A. Rhodopsin .
   - B. Iodopsin .
   - C. Retinol .
   - D. Non of them .

7. **Normal intake of vitamins A ?**
   - A. For a women 700 ug.
   - B. For a male 2,330 IU.
   - C. For a women 3,000 IU .
   - D. For male 900 ug .
   - E. Both A & D .

8. **Xerophthalmia means:**
   - A. Cannot see in the darkness .
   - B. Dryness of the conjunctiva & cornea.
   - C. Prolonged drying & clouding of cornea.
   - D. Blindness .

SAQs

1. **What are the animal sources for vitamins A ?**
   - Retinol, Retinal, Retinoic acid

2. **What is the step of the vision cycle when there is light stimulate?**
   - Change the bent Cis to straighter Trans > Detached the opsin > Trans retinal > trans retinol> 11 –cis retinol > 11-cis retinal > then over again.

3. **What is Dark Adaptation Time ?**
   - The time required to synthesize rhodopsin in the dark.

4. **Deficiency in vitamin A, cloud lead to ...**
   - Nyctalopia = night blindness.
   - Xerophthalmia = drymess of the conjunctiva & cornea .
   - Keratomalacia = Prolonged Xerophthalmia .
   - Bitot's spot = increase thickness of conjunctiva .
   - Blindness .

1-B
2-A
3-A
4-C
5-B
6-B
7-E
8-B

https://www.youtube.com/watch?v=NnmgM_Lz3o0

https://www.youtube.com/watch?v=ISZLTJH5lYg

https://www.kaahe.org/health/en/912-vitamin-a.html

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