

VITAMIN A & VISUAL CYCLE



Color Index:

- **Main Topic**
- **Main content**
- **Important**
- Extra info, Drs' notes
- **Only in girls' slides**
- **Only in boys' slides**



Objectives:

- ✓ Identify the types of vitamin A and their functions.
- ✓ Discuss the transport and metabolism of vitamin A.
- ✓ Comprehend the role of vitamin A in visual cycle
- ✓ Correlate the deficiency of vitamin A with vision impairment and blindness



Overview:

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

Vitamins

What are vitamins?

They are Non-caloric¹, Essential Organic compounds present in small quantities in different types of food and are required in very small amounts

functions

1. Help in various biochemical processes in cell
2. Most act as **coenzymes**
3. Important for growth and maintaining good health

classification

Based on solubility

1. Not a source of energy, thus it doesn't provide energy if consumed. sources of energy are carbohydrates, fats and proteins.

Vitamins Classification

Vitamins

Water soluble¹

- ascorbic acid (vitamin C)
- thiamin (vitamin B₁)
- riboflavin (vitamin B₂)
- niacin
- pyridoxine (vitamin B₆)
- biotin
- pantothenic acid
- folate
- cobalamin (vitamin B₁₂)

Fat soluble

A, D, E, and K

- 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 fats²
- Diseases due to deficiency are rare as large amounts are stored in the body

1. Rarely cause toxicity because its not stored in the body
2. fat soluble vitamins are absorbed by chylomicron so that they go from the intestine to blood.

Vitamin A

Vitamin A from animal sources (Preformed¹)

- Three preformed compounds called **retinoids** that are metabolically active and found in animal products
- **retinol** - alcohol form (can be converted to other forms³)
- **retinal** or retinaldehyde - aldehyde form (essential in vision)
- **retinoic acid** - acid form (for skin and bone growth)

Vitamin A from plant sources (Provitamin²)

- **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 retinal⁴ in the intestine

1.ready to be used (active)

2.not metabolically active form

3.retinol; dehydrogenase converted to retinal,retinal dehydrogenase convert to retinoic acid

*retinoic acid can not be converted to other forms

4.less efficient than the form that comes from animal source

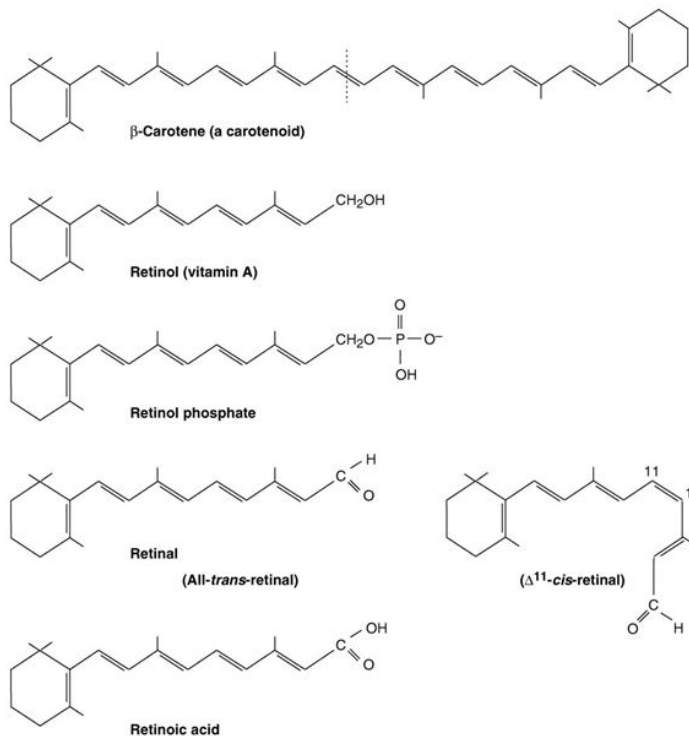


Figure 28.2. Structures of vitamin A and related compounds.

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From 437

1. Each β-carotene will split into 2 Retinol in the intestinal cells.
2. Retinol is the type that is stored in our body.
3. Retinal has two types, all-trans-retinal and 11-cis-retinal.
4. The difference between the two types is the configuration around the **11th double bond**.
5. 11-cis retinal has a cis configuration "bent" around its 11th carbon, whereas All-trans-retinal has a straight form.
6. The two forms can be converted into each other.
7. This interconversion is very important in the visual cycle.

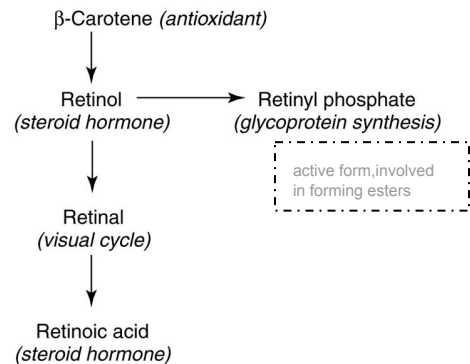
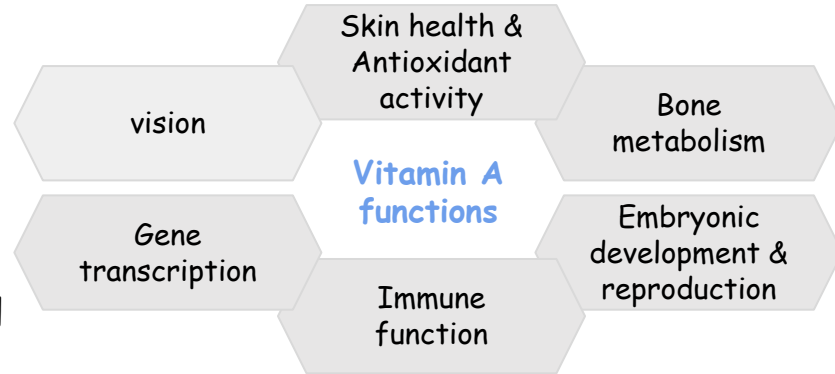


Figure 28.3. Vitamin A metabolism and function.

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Functions of Vitamin A

- **Vision:** Vitamin A is a component of the visual pigment¹ rhodopsin. Retinal is bound to the protein opsin.
- **Growth:** Vitamin A deficiency causes loss of appetite, slow bone growth, and affects the CNS.
- **Reproduction:** Retinol and retinal are essential for normal reproduction
- **Maintenance of epithelial cells**²: Essential for normal differentiation of epithelial tissues and mucus secretion.



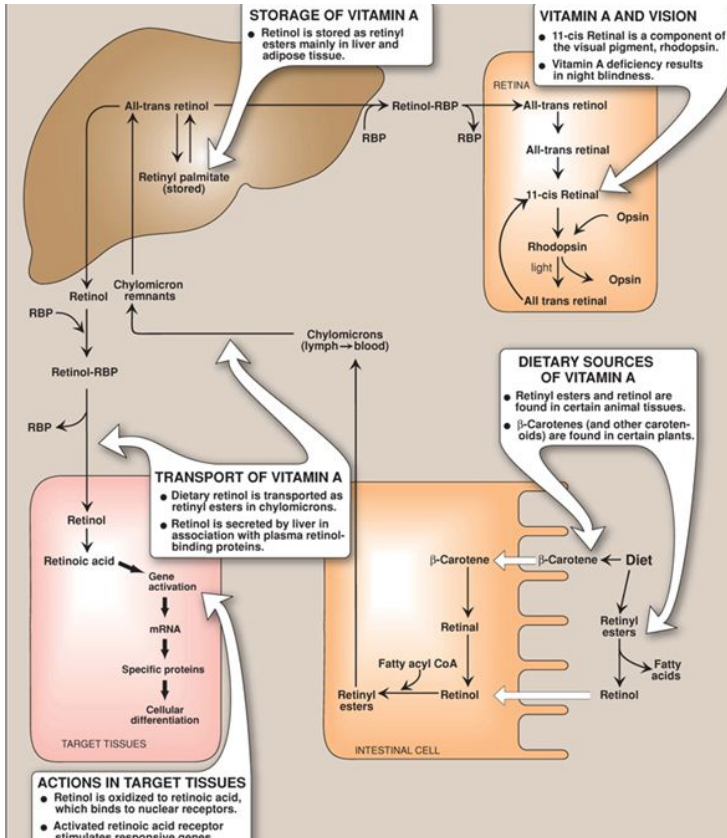
- Essential role in vision and normal cell differentiation
- Deficiency is the most significant cause of blindness in the developing world.
- Large doses over a prolonged period of time can produce intoxication³ and eventually lead to **liver disease**.
- Excessive **carotenoids** intake can result in **yellowing of the skin**, but appears to be harmless.

1.visual pigment AKA visual purple.

2.mainly by retinoic acid form

3.toxicity symptoms usually because of supplements, vit A rich diet doesn't cause toxicity.

Vitamin A metabolic pathway



1. Dietary source:

- Animal: retinyl ester¹ and retinol
- Plant: beta carotene - taken in by enterocyte and broken to retinal then retinol

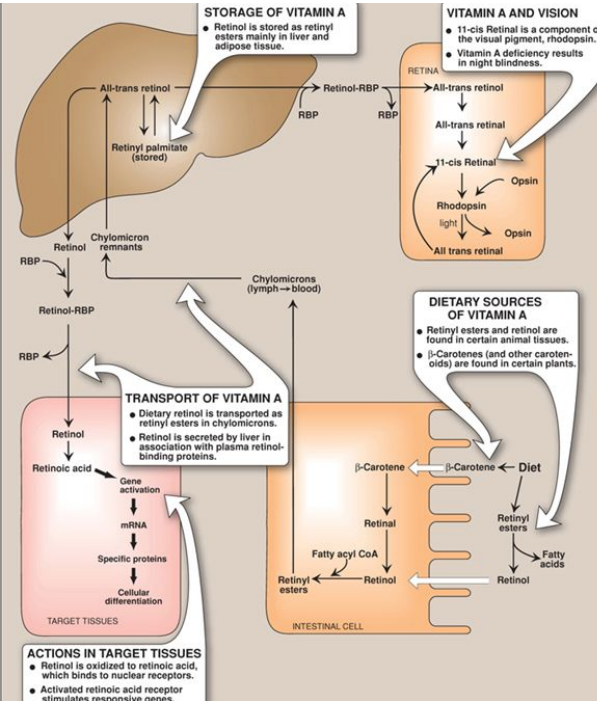
2. Storage:

- In the **cytoplasm**, We convert the retinyl ester coming from the diet into retinol by removing a fatty acid
- Retinol and b-carotene go into the intestinal epithelial cells, where the B-carotene is also converted to retinol.
- Then the retinol is re-esterified to long chain fatty acids to make retinyl esters by the enzyme fatty acyl coA, and secreted as a component of chylomicrons into the blood.
- once chylomicron reaches the liver it gets converted to all-trans retinol, & then converted into retinyl palmitate (retinol + palmitic acid) which is a **retinyl ester**, the form that is stored in liver.

- ## 3. Transport:
- when tissues need vit A its transported from liver to blood as retinol by RBP².
 - Before entering tissue RBP stay out and retinol goes in.

1. retinyl ester is vit A with fatty acid attached to it (usually the fatty acid is palmitic acid and that's why stored as retinyl palmitate)
 2. retinol binding protein

Vitamin A metabolic pathway



4. Vit A in tissues:

A. In retina:

-All trans retinol is converted to all trans retinal and then to 11-cis retinal, which binds to opsin and becomes rhodopsin "photosensitive pigment in the retina".

- When rhodopsin absorbs light, the 11-cis retinal is converted back to all trans retinal and dissociates from opsin. And that is how the visual cycle happens.

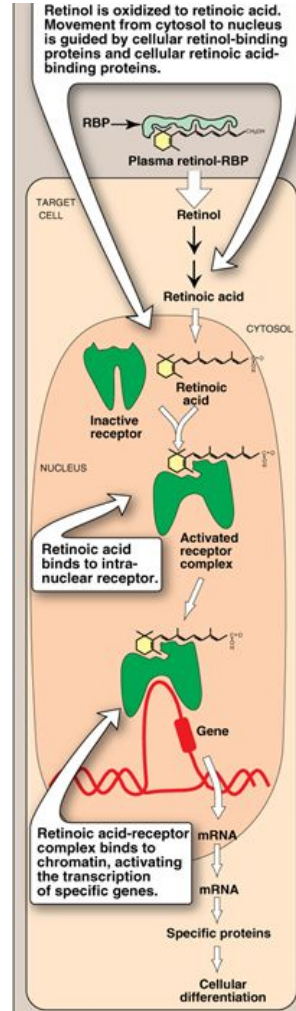
B. Other tissues:

retinol oxidized into retinoic acid(steroid hormone) which bind to nuclear receptors and cause gene activation lead to activation of mRNA and that lead to cellular differentiation.

- retinol oxidized to retinoic acid in the **cytosol**, then it enter the nucleus

-once inside nucleus it binds to inactive receptor and become activated

-The activated receptor complex(retinoic acid-receptor complex) then binds to chromatin to activate the transcription of specific genes, and that lead to upregulation of the synthesis of proteins causing cellular differentiation.



Remember:

Vit A transported by:

-Chylomicron: from intestine into blood.

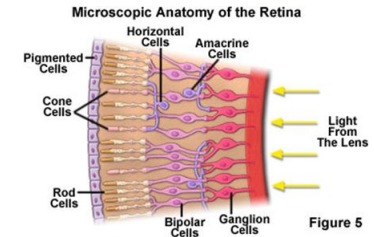
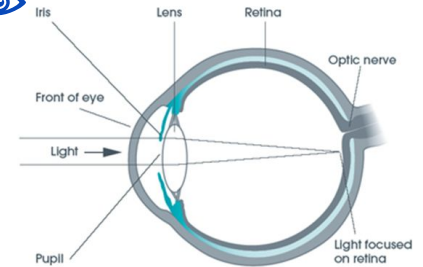
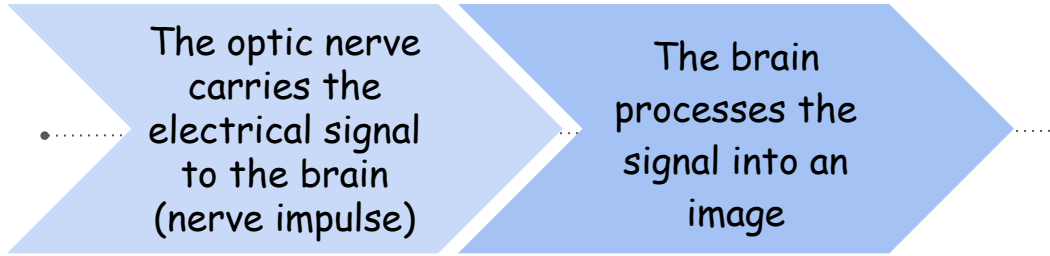
-RBP: from liver to the tissues.

Role of Vitamin A in Vision



Visual Cycle

- A process by which light impacting on the retina of the eye is converted to an electrical signal

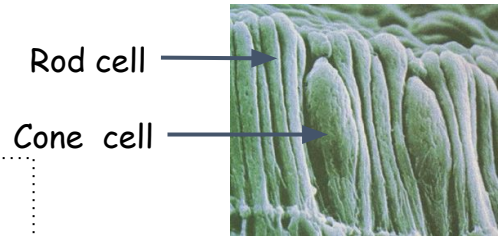


Retina is a light-sensitive layer of cells at the back of the eye where an image is formed.

Cone cells process color image (works in bright light)

Retina consists of:
Rod and cone cells (photosensitive cells)

Rod cells process black & white image (works in dim light)



Role of Vitamin A in Vision

Normal vision depends on :

- retina
- adequate vitamin A

First discovered by George Ward in 1967 (a Nobel Laureate)

In the retina, vitamin A in the form of retinal binds to a protein called **opsin** to make **rhodopsin** (in rod cells) and **iodopsin** (in cone cells)

Rhodopsin and iodopsin are light-sensitive pigments

1 When stimulated by light **vitamin A** isomerizes from its bent '**cis**' form to a straighter '**trans**' form and detaches from **opsin**

2 The **opsin** molecule changes shape, which sends a signal to the brain via optic nerve and an image is formed

3 Most retinal released in this process is quickly converted to trans-retinol and then to cis-retinal, to begin another cycle

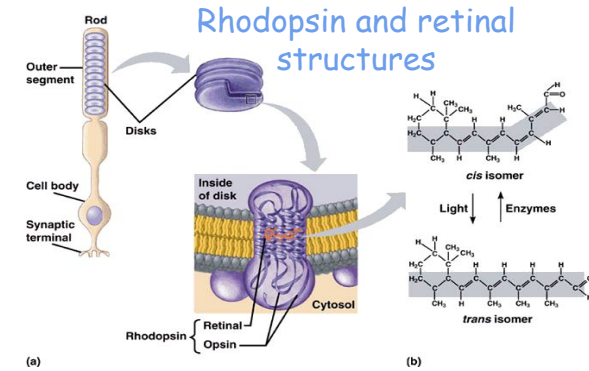


Figure 1

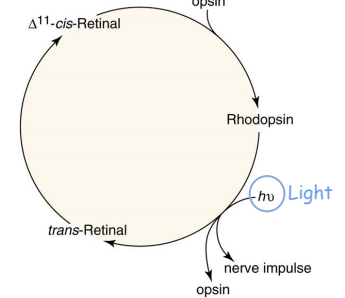
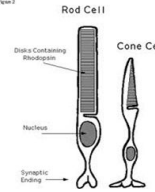
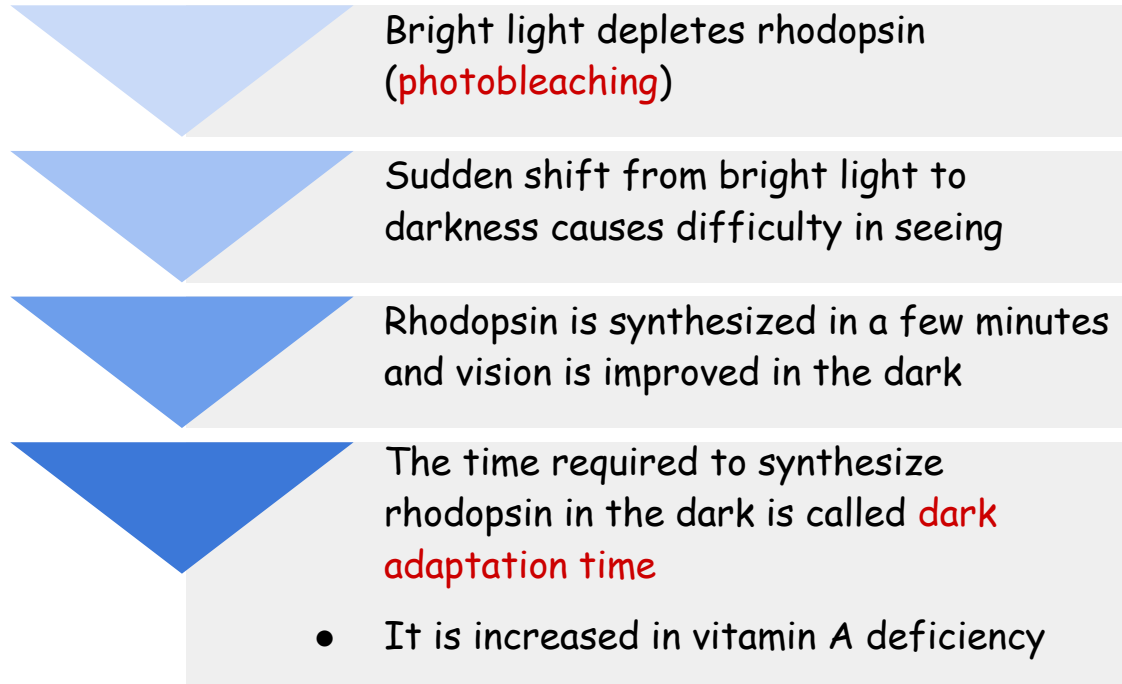


Figure 28.4. Role of vitamin A in vision.

Role of Vitamin A in Vision

Dark Adaptation time



Recommended Dietary Allowance (RDA) Vitamin A for Adults

Women:
700 μg or 2,330 IU

Men:
900 μg or 3,000 IU

UL¹ Men or women: 2
3,000 μg or 10,000 IU

1.UL: upper limit



Vitamin A Deficiency and Diseases

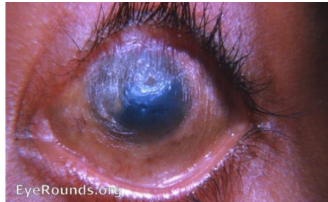
Nyctalopia (night blindness)

Patient cannot see in low light or near darkness conditions

One of the earlier signs of vitamin A deficiency

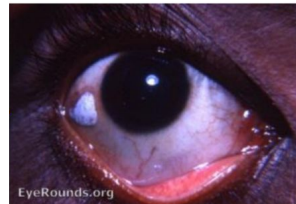
Xerophthalmia

Dryness of the conjunctiva and cornea



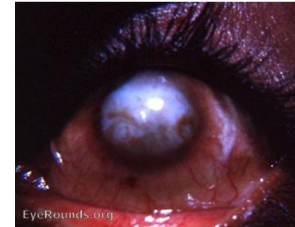
Bitot's spots

Localized increased thickness of the conjunctiva



Keratomalacia

Prolonged xerophthalmia leads to drying and clouding of cornea



Complete blindness

In severe deficiency

Take Home Messages



Vitamin A plays a major role in visual cycle and color vision.



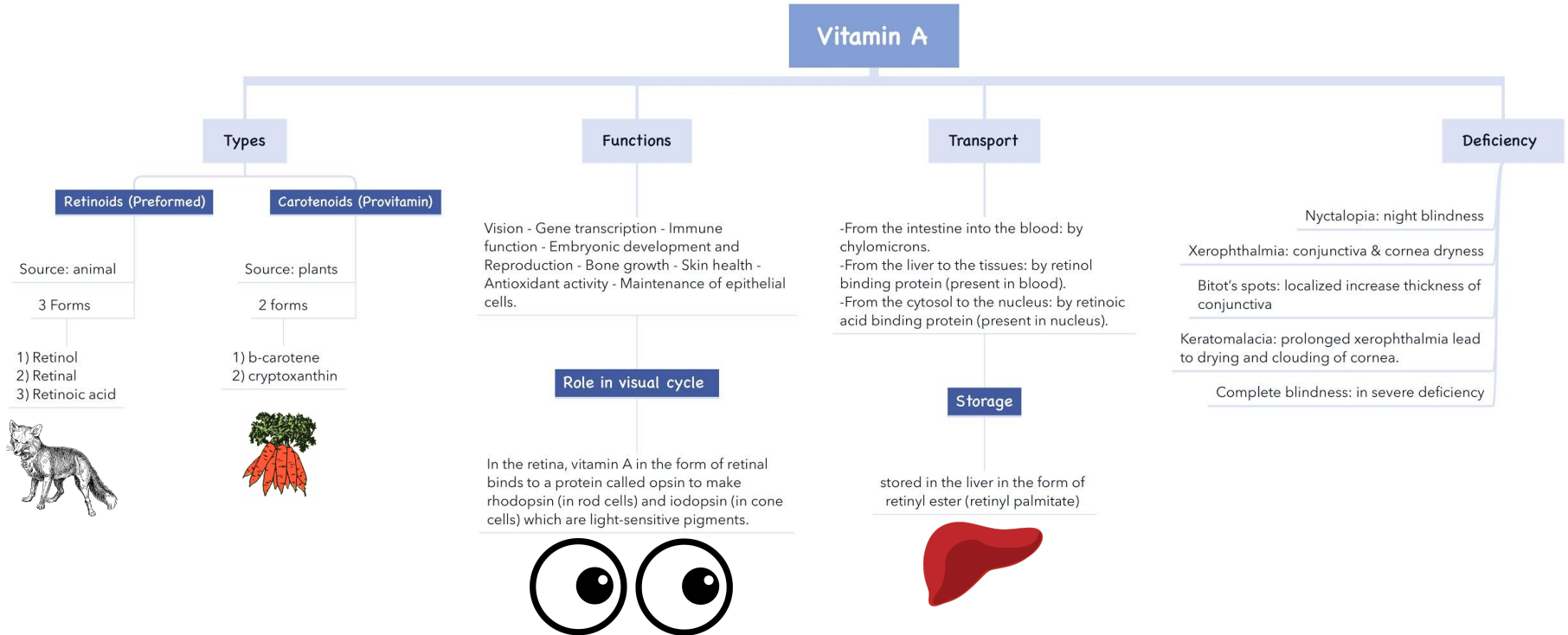
Its deficiency can lead to vision impairment and blindness.

JUST KEEP STUDYING...



STUDYING STUDYING...

Summary:



Quiz

MCQs :

Q1: Which one of the following is a fat soluble vitamin:

- a) ascorbic acid b) Retinoid c) riboflavin d) niacin

Q2: B-carotene can be cleaved into how many molecules and where:

- a) 2 retinol, in liver b) 3 retinal, intestine c) 2 retinal, intestine d) 3 retinol, liver

Q3: Which vitamin A deficiencies does the conjunctiva increase in thickness:

- a) xerophthalmia b) bitot's spots c) keratomalacia d) Nyctalopia

Q4: When stimulated by light vitamin A:

- a) isomerizes from its bent Cis form to straighter Trans form
b) isomerizes from its straight Cis form to bent Trans form
c) isomerizes from its bent trans form to straighter Cis form
d) isomerizes from its straight trans form to bent Cis form

Q5: Vitamin A is stored in the liver and adipose tissue in the form of:

- a) all trans retinol b) retinyl palmitate c) retinoic acid d) carotenoid

Q6: Vitamin A is transported from the intestine into the blood by:

- a) retinol binding protein b) chylomicrons
c) retinoic acid binding protein d) doesn't require a carrier

SAQs :

Q1: list 3 Functions of Vitamin A

Q2: list 3 vitamin A deficiencies and diseases.

Q3: what is the dark adaptation time & what can increase it?

Q4: what happens to the rhodopsin when it's stimulated by light?

★ MCQs Answer key:

1) B 2) C 3) B 4) A 5) B 6) B

★ SAQs Answer key:

1) vision - gene transcription- reproduction- bone metabolism

2) nyctalopia - keratomalacia - xerophthalmia

3) it's the time required to synthesize rhodopsin in the dark to improve the vision, vitamin A deficiency will increase the dark adaptation time.

4) bent 'cis-retinal' form will be converted to a straighter 'trans-retinal' form and detaches from opsin, opsin will change shape, which sends a signal via optic nerve to the brain to form an image.

Team members

Girls Team:

- ★ Ajeed Al-Rashoud
- Alwateen Albalawi
- Amira AlDakhilallah
- Arwa Al Emam
- Deema Almaziad
- Ghaliah Alnufaei
- Haifa Alwaily
- Leena Alnassar
- Lama Aldakhil
- Lamiss Alzahrani
- Nouf Alhumaidhi
- Noura Alturki
- ★ Sarah Alkhalife
- ★ Shahd Alsalamah
- Taif Alotaibi

Boys Team:

- Abdularahman Bedaiwi
- Alkassem Binobaid
- Naif Alsolais
- Omar Alyabis
- Rayyan Almousa
- Sultan Alhammad
- Tariq Alanezi

Team Leaders

Lina Alosaimi

Mohannad Alqarni

★ The future belongs to those who believe in the beauty of their dreams. ☀



We hear you

Reference:

- Doctor's slides
- 437