

Vitamin A & Visual Cycle

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Objectives

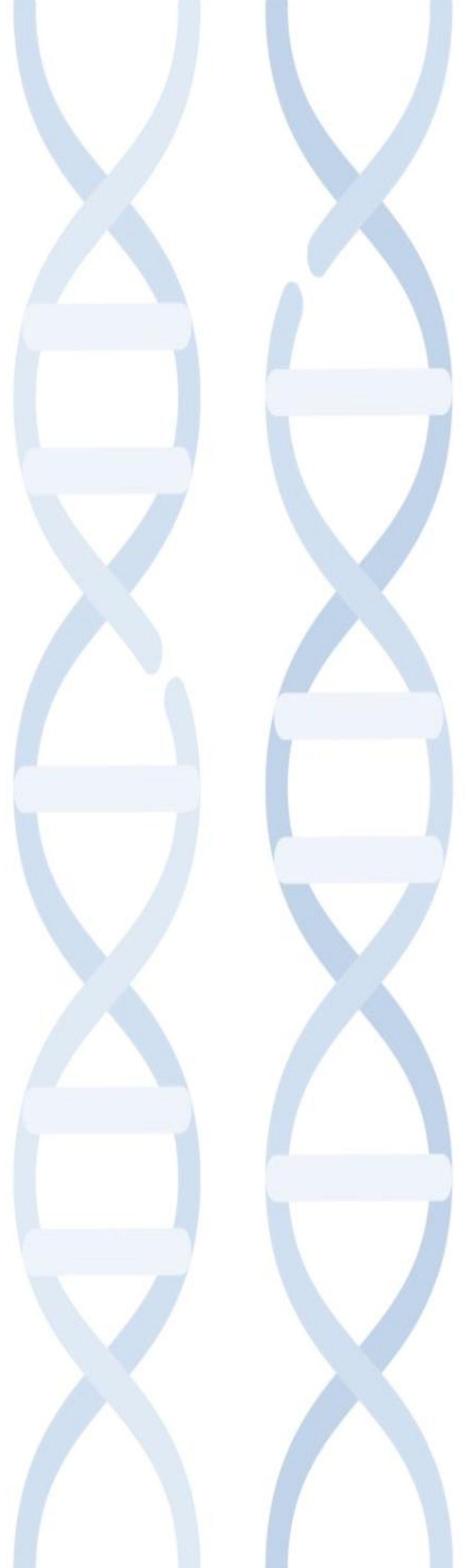


Click on the objective to go to the related slide

-  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

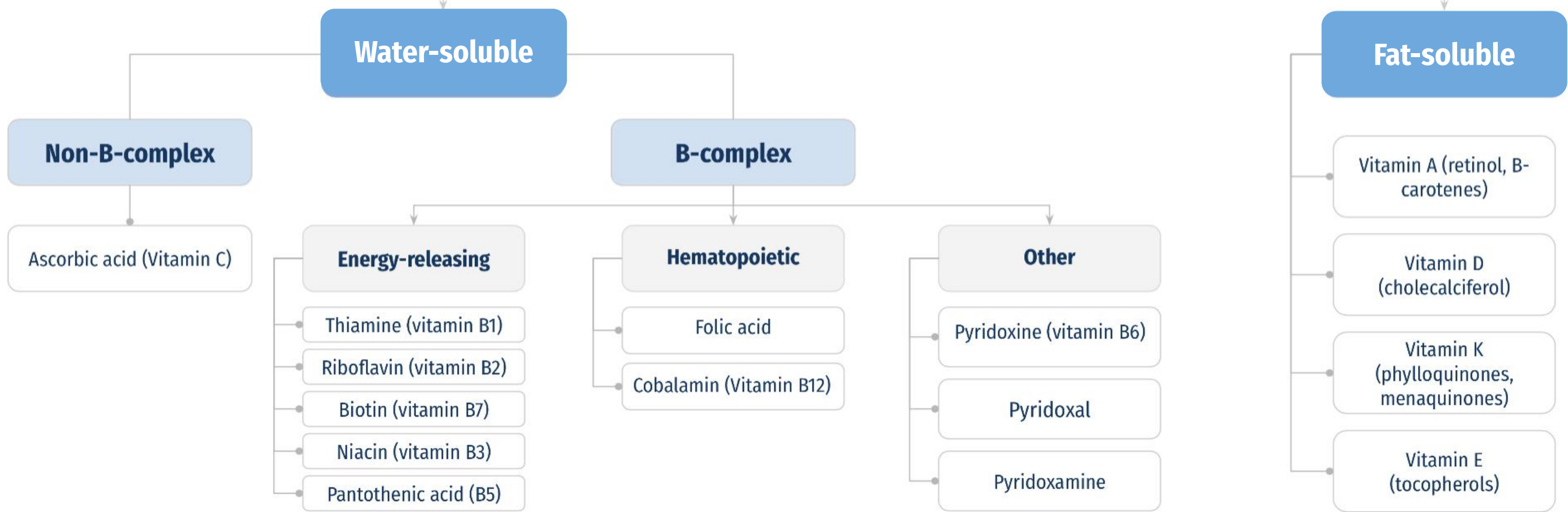


Level 4 (with each lecture you will level up and it will get harder to find the scientist)
Hello my name is Gowland Hopkins, Find me in this lecture!
Then click me for more info about what I discovered.



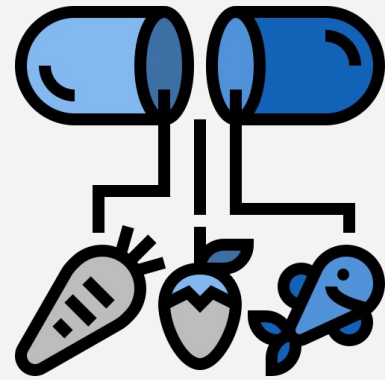
Classification of Vitamins

Click on the diagram for more info



Vitamins

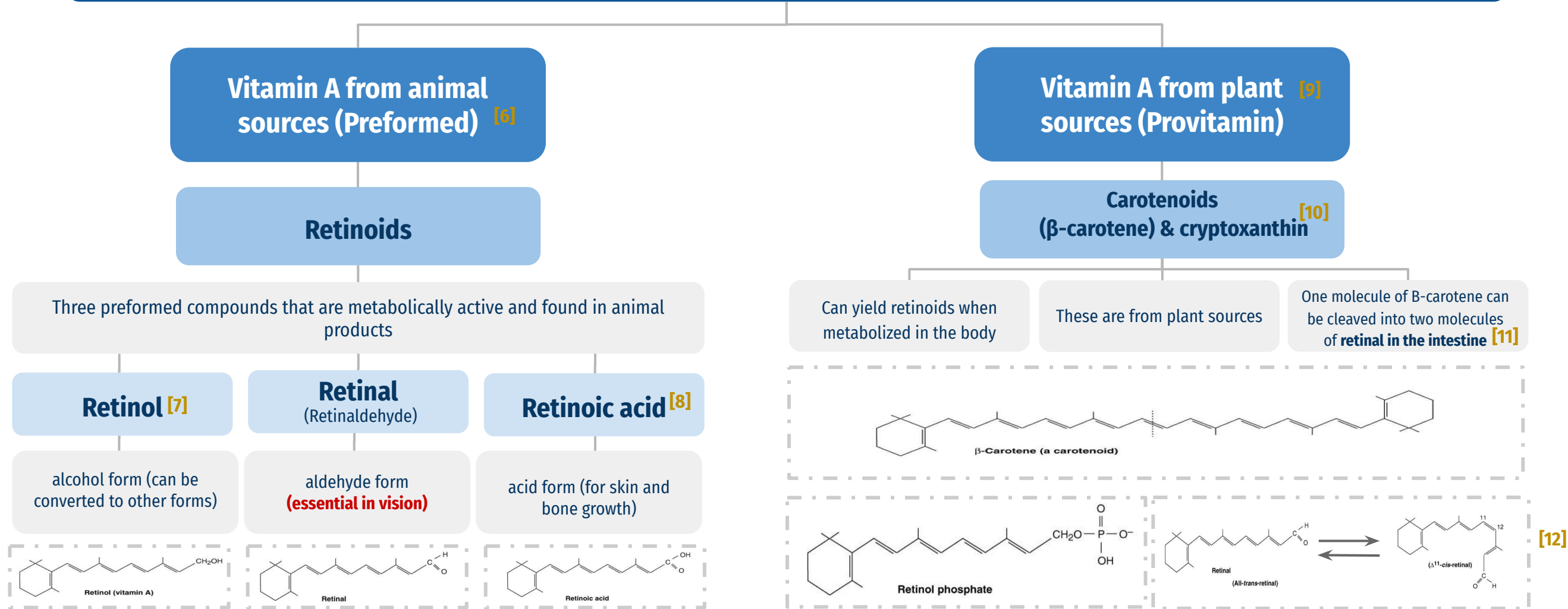
- ▶ Organic compounds present in small quantities in different types of food
- ▶ Help in various biochemical processes in cell
- ▶ Most act as coenzymes
- ▶ Important for growth and maintaining good health
- ▶ Essential [1]
- ▶ Non-caloric [2]
- ▶ Required in very small amounts [3]



Fat soluble vitamins (AKED)

- Stored in the liver and adipose tissue [4]
- Excess may accumulate and cause toxicity and 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 [5]
- Diseases due to deficiency are rare as large amounts are stored in the body

Vitamin A sources



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 [13]
- ▶ Excessive carotenoids intake can result in yellowing of the skin, but appears to be harmless [14]

Functions of vitamin A

Vision [15]
 Vitamin A is a component of the visual pigment rhodopsin. **Retinal** is bound to the protein opsin

Growth and Bone metabolism
 Vitamin A deficiency causes: -Loss of appetite
 -Slow bone growth -Affects CNS

Embryonic development and reproduction
Retinol and **retinal** are essential for normal reproduction

Maintenance of epithelial cells
 Essential for normal differentiation of epithelial tissues and mucus secretion

Gene transcription

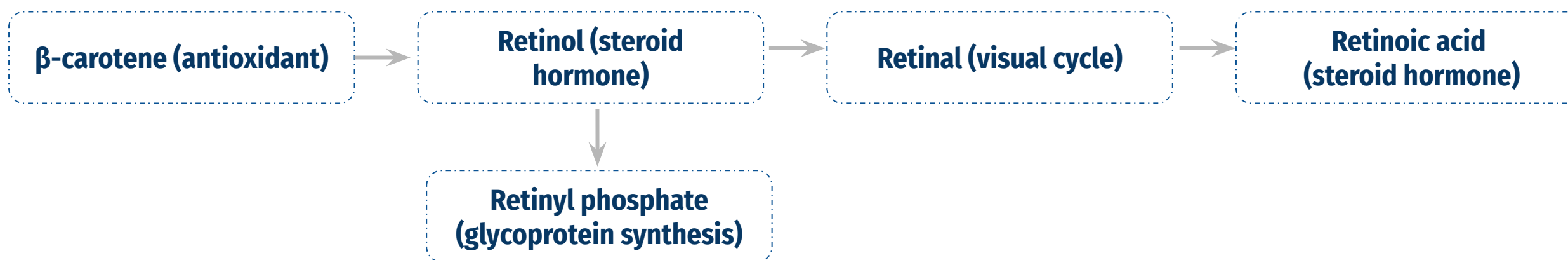
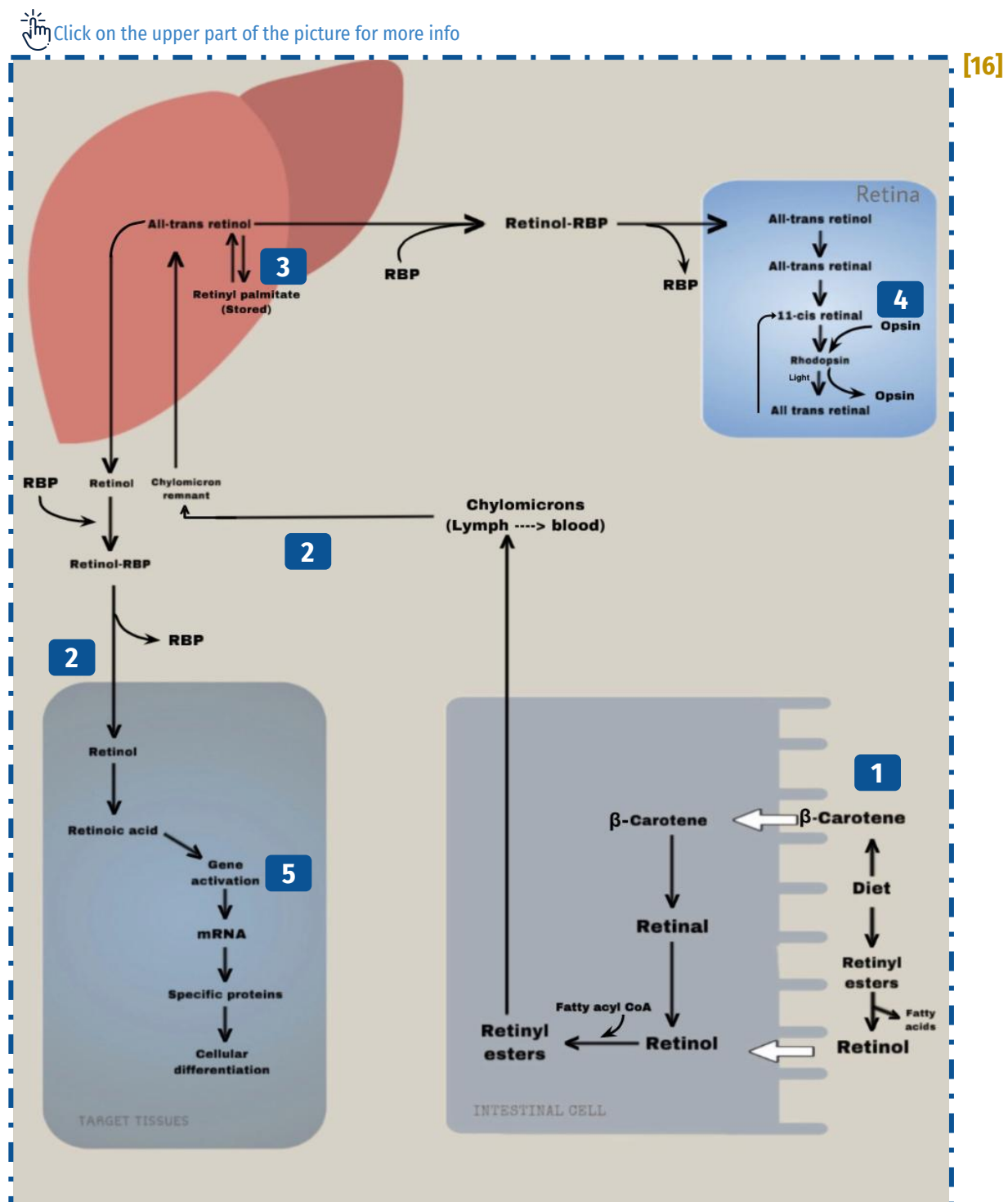
Immune function

Skin health

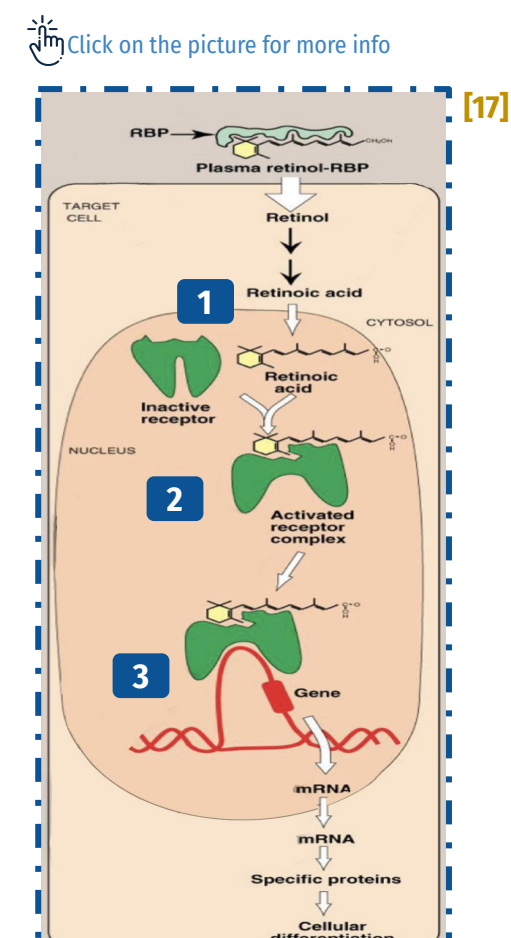
Antioxidant activity

Vitamin A metabolic pathway

1	<p>DIETARY SOURCES OF VITAMIN A</p> <p>Retinyl esters and retinol are found in certain animal tissues. 3-Carotenes (and other carotenoids) are found in certain plants.</p>
2	<p>TRANSPORT OF VITAMIN A</p> <p>Dietary retinol is transported as retinyl esters in chylomicrons. Retinol is secreted by liver in association with plasma retinol-binding proteins.</p>
3	<p>STORAGE OF VITAMIN A</p> <p>Retinol is stored as retinyl esters mainly in liver and adipose tissue.</p>
4	<p>VITAMIN A AND VISION</p> <p>11-cis Retinal is a component of the visual pigment, rhodopsin. Vitamin A deficiency results in night blindness.</p>
5	<p>ACTIONS IN TARGET TISSUES</p> <p>Retinol is oxidized to retinoic acid, which binds to nuclear receptors. Activated retinoic acid receptor stimulates responsive genes.</p>



1	Retinol is oxidized to retinoic acid. Movement from cytosol to nucleus is guided by cellular retinol-binding proteins and cellular retinoic acid-binding proteins.
2	Retinoic acid binds to intranuclear receptor.
3	Retinoic acid-receptor complex binds to chromatin, activating the transcription of specific genes.

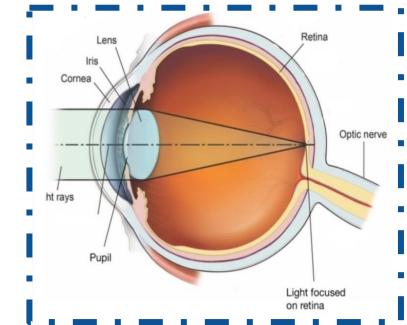




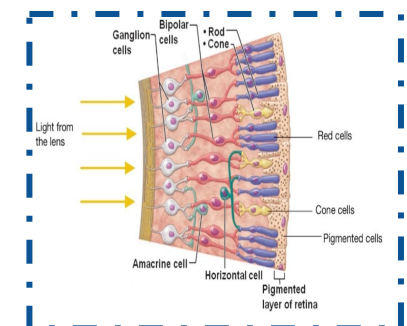
Role of Vitamin A in Vision

Visual cycle

- A process by which light impacting on the retina of the eye is converted to an electrical signal
- The optic nerve carries the electrical signal to the brain (nerve impulse)
- The brain processes the signal into an image



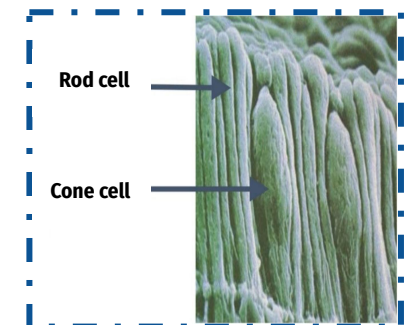
- Retina is a light-sensitive layer of cells at the back of the eye where an image is formed
- Retina consists of: **Rod** and **cone** cells (**photosensitive cells**)
- **Rod** cells process **black & white image**
- **Cone** cells process **color image**



Normal vision depends on:[18]

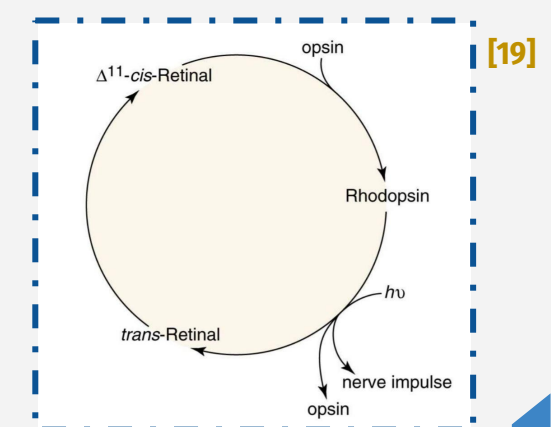
- **Retina**
- **Adequate vitamin A**

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



Role of Vitamin A in Vision

- ▶ When stimulated by light vitamin A isomerizes from its bent **cis** form to a straighter **trans** form and detaches from opsin
- ▶ The opsin molecule changes shape, which sends a signal to the brain via optic nerve and an image is formed
- ▶ Most retinal released in this process is quickly converted to **trans-retinol** and then to **cis-retinal**, to begin another cycle

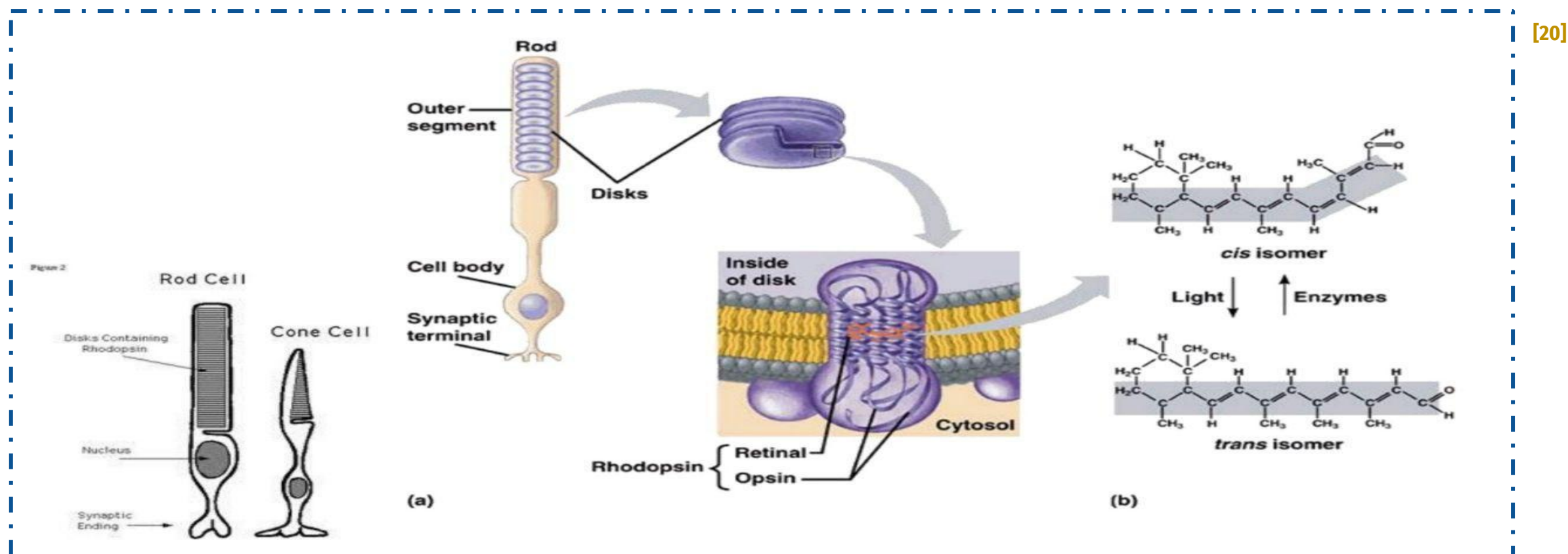


Dark adaptation time

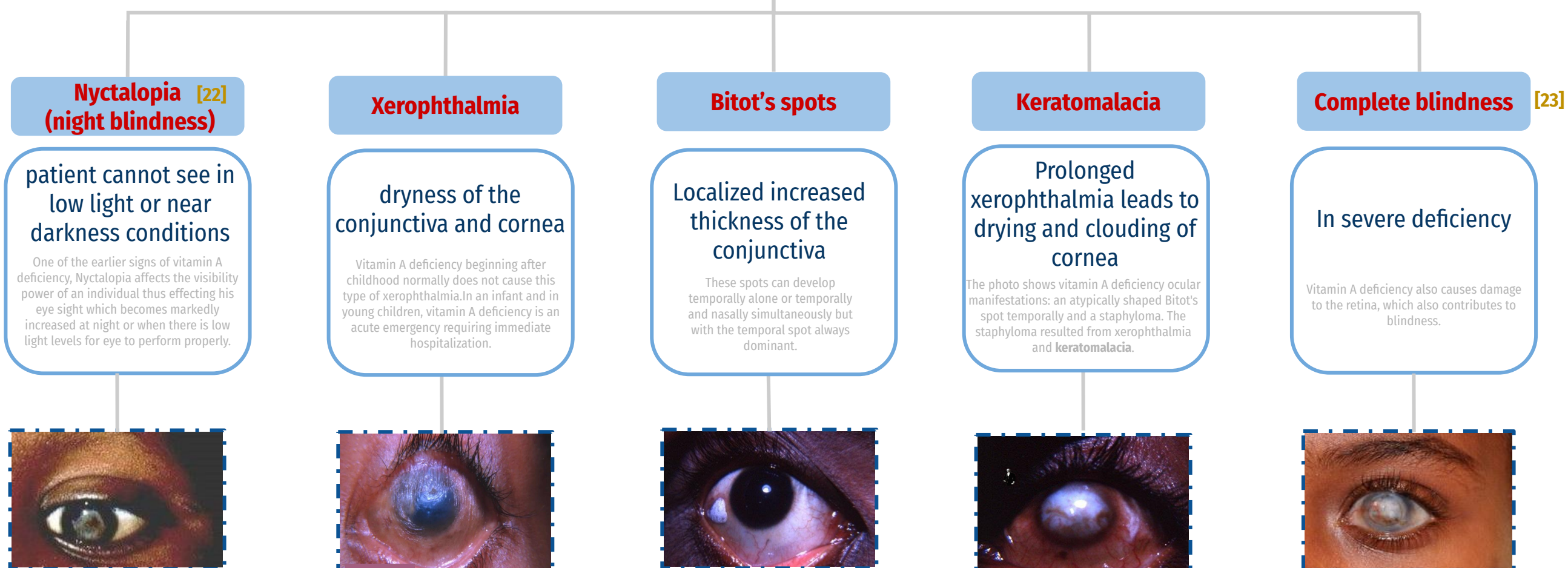
- ▶ Bright light depletes rhodopsin (**photobleaching**)
- ▶ Sudden shift from bright light to darkness causes difficulty in seeing
- ▶ Rhodopsin is synthesized in a few minutes and vision is improved in the dark
- ▶ The time required to synthesize rhodopsin in the dark is called **dark adaptation time**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



Rhodopsin and retinal structures



Vitamin A Deficiency and Disease [21]



Recommended Dietary Allowance (RDA) Vitamin A for Adults

Numbers are not important


- ▶ Women: 700 μ g or 2,330 IU
- ▶ Men: 900 μ g or 3,000 IU
- ▶ UL Men or Women: 3,000 μ g or 10,000 IU

- [1] essential means when there is no enough supply of vitamins, a deficiencies can be developed. They are required for energy production
- [2] Non caloric means they don't give energy themselves, rather they participate in metabolic reactions that yield energy.
- [3] Vitamins are required in micrograms and milligrams units.
- [4] Fat soluble vitamins are absorbed with dietary fat.
- [5] Mainly they get absorbed by triglycerides which is transported by chylomicrons in the blood.
- [6] Animal source of vitamin A is liver and fat tissue of the animal, it's preformed meaning vitamin A is in an active form.
- [7] Retinol can be converted into retinal or retinoic acid, retinal can be converted to retinol or retinoic acid. but retinoic acid one it's formed, it can Not be converted to any other forms.
- [8] Can't be converted to another form but ones is formed from retinol it stays as retinoic acid.
- [9] Plant sources of vitamin A are yellow-orange fruits and vegetables like carrots, and it's a provitamin (inactive) meaning it has to be metabolized or modified to active form of vitamin A.
- [10] Carotenoids actually include alpha, beta, gamma carotenes. But the most useful form is beta carotene.
- [11] In Intestinal Lumen, there are enzymes that breakdown beta carotene into 2 retinal molecules, but these 2 retinal molecules are much less effective than those are coming from animal sources.
- [12] Retinal has two forms: straight form called (all-trans retinal) & Bent form called (cis-retinal). C11-cis-retinal means cis configuration around double bond of carbon number 11.
- [13] Acute dose of vitamin A from animal source "preformed" can lead to GI defect, headache, blurred vision. When this acute dose get removed from the body, these symptoms will relieve. But if the dose is large for prolong time "chronic" it will lead to permanent damage like hair loss, muscle and bone pain, skin dryness and hepatomegaly "increased liver size".
- [14] Large dose of vitamin A from planet source "provitamin" is not harmful and it may cause yellowing of the skin.
- [15] Rhodopsin is a holoprotein made up of two parts: protein part "opsin" & non protein part "vitamin A"
- [16] steps:
- 1-Vitamin A is absorbed from the diet (B-carotene from plants or retinyl esters from animals)
 - 2-removal of fatty acids from retinyl esters will convert it to retinol
 - 3-this retinol molecule with the B-carotene from the plant source are absorbed through intestinal cells
 - 4-B-carotene is broken down to retinal and then retinal is converted to retinol
 - 5-retinol is esterified again to retinyl esters which will be carried out by chylomicrons
 - 6-to liver where we remove the fatty acid and add palmitate to retinol which will form retinyl palmitate
 - 7-**retinyl palmitate is the stored form of vitamin A in the liver (imp note)**
 - 8-**if retinol is needed anywhere in the body, first we remove palmitate from retinyl palmitate to form retinol then retinol is carried with retinol binding protein (imp note)**
- [17] When the retinol is needed by a target tissue > get carried by RBP to the target tissue which passes through the membrane into the cytoplasm of the cell then to nucleus > binds to activated receptor complex to activate gene transcription > play a role with RNA for cellular differentiation
- [18] (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
- [19] After detachment of opsin, remained retinal will recycled as follow: retinal—> trans retinol—> cis-retinol—> cis-retina. then a new cycle is begin.
- [20] "Cis isomer of rhodopsin" once it receives light, it will be converted into "trans isomer"
- [21] Deficiency of vitamin A alters the cell differentiation. keratinocytes would also be affected and formed in an abnormal forms "become larger in size" and they deposit in Tears"lacrimal" gland causing blockage in secretion of tears—>"xerophthalmia", or they may deposit in conjunctiva causing—> Bitot's spots.
- [22] In nyctalopia the effect is more prominent shortly before sunrise and shortly after sunset.
- [23] Complete blindness caused by deficiency in vitamin A can be reversed by high doses of vitamin A, assuming there is no damage in the eye itself

Take Home Messages

- 🧠 Vitamin A plays a major role in **visual cycle** and **color vision**.
- 🧠 Its deficiency can lead to **vision impairment and blindness**.

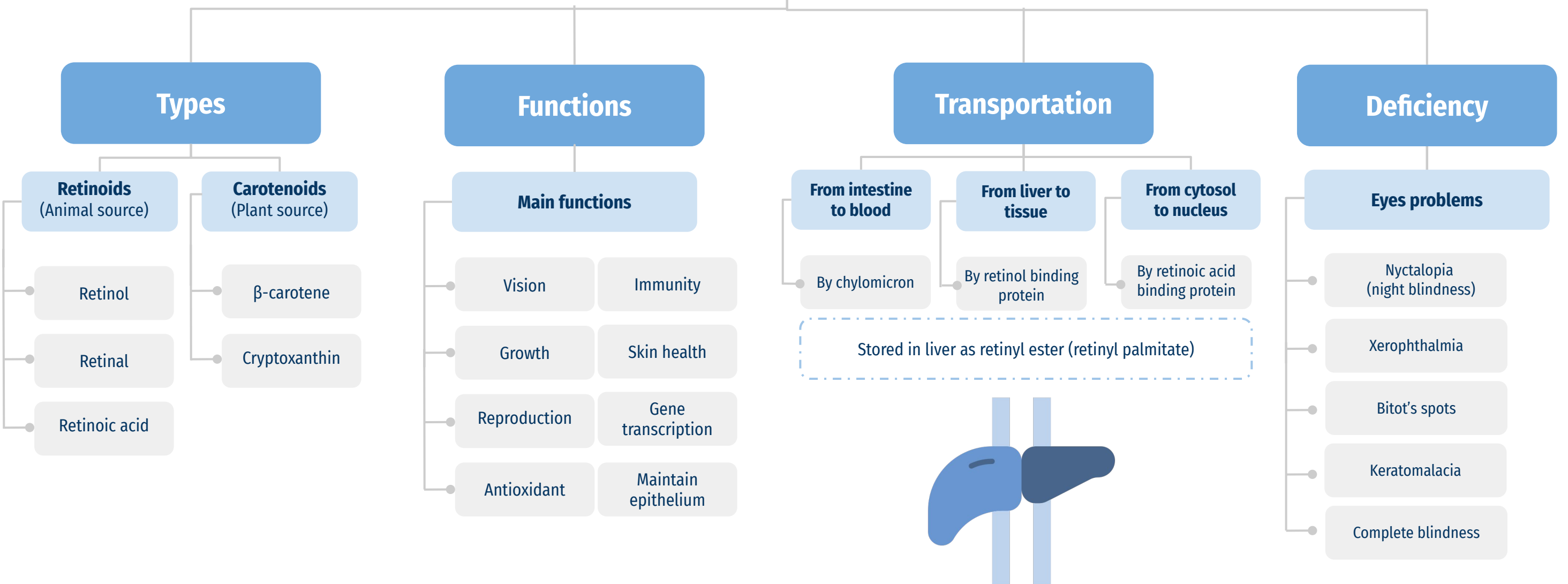


 [Click on the picture to read more about vitamin A](#)



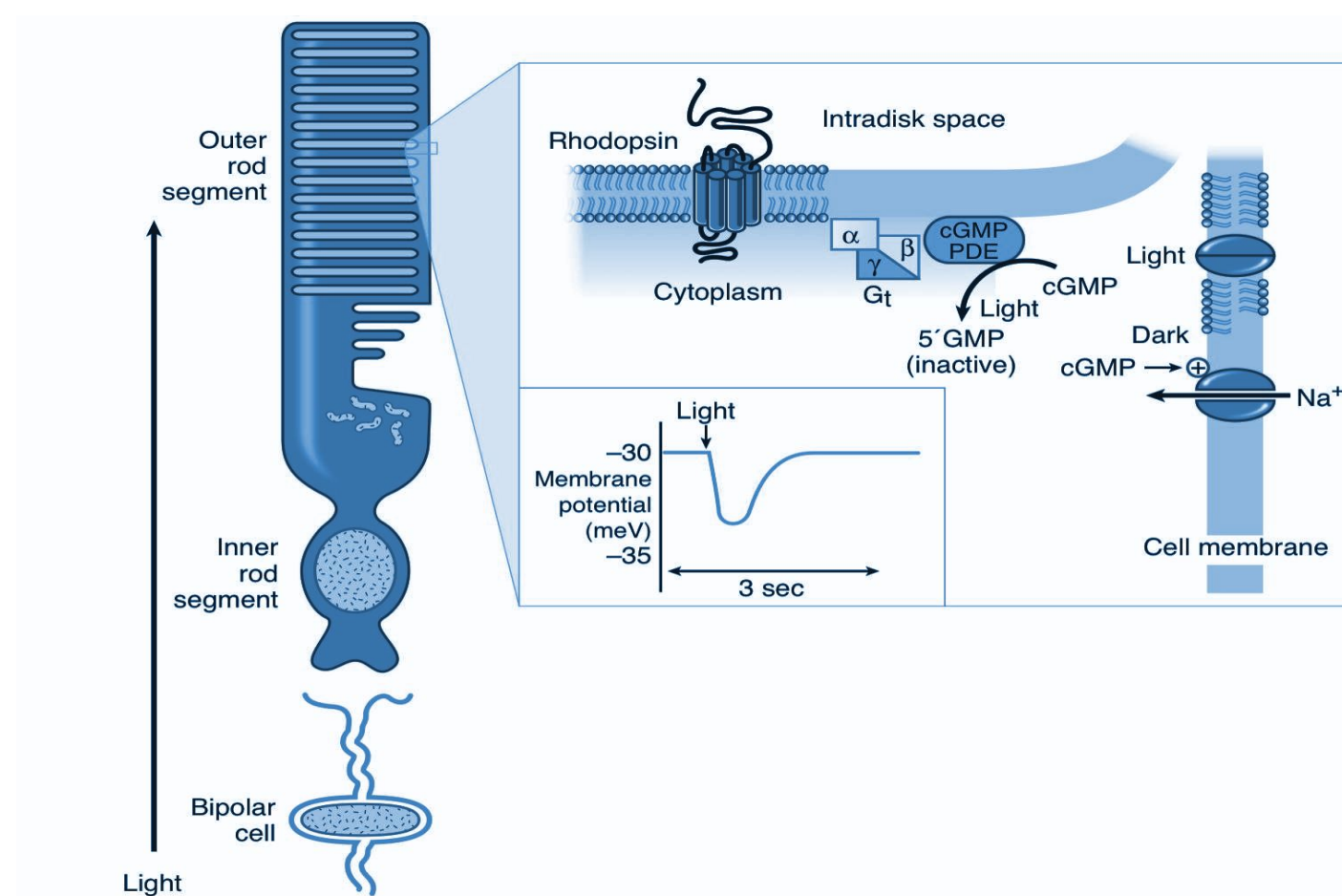
Summary

Vitamin A



Role in visual cycle

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) which are light-sensitive pigments.



 **MCQs**

1-Which vitamin is required for vision in dim light?

- A- Vitamin D
- B- Vitamin B
- C- Vitamin A
- D- Vitamin E

2-Excessive carotenoids intake lead to skin discoloration in what color?

- A- Blue
- B- Orange
- C- Brown
- D- Yellow

3-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

4-In the retina opsin bind with to form rhodopsin.

- A- 11 cis retinol.
- B- 11 cis retinal.
- C- All trans retinal.
- D- All trans retinol.

5-Which of the is the plant source of vitamin A ?

- A-Pyridoxine
- B-Retinoids
- C- β -carotene
- D-Biotin

6-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

Answers key

1- C 2- D 3- B 4- B 5- C 6- B

SAQs

1- What diseases are caused by Vitamin A deficiency?

- nyctalopia
- xerophthalmia
- bitot's spots
- keratomalacia
- complete blindness.

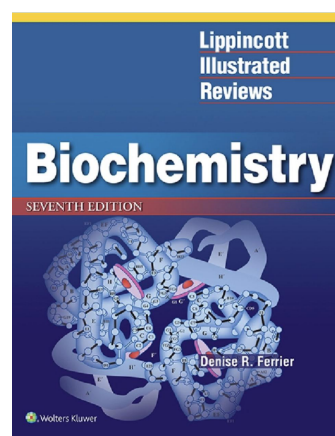
2- what is the dark adaptation time & what can increase it?

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

3- list 3 Functions of Vitamin A:

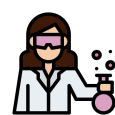
- vision
- gene transcription
- reproduction
- bone metabolism

Resources [Click on the book to download the resource](#)





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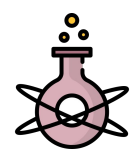
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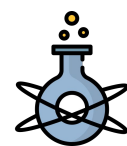
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