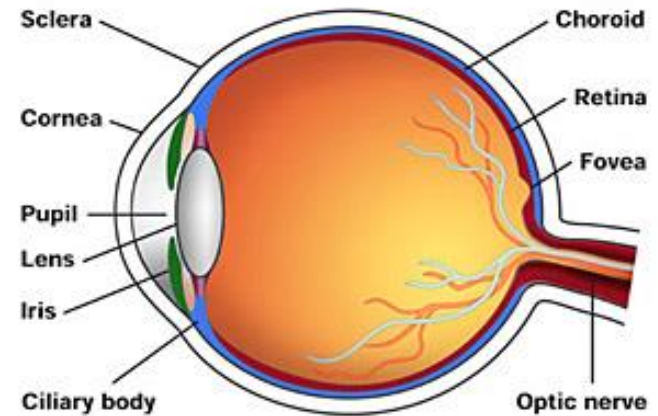


Vitamin A & Visual Cycle



Neuropsychiatry Block
Dr. Usman Ghani
Biochemistry

1 Lecture

Objectives

By the end of this lecture the Second Year students will be able to:

- 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

- 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
 - Non-caloric
 - Required in very small amounts
-

Vitamins - Classified Based on Solubility

■ **Fat-Soluble Vitamins**

- **A**, D, E, and K

■ **Water-Soluble Vitamins**

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

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)
 - **retinal** or retinaldehyde – aldehyde form
(essential in vision)
 - **retinoic acid** – acid form
(for skin and bone growth)

Vitamin A from plant sources (Provitamin)

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

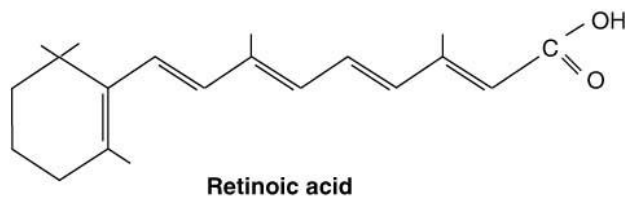
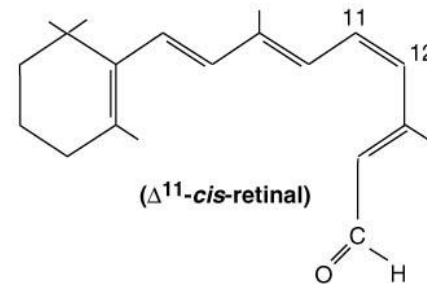
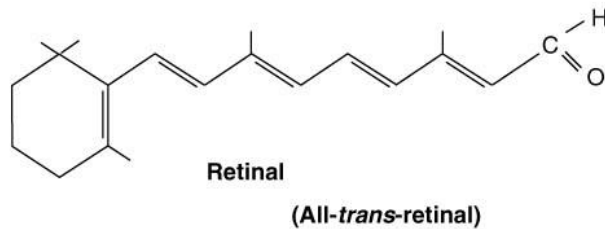
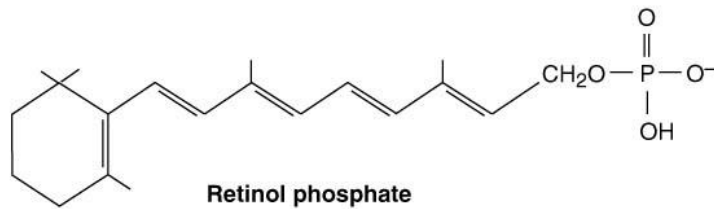
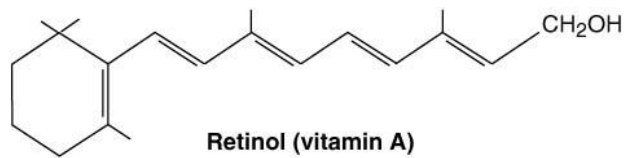
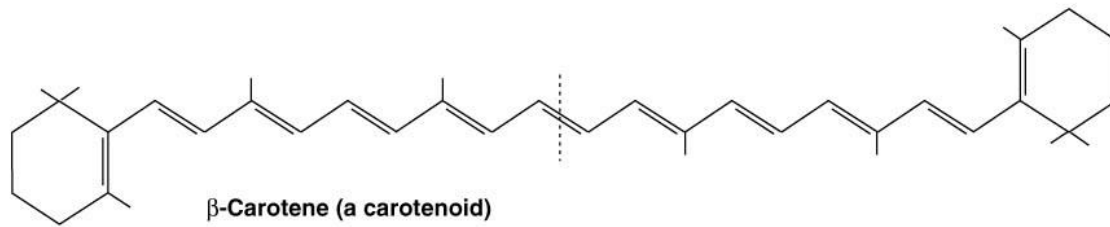
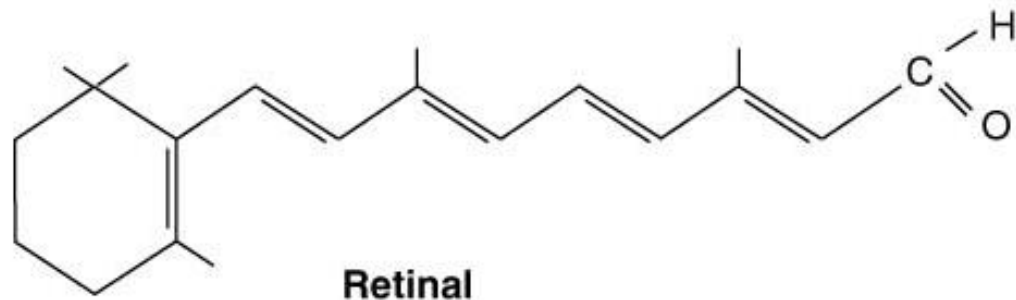
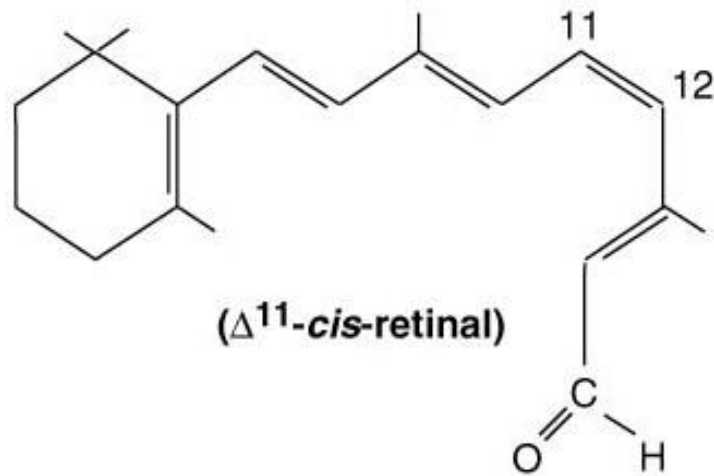
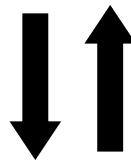


Figure 28.2. Structures of vitamin A and related compounds.



Retinal

(All-*trans*-retinal)



(Δ^{11} -*cis*-retinal)

Functions of Vitamin A

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

Functions of Vitamin A

- 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
-

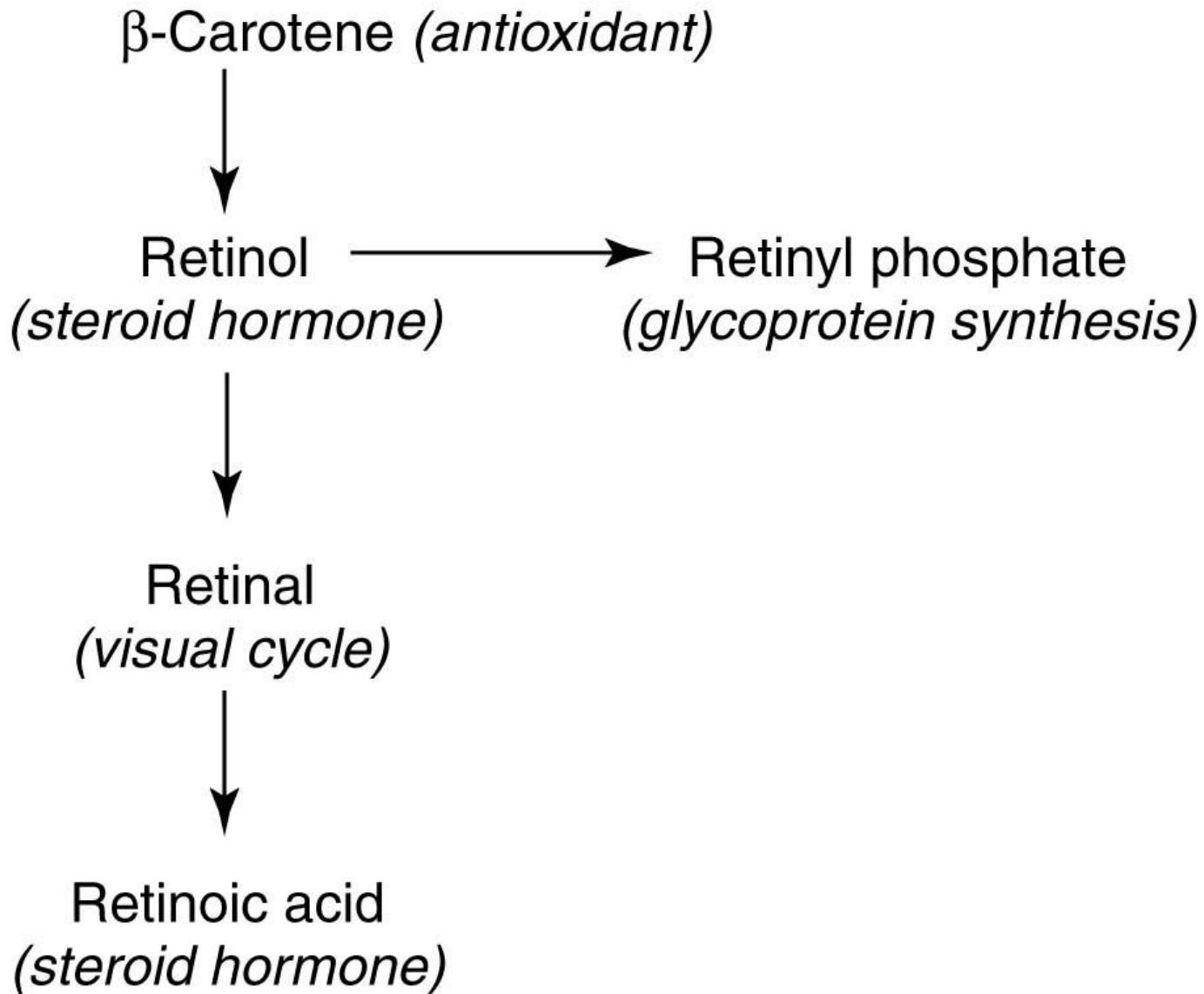
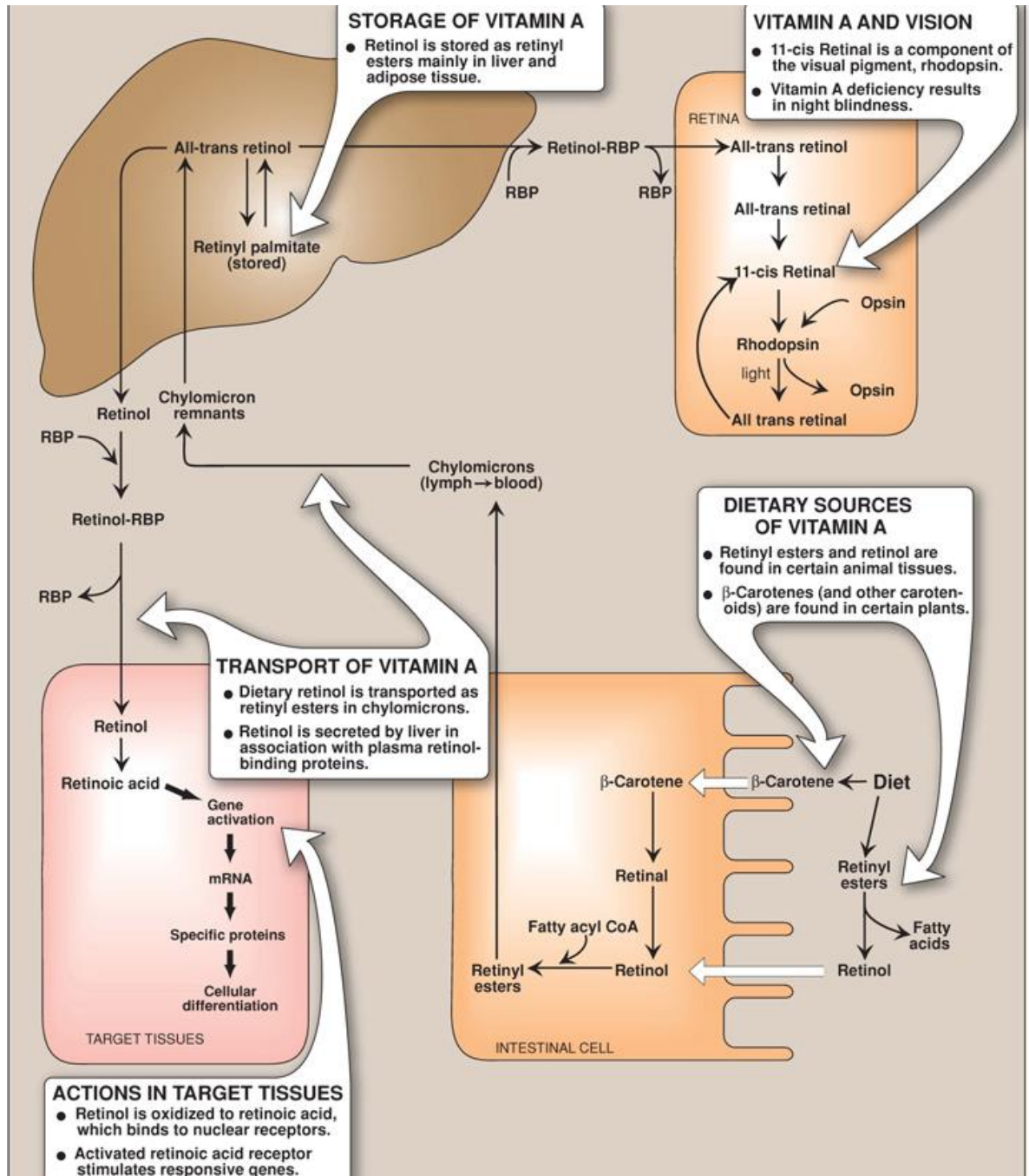
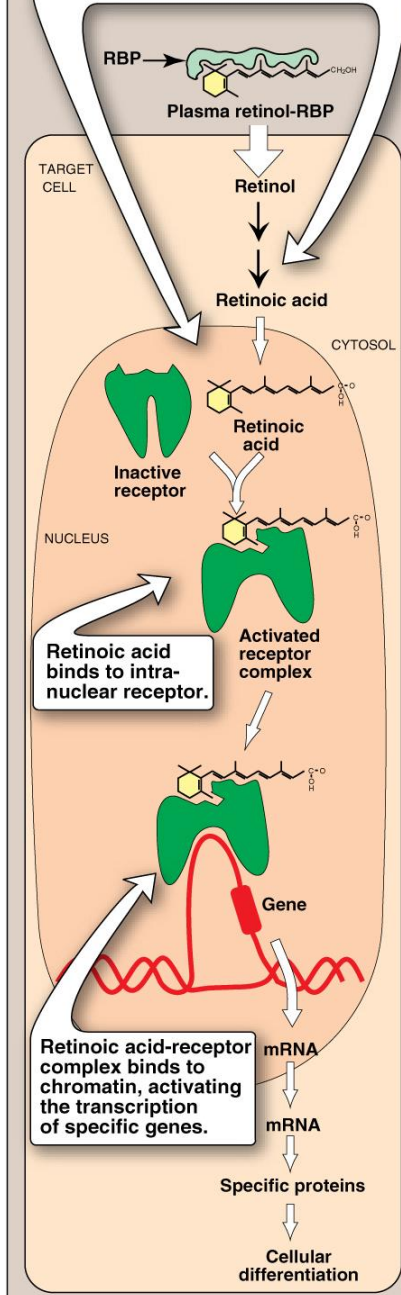


Figure 28.3. Vitamin A metabolism and function.



Retinol is oxidized to retinoic acid. Movement from cytosol to nucleus is guided by cellular retinol-binding proteins and cellular retinoic acid-binding proteins.



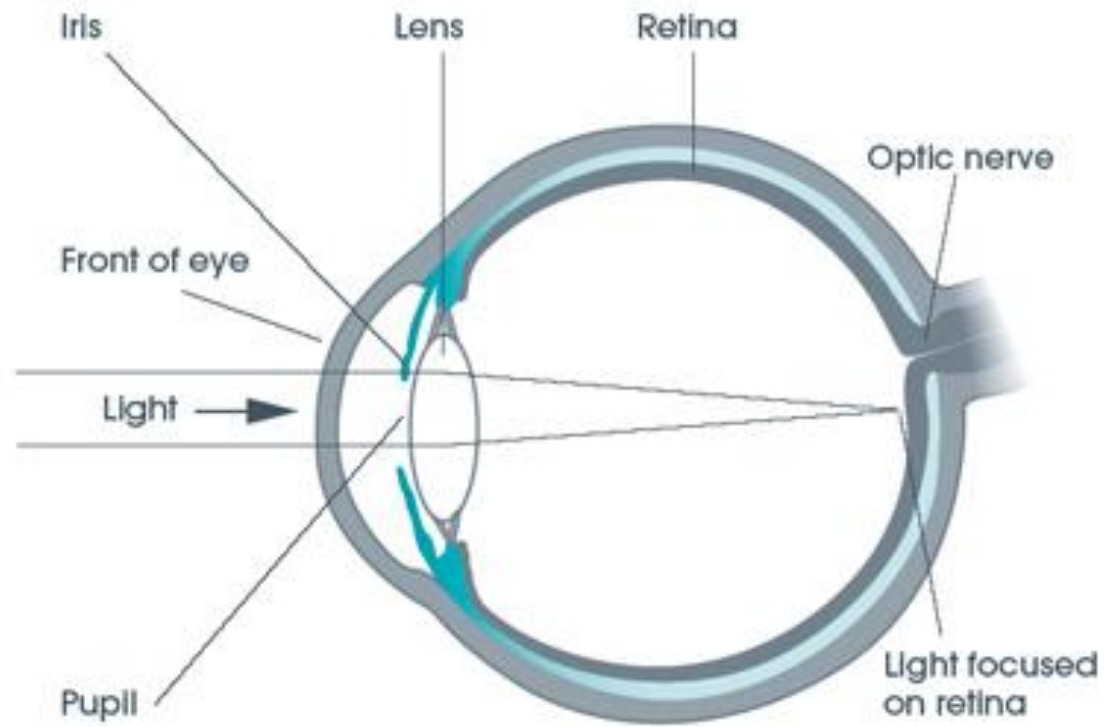
Role of Vitamin A in Vision

Visual Cycle

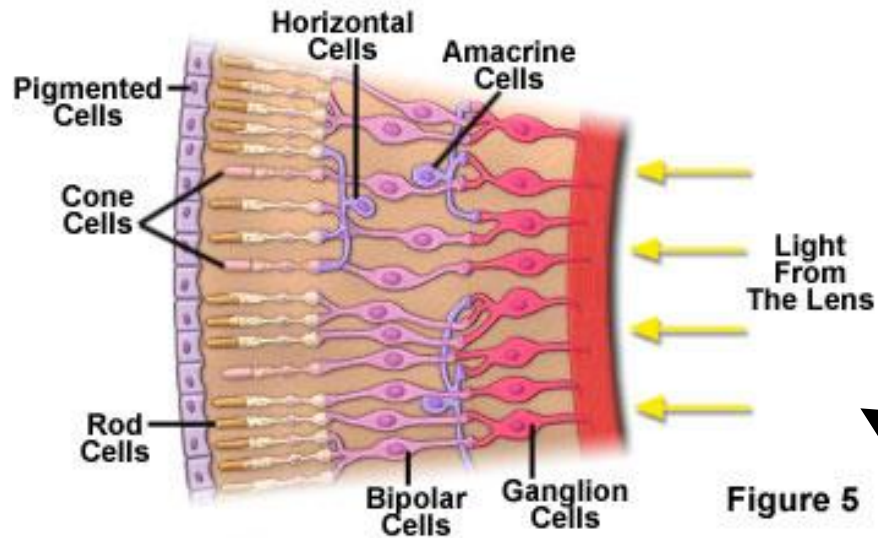
- A process by which light impacting on the retina of the eye is converted to an electrical signal
 - The optic nerve carries the electrical signal to the brain (nerve impulse)
 - The brain processes the signal into an image
-

Role of Vitamin A in Vision

- 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
-

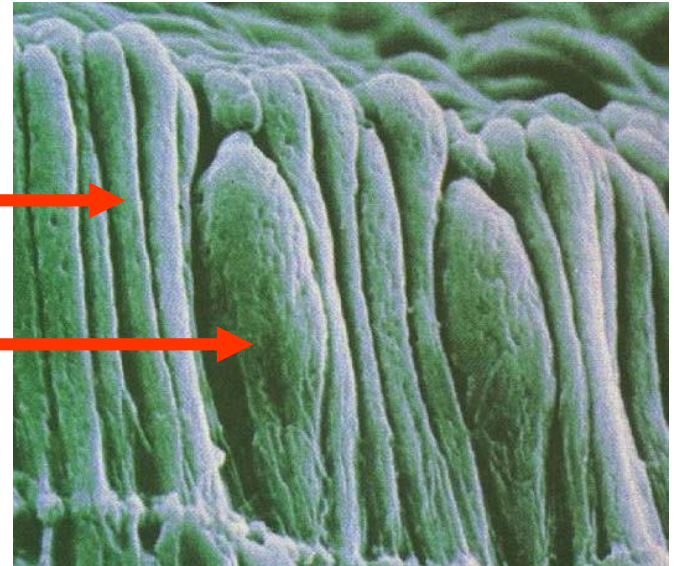


Microscopic Anatomy of the Retina



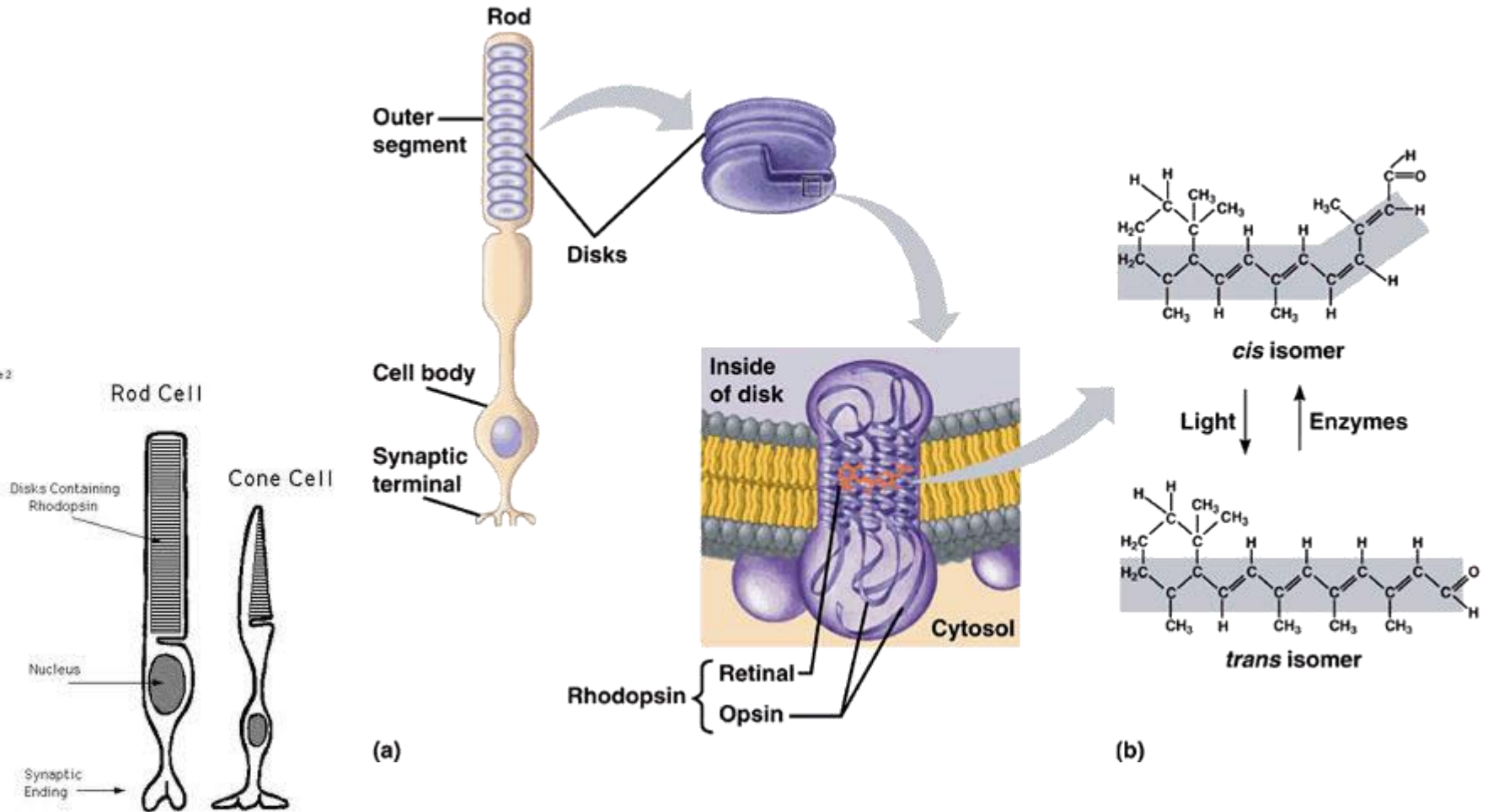
Rod Cell

Cone Cell



Rhodopsin and retinal structures

Figure 2



Role of Vitamin A in Vision

- Normal vision depends on the retina and on adequate vitamin A
- First discovered by George Wald 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

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
-

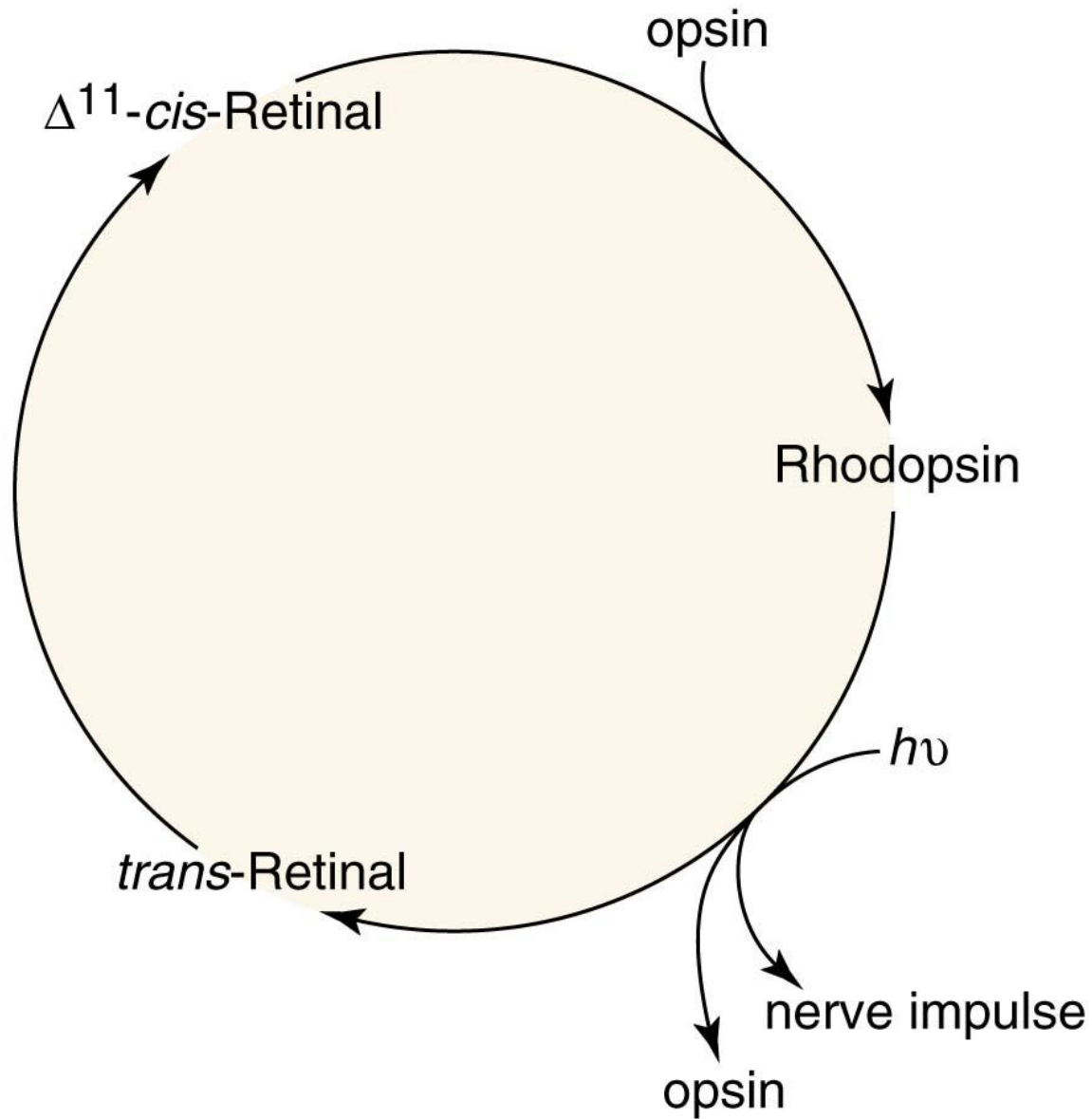


Figure 28.4. Role of vitamin A in vision.

Role of Vitamin A in Vision

Dark Adaptation time

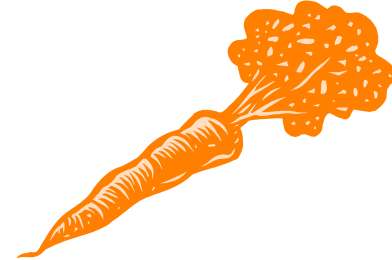
- Bright light depletes rhodopsin (**photobleaching**)
 - Sudden shift from bright light to darkness causes difficulty in seeing
 - Rhodopsin is synthesized in a few minutes and vision is improved in the dark
-

Role of Vitamin A in Vision

- The time required to synthesize rhodopsin in the dark is called **dark adaptation time**
 - It is increased in vitamin A deficiency
-

Recommended Dietary Allowance (RDA)

Vitamin A for Adults



- **Women: 700 μg or 2,330 IU μg**
- **Men: 900 μg or 3,000 IU**
- **UL Men or Women: 3,000 μg or 10,000 IU**



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
 - **Bitot's spots**: localized increased thickness of the conjunctiva
-

Vitamin A Deficiency and Diseases

- **Keratomalacia**: prolonged xerophthalmia leads to drying and clouding of cornea
 - **Complete blindness** (in severe deficiency)
-

Take-home message

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



References

Lippincott's Biochemistry, 5th Edition
pp 381-384, Lippincott Williams & Wilkins
New York, NY, USA.
