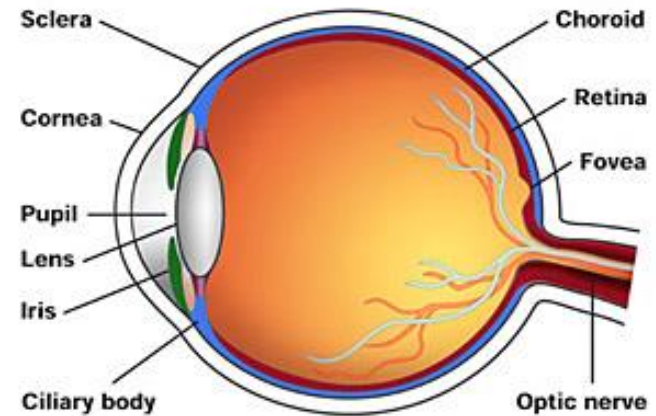


# *Vitamin A & Visual Cycle*



**Neuropsychiatry Block**  
**Dr. Usman Ghani**  
**Biochemistry**

**1 Lecture**

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# *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
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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
-

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# *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 B<sub>1</sub>)
- riboflavin (vitamin B<sub>2</sub>)
- niacin
- pyridoxine (vitamin B<sub>6</sub>)
- biotin
- pantothenic acid
- folate
- cobalamin (vitamin B<sub>12</sub>)

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# *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
-

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# *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)
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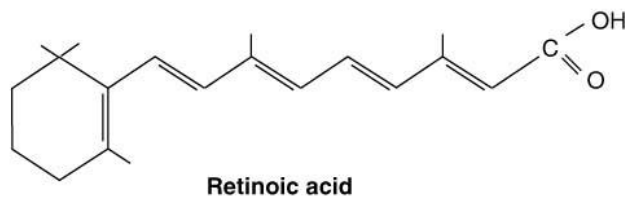
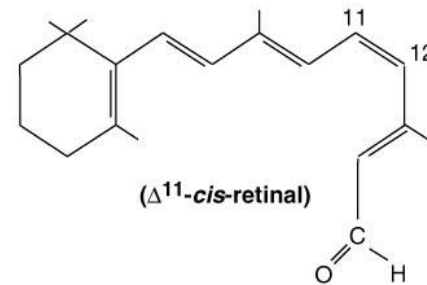
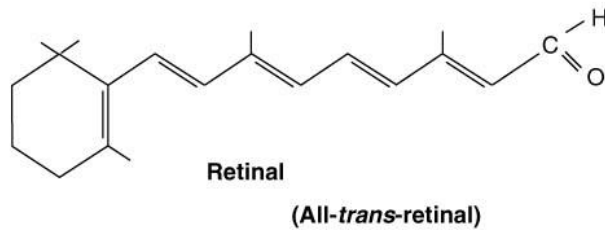
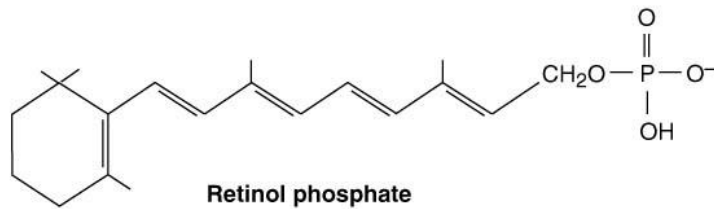
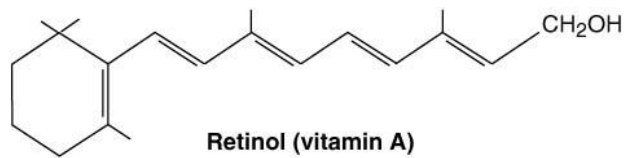
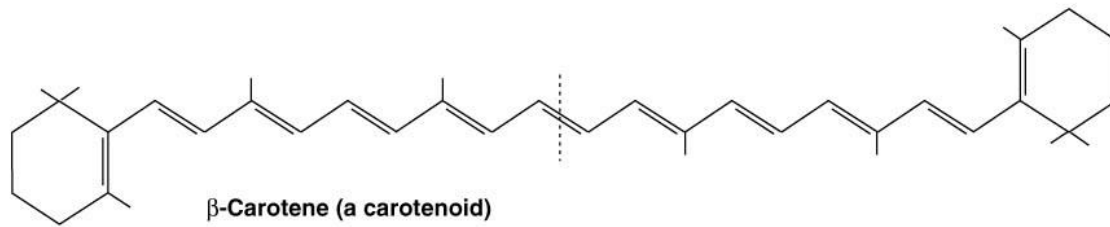
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# *Vitamin A from plant sources*

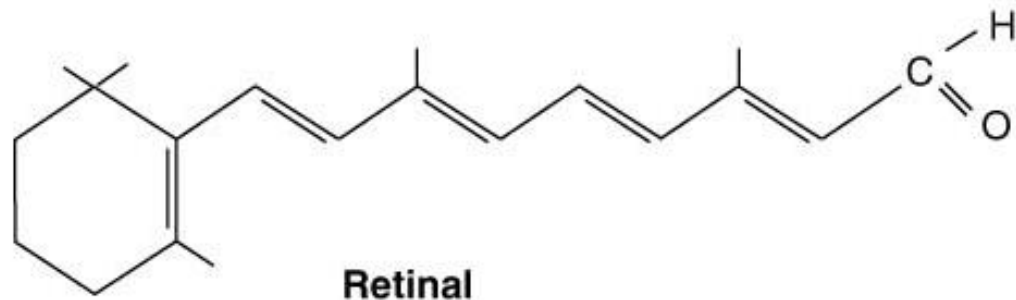
## *(Provitamin)*

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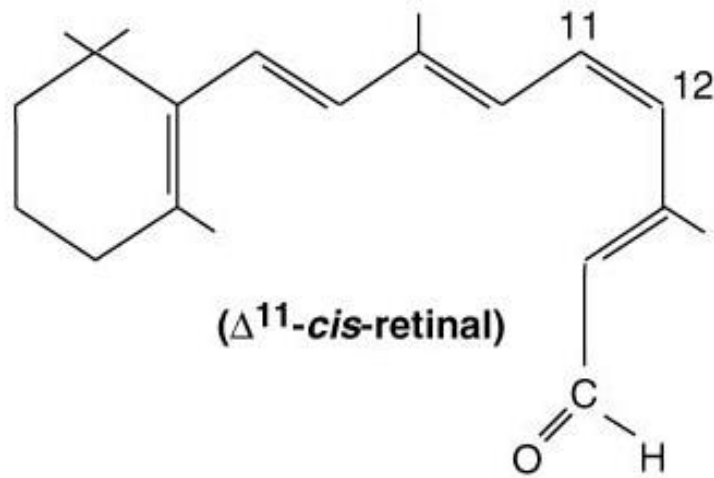
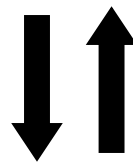


**Figure 28.2. Structures of vitamin A and related compounds.**



**Retinal**

**(All-*trans*-retinal)**



**( $\Delta^{11}$ -*cis*-retinal)**

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# *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
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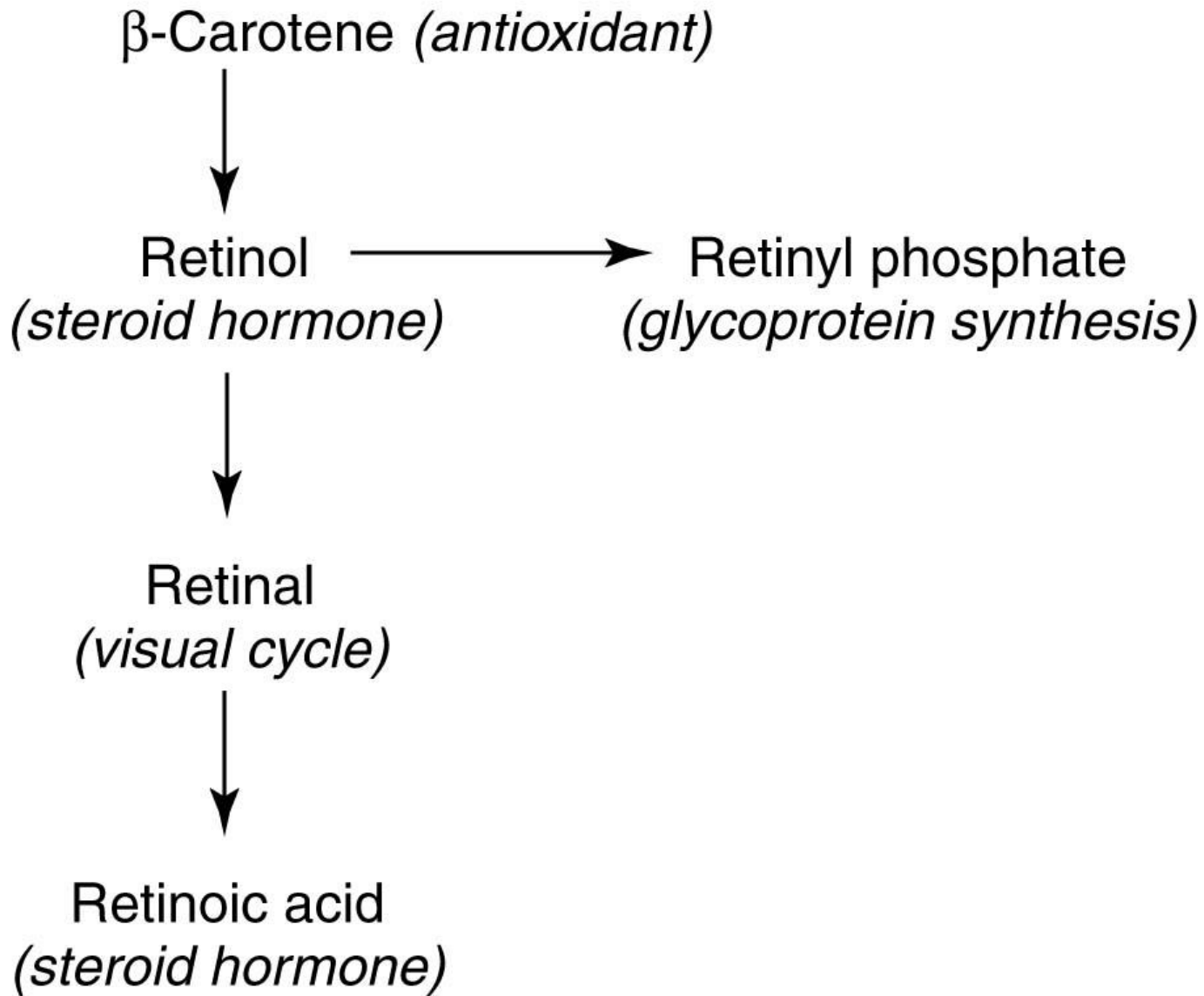
# *Functions of Vitamin A*

- Vision
  - Gene transcription
  - Immune function
  - Embryonic development and reproduction
  - Bone metabolism
  - Skin health
  - Antioxidant activity
-

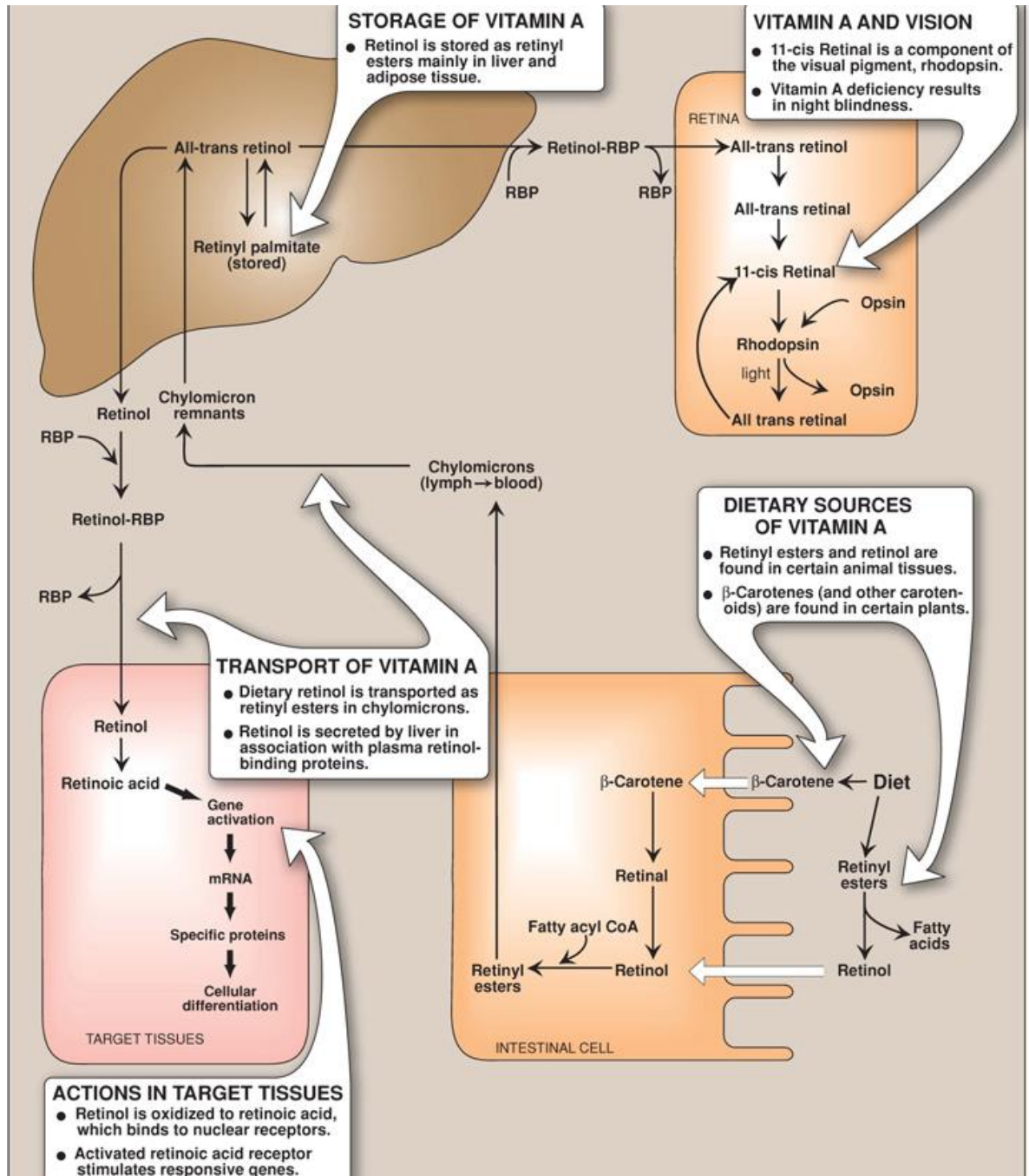
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# *Vitamin A*

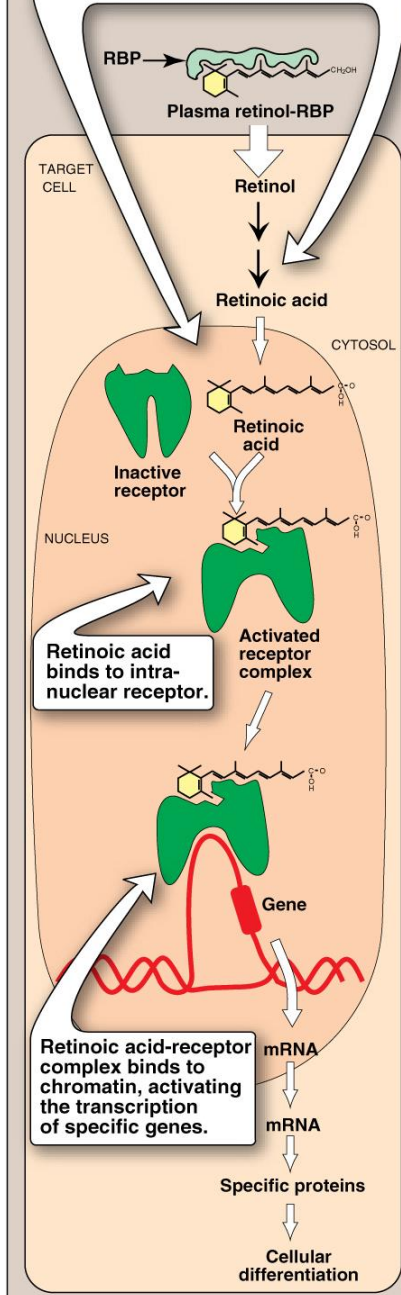
- Essential role in vision and normal cell differentiation
  - Deficiency is the most significant cause of blindness in the developing world
  - Large doses over a prolonged period of time can produce intoxication and eventually lead to liver disease
  - Excessive carotenoids intake can result in yellowing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





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# *Role of Vitamin A in Vision*

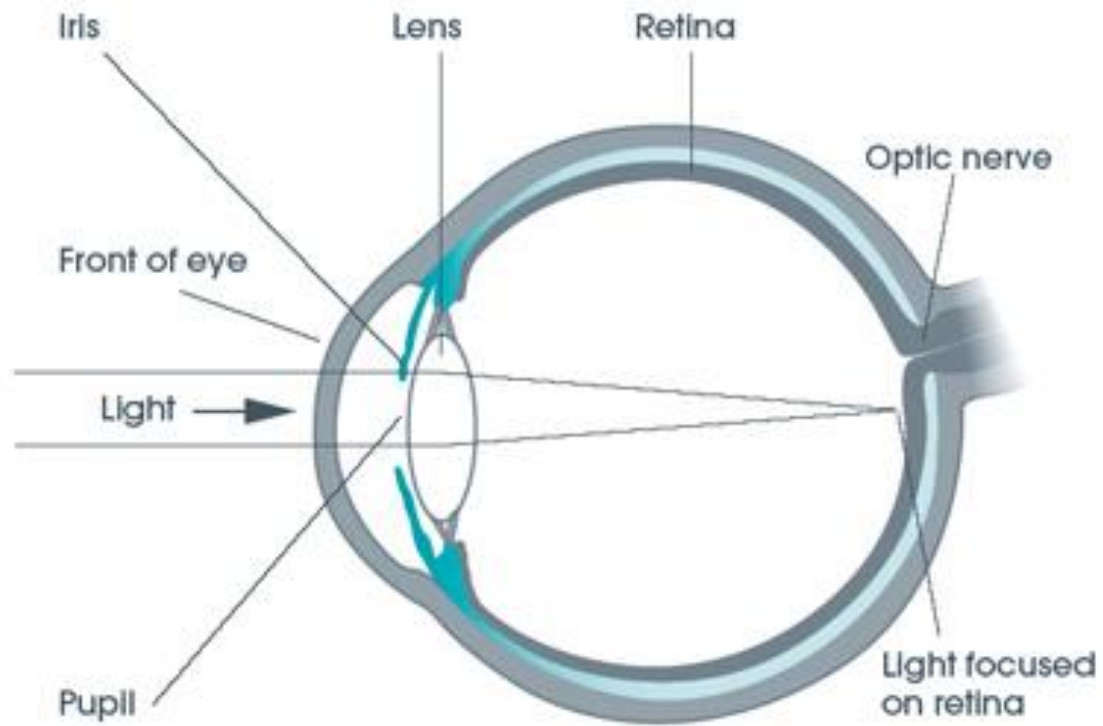
## Visual Cycle

- 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
-

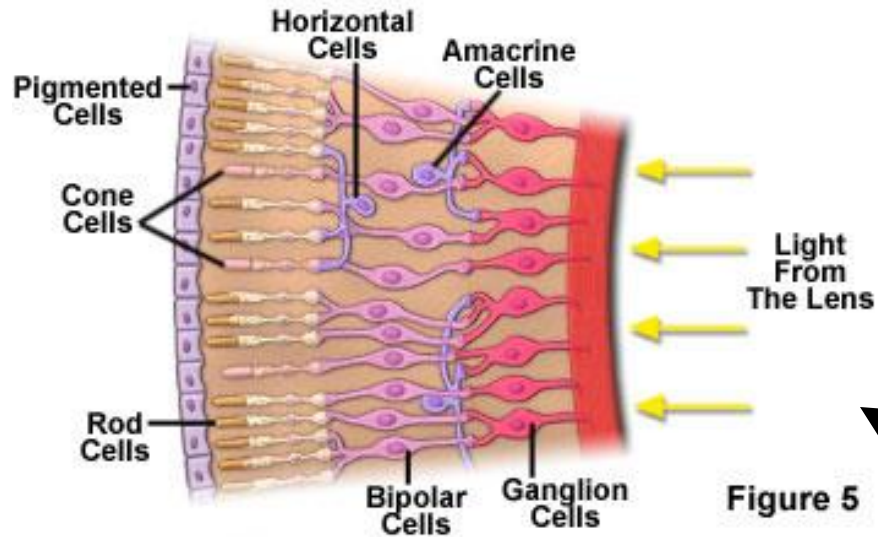
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# *Role of Vitamin A in Vision*

- 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
-

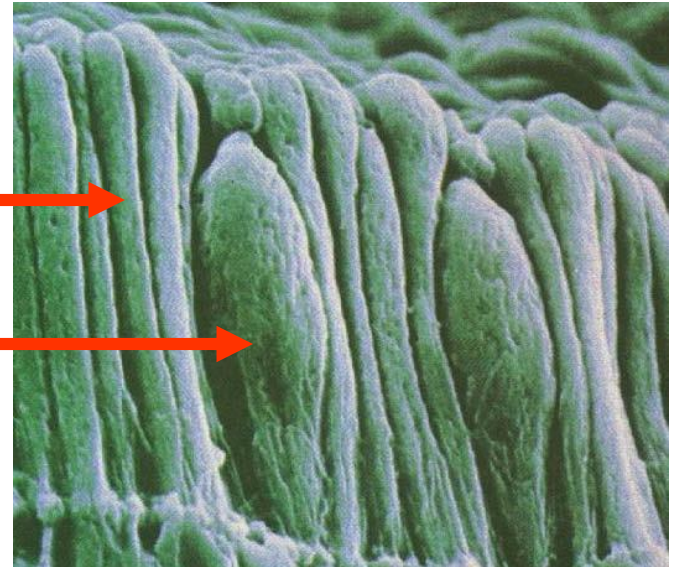


# Microscopic Anatomy of the Retina



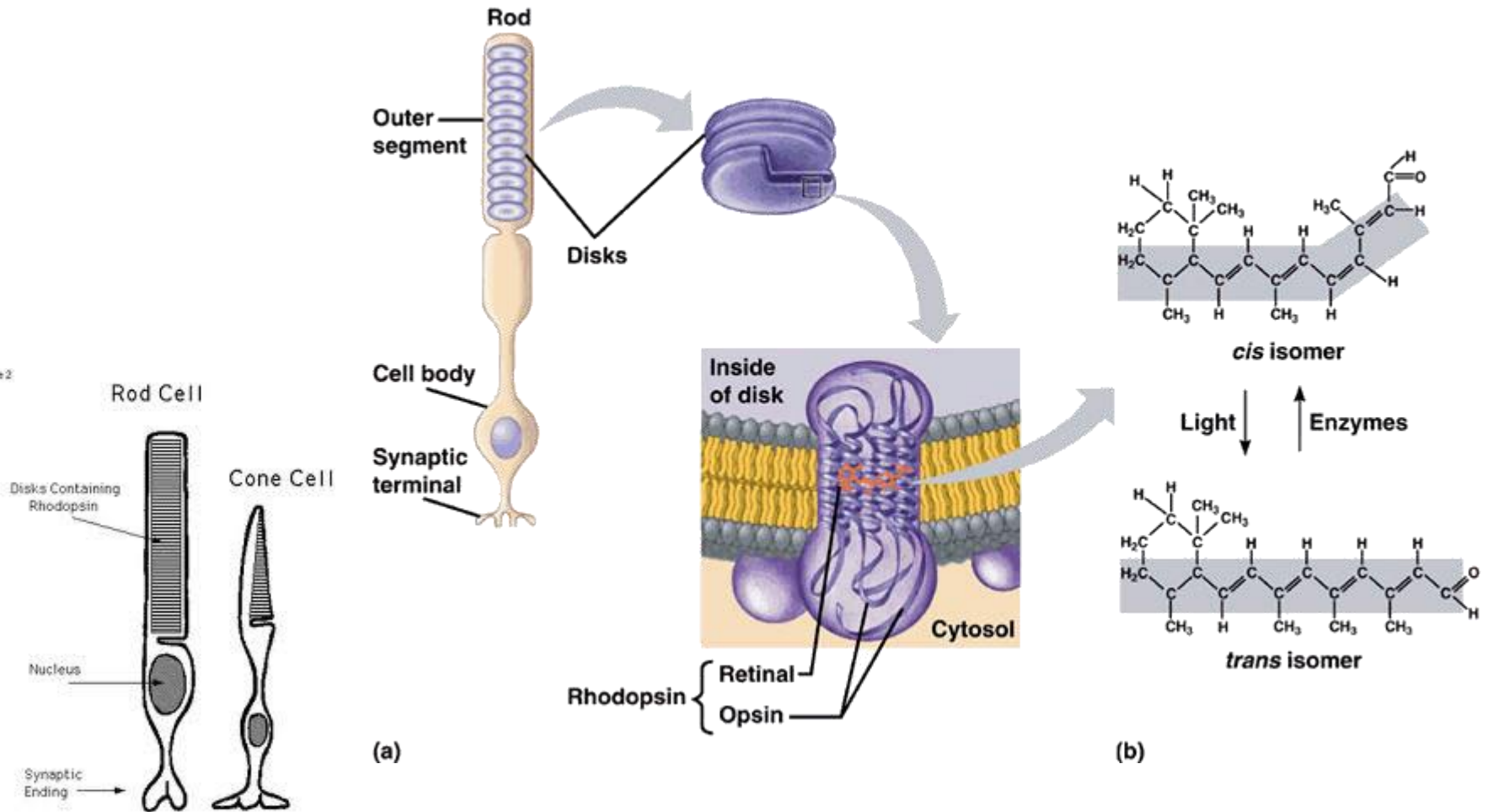
Rod Cell →

Cone Cell →



# Rhodopsin and retinal structures

Figure 2



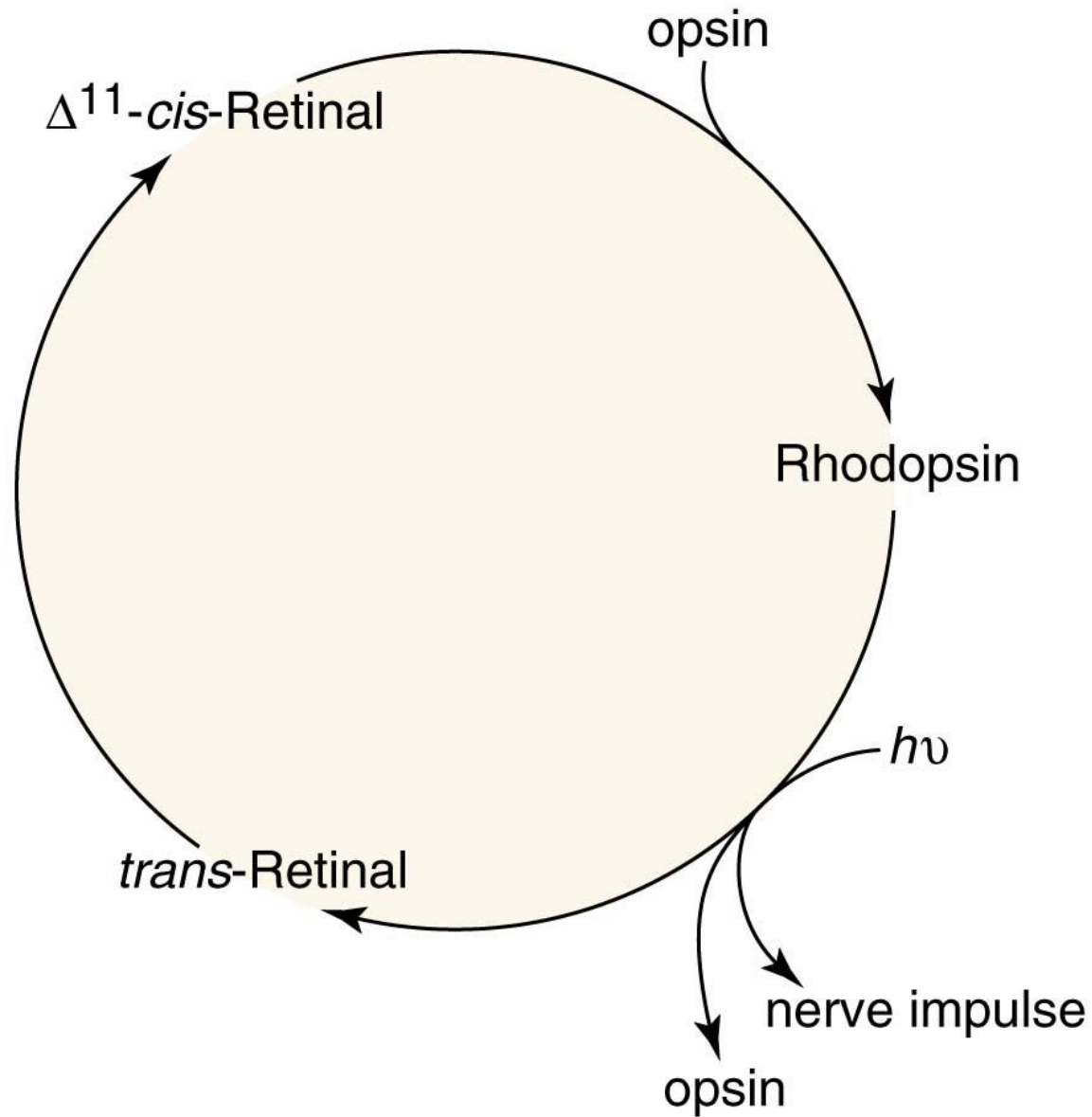
# *Role of Vitamin A in Vision*

- 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

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# *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.**



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# *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
-

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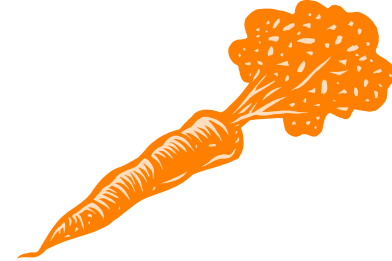
# *Role of Vitamin A in Vision*

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

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# *Recommended Dietary Allowance (RDA)*

## *Vitamin A for Adults*



- **Women: 700  $\mu\text{g}$  or 2,330 IU  $\mu\text{g}$**
- **Men: 900  $\mu\text{g}$  or 3,000 IU**
- **UL Men or Women: 3,000  $\mu\text{g}$  or 10,000 IU**



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# *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
-

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# *Vitamin A Deficiency and Diseases*

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

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# *Take-home message*

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



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# *References*

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

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