بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ


How to Focus on studies
Turn off the Phone
Find a Comfortable Place
Make a list
Shut off every thing
Time Yourself
Clear your Desk
Award your Self
Frame a picture of your Goal

Learning Objectives

By the end of the lecture the student should be able to

- Describe Photochemistry of vision.
- Describe dark and light adaptation.

Recall Cones Vs Rods ?

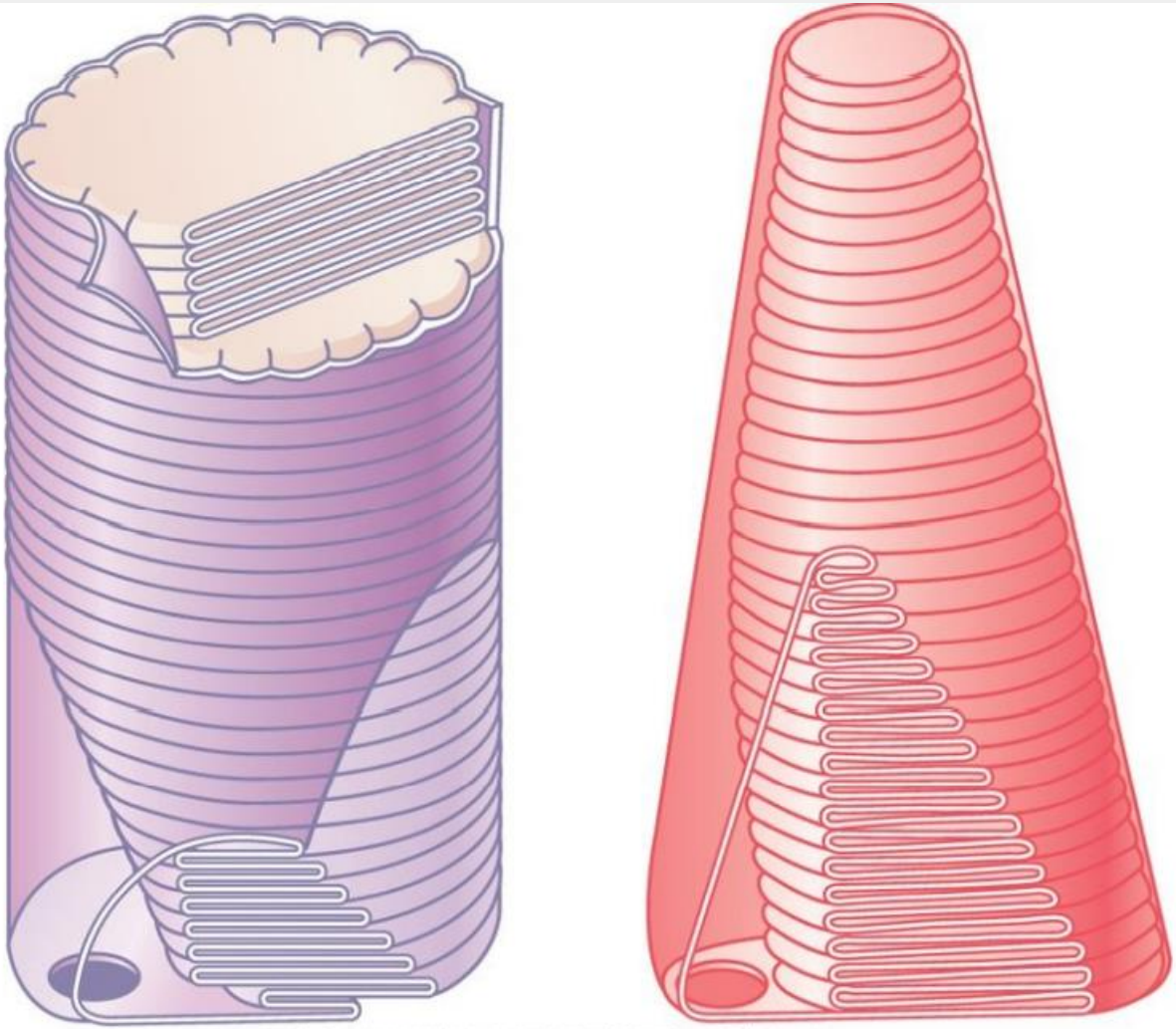
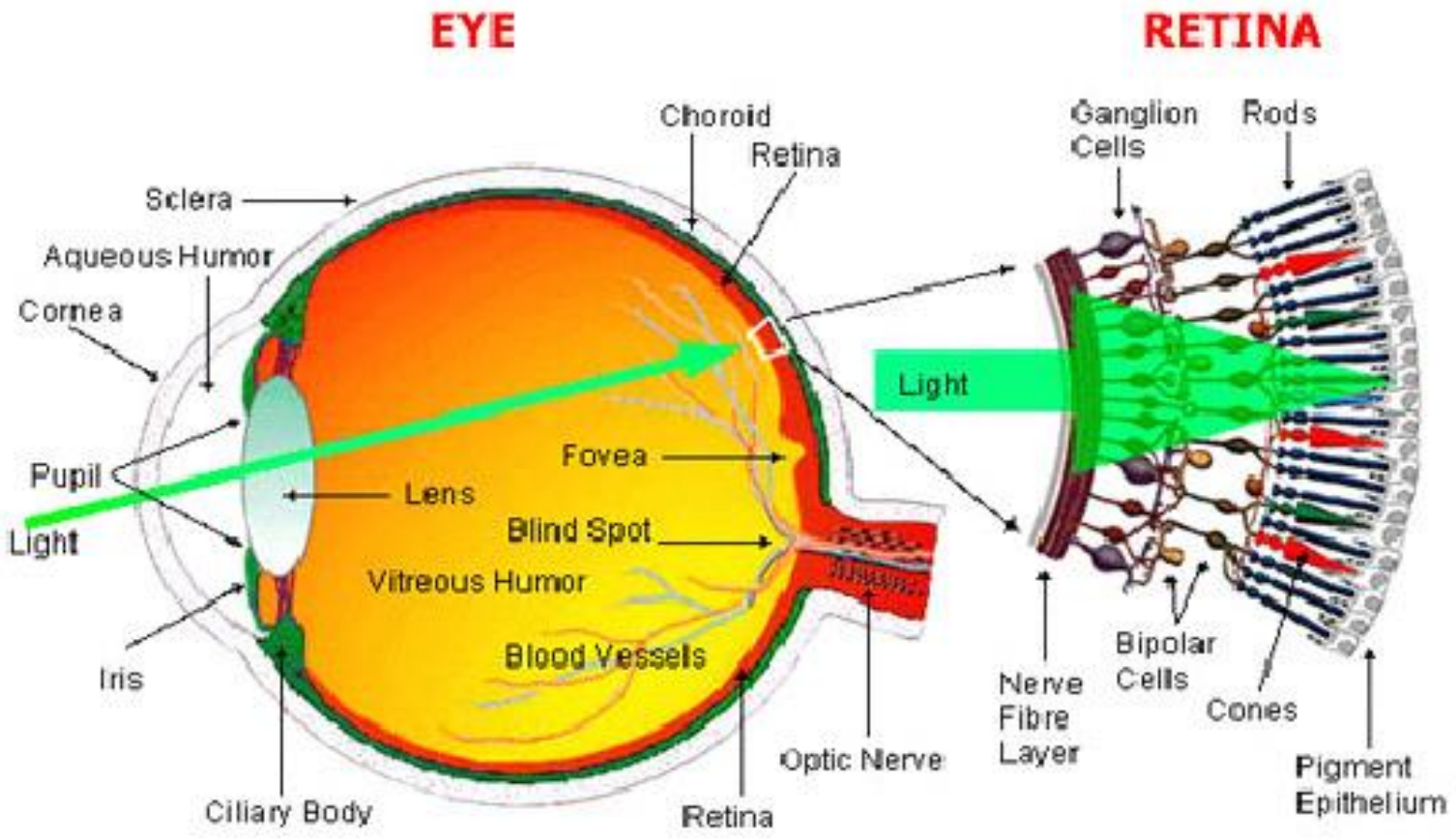


Figure 50-4 Membranous structures of the outer segments of a rod (*left*) and a cone (*right*). (Courtesy Dr. Richard Young.)

PHOTOCHEMISTRY OF VISION



Adapted from WEBVISION http://webvision.med.utah.edu/

What happens in Retina?

- Light Rays are focused on retina
- Light energy is converted to a neural signal
- Through visual pathways these signals reach brain

Mechanism of Vision

3 Mechanisms

- Initiation of vision **(Phototransduction)**
- Processing and transmission of visual sensation
- Visual Perception

Phototransduction

- The whole phenomenon of converting light energy into nerve impulse is **Phototransduction**

- Light falling on retina triggers Photochemical changes → cascade of biochemical changes → resulting in electrical changes

Photochemistry Of Vision

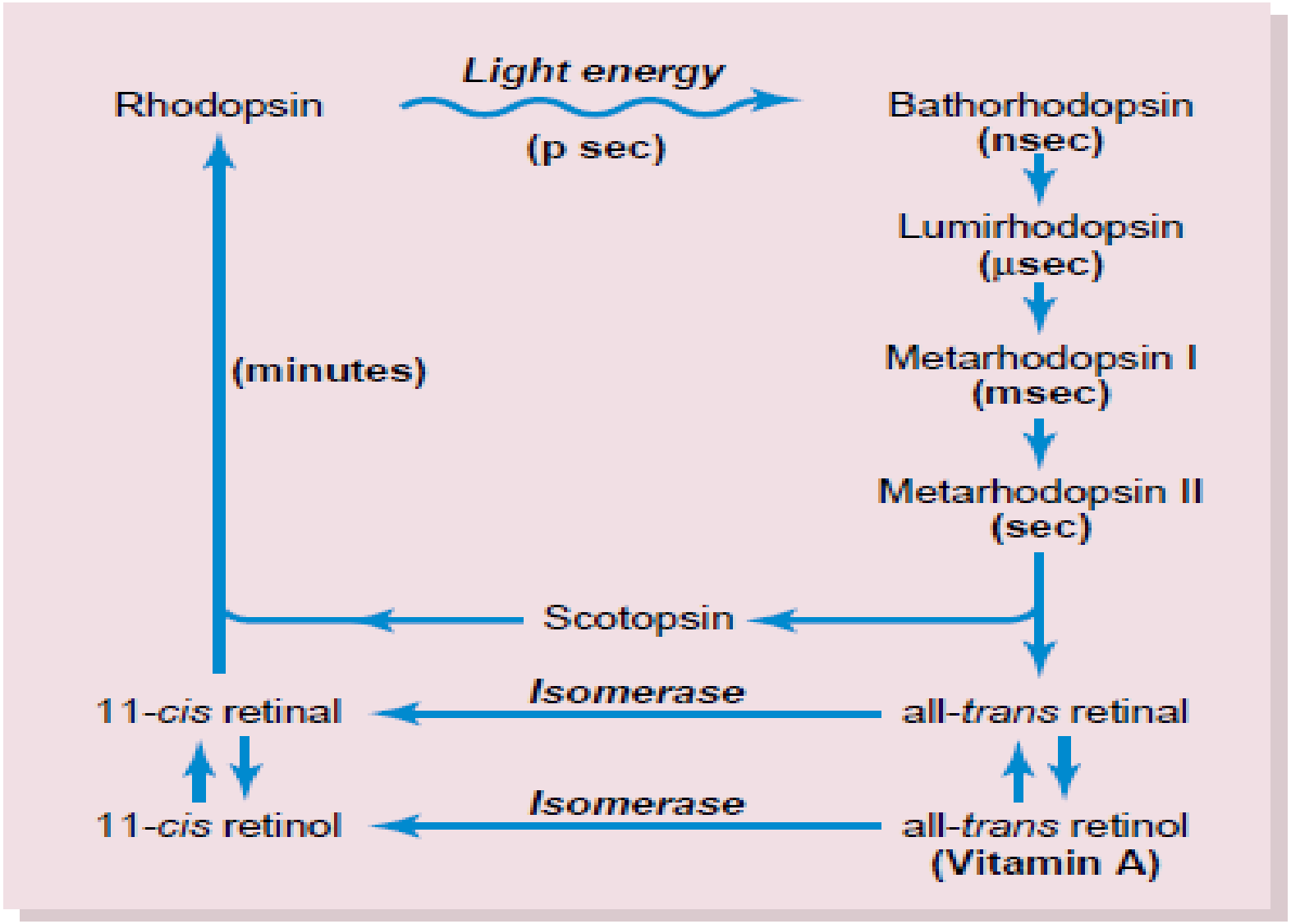
- Photosensitive pigment **decomposes** on absorption of light energy
- Outer segments of rods have high Rhodopsin (**40% of the total mass)**
- Rhodopsin is a combination of
  - **11 cis retinal + Scotopsin**
- Light converts 11 cis retinal → all-trans retinal
- In the darkness reformation of Rhodopsin occurs

Light Induced Changes

- Rhodopsin bleaching
- Rhodopsin regeneration
- Visual cycle

RHODOPSIN VISUAL CYCLE (WALD'S)

Rhodopsin Visual Cycle (Wald's)



What is the active form of rhodopsin?

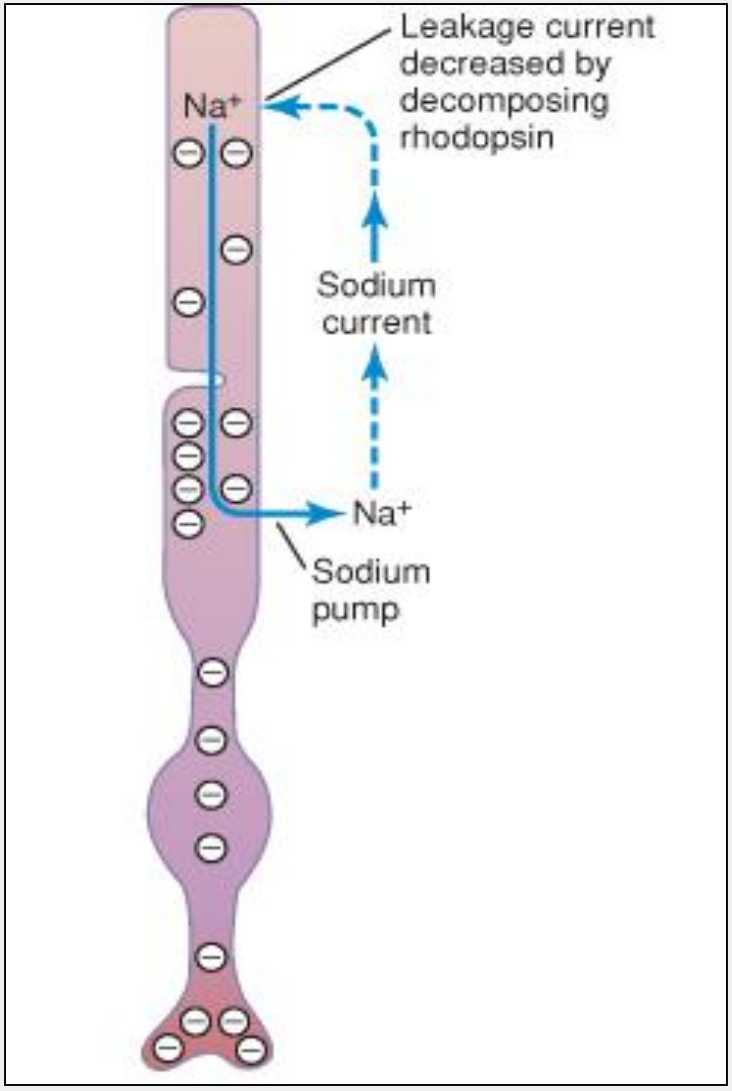
PHOTOTRANSDUCTION

RMP of Rods (and Cones)

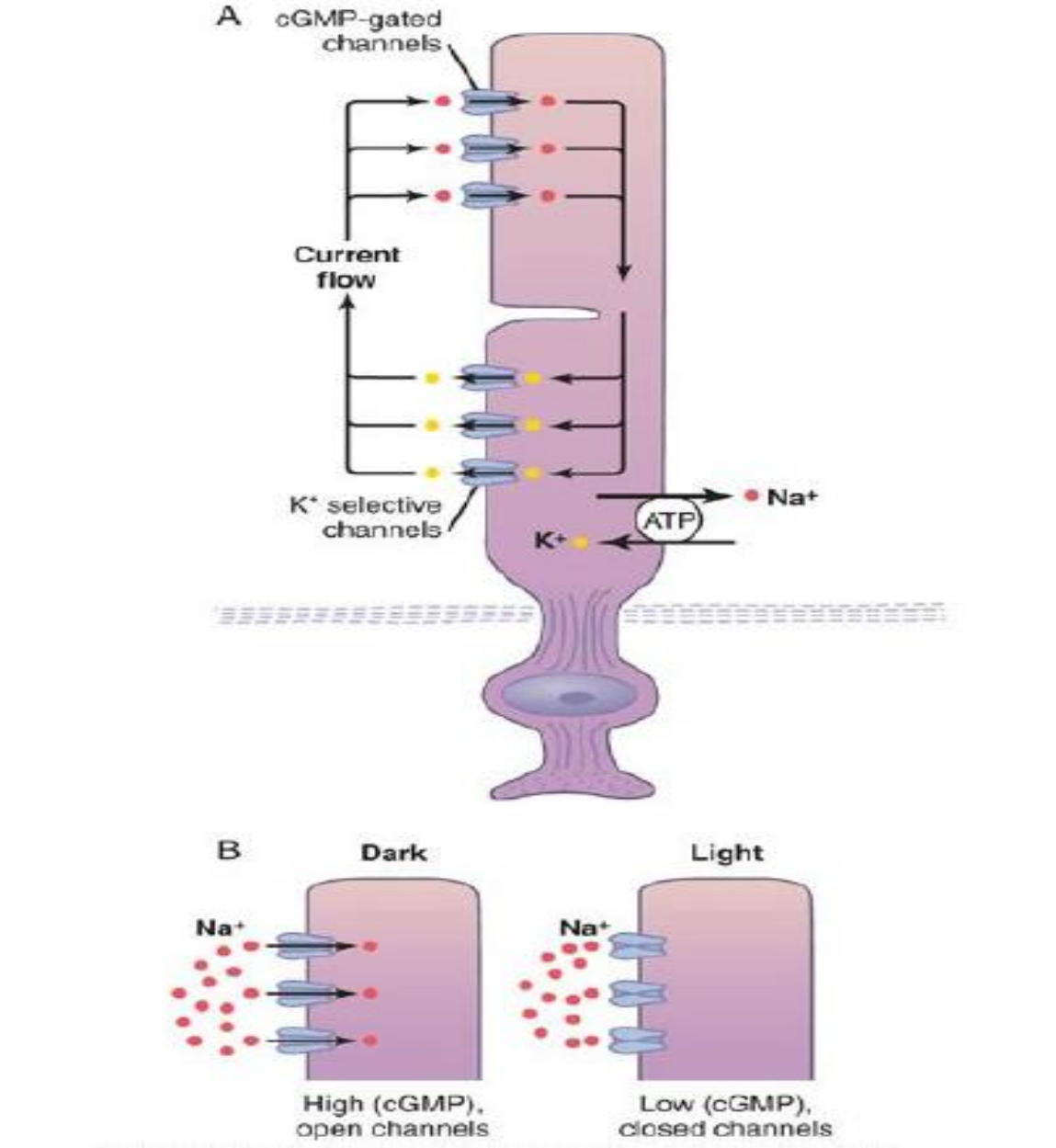
- Normally **inner segment** constantly **pumps the Na^+ to the exterior** and creates electro-negativity

- **Outer segment** is **leaky to Na^+** and neutralizes the electro-negativity

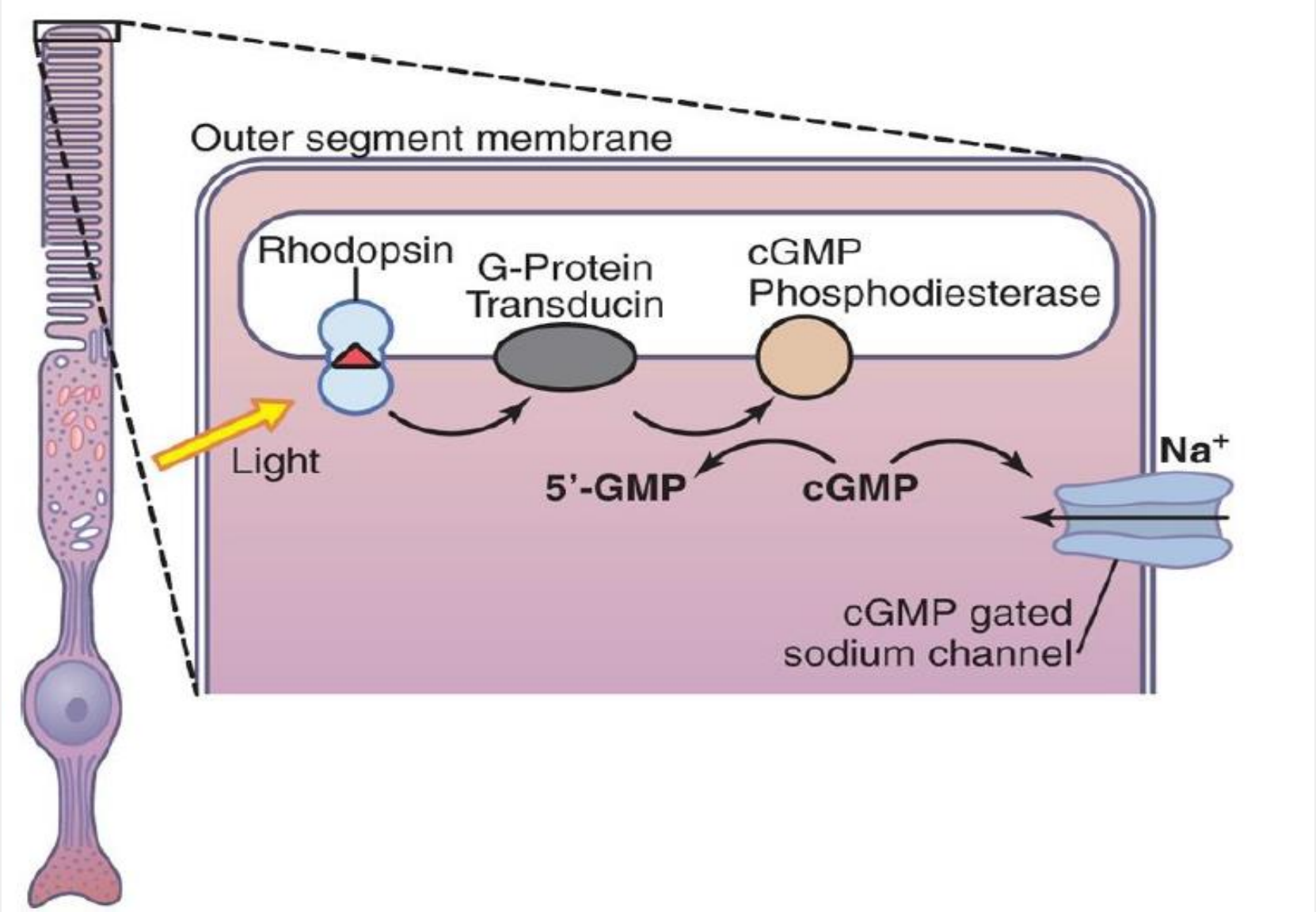
- **RMP is only -40 mv**

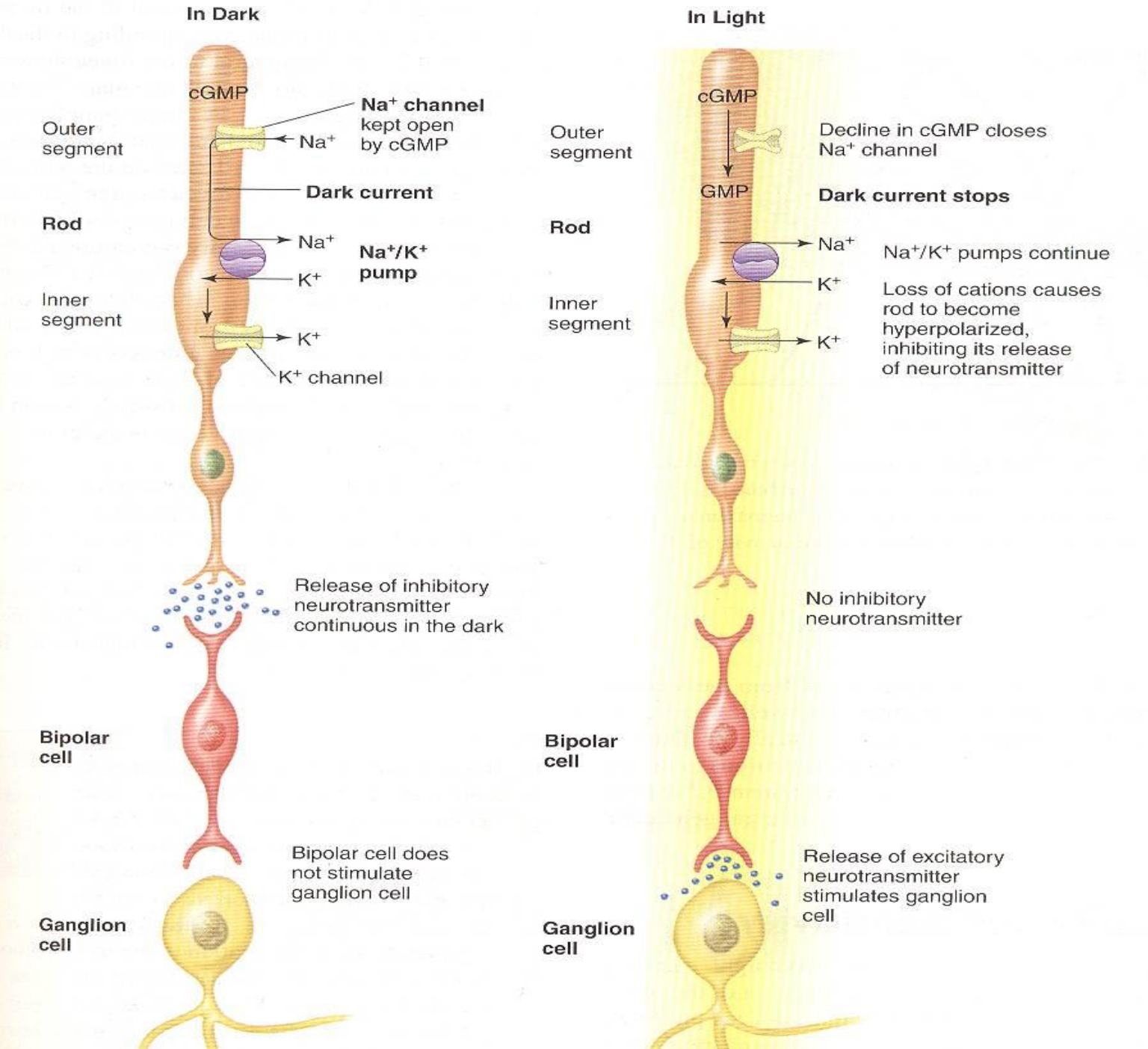


Rod Receptor Potential Is Hyperpolarizing



Phototransduction in Outer Rod Segment




In Dark
cGMP
Na+ channel kept open by cGMP
Outer segment
Na+
Dark current
Rod
Na+
Na+/K+ pump
K+
Inner segment
K+
K+ channel
Release of inhibitory neurotransmitter continuous in the dark
Bipolar cell
Bipolar cell does not stimulate ganglion cell
Ganglion cell
In Light
cGMP
Decline in cGMP closes Na+ channel
Outer segment
GMP
Dark current stops
Rod
Na+
Na+/K+ pumps continue
K+
Loss of cations causes rod to become hyperpolarized, inhibiting its release of neurotransmitter
Inner segment
K+
No inhibitory neurotransmitter
Bipolar cell
Release of excitatory neurotransmitter stimulates ganglion cell
Ganglion cell

Phototransduction

- Conversion of Light stimuli into Electric signals
- Photoreceptor potential is HYPERPOLARIZING on light absorption (-70 to -80mV)

The Excitation Cascade

A **Photon** activates Rhodopsin ⇨ Metarhodopsin II

Metarhodopsin II

⇩

activates **Transducin**

⇩

Activates Phosphodiesterase

⇩

hydrolyzes **cGMP** ⇨ **closes Na+ channels** ⇨ **Rod excitation**

- **Rhodopsin kinase** inactivates Metarhodopsin II and brings back the cascade to normal state

- Metarhodopsin II activates enzyme?

- Enzyme that inactivates Metarhodopsin II ?

Photochemistry of Colour Vision By Cones

- Photopsins + Retinal = Cone Photochemical

- Cones are 30 to 300 times **less sensitive** than rods but even this allows colour vision at any intensity of light greater than extremely dim twilight

Phototransduction Cascade

11 cis retinal

↓

Metarhodopsin II

↓

Activation of G protein (Transducin)

↓

Activation of cGMP phosphodiesterase

↓

cGMP → 5- GMP

↓

Closure of Na channels by decrease in cGMP

↓

Hyperpolarization in receptor cells (no inhibitory NT)

VITAMIN A

Role Of Vitamin A

A second chemical route → all-trans retinal can be converted into 11-cis retinal

All-trans retinal → All-trans retinol, which is a form of vitamin A

All-trans retinol → 11-cis retinol under the influence of the **enzyme isomerase**

- 11-cis retinol → 11-cis retinal → combines with scotopsin → rhodopsin

Vitamin A and Night Blindness

Different forms of vitamin A or its derivatives

- **11 cis retinal, all trans-retinal**
- **11 cis retinol , all trans retinol**
- **11 cis retinyl ester , all-trans retinyl ester**

- Vitamin A is essential for the formation of photosensitive pigment
- Very high concentration of Rhodopsin is required in the darkness

- **Deficiency of Vitamin A → Night blindness**

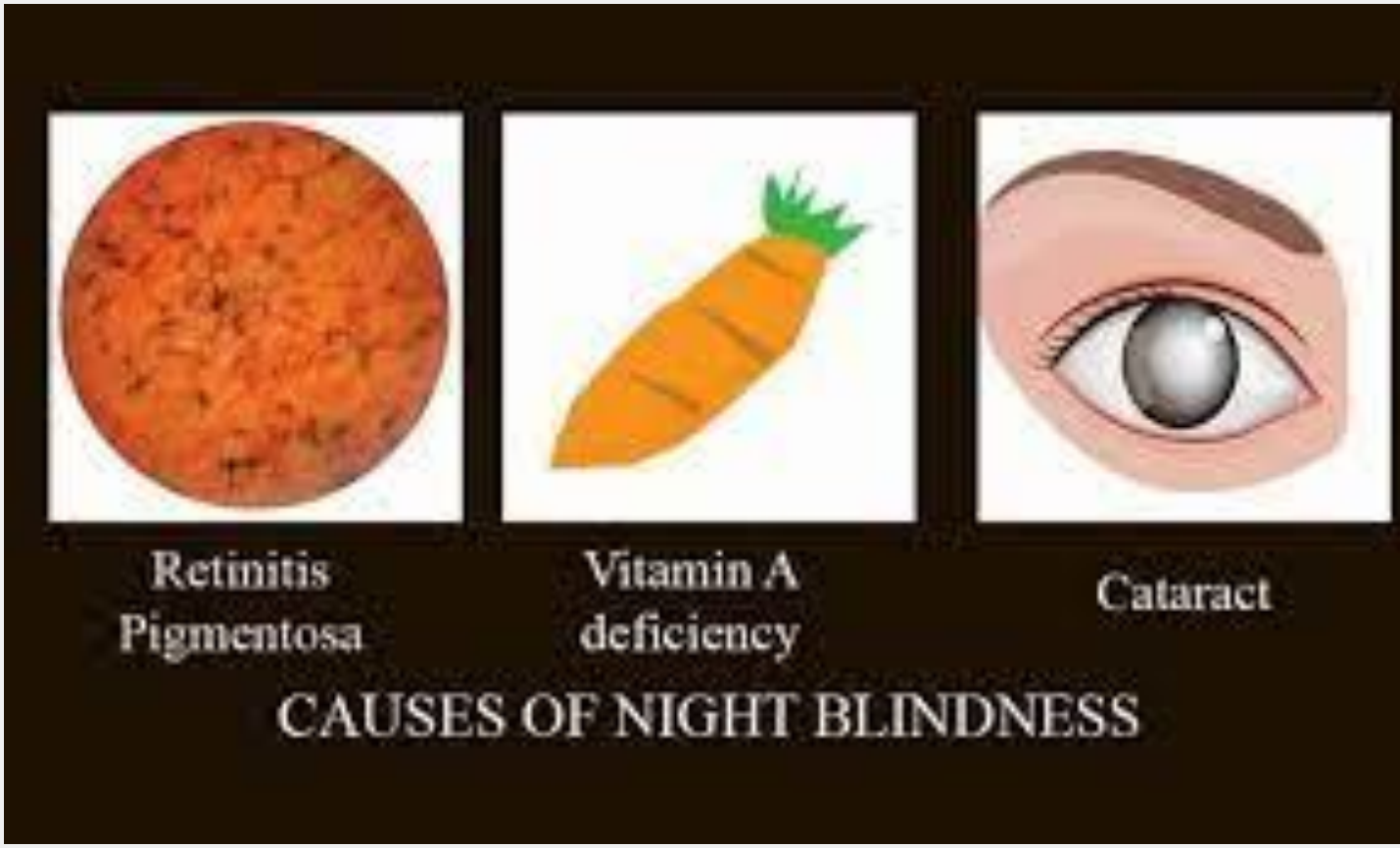
NIGHT BLINDNESS

Night Blindness

- Is moving around the house in dim light a challenge?
- Is driving at night increasingly difficult?
- Is it tricky to recognize faces in dim light?
- Does it take an abnormally long time to adjust to a light room after being in the dark?
- Does it take a long time to see in a darkened room after being in the light?

Night Blindness

- Affects a person's ability to see in dim light but **does not cause** complete blindness
- May create problems seeing **road signs** while driving at night
- May take a longer time for the eye **to adapt** when going from light to dark settings
- Night blindness is a **symptom** of underlying conditions


Retinitis Pigmentosa
Vitamin A deficiency
Cataract
CAUSES OF NIGHT BLINDNESS

Causes of Night Blindness

- Glaucoma
- Cataract
- Myopia
- Vitamin A deficiency
- Retinitis Pigmentosa

Night Blindness (Nyctalopia)…

- Severe **Vitamin A deficiency**
- **Retinal And Rhodopsin ↓↓**

- amount of light at night is too little to permit adequate vision in vitamin A-deficient persons

- Vitamin A is stored in the **liver** and can be made available to the eyes

- Night blindness if due to Vit A deficiency, can be reversed in less than an hour of intravenous **injection of vitamin A**

Treatment of Vitamin A Deficiency

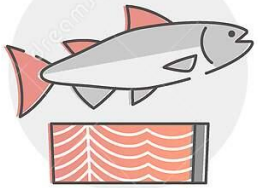
Adding more Vitamin, A to the diet

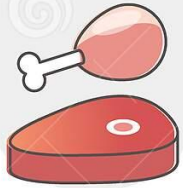
Good sources of vitamin A include

- eggs
- fortified cereals
- fortified milk
- orange and yellow vegetables and fruits
- cod liver oil
- dark, leafy green vegetables

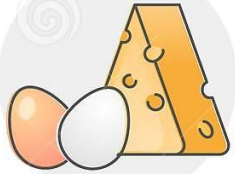
SOURCES OF
VITAMIN A


BROCCOLI


FISH


MEAT


AVOCADO


EGGS AND CHEESE


MANGOS

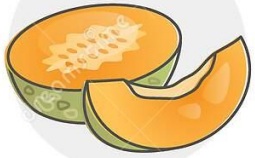

PAPAYA


CARROTS


PEPPERS


SWEET POTATO

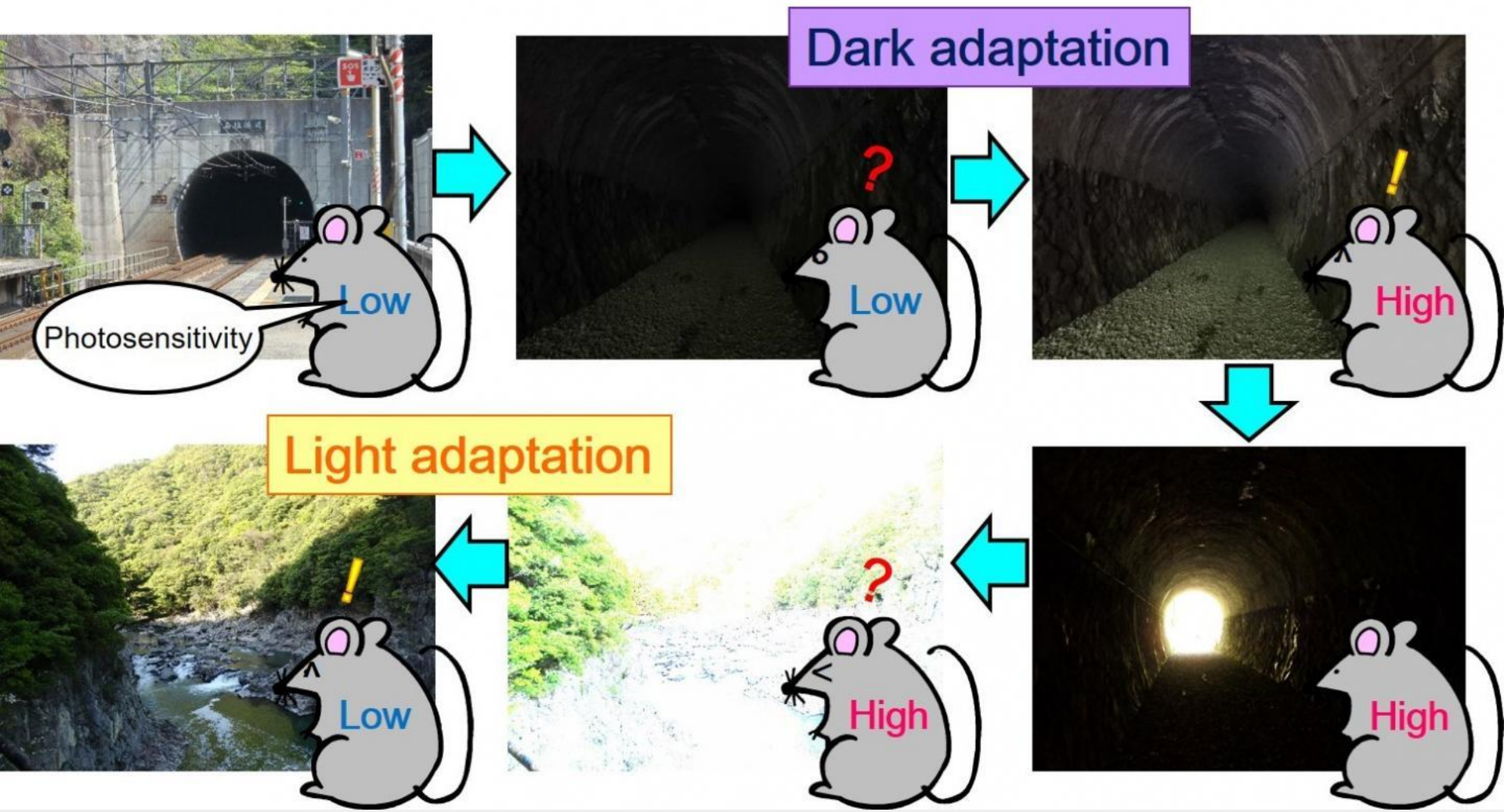

APRICOTS


MELON

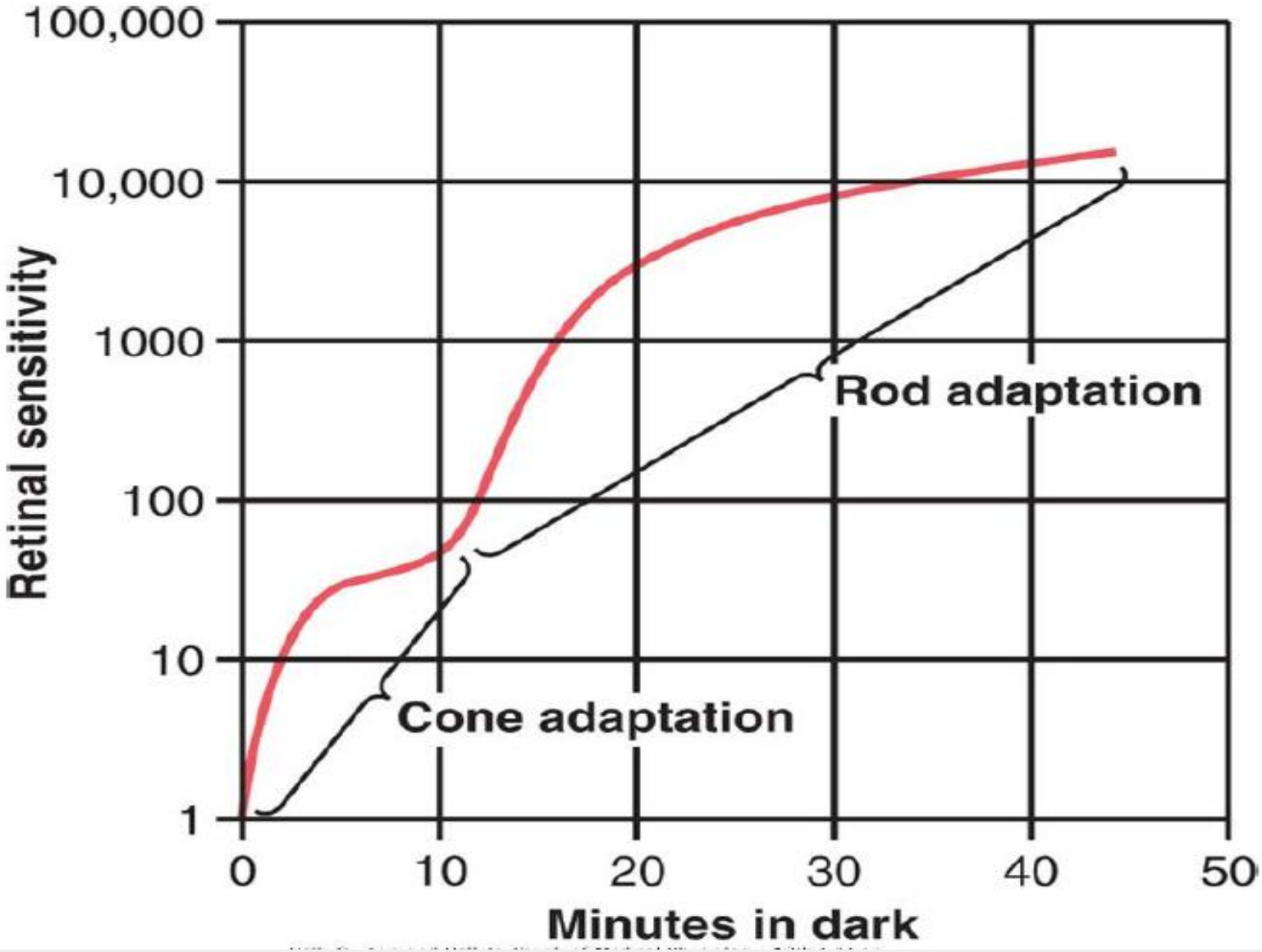

SQUASH


PEACHES

What is Dark and Light Adaptation?


Dark adaptation
Photosensitivity
Low
?
Low
!
High
Light adaptation
!
Low
?
High
High

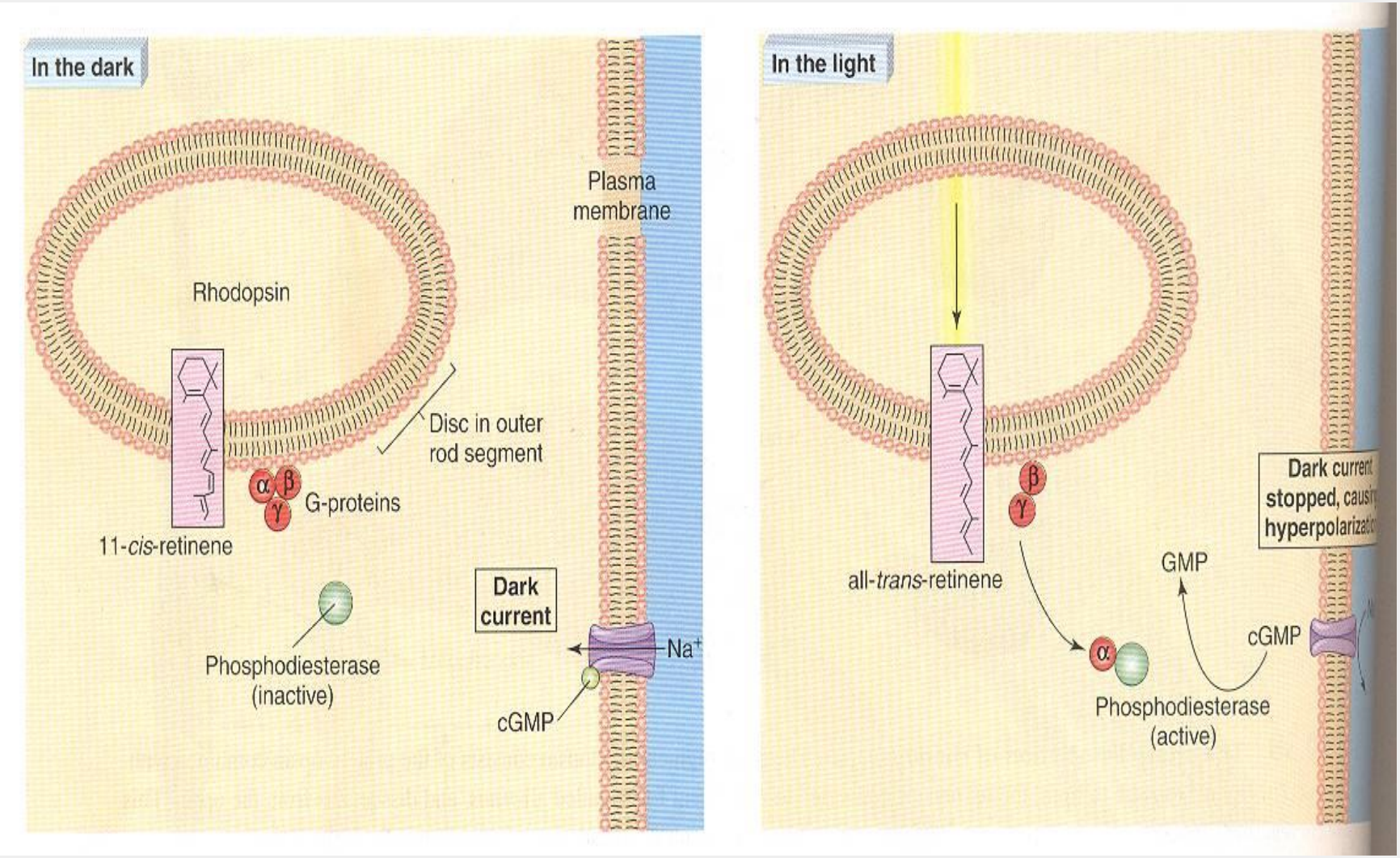
Dark Adaptation



Light and Dark Adaptation

- Chemical Adaptation
- Pupillary Adaptation
- Neural Adaptation

Chemical Adaptation



Light and Dark Adaptation…

Pupillary Adaptation

30-fold adaptation within a fraction of a second due to changes in the amount of light allowed through the pupillary opening

Neural adaptation

Increase in light intensity → signals transmitted are intense

- Signals decrease in the neural circuit
- occurs in a fraction of a second though degree of adaptation is a few fold

Flow Chart of Light Adaptation

dark into bright light

bright light dazzles and we see white light because the sensitivity of the receptors is set to dim light

Rods and cones are both stimulated and large amounts of the photopigment are broken down

sensitivity of the retina decreases dramatically

Within about one minute the cones are sufficiently excited by the bright light to take over

Dark Adaptation

rod pigment is bleached out due to the bright light and the rods are initially nonfunctional

Once in the dark, rhodopsin regenerates and the sensitivity of the retina increases over time (can take an hour).

During these adaptation process reflexive changes occur in the pupil size

Value of Light and Dark Adaptation in Vision

- Eye can change its sensitivity to light as much as **500,000 to 1 million times**

- **Maladjustment of Retinal adaptation -** when a person leaves a movie theater → bright sunlight

- A person when **enters dark** the sensitivity of the retina is usually low

After dark adaptation, the light spots begin to register

Summary

References

- Guyton and Hall Physiology
- Sherwood Physiology


Thank
you !!!
...