VISION –3rd note

--Photoreceptors

--Phototransduction

PHOTORECEPTORS

- Photoreceptors convert light energy into visual impulses.
- 2 types—rods and cones

Photoreceptors

Rods

- 120 million/retina
- rods : cones =20 : 1
- **Shape** slender,elongated, rod like
- Photopigment-rhodopsin
- Lower threshold for light stimulus.
- Operate at low intensity
- extremely sensitive to light
- Responsible for dim light vision,
- Absent in fovea centralis

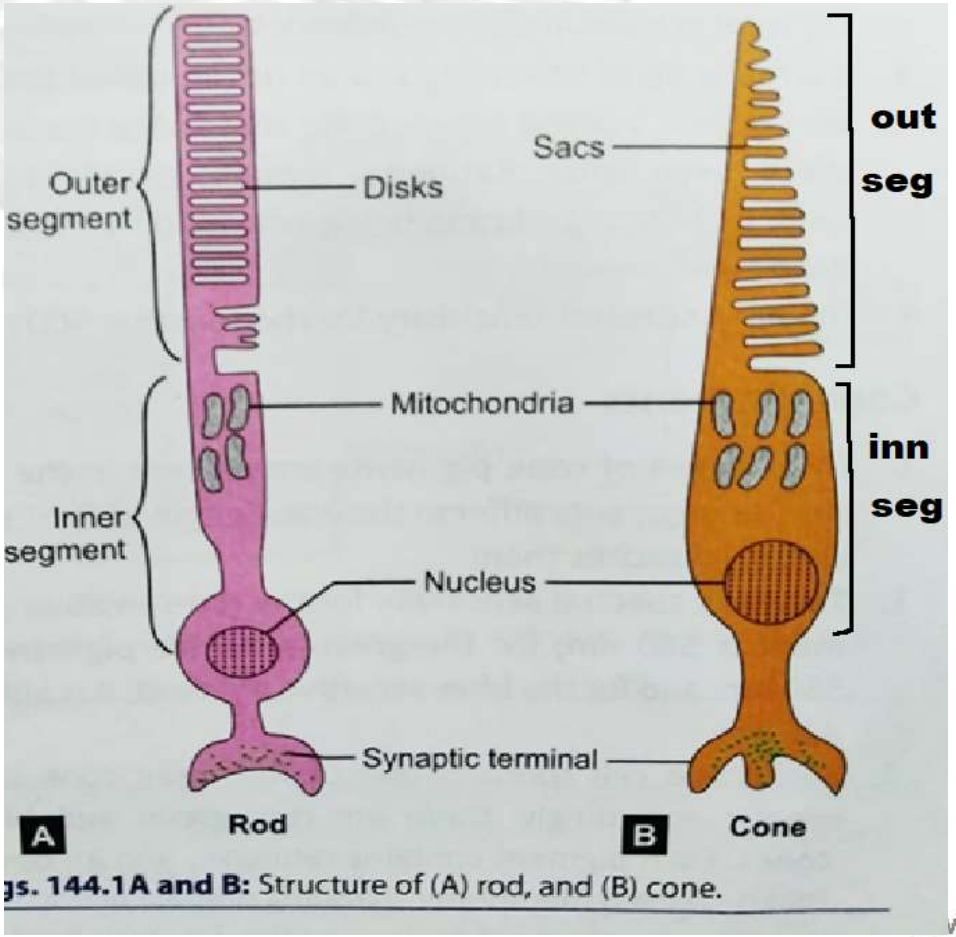
Cones

- 6 million/retina
- rods : cones =20 : 1
- Conical
- Iodopsin
- High threshold
- High intensity.
- Sensitive only to bright light
- Bright light light vision,& color vision
- Max no of cones present in fovea centralis

Structure of rods & cones

- Structurally rods and cones are almost same , except for shape of outer segment.
- Rods and cones have 3 parts

- Outer segment
- Inner segment
- Synaptic terminal



gs. 144.1A and B: Structure of (A) rod, and (B) cone.

Outer segment

- These are modified cilia concerned with light reception.
- Shape – long slender and cylindrical appearance ie, rod shape
- (in cones outer seg is cone shape)
- Contains discs / saccules ,1000 discs / rod
- discs contain photosensitive pigment- rhodopsin
- In rod, discs are separated from cell membrane
- (In cones discs are actually infoldings of cell membrane)

- Discs are constantly being renewed

New discs are formed in the inner edge of outer segment. They push older discs towards outer tip and from there they are engulfed by phagocytic cells of pigment epithelium.

- Rate of formation of discs= **30 discs / day**.

- In **retinitis pigmentosa** phagocytic proces is defective.Therefore a layer of debris accumulates between rods and pigment epithelium–- finally producing blindness

Inner segment

- It contains mitochondria, golgibodies , enzymes etc

- Visual pigments are synthesized here-

Mitochondria provide energy

- After synthesis pigments migrate towards outer segment and stored in discs.

- Inner segment contain nucleus.

Synaptic terminal

- Terminal parts of rods and cones.
- They contain synaptic vesicles which store neurotransmitter glutamate.

- It synapse with bipolar and horizontal cells

Photosensitve pigments

- Rods—rhodopsin
- Cones –iodopsin
- Both have 2 parts – a protein part and
- a non protein part
- Non protein part – retinal or retinene

(same for both)

Protein part – for rhodopsin - scotopsin

" " - for iodopsin - photopsin

Scotopsin + retinene = rhodopsin

Photopsin + retinene = iodopsin

- Retinene exist in 2 forms
- 11- cis retinene (retinal)
- all trans retinene (retinal)
- They have same chemical structure but physical properties different
- Only cis form can bind with scotopsin to synthesis rhodopsin.

- **Chemical basis of visual process**
- Rods and cones contain pigments.
- Light falls--------→ pigments
- (Photochemistry)

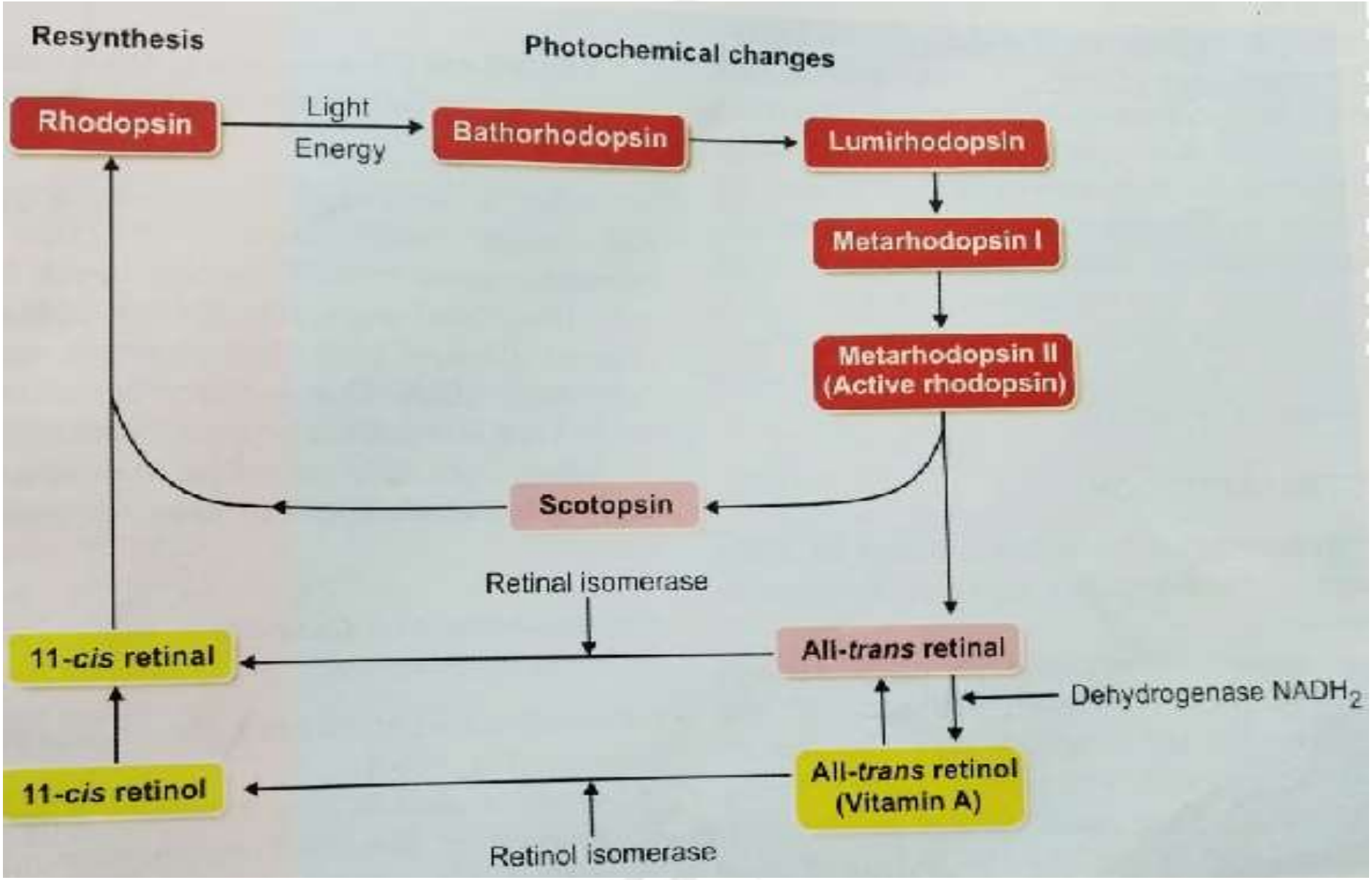
➢ chemical reactions in pigments

(electrophysiology)

➢ development of electrical activity in retina and generation of impulses (AP)

➢ AP is transmitted through optic nerve to **visual cortex**

Walds visual cycle



Following changes occur due to absorption of light energy by rhodopsin:

1. First, **rhodopsin** is decomposed into **bathorhodopsin** that is very unstable
2. Bathorhodopsin is converted into **lumirhodopsin**
3. Lumirhodopsin decays into **metarhodopsin I**
4. Metarhodopsin I is changed to **metarhodopsin II**
5. Metarhodopsin II is split into **scotopsin** and **all-*trans* retinal**
6. All-*trans* retinal is converted into **all-*trans* retinol (vitamin A)** by the enzyme dehycrogenase in the presence of reduced nicotinamide adenine dinucleotide ($NADH_2$).

Metarhodopsin is usually called **activated rhodopsin** since it is responsible for development of receptor potential in rod cells.

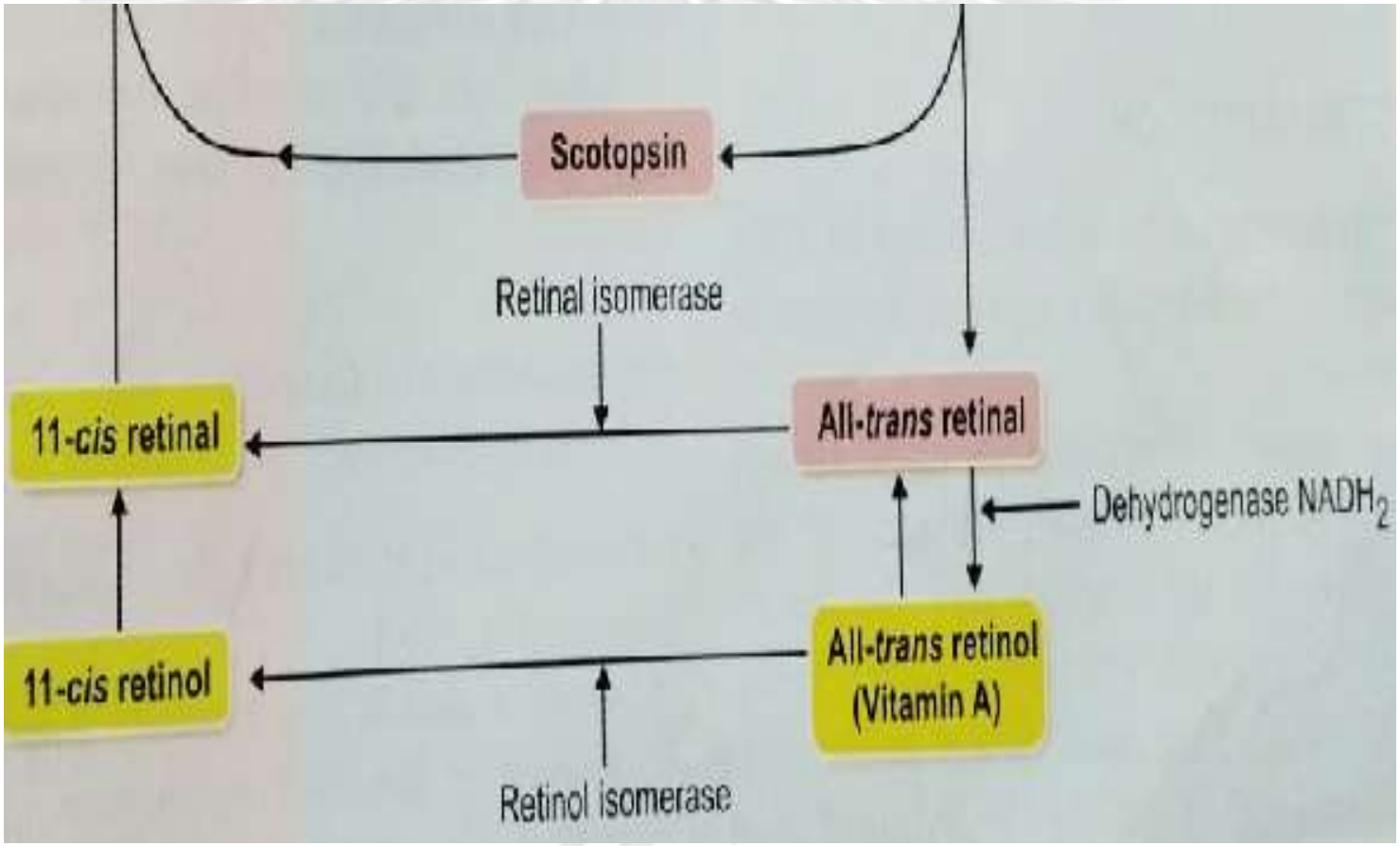
Resynthesis of rhodopsin

- All trans retinal is converted into 11-cis retinal by the enzyme retinal isomerase.
- 11 cis retinal immediately combines with scotopsin to form rhodopsin.
- ----------
- **When light falls** on rhodopsin, **bleaching or breakdown occurs.**

- **Resynthesis** occurs in dark as well as in light . Resynthesis is slower than bleaching

Role of vit A

- In walds cycle, there is an alternate route by which All-trans retinal can be converted to 11-cis retinal



Vit A is present in cytoplasm of rods and in pigment layer of retina

Normally Vit A is always available to form new retinal when needed.

- When retinal is in excess, it can convert into vit A and store in that form .

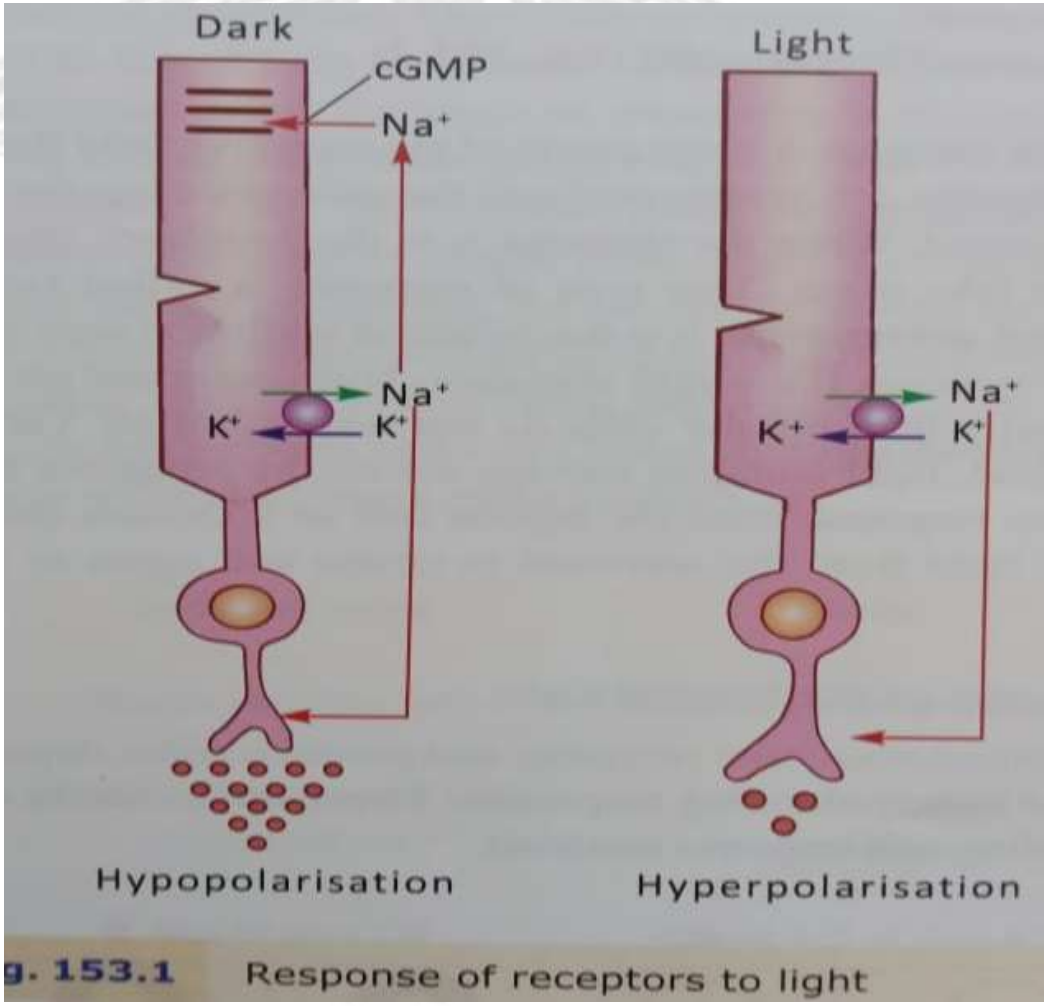
- Vit A acts as a store house for rhodopsin resynthesis

- **Night blindness or nyctalopia**
- Inability to see in dimlight
- For dimlight vision rhodopsin is necessary.
- Rhodopsin can be resynthesized from vit A
- Continous supply of vit A is essential.

Vit A deficient people suffer from night blindness because adequate amount of rhodopsin cannot be synthesized. This can be prevented by administering therapeutic doses **of Vit A**

Phototransduction (electrophysiology)

- Is the process by which light energy is converted into receptor pot. in visual receptors

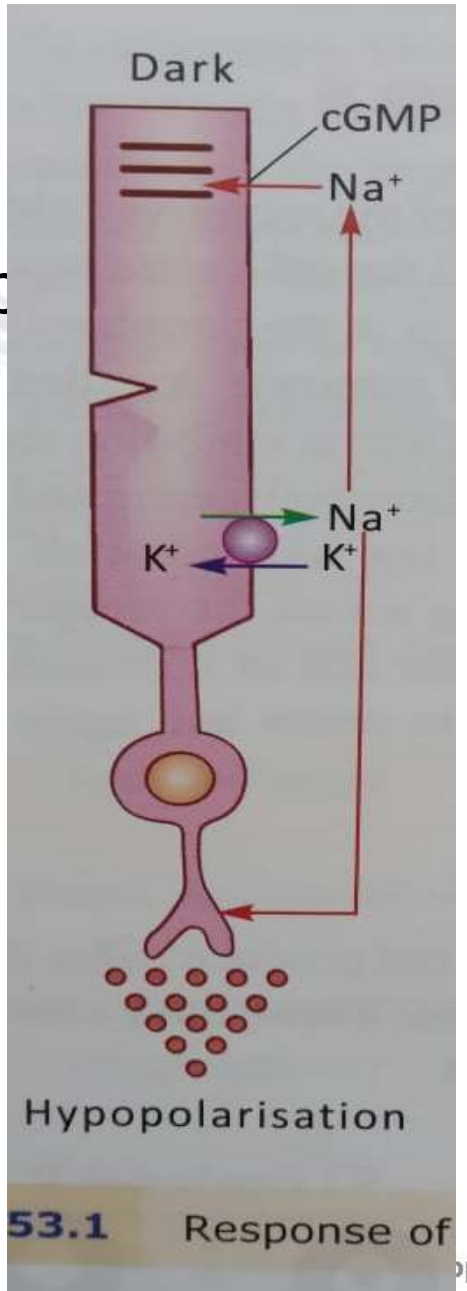


- **<u>In dark</u>** (ie, in resting condition)

  In Inner segment

- Na+ is actively pumped out from inner segment of rod by Na+K+ pump

-Then **in interior –vity is increased**



- **In The outer segment**
- Na channels kept open by cGMP ,Through them Na ions returns into rod continuously in the dark

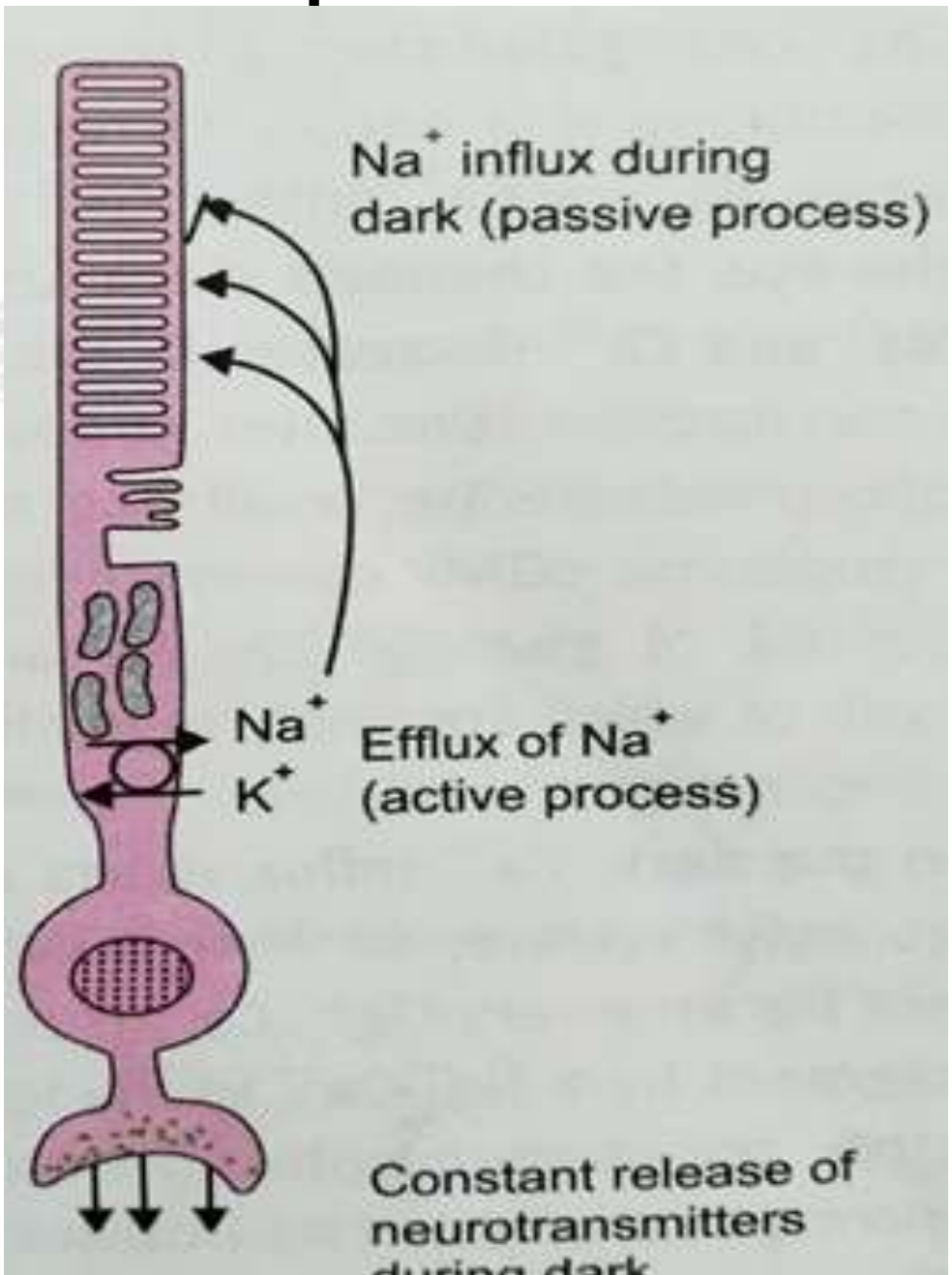
- This is called dark current. This decreases negativity upto – 40 mv---depol occurs

----results in continuous release of **NT glutamate** (which inhibit bipolar cells indirectly in dark)

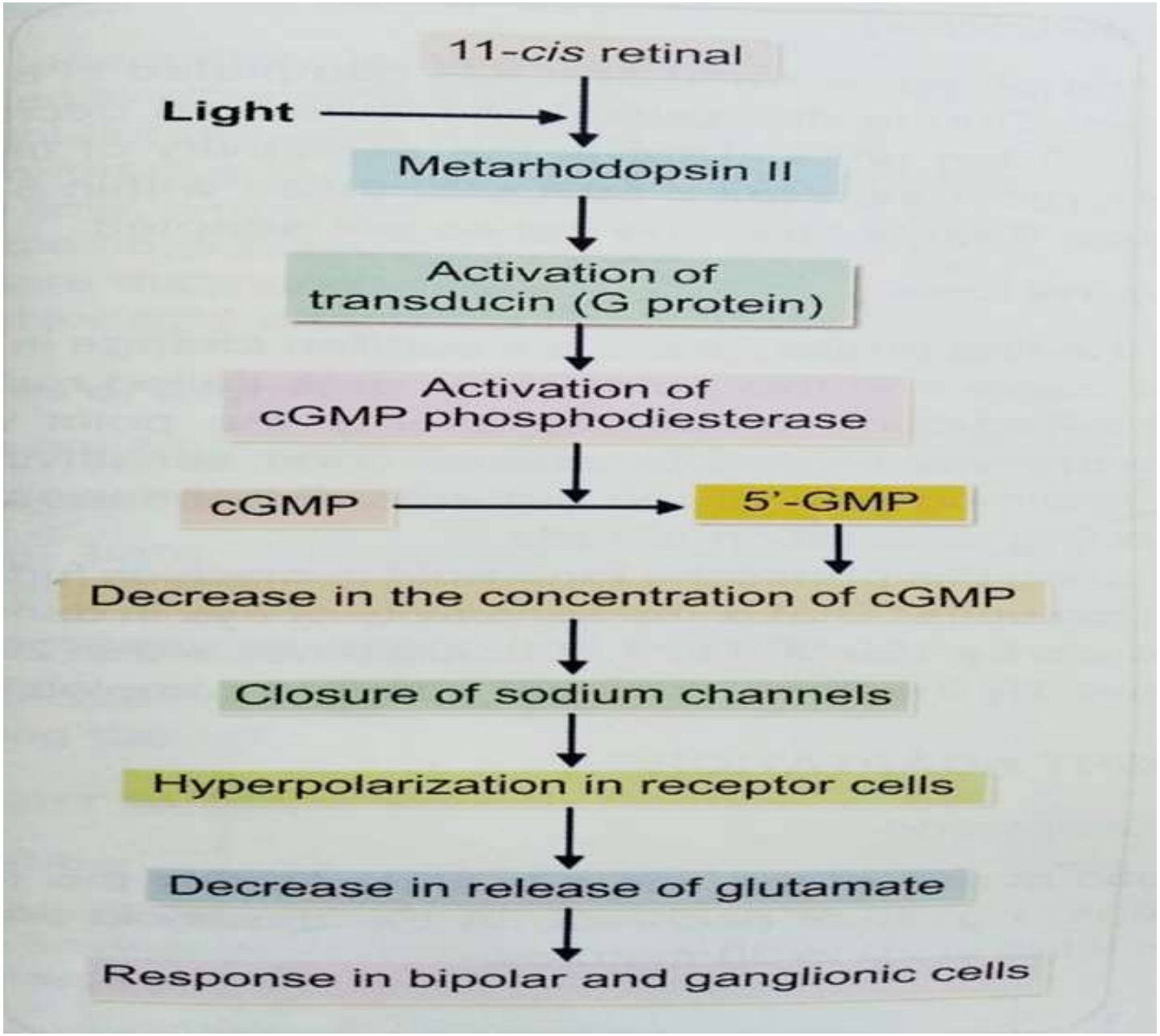
ie, rmp = - 40 mv , in dark----depol.

- (In all other cells, rmp = -70 mv -- -90 mv)

Rmp of rod



Phototransduction cascade



- **When light falls on retina** , the rhodopsin is excited & leading to the development of receptor pot in the rod cell.
- **When light falls**

1 rhodopsin ---→metarhodopsin II

2 -metarhodopsin II activates a G-protein called **transducin**

3 The activated transducin activates enzyme cGMP phosphodiesterase.

- 4. It hydrolyses cGMP to 5'GMP
- 5. Conc. of cGMP is reduced
- 6. Na channels close and prevents entry of Na ions leading hyperpolarization

  - 70 mv – 90mv

- 7. decreased release of glutamate
- 8. stimulation of bipolar cells and thus an AP develops in ganglion cells

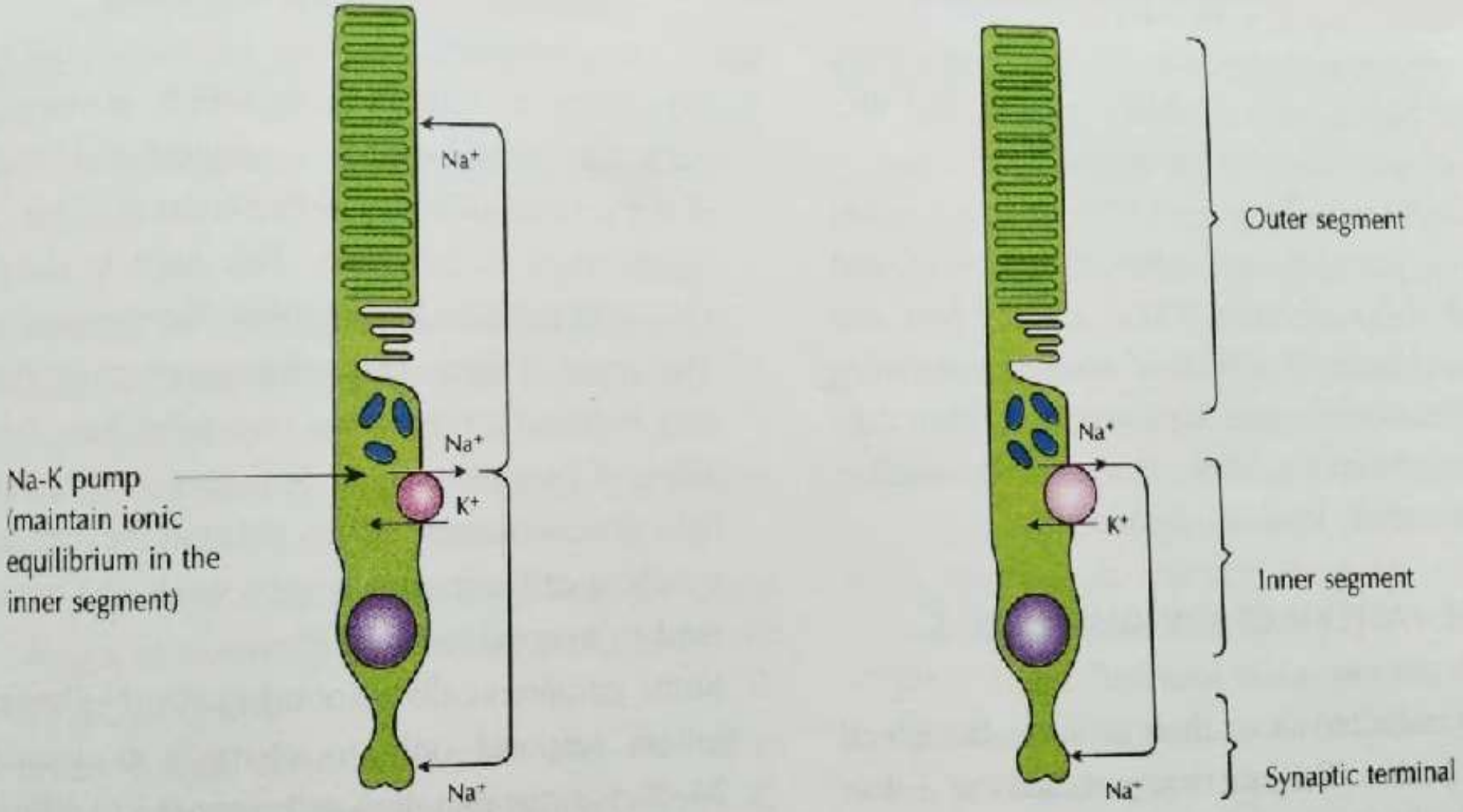
- 9. Transmission of AP to visual cortex through visual pathway.

Significance of hyperpolarization

Hyperpol. reduces release of synaptic NT glutamate

It leads development of response in bipolar and ganglionic cells

Therefore action pot is transmitted to visual cortex through optic pathway



In the Dark

In the outer segment (cGMP by opening Na^+ channel increases its permeability and depolarizes the receptor, resulting in continuous release of synaptic transmitter)

In the Light

(Decrease in intracellular cGMP closes Na^+ channels, resulting hyperpolarization reduces the release of synaptic transmitter)

Fig. 12.110.32 Effect of light on current flow and release of synaptic transmitter in photoreceptors.

.	Dark	Light
Visual receptors	Depol - 40 mv	Hyperpolarisation - 70 - -90 mv
Synaptic terminal	Release inhibitory NT glutamate	Decrease release NT
Bipolar cells	Not activated	Depol
Ganglion cells	Not activated	Excited

- End