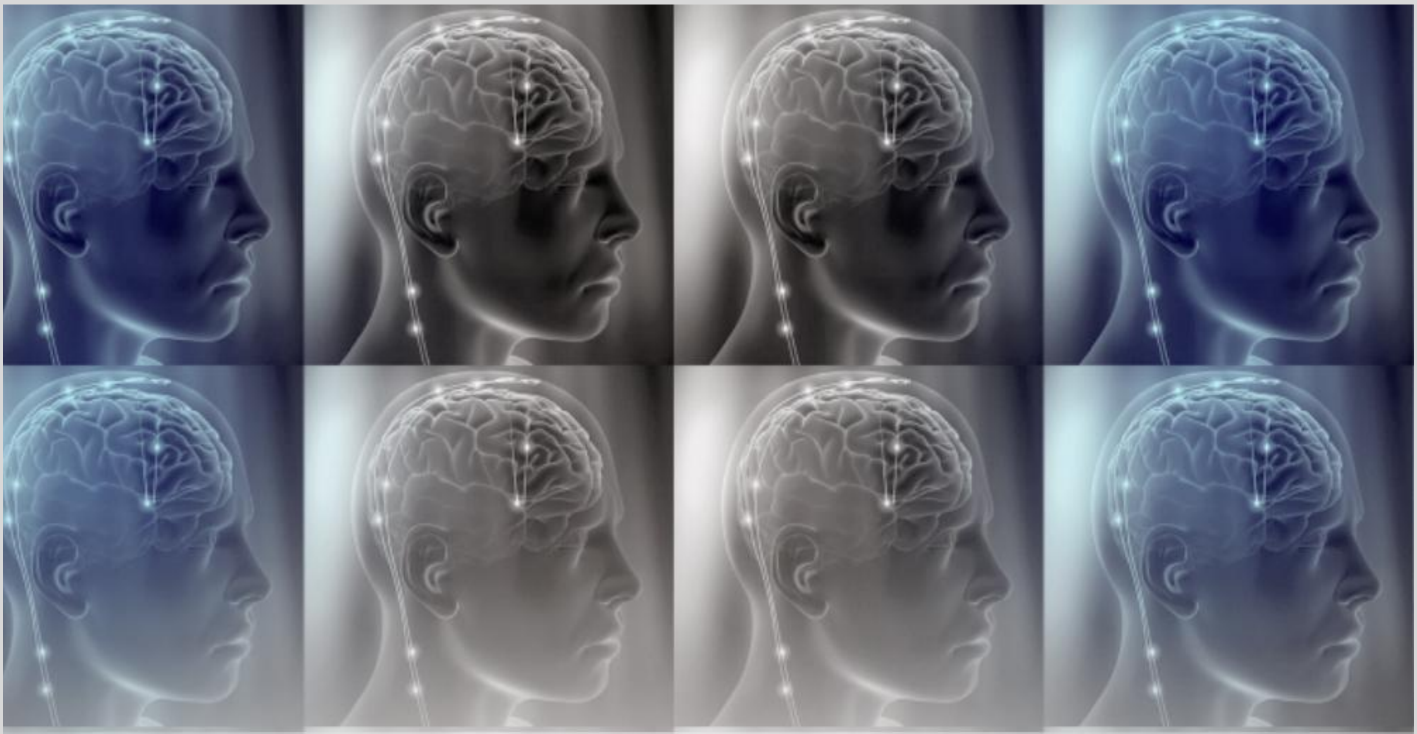


431

CNS
central Nervous System

Block

Physiology Team

	Female Side	Male side
Done By :	Jumanah Al-Shammari	Abdullah Almazyad
Revised By:	Rawan Almisned	

CNS Block

central Nervous System

Slide No.(1)

Vision

Phototransduction of light

By

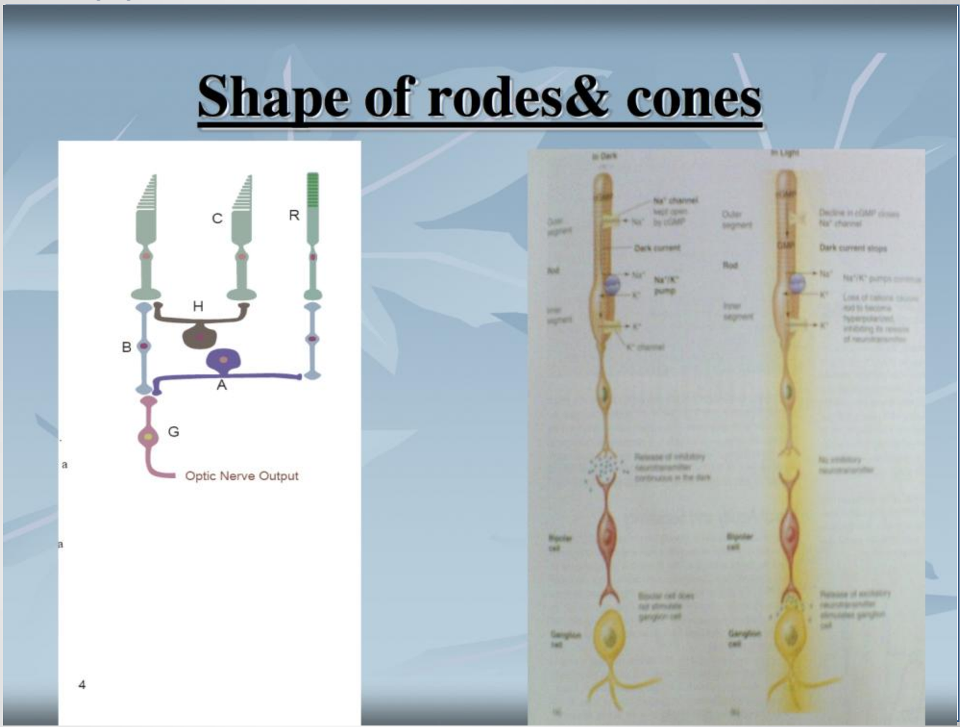
Dr/Faten zakareia
King Saud University
Physiology Dept

Team Notes :

CNS central Nervous System

Block

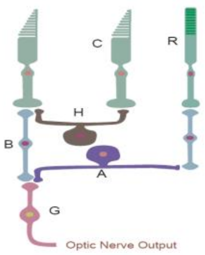
Slide No.(2)



Team Notes :

Slide No.(3)

- **Receptors of vision (Rods&cones):-**
- **1- Outer segment (modified cilia) has disks full of photosensitive pigment (rhodopsin) react with light to initiate A.P**
- **-In cones is conical , small and contain 3 types of rhodopsin**
- **- in rods it is big, rode like and contain one type of rhodopsin**
- **-There are Na channels in the outer segment**
- **2- Inner segment full of mitochondria (source of energy for Na-K pump), it is thick in cones**
- **There is Na-K pump in inner segment**



Team Notes :

A.P= Action Potential

-Na-K pump is active pump which needs energy therefor the inner segment is full of mitochondria.

CNS central Nervous System Block

Slide No.(4)

Visual Receptors: Rods and Cones

Rods	Cones
-abundant in the periphery of the retina	- abundant in & around fovea
-best for low light conditions	- best for bright light conditions
-see black/white and shades of gray	-see all colors

Team Notes :

#aevof dnuora & retnec eht ni tnadnuba era senoC

noisiV cipotohP→senoC

noisiV cipotocS→ sdoR

Scotopic vision (Rods) → incapable of resolving the details and bounders of the objects or determining their color .

Photopic vision (cones) → it can resolve the derails and bounders of the object or determining their color .

Slide No.(5)

- **Convergence:-**
- **low convergence in cones / each foveal cone synapse with →one bipolar cell →one ganglion cell →single optic nerve fiber**
- **Value of low convergence //increases visual acuity → integrated information from small area of retina**

Disadvantage// decreases sensitivity to light i.e need high threshold of illumination to stimulate cones)

Team Notes :

-Value of low convergence increases the behavioral ability to resolve fine image details

-The disadvantage is usually in the cones

CNS Central Nervous System Block

Slide No.(6)

- 2- high convergence of rods/
- several rodes about 300 synapse with one bipolar cell& one ganglion cell
- -high convergence/// decreases visual acuity acuity = integrated information from large area of retina
- - but increases sensitivity to light i.e so low light threshold stimlate the rods)
- 3- 120 million rode& 6 million cone &1.2 million optic nerve fibers , so convergence is 105 receptor : 1 fiber.

Team Notes :

-Rods are the complete opposite of cones

-The Convergence is from 105 receptor*mostly rods*to one nerve fiber

CNS
central Nervous System
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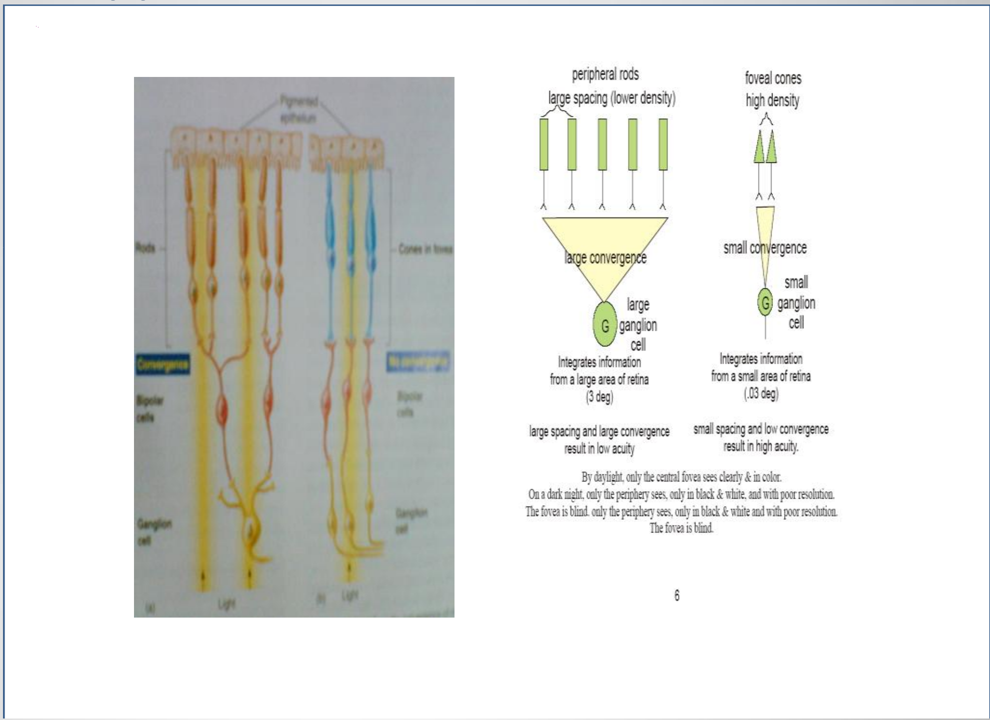
Slide No.(7)



Team Notes :

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Block

Slide No.(8)

Genesis of photoreceptor potential

- -Rodes &cones potentials are graded, local potential (generator potential) propagated as A.P in ganglion cells.
- -Ganglion cell action potential (all or none A.P) transmitted to optic nerve.
- Rodes &cones & horizontal cells & Bipolar cell responses are depolarization at dark and hyperpolarization at light

Team Notes :

A.P = Action Potential

-Generator Potential is like action potential but graded

CNS
central Nervous System
Block

Slide No.(9)

- - Cones respond to **high** levels of light intensity (illumination)
- -Rods respond to levels of light intensity (illumination) **below** threshold levels for cones, so **rods** are **more sensitive**
- s

Team Notes :

CNS central Nervous System

Block

Slide No.(10)

- **Photosensitive compounds:-**
- 1- In cones it is rhodopsin formed of :-
- Opsin protein + retinene 1 (retinal = aldhyde form of Vit A) = visual purple
- 2-There are 3 types of rhodopsin in 3 types of cones each respond to a certain wave length of light
- 3-In Rods its rhodopsin formed of /
- Scotopsin protein + retinene 1
- It is stored in disks of rods at outer segment
- -It forms (90% of its protein)
- -At dark rhodopsin is in 11-cisretinal form (inactive) but light sensitive form which increase sensitivity of rods to light

Team Notes :

11-cis- retinal (inactive) is light sensitive *can work in minimal light*

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Slide No.(11)

- Ionic basis of photoreceptor potential at dark
- -In dark Na channels in rods outer segment are open
- -Na-K pump in inner segment pump Na
- -Na flow from inner to outer segmet (called Na current) ⟶ Depolarization flow to synaptic endings ⟶ steady release of neurotransmitter at synapses with bipolar cells ⟶ which get depolarization potential →ganglion cells

Team Notes :

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Slide No.(12)

ELECTROPHYSIOLOGY OF VISION (PHOTOTRANSDUCTION)

- **A-At Dark (scotopic vision, dimlight vision):-**
- **1-Rhodopsin in 11-cisretinal (inactive form-light sensitive form which increase sensitivity of rods to light)**
- **2- (5 –GMP) in the c-GMP form**
- **c-GMP at c-GMP gated Na channels, it bound to proteins at Na channel membrane & keep them open) → opening of Na channels at outer segment → allow Na influx- → depolarization.**
- **3- Dark current (Na current):- At the inner segment Na pumped by Na- K pump to outside & re-entered through Na channels (at outer segment) .**

Team Notes :

Na-channels in the outer segments is surrounded by c-GMP(not 5-GMP) which keeps it open

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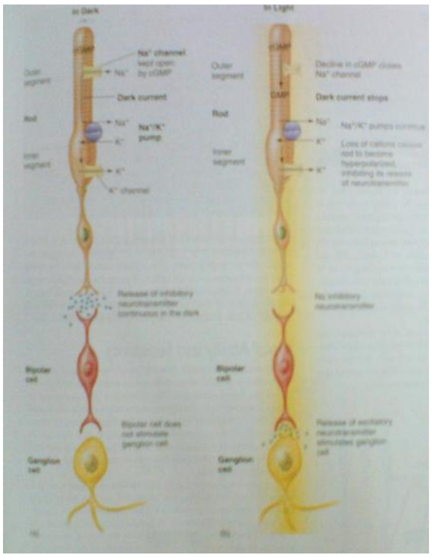
Slide No.(13)



Team Notes :

CNS central Nervous System

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Slide No.(14)

4- A wave of depolarization spread to synaptic terminals.

5- Synaptic mediators are continuously (steadily) released (mainly glutamate + Ach + dopamine + GABA.)

6- Response in bipolar cells(depolarization) → ganglion cells- → AP in optic nerve- → vision at dark.

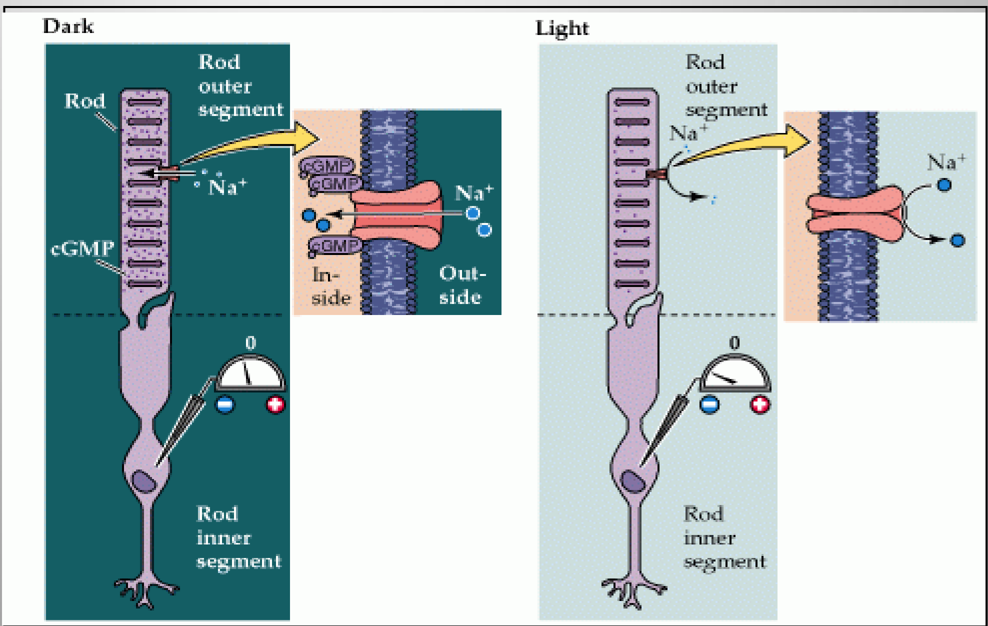
NB/

1-at dark rhodopsin is inactive (cis-retinal needs light for its activation) / inactive rhodopsin is essential for depolarization

- its inactivation keeps Na channels open& Na current occurs,this is the causative factor for depolarization.

2-at dark rhodopsin is regenerated from retinine + scotopsin

Team Notes :



Slide No.(15)

B-Incident light (PHOTOPIC VISION)

- - Light- ⟶ Conformational change of photopigment retinine-1 in rhodopsin (11-cisretinal form changed to ⟶
- all-trans isomer called metarhodopsin II which is an active rhodopsin) ⟶Activation of G – protein (transducin) ⟶ activation of phosphodiestrase enzyme ⟶ conversion of c-GMP to 5- GMP ⟶ Decreased intracellular c-GMP ⟶ closure of Na channels in outer segment .
- -but still Na pump out of inner segment ⟶ Hyperpolarization of photoreceptors (-70 ~ -80)

Team Notes :

Useful link

http://www.youtube.com/watch?v=Fm45A4yjmvo

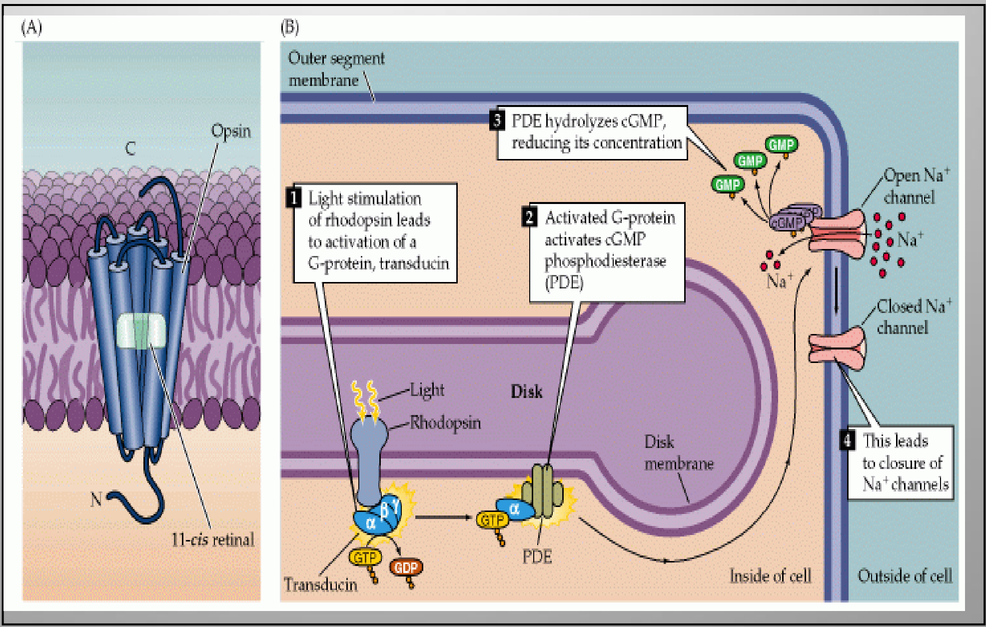
CNS Block

Slide No.(16)

- **Hyperpolarization → <u>Decreased</u> release of synaptic transmittere→ R sponse in bipolar cells (hyperpolarization) (this cause <u>decreased</u> release of inhibitory synaptic transmitter) → G nerator potential in amakrine cells & ganglion cells (depolarize) → AP → optic nerve → optic pathway**

- **NB/**
- **-these reactions occur in both rods &cones but in rods occur at low illumination as in dimlight & in cones at high illumination.**
- **- in cones 4 times faster**

Team Notes :



CNS central Nervous System
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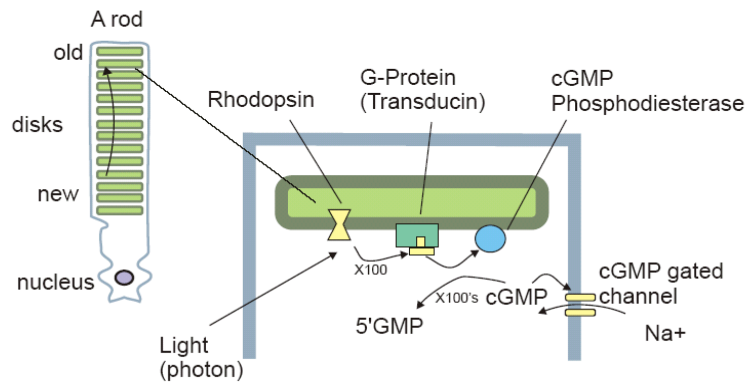
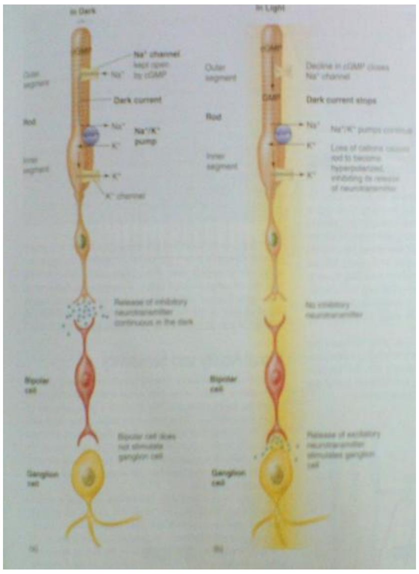
Slide No.(17)



Team Notes :

CNS Block

Slide No.(19)



Team Notes :

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Central Nervous System
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Slide No.(19)

- <u>**Synaptic mediators in retina:-**</u>
- **Ach, glutamate, dopamine, serotonine,GABA, substance P,somatomedin, VIP, enkephalins, glucagons,neurotensin.**
- <u>**In dark:-**</u> **all transmitters are** <u>**continuously (steadily)**</u> **released by depolarization of rods depolarize bipolar cell →generator potential → AP ni ganglion cells**
- <u>**In light:-**</u> **hyperpolarization of the receptors** <u>**decrease inhibitory**</u> **transmitter release →→ depolarize amacrine cell →e nerator potential → A i ganglion cells.**

Team Notes :

VIP= Vascular inhibitory peptide

AP= Action Potential

Dark: all transmitters are released steadily by large amounts

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Slide No.(20)

*-metarhodopsin II (in rods&cones)decompose by light into:-

- Retinine 1 + scotopsin

-Retinine 1 + scotopcin at dark → vit A + scotopsin → rhodopsin regeneration

- then decompose by light.

* NYCTALOPIA:- (night blindness)

-- Vitamine A deficiency cause rods , cones & retinal degeneration & loss of rods

-- R / vit A if receptors are well.

Team Notes :

-The Reason for nyctalopia is that without vitamin A, the amounts of retinal and rhodopsin that can be formed are severely depressed.

-In severe cases the rods are degenerated and it won't benefit from vitamin A

Slide No.(21)

Dark adaptation:-

- -When a person moves from lighted environment → a dimly lighted environment, the retina becomes more sensitive to light & the person will see at dark (accustomed to dark) in about 20 min.(only gross features but no details or colors) .
- - Rhodopsin in darkness is essential for depolarization of rodes to see in dark
- (Na channels to open & for dark adaptation)
- -Once light enters the eye metarhodopsin from rhodopsin initiates cycle of events for light vision.

Team Notes :

-You can't see any colors in the dark because you're only using Rods *(without cones)*

-Dark adaption takes about 20 min. to make rhodopsin

CNS
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Slide No.(22)

- <u>Dark adaptation has 2 components:-</u>
- 1- rapid (about 5 minutes) drop in visual threshold .
- Fast dark adaptation of <u>cones</u> , only in fovea
- -sensitivity of cones to light increase to see at that time.
- 2- less rapid (till 20 min) drop in visual threshold .
- - dark adaptation of <u>rodes</u> in the peripheral retina
- - sensitivity of rodes to light increase, in 1 min increase 10 folds
- (rodes increase their sensitivity to light by convergence 300:1 ganglion cell , so summation at ganglion cells potential will increase sensitivity of rods to light)

Team Notes :

Slide No.(23)

- **<u>N.B</u> (20 min for dark adaptation are for regeneration of rhodopsin → increase sensitivity of rodes to light → a drop in visual threshold**

- **Q- Why radiologists & aircraft pilots wear red goggles in bright light?**
- A- Light wavelength of the red (at end of spectrum) stimulate the cones & stimulates rods to some extent, so red goggles for rods act as dimlight, so with it rods are adapted to darkness & form large amounts of rhodopsin while the person in bright light & when person enter dark places he can see well & not remain 20 mint.

- **<u>2-Light adaptation:-</u>**
- **-When light switched on again, the rodes are knocked out of action (they stop sending AP at high levels of light) & cones start to function to adjust & adapt to the level of brightness in 5 min this is called <u>Light adaptation</u>**

Team Notes :

Questions

1- Which of the following is a step in photoreception in the rods?

A. Light converts all-*trans* rhodopsin to 11-*cis* rhodopsin

B. Metarhodopsin II activates transducin

C. Cyclic guanosine monophosphate(cGMP) levels increase

D. Rods depolarize

E. Release of neurotransmitter increases

2- Which of the following statements is true :-

A. Rodes and cones are hyperpolarized at dark

B. Rodes and cones are depolarized at light

C. Rodes and cones are hyperpolarized at light

D. None of the above

Answers :-

1- B

2- C