

Vision 2

Phototransduction of Light

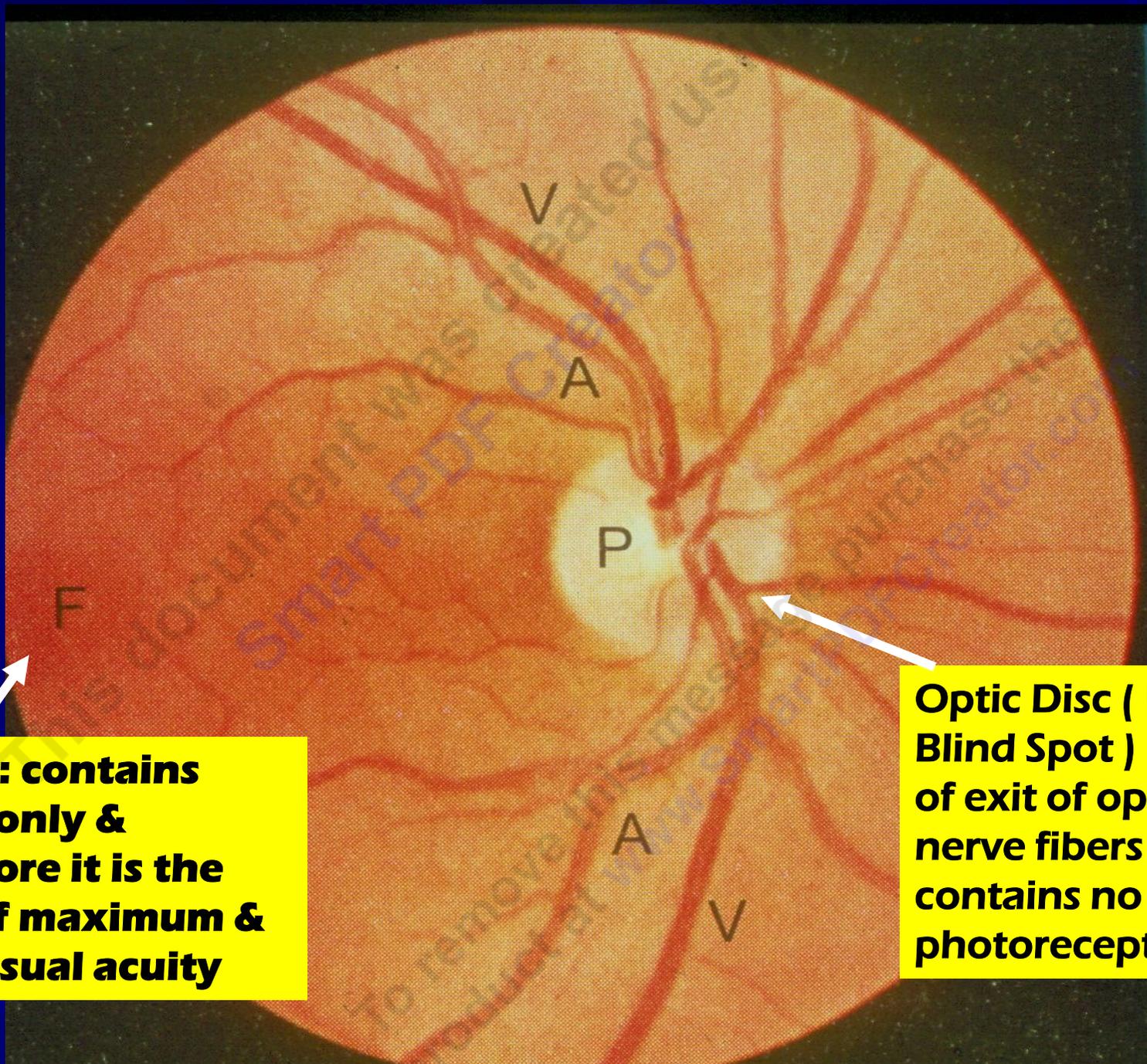
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Comparison Between Photoreceptors

- Rods : 120 millions
- Cones : 6 millions

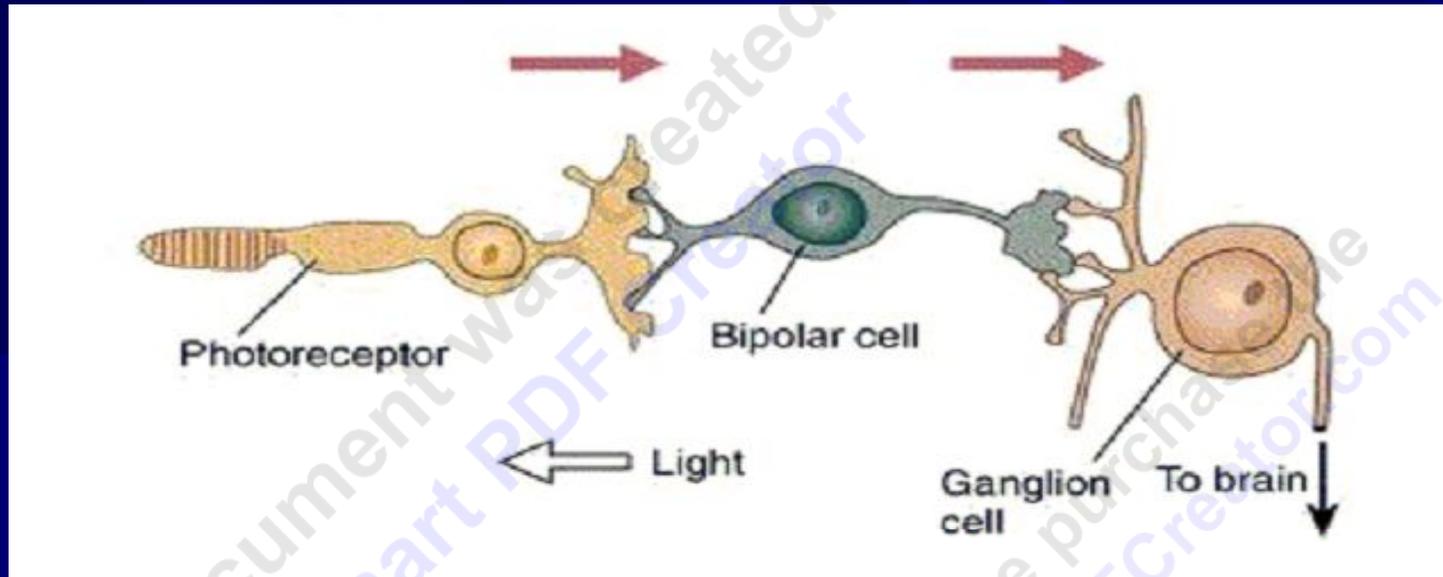
Cones	Rods
Maximum at Fovea	More at Periphery
Active at High light levels	Active at Low light levels
Good Visual acuity	Poor Visual acuity
Trichromatic (Color) vision (3 pigments)	Monochromatic
Detect all colors	Detect : black/white and shades of gray+ Flicker



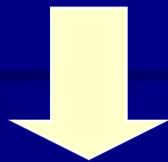
Fovea : contains cones only & therefore it is the area of maximum & best visual acuity

Optic Disc (Papilla , Blind Spot) : point of exit of optic nerve fibers , contains no photoreceptors

Convergence of Photoreceptors on Ganglion Cells



- 120 million rods
- 6 million cones
- 1.2 million ganglion cells



Convergence : 105 receptor per one ganglion cell (optic nerve fiber)

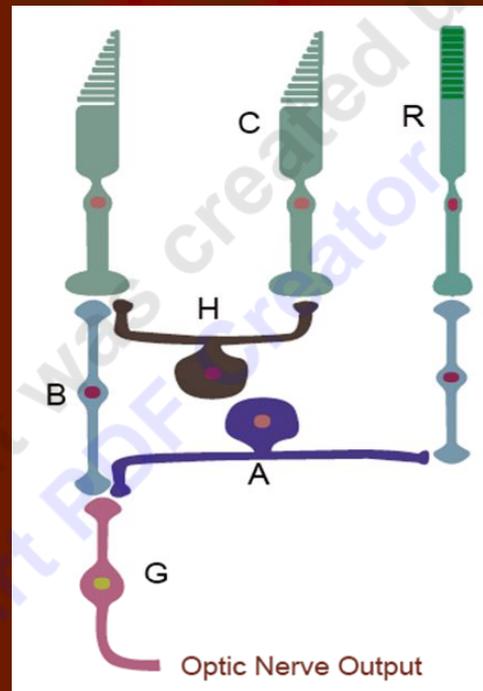
■ Convergence in Cones

- Cones have low convergence .
- Q : What are the consequences/significance of low convergence ?
- Low convergence :
 - (1) increases visual acuity
 - (2) decreases sensitivity to light

■ Convergence in Rods

- Rods have high convergence.
- Q : What are the consequences of high convergence ?
- (1) increases sensitivity to light
- (2) decreases visual acuity

Morphology of Visual Receptors



Outer Segment
of
Photoreceptor

- The outer segment of each photoreceptor has disks full of photosensitive pigment (pigment that reacts with light) → to initiate electrical potential
- In cones , the outer segment is conical , & contain 3 types of Rhodopsin
- In rods it is big,, rod-like , & contains one type of Rhodopsin

Electrophysiology of the Retina

Genesis of electrical responses

- Photosensitive compounds

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

Retinal photoreceptors mechanism

Light



Absorption by photosensitive substances



Structural change in photosensitive substances



Phototransduction



Action potential in the optic nerve

Electrical Potentials in the Retina

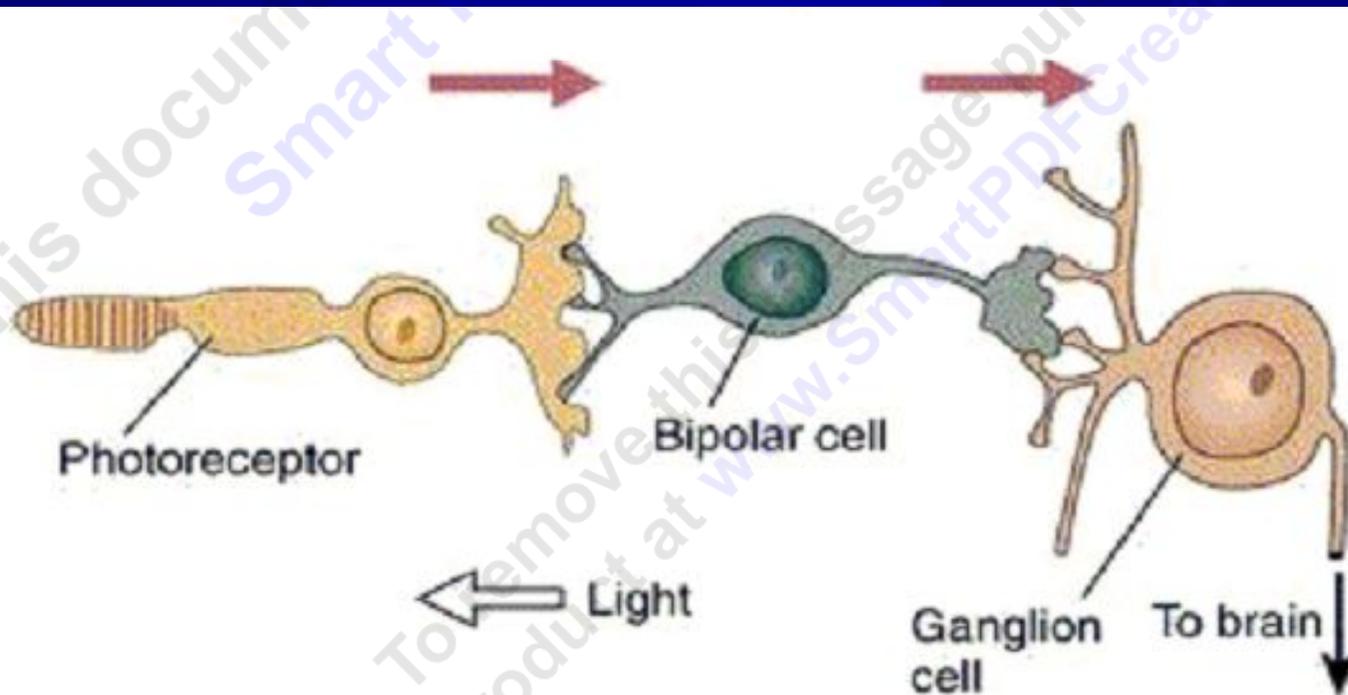
- Rods & cones potentials are **graded, local potential (generator potential)**
- Rods , cones, horizontal cells & Bipolar cell responses are depolarization at dark & hyperpolarization at light
- Graded local potentials act as generator potentials for the propagated AP in optic nerve fibers that is produced by ganglion cells.
- i.e., Ganglion cell responses are action potentials that obey All-or-None Law → transmitted along the optic nerve .

Retina: Neural Circuitry

Light hits photoreceptors, sends signal to the bipolar cells

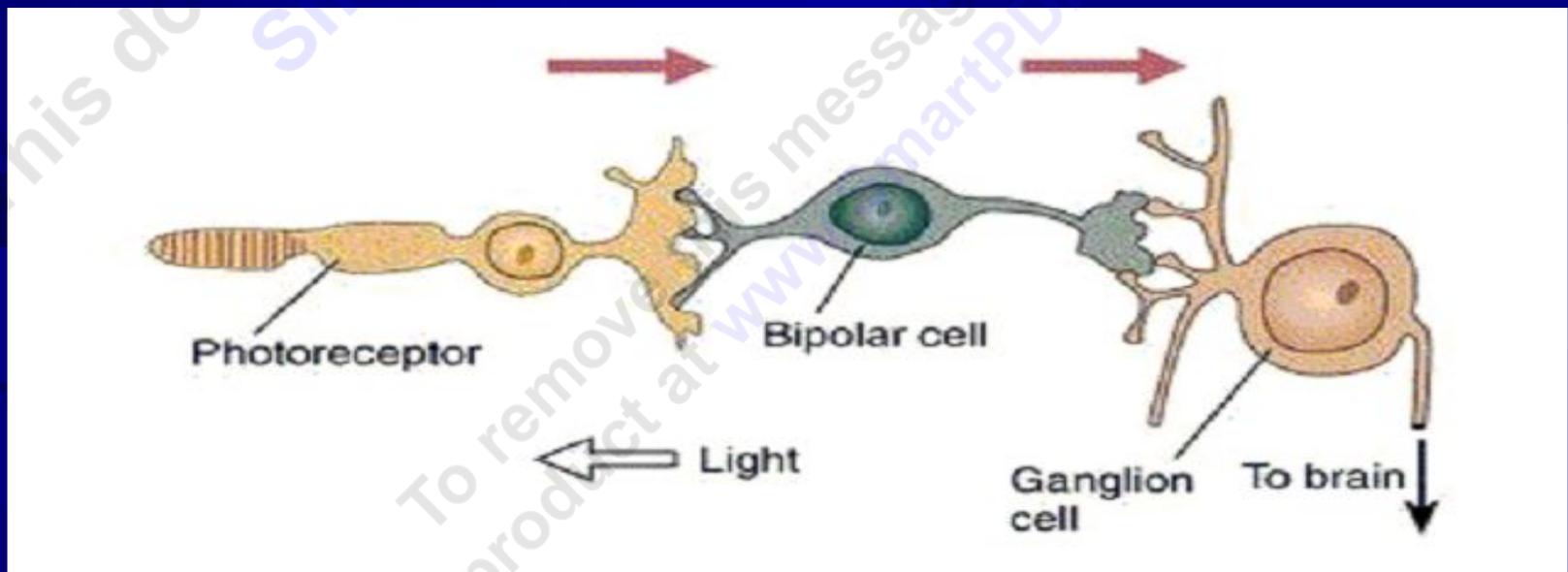
Bipolar cells send signal to ganglion cells

Ganglion cells send signal to the brain



Types of Electric Potentials Recording from Retinal Cells

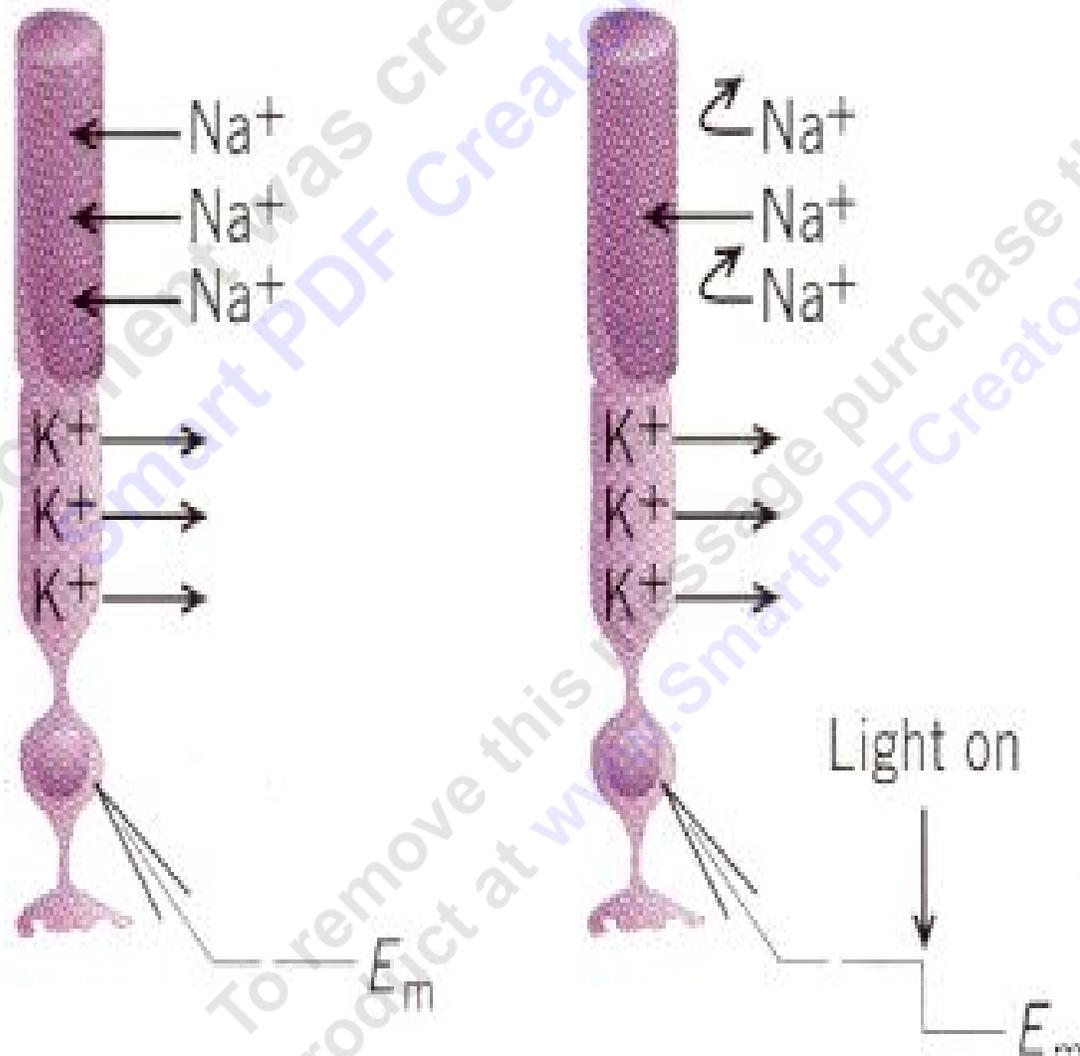
- **Rods & Cones: Hyperpolarization**
- **Bipolar cells: Hyper- & Depolarization**
- **Horizontal cells: Hyperpolarization**
- **Amacrine cells: Depolarizing potential**
- **Ganglion cells: Depolarizing potential**



B

Dark

Light



Photoreceptor compounds

■ Composition:

- Retinene1 (Aldehyde of vitamin A)
 - Same in all pigments
- Opsin (protein)
 - Different amino acid sequence in different pigments

Rhodopsin (Rod pigment):

Retinene + scotopsin

Photoreceptor compounds_{-cont}

Rhodopsin (visual purple, scotopsin):

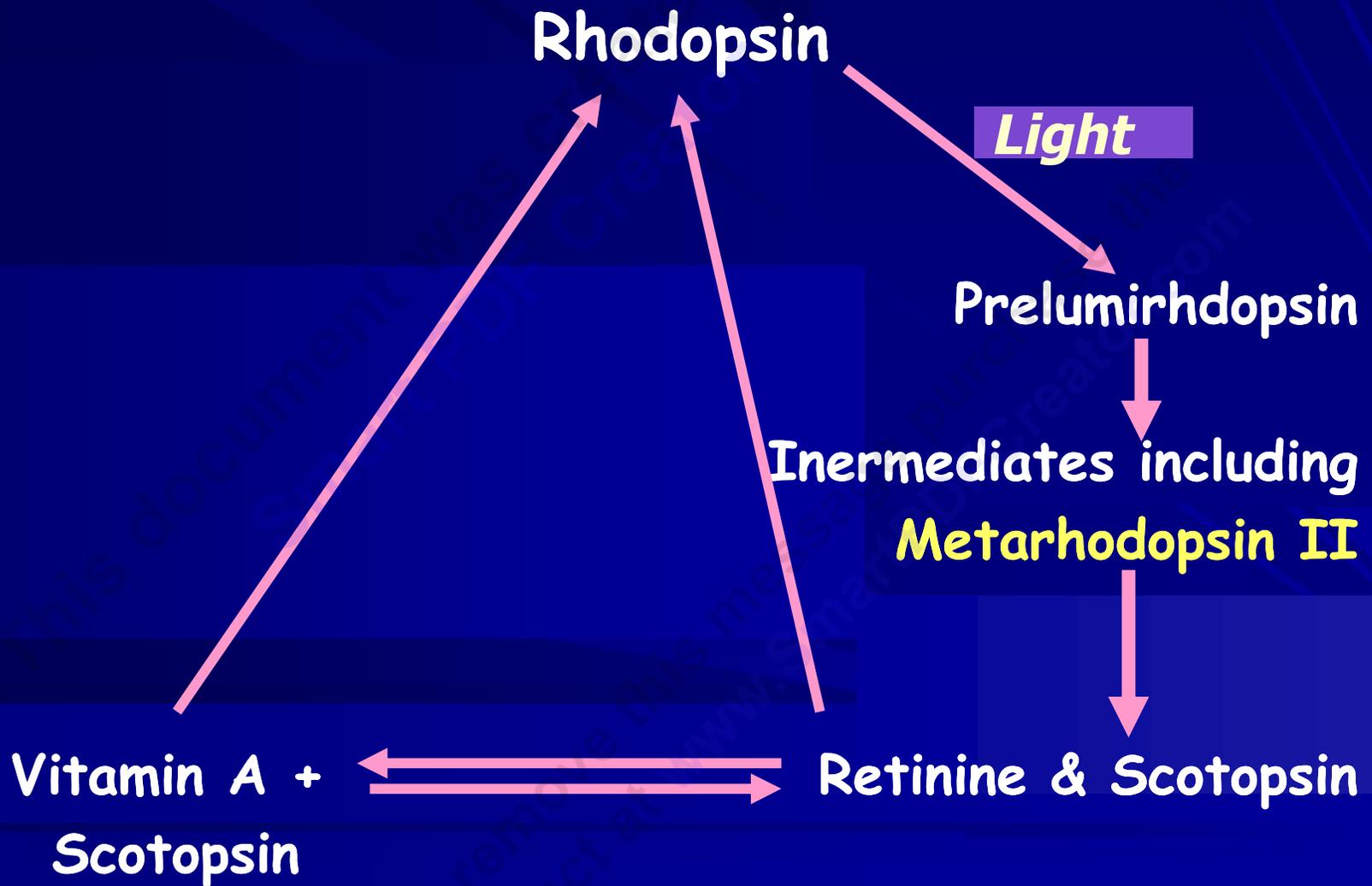
Activation of rhodopsin:

■ **In the dark:**

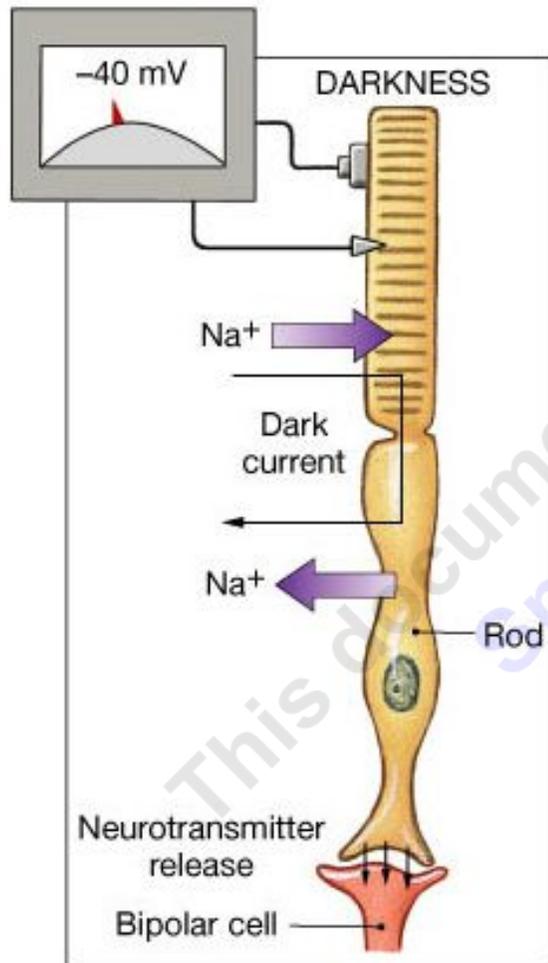
retinene1 in the 11-*cis* configuration



Visual cycle

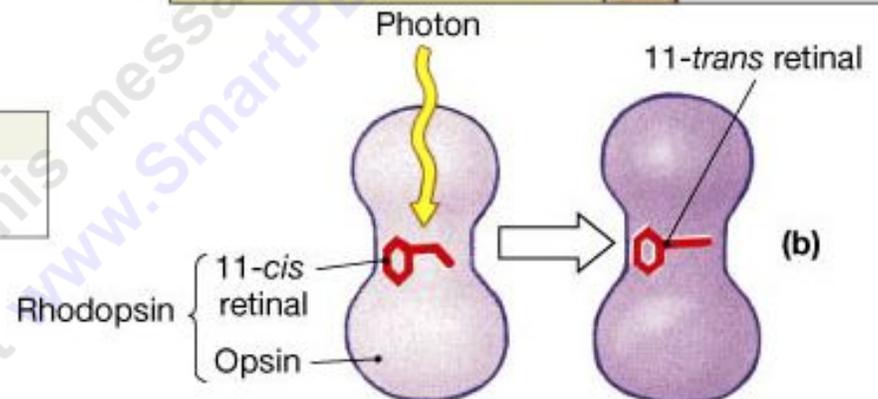
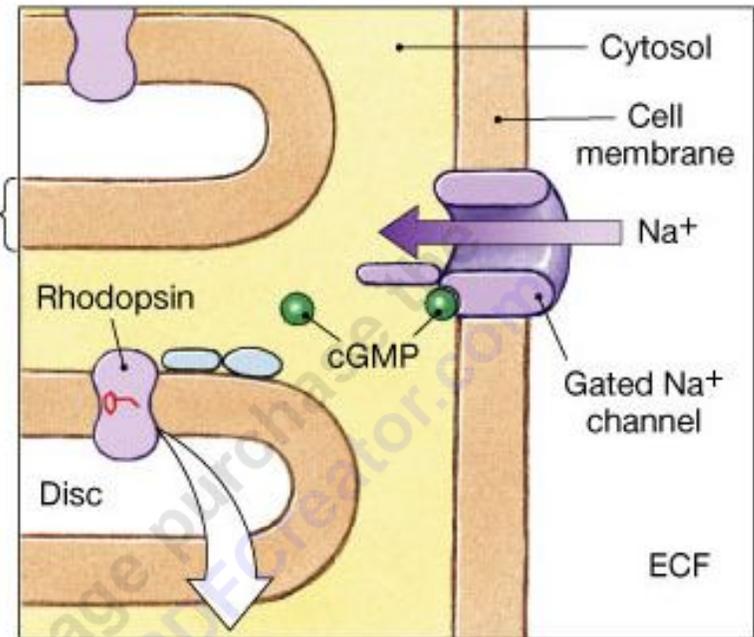


Photoreception

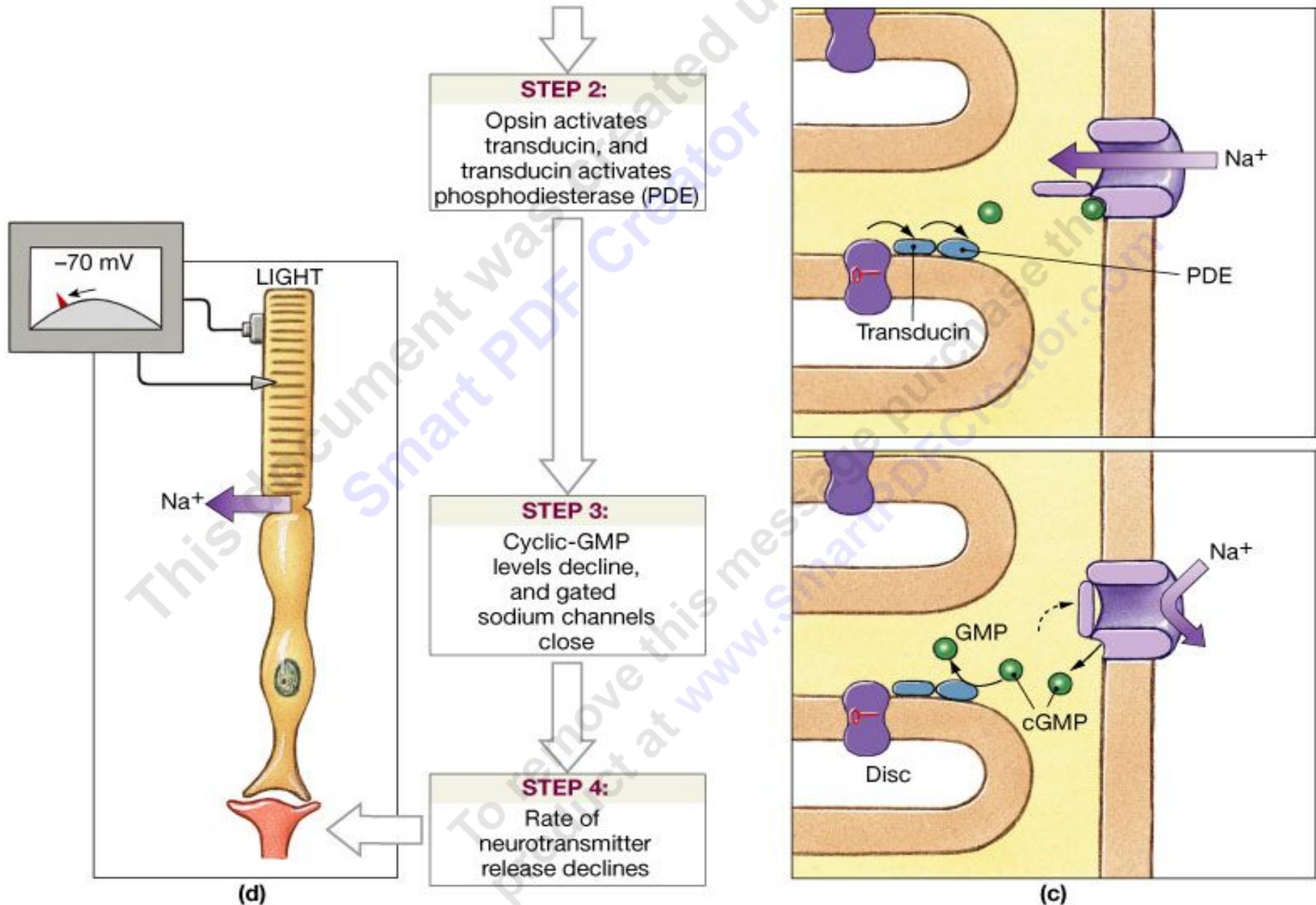


(a)

STEP 1:
Opsin activation occurs



Photoreception- cont.



Light



Change in photopigment



Metarhodopsin II



Activation of transducin



Activation of phosphodiesterase



Decrease IC cyclic GMP



Closure of Na channels



Hyperpolarization of receptor
Decrease release of synaptic transmitter
Action potential in optic nerve fibres

Dark adaptation

Dark adaptation

- Reaches max in 20 minutes
- First 5 minutes threshold of cones ↓
- 5 to 20 mins Sensitivity of rods

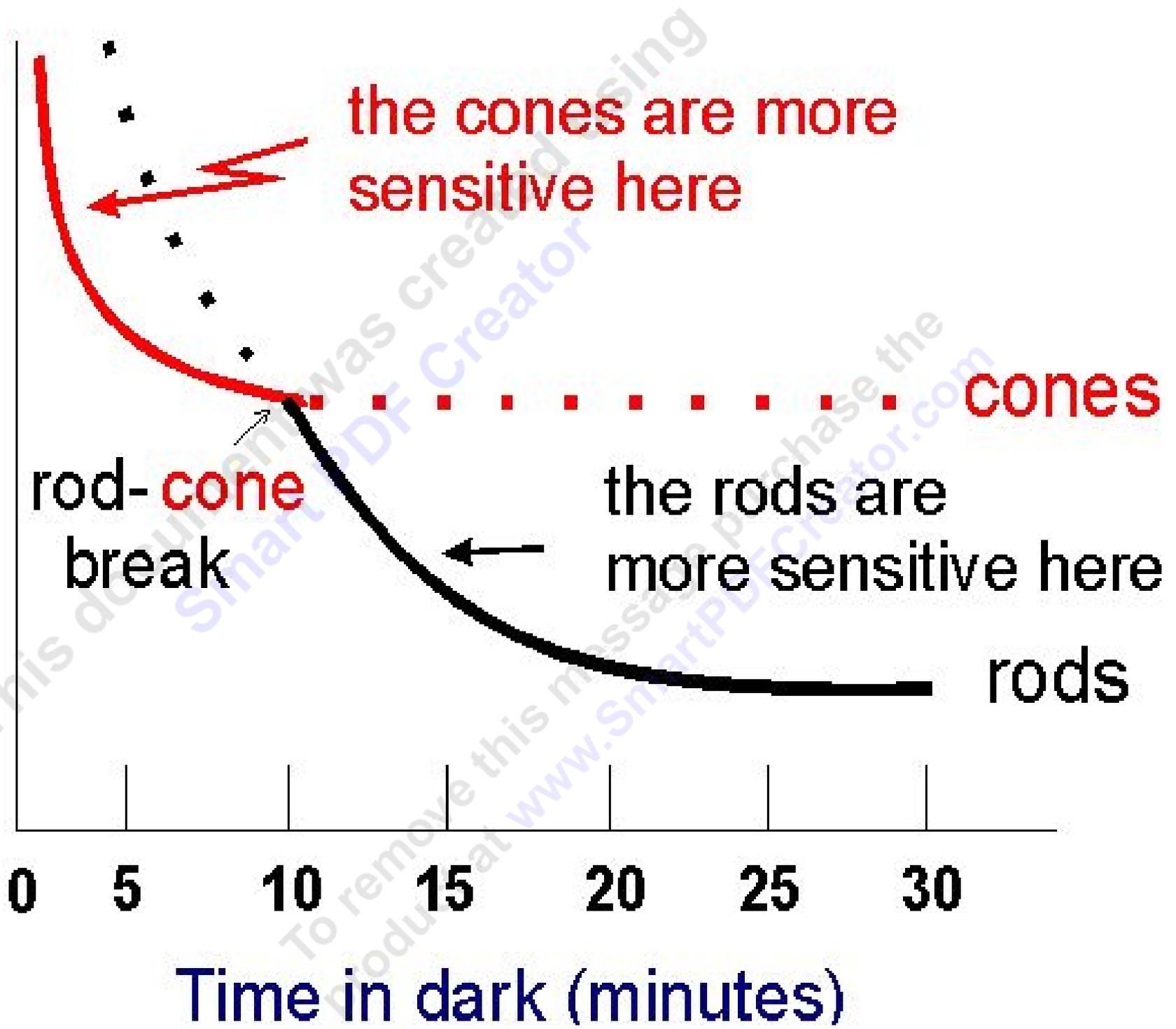
Mechanism of dark adaptation:

↑ Regeneration of rhodopsin

Threshold Intensity

hi

lo



the cones are more sensitive here

rod-cone break

the rods are more sensitive here

cones

rods

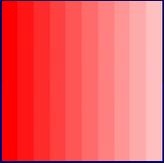
Time in dark (minutes)

Dark adaptation_{-cont.}

In vitamin A deficiency

What happens to Dark adaptation?

Night blindness
(Nyctalopia)



Thanks