

# Vision 2

## Phototransduction of Light

***Dr. Taha Sadig Ahmed,***

- *Medicine Bachelor and Bachelor of surgery ( MB, BS )*
- *PhD in Clinical Neurophysiology ( England ) ,*
- *Membership of the American Association of Neuromuscular and Electrodagnostic Medicine ( AANEM , USA)*
- *Consultant in Clinical Neurophysiology*

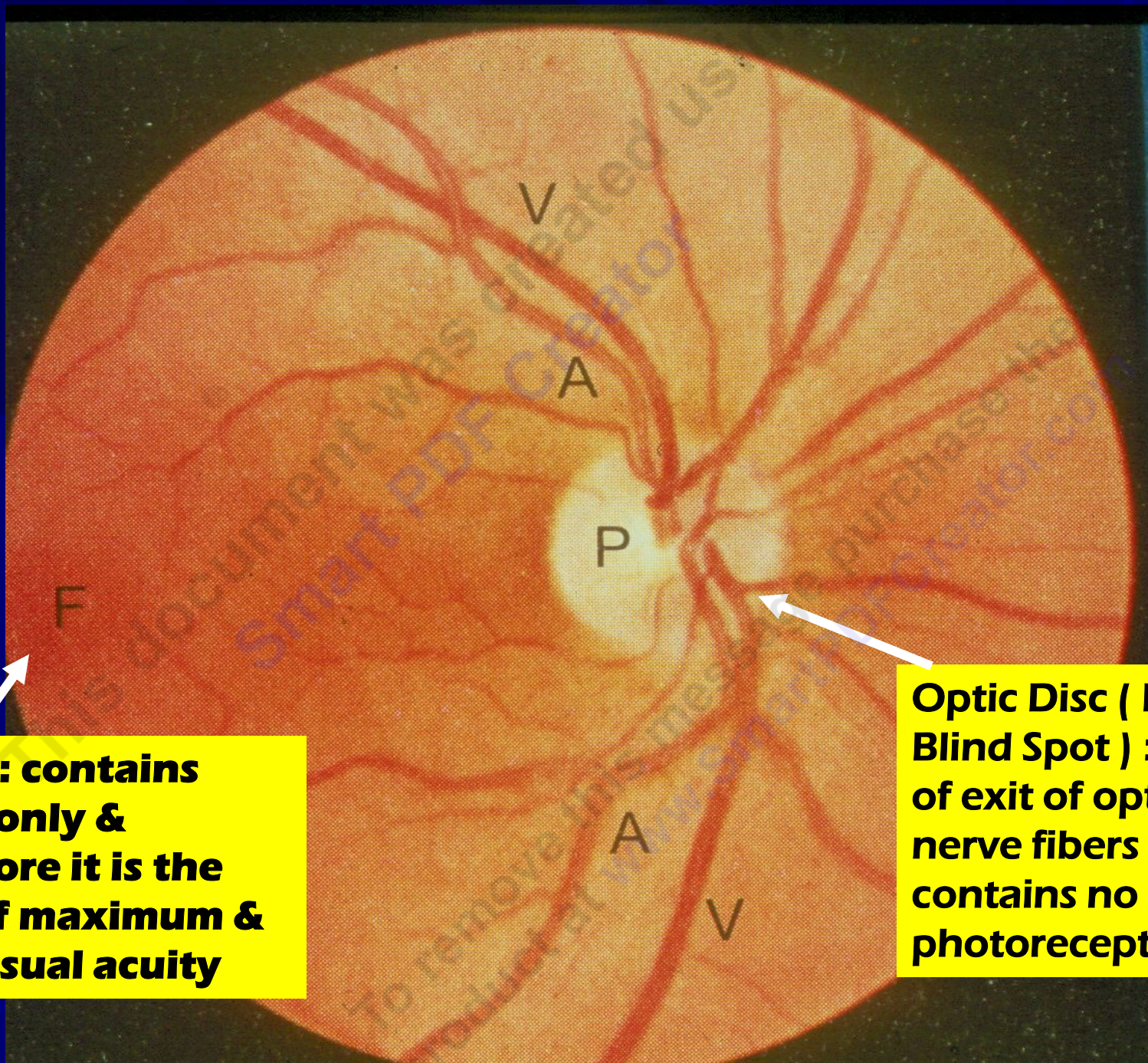
# Comparison Between Photoreceptors

■ 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



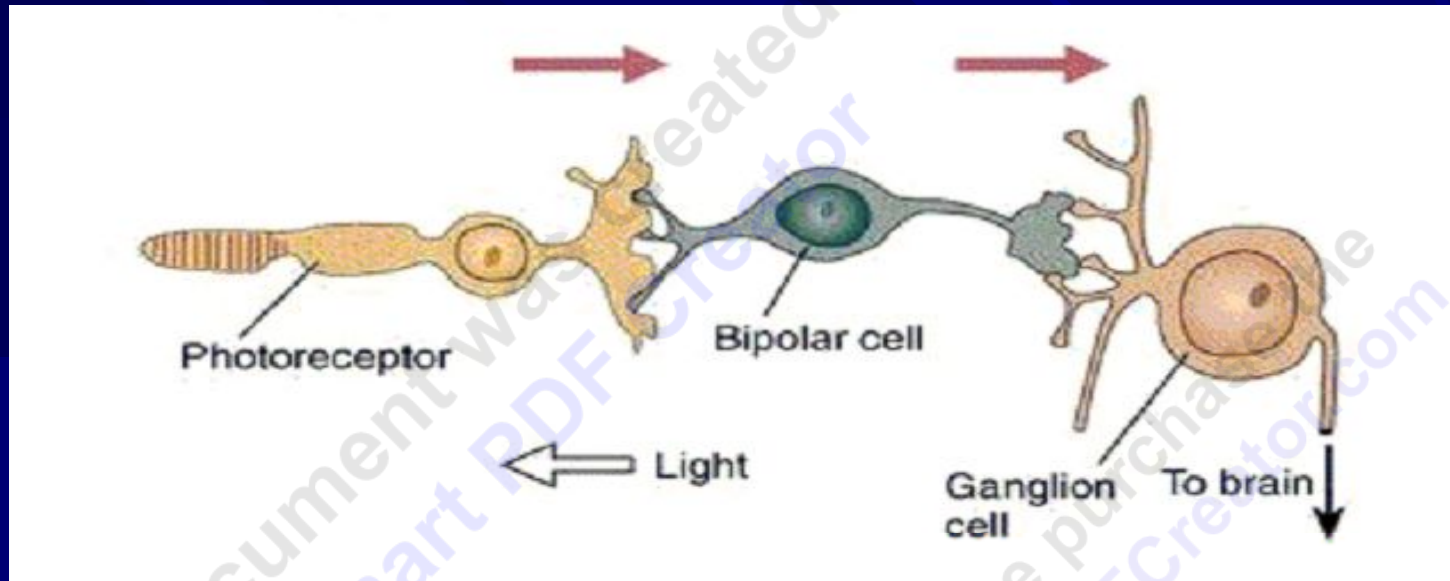


**Fovea : contains  
cones only &  
therefore it is the  
area of maximum &  
best visual acuity**

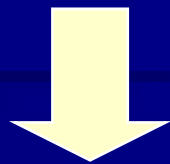
**Optic Disc ( Papilla ,  
Blind Spot ) : point  
of exit of optic  
nerve fibers ,  
contains no  
photoreceptors**



# 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 )

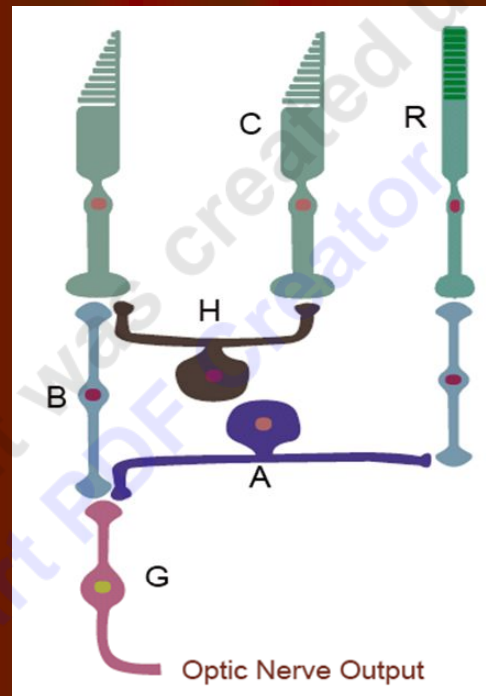
## ■ Convergence in Cones

- 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

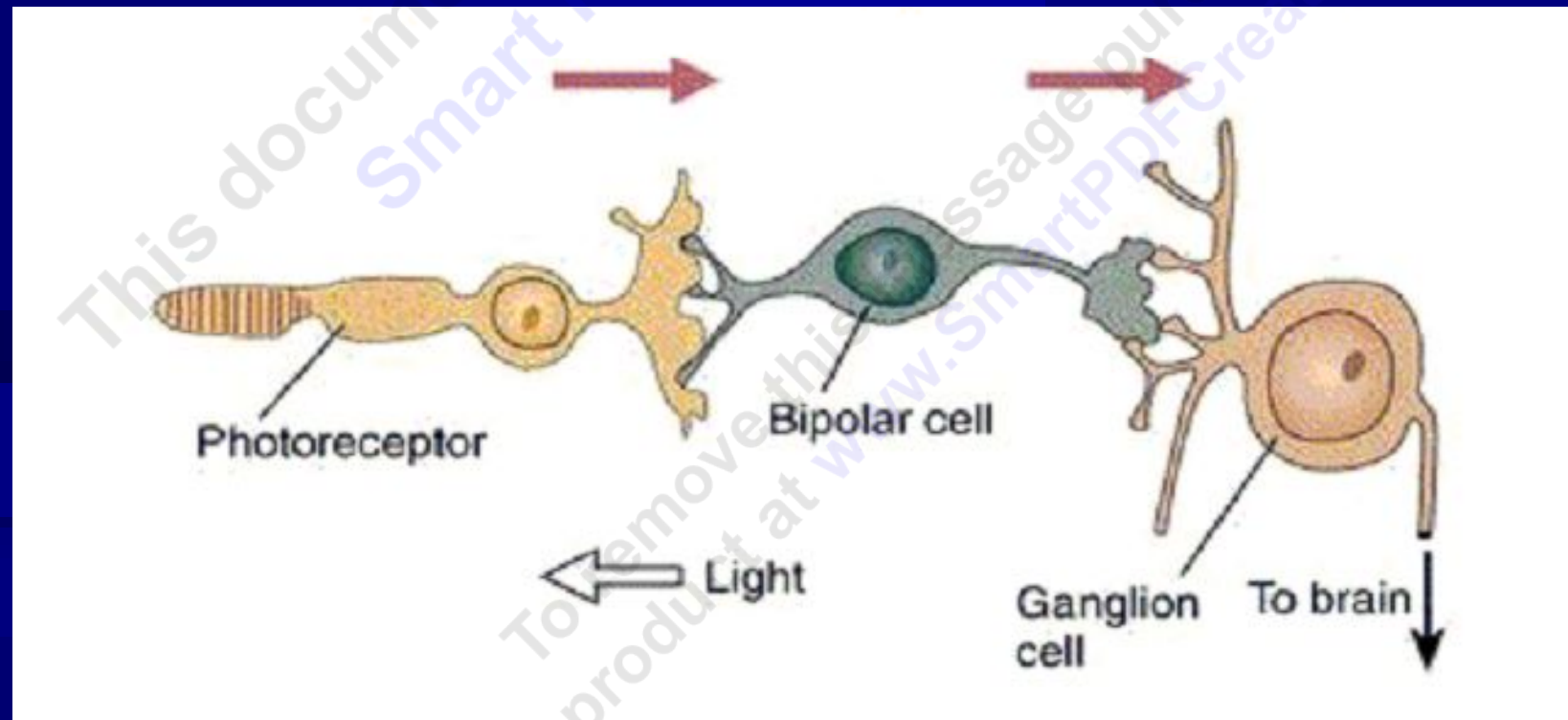
- Rods & cones potentials are **graded, local potential (generator potential)**
- Rods , cones, horizontal cells & Bipolar cell responses are depolarization at dark & hyperpolarization at light
- Graded local potentials act as generator potentials for the propagated AP in optic nerve fibers that is produced 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*

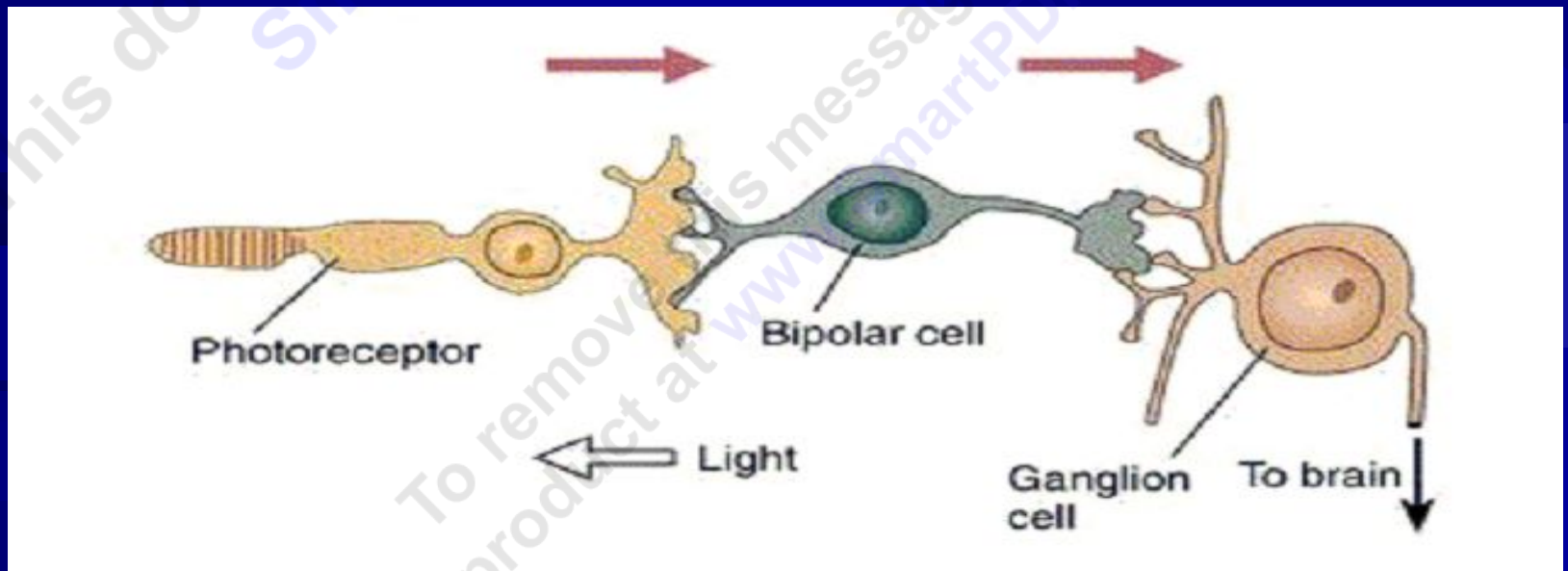
*Bipolar cells  
send signal to  
ganglion cells*

*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**

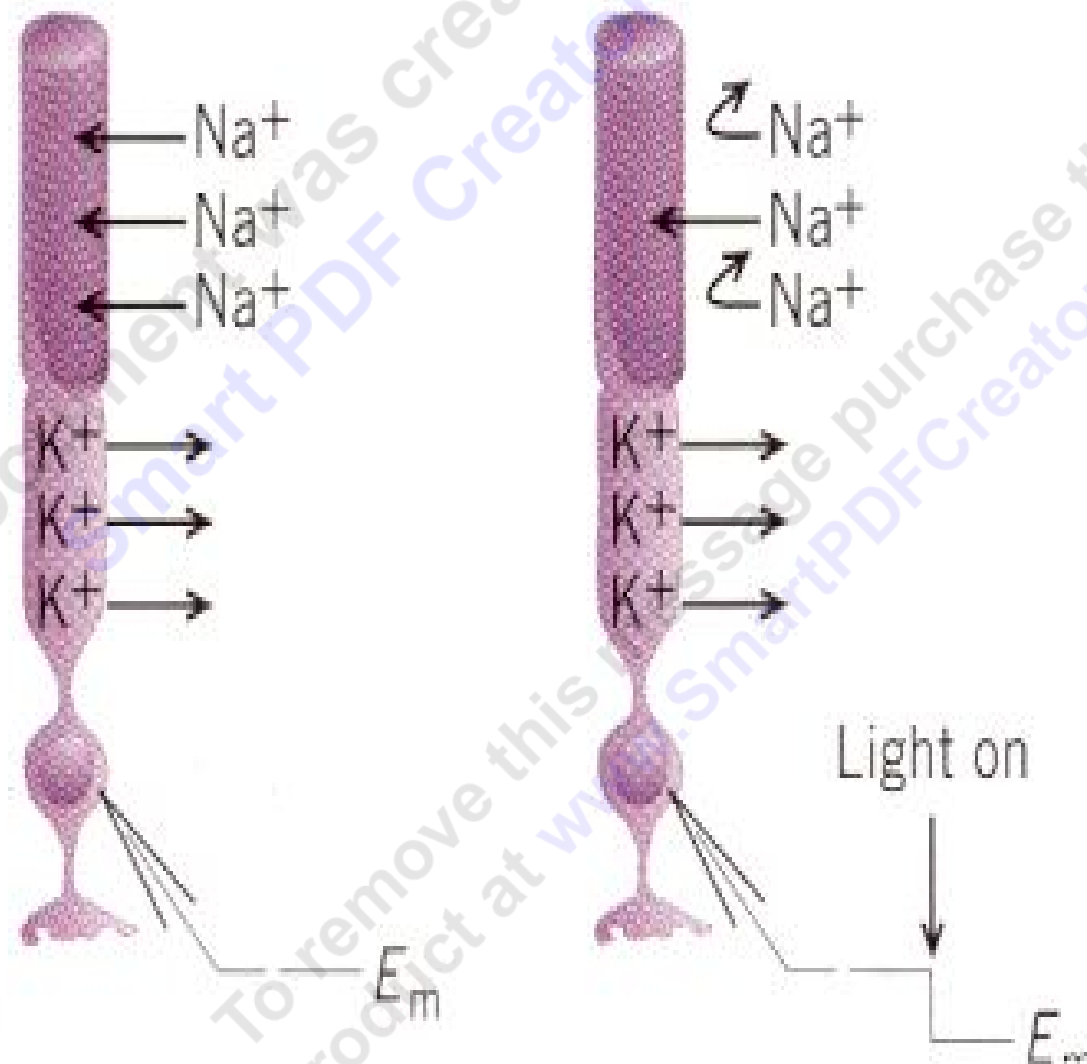




B

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<sub>-cont</sub>

Rhodopsin (visual purple, scotopsin):

### Activation of rhodopsin:

■ **In the dark:**

retinene1 in the 11-*cis* configuration



*Light*

*All-trans isomer*

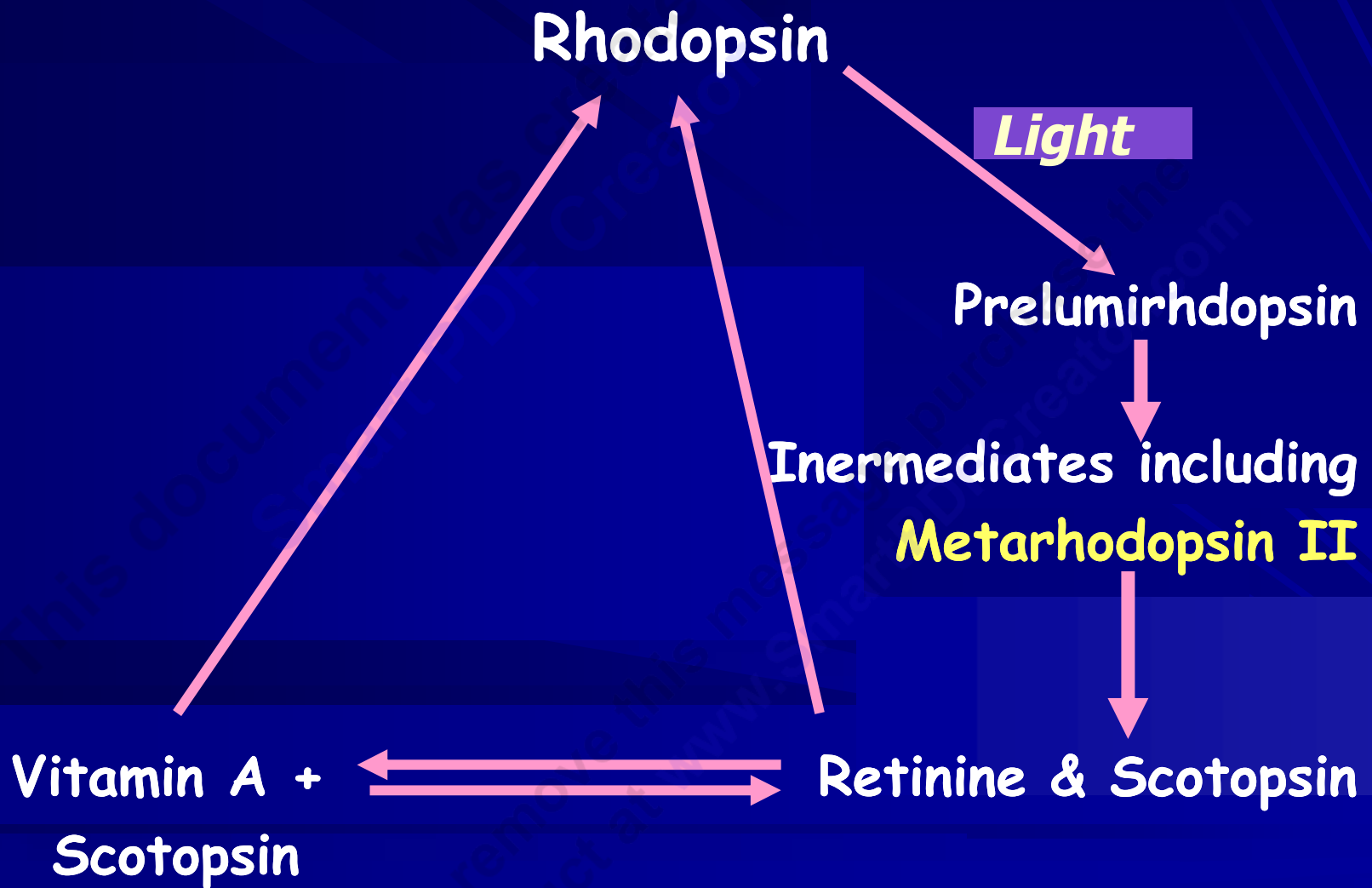


Metarhodopsin II

Closure of Na channels

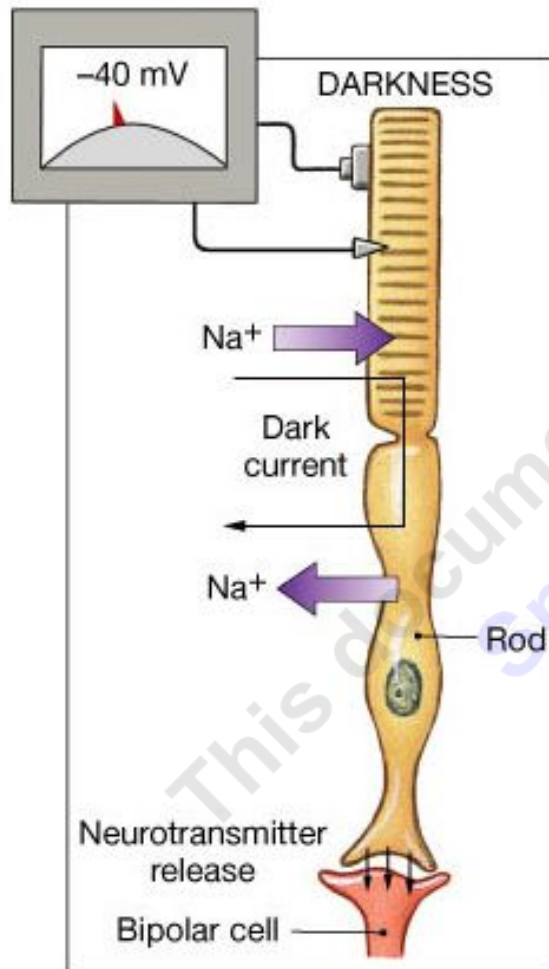


# Visual cycle



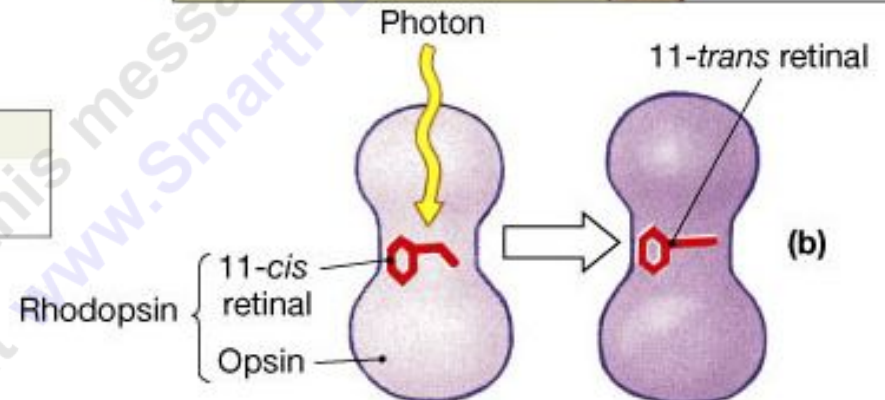
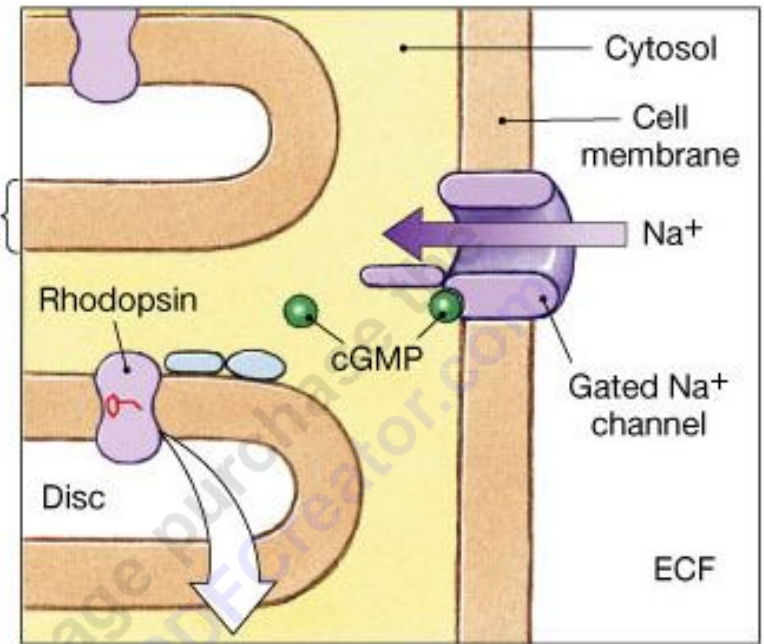


# Photoreception



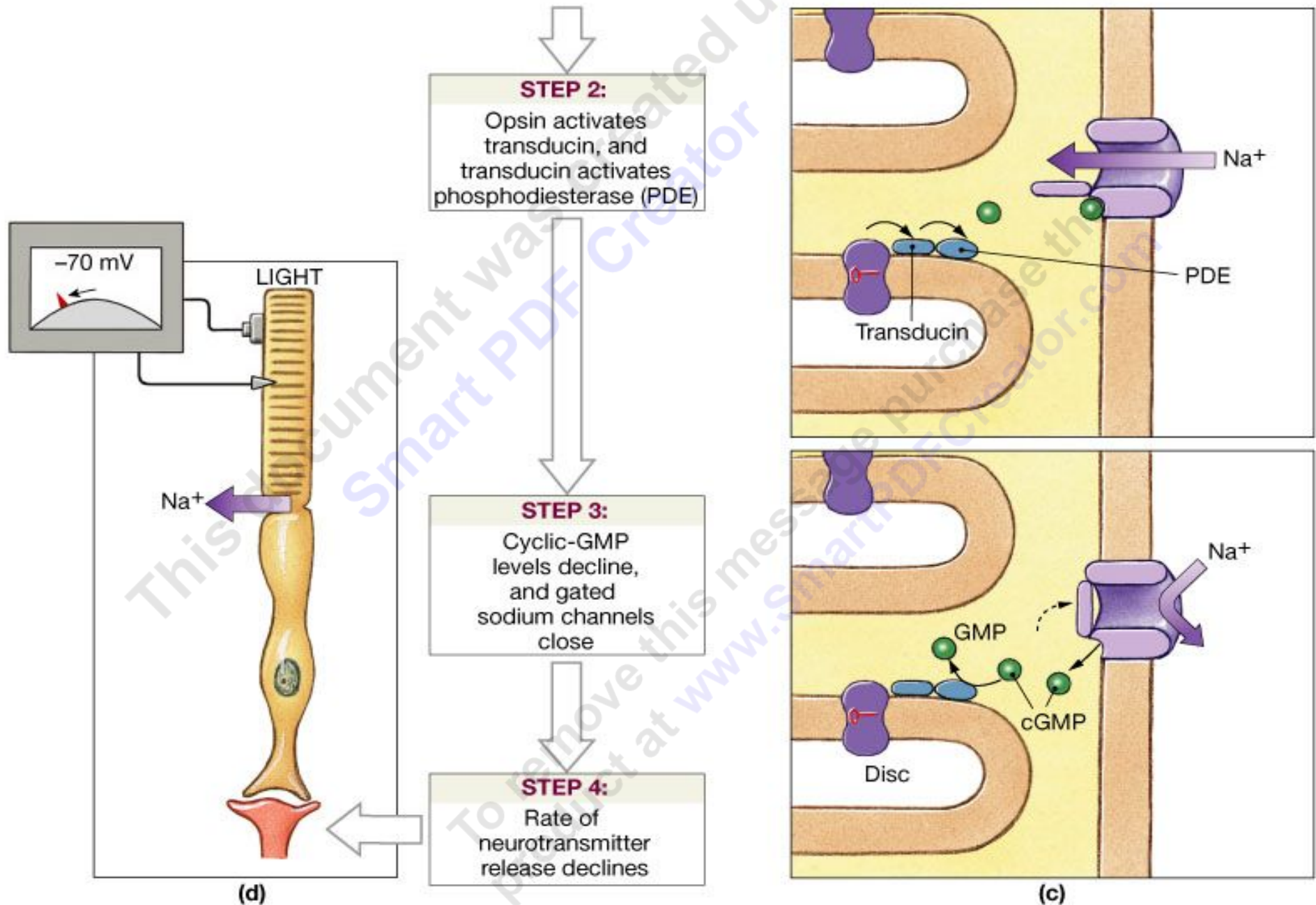
(a)

**STEP 1:**  
Opsin activation occurs



(b)

# 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

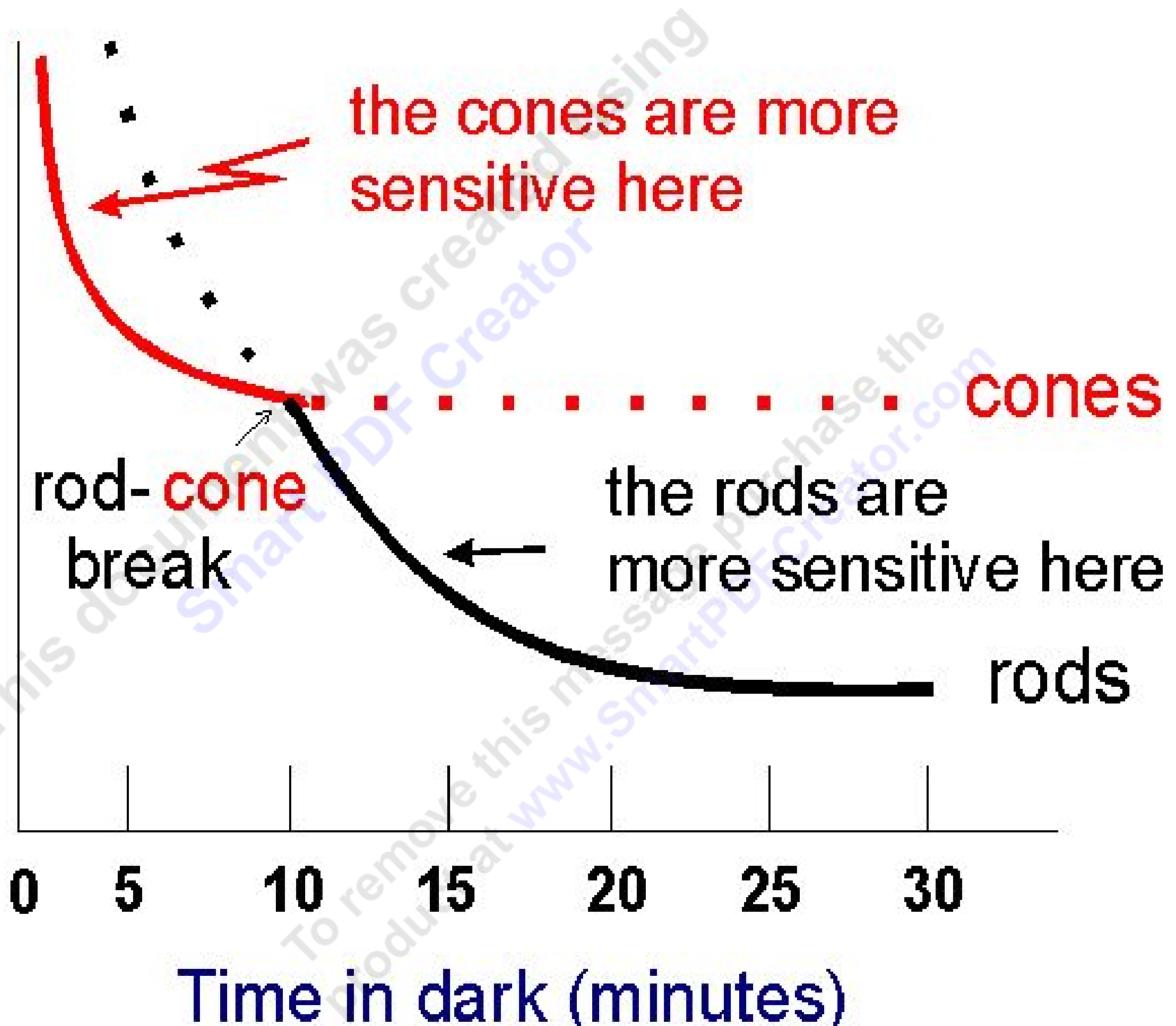
Mechanism of dark adaptation:

↑ Regeneration of rhodopsin

# Threshold Intensity

hi

lo



# Dark adaptation<sub>-cont.</sub>

In vitamin A deficiency  
What happens to Dark adaptation?

Night blindness  
(Nyctalopia)



# Thanks