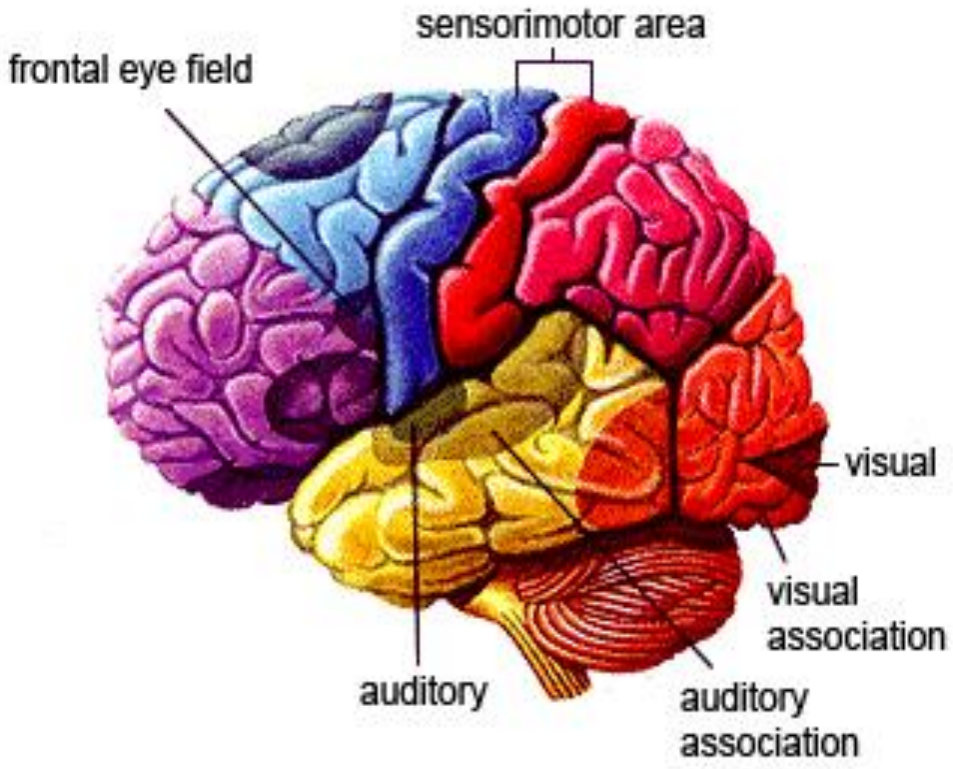
Physiology Team



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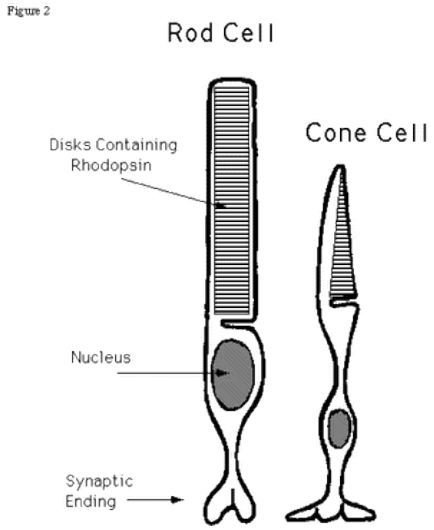
(these notes are combination of female and male slides + our notes)

Phototransduction of light

Receptors of vision(Rods&cones):-

1- Outer segment : (modified cilia) has disks full of photosensitive pigment react with light to initiate action potential.



Two types:

-In cones it is conical , contain 3 types of rhodopsin

- in rodes it is big,, rode like and contain one type of rhodopsin

2- Inner segment:

- **-its full of mitochondria to produce ATP for Na/K pump**
- **it is thick in cones**

Na/K pump:

(3 NA) out

(2 K) in

Convergence:-

	Cones	Rodes
Level of convergence	Low convergence.	High convergence.
Function	Increases visual acuity.	Decreases visual acuity.
Result	Decreases sensitivity to light. -needs high threshold to stimulate them.	Increases sensitivity to light (dim light). - need low threshold to stimulate them

- **120 million rods & 6 million cones &1.2 million ganglion cells (optic nerve fibres) , so convergence is 105 receptor per ganglion cell (1 fiber)**

Cones:

- **abundant (maximum) at fovea**
- **best for bright light conditions**
- **see all colors**
- **photopic vision**

Rodes:

- **abundant in the periphery of the retina**
- **best for low light conditions**
- **see black/white and shades of gray**
- **scotopic vision(dimlight vision)**

Electrical potentials in the Retina:

- **Rodes &cones potentials are: graded local potential (generator potential) (it can be summated).**
- **Rodes, cones, horizontal cells & Bipolar cell responses are: depolarization at dark & hyperpolarization at light.**
- **graded spike potentials act as generator potentials for the propagated AP in ganglion cells.**
- **Ganglion cells response is ONLY depolarization**
- **Ganglion cell action potential obey (all or none law) transmitted along the optic nerve.**
- **Cones respond to high levels of light intensity (illumination)**
- **Rods respond to low levels of light intensity (illumination) below threshold levels for cones, so rods are more sensitive**

-So Cones starts responding to high levels of illumination when rodes response is maximal ((rods respond before cones till we reach high levels of illumination then cone starts it response))

- **Neural circuitry :**
  Light → photoreceptor → signals to bipolar cells → signals to ganglion cells → signals to Brain

Photosensitive compounds:-

	Cones:	Rodes:
Rhodopsin component:	**Opsin protein + retinene1**	**scotopsin protein + retinene 1.**
Rhodopsin types:	**There are 3 types of rhodopsin &3 types of cones each respond to a certain wave length of light**	**only one type, It is stored in rodes disks at outer segment it forms (90% of its protein).**

(retinine 1 = aldhyde form of Vit A = visual purple)

- **-At dark rhodopsin is in 11-cisretinal form (inactive) & light sensitive form which increases sensitivity of**

  - rodes to light ((low illumination))

  - cones to light ((High illumination))

Ionic basis of photoreceptor potential:

At Dark (Scotopic Vision):

1- **Rhodopsin in 11-cisretinal convert (5 –GMP) to (c-GMP).**

2- **C-GMP keeps Na channels (in rodes & cones outer segment) open.**

3- **Na is pumped through Na/K pump.**

4- **Na current happen (Na is out by Na/K pump"At the inner segment" then it return back through Na channel "outer segment")→ depolarization.**

5- **Depolarization flow to synaptic endings → steady release of neurotransmitter at synapses with bipolar cells → get depolarization potential in Gangleon cells →AP in Optic nerve.**

At Light (Photopic Vision):

1. **Light → Conformational change of photopigment retinine-1.**
2. **11-cisretinal form changed to → all-trans isomer called "metarhodopsin II" which is an active rhodopsin.**
3. **Activation of G–protein (transducin) → activation of phosphodiestrase enzyme.**
4. **conversion of (c-GMP) to (5-GMP) → Decreased intracellular**

   c-GMP → closure of Na channels in outer segment.
5. **-but still Na pump out of inner segment → Hyperpolarization of photoreceptors (-70 ~ -80).**

6. **Hyperpolarization → decreased release of inhibitory synaptic transmitter → Generator potential in amacrine cells & ganglion cells (depolarize) → AP in optic nerve.**

- **Retinine + scotopcin at dark → vit A + scotopsin → rhodopsin regeneration**
- **Then decompose by light.**

N.B:

- **Synaptic mediators in retina: Ach, glutamate, dopamine, serotonine, GABA, substance P, somatomedin, VIP, enkephalins, glucagons, neurotensin.**

In dark: **all transmitters are continuously (steadily) released by depolarization of receptors.**

In light: **hyperpolarization of the receptors decrease inhibitory transmitter release.**

*** NYCTALOPIA(night blindness):**

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

- Treatment/ vit A if receptors (rods + cones) are well.

Dark adaptation:-

- **Visual threshold: is the minimal amount of light elicits light sensation.**
  - **When a person moves from lighted environment to 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.**

Dark adaptation has 2 components:-

1-Rapid: (about 5 minutes) drop in visual threshold .

- **Fast dark adaptation of cones , only in fovea.**
- **sensitivity of cones to light increase to see at that time.**

2- Less rapid: (till 20 min) drop in visual threshold .

- **(20 min are for regeneration of rhodopsin).**
- **dark adaptation of rodes 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.**

Q- Why radiologists & aircraft pilots wear red goggles in bright light?

A- Light wavelength of the red color stimulate the cones reasonably & stimulates rodes to some extent, so red goggles for rodes act as dimlight, so with it rodes are adapted to darkness and form large amounts of rhodopsin while the person in bright light , so when he enters dark places he can see well without waiting for 20 mint.

Light adaptation:-

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.