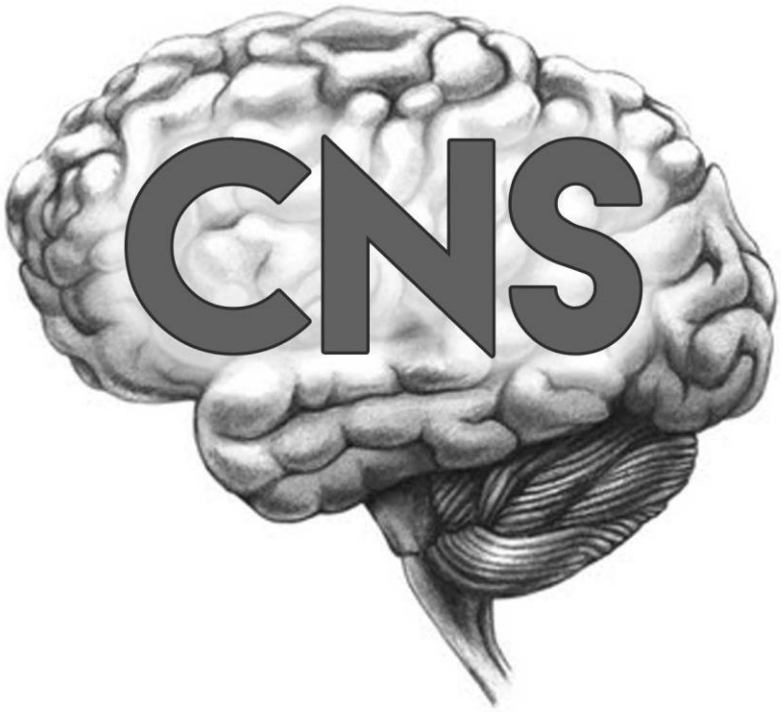

ANATOMY

☑ Sheet ○ Slide ○ Handout

Number

15.1

Subject

The Vision

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Date: 14/03/2017

Price:

- this sheet is written according to section 1 recording

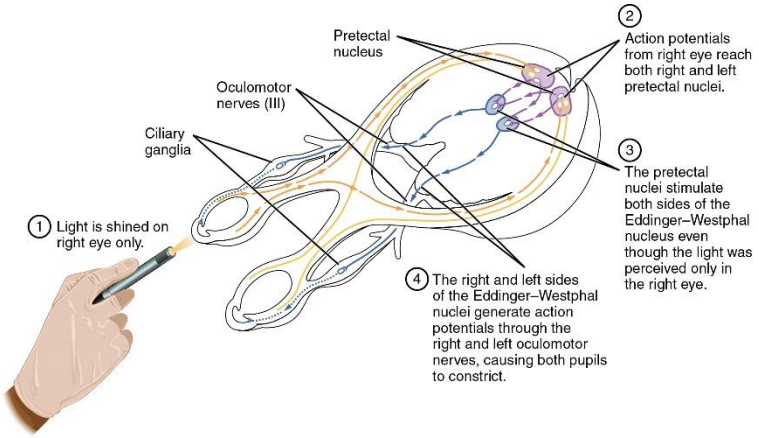
The Light & Accommodation reflex

The light reflex:

- *"if you expose one eye to light, the pupil of this eye and the opposite eye will constrict, this is the normal light reflex"*

- Any reflex is formed of afferent and efferent parts
- The Afferent part of this reflex is the **Optic nerve**, it goes to the optic chiasm and then form the optic tract, part of the optic tract pass to the **Pretectal nucleus**, "lies at the junction between the mid-brain and the thalamus", (the pretectal nucleus is the center of this)
- Coming out from the pretectal nucleus "efferent" to Edinger-westphal nucleus which is part of the oculomotor nucleus on both sides *"bilaterally"*, this nucleus contain the preganglionic parasympathetic fibers that goes to both ciliary ganglia *"accompanying the oculomotor nerve"* ➔ post ganglionic parasympathetic fibers to constrictor "sphincter" pupillae of the eyes
- So when light is thrown on one retina → both pupils will respond by constriction

"Response of ipsilateral pupil → **Direct** light reflex, contralateral pupil → **Consensual** light reflex



- What happens if there's a lesion in the afferent or efferent part of this reflex?
  - Lesion of the afferent part "optic nerve, chiasm or tract" → loss of both direct & consensual light reflex
  - Lesion of the efferent part "oculomotor" → loss of the only direct reflex,

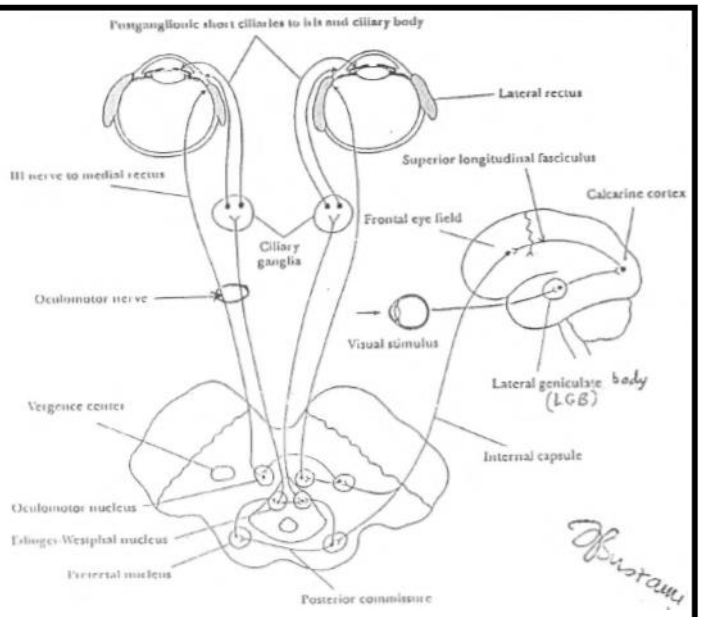
❖ In both light and accommodation reflex, constriction of the pupil occurs, but there's an evidence that the light reflex has a pathway different from the accommodation reflex, and that's by the fact that we can lose the light reflex without losing the accommodation reflex due to CNS diseases like (Syphilis) → causes Argyll Robertson pupil, which is the loss of the light reflex while maintaining the accommodation reflex.

Accommodation reflex

- Accommodation is responsible for giving the ability to look at close objects "near objects"
- The main actions of the Accommodation reflex are:
  1. **Contraction** of the ciliary muscle, causing an increased **thickness** of the lens,

  2. **Convergence**

➢ Pathway of accommodation:

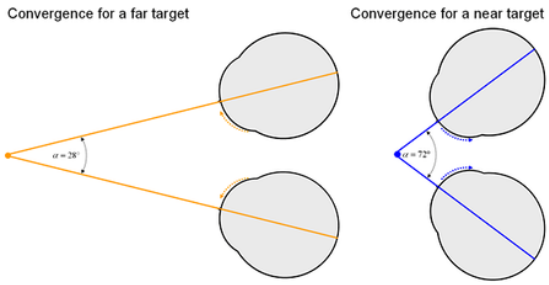


↳ Light stimulus → Optic nerve → optic chiasm → optic tract → large portion of optic tract goes the **LGB** of thalamus → visual cortex (calcarine cortex) → efferent to frontal eye field (FEF) → at this point the accommodation reflex starts → efferent fibers goes through the internal capsule to two areas in the mid-brain → (1) **Pretectum** and (2) a tegmental reticular **"convergence center"**

(1) **The pretectum** carries signals to the **Edinger-Westphal** nucleus on **both sides** → preganglionic parasympathetic fibers emerge and accompany the oculomotor nerve → ciliary ganglia → post ganglionic fibers → constrictor pupillae and ciliary muscle

(2) **Convergence center**, essential part of the accommodation reflex, which causes adduction of both eyes while looking at close objects "like when you try to put a thread through a needle" by the action of **medial rectus muscles,**

- The convergence center sends impulses to the oculomotor nucleus on both sides and these will supply the medial rectus muscles by the oculomotor nerve



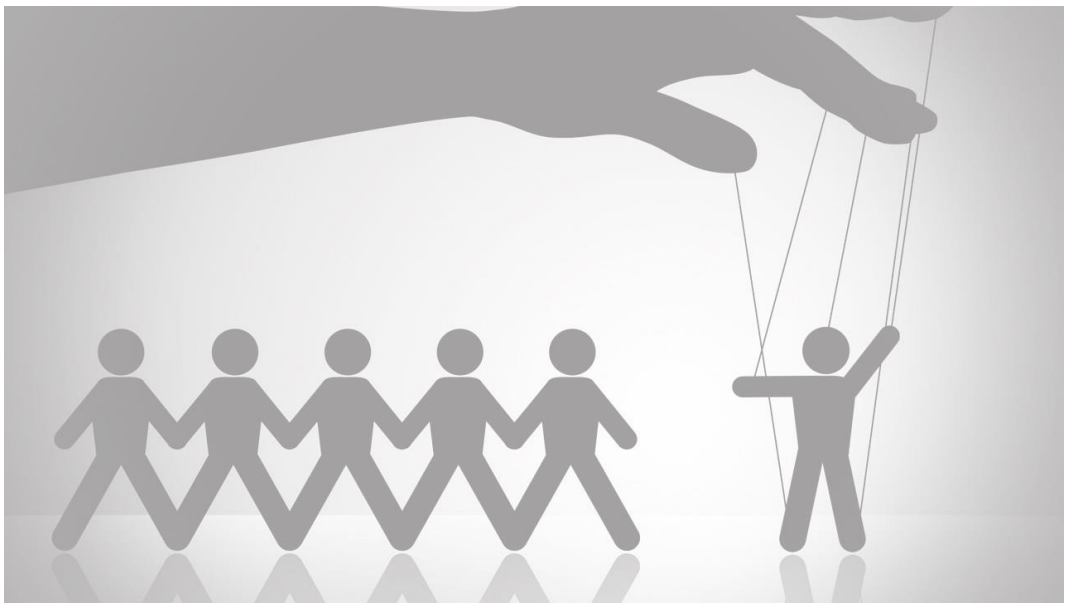
Again, the 3 responses of the accommodation reflex are:

1. Increased lens thickness, by contraction of ciliary muscles → relaxation of suspensory ligaments → increasing the thickness of the lens and thus increasing its power
2. Pupil constriction: by the influence of the pretectal nucleus on the constrictor pupillae
3. Convergence: by the two medial rectus muscles

- Why does the pupil constrict during light and accommodation reflex?

- In the light reflex it constricts to protect the retina from strong light ray
- In accommodation reflex, to prevent the dispersion of the image and concentrates it to a certain focus (area) on the retina

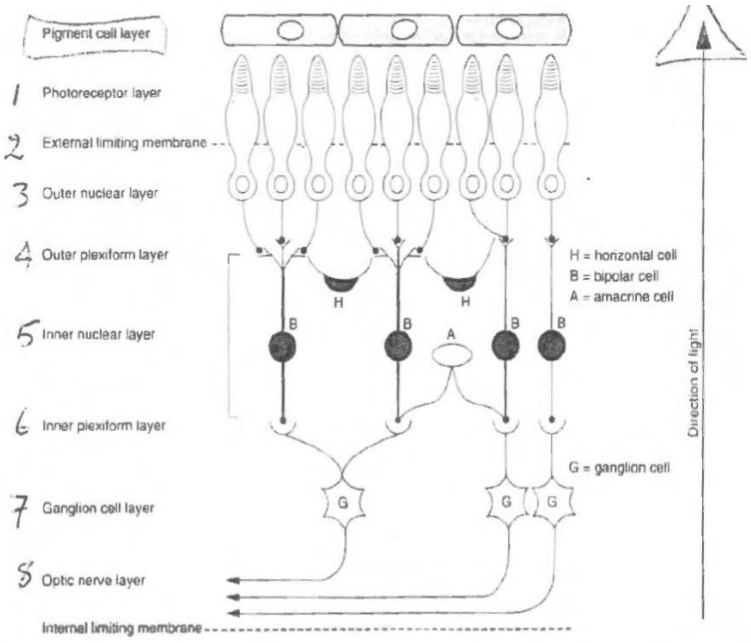
❖ Accommodation reflex is lost after the age of 40 due to the loss of the lens flexibility, a condition called **Presbyopia,** and it's considered a physiological condition



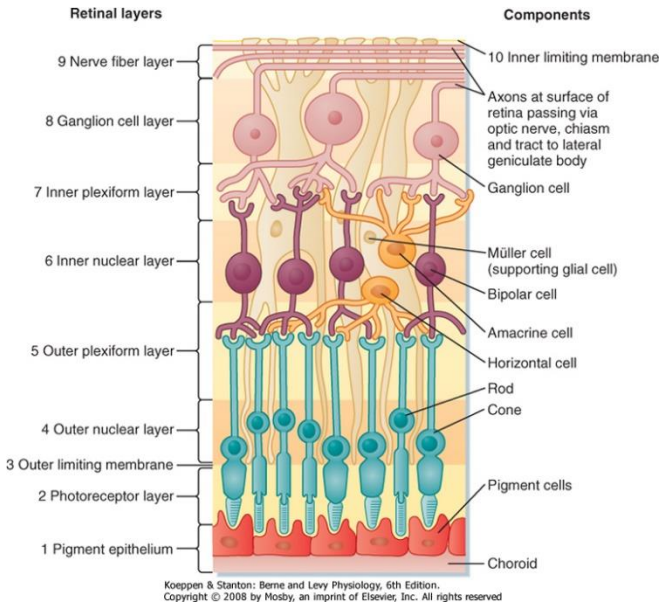
Retinal layers

The layers of the retina organized in an inside out fashion are:

1. The **photoreceptors layer** is the deepest layer! , although it supposed to be the first layer, yet here it lies near the choroid as the deepest layer of the retina, So light will pass through all the layers to reach the receptors, These receptors are the **cones and rods**



2. The **external limiting membrane**
3. **Outer nuclear layer** of rods and cones
4. **Outer plexiform layer** ➔ synapses found here between: (axons of receptors, bipolar cells and horizontal cells)
5. **Inner nuclear layer** ➔ nuclei of bipolar cells
6. **Inner plexiform layer** ➔ synaptic connection between bipolar cell, ganglion cell & *amacrine cell*
7. **Ganglion cell layer**, axons of it form the optic nerve.
8. **Optic nerve layer**
9. **Internal limiting membrane**



- ❖ These layers has the most important cells that we talked about before which are the:

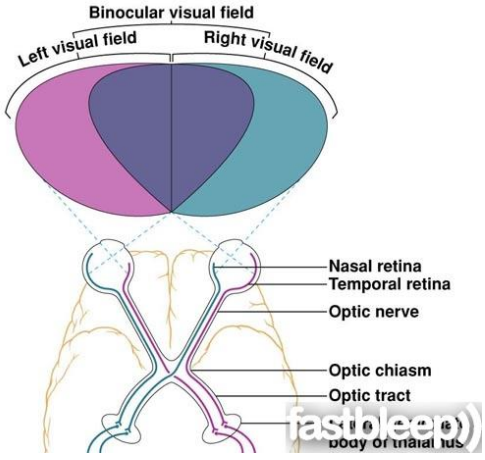
I. Photoreceptors cells (cones & rods)
II. Bipolar cells
III. Ganglion cells

And the other cells work as interneurons

- ➢ The only cells that generate the action potential are the **ganglion cells!!**
- ➢ All reactions occur between the other cells will finally put an effect on the ganglion cell and its activity

- Photoreceptors don't generate action potential, rather they experience a graded change in membrane potential "which will not reach threshold", this is called graded potential (local potential)

binocular visual field



- As mentioned in the previous lecture that each eye has a visual field
- And there is a common area between them called binocular vision, and it represents the nasal visual field of each side, and its receptors on the temporal half.
- The importance of the binocular vision is to prevent double vision by making the image lie on the same focus in both eyes

✍ *The Photoreceptors:*

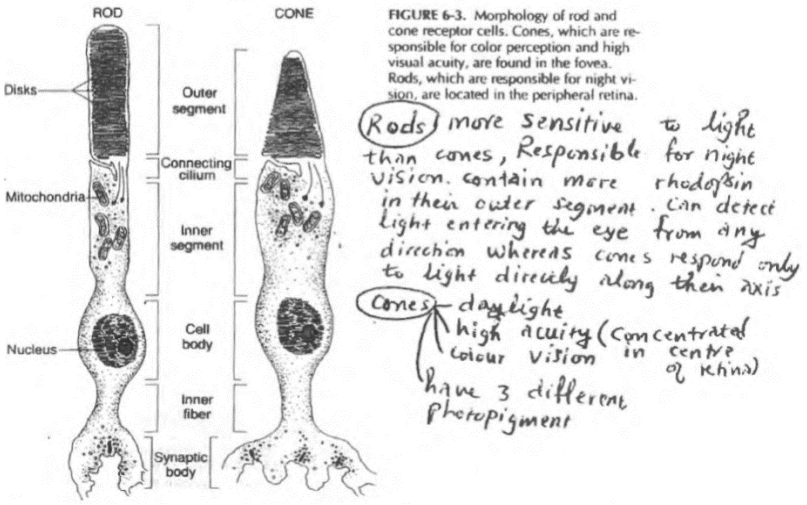
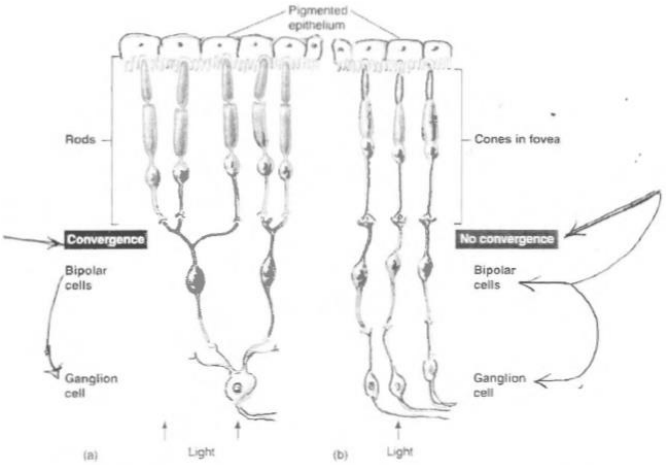


FIGURE 6-3. Morphology of rod and cone receptor cells. Cones, which are responsible for color perception and high visual acuity, are found in the fovea. Rods, which are responsible for night vision, are located in the peripheral retina.

The Cones & Rods consist of:

- ❖ inner segment & outer segment:
  - **Inner segment**: contain the nucleus, abundant mitochondria & synaptic vesicles
  - **Outer segment:** containing a membranous disks
    - the membranous disks contain a visual pigment, called **rhodopsin**, which absorbs light rays

- ➢ The Rods are more sensitive to light than cones, but doesn't give much detailed vision like the cones, so rods are responsible for **night vision**
- ➢ The Cones on the contrary are less sensitive to light (i.e. used in day light), and they're responsible for **colored vision**, so it gives us details about what we see
  - o what Is the cause of this phenomenon?

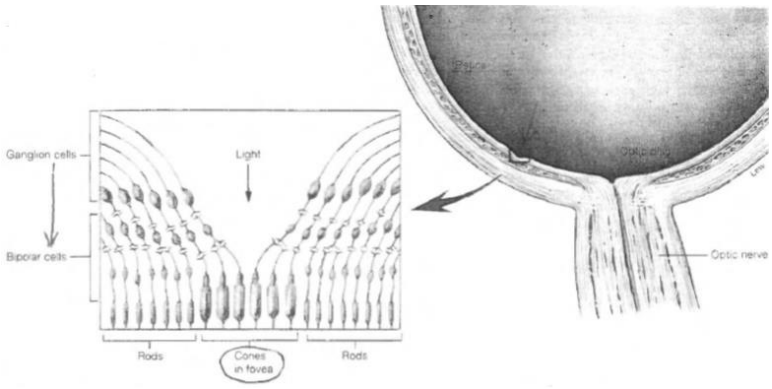


- We see in this figure that the rods has what is called <u>convergence</u>, which is that many rods (let's say 10) will **converge** and give signals to only one bipolar cell, and a group of bipolar cells will also **converge** to one ganglion cell, (10 rods → 1 bipolar, many bipolars → 1 ganglion) this will be responsible

for the high sensitivity of rods to light,

While each cone is connected to one bipolar "no convergence", (1 cone → bipolar → 1 ganglion) giving it the ability to give detailed vision to the brain yet it will be less sensitive to light.

The Macula Lutea:

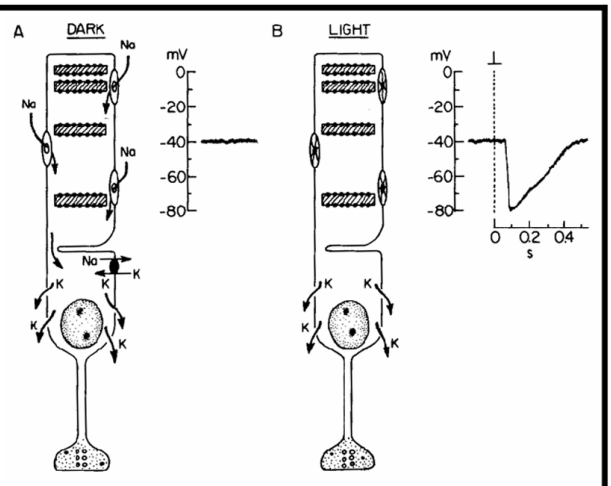


- Lies Lateral to the optic disc, it has the **fovea centralis,** which is the area of the most accurate vision, and that is because:
  - The receptors there has no other layers on top of them (exposed to light directly),
  - Also in this area only cones are present, and as we said the cones are responsible for the accuracy of vision in addition to the colored vision,

*Some facts you need to know about photoreceptors:

- ❖ the rods and cones are depolarized (excited) in the dark, and hyperpolarized in the light
- ❖ so they are considered the only receptors that respond to their specific stimulus by hyperpolarization (unlike the general rule)

- This nerve impulse must reach the ganglion cells at the end, yet some of the ganglion cells respond to light by inhibition while others respond by excitation, how so?
  - In the outer segment of the photoreceptors, Na channels in the dark are opened, and in order for them to open they must bound to a cGMP, Na will enter the cell through them in the outer segment then exit from the inner segment through Na^+-K^+ pump, the entering of the Na will cause depolarization as the membrane potential will rise from -70mV to -40mV *(may reach -30mV)*
  - The Na^+-K^+ pump requires energy to function, and this energy s provided from the numerous mitochondria in the inner segment which will synthesize the required ATP for the pump to work
  - The entering and exit of the Na is called the dark current
  - This dark current caused depolarization of the membrane down to -30mV!, but remember this is not enough to generate action potential *"we said before that these cells are not able to generate it"* , yet this graded potential (local potential) is able to make the cell release its neurotransmitters which are stored in the synaptic vesicles it has
  - Bipolar cells will respond to the released neurotransmitters, if this neurotransmitter was inhibitory let's say, the bipolar cell will either respond to it by **hyperpolarization "inhibiting itself and the ganglion cell with it"**, OR it will respond by **depolarization "exciting itself and the ganglion cell with it"** which will generate action potential in the ganglion cell!
  - Keep in mind that ALL of these events occur during **darkness**!



- What happens when there's light?
- When the photoreceptor is exposed to light, the cGMP will be hydrolyzed to GMP, so the Na channel will close preventing the entry of Na, and only the Na^+-K^+ pump will be working and this will cause hyperpolarization of the membrane, this will prevent the release of neurotransmitters, and the bipolar cell that stopped receiving the neurotransmitter will also respond by either hyperpolarization or depolarization.
- So from this we conclude that in either darkness or presence of light, there's a little activity of the ganglion cell, this activity might increase if we introduce more light rays to the eye

The Lateral inhibition:

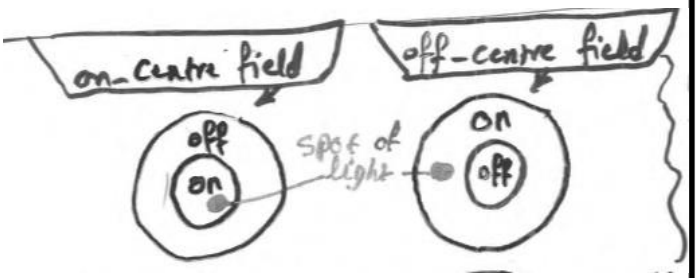
- Suppose we have a row of 10 receptors (cones and rods) in the retina, and we shed a light on 3 of them, these will be considered as a receptive field, and will conduct the stimulus to the ganglion cell
- If we shed a light on all 10 receptors, and the previous reaction happened in them, the impulse that is received in the ganglion cell from them is relatively weak
- While if we only stimulated 3 receptors in the central and inhibited the rest by lateral inhibition, the impulse reaching the ganglion cell will be stronger
- So out of these 10 receptors, if we inhibit 7 and only stimulate 3 we will strengthen the impulse, this is what lateral inhibition means

*More details about this phenomenon will be discussed in the next sheet.

Now, The ganglion cell (the main cell of the retina) has a **receptive field,** which is a group of photoreceptors connected to it *(remember the convergence)*

The receptive field of the ganglion cell is **circular**, having a center and a surround (functionally).

Stimulation of the center of the receptive field of the ganglion cell causes burst of action potential, this cell that's stimulated by light, is called **on-center ganglion cell**.



While if another cell is inhibited by light, (off center ganglion cell) this will decrease the rate of action potential

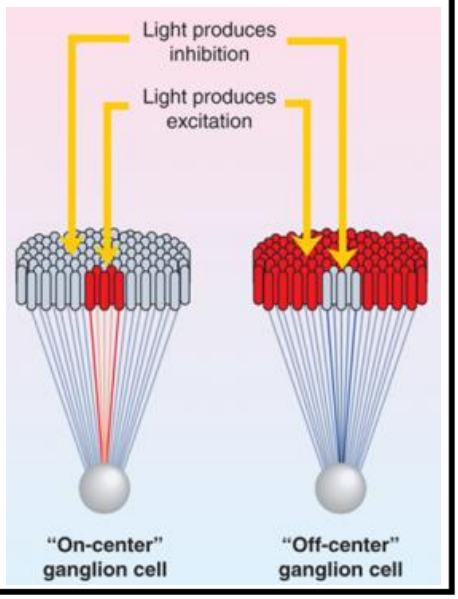
Most of The ganglion cells receptive fields are **on center off surround**..

- What's the significance of this??

- Most of the ganglion cells are active when you stimulate the central part of the receptive field and will send a strong impulses to the brain, but they will be inactive if the periphery (surrounding) is stimulated…
- On the other hand, the (off center on surround) cells are active when the surround is stimulated...

- What's the effect of having antagonism here??

- Whenever a ray of light hits the receptive field, we will have a signal from the center that will be antagonized from the periphery, and this will weaken this signal,
- But if we inhibited the surrounding part, only the central part will be working and thus the signal will be sharp, this is the concept of lateral inhibition.



- This information leads to another important concept, which states that ganglion cells and bipolar cells highly respond to the difference In light between the center and the surround, so if you look at an object, the most sharp vision is done by putting it in the dark, and put a light straight on it...
- Now who is responsible for this lateral inhibition "activates the central part & inhibit the surrounding"?

The horizontal cells!

ꕥ Cells of the retina

Thalamic center for vision LGB:

6 layers,

Layer 1, 2 Large cells, called magnocellular pathways

Layer 3-6 Parvocellular

Layer 1,4,6 receive the crossed fibers, (the nasal) so it receives vision from the same side of the visual field

Layer 2,3,5 receive uncrossed, (the temporal) so it receives vision from the other side of the visual field

- The last two subjects will be further discussed in the next sheet ☺