Human and animal models in BioRobotics

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Pontedera, 01 October 2019
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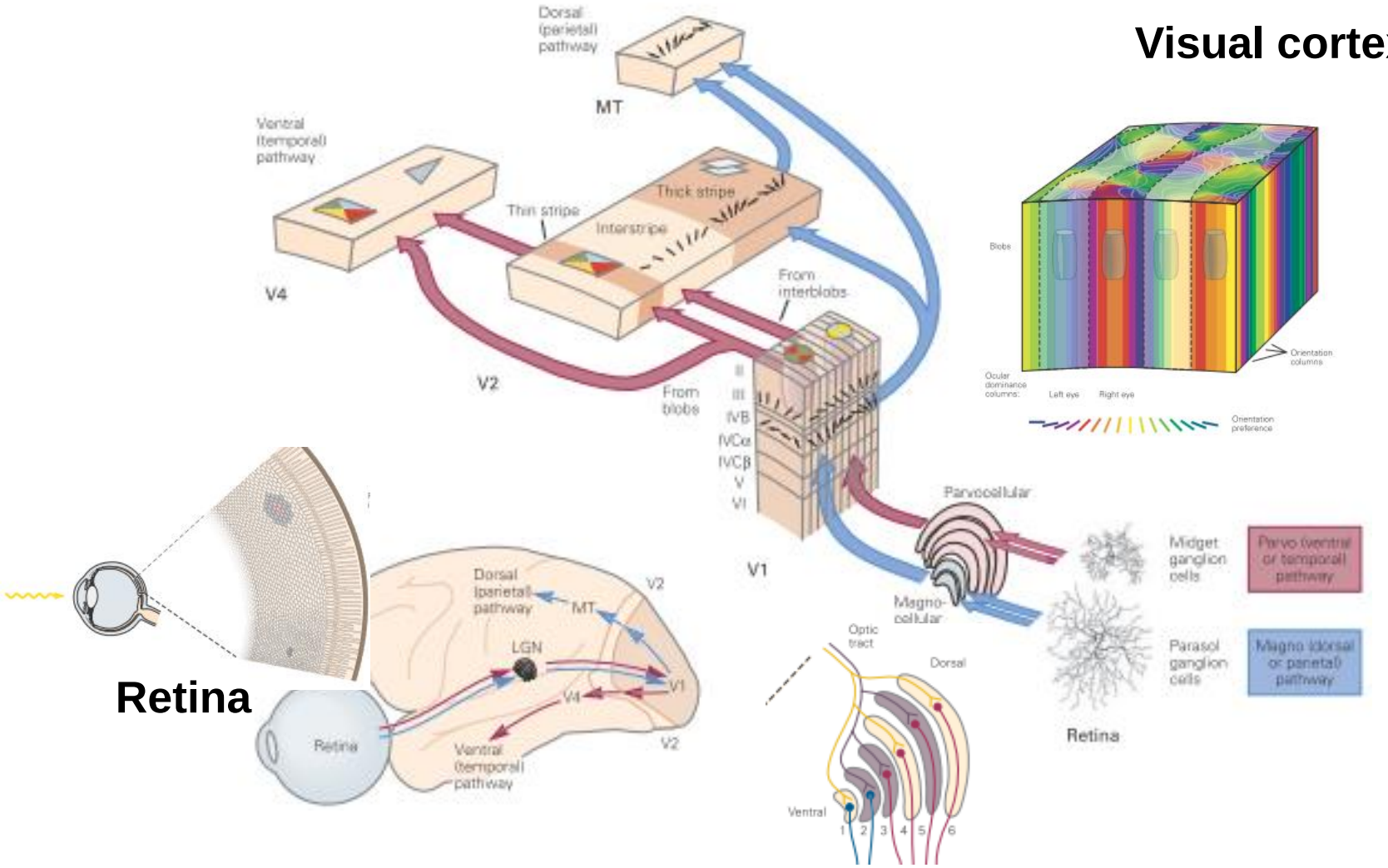
Visual pathways

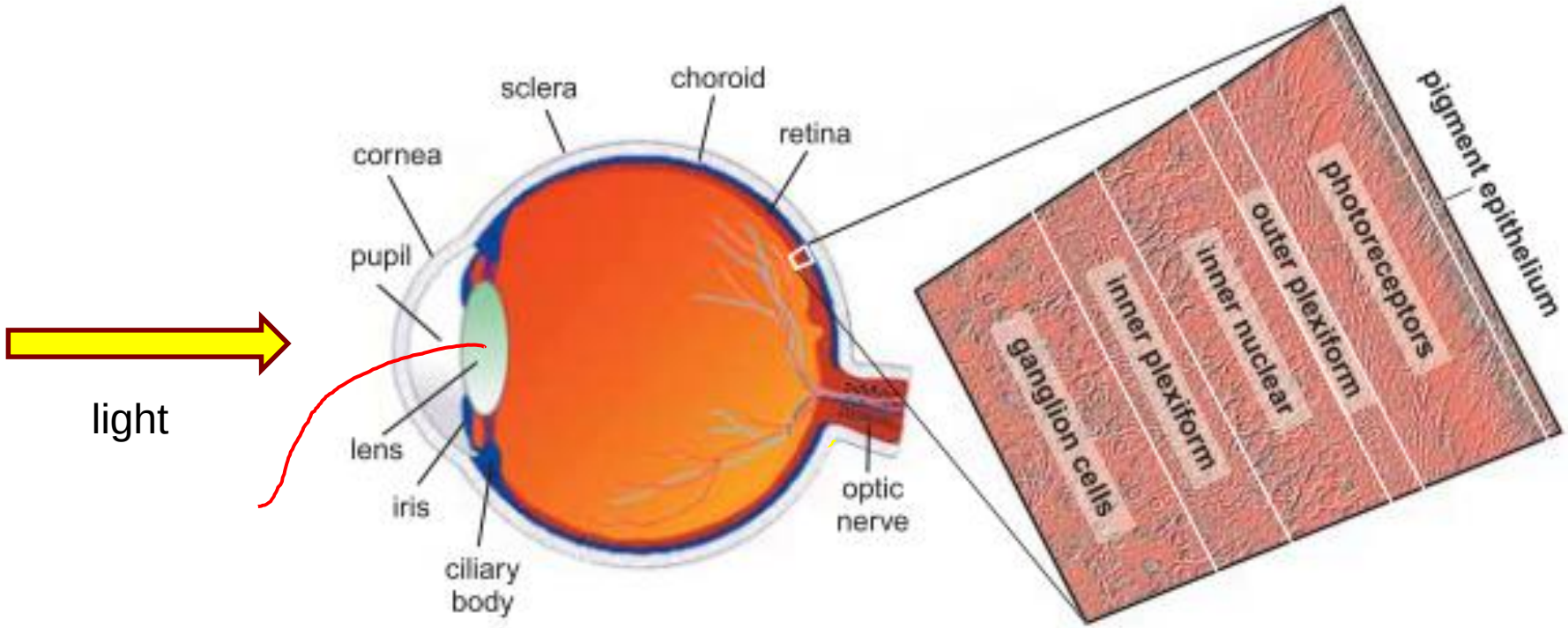


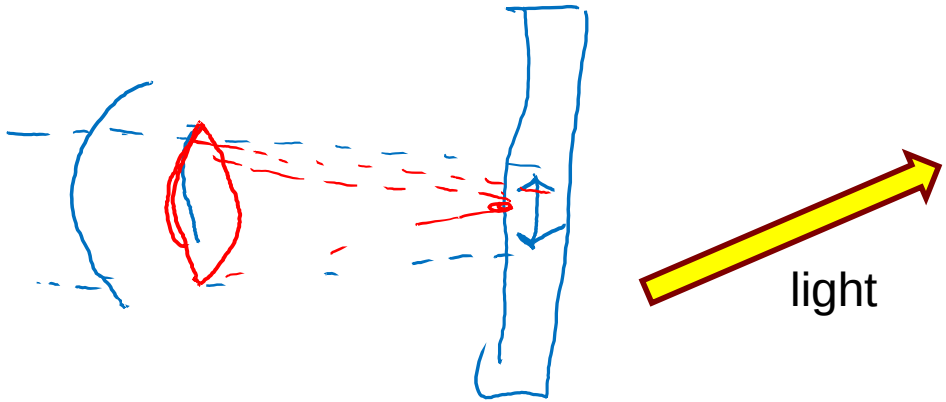
Visual cortex V1

Retina

Laterial geniculate nucleus

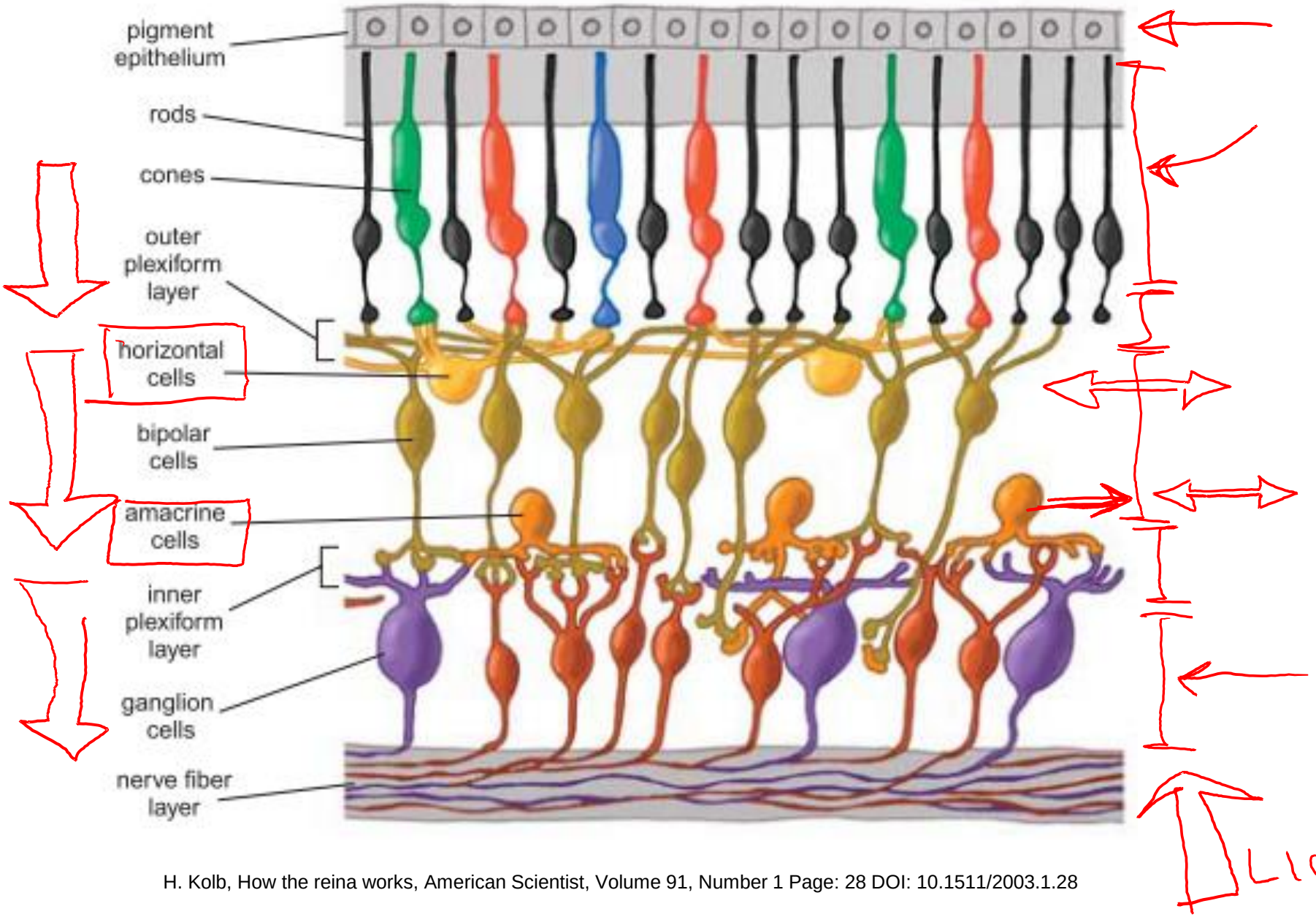
H. Kolb, How the reina works, American Scientist,
Volume 91, Number 1 Page: 28 DOI: 10.1511/2003.1.28





light

Light passes from glanglion to photoreceptors



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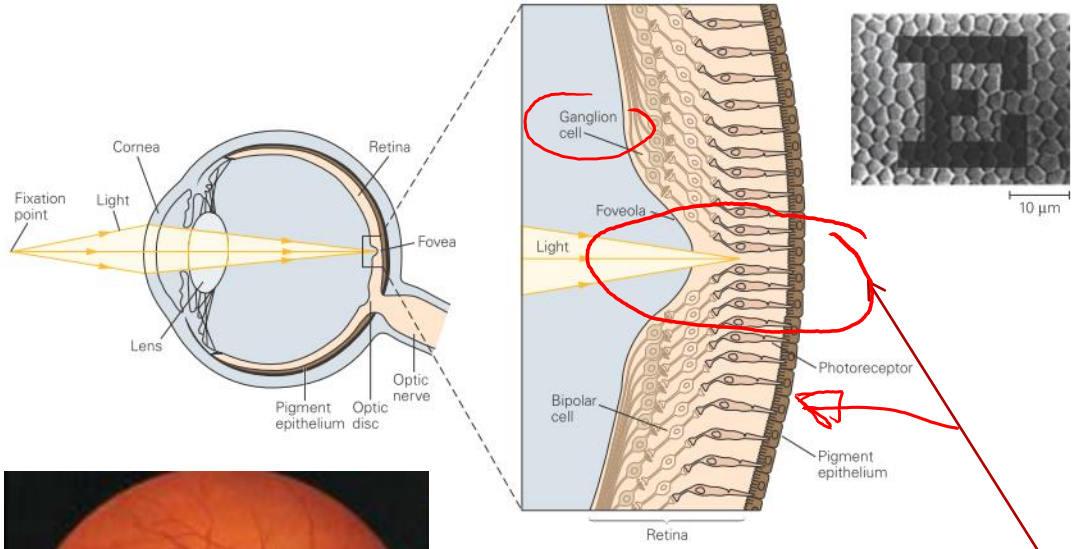
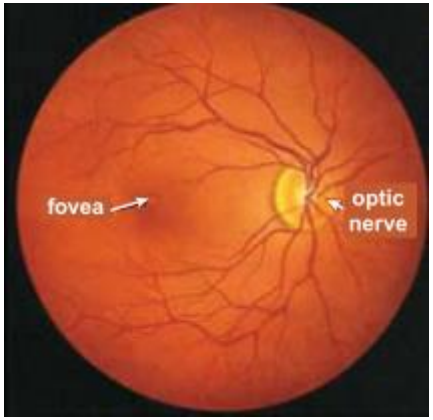
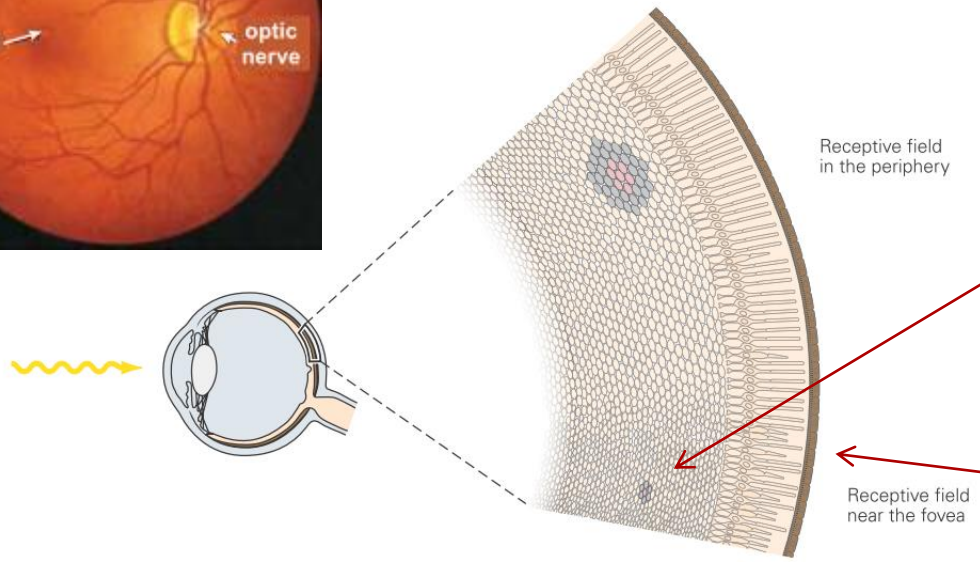






Detailed vision in the fovea:

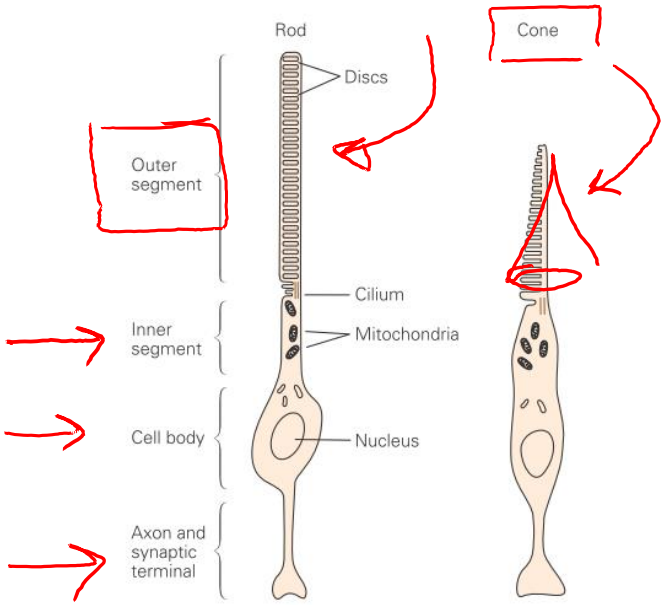
- Bipolar and gangliar cell open
- High density of photoreceptors

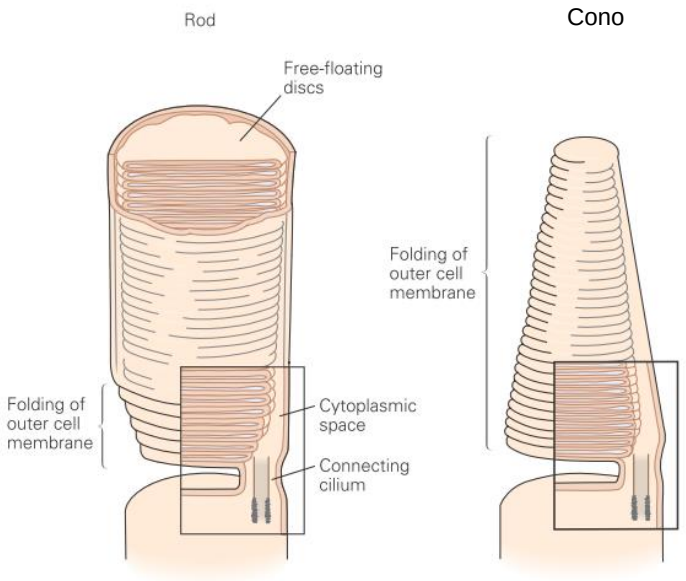
Pigment epitelium

Optic disc and blind spot

- How to redesign the eye to avoid?
- Why the eys is designed in this way?

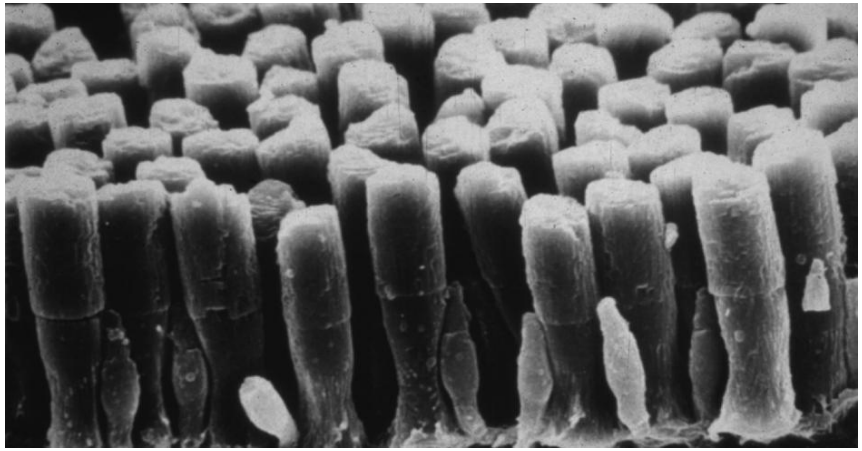
Cones and rods



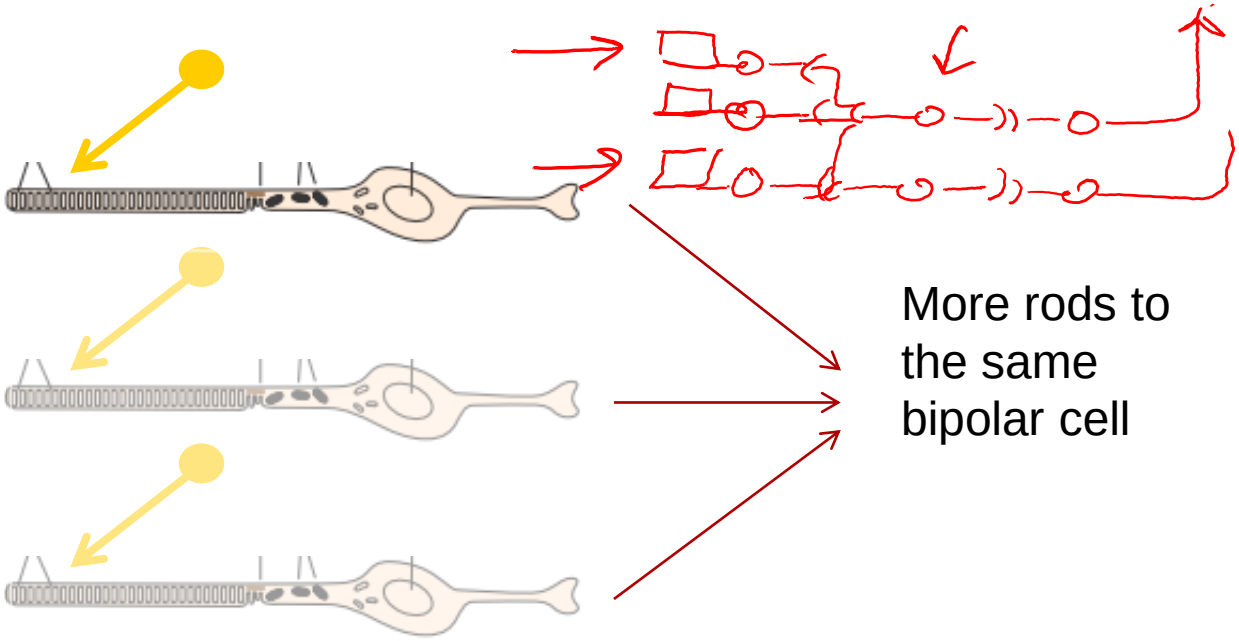


Anatomical and functional differences

About:
100 milion rods
6 miilioni di cones



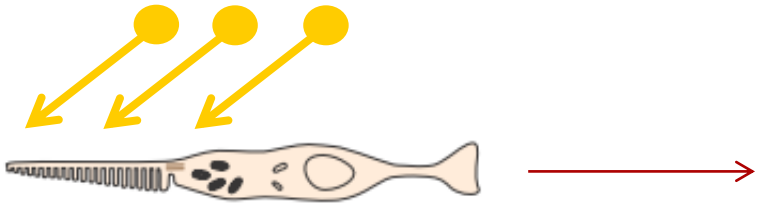
Different sensitivity



More rods to the same bipolar cell

One photon activates the transduction

Nocturnal



One cone one bipolar cell

More photons are required to activete the transduction

Diurnal

Topography of the retina

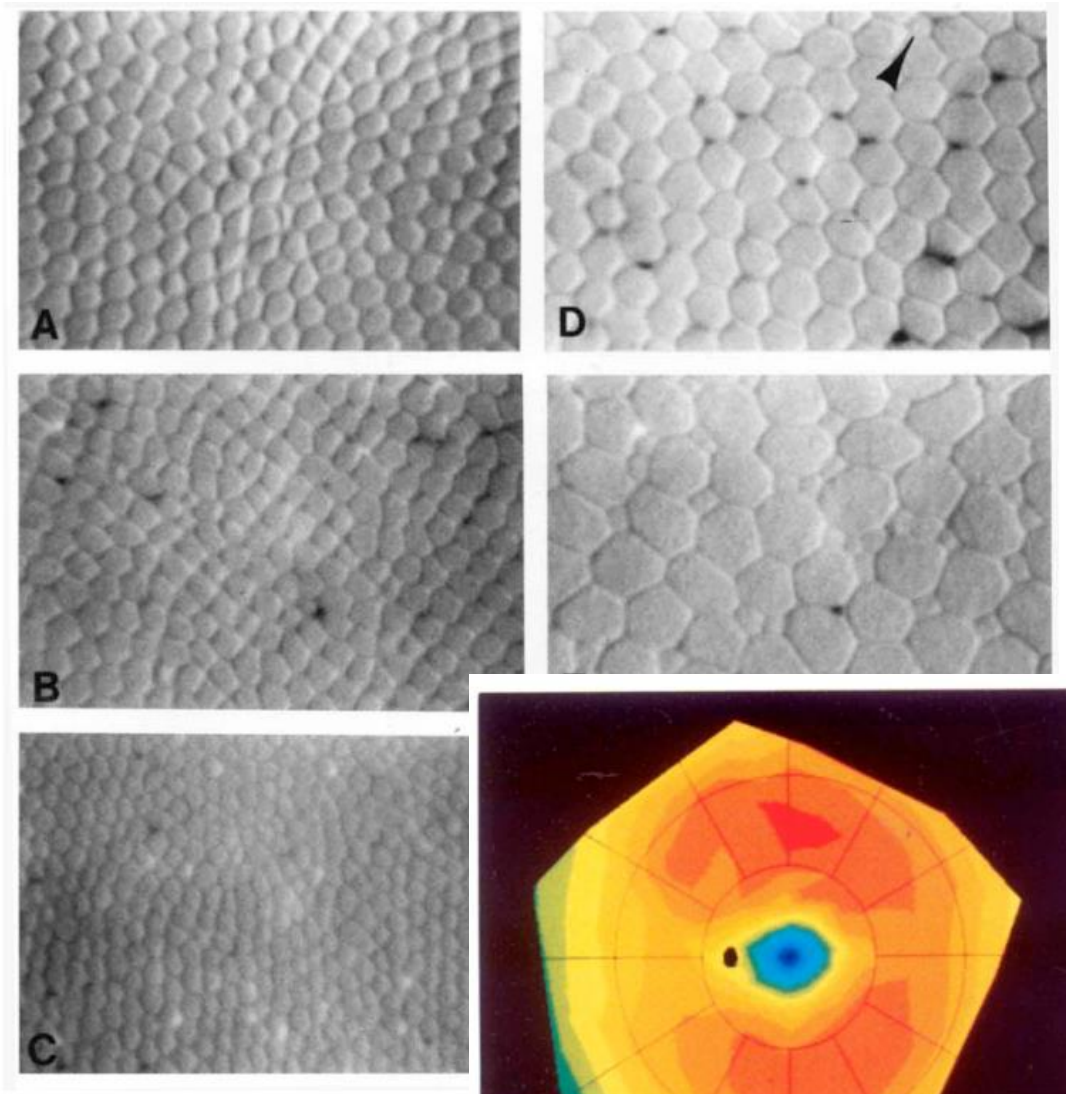
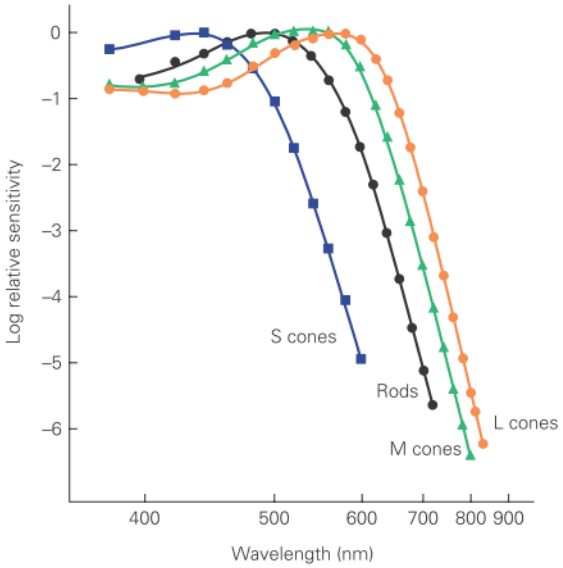
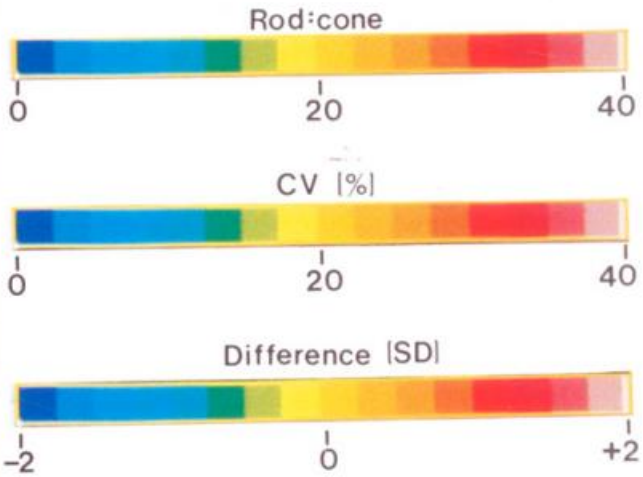


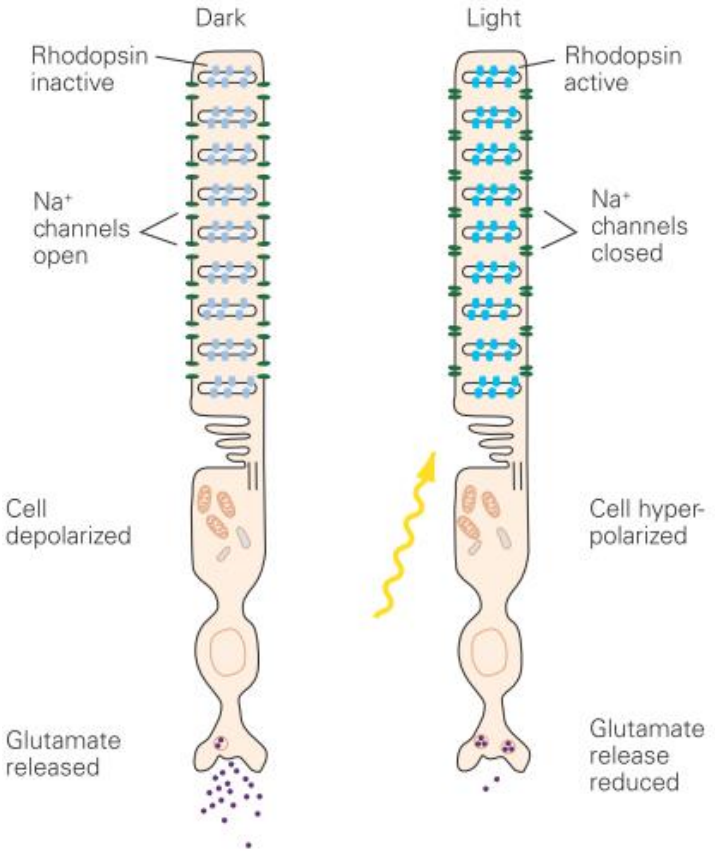
Fig. 2. Optical sections of the foveal cone mosaic, showing betw
individual variability at the foveal center and variation in cell den
and size with eccentricity. **A–C:** Foveal centers, containing only co
of H5L (A), H4 (B), and H6 (C). Note much higher density of cone
H6. **D:** Edge of rod-free zone in H4, 0.125 mm temporal to the fo
center. Arrowhead points to one rod. Note that cone inner segments

Photoreceptors sensitivity





Phototransduction



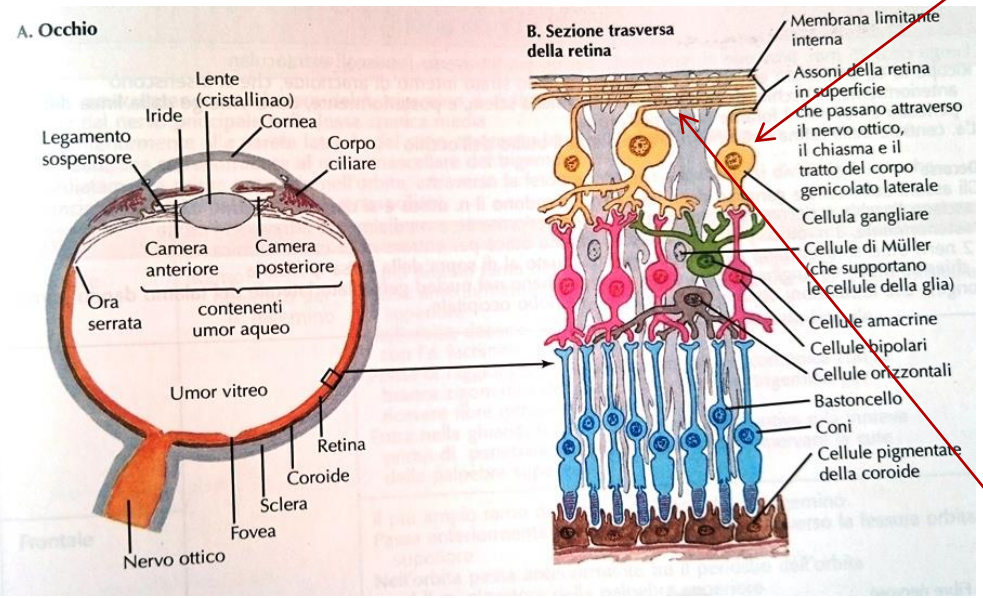
Three steps:

1. Light activates the photo-pigments
2. I photo-pigments reduces the number of GMPc
3. With less GMPc, Na+ channles close, photoreceptor hyperpolarizes

GMPc: guanosin-monofosfato 3’-5’ ciclico

Early signal processing

La retina non si limita soltanto a trasformare la luce in impulsi elettrici, ma effettua anche una **prima elaborazione a basso livello** delle informazioni

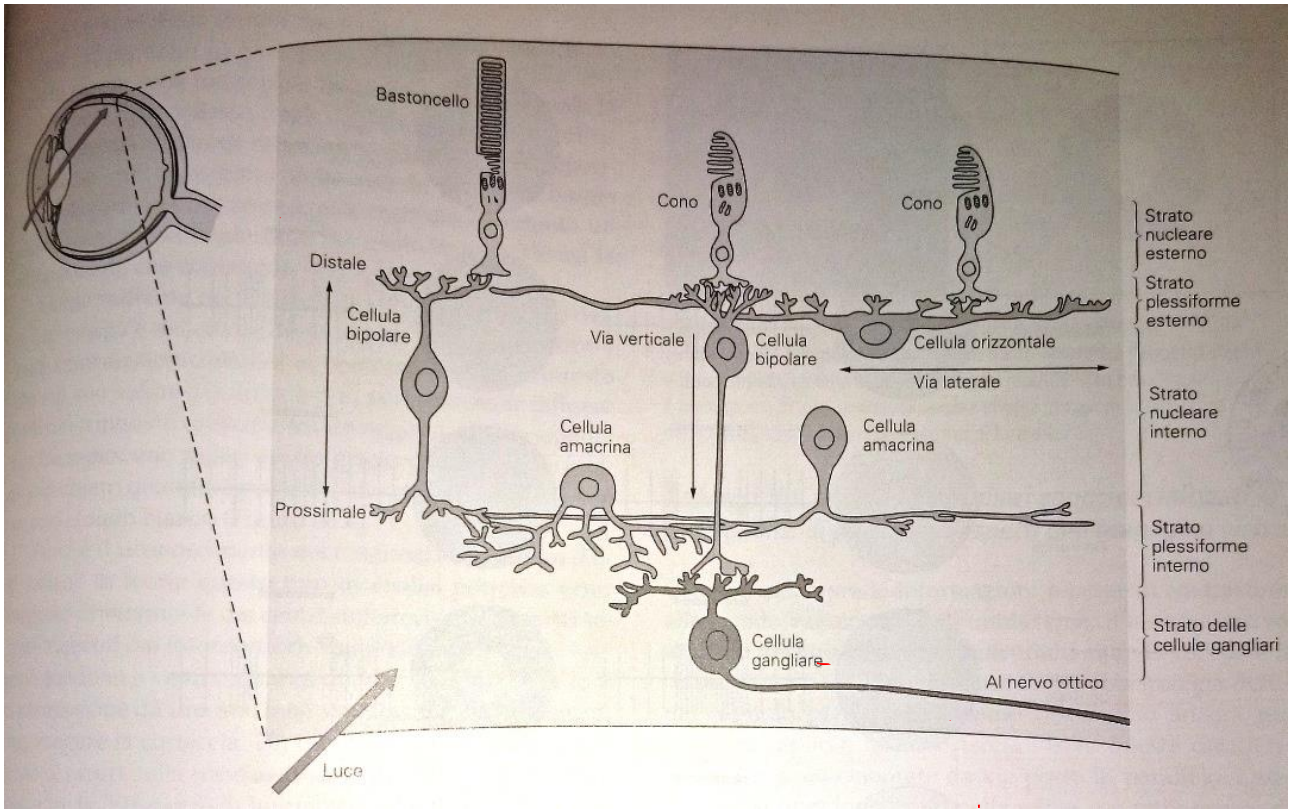


Ganglion cells are the **output neurons** of the retina: **they produce a train of spikes**

Axons of the ganglion cell are collected into the **optic nerve**, which reaches the **lateral geniculate nucleus**, the **superior colliculus**, al **pretectum** and other targets.

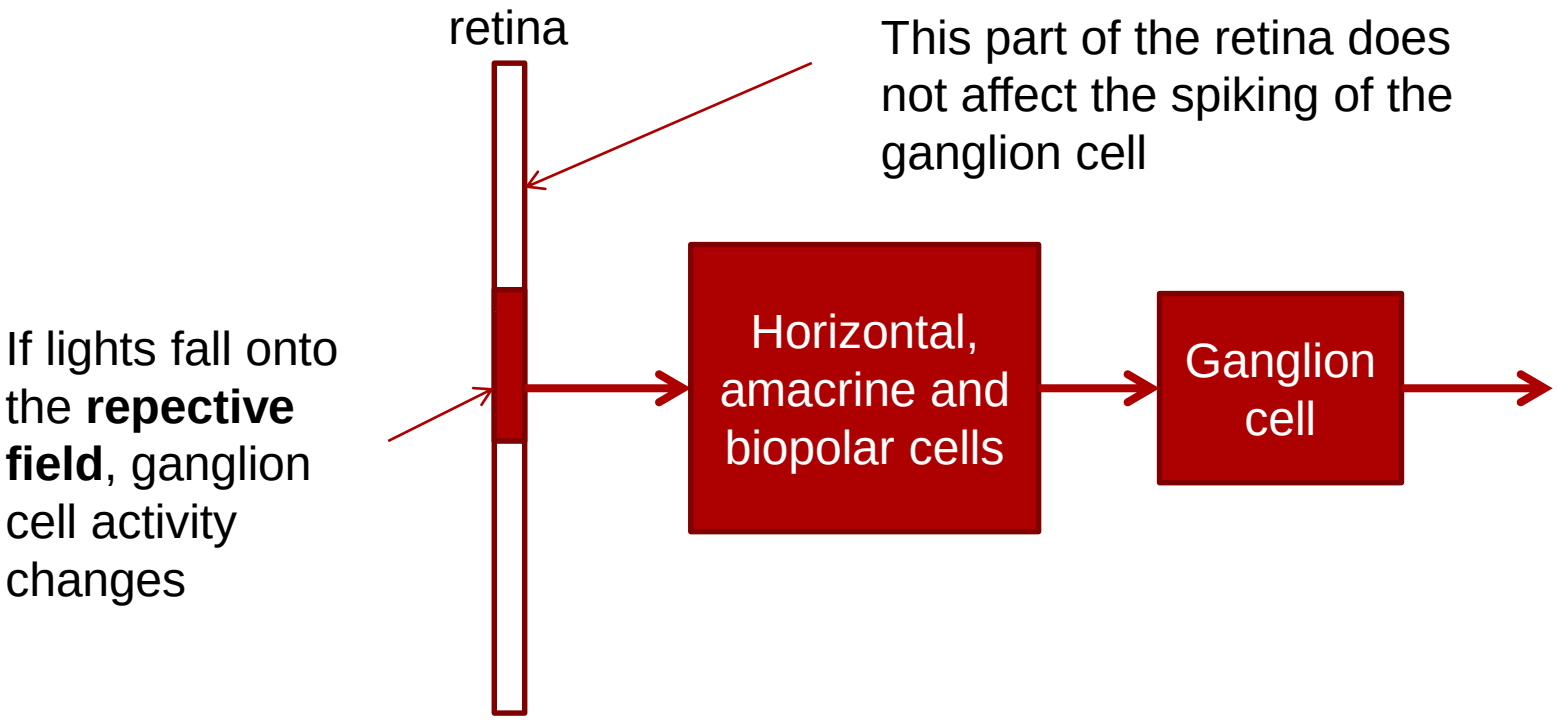
Within the optic nerve, we have **1 axon** each **100 photoreceptors**!

Between photoreceptors and ganglion cells we have: bipolar, horizontal and amacrine cells.

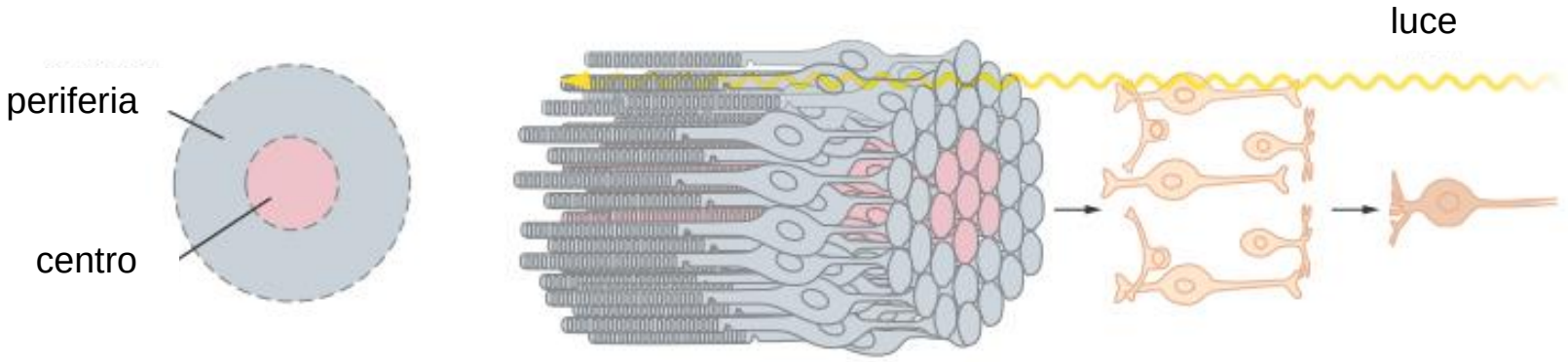


Those neurons **process the signal** which is further projected to the ganglion cells

Each ganlglion cell has a **receptive field**.



Receptive field are circular in the retina, and we have an **antagonistic** behaviour between the centre and the surround (peripheral area)



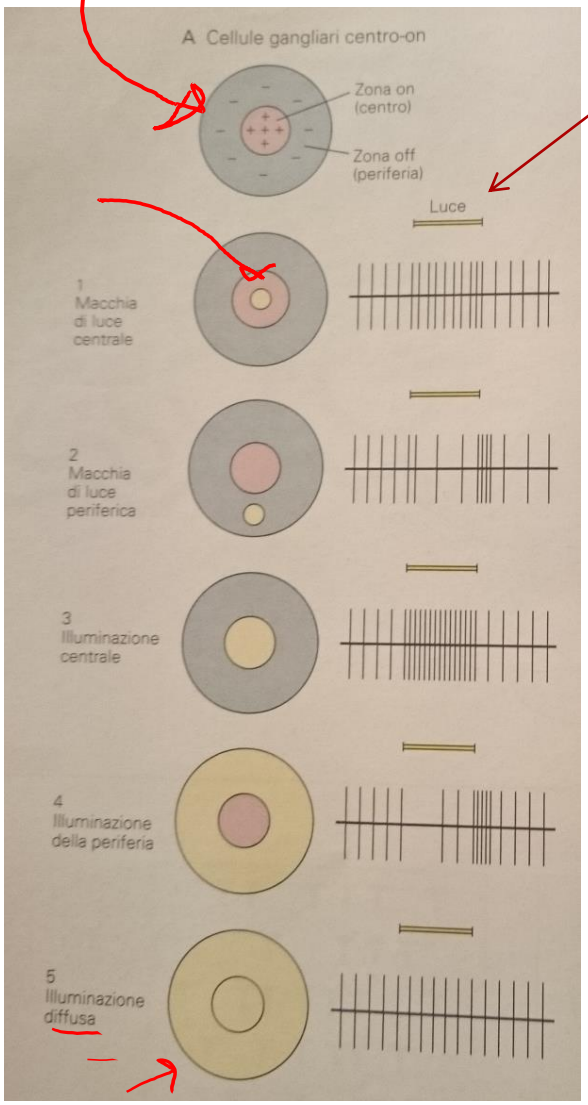
Ganglion cells have optimal output when the illumination is different between the centre and the surround.

With respect to the behaviour of centre-surround, we can classify two different kinds of ganglion cells:

- **centre-on**
- **centre-off**

Centre-ON

Position of the light

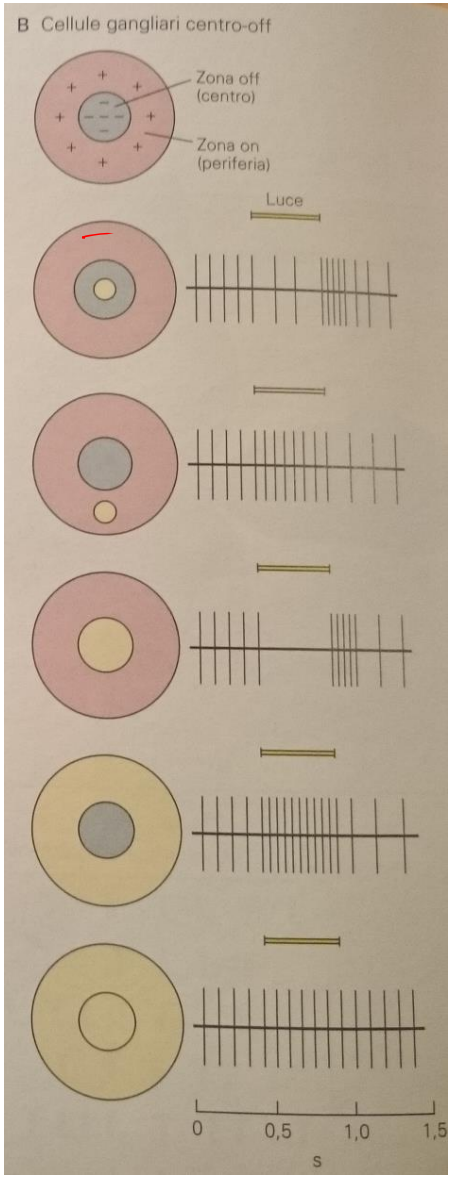


Duration of the light

Light on the centre, increases the number of spikes

Light on the surround, decreases the number of spikes

Centre-OFF

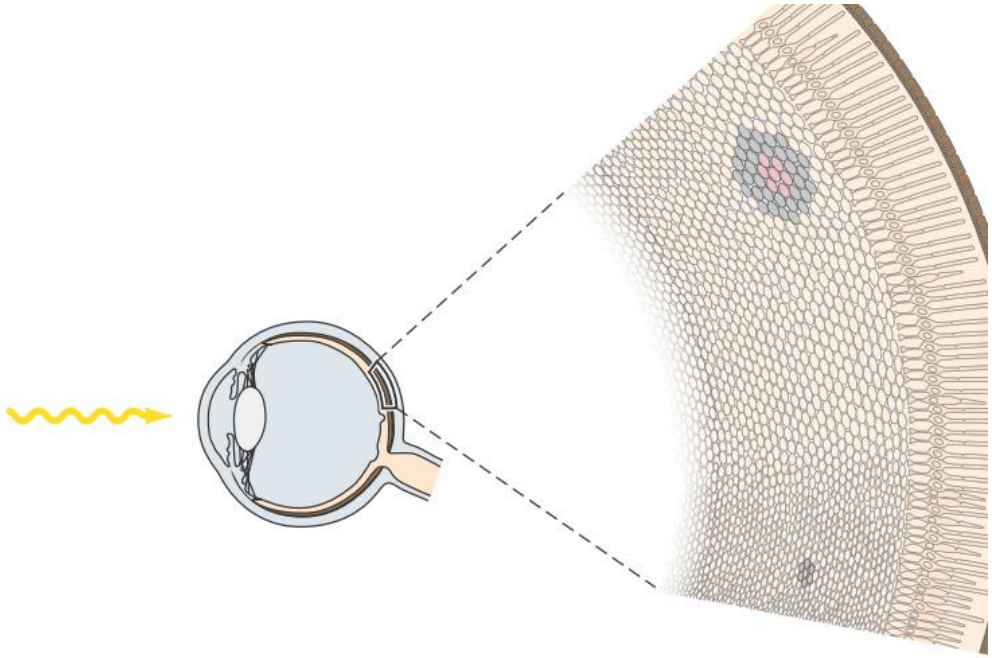


Centre-OFF cells have opposite behaviour: when light hits the centre, spike frequency decreases.

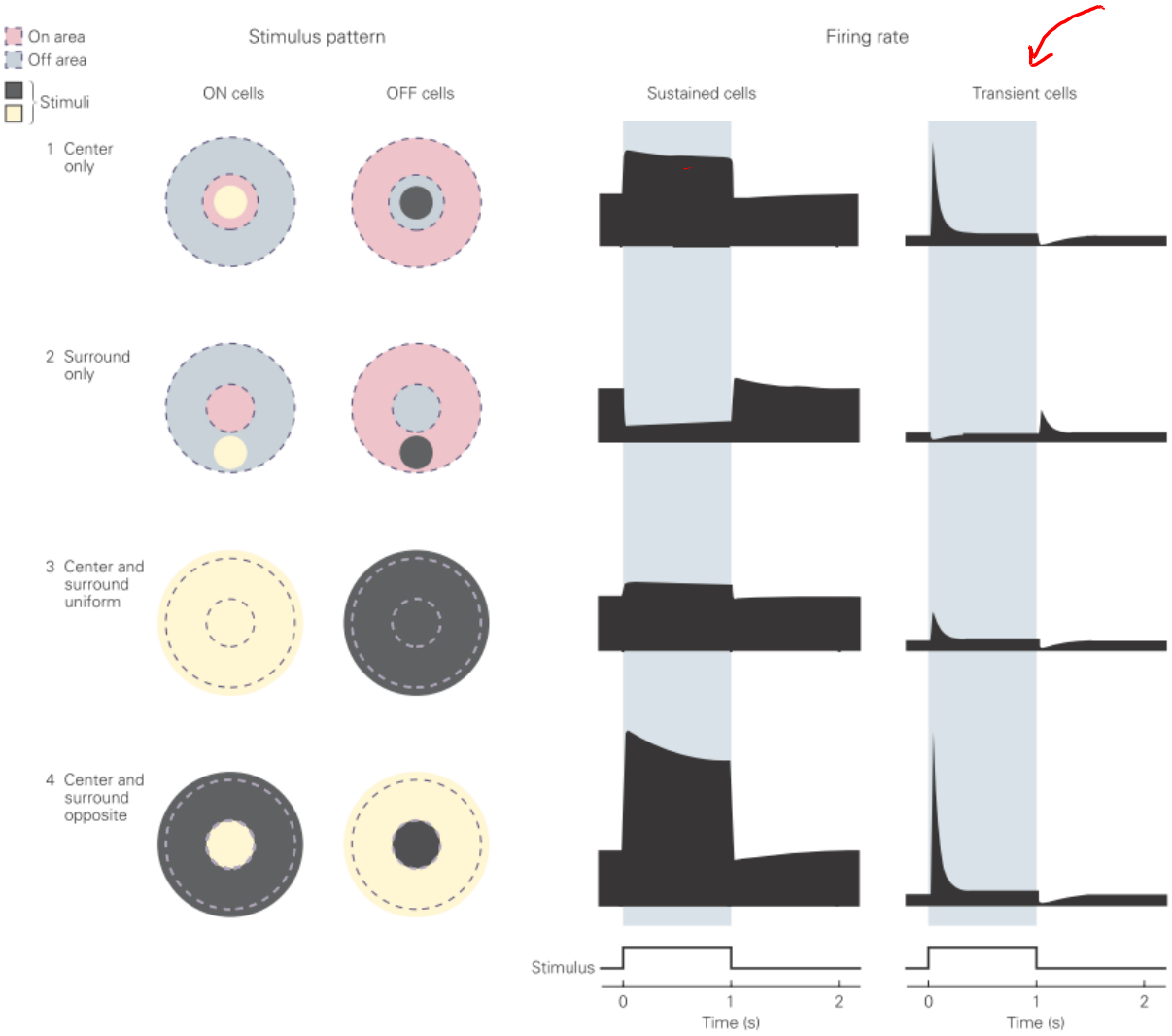
On the other end, when lights hit the surround, spike frequency increases.

We have a similar number of center-on e center-off cells, thus they elaborate the information together

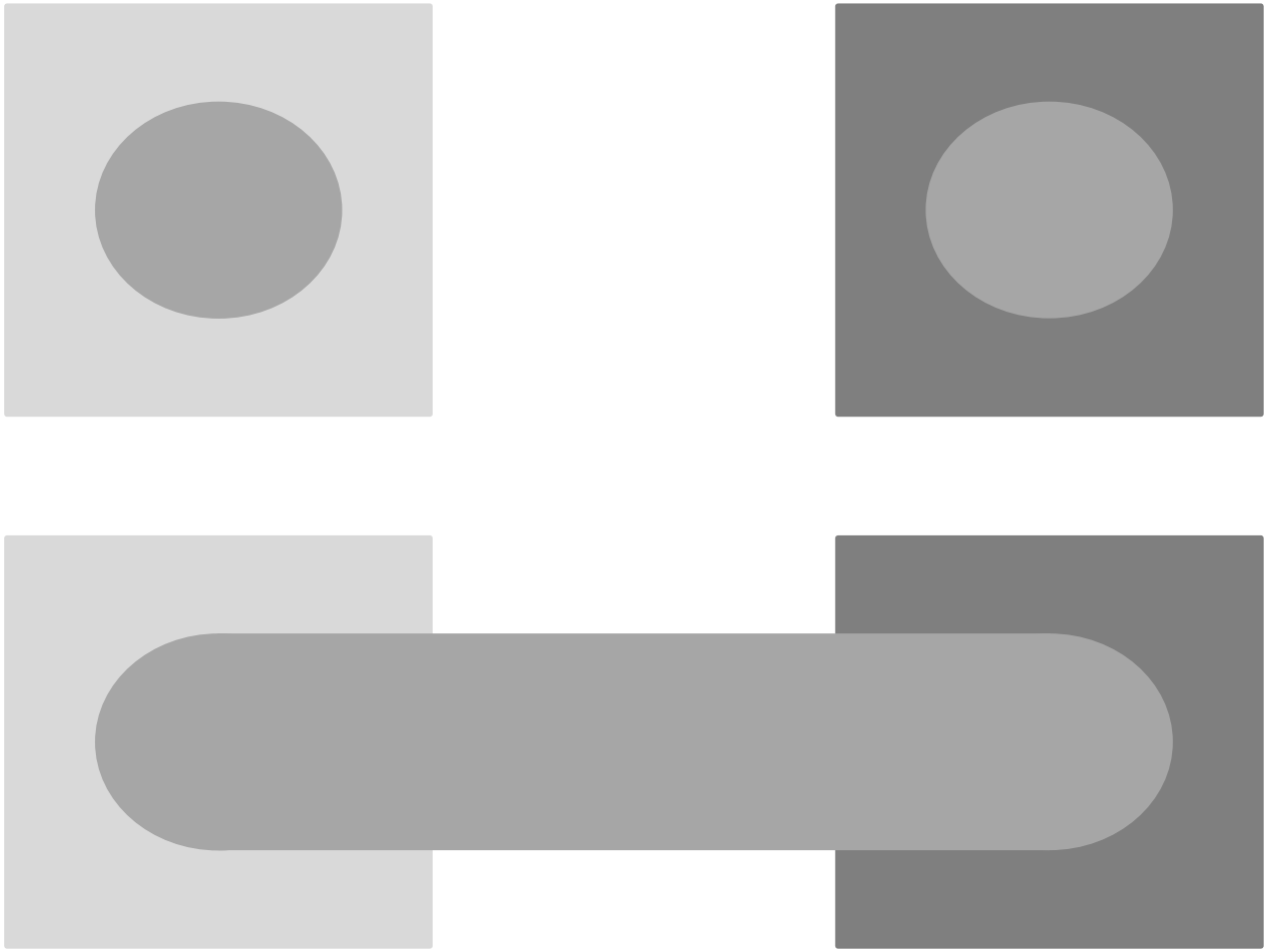
Receptive fields are **smaller in the fovea rather than in the periphery of the retina**



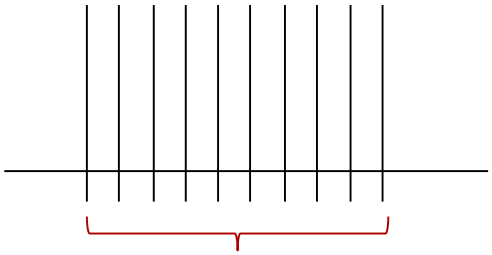
We have another classification if excitation persists throughout stimulation. We call **sustained cells** if the excitation persists, **transient cells** otherwise.



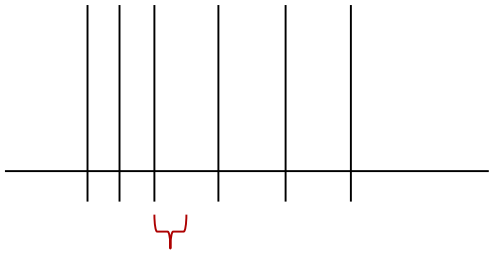
We do not perceive the absolute value of illumination. Our eye detects **intensity contrast** within the scene.



❖ Why two complementary systems?

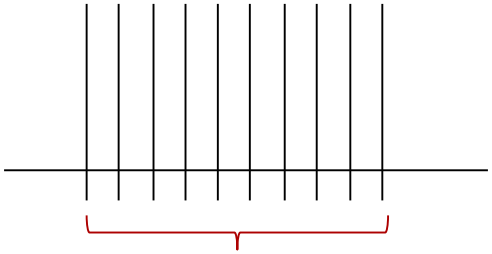


decrease

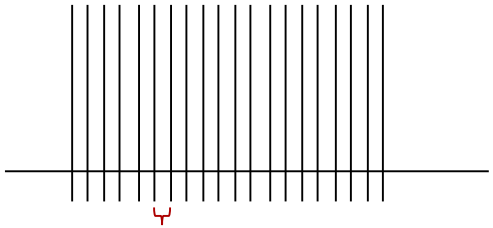


10 spike /s = 1 spike each 0,1s

post-sinaptic neuron needs 0,1s to identify the change



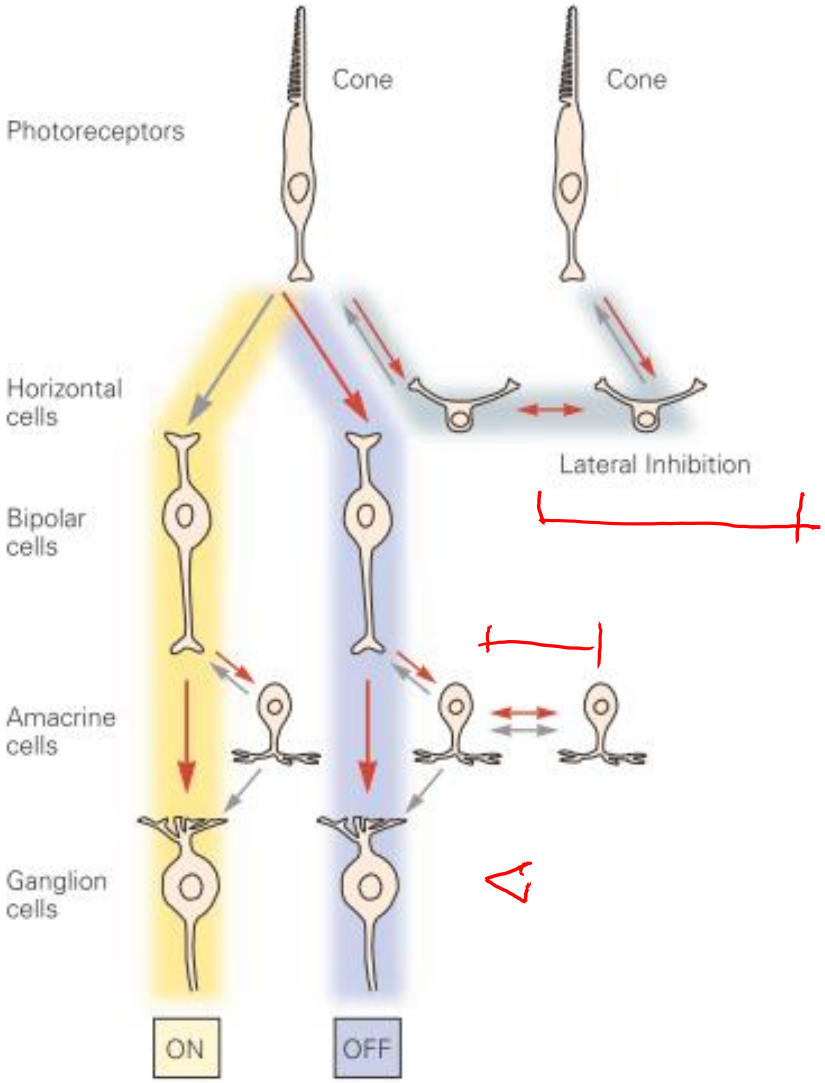
increase



10 spike / s = 1 spike ogni 0,1s

post-sinaptic neuron detects in less than 0,1s the change

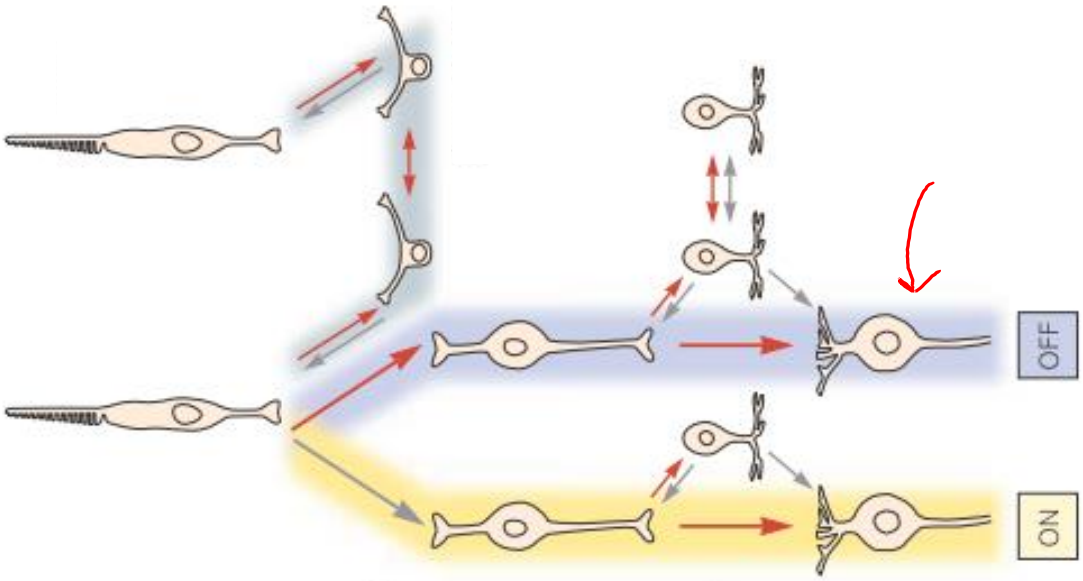
This is a hypothetic explanation of the existence of two complementary systems



We have two pathways in the retina: one vertical and one horizontal

Cone -> Bipolar -> Ganglion cells is called **direct pathway**.

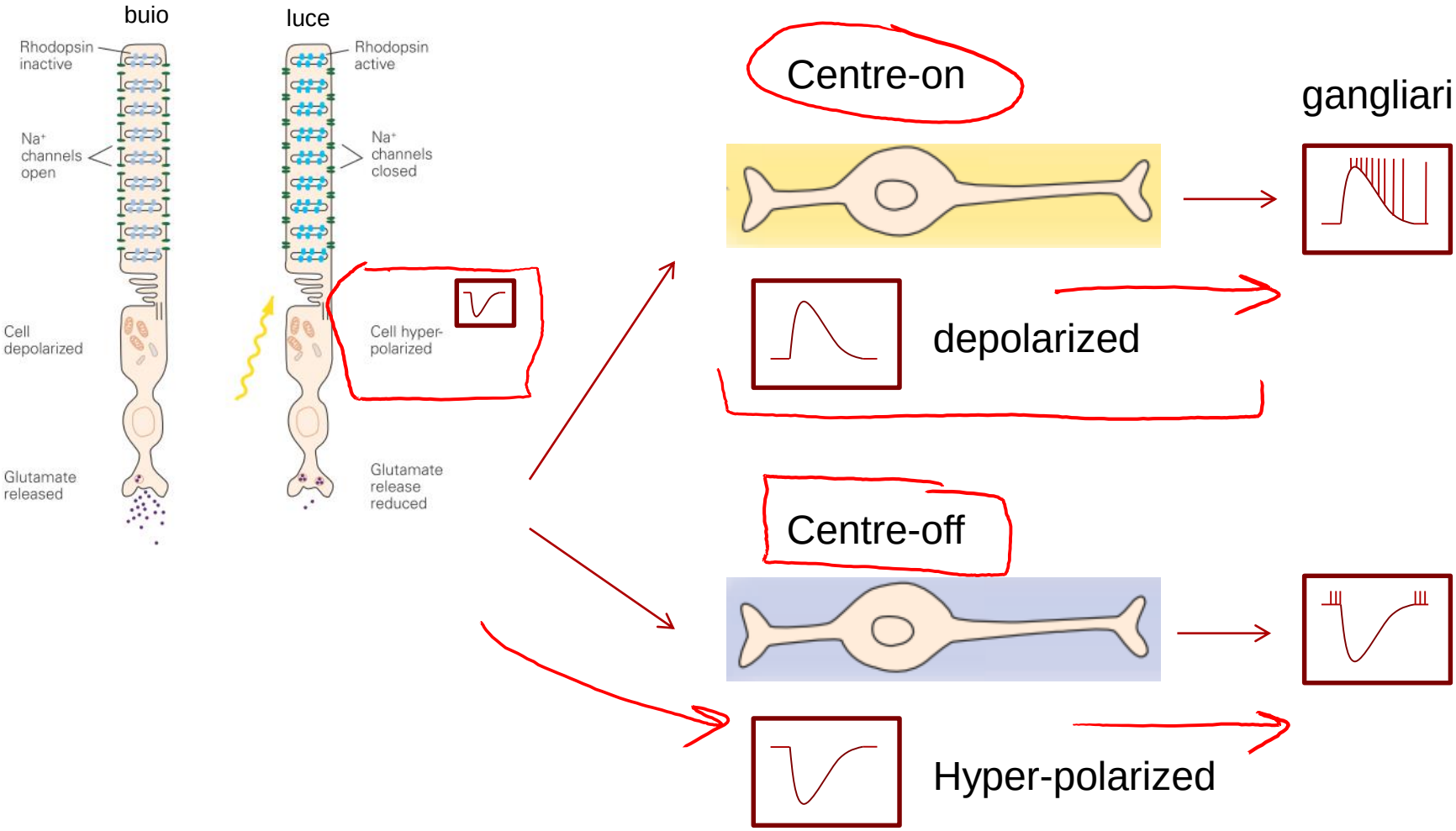
Cone -> Horizontal -> Bipolar -> Ganglion cells, it is an indirect way, called **lateral pathway**



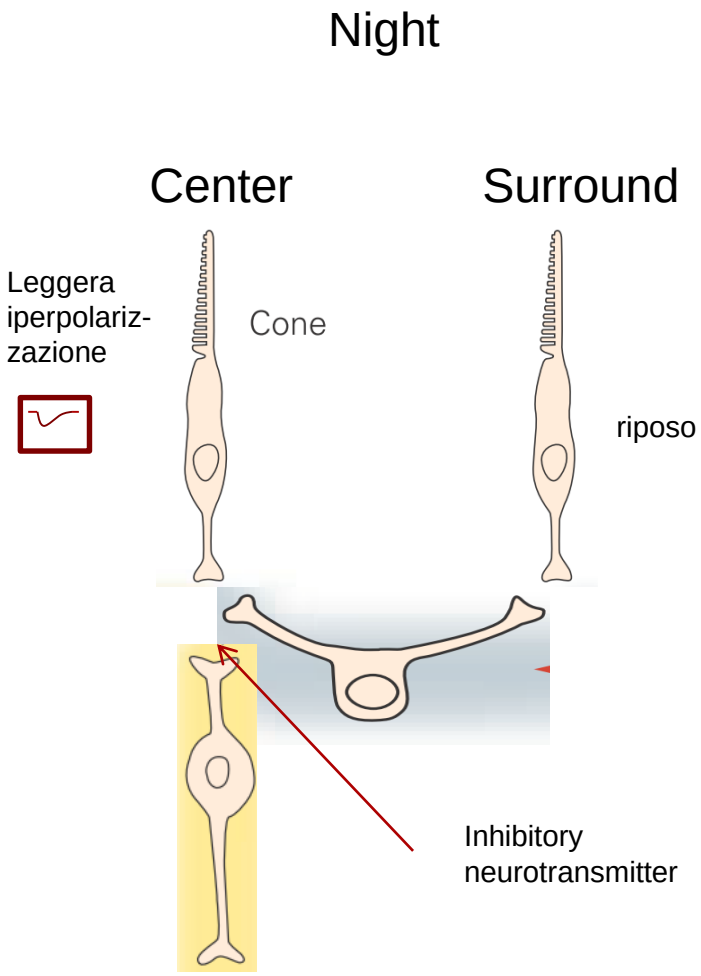
Also bipolar cells have a different behavior on center-on and center-off receptive field

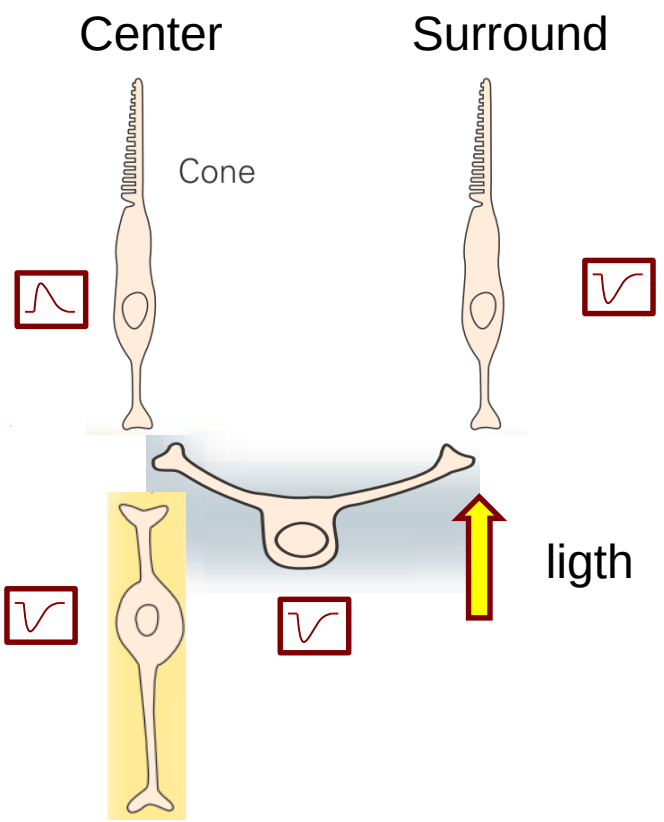
Bipolar center-on cells depolarize when subject to illumination, and further depolarize center-on ganglion cells. Bipolar center-off cell, hyper-polarize when subject to illumination, and hyperpolarize center-off ganglion cells

Bipolar (centre-on and centre-off) have a different response to glutamate, released by photoreceptors



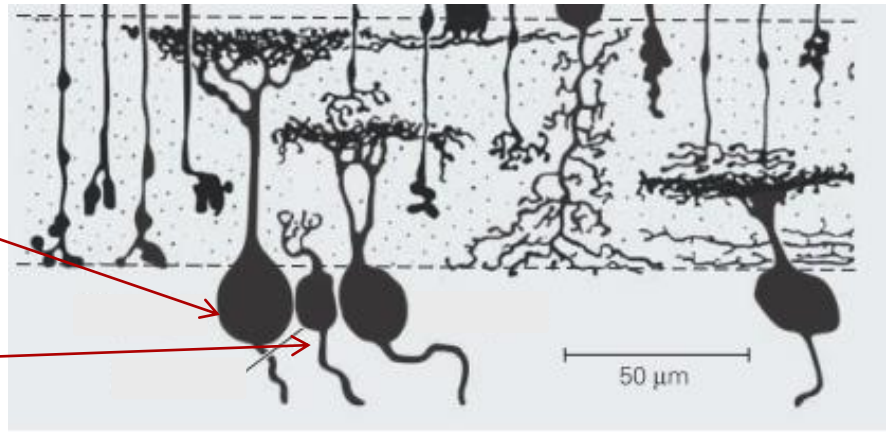
Lateral **inhibitory** connections create the antagonistic mechanism of receptive field

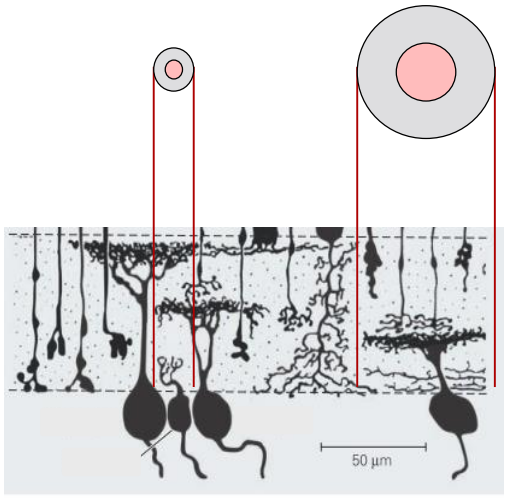




Another difference is related to the size of the ganglion cells, **M cells** (magnae, big) and **P cells** (parvae, small).

With have either centre-on and centre-off cells





Receptive fields are different for M and P cell. They are big for M cell, and small for P.