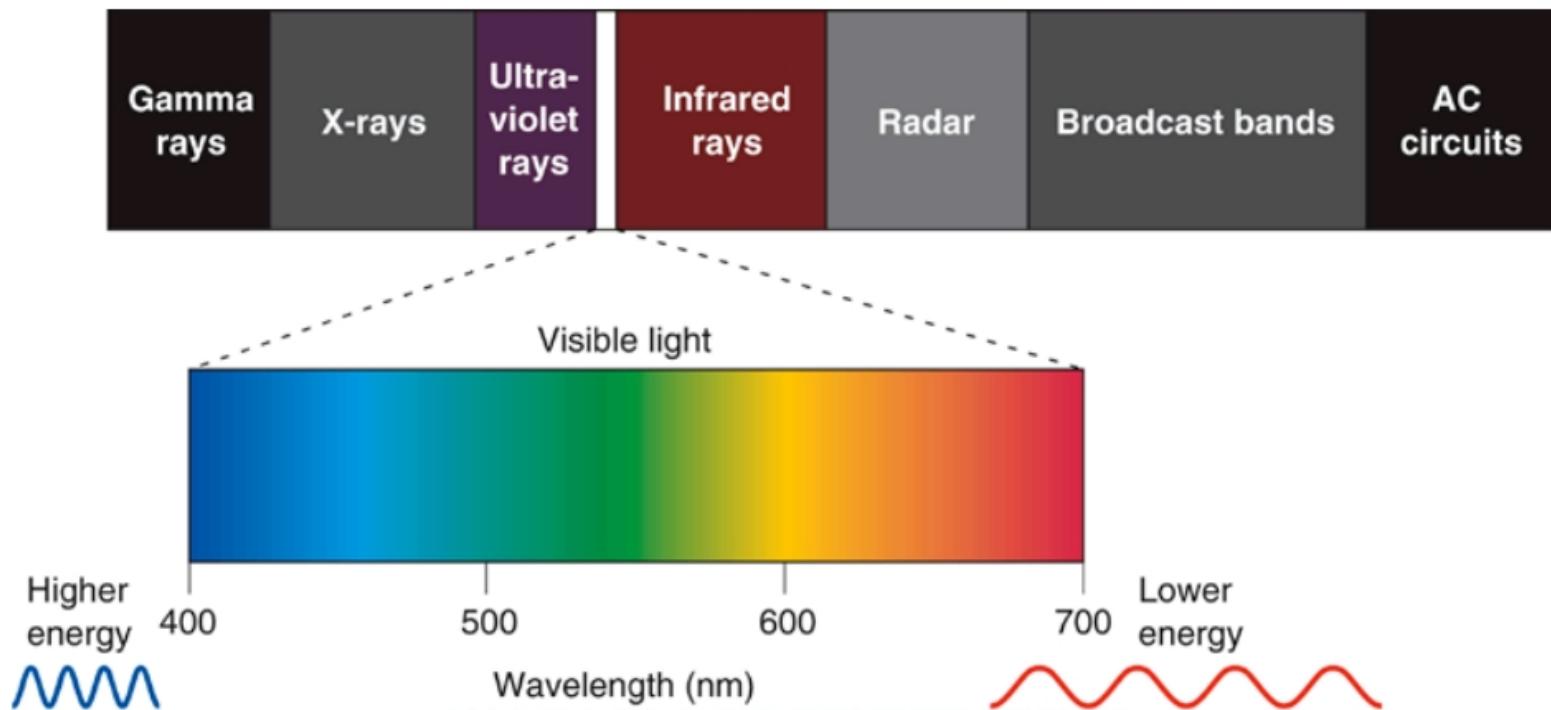


Sub-cortical Vision

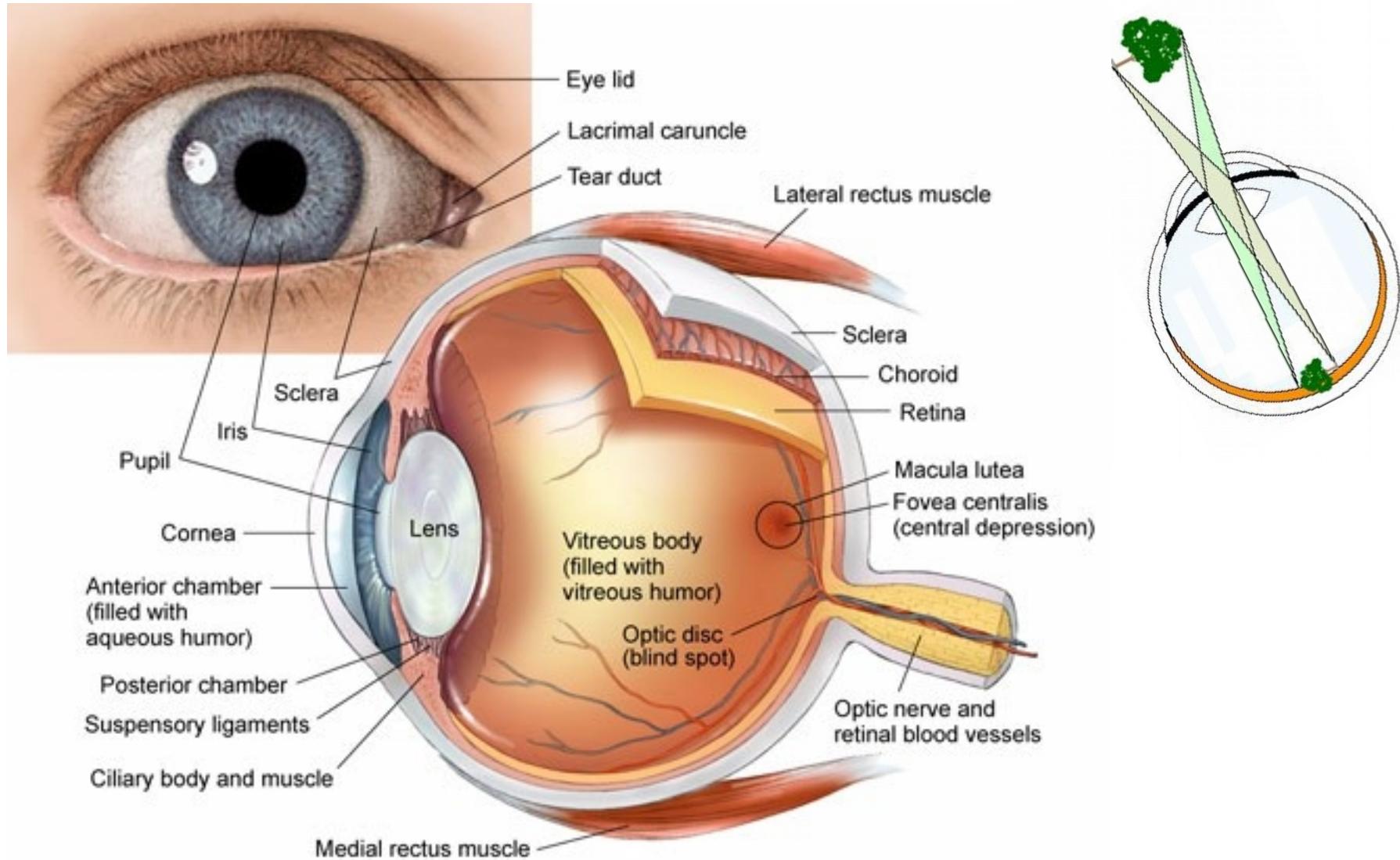
NAIL088
Ján Antolík
MFF UK, 2019

Light



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The Eye



+



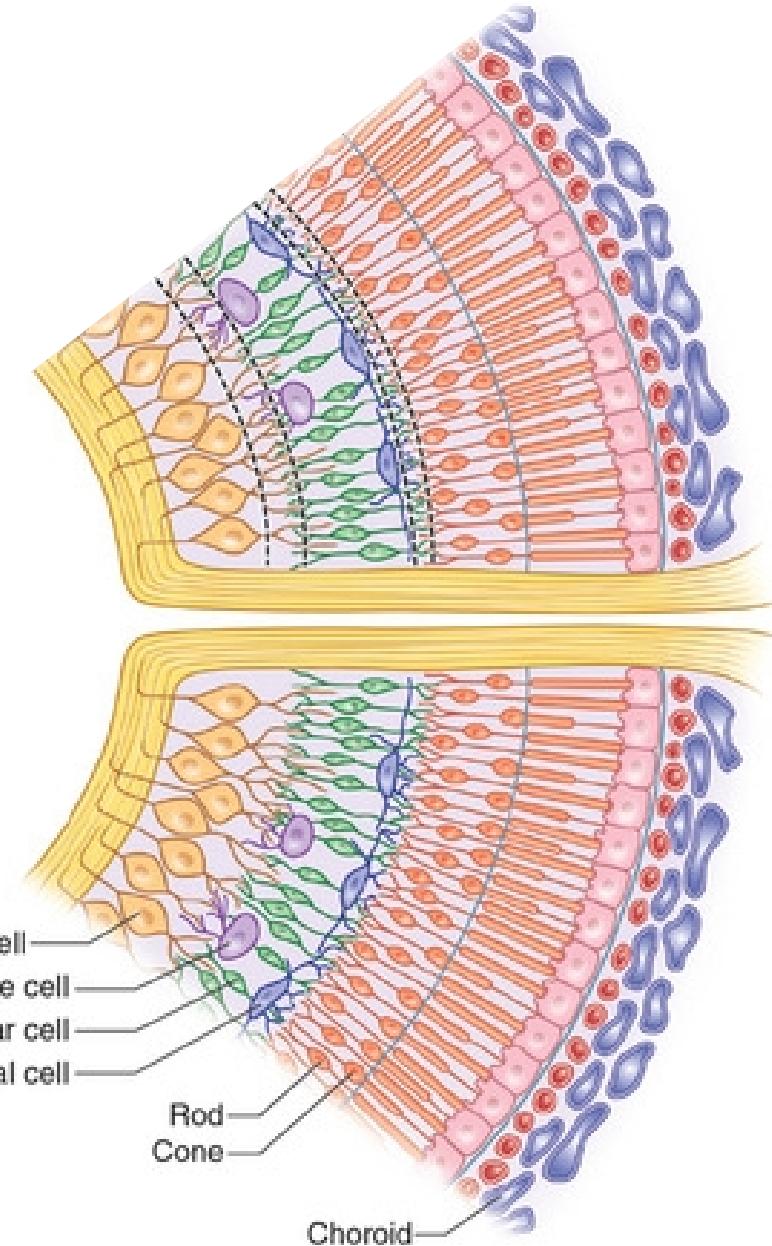
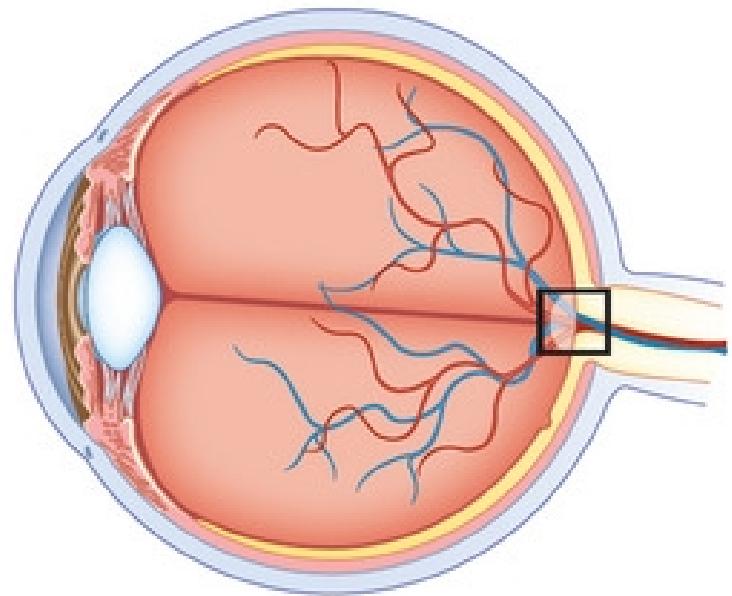
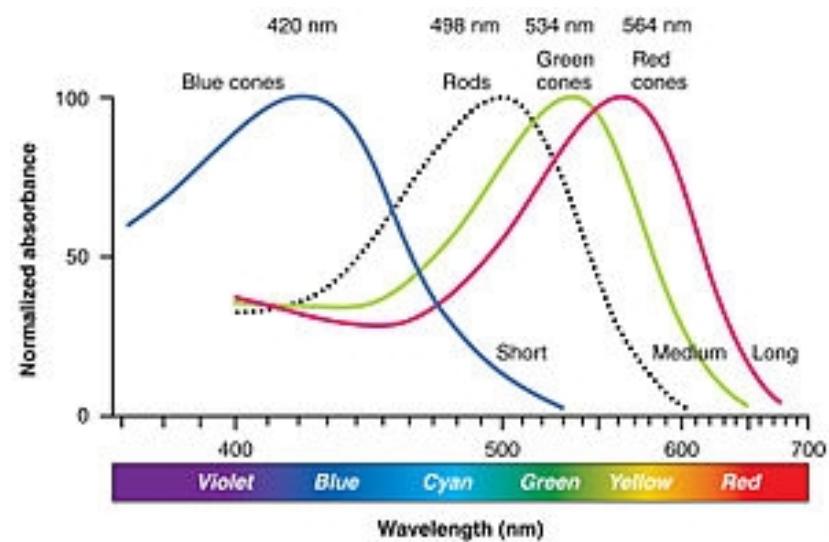
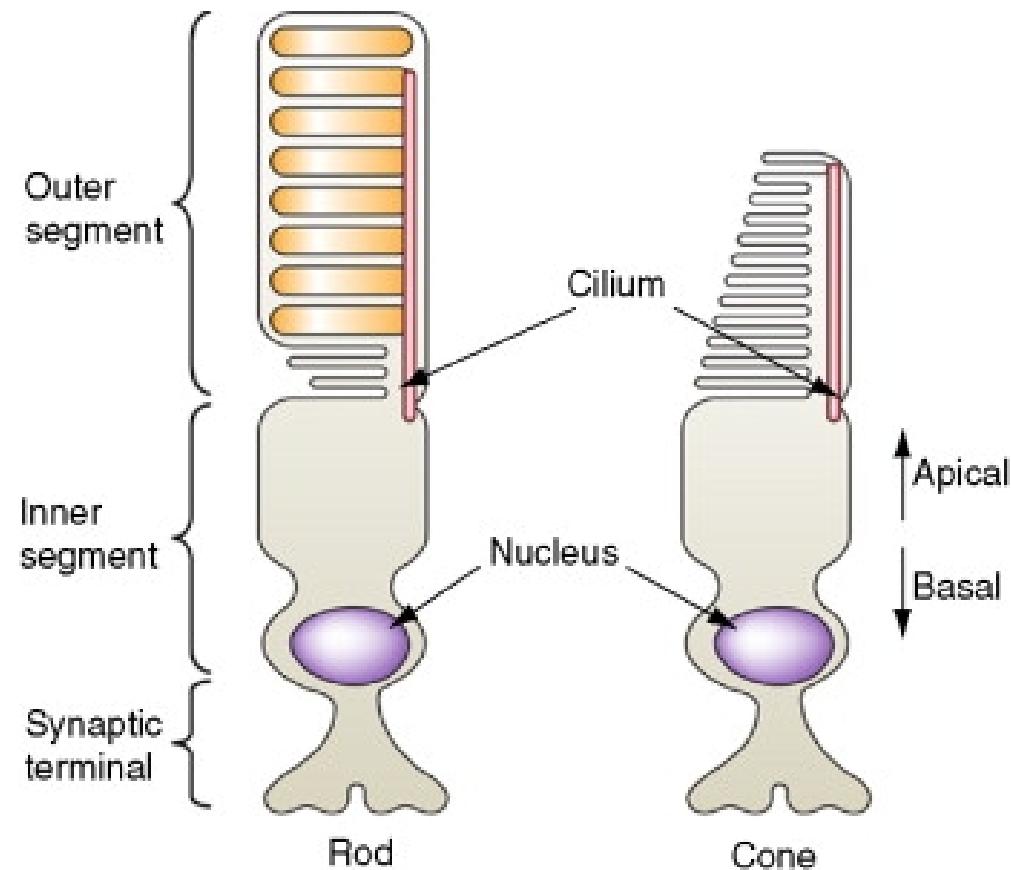
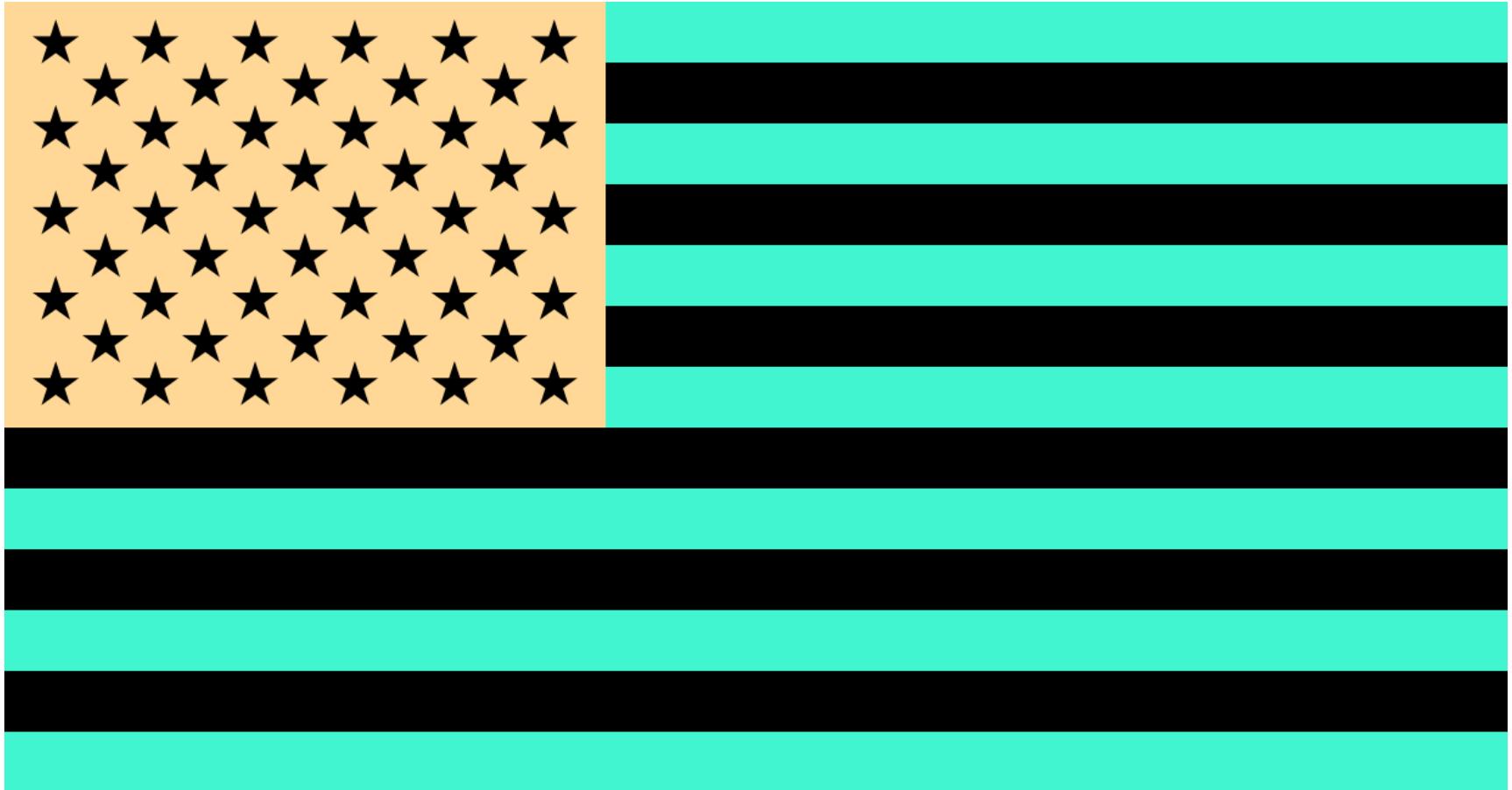
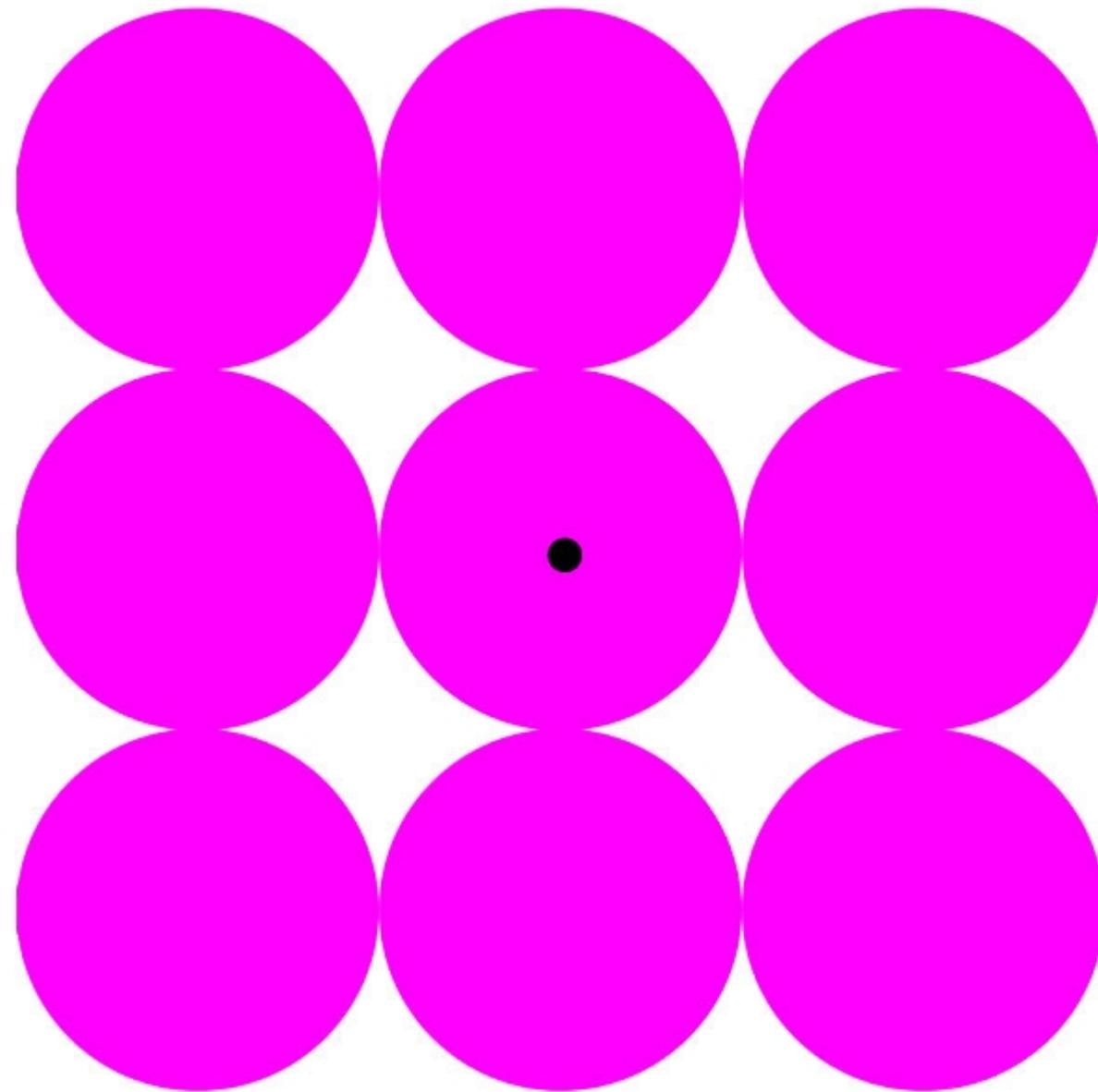


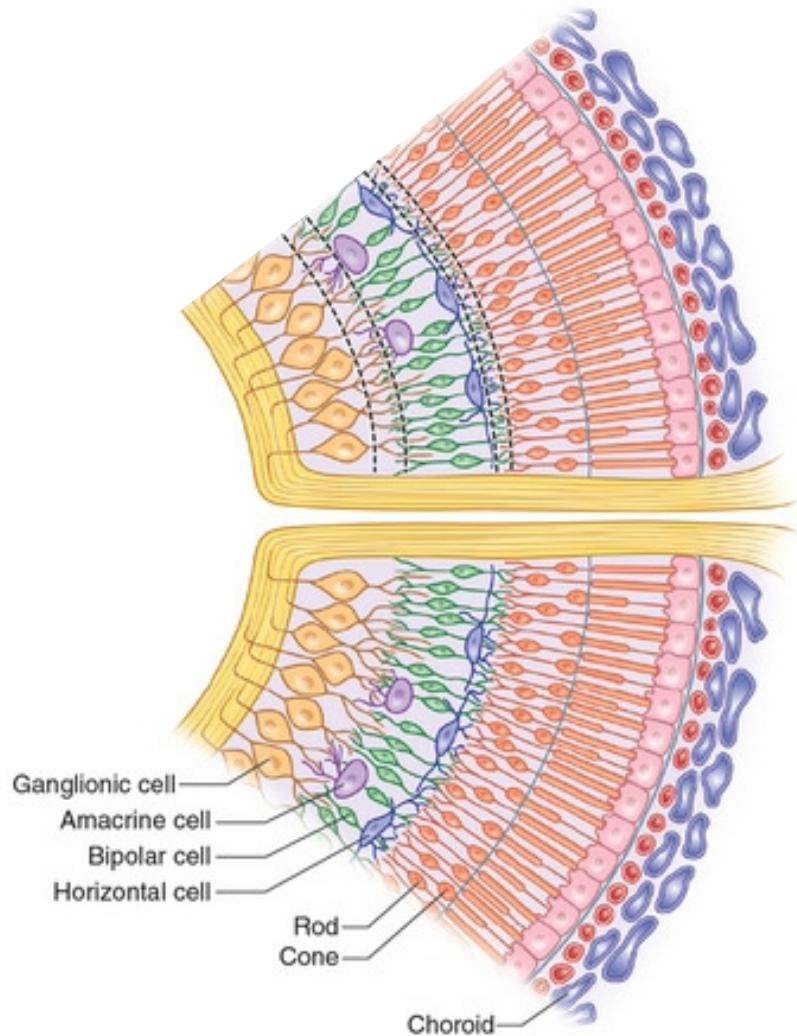
Photo-receptors & color vision



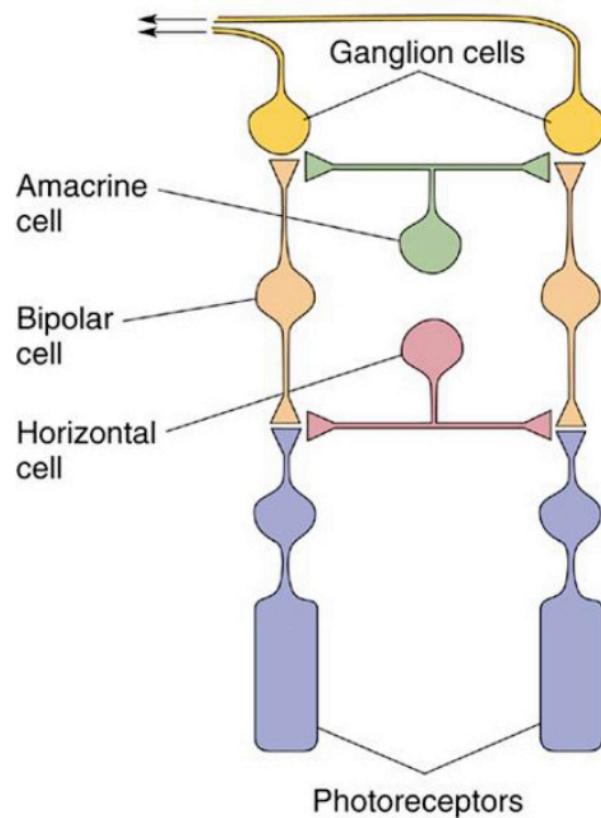




Retina as layered computation

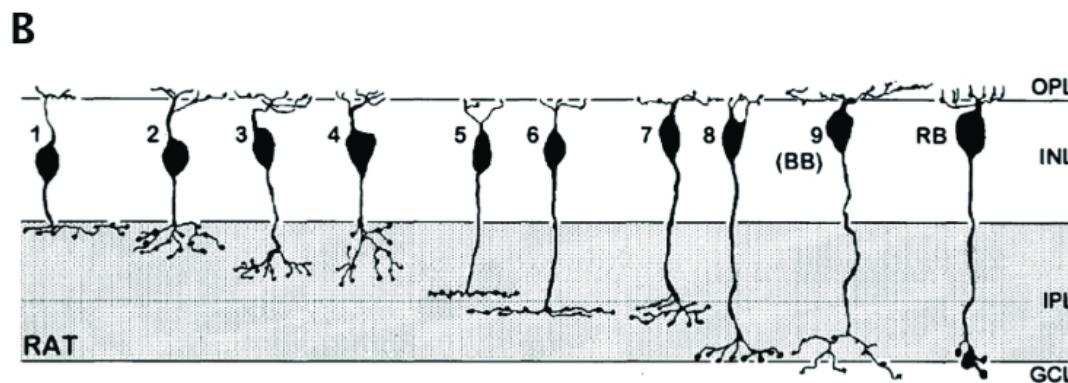
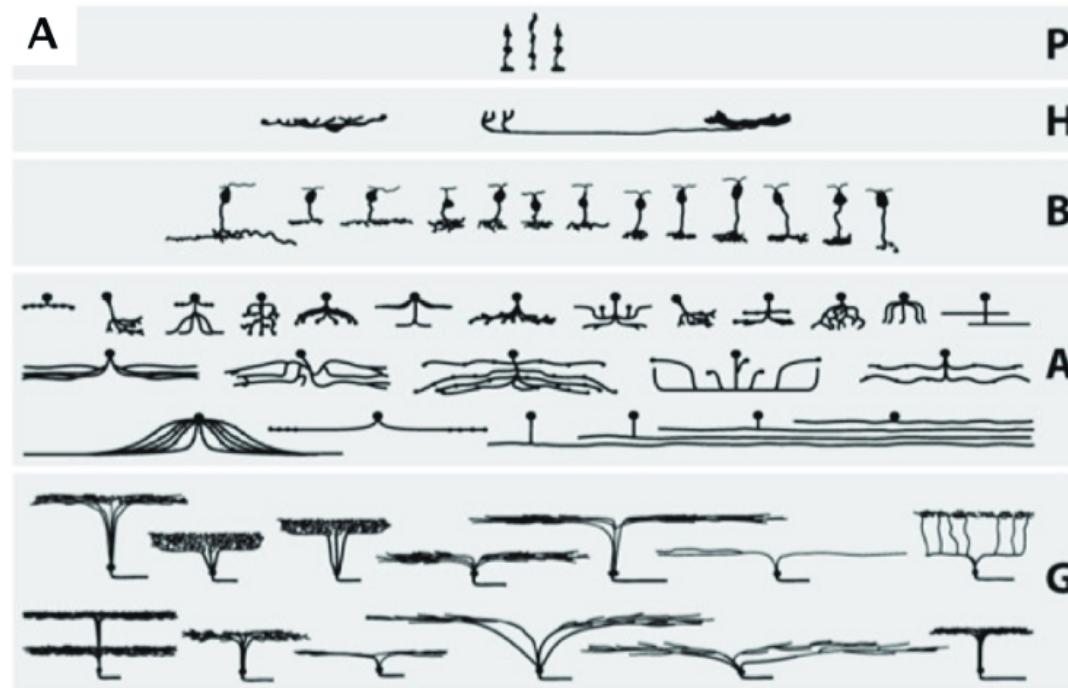


Ganglion cell axons
projecting to forebrain

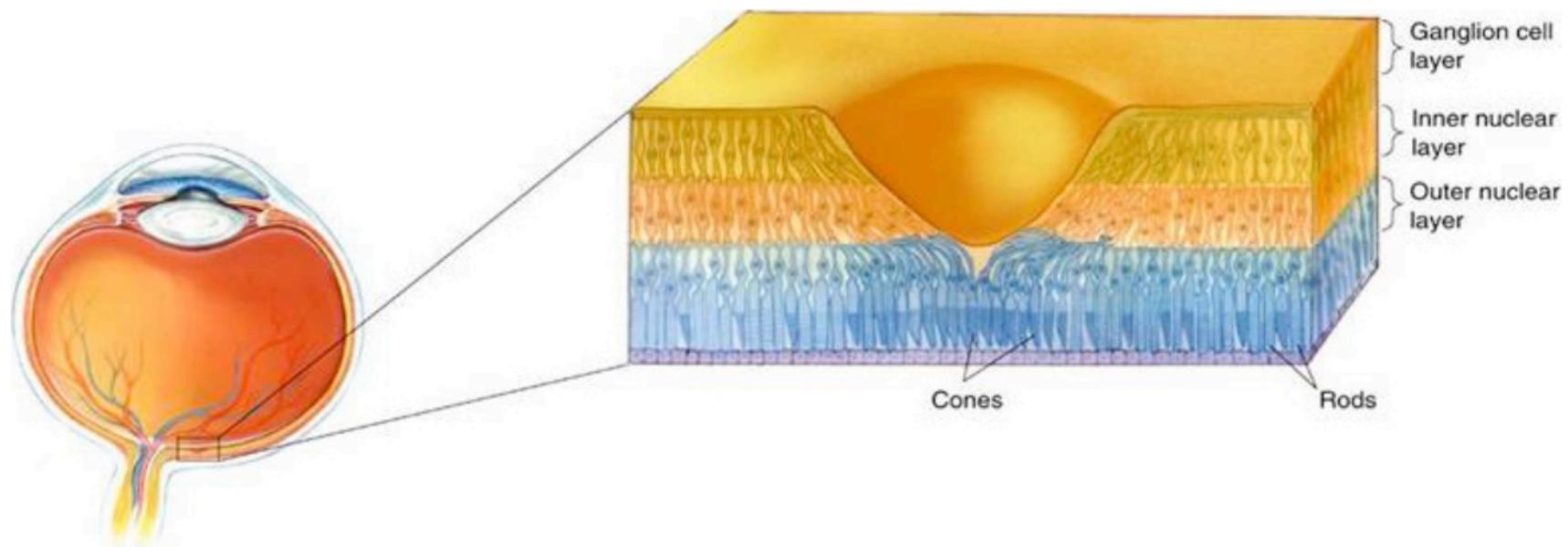


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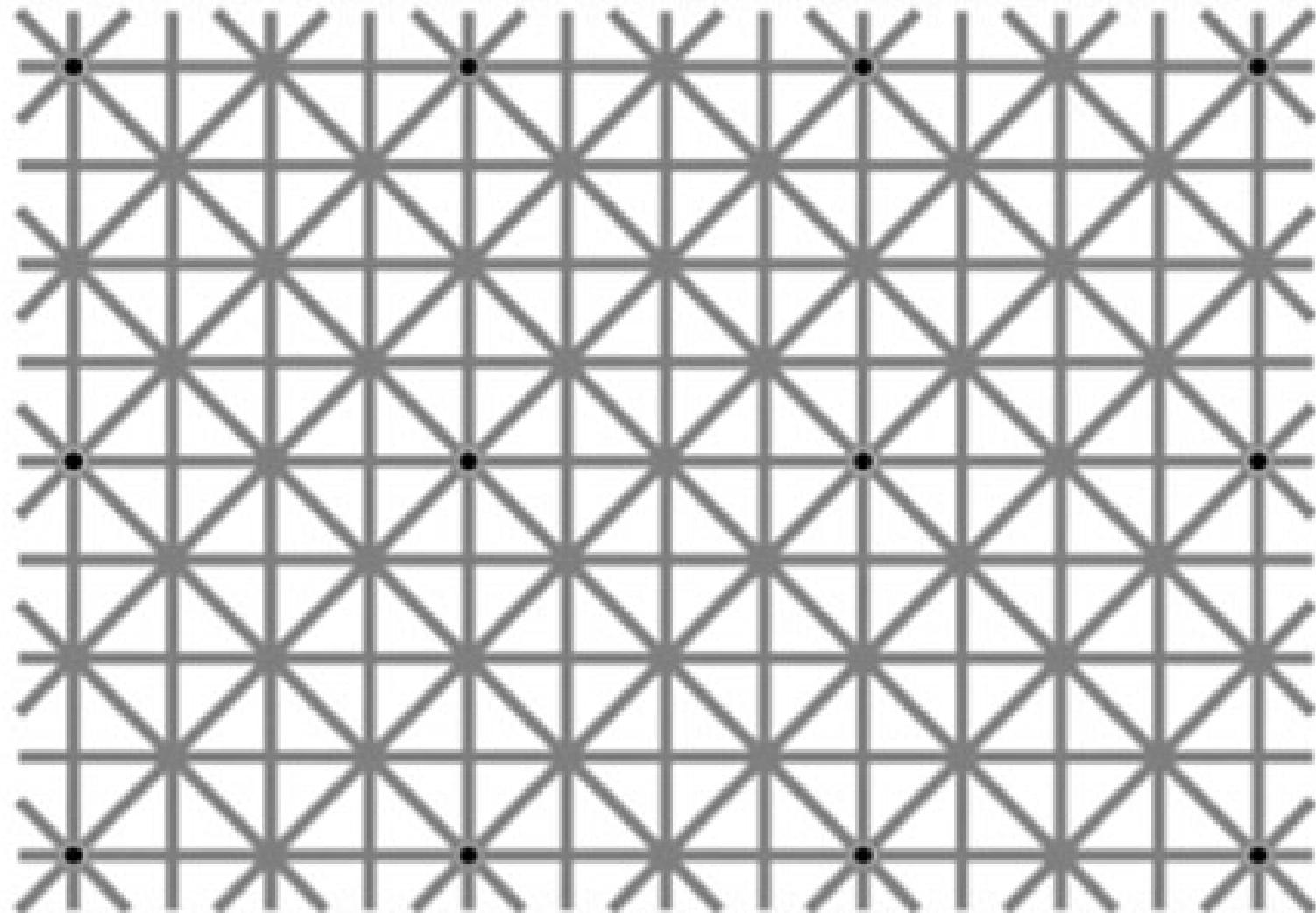
More than 80 retinal cell types



Fovea – macular pit

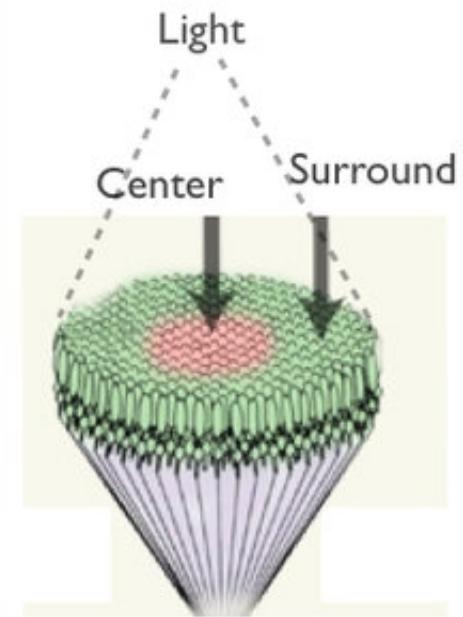
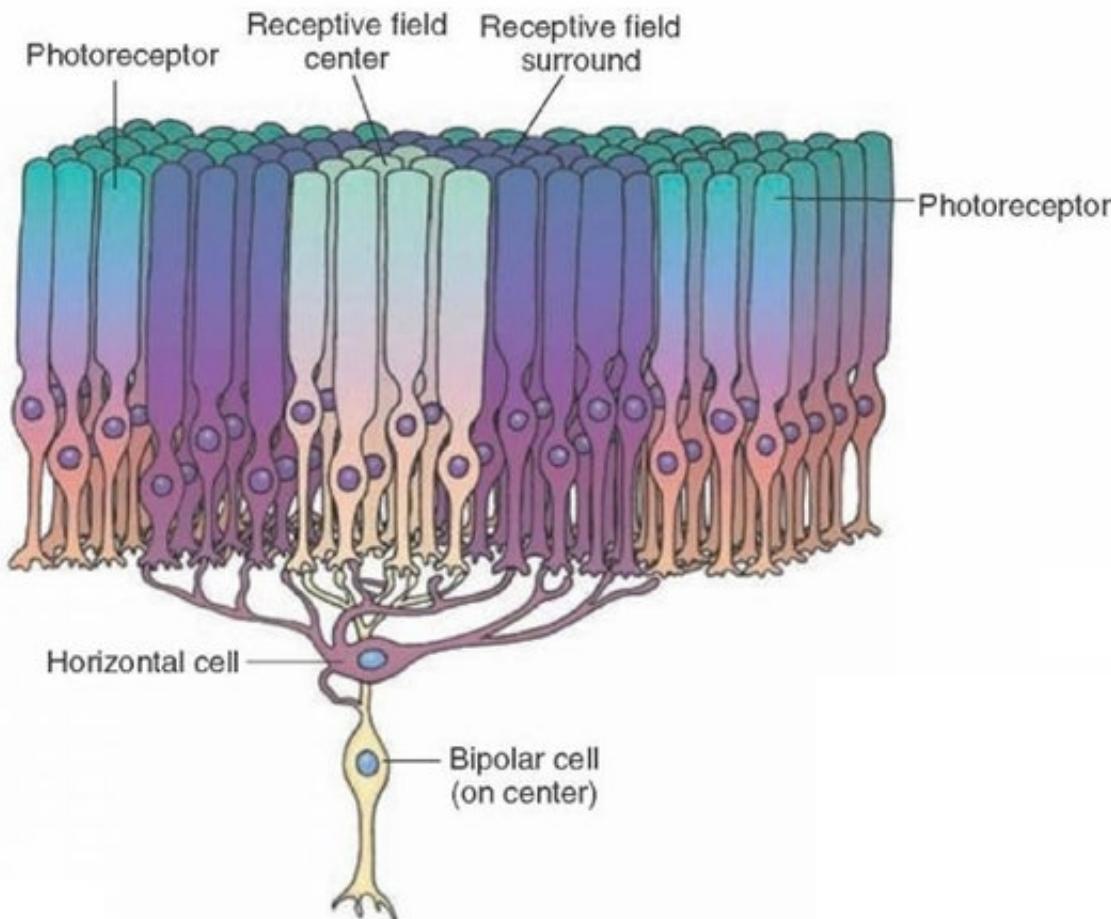


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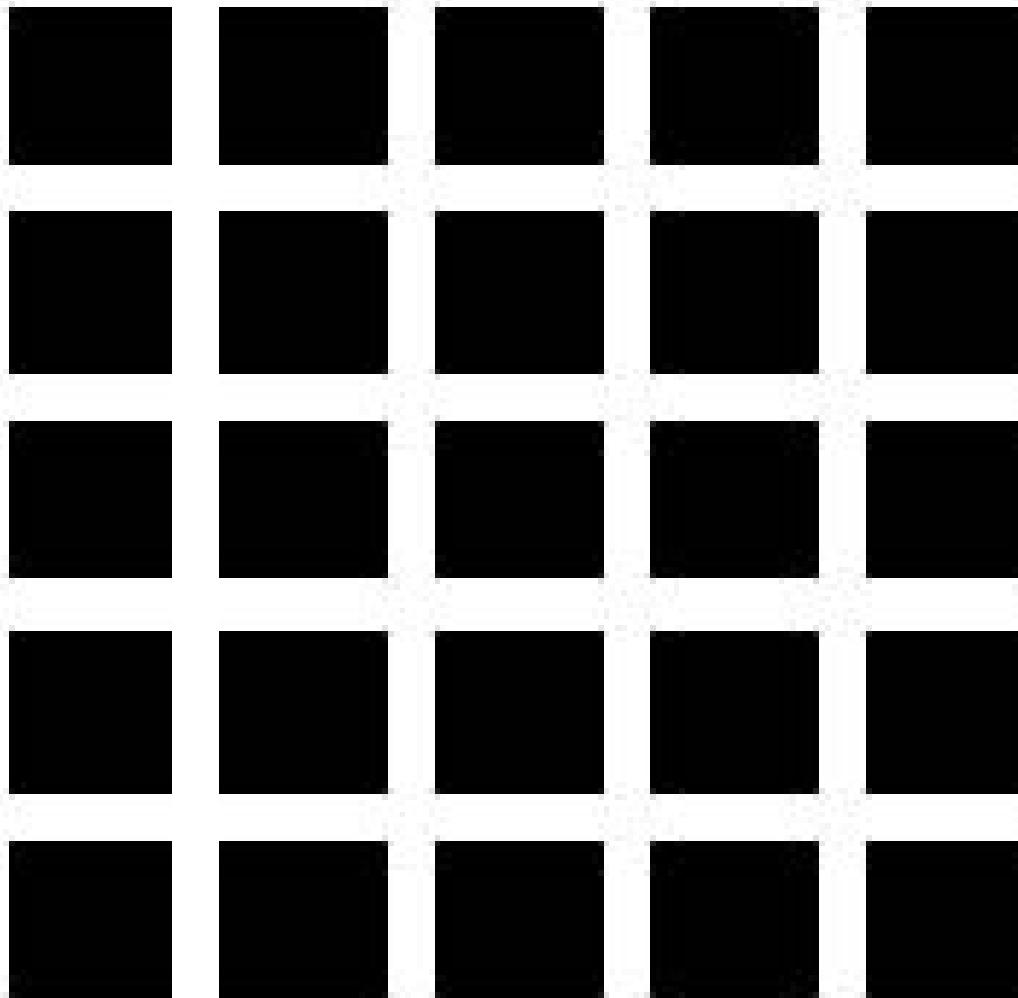


How to RFs come about?

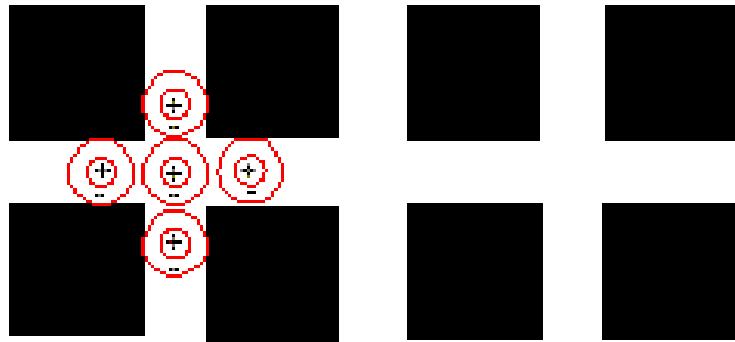
Retinal receptive fields



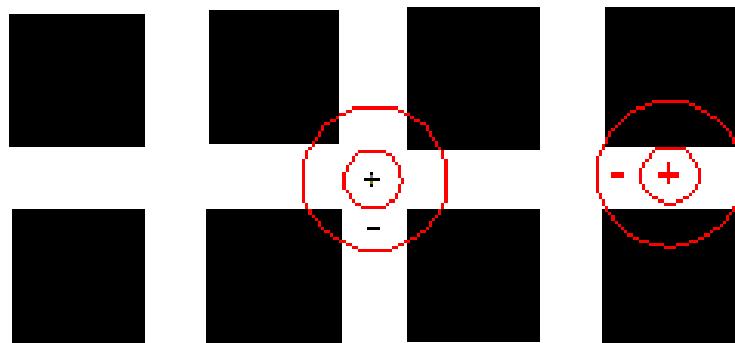
Retinal ganglion cell

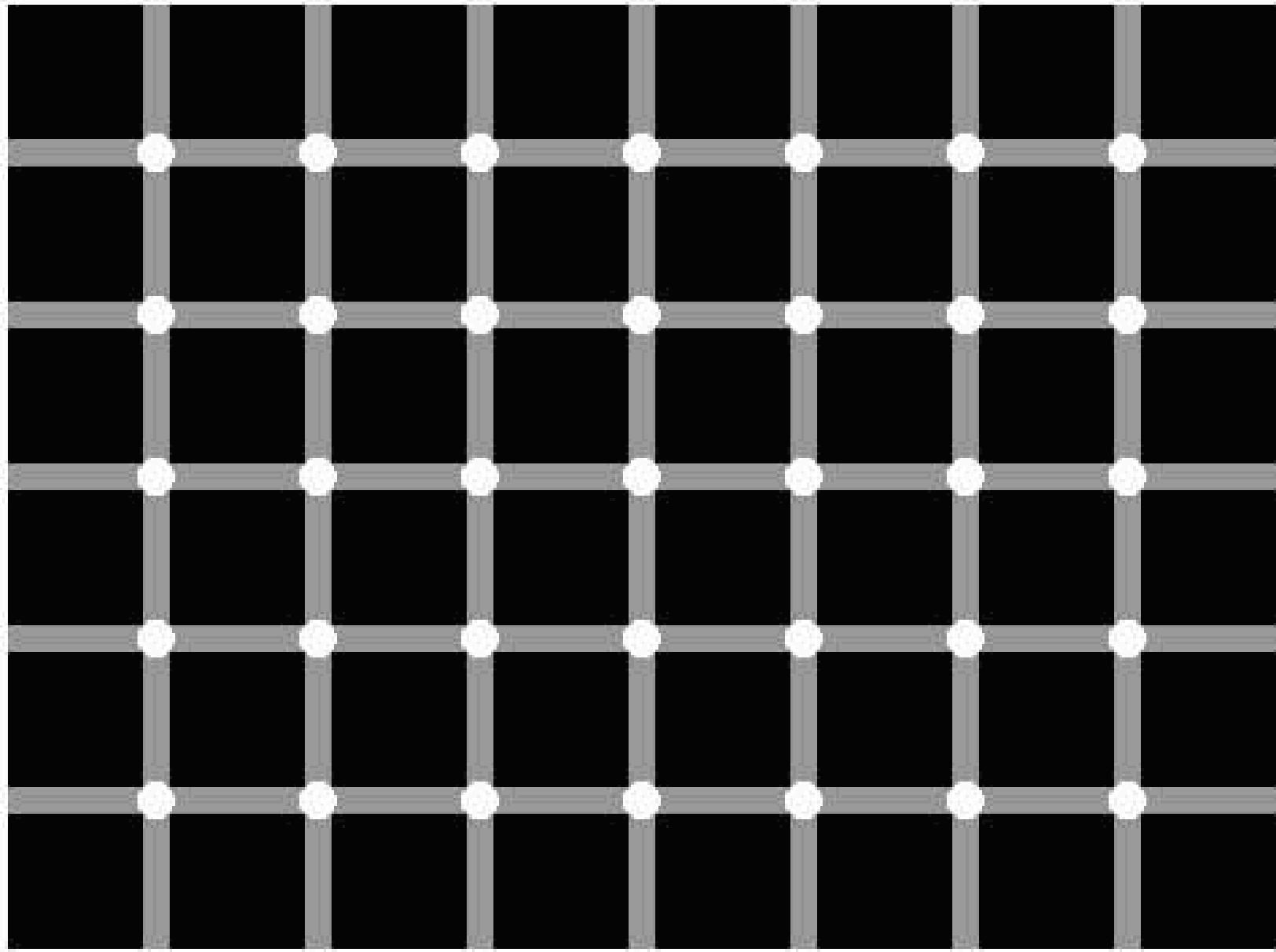


foveal
representation

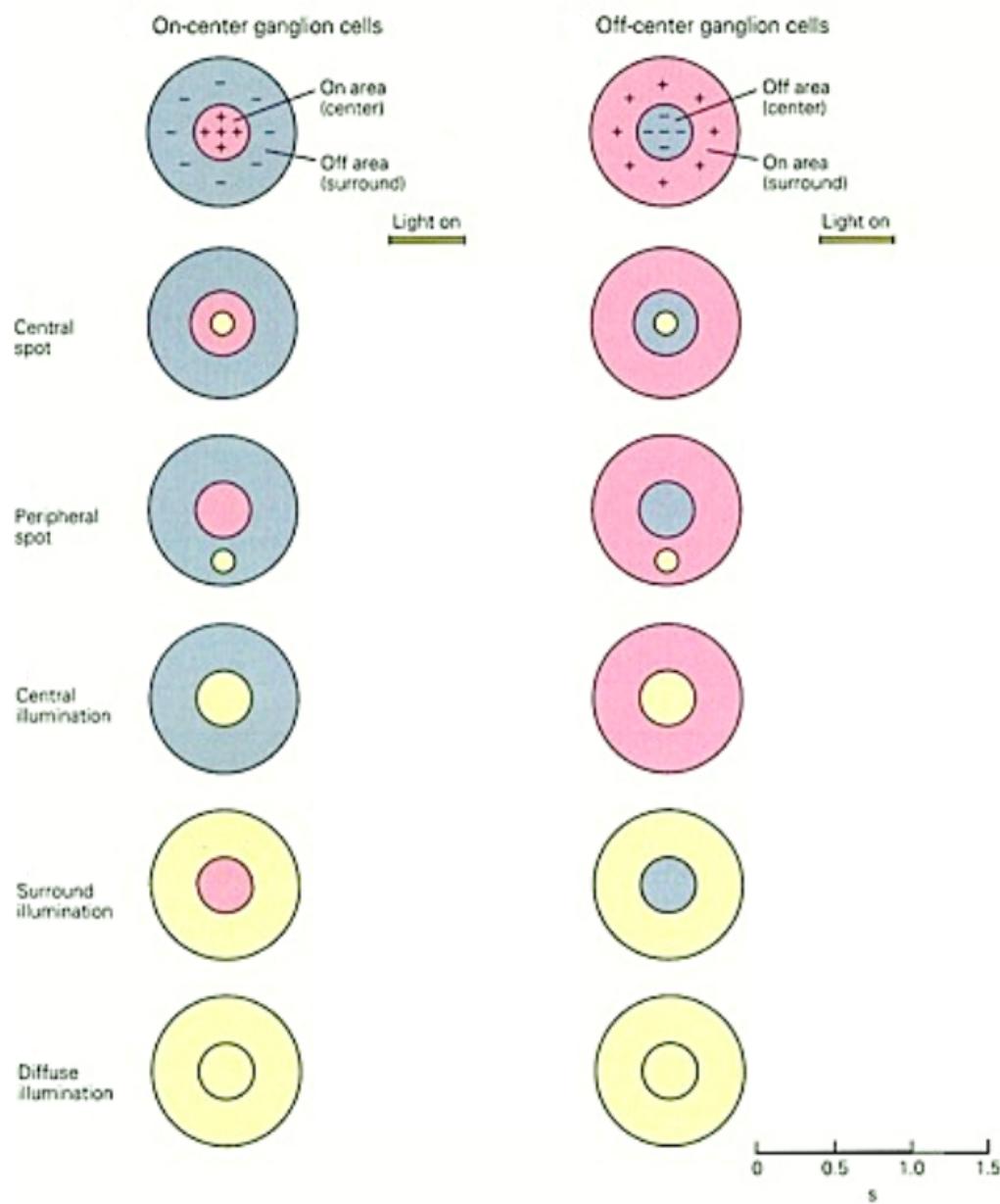
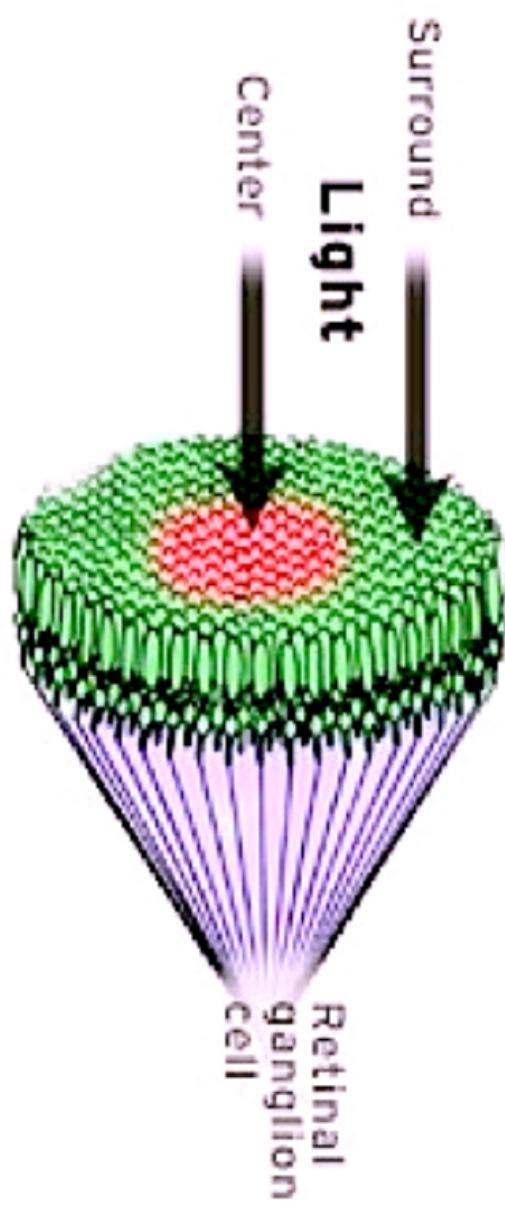


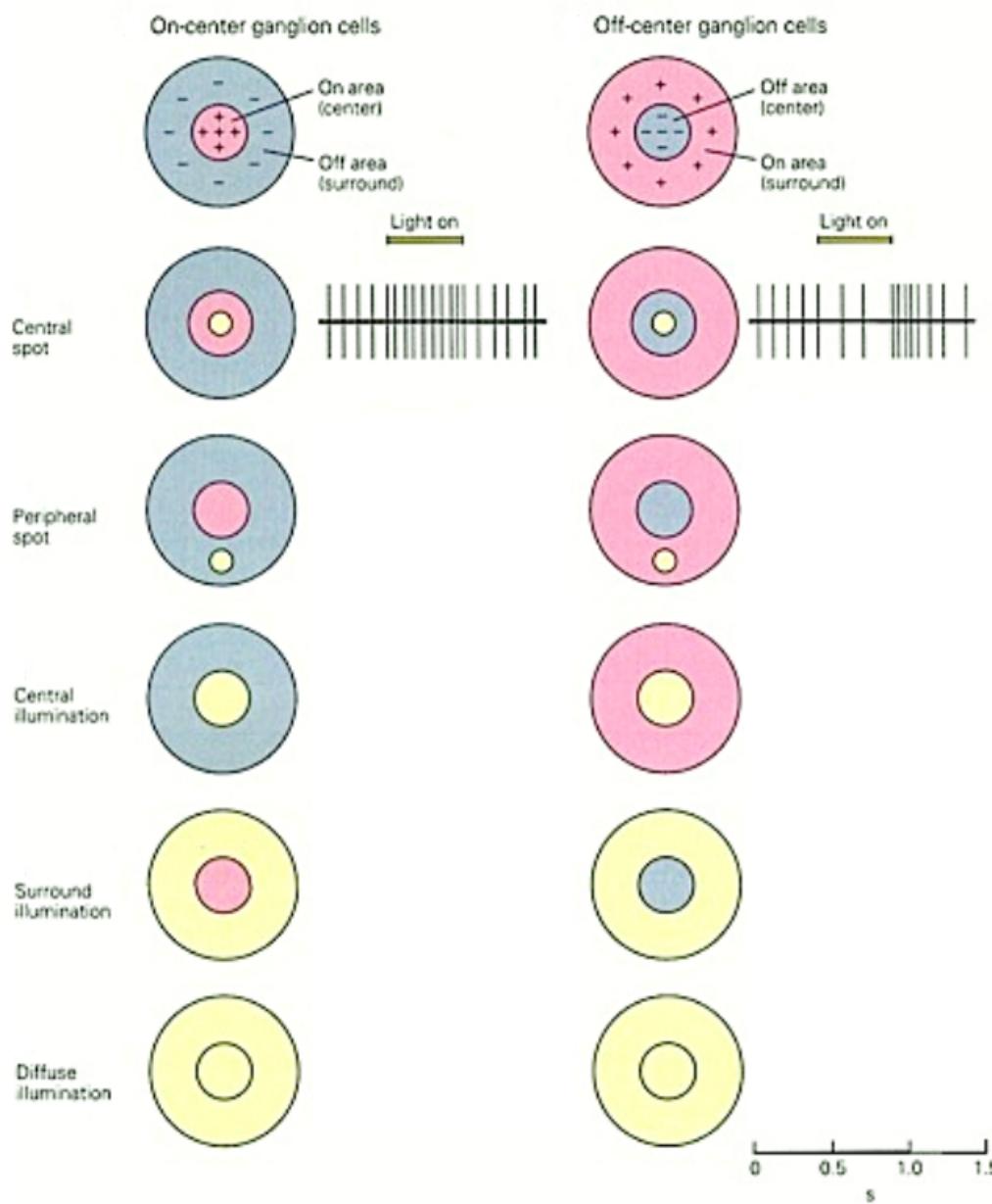
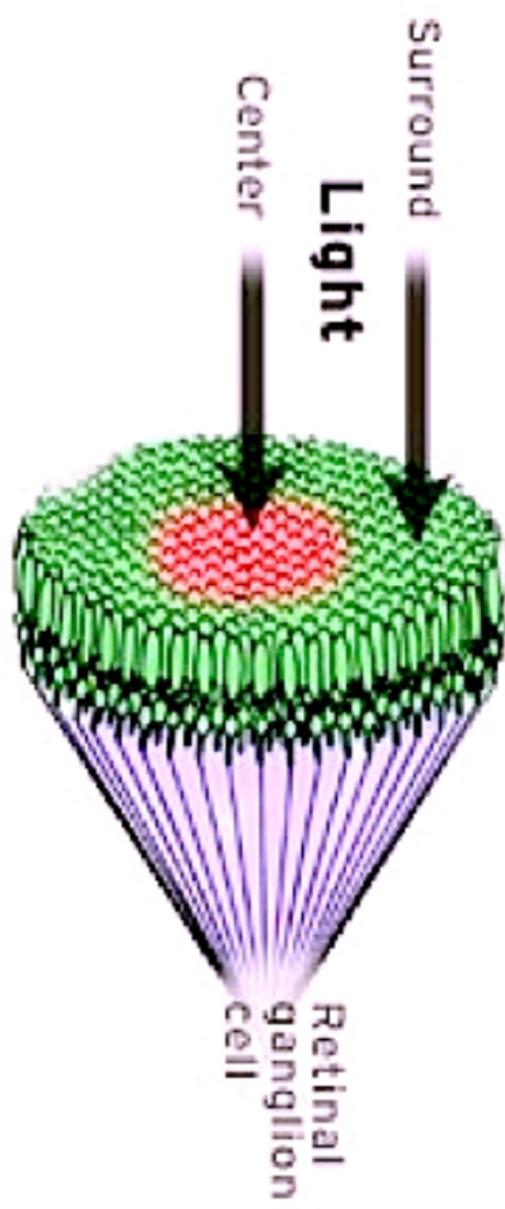
extra-foveal
representation

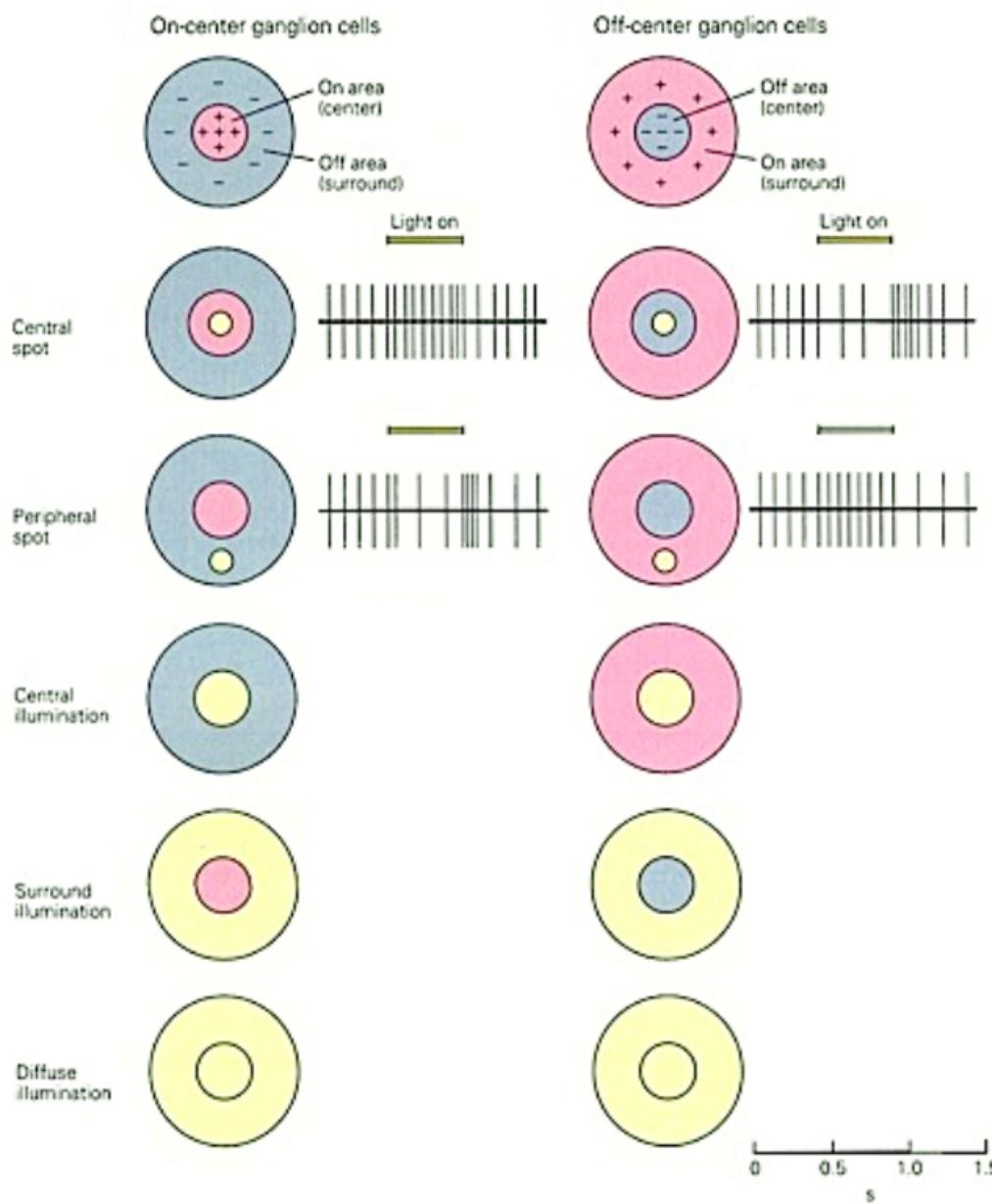
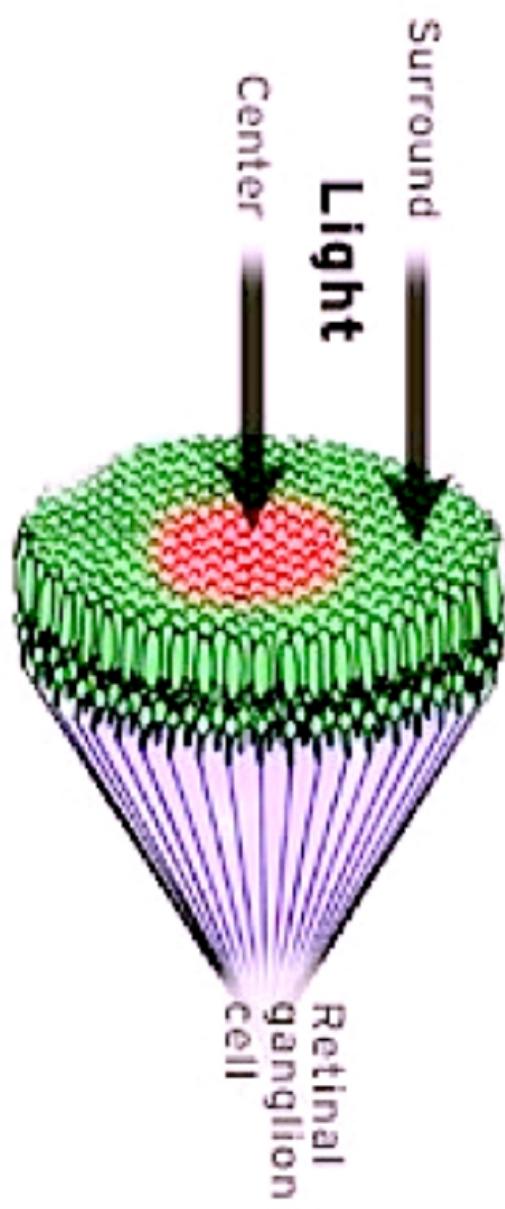


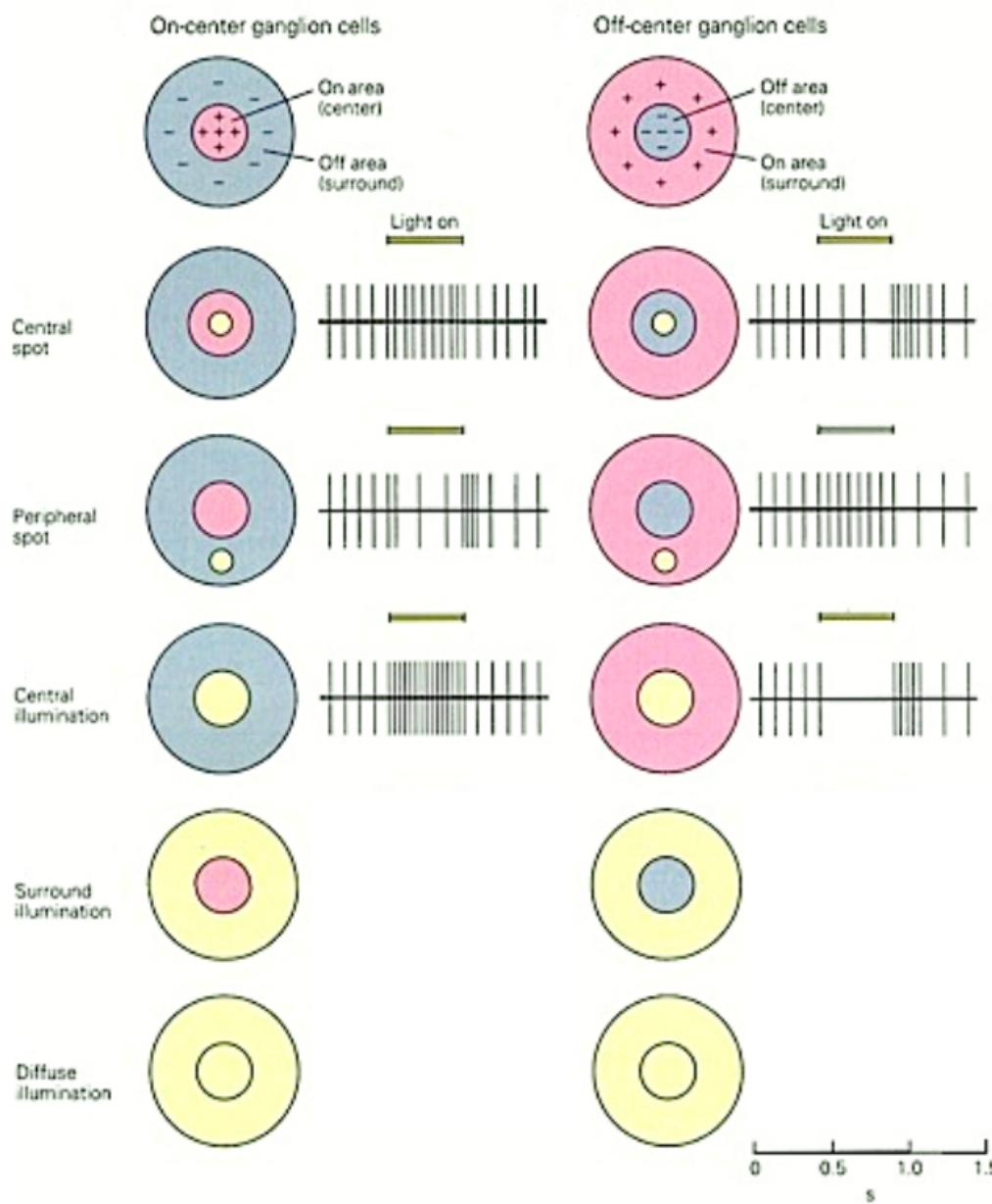
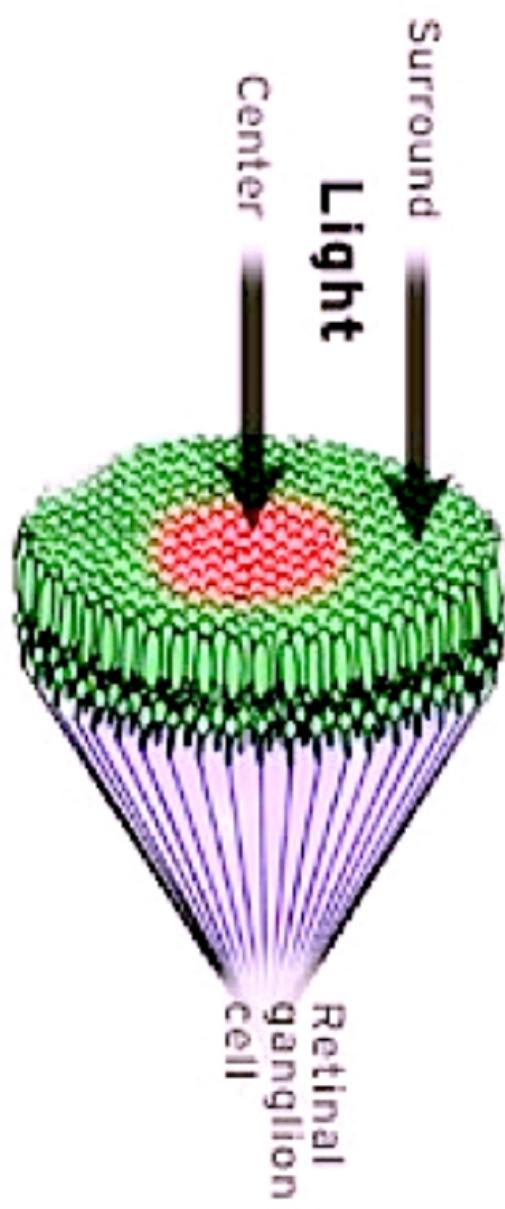


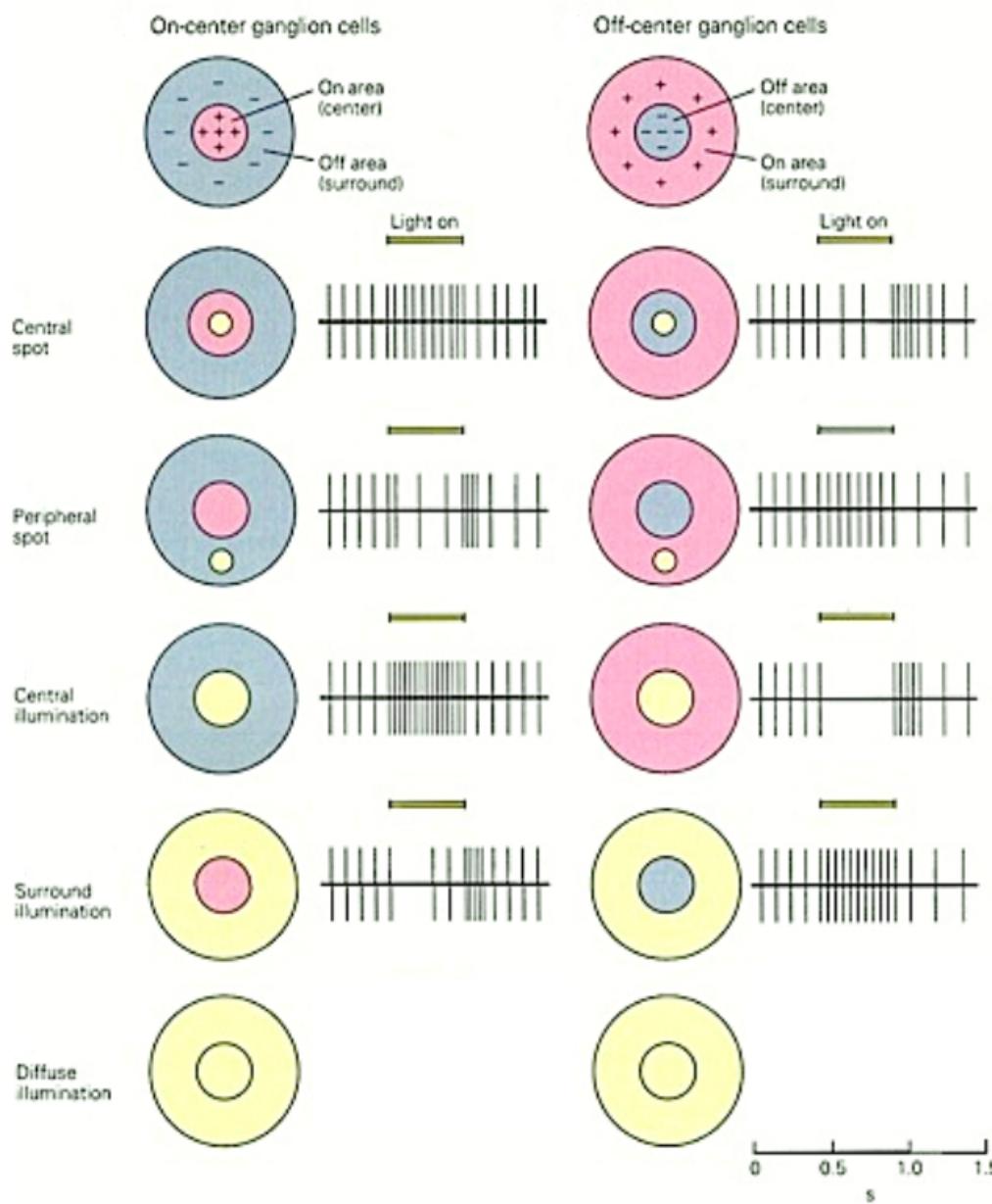
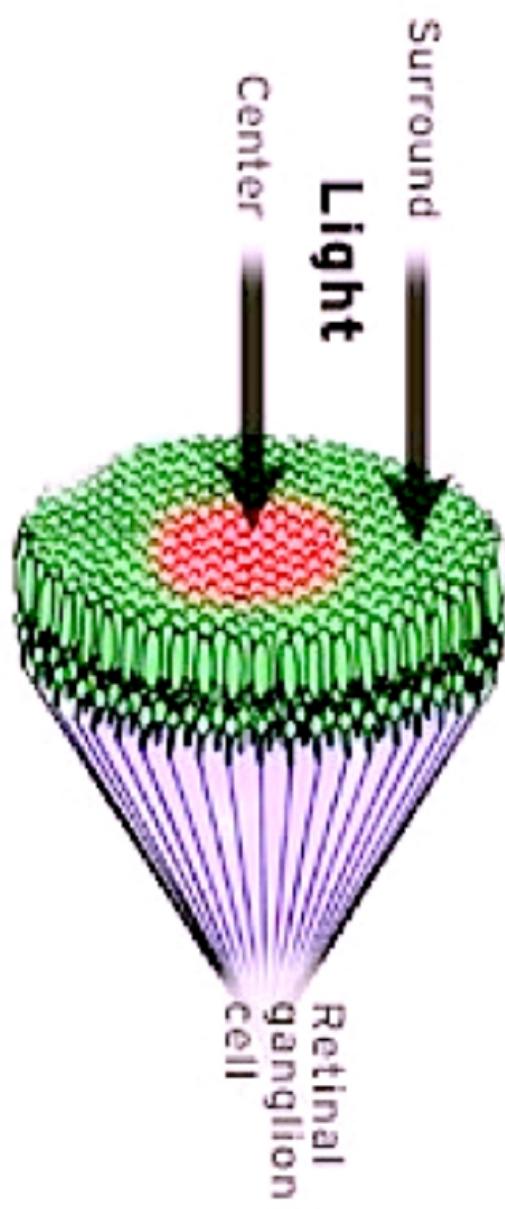
Spatial properties of RF











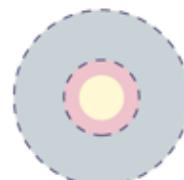
Temporal properties of RF

■ On area
□ Off area

■ } Stimuli

Stimulus pattern

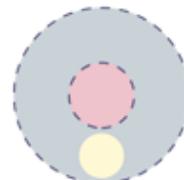
1 Center only



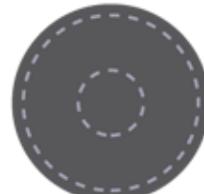
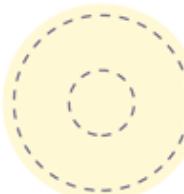
ON cells



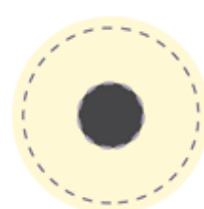
2 Surround only



3 Center and surround uniform



4 Center and surround opposite



Stimulus

0

1

2

Time (s)

0

1

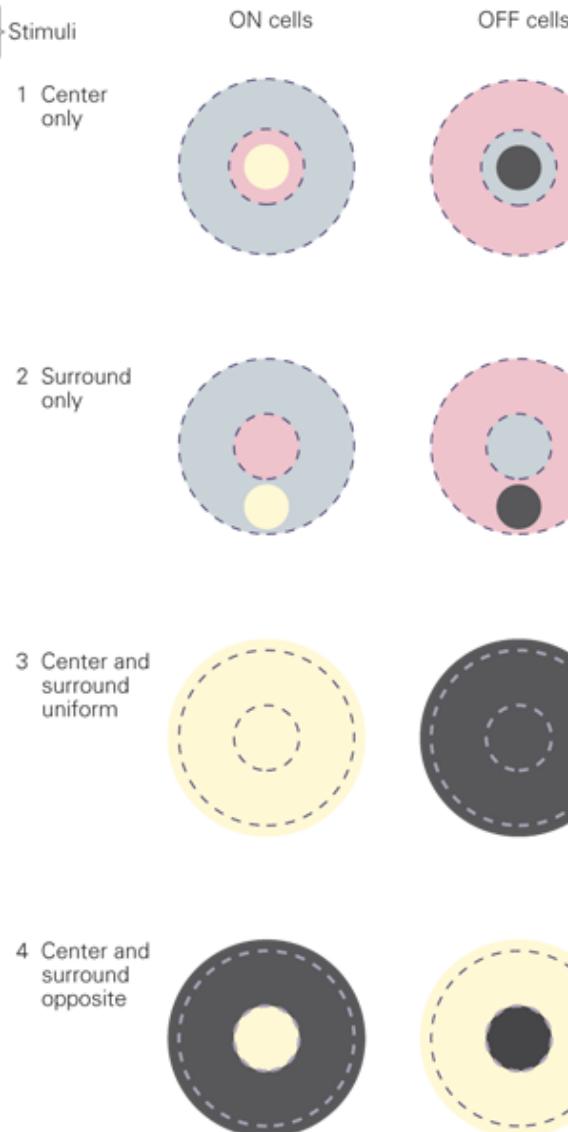
2

Time (s)

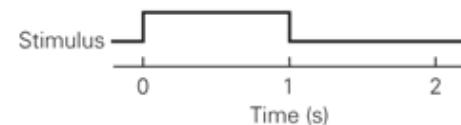
■ On area
□ Off area

■ } Stimuli

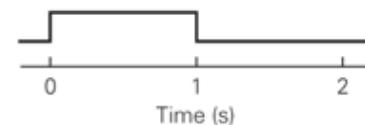
Stimulus pattern



M-type



P-type



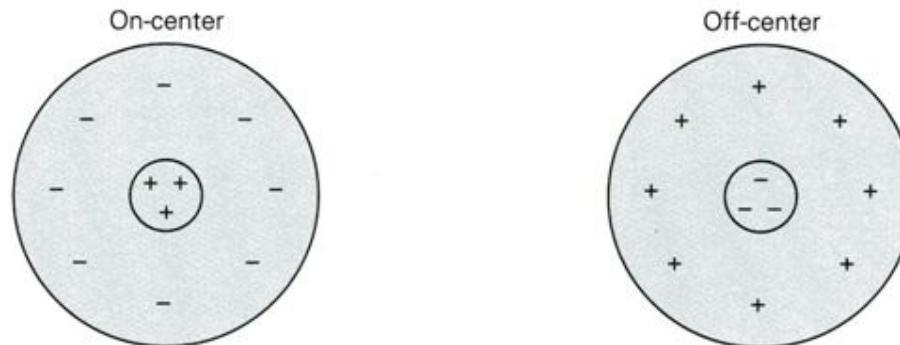
M,P,K cell types

- P-type are 90% of the population
- M-type are 5% of the population
- M-type
 - Larger RF
 - Faster (conduct APs faster)
 - Transient
 - Achromatic

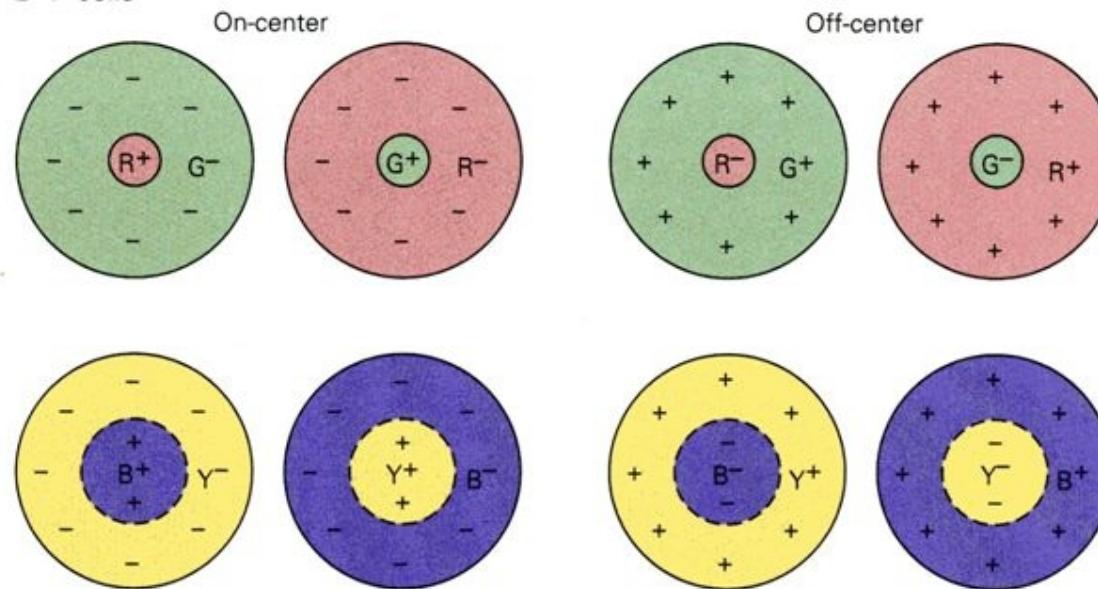
Color properties of RF

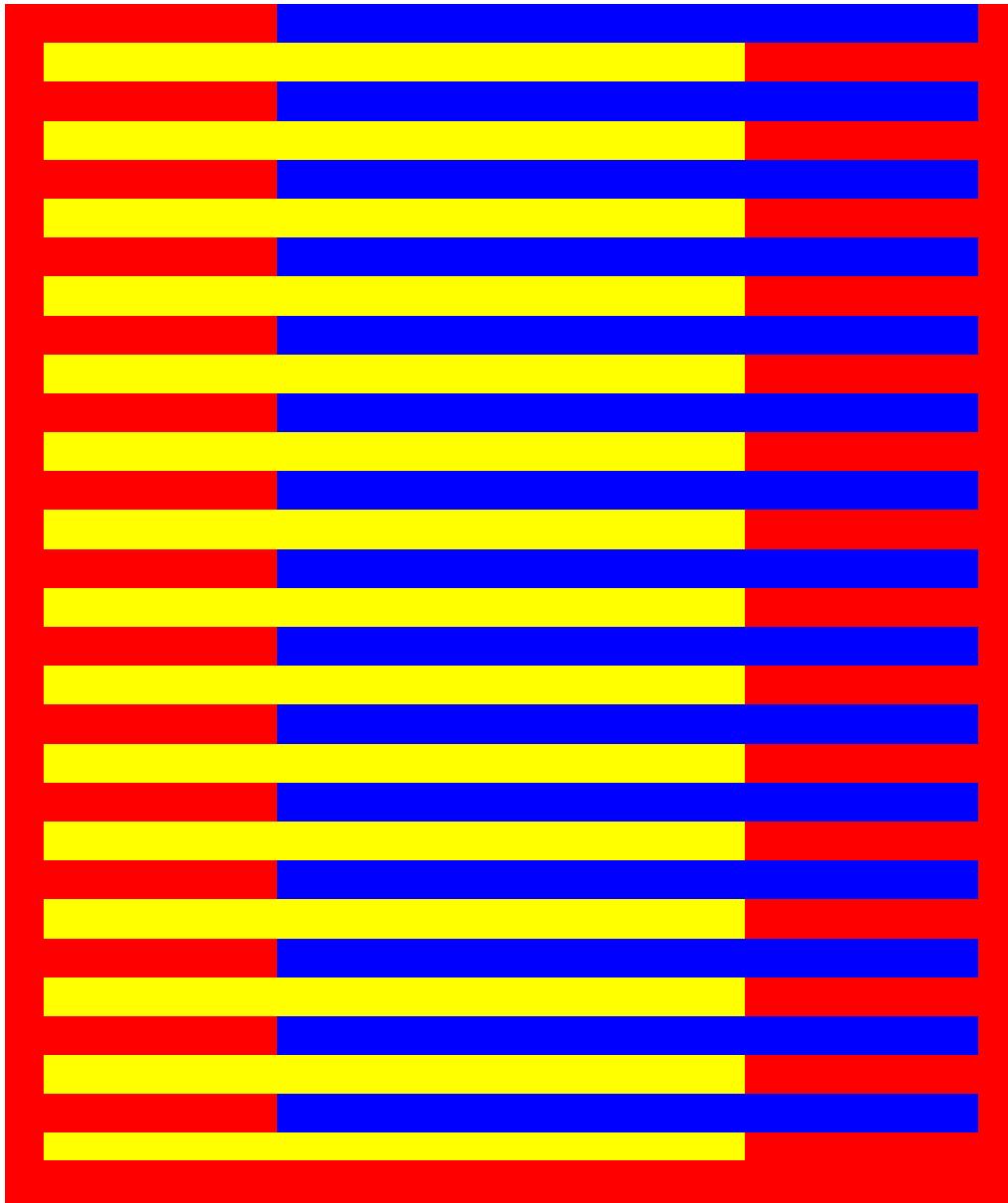
Colour opponent ganglion cells

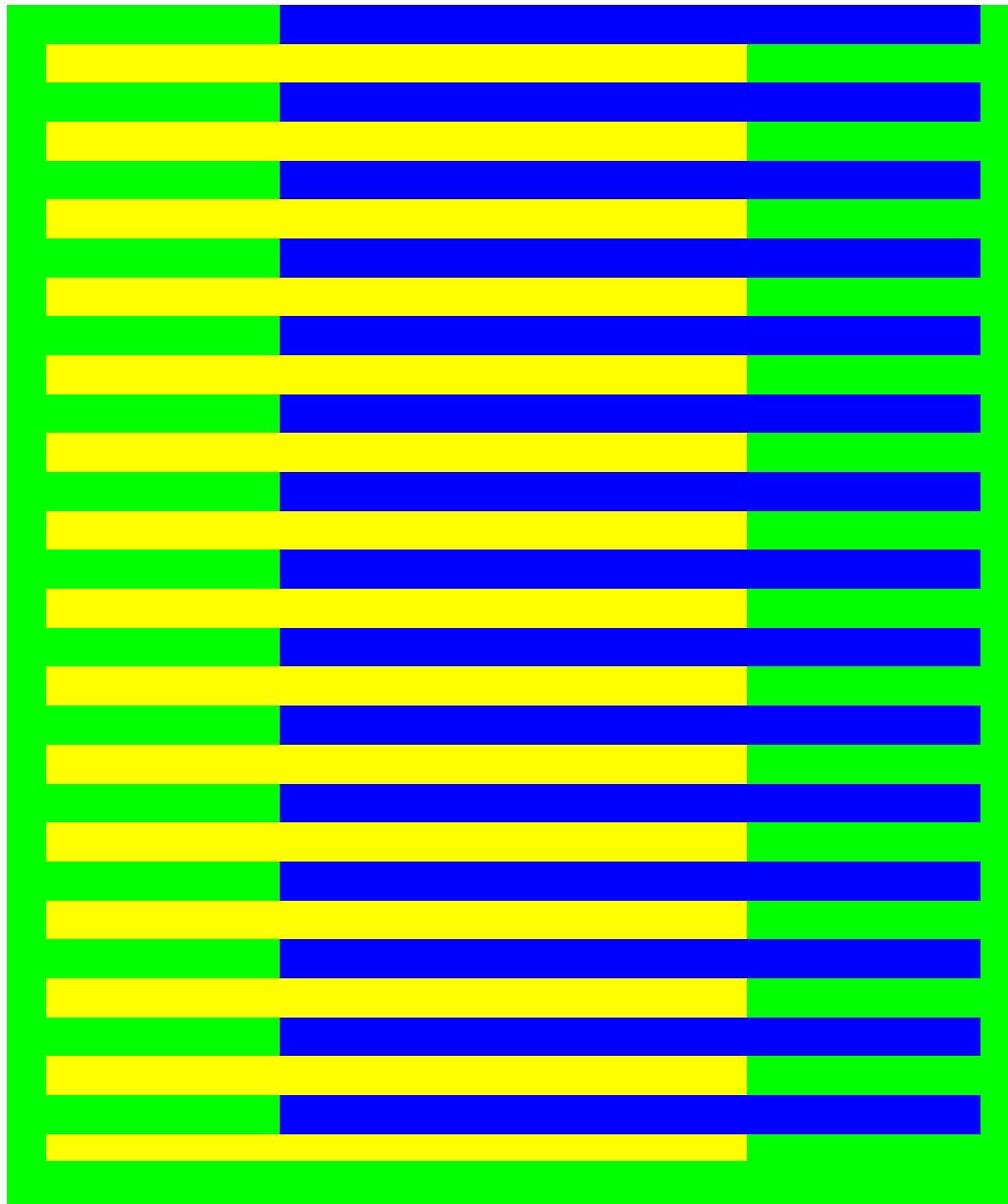
A M cells



B P cells

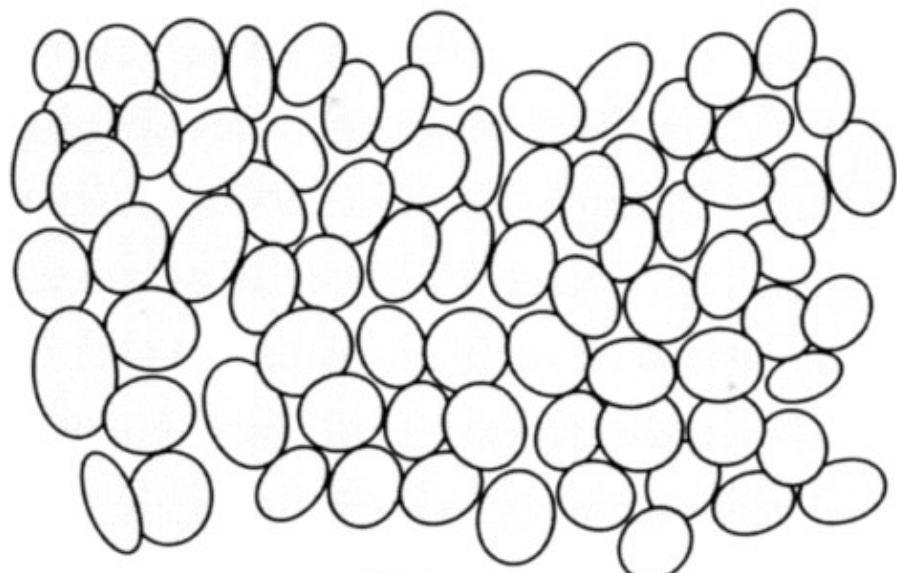




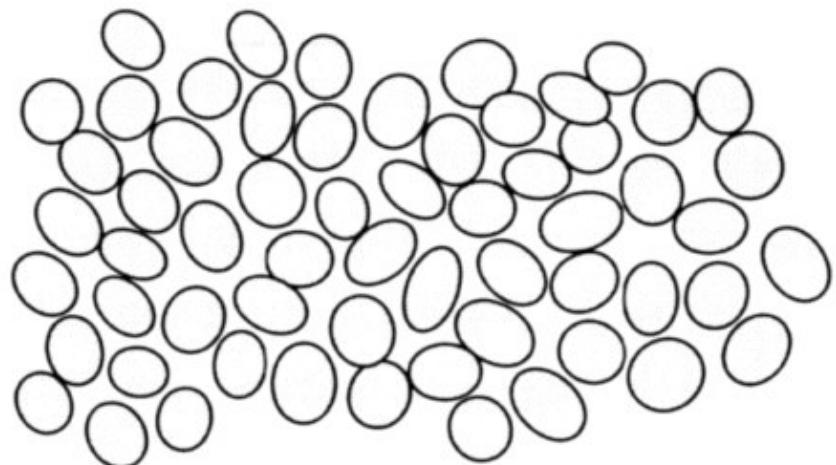


Retinal mosaics

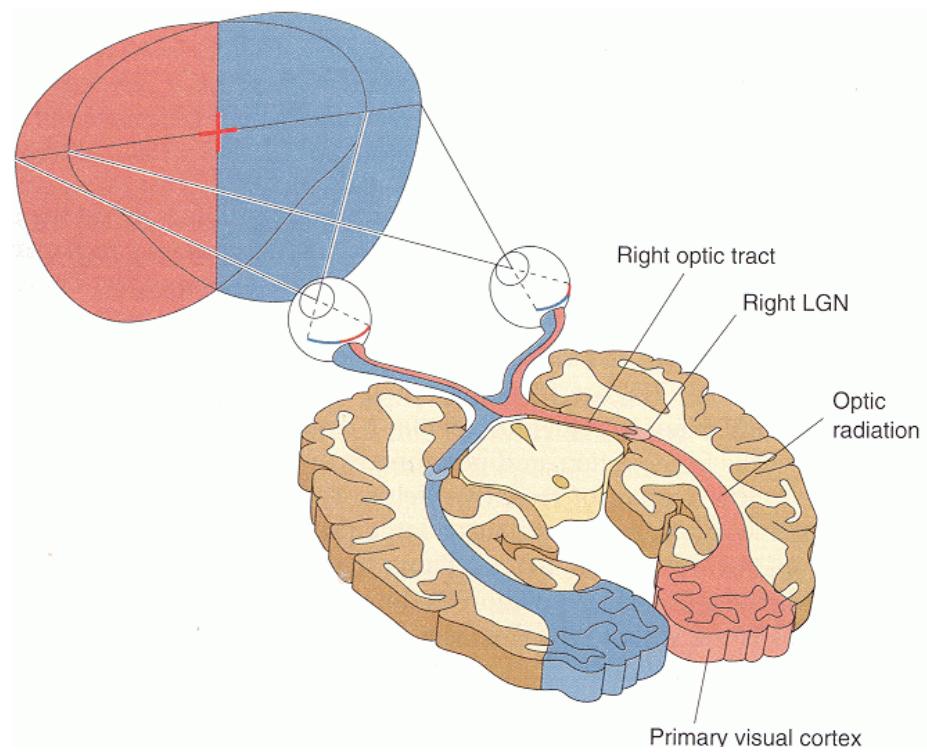
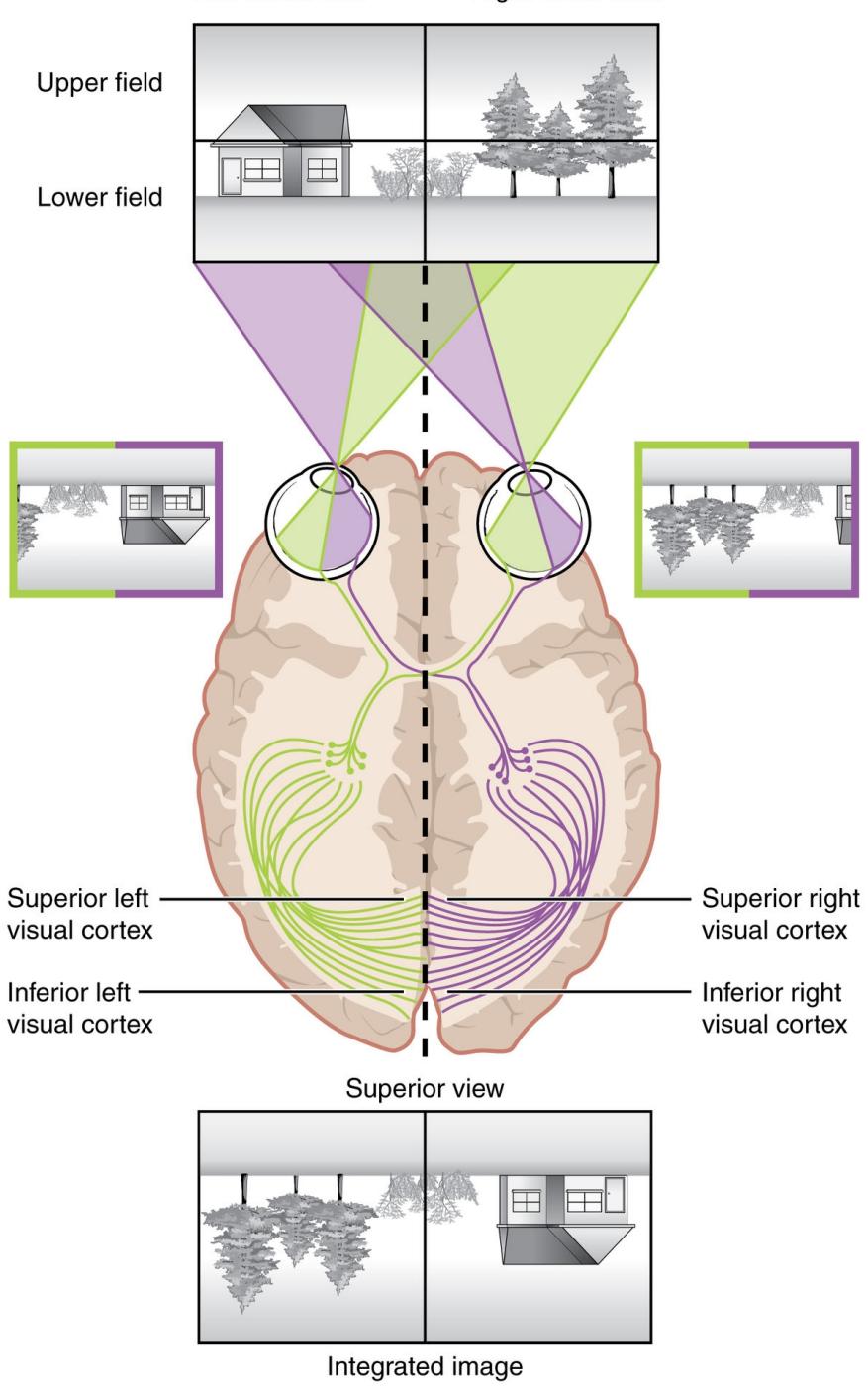
ON parasol



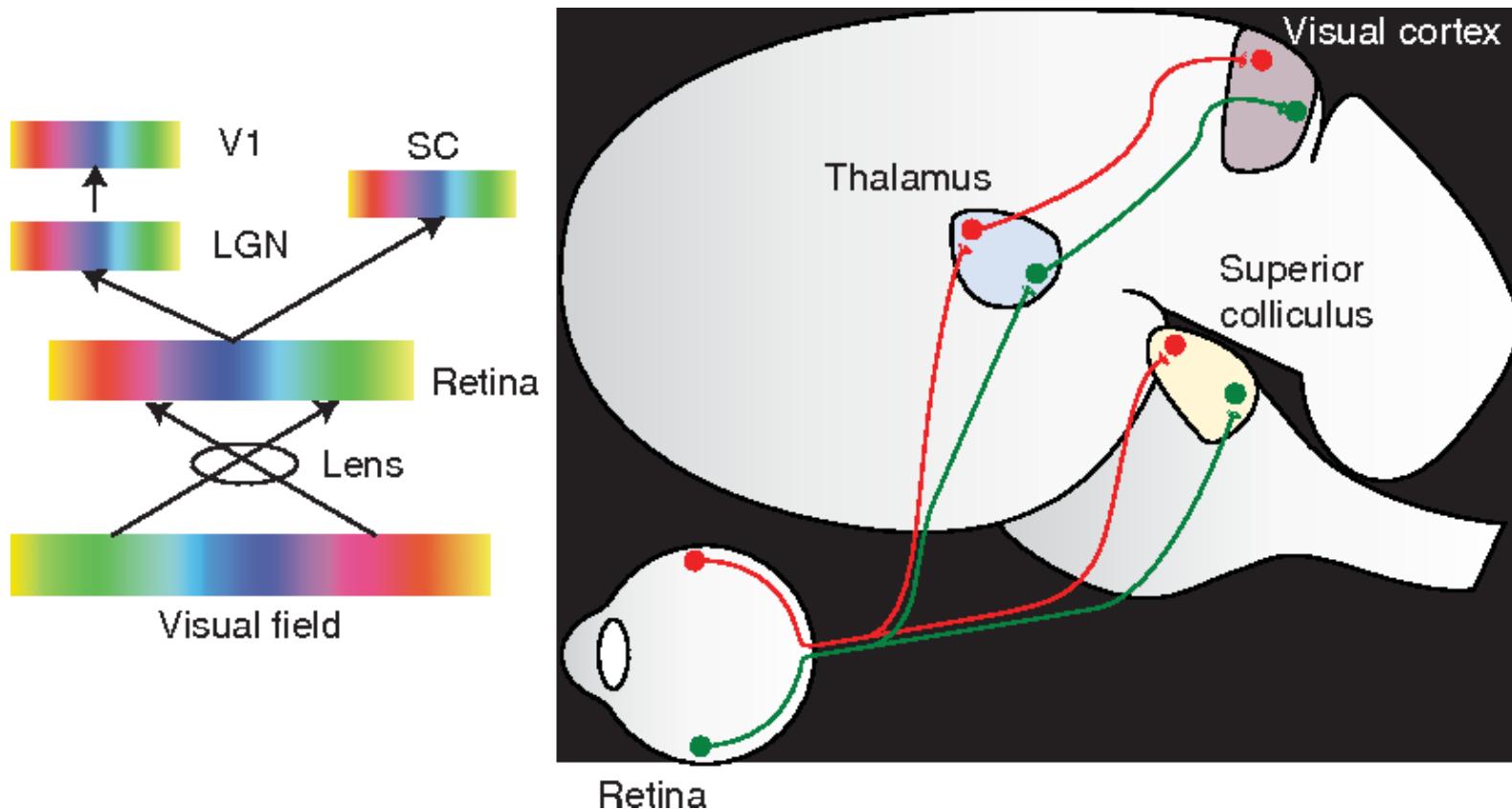
OFF parasol



Organization of visual field

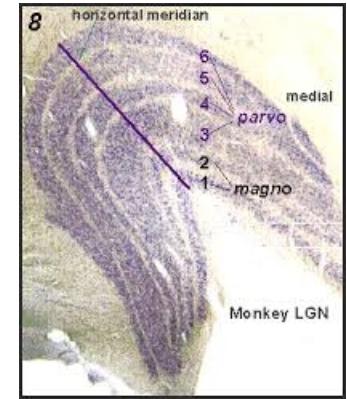


Retinotopy



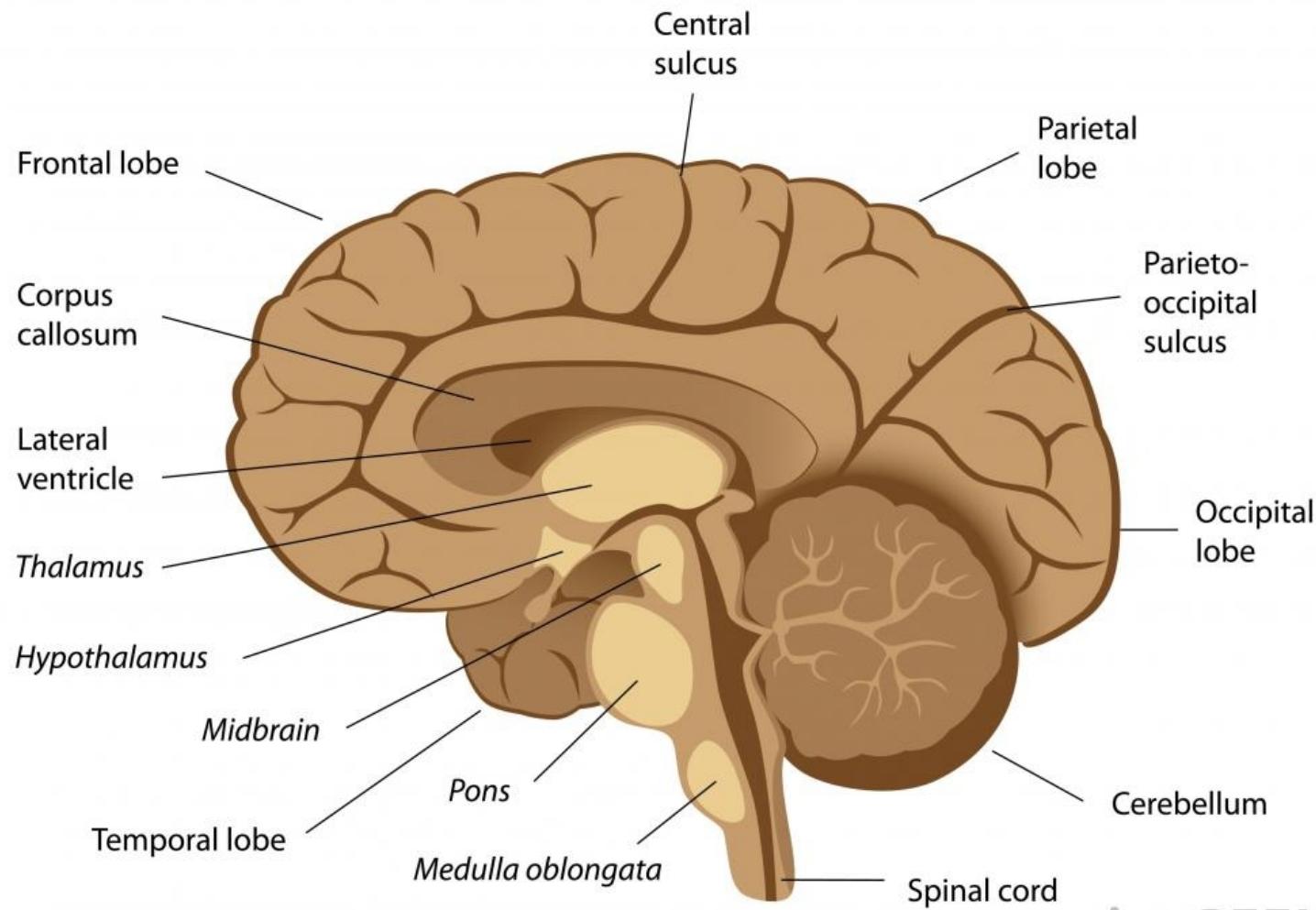
90% retinal output goes to thalamus
10% to superior colliculus

THALAMUS



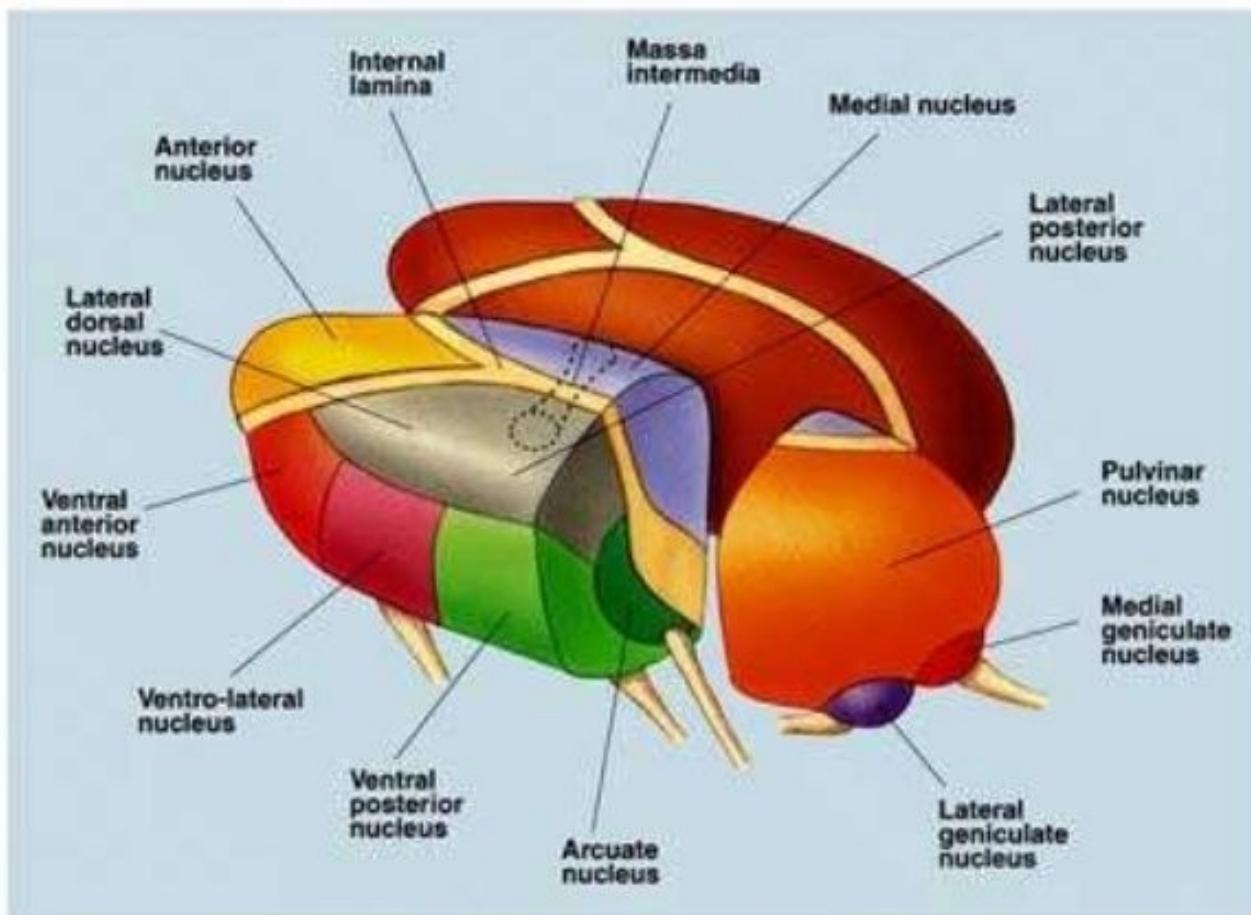
LATERAL GENICULATE NUCLEUS (LGN)

Where is thalamus?

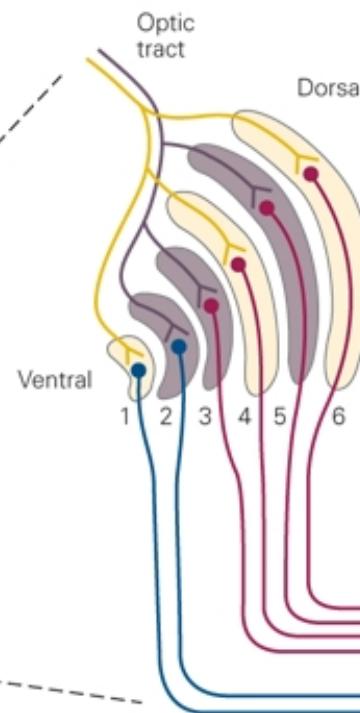
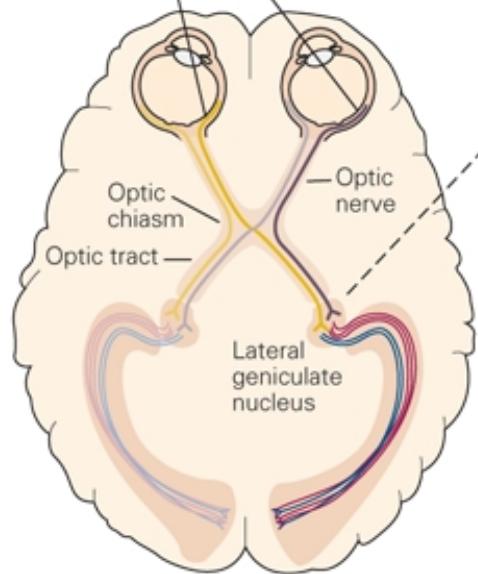
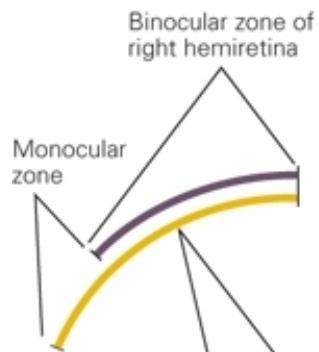


Where is LGN

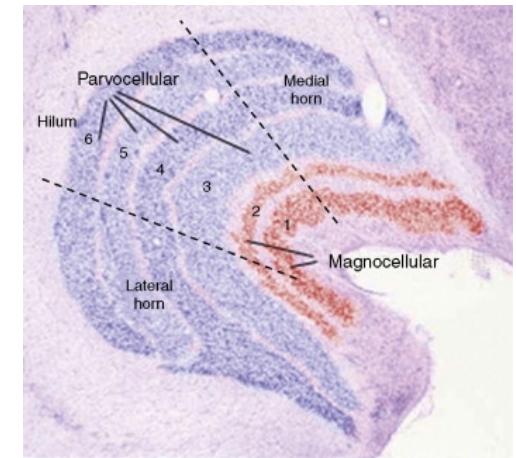
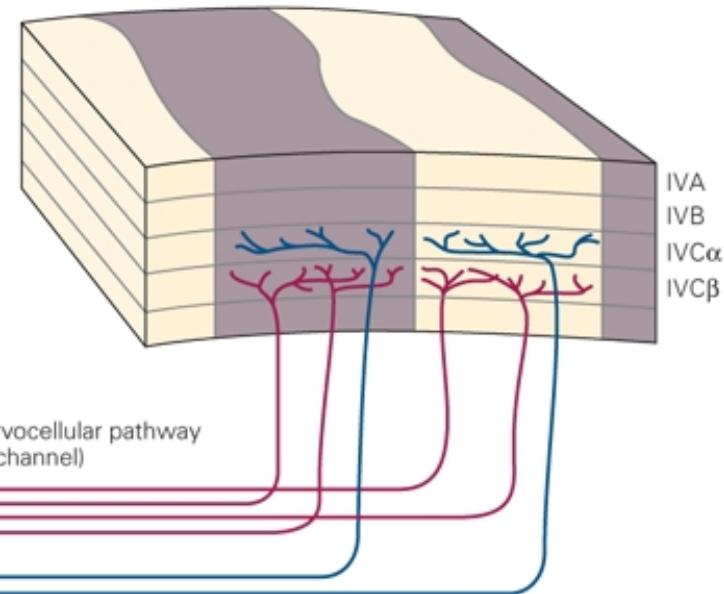
► Nuclei of the Thalamus



The Magno & Parvo pathway



Magnocellular pathway
(M channel)



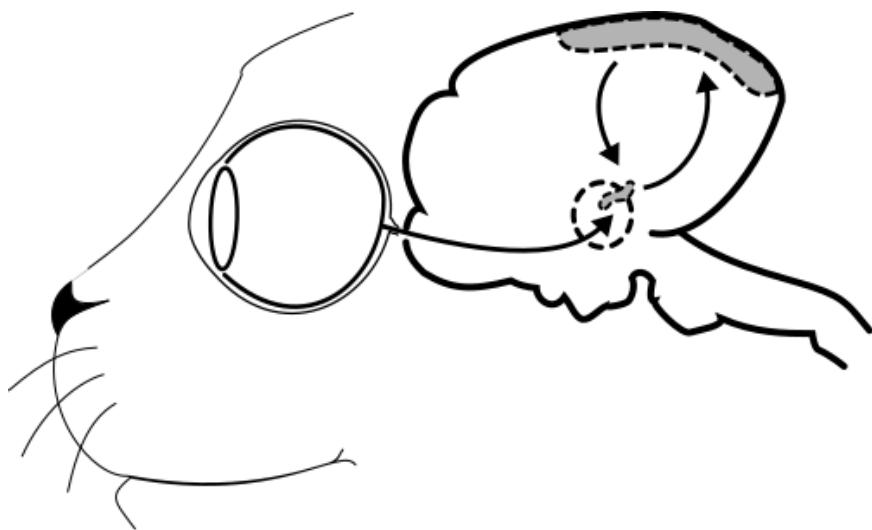
IVA
IVB
IVC α
IVC β

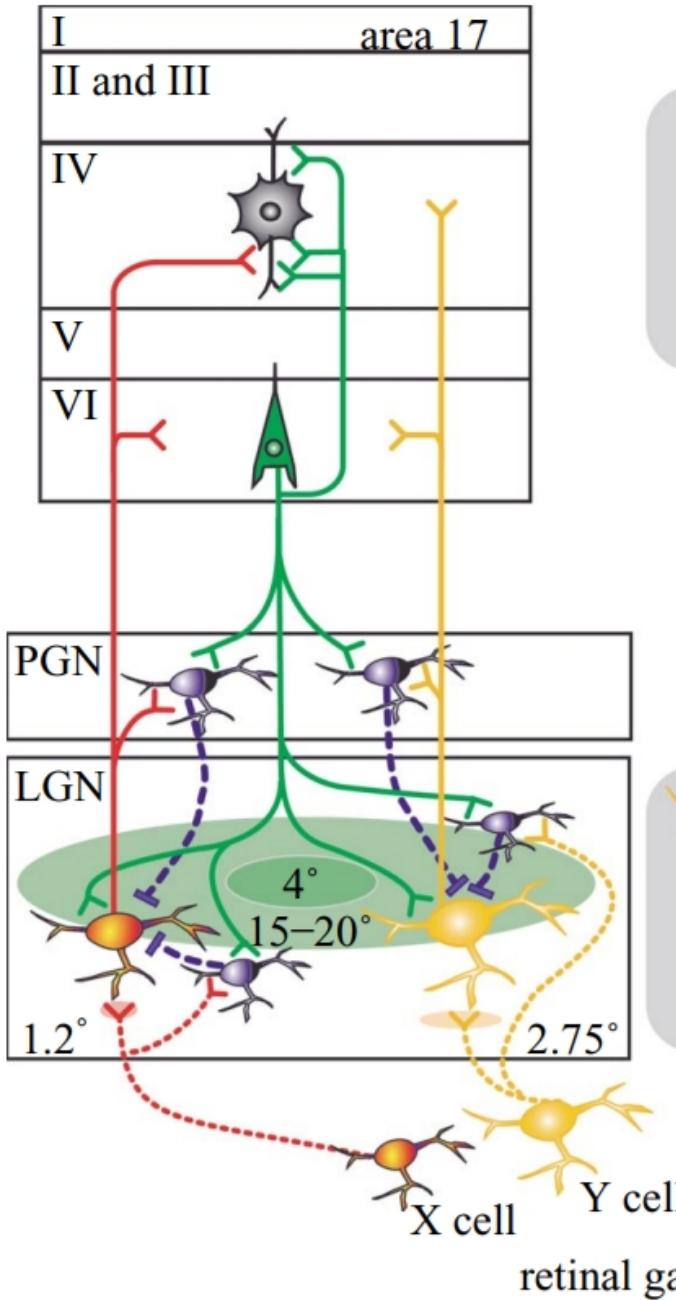
Receptive fields in LGN

- ON/OFF
- Magnocellular
 - Contrast detection already at 2%
 - Low acuity (spatial resolution)
 - Fast (high temporal resolution)
- Parvocellular
 - Contrast detection at 10%
 - Color
 - High acuity

**Most text-books stop here, but
there is a lot more to LGN!**

Massive feedback from cortex to LGN





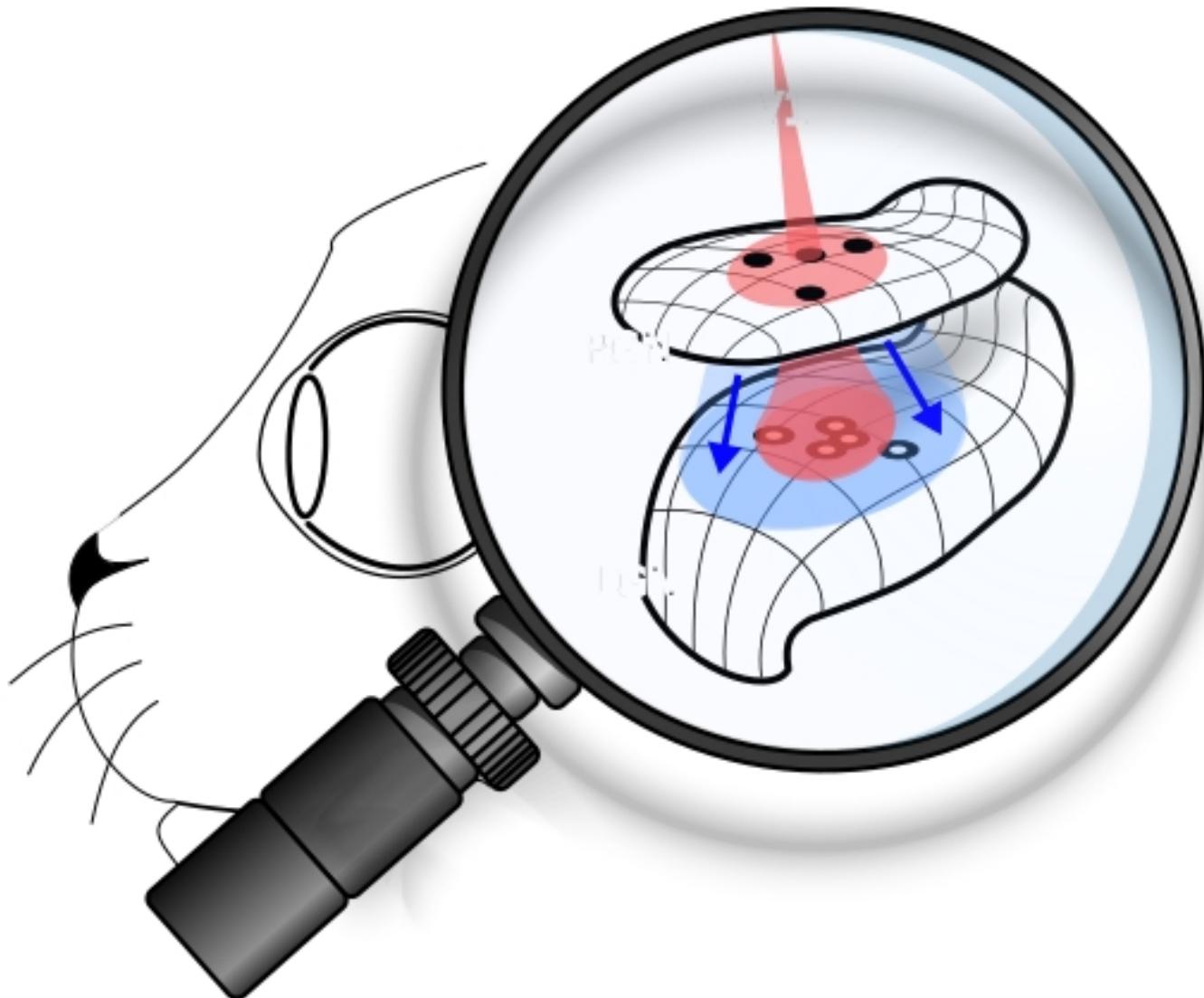
Connectivity LGN

+ modulation from brain stem





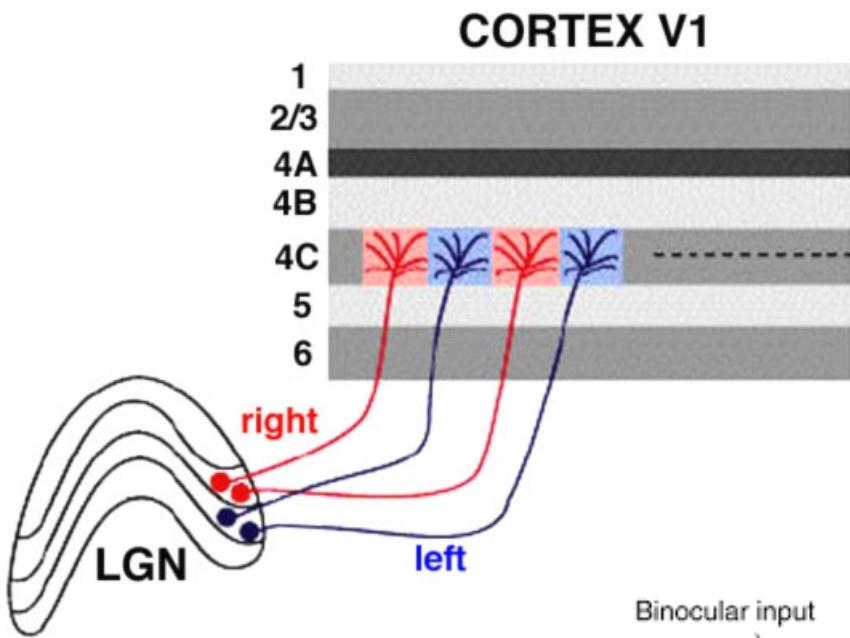




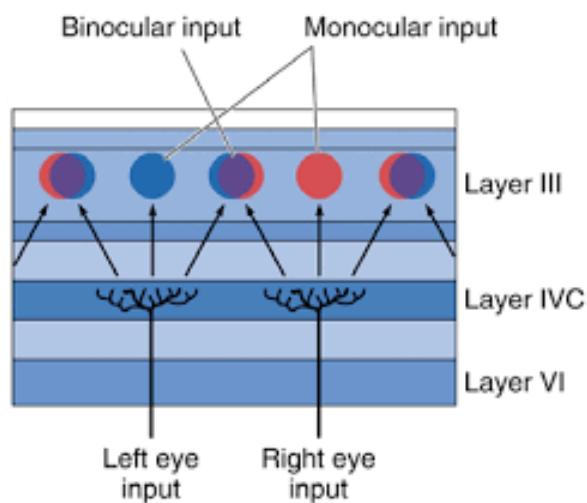
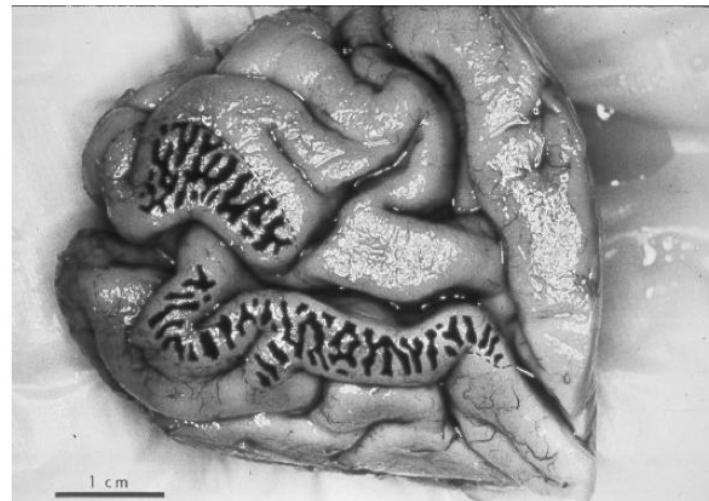
Classice short-range excitation and
long-range inhibition circuit motif?

What is all of this good for?

Visual pathway continued

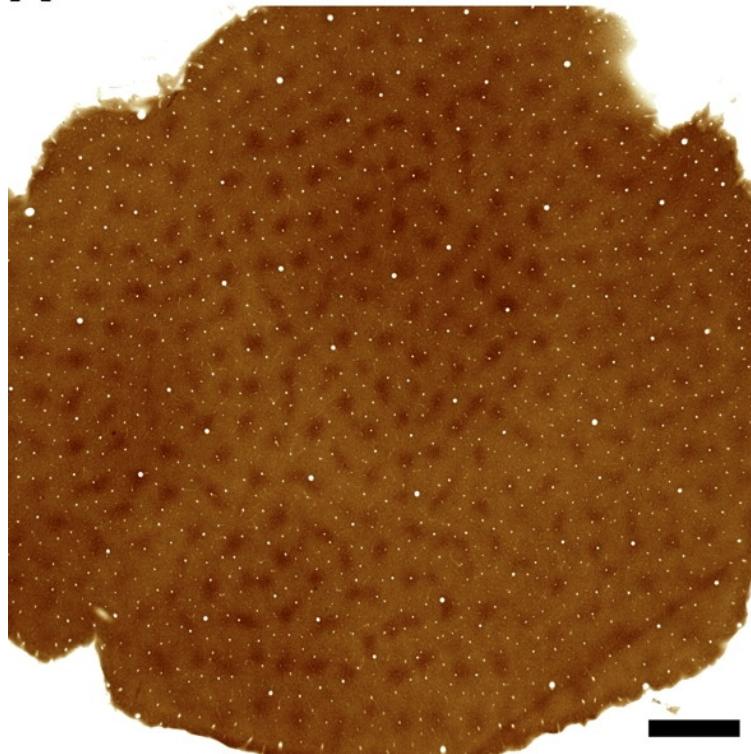


Human ocular dominance columns

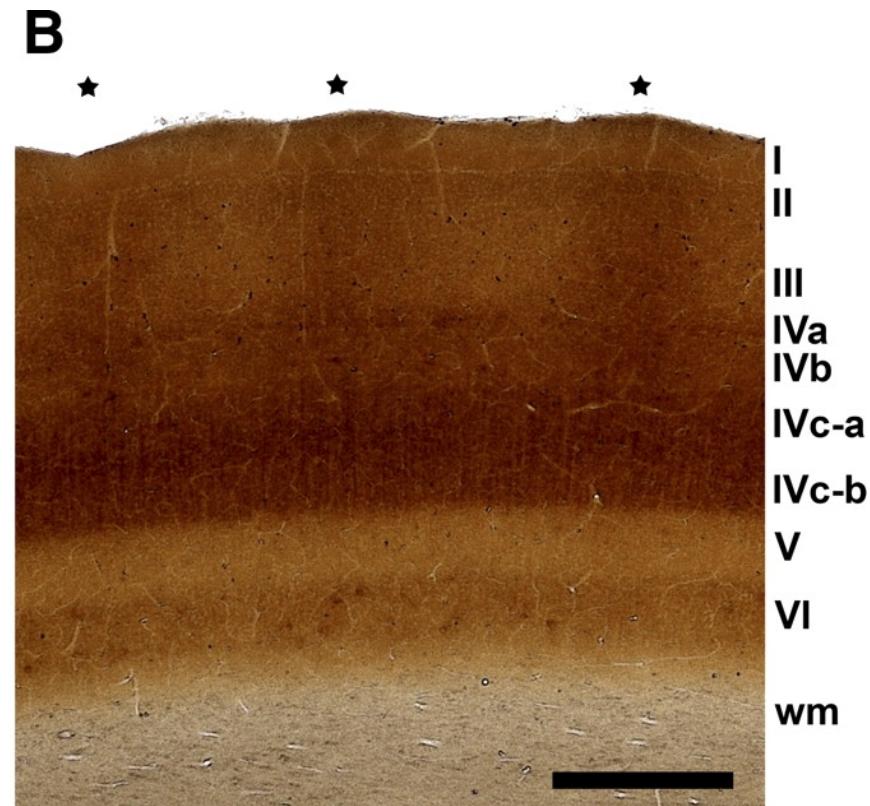


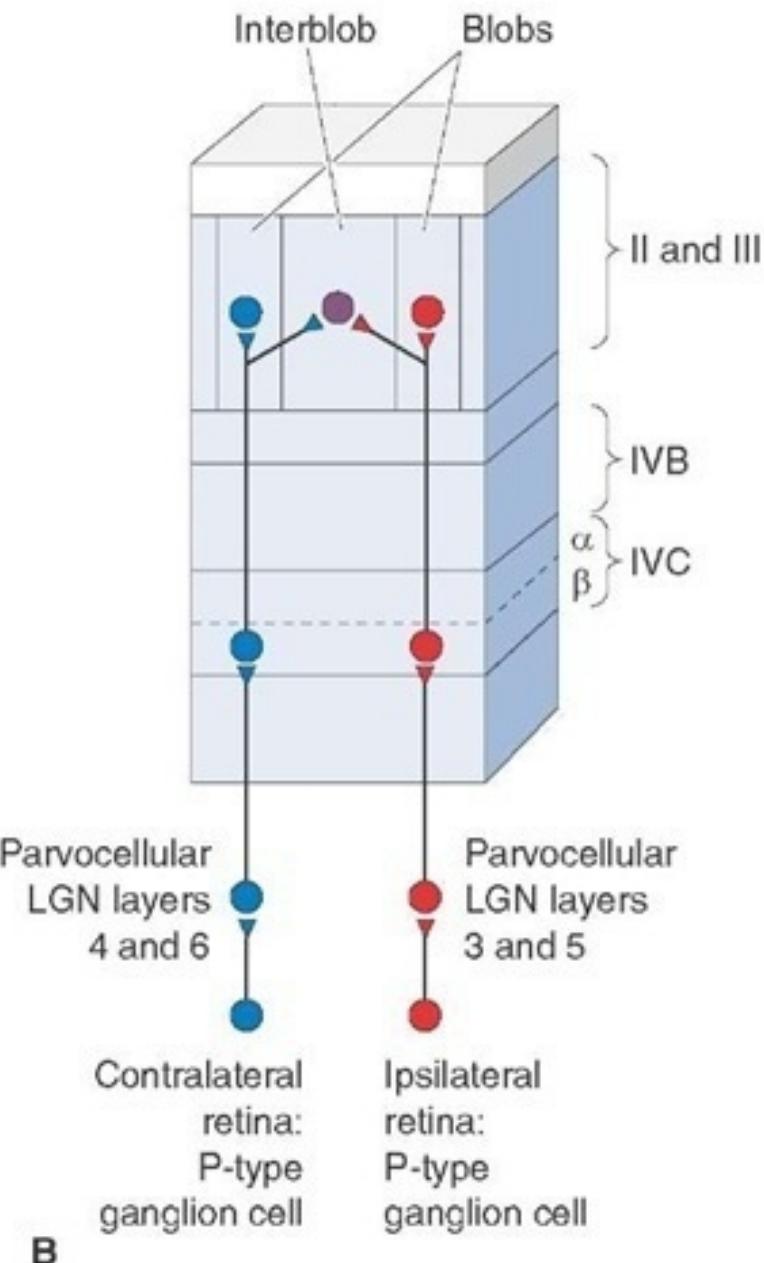
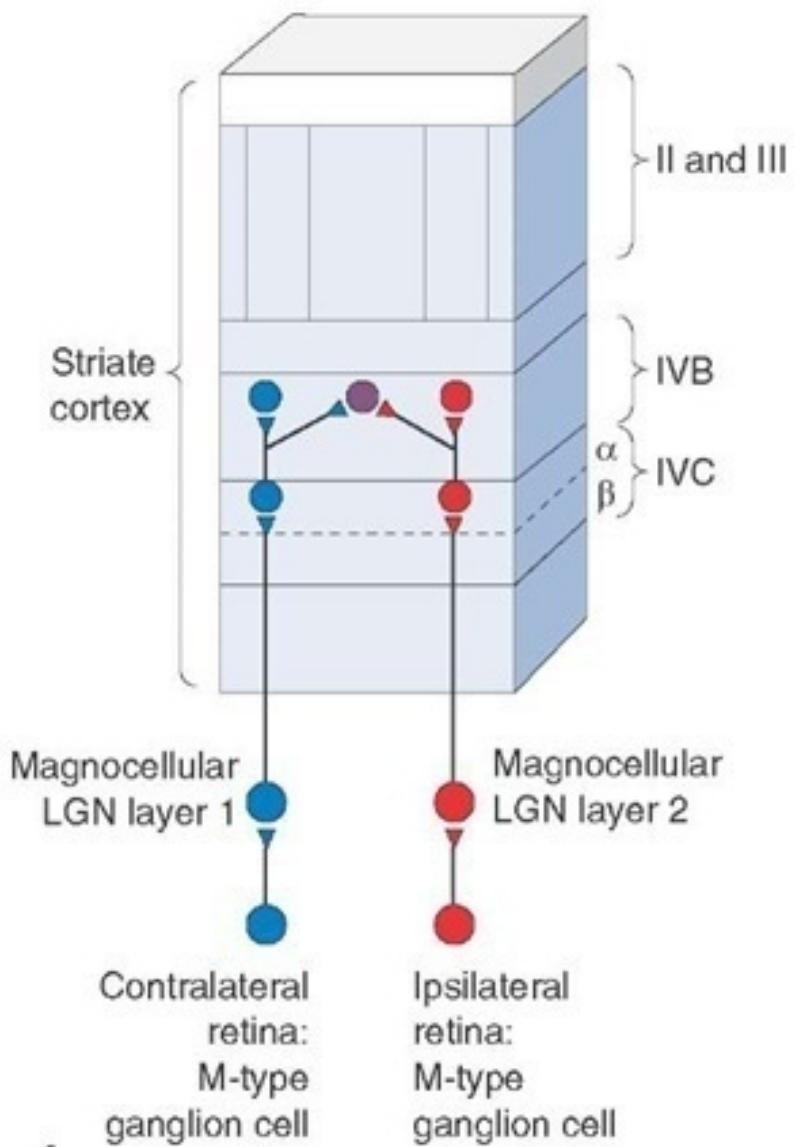
Blobs and interblobs

A

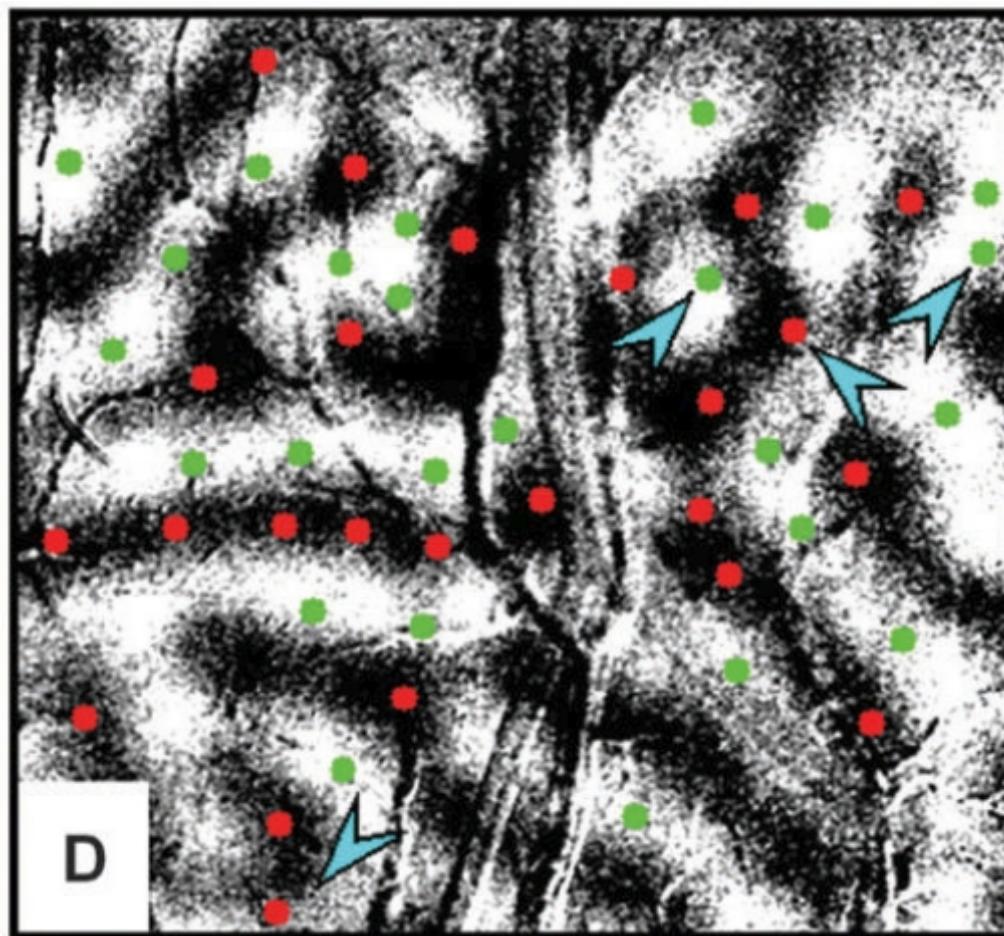


B





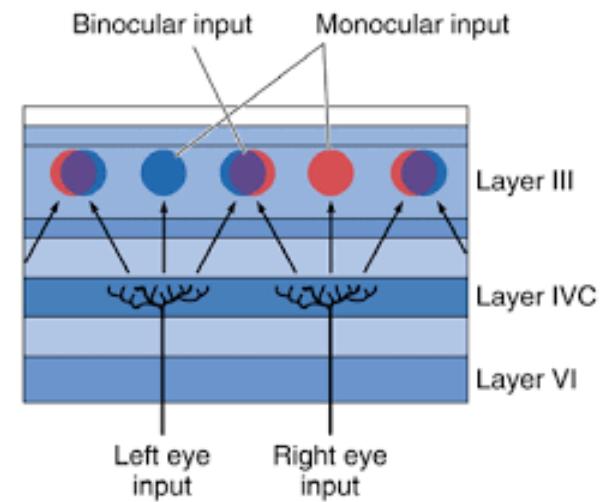
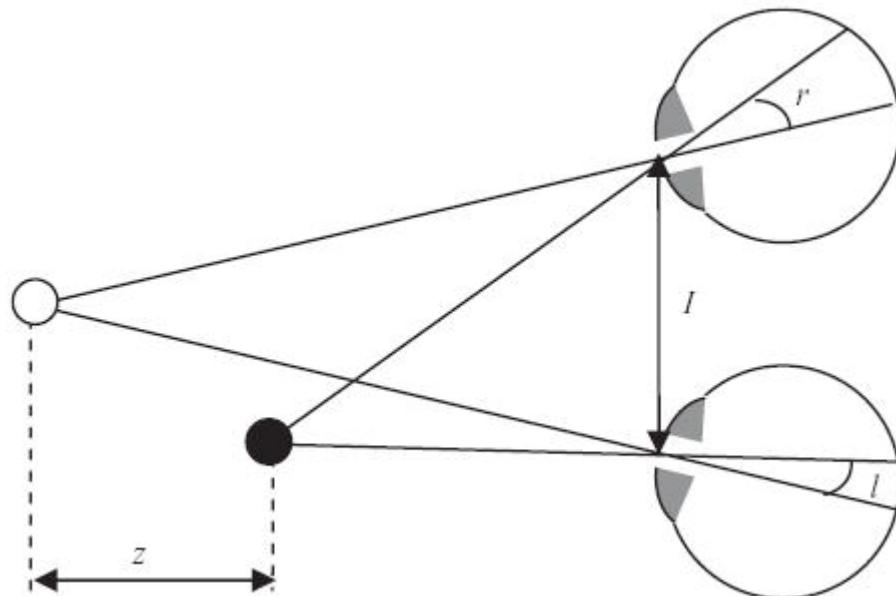
Alignment of color-blobs and OD maps



Blob vs. inter-blobs

- Inter-blobs
 - Orientation & direction selective
 - Binocular
 - Simple & complex
 - Mostly achromatic
- Blobs
 - Color sensitive
 - Monocular
 - Not orientation & direction selective
 - Coincide with ocular dominance maps.

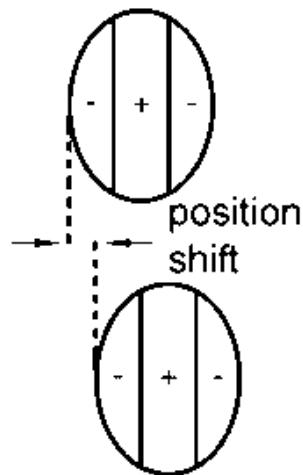
Binocular vision & stereopsis



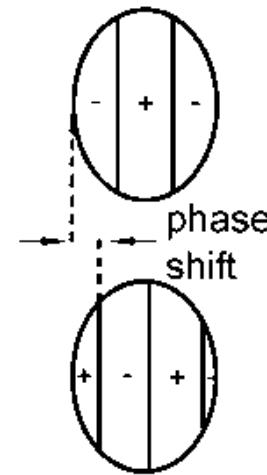
Disparity sensitive V1 neurons

A

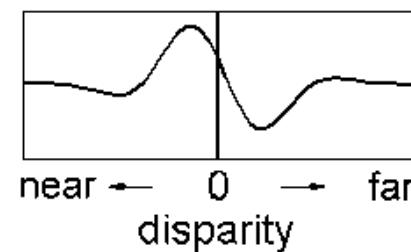
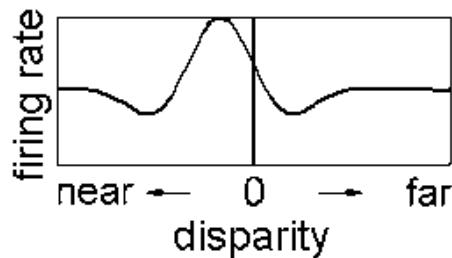
Position Shift
Model



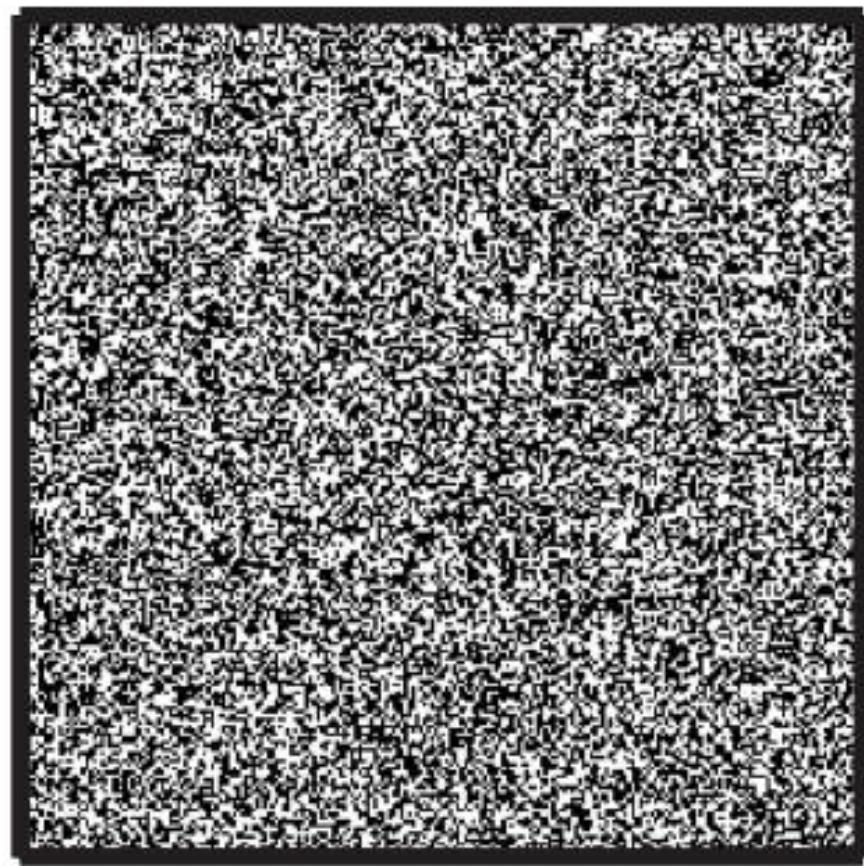
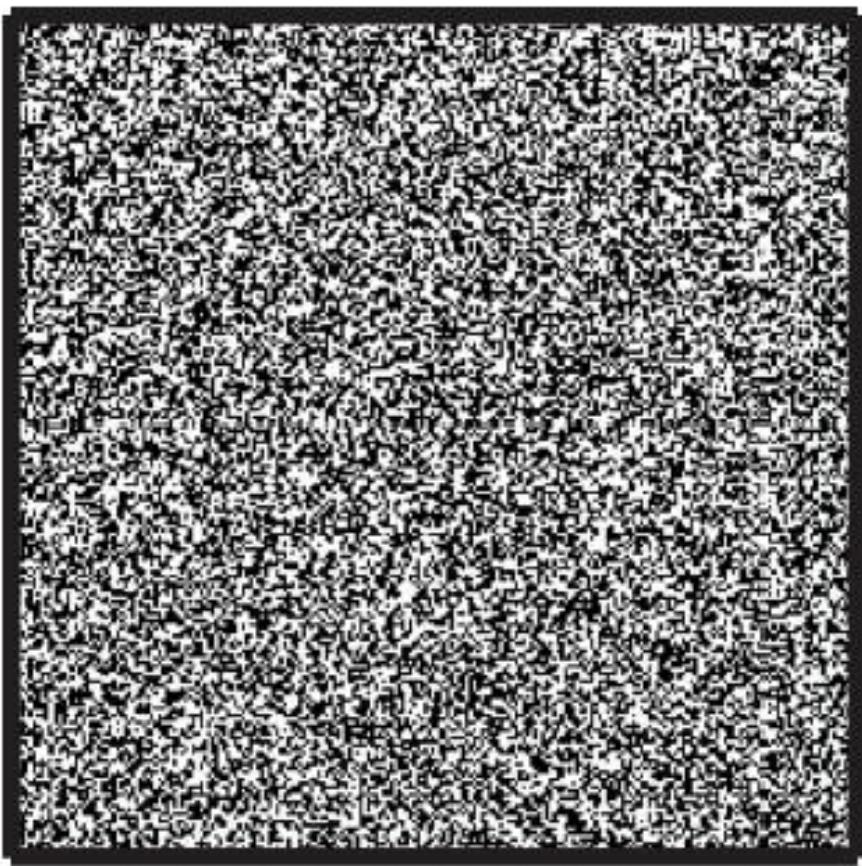
Phase Shift
Model

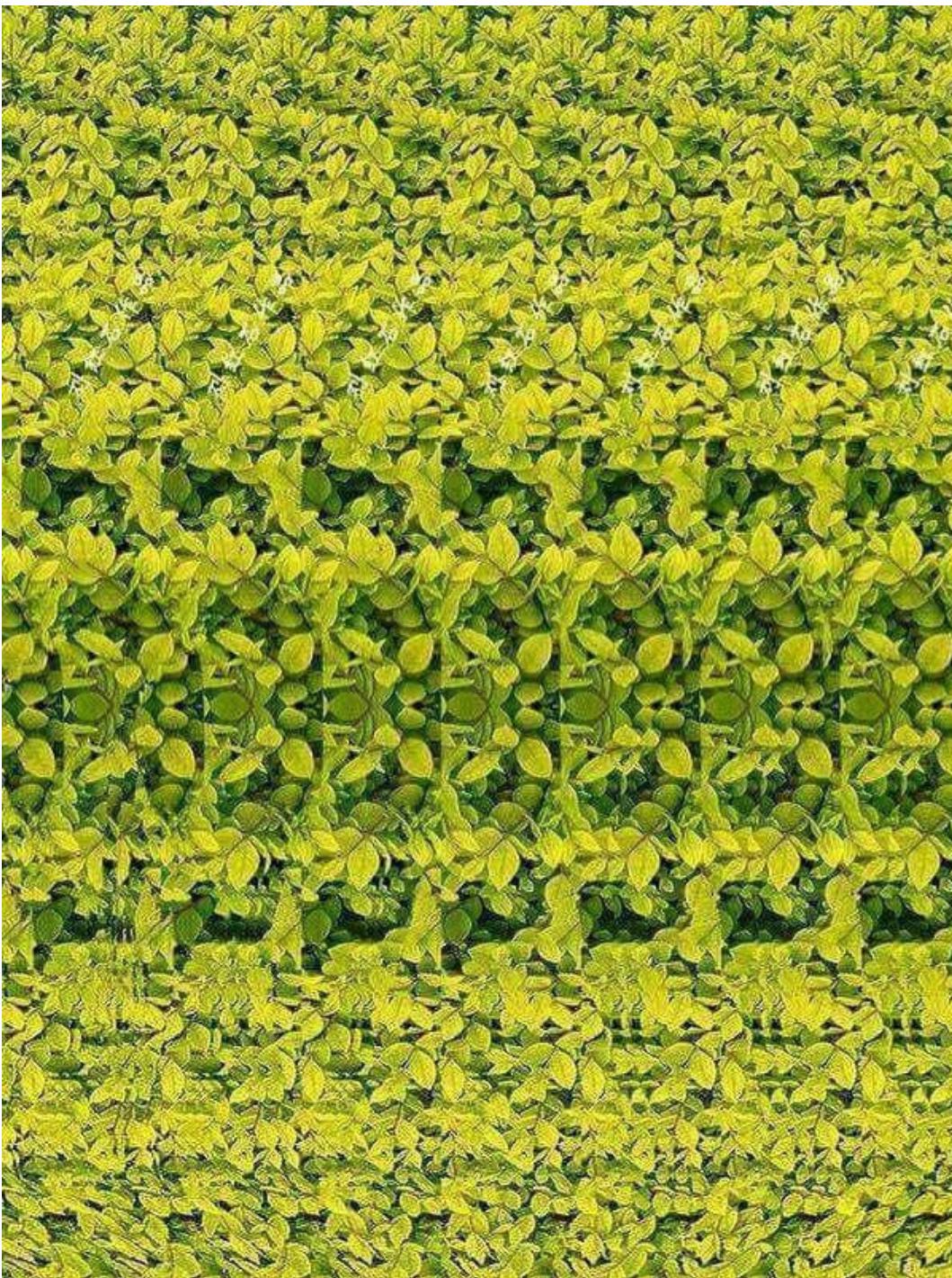


B

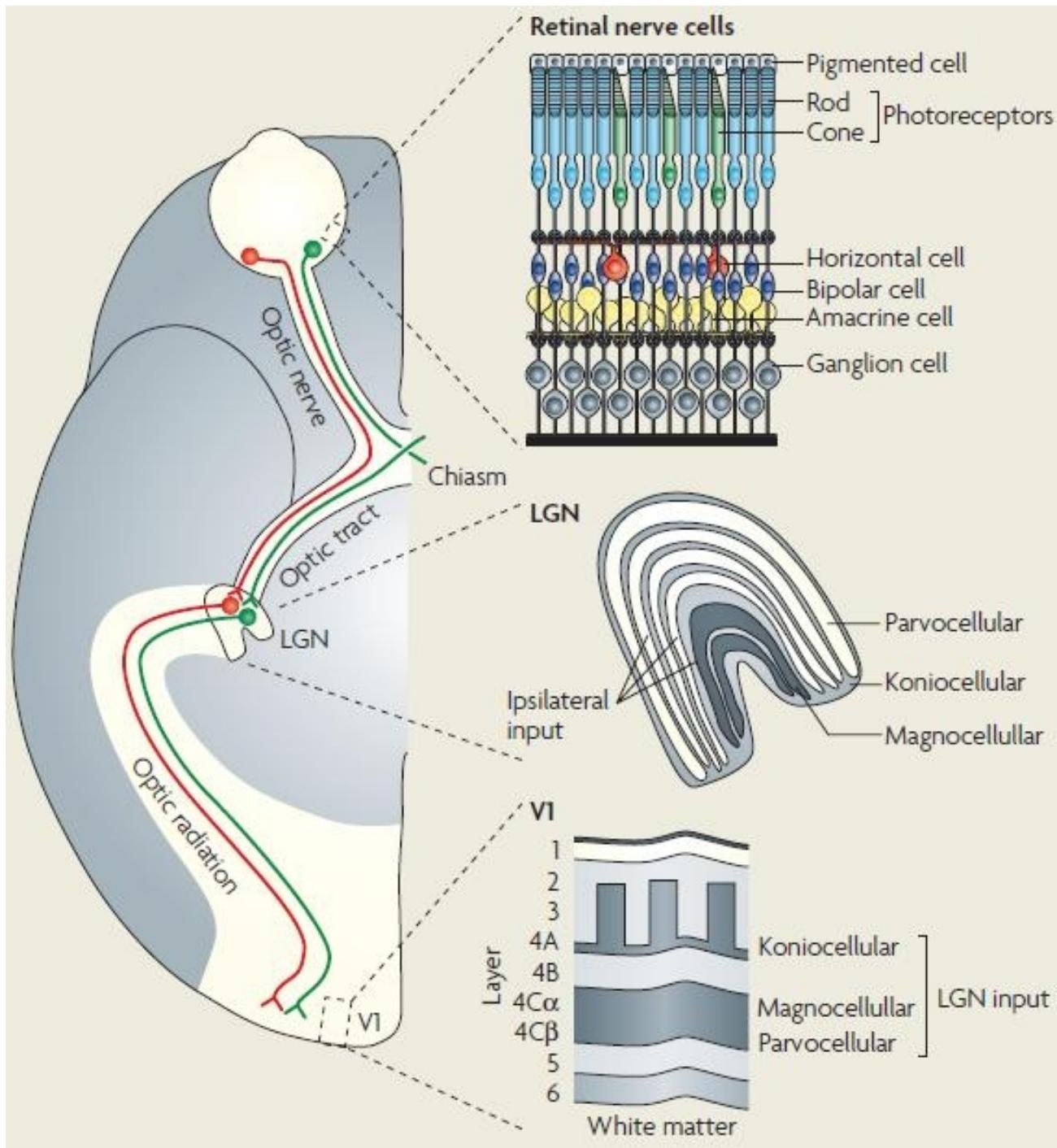






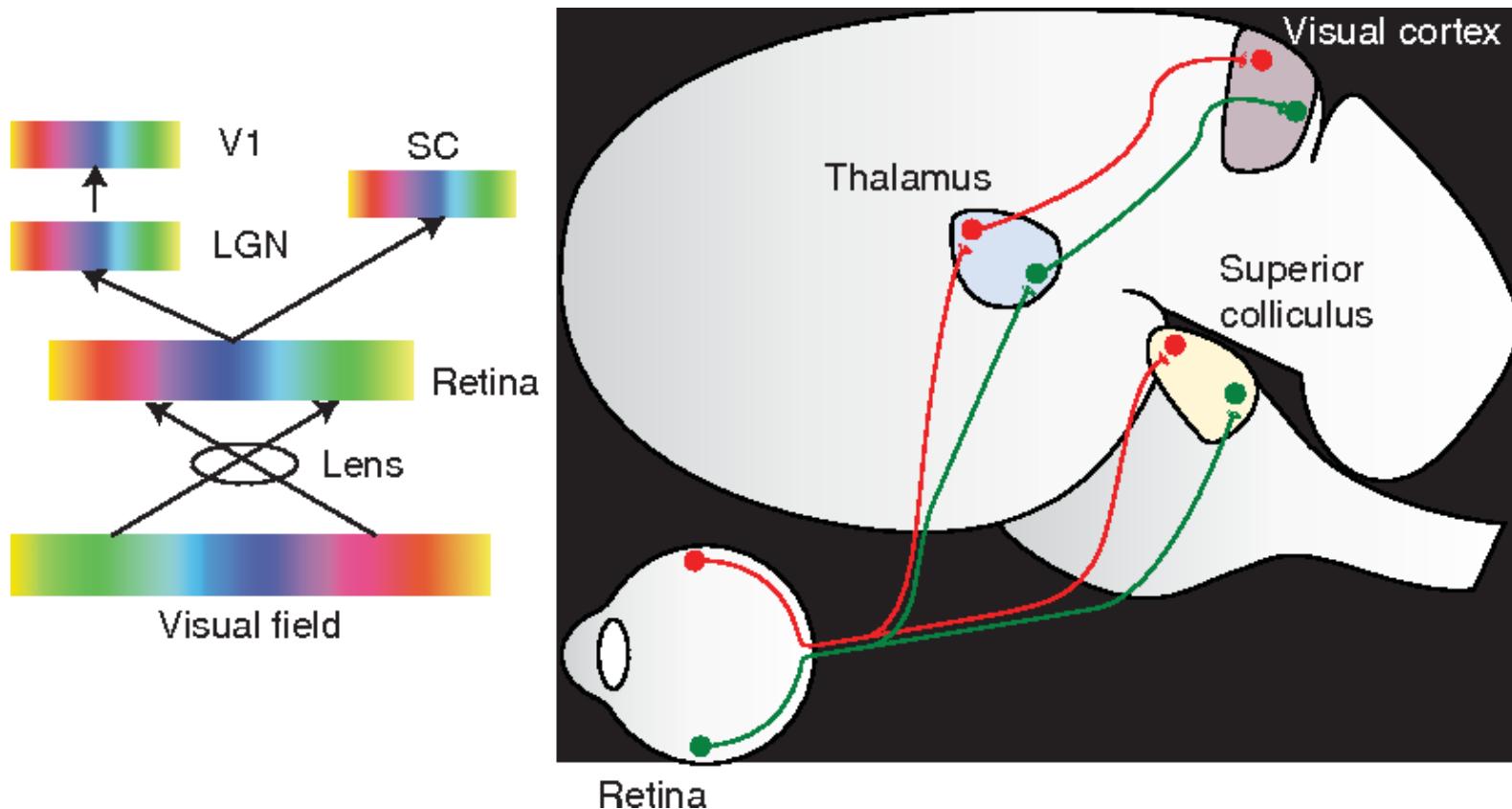


Summary of broad organization

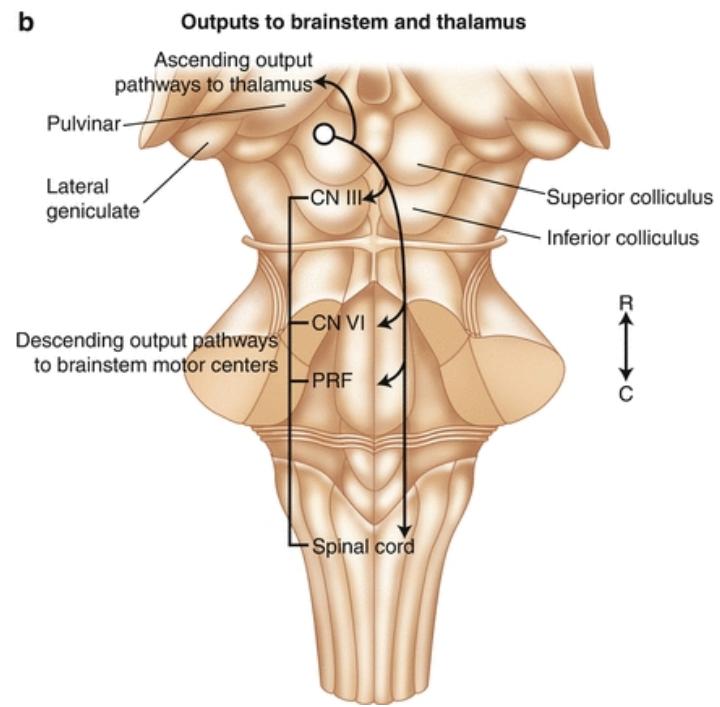
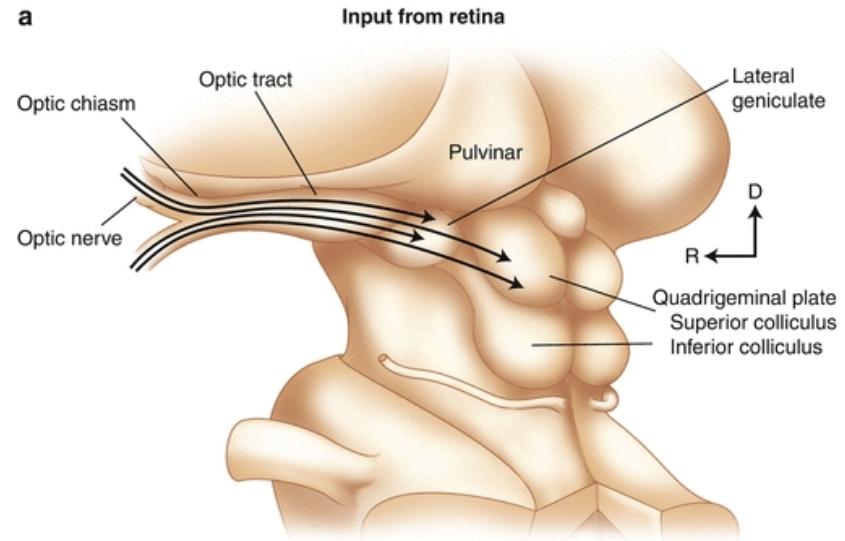
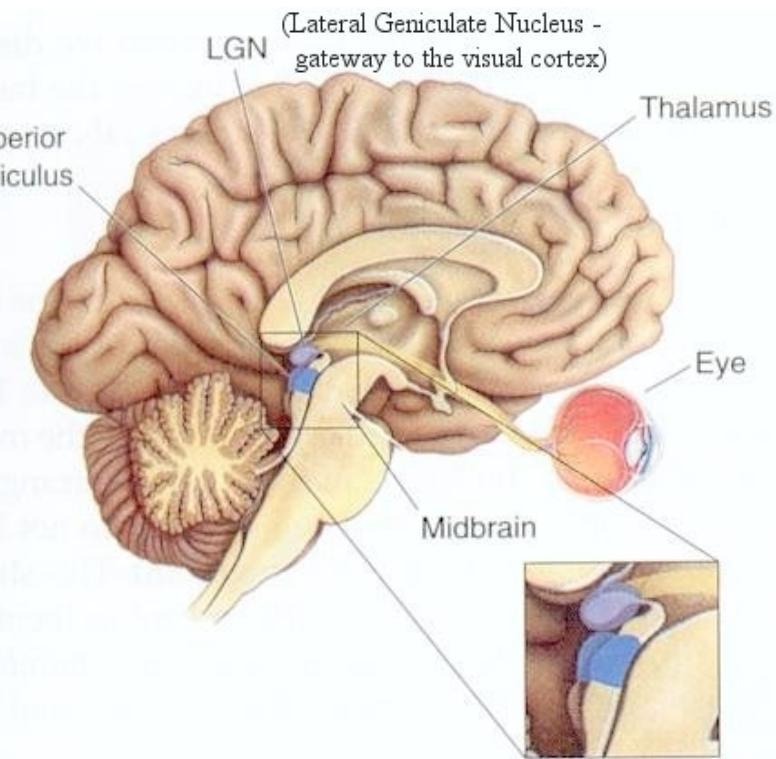


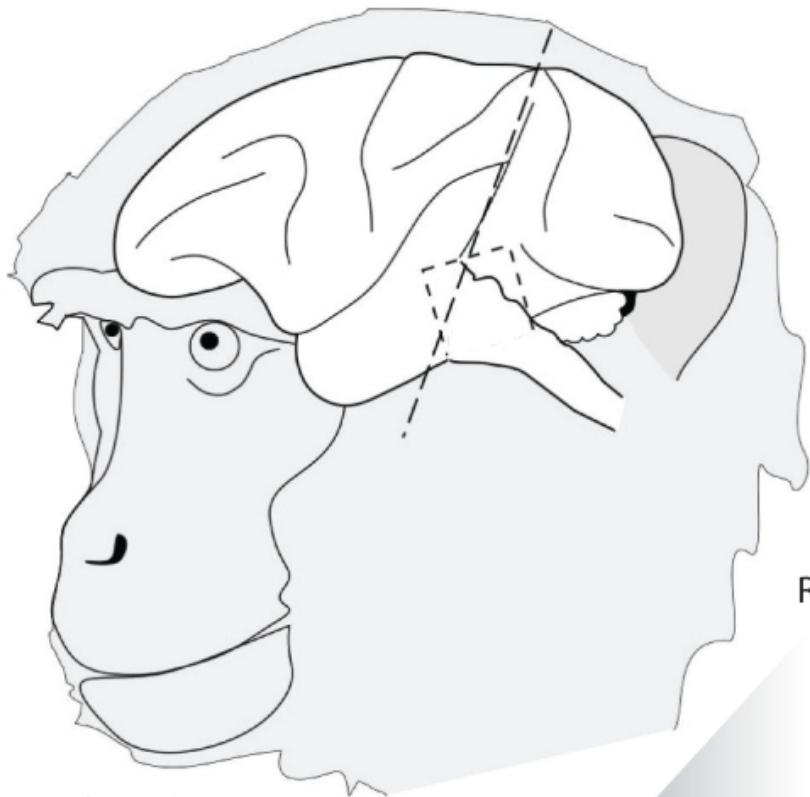
Superior Colliculus

Retinotopy

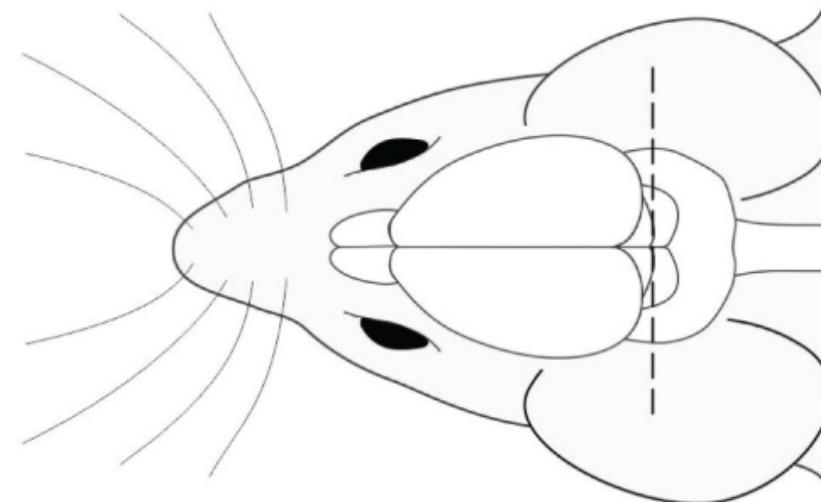


90% retinal output goes to thalamus
10% to superior colliculus

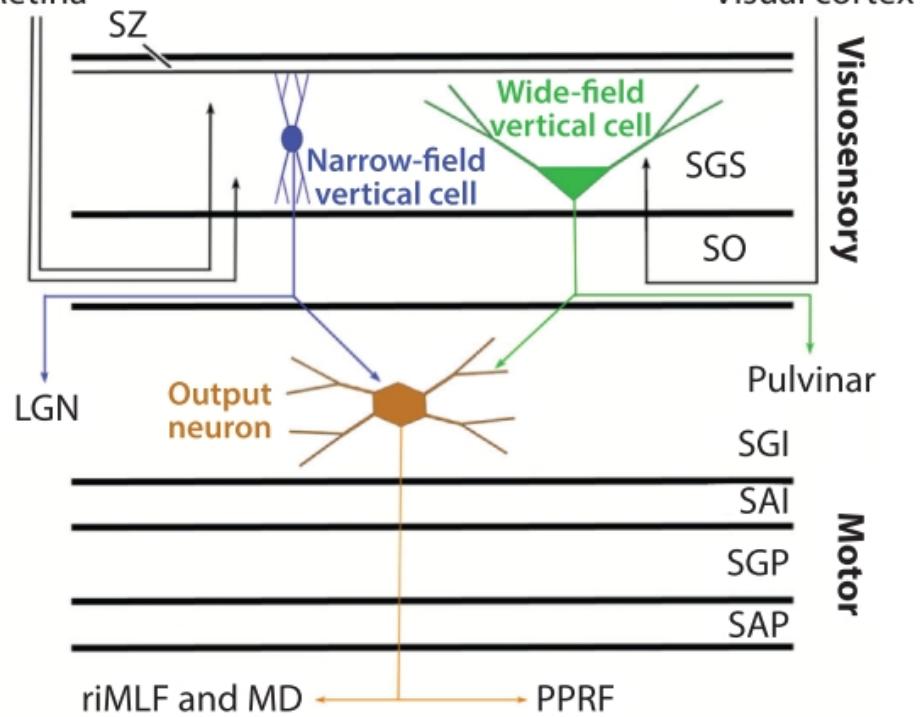




Visuosensory



Retina



Visuosensory

Motor

Inputs to *visuosensory* layers of SC

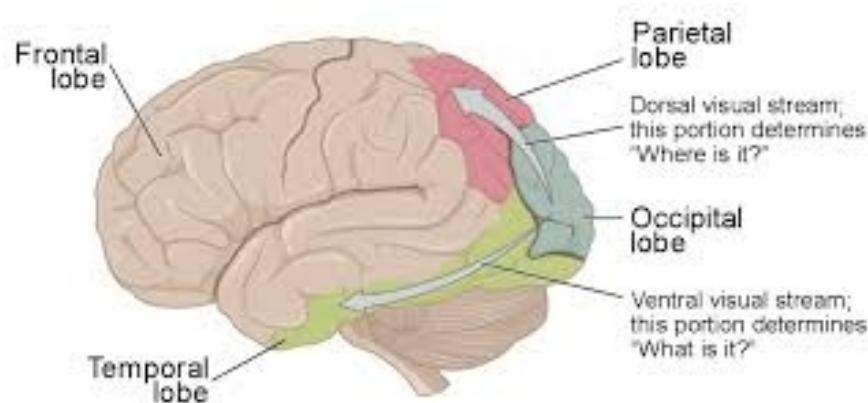
- Primary inputs
 - Retina (M and K type)
 - V1
 - Higher cortical visual areas
 - Inputs spatially segregated
- Secondary inputs
 - Ventral LGN
 - parabigeminal nucleus
 - Prepectum
 - locus coeruleus

Outputs to *visuosensory* layers of SC

- Dorsal neurons to LGN
- Ventral neurons to Pulvinar (*attention, visuo-motor behavior*)
- Retinal afferents more densely target colliculo-geniculate neurons, and cortical afferents more densely target tecto-pulvinar neurons

The role of visuosensory layers of SC

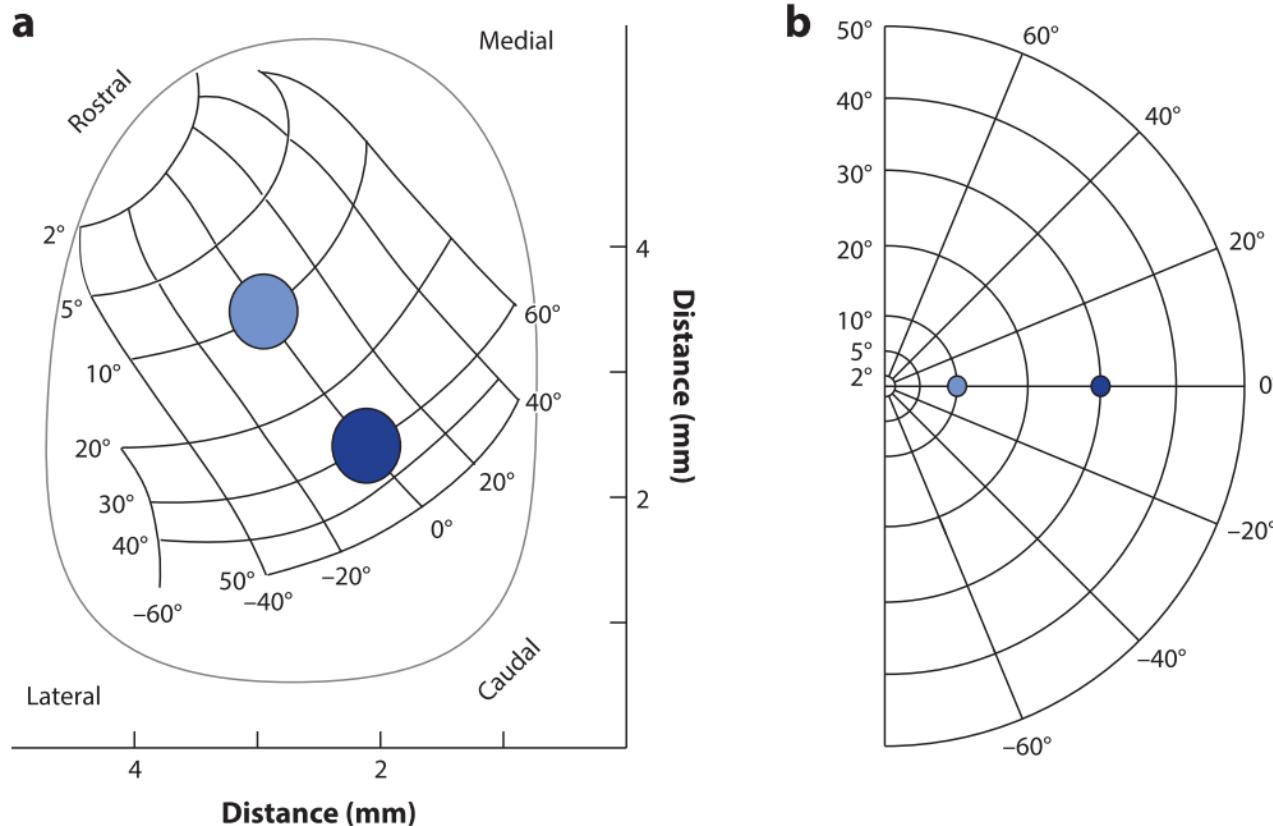
- V3 and MT of the dorsal stream, but not areas V2 and V4 of the ventral stream, are targets of collicular outputs
- Process and relay visual information related to motion and orienting
- Not high-res ‘what’ vision



Motor layers of SC

- Inputs from virtually the entire brain and parts of the spinal cord
- Outputs target nuclei throughout the neuraxis (pons, spinal cord, thalamus)
- Roles
 - orienting
 - attention
 - decision making
- Patchy molecular markers in motor layers

SC and eye-movements



- Two maps: one of visual space (a), superficially, and one of saccadic eye movement space(b), ventrally
- Neurons in the motor layers discharge in close temporal relationship to the generation of eye movements (**movement field**)

SC eye-movements II

- The location of the maximal discharge of movement neurons on the collicular map determines the vector of saccades, whereas the frequency of their discharge determines their speed
- Other orienting movements also involved
- Auditory and somatosensory maps also present
- Sparks (1988) proposed that all the maps were organized according to motor error—the position of the eyes relative to the target position.



