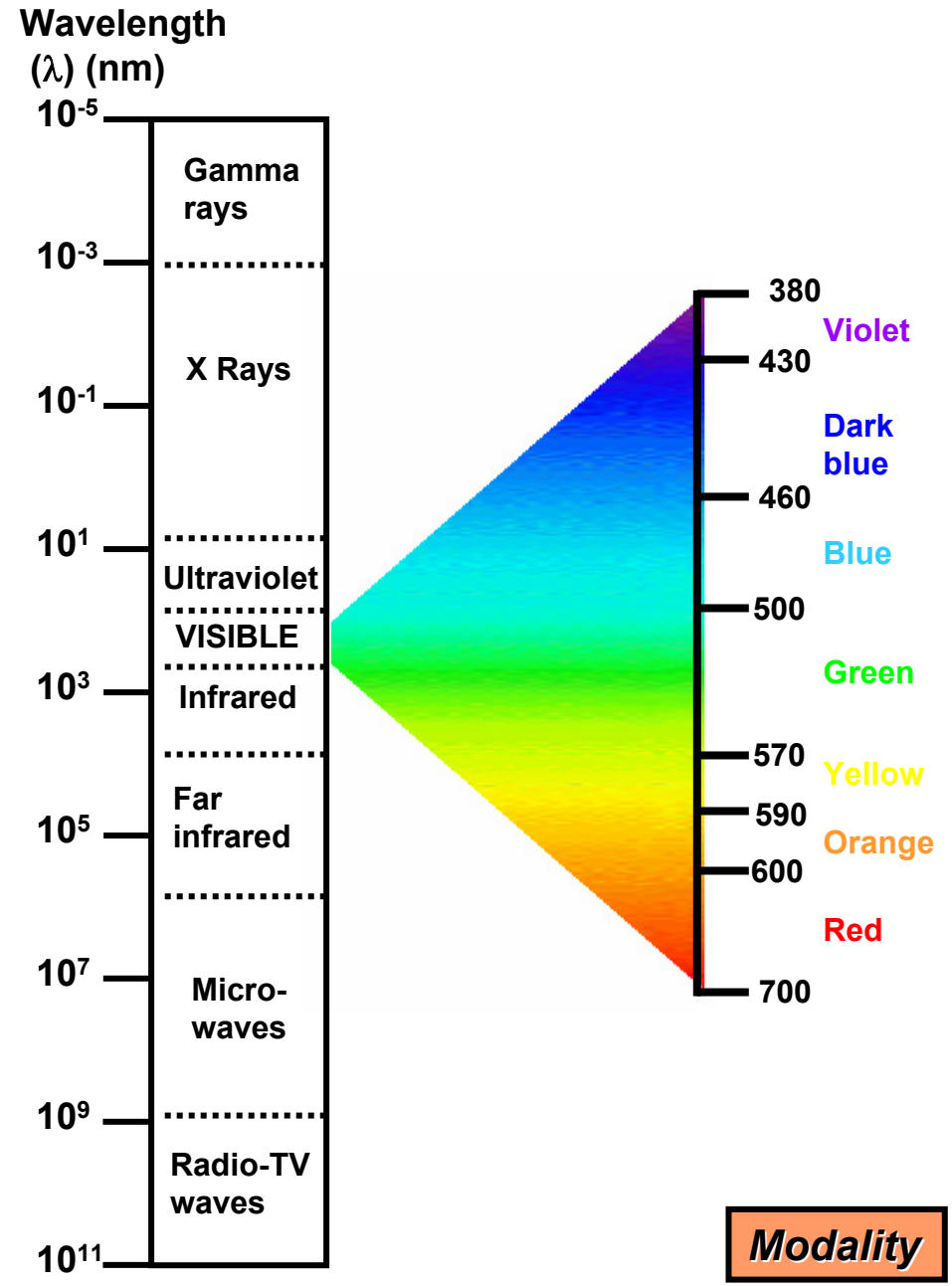
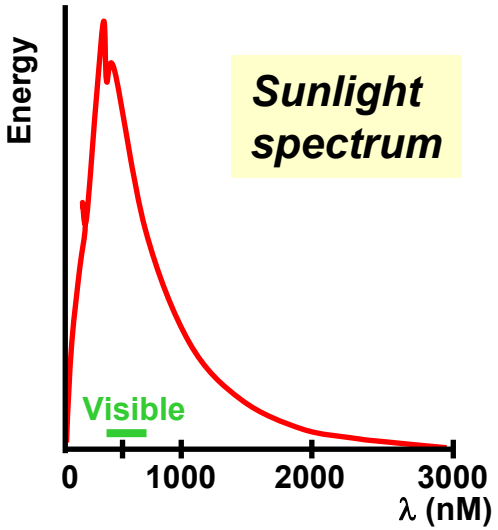
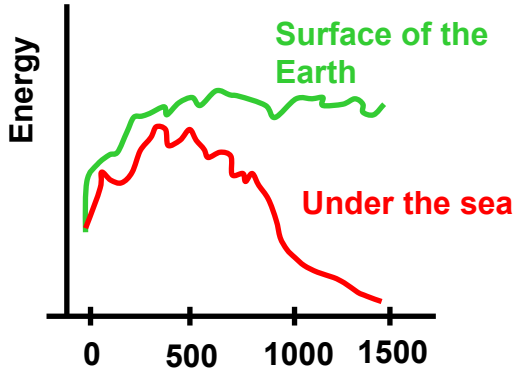
Visual stimulus: The visible spectrum

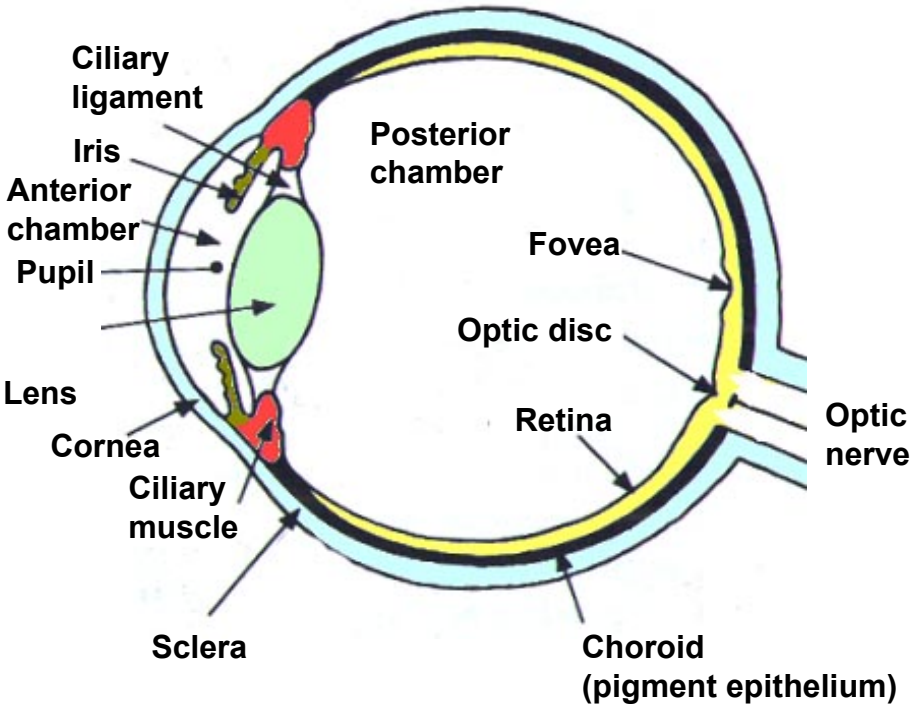




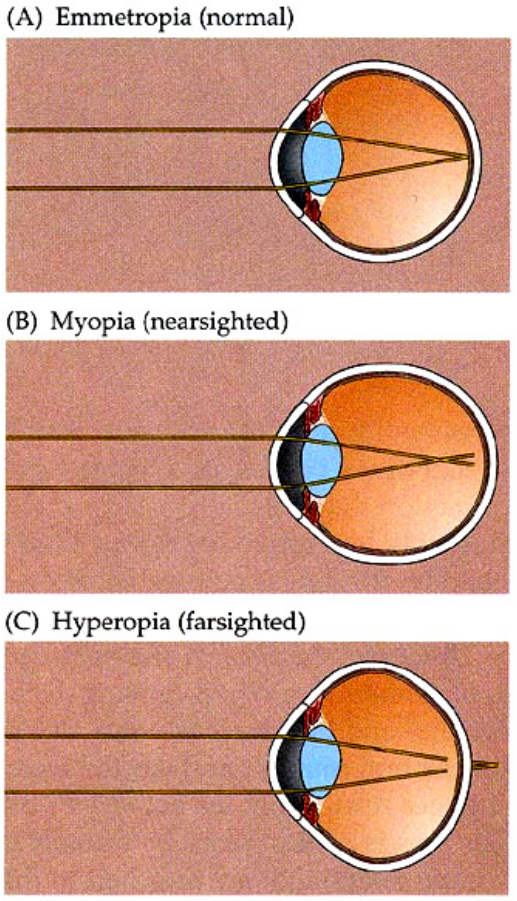


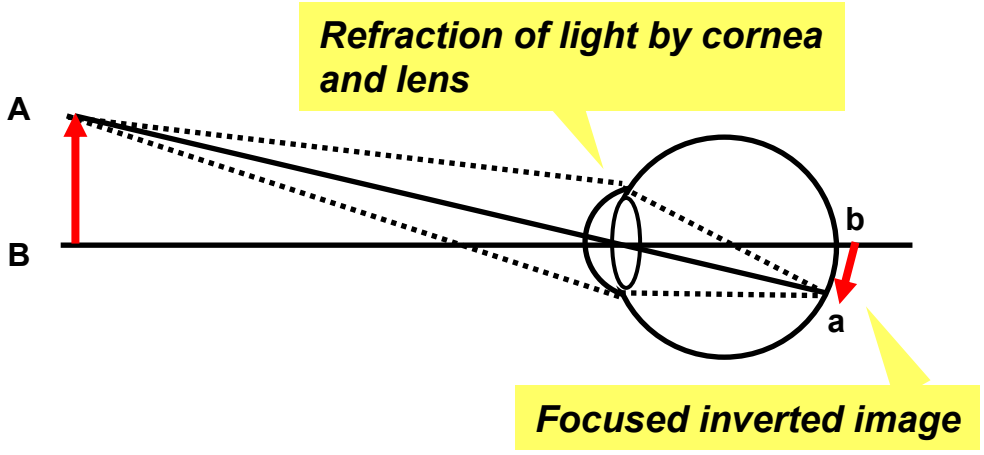
Modality | Location | Intensity | Timing

Functional structure: The eye

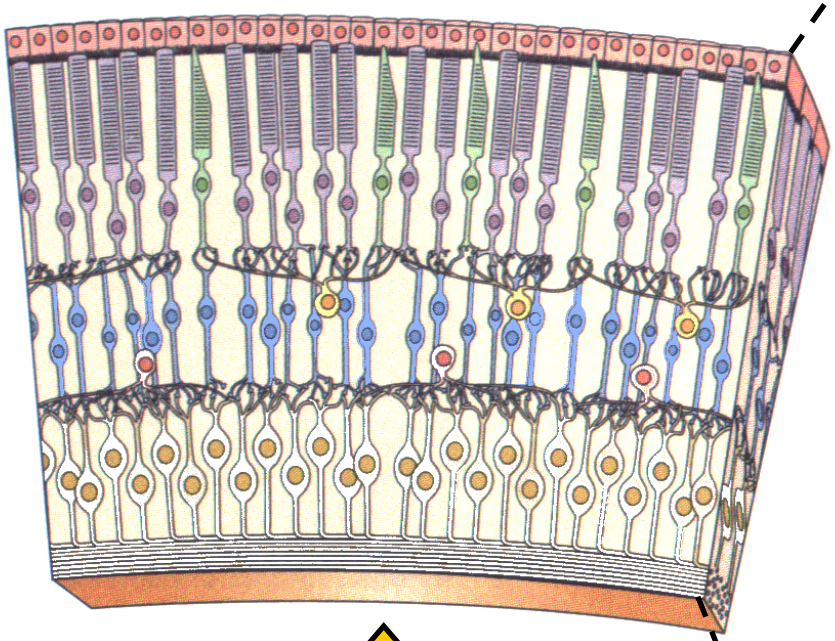


Refractive errors

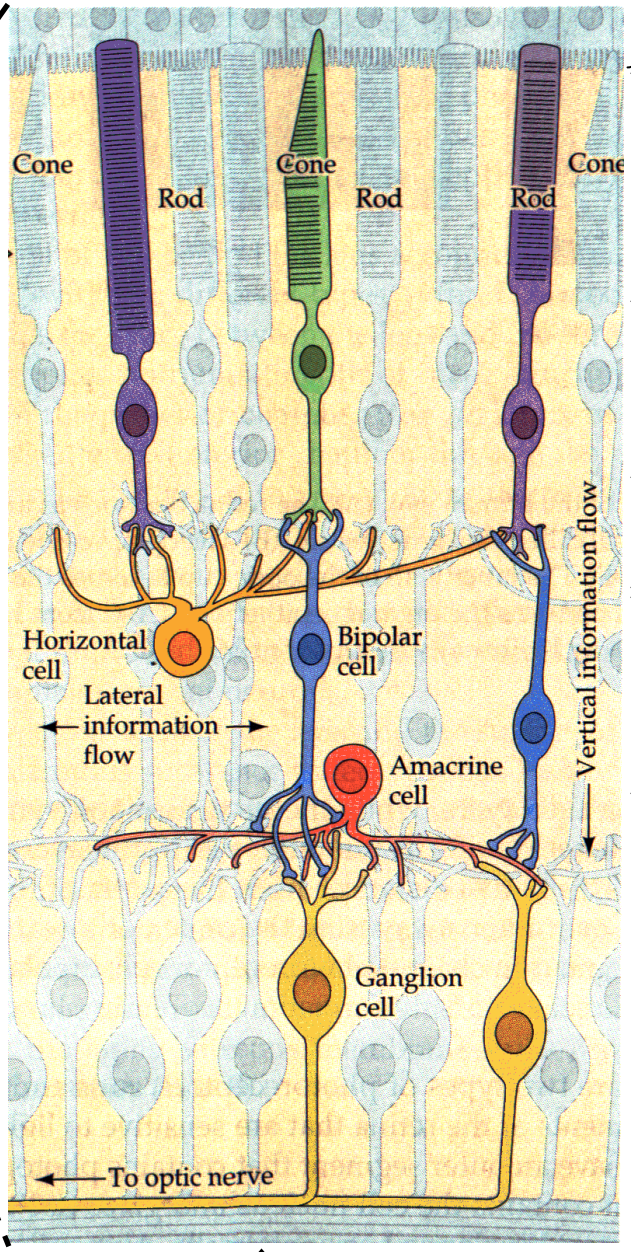




Functional structure: The retina



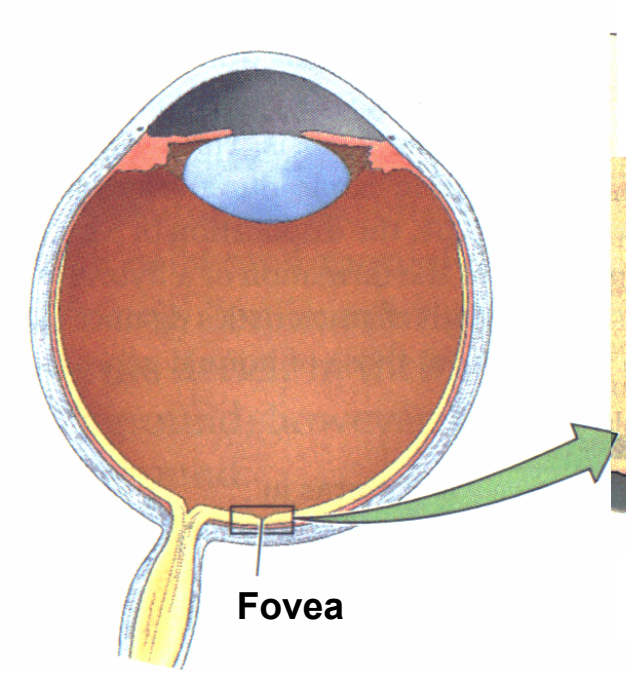
Light

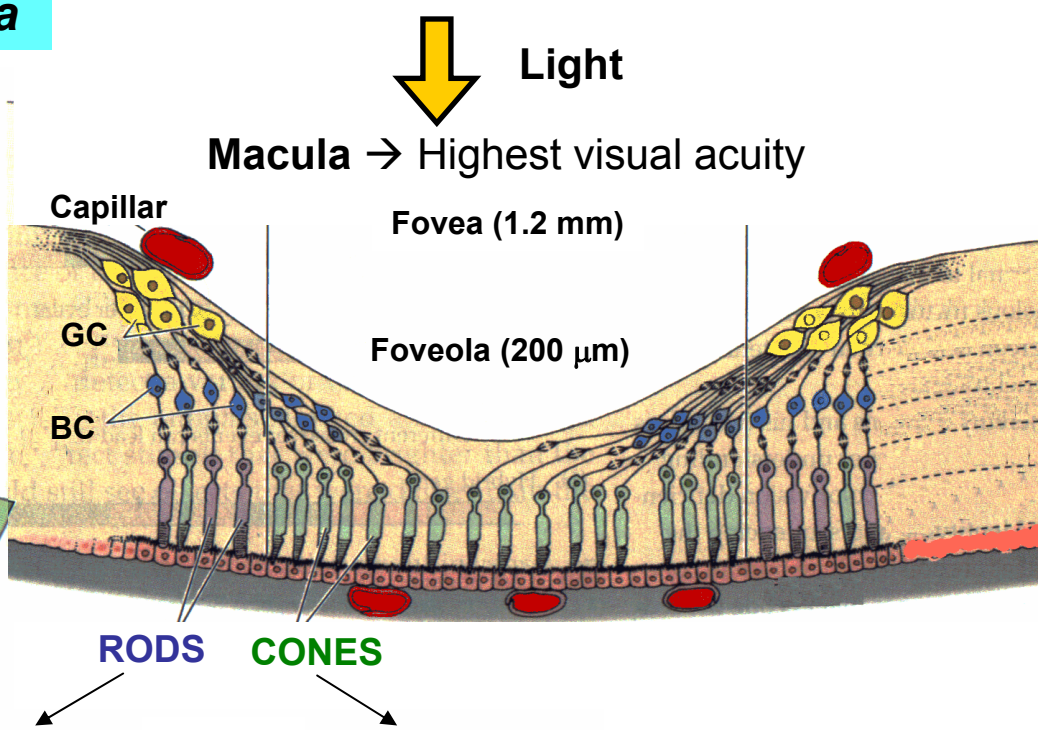


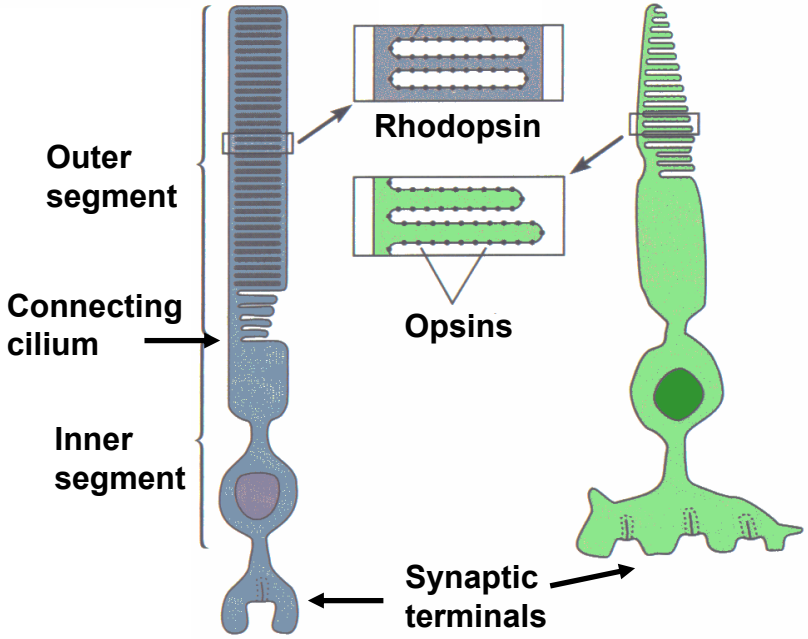
Light

Retina = First processing steps

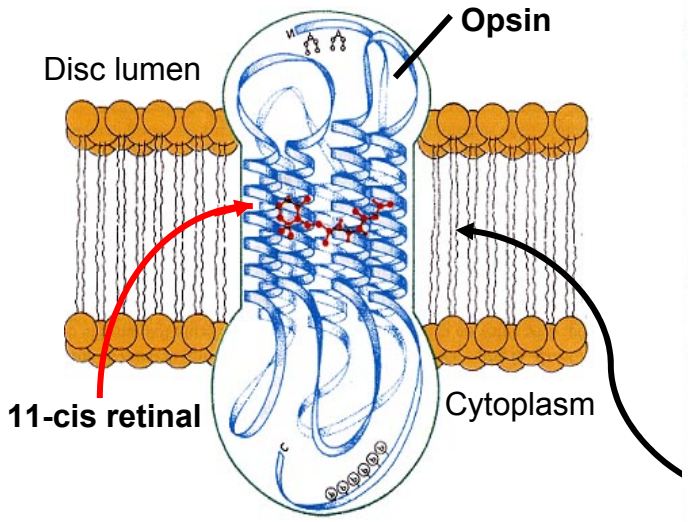
Functional structure: The retina



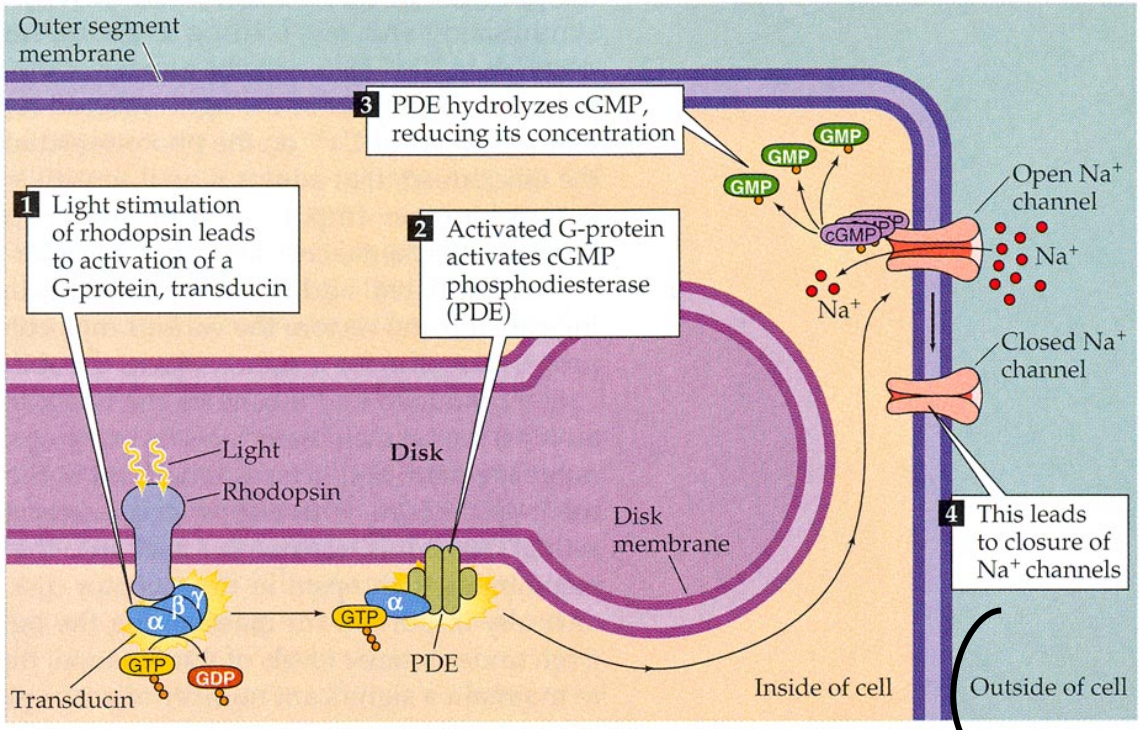


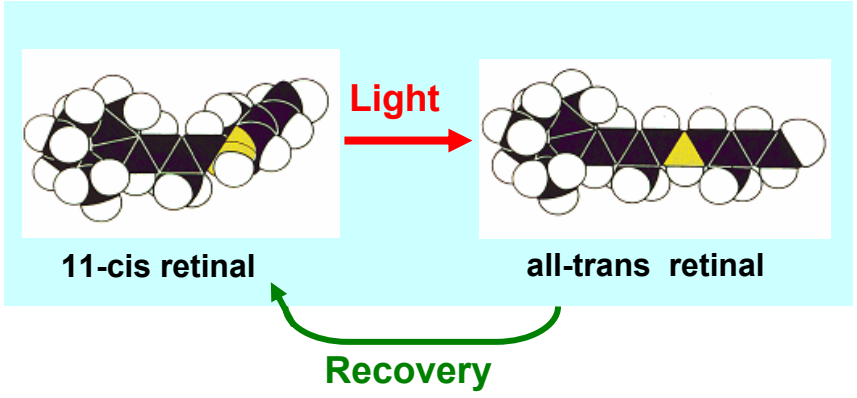


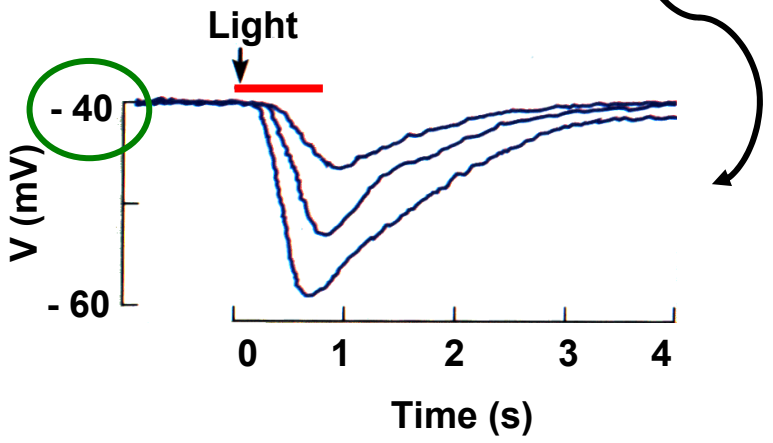
Photoelectrical transduction of light



Photopigment = opsin + retinal







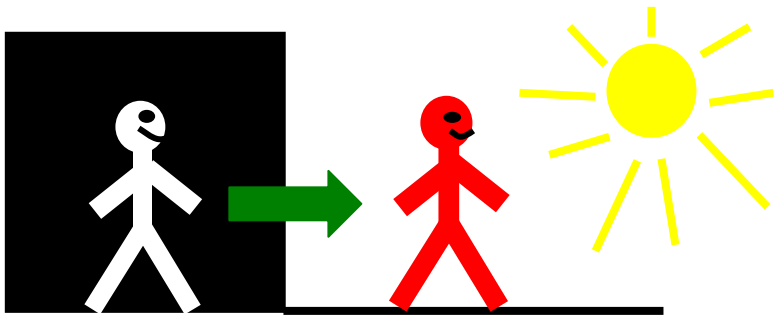
Photoelectrical transduction of light

Properties:

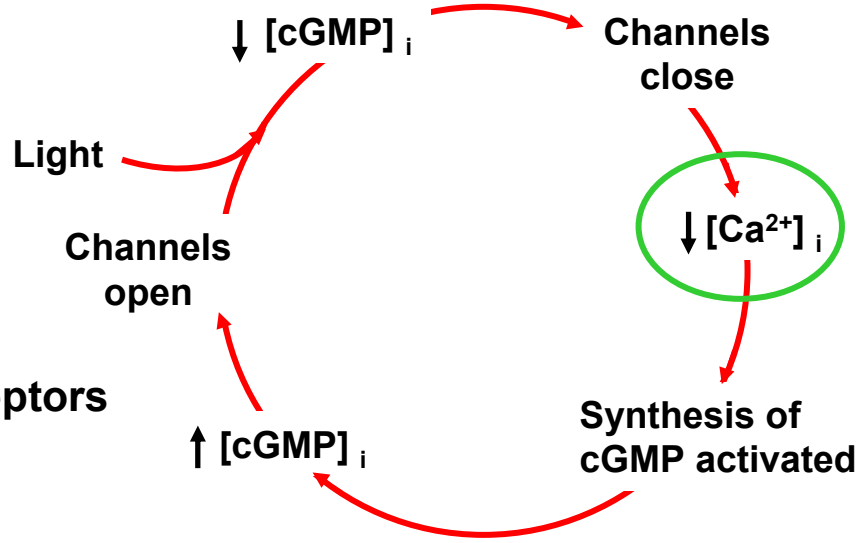
1) Signal ***amplification***

1 photon	*1 activated rhodopsin molecule*	*800 G-proteins*	*800 PDE*	*800 x 6 = 4800 cGMP hydrolyzed*	*200 channels close*	*1 mV change*

2) ***Adaptation*** to the level of light → **Ca^{2+} dependent modulation of the transduction cascade.**



↑ Light ↓ Sensitivity → **Prevents photoreceptors from saturating**

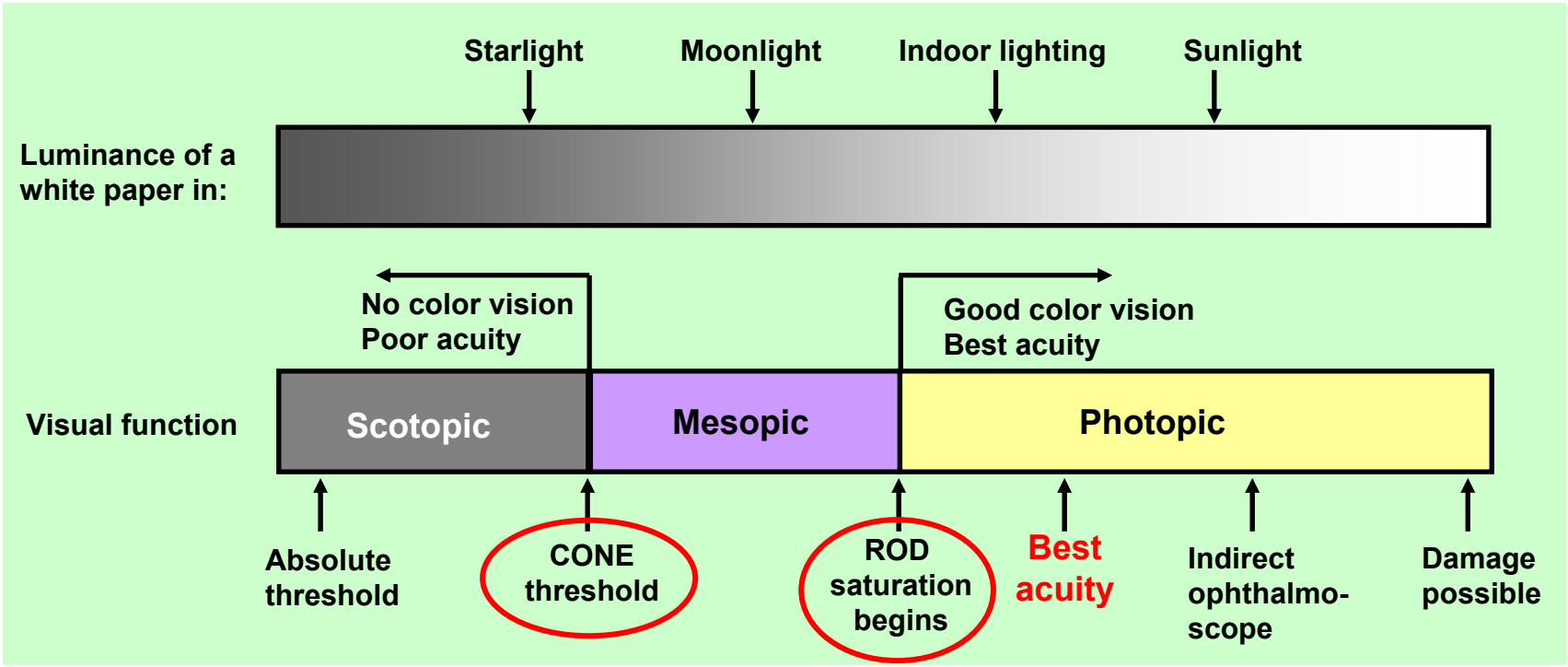


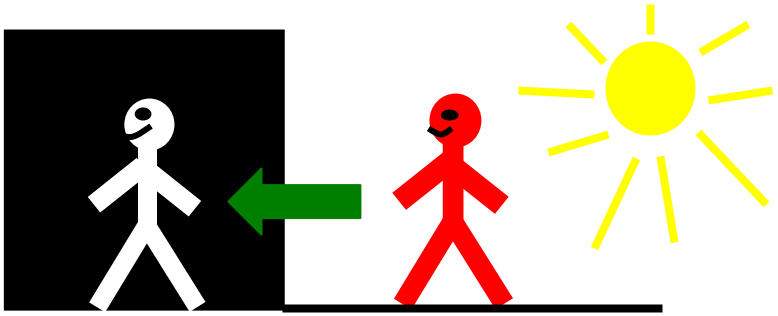
3) Temporal answer = very fast → **Restoring molecules to the inactive state**

Modality ***Location*** ***Intensity*** ***Timing***

Functional specialization: Rod and Cone Systems

Differences in the sensitivity to luminance



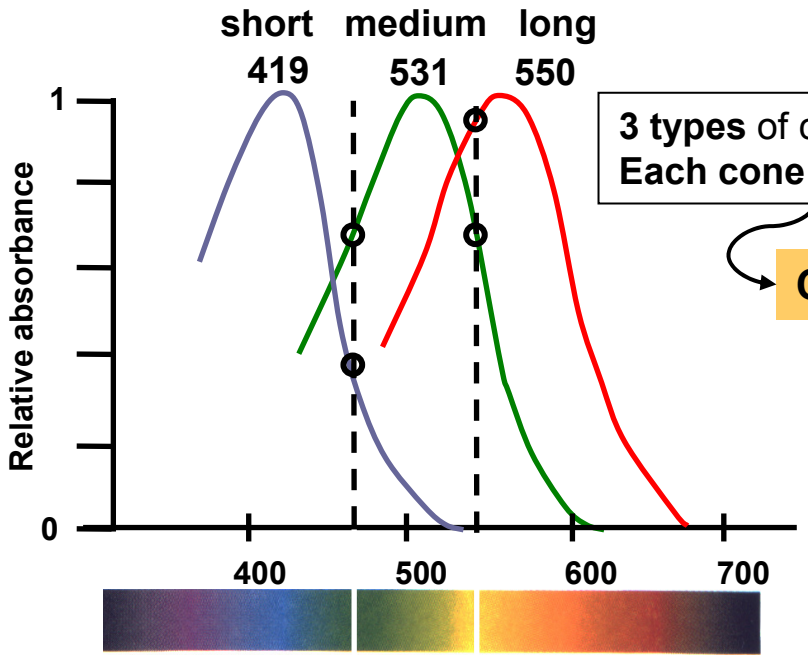


Adaptation to dark

Modality ***Location*** ***Intensity*** ***Timing***

Functional specialization: Rod and Cone Systems

Differences in phototransduction



3 types of cone **opsins**
Each cone → 1 opsin

Color vision = Based on comparisons

	RODS	CONES
SENSITIVITY	High (Scotopic vision)	Low (Photopic vision)
PHOTOPIGMENT	Single: Rhodopsin More quantity LUMINANCE	Three types of cone opsins Less quantity COLOR VISION
AMPLIFICATION	High (1 photon)	Low

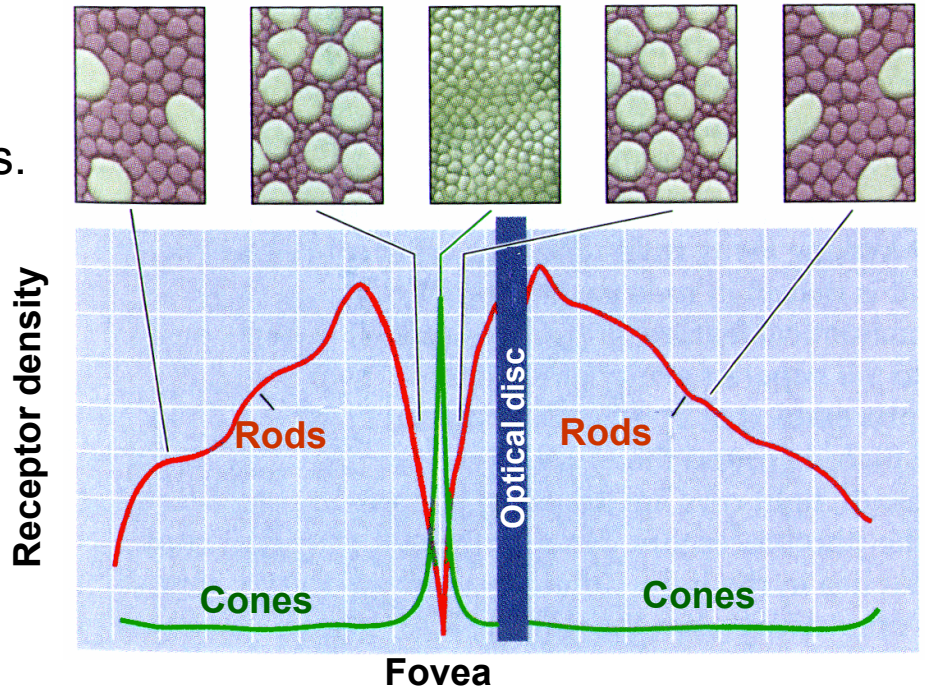
Functional specialization: Rod and Cone Systems

Differences in spatial resolution

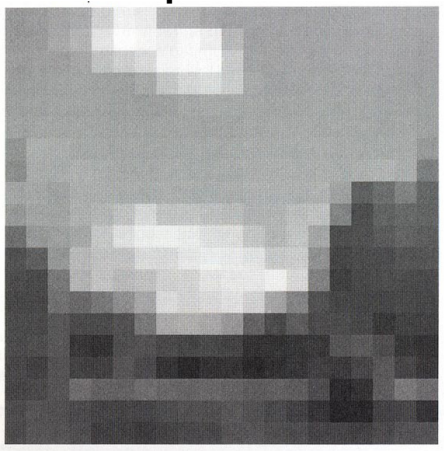
1) **Density and location** of photoreceptors.

2) **Morphology** of photoreceptors.

Size of receptive field

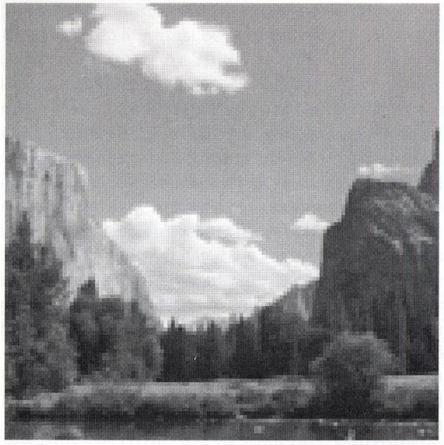


400 receptors

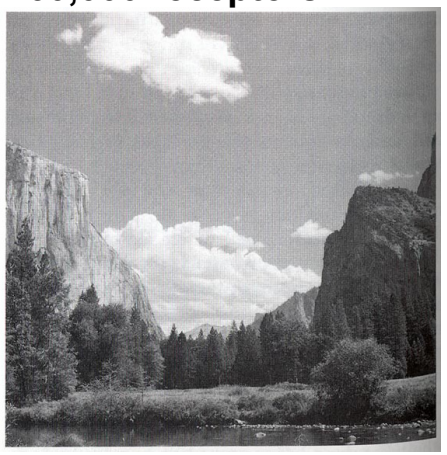


3,600 receptors

14,400 receptors



160,000 receptors

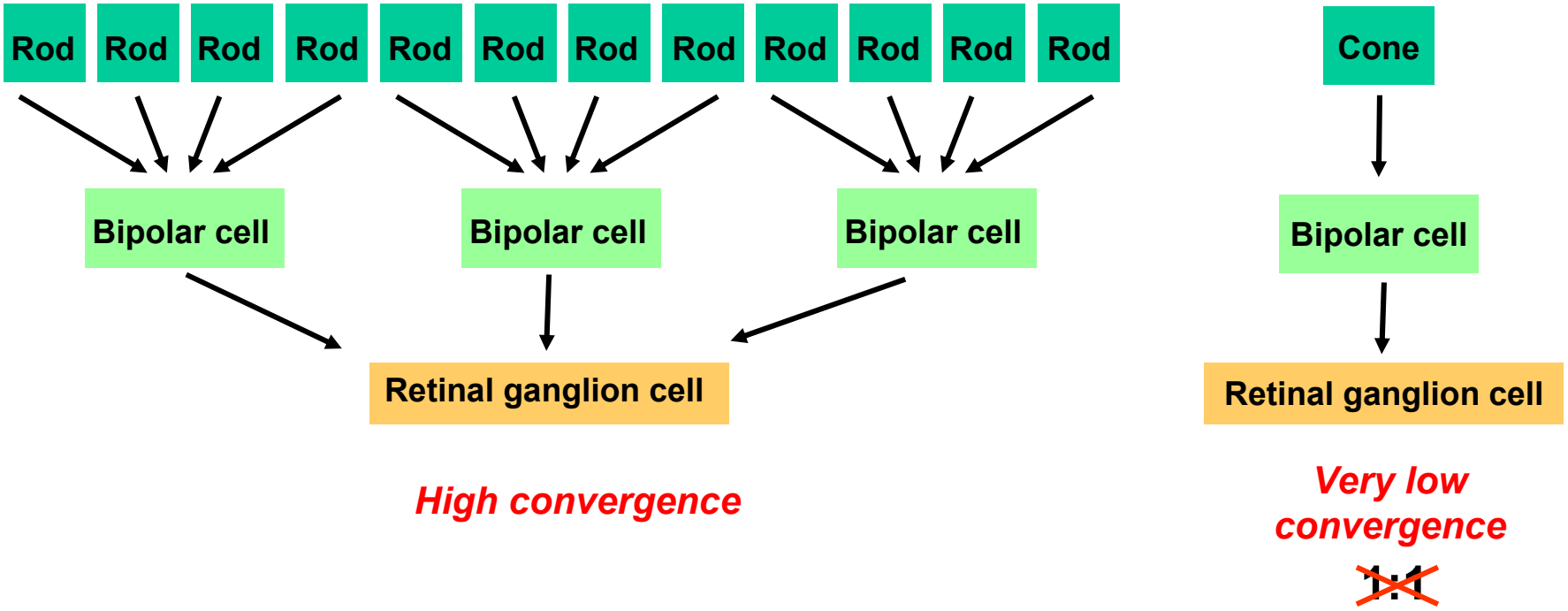


Functional specialization: Rod and Cone Systems

Differences in spatial resolution (cont.)

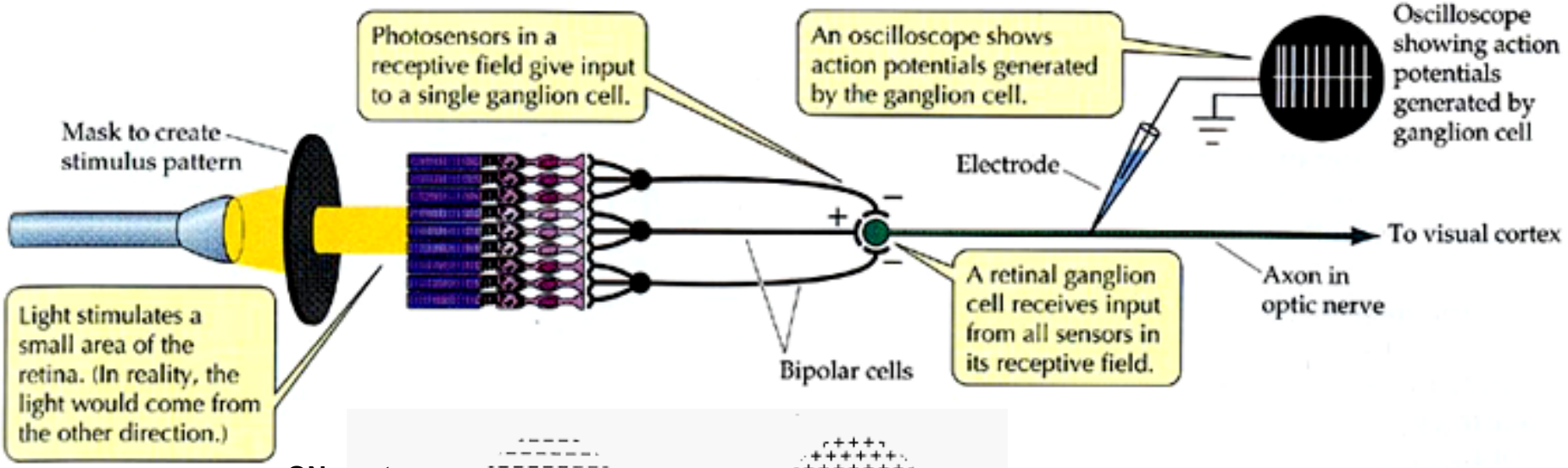
3) Retinal circuits
(from photoreceptor to ganglion cells)

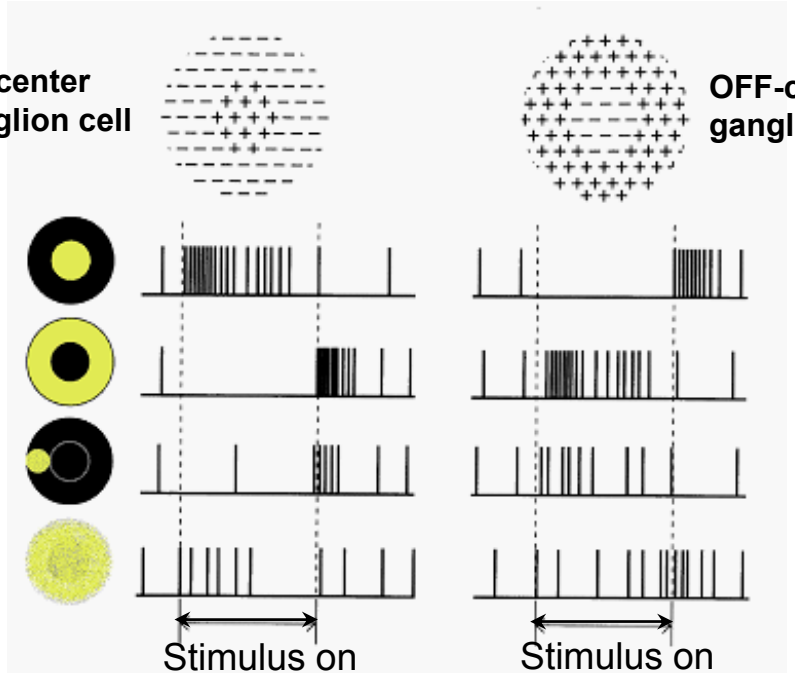
→ **Size of receptive field**



Information processing in the retina

Response of retinal ganglion cells: center-ON, center-OFF

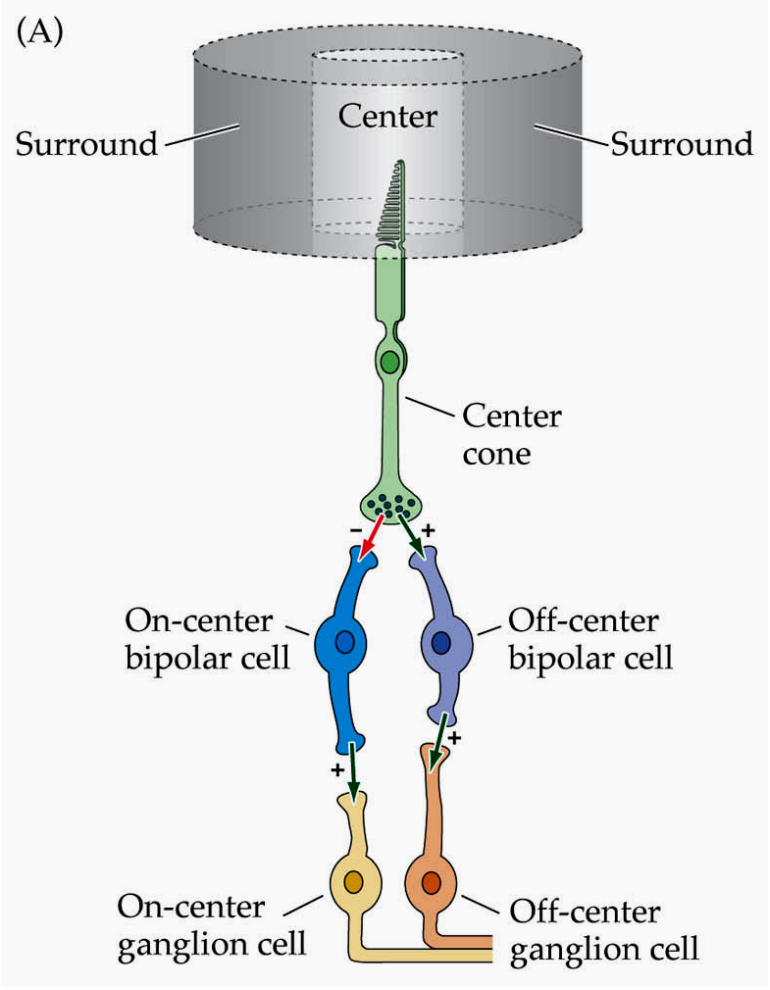


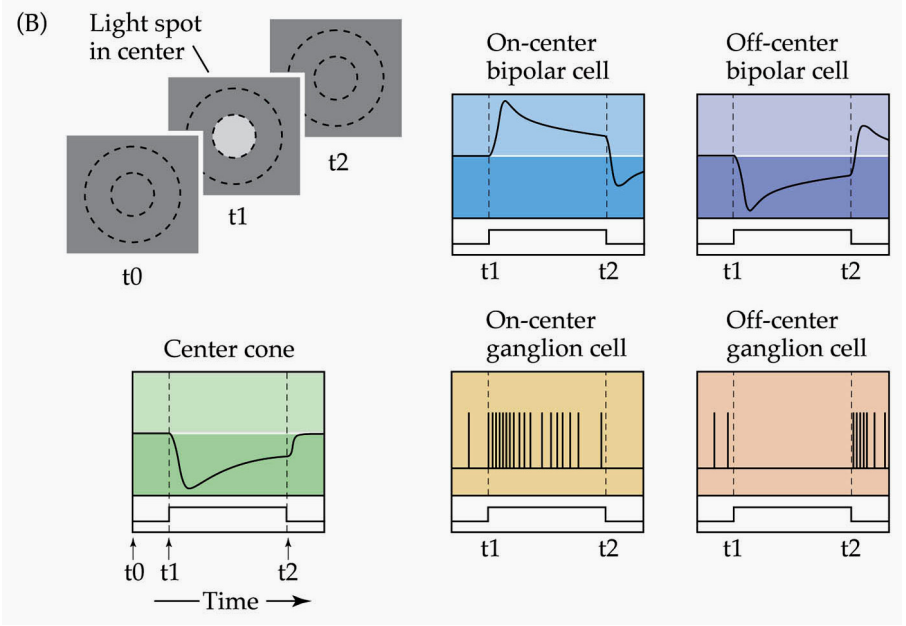


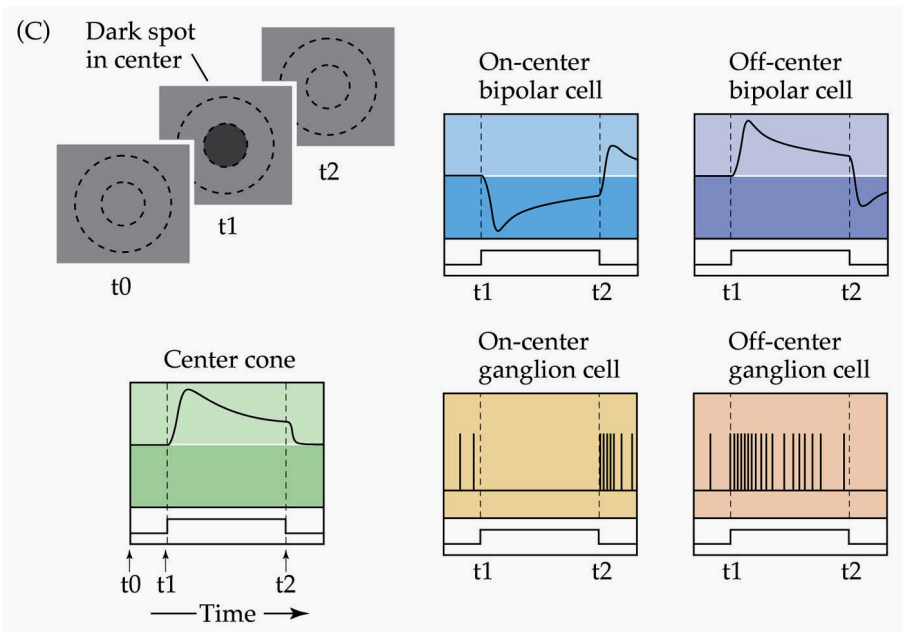
The visual system uses two channels to get information about luminance

Retinal processing of visual information

Circuitry for generating receptive field center responses of retinal ganglion cells

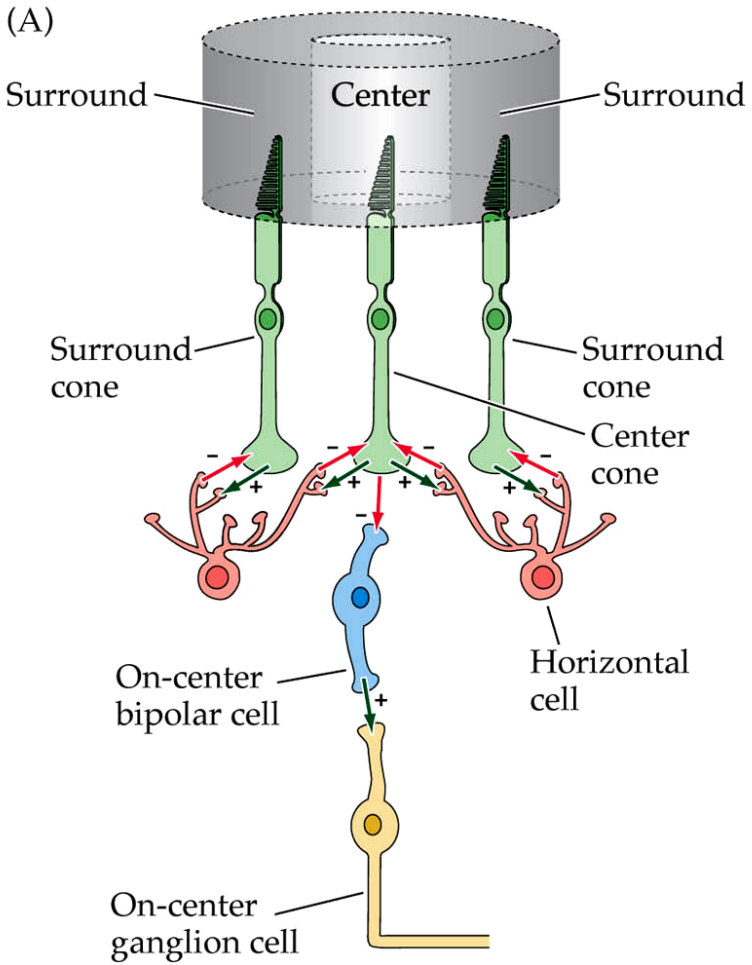


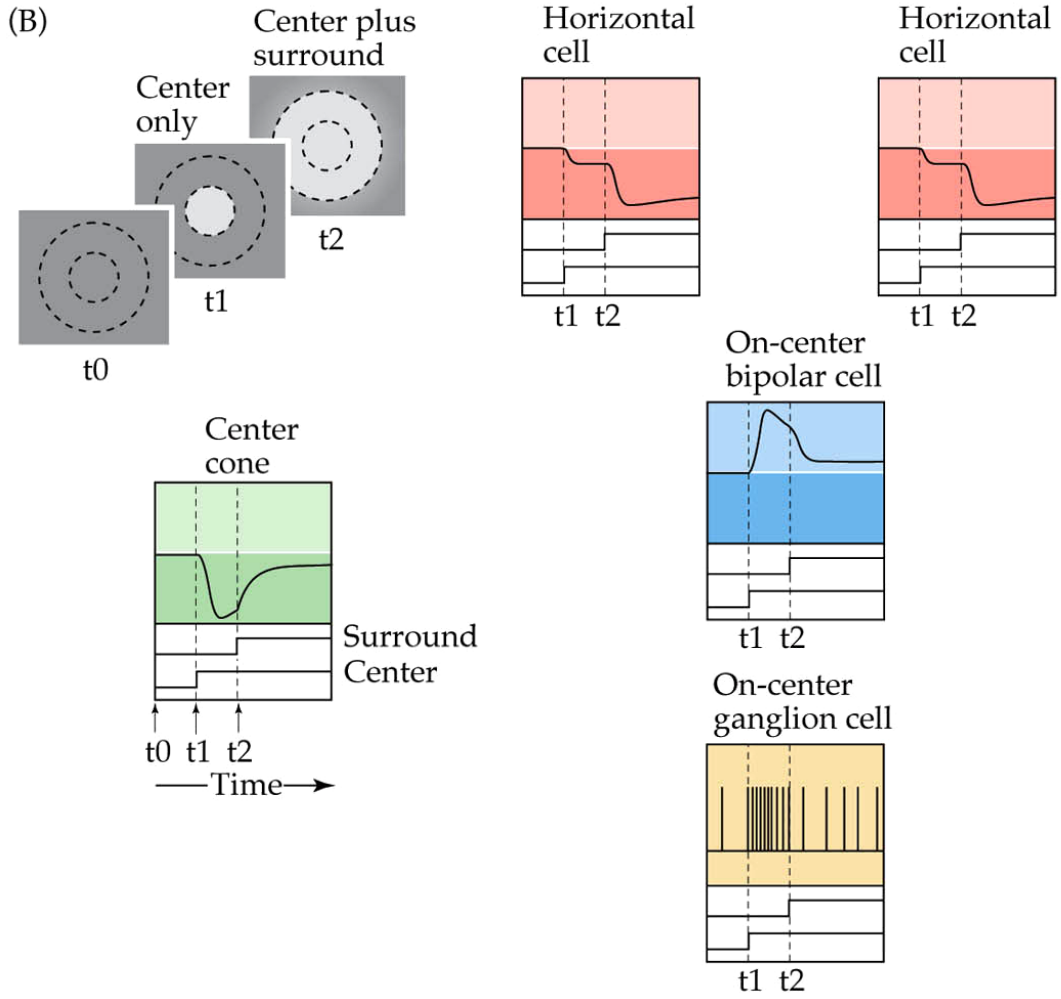




Retinal processing of visual information

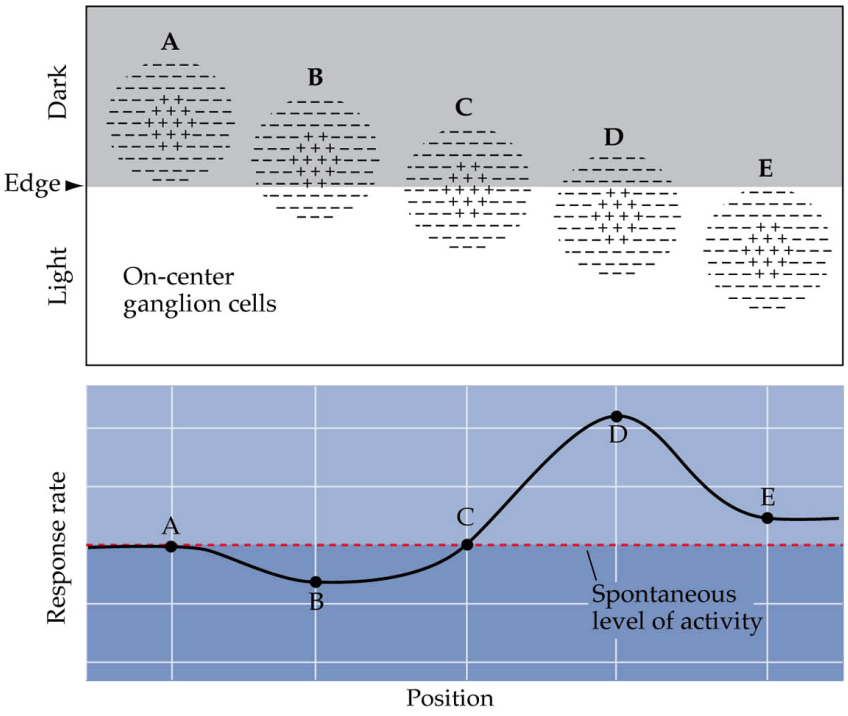
Circuitry for generating receptive field surround of an on-center retinal ganglion cell.





Retinal processing of visual information

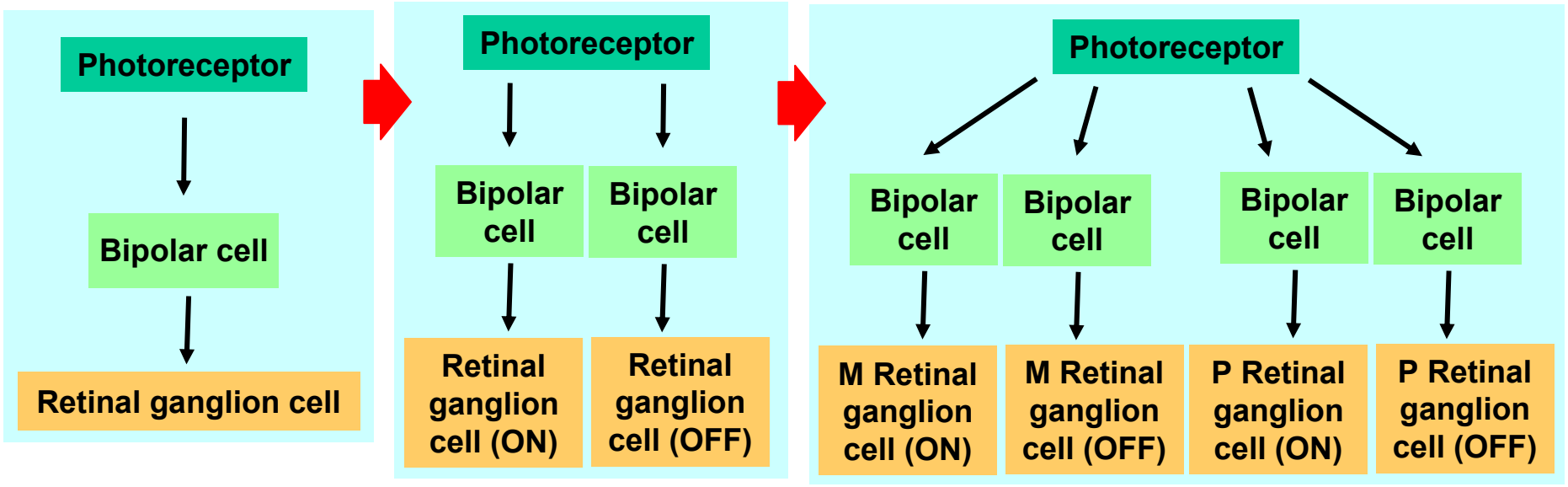
Responses of on-center ganglion cells distributed across a light-dark edge



RGC are specialized in contrast detection. The retina “sees” the world by translating the raw light array captured by photoreceptors into a pattern of spots surrounded by darkness or vice versa processed by RGC.

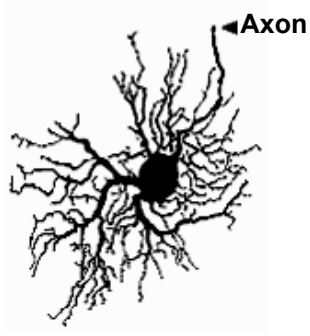
Information processing in the retina

Parallel procesing of color, shape and movement in the retina



Two types of retinal ganglion cells (M = magno, P = parvo):

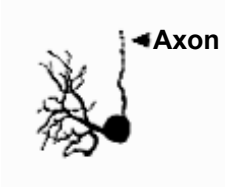
M Retinal ganglion cells



Big receptor field

Rapid adaptation

P retinal ganglion cells



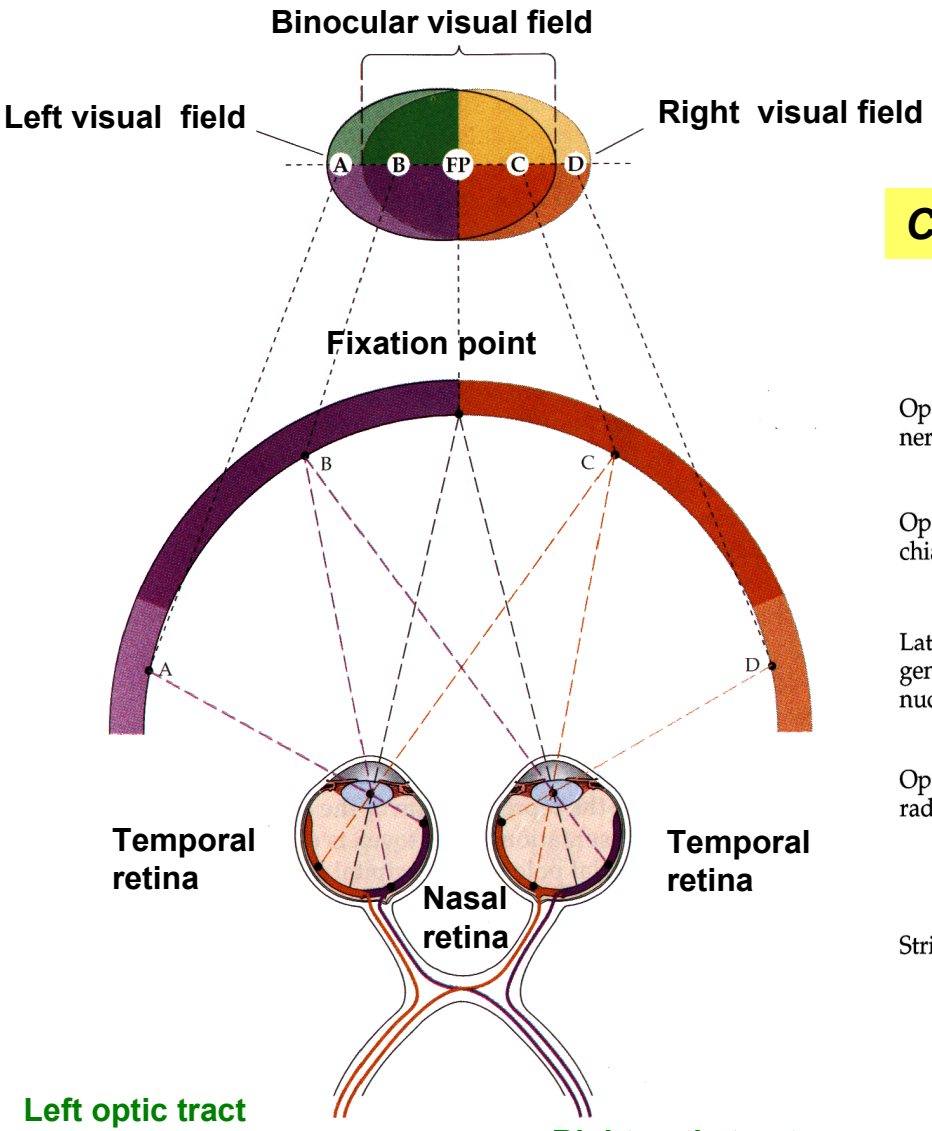
Small receptor field

Slow adaptation

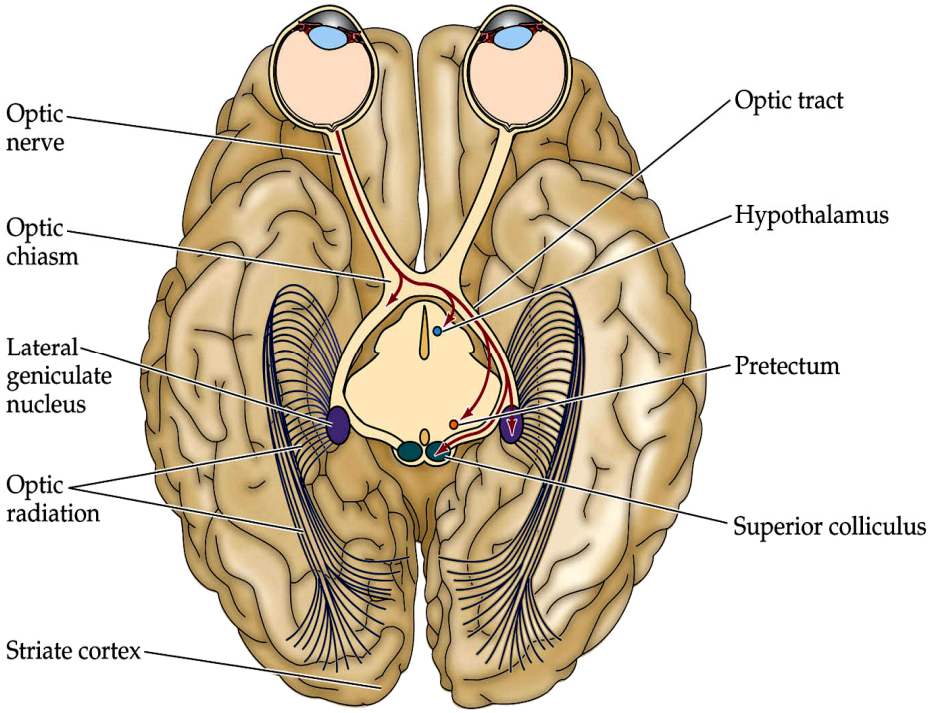
Selective response to specific wavelenghts

Information processing in the retina

Retinotopic representation of the visual field in the retina

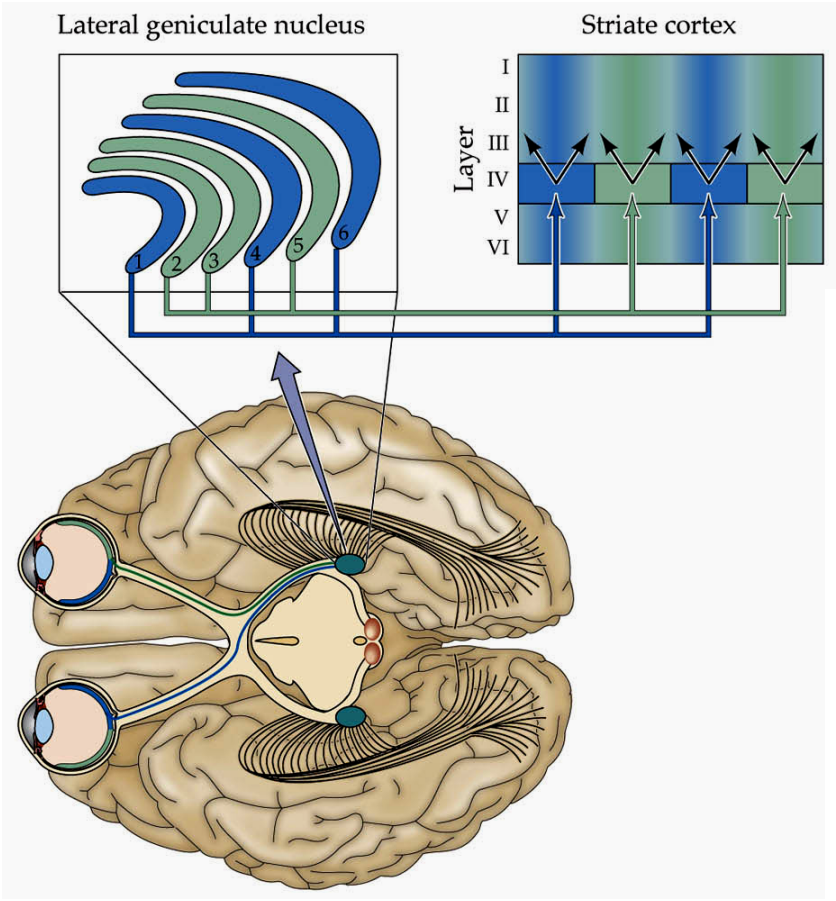


Central projections of retinal ganglion cells

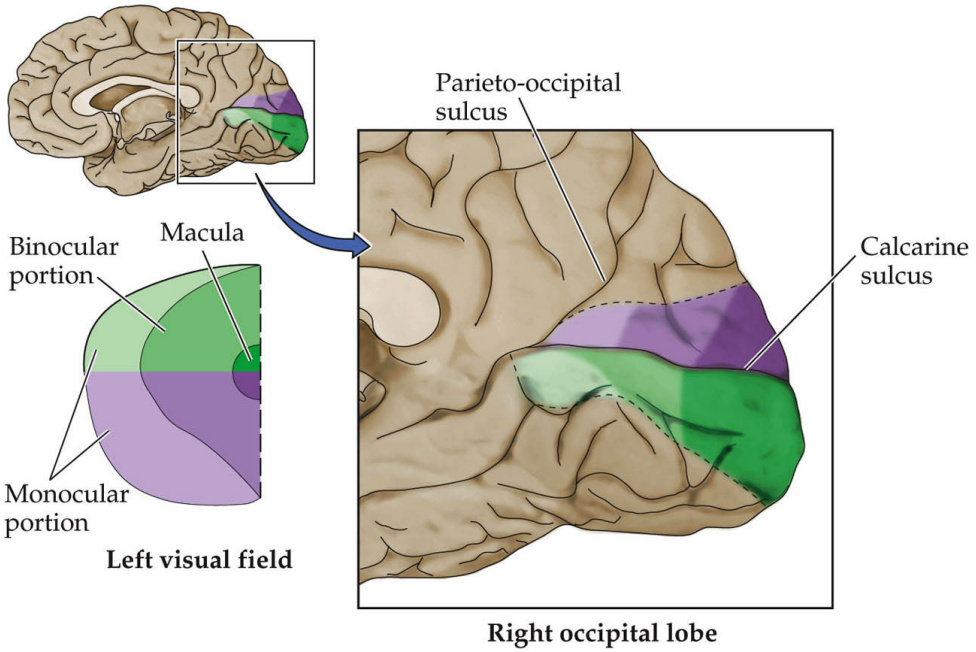


Central processing of visual information

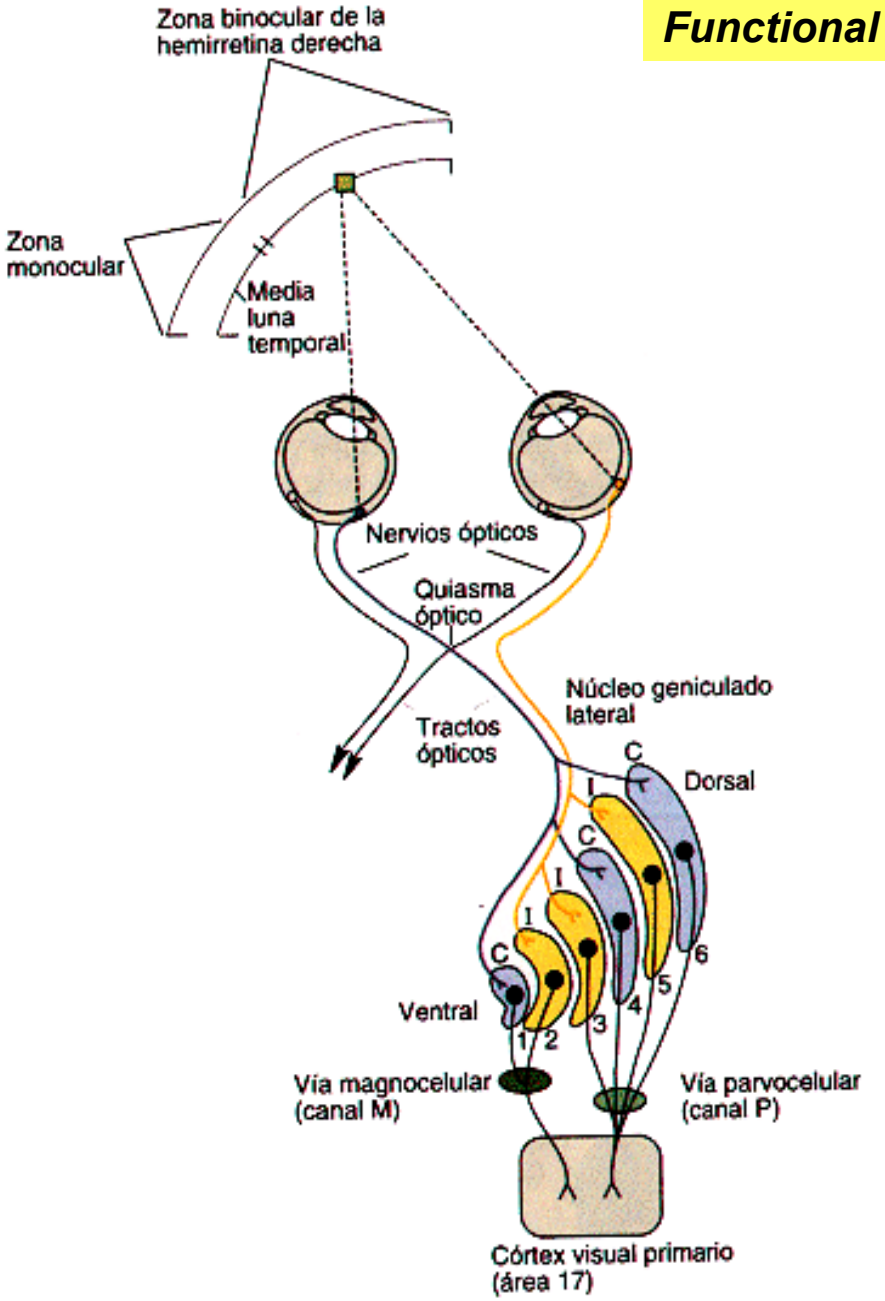
Segregation of inputs from both eyes in the LGN and its projections to cortex



Visuotopic organization of the striate cortex (V1) in the occipital lobe



Central processing of visual information



Functional organization of the LGN

Properties:

1) LGN neurons are **monocular**

2) Parallel pathways → Segregation of information about stimuli

3) P channel → **Color** information
→ **Form** information (fine detail)

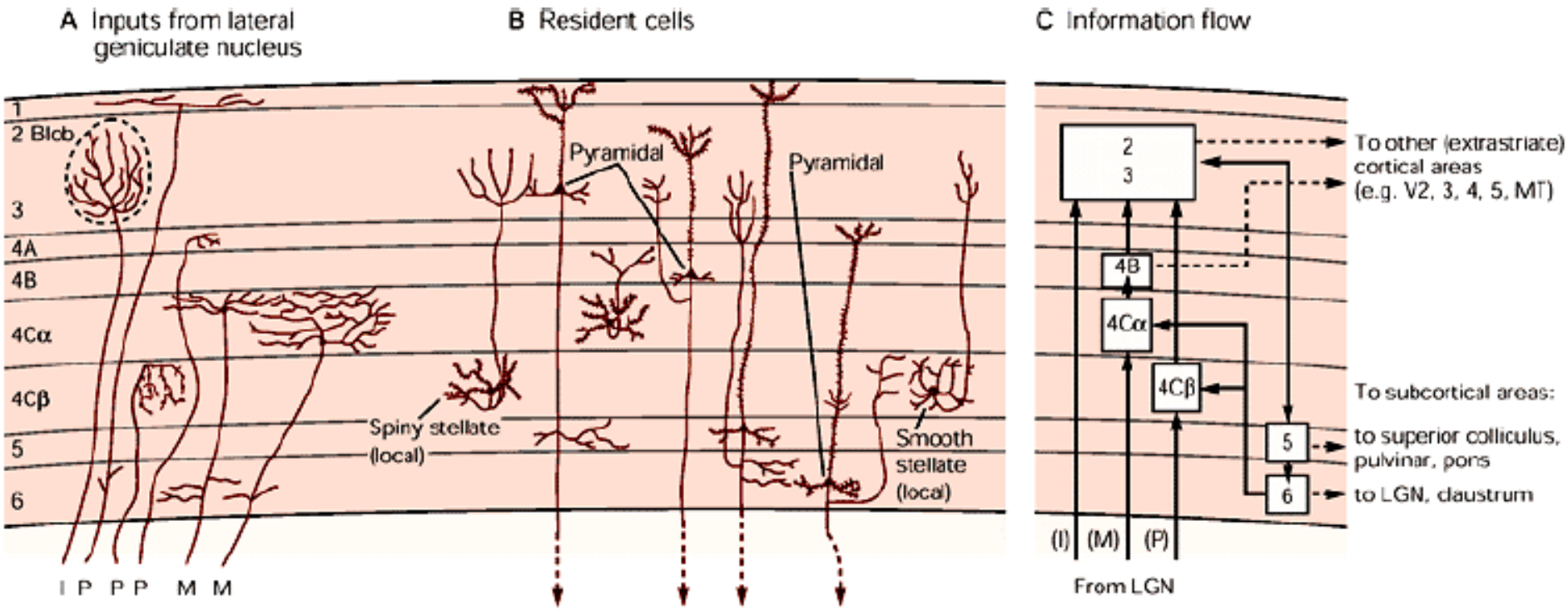
4) M channel → **Movement** information
→ **Luminance contrast** information
→ **Form** information (gross features)

5) LGN neurons have **circular receptive fields**
Center-ON and Center-OFF

6) Retinotopy

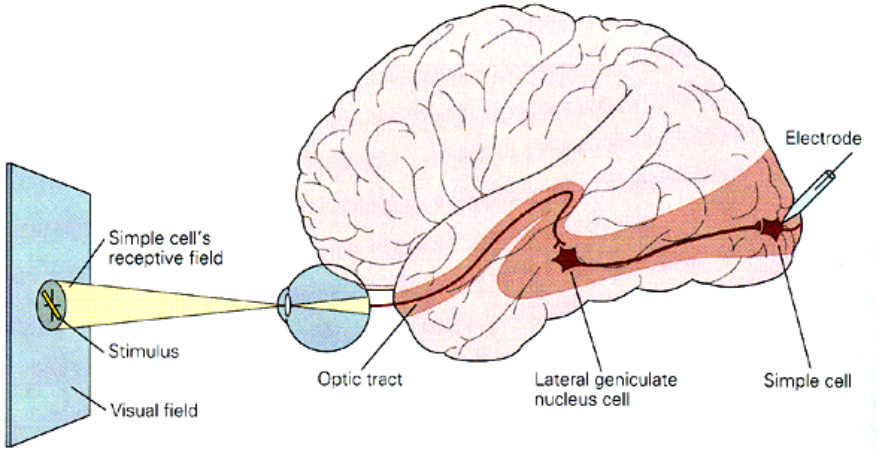
Cortical processing of visual information

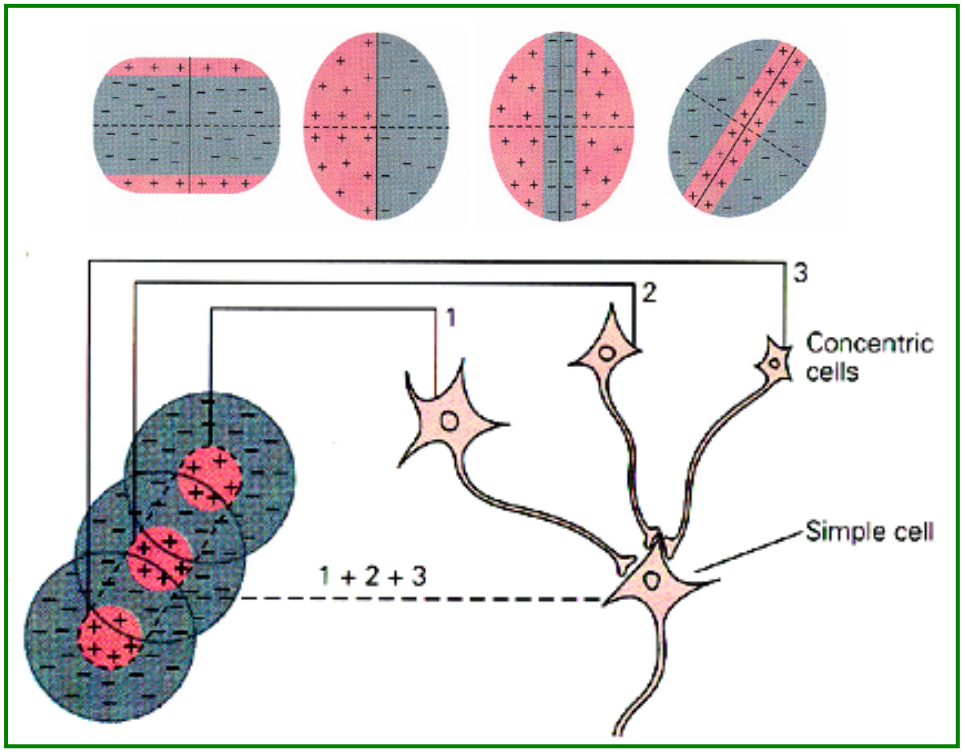
The primary visual cortex has distinct anatomical layers, each with characteristic synaptic connections



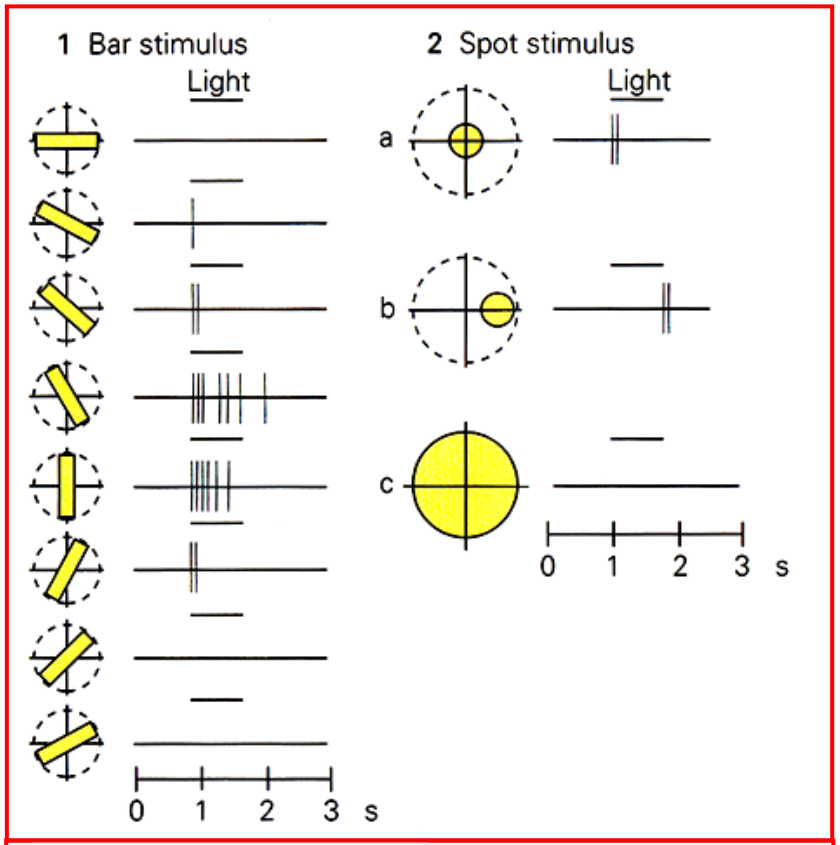
Central processing of visual information

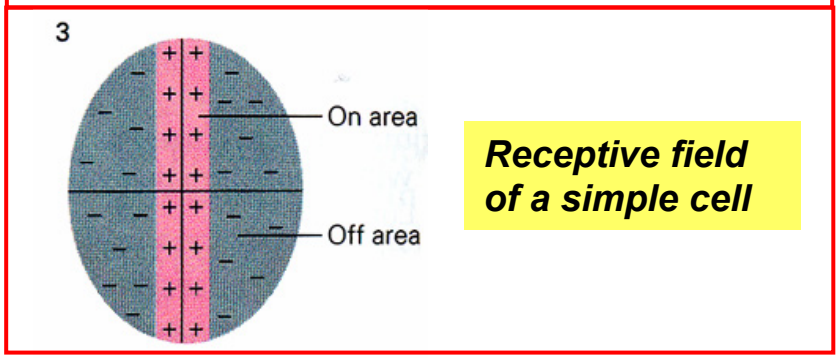
Functional organization of the Striate Cortex





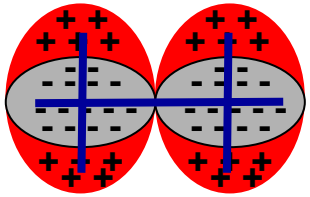
Receptive fields





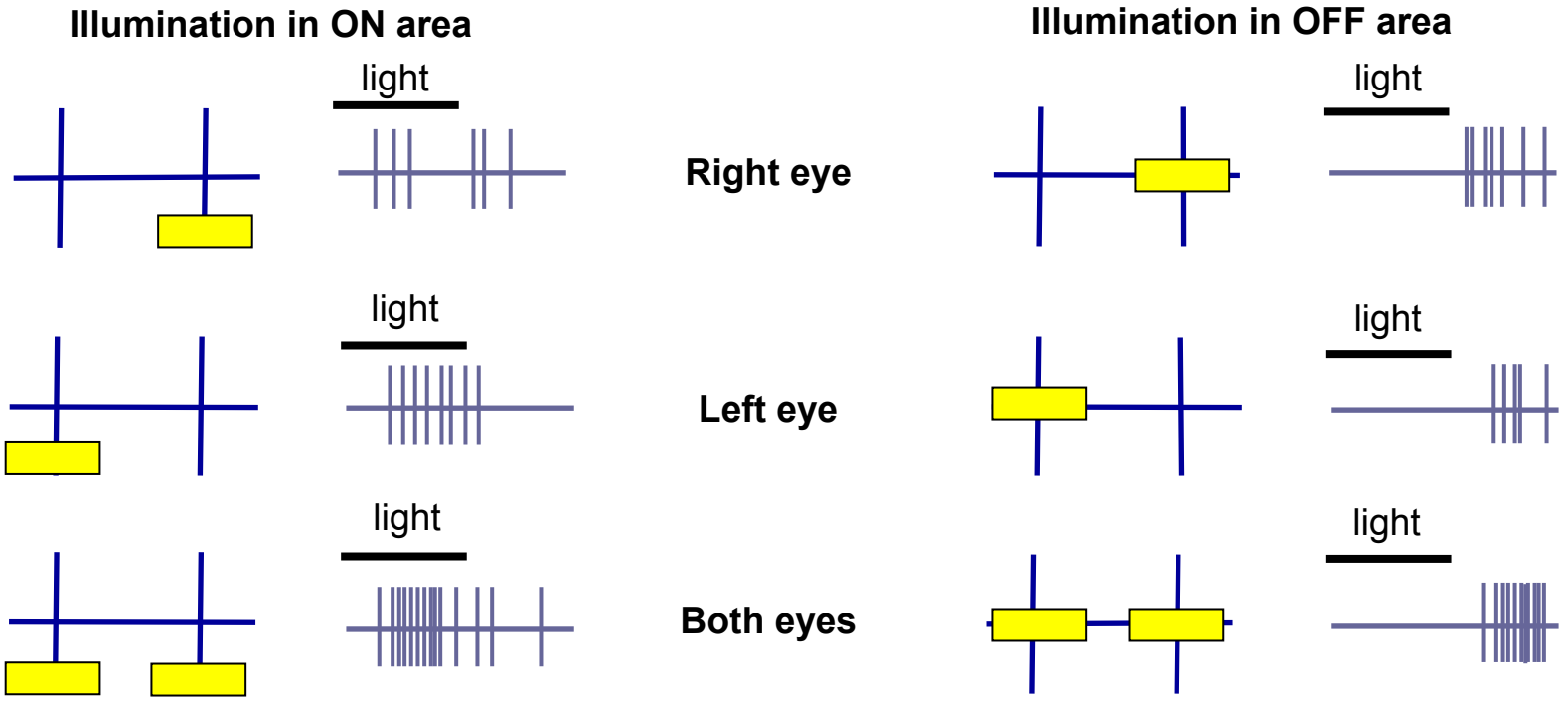
Receptive field of a simple cell

Functional organization of the Striate Cortex → Binocularity



Most cortical neurons have binocular receptive fields

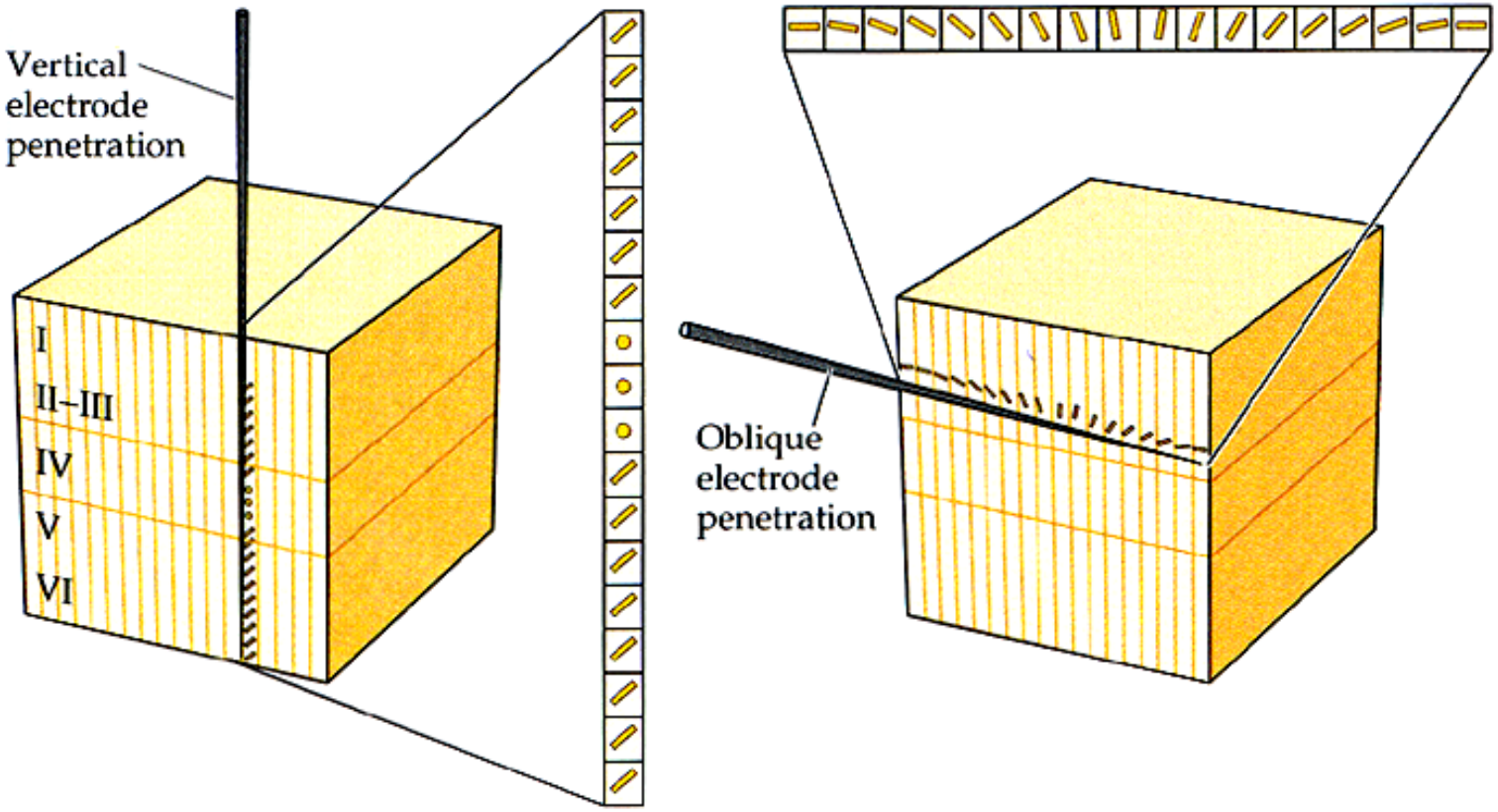
Binocular activation of a cortical neuron:



Functional organization of the Striate Cortex

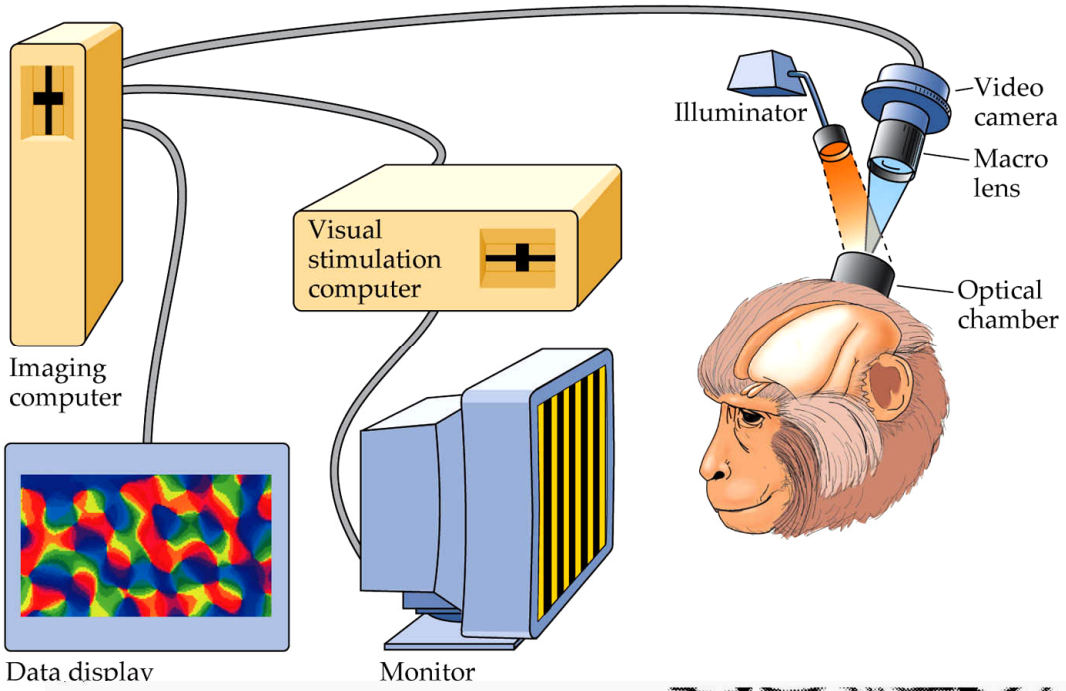
→ **Columnar organization:**

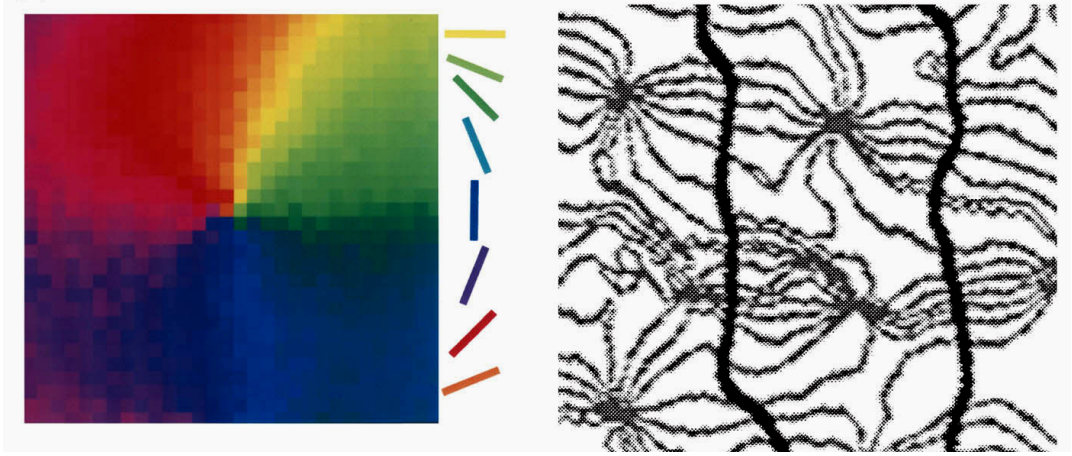
Orientation selectivity

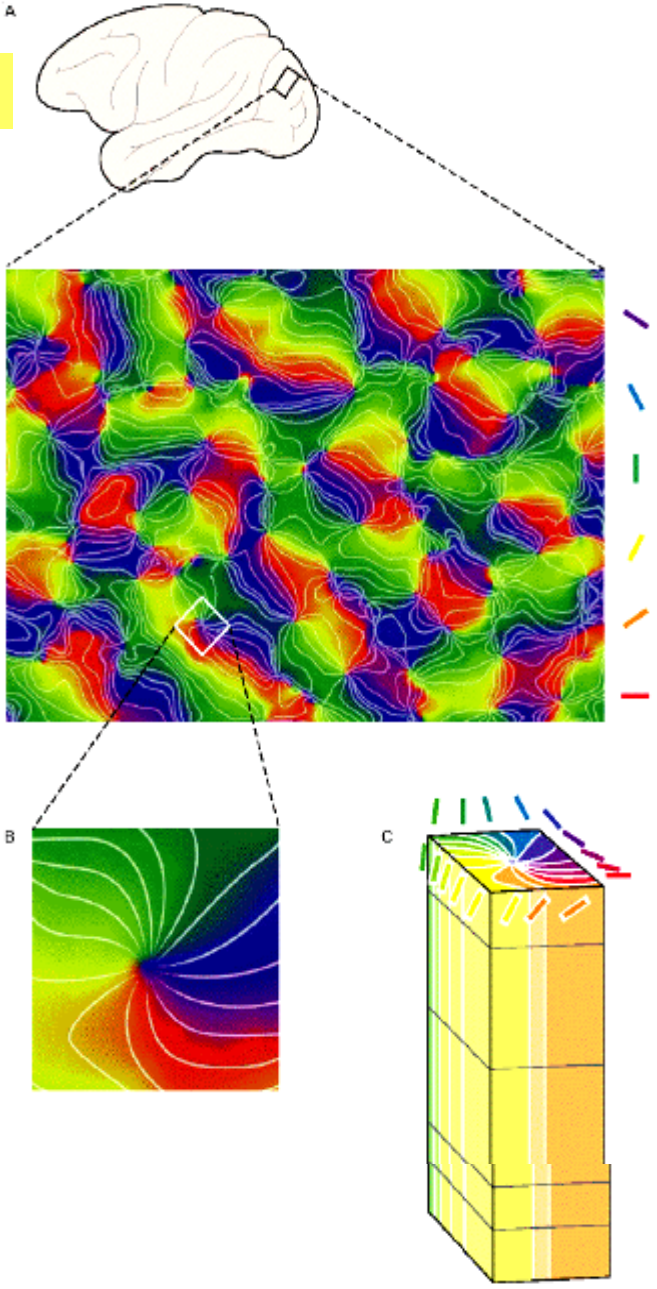


Cortical processing of visual information

Optical Imaging of Functional Domains in the Visual Cortex



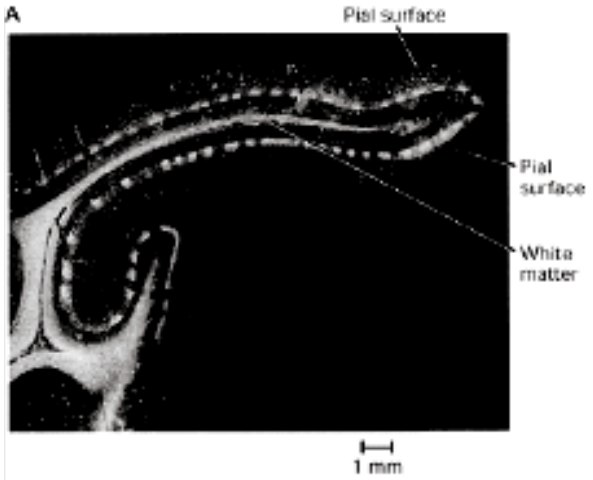


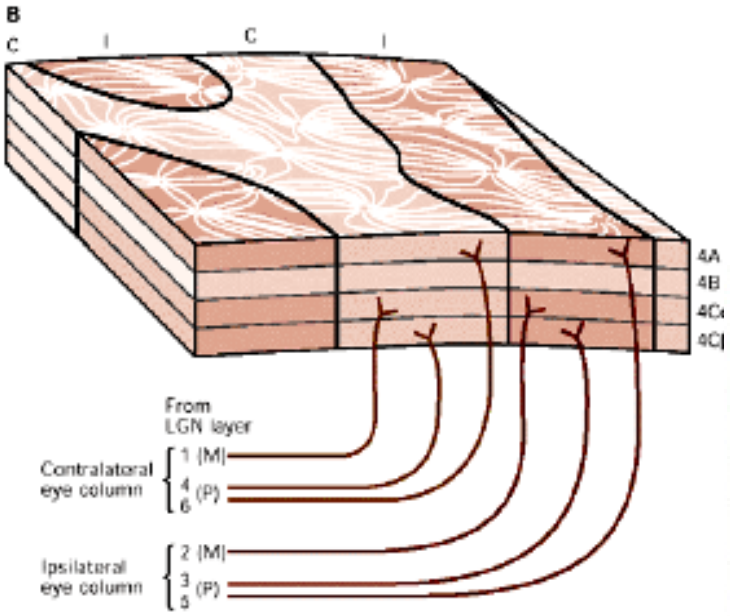


7.23

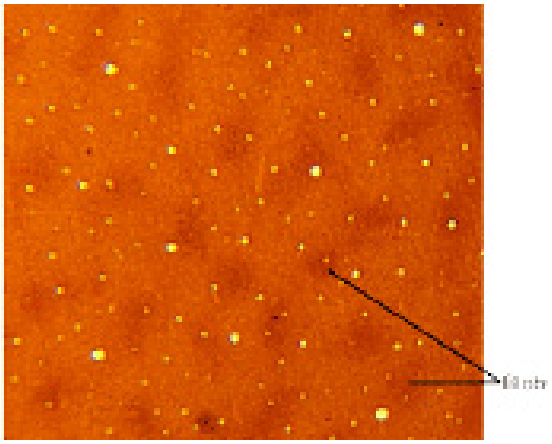
Cortical processing of visual information

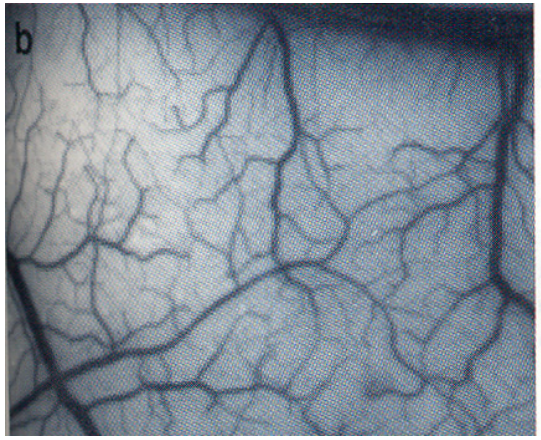
Binocular Domains in the Visual Cortex

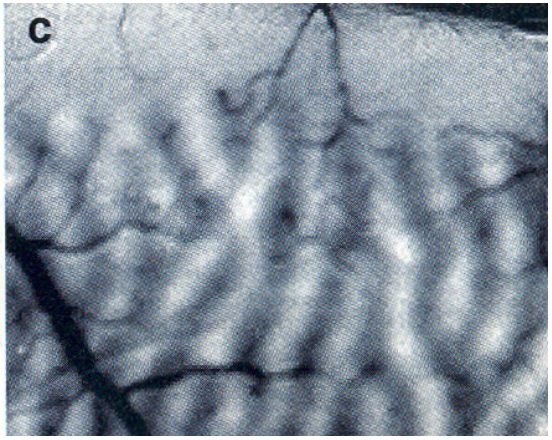


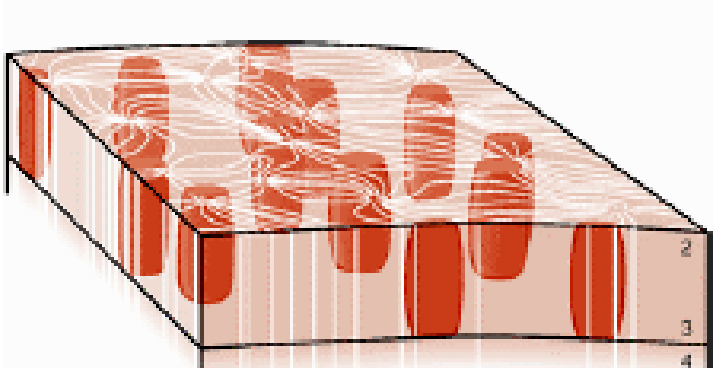


Color Domains (blobs) in the Visual Cortex

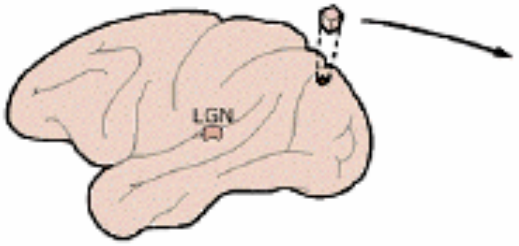




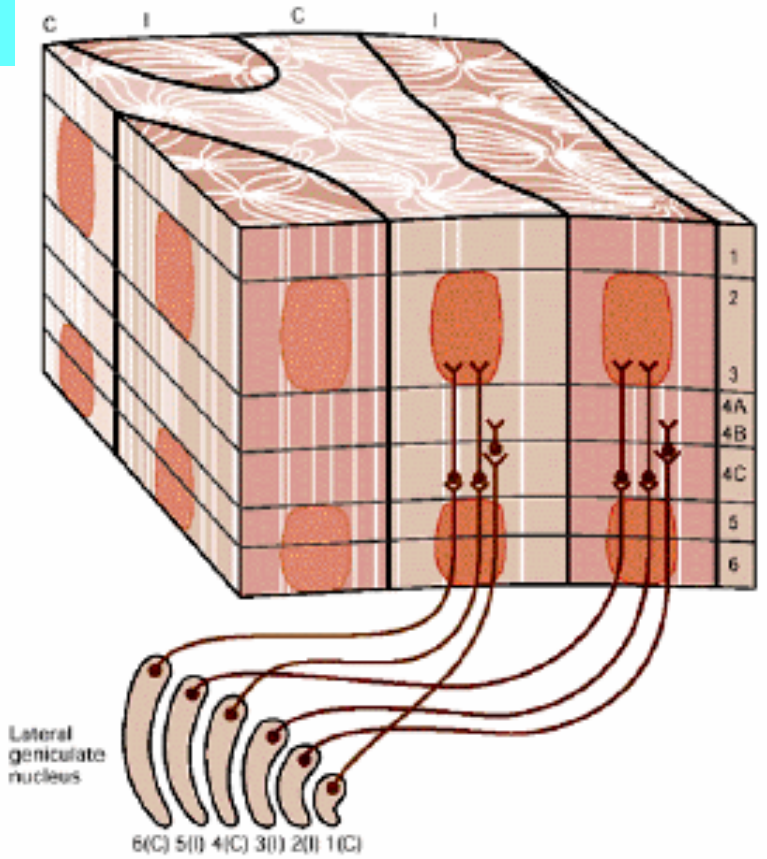


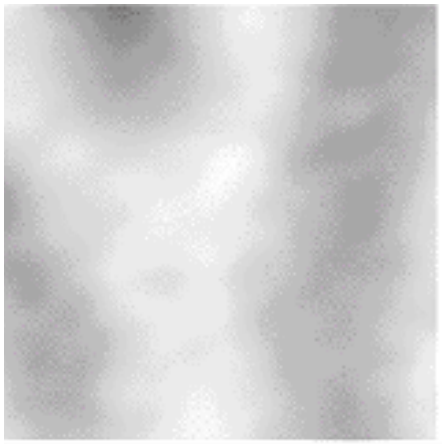


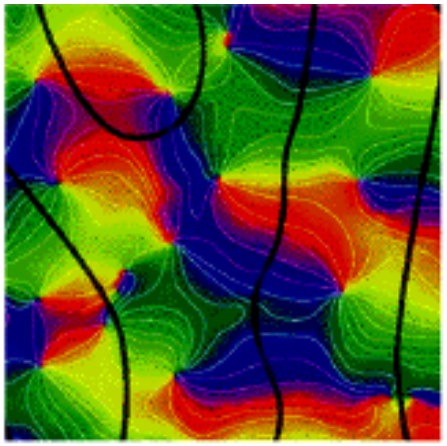
Cortical processing of visual information



Functional domains in the Visual Cortex: a summary





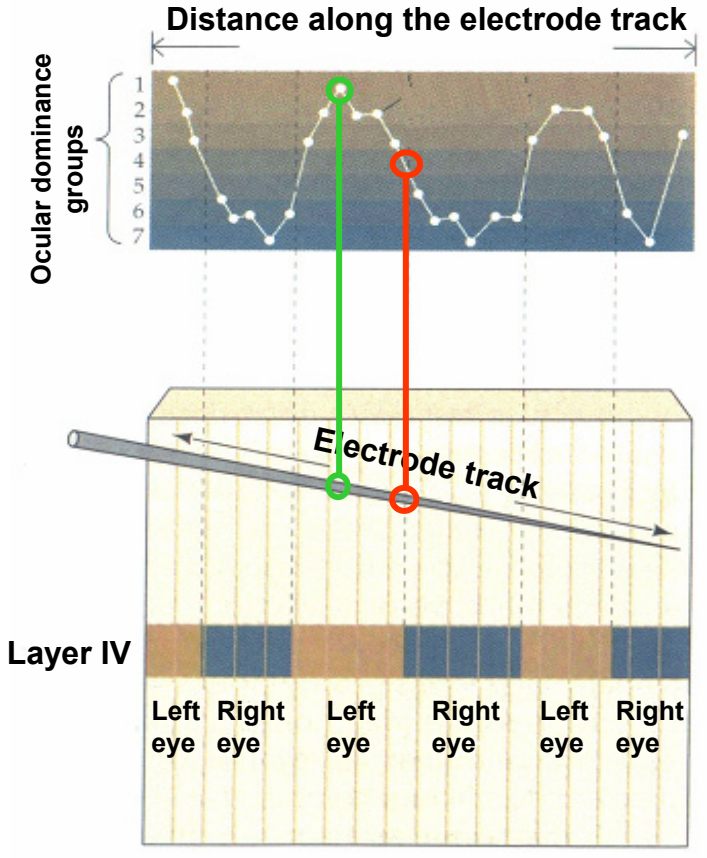


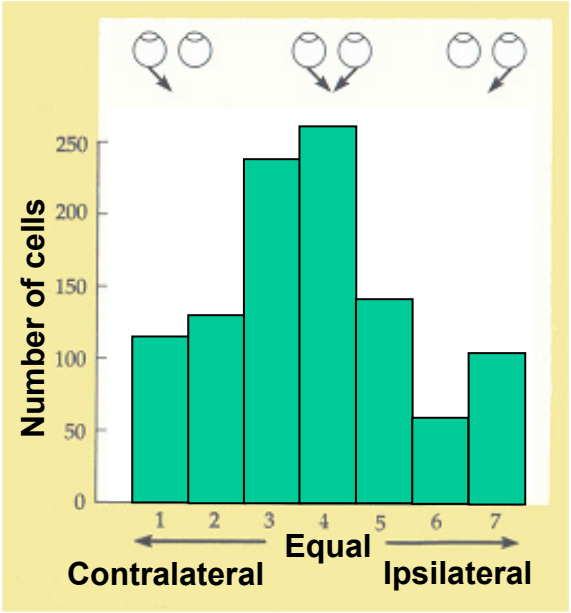
Central processing of visual information

Functional organization of the Striate Cortex

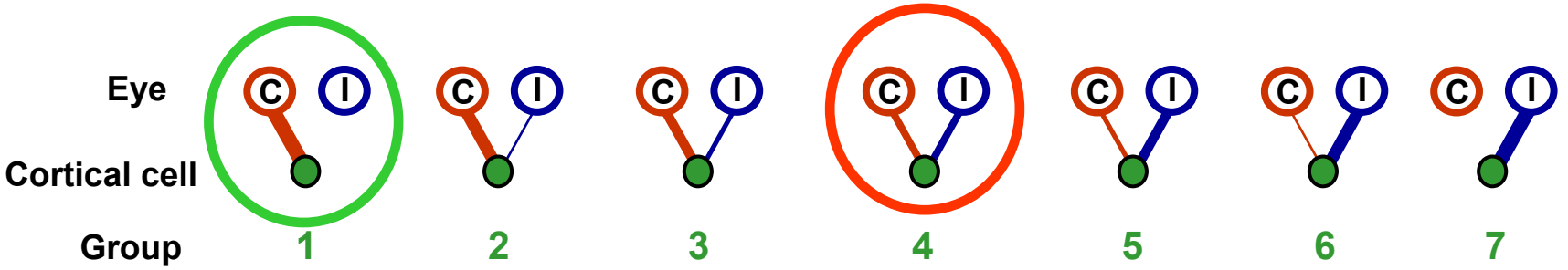
→ **Columnar organization:**

Ocular dominance columns



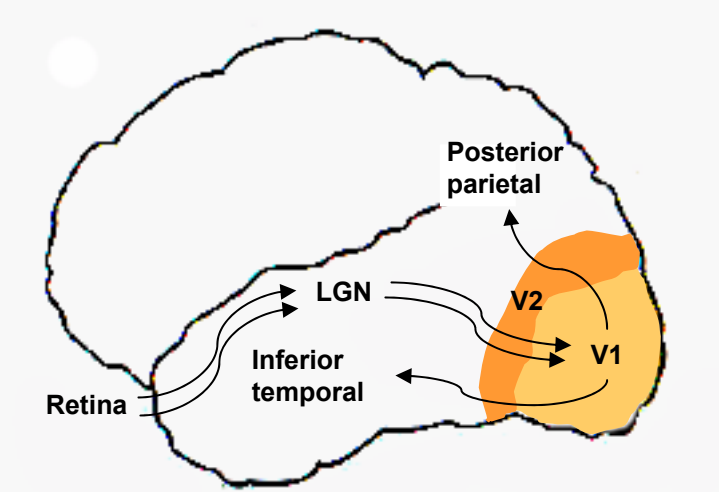


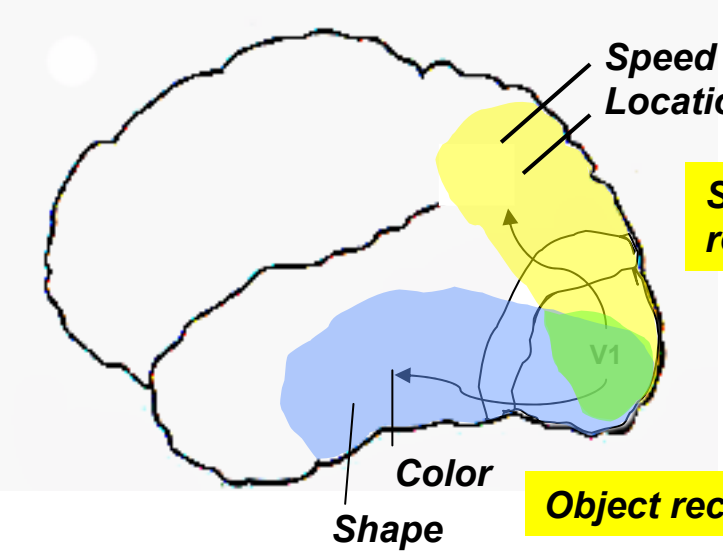
Ocular dominance groups



Central processing of visual information

Functional organization of the Striate Cortex





Spatial relationships

Object recognition

Properties:

1) Many striate cortex neurons are **binocular** (80%)
→ Sensation of **depth**.

2) Parallel pathways → Segregation of information about stimuli

3) Receptive field of cortex cells → more **complexity**

- Circular-antagonic
- Orientation selective: simple cells
  complex cells

4) Columnar organization

5) Retinotopia

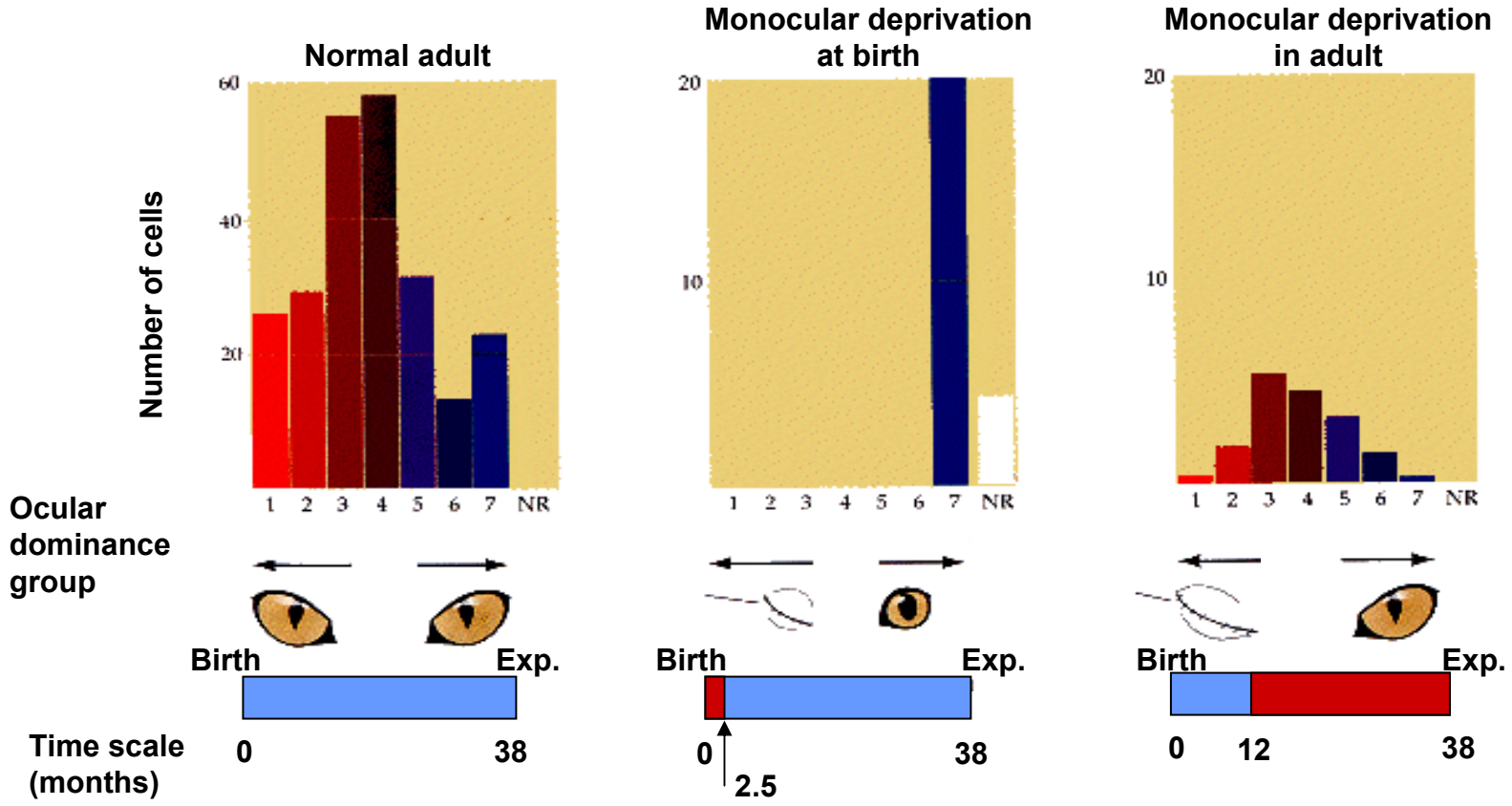
Embryonic and perinatal development of the visual system

Critical periods in Visual System development

1) Genetic factors → Structural organization

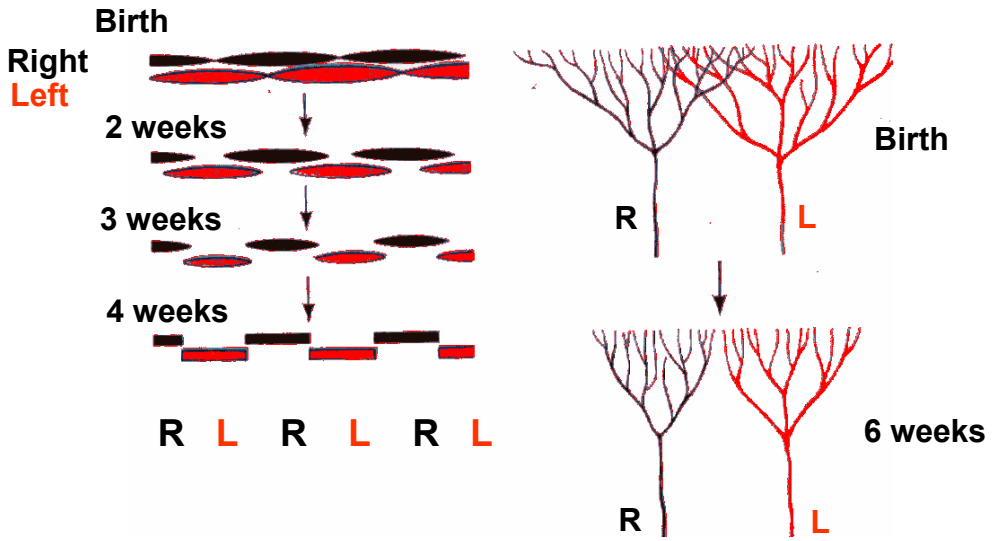
2) Environmental factors → Patterns of neural activity

→Development of the ocular dominance columns:
effects of sensory deprivation



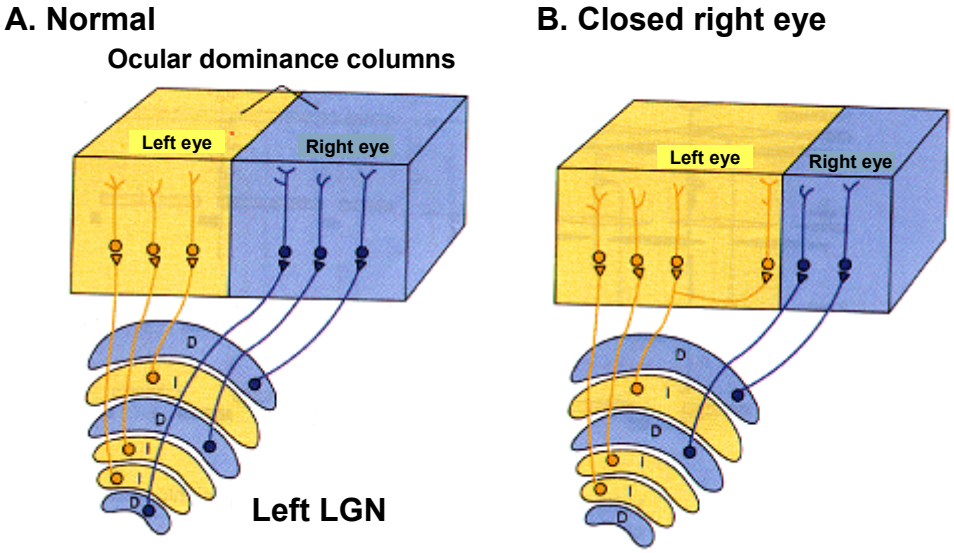
Embryonic and perinatal development of the visual system

Development of the ocular dominance columns



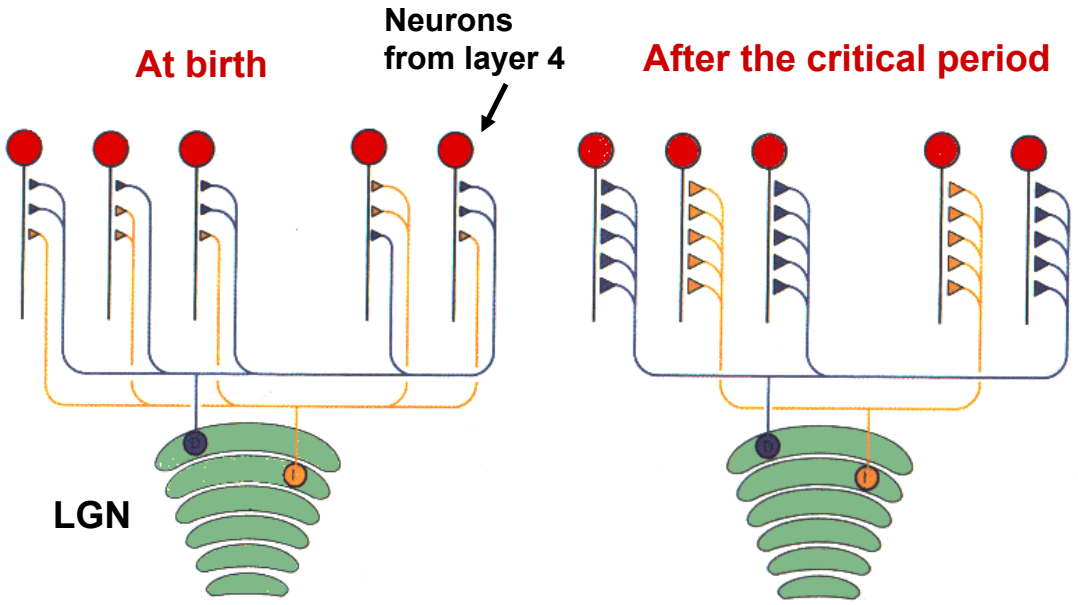
LGN axons branch at the layer 4 level in the cortex. Many branches retract during the first 6 weeks of life.

Effects of monocular deprivation:



Embryonic and perinatal development of the visual system

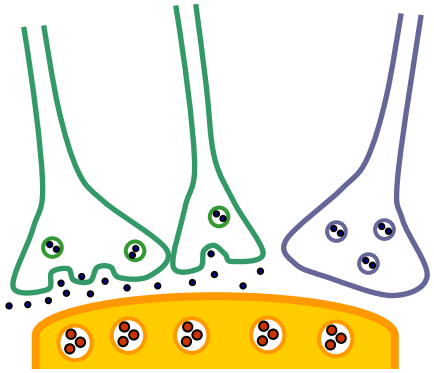
Mechanisms of the establishment and maintenance of cortical connections



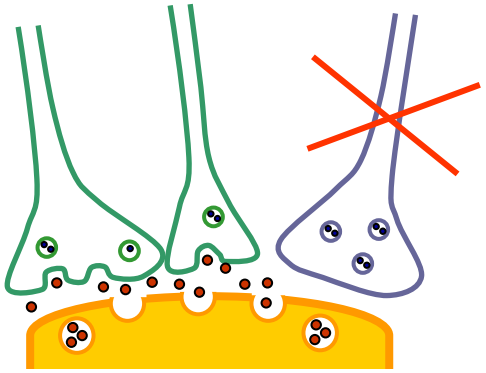
Both eyes <u>compete</u> to establish cortical connections.

The critical factor is an equilibrated <u>neural activity</u>.

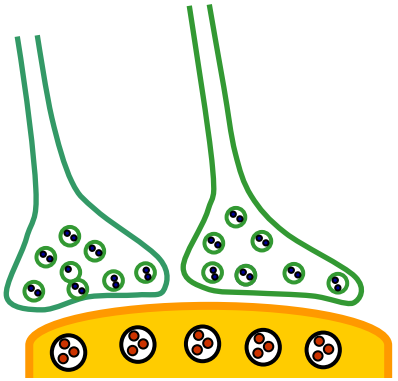
→ Mechanism of cooperation-competition:



The most numerous synaptic terminals depolarize the postsynaptic neuron.



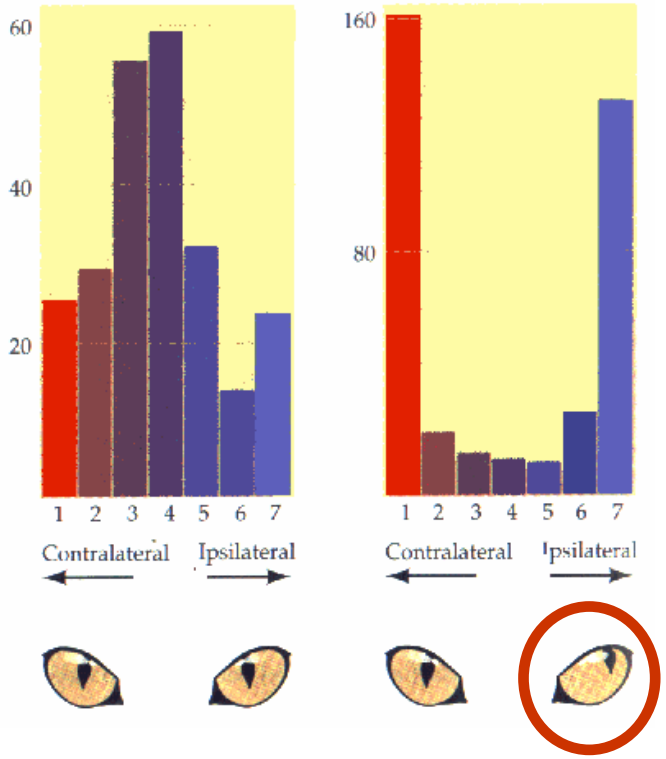
The postsynaptic cell releases trophic factors that are captured by the active terminals



Trophic factors stabilize the most numerous synaptic connections.

Developmental alterations in the visual system

The problem of incorrect alignment of the two eyes



Critical periods in the development of the human visual system