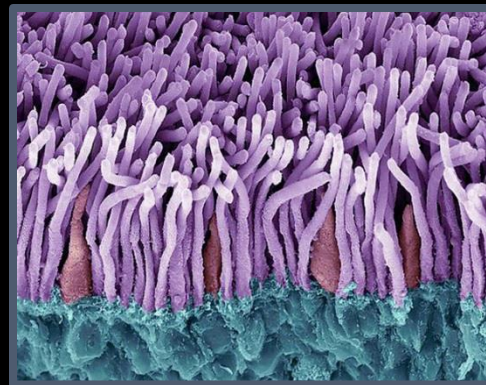


CS4495/6495

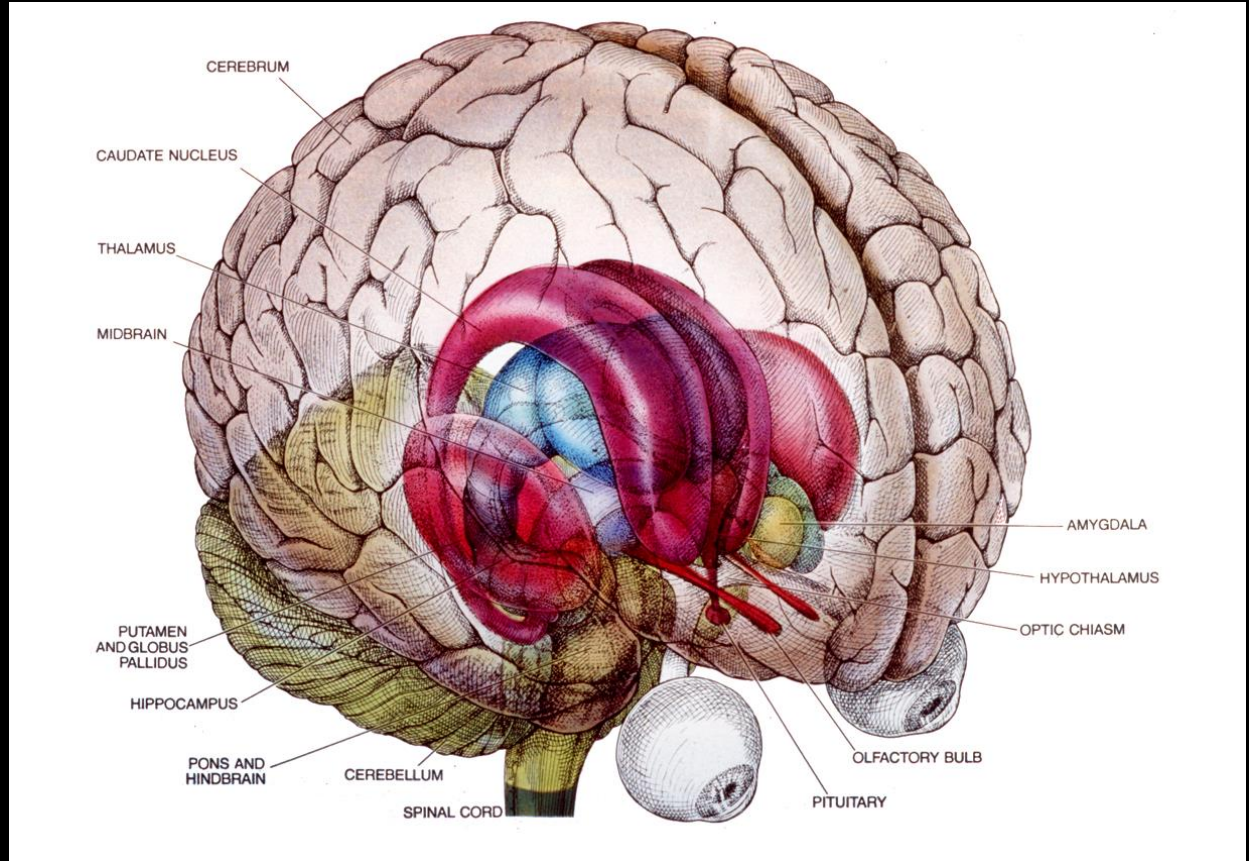
# Introduction to Computer Vision

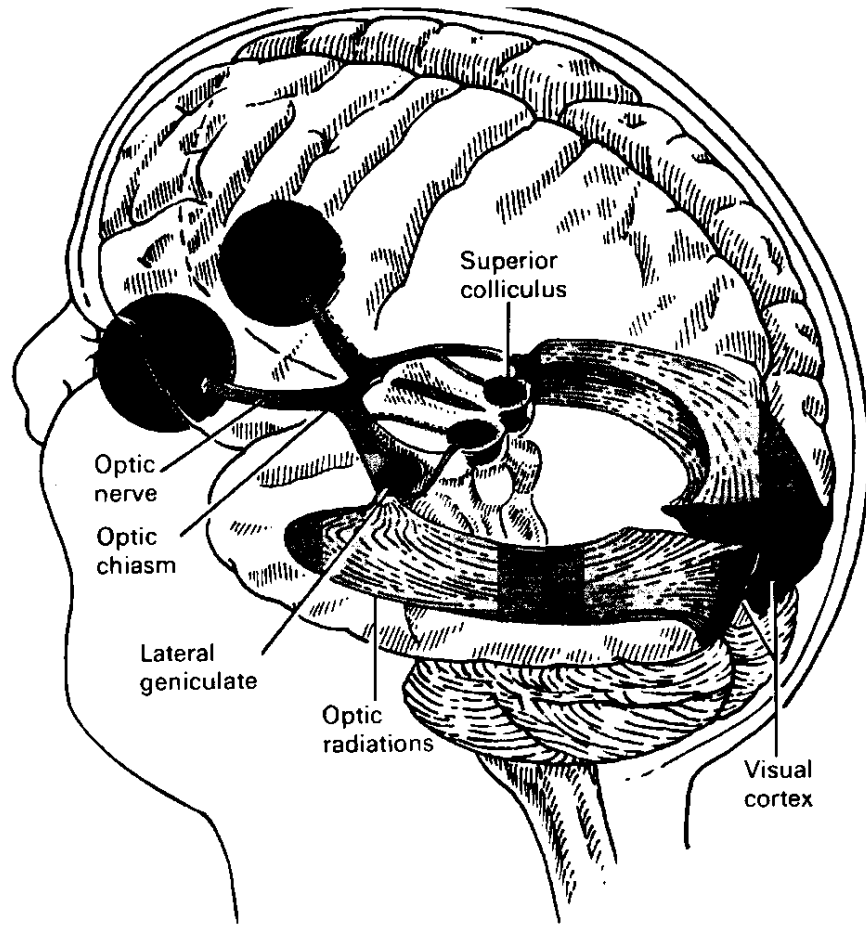
---

## 10A-L1 *The retina*



# The Human Brain: Overall View



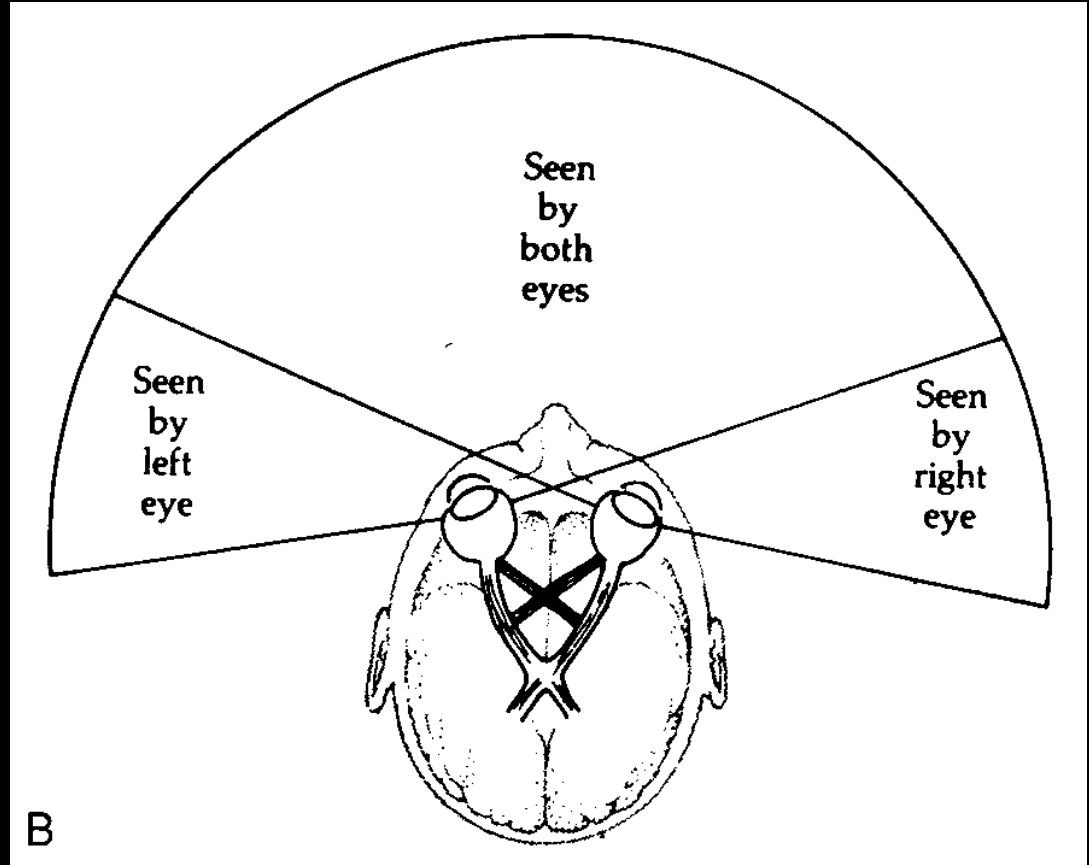


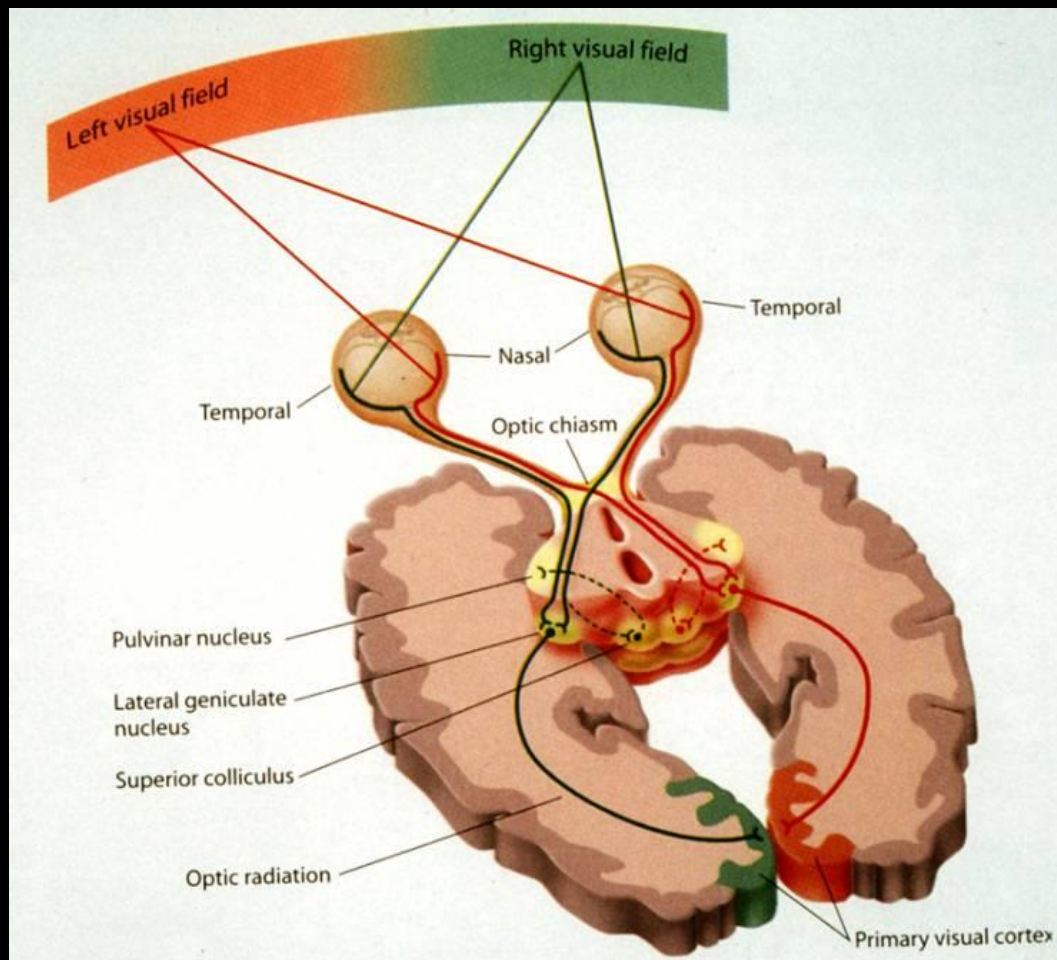
# Visual field

Monocular Visual Field:  
each eye  $160^{\circ}$  (h)

Binocular Visual Field:  
 $120^{\circ}$  (h)

Total Visual Field:  
 $200^{\circ}$  (h) x  $135^{\circ}$  (v)

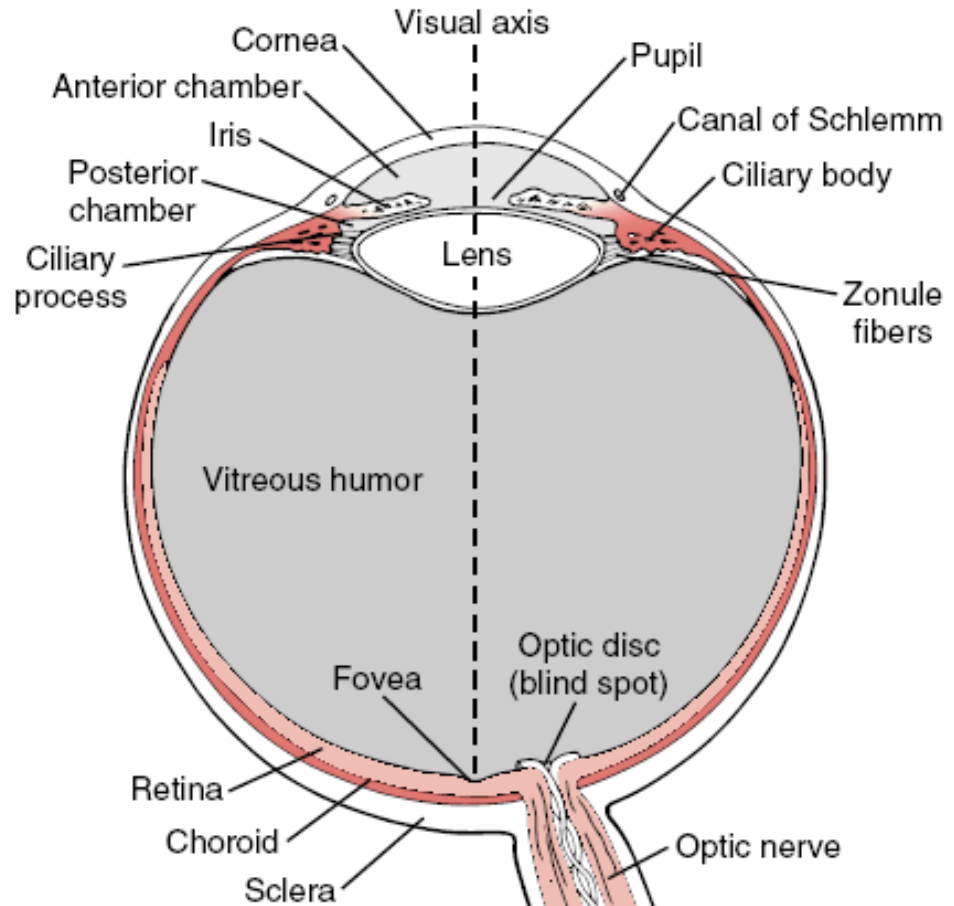




# Hemifield Neglect



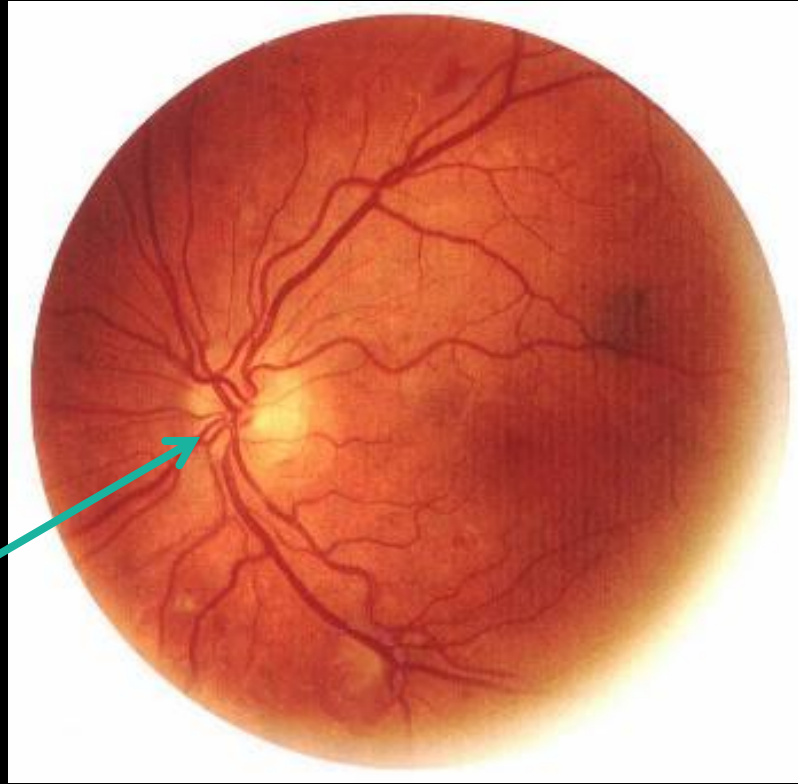
# The Human Eye





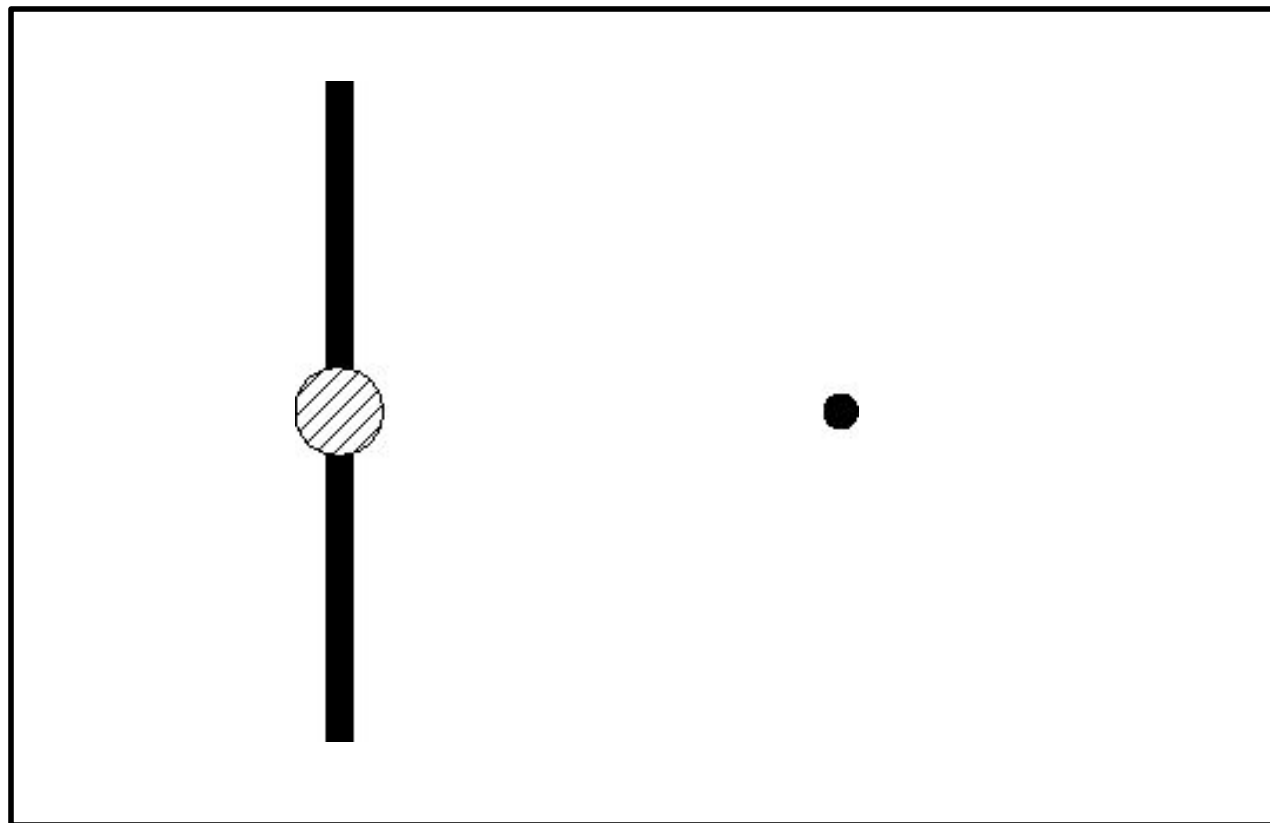
# What your doc sees

Blind spot





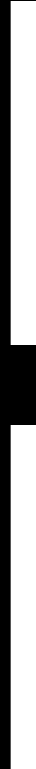




Look closely at the cross with right eye,  
slowly move your head back.

The line appears...

- ☐ Broken (as-is)
- ☐ Dashed
- ☐ Continuous
- ☐ It disappears!

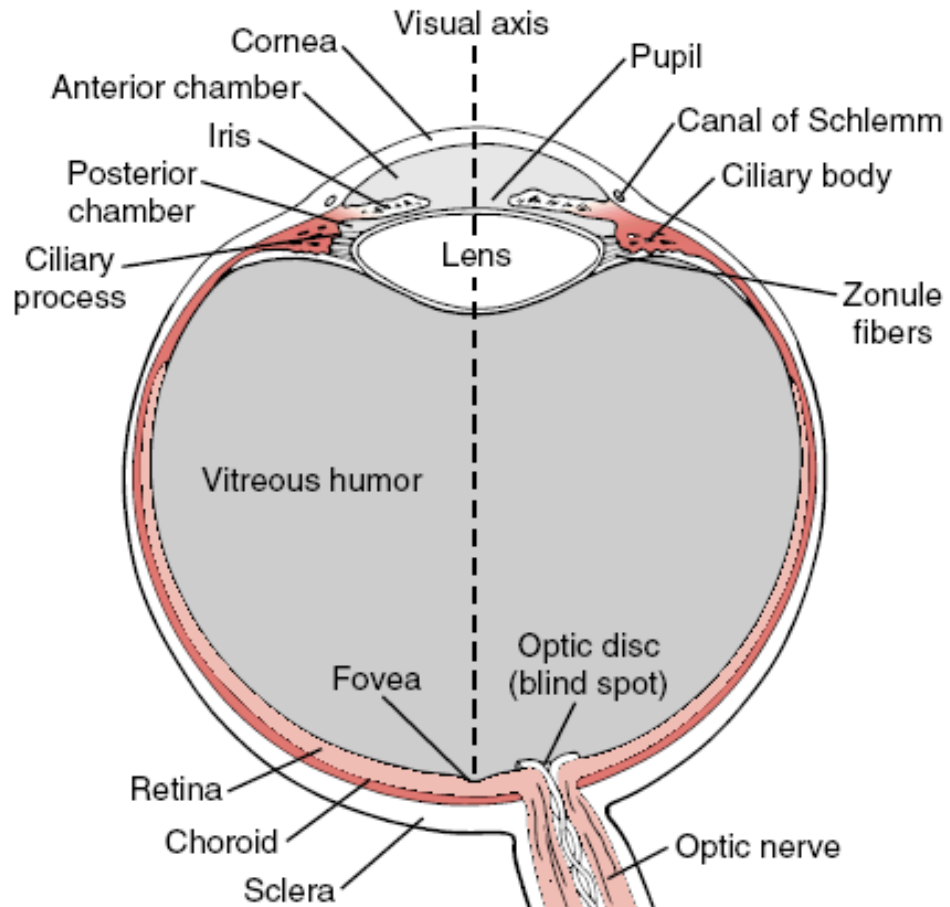


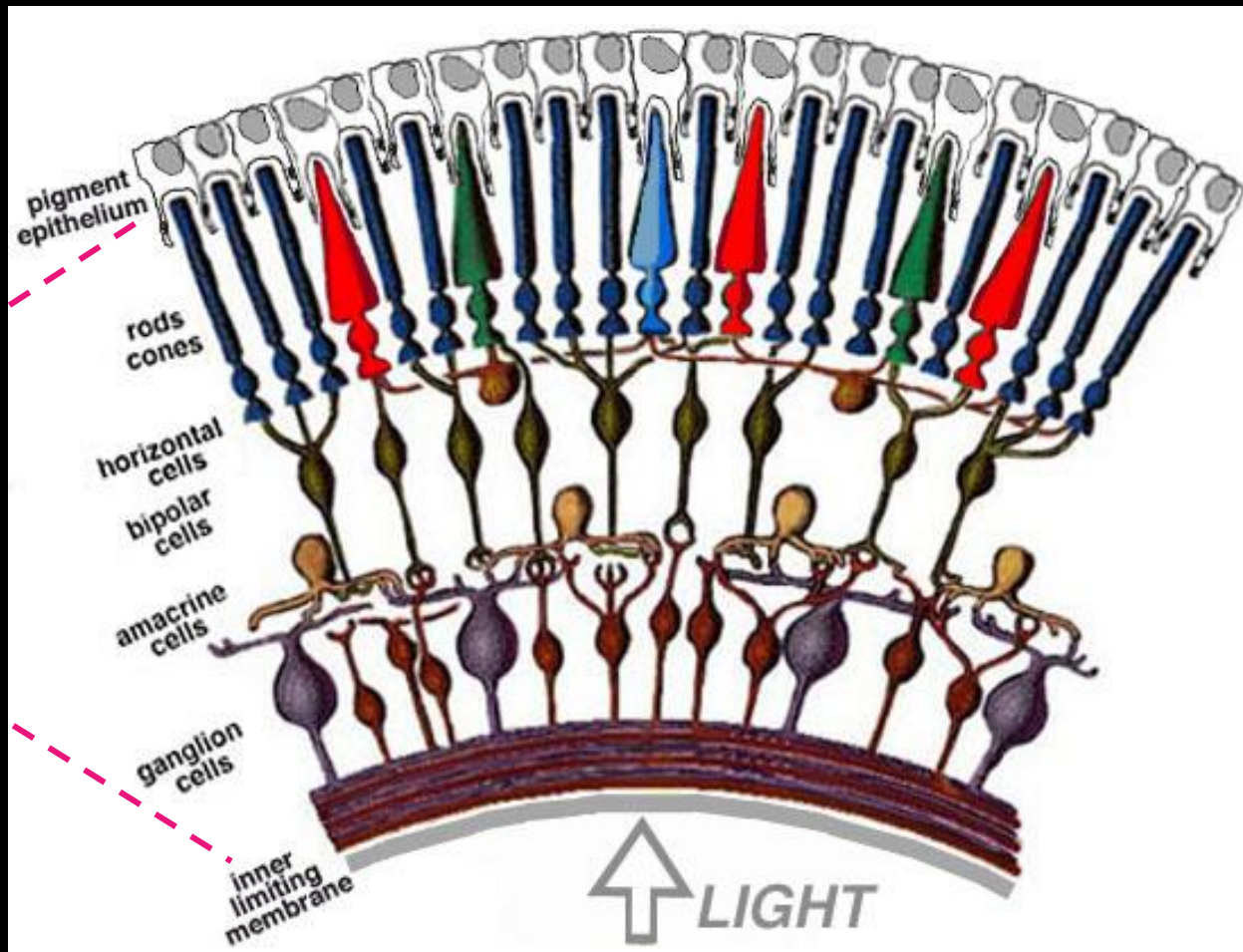
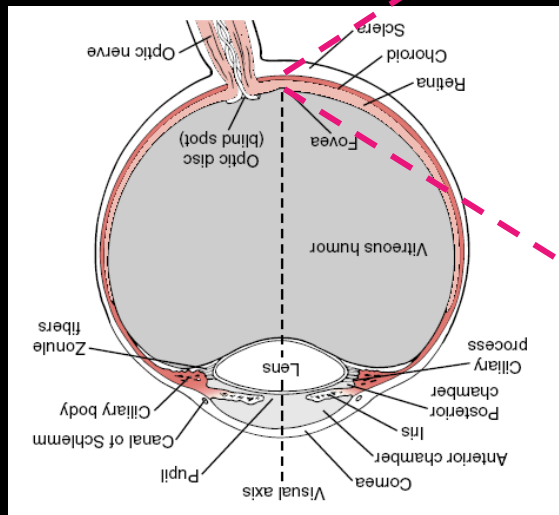
The line appears...

- ☐ Broken (as-is)
- ☐ Dashed
- ☒ Continuous
- ☐ It disappears!



## The Eye

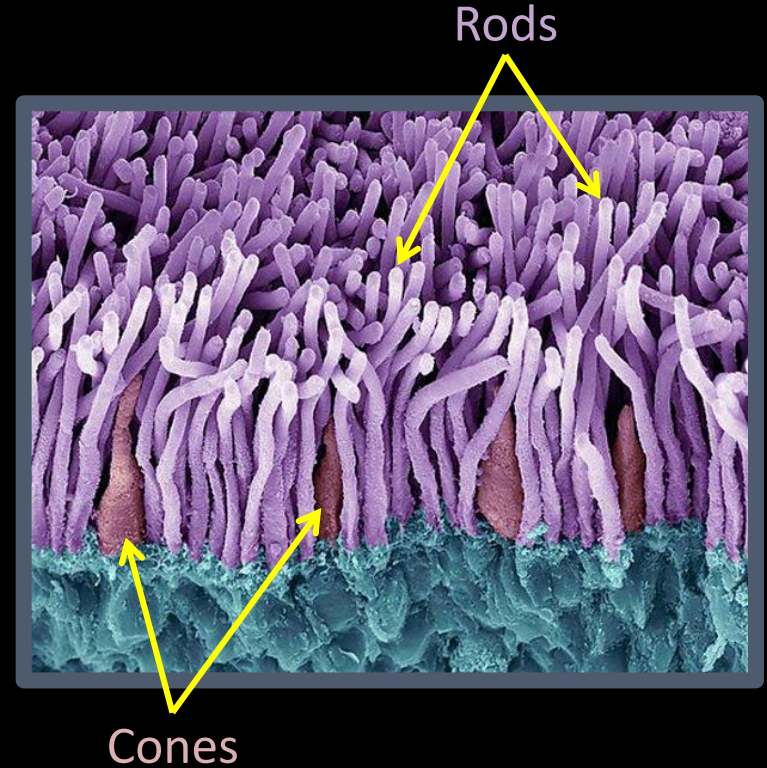




# Light Detection: Rods and Cones

## Rods:

- 120 million rods in the retina
- 1000X more sensitive than cones
- Discriminate between brightness levels, in low illumination
- Short-wavelength sensitive

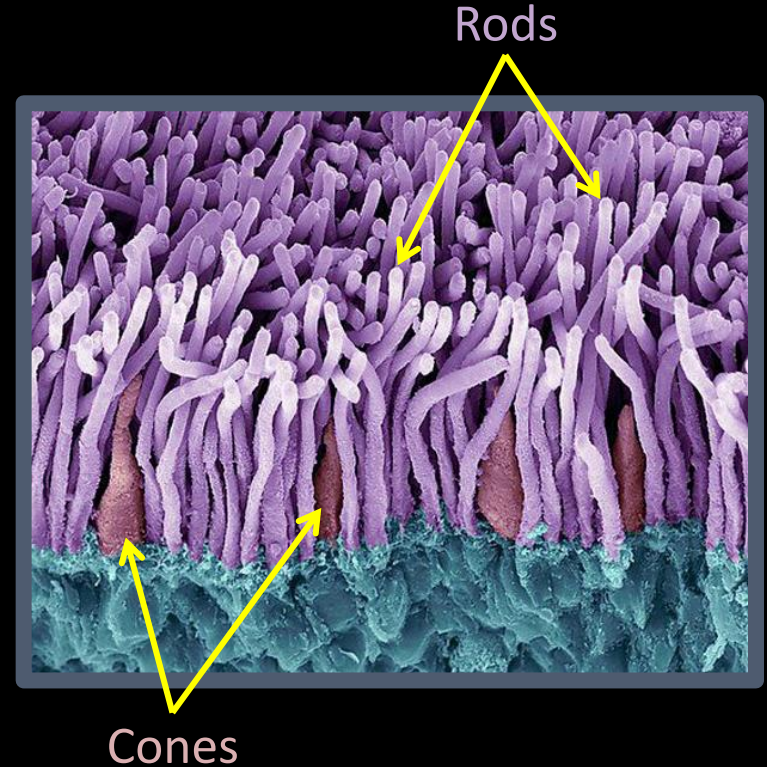




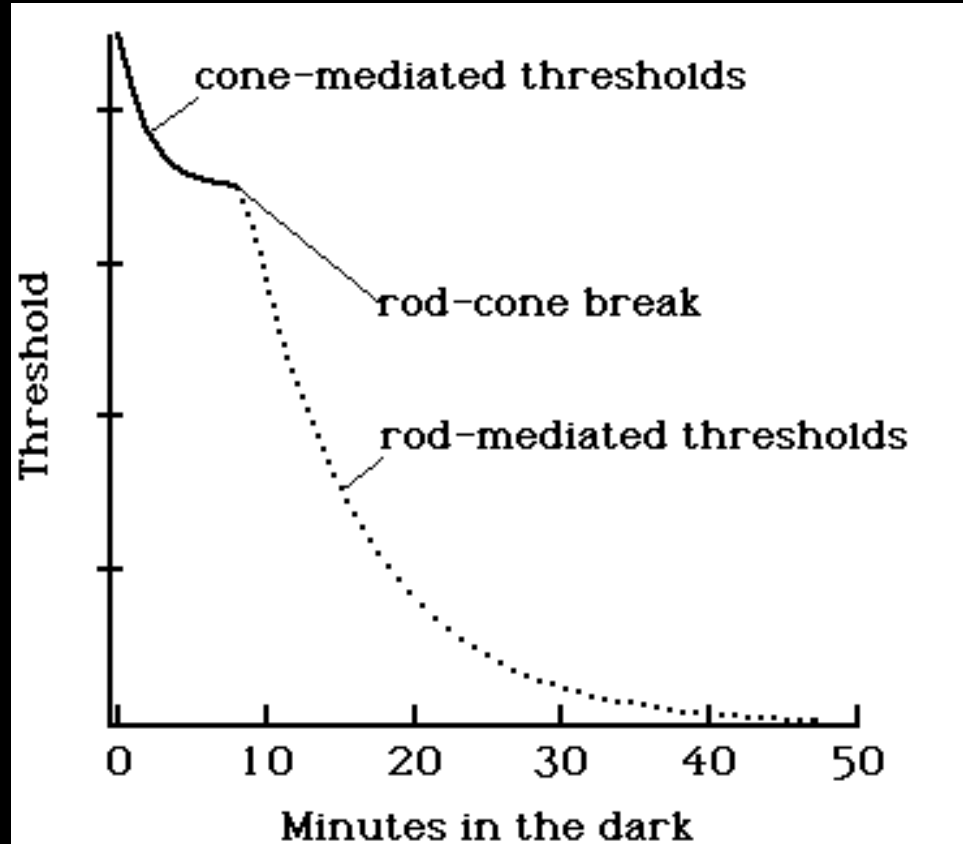
# Light Detection: Rods and Cones

## Cones:

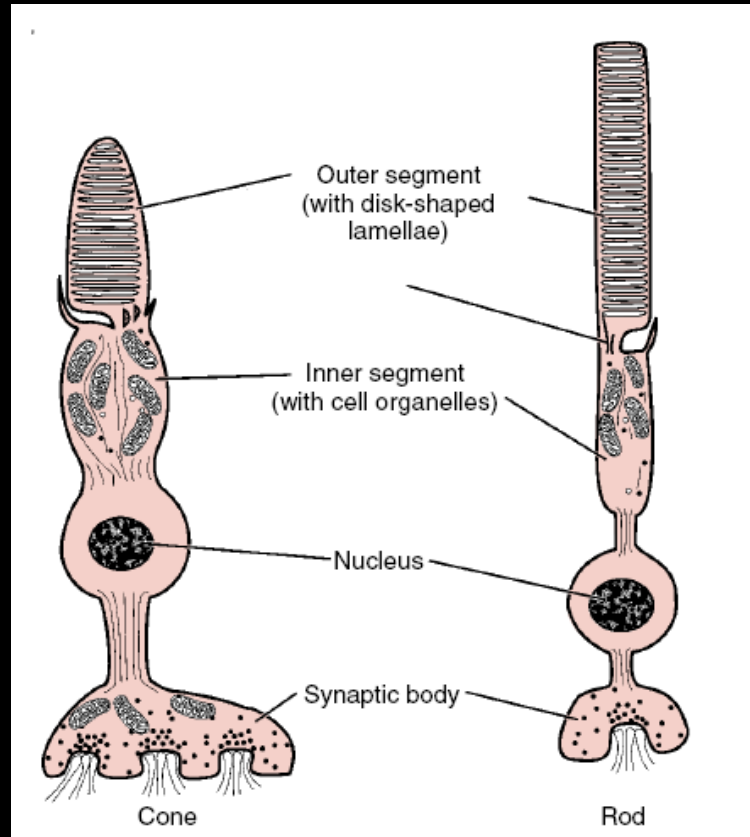
- 6-7 million cones in the retina
- Responsible for high-resolution vision
- Discriminate colors
- Three types of color sensors (64% red, 32% green, 2% blue)
- Sensitive to any combination of the three



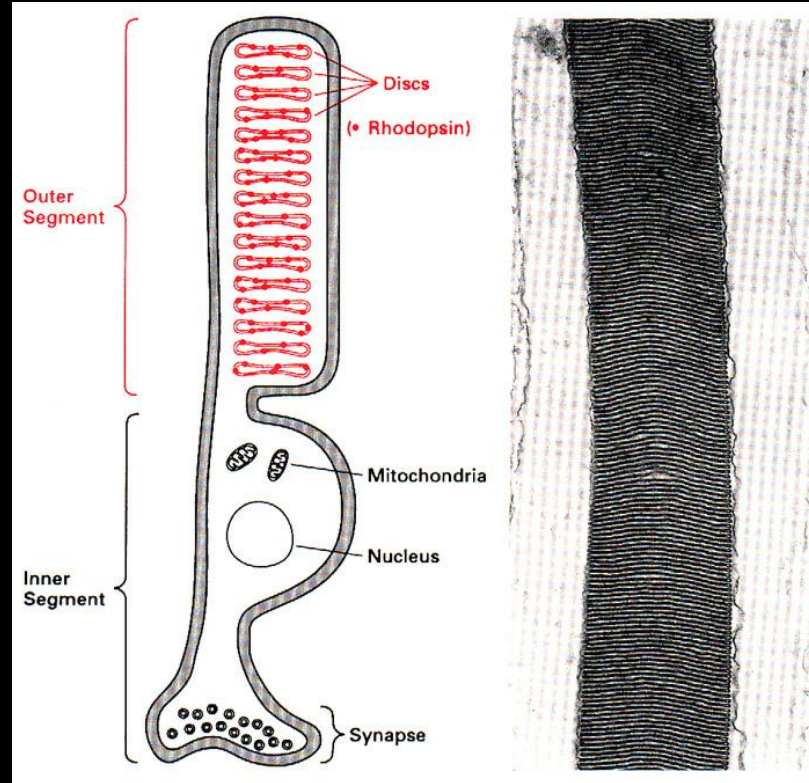
# Rods and Cones: Sensitivity

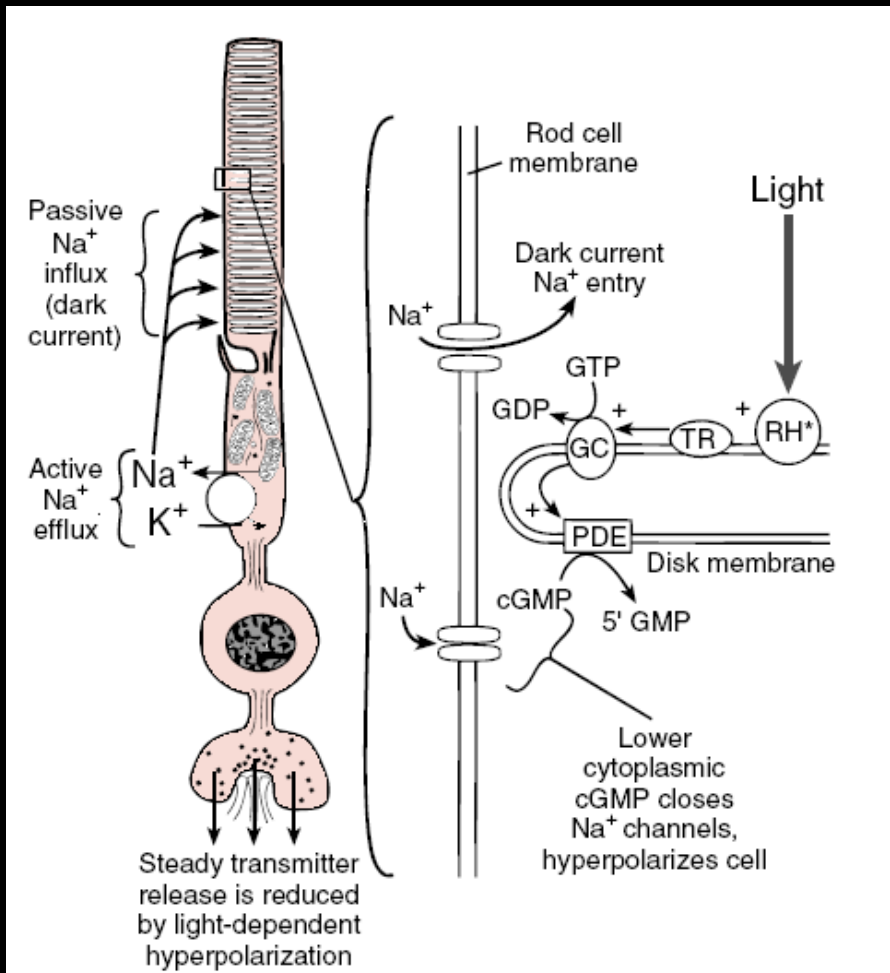


# Rods and Cones

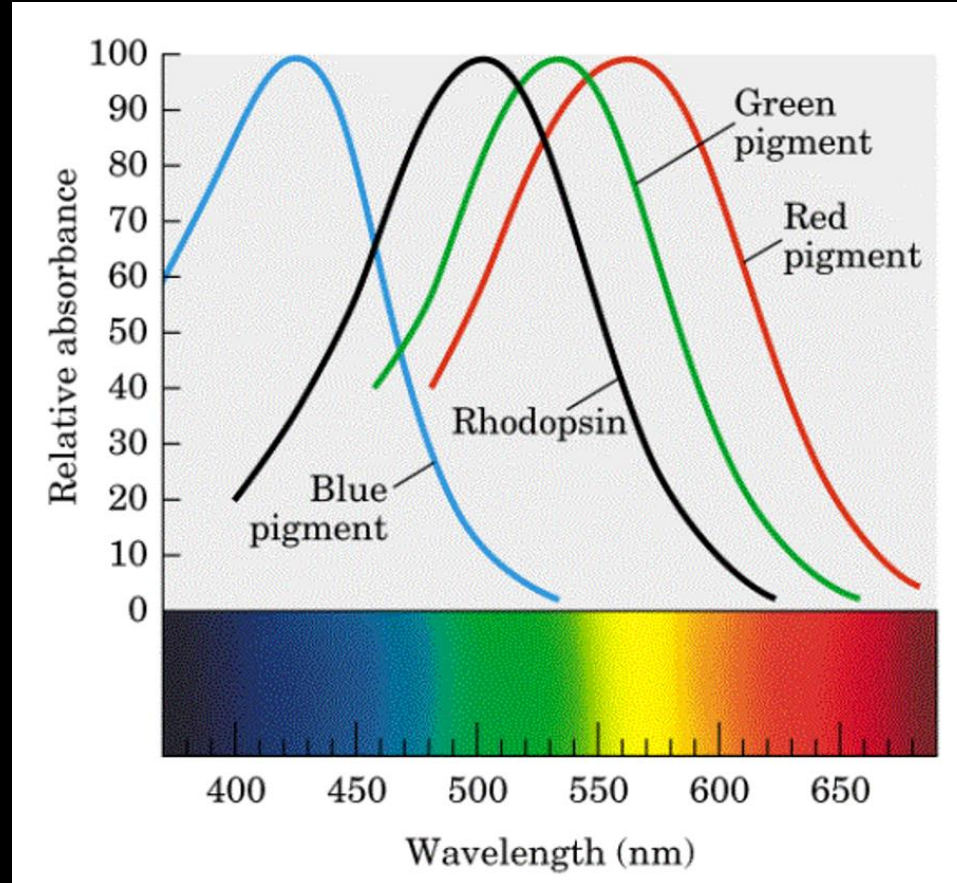


# Photoreceptors



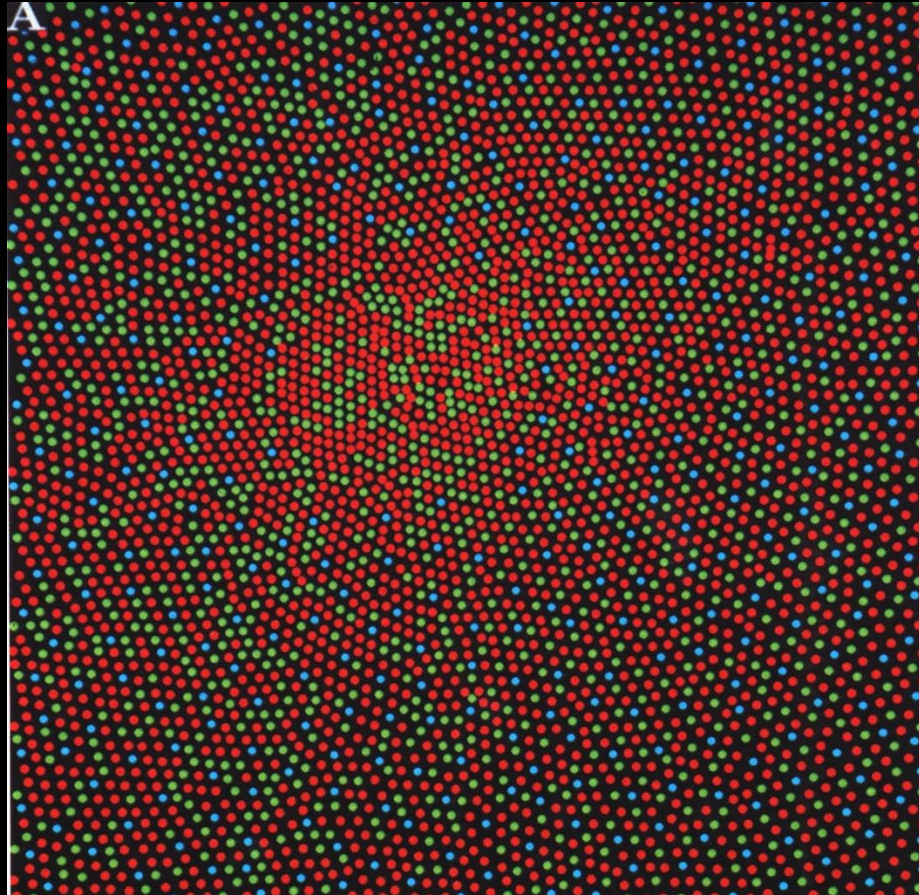


# Receptor responses





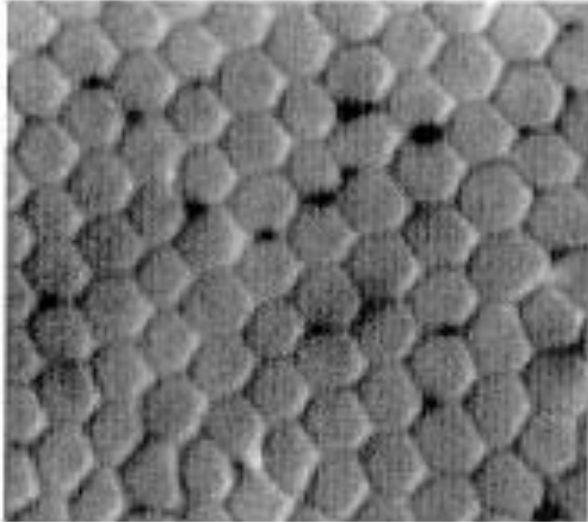
# Retina Mosaic



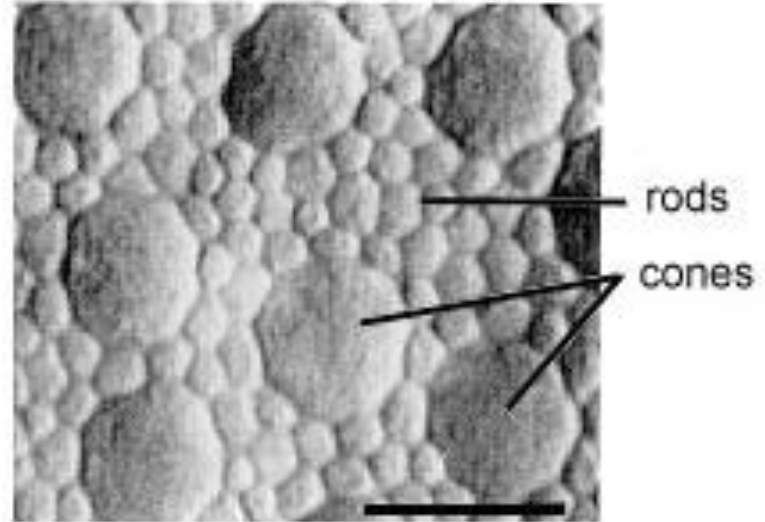


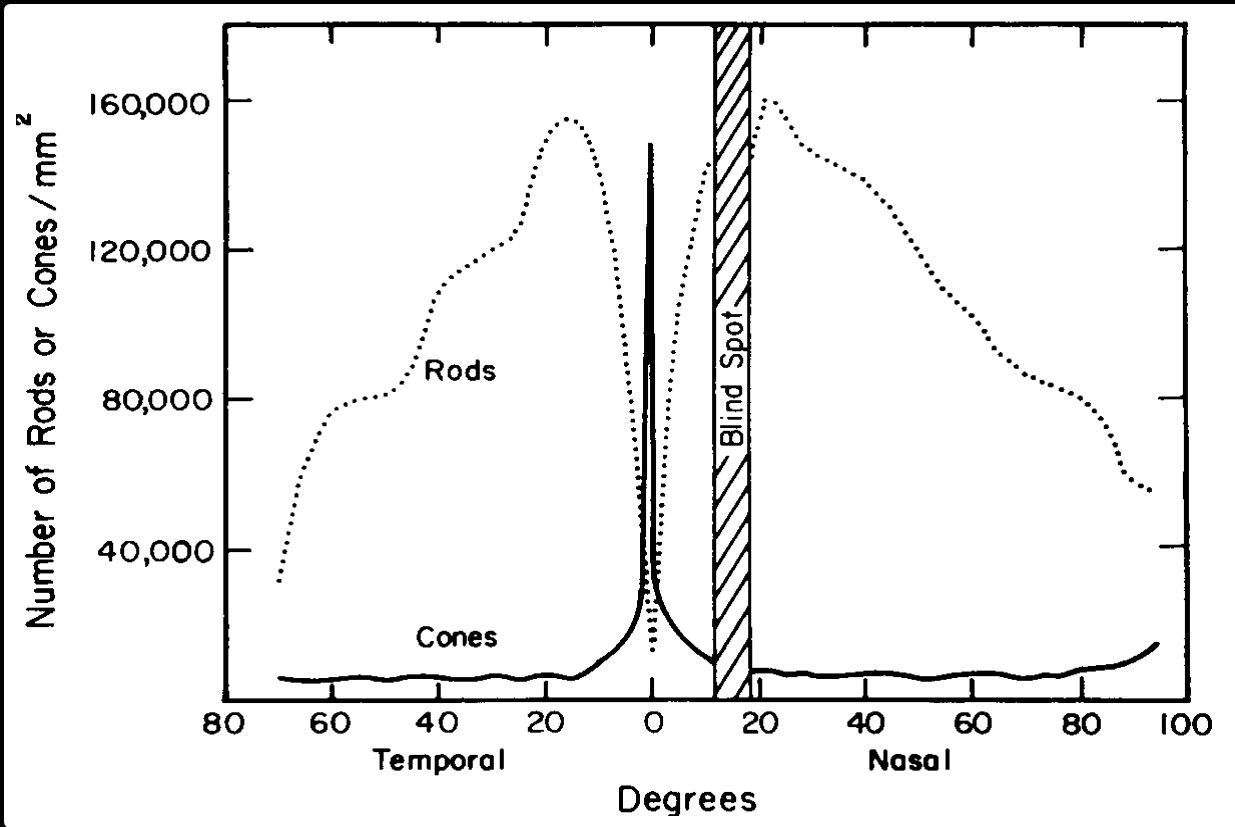
# Photoreceptors

Fovea

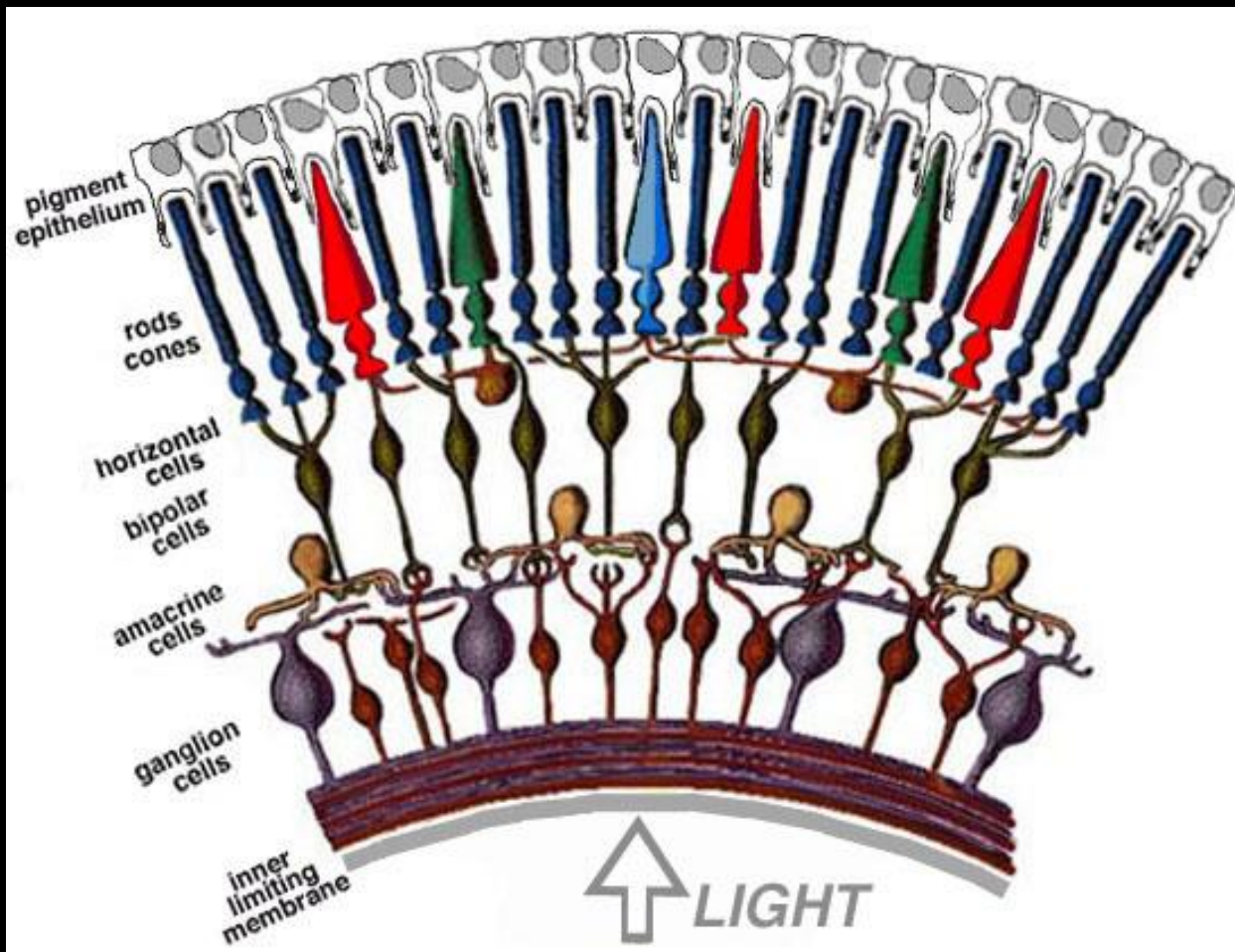


Periphery





Microscopic view of the retina



# Image Capture

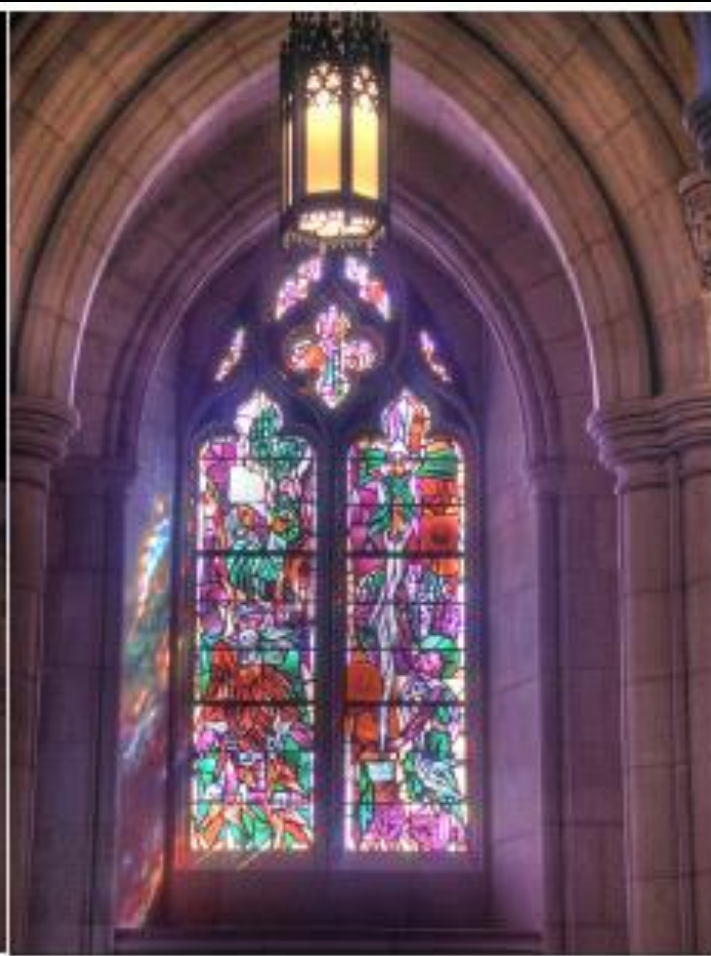
- Huge dynamic range:
  - Overall :  $10^{-6} - 10^{+8}$  cd/m<sup>2</sup> (*candelas*)
  - Static: at least 100:1 probably more
  - A given scene in the real world: 100,00:1
- Everyone knows about the pupil, but it's actually the retina's ganglion cells that make this work.



Figure 1: A series of five photographs. The exposure is increasing from left ( $1/1000$  of a second) to right ( $1/4$  of a second).

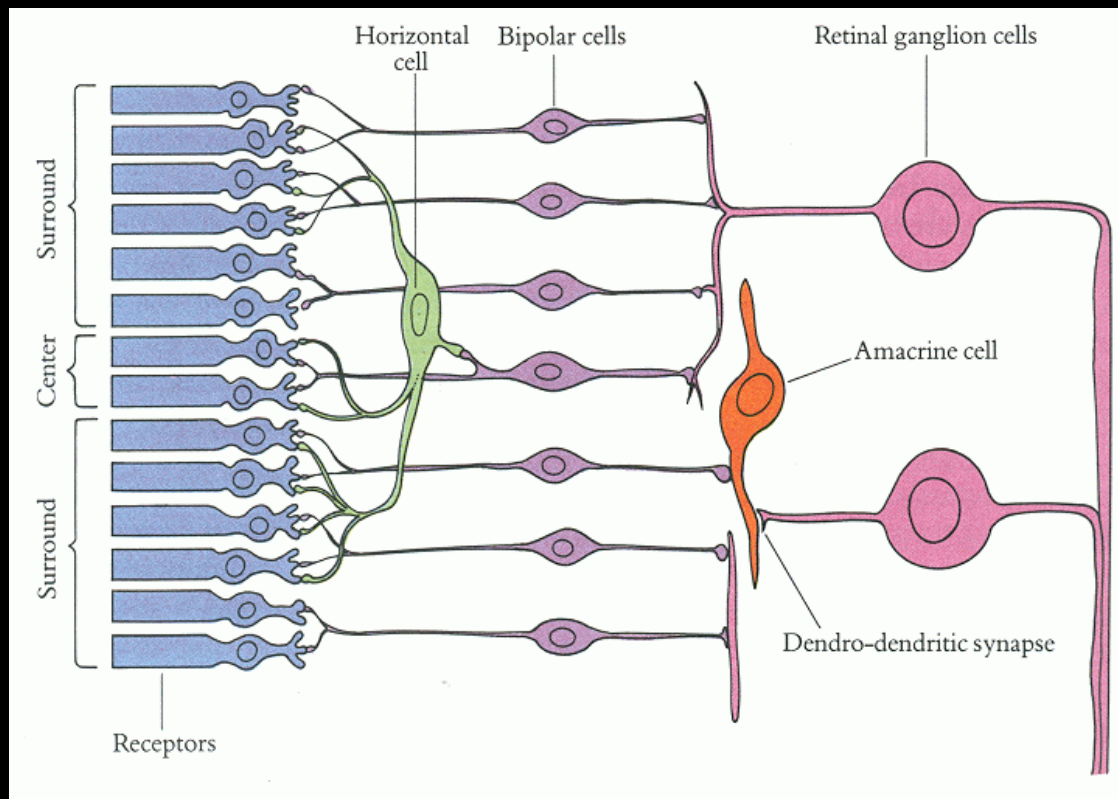
Dynamic Range:





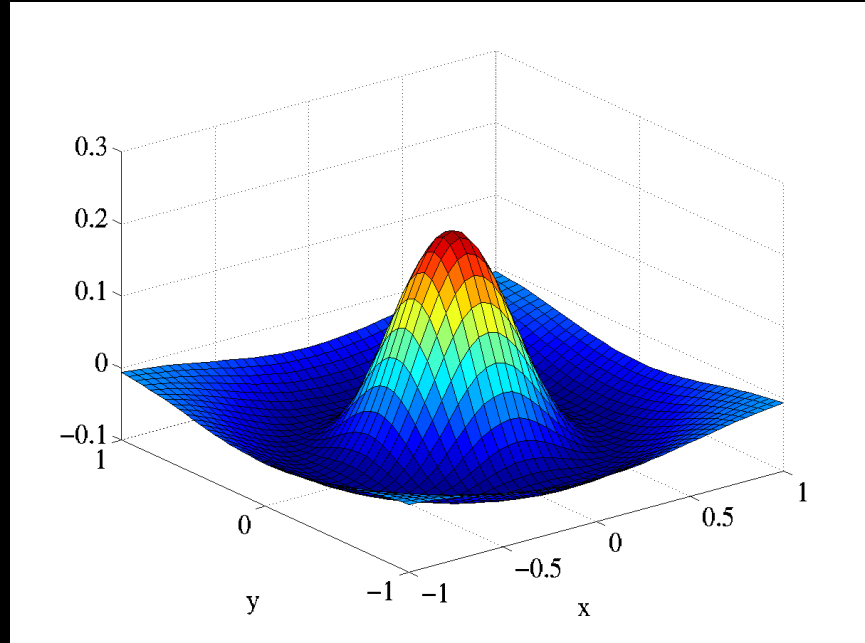
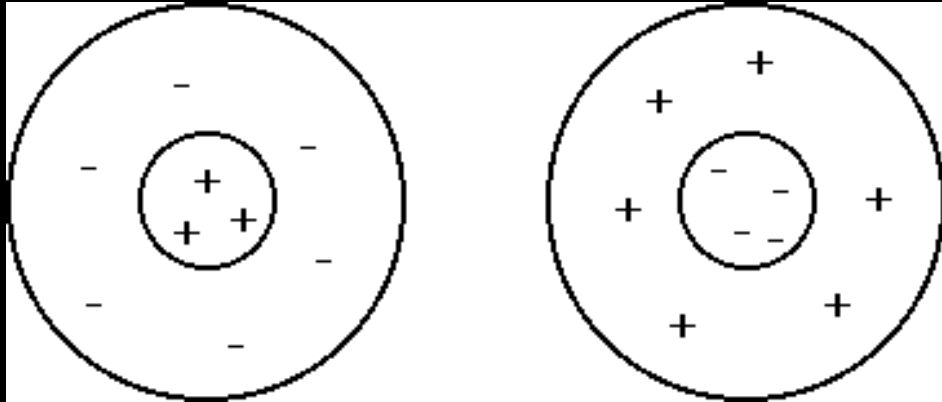


# Ganglion processing

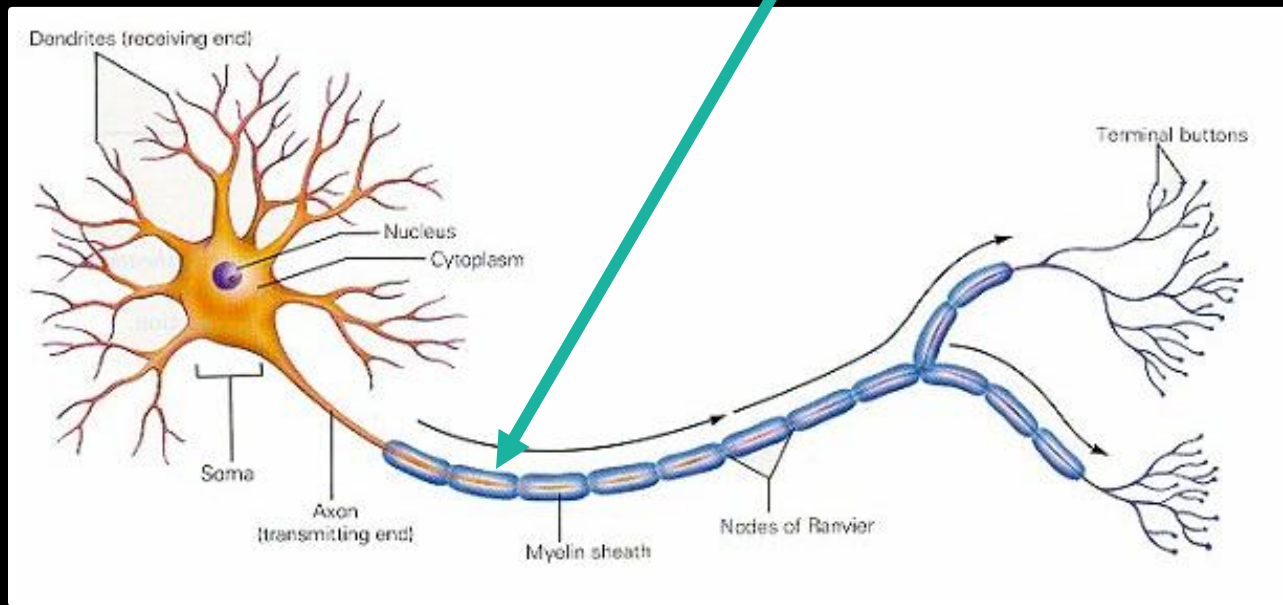
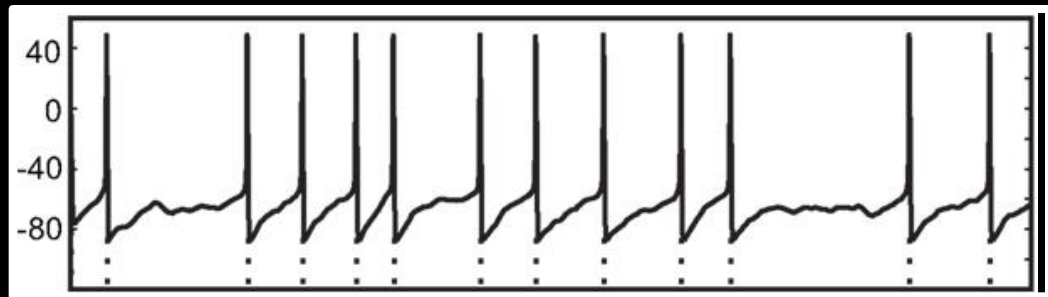




# Center-surround Receptive Fields



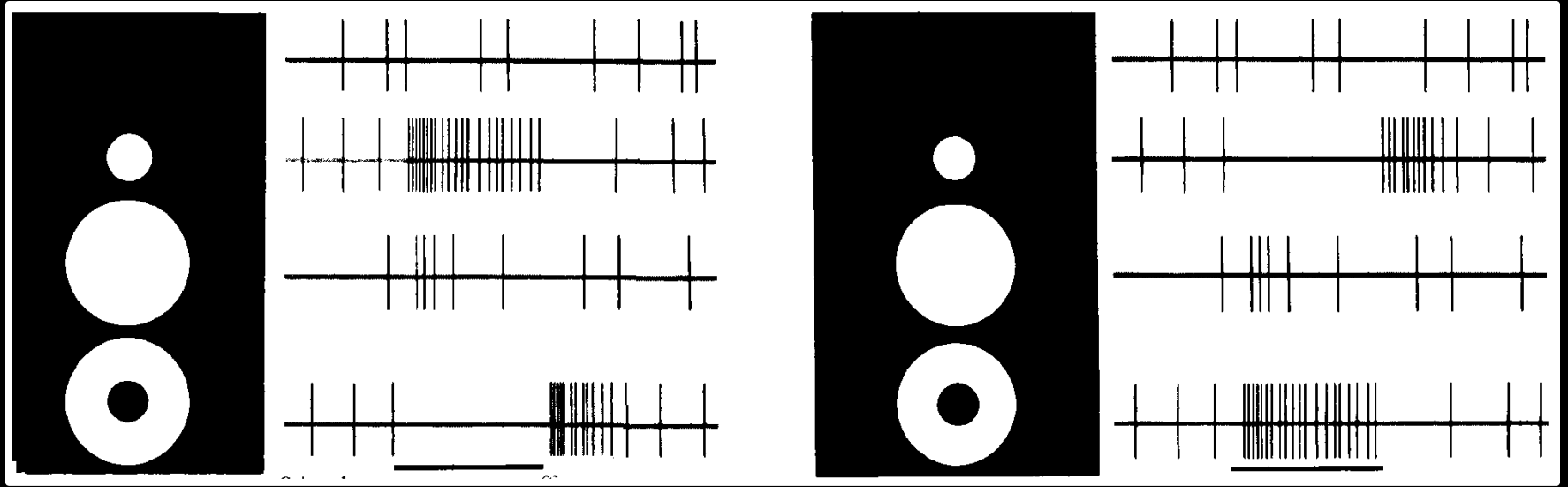
# Cell recording

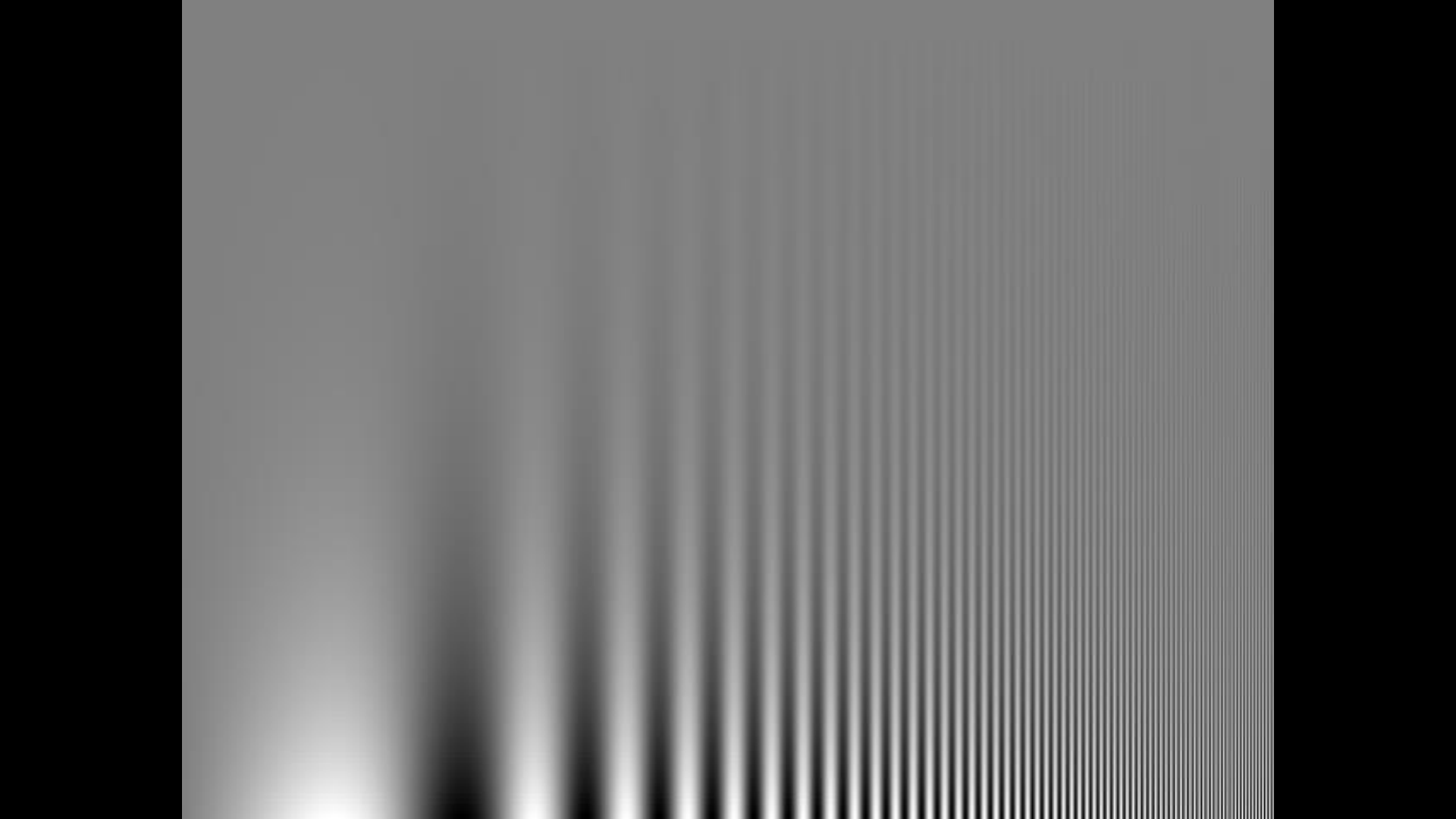


# Recording from a Neuron

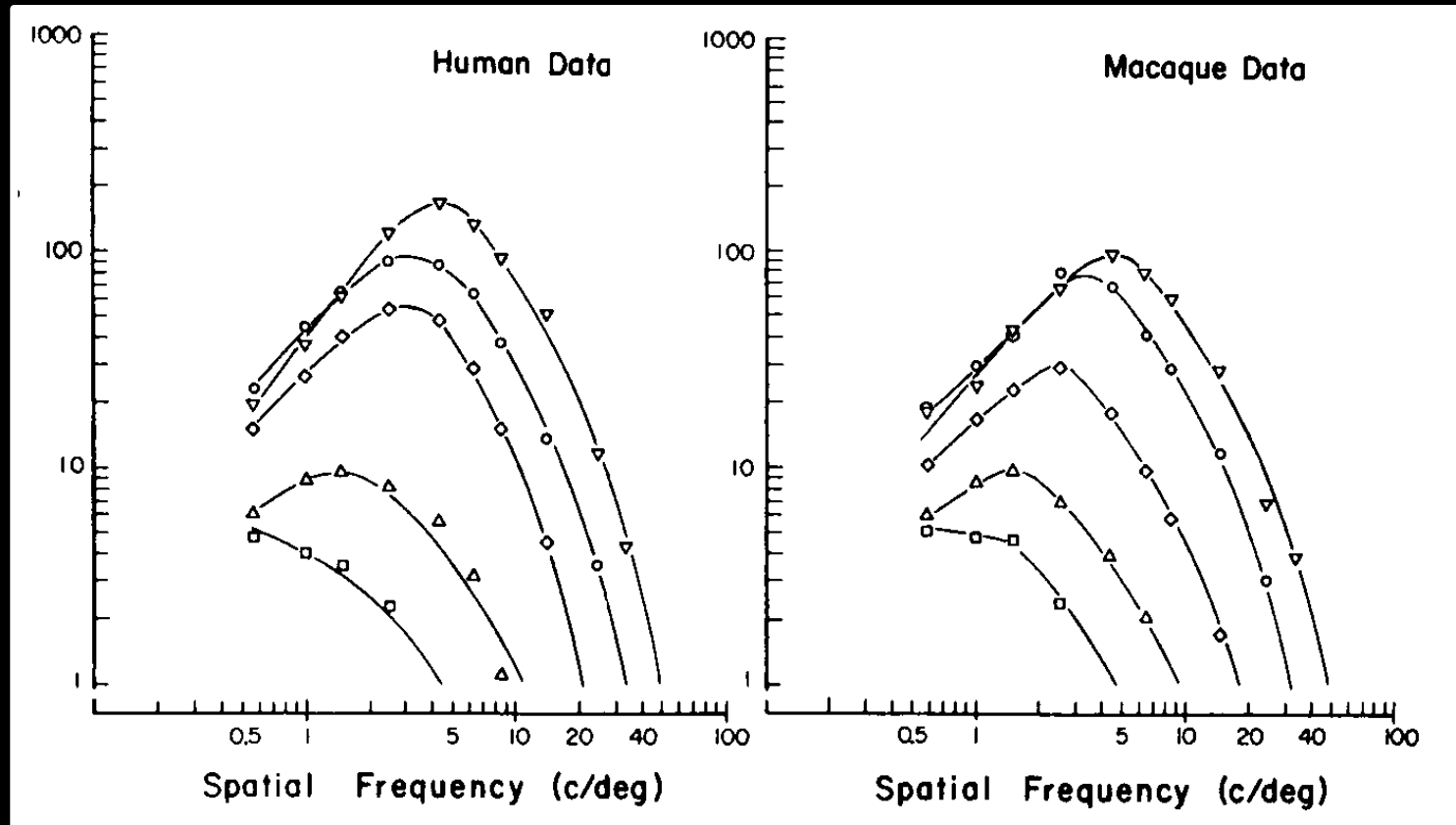


# ON and OFF cells in retinal ganglia





# Contrast Sensitivity Function



# Retina to Brain

- Local contrast information is carried by Ganglion cell axons (which make up the optic nerve) to the LGN.
- Further visual processing takes place in the visual cortex, located at the rear side of the brain.