

# Computer Vision

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**Lecturer,**

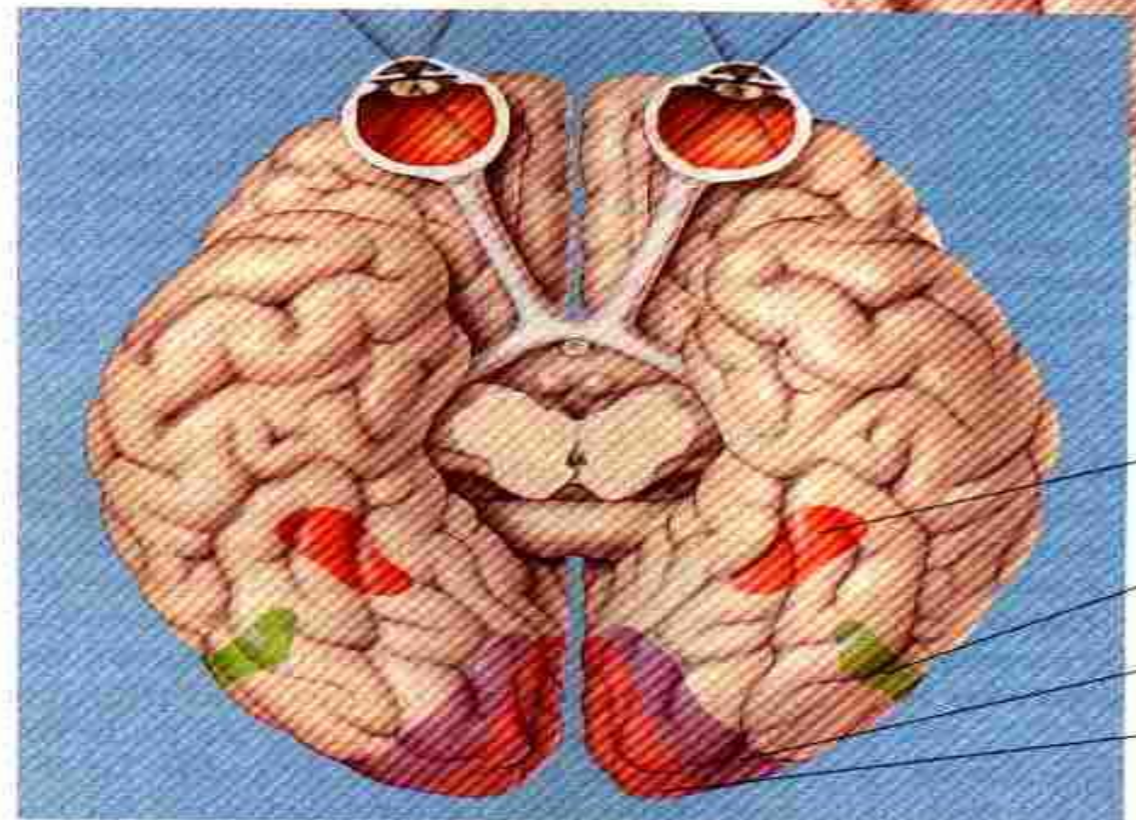
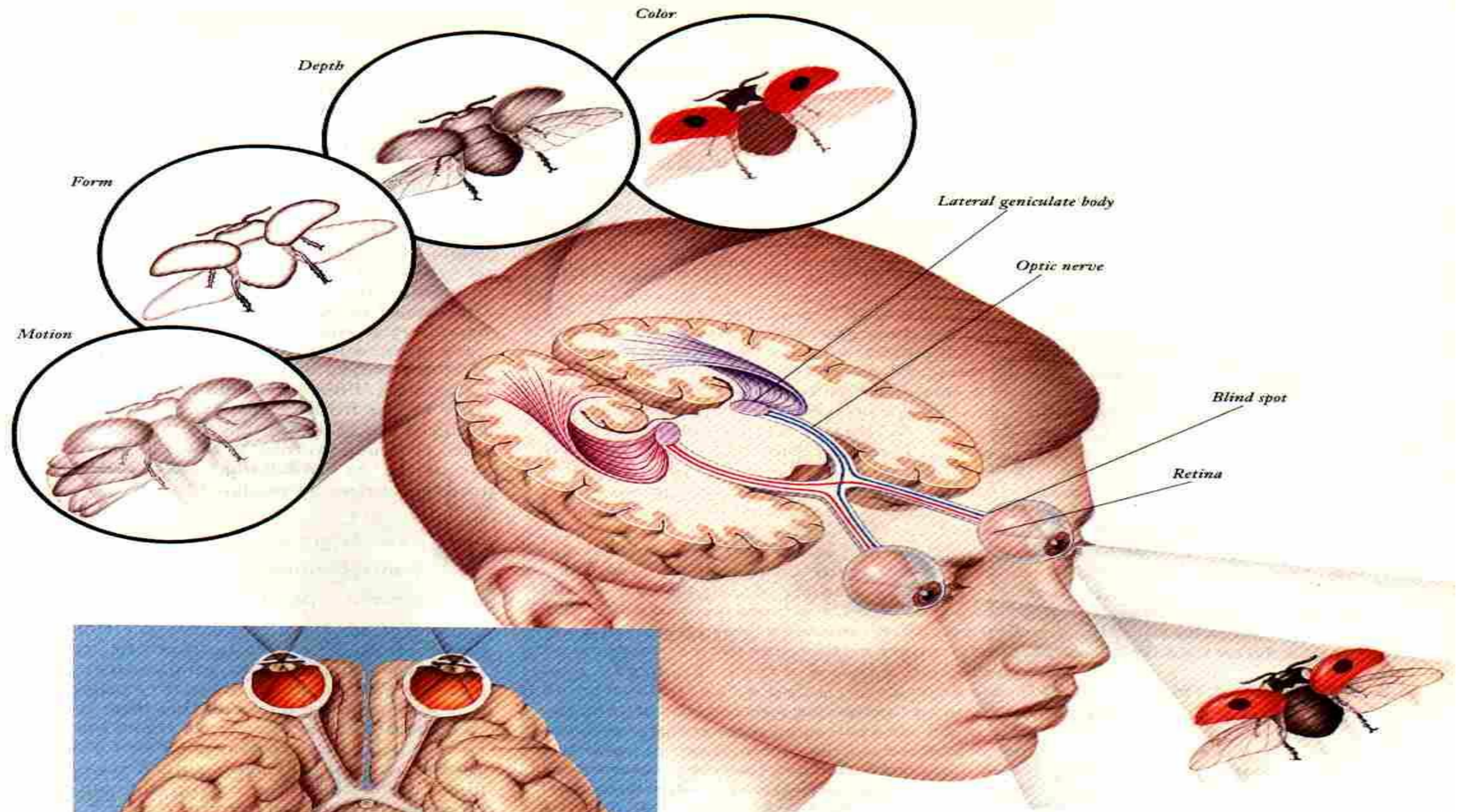
**CS and IT Department,**  
**The University of Lahore.**

**Web: [raoumer.com](http://raoumer.com)**

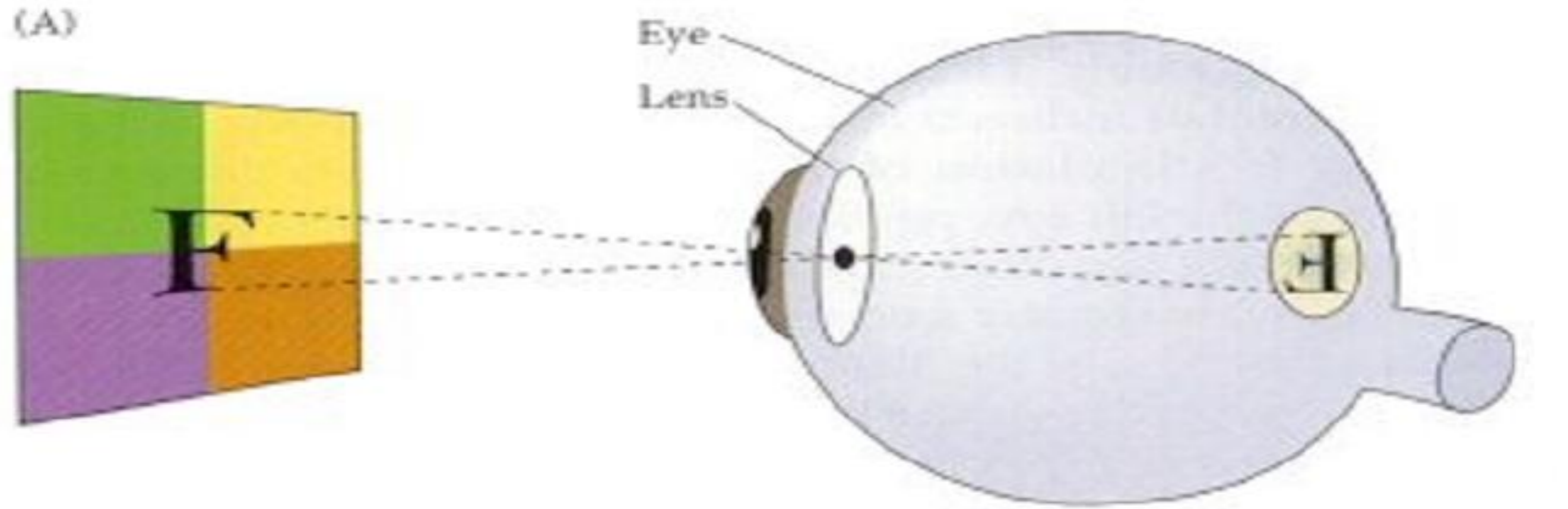


# Human Vision vs Computer Vision





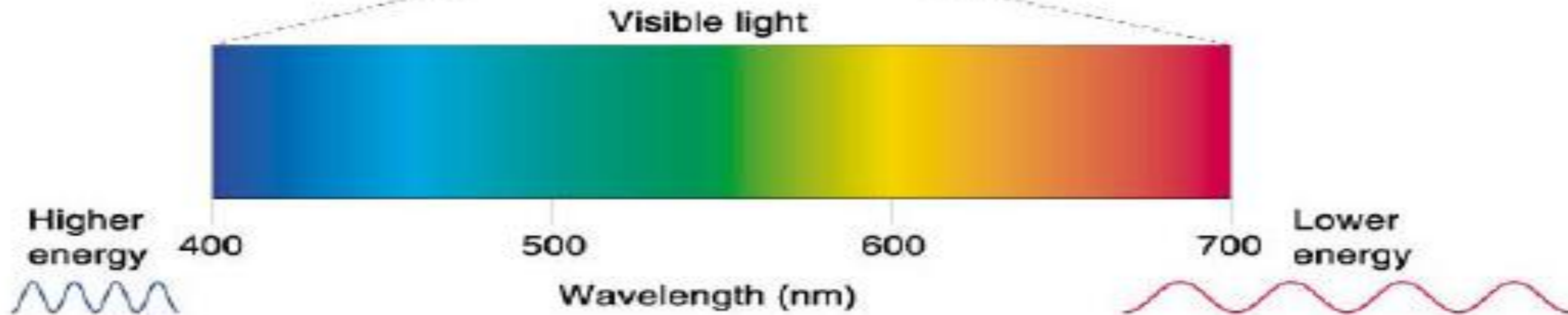
# Image Formation



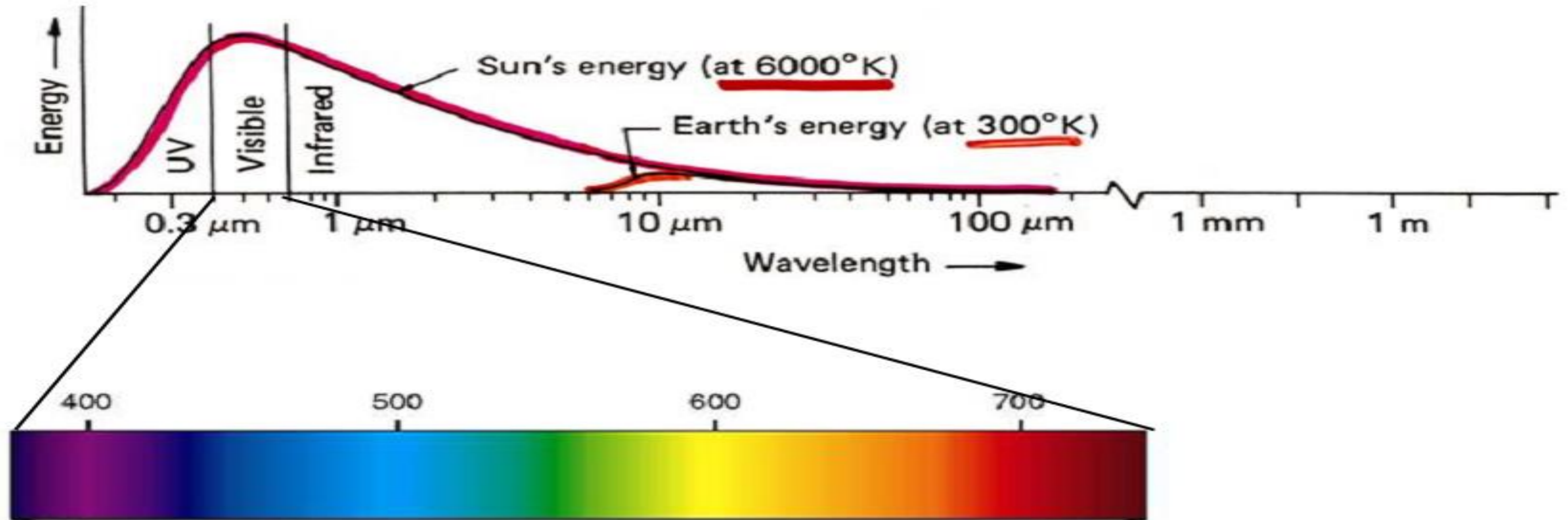
Pinhole camera model



# Light visible to the human eye

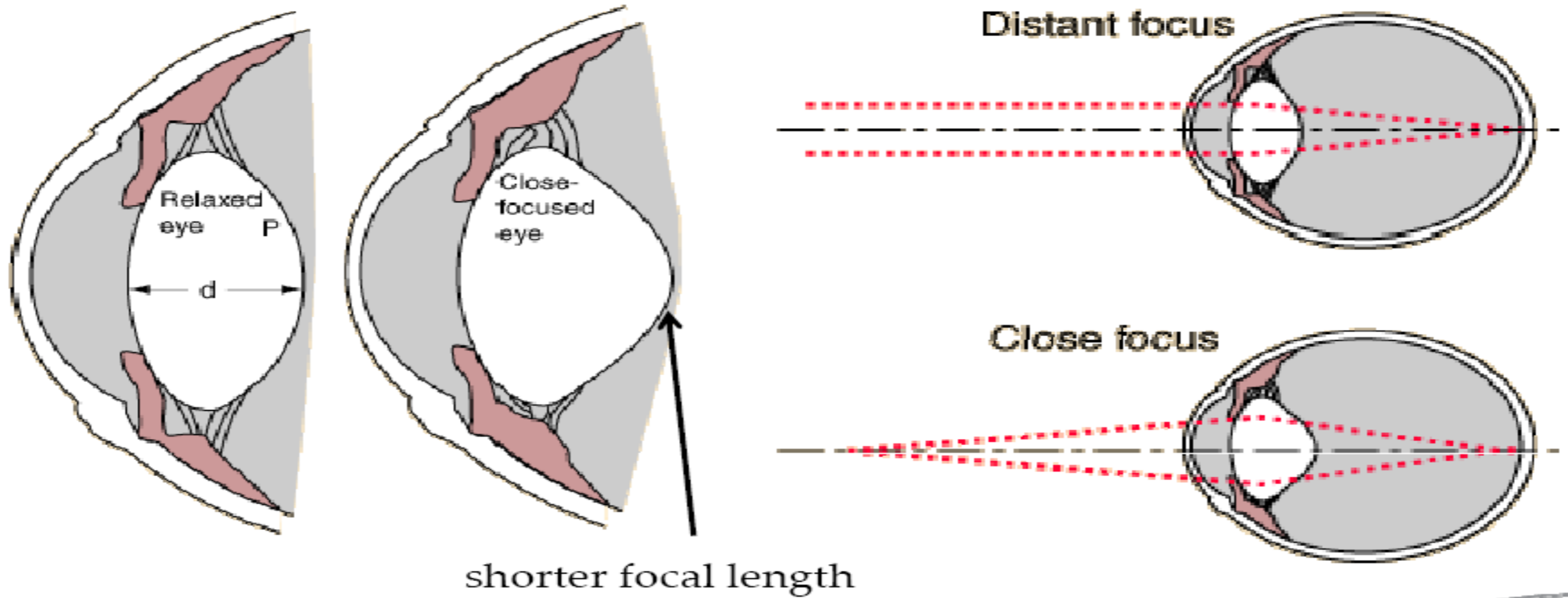


**Our vision appears to be optimized for receiving the most abundant spectral radiance our star emits**

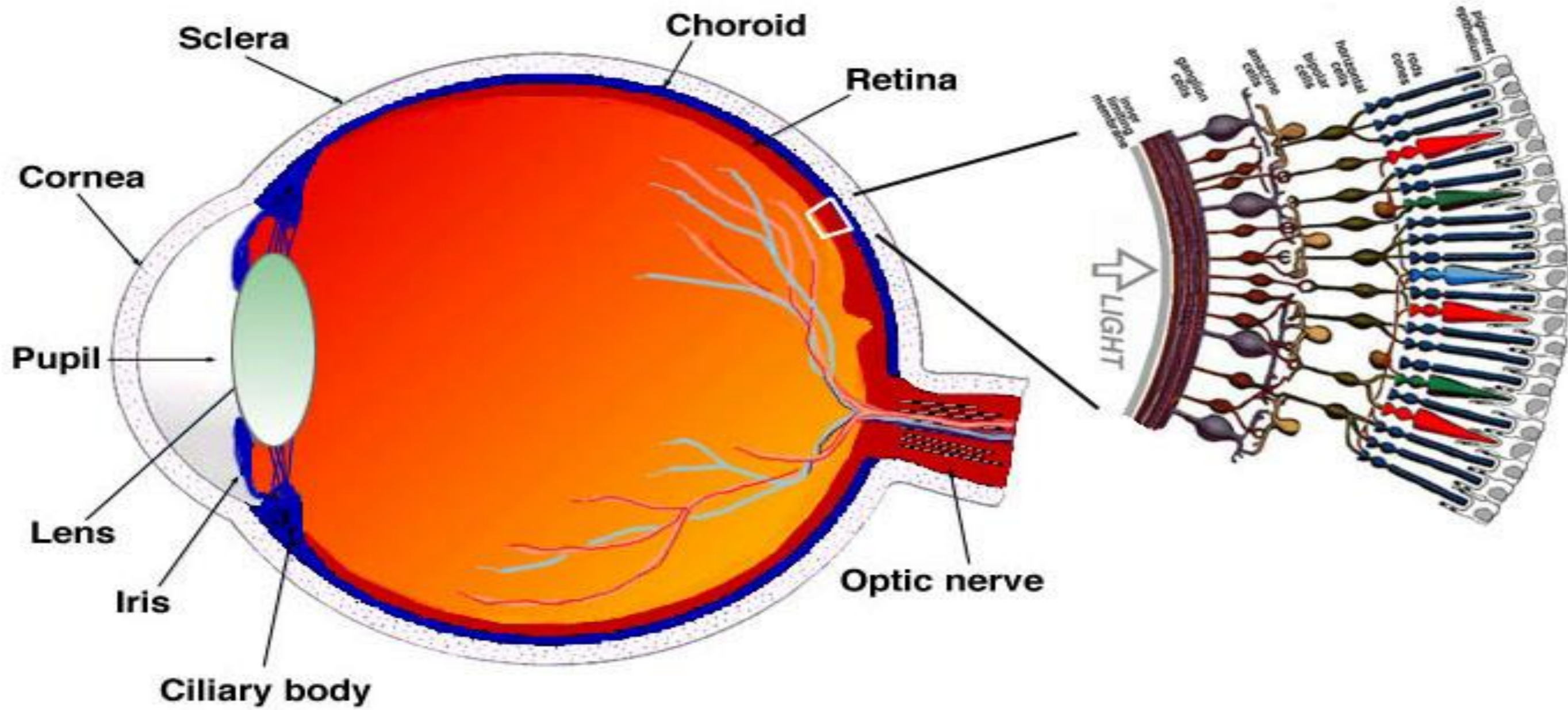


# Focal length

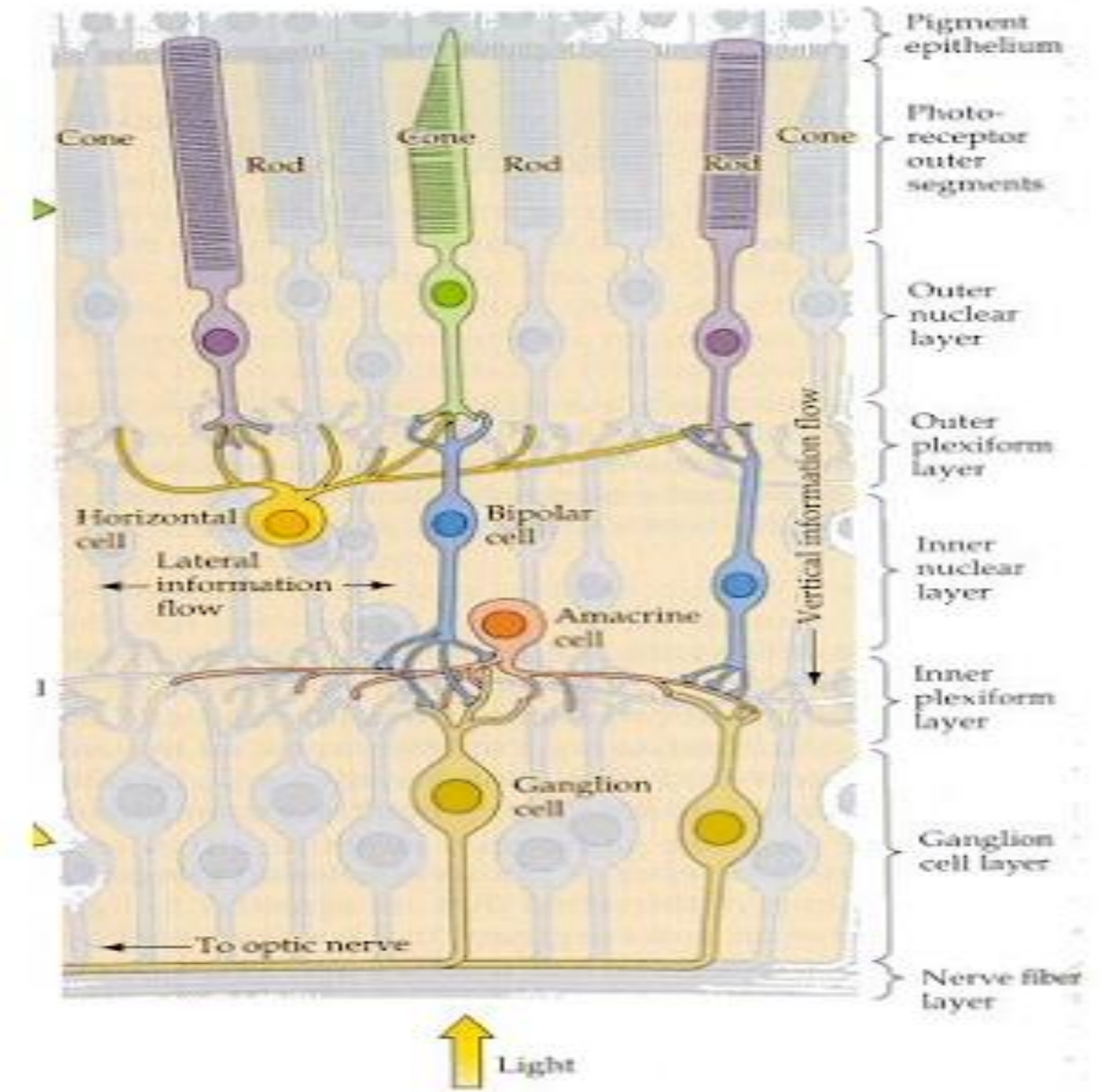
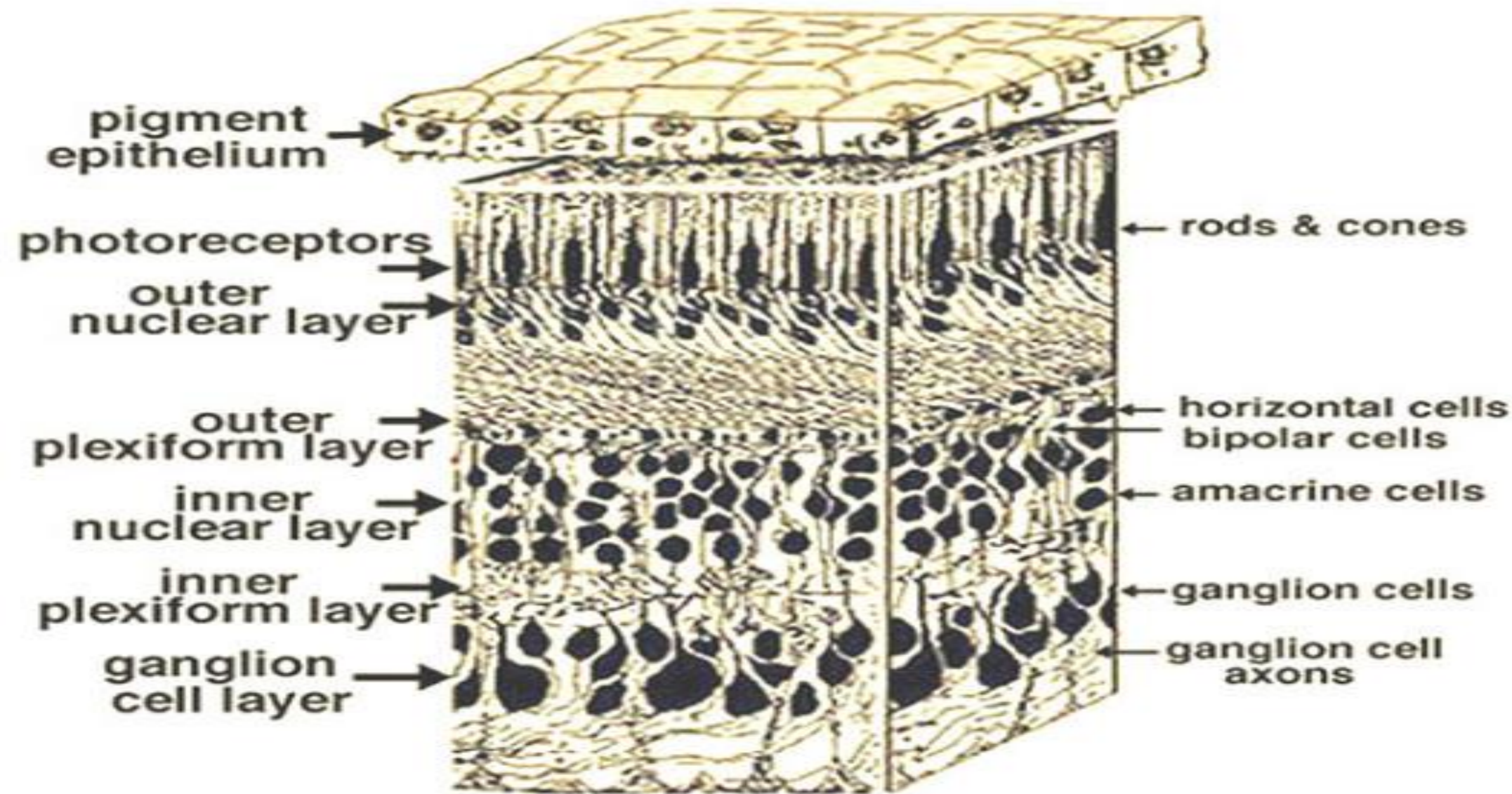
- Changes the focal length of the lens



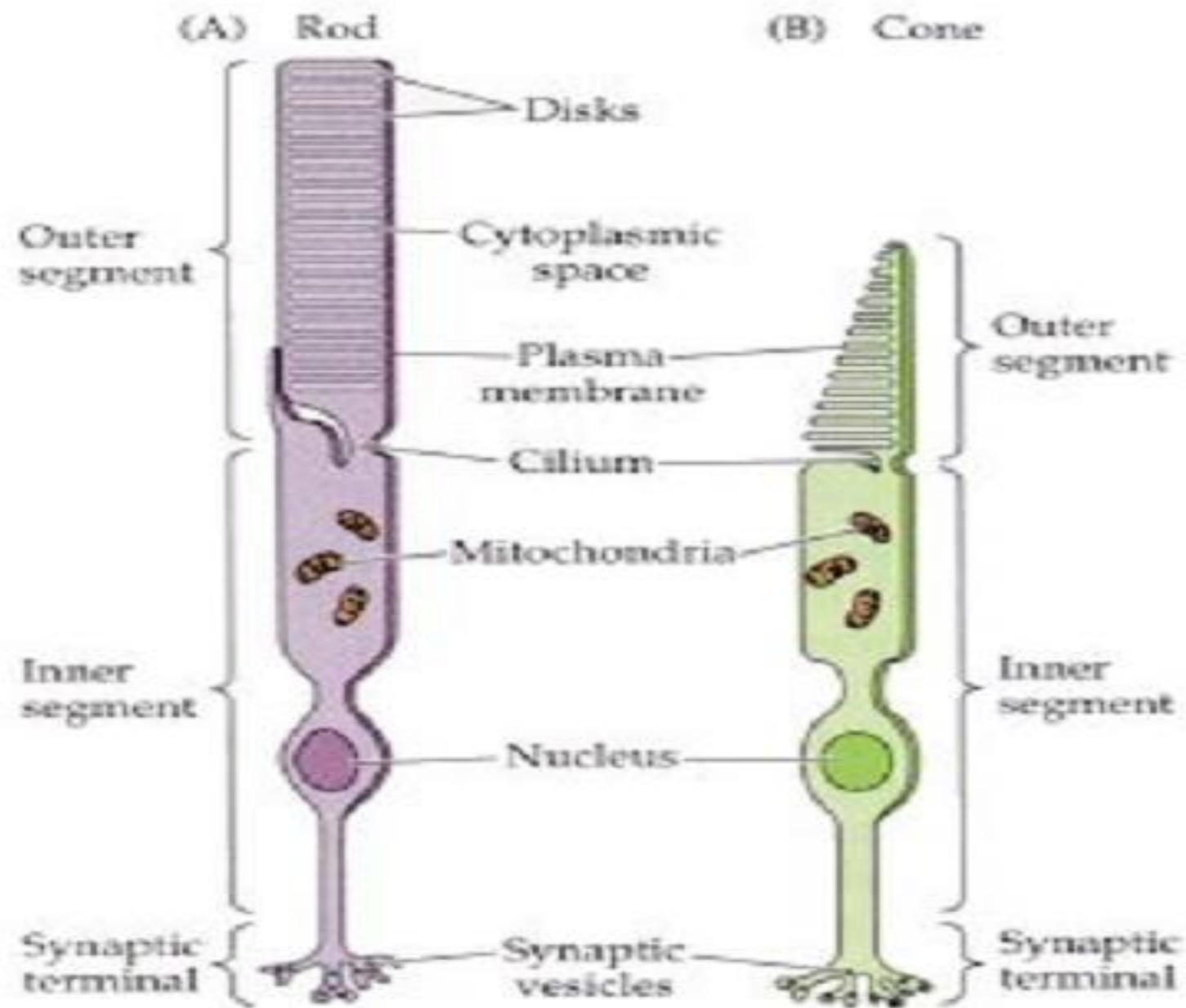
# Human Vision



# Retina



# Rods and Cones



**Rods: Low-intensity light vision, e.g. night vision.**

**Cones: Color-vision with higher intensity light.**

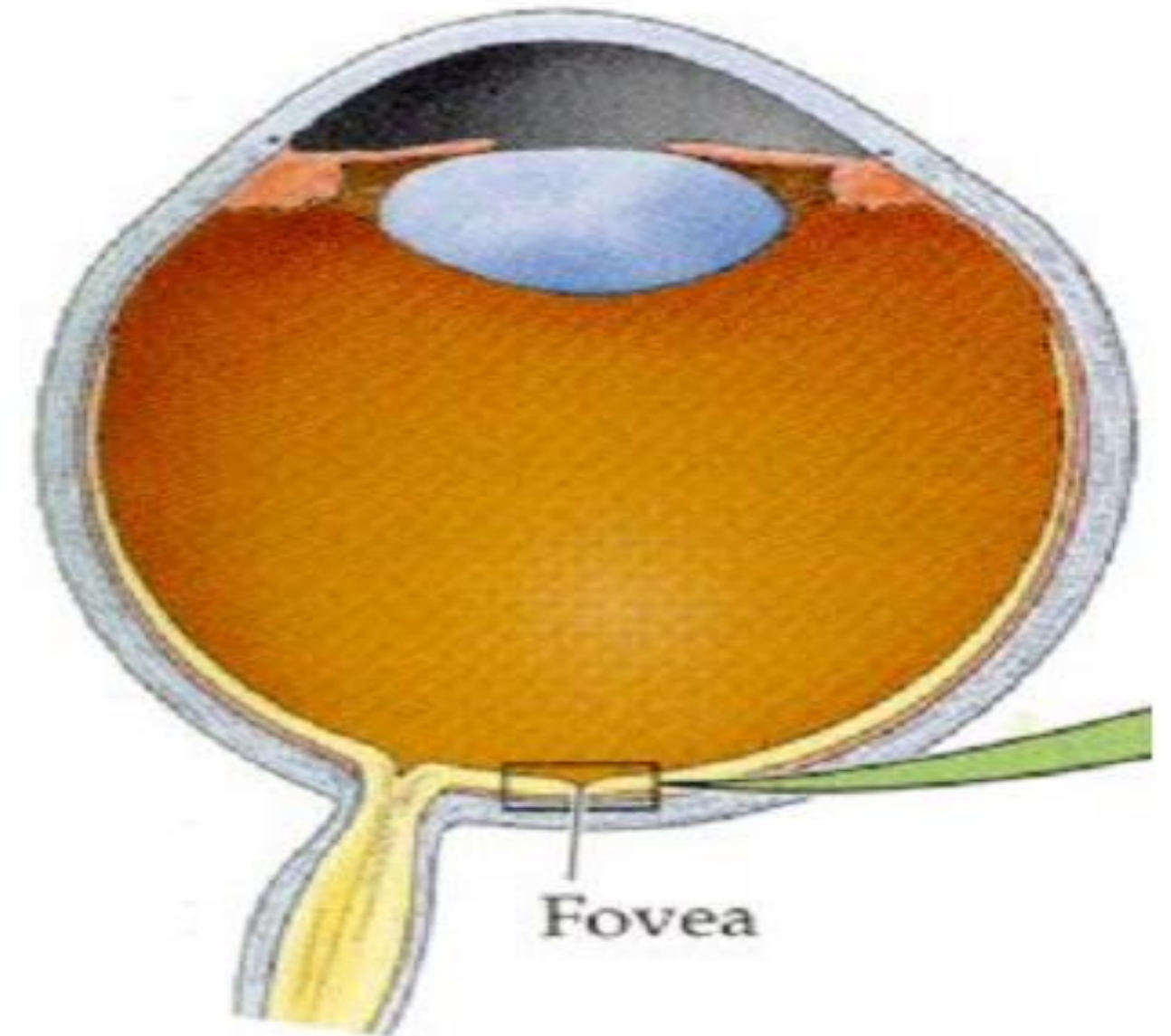


# Peripheral vs Foveal Vision

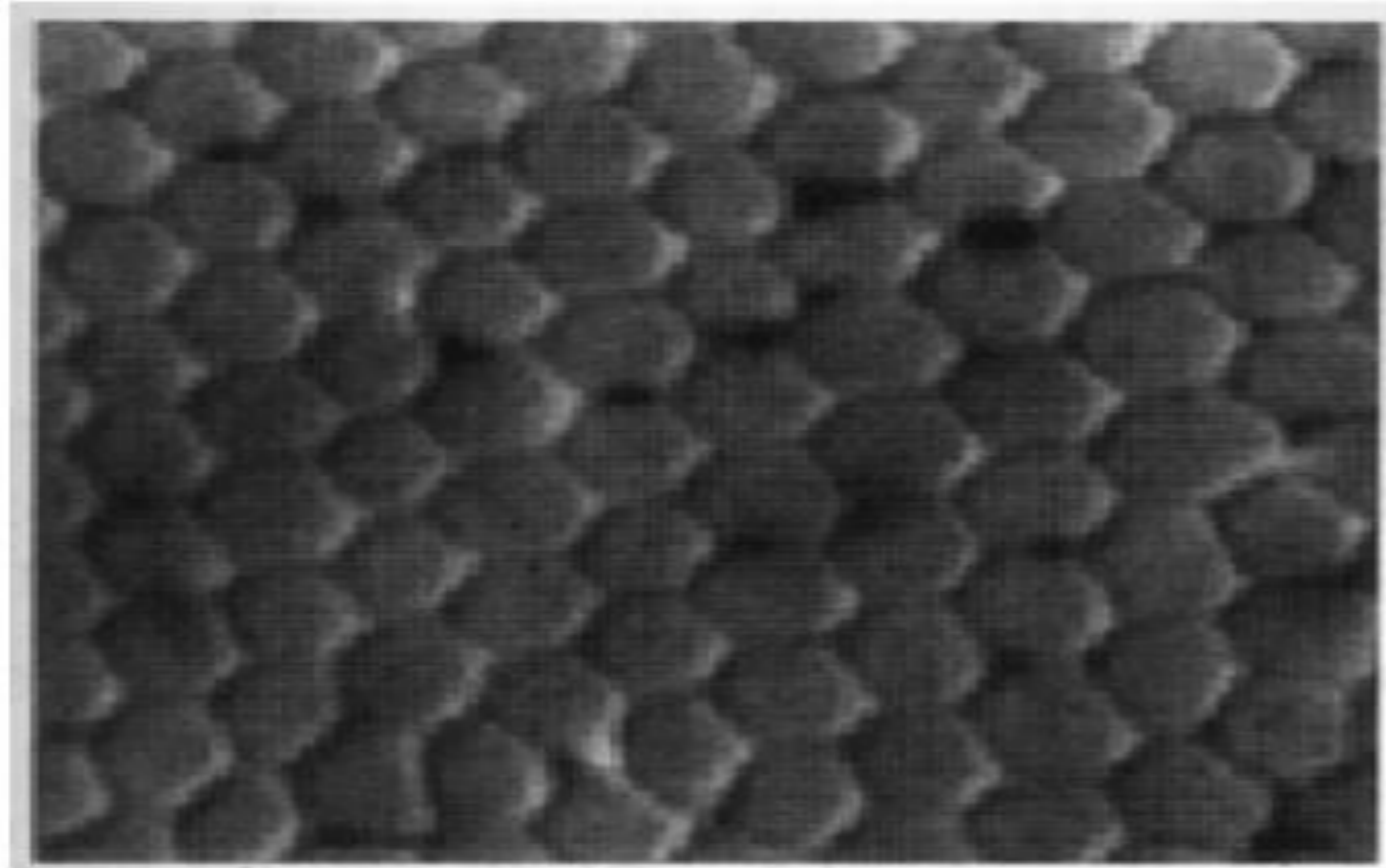
Much higher concentration of cells on the Fovea

→ Active vision:

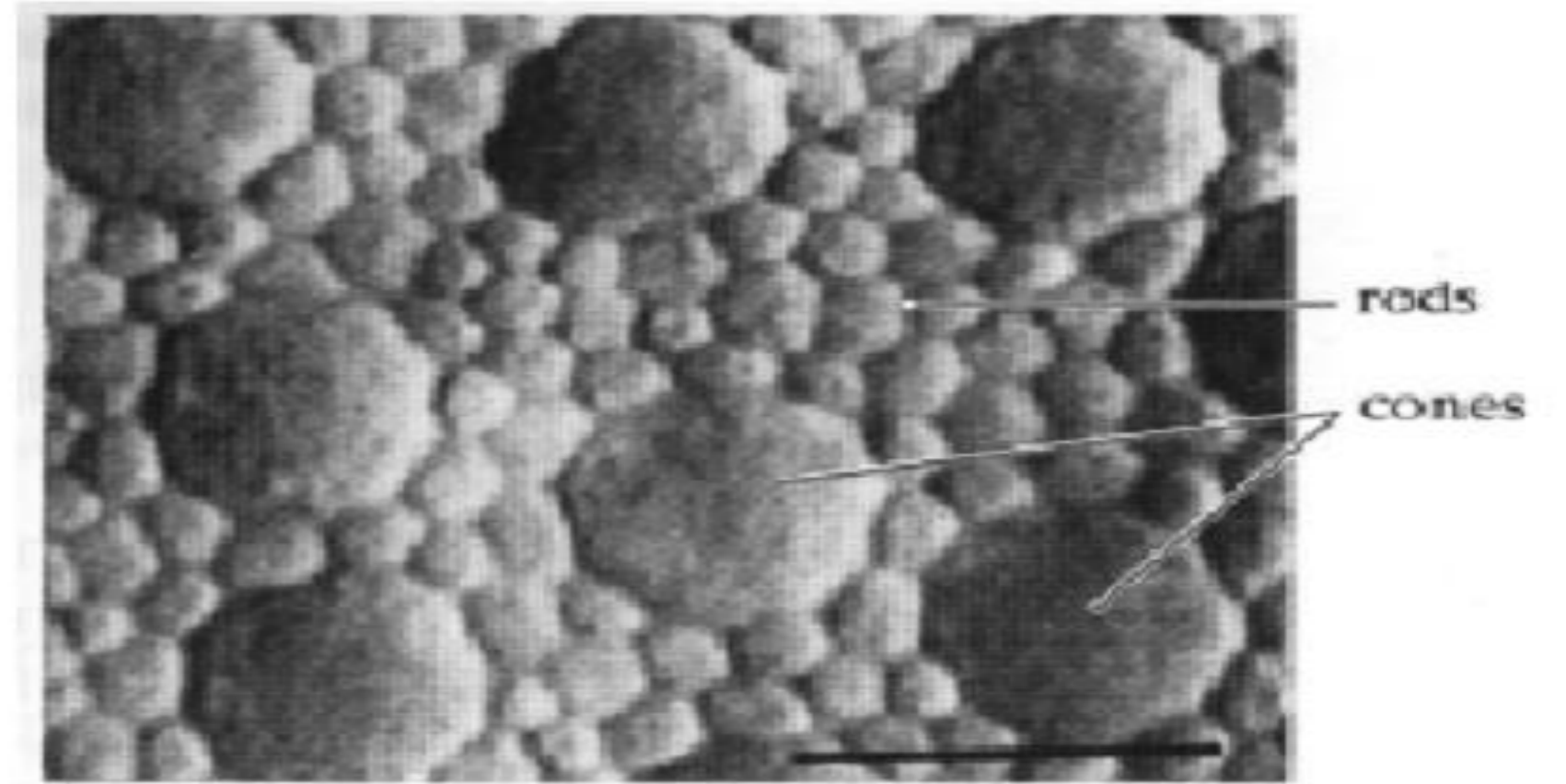
- We find objects using our peripheral vision
- We concentrate our gaze on objects of interest.



# Fovea vs Periphery



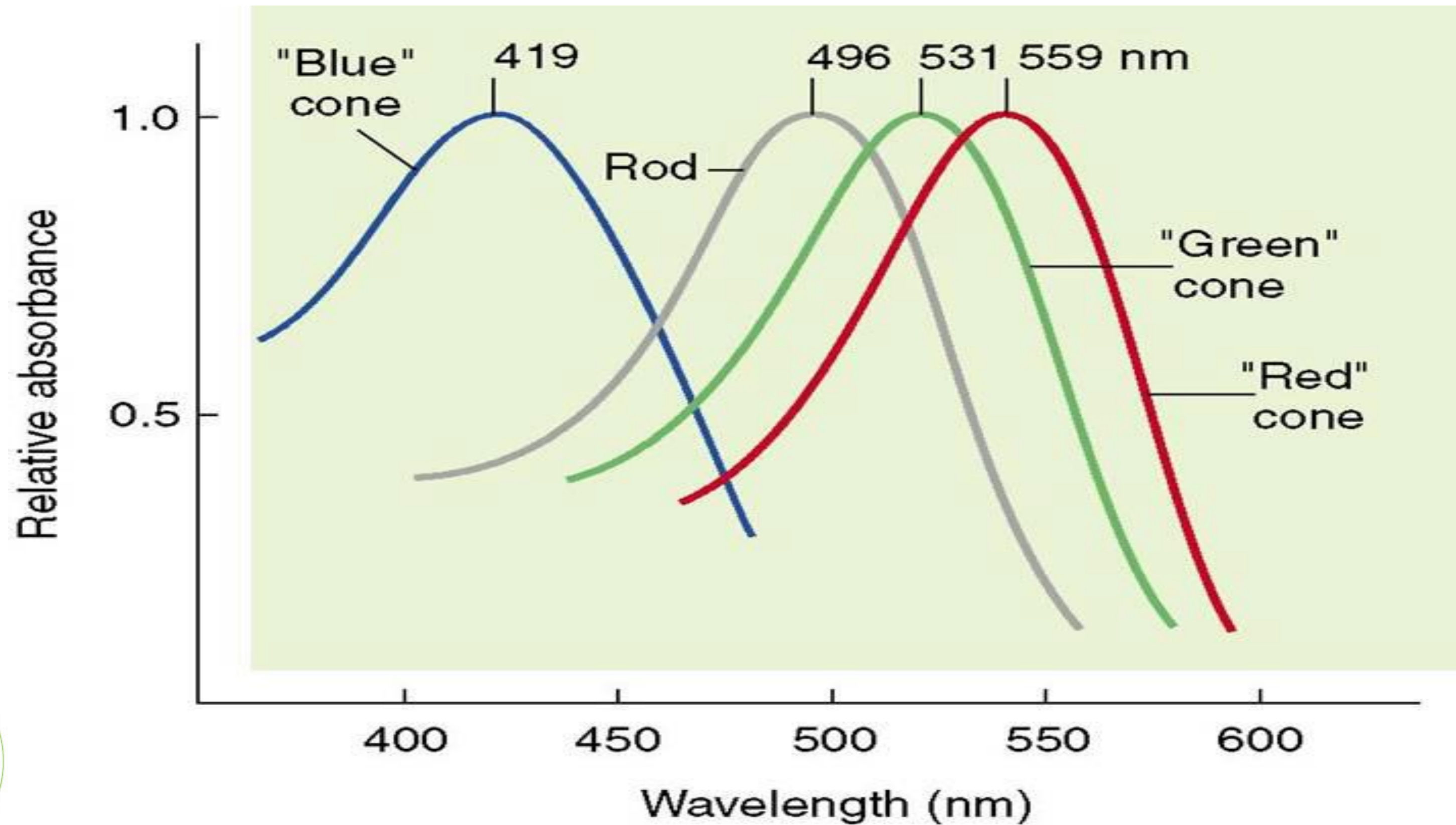
Fovea



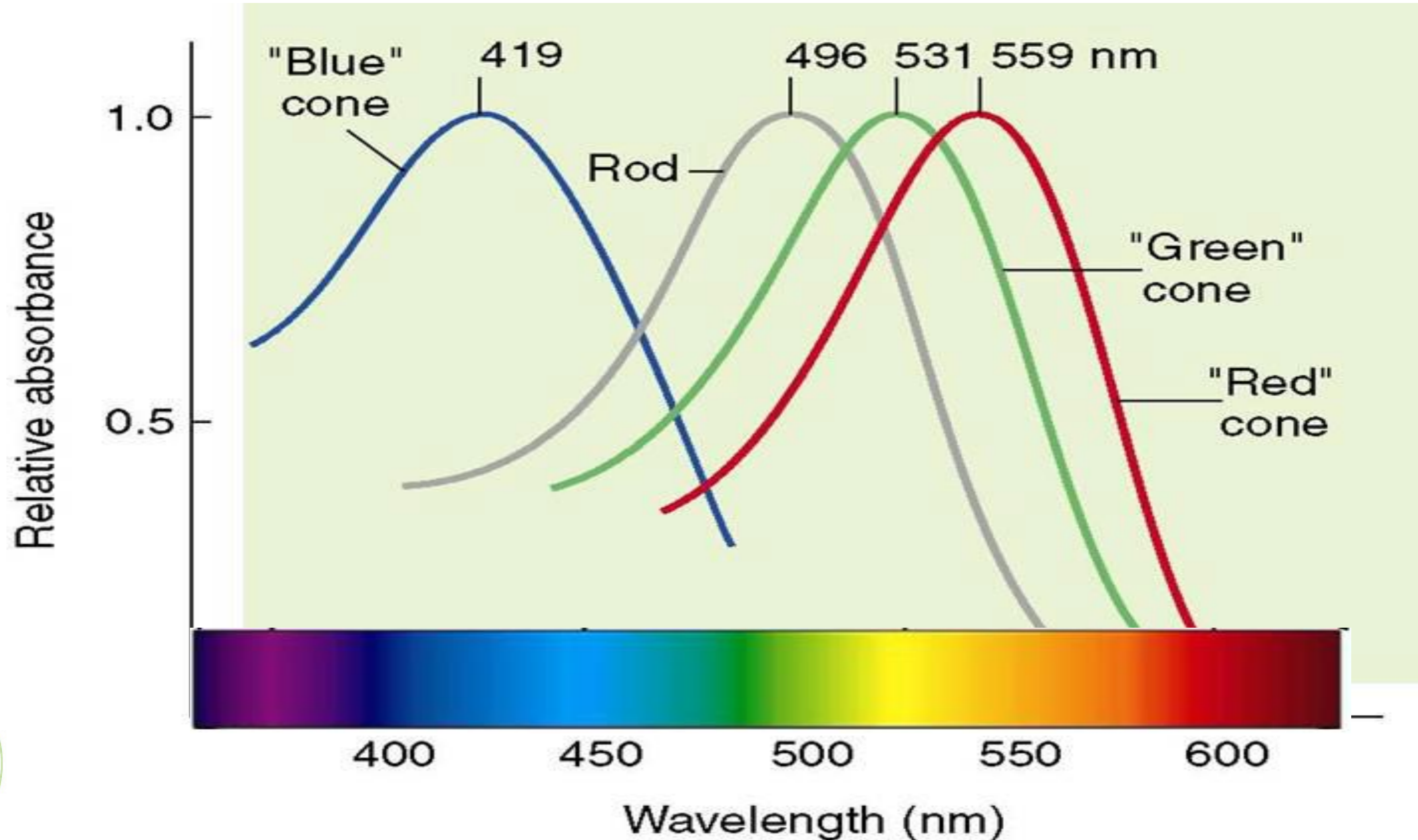
Periphery



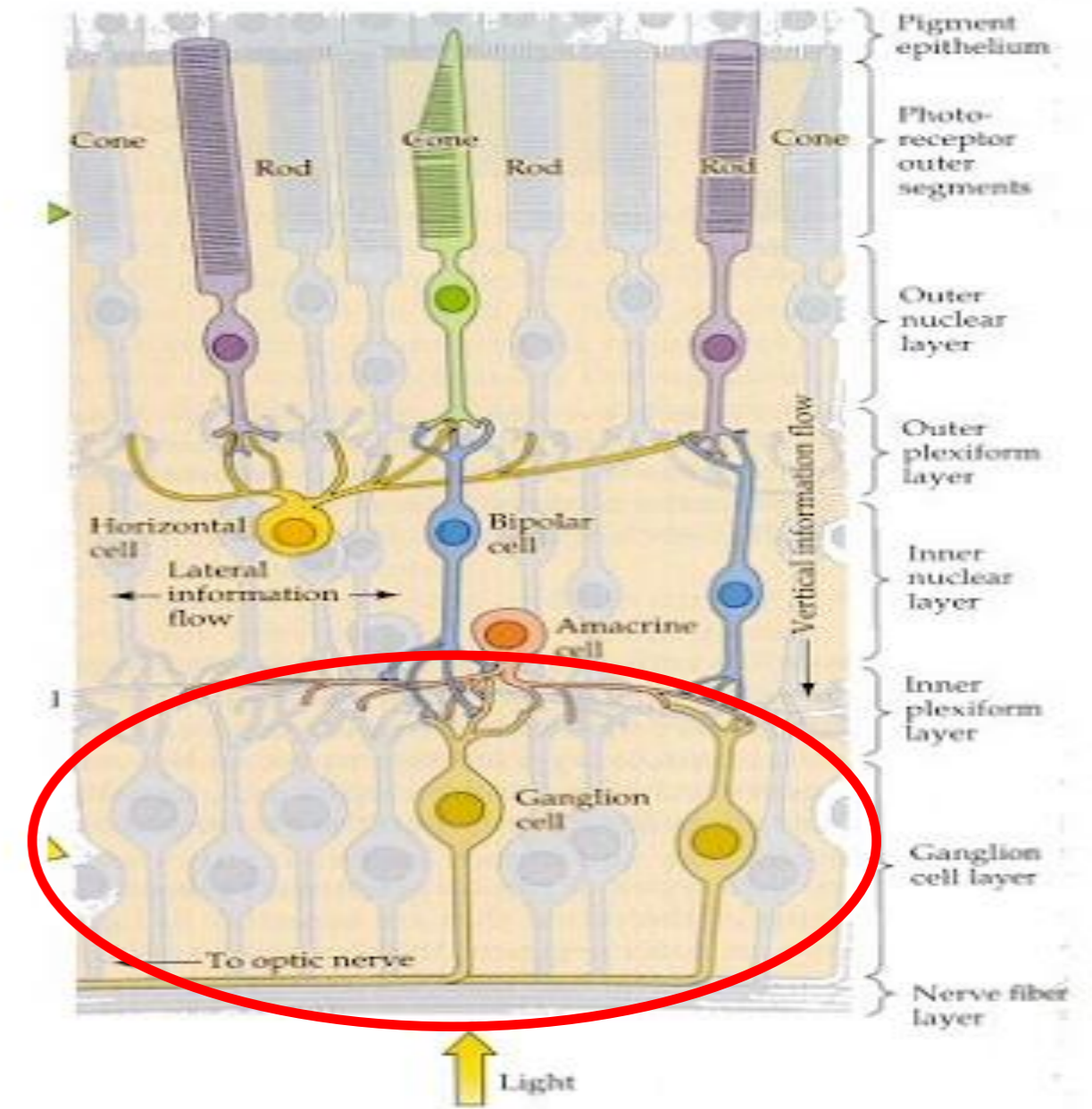
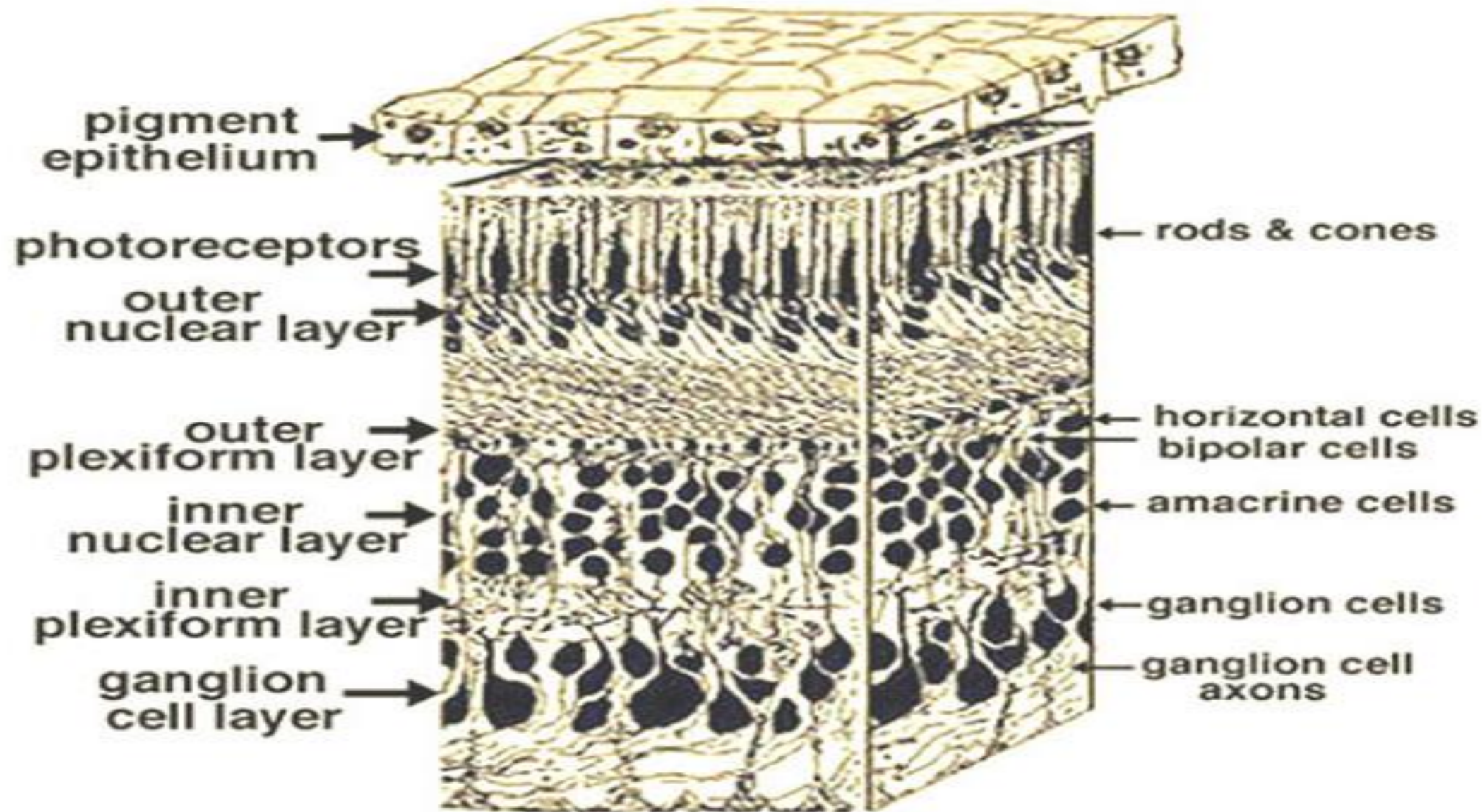
# Sensitivity to Different wavelengths



# Sensitivity to Different wavelengths

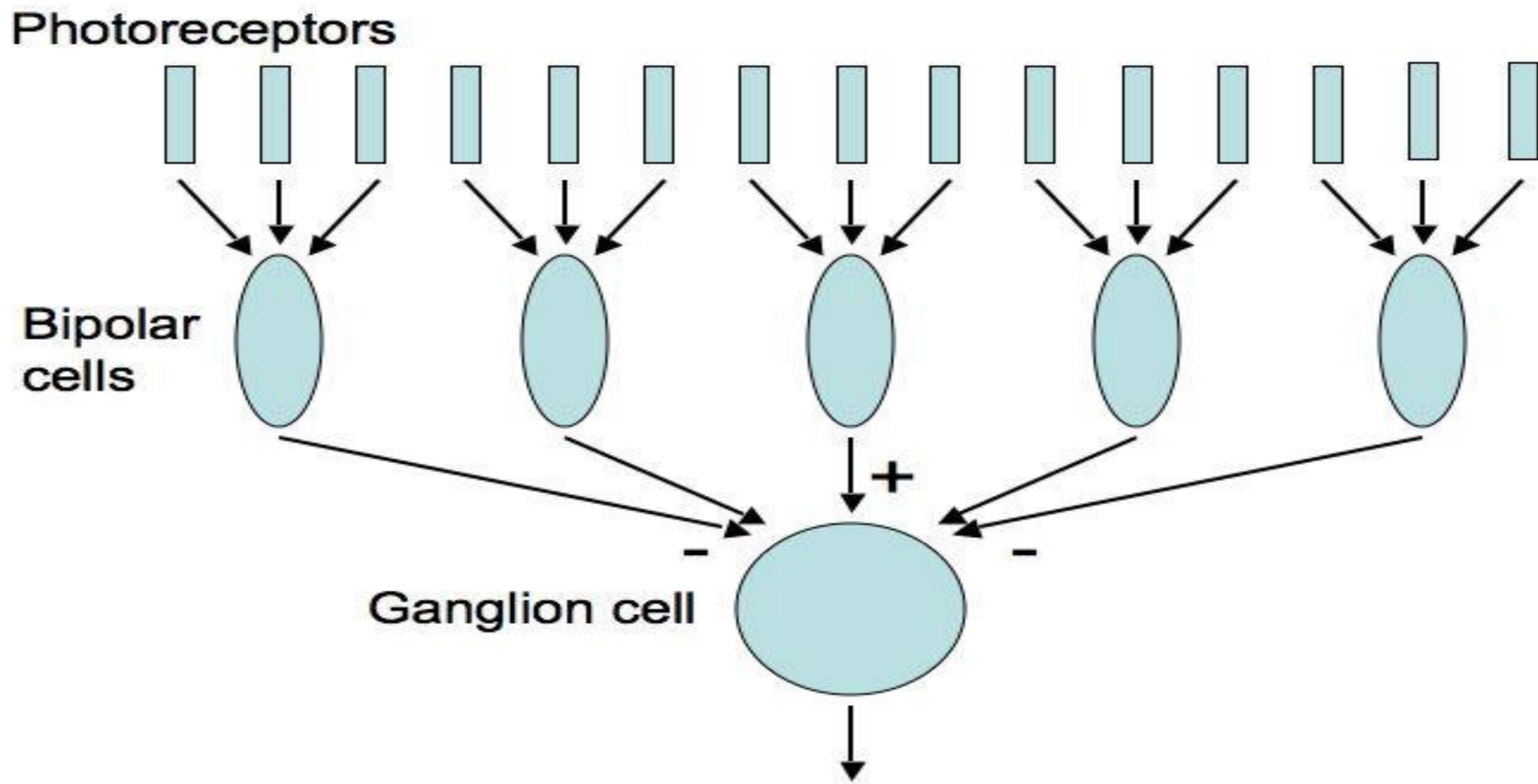


# Retina



# Ganglion Cells

## Linear receptive field model

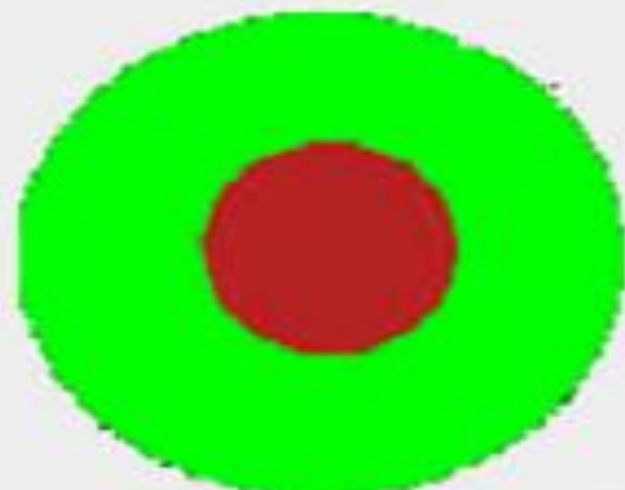


# Ganglion Cells

## *Color opponent ganglion cells*

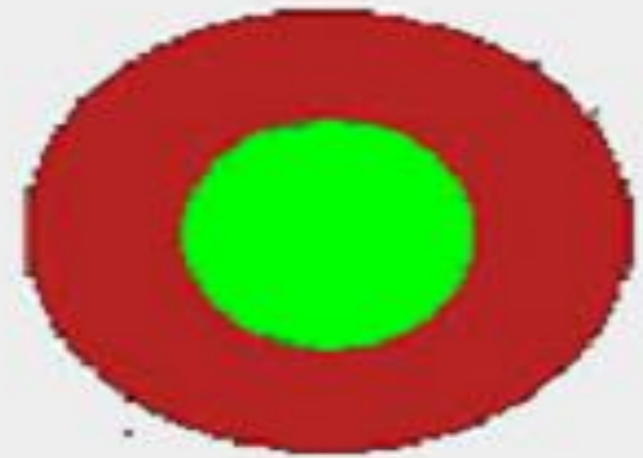
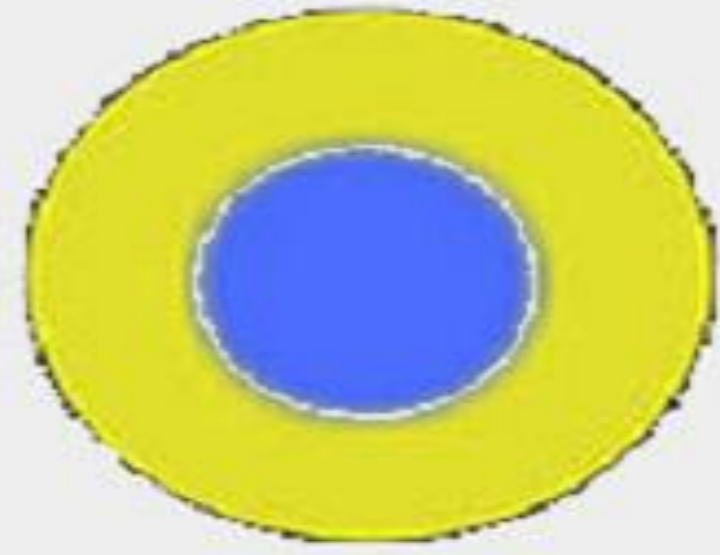


red ON/green OFF



red OFF/green ON

blue ON/yellow OFF



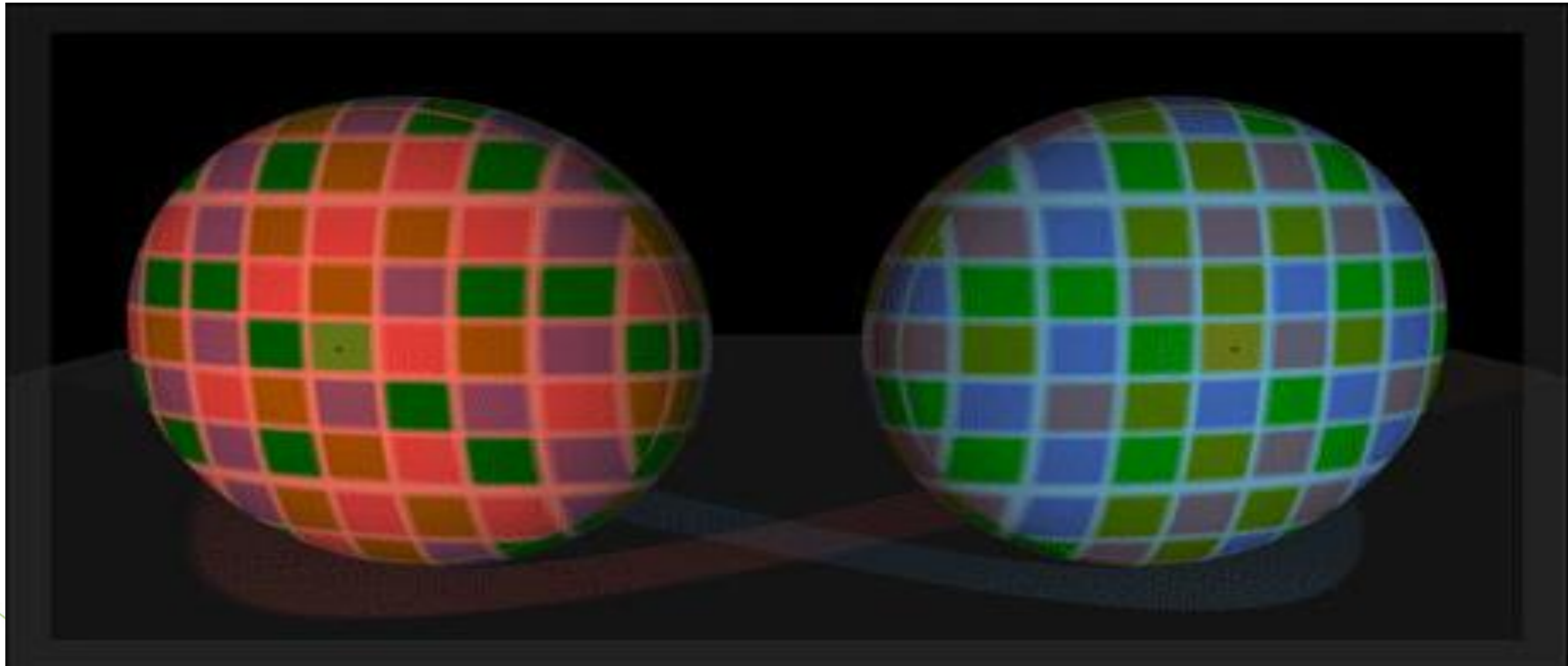
green ON/red OFF



green OFF/red ON



# Color Illusion



# Human Eye in short

## The Retina:

- rods (low-intensity light, night vision)
- cones (color-vision)
- Synapses and ganglions
- Optic nerve fibers

## Sensing and low-level processing layer:

- 125 millions rods and cones feed into 1 million nerve fibers



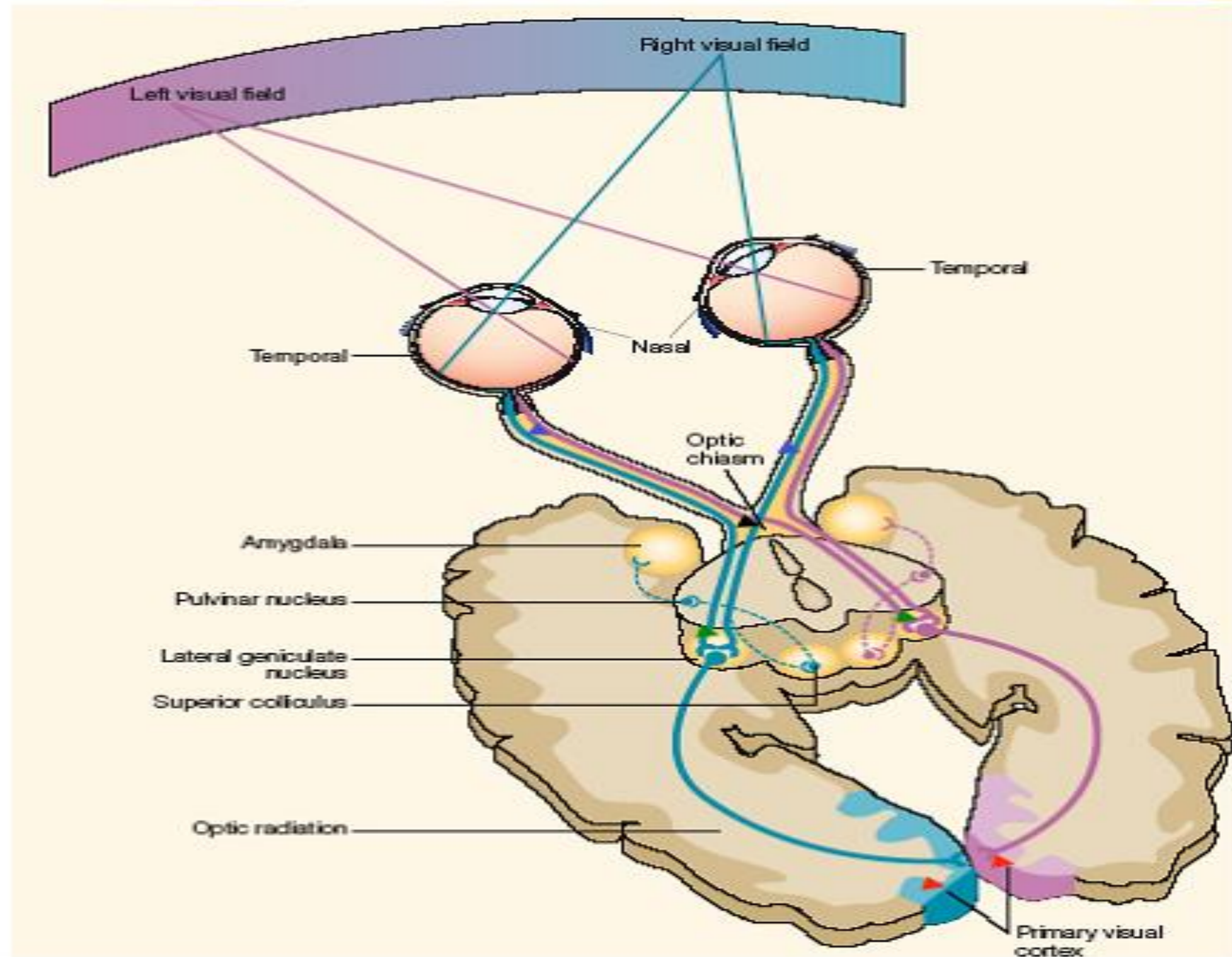
# Hemispherical Vision

Optical Nerves

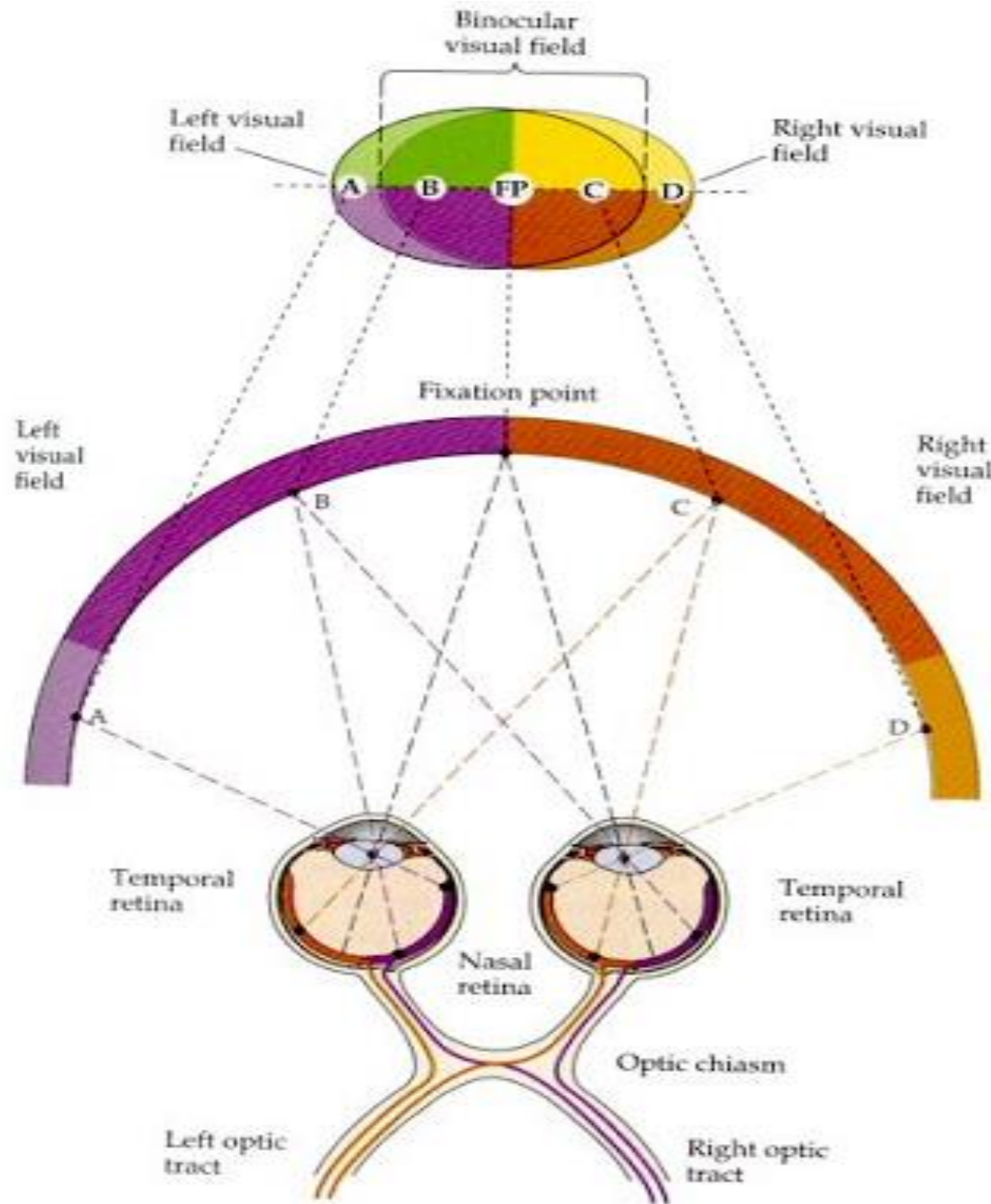
Optic Chiasm

Lateral Geniculate Nucleus

Primary Visual Cortex (V1)



# Stereo-scopical Vision

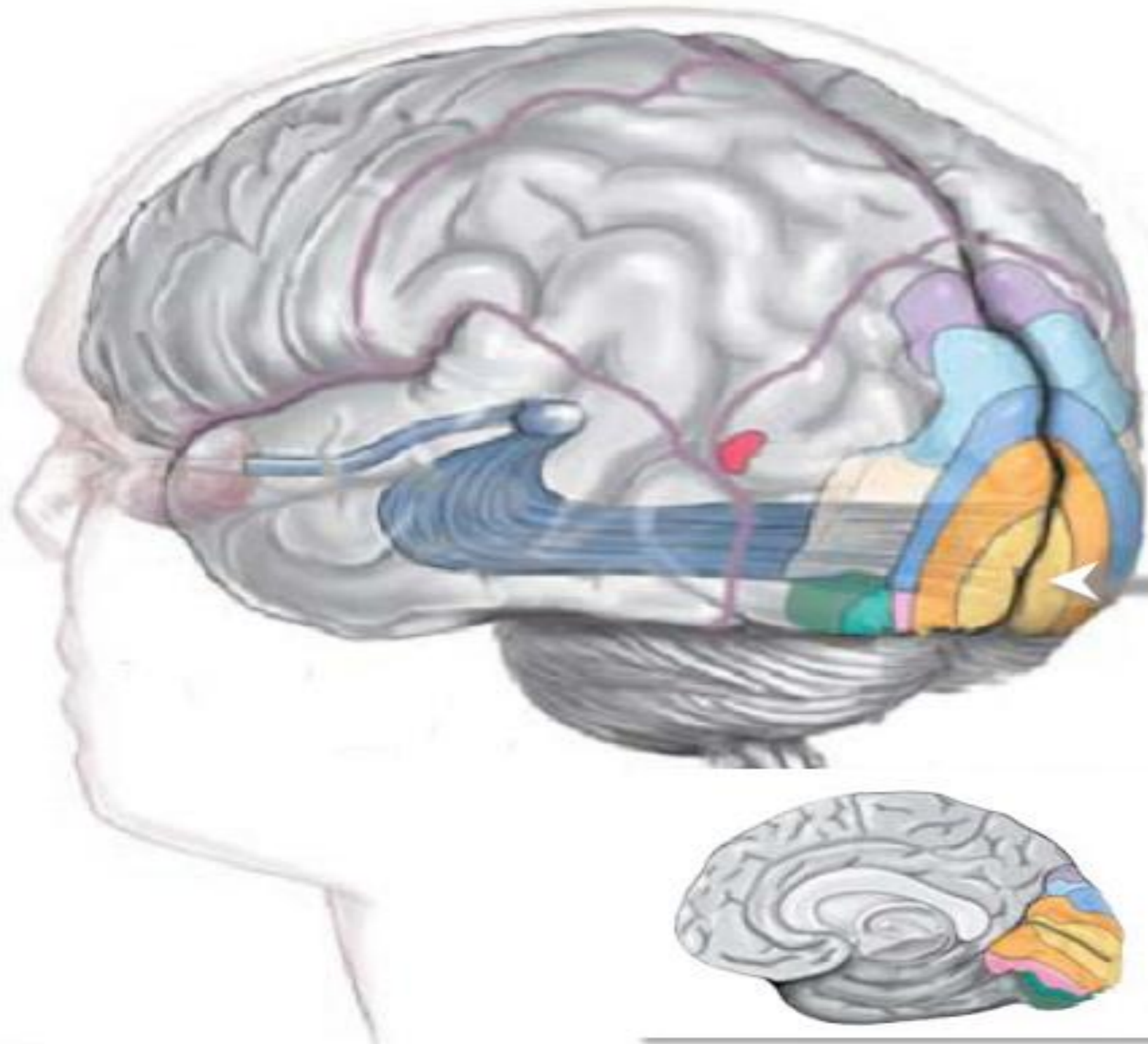


Our brain is wired for stereo vision:

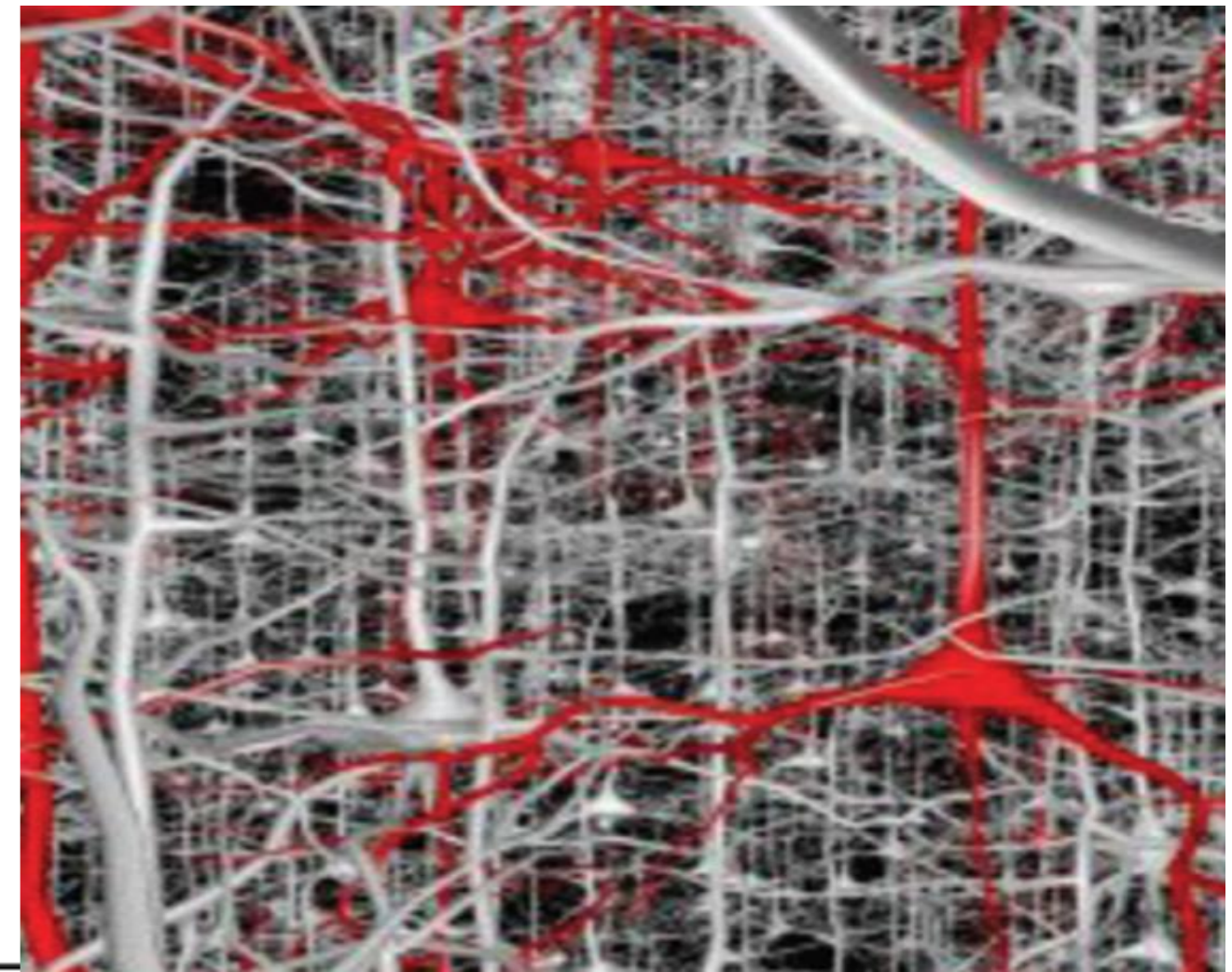
- Redundancy
- Depth perception

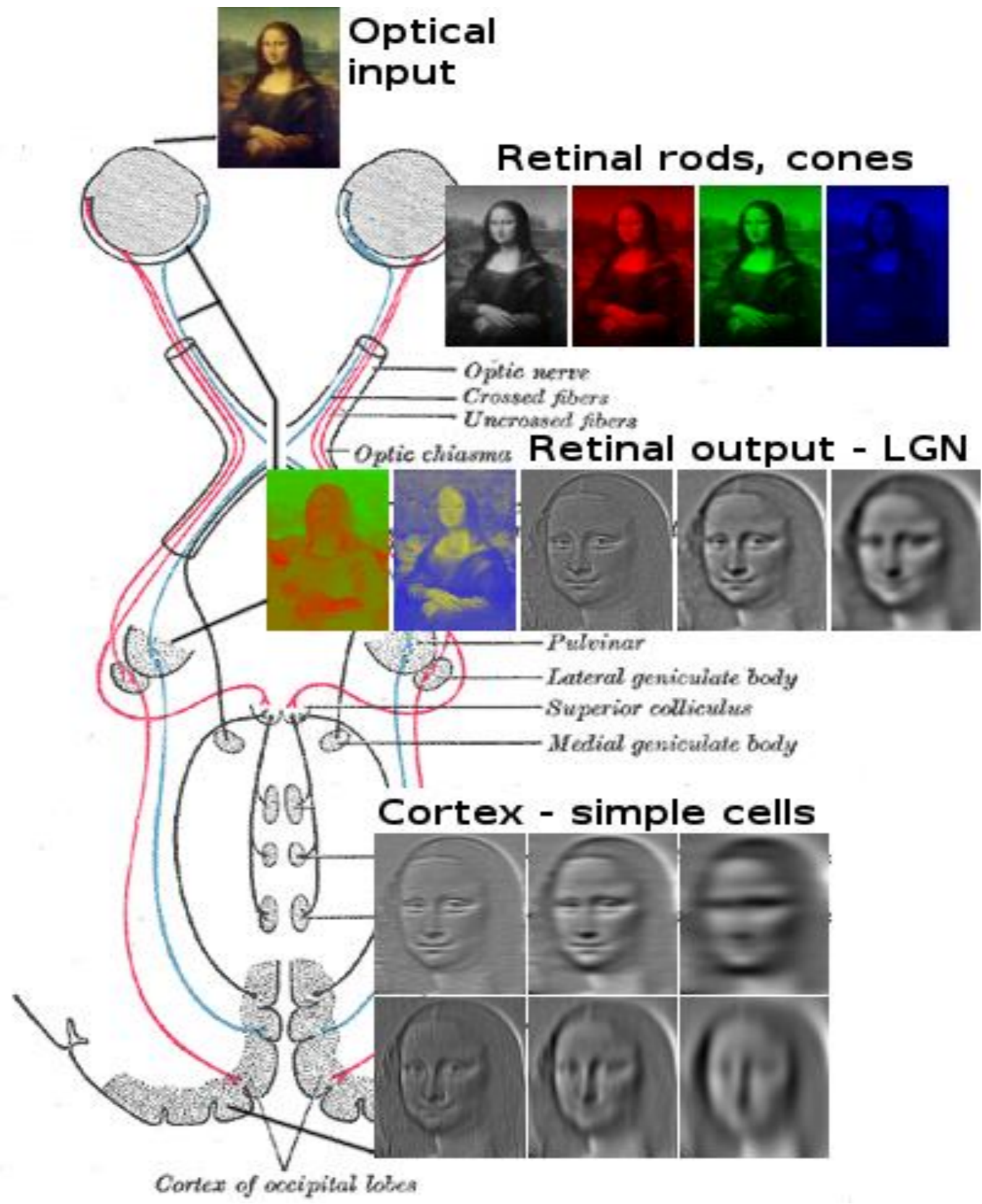


# Primary Visual Cortex (v1)



- Largest area in the visual cortex.
- 100 times as many neurons as retinal ganglion cells  
→ Overcomplete representation.





[https://en.wikipedia.org/wiki/Visual\\_system](https://en.wikipedia.org/wiki/Visual_system)

# Human Vision

## **It Works!!**

--> Proof of existence.

- The image formation process is well understood
- The image understanding one remains mysterious



# Biological Paradigm

## **Pros:**

- Works better than any algorithm we have ever designed.

## **Con:**

- Developed by Evolution over a long period of time under different constraints.
- We don't really understand it.

→ Possible synergy between computer vision research and psychophysics.



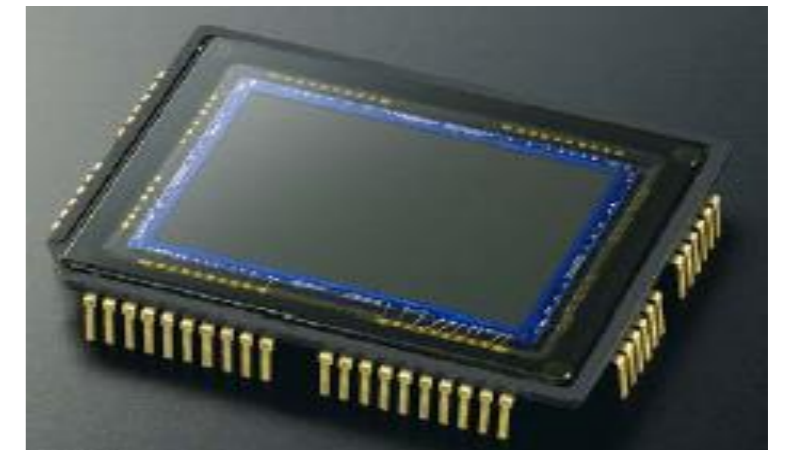
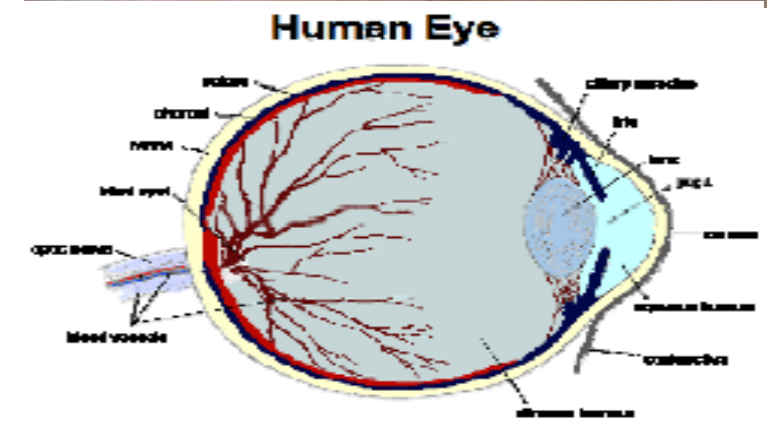
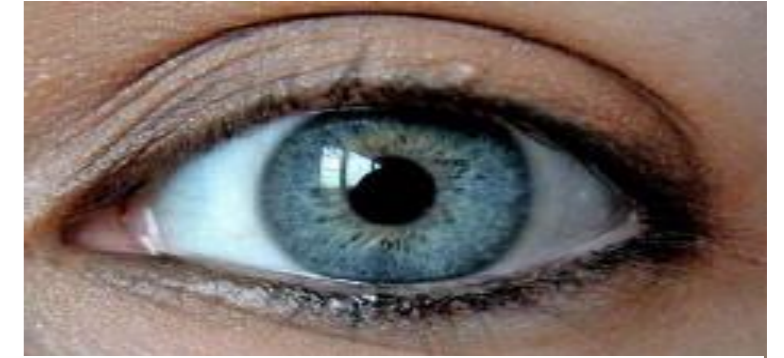
# Human vs Computer Vision

The camera replaces the eye:

- Eye lens → Camera Optics
- Cones and Rods → CCD array
- Ganglion cells → Filter banks

The computer replaces the brain:

- But how?



# To Do

- **Reading**

- Required

- [https://en.wikipedia.org/wiki/Visual\\_system](https://en.wikipedia.org/wiki/Visual_system)
    - [https://en.wikipedia.org/wiki/Visual\\_perception](https://en.wikipedia.org/wiki/Visual_perception)



# Acknowledgement

- Mostly Slides taken from “**Computer Vision**” course by Dr. Naeem Akhter, PIEAS.

