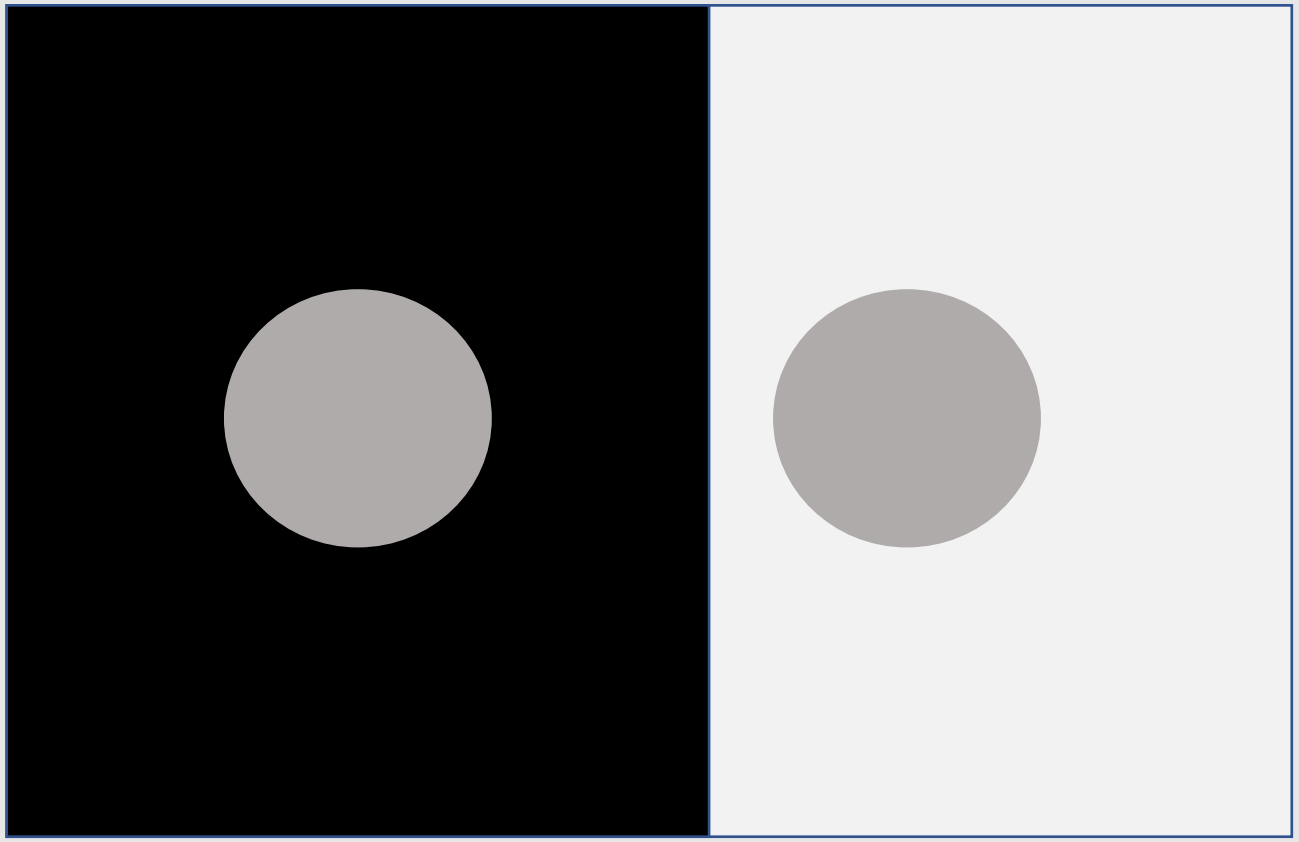
Visual System
Eye to Brain
Perception & the visual system?

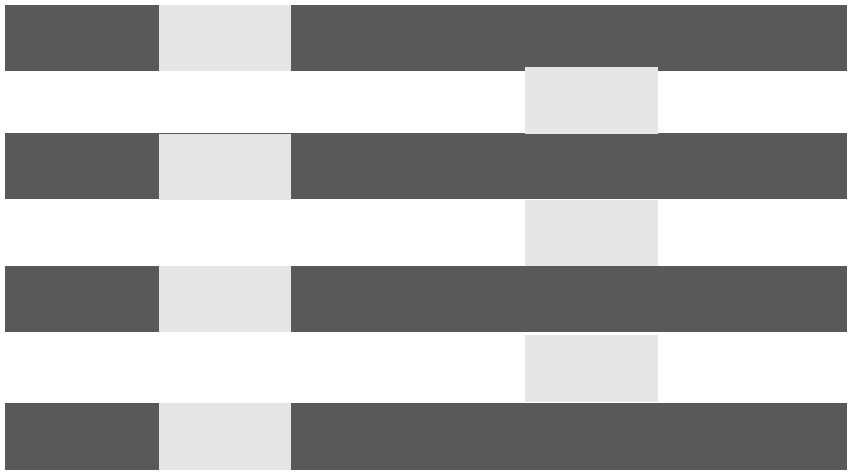
# The visual system

- Light/brightness/luminance/illuminance
- Color
- Shapes - size
- Depth
- Motion
- Texture
- ??

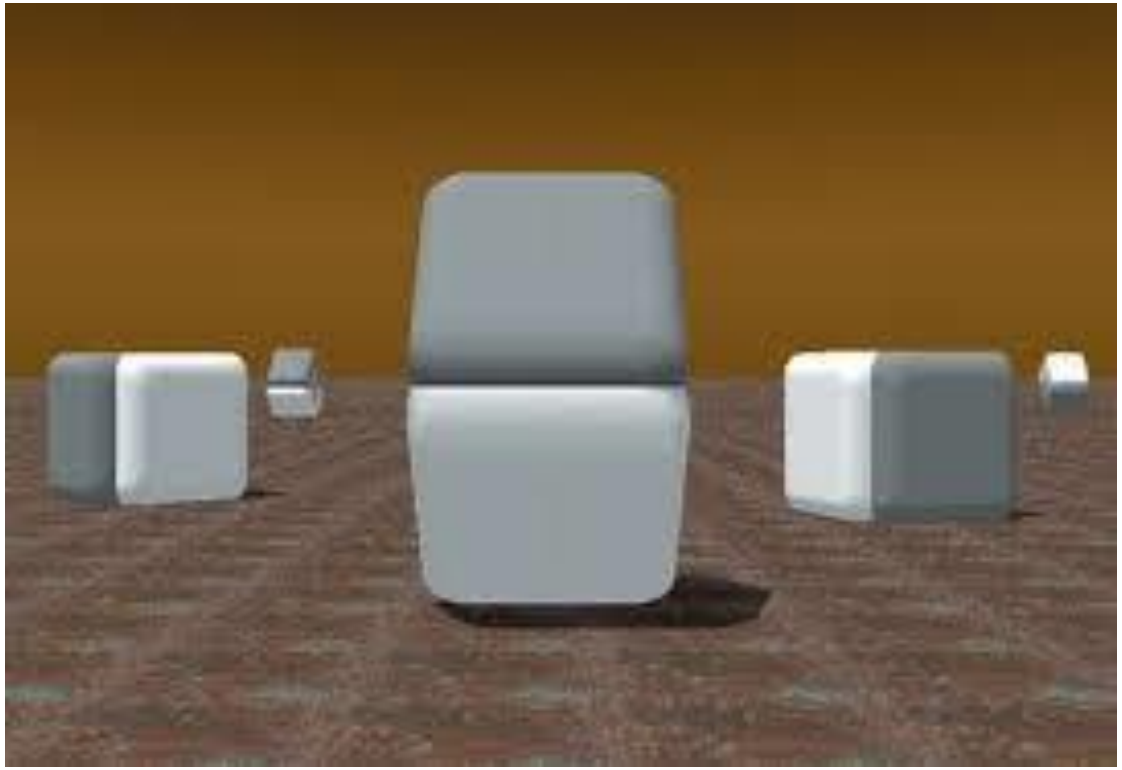
David Katz, a German psychologist. His World of Color, published in German in 1911, and in English in 1935, ranks in importance to the art of color with the works of Goethe, Chevreul and Rood. Wrote Katz: 'The way in which we see the color of a surface is in large measure independent of the intensity and wavelength of the light it reflects'. With this, Katz opened a new door into color expression

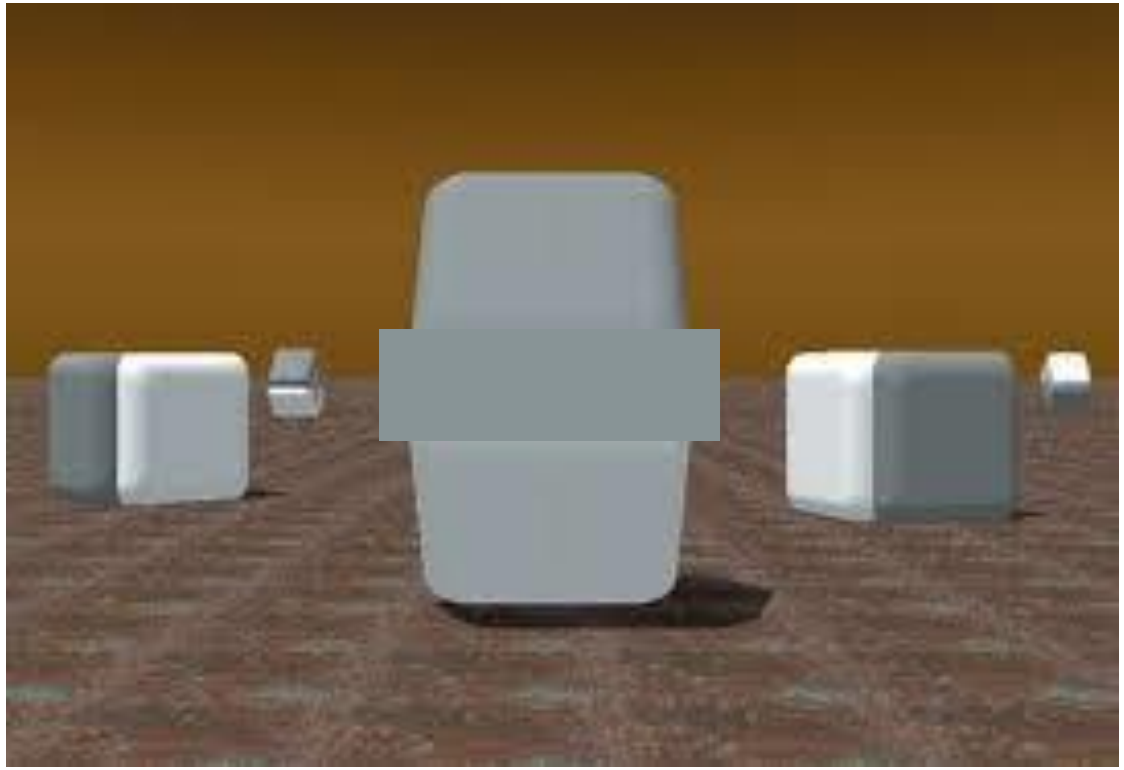


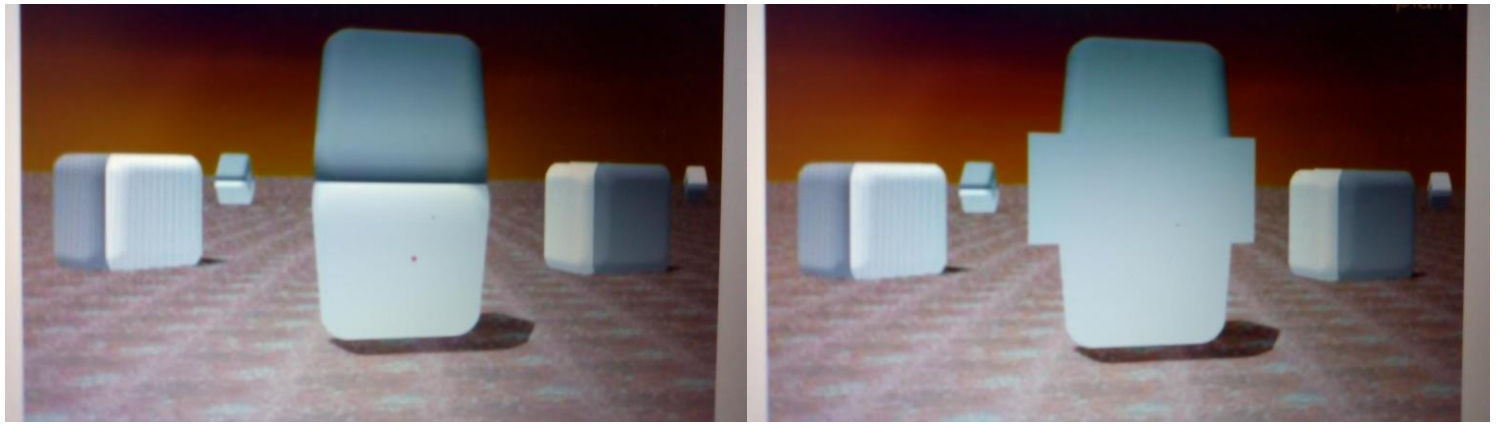
White’s Illusion



# Cornsweet Edge

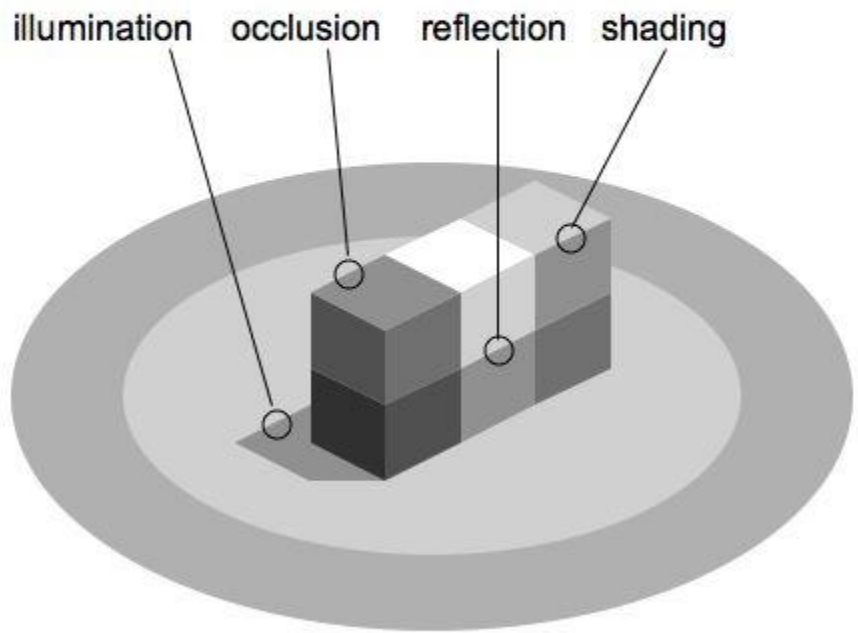




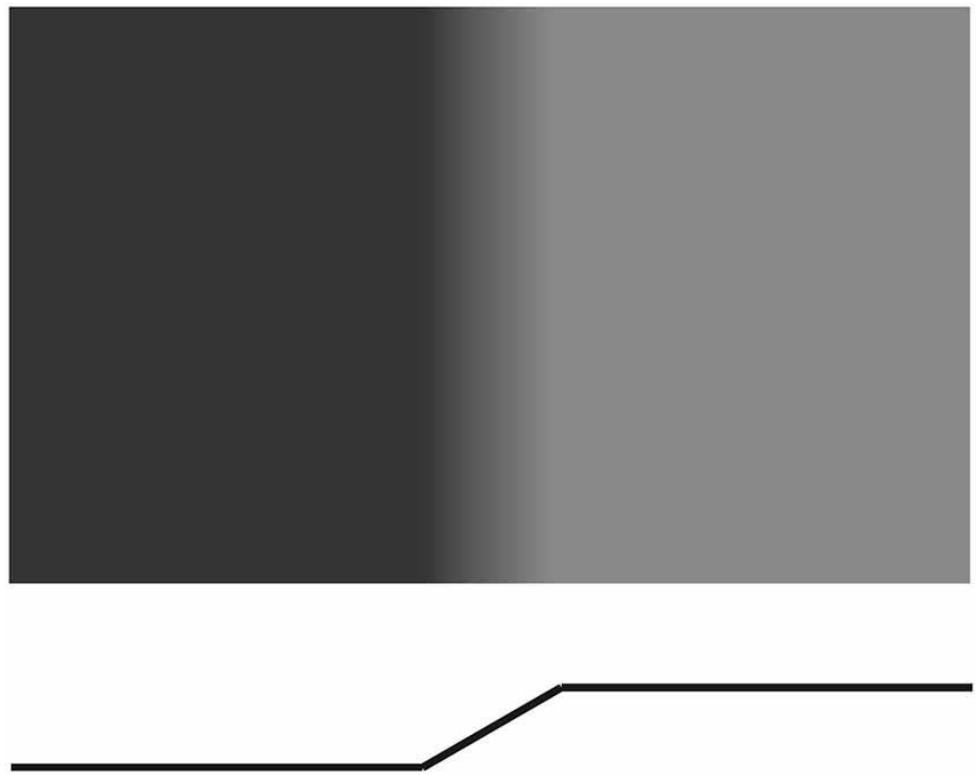


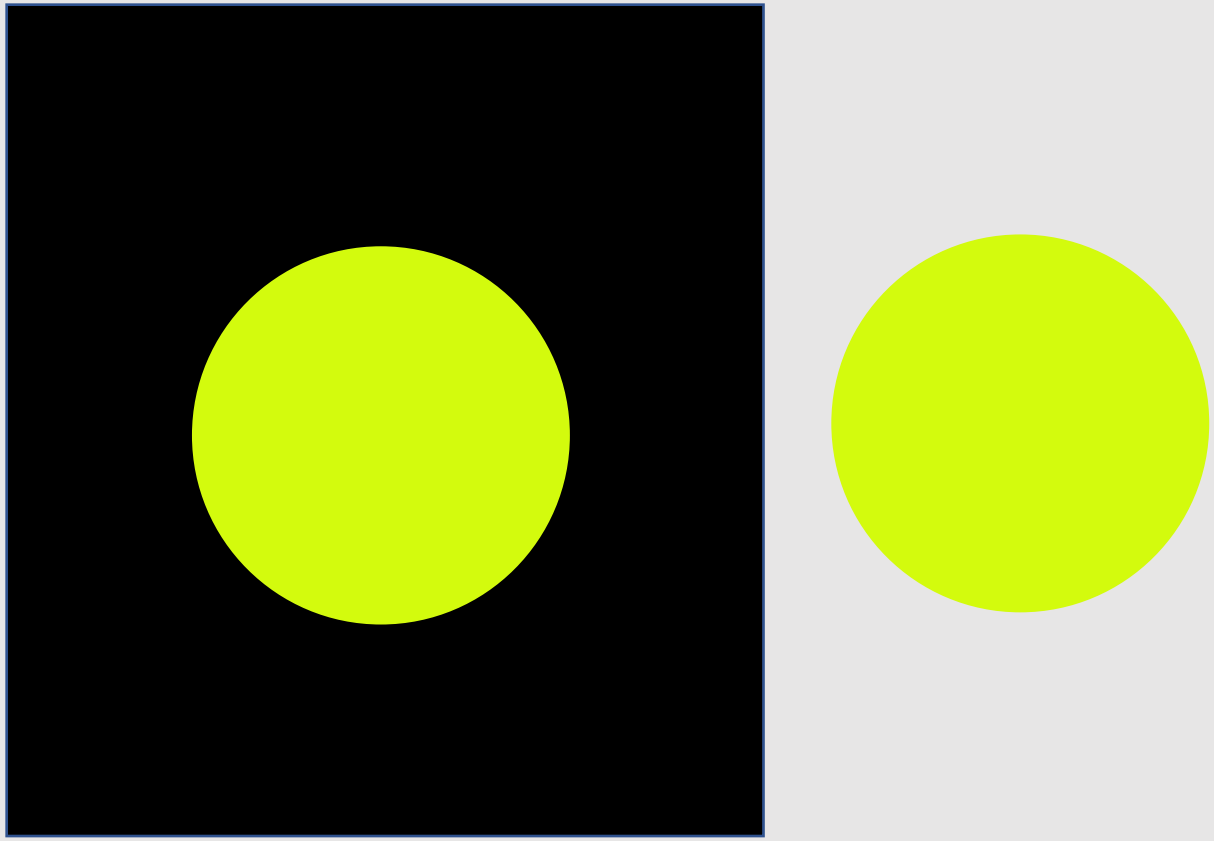
Photograph of the pic on the computer screen

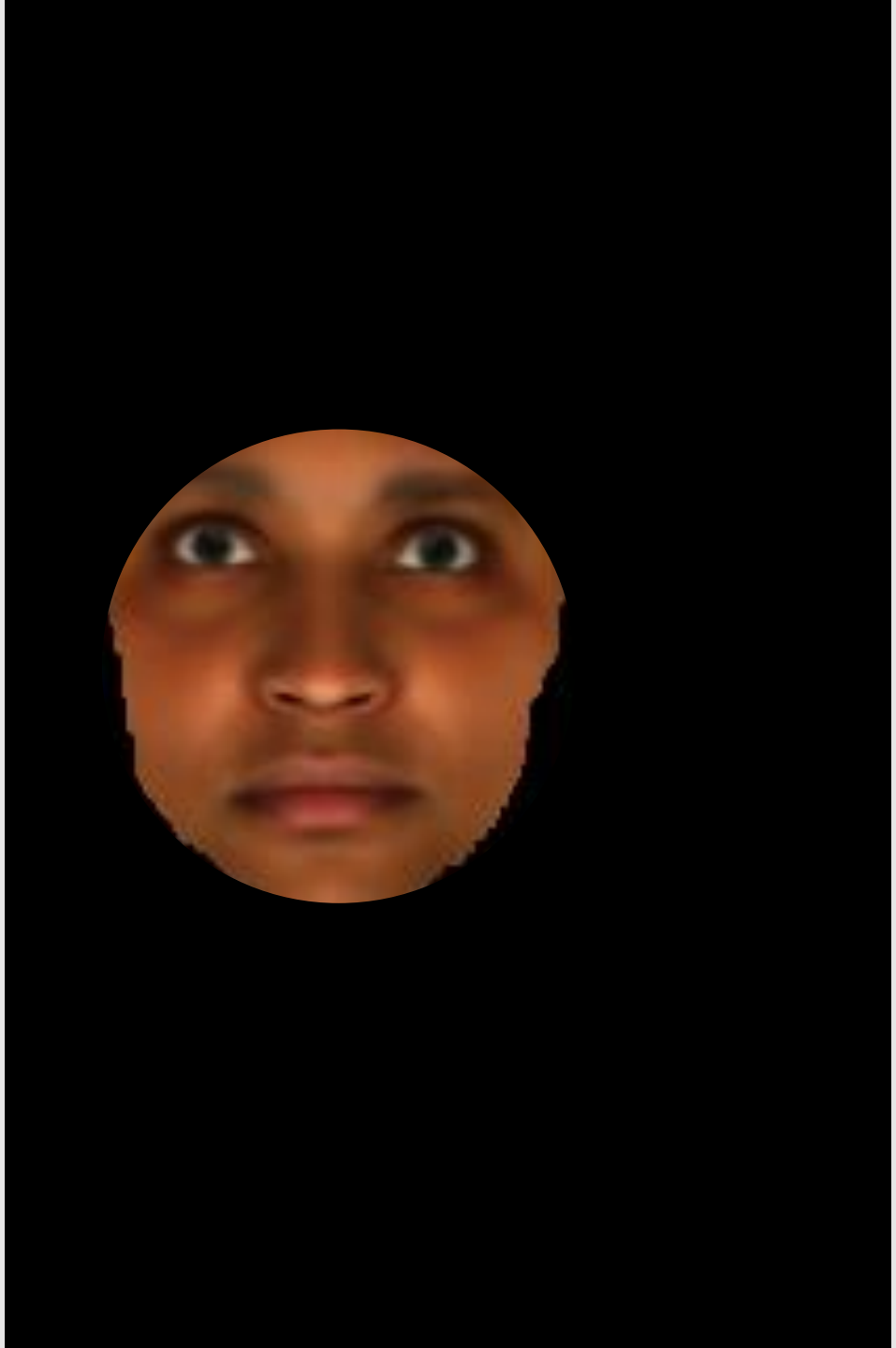
# Shading, reflection, and illumination

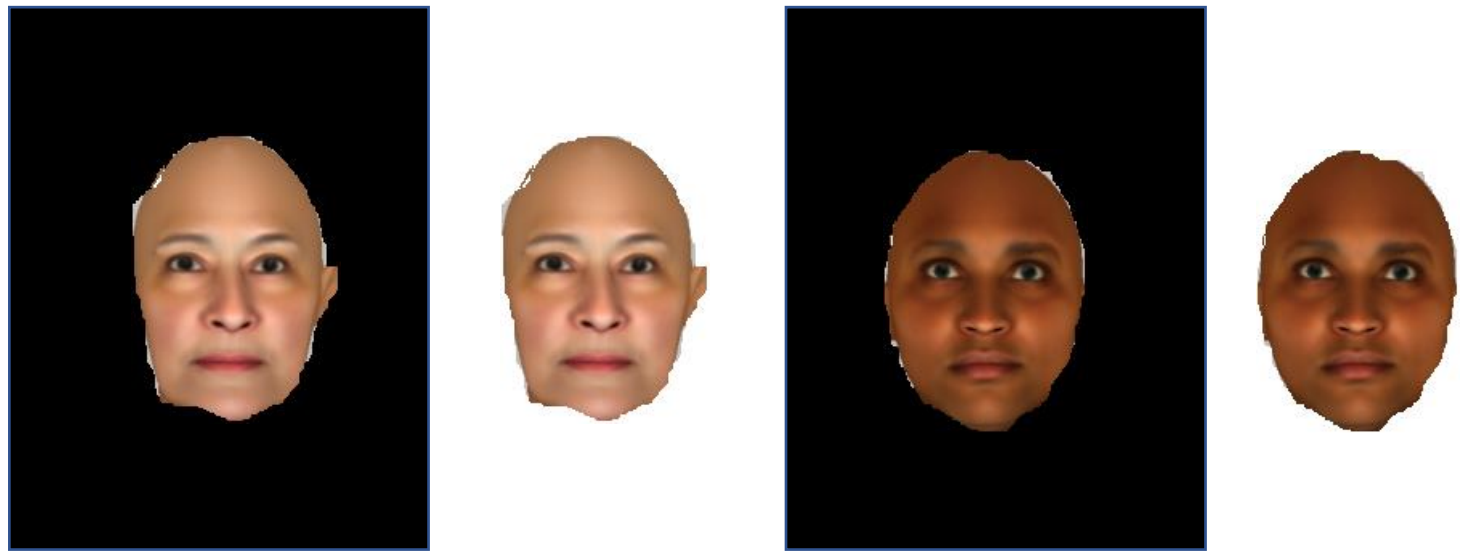



https://www.cns.nyu.edu/~david/courses/perception/lecturenotes/depth/depth-size.html



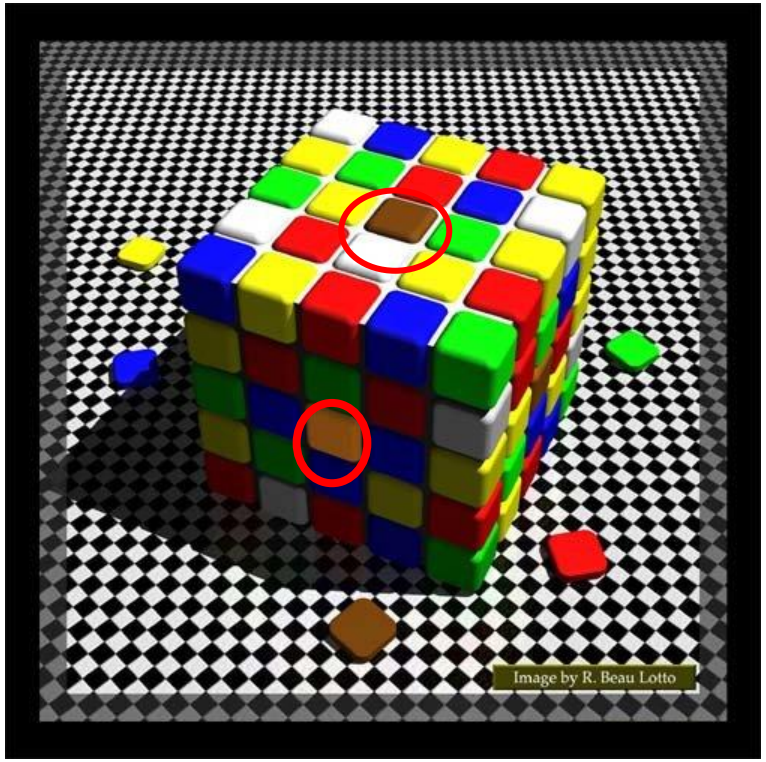






- https://researchweb.iiit.ac.in/~saksham.agrawal/honors/blue_eyes

- https://michaelbach.de/ot/col-context/index.html

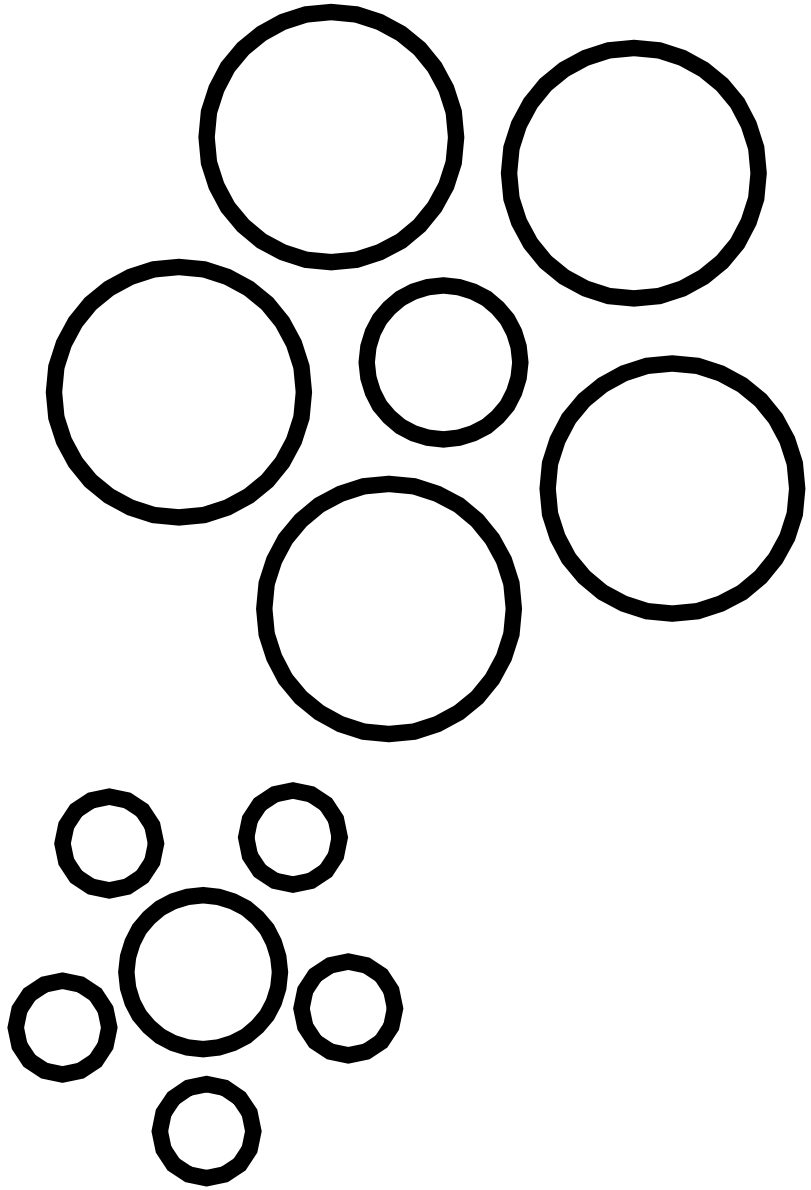


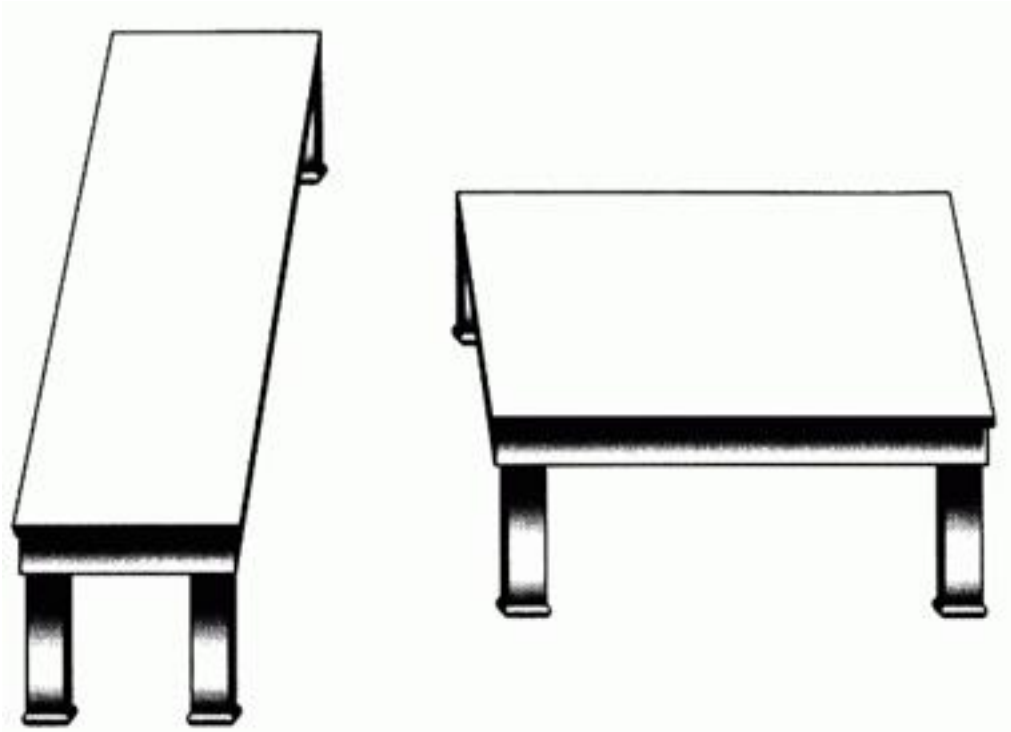

HSL : 19,185,70

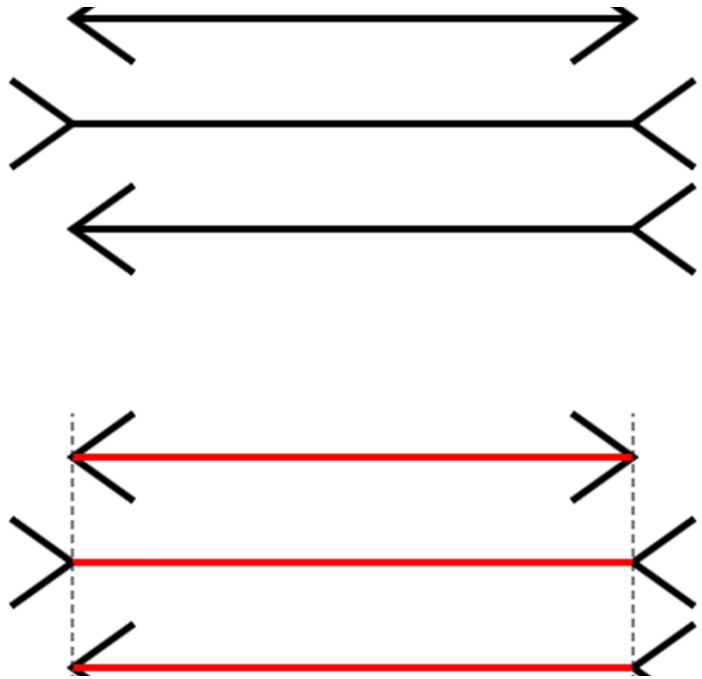
Depth Perception

https://www.youtube.com/watch?v=WanGt1G6ScA

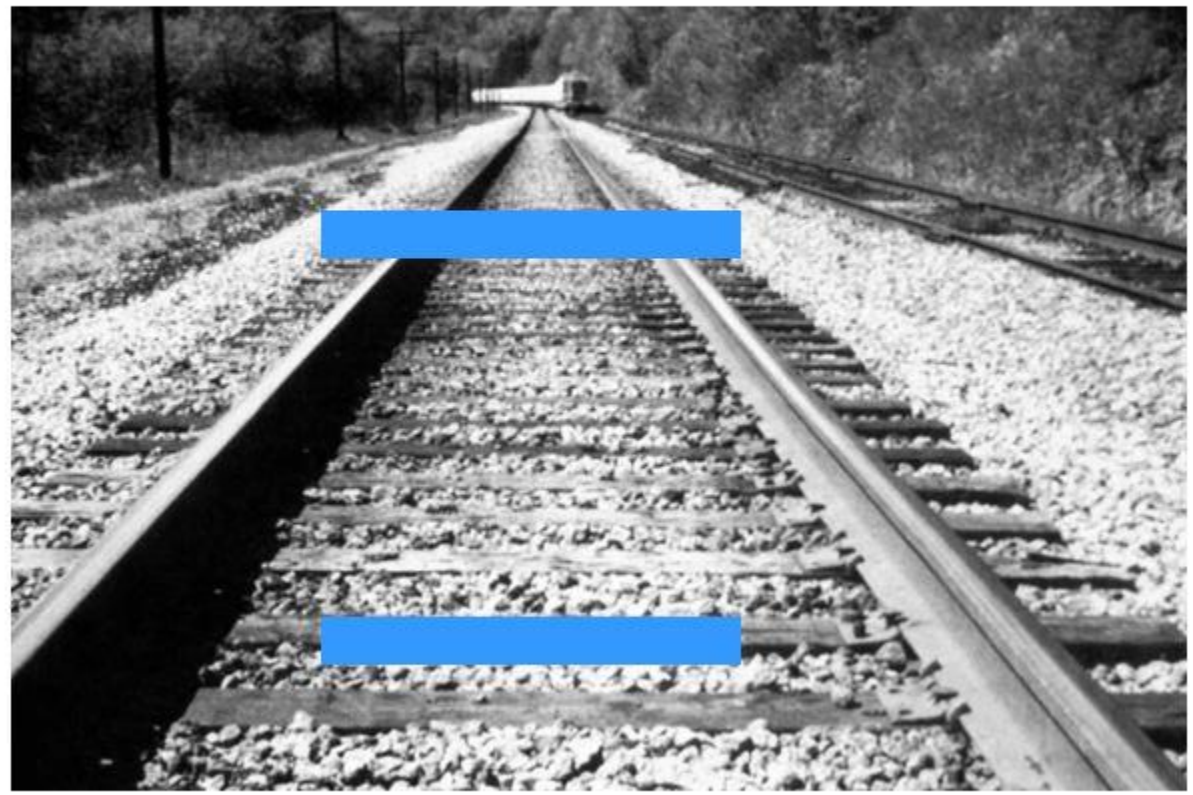
Shapes



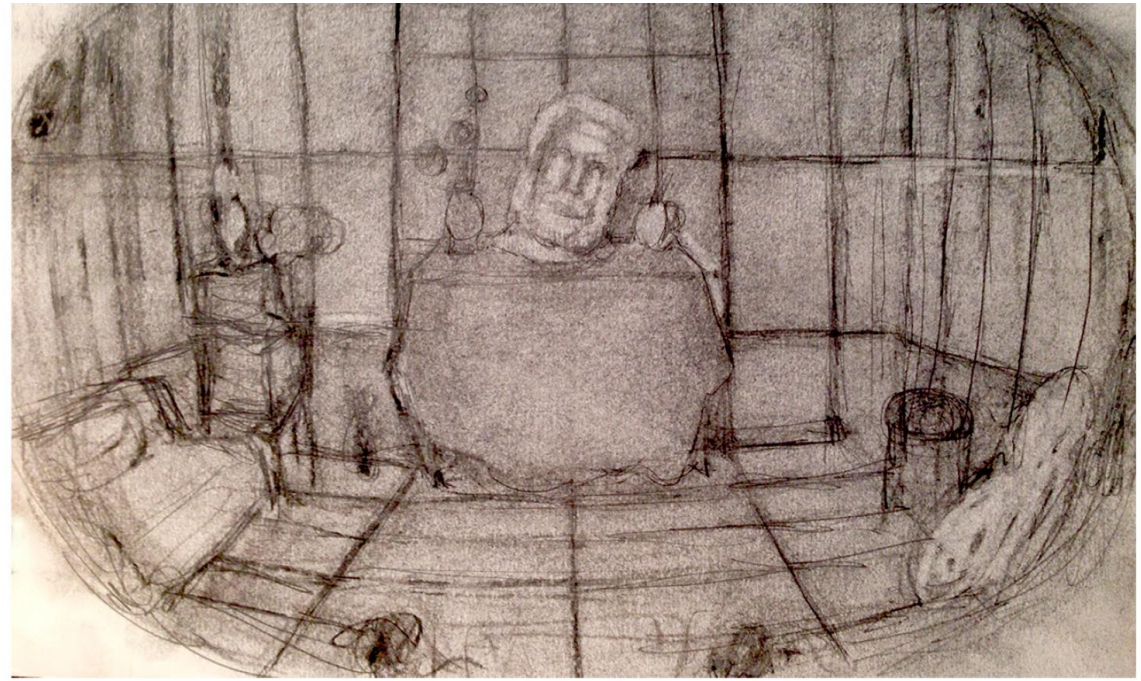


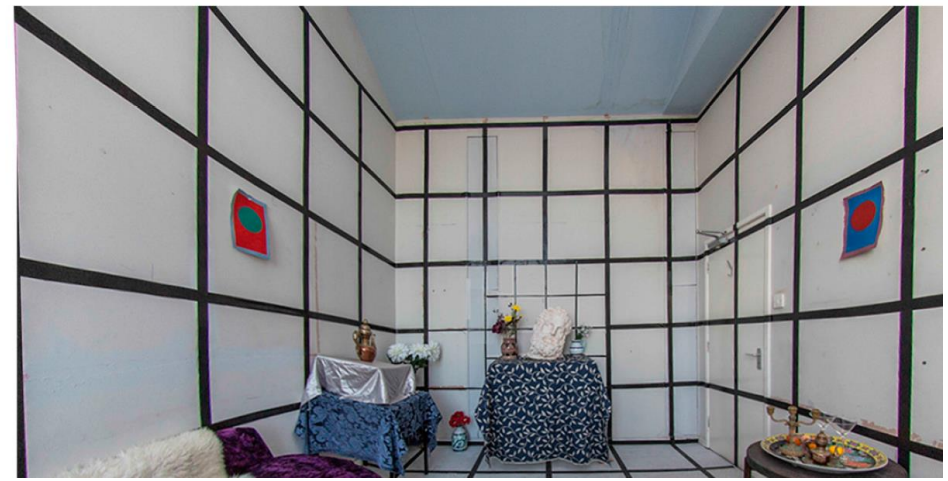


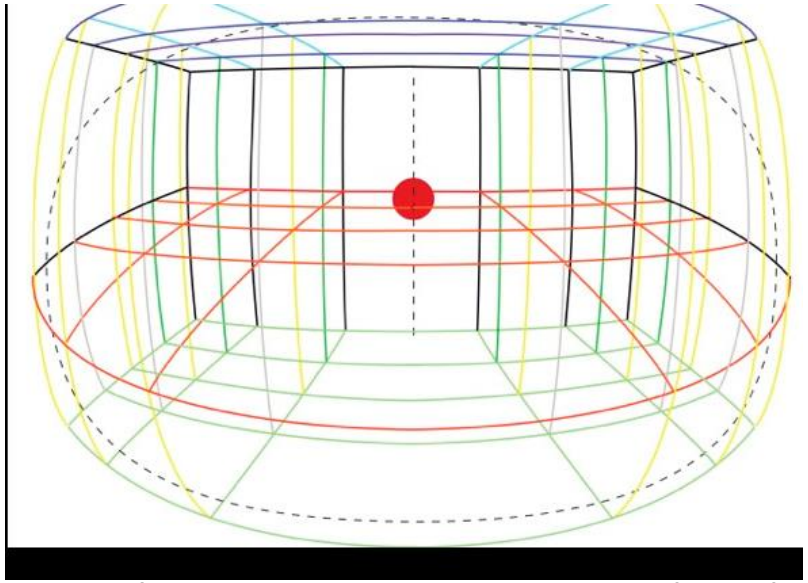
# Linear perspective



https://www.cns.nyu.edu/~david/courses/perception/lecturenotes/depth/depth-size.html

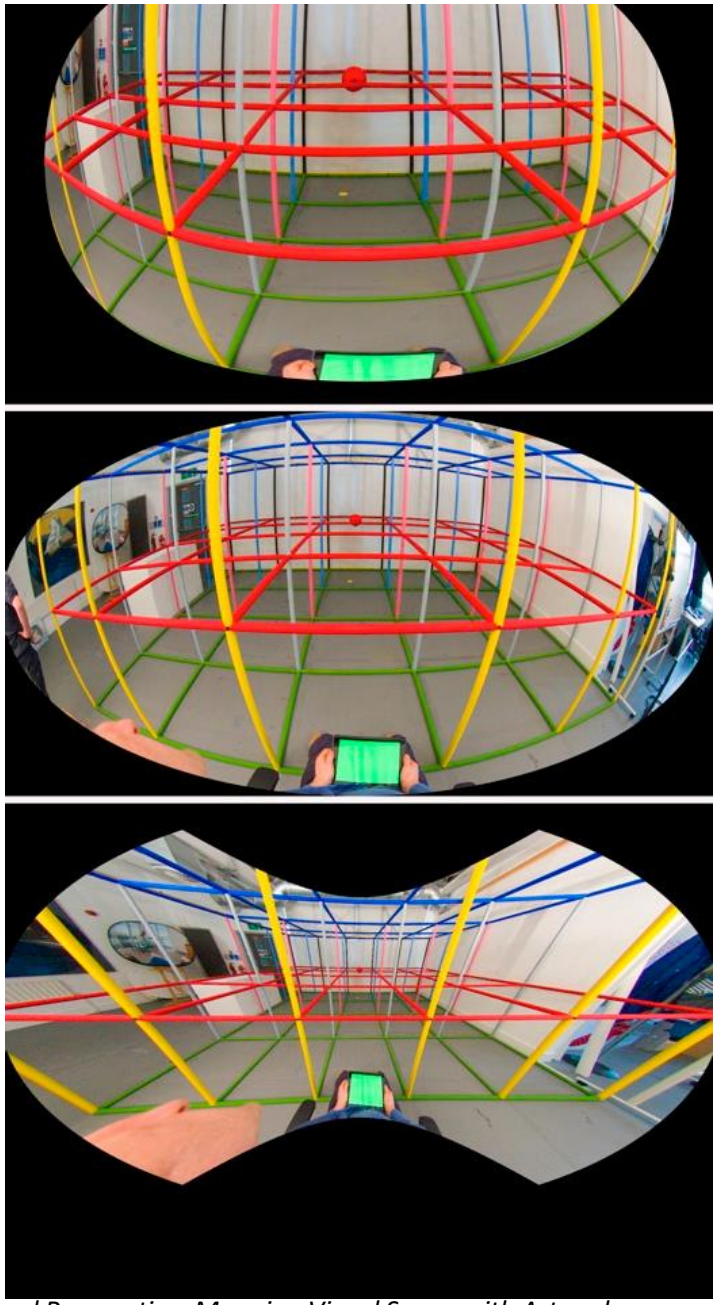






Natural Perspective Depiction, as done by an artist

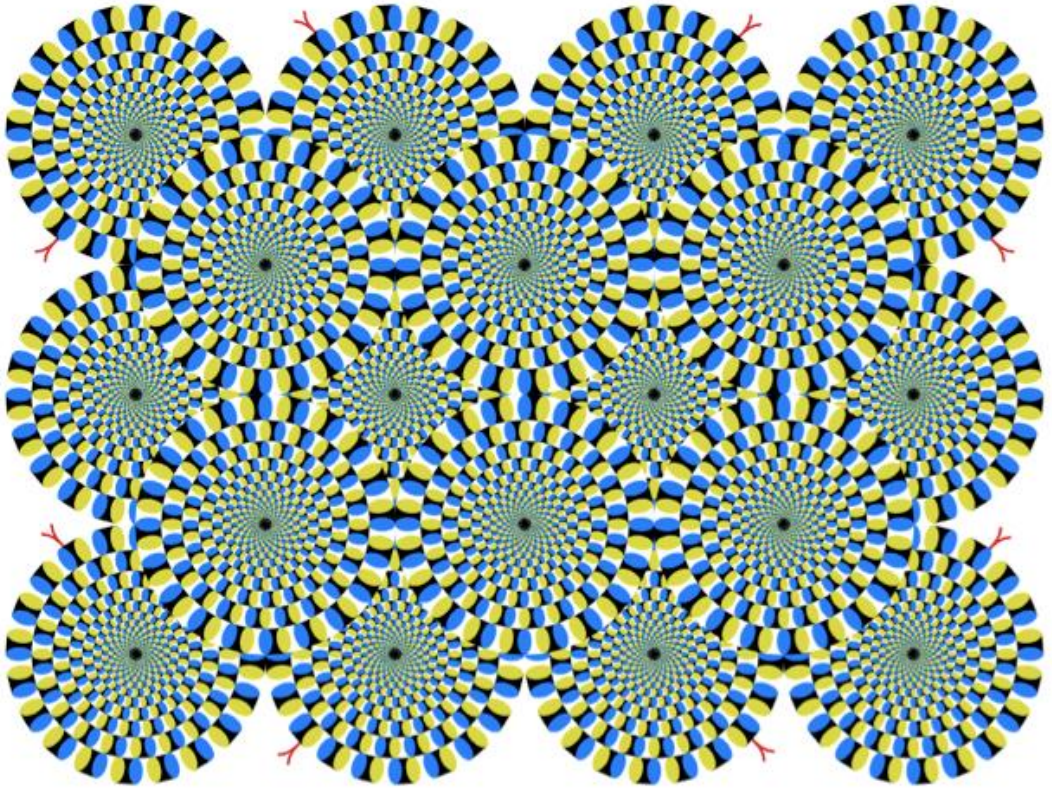
Photograph
1. Natural
2. Fisheye
3. Linear



*Burleigh, A., Pepperell, R. and Ruta, N., 2018. Natural Perspective: Mapping Visual Space with Art and Science. Vision, 2(2), p.21.*

# Motion

barber pole illusion

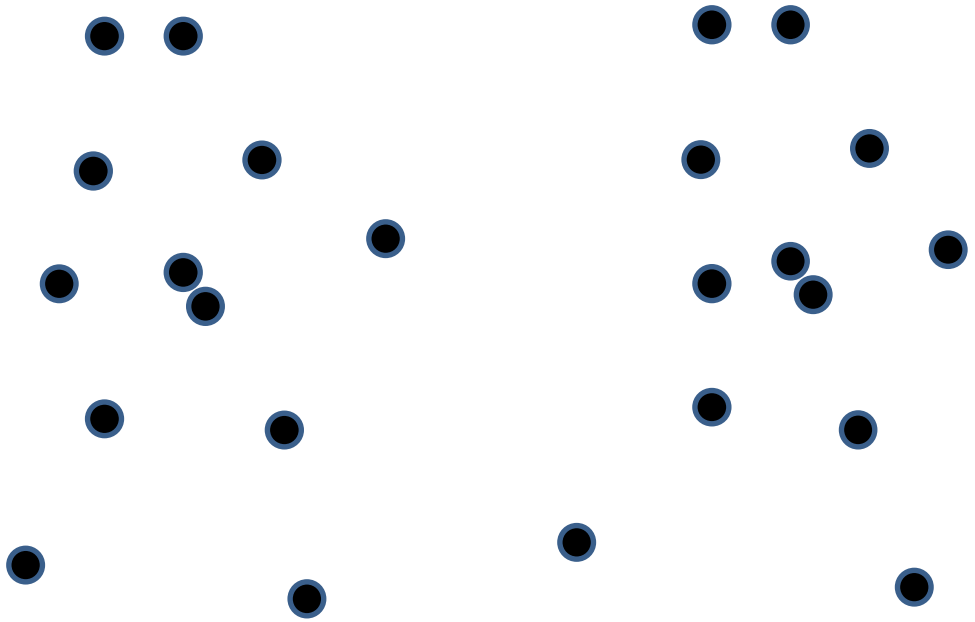


A barber pole is rotated along the x-axis, but the diagonal stripes appear to move along the pole in a vertical fashion (y-axis) that is inconsistent with the actual direction the pole is turning in.

# Motion Perception

- First-order mechanism sensitive to luminance changes
- Second-order motion mechanism sensitive to contrast changes

Reconstructing shape from movement

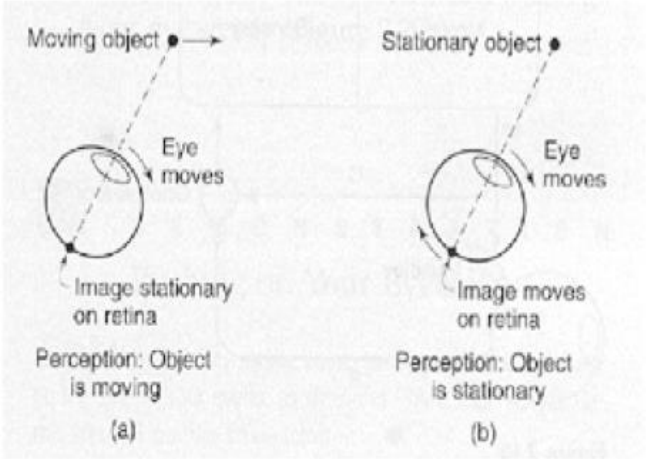


Johansson (1973)

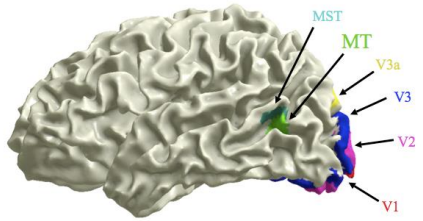
https://www.youtube.com/watch?v=rEVB6kW9p6k

# Eye Movements and Motion

## Visual motion and eye movements



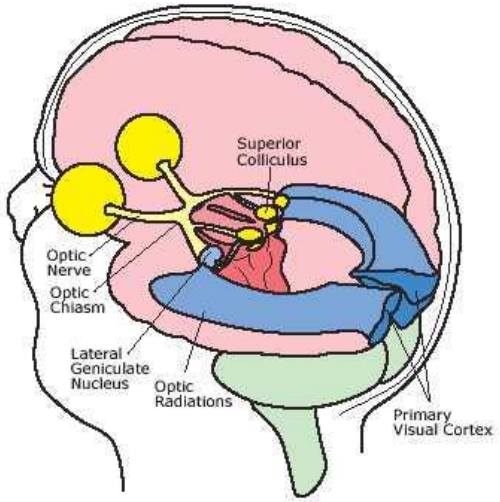

Visual area MT

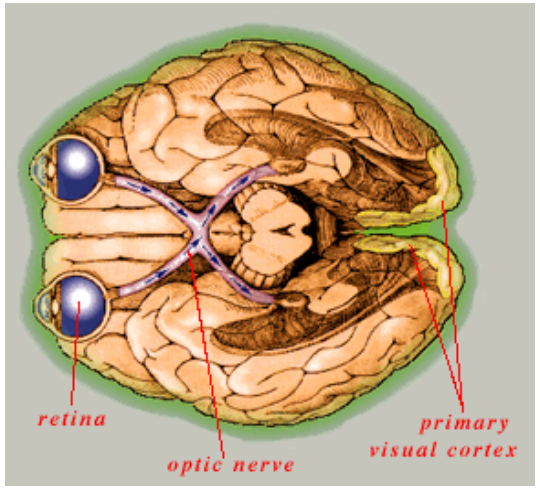


# Visual System

# The Visual System

Both eye and brain are required for functional vision

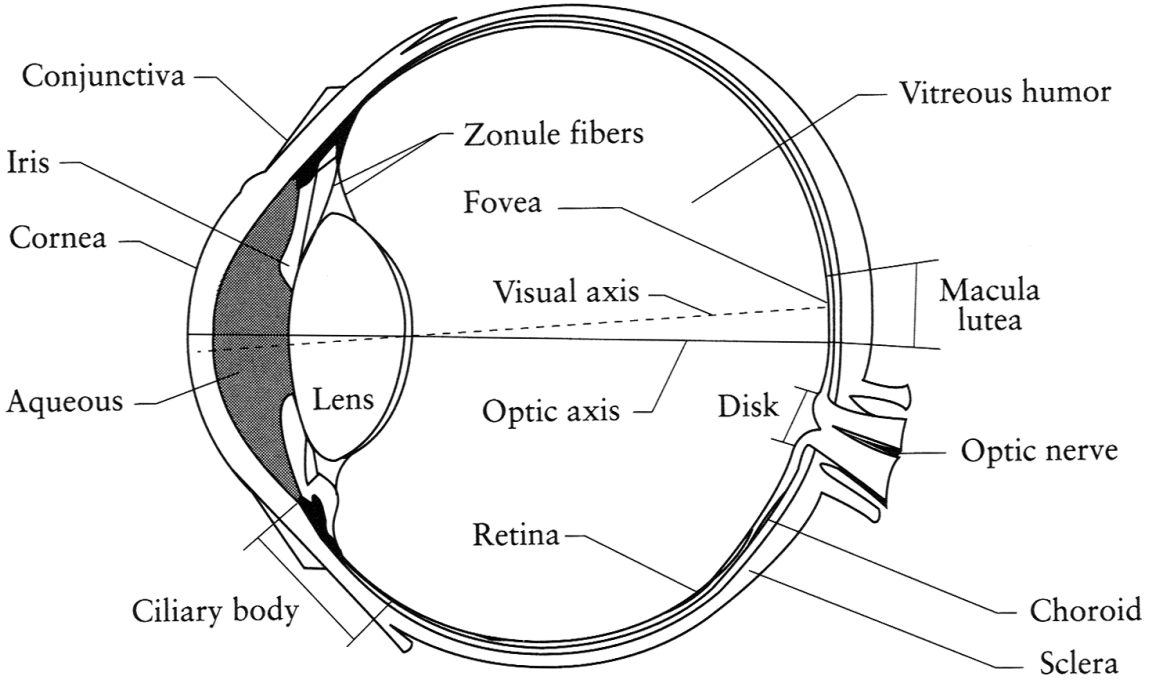



Two kinds of blindness:

- Normal blindness (eye dysfunction)
- Cortical blindness (brain dysfunction)

# The Eye is a camera?

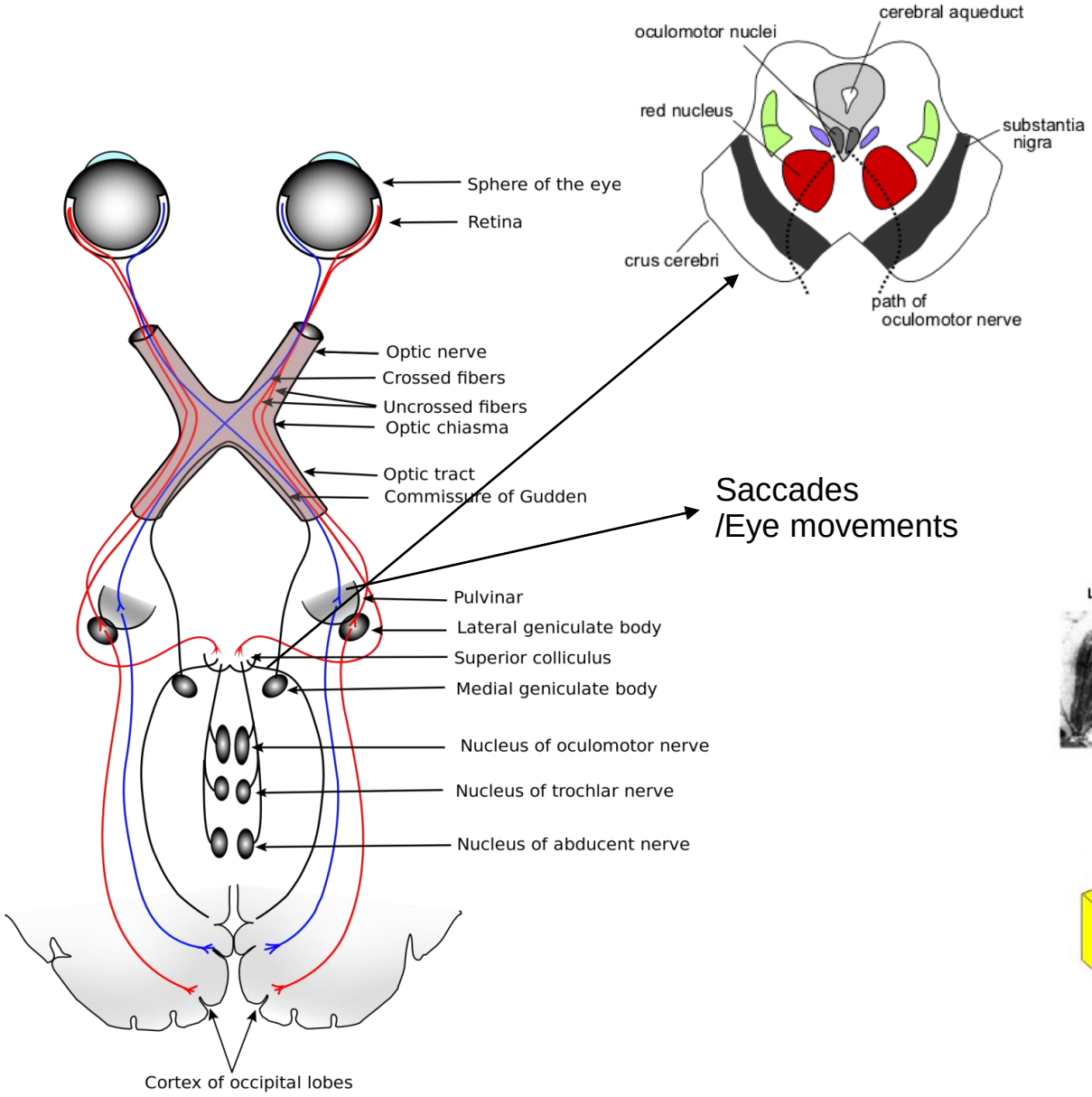



The camera is designed as the eye!

- **Iris** - colored annulus with radial muscles
- **Pupil** - the hole (aperture) whose size is controlled by the iris
- What's the "film"?

  –photoreceptor cells (rods and cones) in the **retina**

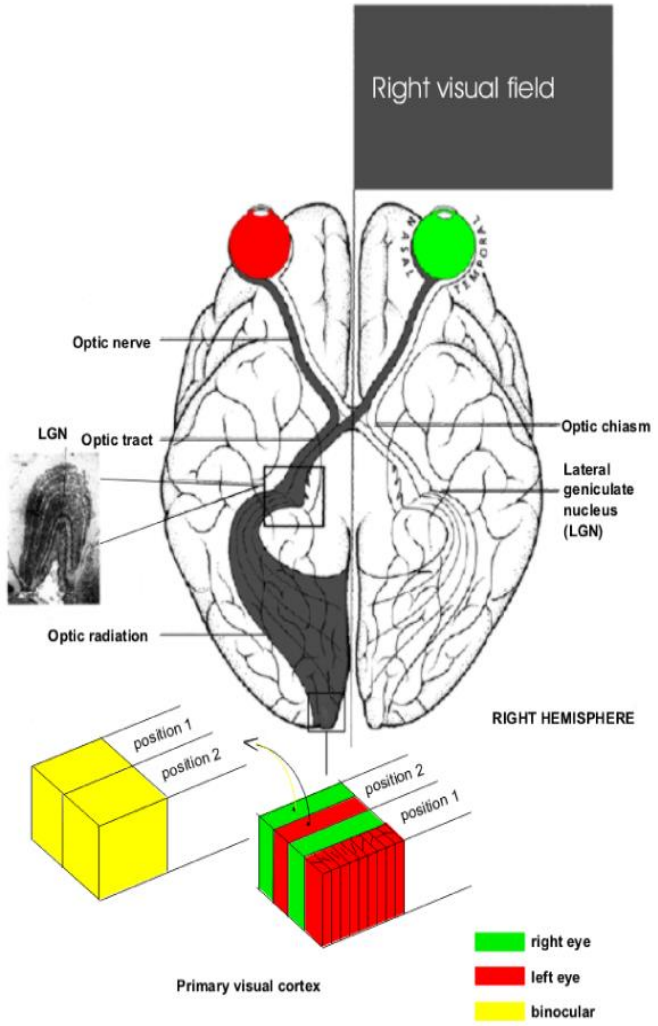
# Pathway to Visual Cortex







Saccades
/Eye movements



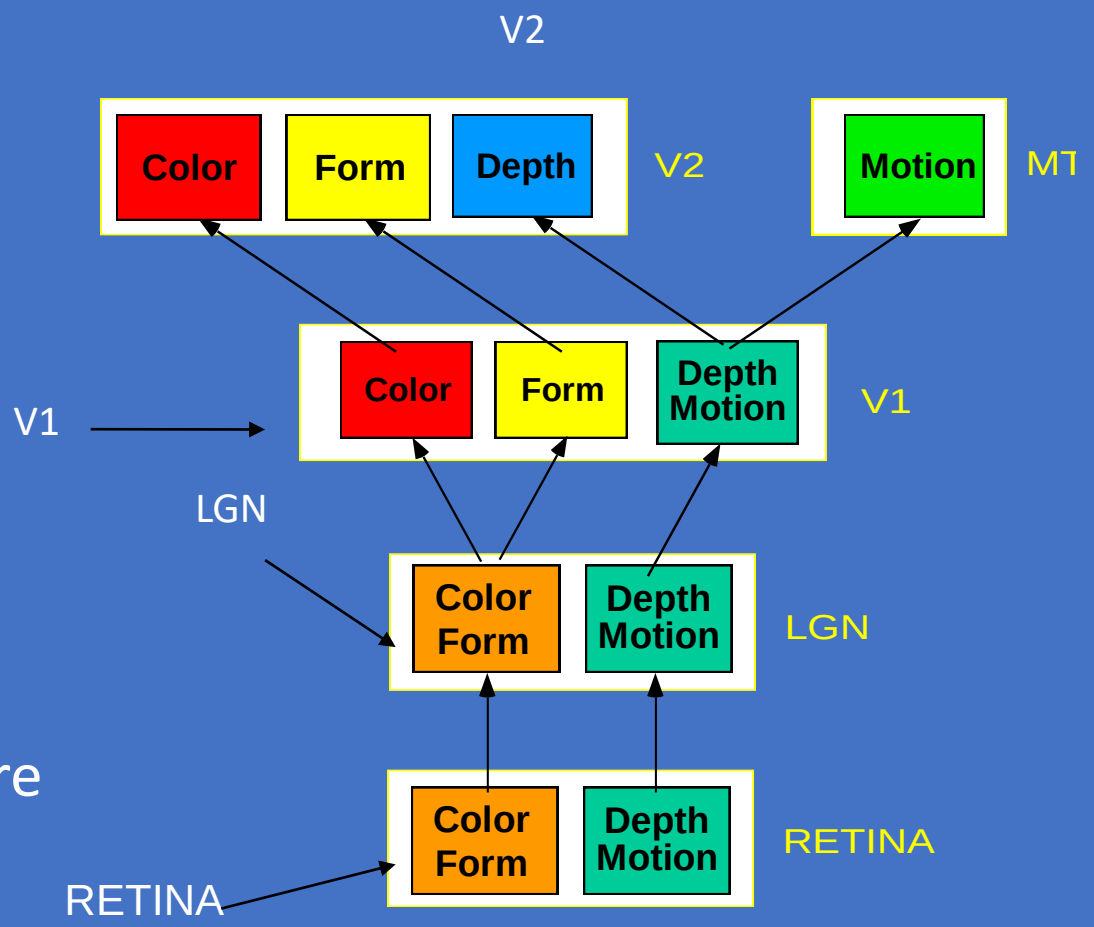
# Feature-based Pathways Hypothesis

**Visual Features**

Color
Shape
Depth
Motion

**Featural Pathways**

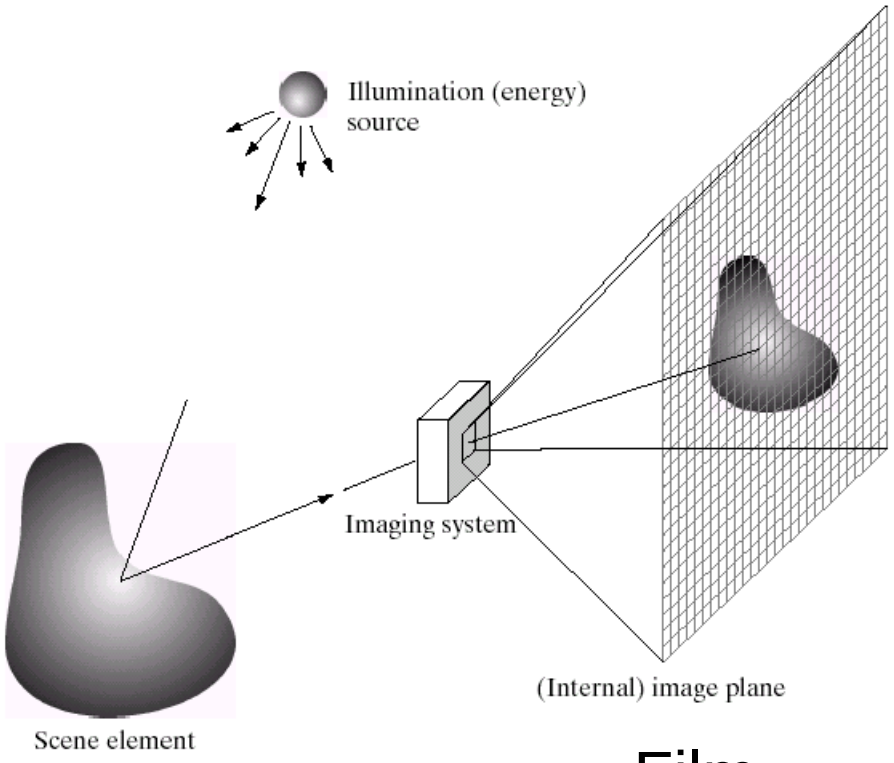
Separate neural pathways in which different features are processed.



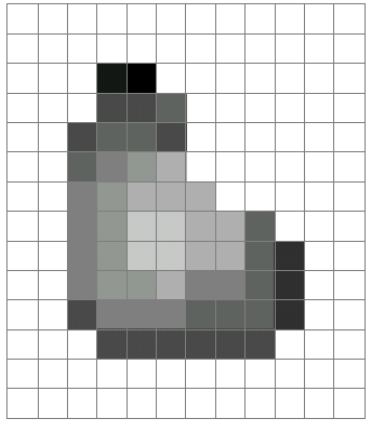



© Stephen E. Palmer, 2002

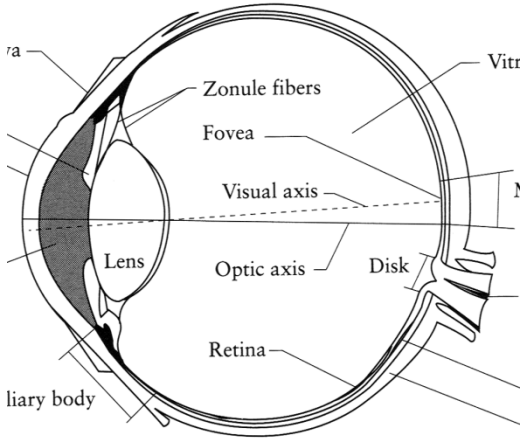
# Image Formation




Film

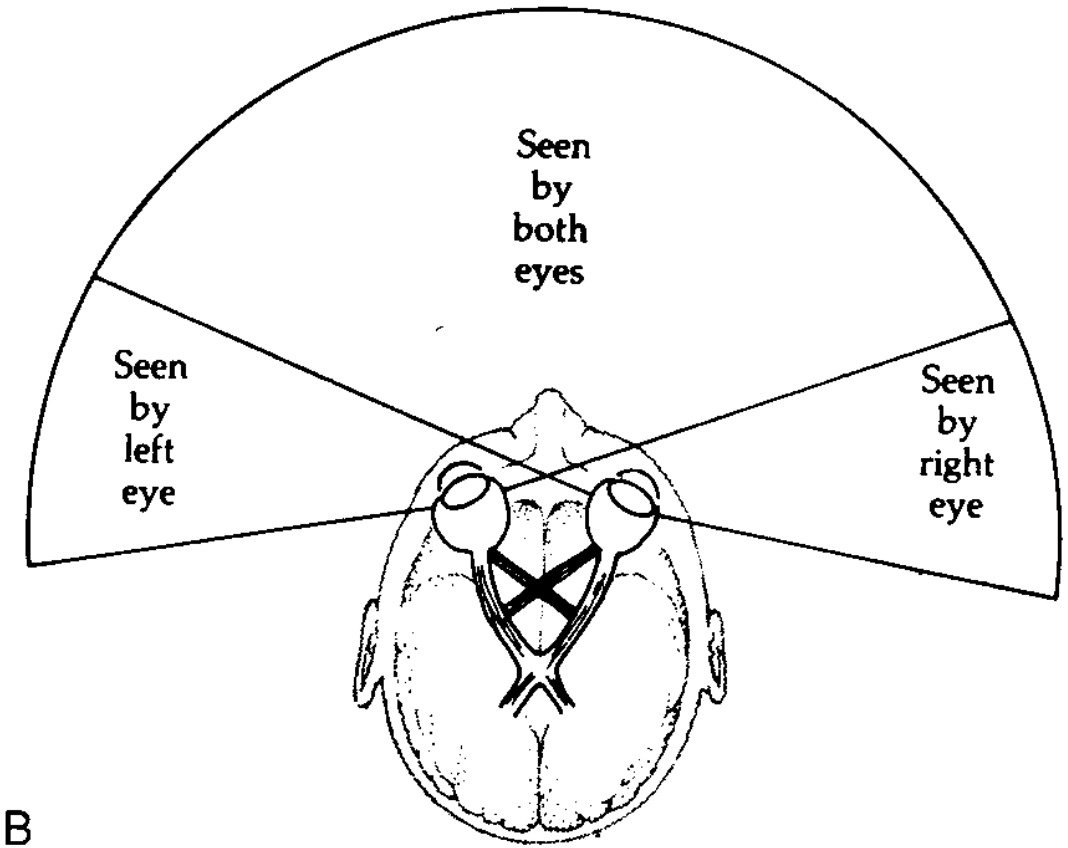


Digital Camera




The Eye

Monocular Visual Field: 160 deg (w) X 135 deg (h)
Binocular Visual Field:  200 deg (w) X 135 deg (h)




B

## ANIMAL VISION – typical ... with two normally functioning eyes

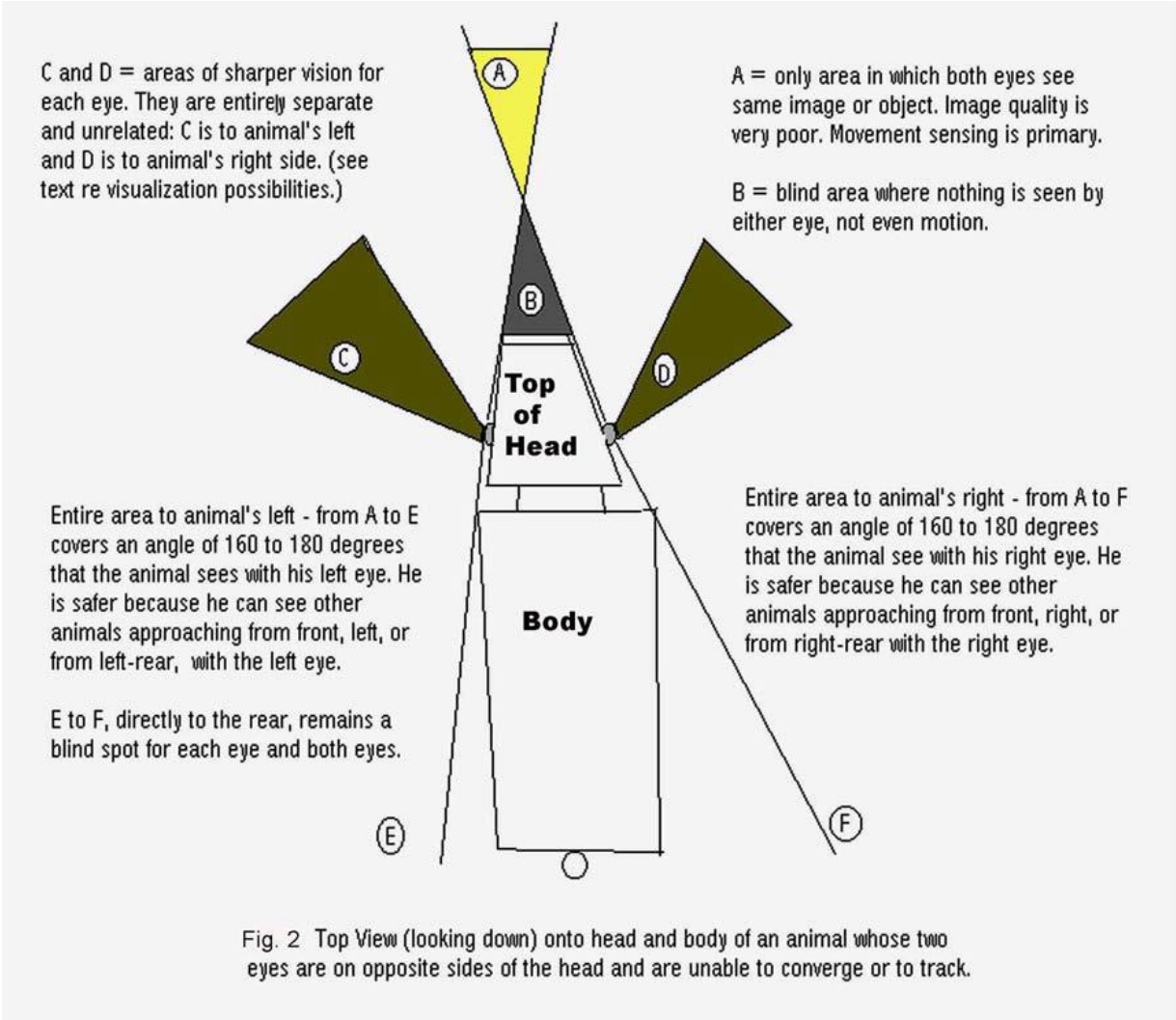
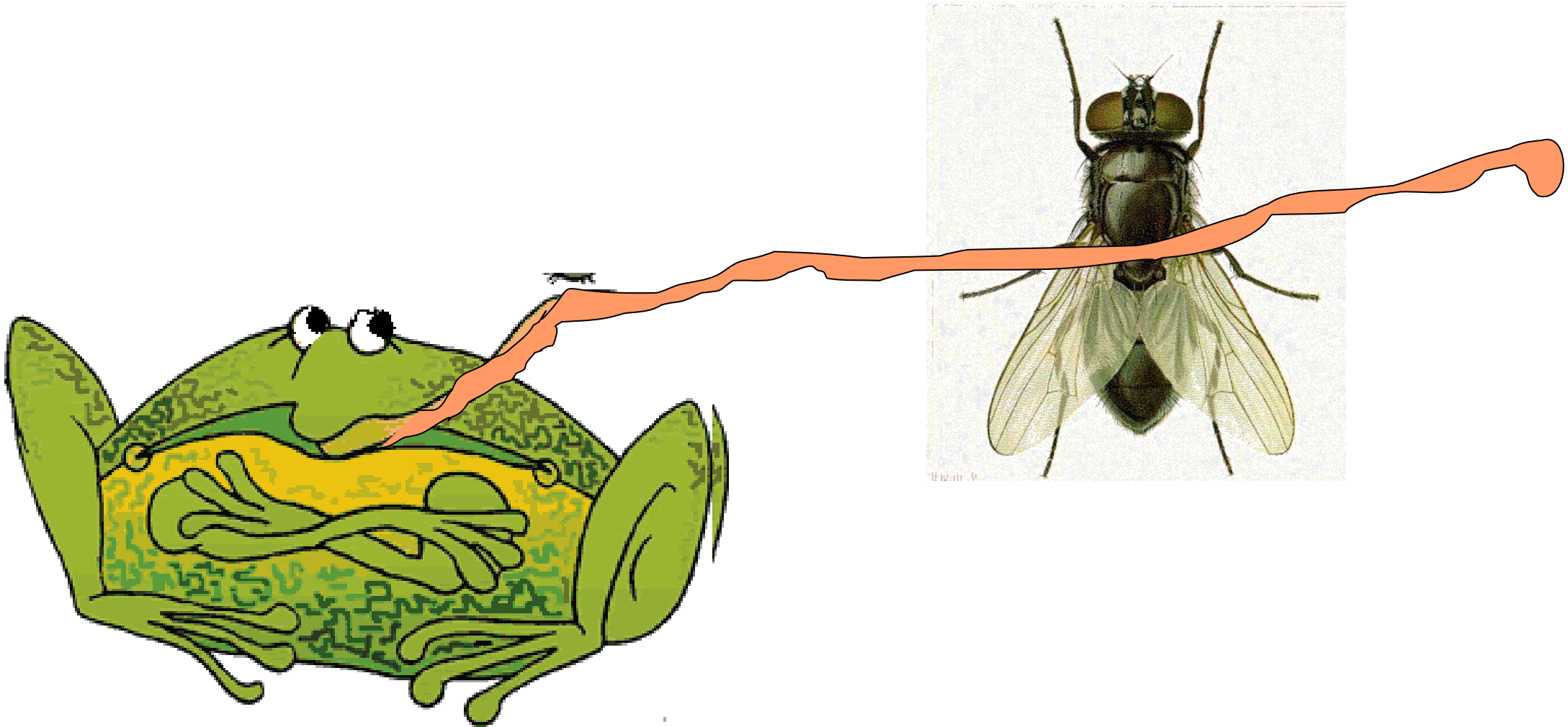
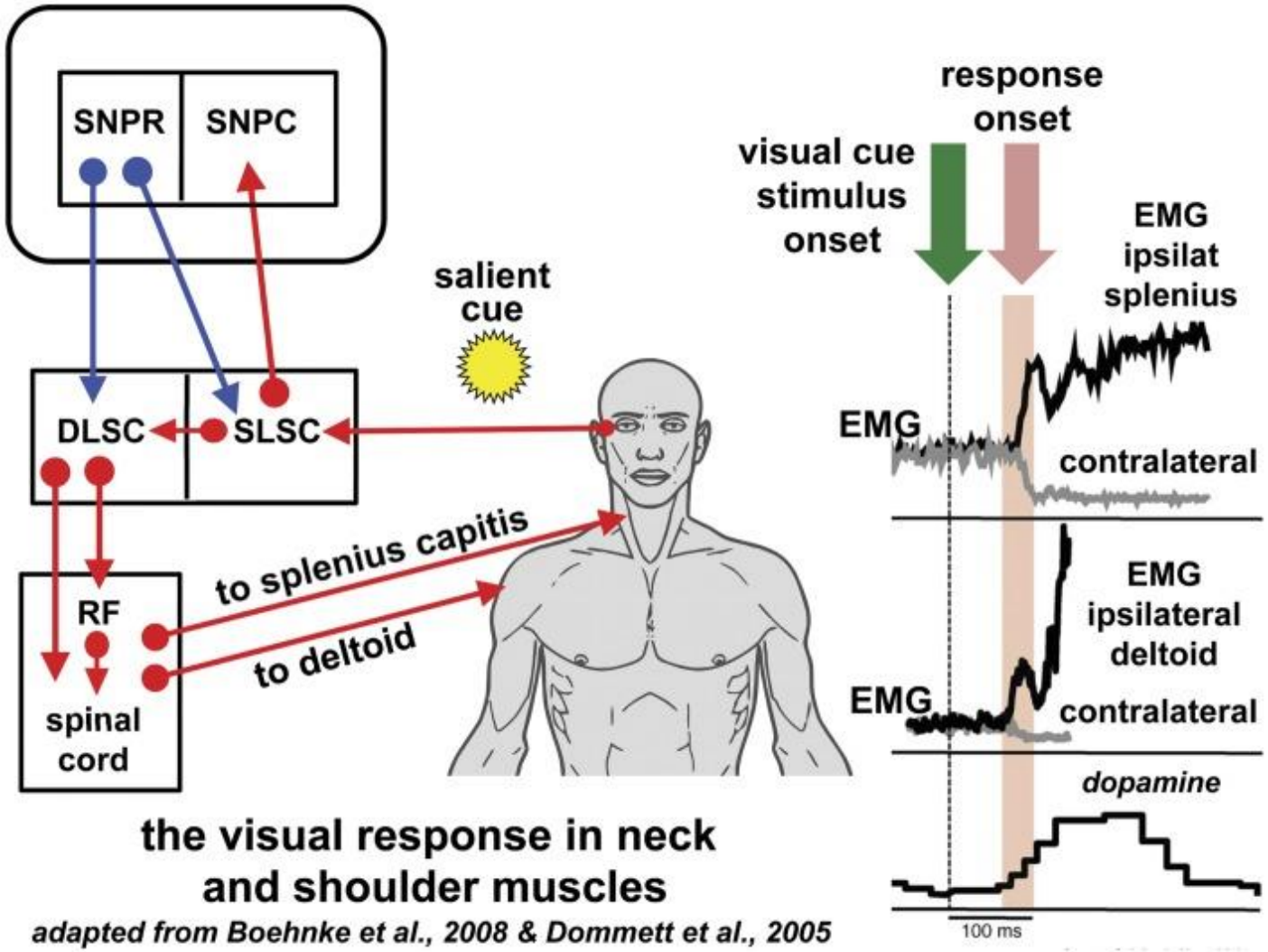



Fig. 2  Top View (looking down) onto head and body of an animal whose two eyes are on opposite sides of the head and are unable to converge or to track.

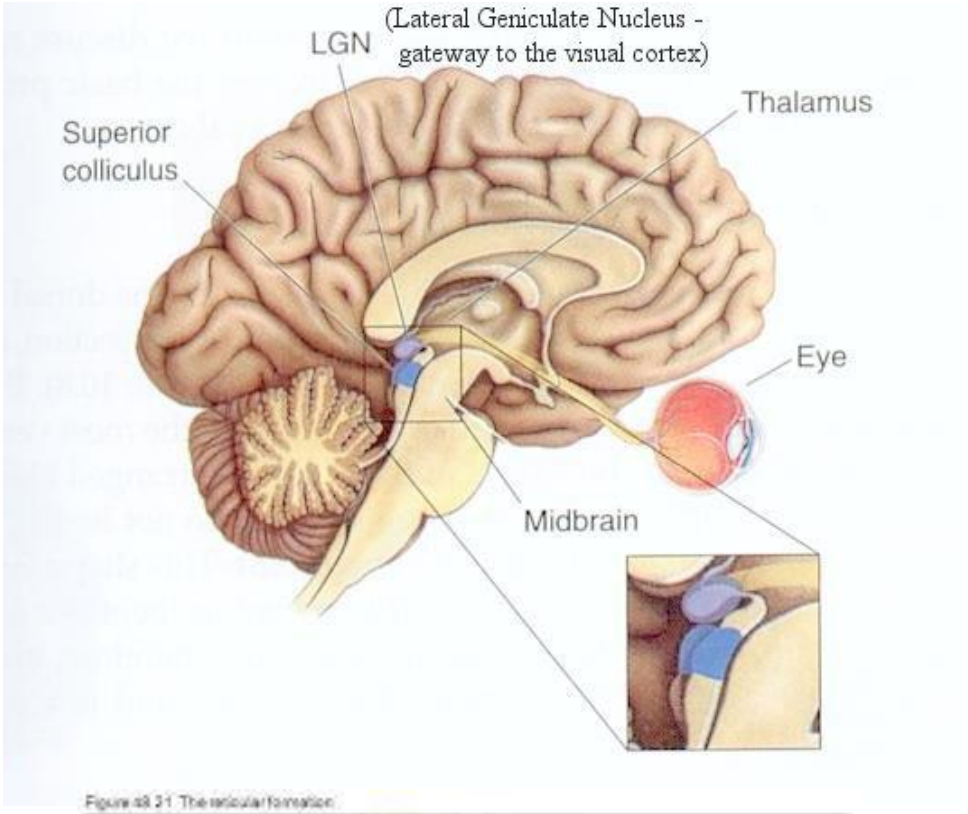
The Visual Grasp Reflex moves the eyes towards a suddenly appearing peripheral signal



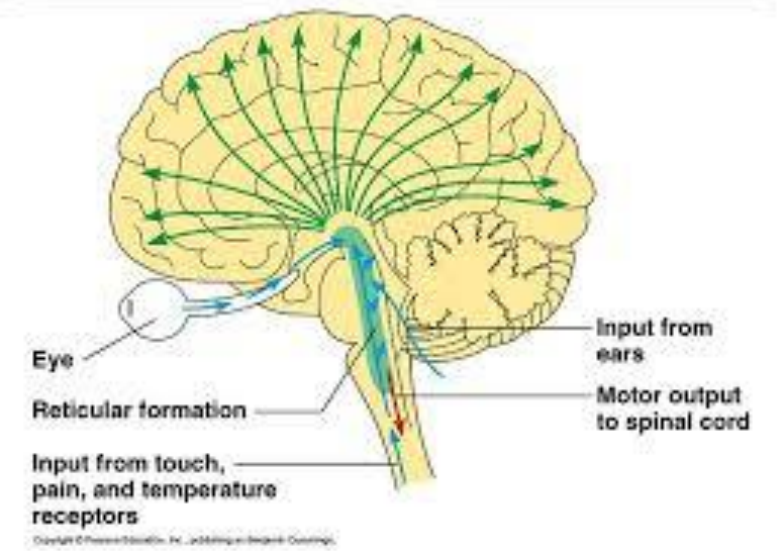



substantia nigra pars compacta (SNPR)
substantia nigra pars compacta.(SNPC)

Michael Hutchinson et al., Frontiers in Neurology 5:54 · April 2014

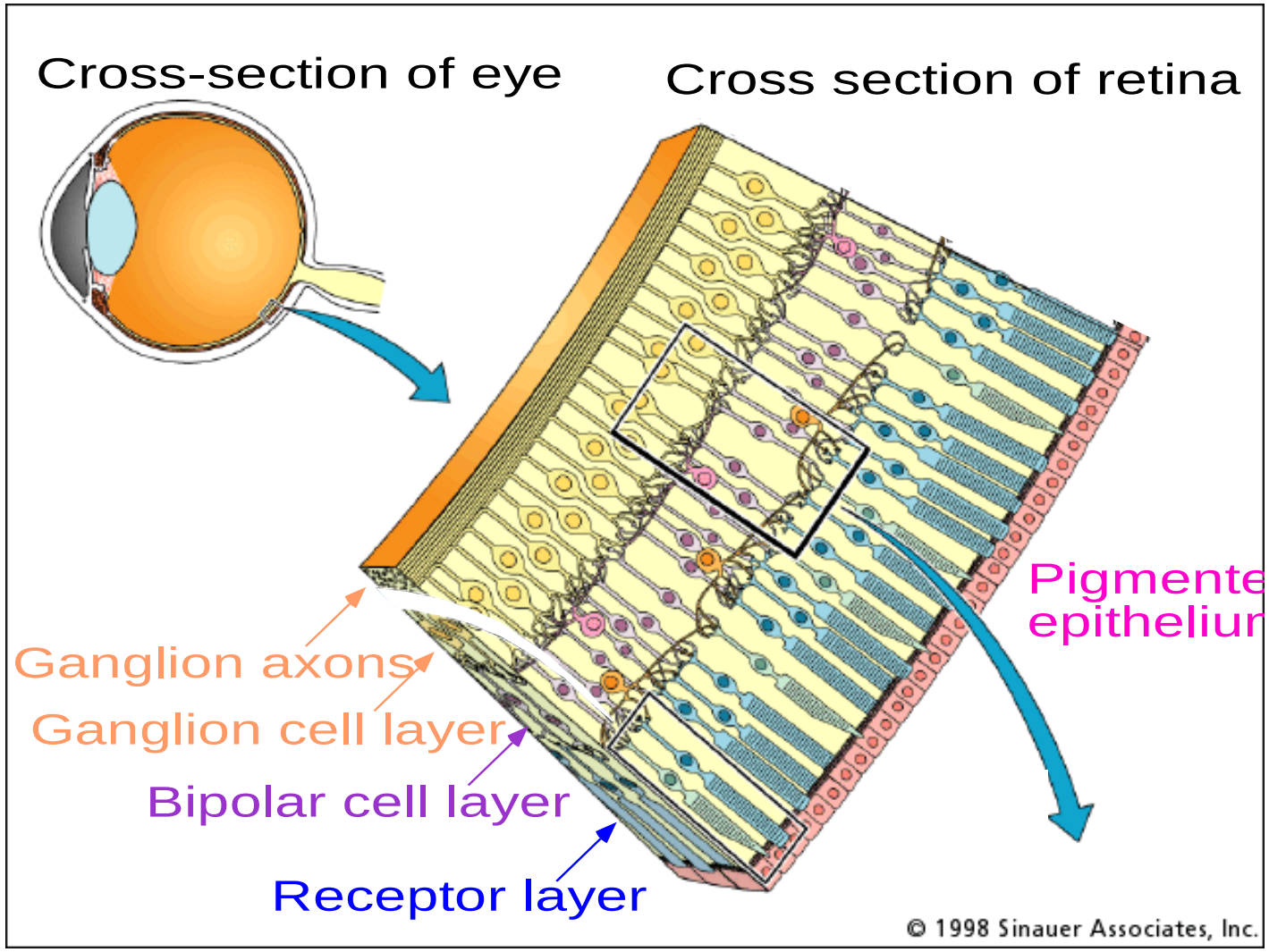



The superior colliculus integrates multimodal sensory information from visual, auditory, and tactile sources; generates outputs for gaze, head, and arm movement; and sends priority signals to the substantia nigra pars compacta and the intralaminar nucleus of the thalamus

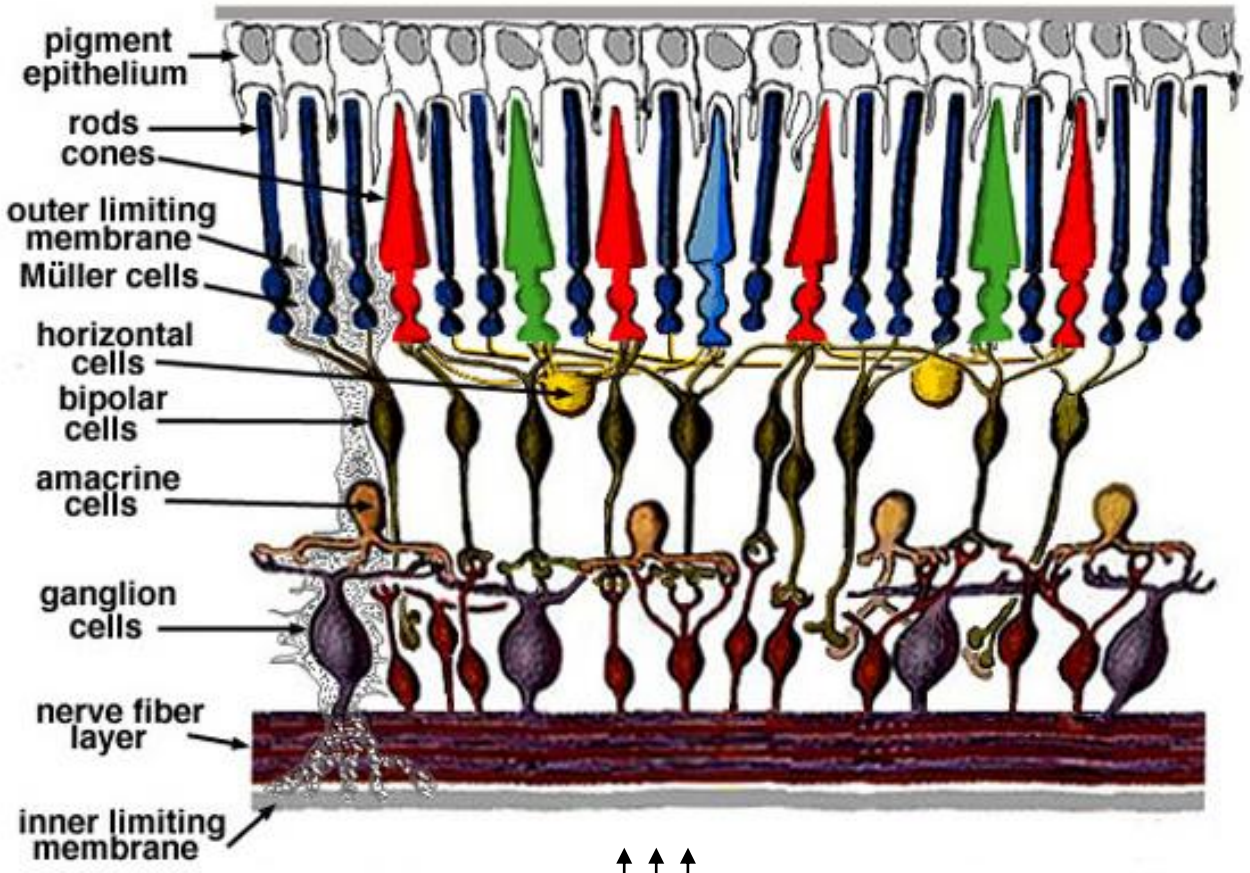



The **reticular formation** is a phylogenetically primitive network of small neurons extending throughout the brainstem and into the spinal cord.

# The Retina


Cross-section of eye
Cross section of retina
Pigmente
epitheliur
Ganglion axons
Ganglion cell layer
Bipolar cell layer
Receptor layer
© 1998 Sinauer Associates, Inc.

# Retina up-close




↑↑↑

Light

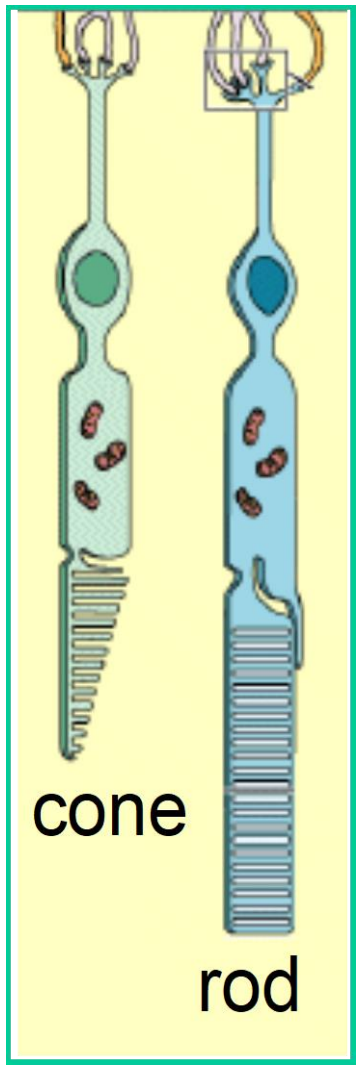
# Two types of light-sensitive receptors

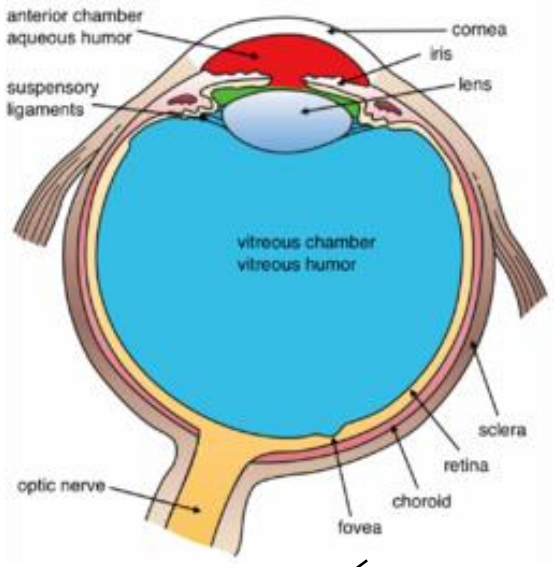
**Cones**

- cone-shaped
- less sensitive
- operate in high light
- color vision

**Rods**

- rod-shaped
- highly sensitive
- operate at night
- gray-scale vision




0.3 mm diameter rod-free area

Retina is organized into macula, optic disc, fovea and peripheral retina

# Retinal ganglion cells respond to edges

Input image
(cornea)

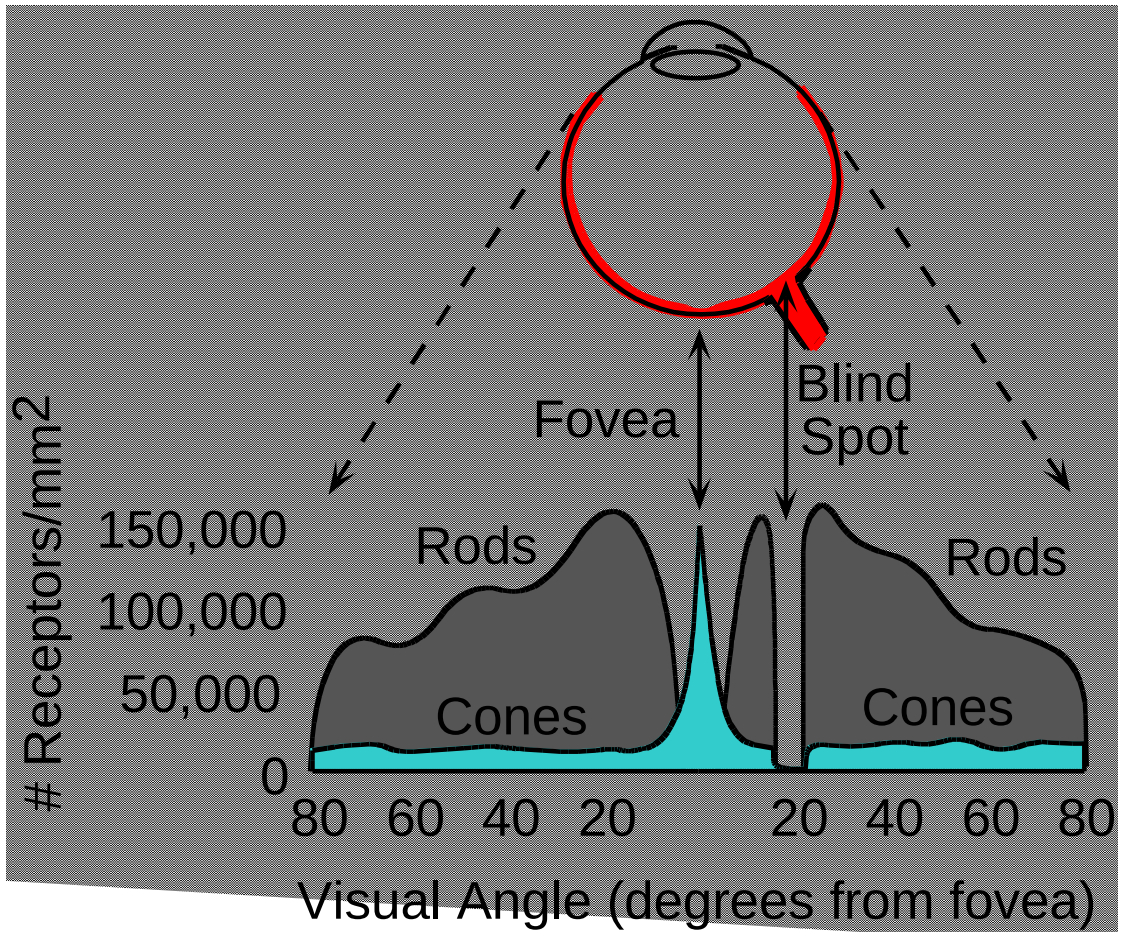
"Neural image"
(retinal ganglion cells)

Center-surround receptive fields: emphasize edges.

http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/ganglion/ganglion.html

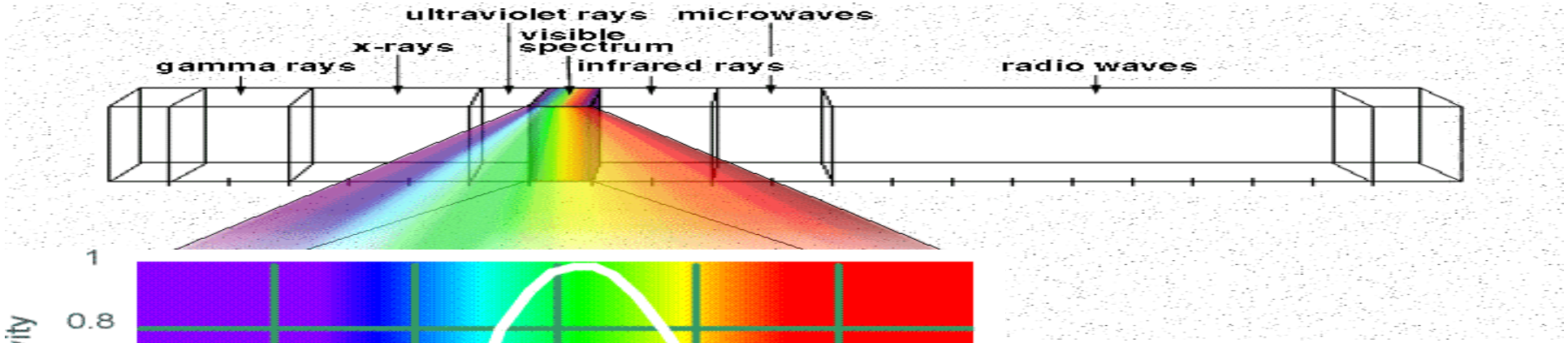
# The Eye and Light

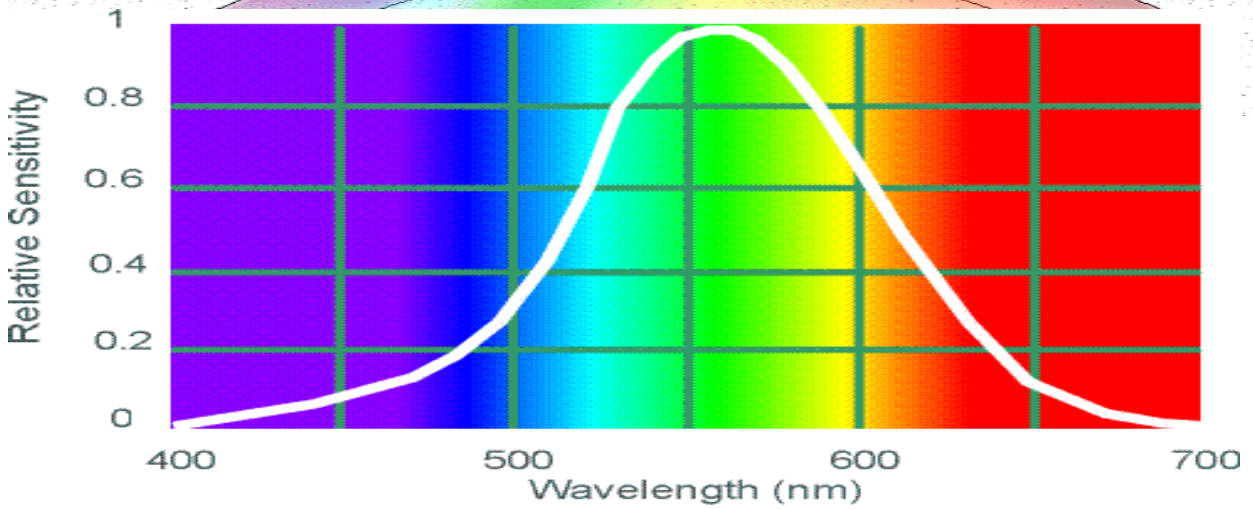
# Distribution of Rods and Cones




Night Sky: why are there more stars off-center?

# Electromagnetic Spectrum

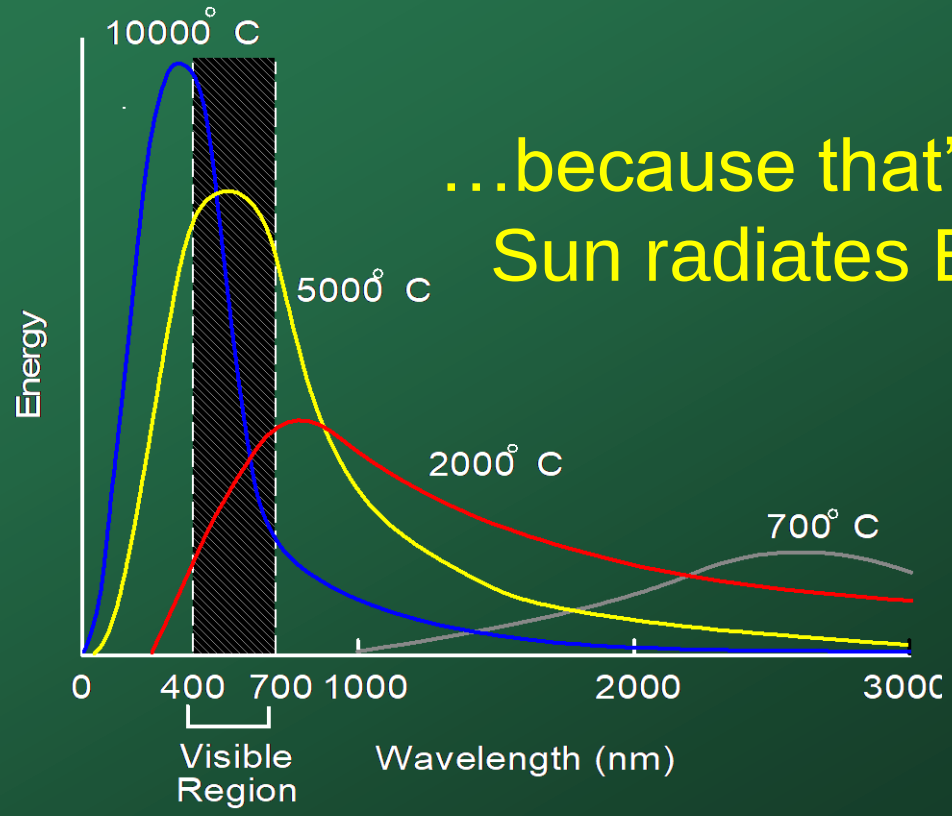



Human Luminance Sensitivity Function

# Visible Light

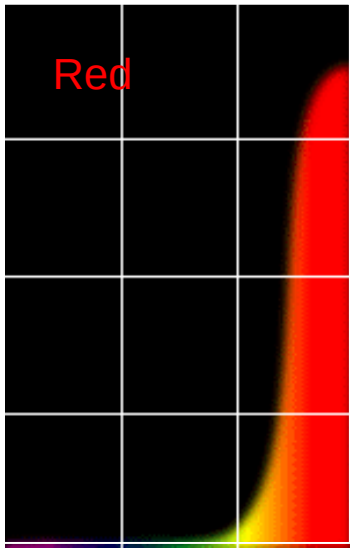
Why do we see light of these wavelengths?

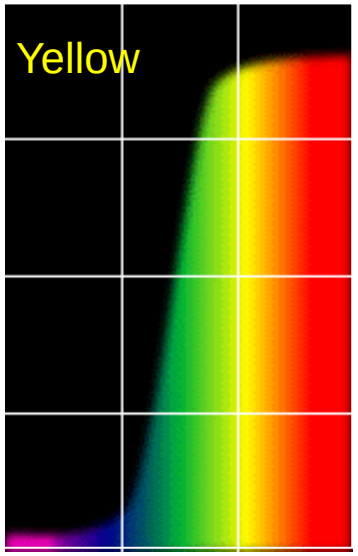


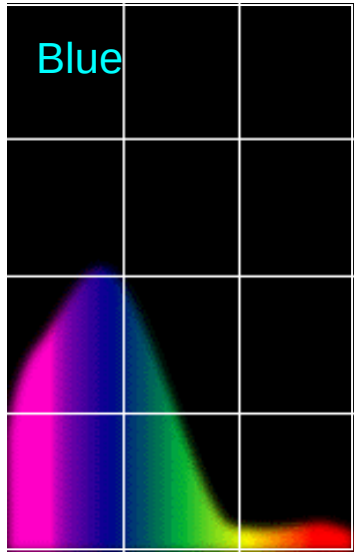

…because that's where the Sun radiates EM energy

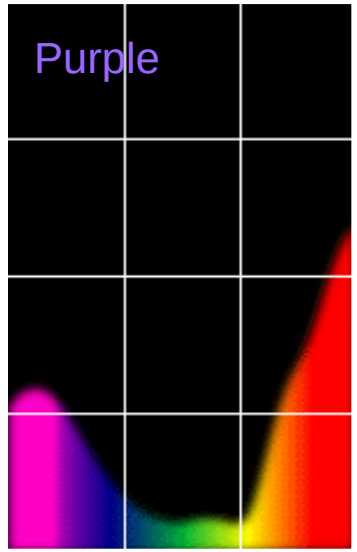
# The Physics of Light

Some examples of the reflectance spectra of surfaces



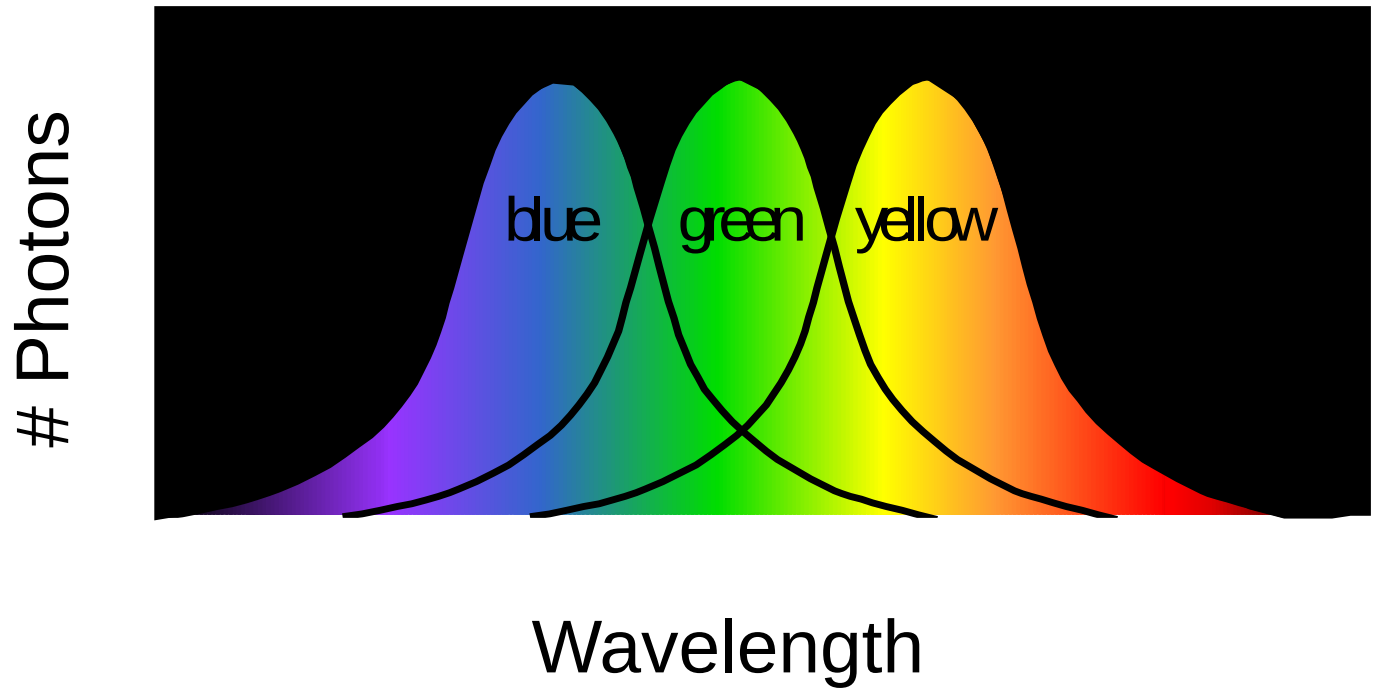



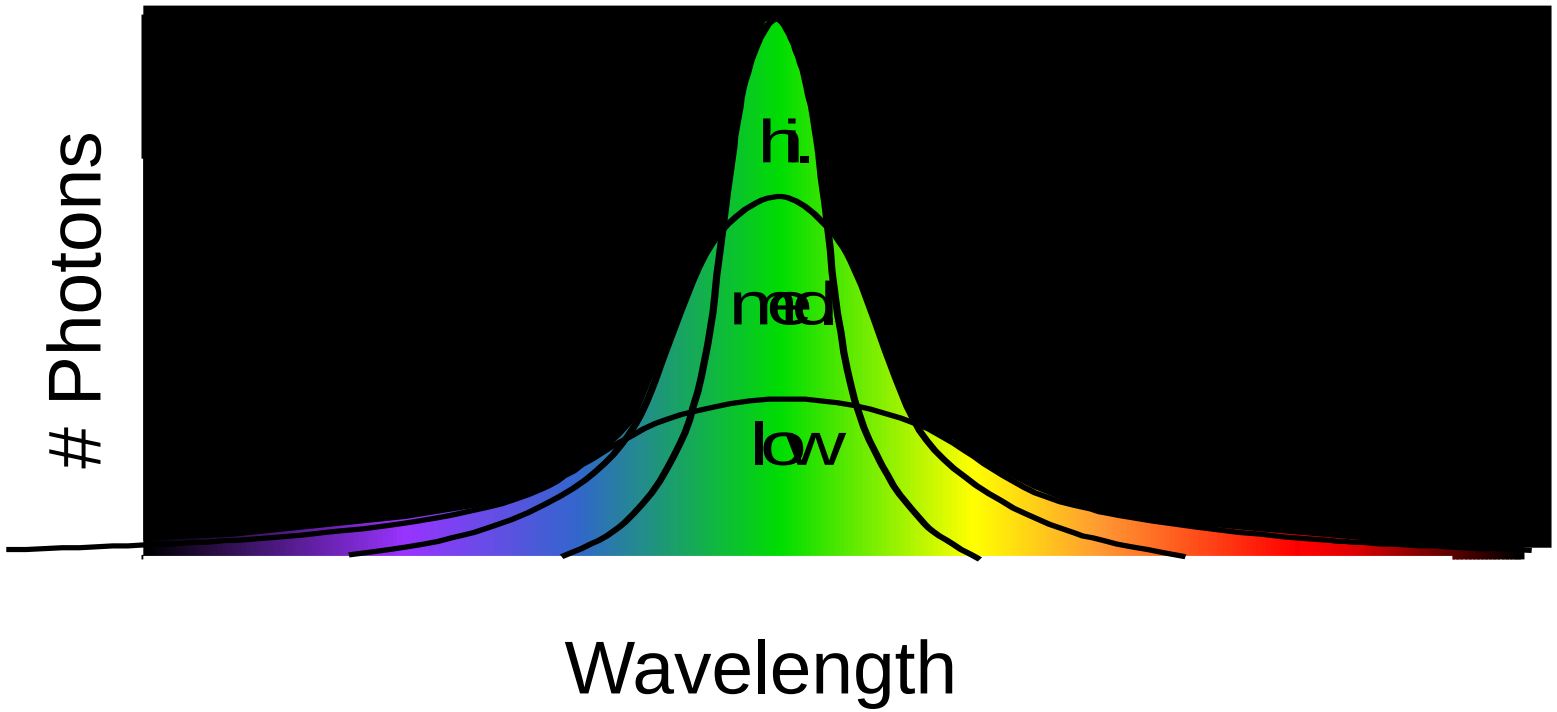
# The Psychophysical Correspondence

**Mean** ⟷ **Hue**



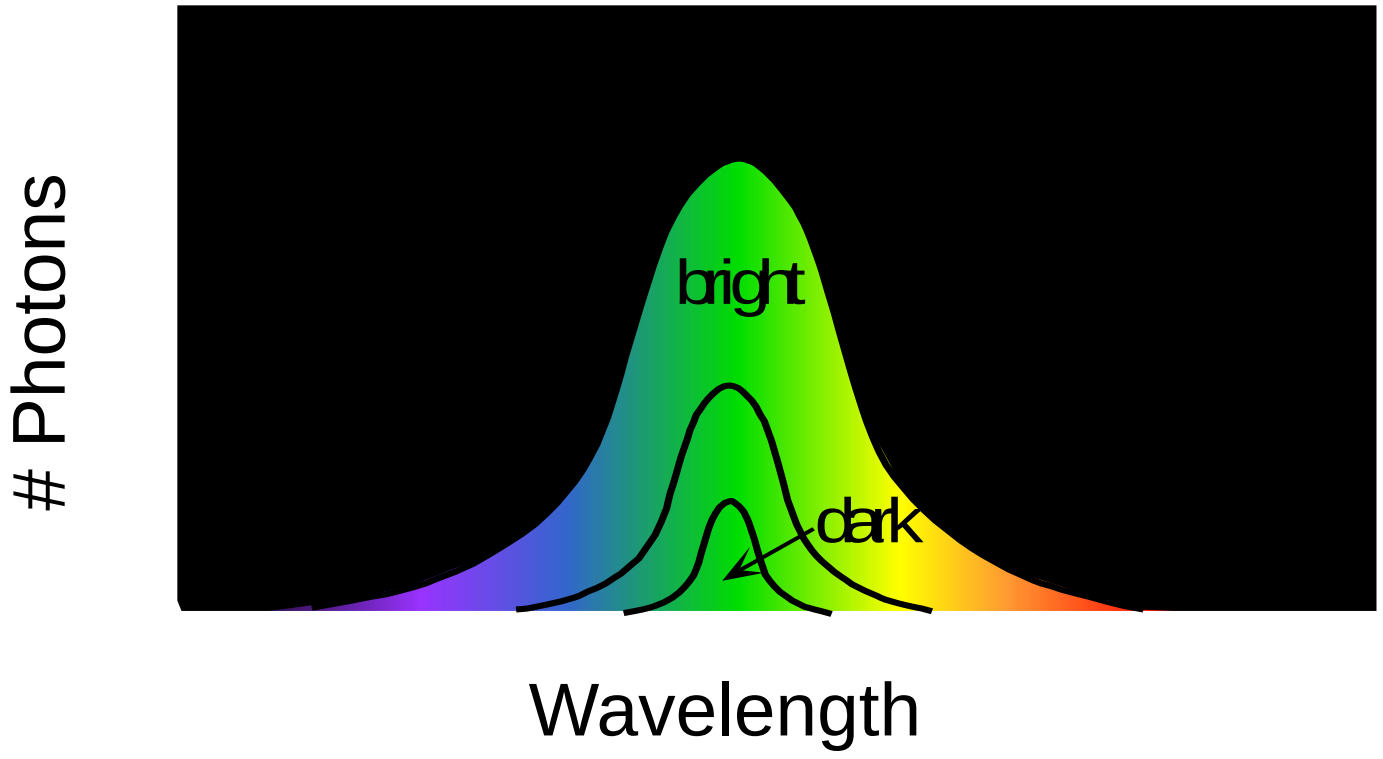
# The Psychophysical Correspondence

**Variance ⟷ Saturation**



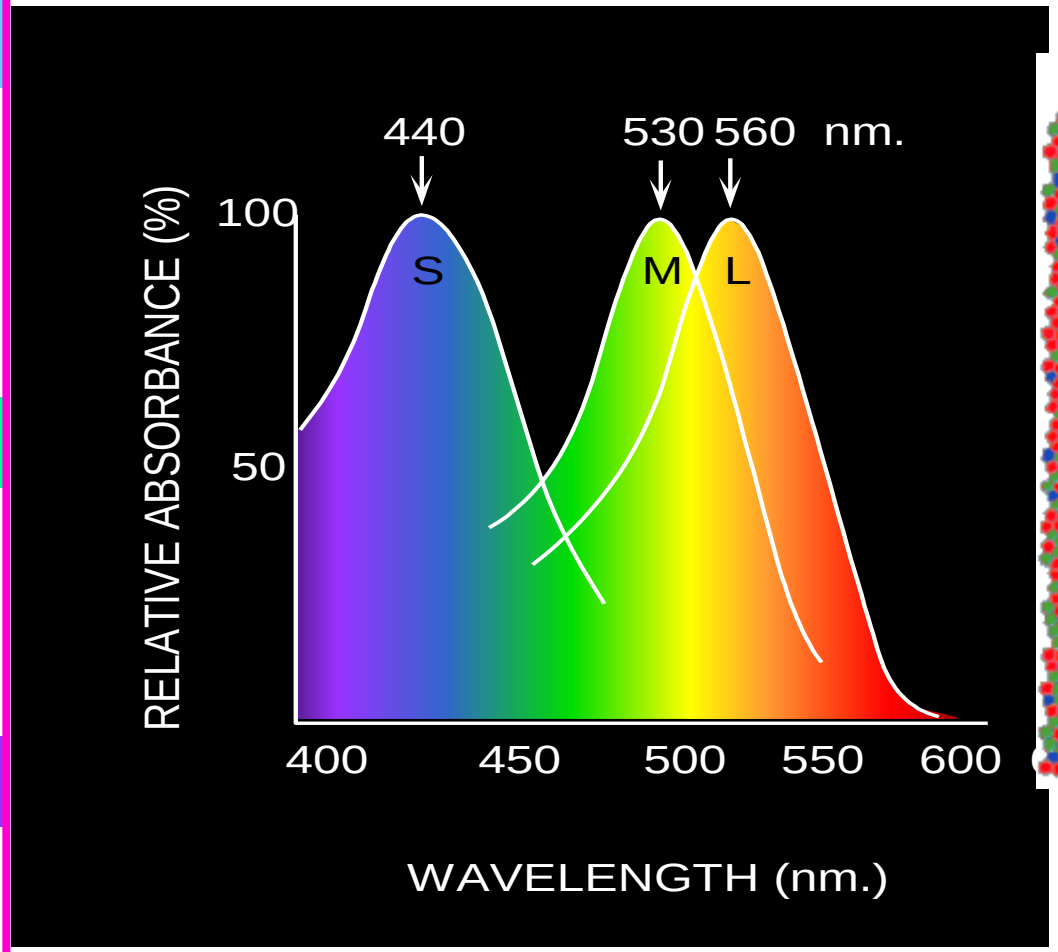
# The Psychophysical Correspondence

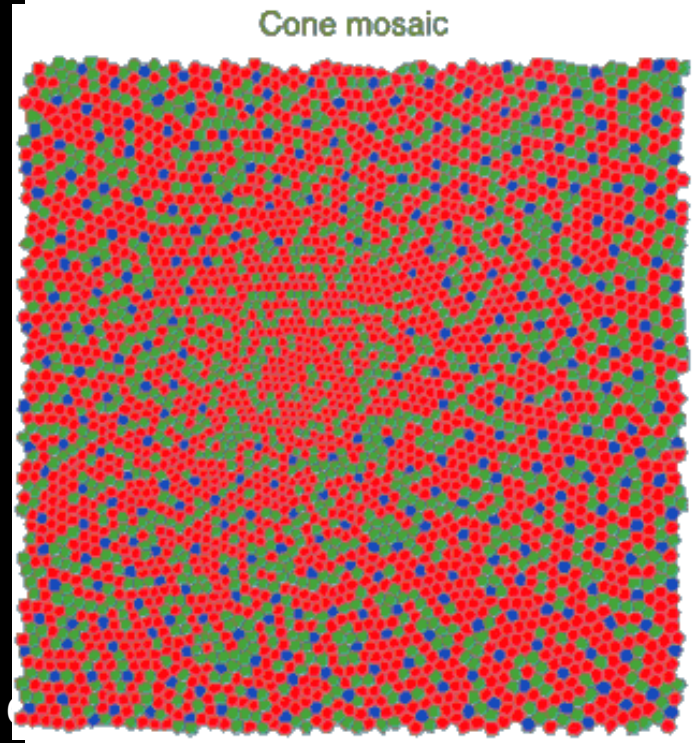
**Area ⟺ Brightness**



# Physiology of Color Vision

Three kinds of cones:

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