260-2017-11-15-vision

2017-11-15 08:29:36

Prelude

GoPro: Backflip Over 72ft Canyon - Kelly McGarry Red Bull Rampage 2013

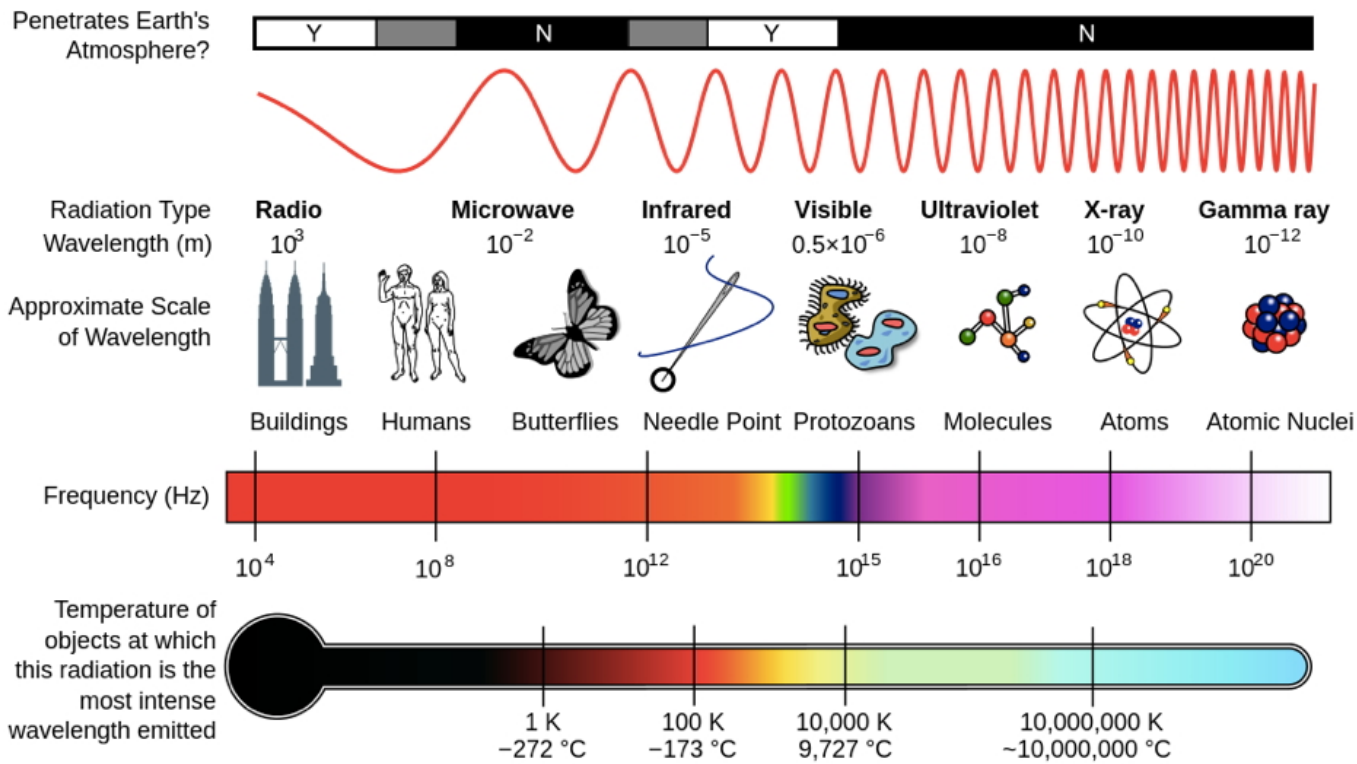
Today's topics

- Vision

How vision informs

- What's out there?
    - Shape, form, color
- Where is it?
    - Position, orientation, motion

Electromagnetic (EM) radiation

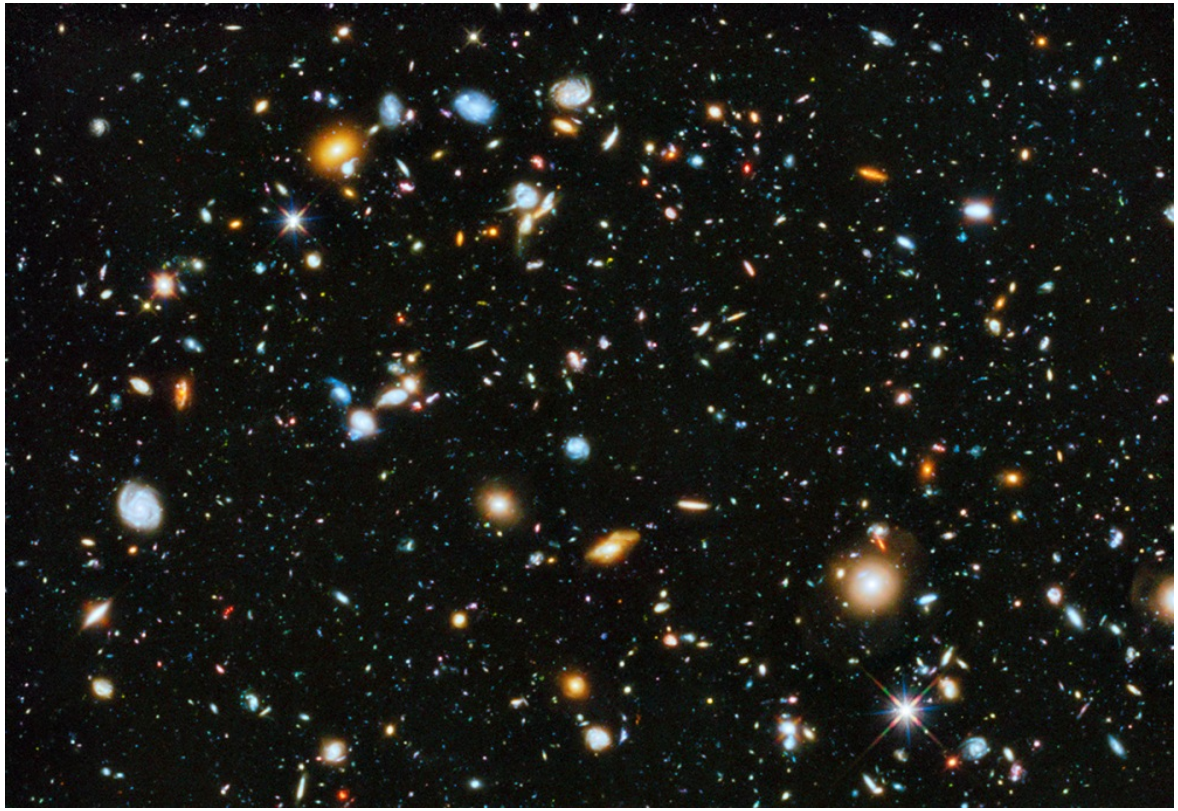


http://en.wikipedia.org/wiki/File:EM_Spectrum_Properties_edit.svg

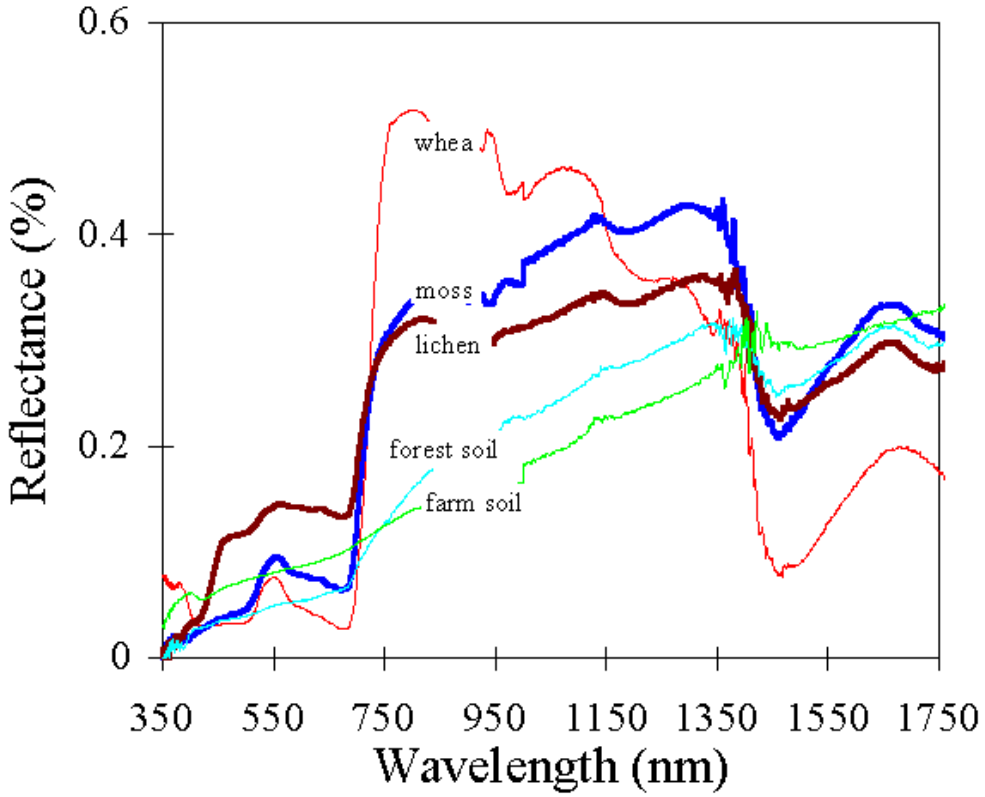
Features of EM radiation

- Wavelength/frequency
- Intensity
- Location/position of source
- Reflects off some materials
- Refracted (bent) moving through other materials

EM radiation provides information across space (and time)

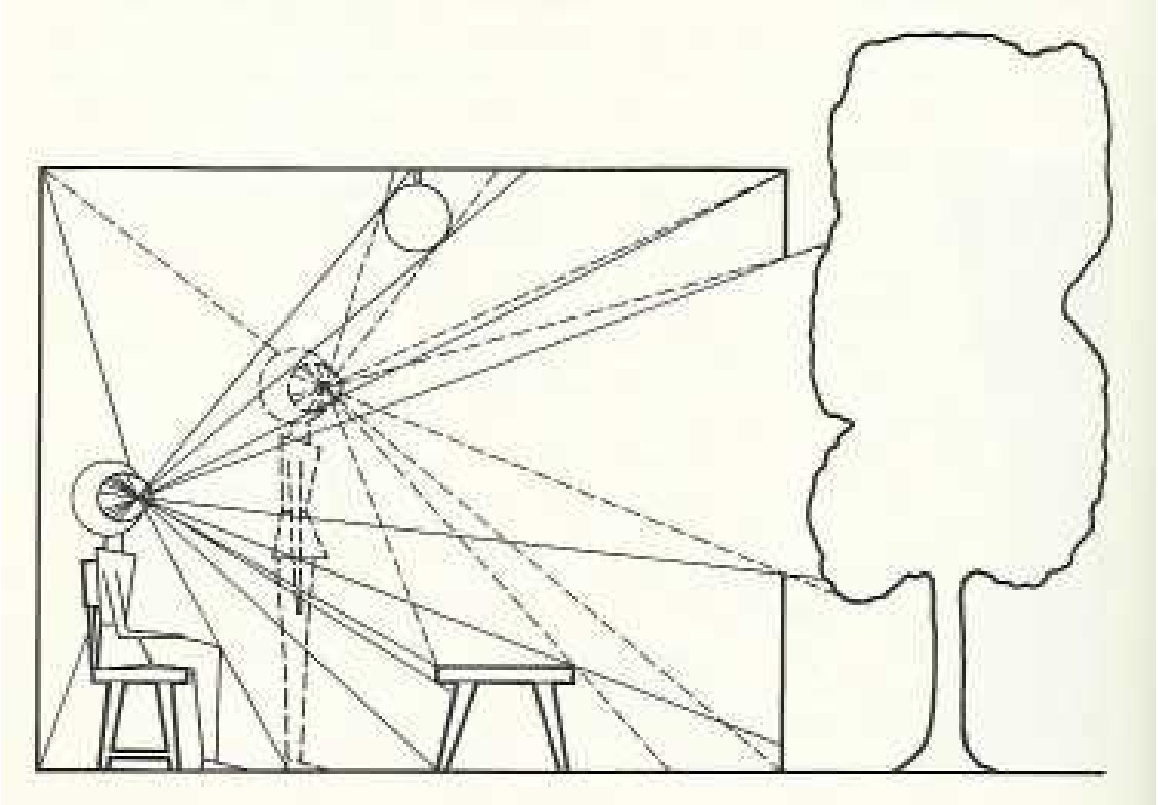


Reflectance spectra differ by surface



http://http://www.vgt.vito.be/userguide/book_1/4/42/ie42bd.gif

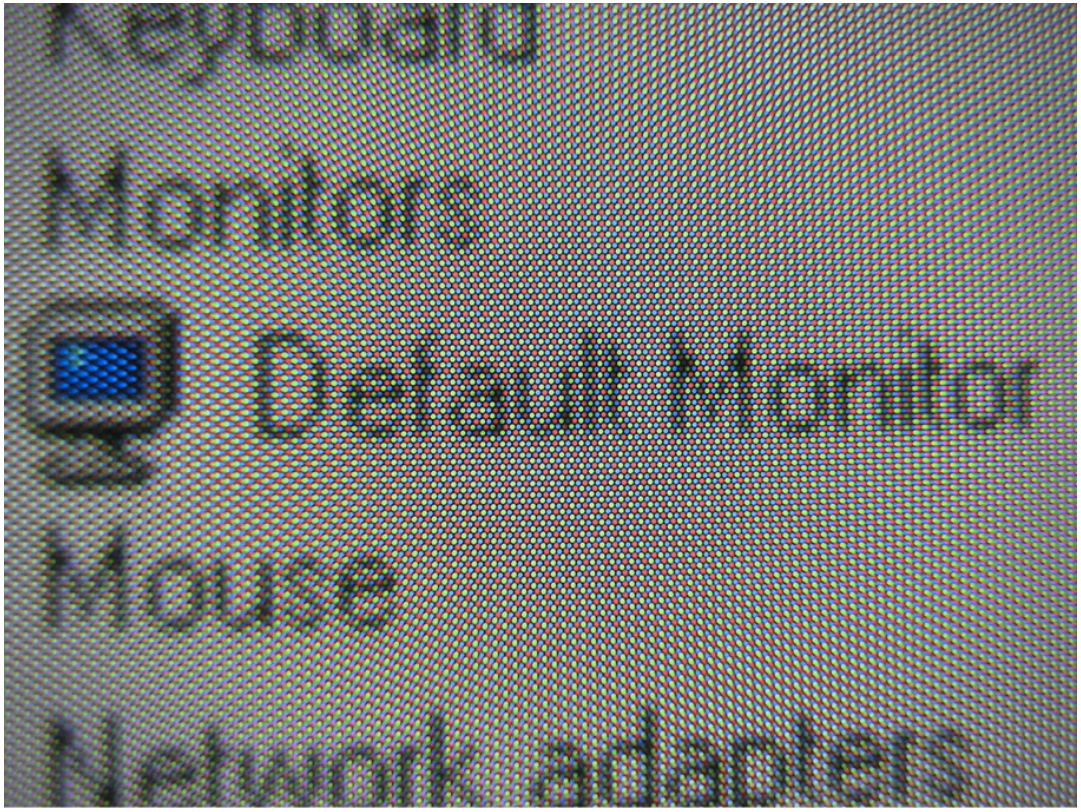
Optic array specifies geometry of environment



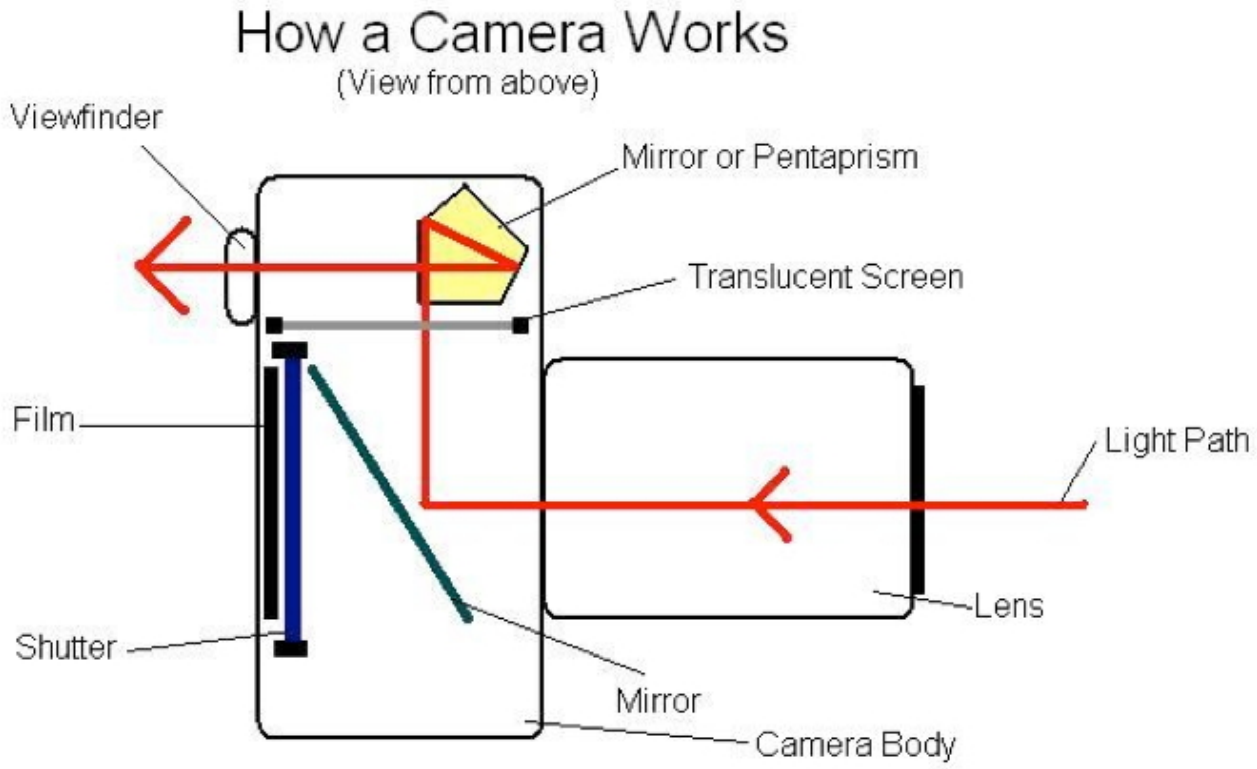
Color == categories of wavelength

- Eyes categorize wavelength into relative intensities within wavelength bands
- RGB ~ Red, Green, Blue
    - Long, medium, short wavelengths
-

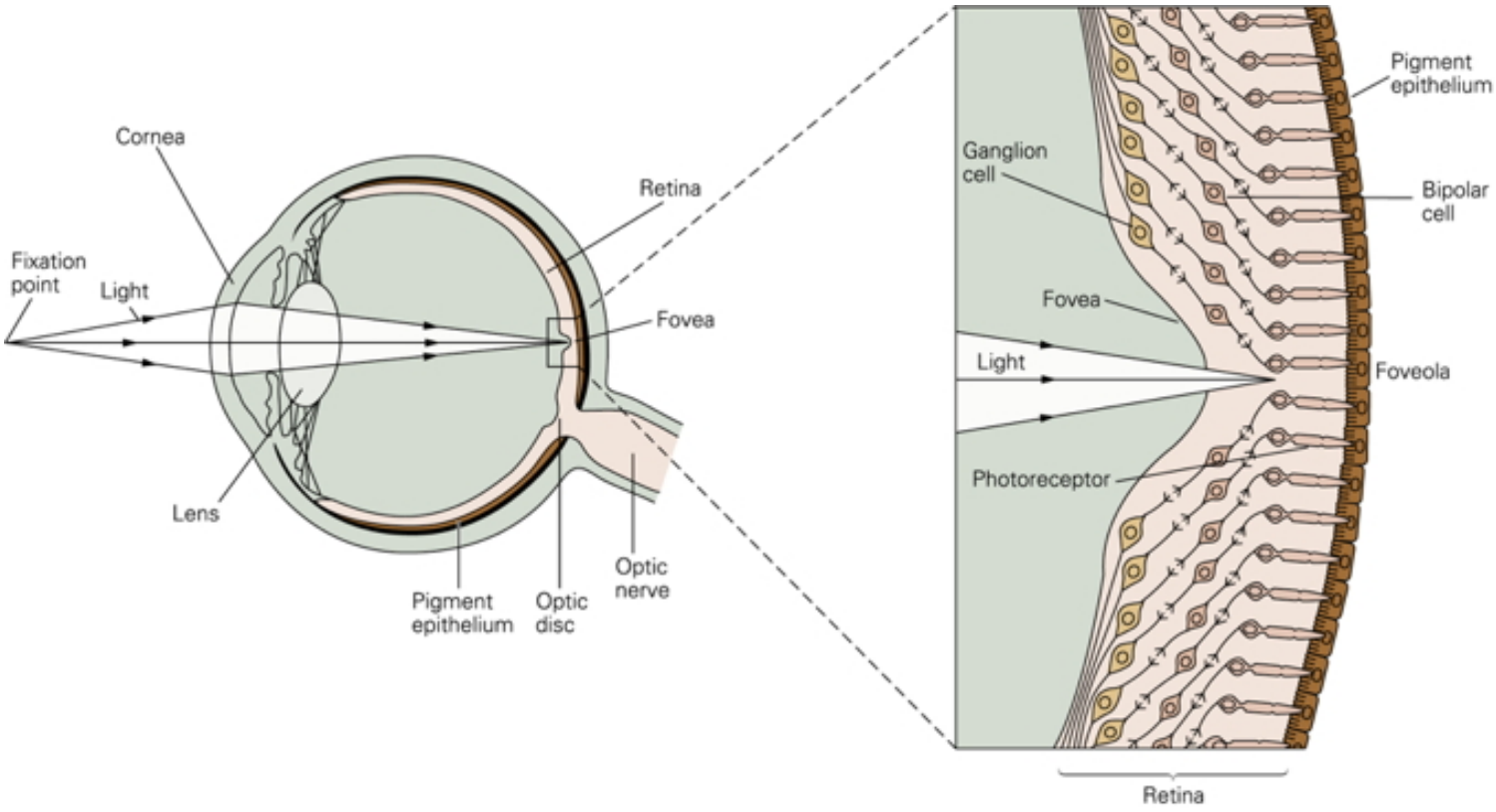
RGB monitors



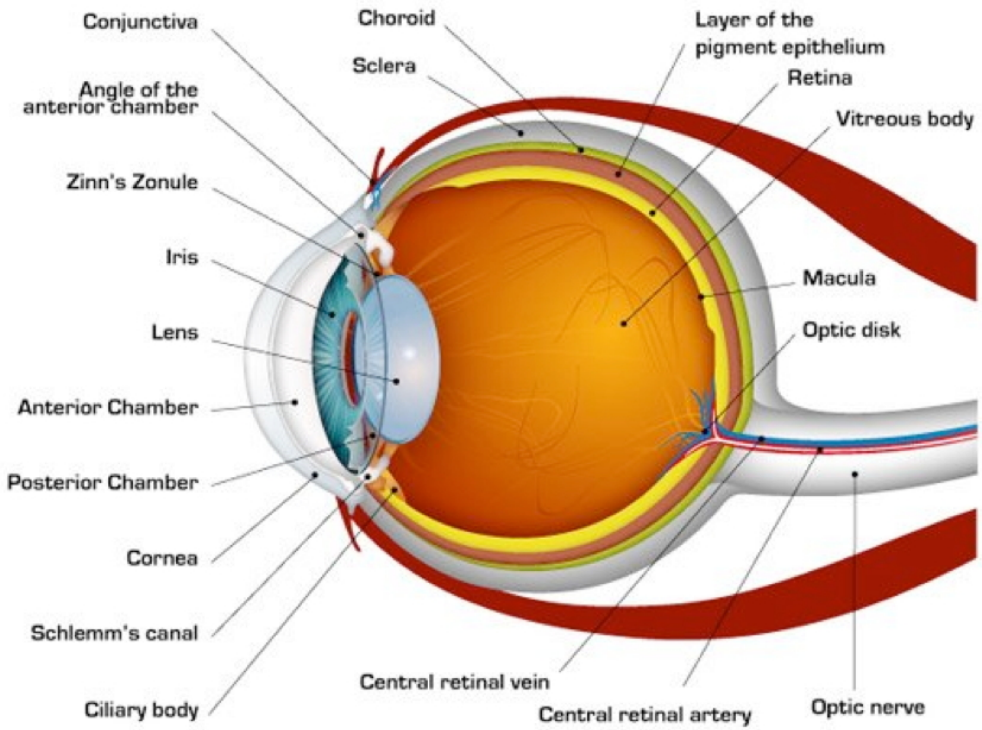
How a camera works



The biological camera



The biological camera



Parts of the eye

- - refraction (2/3 of total)
- - light intensity; diameter regulated by Iris.
- - refraction (remaining 1/3; variable focus)

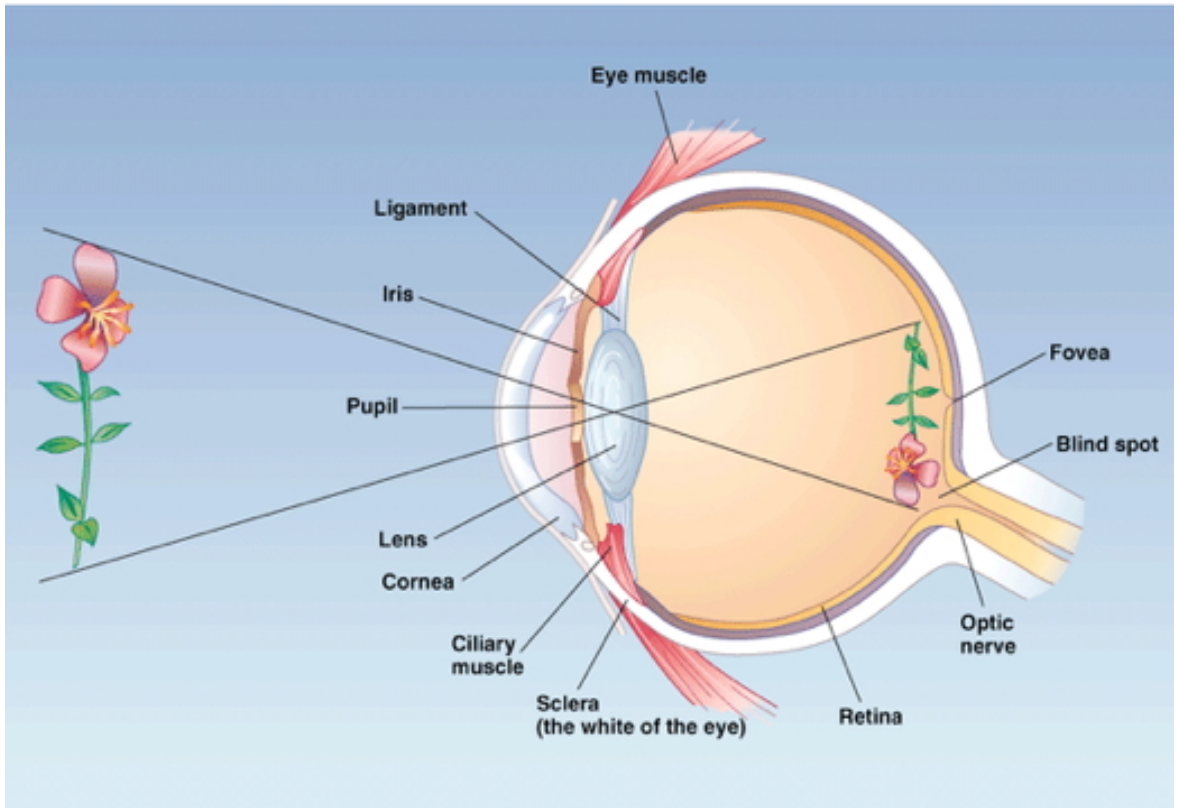
Parts of the eye

- - light detection
  - ~ skin or organ of Corti
- - regenerate photopigment
- - move eye, reshape lens, change pupil diameter

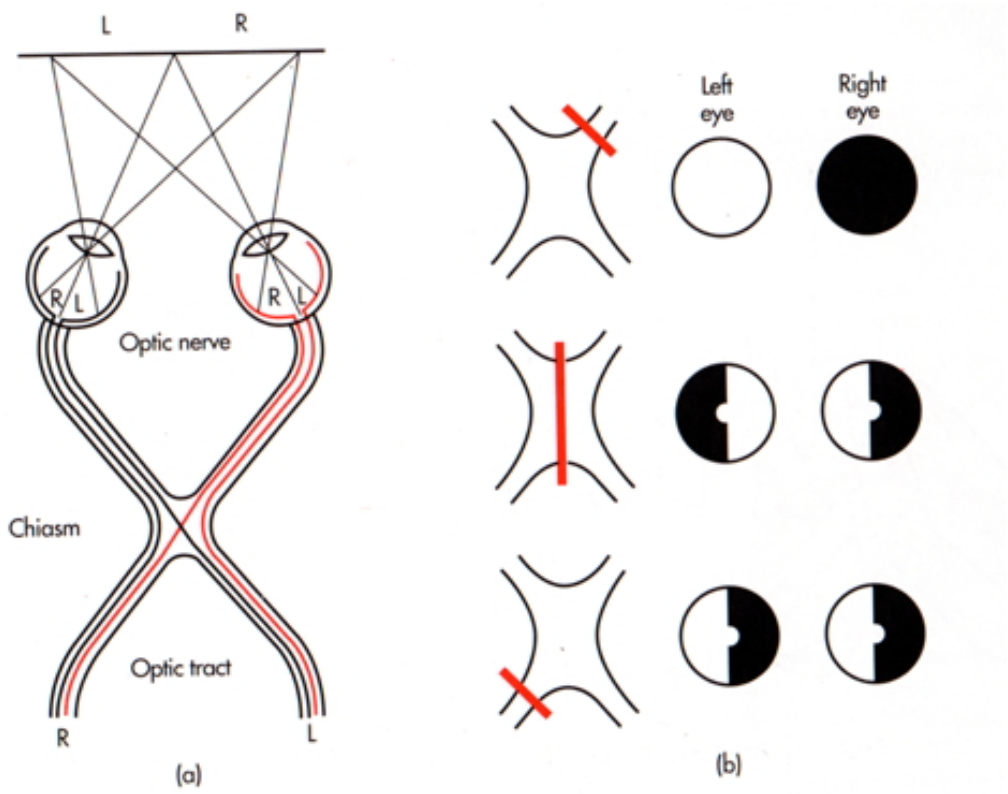
Eye forms image on retina

- Image inverted (up/down)
- Image reverseed (left/right)
- Point-to-point map ( )
- Binocular and monocular zones

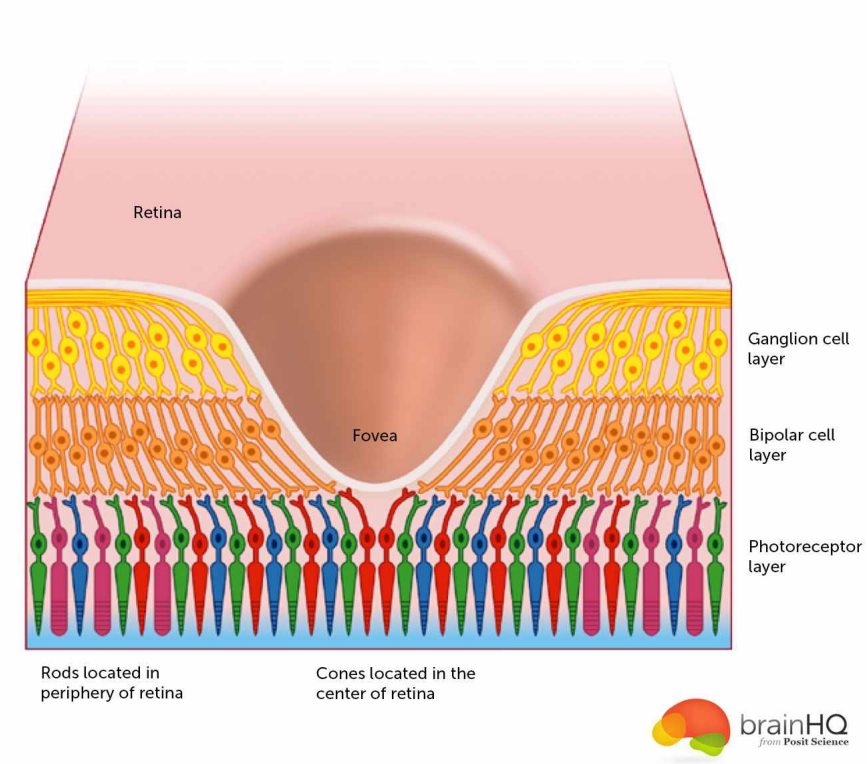
Retinal image



Eyes views overlap



The

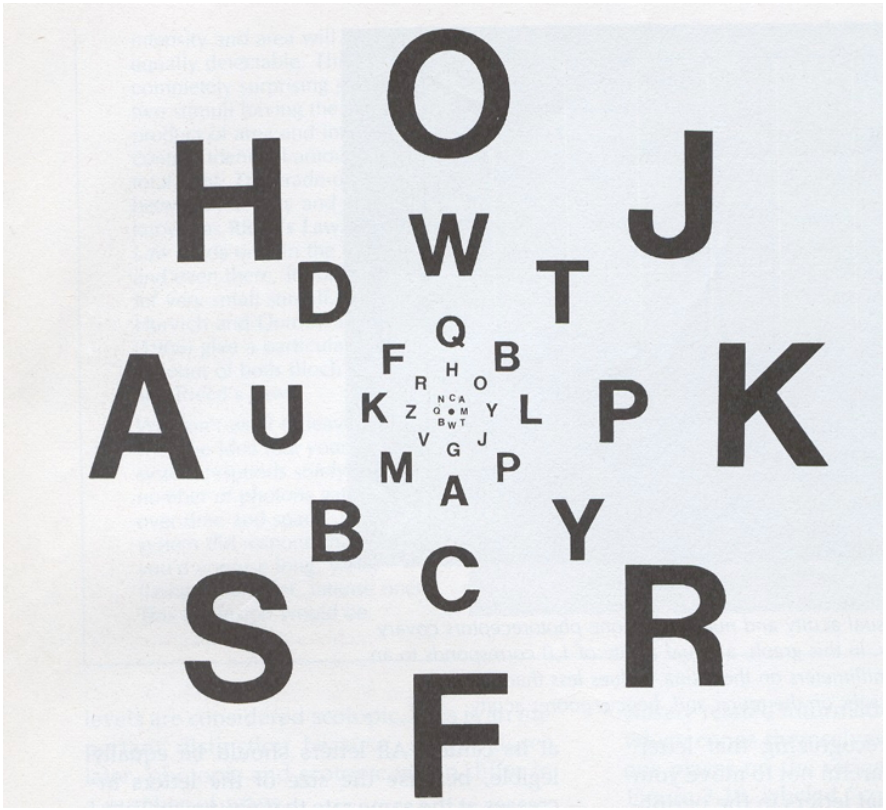


http://www.brainhq.com/sites/default/files/fovea.jpg

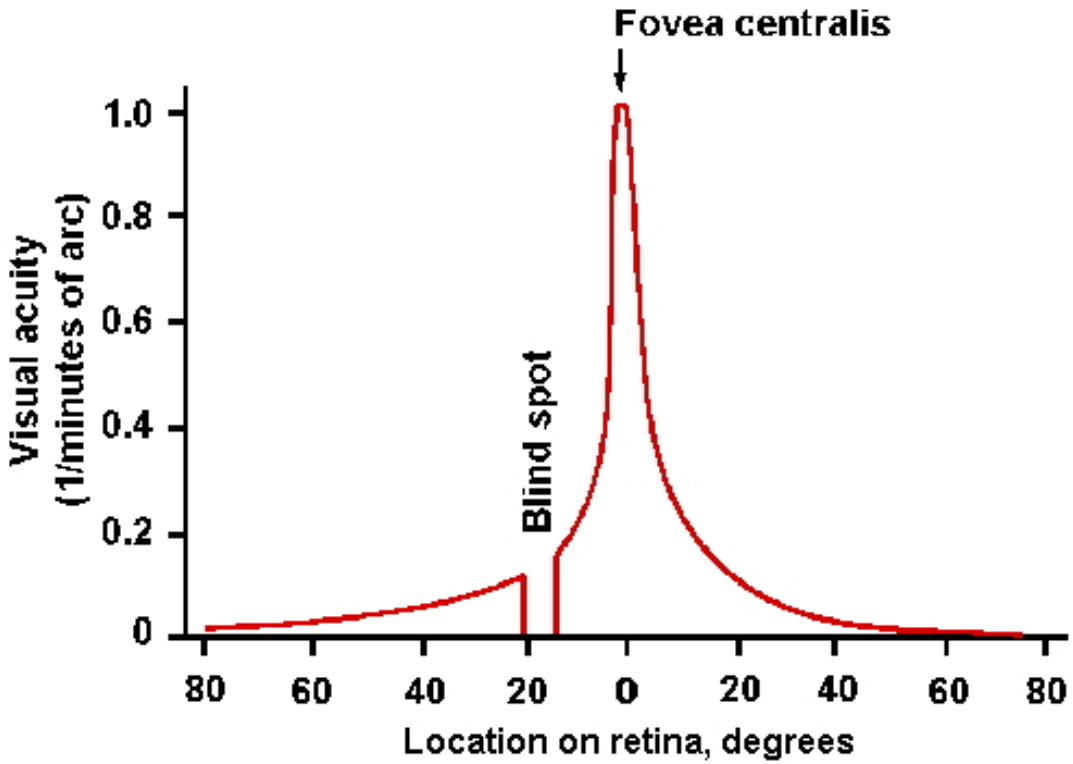
The fovea

- Central 1-2 deg of visual field
- Aligned with visual axis
- pushed aside
- Highest vision == best for details

Acuity varies across fovea



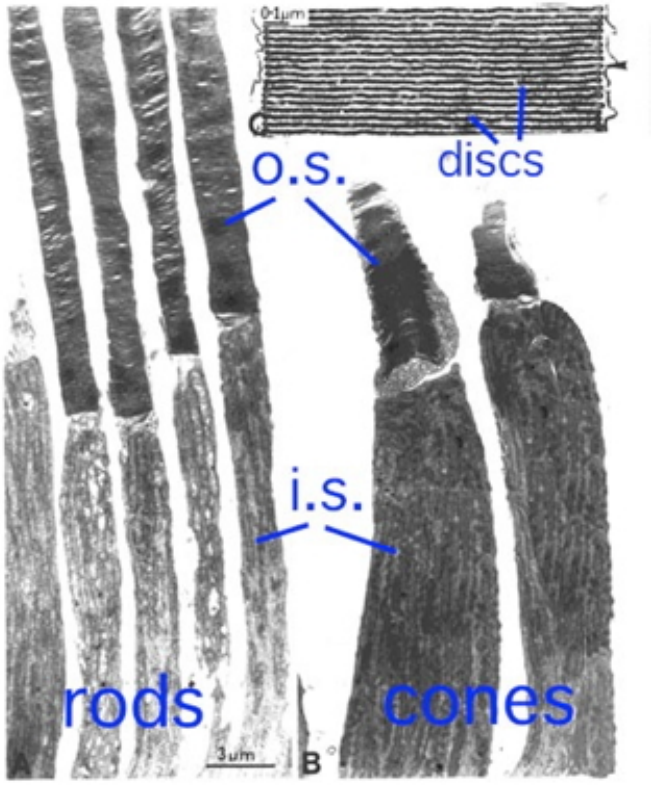
Acuity varies across fovea



http://michaeldmann.net/pix_7/blndspot.gif

What part of the skin is like the fovea?

detect light



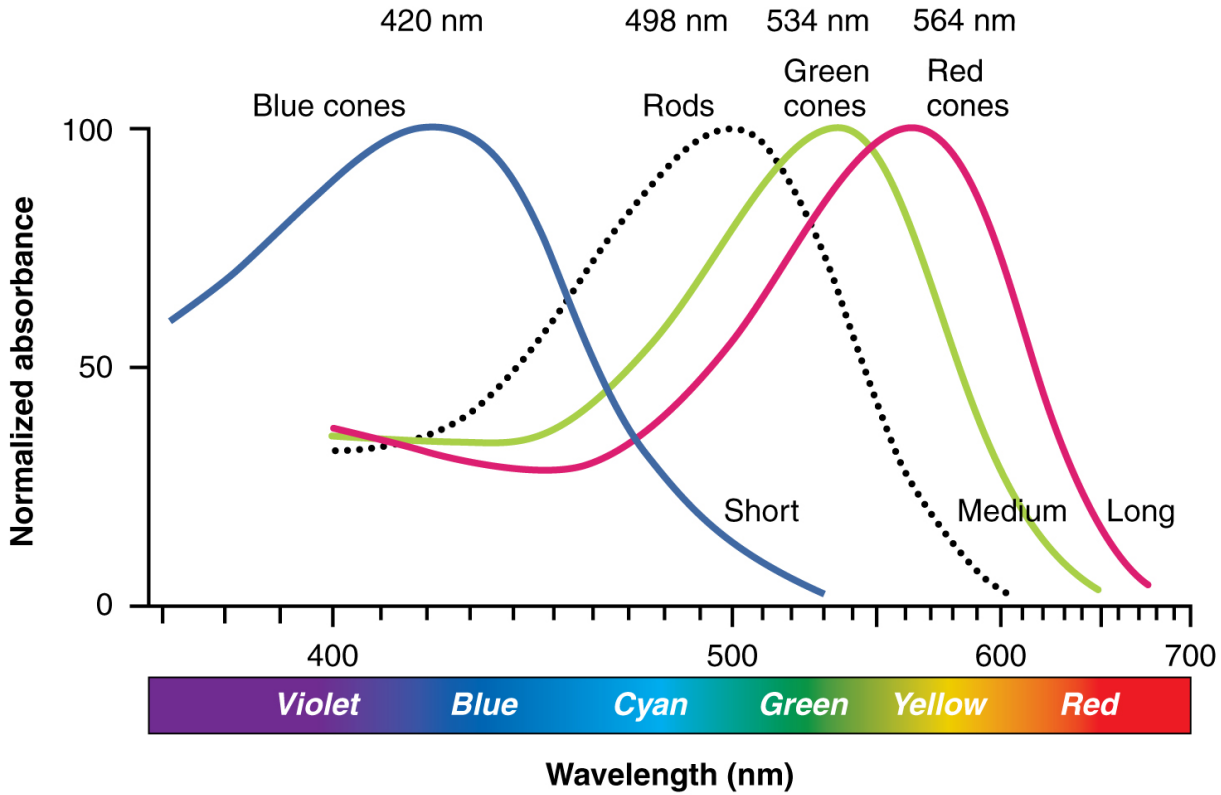
Photoreceptors detect light

- ~120 M/eye
- Mostly in periphery
- Active in low light conditions
- One wavelength range

Photorceptors detect light

- ~5 M/eye
- Mostly in center
- 3 wavelength ranges

Photoreceptors "specialize" in particular wavelengths



Anatomy & Physiology, Connexions Web site. http://cnx.org/content/col11496/1.6/, Jun 19, 2013.

How photoreceptors work

- Outer segment
  - Membrane disks
  -
    - Sense light, trigger chemical cascade
- Inner segment
  - Synaptic terminal
- Light photoreceptor!
  - The

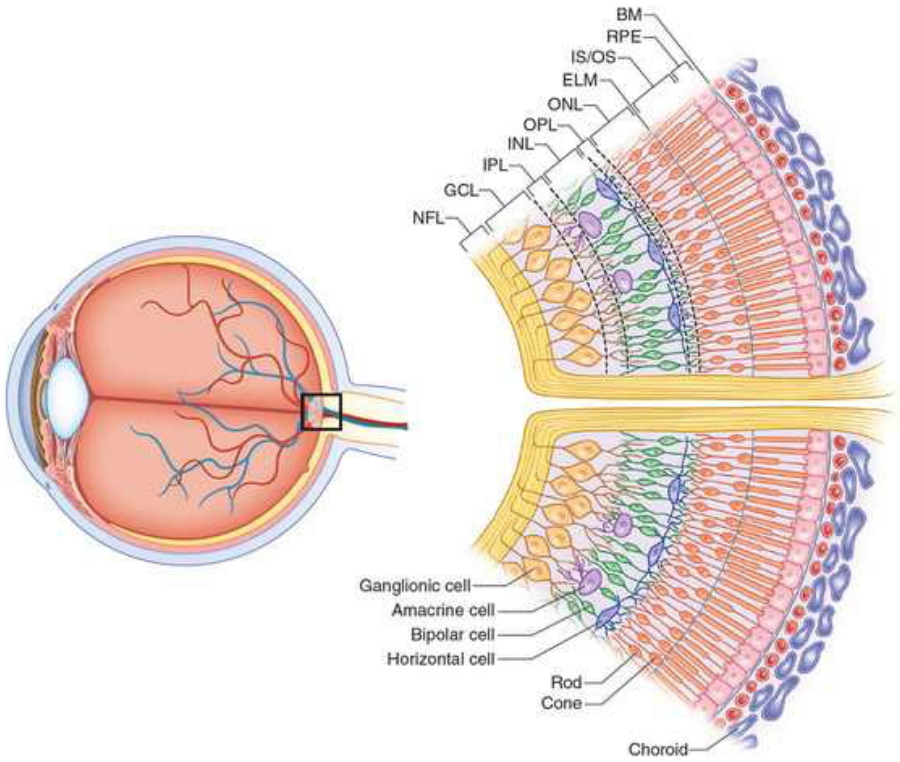
Retina

- Physiologically
  - How?
- Anatomically
  - How?

Retina

- Physiologically
  - Dark current
- Anatomically
  - Photoreceptors at back of eye

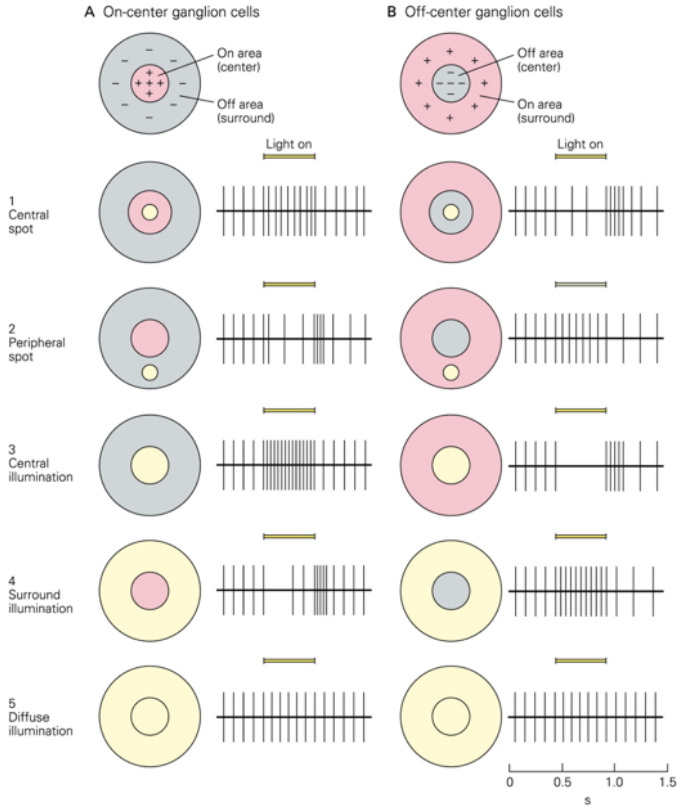
Retinal layers



http://www.retinareference.com/anatomy/

Retinal layers

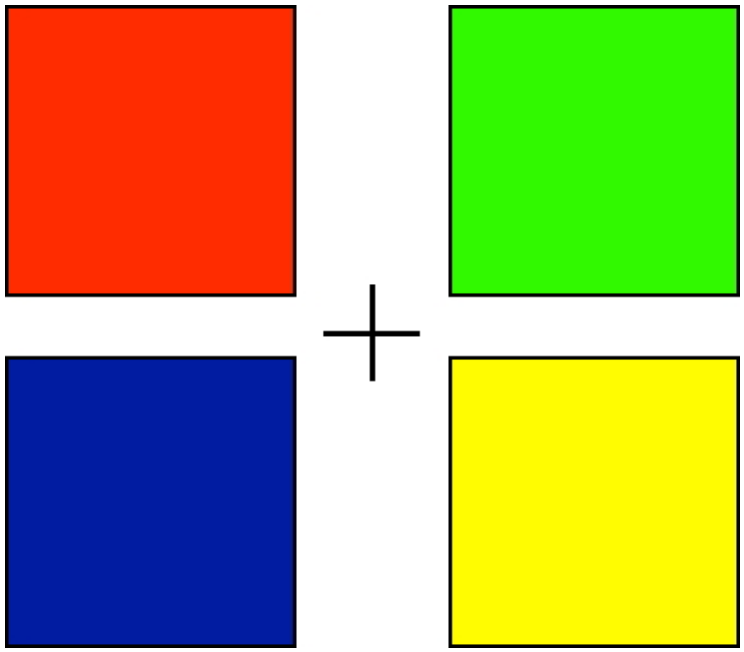
- Bipolar cells
  - Horizontal cells
- Retinal ganglion cells
  - Amacrine cells


A On-center ganglion cells
B Off-center ganglion cells
On area (center)
Off area (surround)
Off area (center)
On area (surround)
Light on
Light on
1 Central spot
2 Peripheral spot
3 Central illumination
4 Surround illumination
5 Diffuse illumination
0
0.5
1.0
1.5
s

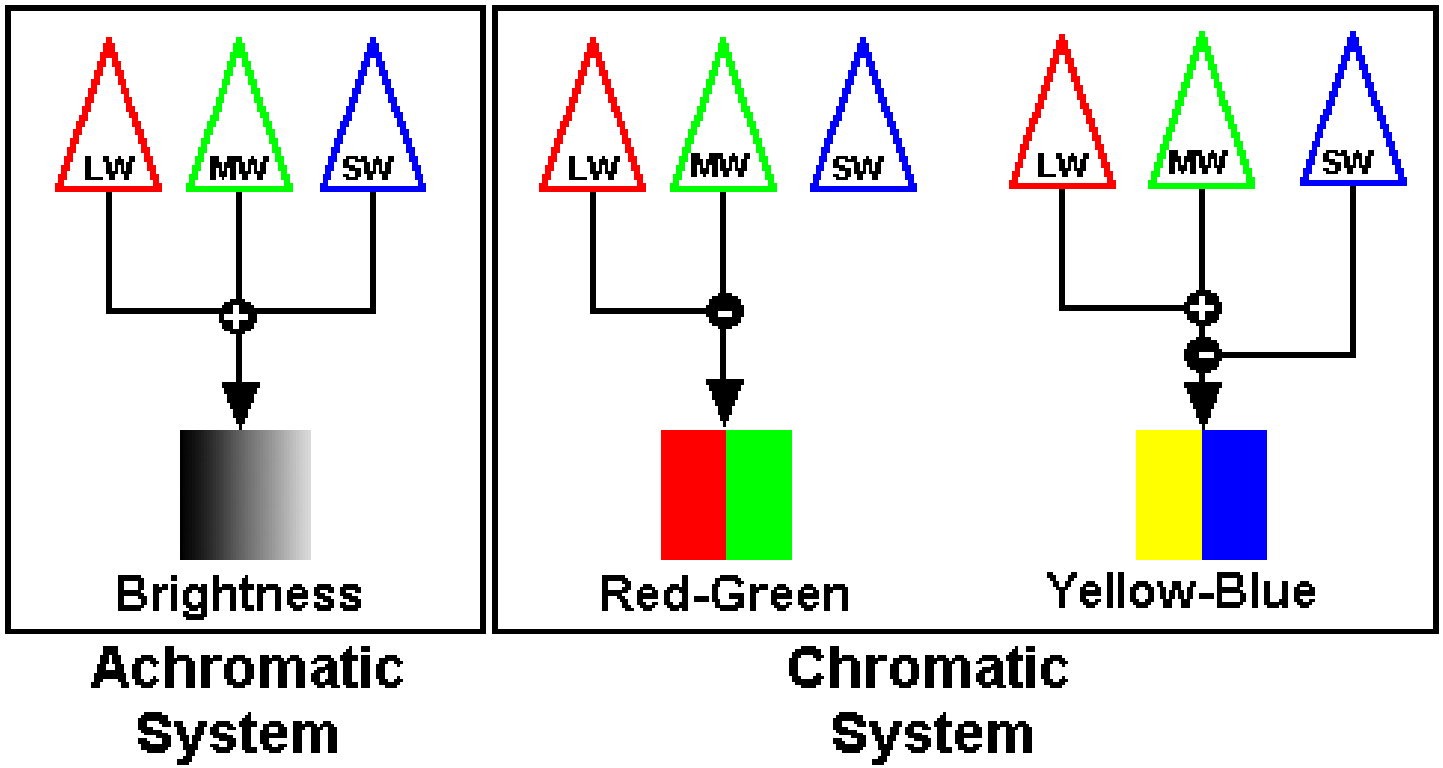
Center-surround receptive fields

- Center region
  - Excites (or inhibits)
- Surround region
  - Does the opposite
- Bipolar cells & Retinal Ganglion cells ->
- Most activated by "donuts" of light/dark
  - Local contrast (light/dark differences)

What's a reddish-green look like?



What's a reddish-green look like?

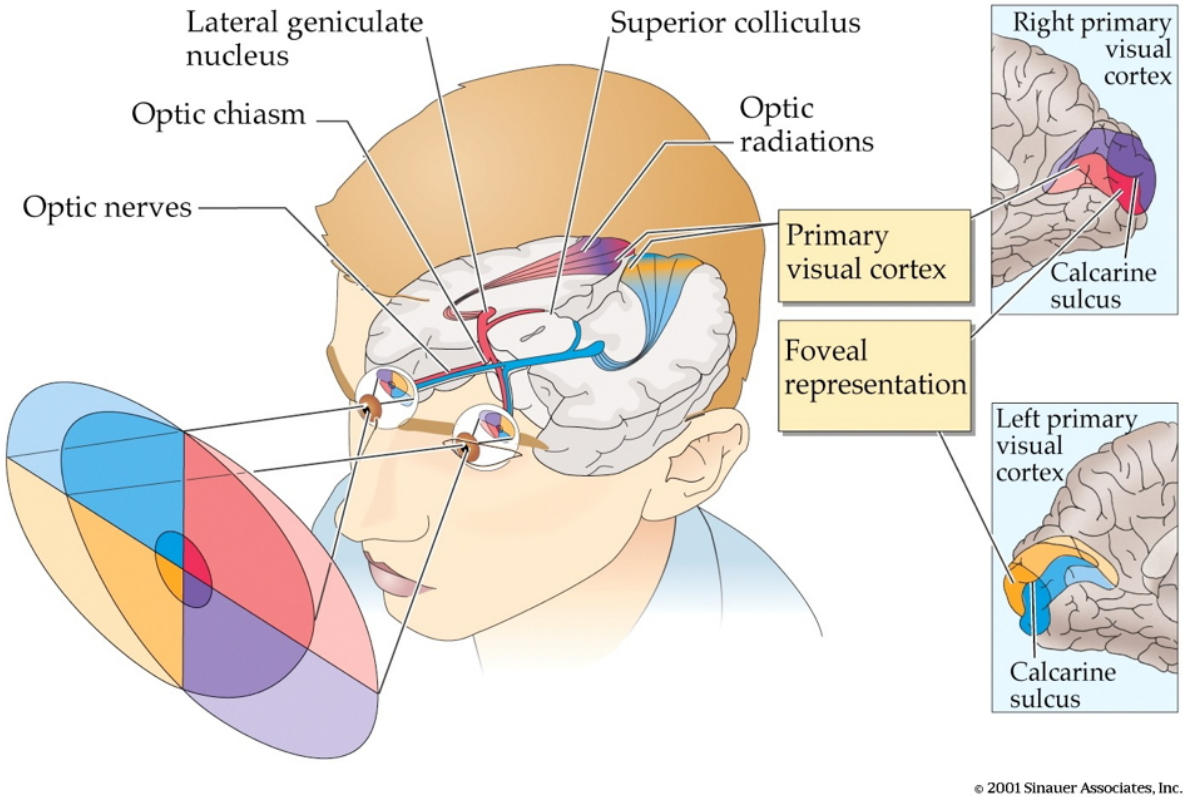


http://www.visualexpert.com/sbfaqimages/RGBOpponent.gif

Opponent processing

- Black vs. white (achromatic)
- Long (red) vs. Medium (green) wavelength cones
- (Long + Medium) vs. Short cones
- Can't really see reddish-green or bluish-yellow

From eye to brain



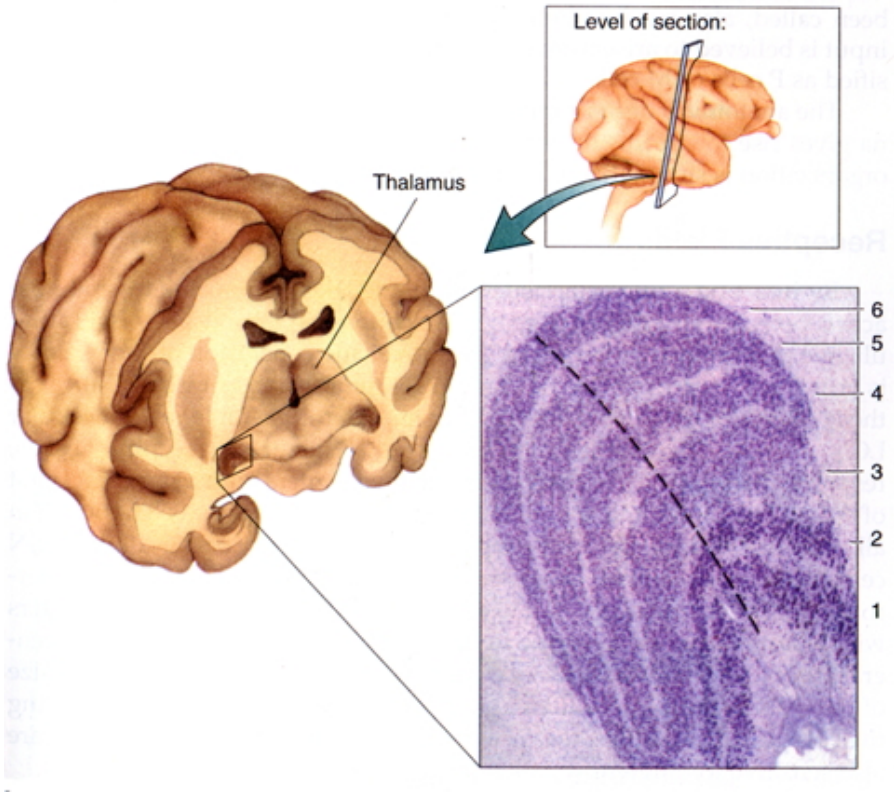
From eye to brain

- Retinal ganglion cells
- 2nd/II cranial (optic) nerve
    - Optic chiasm
- of thalamus (90% of projections)

From eye to brain

- Hypothalamus
  - Suprachiasmatic n.
- Superior colliculus & brainstem

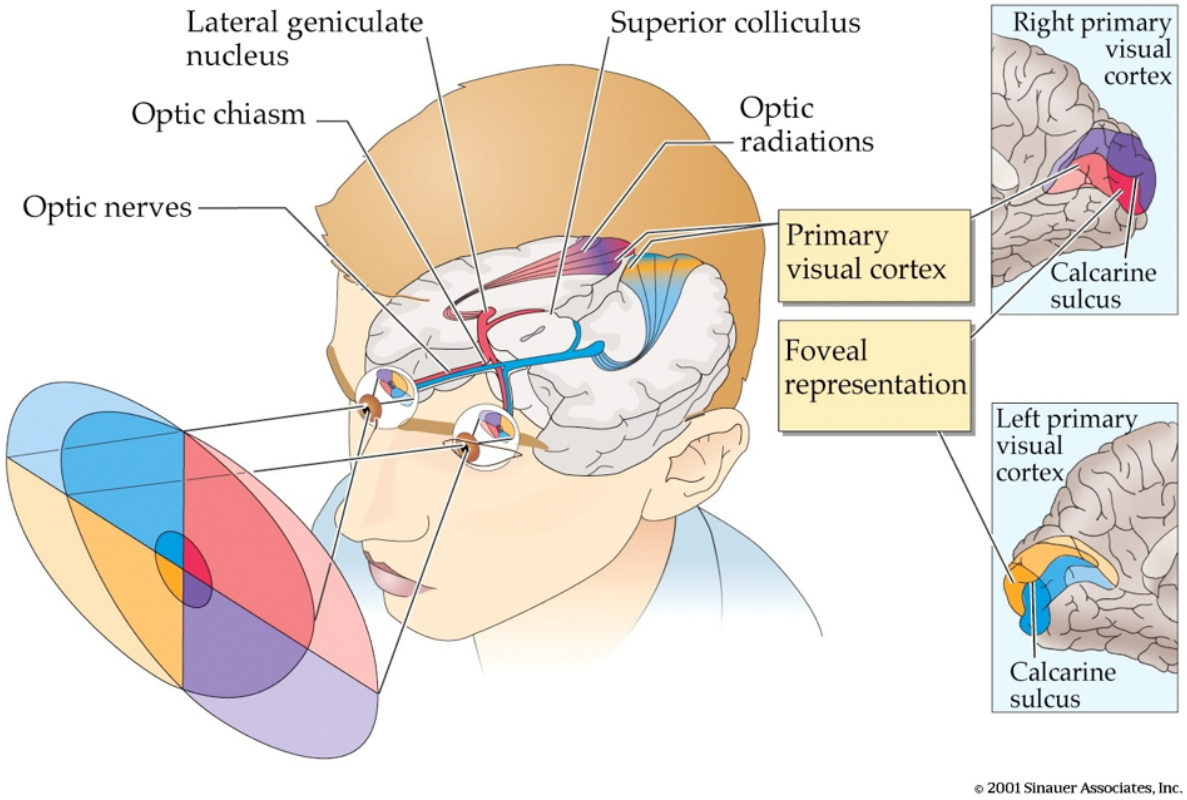
LGN



LGN

- 6 layers + intralaminar zone
  - Parvocellular (small cells): chromatic
  - Magnocellular (big cells): achromatic
  - Koniocellular (chromatic - short wavelength?)
- Retinotopic map of opposite visual field

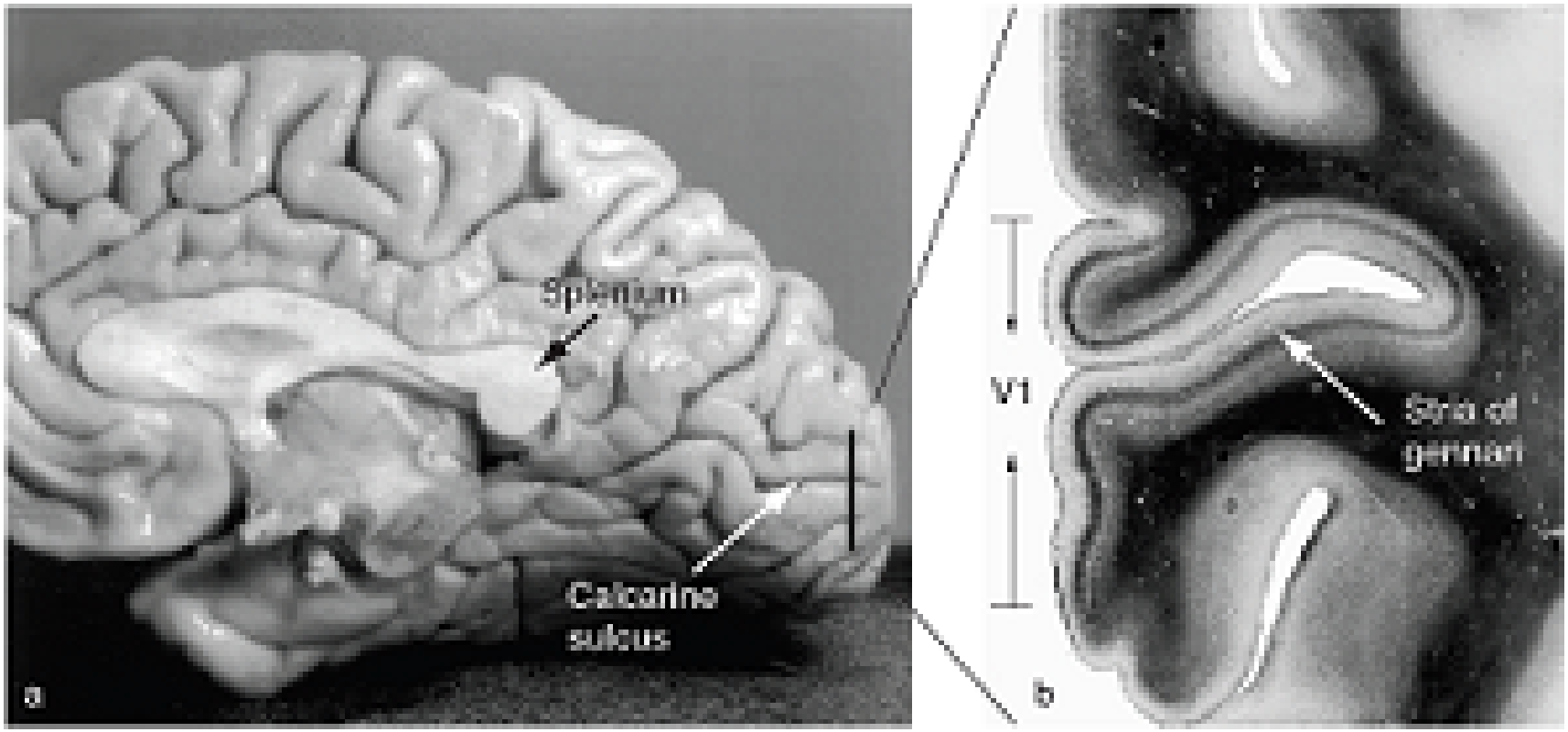
From LGN to V1



From LGN to V1

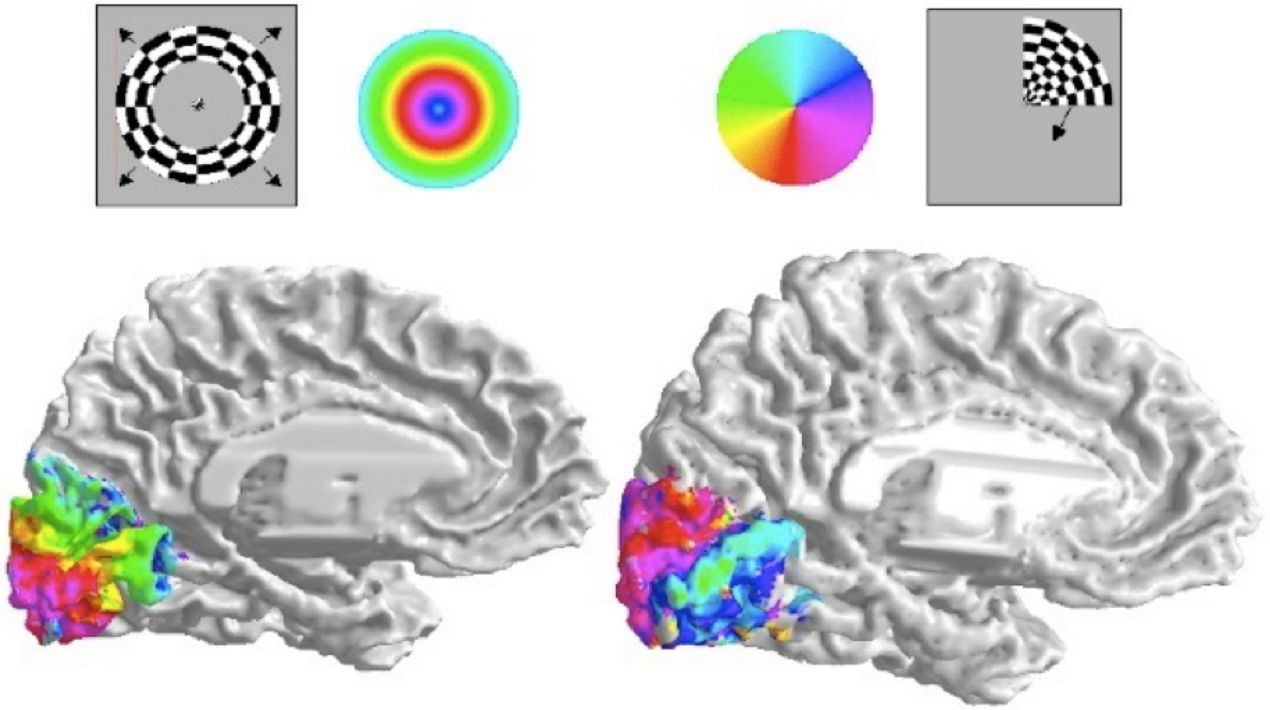
- Via optic radiations
- _____ in occipital lobe

Human V1



http://www.scholarpedia.org/w/images/3/3a/03-Human-V1.png

Measuring retinotopy in V1

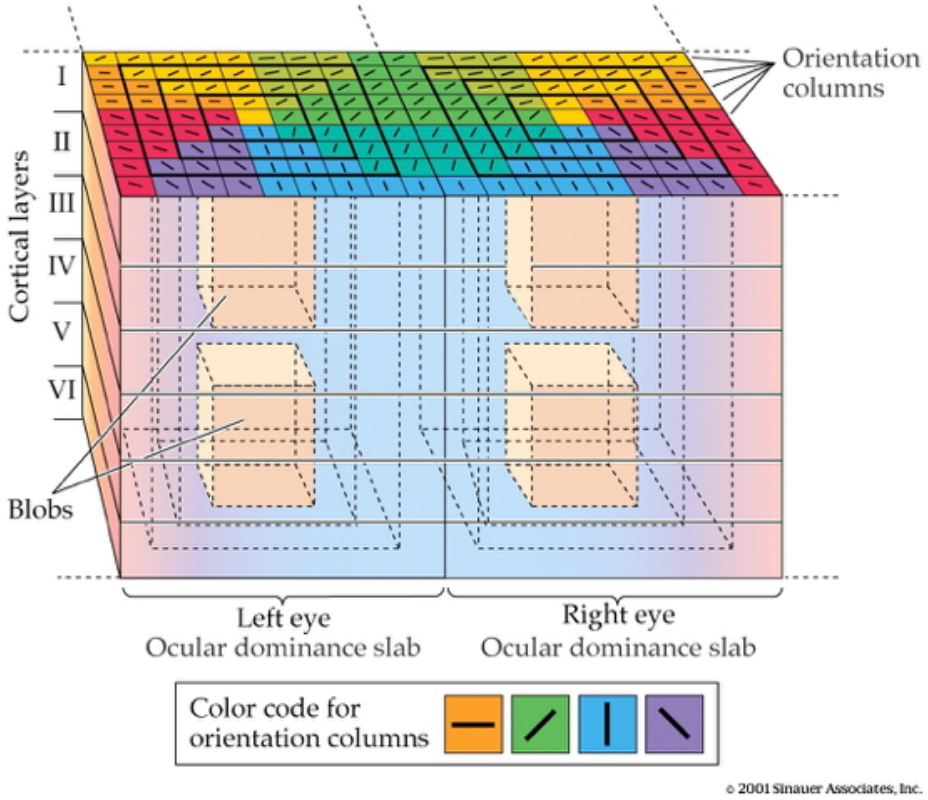


(Dougherty et al. 2003)

Retinotopy in V1

- Fovea overrepresented
  - Analogous to somatosensation
  - High acuity in fovea vs. lower outside it
- Upper visual field/lower (ventral) V1 and

V1 has laminar, columnar organization



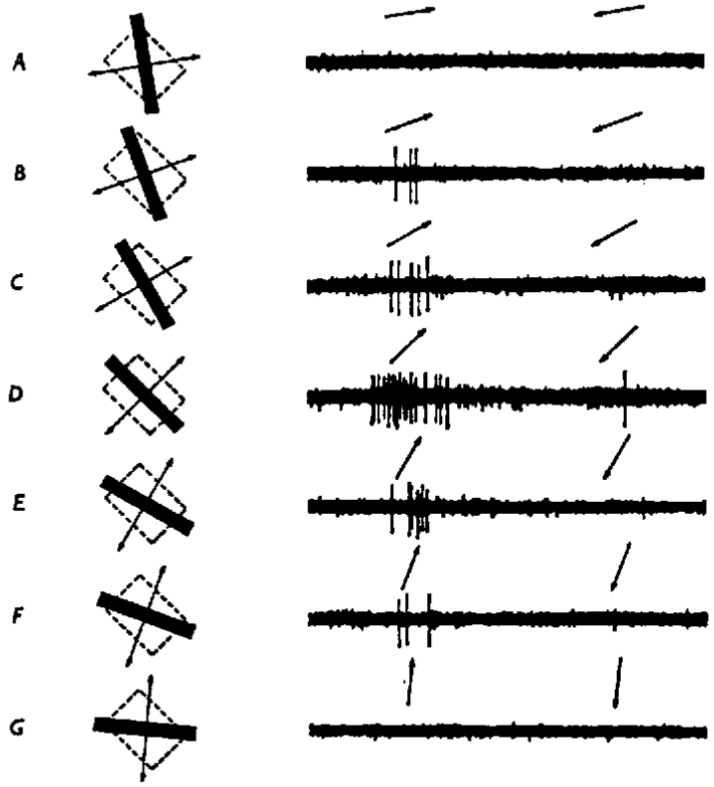
V1 has laminar, columnar organization

- 6 laminae (layers)
  - Input: Layer 4
  - Output: Layers 2-3 (to cortex), 5 (to brainstem), 6 (to LGN)

V1 has laminar, columnar organization

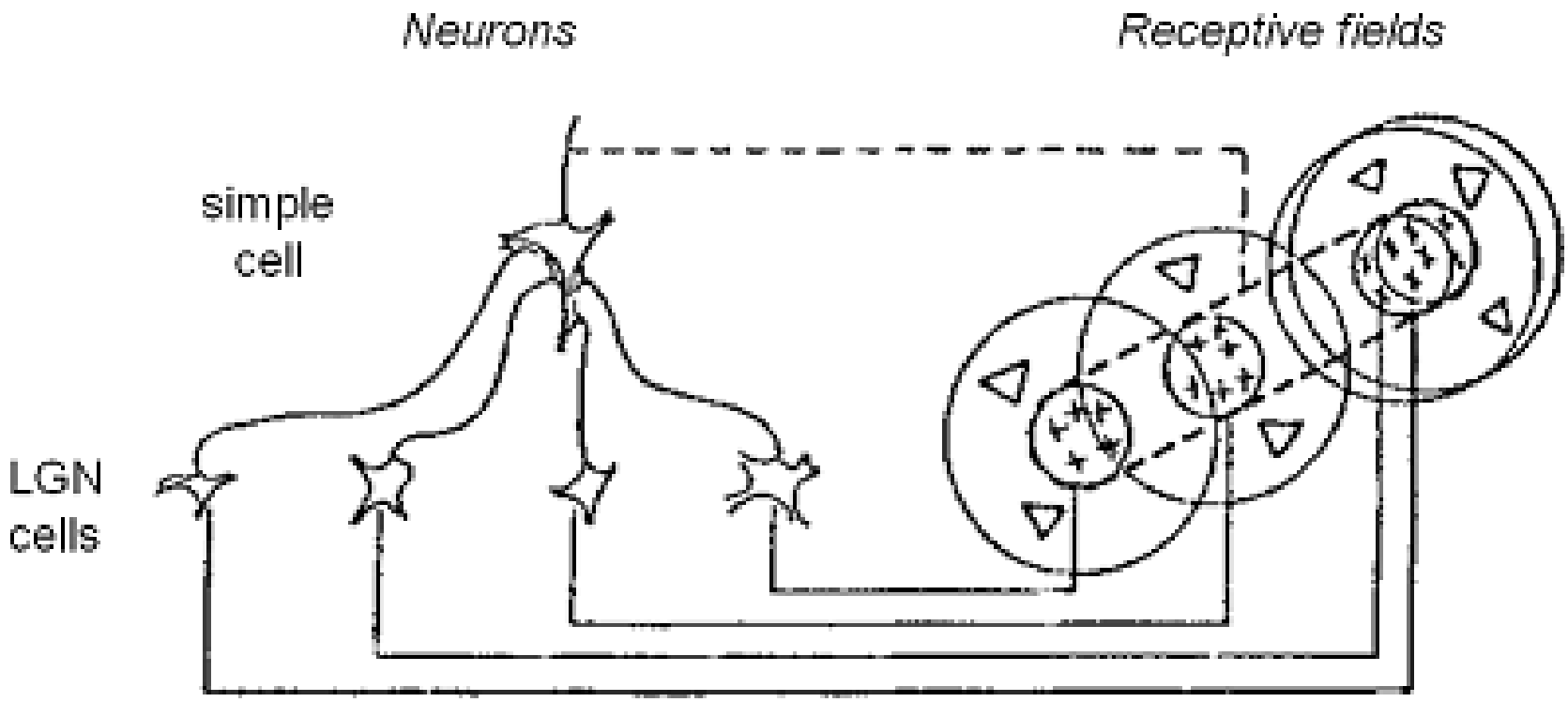
- Columns
  - Orientation/angle
  - Spatial frequency

Orientation/angle tuning



https://foundationsofvision.stanford.edu/wp-content/uploads/2012/02/dir.selective.png

From center-surround receptive fields to line detection



Spatial frequency tuning

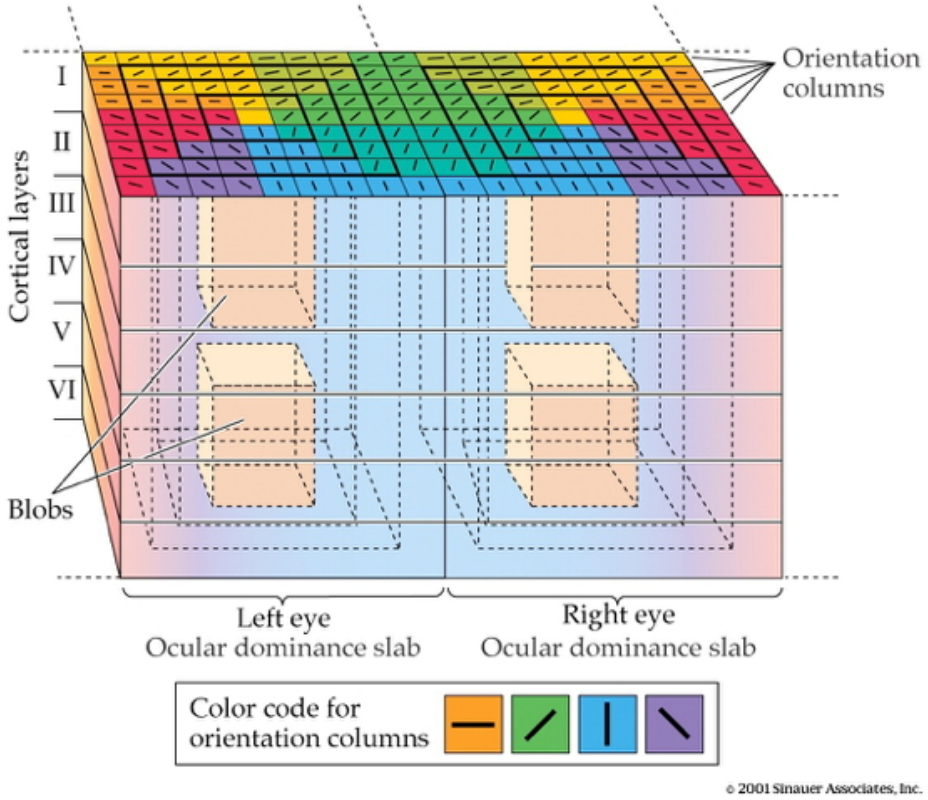
Low == gist || high == details

(Panichello, Cheung, and Bar 2013)

V1 has laminar, columnar organization

- Columns
  - Color/wavelength
  - Eye of origin,

Ocular dominance columns

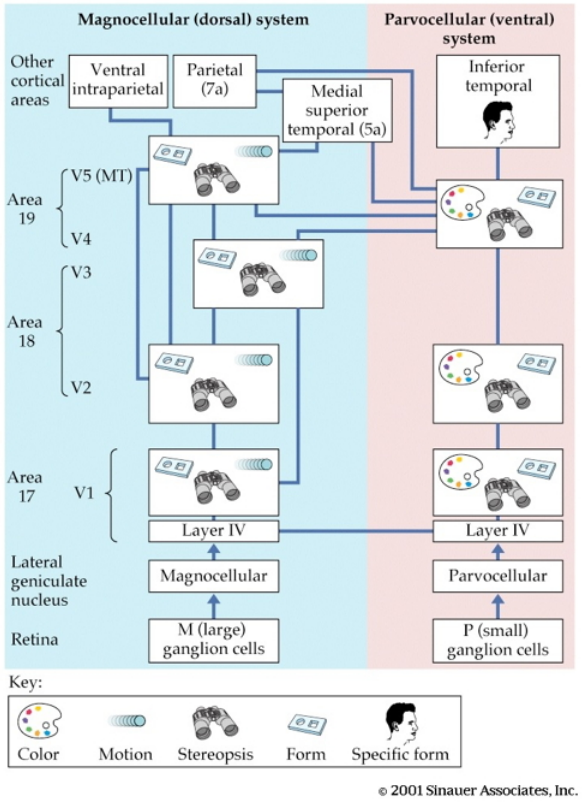


Ocular dominance signals retinal disparity

Cloudy with a Chance of Meatballs 3D Snippet (yt3d:enable=true)

http://www.scholarpedia.org/w/images/9/99/11-Hubel-Wiesel-model.png

Beyond V1


Magnocellular (dorsal) system
Parvocellular (ventral) system
Other cortical areas
Ventral intraparietal
Parietal (7a)
Medial superior temporal (5a)
Inferior temporal
Area 19
V5 (MT)
V4
Area 18
V3
V2
Area 17
V1
Layer IV
Layer IV
Lateral geniculate nucleus
Magnocellular
Parvocellular
Retina
M (large) ganglion cells
P (small) ganglion cells
Key:
Color
Motion
Stereopsis
Form
Specific form
© 2001 Sinauer Associates, Inc.

Beyond V1

- Larger, more complex receptive fields
- (where/how)
  - Toward parietal lobe
- (what)

What is vision for?

- What is it? (form perception)
- Where is it? (space perception)
- How do I get from here to there (action control)
- What time (or time of year) is it?

References

Dougherty, R. F., V. M. Koch, A. A. Brewer, B. Fischer, J. Modersitzki, and B. A. Wandell. 2003. “Visual Field Representations and Locations of Visual Areas V1/2/3 in Human Visual Cortex.” 3 (10): 1–1. doi:10.1167/3.10.1.

Panichello, Matthew F., Olivia S. Cheung, and Moshe Bar. 2013. “Predictive Feedback and Conscious Visual Experience.” 3: 620. doi:10.3389/fpsyg.2012.00620.