

# **PSYCH 260/BBH 203**

Vision

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2022-04-14 09:17:57

# Traveling at Warp 1

<https://vimeo.com/117815404>

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# Announcements

- Blog post 3 and papers due today
- Schedule change: **No class next Thursday, April 21**
- Quiz 4 still on for next Thursday, April 21

# Today's topics

- Vision

# Warm-up

# Which type of muscle fiber is also a sensory organ?

- extrafusal
- intrafusal
- exteroceptive
- extrapyramidal

# Which type of muscle fiber is also a sensory organ?

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- **intrafusal**
- exteroceptive
- extrapyramidal

How many synapses are involved in the circuit connecting the Ia (stretch receptor) sensory afferent in a muscle to the  $\alpha$  motor neuron activating the *same* muscle?

- 1
- 2
- 10s
- too many to count

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Parkinson's and Huntington's disease are similar in that both affect this part of the brain.

- Spinal cord
- Primary motor cortex
- Basal ganglia
- Primary somatosensory cortex

Parkinson's and Huntington's disease are similar in that both affect this part of the brain.

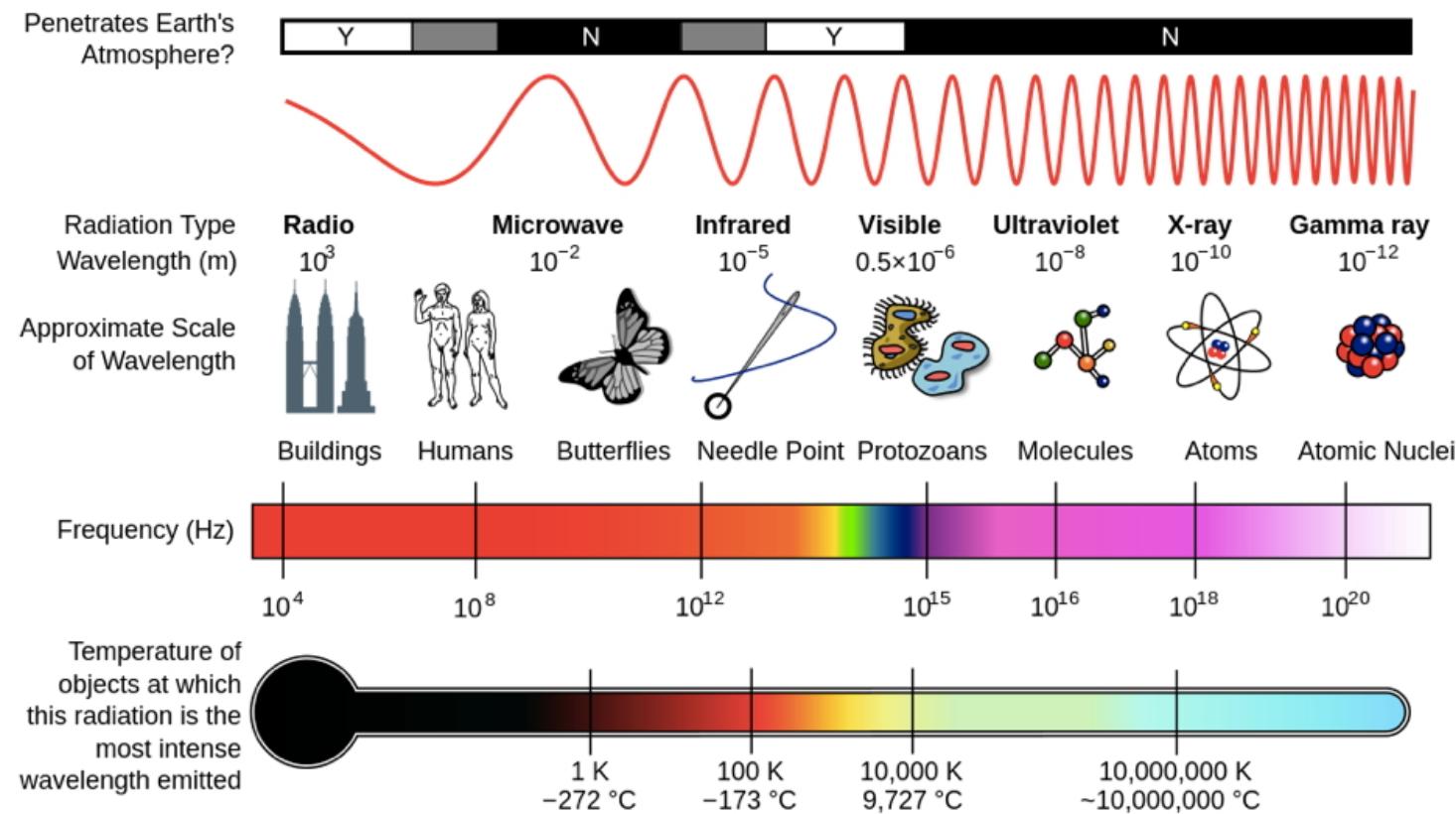
- Spinal cord
- Primary motor cortex
- **Basal ganglia**
- Primary somatosensory cortex

# Vision

# How vision informs

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

# Electromagnetic (EM) radiation

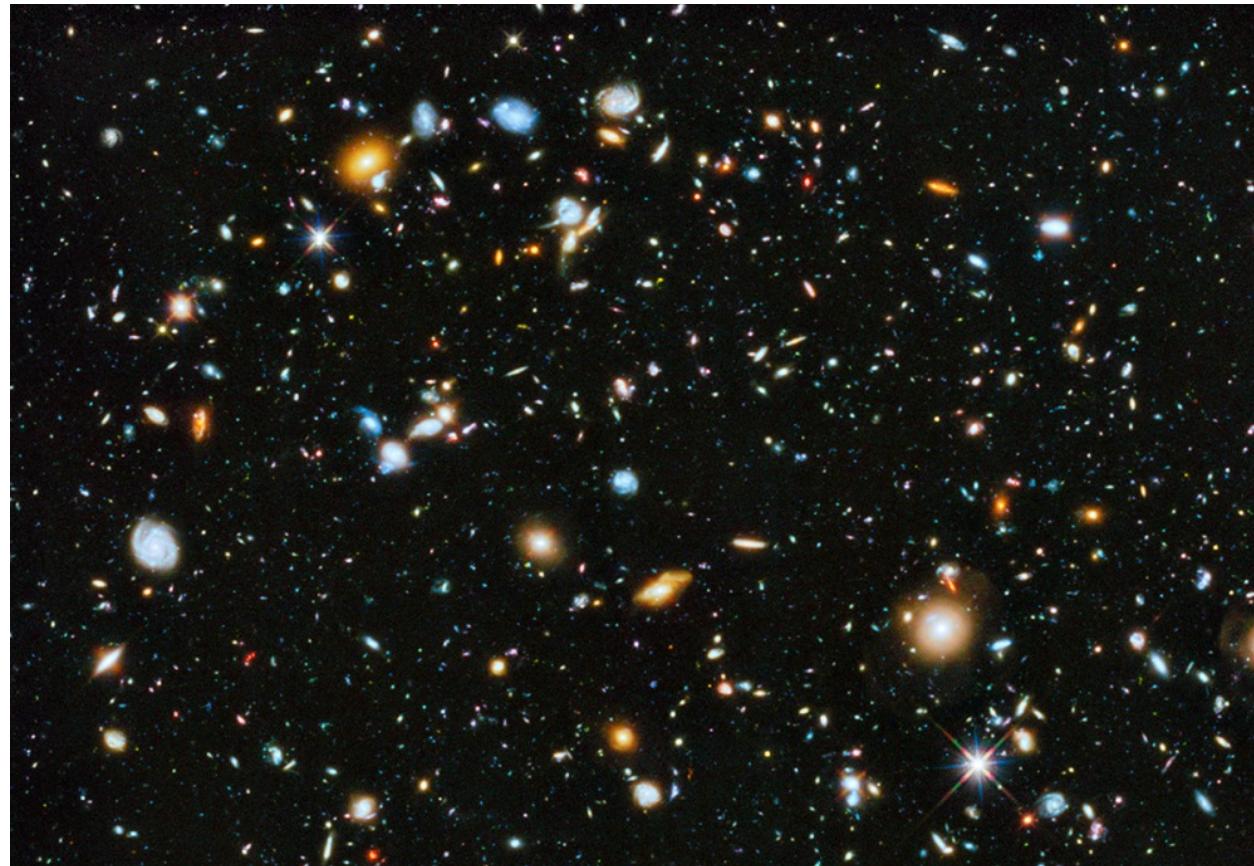


[http://en.wikipedia.org/wiki/File:EM\\_Spectrum\\_Properties\\_edit.svg](http://en.wikipedia.org/wiki/File:EM_Spectrum_Properties_edit.svg)

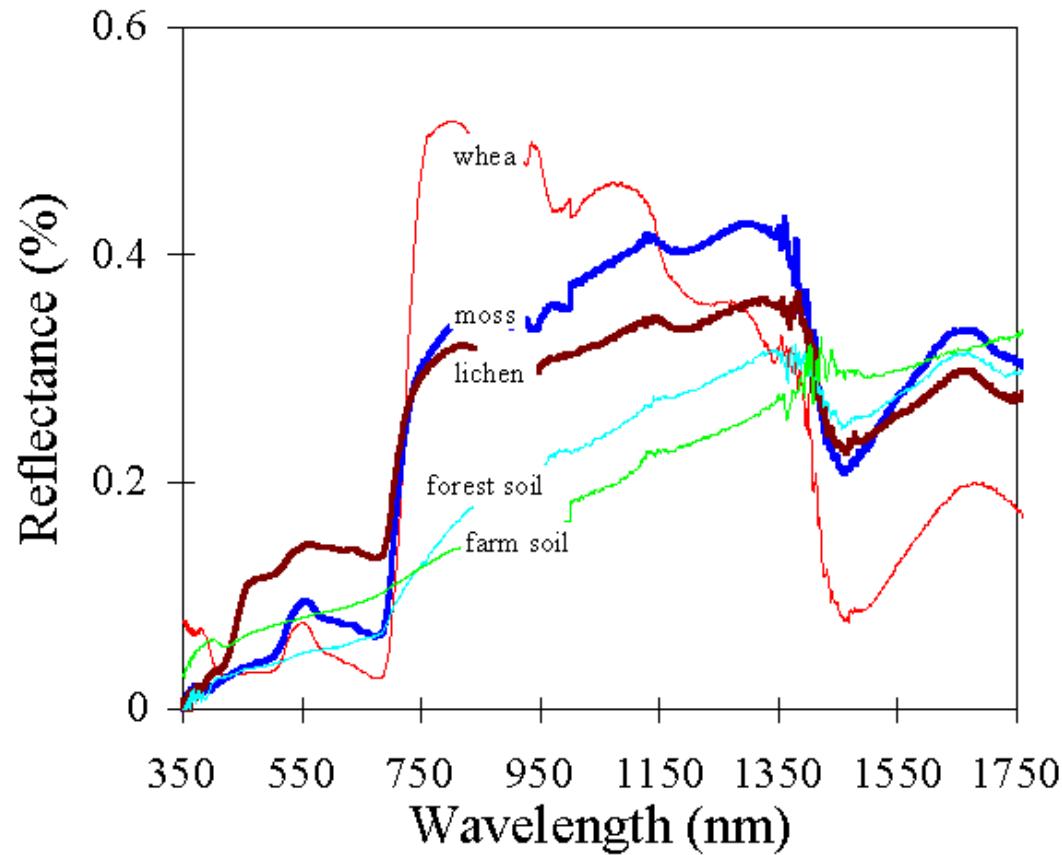
# Features of EM radiation

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

# EM radiation provides information across space (and time)

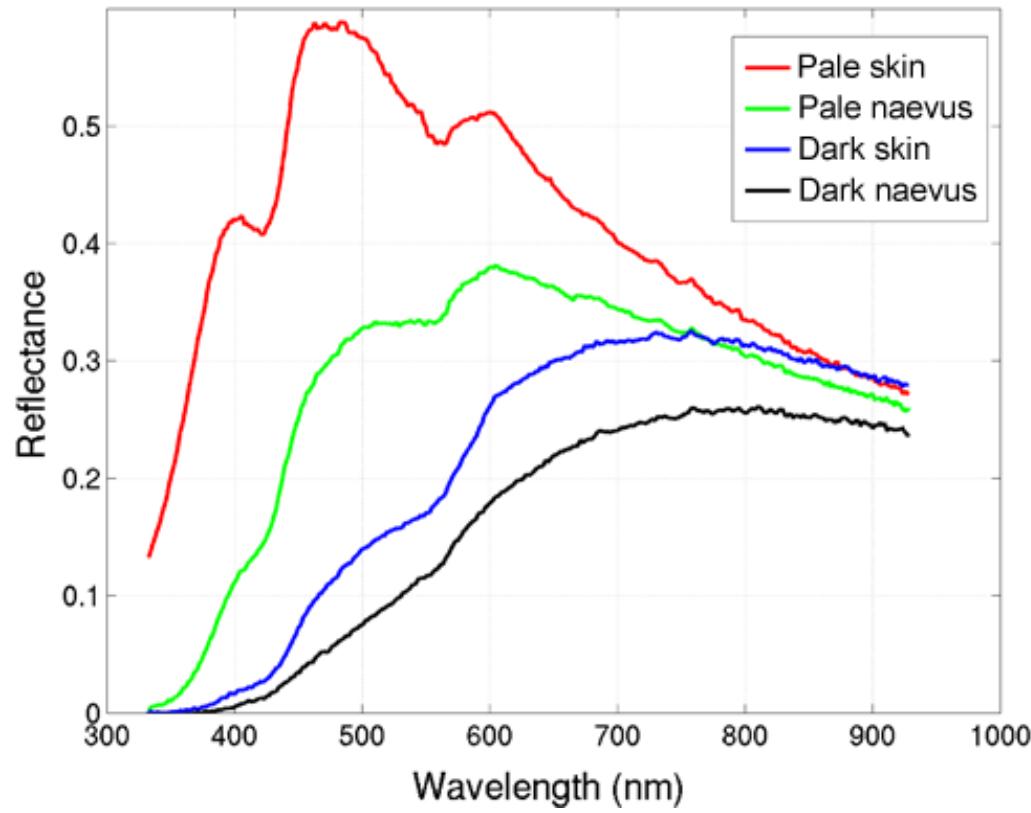


# Reflectance spectra differ by surface

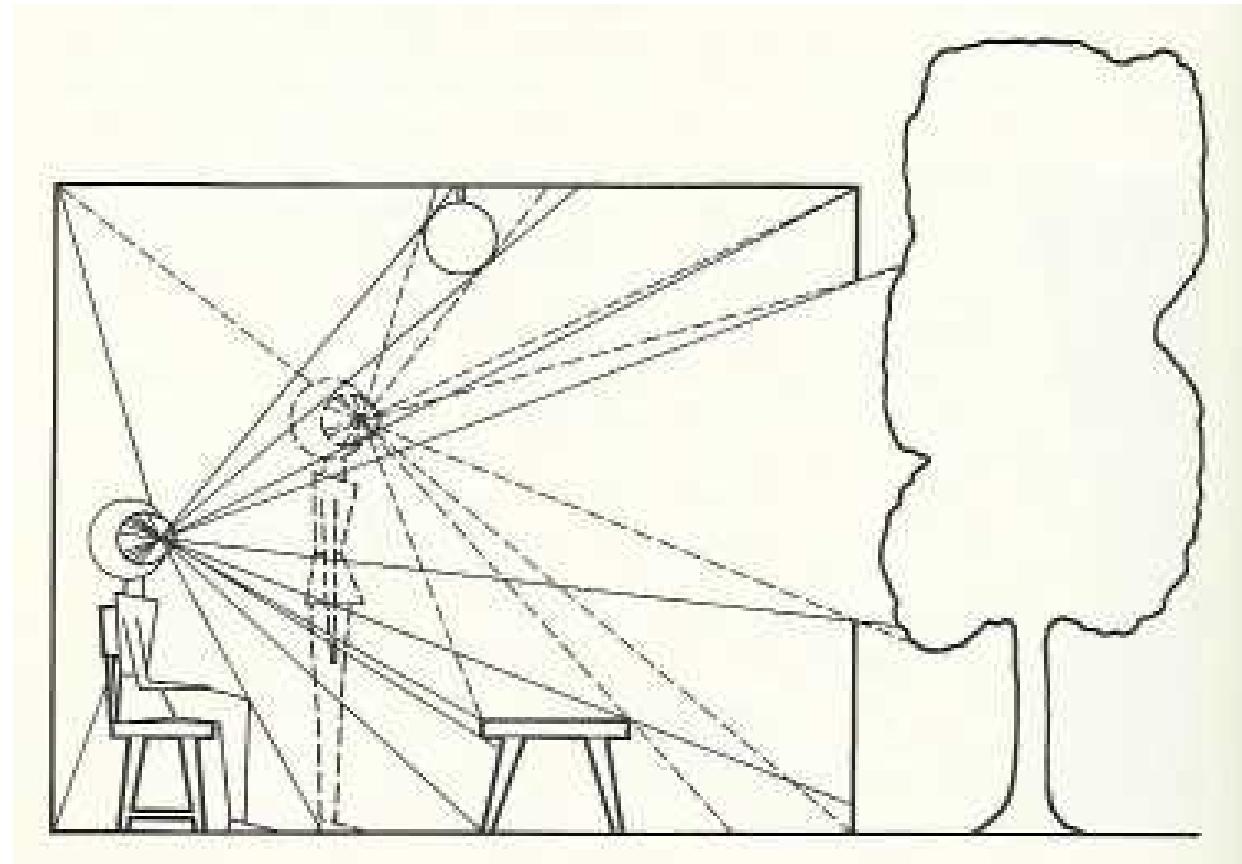


[http://www.vgt.vito.be/userguide/book\\_1/4/42/ie42bd.gif](http://www.vgt.vito.be/userguide/book_1/4/42/ie42bd.gif)

# Reflectance spectra



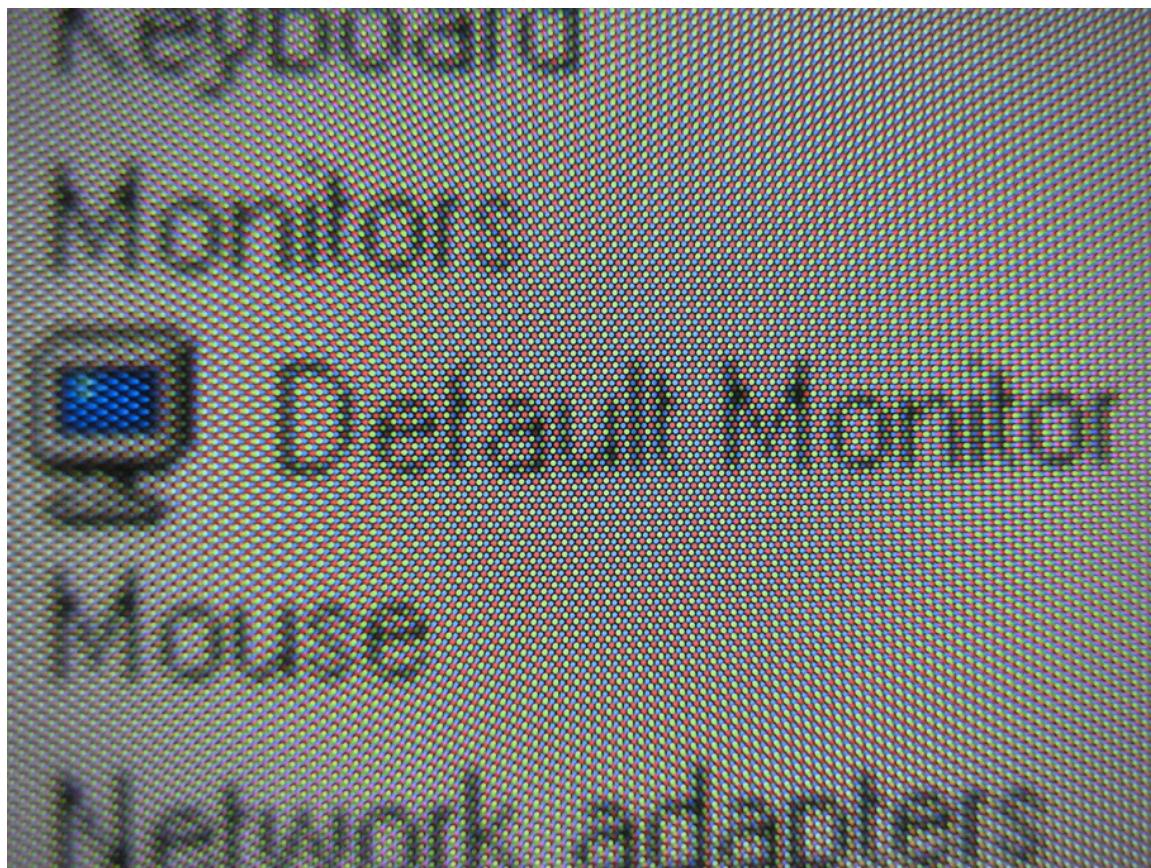
# Optic array specifies geometry of environment



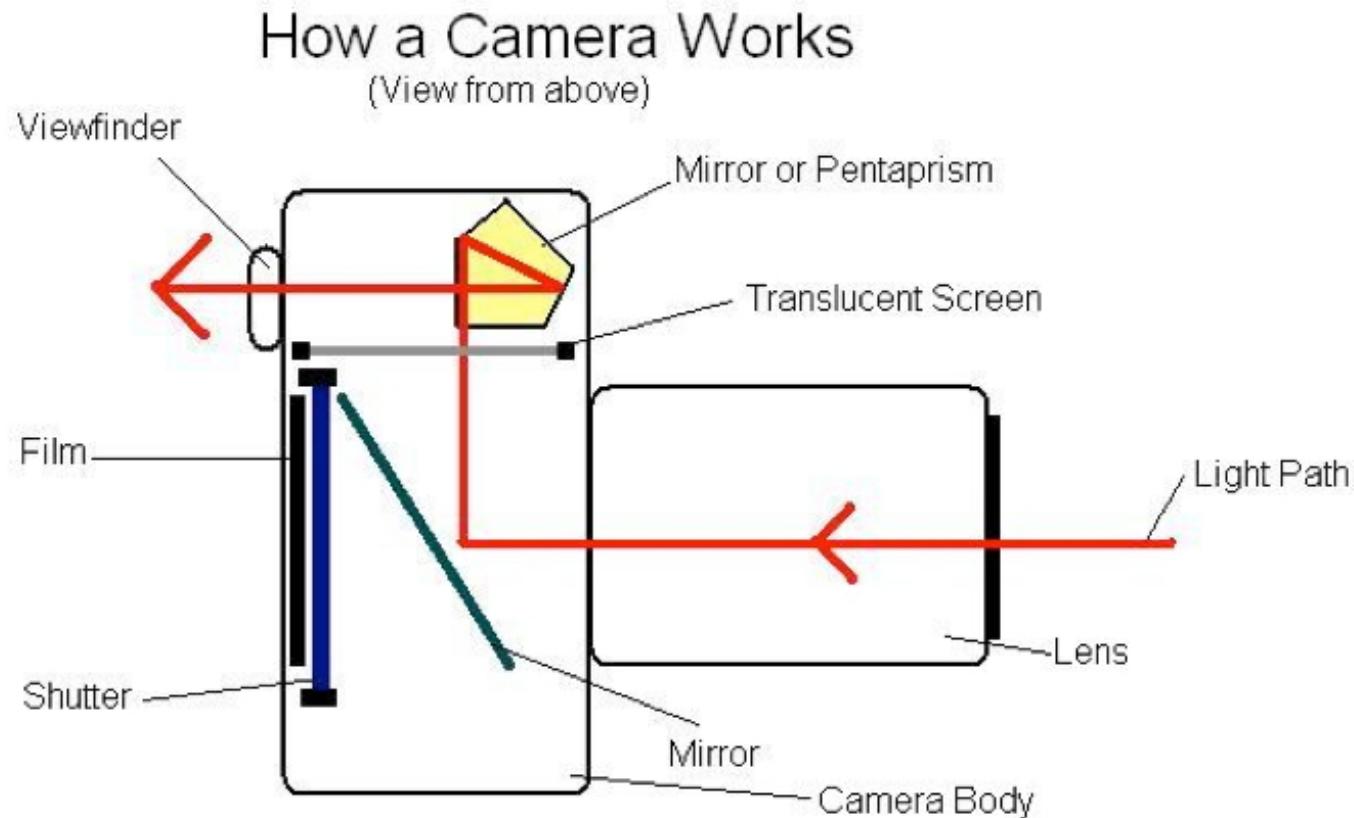
# Color == categories of wavelength

- Eyes categorize wavelength into relative intensities within wavelength bands
- RGB ~ Red, Green, Blue
  - Long, medium, short wavelengths
- *Color is a neural/psychological construct*

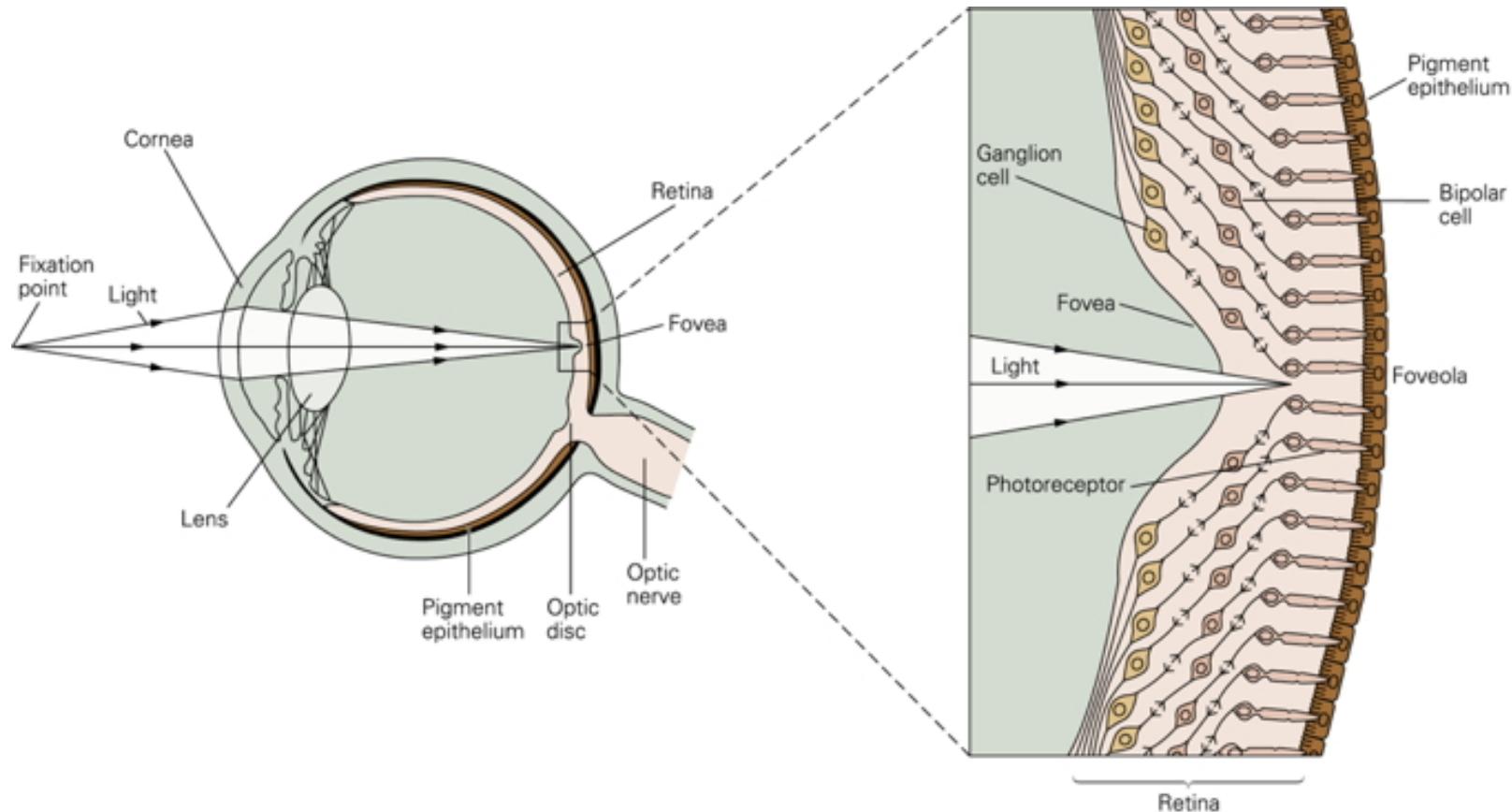
# RGB monitors



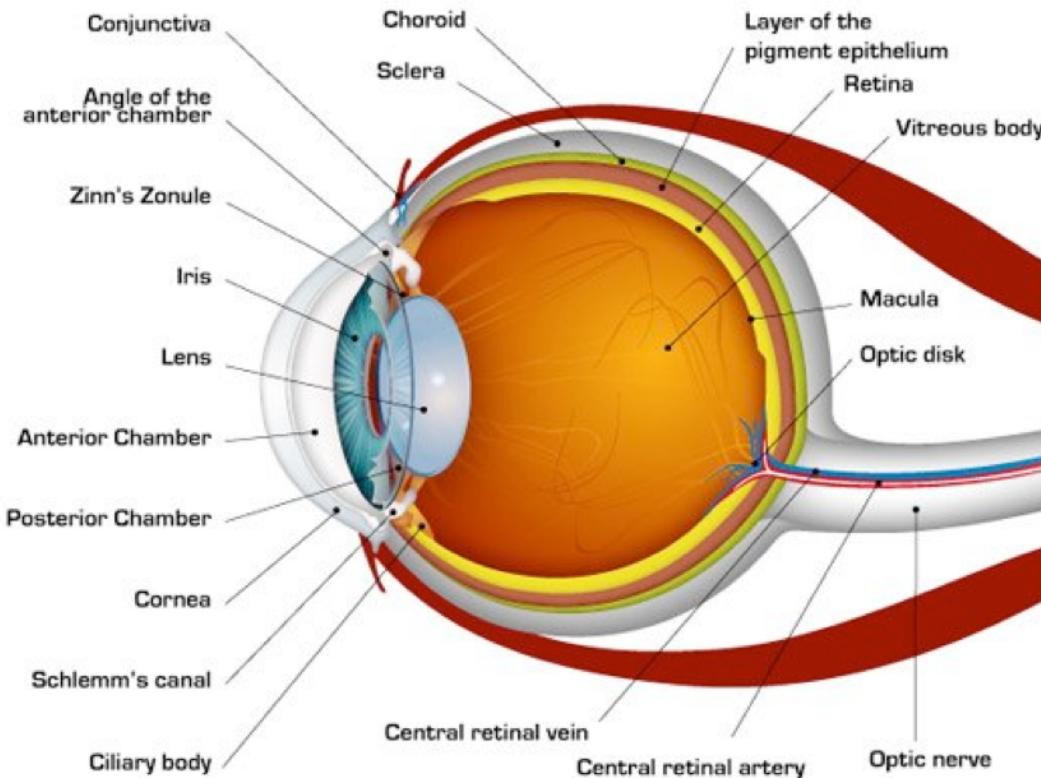
# How a camera works



# The biological camera



# The biological camera



# Parts of the eye

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

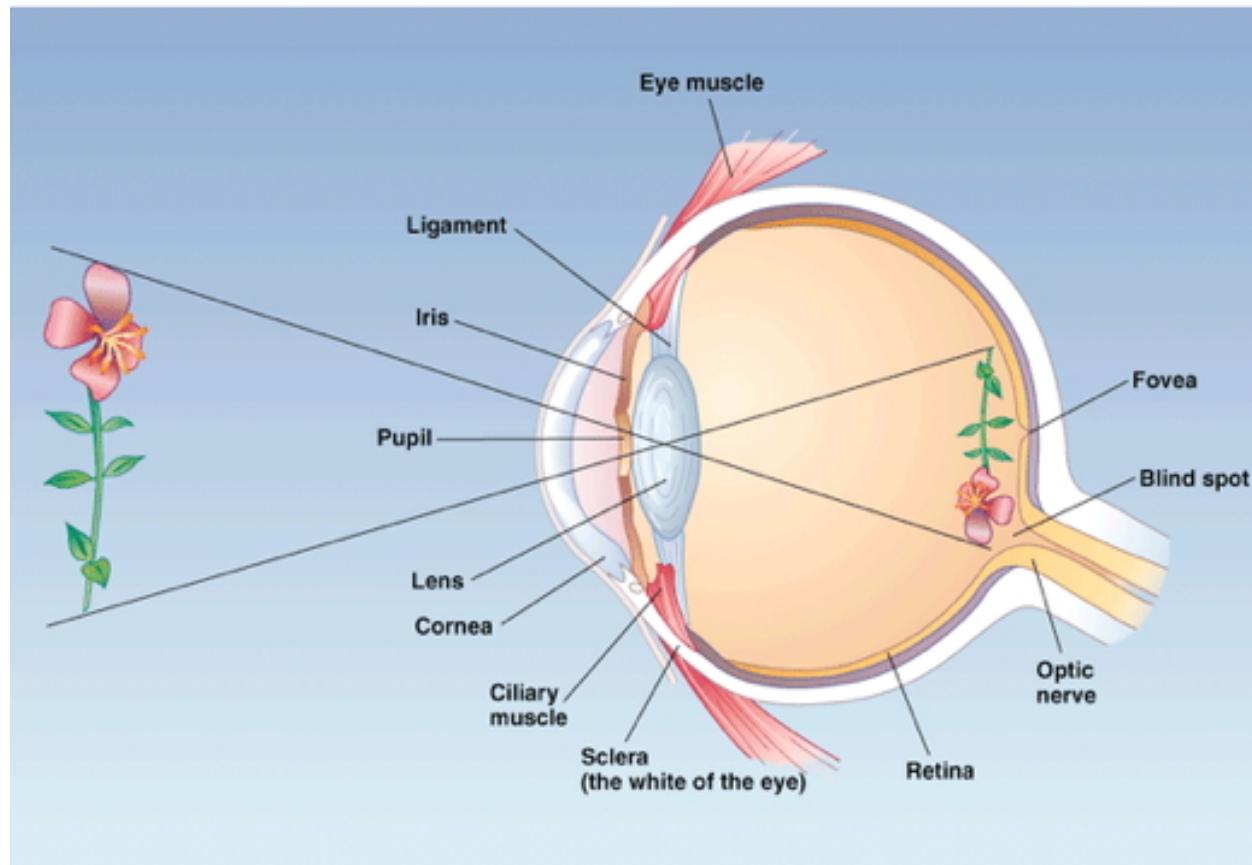
# Parts of the eye

- *Retina* - light detection
  - ~ skin or organ of Corti
- *Pigment epithelium* - regenerate photopigment
- *Muscles* - move eye, reshape lens, change pupil diameter

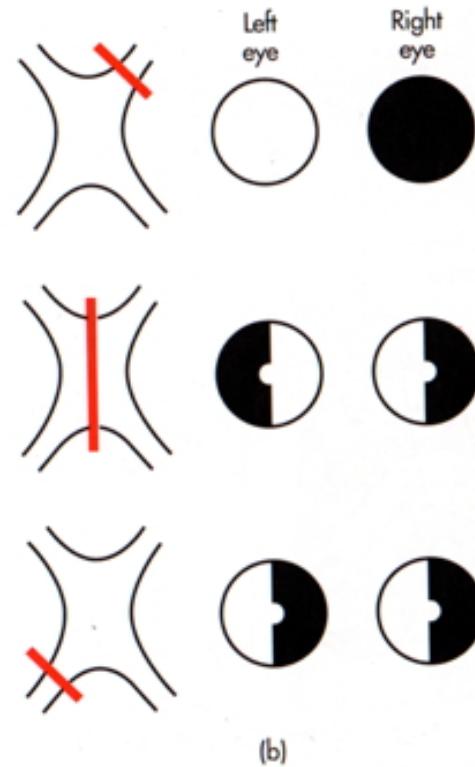
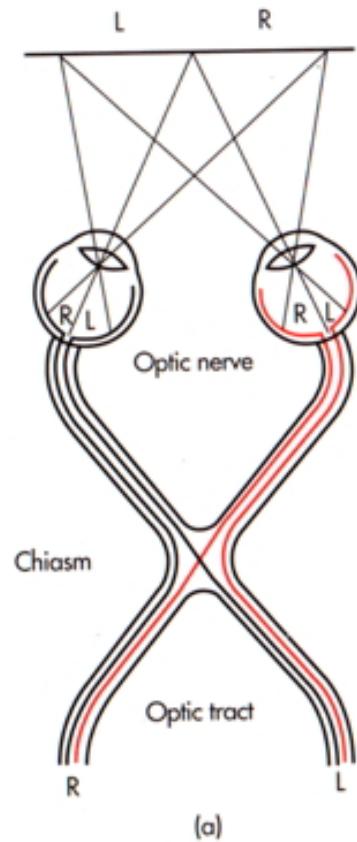
# Eye forms image on retina

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

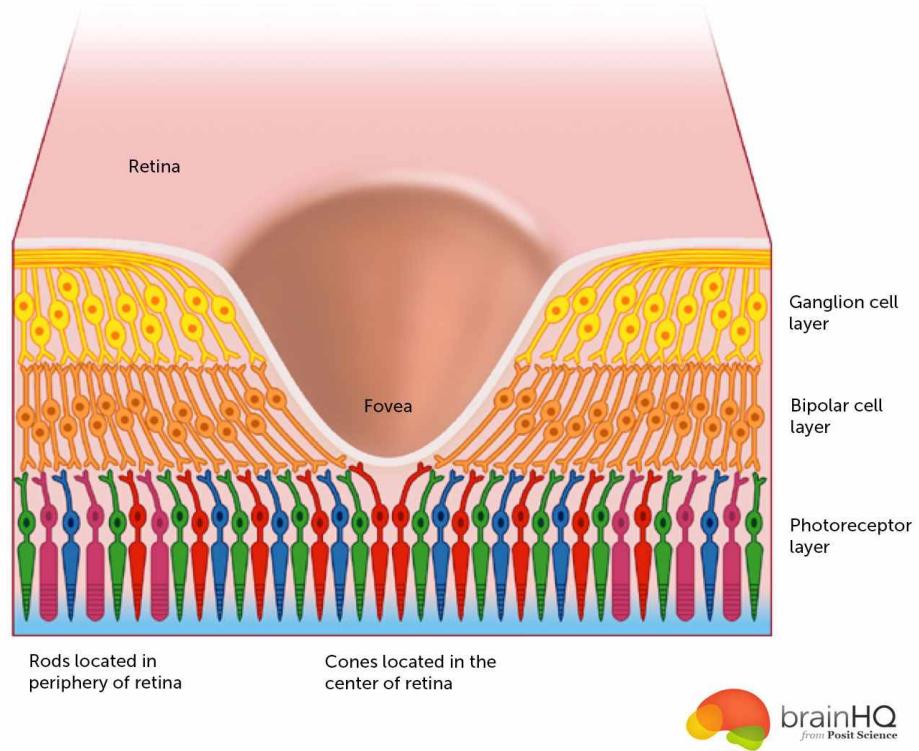
# Retinal image



# Eyes views overlap



# The *fovea*

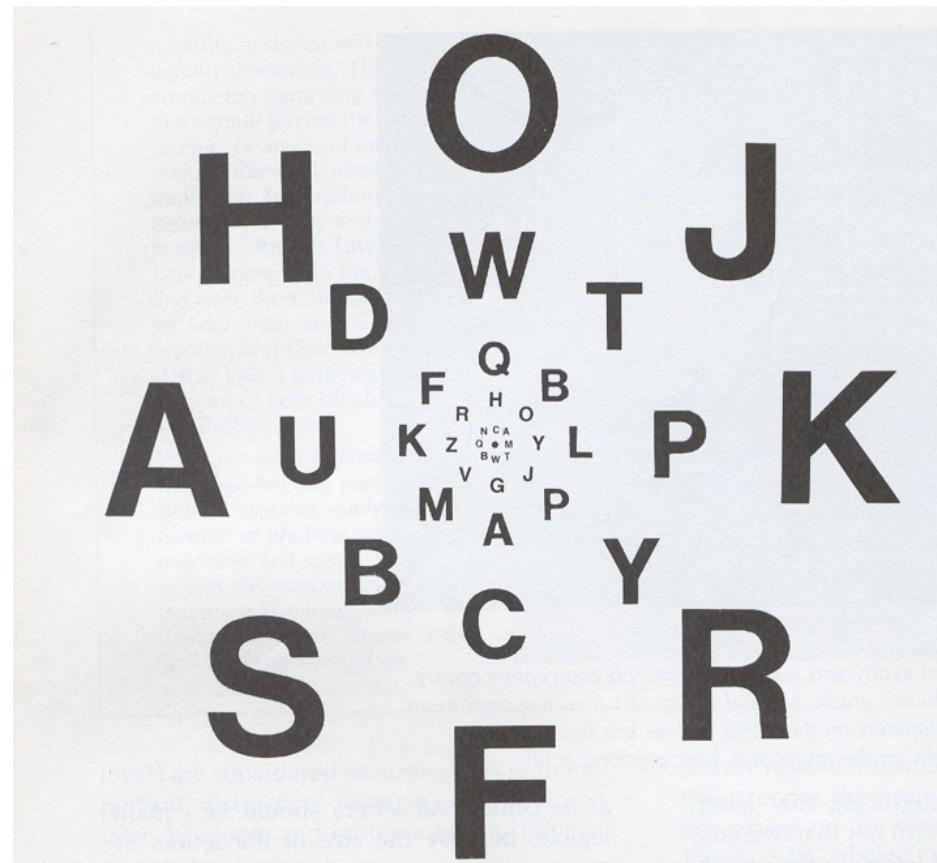


<http://www.brainhq.com/sites/default/files/fovea.jpg>

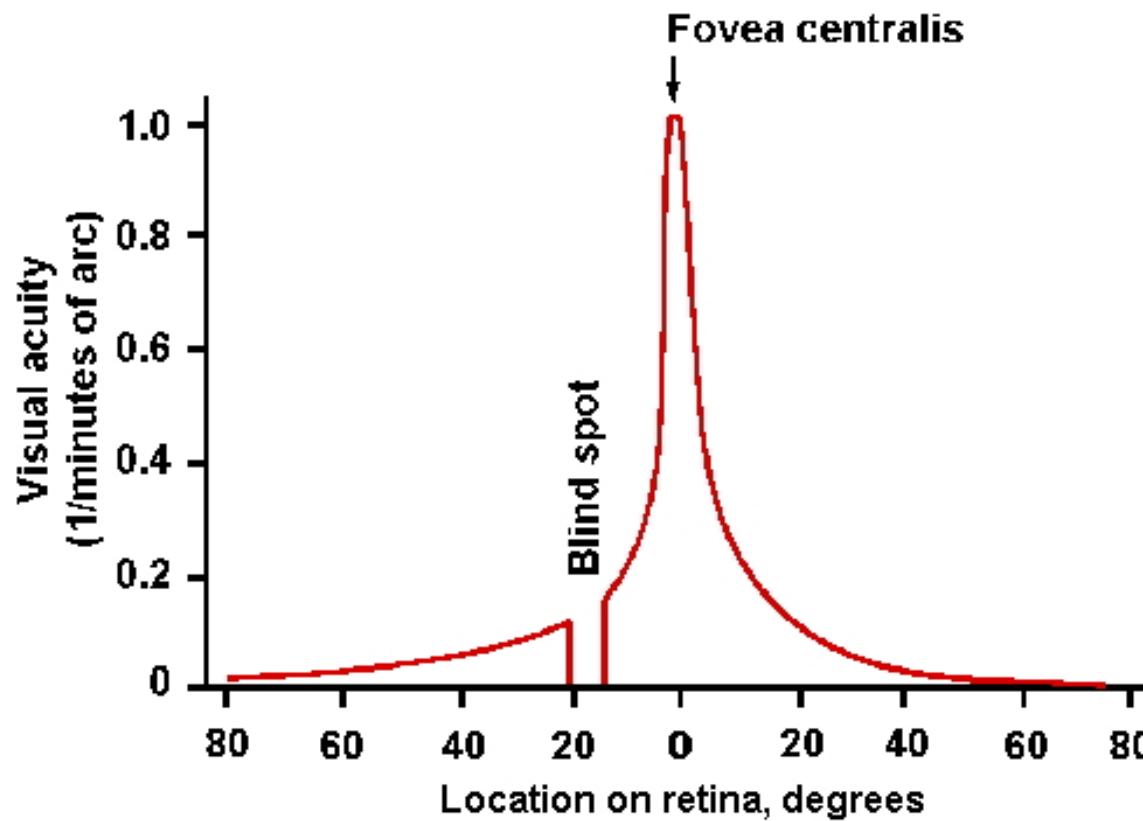
# The fovea

- Central 1-2 deg of visual field
  - ~ thumbnail @ arm's length
- Aligned with visual axis; center of gaze
- *Retinal ganglion cells* pushed aside
- Highest *acuity* vision == best for details

# Acuity varies across the retina



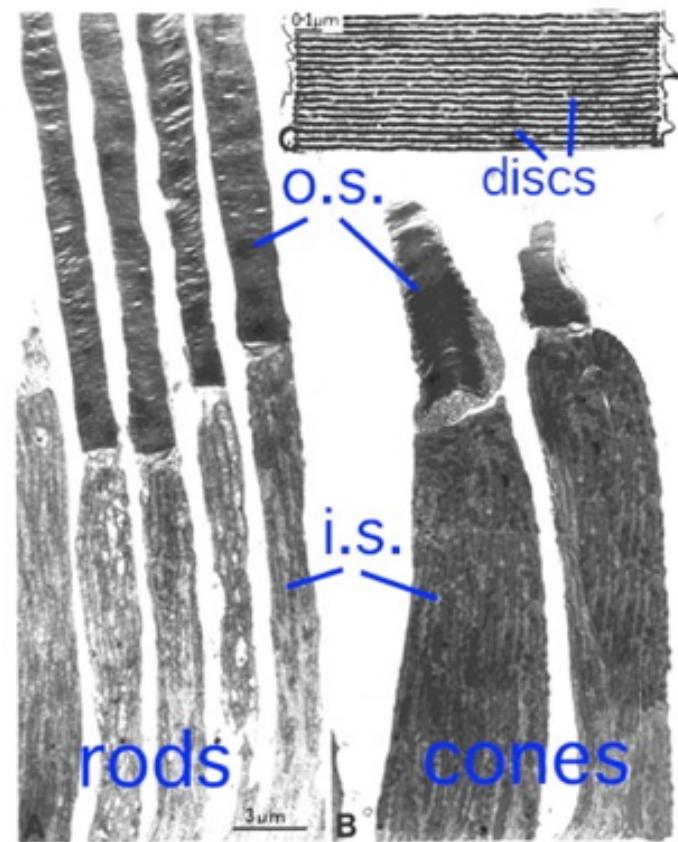
# Acuity varies across the retina



[http://michaeldmann.net/pix\\_7/blndspot.gif](http://michaeldmann.net/pix_7/blndspot.gif)

# What part of the skin is like the fovea?

# *Photoreceptors detect light*



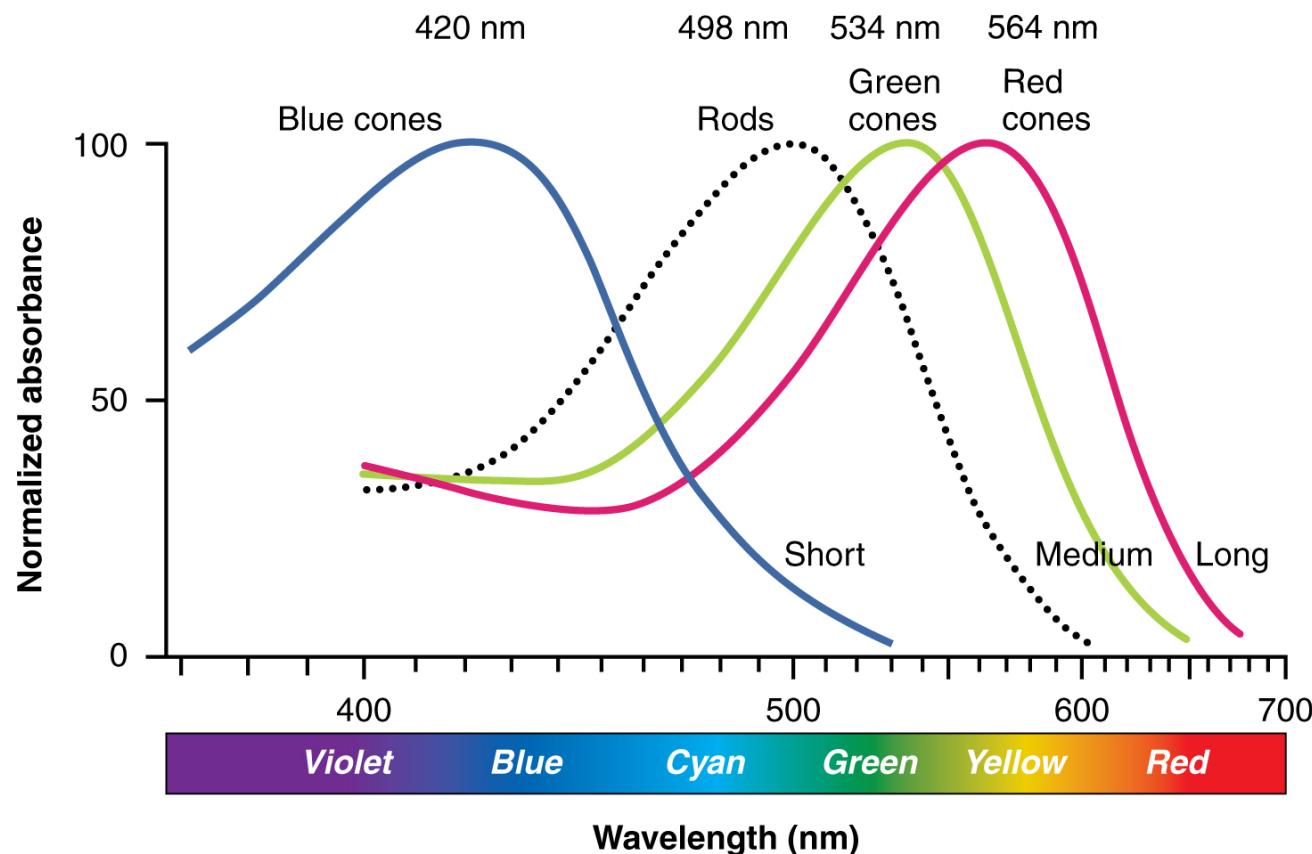
# Photoreceptors detect light

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

# Photoreceptors detect light

- *Cones*
  - ~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
  - *Photopigments*
    - Sense light, trigger chemical cascade
- Inner segment
  - Synaptic terminal
- Light *hyperpolarizes* photoreceptor!
  - The *dark current*

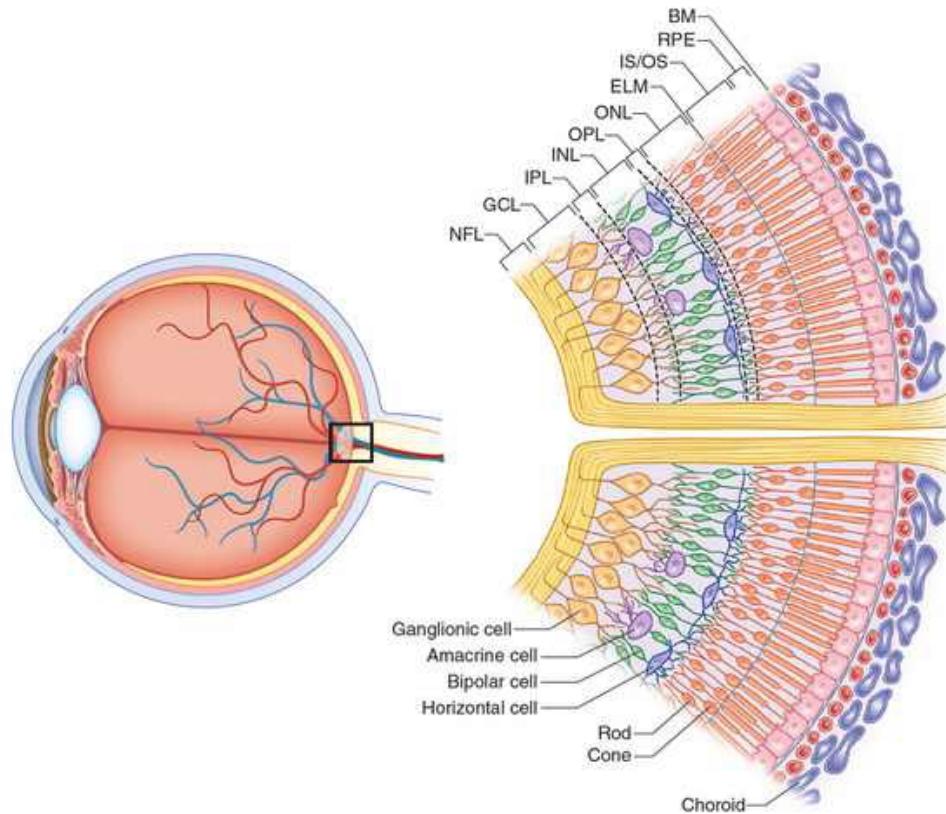
# Retina

- Physiologically *backwards*
  - How?
- Anatomically *inside-out*
  - How?

# Retina

- Physiologically *backwards*
  - Dark current (more NT released in dark)
- Anatomically *inside-out*
  - Photoreceptors at back of eye

# Retinal layers

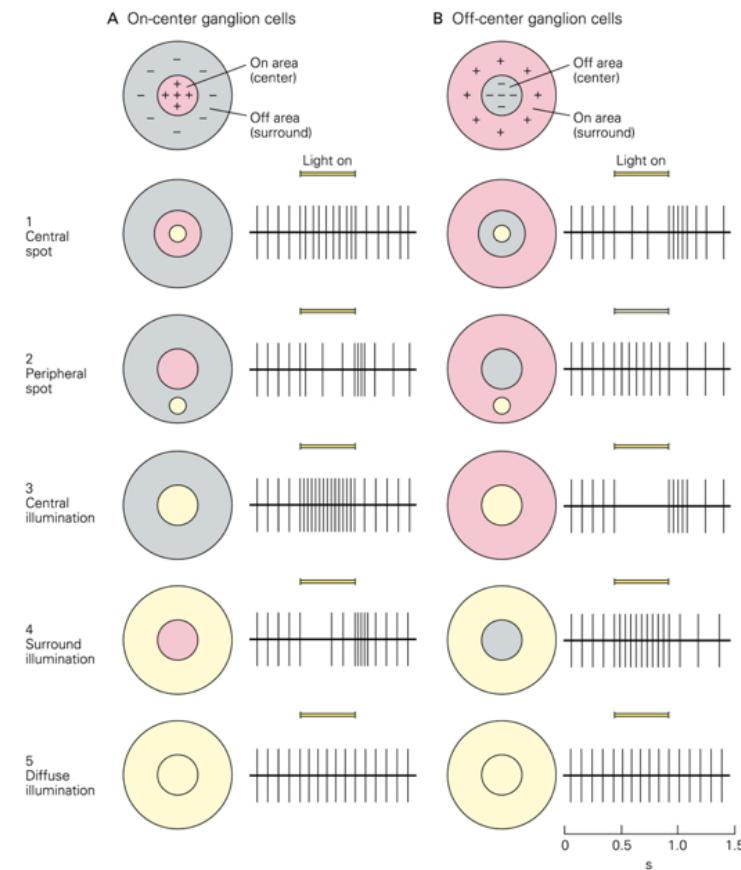


<http://www.retinareference.com/anatomy/>

# Retinal layers

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

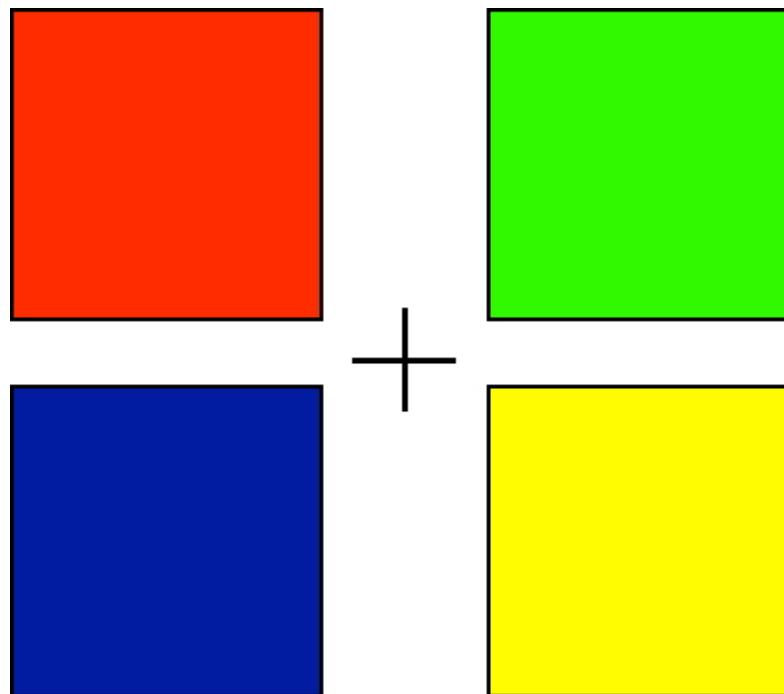
# *Center-surround receptive fields*



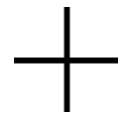
# Center-surround receptive fields

- 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)

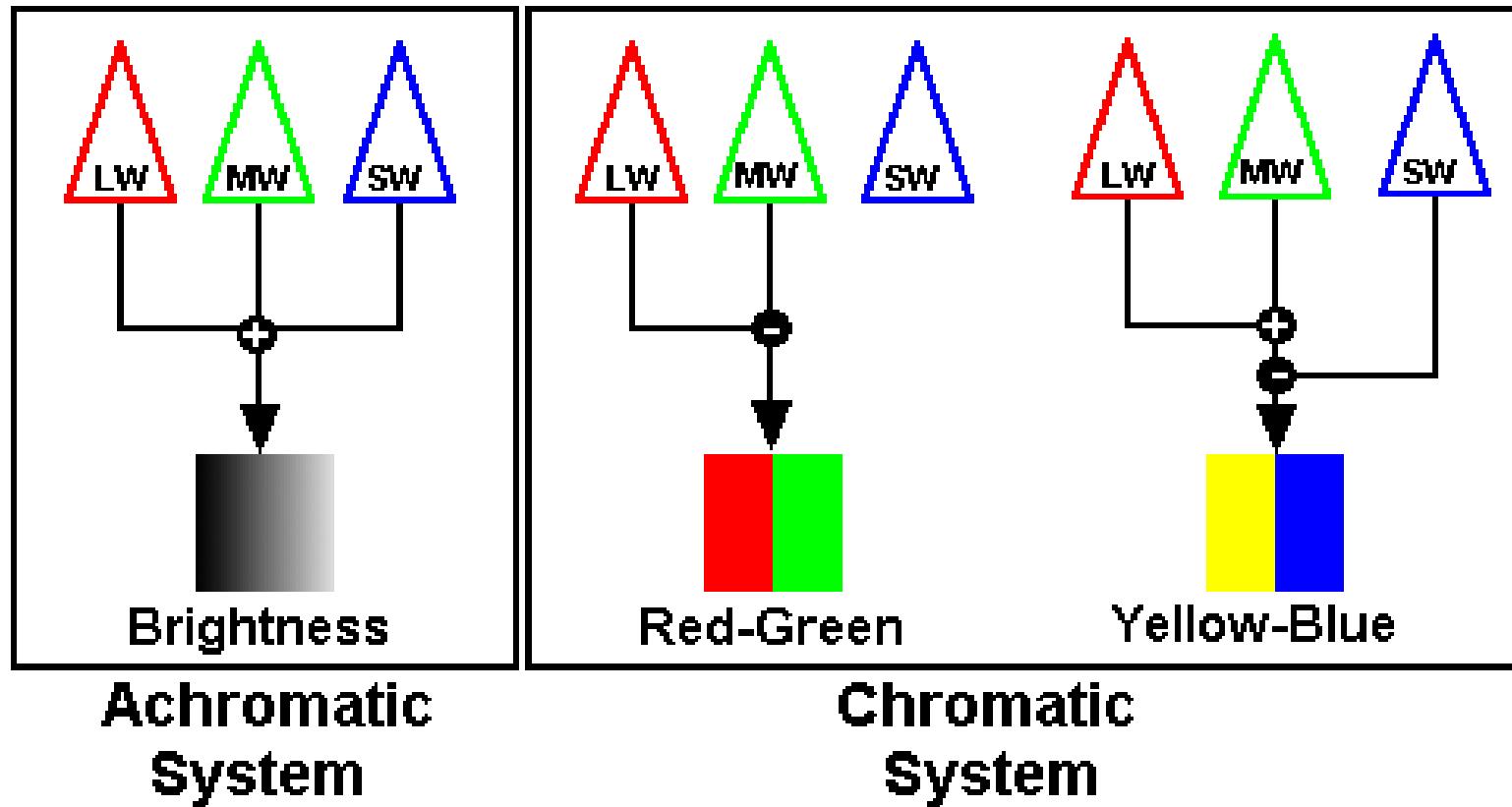
# What's a reddish-green look like?



# What's a reddish-green look like?



# *Opponent processing*

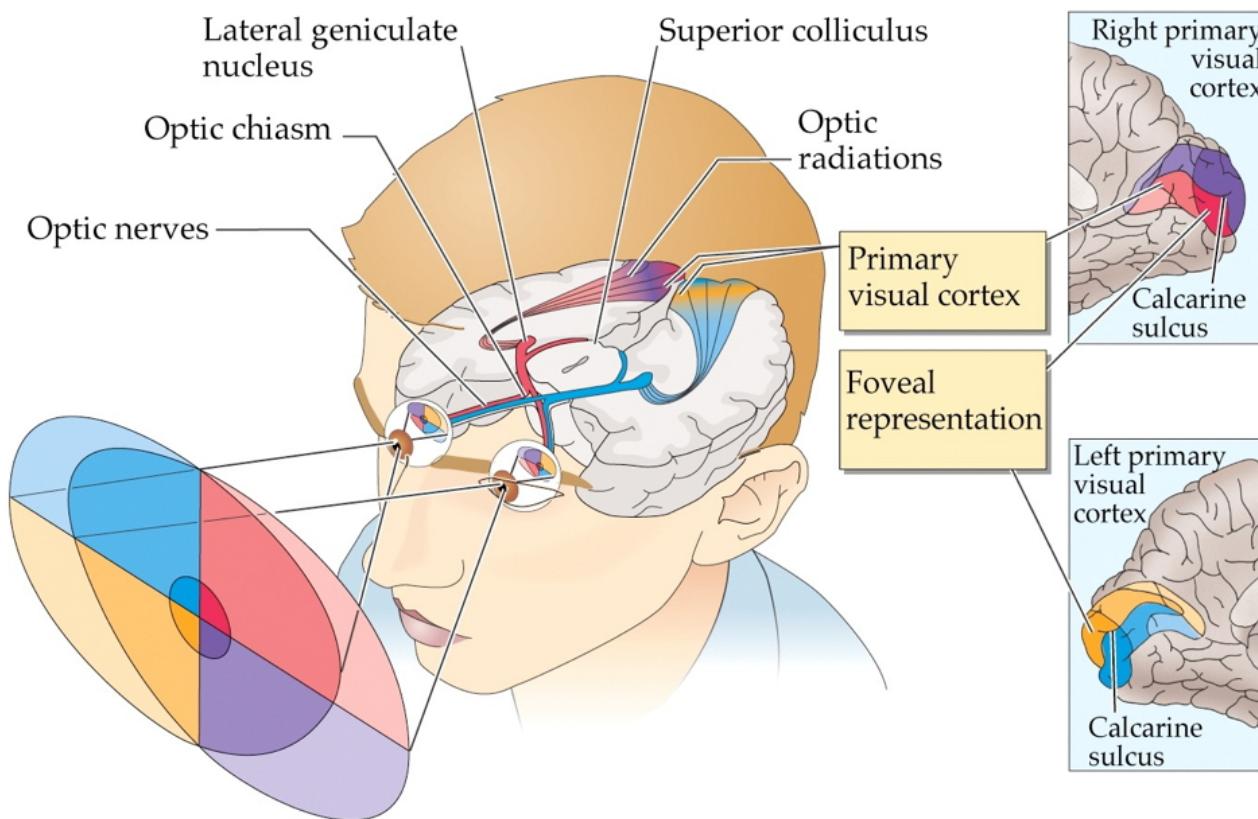


<http://www.visualexpert.com/sbfaqimages/RGBOpponent.gif>

# Opponent processing

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

# From eye to brain



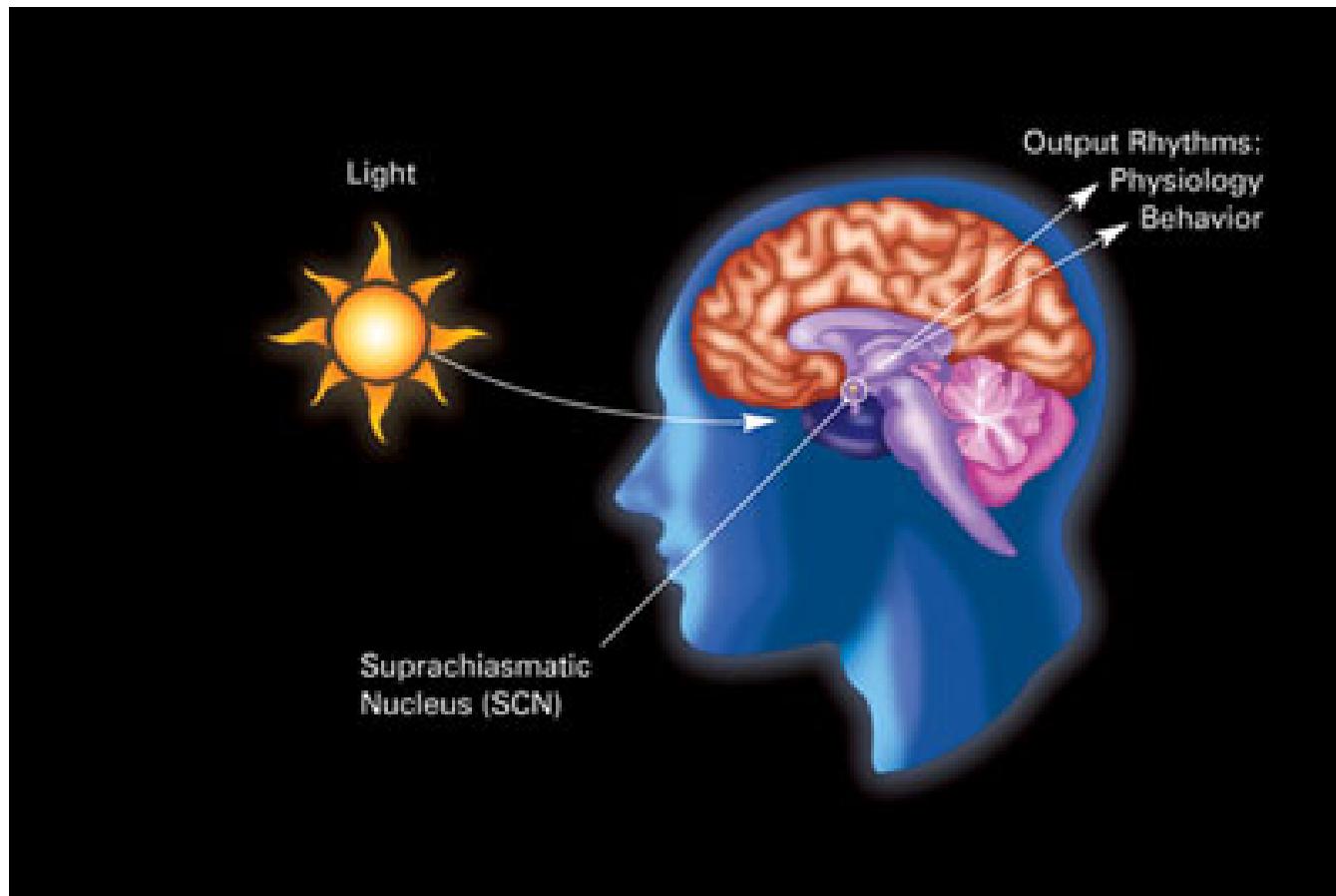
© 2001 Sinauer Associates, Inc.

# From eye to brain

- Retinal ganglion cells
- 2nd/II cranial (optic) nerve
  - Optic chiasm

# From eye to brain

- Hypothalamus
  - Suprachiasmatic nucleus
    - Regulates circadian (day/night) rhythm via pineal gland



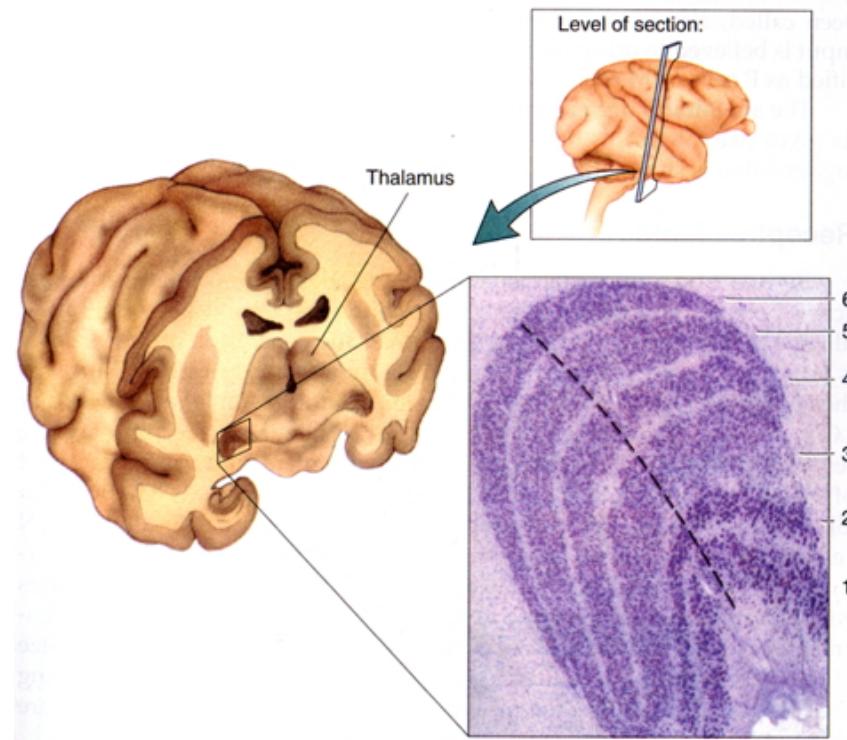
[https://en.wikipedia.org/wiki/Retinohypothalamic\\_tract](https://en.wikipedia.org/wiki/Retinohypothalamic_tract)

# From eye to brain

- Superior colliculus & brainstem

# *Lateral Geniculate Nucleus (LGN) of thalamus*

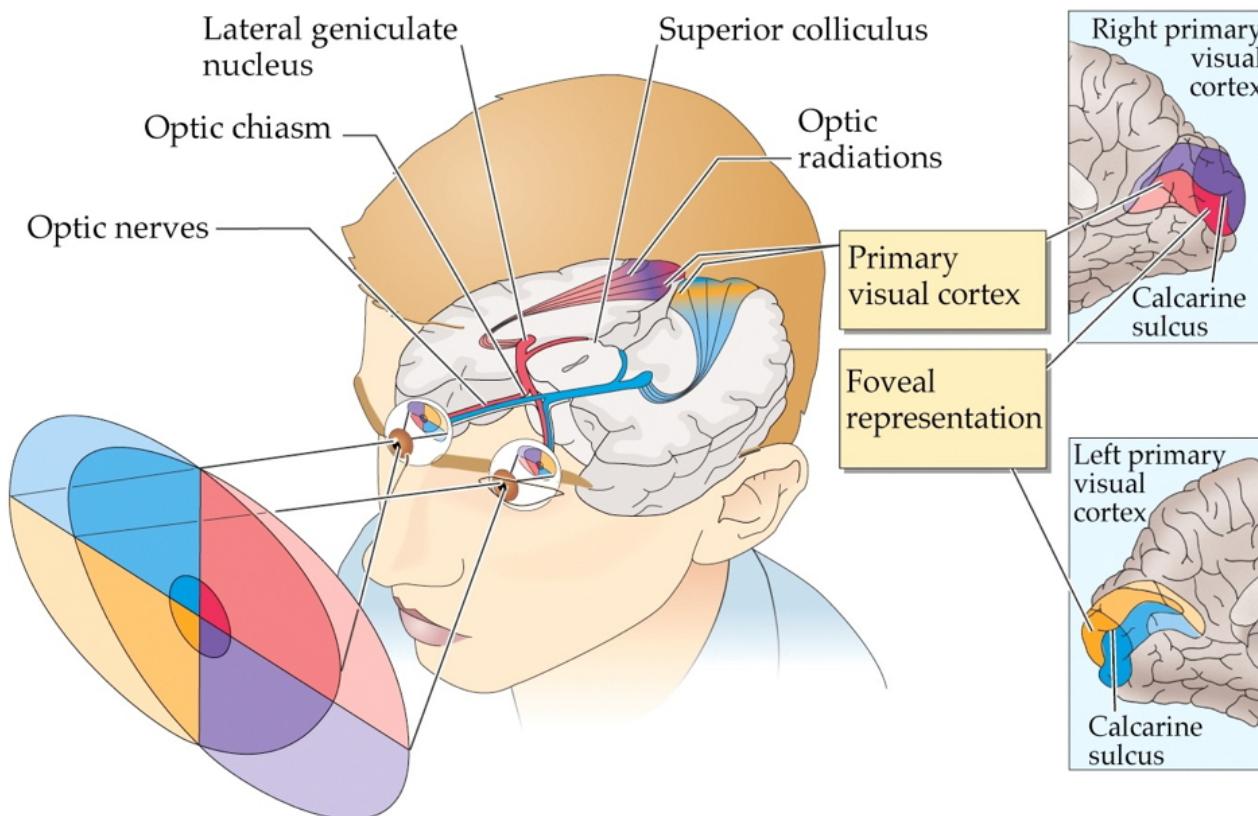
- ~90% of axons from retina



# 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

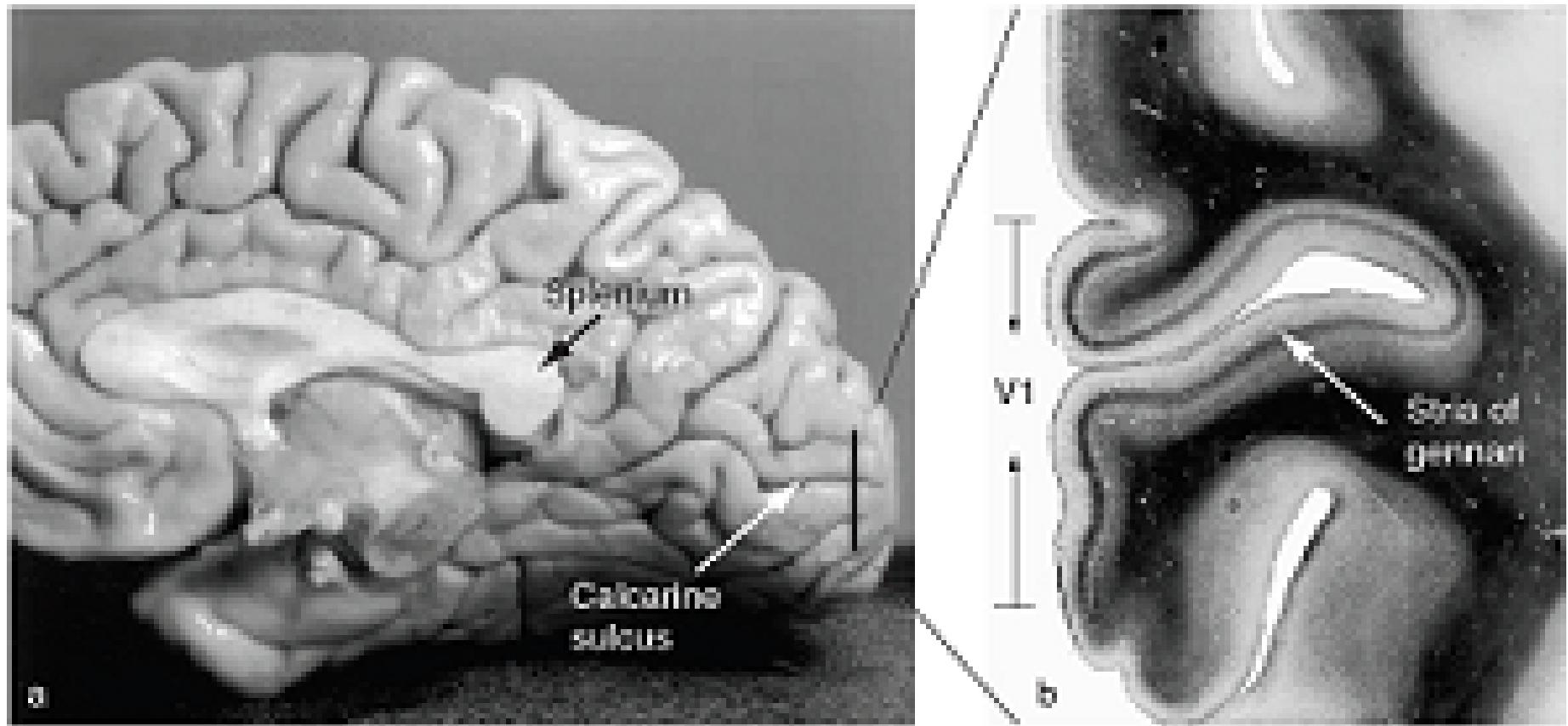


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# From LGN to V1

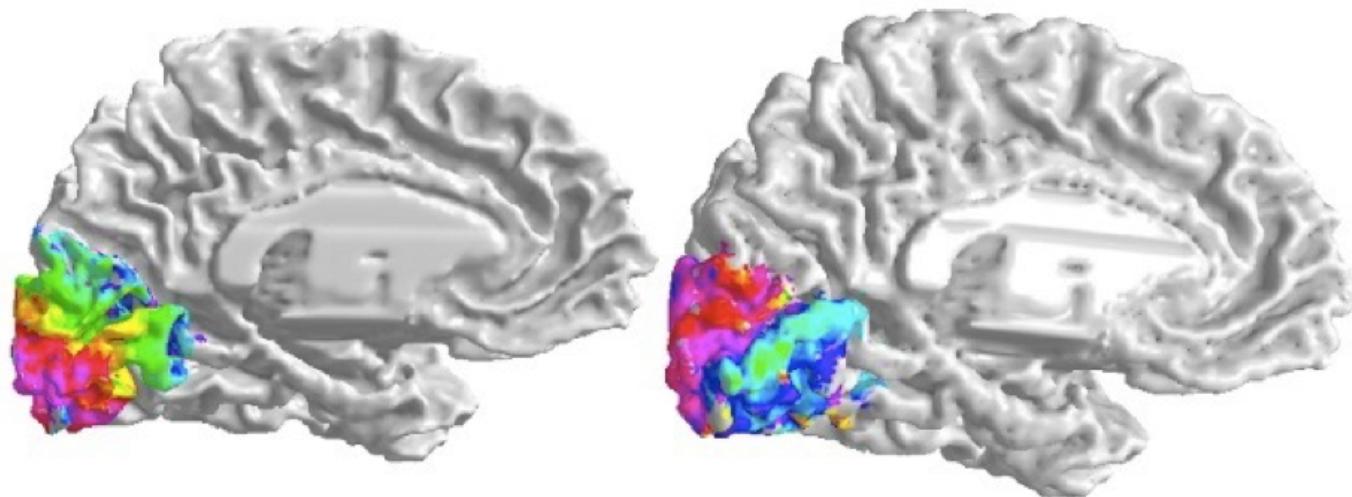
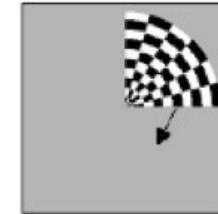
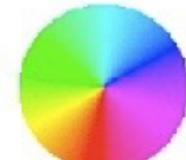
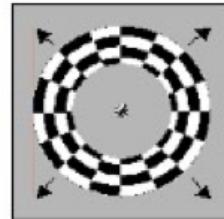
- Via optic radiations
- *Primary visual cortex (V1)* in occipital lobe

# 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

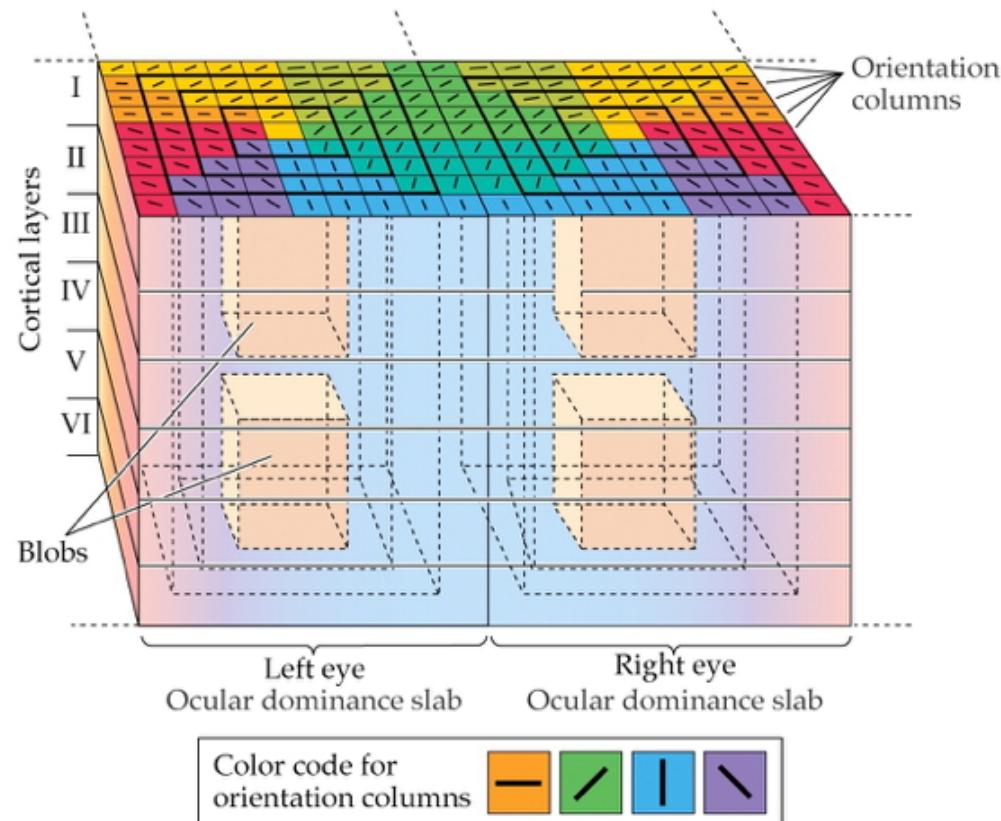
- Fovea overrepresented
  - Analogous to somatosensation
  - High acuity in fovea vs. lower outside it
- Upper visual field/lower (ventral) V1 and *vice versa*

# Recording from V1





# V1 has laminar, columnar organization



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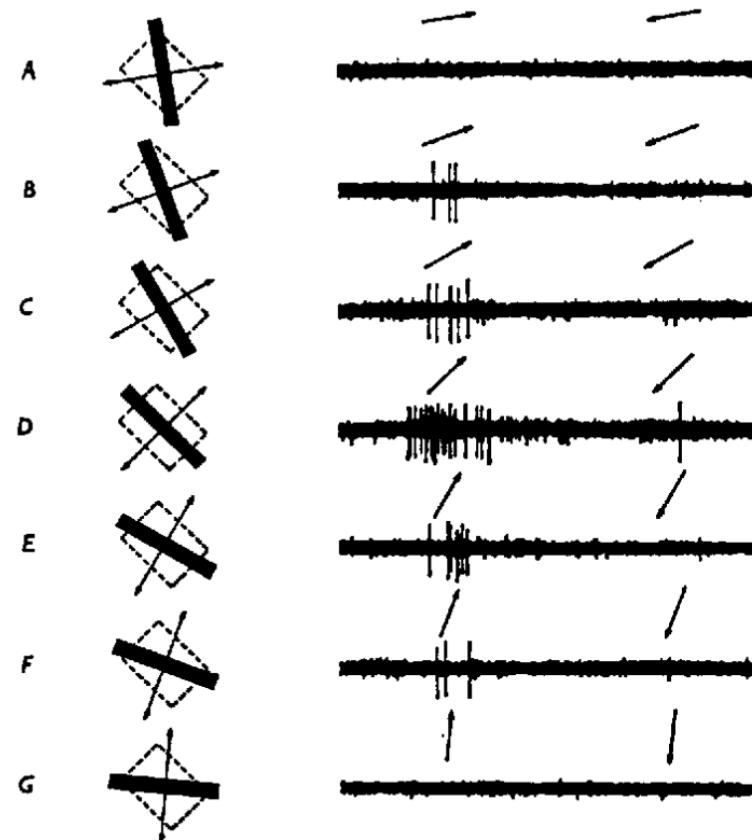
# V1 has laminar, columnar organization

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

# V1 has laminar, columnar organization

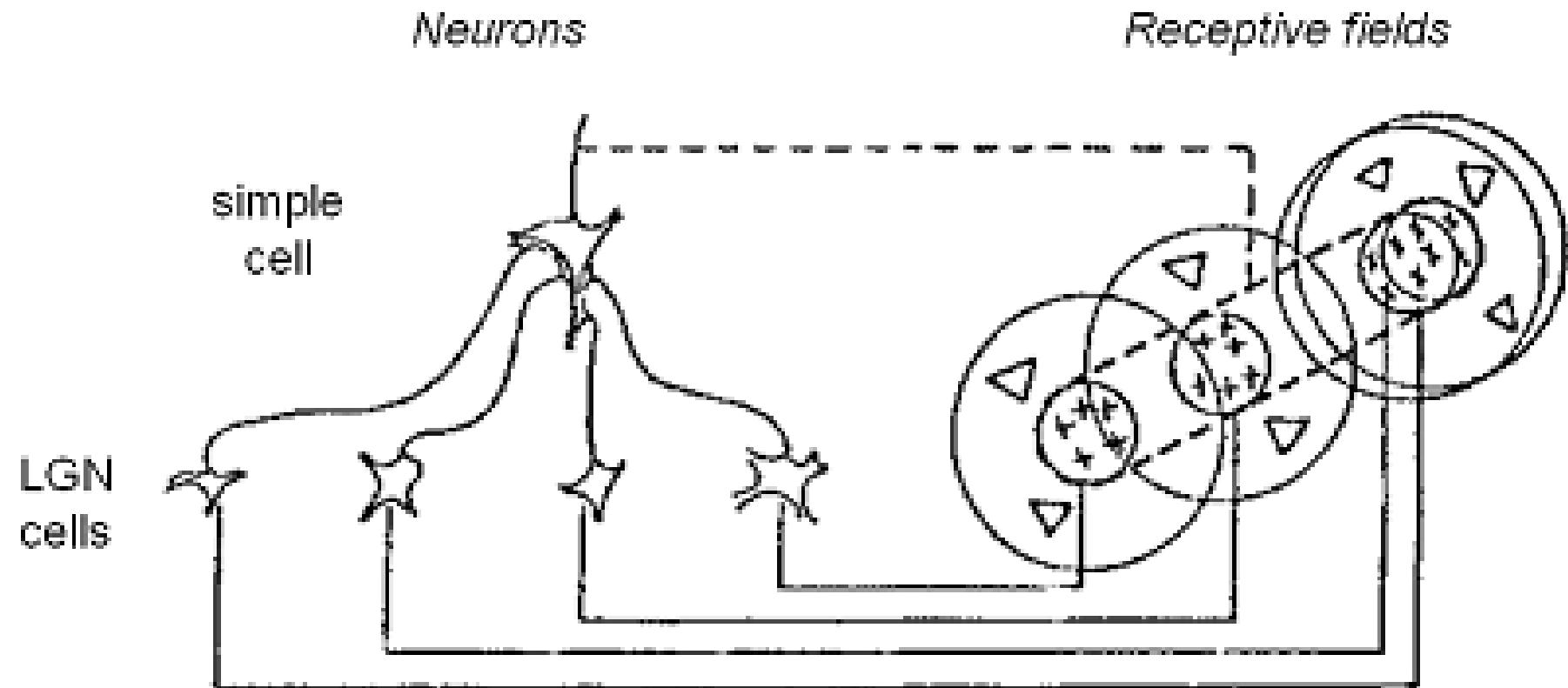
- Columns
  - Orientation/angle
  - Spatial frequency

# 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

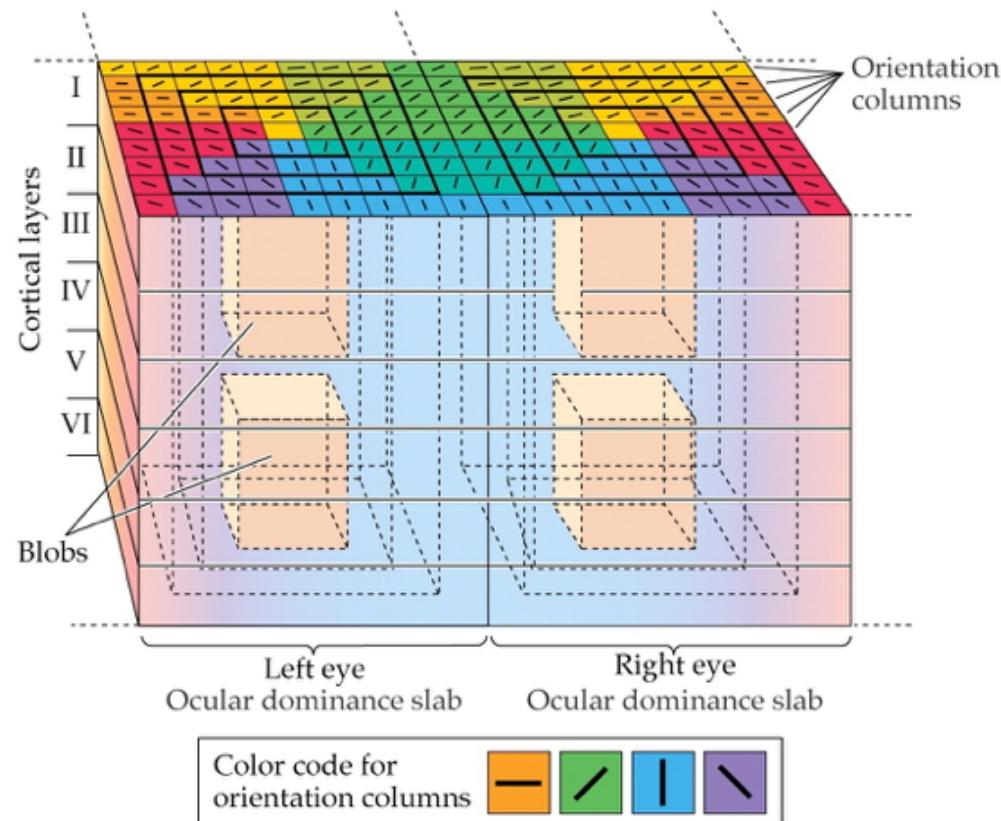


(Panichello, Cheung, & Bar, 2013)

# V1 has laminar, columnar organization

- Columns
  - Color/wavelength
  - Eye of origin, *ocular dominance*

# Ocular dominance columns



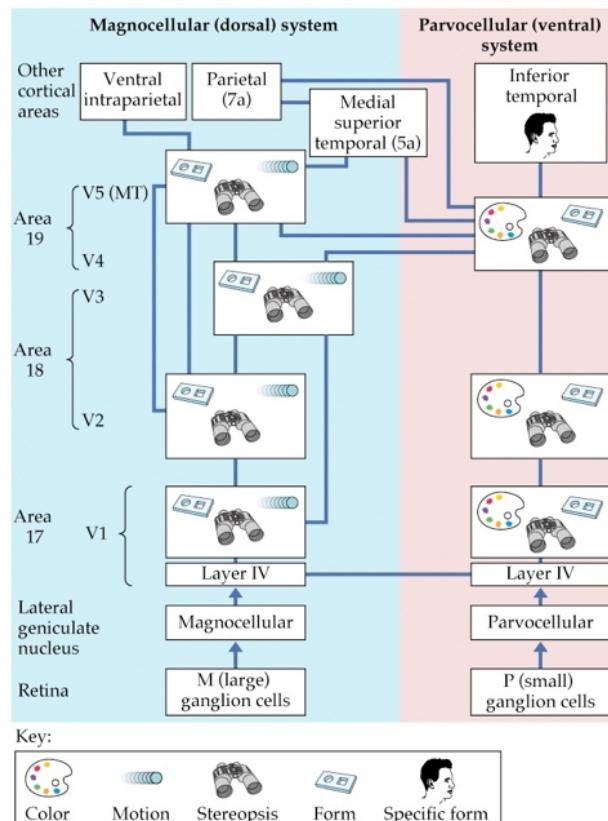
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# Ocular dominance signals retinal disparity



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

# Beyond V1



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# Beyond V1

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

# “Rich” perception from “impoverished” info

<https://www.biomotionlab.ca/html5-bml-walker/>

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# 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?

# Computer vision inspired by biological vision

<https://github.com/CMU-Perceptual-Computing-Lab/openpose>



# References

- Dougherty, R. F., Koch, V. M., Brewer, A. A., Fischer, B., Modersitzki, J., & Wandell, B. A. (2003). Visual field representations and locations of visual areas V1/2/3 in human visual cortex. *Journal of Vision*, 3(10), 1–1. <https://doi.org/10.1167/3.10.1>
- Panichello, M. F., Cheung, O. S., & Bar, M. (2013). Predictive feedback and conscious visual experience. *Perception Science*, 3, 620. <https://doi.org/10.3389/fpsyg.2012.00620>