

# 511-2017-10-13-perception-II

Rick Gilmore

2017-10-17 08:24:47

# Prelude

Johnny Nash - I Can See Clearly Now



I can see clearly now.

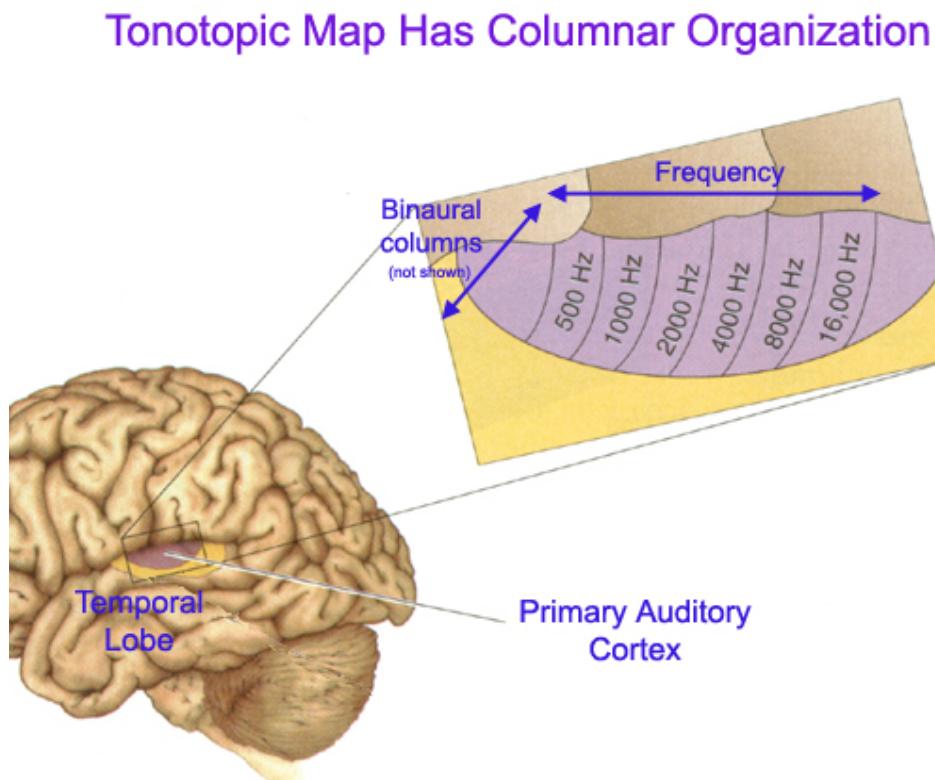
# Today's topics

- Common principles in sensation & perception
- Case study: Vision

# Common Principles

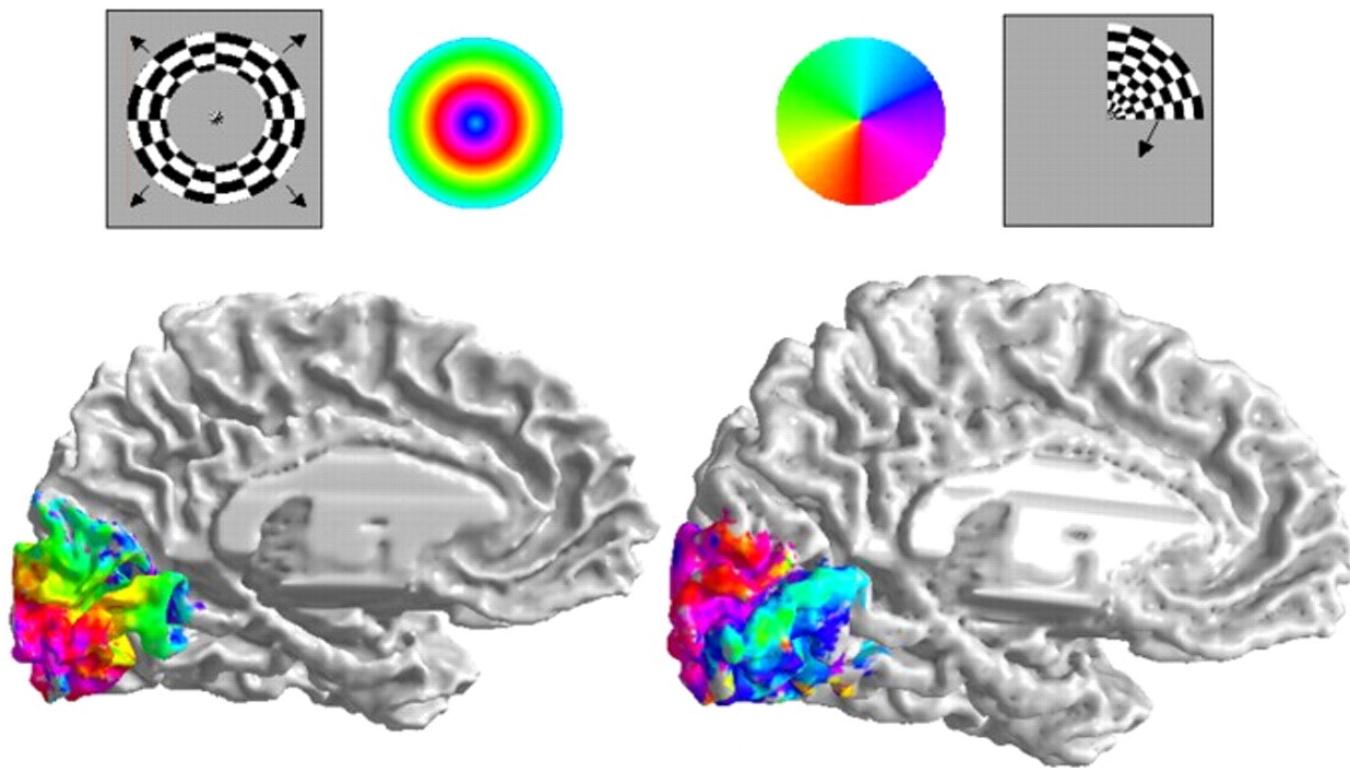
- Topographic maps

# Tonotopic (frequency) maps in auditory cortex



<http://www.his.kanazawa-it.ac.jp/~tomi/public/MEGLab/Auditory/tonotopy.gif>

# Retinotopic maps in visual cortex

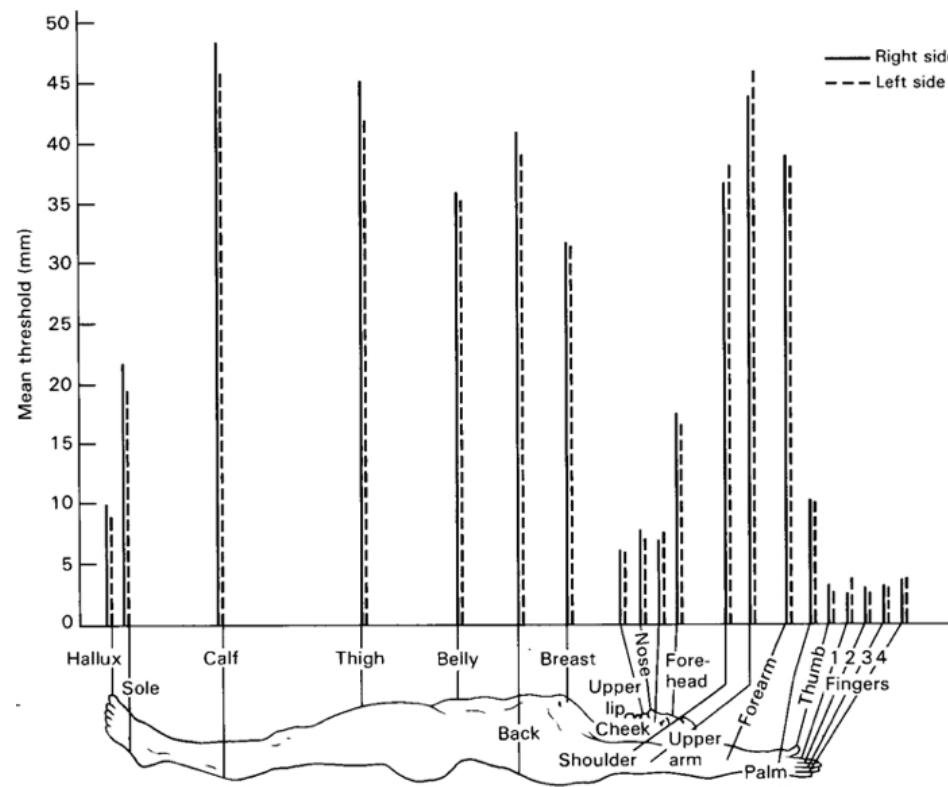


<http://jov.arvojournals.org/data/Journals/JOV/933499/jov-3-10-1-fig001.jpeg>

# Common principles

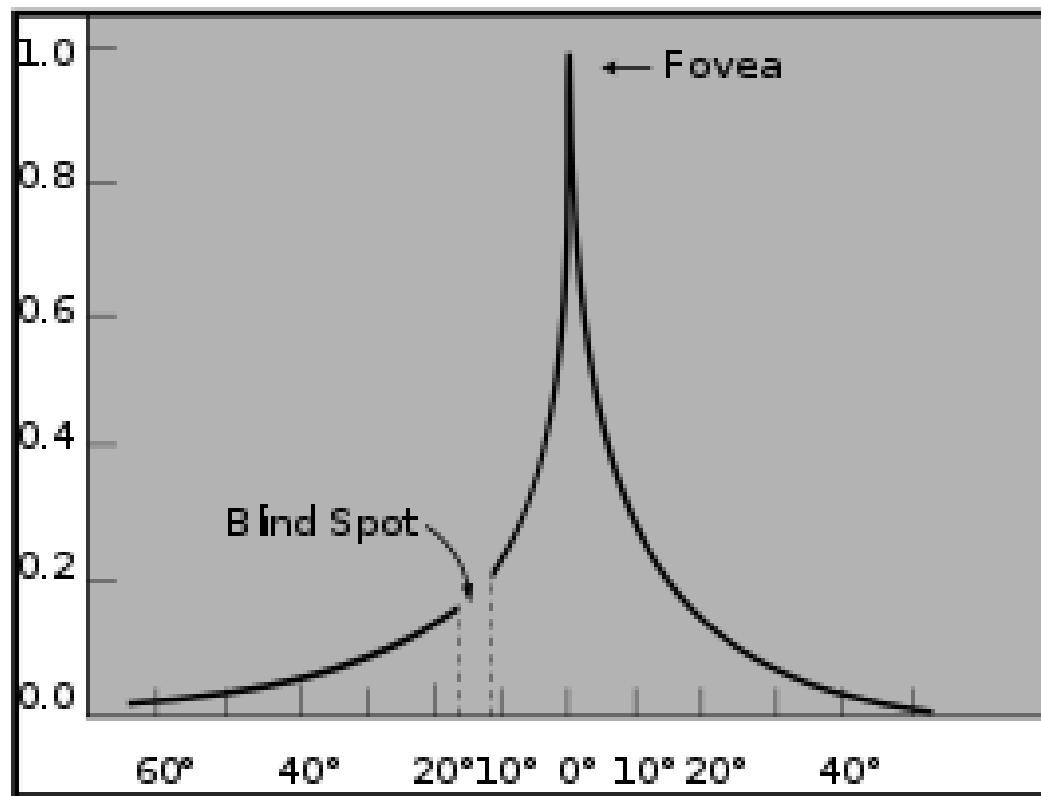
- Non-uniform sensitivity

# Two-point touch thresholds



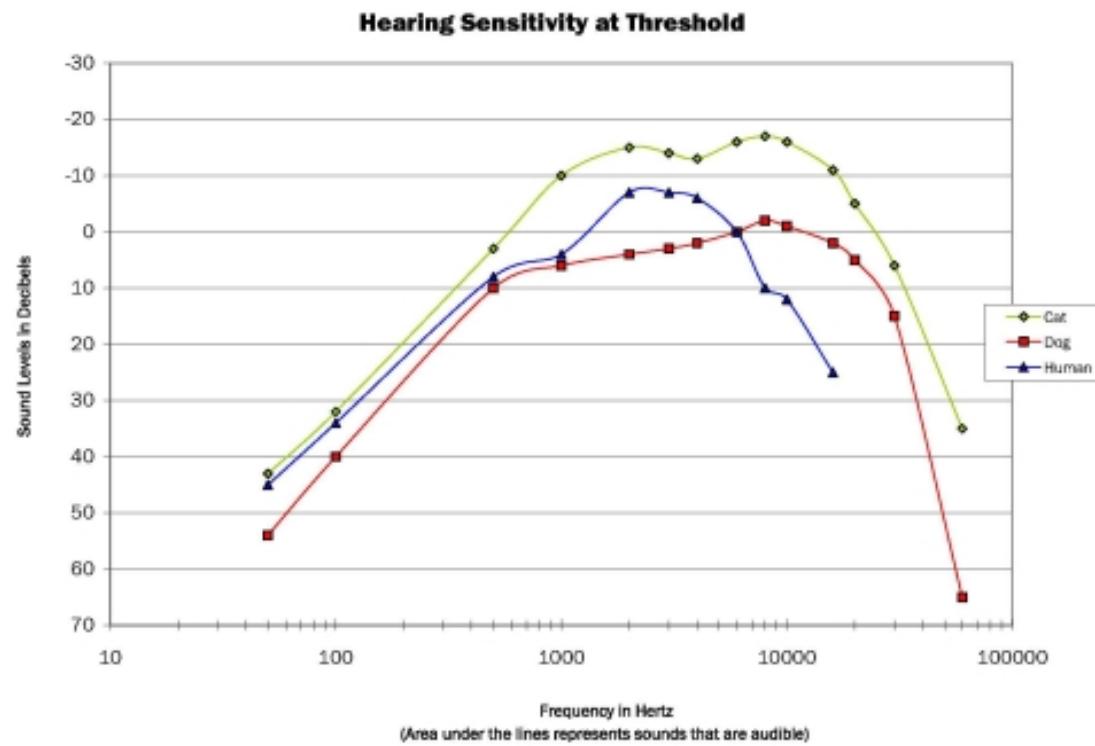
<http://jov.arvojournals.org/data/Journals/JOV/933499/jov-3-10-1-fig001.jpeg>

# Acuity variations across visual field



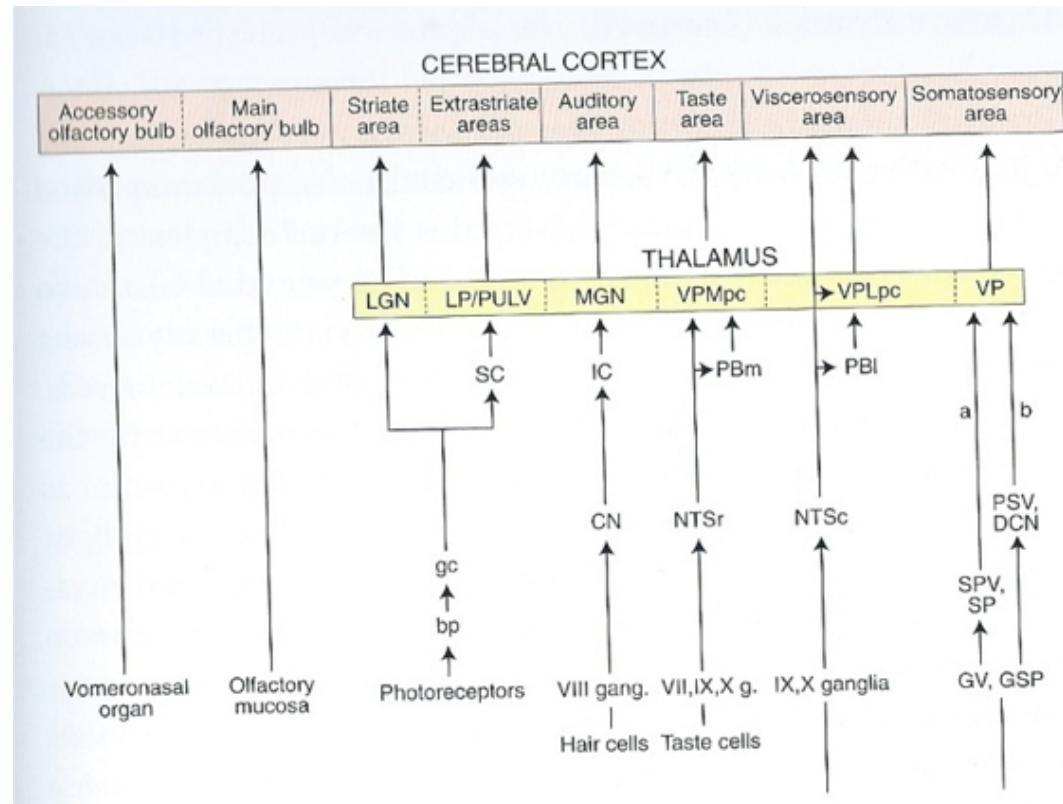
<https://upload.wikimedia.org/wikipedia/commons/thumb/2/27/AcuityHumanEye.svg/270px-AcuityHumanEye.svg.png>

# Hearing threshold varies across frequency

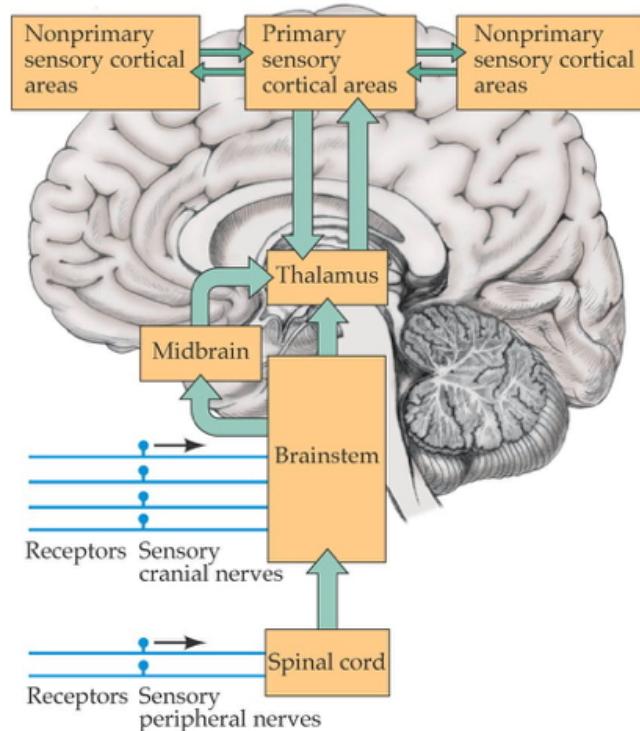


[http://www.hearforever.org/userfiles/image/tools\\_to\\_learn/SS4\\_Hearing\\_Sensitivity.jpg](http://www.hearforever.org/userfiles/image/tools_to_learn/SS4_Hearing_Sensitivity.jpg)

# Hierarchical processing

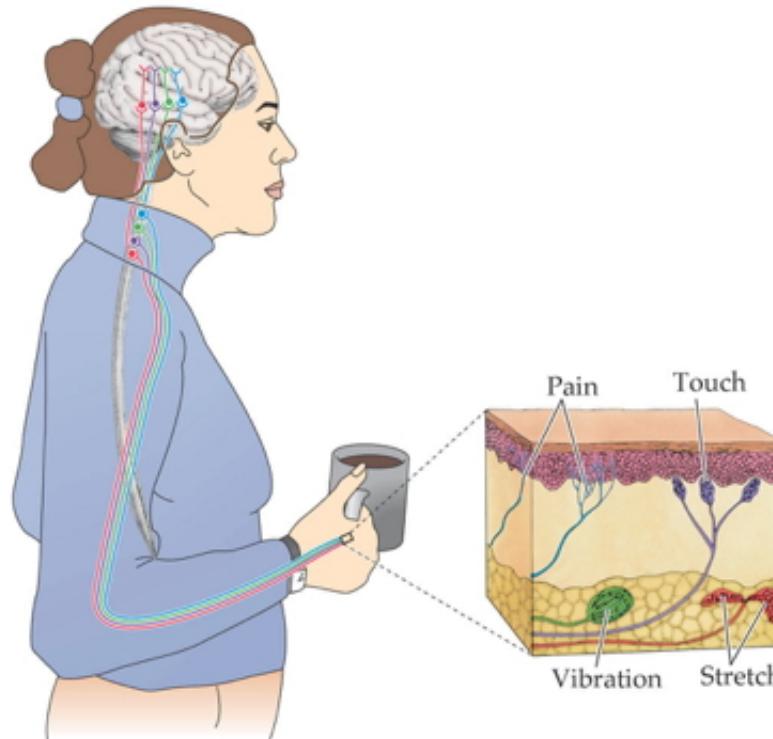


# Parallel processing



BIOLOGICAL PSYCHOLOGY, Fourth Edition, Figure 8.8 © 2004 Sinauer Associates, Inc.

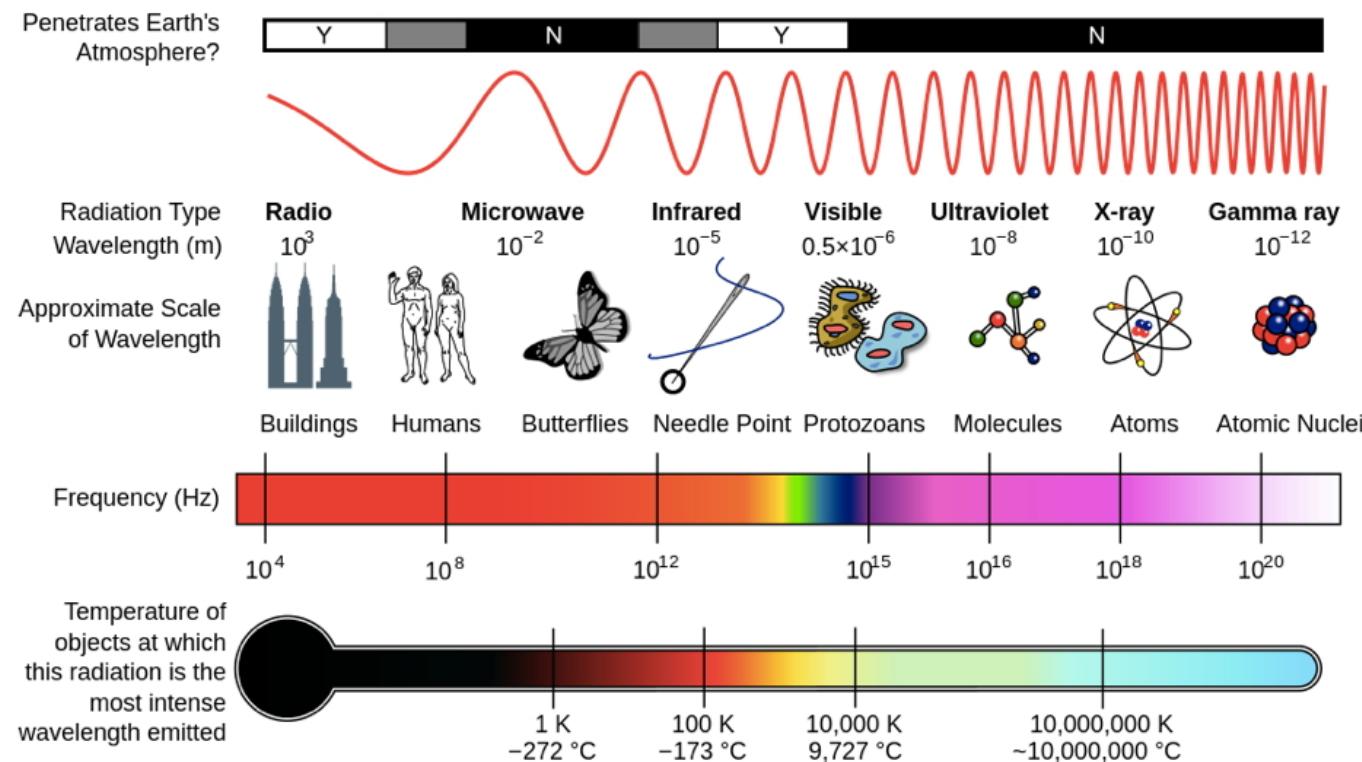
# Parallel processing



BIOLOGICAL PSYCHOLOGY, Fourth Edition, Figure 8.3 © 2004 Sinauer Associates, Inc.

# Case study: Vision

# Electromagnetic (EM) radiation

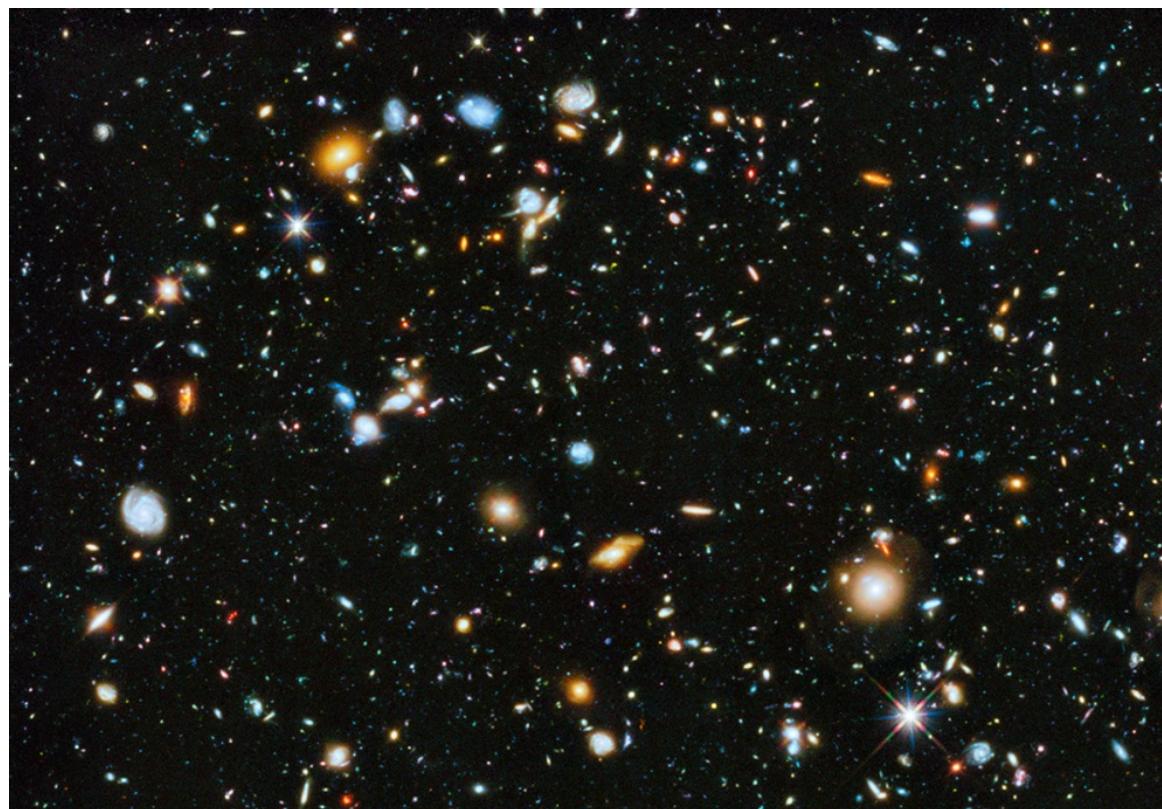


[http://en.wikipedia.org/wiki/File:EM\\_Spectrum\\_Properties\\_edit.svg](http://en.wikipedia.org/wiki/File:EM_Spectrum_Properties_edit.svg)

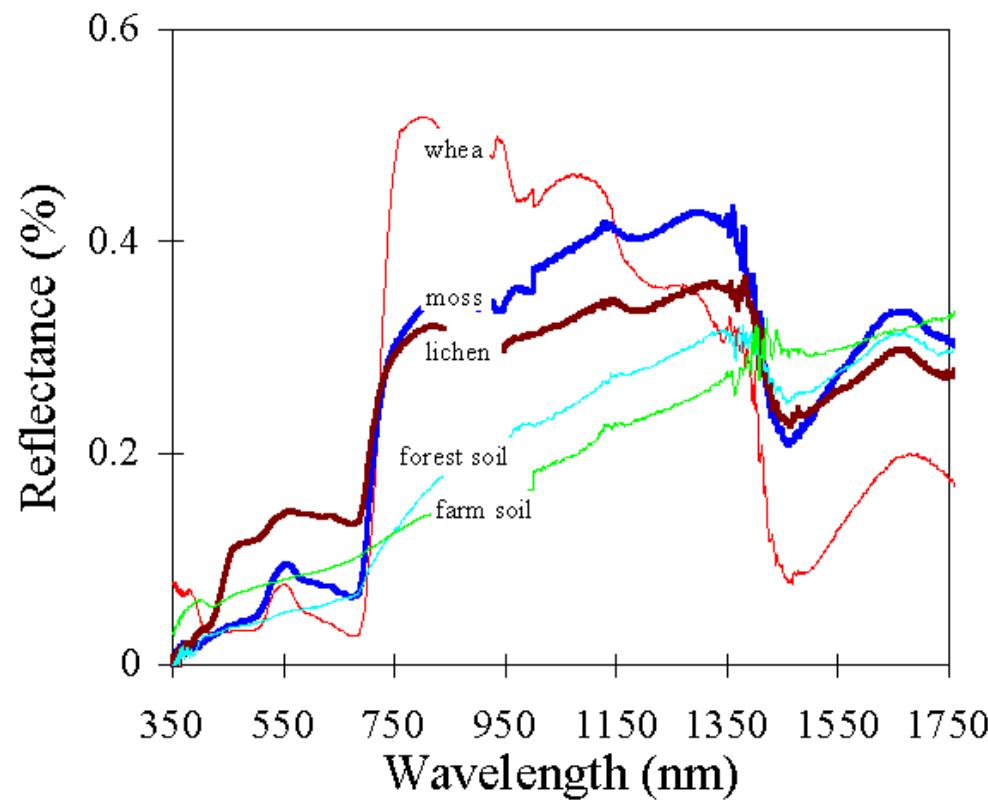
# Features of EM radiation

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

# EM radiation provides information across space (and time)

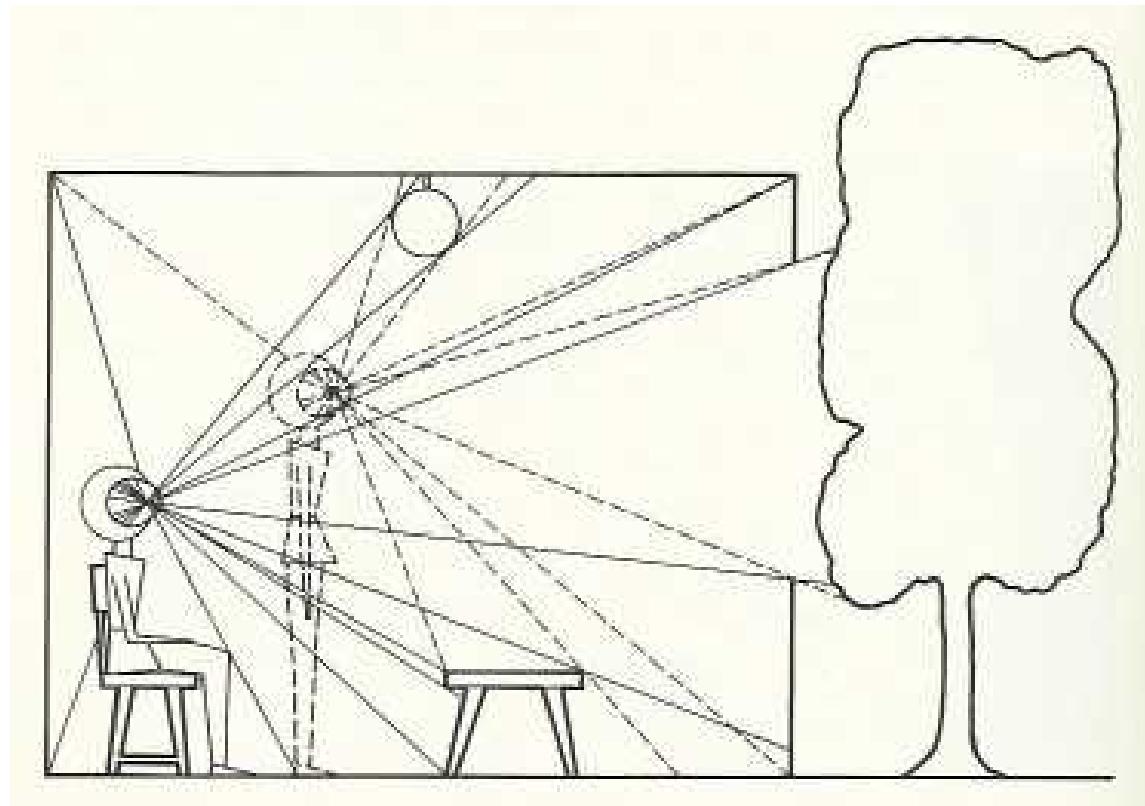


# Reflectance spectra differ by surface



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

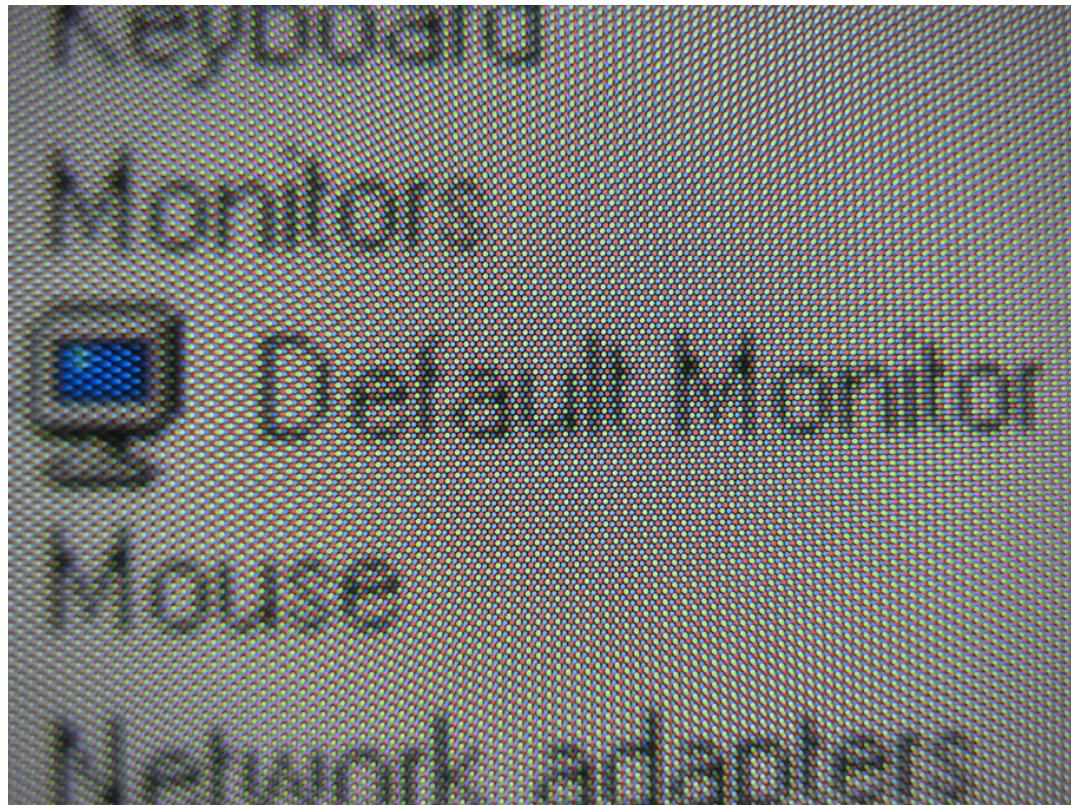
# Optic array specifies geometry of environment



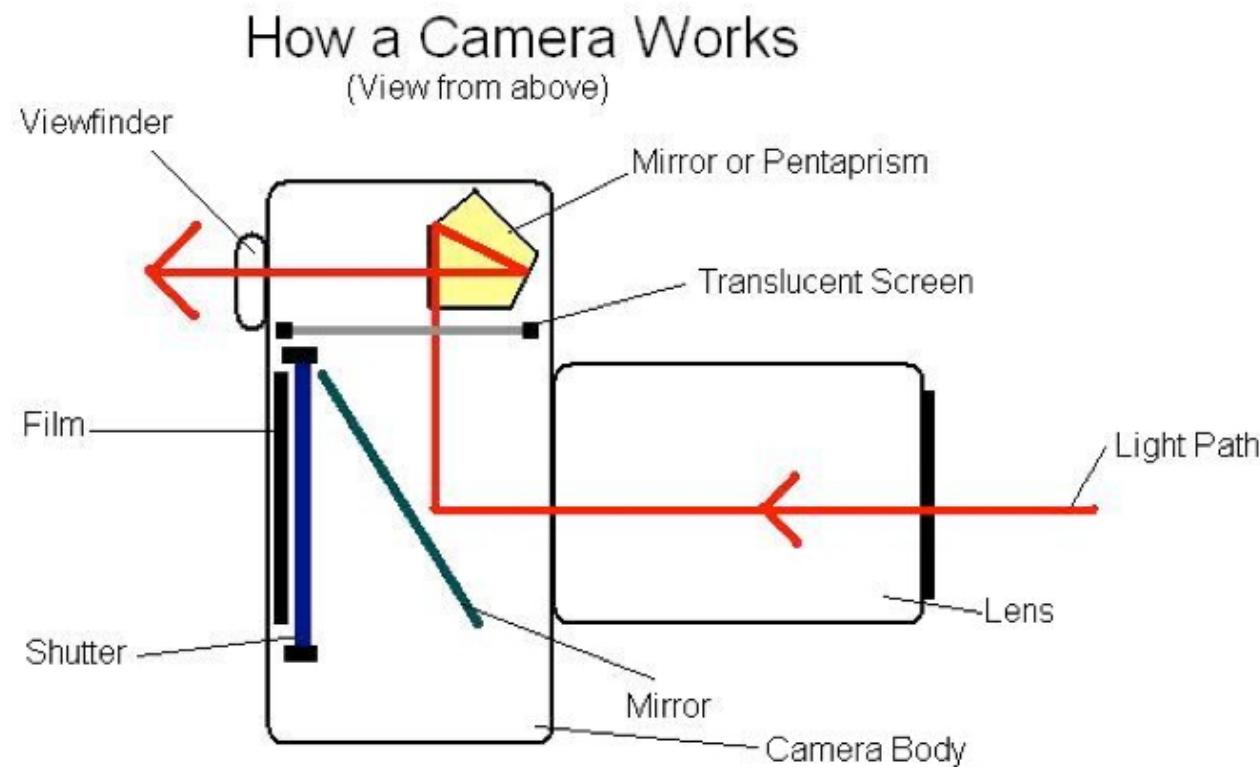
# Color == categories of wavelength

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

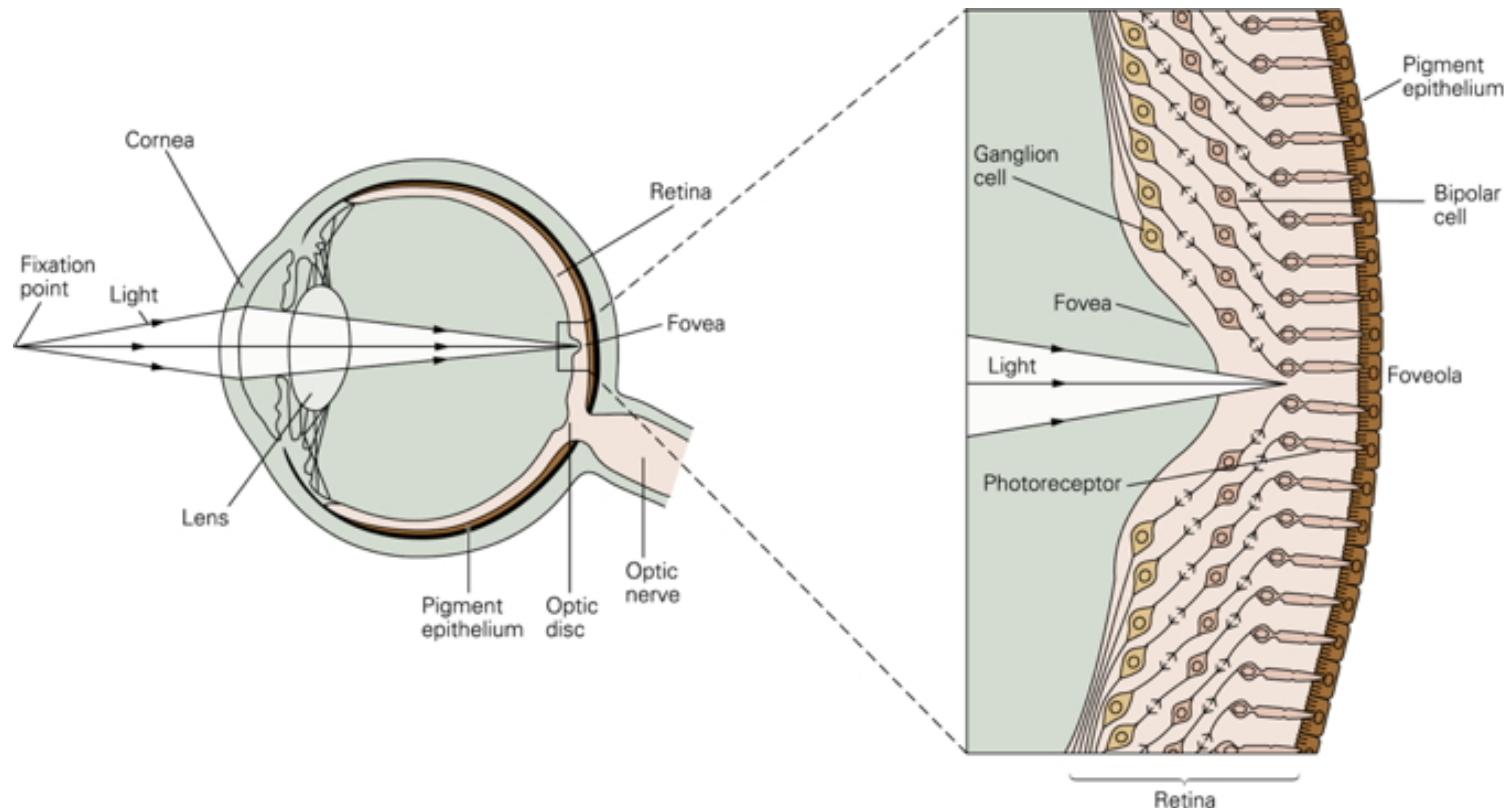
# RGB monitors



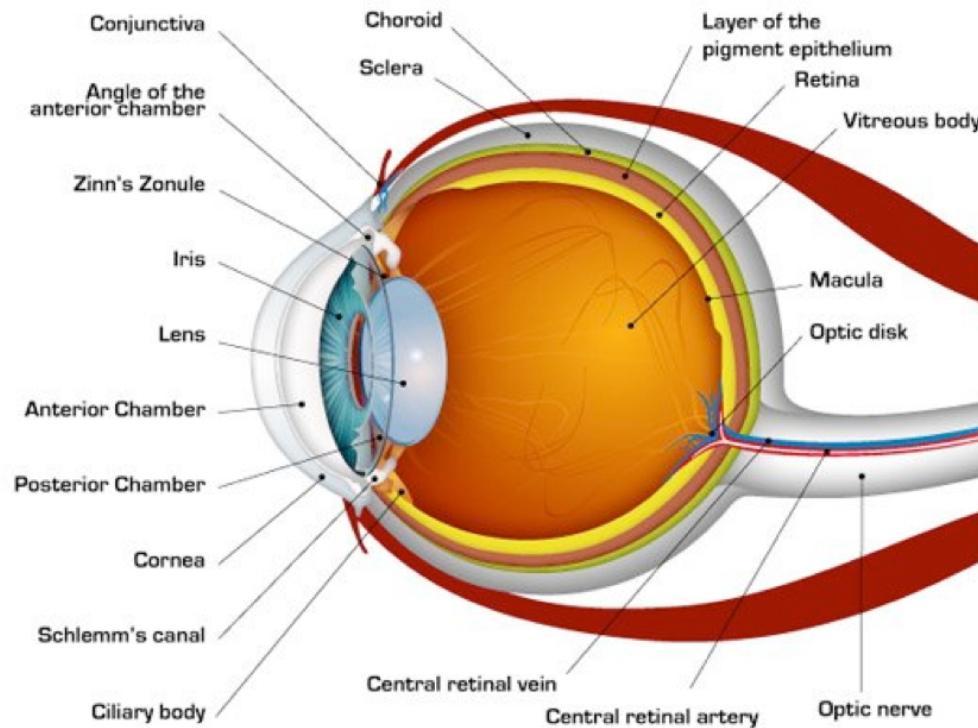
# How a camera works



# The biological camera



# The biological camera



# Parts of the eye

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

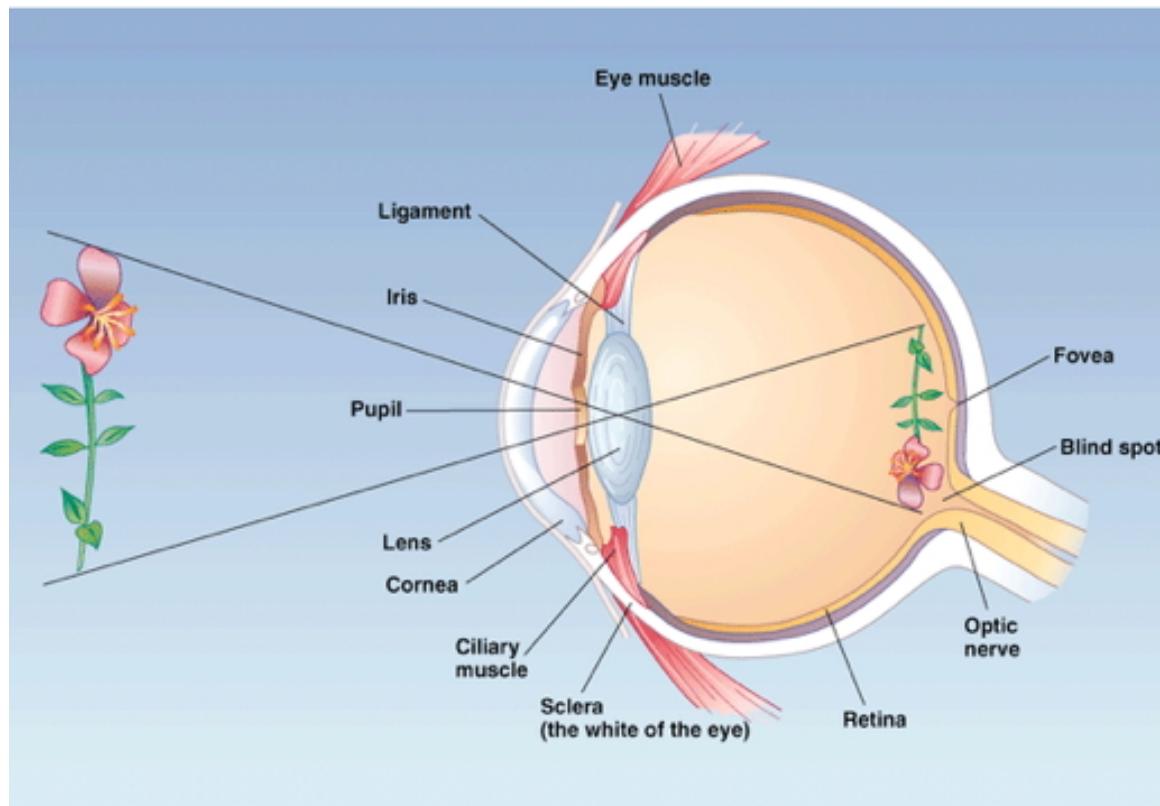
# Parts of the eye

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

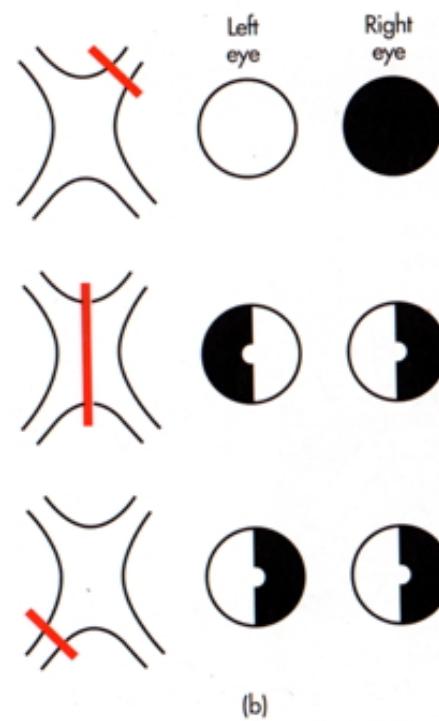
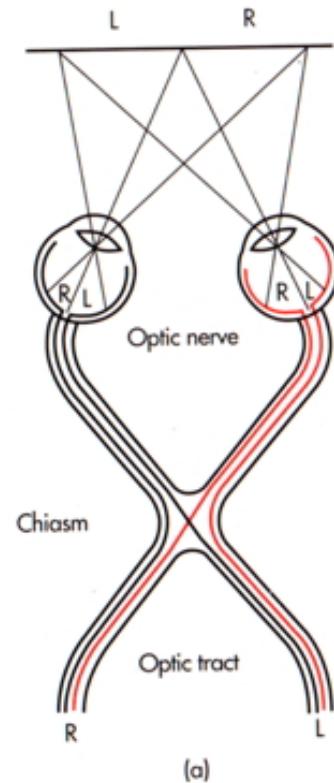
# Eye forms image on retina

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

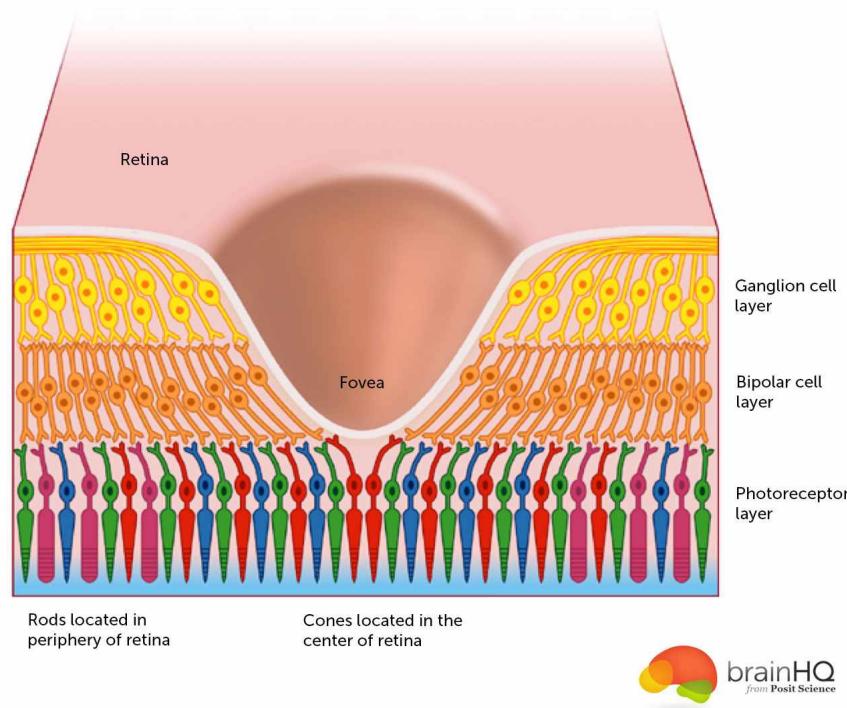
# Retinal image



# Eyes views overlap



# The *fovea*

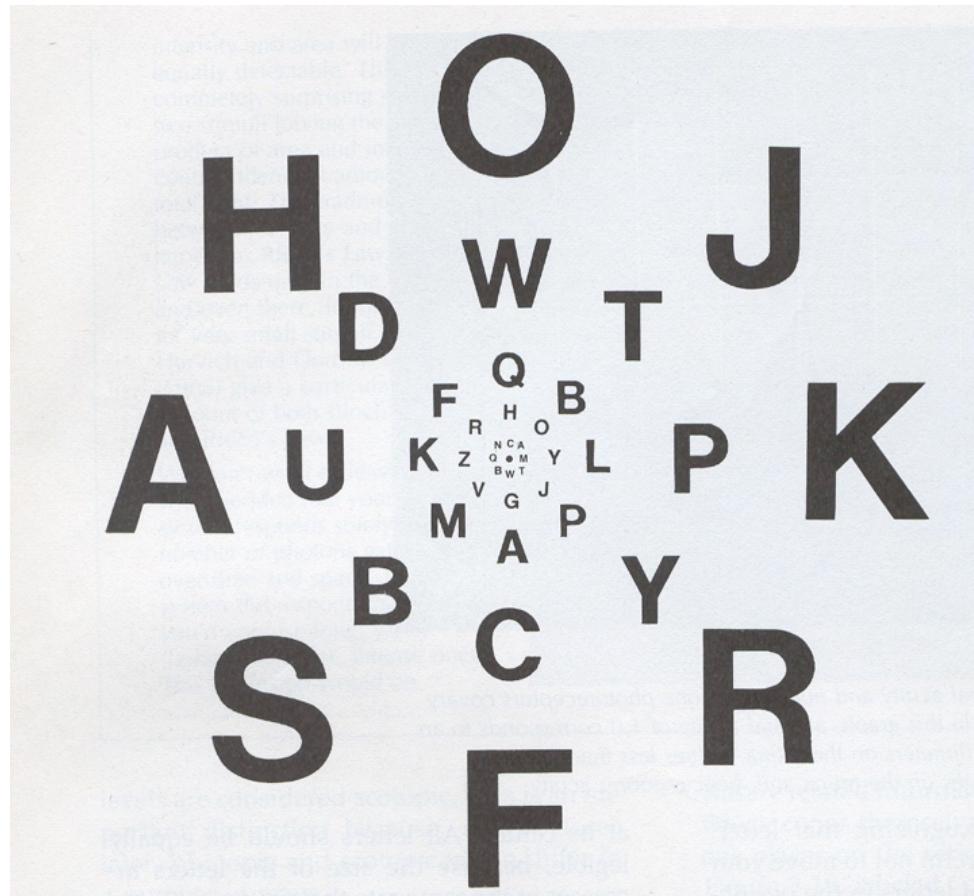


<http://www.brainhq.com/sites/default/files/fovea.jpg>

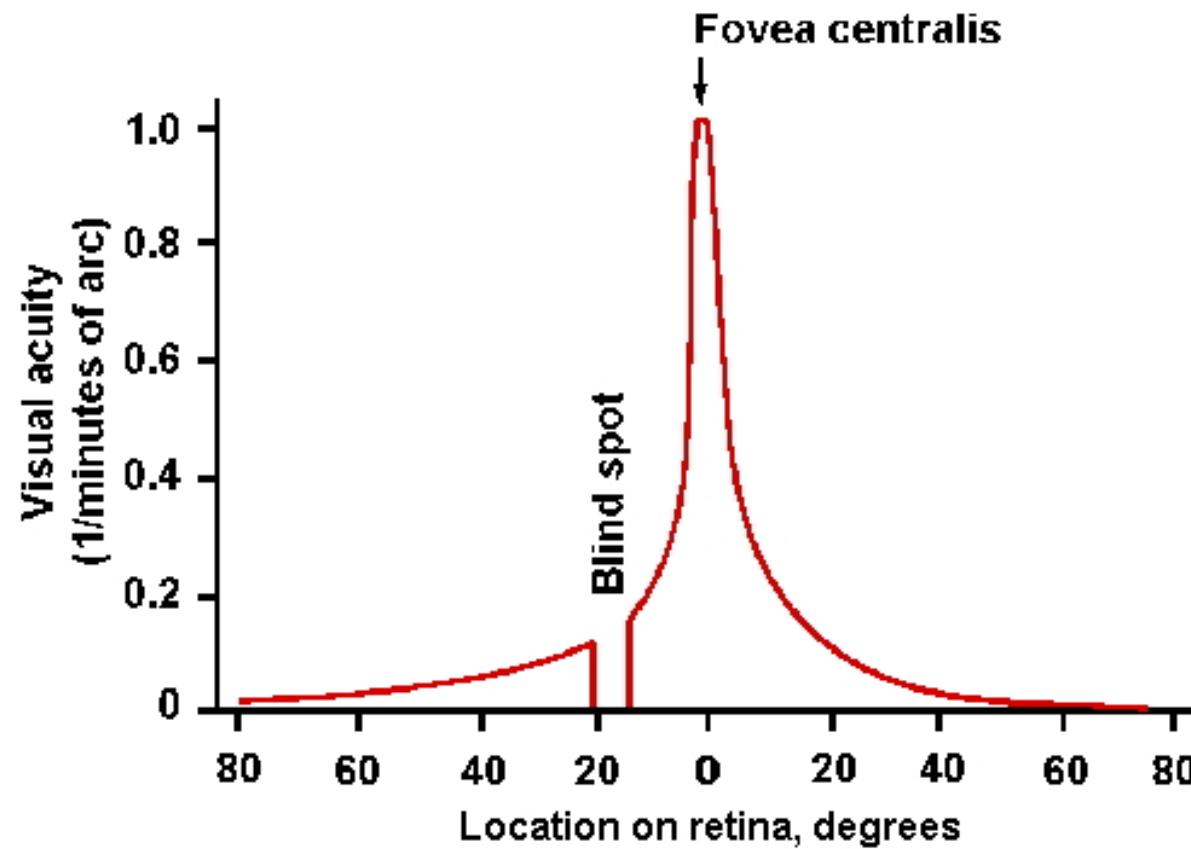
# The fovea

- Central 1-2 deg of visual field
- Aligned with visual axis
- *Retinal ganglion cells* pushed aside
- Highest *acuity* vision == best for details

# Acuity varies across fovea



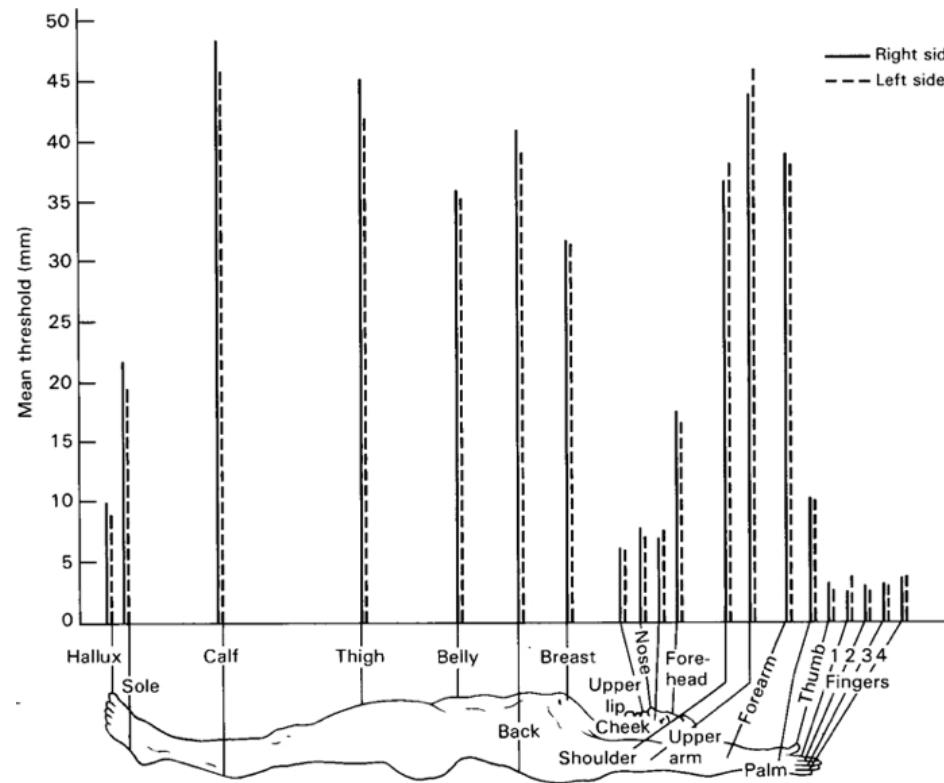
# Acuity varies across fovea



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

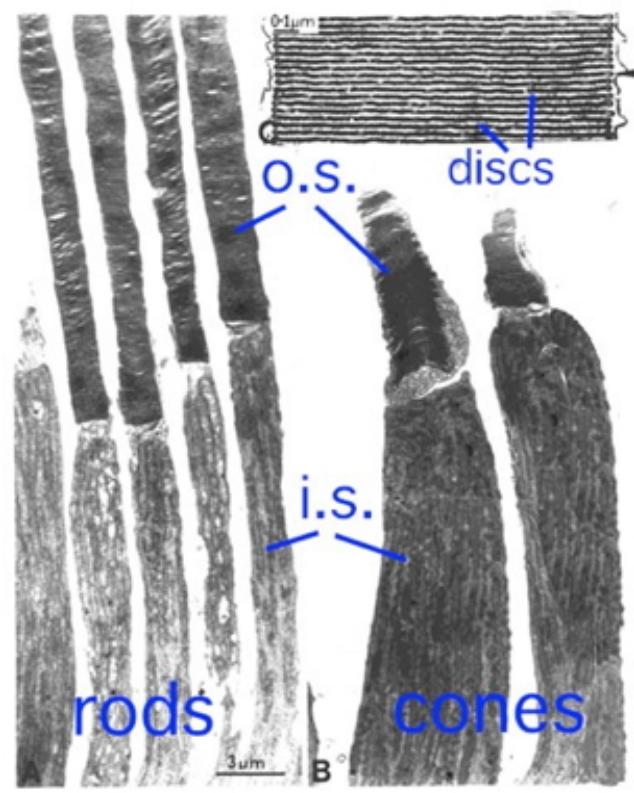
# What part of the skin is like the fovea?

# What part of the skin is like the fovea?



<http://jov.arvojournals.org/data/Journals/JOV/933499/jov-3-10-1-fig001.jpeg>

# *Photoreceptors detect light*



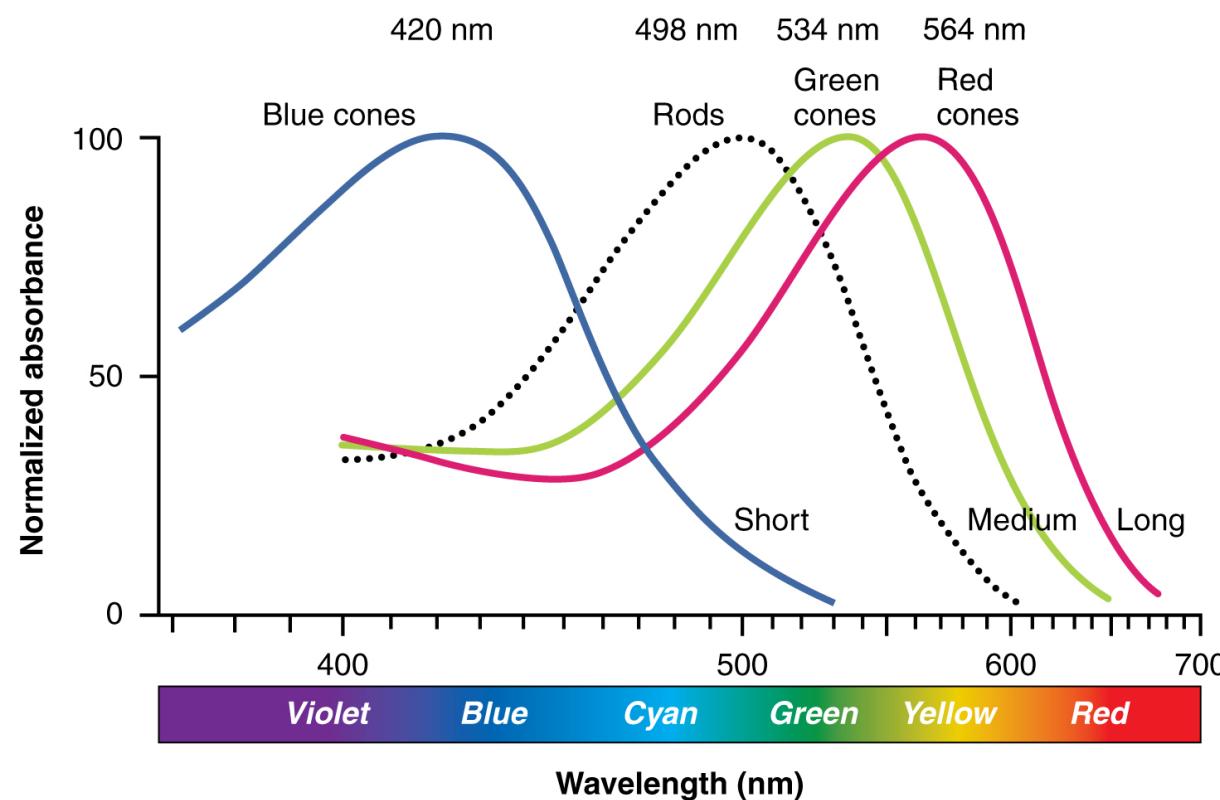
# Photoreceptors detect light

- *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*

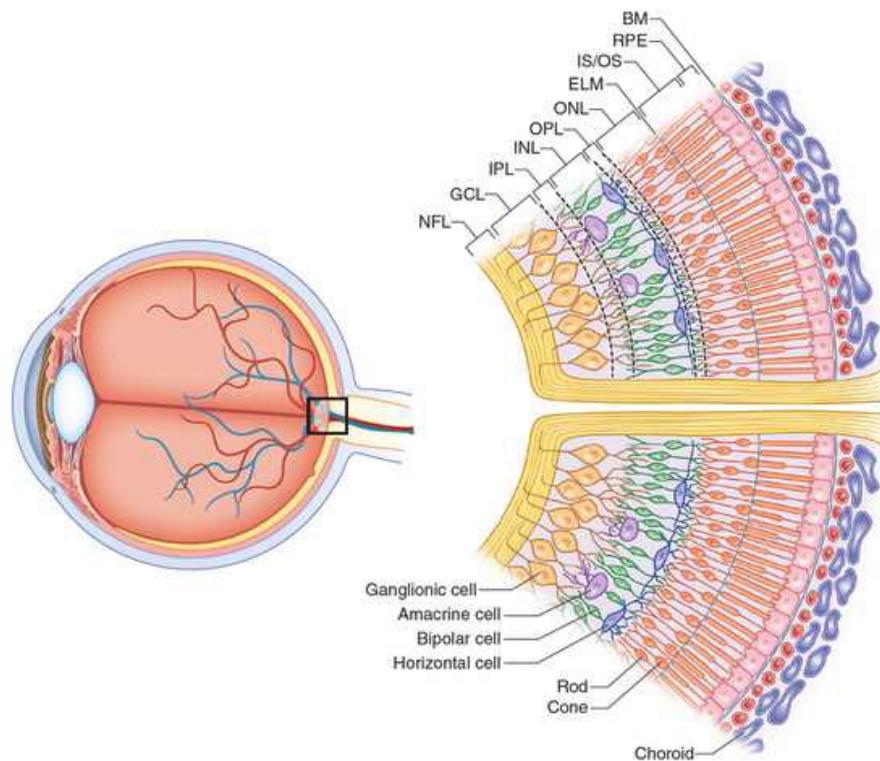
# Retina

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

# Retina

- Physiologically *backwards*
  - Dark current
- Anatomically *inside-out*
  - Photoreceptors at back of eye

# Retinal layers

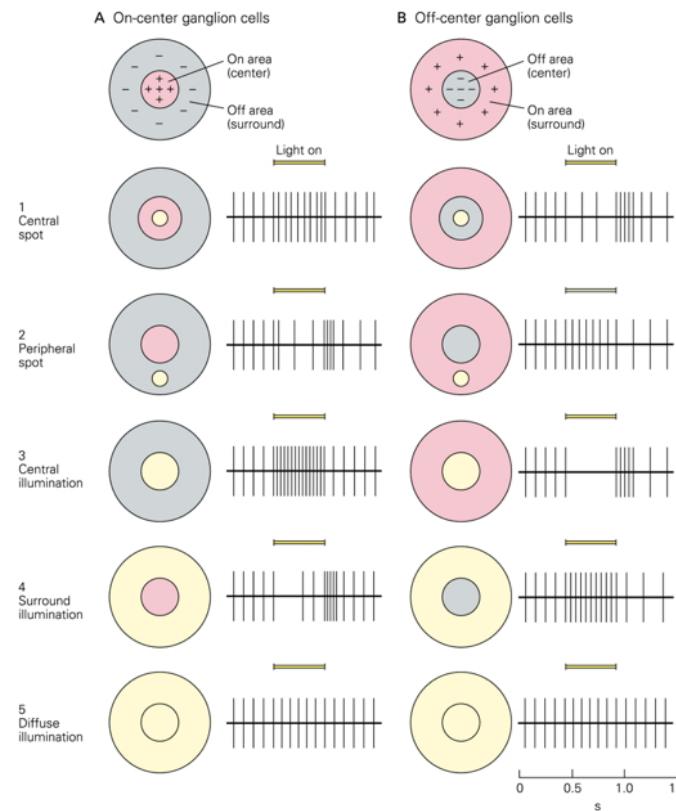


<http://www.retinareference.com/anatomy/>

# Retinal layers

- From photoreceptors...
- To *Bipolar cells*
  - <-> and *Horizontal cells*
- To *Retinal ganglion cells*
  - <-> and *Amacrine cells*

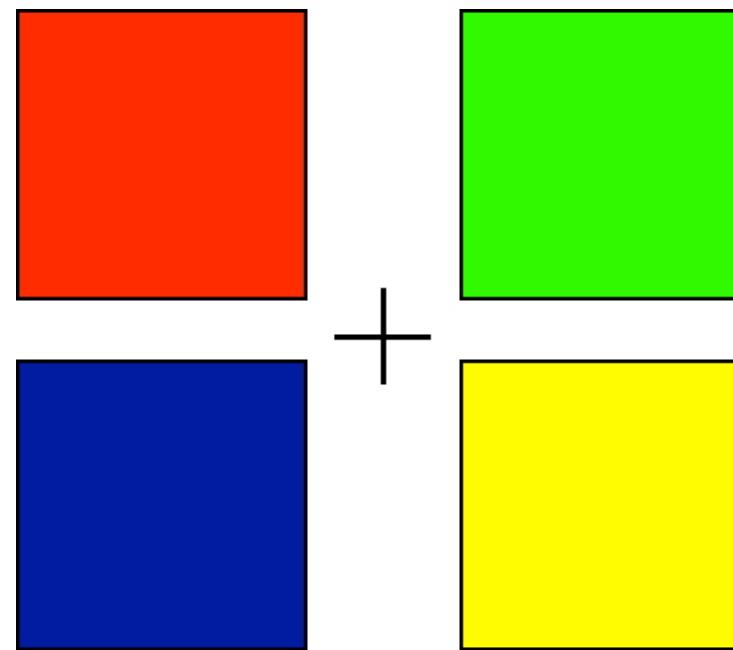
# *Center-surround receptive fields*



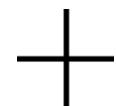
# Center-surround receptive fields

- 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)

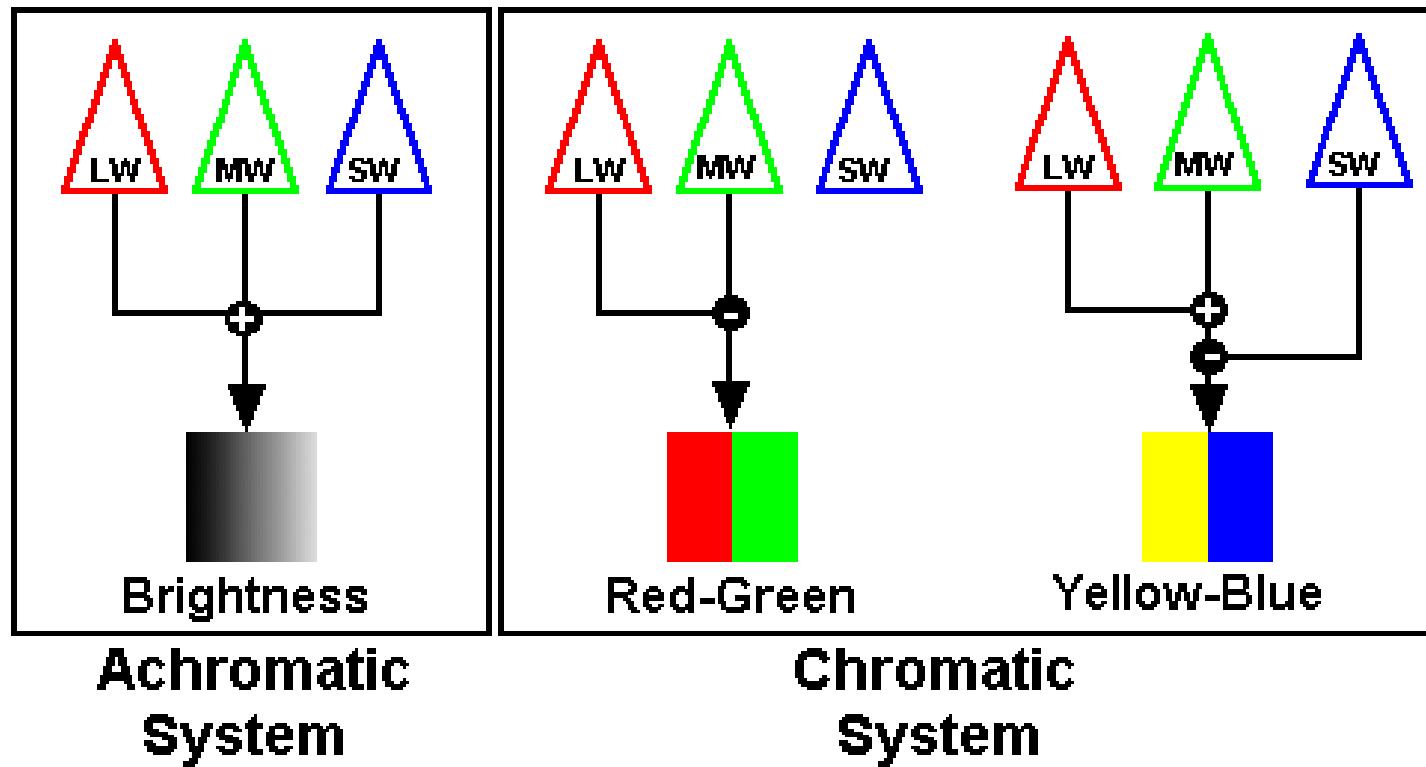
# What's a reddish-green look like?



# What's a reddish-green look like?



# *Opponent processing*

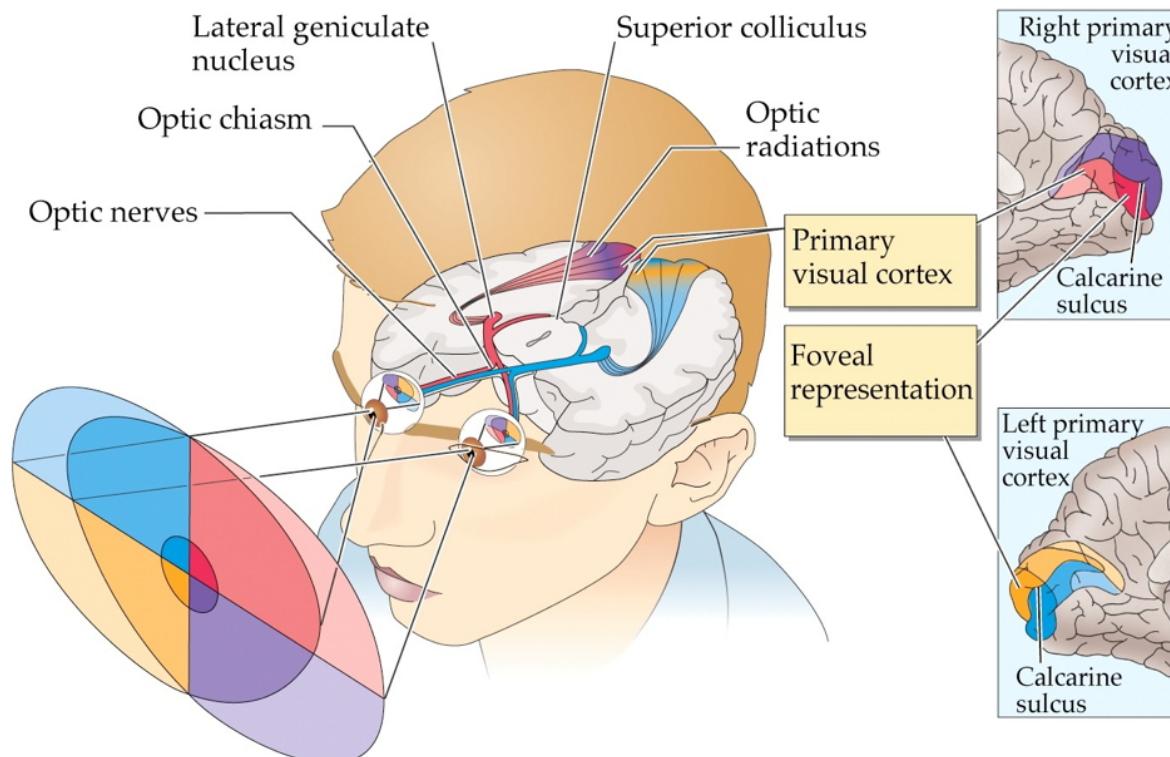


<http://www.visualexpert.com/sbfaqimages/RGBOpponent.gif>

# Opponent processing

- Black vs. white (achromatic)
- Long (red) vs. Medium (green) wavelength cones
- (Long + Medium) vs. Short cones
- Can't really see reddish-green or bluish-yellow
  - "Oppose" one another at cellular/circuit level

# From eye to brain



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# From eye to brain

- Retinal ganglion cells
- 2nd/II cranial (optic) nerve
  - Optic chiasm ( $\chi$  - asm): Partial crossing of fibers
  - Nasal hemiretina (lateral/peripheral visual field) cross
  - Left visual field (from L & R retinae) -> right hemisphere & vice versa
- *Lateral Geniculate Nucleus (LGN)* of thalamus (receives 90% of retinal projections)

# From eye to brain

- Hypothalamus
  - *Suprachiasmatic nucleus* (superior to the optic chiasm): Synchronizes day/night cycle with circadian rhythms
- Superior colliculus & brainstem

# Next time...

- Wrap up on vision
- Principles of action