Sensation, Part 4
Gleitman *et al*. (2011), Chapter 4

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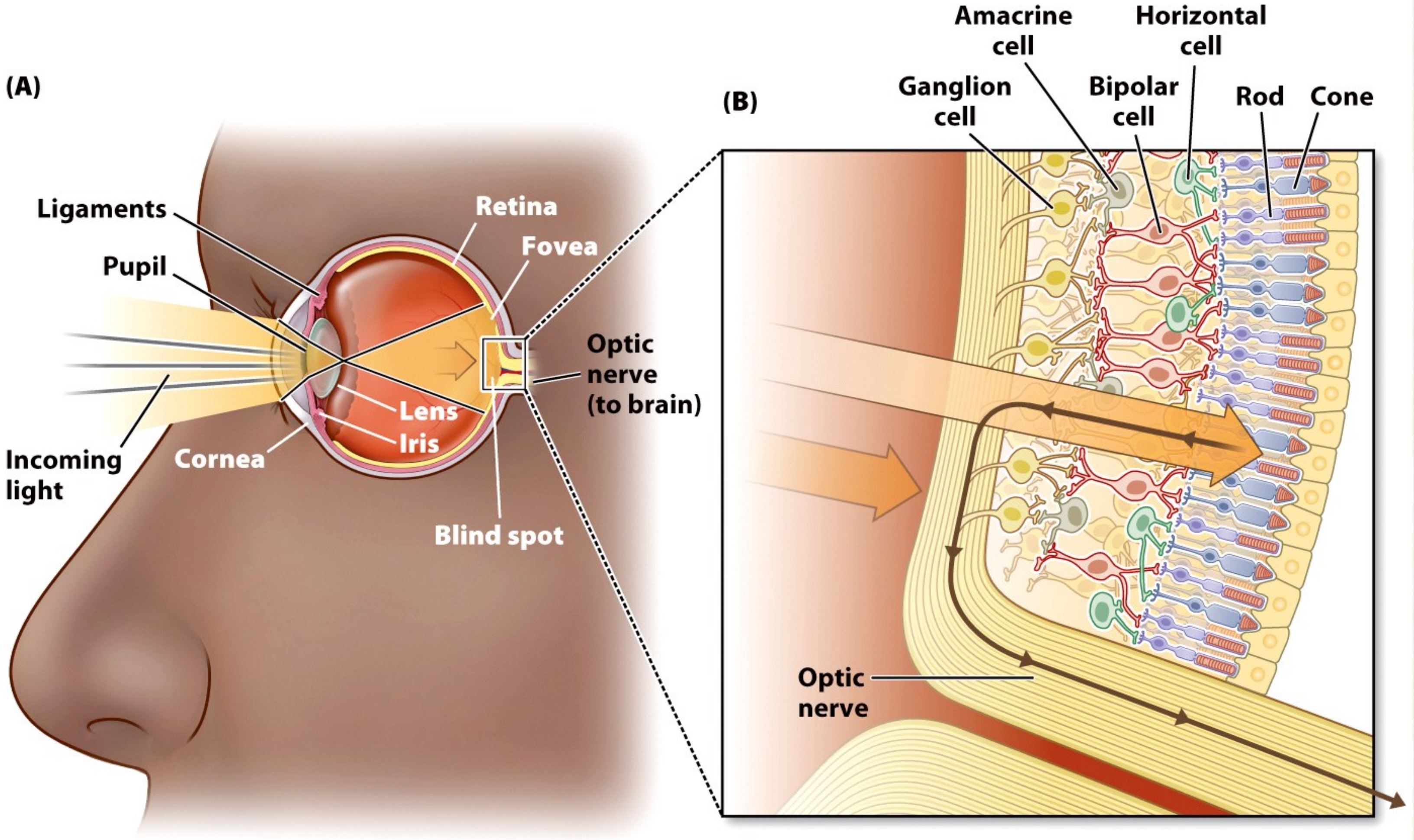
Psych 9A / Psy Beh 11A

February 20, 2014

From last time…



Psychology, 8/e Figure 4.24

Rod Transduction

Rhodopsin

("visual purple")

-rod photopigment

-absorbs photons

-a combination of

1) **Retinal**

(like vitamin A)

+

2) **Opsin**

(protein coded genetically)

-embedded in disc membrance

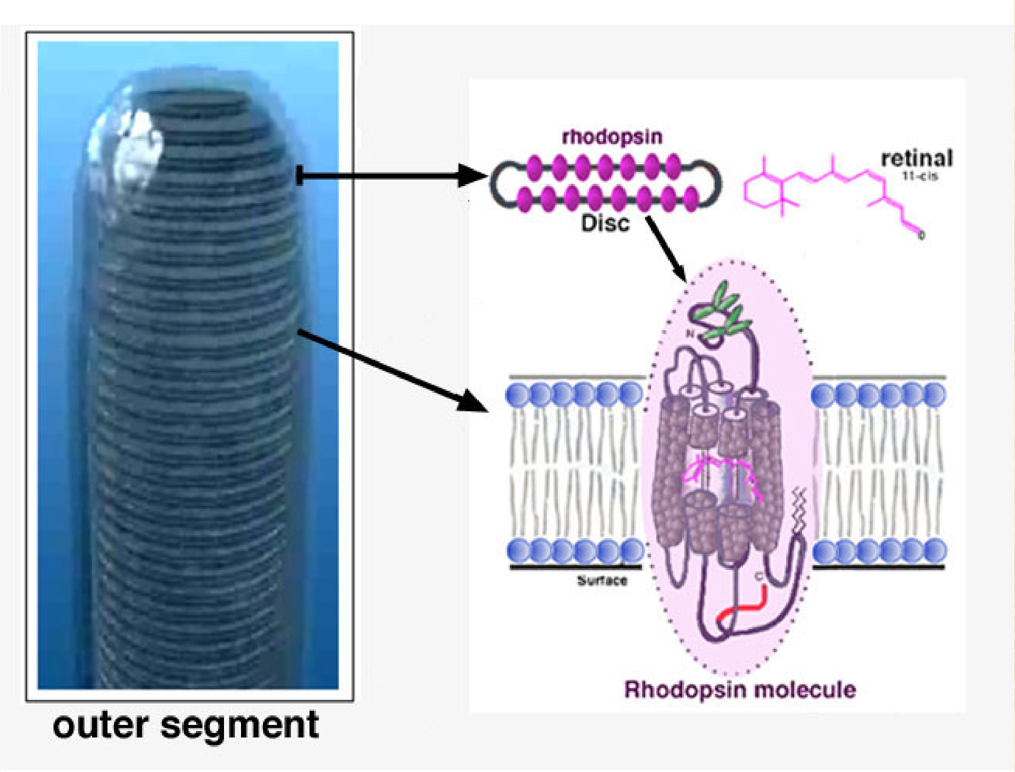
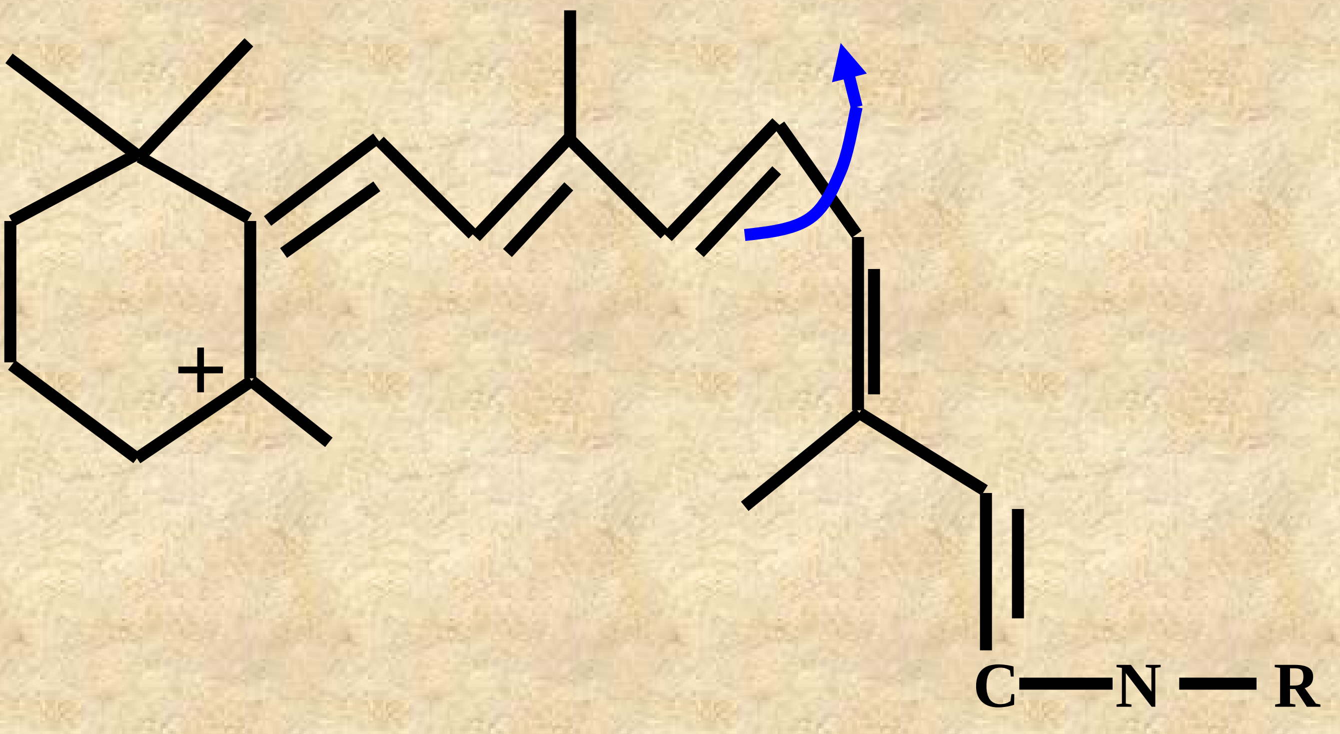
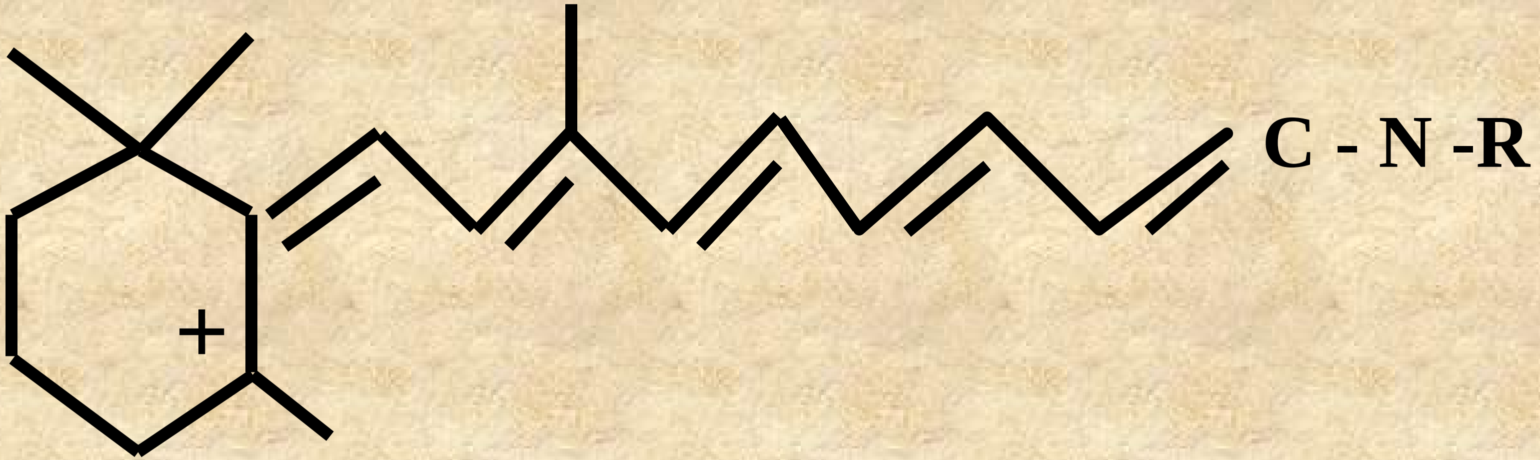


Fig 8. Schematic diagram of Rhodopsin in the outer segment discs.

Retinal changes shape when it absorbs a photon of light...

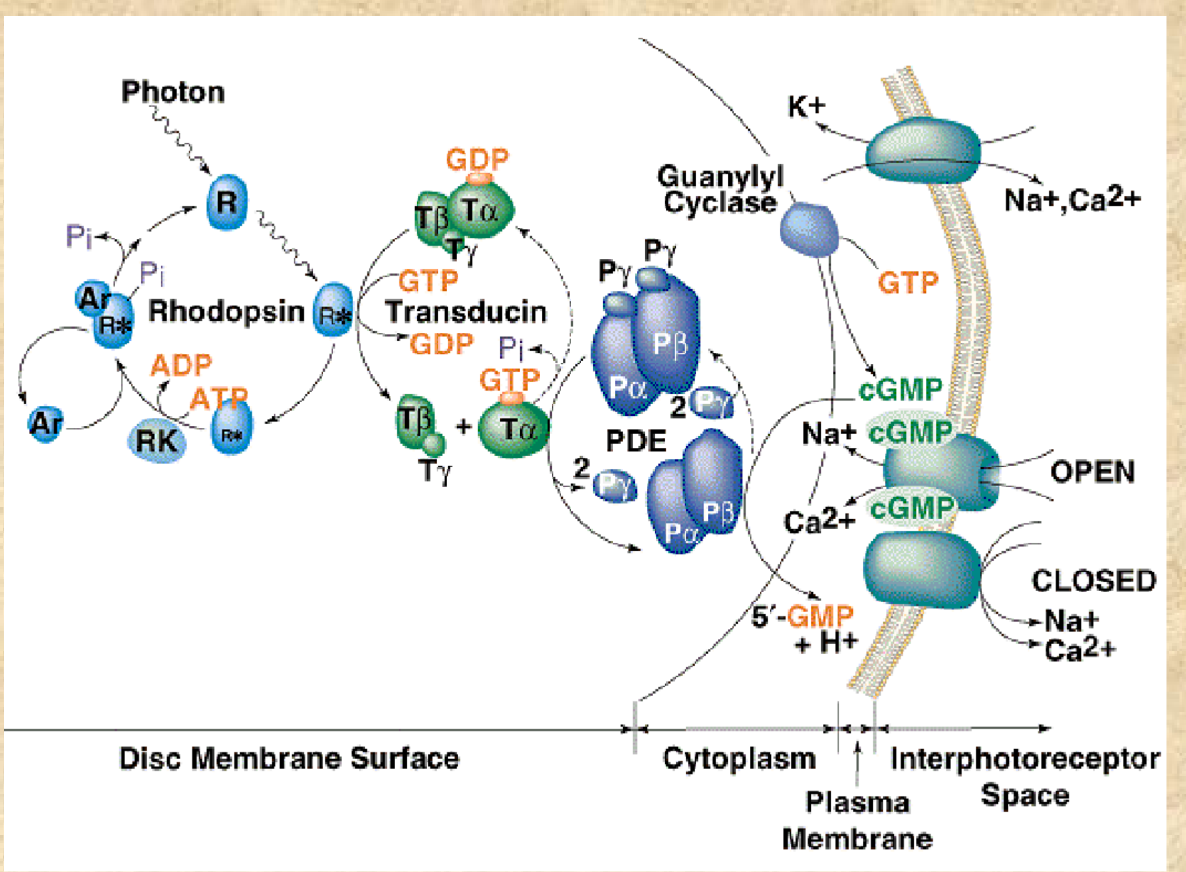


11-cis-retinal



bond rotation to all-trans retinal

Cascade of biochemical events upon photon absorption by a rod results in *closing* of ion channels and hyperpolarization



movie of intracellular biochemical events in rod **phototransduction**

http://webvision.med.utah.edu/movies/trasduc.mov

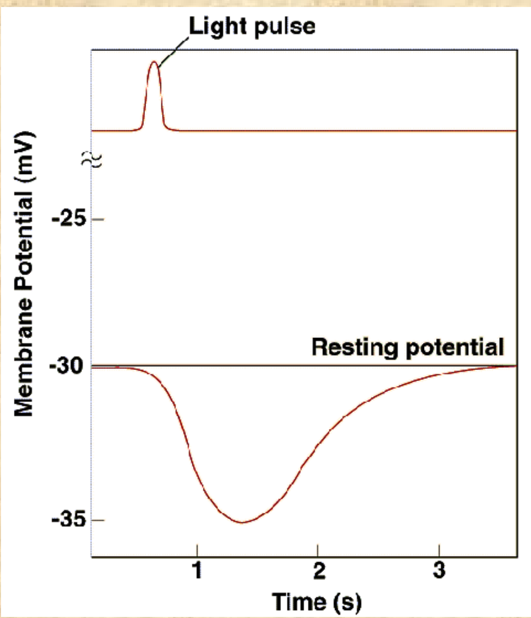
Rod Transduction

In the dark:

Membrane ion channels are open, causing a relatively depolarized membrane potential. Synaptic transmitter is released.

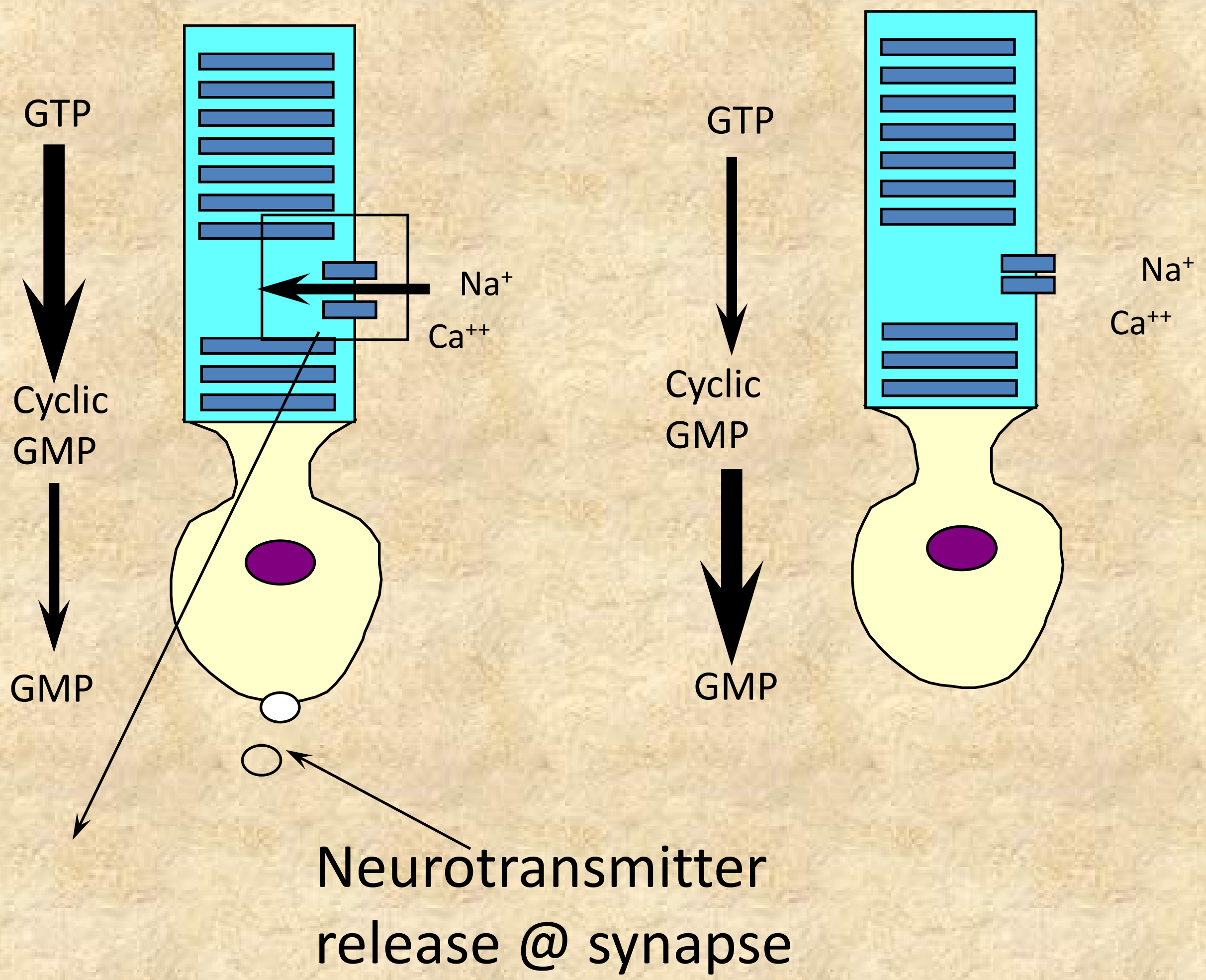
In the light:

Change in shape of rhodopsin causes (indirectly) membrane ion channels to close, in turn causing a relatively hyperpolarized membrane potential. Synaptic transmitter is no longer released.



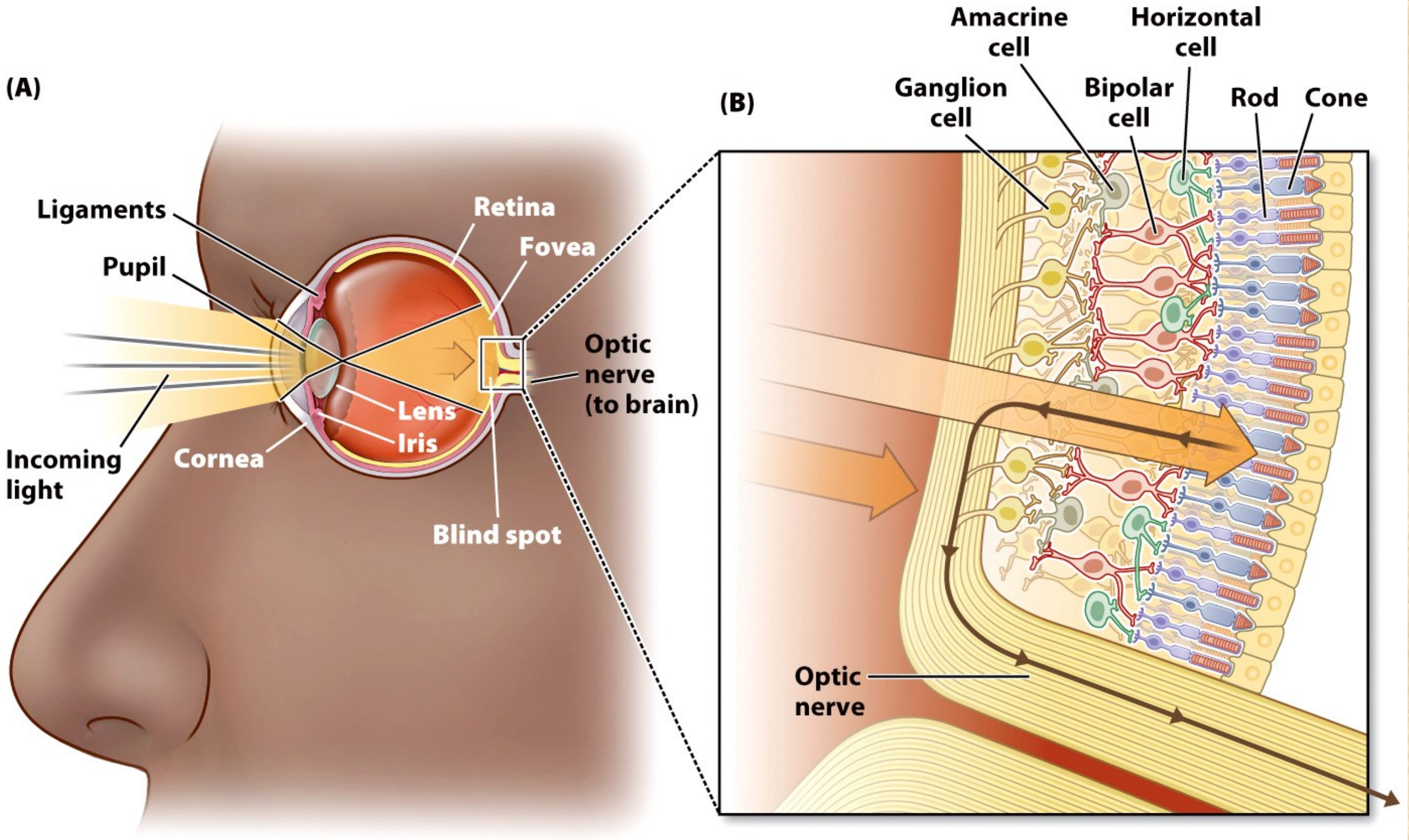
Rods in Dark

Rods in Light



channel open – high cGMP

channel closed – low cGMP



Psychology, 8/e Figure 4.24

Mapping of the visual field

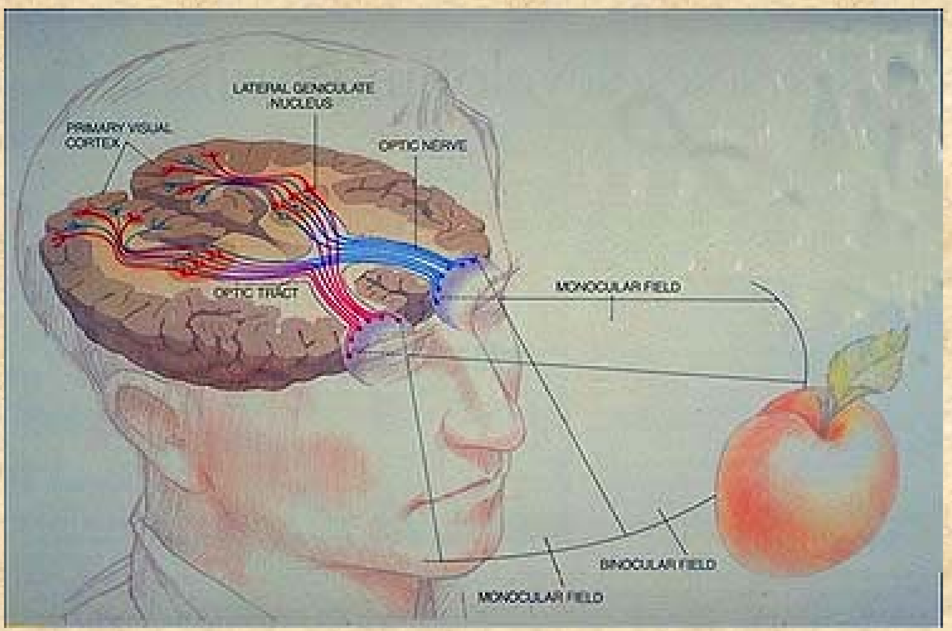
The lateral geniculate nucleus (LGN) receives information from both eyes.

The left half of the LGN receives information from the right side of the visual field.

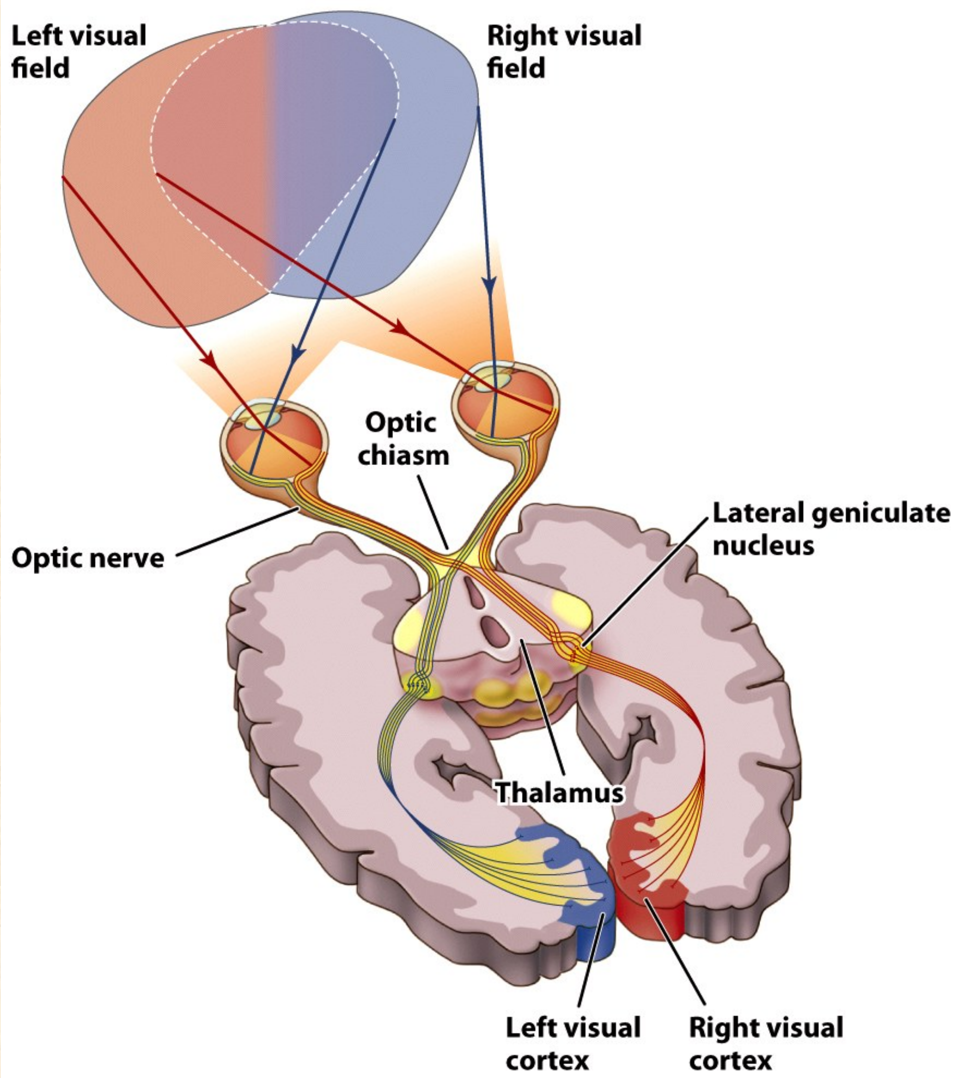
The right half of the LGN receives information from the left side of the visual field.

Some optic nerve fibers must cross sides for this to occur.

Contralateral organization also holds true for neurons in primary visual cortex (area V1).



The Retinogeniculate Pathway

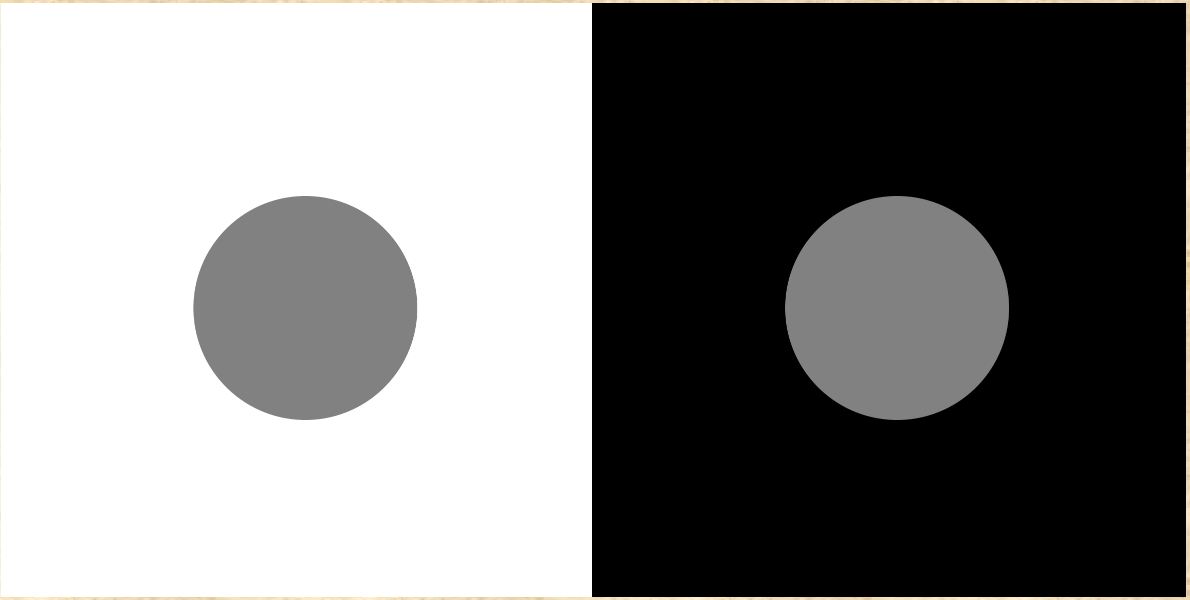


Psychology, 8/e Figure 4.26

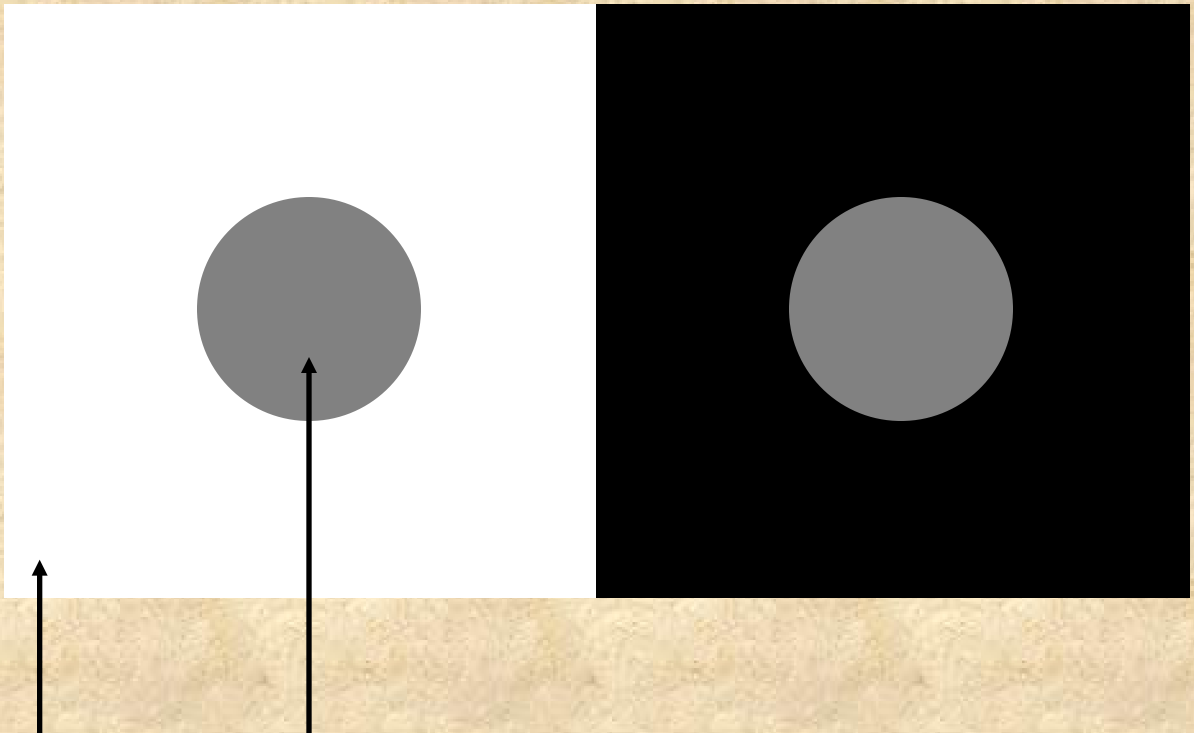
Visual Processing: Contrast Effects and Spatial Opponency

- *Contrast effects*
  - accentuate edges
    - example: Mach bands
  - *lateral inhibition*
    - an example of how the visual system refines stimulus information by emphasizing various aspects and understating others

Simultaneous Contrast

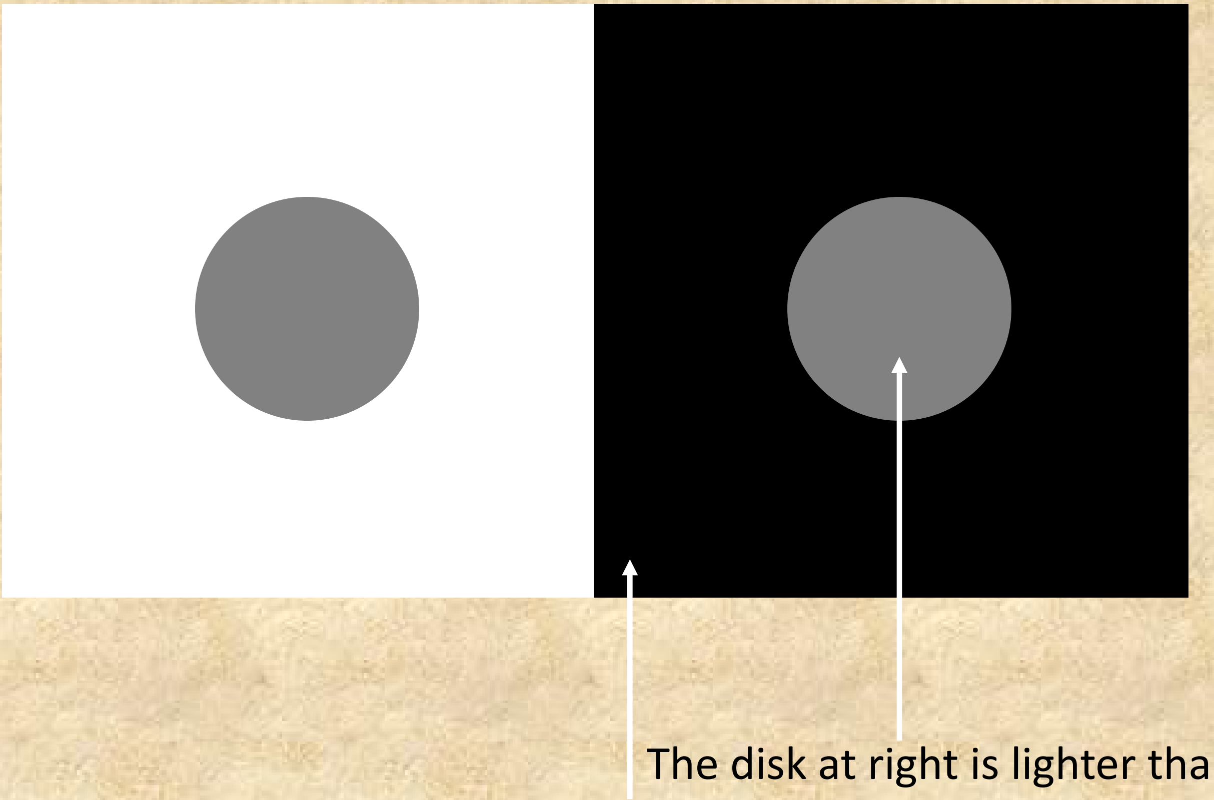


Simultaneous Contrast



The disk at left is darker than the surrounding white area. *By contrast*, the disk at left ends up looking even darker.

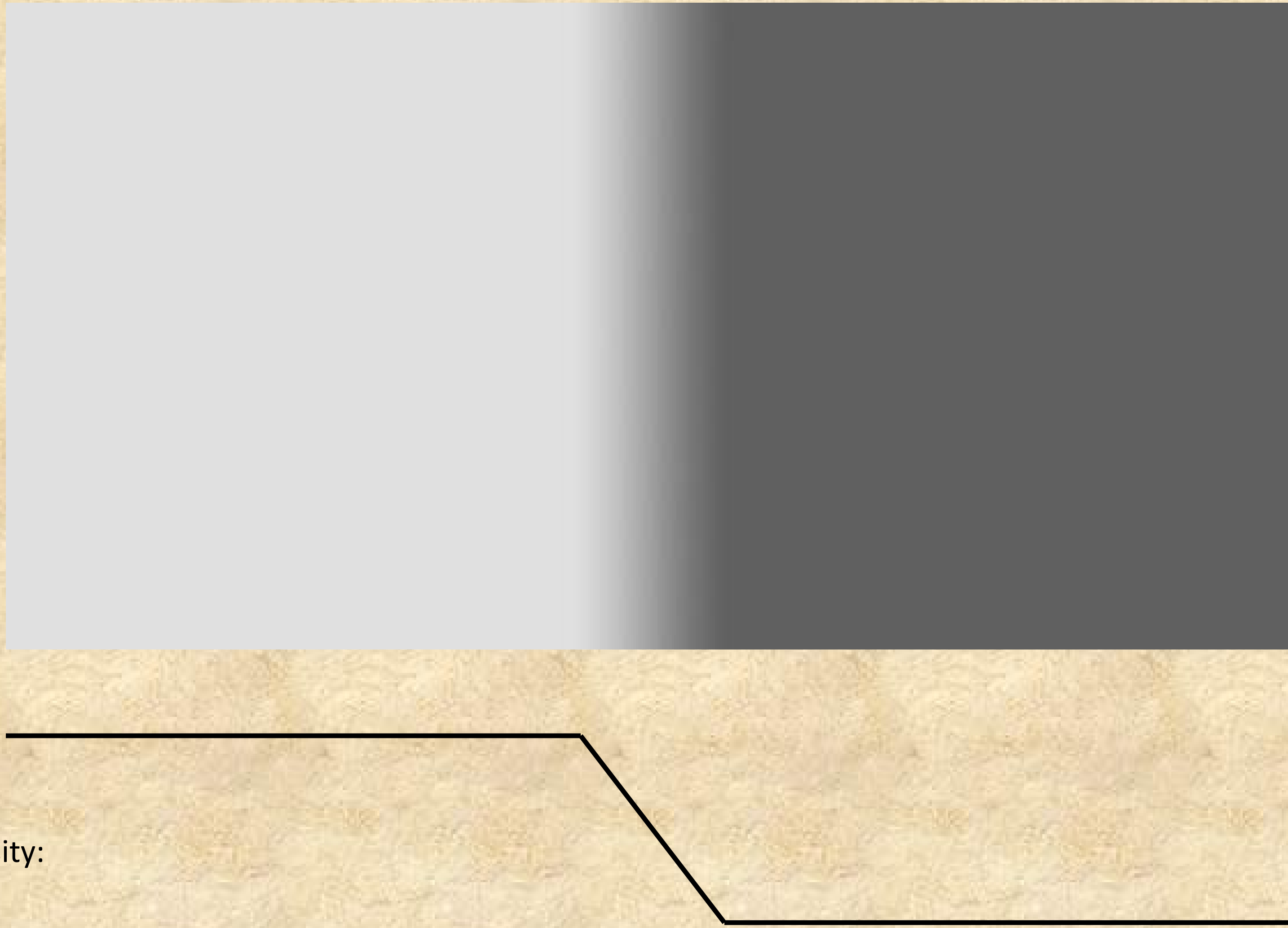
Simultaneous Contrast



The disk at right is lighter than the surrounding black area. *By contrast*, the disk at right ends up looking even lighter.

We need neurons that compare photoreceptoral responses from different retinal image locations.

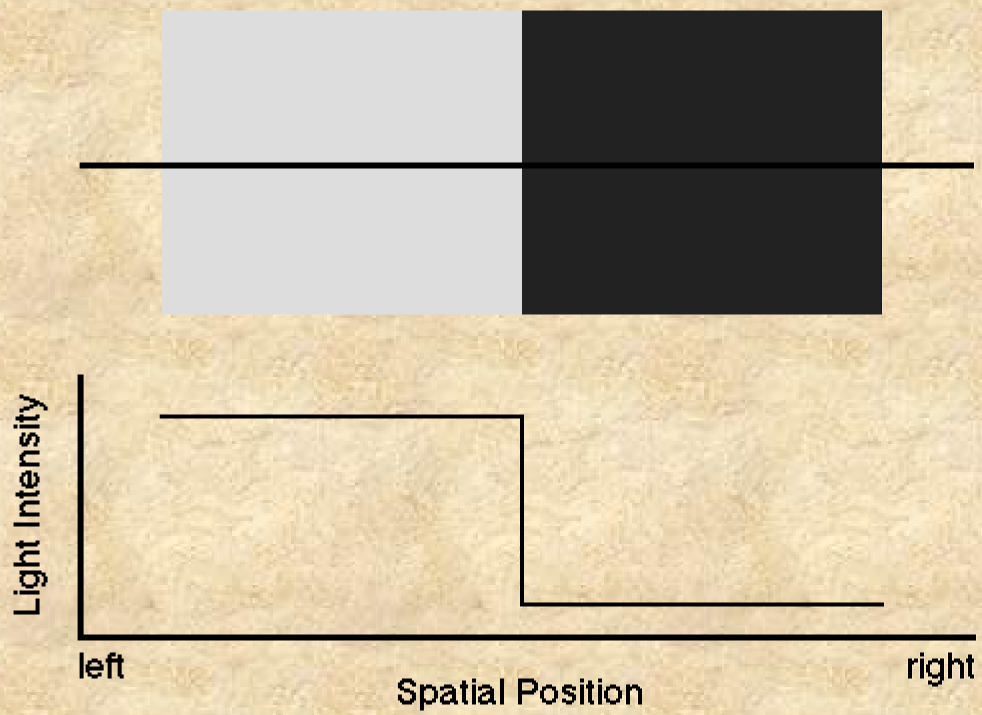
These are Chevreul Stripes



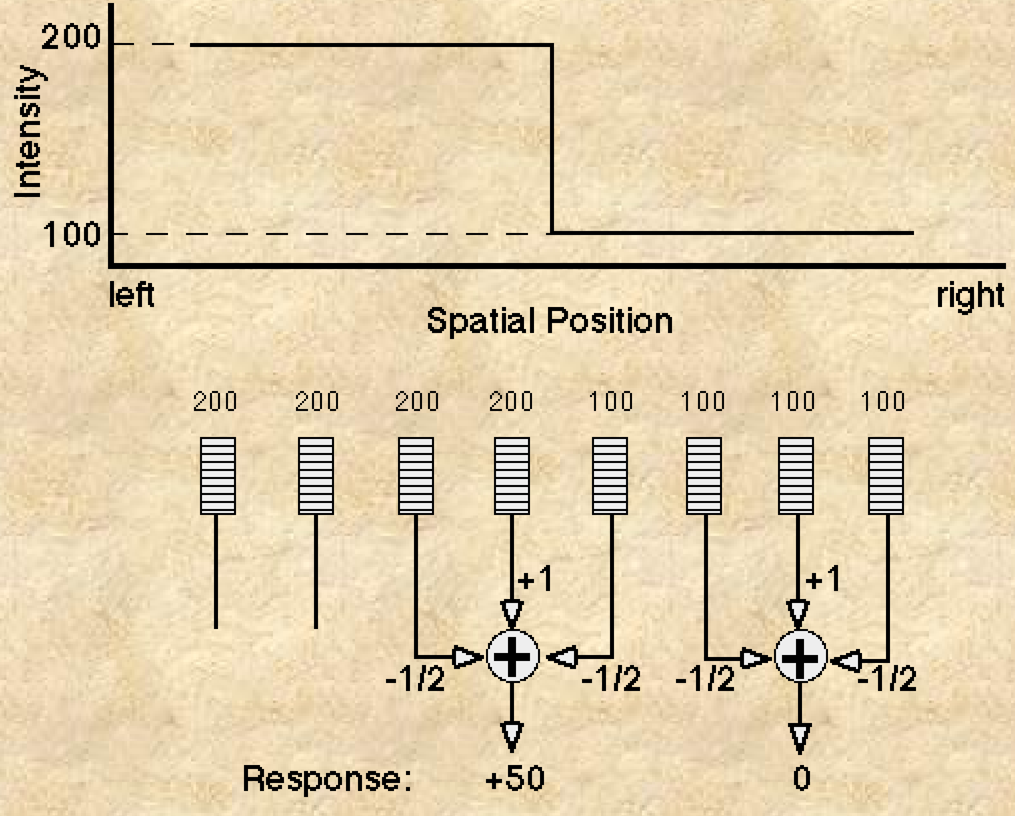
light intensity:

This is a Mach Band

Spatial Opponency & Lateral Inhibition



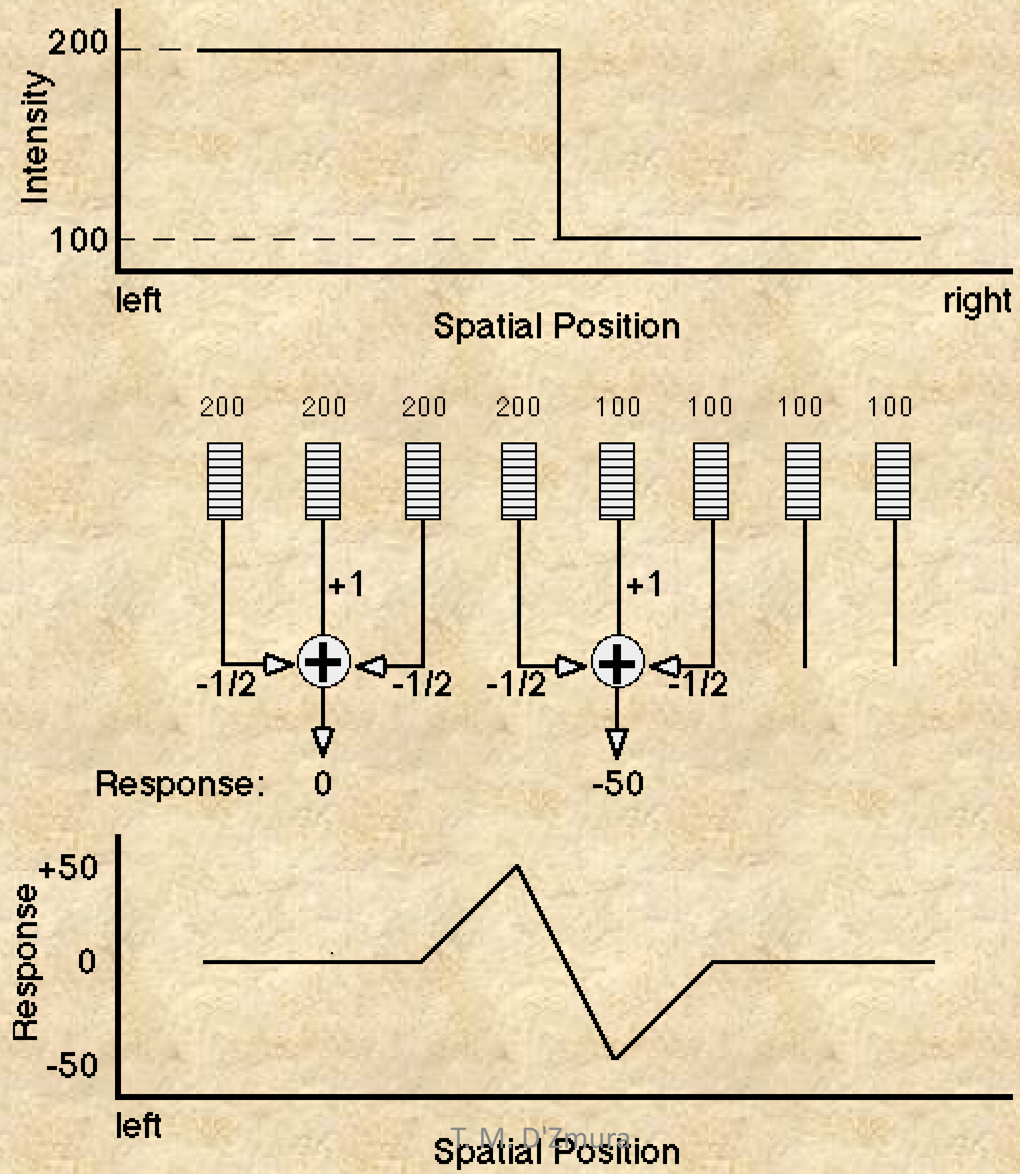
Spatial Opponency & Lateral Inhibition



Photoreceptors

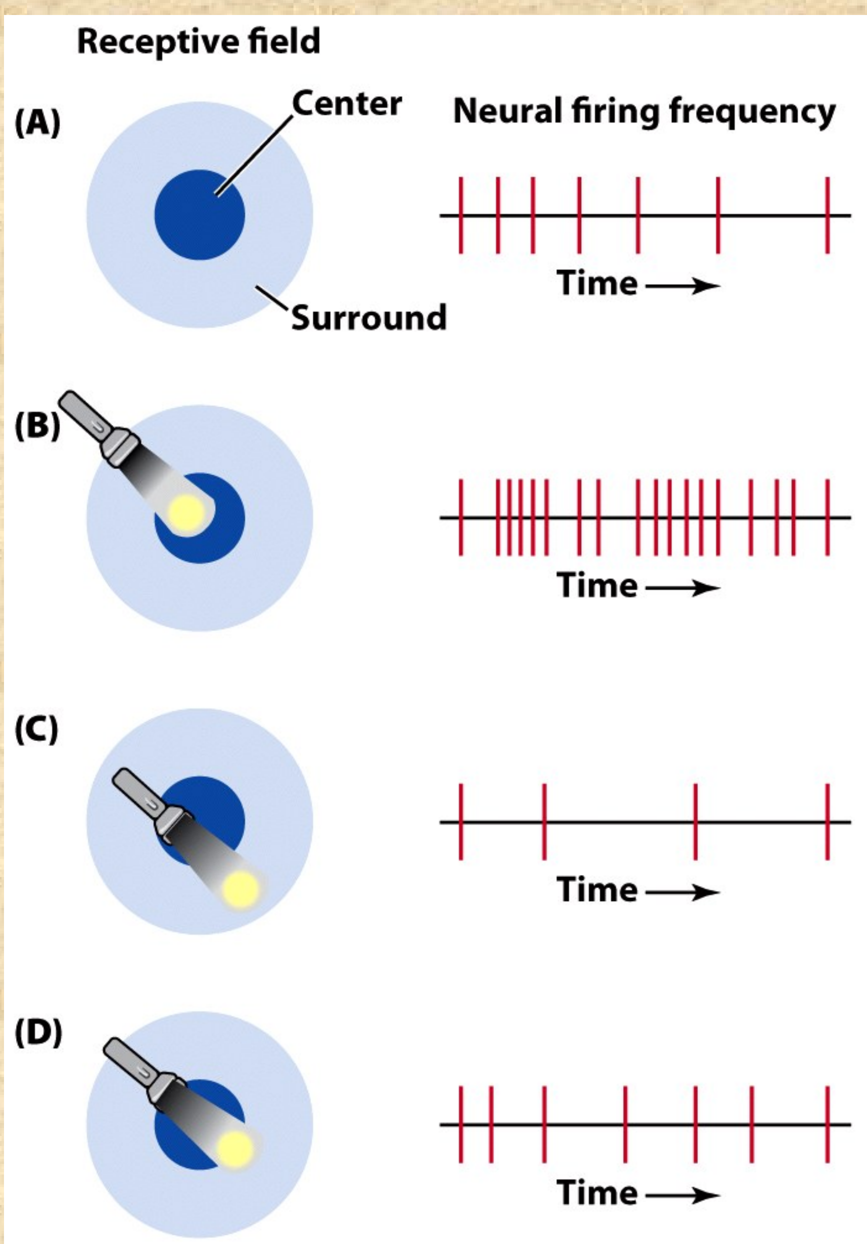
Center-surround opponent units

Spatial Opponency & Lateral Inhibition



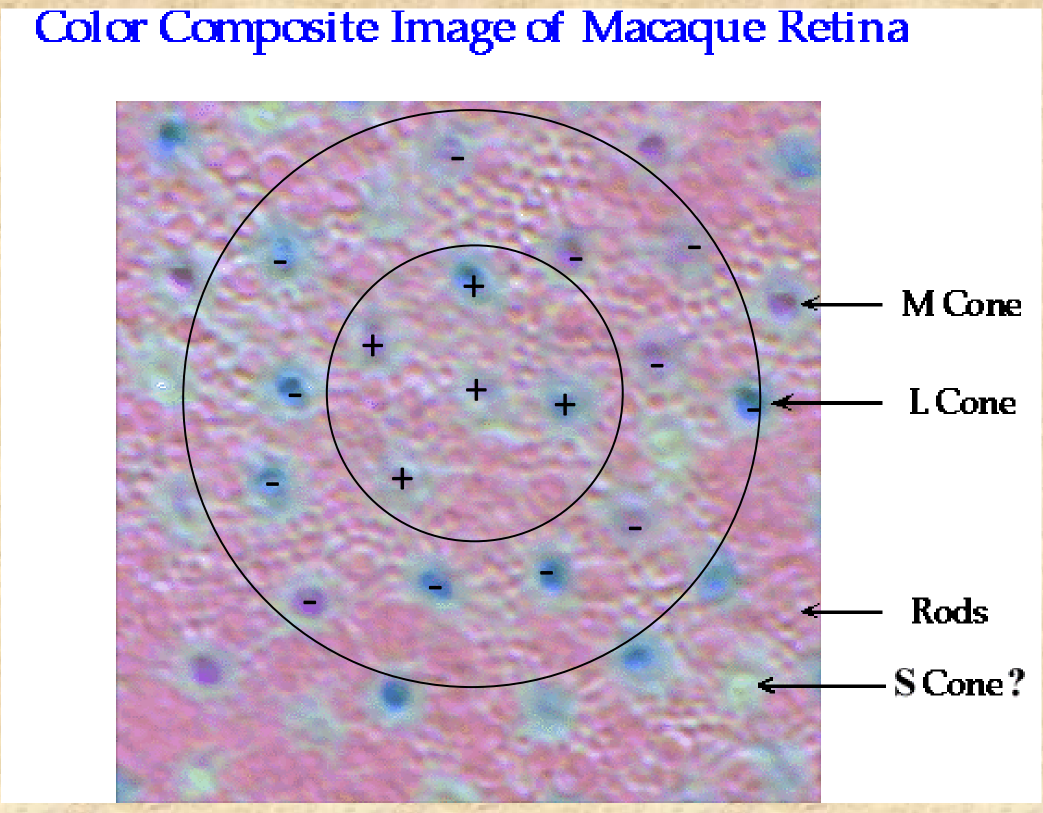
Lateral inhibition or *Center-surround opponency* enhances edges

Cat retinal ganglion cell response to a point of light depends on light location in its *receptive field*.



Psychology, 8/e Figure 4.43

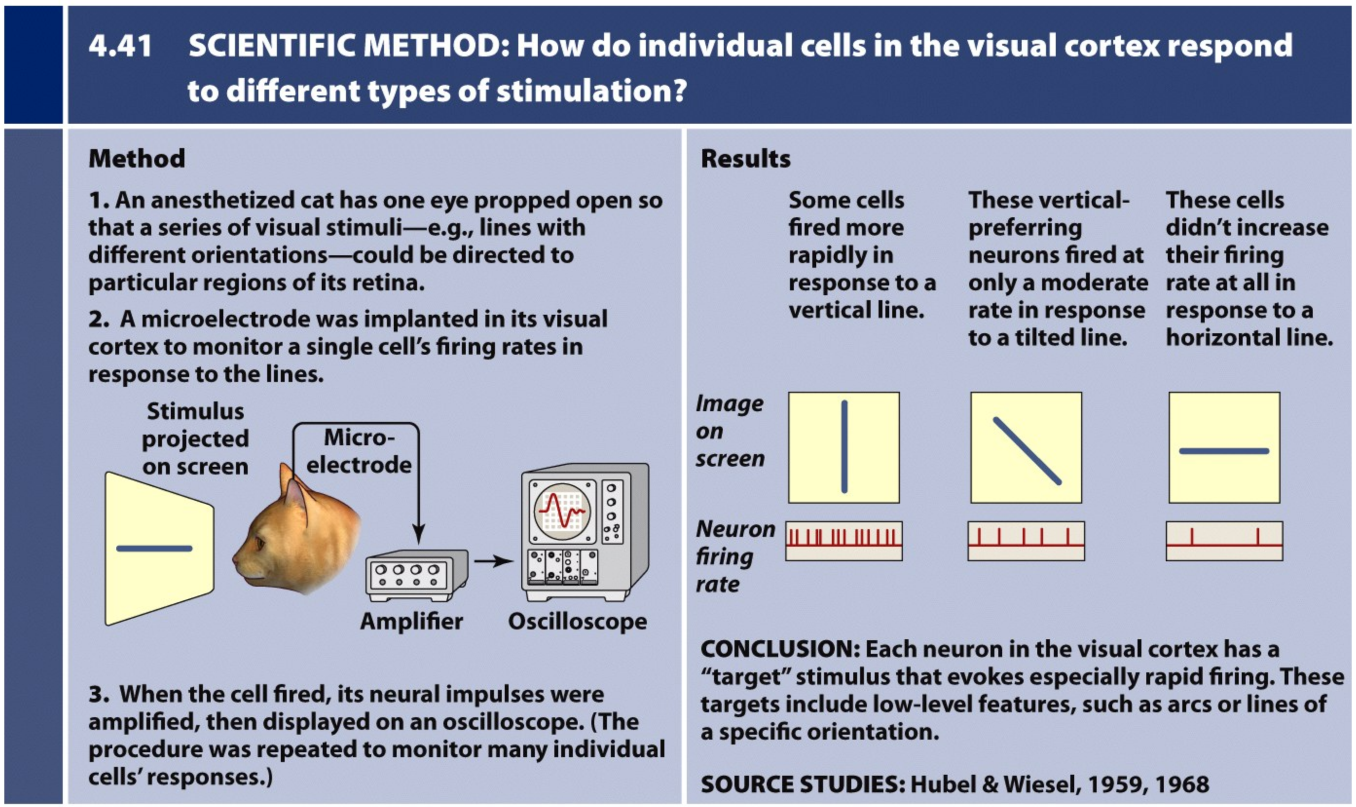
Retinal ganglion cells (and bipolars) have a **center-surround** receptive field structure



Packer, Bensinger & Williams, at http://www.cvs.rochester.edu/people/d_williams/d_williams.html

A center-surround receptive field structure is spatially opponent. Cells with center-surround receptive fields enhance edges.

Edge and bar detectors were found in cat primary visual cortex by Nobel Prize winners Hubel & Wiesel

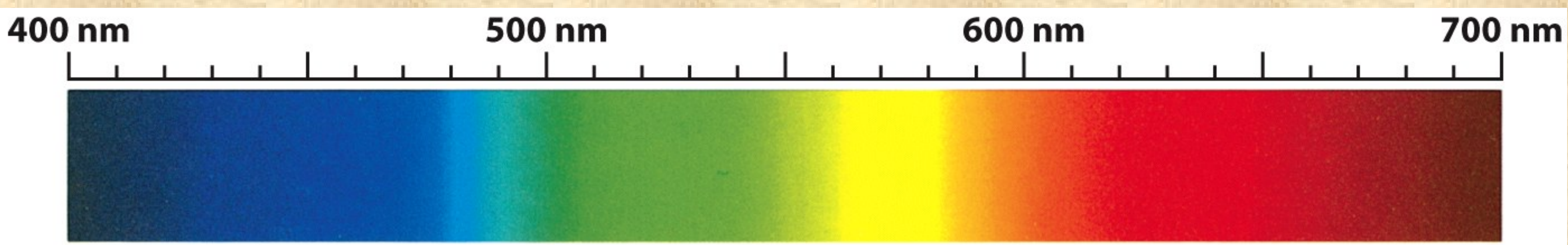


Psychology, 8/e Figure 4.41

Visual Processing: Color and Color Opponency

- Visual sensations vary in *color*, and color sensations can be ordered by
  - hue, brightness, and saturation.
- Normal human color vision is *trichromatic,* depending on three cone types.
- Responses from different cone types are compared to produce opponent color pairs, so accounting for
  - complementary colors, color contrast, and negative afterimages.

The visible spectrum

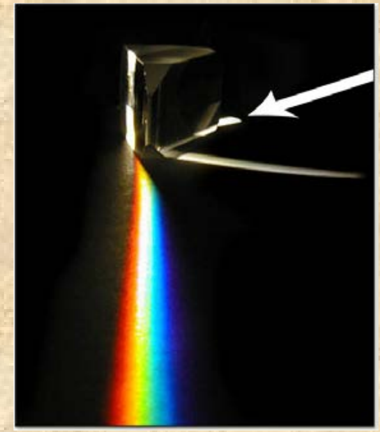


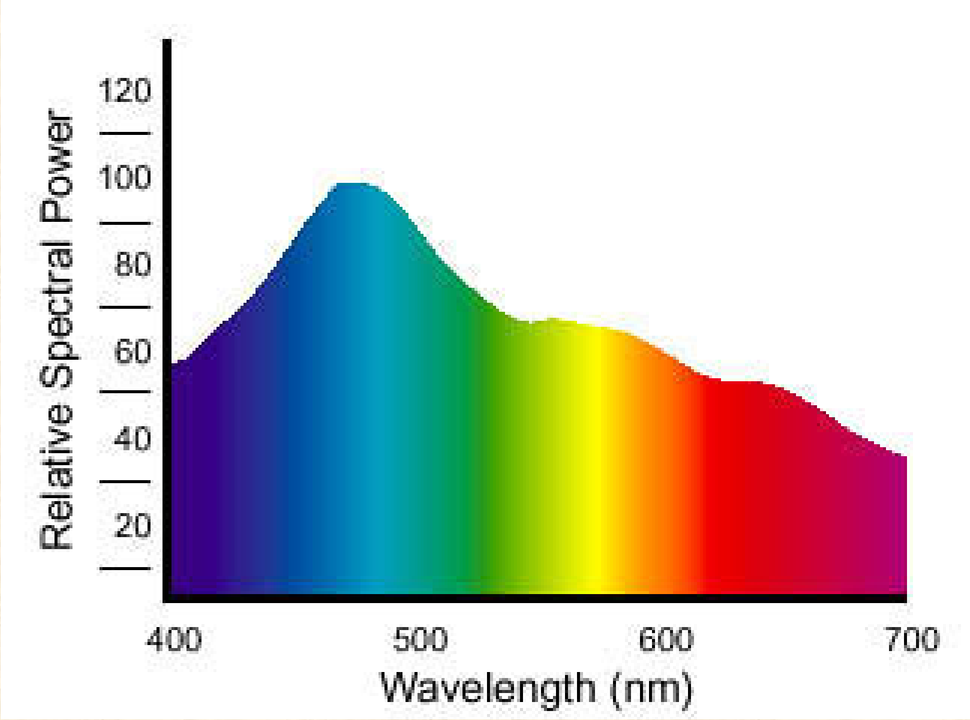
Psychology, 8/e Figure 4.32

Roy G. Biv

Light Sources

Sunlight and most natural lights comprise light at a large number of wavelengths





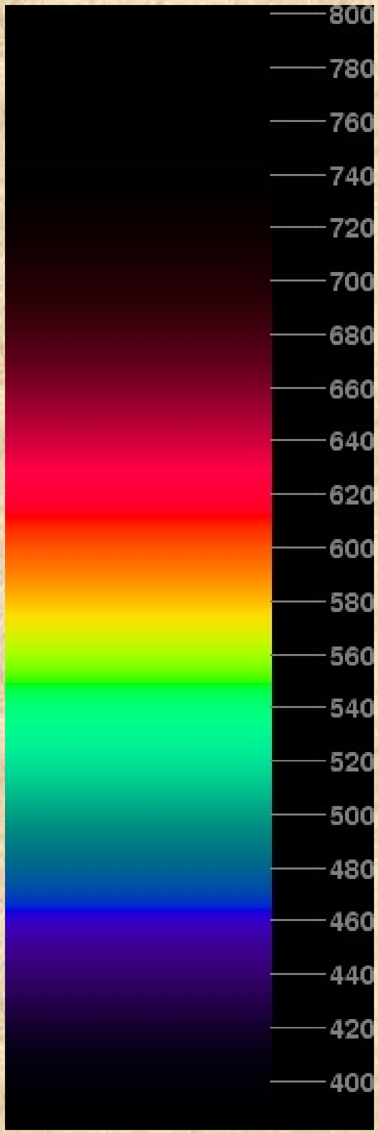
Spectral Power Distribution of Average Daylight D65
http://www.creativepro.com/story/feature/13036.html?origin=story

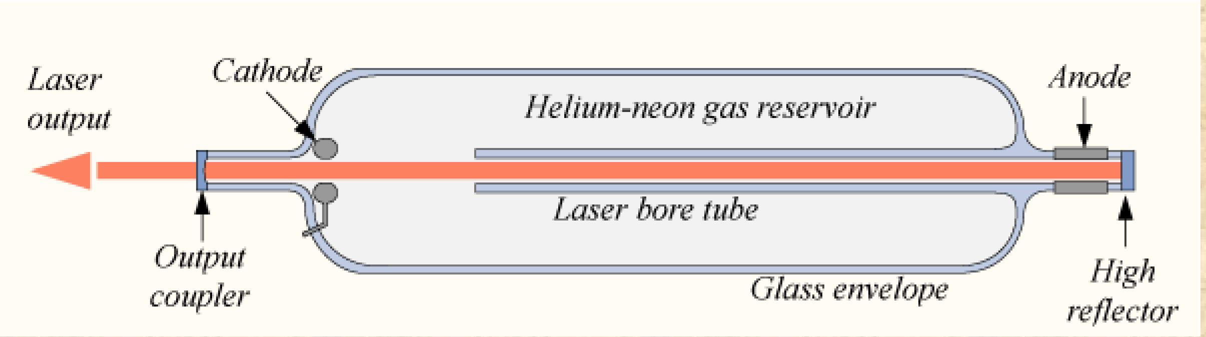
Light Sources

Lights with energy at only a single wavelength are called *monochromatic*

A helium-neon laser light (standard red laser) has energy at 632.8 nm.
Green laser pointers provide light at 532 nm.

λ = 632.8 nm





from http://en.wikipedia.org/wiki/Helium-neon_laser

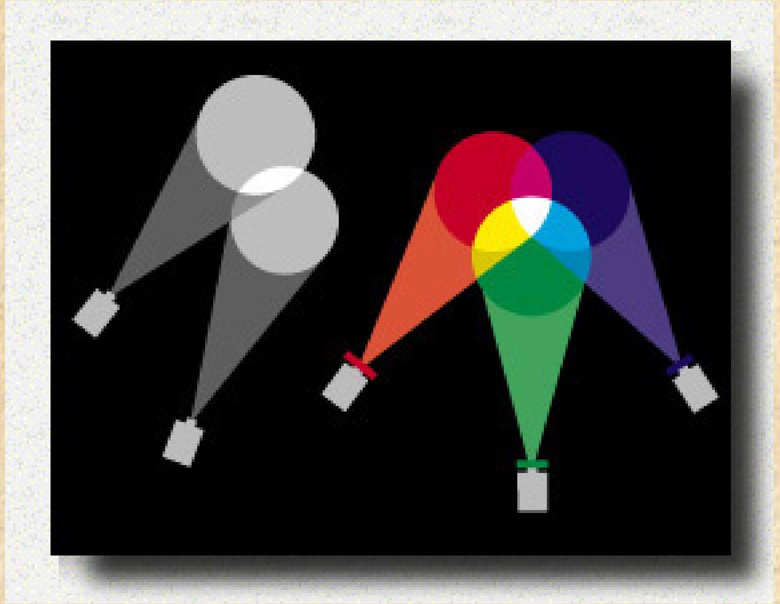
Additive Color Mixture

Lights may be combined additively.

-three slide projectors displaying on a single screen

-color television set (red, green and blue phosphors)

-spotlights and other lights at a theater



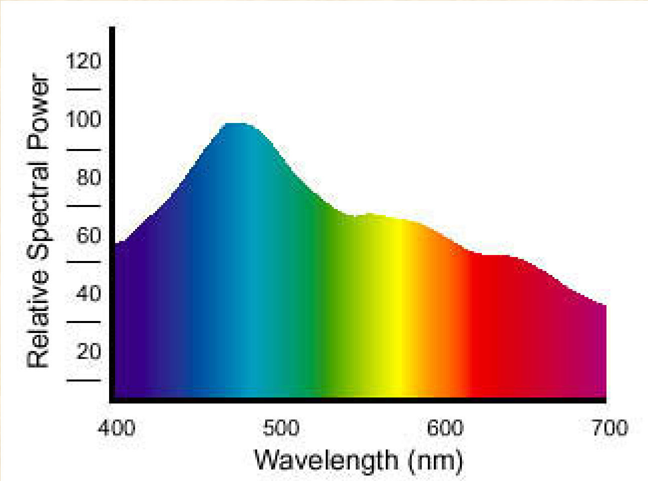
from http://www.experience.epson.com.au/help/understandingcolour/COL_G/0503_5.HTM

Subtractive Color Mixture

Pigments are combined subtractively; they absorb light.

Trichromacy

A light with complex spectral properties has a visual effect that we can represent by just three numbers.



→ just three numbers!

Trichromacy

-Thomas Young
-Hermann von Helmholtz

Only three distinct lights are needed to reproduce the full gamut of colors.

One generally chooses three lights of very high *saturation* and of differing *hue* (e.g., red, green and blue lights) as *primaries.*

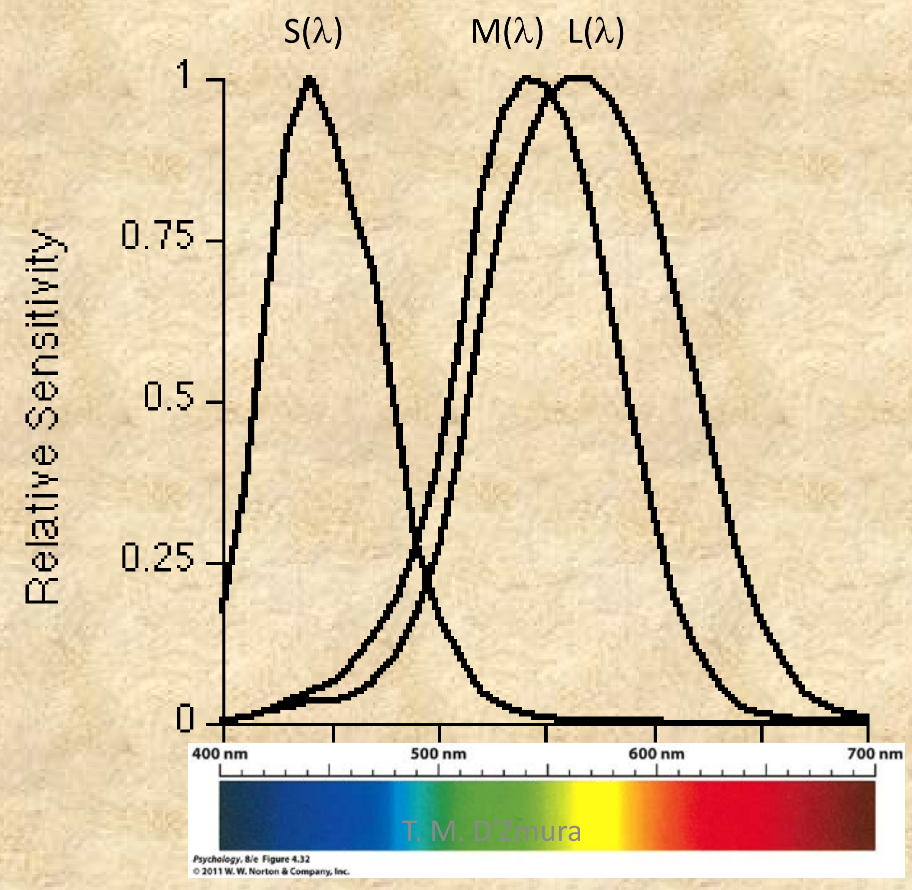
Hue

Saturation
or Chroma

Brightness
or Lightness
or Value

Trichromacy

Generally held to be a consequence of our having (for *normal* color vision) 3 types of cone, namely L-cones, M-cones, and S-cones, distinguished by their photopigments, which differ in spectral sensitivity.



Color Blindness

Dichromatic color vision

Protanopia – lack of L-cones
Deuteranopia – lack of M-cones
Tritanopia – lack of S-cones

relatively rare

Anomalous color vision

Protanomaly – paucity of L-cones
or altered L-cone pigment sensitivity
Deuteranomaly – paucity of M-cones
or altered M-cone pigment sensitivity
Tritanomaly – paucity of S-cones
or altered S-cone pigment sensitivity

more common

Color Blindness

L-cone and M-cone pigments (the *opsins*) are coded by genes on the X-chromosome.

Females (XX) have two X-chromosomes (which differ) and so are unlikely to exhibit problems with L- or M-cones

Males (XY) have only one X-chromosome, so that if there is a problem with the opsin genes, that problem will lead to color blindness

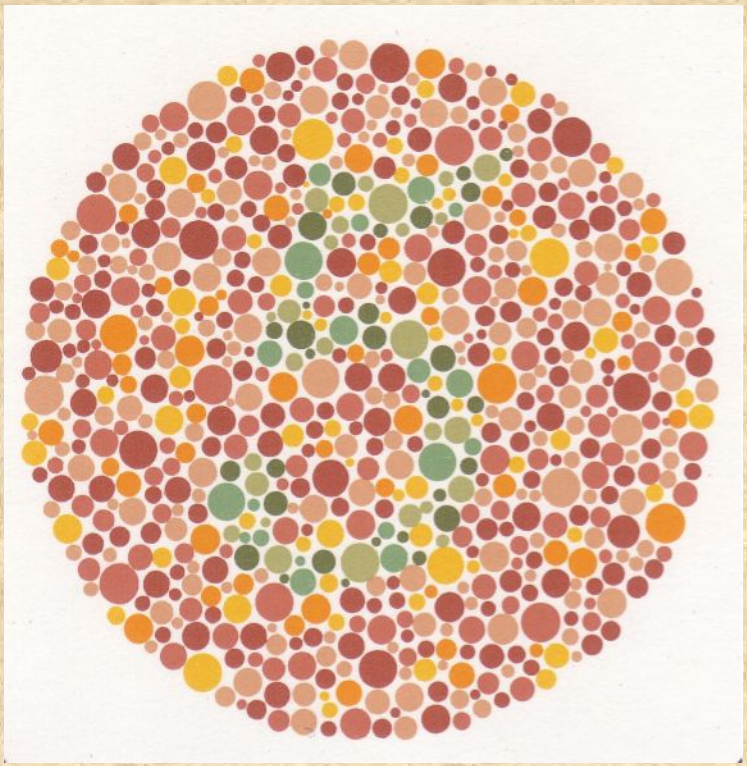
Inherited L-cone and M-cone abnormalities lead to *red-green color blindness*
This is the most common form of color blindness: 8% of males

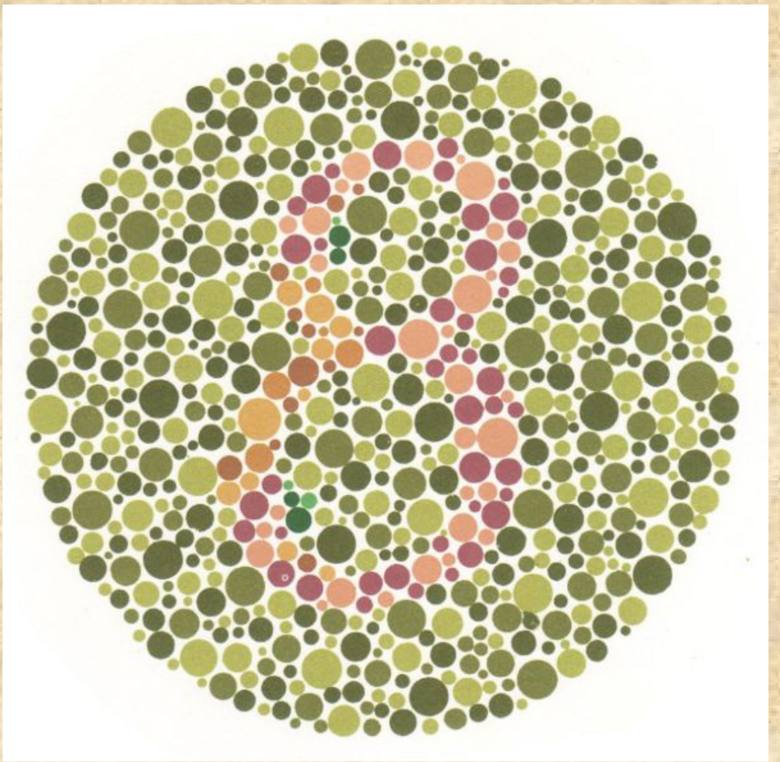
Inherited S-cone related color vision deficiency is rare. However, there are medical conditions like diabetes which can weaken and kill off S-cones (an "acquired" color vision deficiency).

Inherited color vision deficiency is rare among females.

Tests of Color Blindness

Ishihara Plates





from R. Littlewood http://www.cleareyeclinic.com/ishihara.html

There's a neat web exhibit suggesting how things appear to color-blind people at http://webexhibits.org/causesofcolor/2B.html

Color Opponency

Hering
Hurvich & Jameson
Svaetichin
DeValois

There *appear* to be four primary hues
red, green, yellow and blue

One never sees a light which looks both red and green
or a light which looks both blue and yellow – color *opponency*

There appear to be lights with a *unique hue* appearance
unique red – appears neither yellowish nor bluish
unique green – appears neither yellowish nor bluish
unique blue – appears neither reddish nor greenish
unique yellow – appears neither reddish nor greenish

Color Opponency: Unique Hues

There appear to be lights with a unique hue appearance

unique blue – appears neither reddish nor greenish

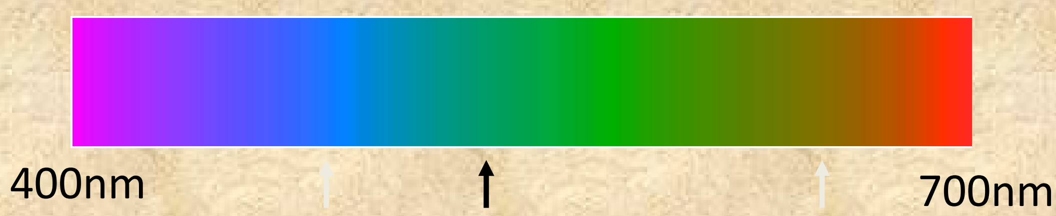
Unique Hues

There appear to be lights with a unique hue appearance

unique blue – appears neither reddish nor greenish

unique yellow – appears neither reddish nor greenish

Unique Hues



There appear to be lights with a unique hue appearance

unique blue – appears neither reddish nor greenish

unique yellow – appears neither reddish nor greenish

unique green – appears neither yellowish nor bluish

Unique Hues

There appear to be lights with a unique hue appearance

unique blue – appears neither reddish nor greenish

unique yellow – appears neither reddish nor greenish

unique green – appears neither yellowish nor bluish

unique red – appears neither yellowish nor bluish

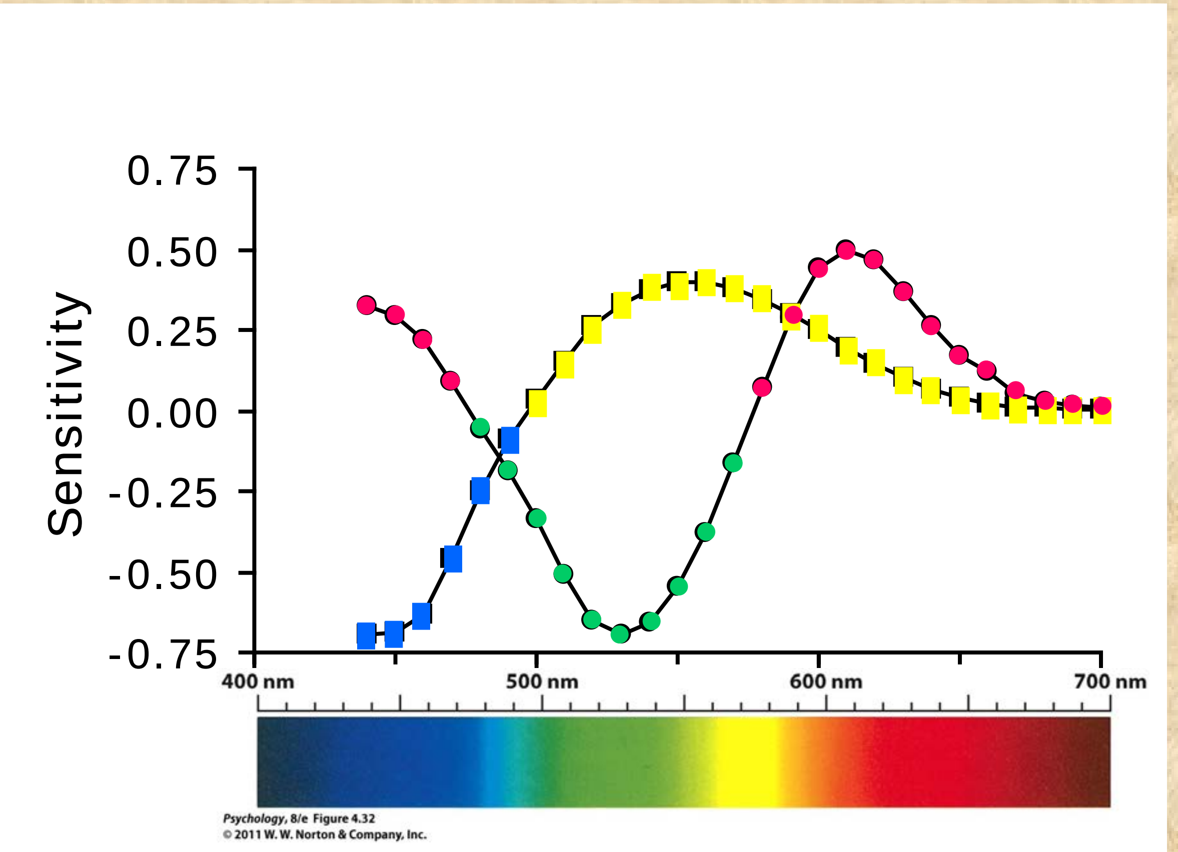
The shortest visible wavelength appears violet when presented as a monochromatic light.

The longest visible wavelength appears an orangish red when presented as a monochromatic light.

Unique red (neither blue nor yellow) is an *extraspectral color*

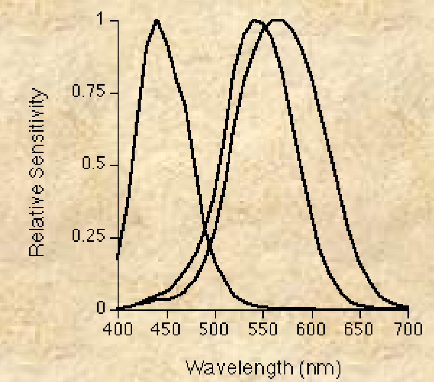
Color Opponency

Hue Cancellation Experiment Results (Hurvich & Jameson)



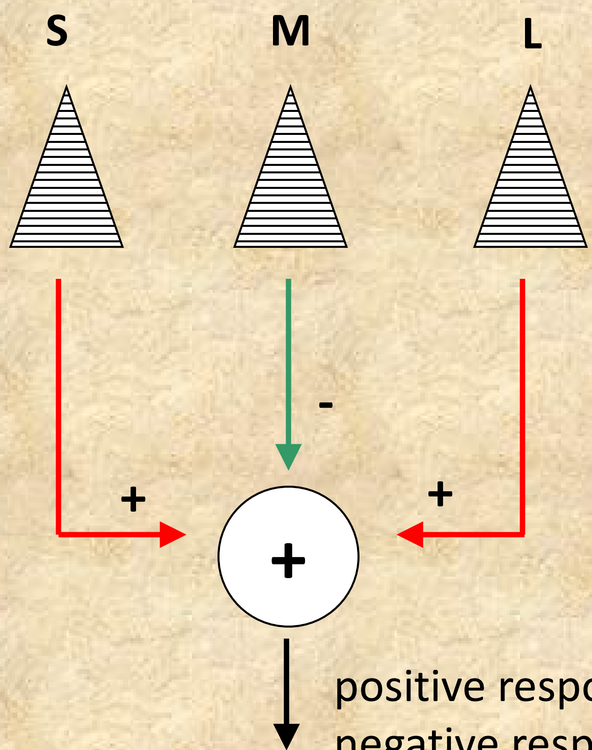
Hurvich-Jameson color-opponent functions

Color Opponency



Compare LMS cone responses

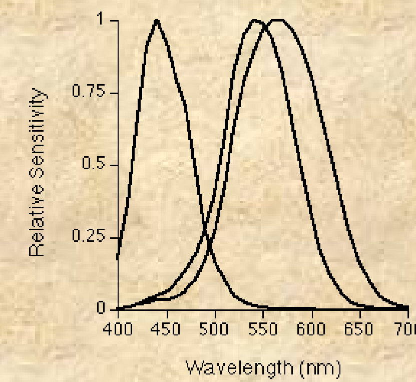
Red-Green



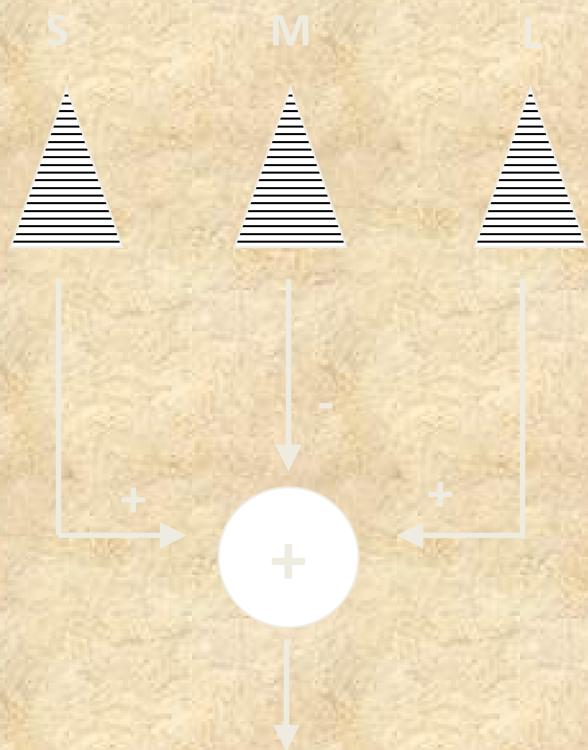
positive response: red
negative response: green
zero response: neither red nor green

Color Opponency

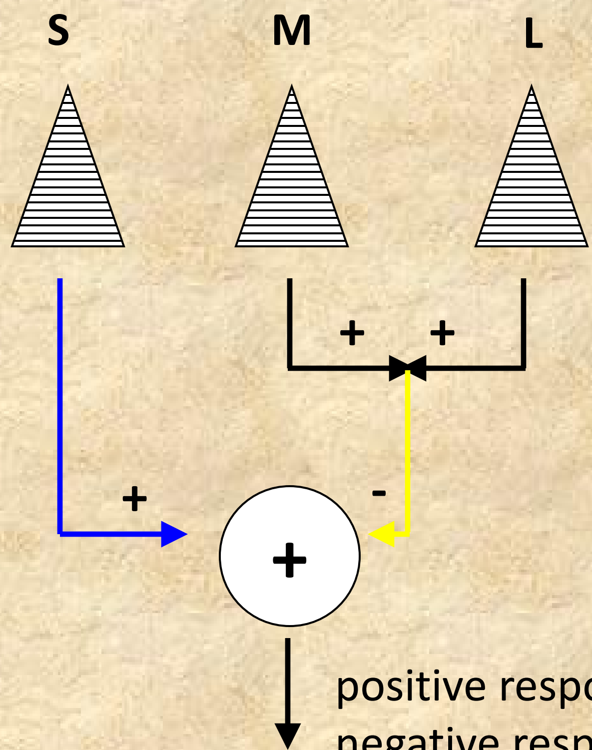
Compare LMS cone responses



Red-Green

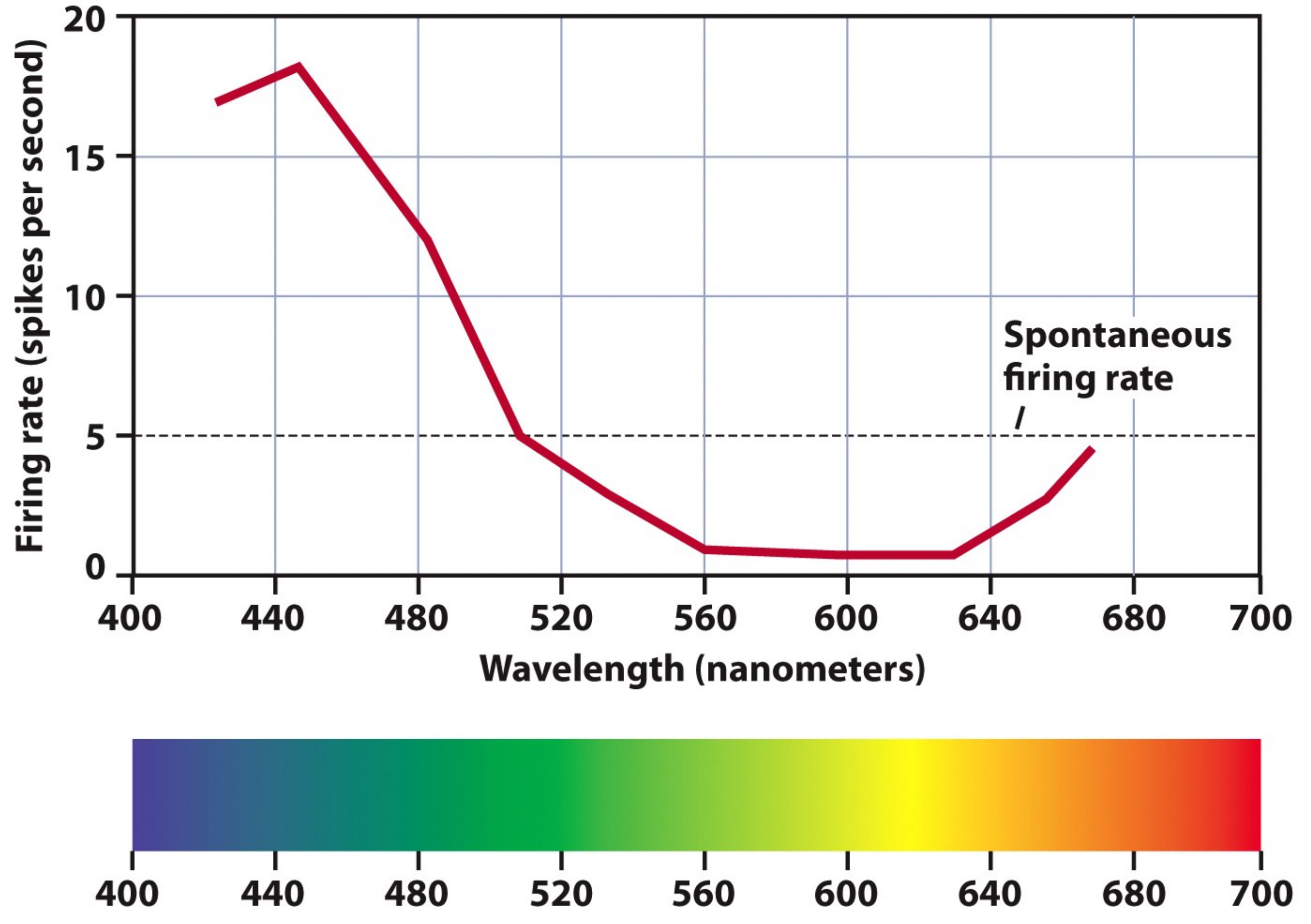


Blue-Yellow



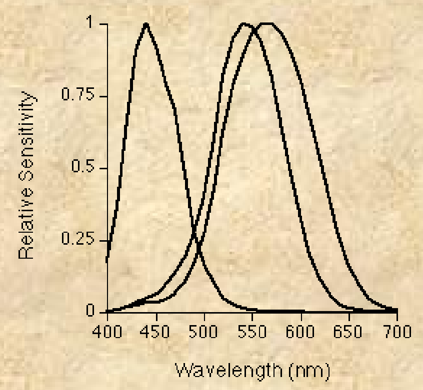
positive response: blue
negative response: yellow
zero response: neither blue nor yellow

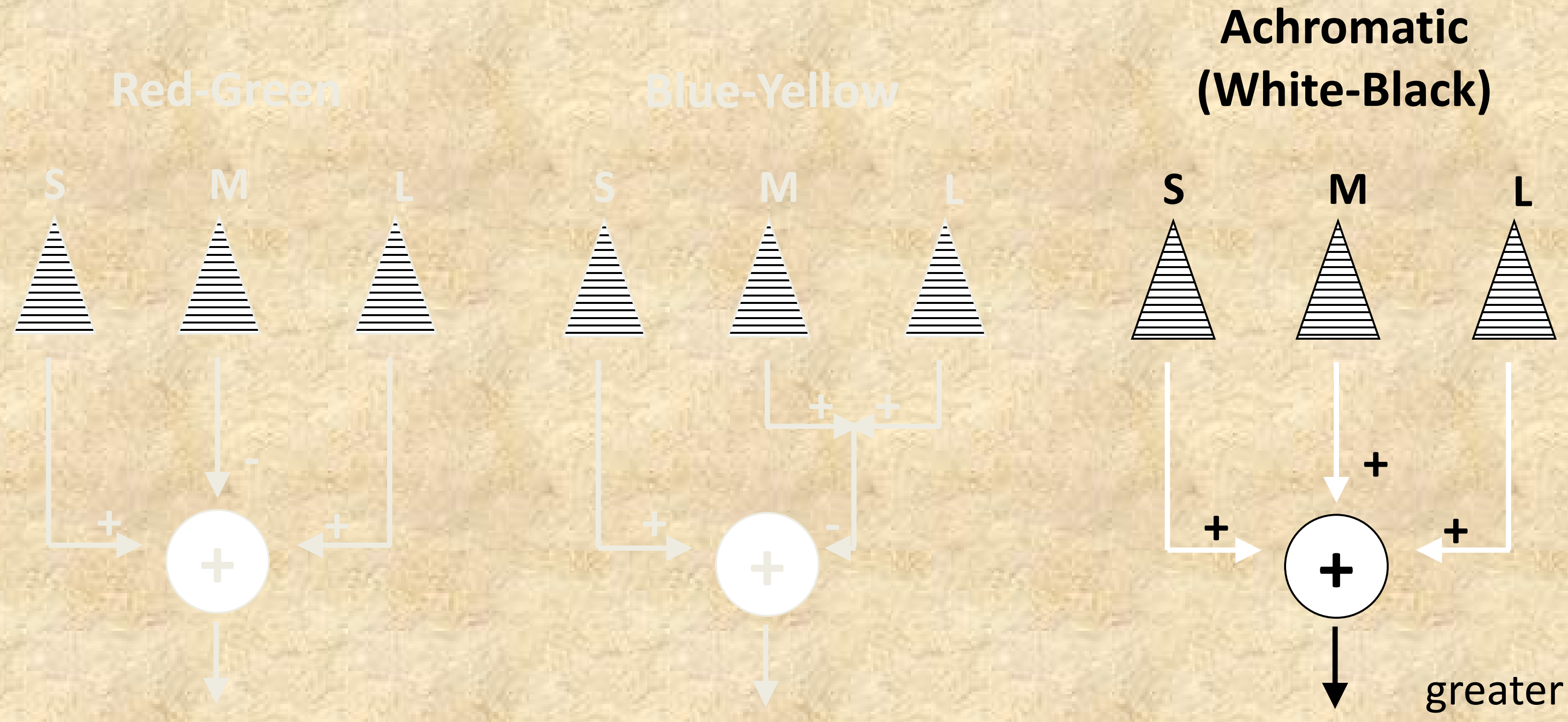
Monkey "blue-yellow" cell is excited by short-wavelength light and is inhibited by longer-wavelength light



Psychology, 8/e Figure 4.39

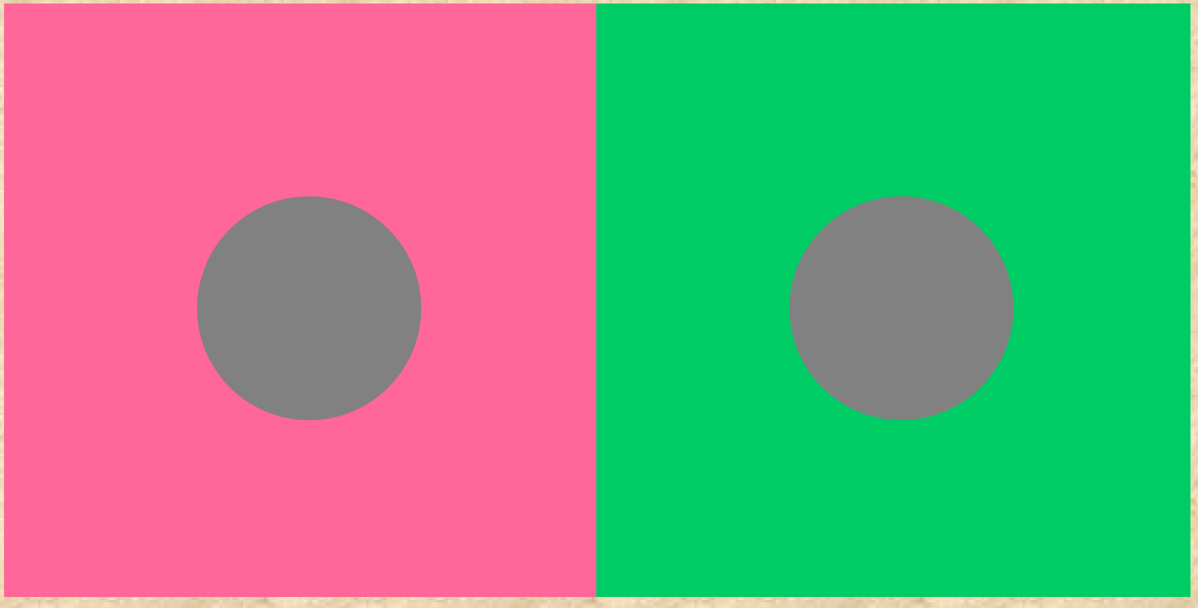
Color Opponent and Achromatic Channels





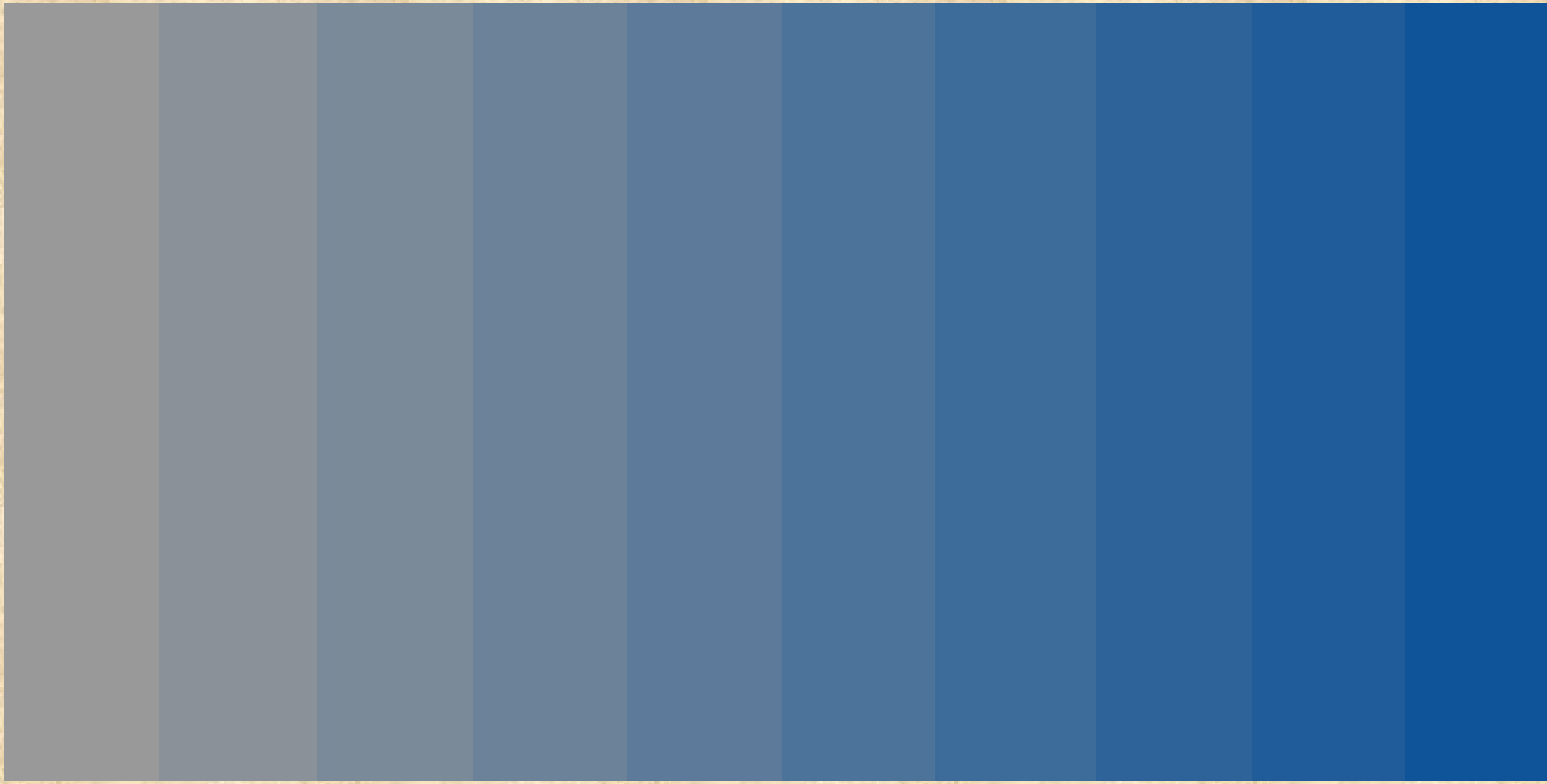
greater response:
brighter
lesser response:
darker

Simultaneous Color Contrast



not as strong as with a black-white stimulus

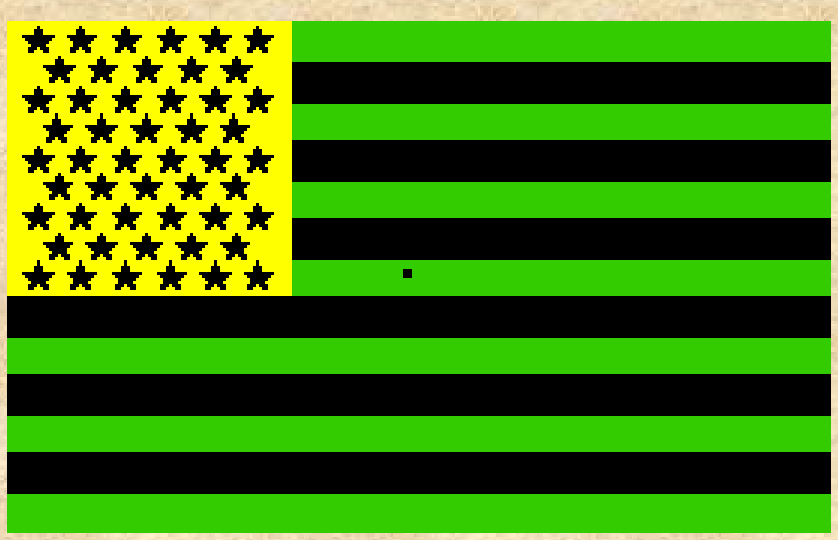
Simultaneous Color Contrast



blue Chevreul stripes – perceived variation in saturation within a stripe

such illusions suggest that there are cortical neurons sensitive to color change across space (e.g., color change across an edge)

Successive Color Contrast



Stare at the black dot on the flag for 30 sec. Then gaze steadily at the dot at right.
You are likely to see a *negative afterimage*.