

Institute of Neuroinformatics  
University of Zurich and ETH Zurich

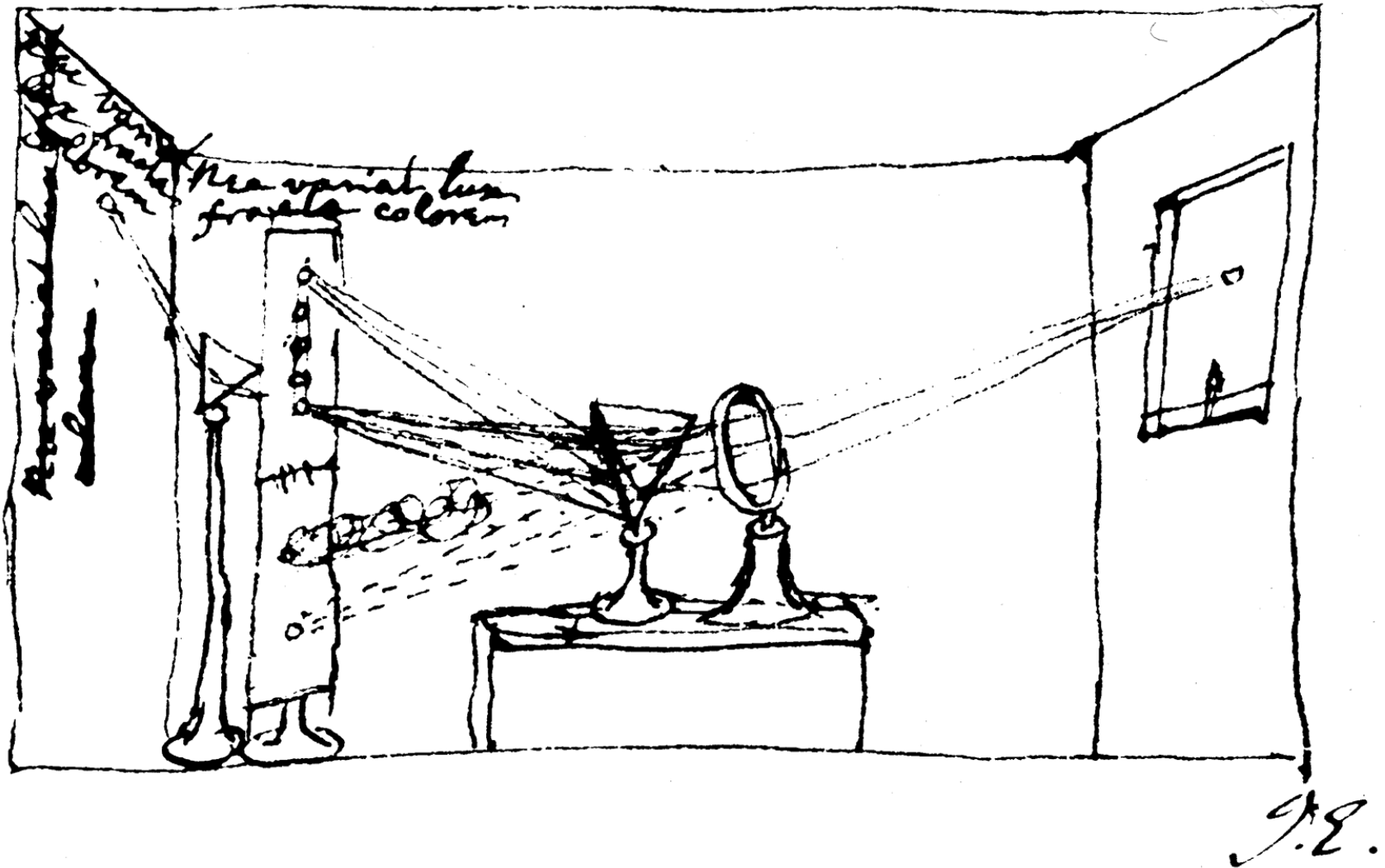
# **Computation in Neural Systems: Biological Vision**

**17.5.2018**

Daniel C. Kiper

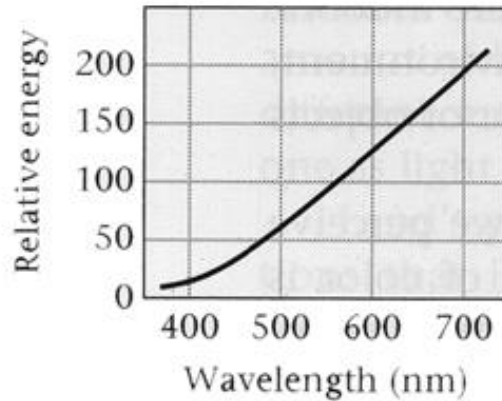
[www.ini.unizh.ch/~kiper/comp\\_vis/index.html](http://www.ini.unizh.ch/~kiper/comp_vis/index.html)

# Newton's experiment

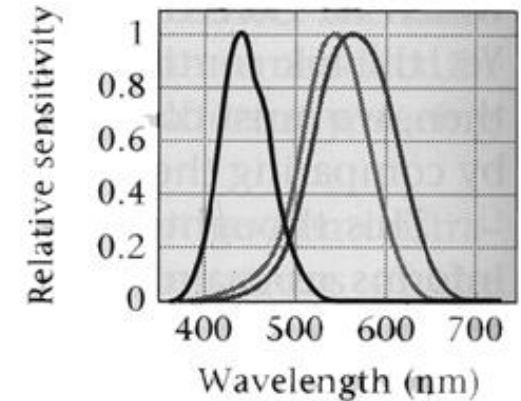


# Real life color perception

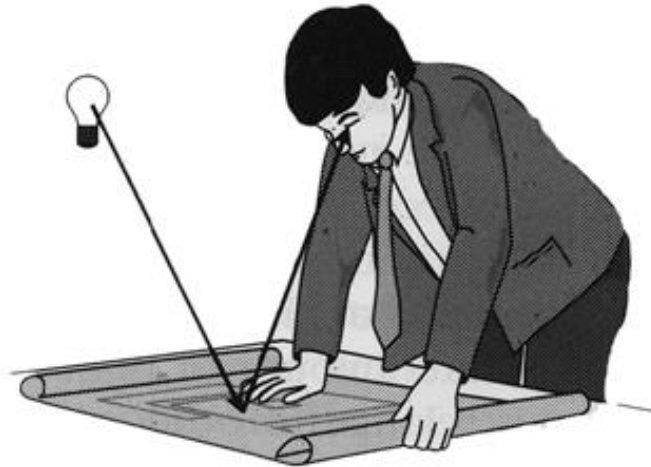
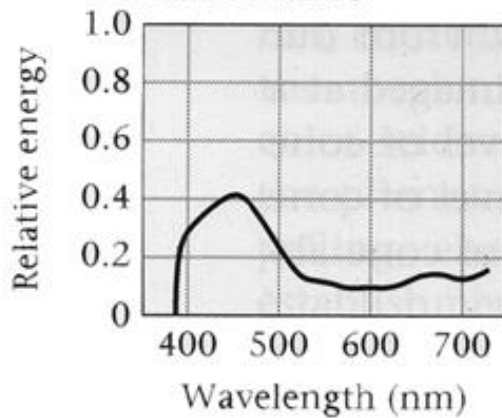
**Illumination**



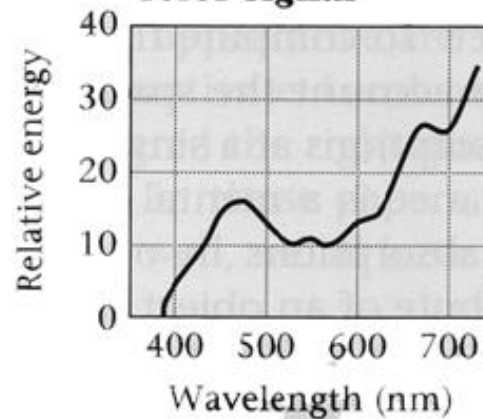
**Cone sensitivities**



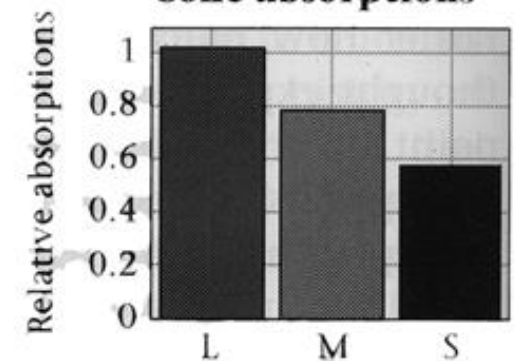
**Reflectance**



**Color signal**

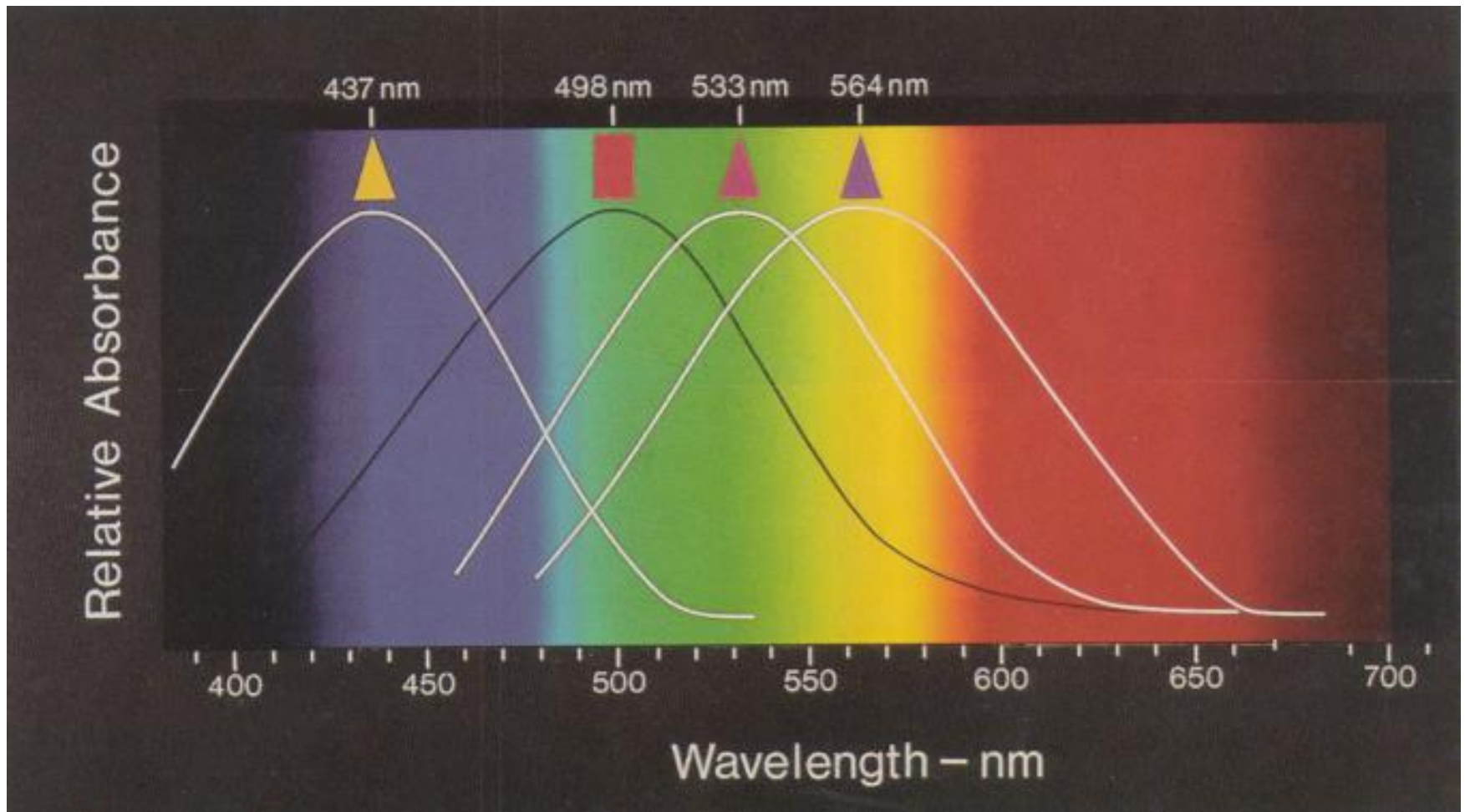


**Cone absorptions**



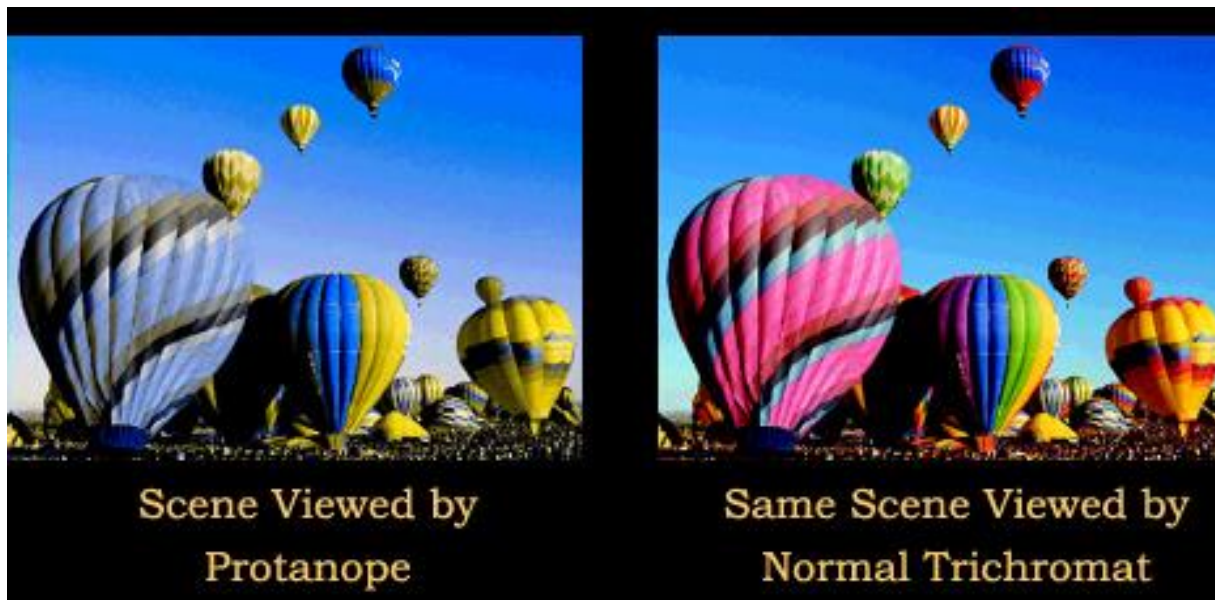
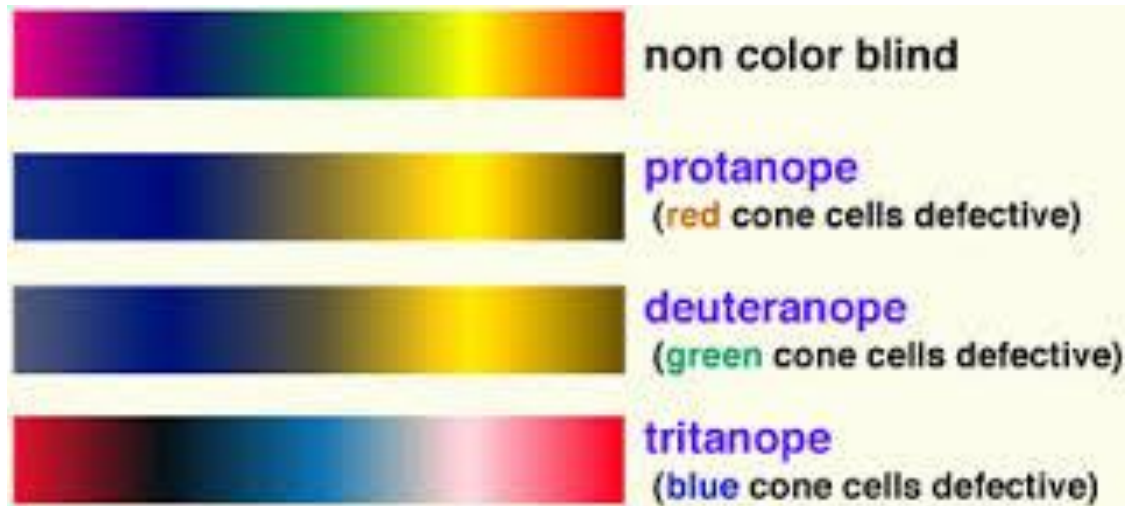
# Photoreceptors sensitivity profiles

S          Rods    M          L

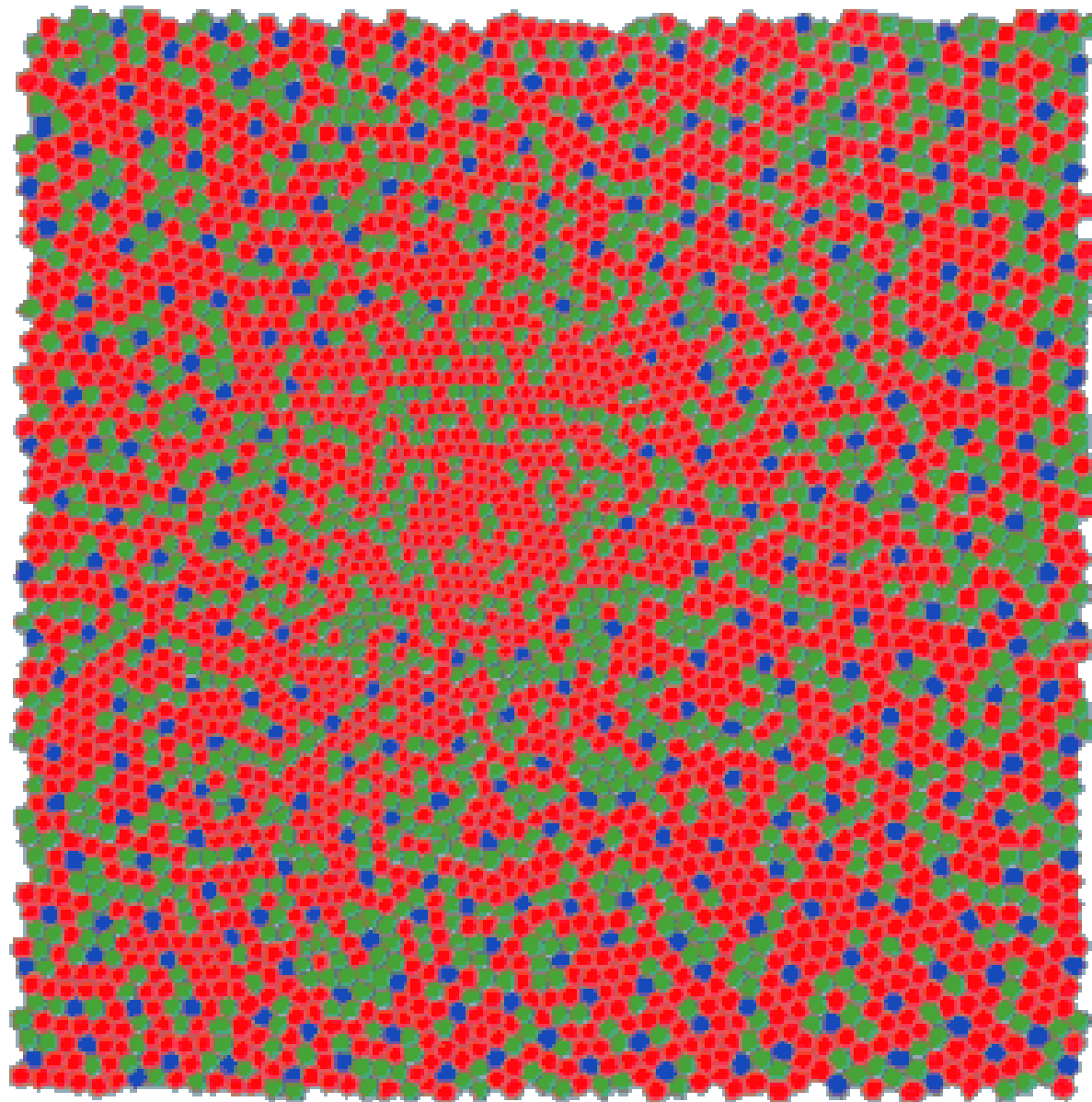




Sekuler and Blake, 1985, plate 6



Cone mosaic





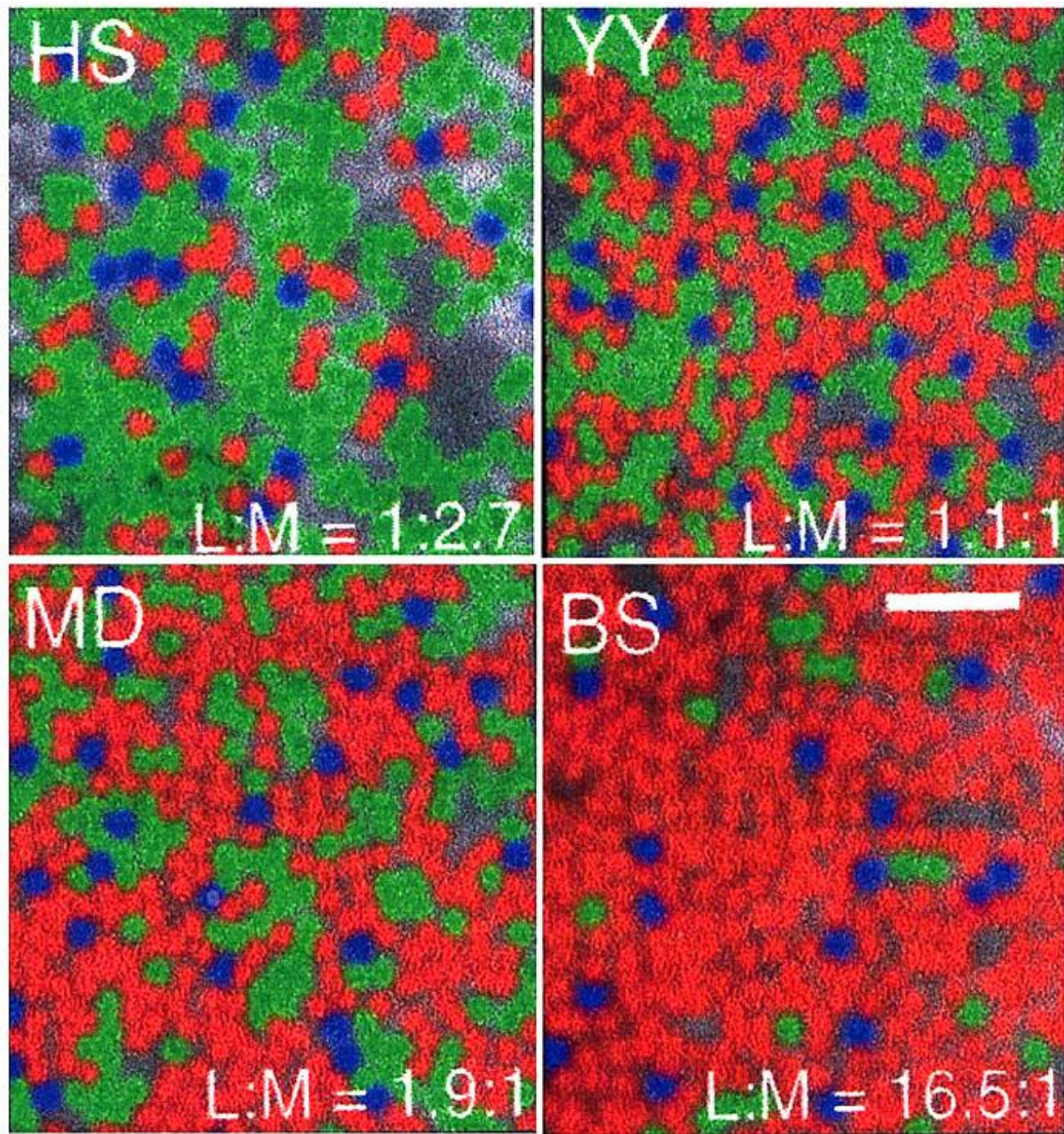
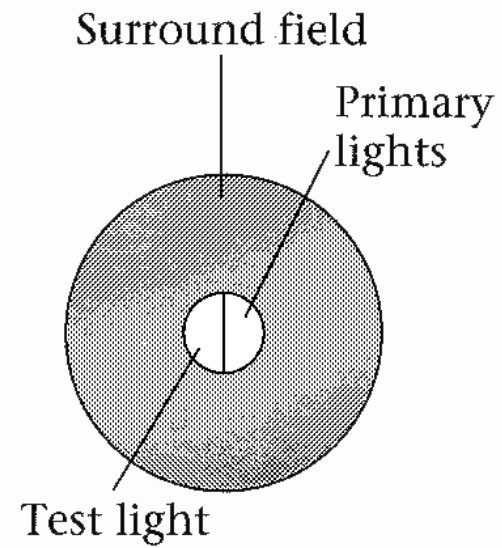
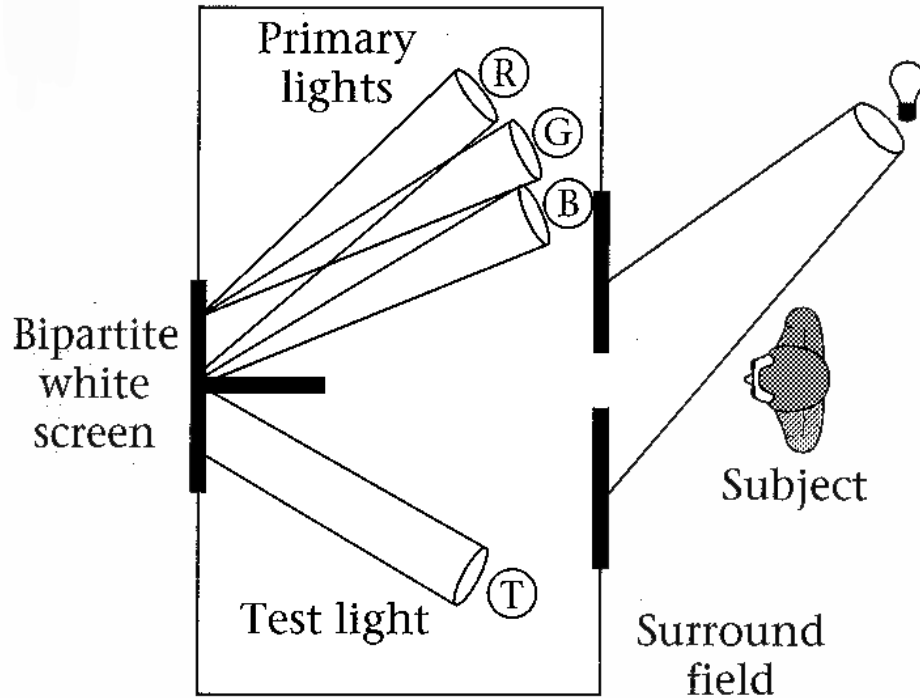


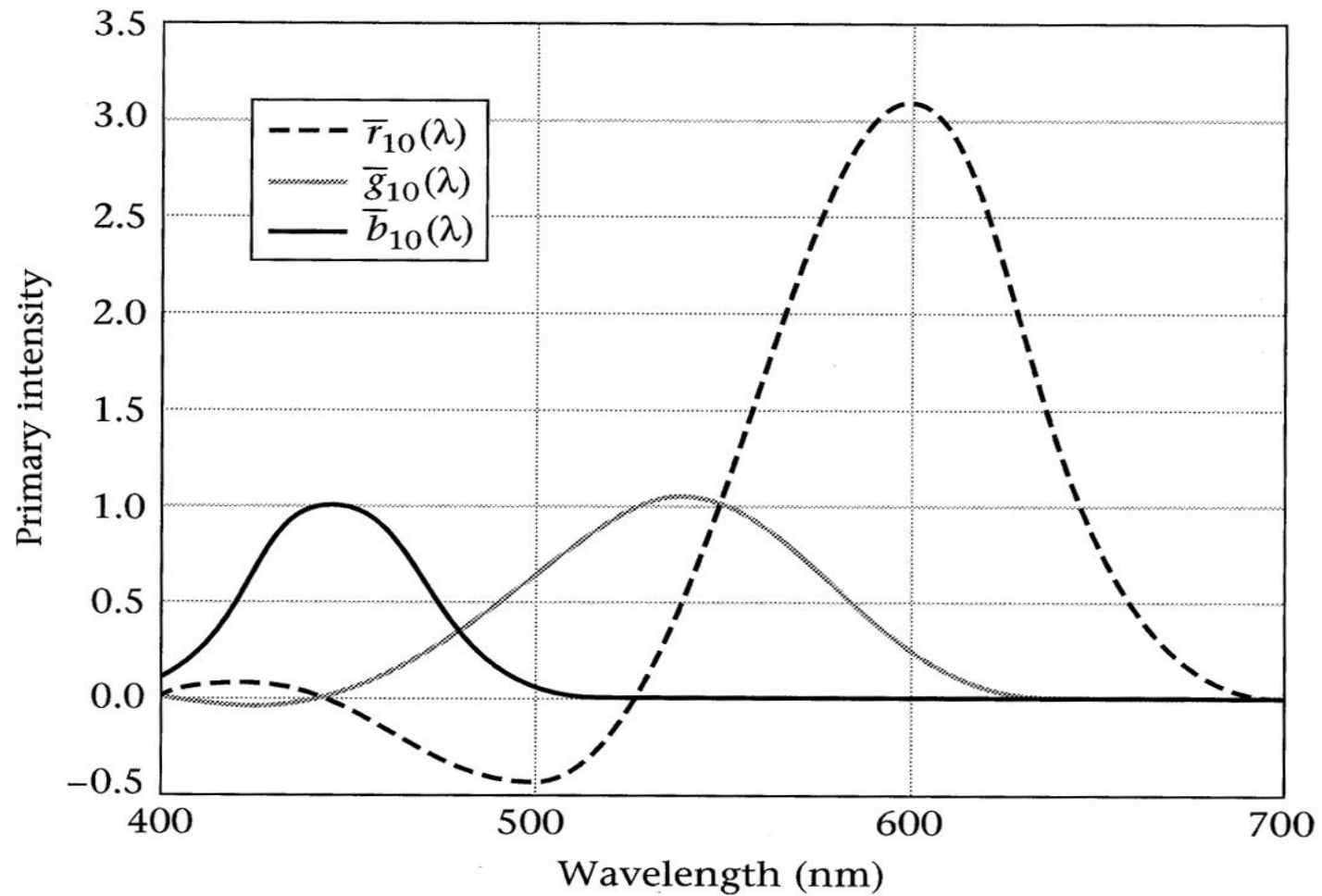
Fig. 21 shows an adaptive optics view of the mosaic of L (red), M (green) and S (blue) cones in four human subjects with normal color vision. The ratio of S to L and M cones is constant but that of L to M cones varies from 1:2.7 (M:L) to 16.5:1 (L:M). (adapted from Williams).



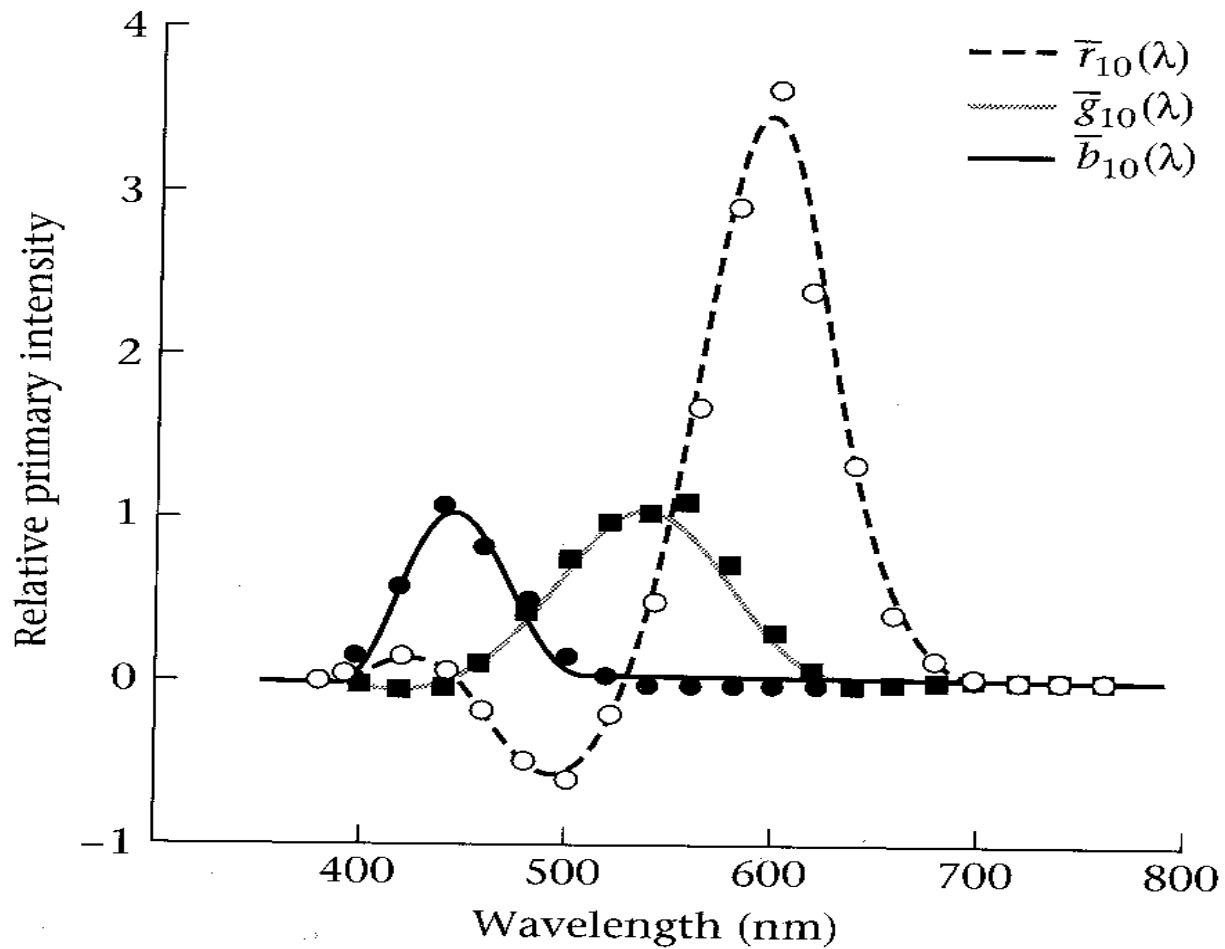
# Color matching experiments



# Color matching: results

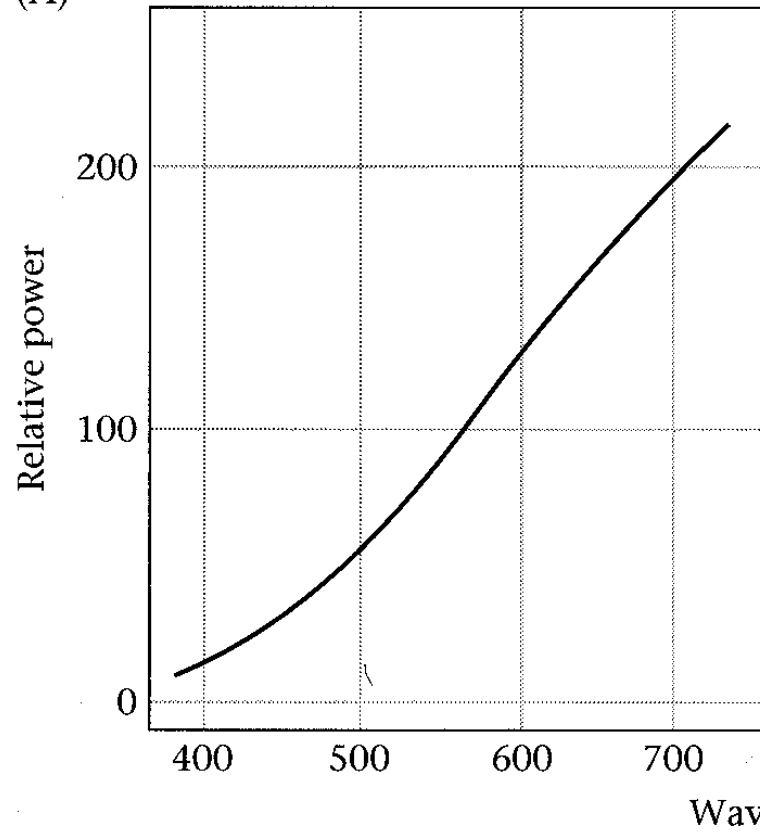


## Color matching: predictions vs. data

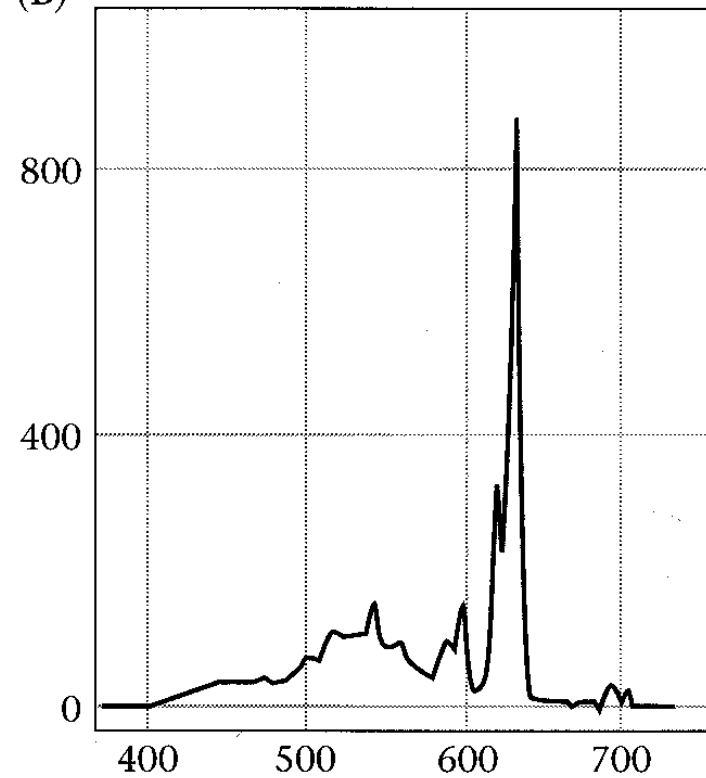


## Two metameric spectral distributions

(A)

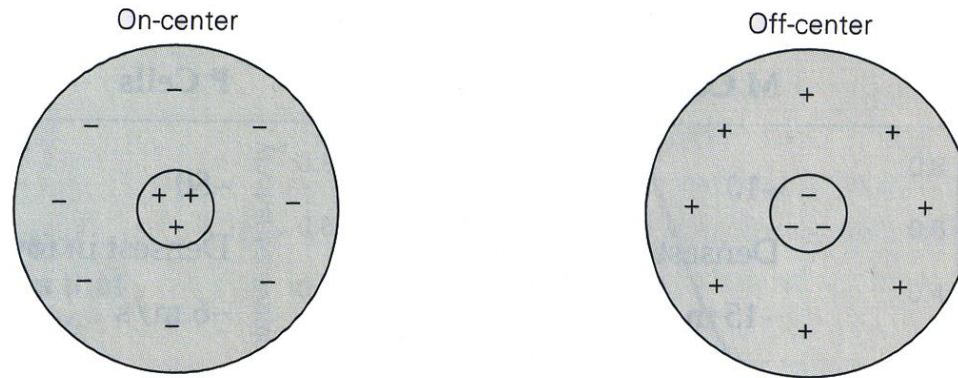


(B)

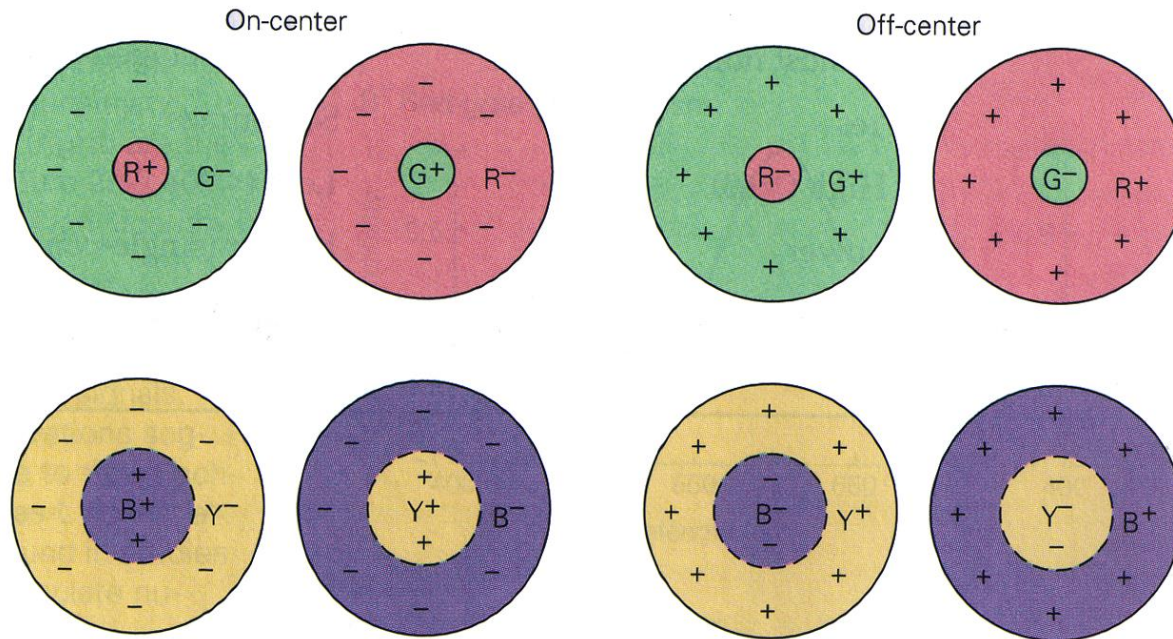


# Receptive fields of LGN neurones

## A M cells

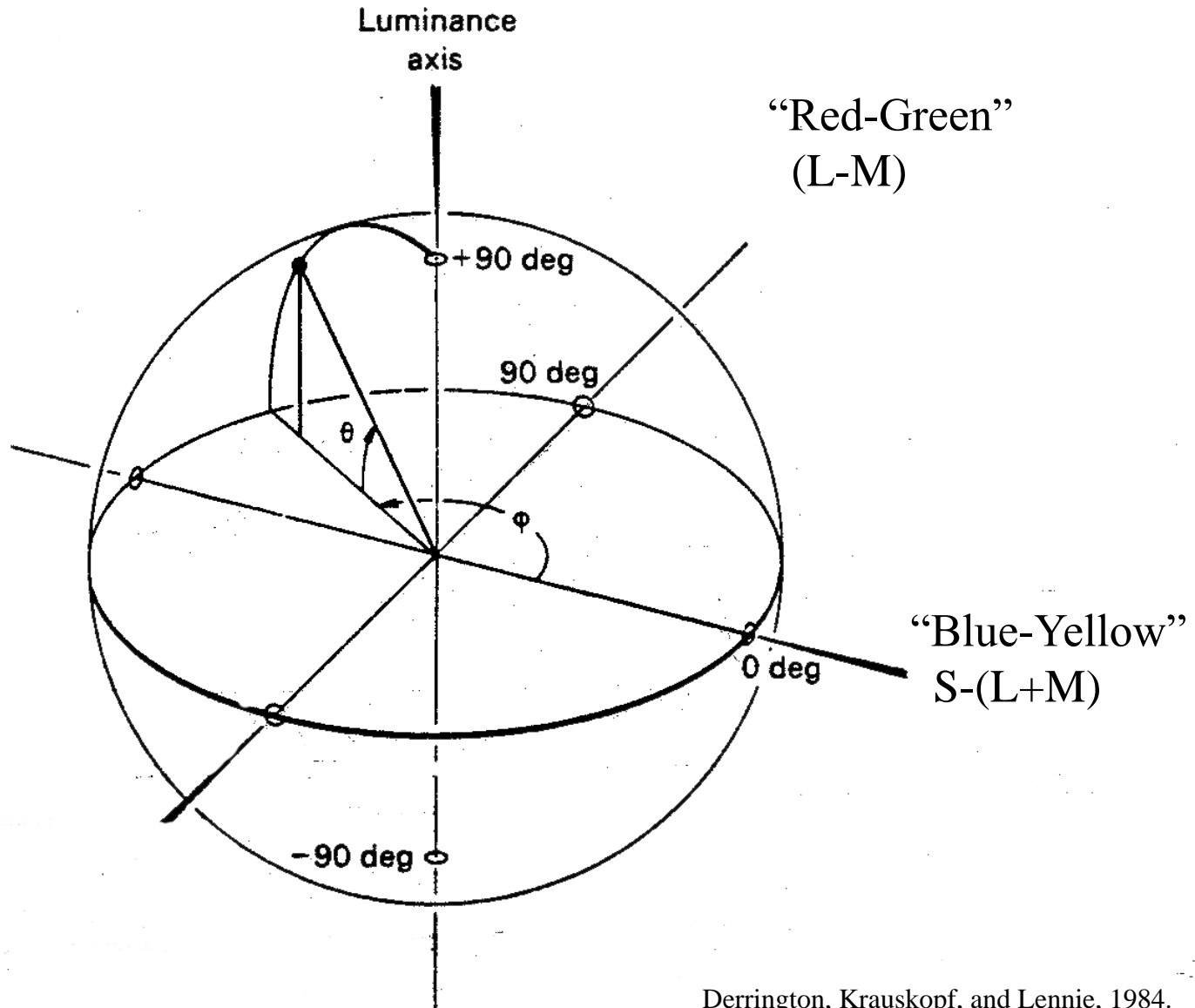


## B P cells



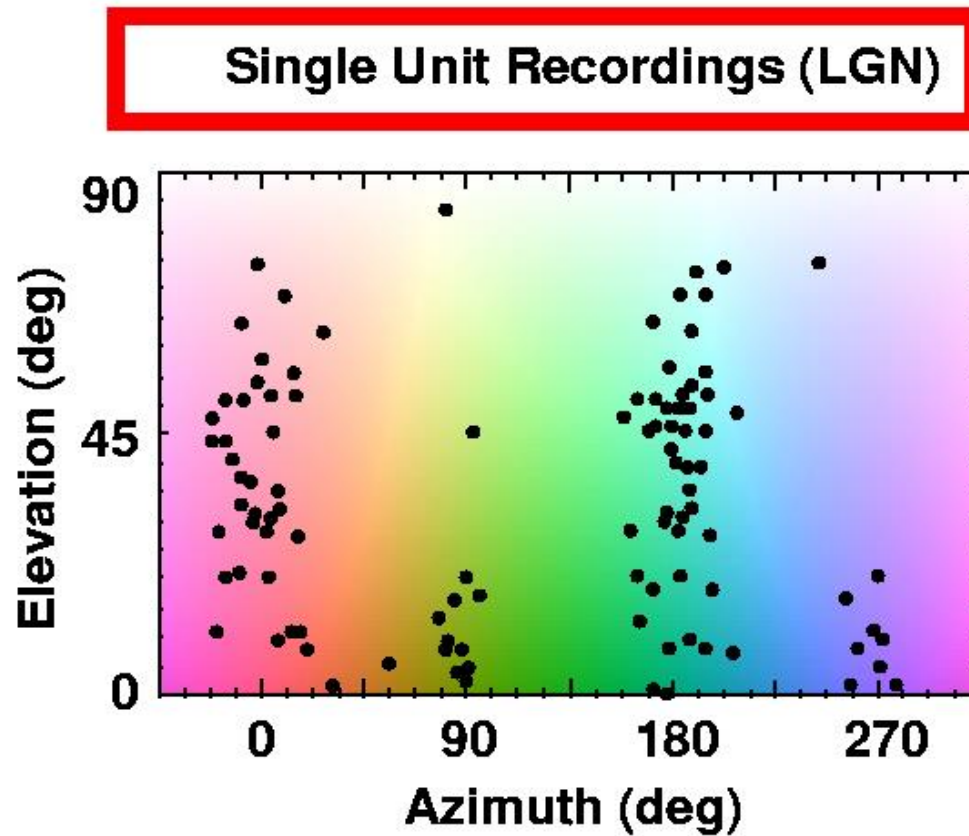


# The “DKL” color space



Derrington, Krauskopf, and Lennie, 1984.

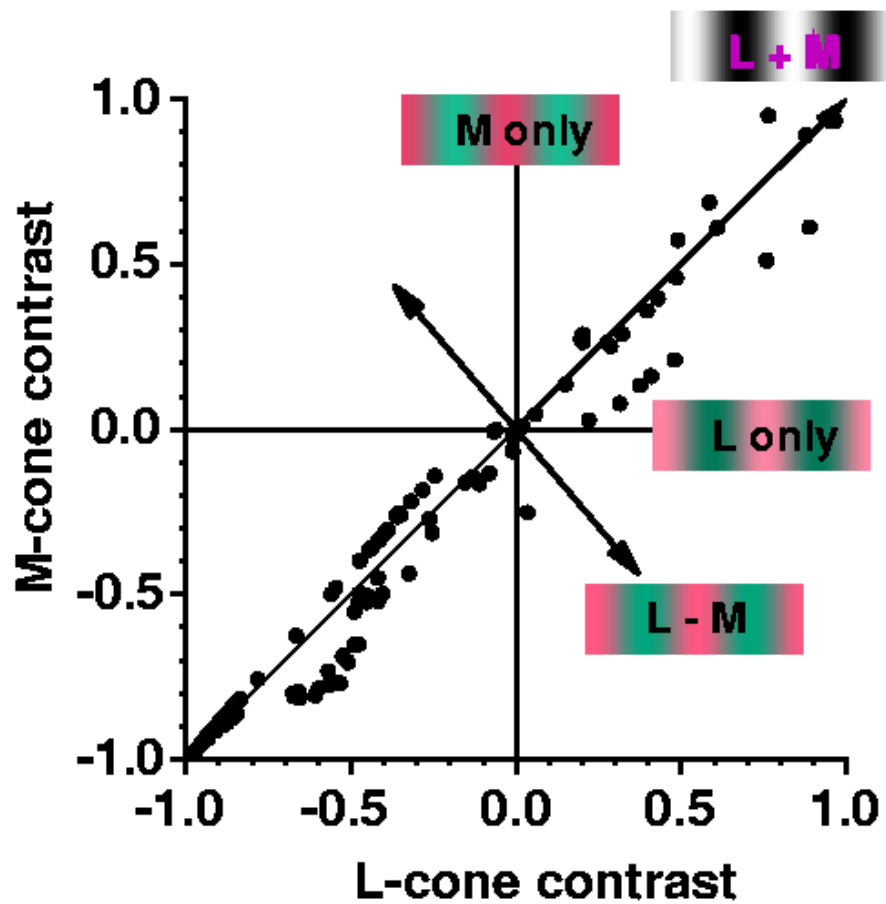
## Preferred color of pLGN neurones



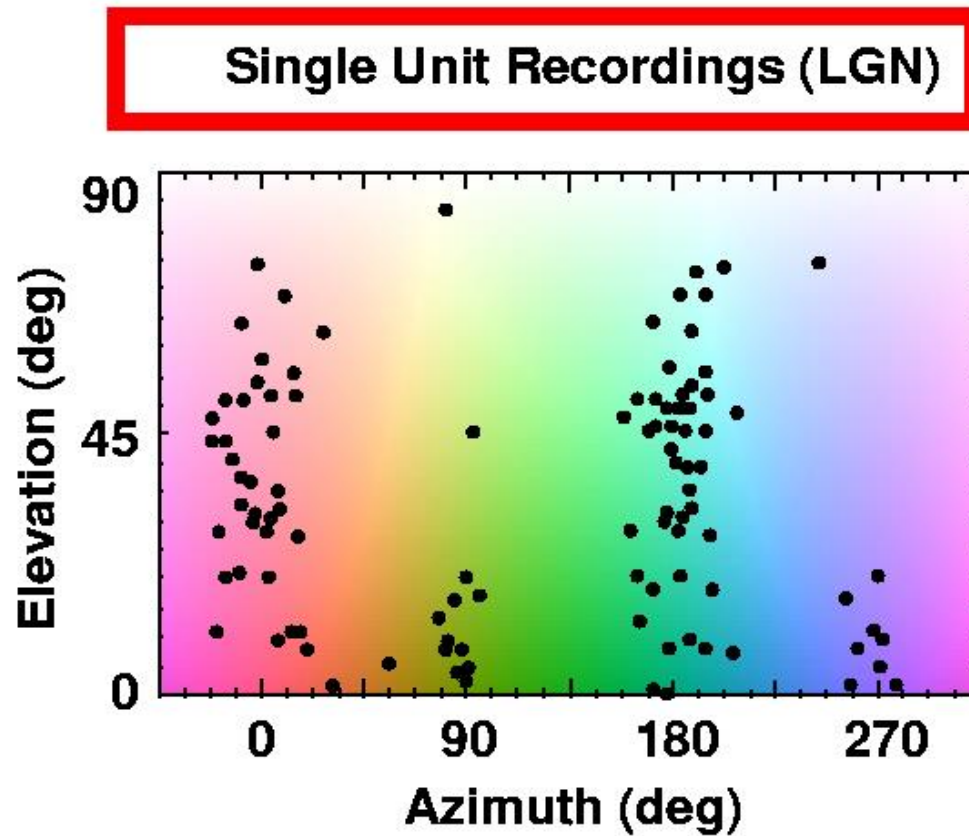
# The world seen through the LGN



## Color contrasts of natural objects



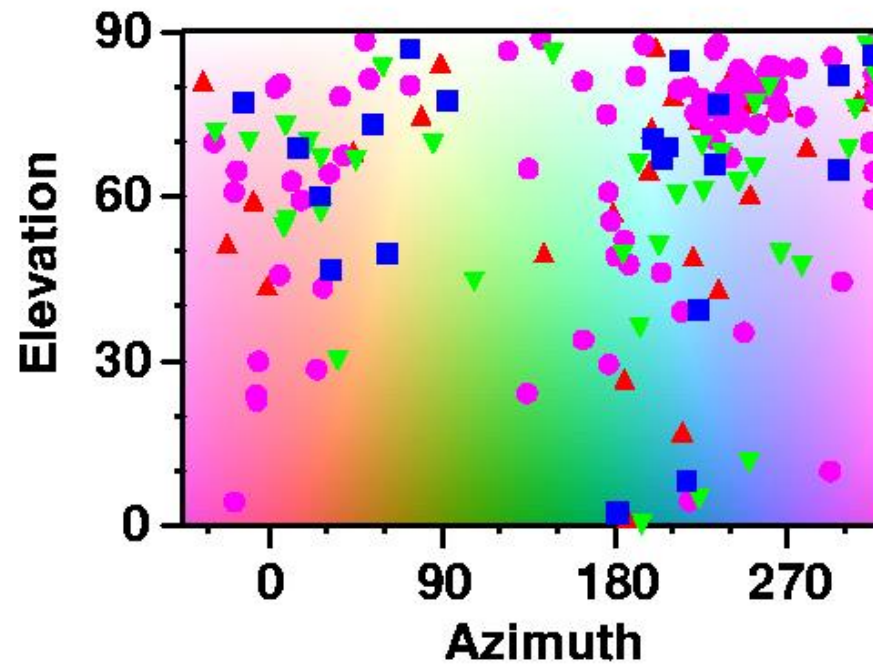
## Preferred color of pLGN neurones



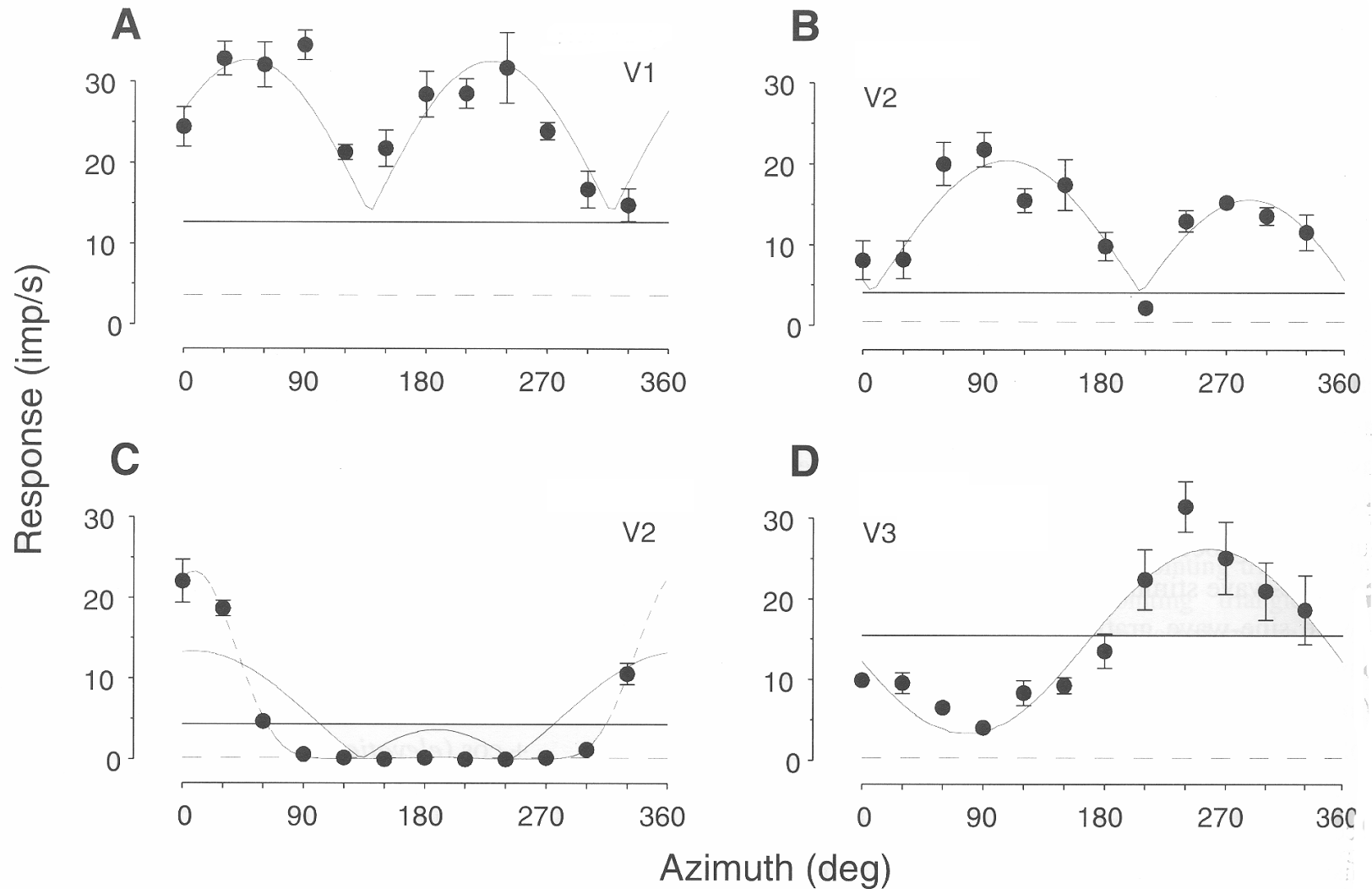


## Preferred color of cortical cells

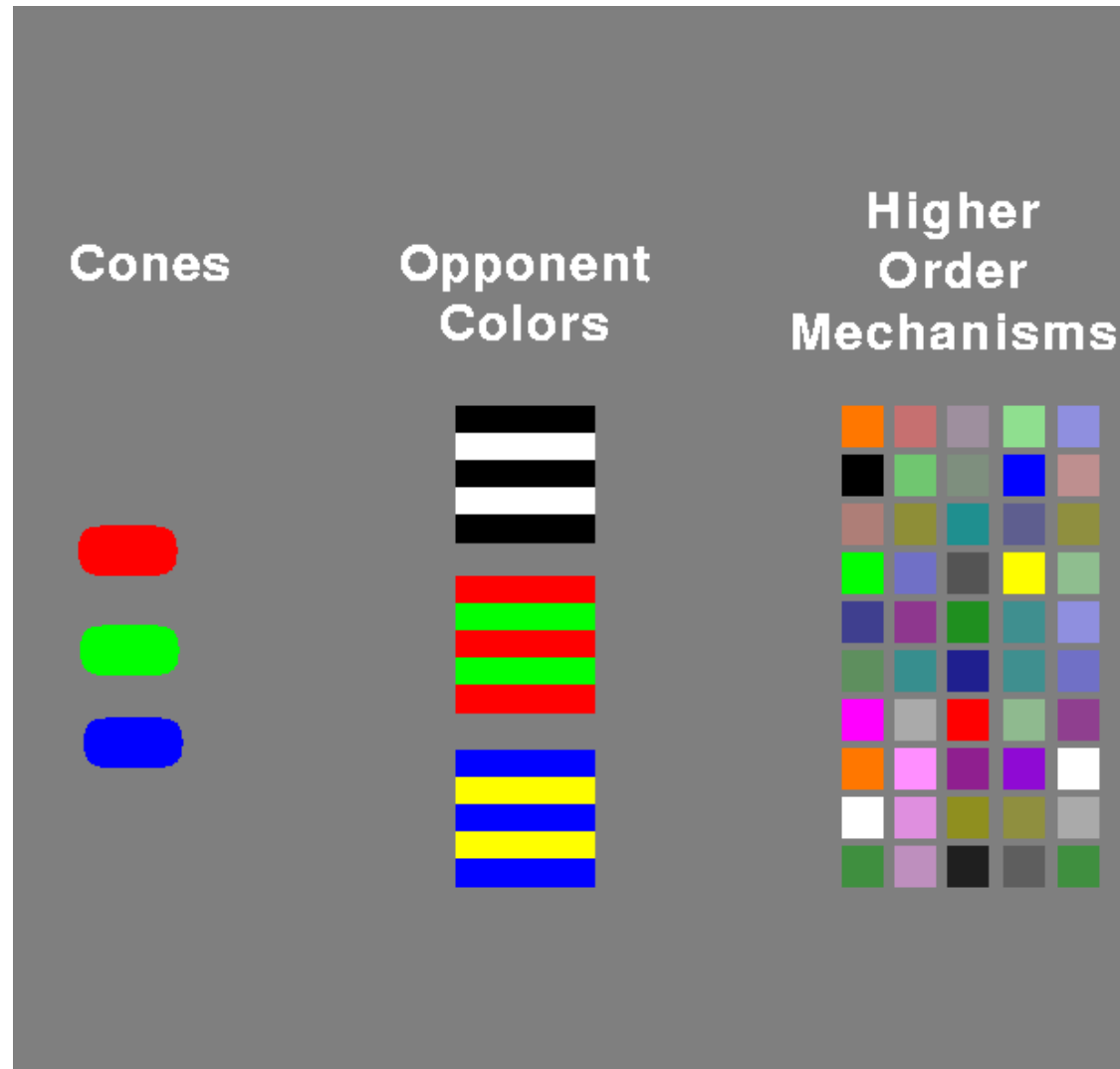
### Single Unit Recordings (V2,V3)



# Examples of cortical cells' responses to color variations



# Three stages of color processing



retina, LGN, V1: care about wavelength  
 V4: care about perceived colour independent of actual wavelength - happens in extrastriate cortex. not in V1 or earlier.

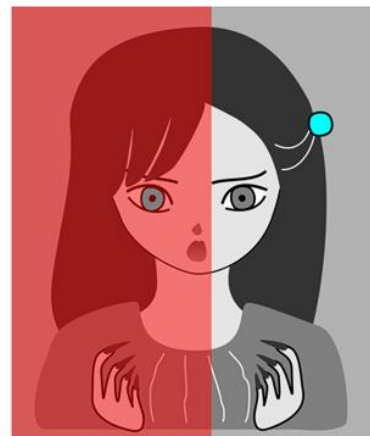
# Later stages: Color constancy

illusions: upper: all women have grey eyes.  
 but our brain corrects, so we see different ones

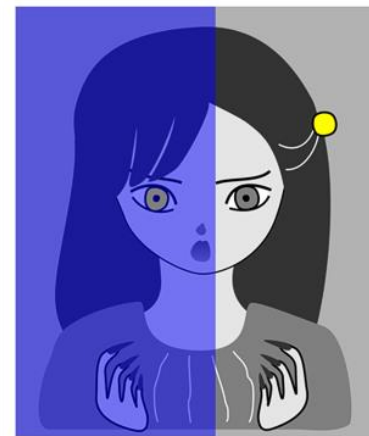
lower left: looks like two spirals, orange and violet or so  
 but the red is actually exactly the same.  
 it's the brain that is tricked.

visual system: wants to compute colour constancy:

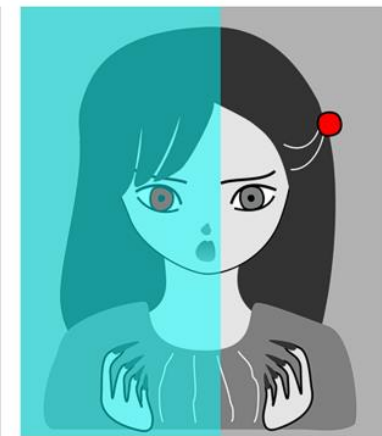
wavelength composition can vary dramatically because of illumination etc. our brain tries to extract colour independent of illumination  
 green tea. different illuminations because of sunlight, artificial light etc. but we always see same green basically, due to our brain doing colour constancy



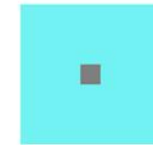
Filter color = red  
 Eye color = cyan  
 Synthesized color = gray



Filter color = blue  
 Eye color = yellow  
 Synthesized color = gray



Filter color = cyan  
 Eye color = red  
 Synthesized color = gray



lower right: some people see one of the two when described: very weird illumination settings: our brain makes unknown assumptions in order to produce these two pictures - our cortex determines illumination and we see these two different pics.