

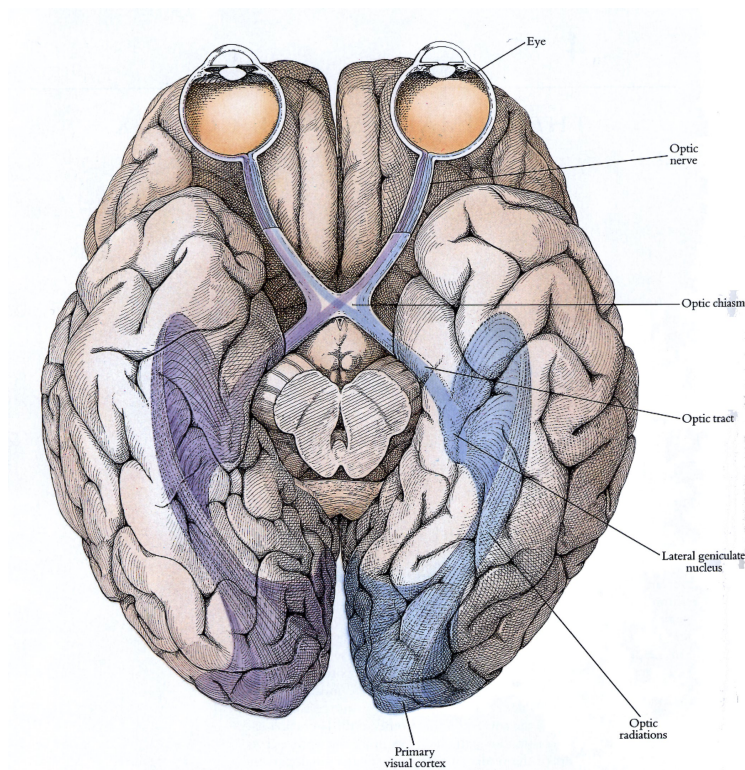
Model networks

Retina and LGN

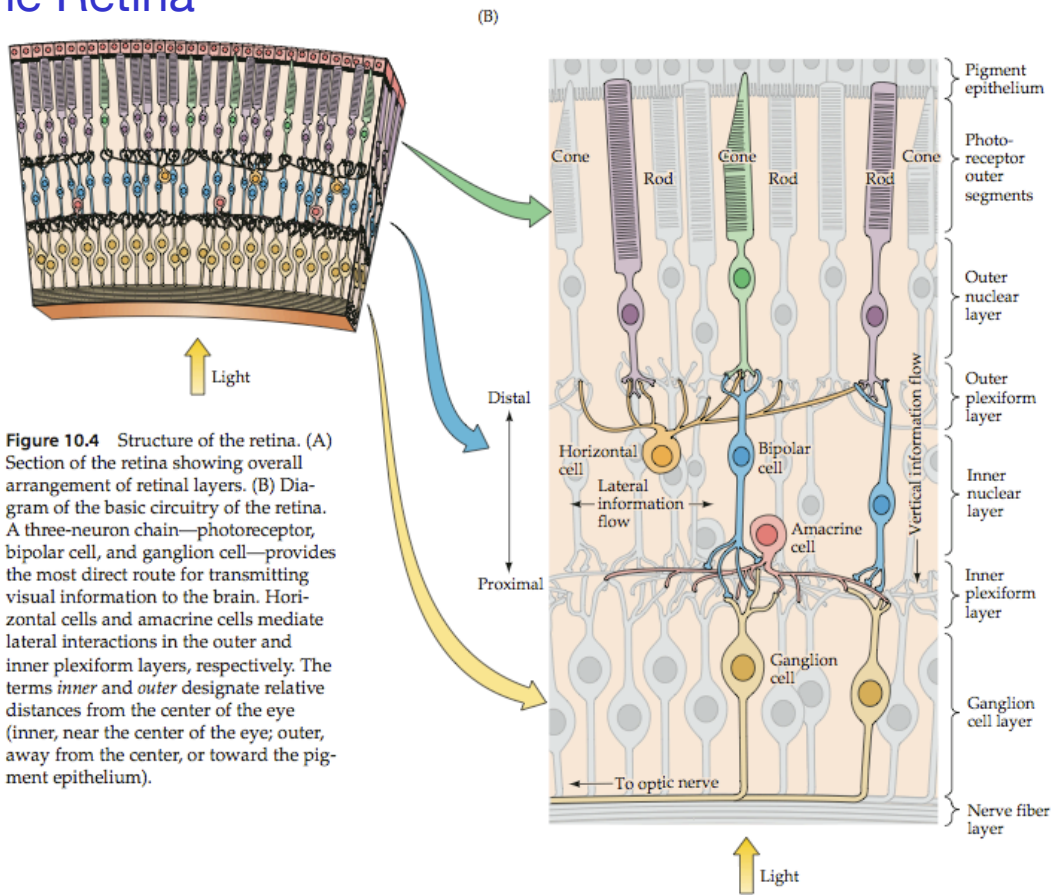
Suggested reading:

- Chapter 2.3 in Dayan, P. & Abbott, L., *Theoretical Neuroscience*, MIT Press, 2001.

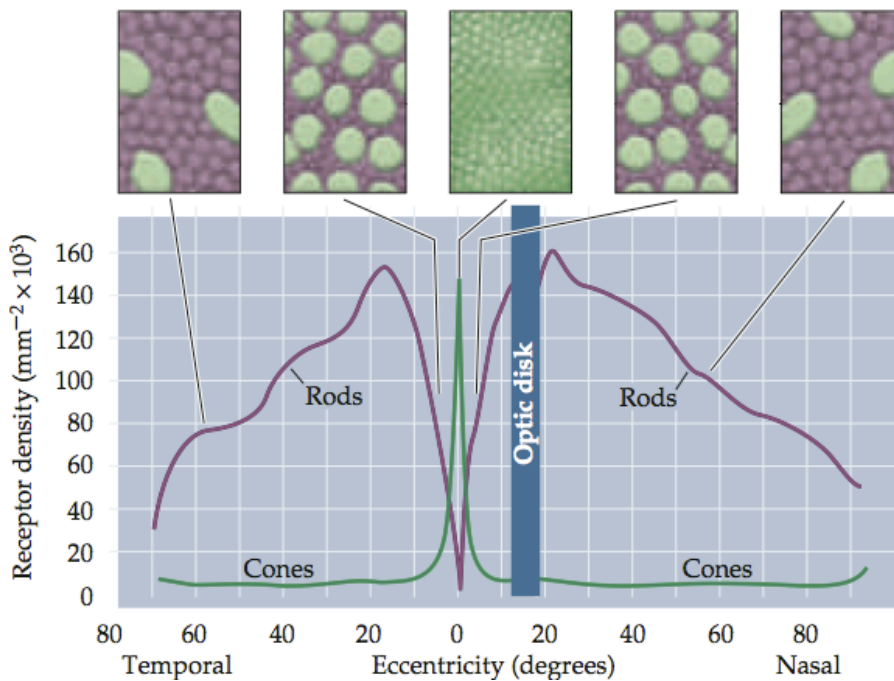
From the eye to primary visual cortex



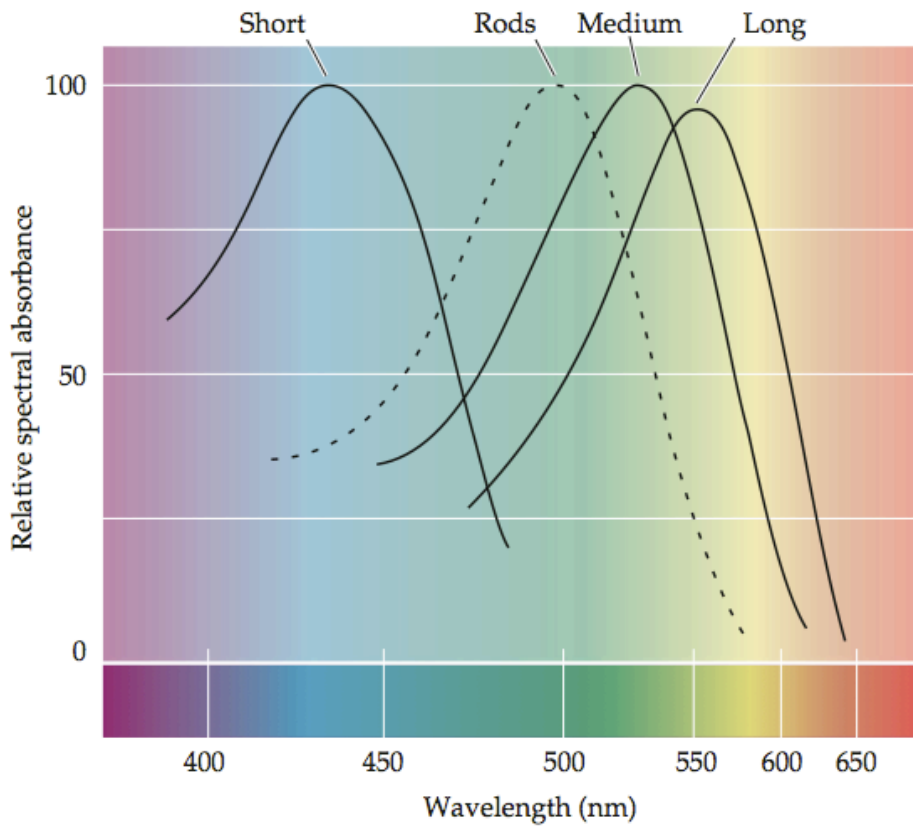
The Retina



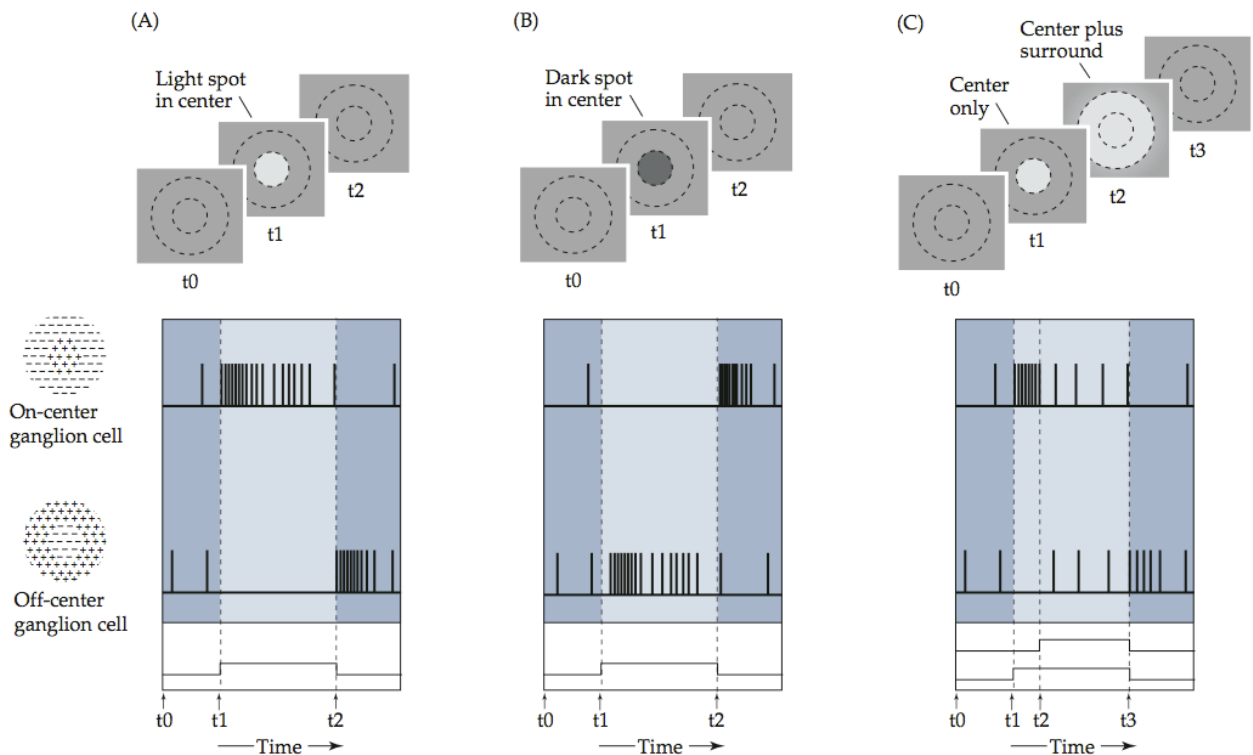
The Retina - Distribution of rod and cones



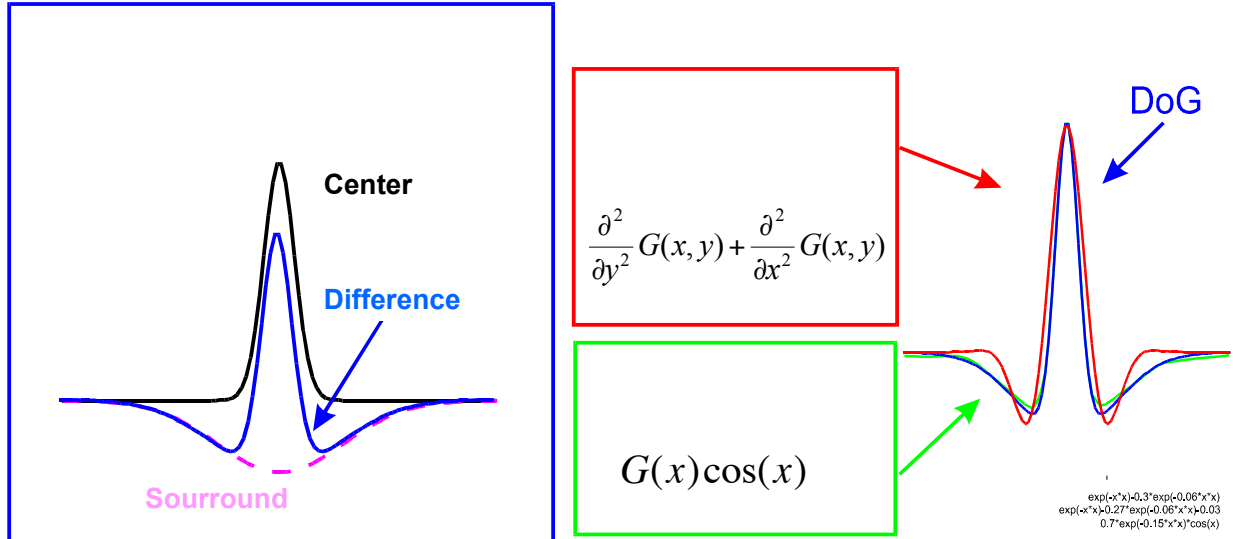
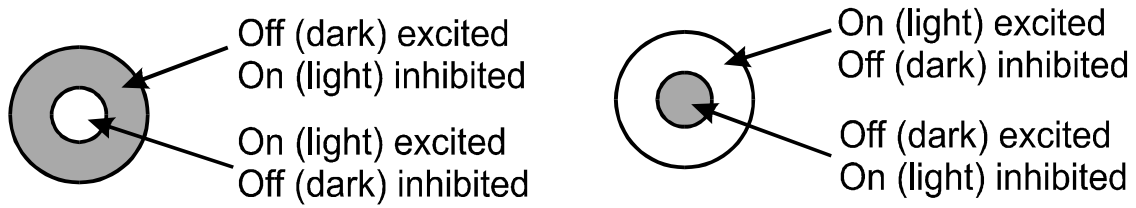
The Retina - Wavelength selectivity of rods and cones



The Retina - On/Off responses



The Retina and the LGN - Models of On/Off responses



The Retina and the LGN - Models of On/Off responses

Difference of Gaussians (DoG):

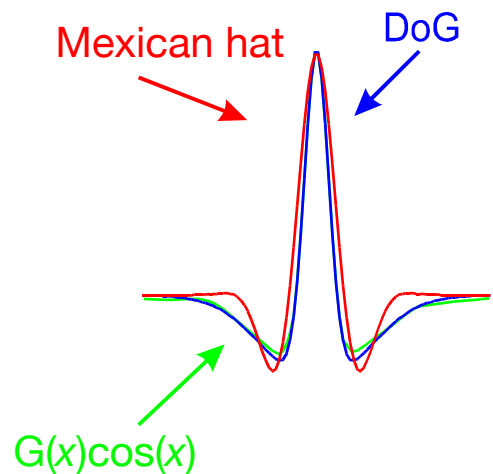
$$y(x) = e^{-x^2} - 0.3e^{-0.06x^2}$$

Second derivative of a Gauss (Mexican hat):

$$y(x) = e^{-x^2} - 0.27e^{-0.06x^2} - 0.03$$

Gauss and cosine ($G(x)\cos(x)$):

$$y(x) = 0.7 \cos(x) e^{-0.15x^2}$$



The Retina and the LGN - Models of On/Off responses

Difference of Gaussians:

$$D_s(x,y) = \pm \left(\frac{1}{2\pi\sigma_{cen}^2} e^{-\frac{x^2+y^2}{2\sigma_{cen}^2}} - \frac{B}{2\pi\sigma_{sur}^2} e^{-\frac{x^2+y^2}{2\sigma_{sur}^2}} \right)$$

Laplacian of the Gaussian:

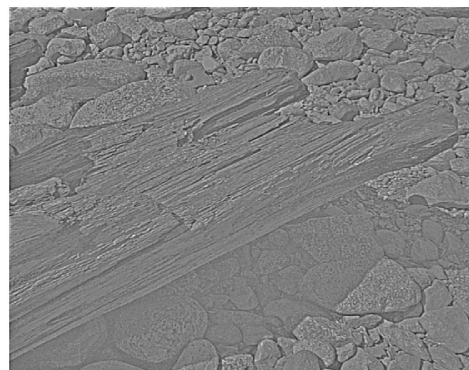
$$\nabla^2 G(x,y) = \pm \frac{-1}{2\pi\sigma^4} \left(2 - \frac{x^2 + y^2}{\sigma^2} \right) e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Output of the LGN

Original Image



On/Off filtered Image



The filtering can also be performed in the frequency domain. Here, an image has been transformed into the frequency domain, multiplied by a zero-phase whitening/lowpassfilter $R(f) = f \exp((-f/f_0)^4)$ with $f_0 = 200$ cycles/picture (Olshausen & Field, 1996). This filter attenuates low frequencies and boosts high frequencies to obtain a roughly flat amplitude spectrum across spatial frequencies. In image-space, this filter has a circularly symmetric, center-surround (mexican hat) shape.

Modeling the Retina and the LGN

The simplest models of processing in the Retina and the LGN focus on the On/Off receptive field structure which

- emphasize local differences
- implement of form of whitening (equal variance of the variables)
- can be implemented in image or frequency space