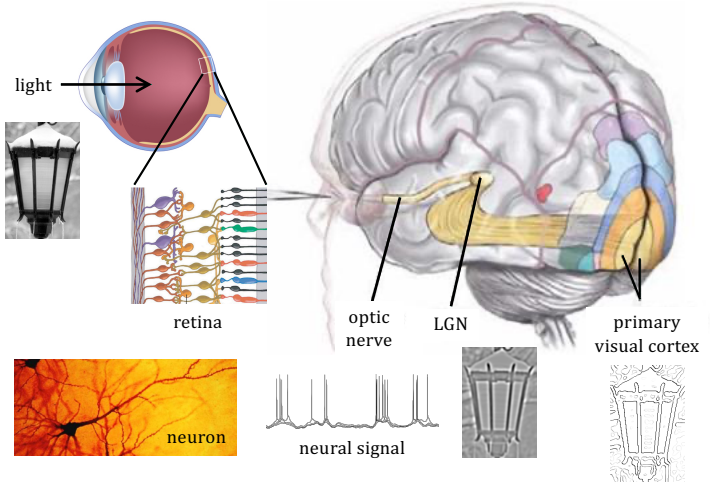
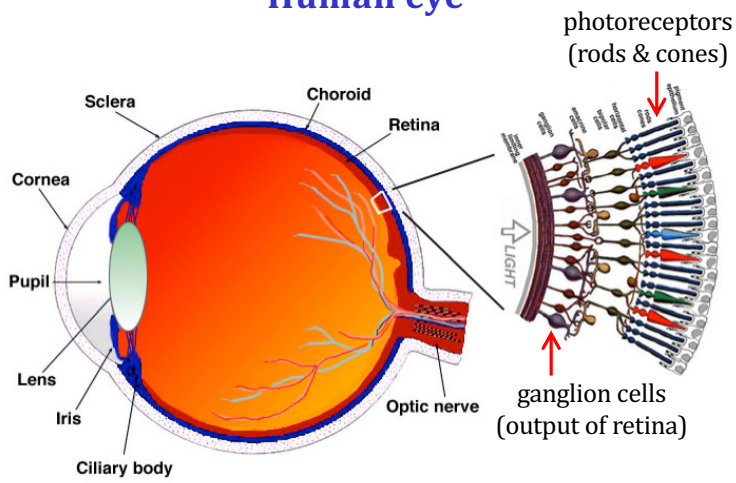
Early processing in human vision



1

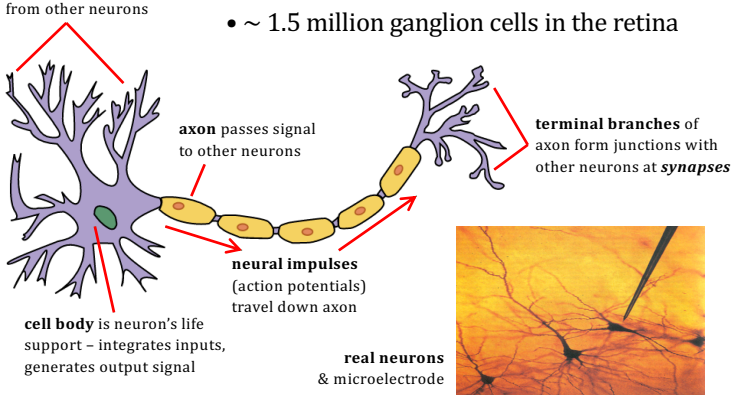
Human eye



2

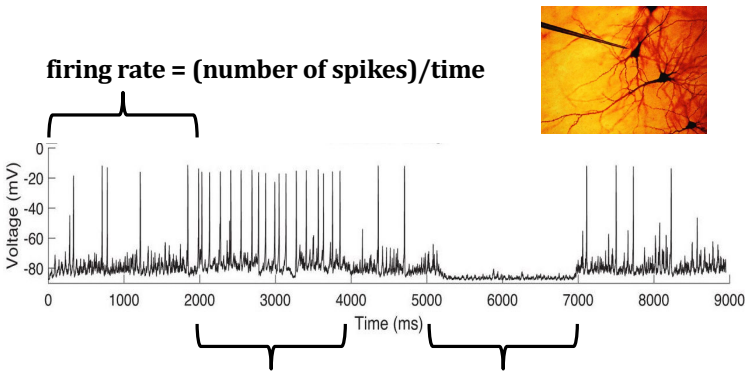
Structure of a neuron

- ~ 10^{11} neurons in the brain
- ~ 1.5 million ganglion cells in the retina



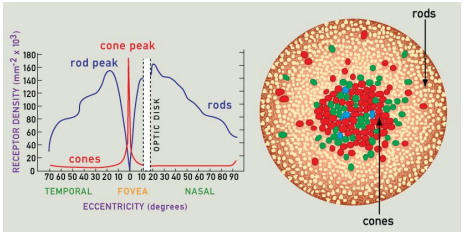
3

Neural signals



4

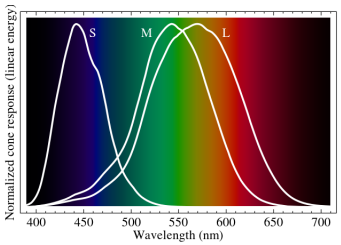
Rods and cones in the retina



fovea:
- central 2° of visual angle
- ≈ 250 receptors across
- high spatial acuity

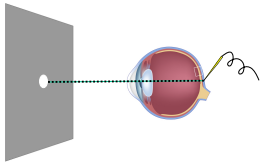
cones:
- sensitive to color
- operate in daylight
- adapt quickly to changing light

rods:
- not sensitive to color
- operate at low light levels
- adapt slowly to changing light

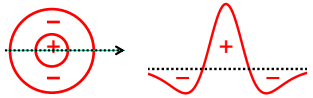


5

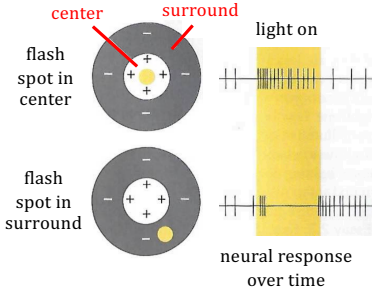
Retinal ganglion cells



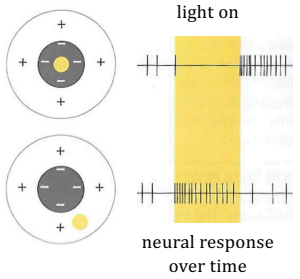
- **receptive fields** have *center-surround* structure
- cross-section ~ difference of two Gaussians



"on-center" ganglion cell

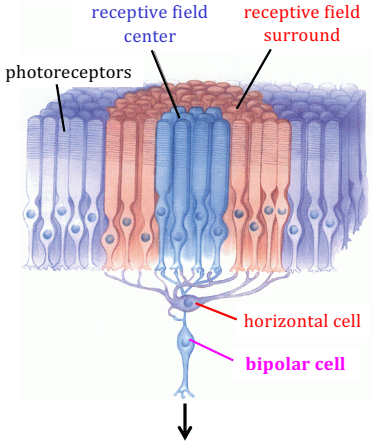


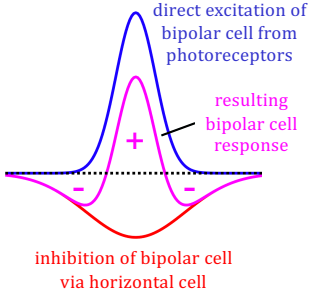
"off-center" ganglion cell



6

Emergence of center-surround receptive field





- retinal processing is *very similar to the convolution computation*
- difference-of-Gaussians is *very similar to the Laplacian-of-Gaussian*

7

Analyzing intensity changes in a 2D image

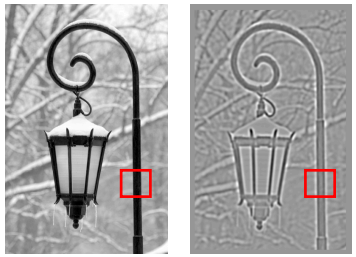
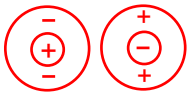
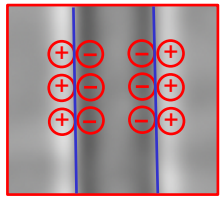


image after smoothing & second derivative

convolution with $\nabla^2 G$ operator





~ convolution of the retinal image is passed up the optic nerve

- on-center cells carry positive part
- off-center cells carry negative part

8

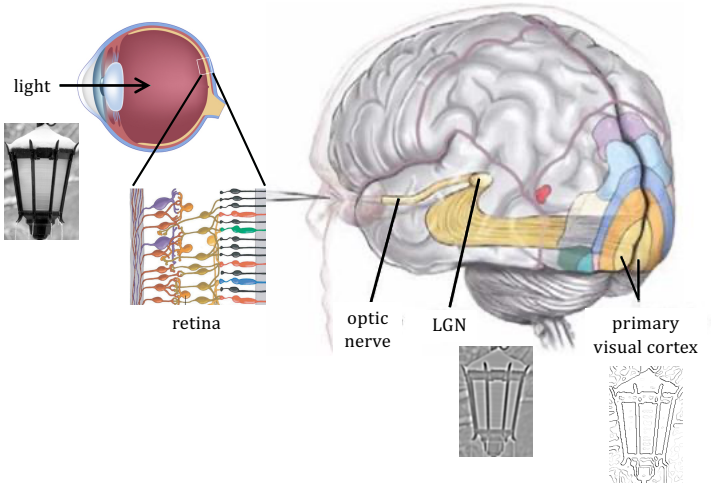
Detecting intensity changes at multiple scales

human vision:

- multiple receptive field sizes in the same region of the visual field
- receptive field sizes increase with eccentricity (distance from the center of the eye)

9

Early processing in human vision



10