The Visual System: Central Processing
Ganglion Cell Receptive Fields

rods

cones

Surround  Center  Surround

Surround  Center  Surround

Depolarized  Hyperpolarized  Depolarized

Increased transmitter release  Decreased transmitter release  Increased transmitter release

On  Off

Cone cells

Bipolar cells

Horizontal cells

Ganglion cells

Increased firing rate  Decreased firing rate  Increased firing rate

On  Off

Increased firing rate  Decreased firing rate  Increased firing rate
The most effective way to alter the firing rate of an on-center (or off-center) ganglion cell is to completely illuminate either the "on area" or the "off area" of its receptive field.

If both areas of a cell's receptive field are illuminated together, there is little reaction from the cell.
The retinal-geniculate-striate pathway includes about 90% of axons of retinal ganglion cells.

Signals from the left visual field of both eyes (blue) reach the right primary visual cortex, and the opposite is true for signals from the right visual field of both eyes (red).
Retinotopic Organization

from Purves et al.
Maintain segregation of inputs from the two eyes

Two channels:
- P: small cells, top 4 layers color, detail, still, cones
- M: large cells, bottom 2 layers no color, motion, rods
LGN cells project to layer IV of cortex

P and M cells project to different subdivisions of layer IV

Cortical neurons continue to be monocular in layer IV of primary visual cortex.
The central (i.e., foveal) region of the visual field is hugely over-represented in the primary visual cortex.
Distinct visual field deficits (black; right) result from damage at different points along the primary visual pathway (black bars; left).
Receptive Fields of Layer IV Neurons

Cells in lower (input) layer IV tend to have receptive fields with a center-surround organization.

Most neurons in upper layer IV are “simple” cells:
- Rectangular receptive field
- “on” and “off” regions, like cells in lower layer IV
- Orientation and location sensitive
- All are monocular.
Simple Cells Detect Bars and Borders

Simple cells can be constructed “simply” from convergence of center surround inputs.
Beyond layer IV, the signals from the two eyes are combined at the cellular level; that is, they are binocular.

However, the input from one eye is usually dominant.

Ocular Dominance Columns

from Purves et al.
Hypercolumns in Visual Cortex

Hypercolumns consist of pairs of ocular dominance columns, blobs and many orientation columns.

Higher-order neurons that prefer the same orientation as layer IV neurons may also be sensitive to the line over larger areas of visual space (complex cells), to the line’s length (hypercomplex), and/or to binocular disparity (depth).
Color Constancy and Blobs

Color constancy: color perception is not altered by varying reflected wavelengths.

Retinex theory (Land): color is determined by comparing the light reflected from adjacent surfaces (contrast).

Dual-opponent color cells are sensitive to color contrast. Found in cortical “blobs”, receive P inputs.

The dress “controversy” Color depends on which part of the daytime chromatic axis is discounted.
Higher-Order Visual Areas

Receptive fields:
- larger
- respond to more complex and specific stimuli

Dorsal vs Ventral streams:
- M vs P pathways
- “where” vs “what”
- “behavior” vs “perception”