Retinal Processing of Visual Information

- Convergent vs. divergent pathways
- Receptive field properties of retinal neurons
- Antagonistic center-surround features of bipolar (BP) cells and retinal ganglion cell (RGC) receptive fields
- “On-center/off-surround” and “off-center/on-surround” cells provide enhanced:
  - Contrast detection
  - Temporal resolution
- Roles of different interneuron types in determining RGC receptive field properties
Receptive Fields of Rod & Cone Bipolar Cells

Convergent connections
- low spatial resolution
- high sensitivity

Divergent connections
- high spatial resolution
- low sensitivity
- “multiplexing” or parallel pathways

=> Multiple outputs from the retina…
Receptive fields of retinal interneurons and ganglion cells are overlapping, as in a Seurat painting...

*La Tour Eiffel* - Georges Seurat, 1889

... created in “little dots.”
Overlapping Receptive Fields…

PR

bipolar cells
Receptive Fields of RGCs Are Not Homogeneous

“On-center/off-surround” cell
or
“on-center” cell or “on” cell

“Off-center/on-surround” cell
or
“off-center” cell or “off” cell

Concentric, antagonistic “center-surround” arrangement
Response Properties of On and Off Cells

Fig. 26-7, Kandel et al., 4th edition
Center-Surround Receptive Fields Enhance Contrast Detection

“looks” brighter here

“looks” darker here

the difference
Center-Surround Receptive Fields

• Enhance contrast at dark-light borders
• On- and off-center retinal ganglion cells provide better temporal resolution than either one alone
  – Can respond to both rapid increases and decreases in light intensities
    • On cells: increase rate of firing at stimulus onset
    • Off cells: increase rate of firing at stimulus offset
On- and Off-Bipolar Cells Drive On- and Off-Ganglion Cells

- **On-center bipolar cells** sign-inverting (-) synapse with photoreceptor cell
- **Off-center bipolar cells** sign-conserving (+) synapse with photoreceptor cell
- Bipolar cell-ganglion cell synapse: sign conserving

*Fig. 10.15, Purves et al., Neuroscience, 3rd edition*
Different Types of Interneurons Are Used to Connect Retinal Ganglion Cells with Photoreceptor Cells from the Center and Surround

- **Center**: direct/vertical pathway from photoreceptor cell to bipolar cell
- **Surround**: lateral inhibitory pathway via horizontal cells to photoreceptor cell in center

Fig. 26-6, Principles of Neuroscience, Kandel et al., 4th edition
Circuitry underlying Antagonistic Surround

- Center cone is inhibited by surround cone via GABAergic input from horizontal cell (HC)
  - Stimulation of surround cone -> cell hyperpolarizes, releases less glu on HC
  - HC hyperpolarizes, releases less GABA on center cone
  - Center cone depolarizes (antagonizes light response)
- Same mechanism for on- and off-center cells (antagonistic effect is on the photoreceptor cell!)

Fig. 10.19, Purves et al., Neuroscience, 3rd edition
Two General Classes of Retinal Ganglion Cells

**Magnocellular (M) cells**
- large dendritic arbors, large receptive fields
- achromatic
- information about gross features and movement
- innervate layers 1 & 2 of LGN

**Parvocellular (P) cells**
- small dendritic arbors, small receptive fields
- wavelength selective
- information about color and fine spatial detail
- innervate layers 3-6 of LGN

⇒ *Parallel pathways used to process information about form, motion, color, etc.*