Section 4
Vision 2

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COGS 17 A04

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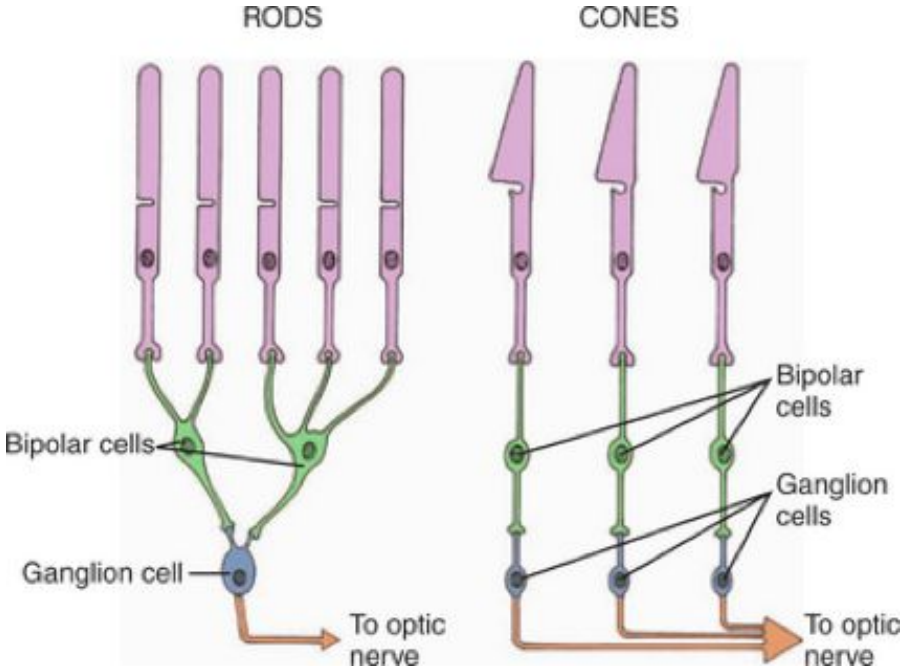
Recap



Visual Pathway

Inter-Neurons

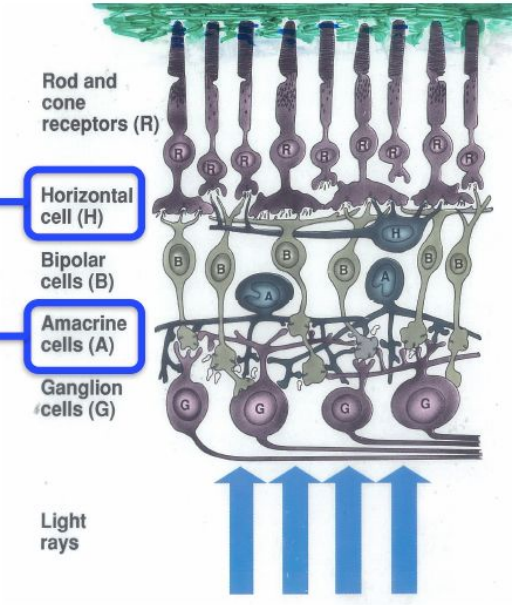
Spontaneous, Graded, & Inhibitory

Spontaneous, Graded, & Inhibitory → Horizontal cell (H)

Spontaneous, Graded, & Excitatory → Bipolar cells (B)

Graded & Inhibitory → Amacrine cells (A)

Action Potentials & Excitatory → Ganglion cells (G)

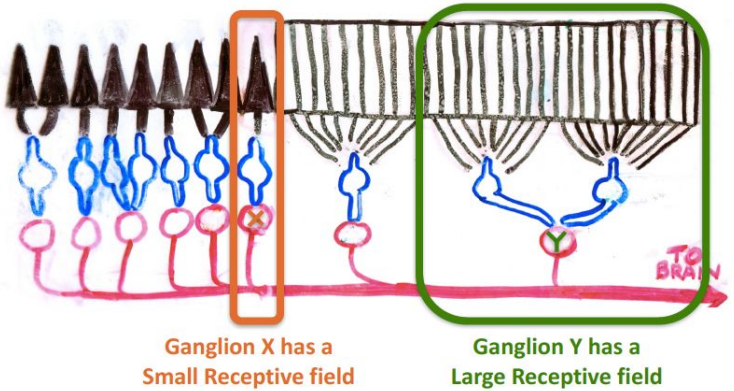


MNEMONIC
Once you get to the Ganglion
Firing is All-or-None

Recap

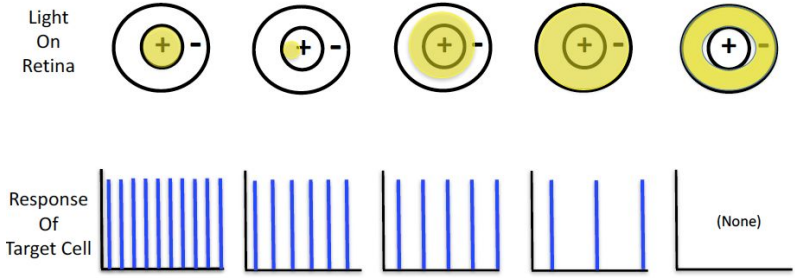
Receptive Field

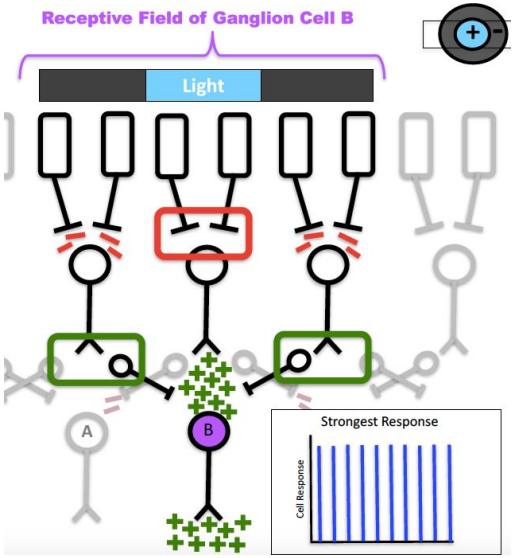
- A set of receptors whose activity influences the activity of a “target” downstream cell
- When a cell has a smaller receptive field → better acuity
- Can think of this as pixel resolution
  - If you have less convergence (smaller receptive field), more neurons (pixels) are dedicated to a particular detail (higher DPI)
  - If you have more convergence (larger receptive field), less neurons (pixels) are dedicated to a particular detail (low DPI)

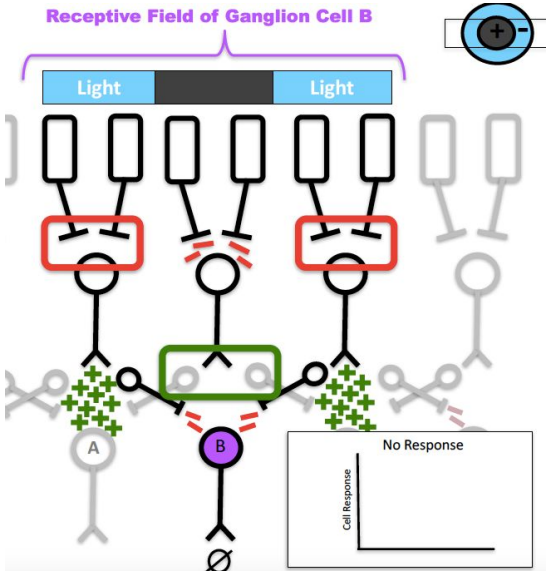


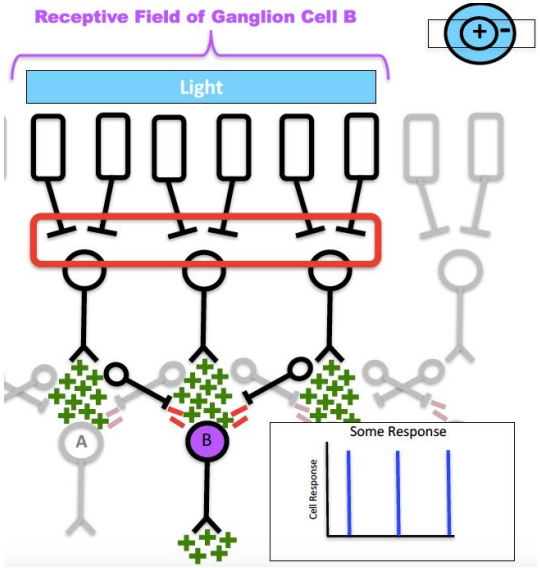
Center-Surround Receptive Fields (RF)

- Excitatory center and inhibitory surround RF
- RF of cells on the retina have Excitatory (+) or Inhibitory (-) activities
- RFs overlap, thus many receptors contribute to multiple RFs









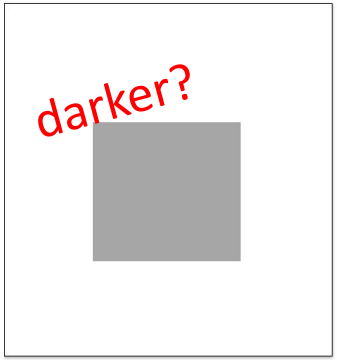
Simultaneous Contrast in the Retina

- Optical Illusion

- Due to Lateral Inhibition, the Ganglions “lie to the brain” about the medium gray, making the one located in the center of the white box look darker

1) More lateral inhibition from the bright surrounding
2) Less lateral inhibition from the dark

1)



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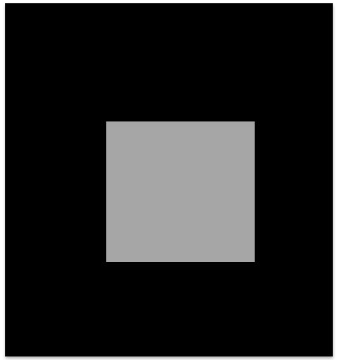
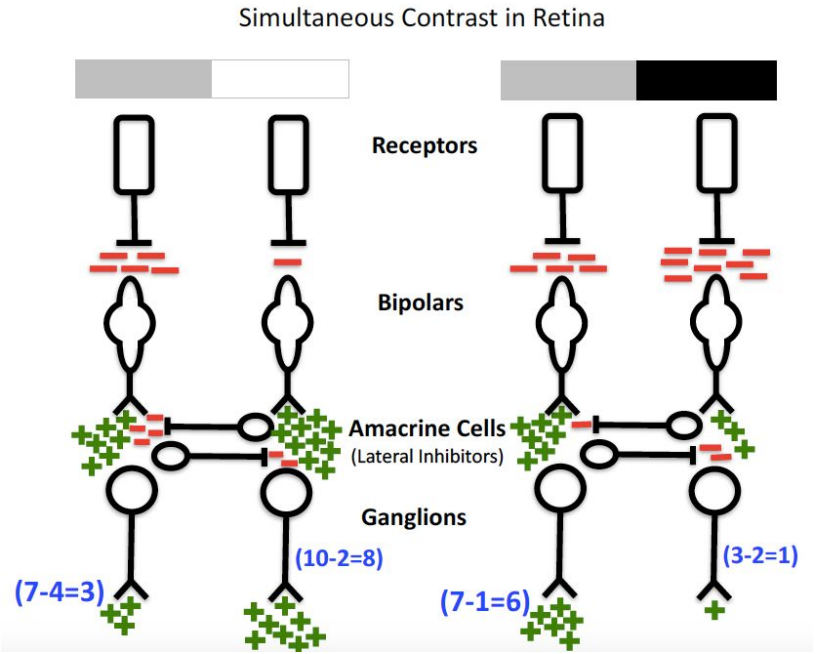
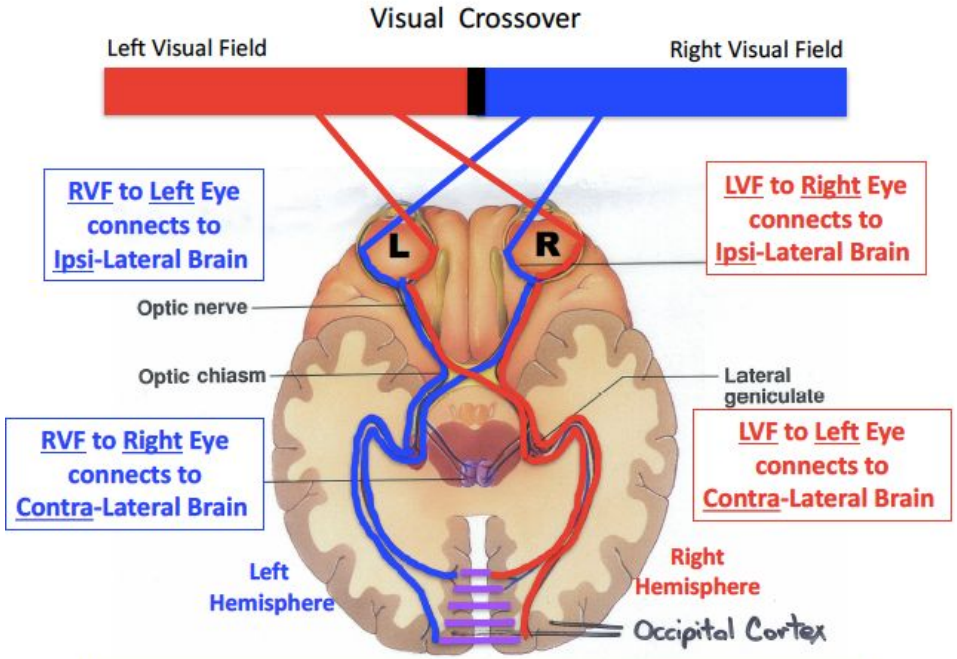




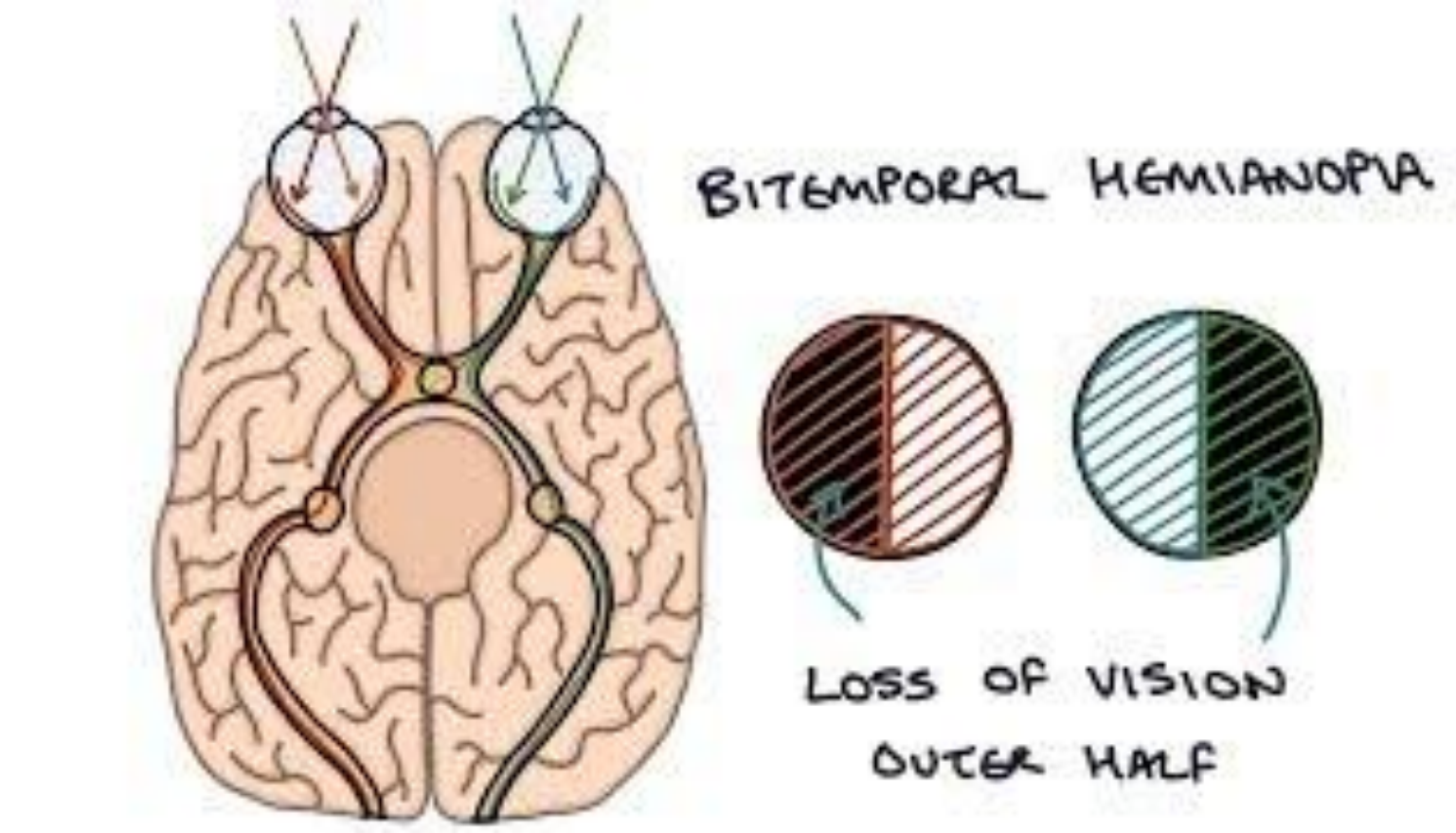
Optical Illusions

Visual Crossover

- The visual field is split into left and right
- The optic nerve from each eye splits and forms connections to both sides of the brain based on the visual field
  - Crosses via the **Optic Chiasm**



Visual Crossover

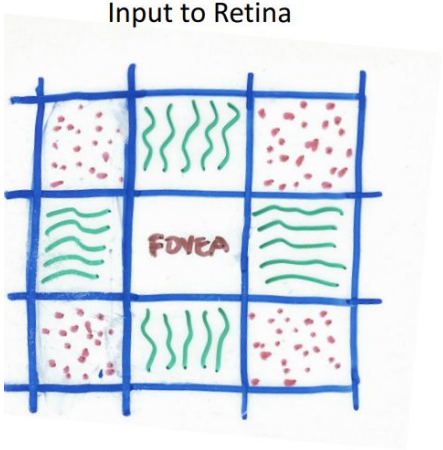


Visual Crossover

- **Magnification Factor:** Cortical cells with small receptive fields have a disproportionately higher projection to the visual area
  - **Fovea** makes up 0.01% of the retina, but accounts for 8% of V1 mapping

- Visual Imagery: Similar cortical activation when seeing an object as when imagining it

Input to Retina



Topological
(preserves spatial relationships)
Map of input in V1

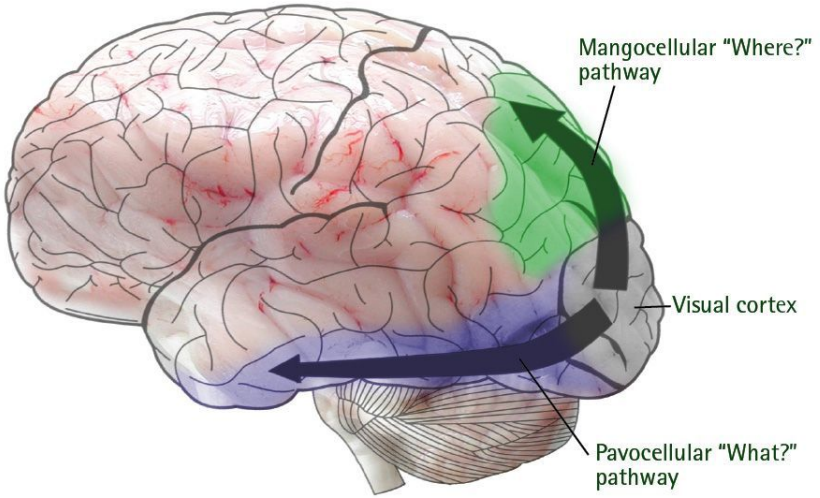
But ABSOLUTE size is not maintained

Fovea is greatly (80X) **Magnified**

Information Pathways

- **Dorsal Pathway (Magnocellular Pathway)**
  - "Where/How" information
  - Motion and Depth
  - Information from Rods & Cones from Periphery
  - Large "Magnocellular" Ganglions (Y Ganglions)
  - **Pathway**: LGN > V1 > V2 >Medial Temporal Cortex > Medial Superior Temporal Cortex

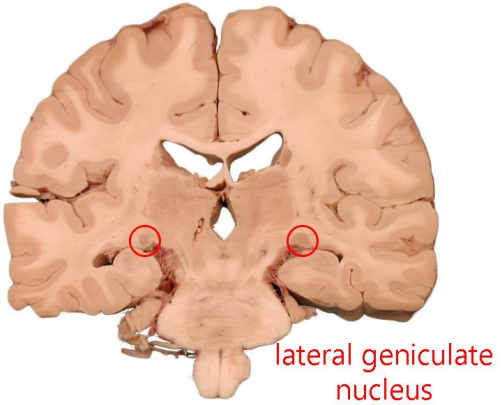
- **Ventral Pathway (Parvocellular Pathway)**
  - "Who/What" information
  - Color and Detail (Contextual information)
  - Information from Cones in and around Fovea
  - Small "Parvocellular" Ganglions (X Ganglions)
  - **Pathway**: LGN > V1 > V2 > V3 > V4 > Inferior Temporal Cortex

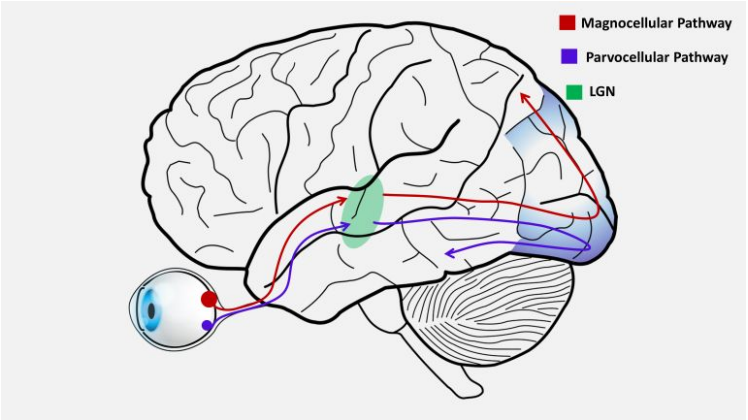


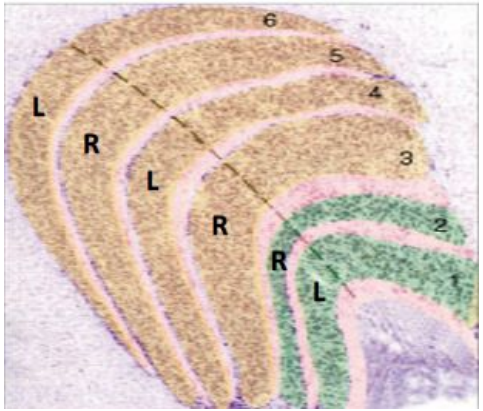
LGN

- LGN is organized into 6 layers:
  - **Magnocellular Pathway (Where Pathway)** projects to and from layers 1 & 2
  - **Parvocellular Pathway (Who/What Pathway)** projects to and from layers 3-6

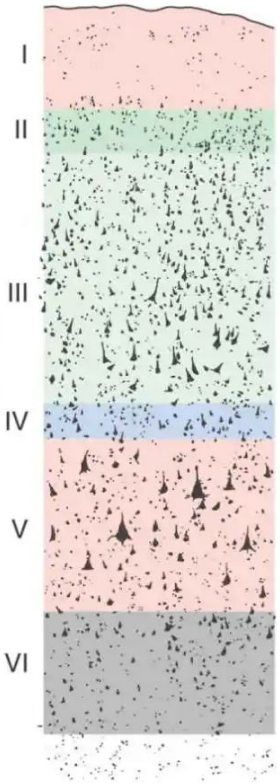
- Some axons from the Magnocellular Pathway go first to the Superior Colliculus in the Tectum of the Midbrain. From there, this sub-pathway goes on to the LGN



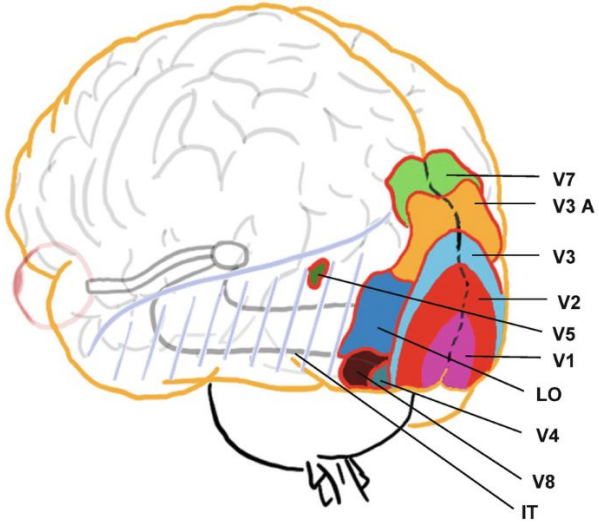




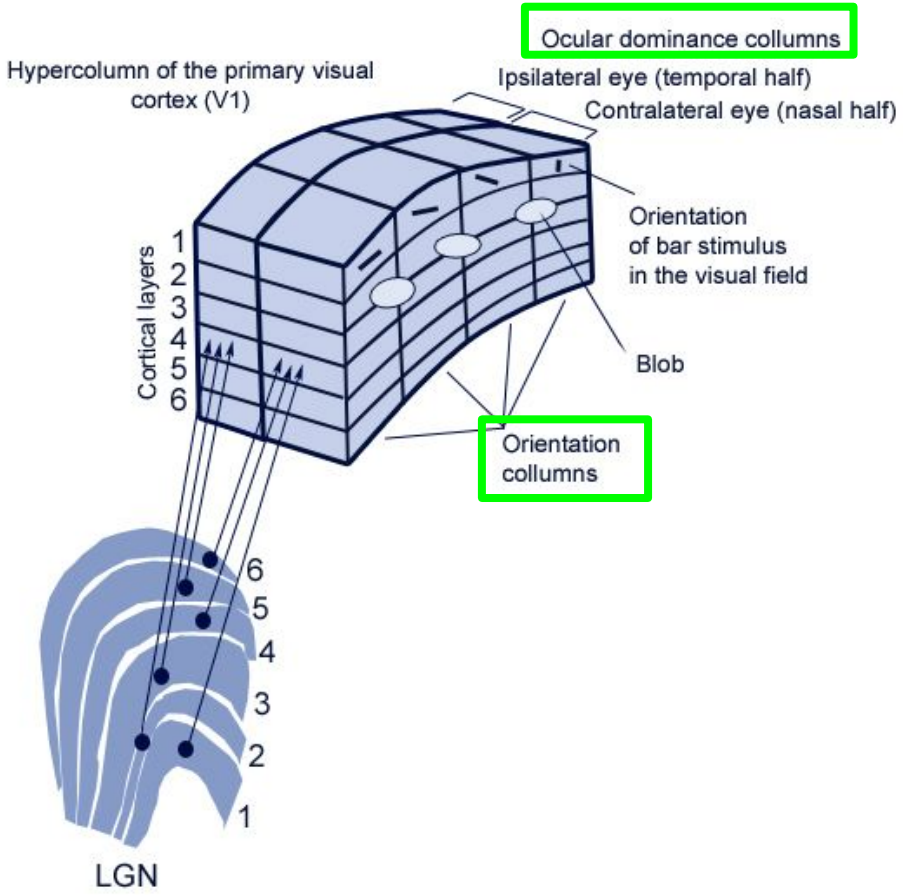
Visual Cortex (Occipital Lobe)



- 6 Layered Cortex
- Layer **4** of the Primary Visual Cortex (V1) receives input from the LGN
- Information is then processed and passed “upwards” to other Visual Cortices (V2-V4) which specialize in processing certain properties (Color, Shape, Orientation, etc)



Columnal Organization



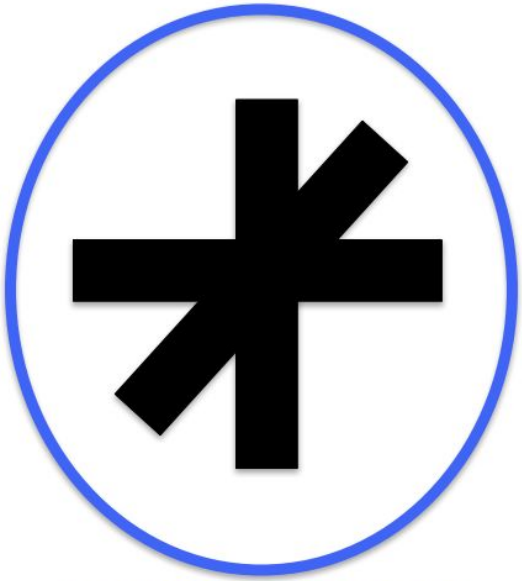
- **Column:** run vertically through the layers of the cortex
  - each column respond to lines oriented in one particular orientation (same "preferred" stimuli like | or / or \ or —, etc)

- **Hypercolumn:** a set of orientation columns with the same receptive field
  - Comes in Pairs: Left or Right eye dominant
  - Adjacent hypercolumns have adjacent receptive fields → Retinotopic map: A topological map that preserves spatial relationships from the information received

Columnal Organization

Simple Cells in V1

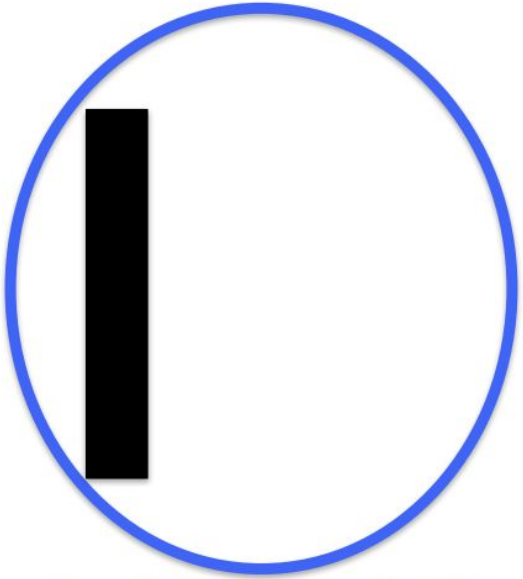
Respond to "bar" in a particular orientation in a given Receptive Field



Receptive Field of Simple Cell in Retina

"Complex" Cells in V2

Respond to **moving** "bar" in particular orientation in given Receptive Field

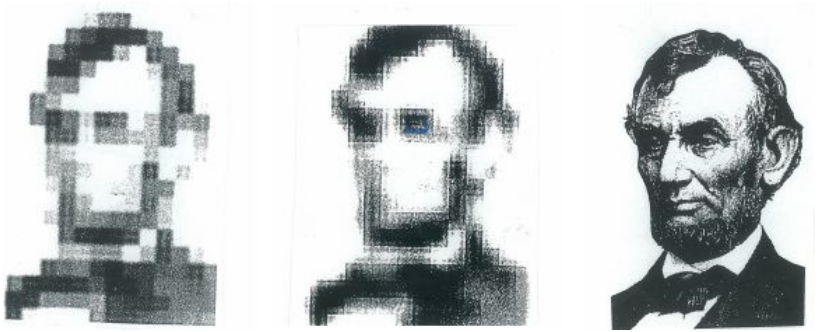


Receptive Field of Complex Cell in Retina

Vivid Vision

- To determine details such as shape and texture, detail information is processed in a hierarchical structure V1 >V2 >V3 >V4
  - Simple cells of V1 responds best to lines of particular Orientation (Orientation tuned)
  - Complex cells of V2 responds best to moving lines of particular orientation (Motion tuned)
  - V3 integrates visual information
  - V4 is tuned to orientation, spatial frequency, and color

- Spatial Frequencies (SF)
  - # of dark-light transitions (changes in contrast) in a given amount of visual space
  - Low SFs for Gross outlines, High SFs for Detail

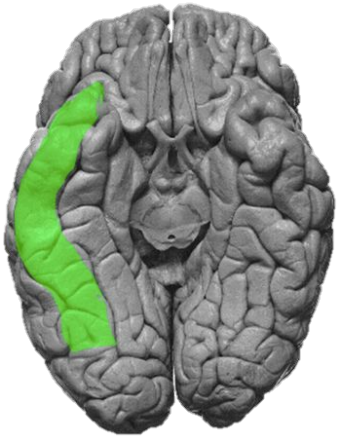


Fusiform Gyrus

- Face recognition in Inferior Temporal (IT) Cortex
  - Aka Fusiform Face Area (FFA)

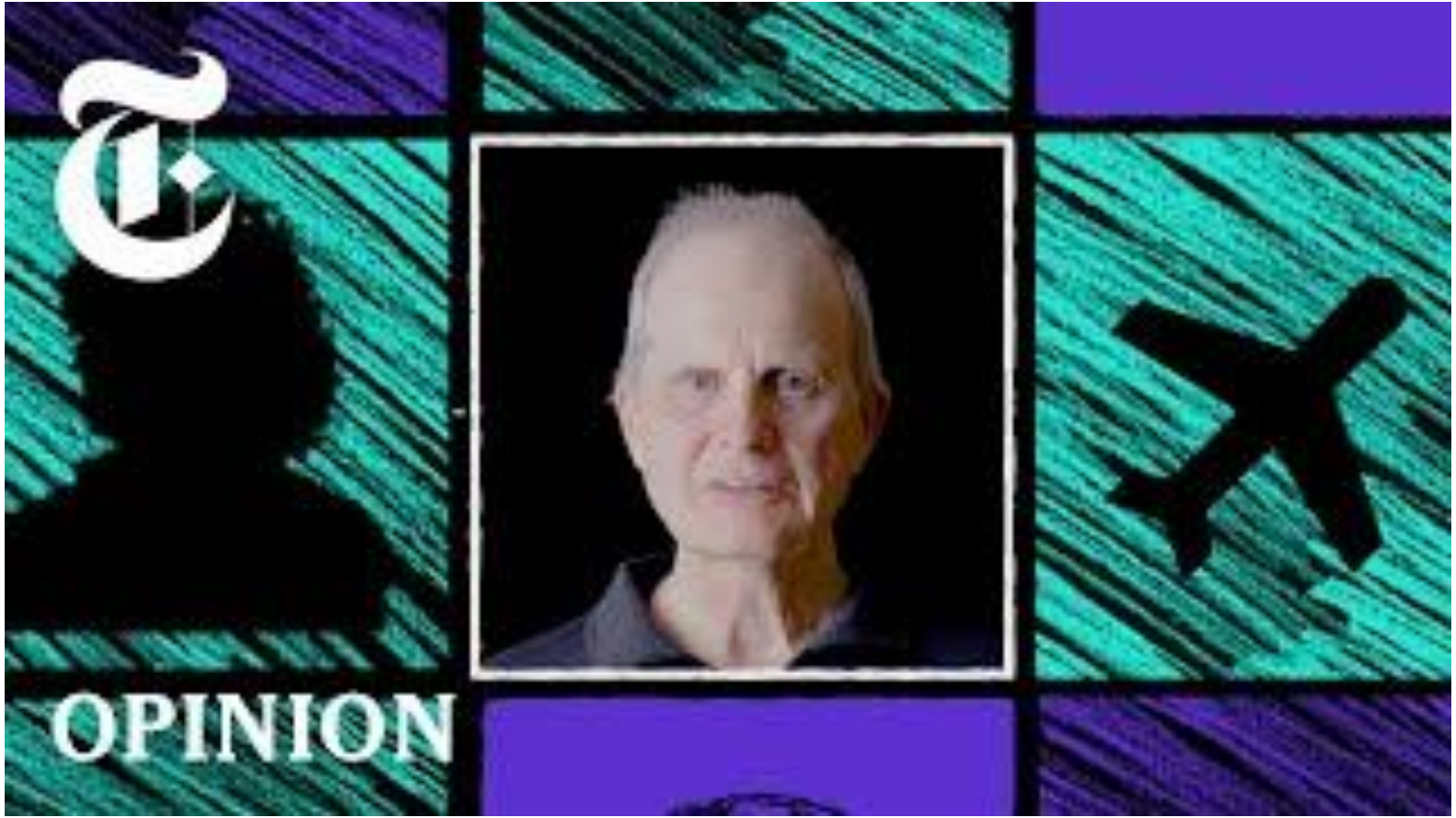
- Damage to this area leads to Prosopagnosia, the inability to identify familiar faces (face blindness)

- Other cells in IT react to objects (dog breeds, cars, etc) of which you are an expert (highly practiced) discriminator



same!

Fusiform Gyrus



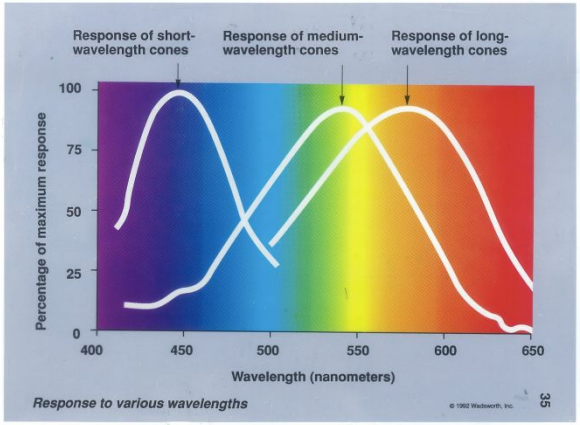
Color Perception

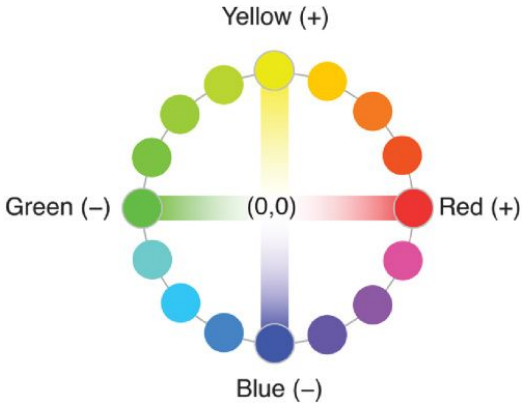
- "Visible light" consists of wavelengths ~350 nm to ~700 nm

- **Trichromatic Color Vision**
  - 3 Cone Types (Blue, Green, Red): each with its own unique type of Opsin that responds to specific wavelengths of light

- **Color Opponency**
  - Trichromatic system is recorded into opponent systems
  - Adapt to Red > Green after image. Adapt to Green > Red after image (same as Yellow vs. Blue)

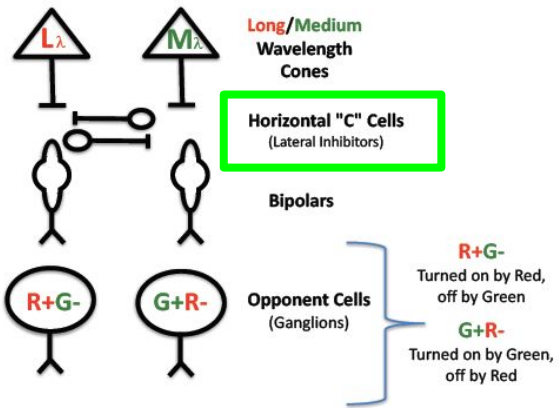
- "Blobs"
  - In each pair of hypercolumns, there are columns that process colors

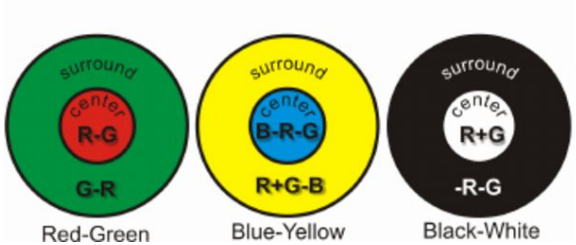


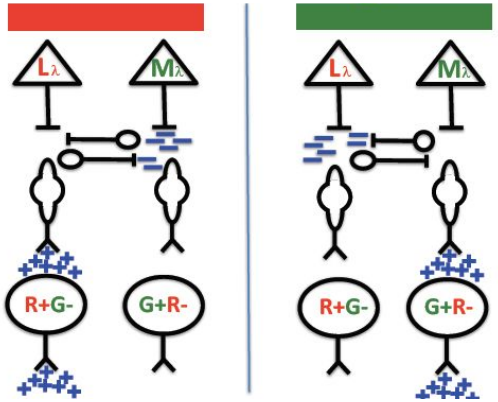


Color Opponency Circuitry

- **Horizontal cells** allow for opponency
- Horizontal “C” cells spontaneously fire, inhibiting neighboring bipolar cells
- **Double Opponent Cells** in Ganglion Cells
  - Most have R+G- Center and G+R- Surround receptive Fields
  - Good for detecting ripe fruit
- Color constancy: Able to recognize colors under varying light conditions (V4 - detects and filters out overall tint of scene)





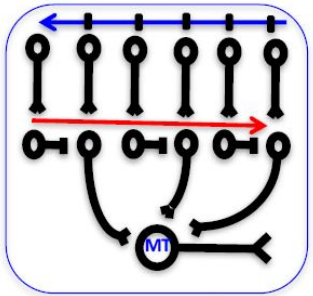


Medial Temporal (MT)

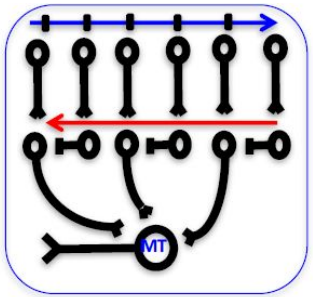
- Along the “Where/How” or “Magnocellular” Pathway
- Includes **direction-sensitive motion detectors**

- **Uni**directional lateral inhibition
  - runs in **OPPOSITE** direction detected by circuit

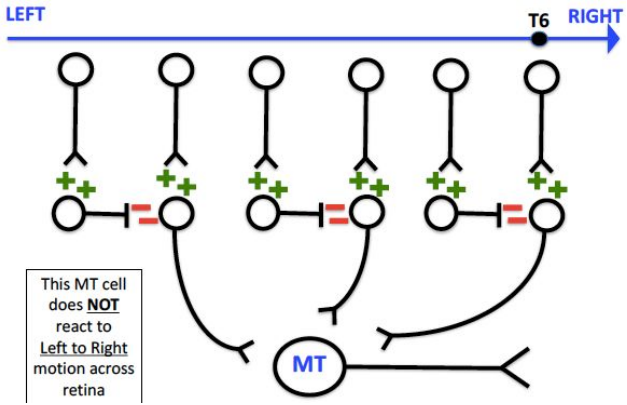
- Feeds to Medial Superior Temporal (MST)
  - Includes “Optic Flow” detectors
  - Responds to the movement of the entire visual field

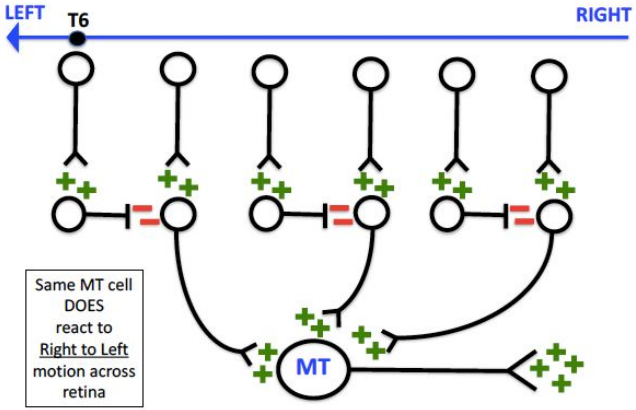


Detects motion
RIGHT to LEFT



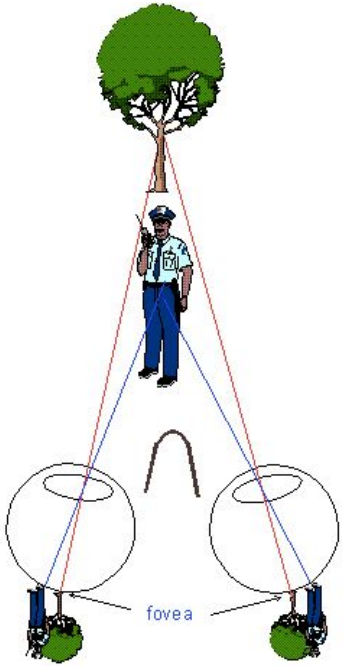
Detects motion
LEFT to RIGHT





Depth Perception

- **Binocular Disparity**: Disparity between the views from each eye allows 3D depth perception
- If both eyes focus on a focal point, the farther any other point is from that point, the greater the disparity in degrees of visual angle between where the points will fall on the two retinas
- In V2, disparity detectors differentially respond to different ranges of disparity
- In MT, the cells respond to different ranges of disparity regardless of receptive field
- Each disparity detector has a “preferred” disparity to which it responds the most to. Some overlap exists



Binocular Disparity

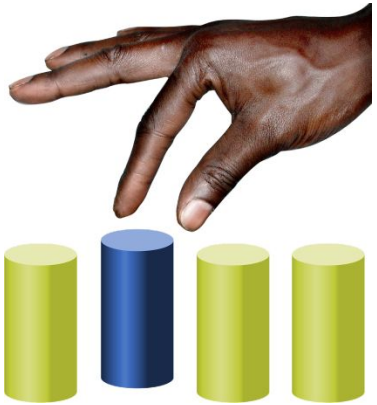
Higher Parietal Cortex

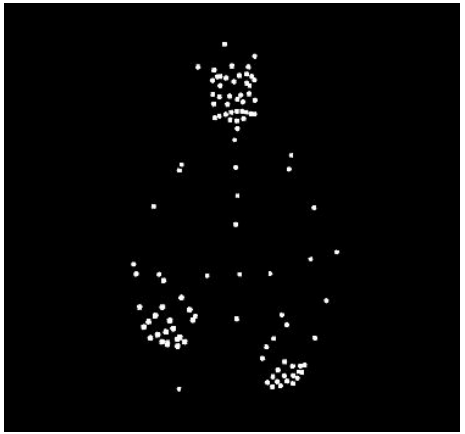
- Integration of visual and somatosensory information

- In Anterior Intra-parietal (AIP) Cortex, "**Canonical cells**" responds to the "affordances" of objects
  - Signals to the premotor cortex to shape the hand in specific motions (reaching out)

- Mirror Cell System
  - Responds to seeing self or other, perform and action
  - Promotes imitation

- Biological Motion Perception
  - Not in Parietal cortex
  - Located in the Superior Temporal Sulcus (STS)






HALF WAY DONE!