Visual Crossover

Left Visual Field

RVF to Left Eye connects to Ipsilateral Lateral Brain

Lateral geniculate

Optic nerve

Optic chiasm

LVF to Right Eye connects to Ipsilateral Lateral Brain

Right Hemisphere

Occipital Cortex

Right Visual Field

RVF to Right Eye connects to Contra-lateral Brain

LVF to Left Eye connects to Contra-lateral Brain

Only after reaches Cortex, is visual field info combined via Corpus Callosum
Magnification in Visual Cortex (V1)

Input to Retina

Topological
(preserves spatial relationships)
Map of input in V1

But ABSOLUTE size is not maintained

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

Activates some of the same areas as actual visual perception

See an elephant far away

Imagine an elephant far away

See an elephant close up

Imagine an elephant close up
Visual Pathways
Visual Pathways

Dorsal Pathway
"Where/How"
(Motion & Depth)
Magnocellular Pathway

Ventral Pathway
"Who/What"
(Color & Detail)
Parvocellular Pathway
Visual Pathways

begin in Retina

Parvocellular Pathway

- Cone in Fovea
- Magnocellular Pathway

Rods & Cones in Periphery

Parvocellular (SMALL) Ganglions

From Low Convergence (1:1) Cones

Magnocellular (LARGE) Ganglions

From High Convergence (Many:1) Rods
Optic Nerve (Axons of Ganglions) to **LGN** (Lateral Geniculate Nucleus) of Thalamus

Where “cross-over” occurs
LGN
Lateral Geniculate Nucleus of the Thalamus

6 layers

Parvocellular Pathways - Layers 3-6

Also organized by which EYE (L or R) is dominant in layer

Magnocellular Pathways - Layers 1 & 2
Some axons along the Magnocellular Pathway go first to the Superior Colliculus in the Tectum of the Midbrain.

Used in Colliculi to map location of visually moving stimuli

Implicated in “Blindsight”

From there, this sub-pathway goes on to the LGN.
Parvocellular Pathway

Color & Detail
Parvocellular Pathway - DETAIL

Includes “Simple Cells” (Bar Detectors) in V1
Columnar Organization in V1

6 Layered Cortex
Columnar Organization in V1

6 Layered Cortex

Column = Cells in all 6 layers that respond to same “preferred” stimulus

In this case, lines of a particular Orientation

“Simple Cells”
Columnar Organization in V1

Hypercolumn = One set of orientation columns w/same Receptive Field

“Simple Cells”
Columnar Organization in V1

Hypercolumns come in pairs (Left or Right Eye Dominant)

6 Layered Cortex

“Simple Cells”

With corresponding Receptive Fields in the two eyes
Columnar Organization in V1

Adjacent Hypercolumn pairs have adjacent Receptive Fields in Retina

= Topological Map of the Retina In V1

“Simple Cells”
"Simple Cells"
aka "Bar Detectors"
**Simple Cells in V1**
Respond to "bar" in a particular orientation in a given Receptive Field

**"Complex" Cells in V2**
Respond to **moving** "bar" in particular orientation in given Receptive Field

**Receptive Field of Simple Cell in Retina**

**Receptive Field of Complex Cell in Retina**
Spatial Frequency

# Changes in Contrast / Degree of Retinal Arc

LOW Spatial Freq

MEDIUM Spatial Freq

HIGH Spatial Freq
Actually, the ideal stimulus is usually a **Sine Wave Gradient** which gradually shifts from dark to light to dark, at different spatial frequencies.
Spatial Frequency Channels

What is this???
Given this stimulus...

**Spatial Frequency Channels**

Simple cells **simultaneously** respond to different Spatial Frequencies at different orientations from a given image on Retina.
Given this stimulus...

**Spatial Frequency Channels**

Simple cells simultaneously respond to different Spatial Frequencies at different orientations from a given image on Retina.

Medium Spatial Frequency gradients
Given this stimulus...

**Spatial Frequency Channels**

Simple cells *simultaneously* respond to different Spatial Frequencies at different orientations from a given image on Retina.

**Low Spatial Frequency gradients**
Given this stimulus... Spatial Frequency Channels

While circuits in Inferior Temporal respond to (enable recognition of) face as a whole.

So, as it moves up pathway, info is "reassembled", but in an abstract (relational) way, so almost any version of face can be recognized.
Fusiform Gyrus

Face recognition in Inferior Temporal (IT) Cortex

Damage to the Fusiform Gyrus can result in
Prosocognosia
- Inability to recognize faces
Fusiform Gyrus

Face recognition in Inferior Temporal (IT) Cortex

Damage to the Fusiform Gyrus can result in

Prosopagnosia
- Inability to recognize faces
Other “Complex” Cells in Inferior Temporal

For visual recognition of other learned distinctions

What Shape Is Its Bill?
Is it small and fine like a warbler’s (1); stout and short like a seed-cracking sparrow’s (2); dagger-shaped like a tern’s (3); or hook-tipped like that of a bird of prey (4)?
Electromagnetic Radiation Spectrum

"Visible Light"
Trichromatic Color Vision

Three Cone Types

-- each with its own type of Opsin

-- each responsive to a different range of wavelengths


Color Opponency

**After-Images**

Adapt to **Red**, will see **Green** afterimage

Adapt to **Green**, See **Red**

Adapt to **Yellow**, will see **Blue** afterimage

Adapt to **Blue**, See **Yellow**
When people are color blind, they will be blind to

Red & Green

or to

Yellow & Blue
Color "Blobs" in V1

Within each pair of Hypercolumns are embedded columns that process color called "Blobs"
Color "Blobs" in V1

Within each pair of Hypercolumns are embedded columns that process color called "Blobs"

6 Layered Cortex

One blob is specialized to process Red & Green, the other Blue & Yellow
Color Opponency

Long/Medium Wavelength Cones

Horizontal "C" Cells
(Lateral Inhibitors)

Bipolars

Opponent Cells (Ganglions)

- R+G- Turned on by Red, off by Green
- G+R- Turned on by Green, off by Red
In absence of inhibition, C Cells spontaneously fire, inhibiting neighboring Bipolars.
Color Opponency

Same circuit, responding to GREEN

R+G- Turned OFF by Green

G+R- Turned ON by Green
Color Opponency

- $L_\lambda$
- $M_\lambda$
- $R+G-$
- $G+R-$

- $L_\lambda$
- $M_\lambda$
- $R+G-$
- $G+R-$
Double Opponent Cell

Most have
R+G- Center / G+R- Surround
Receptive Fields

Double Opponent Cells
in Striate Cortex (V1)
Double Opponent Cell

Created by the convergence of Opponent Cells from LGN

Most have R+G- Center / G+R- Surround Receptive Fields

Double Opponent Cells in Striate Cortex (V1)
Double Color Opponent Cell

Created by the convergence of Opponent Cells from LGN

Most have R+G- Center / G+R- Surround Receptive Fields

Double Opponent Cells in Striate Cortex (V1)

Optimal Stimulus – Ripe Fruit!
Color Opponency

Blue / Yellow opponency works much the same way as Red / Green.

- **Short** wavelength cones are set in opposition to...
- **Medium+Long** wavelength cones when they respond equally, as they do to yellow light.

![Graph showing response of short, medium, and long wavelength cones](image-url)
Color Constancy
Color Constancy

V4 detects & filters out overall tint of scene

Enables recognition of color under varying lighting conditions

= Color Constancy
Magnocellular Pathway

Dorsal Pathway
"Where/How"
(Motion & Depth)

Magnocellular Pathway

Frontal lobe
Precentral gyrus
Central sulcus
Postcentral gyrus
Parietal lobe
Occipital lobe
Temporal lobe
Cerebellum
MT (Medial Temporal)

Along "Where/How"
Visual pathway to Parietal

(----- = Medial, NOT on outer surface)

Includes Direction-Sensitive Motion Detectors
Direction-Sensitive Motion Detector Circuit in MT

**MT** = Medial Temporal Cortex, along Magnocellular Pathway
Direction-Sensitive Motion Detector Circuit in MT
Direction-Sensitive Motion Detector Circuit in MT
Direction-Sensitive Motion Detector Circuit in MT
Direction-Sensitive Motion Detector Circuit in MT

LEFT

RIGHT

T4

MT
Direction-Sensitive Motion Detector Circuit in MT
Direction-Sensitive Motion Detector Circuit in MT

This MT cell does **NOT** react to Left to Right motion across retina.
Direction-Sensitive Motion Detector Circuit in MT

LEFT  T1  RIGHT

MT

[Diagram of a circuit with various nodes and connections, including left and right directions indicated by arrows and labels.]
Direction-Sensitive Motion Detector Circuit in MT
Direction-Sensitive Motion Detector Circuit in MT
Direction-Sensitive Motion Detector Circuit in MT
Direction-Sensitive Motion Detector Circuit in MT
Direction-Sensitive Motion Detector Circuit in MT

Same MT cell DOES react to Right to Left motion across retina
Direction-Sensitive Motion Detector Circuit in MT

HINT = Uni-Directional Lateral Inhibition runs in OPPOSITE direction detected by circuit
Direction-Sensitive Motion Detector Circuit in MT

- Detects motion RIGHT to LEFT
- Detects motion LEFT to RIGHT
- Detects motion DOWNWARD
- Detects motion UPWARD
- Detects motion DIAGONALLY DOWN

Etc...
MST (Medial Superior Temporal) Includes "Optic Flow" Detectors

**Figure 8.49** The flow of the environment as seen from a car speeding across a bridge toward point A. The flow, shown by the arrows, is more rapid closer to the car (as indicated by the increased blur) but occurs everywhere except A, the focus of expansion, toward which the car is moving. (Also see Figure 8.48a)
Optic Flow Detectors in MST

**Figure 8.48** Flow patterns that occur (a) when we move forward and (b) when we move backward.
Binocular Disparity

Part of WHERE
In the “Where/How” Pathway

Used for Depth Perception
When focused on tree...

Closer policeman falls (~15°) to Right of Fovea in Left Eye

Same policeman falls (~15°) to Left of Fovea in Right Eye

Total disparity between where closer object falls (on right vs. left eye) = 15° + 15° = 30°
Disparity Detectors

In V2

Each detector has a “preferred” disparity to which it responds the most, but also responds to other, overlapping disparities

(0° disparity = Images fall on same place on both Retinas)
Higher Parietal Cortex

Dorsal Visual Pathway "Where/How"
- integrated w/ Tactile & Proprioception

Activity reverberates w/Premotor Cortex, to shape how hand approaches

In AIP (Anterior Inter-Parietal)
Canonical Cells
Respond to "affordances" of objects
Higher Parietal Cortex

Mirror Cell System
Respond to seeing self, or other, perform and action.

Activity reverberates with Mirror Cells in Premotor Cortex

Promotes Imitation
Visual Pathways

Superior Temporal Sulcus (Biological Motion)
STS Biological Motion

http://www.biomotionlab.ca/Demos/BMLwalker.html
Modularity & the Binding Problem

• **Module** = Brain area specialized for particular function
  • e.g. MT, MST, STS, V1, V4, Fusiform Gyrus, etc . . .

• If each feature (color, shape, location, motion, etc) is coded along an INDEPENDENT pathway, how is it we perceive coherent whole?

  = The “Binding Problem”

• **Answer??**
  • Perhaps a TEMPORAL solution?
  • i.e. Synchronized cell assemblies, across different brain regions, when inputs originate from same stimulus