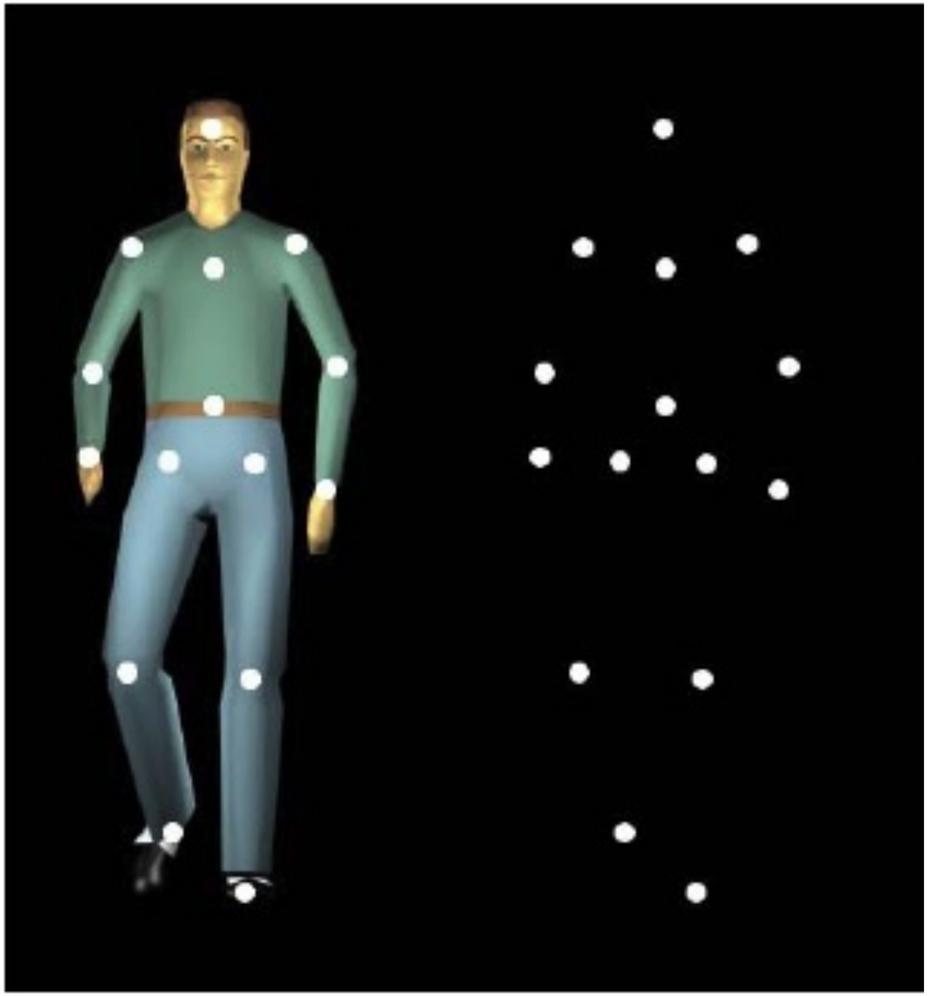
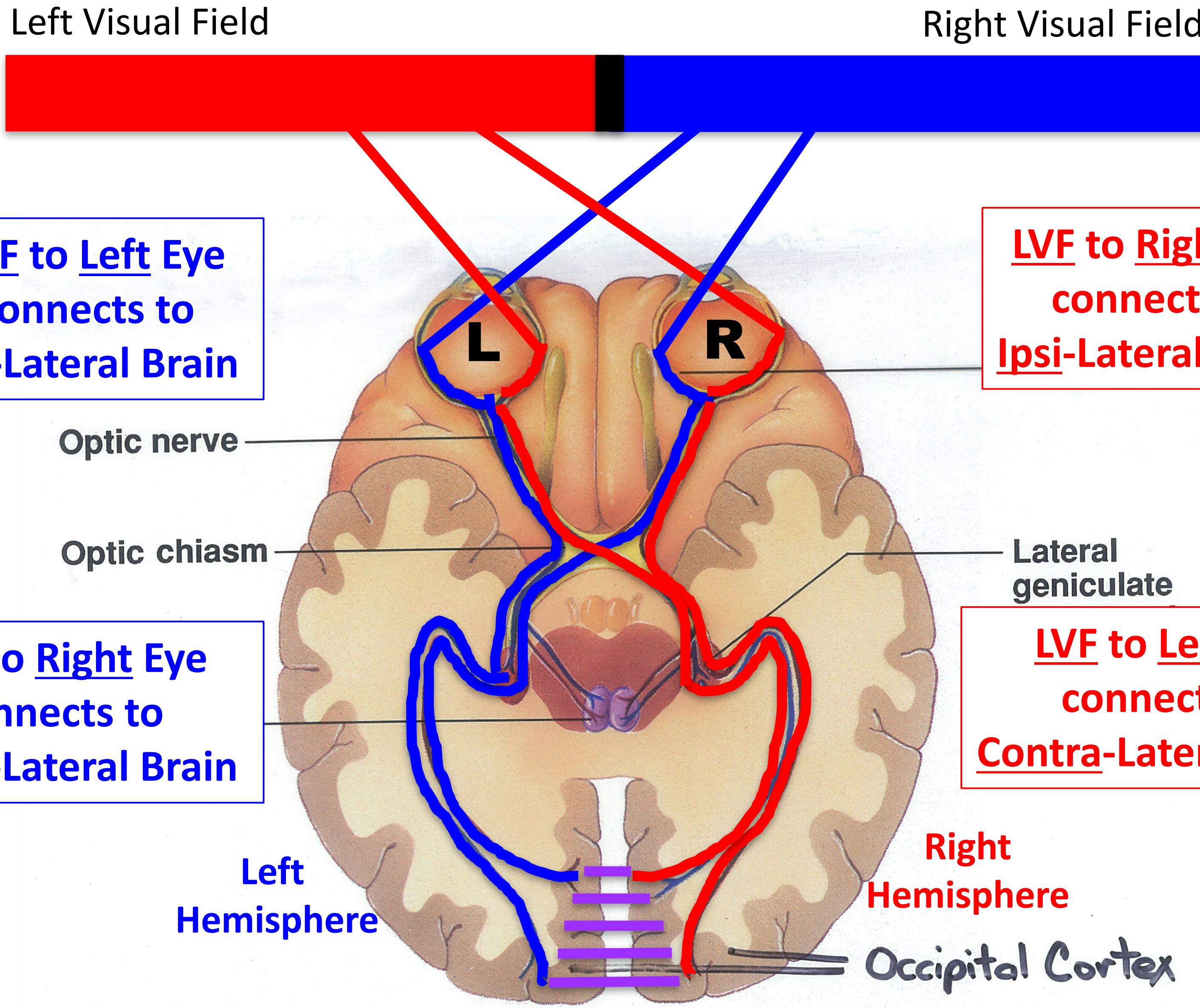


Lecture 4.2

Vision

Cogs17 * UCSD

Visual Crossover



RVF to Left Eye connects to Ipsi-Lateral Brain

LVF to Right Eye connects to Ipsi-Lateral Brain

RVF to Right Eye connects to Contra-Lateral Brain

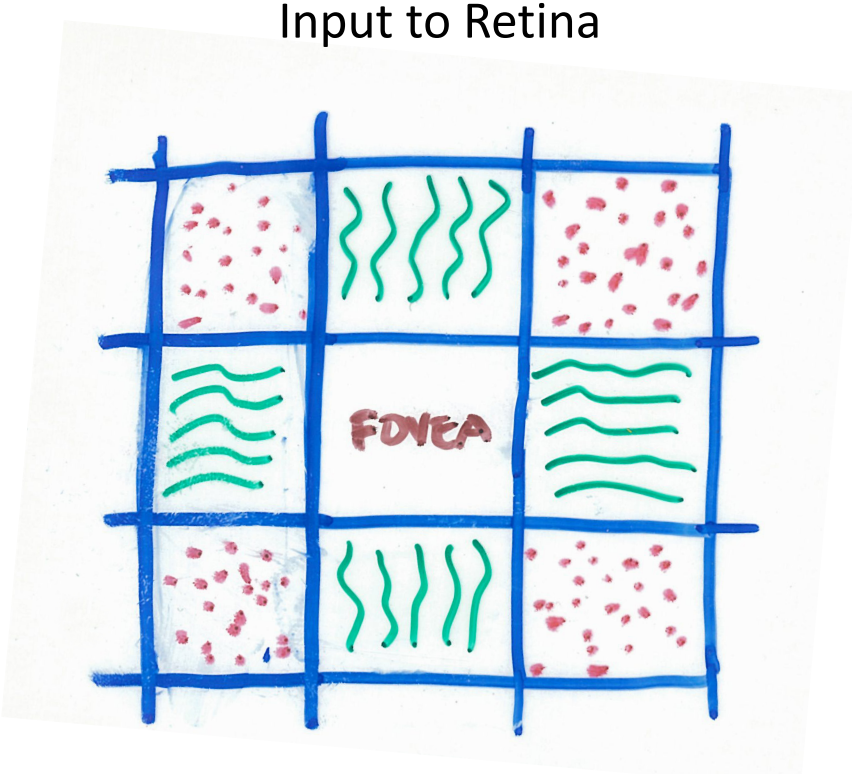
LVF to Left Eye connects to Contra-Lateral Brain

Only after reaches Cortex, is visual field info combined via Corpus Callosum

Magnification

in Visual Cortex (V1)

Input to Retina



Topological

(preserves spatial relationships)

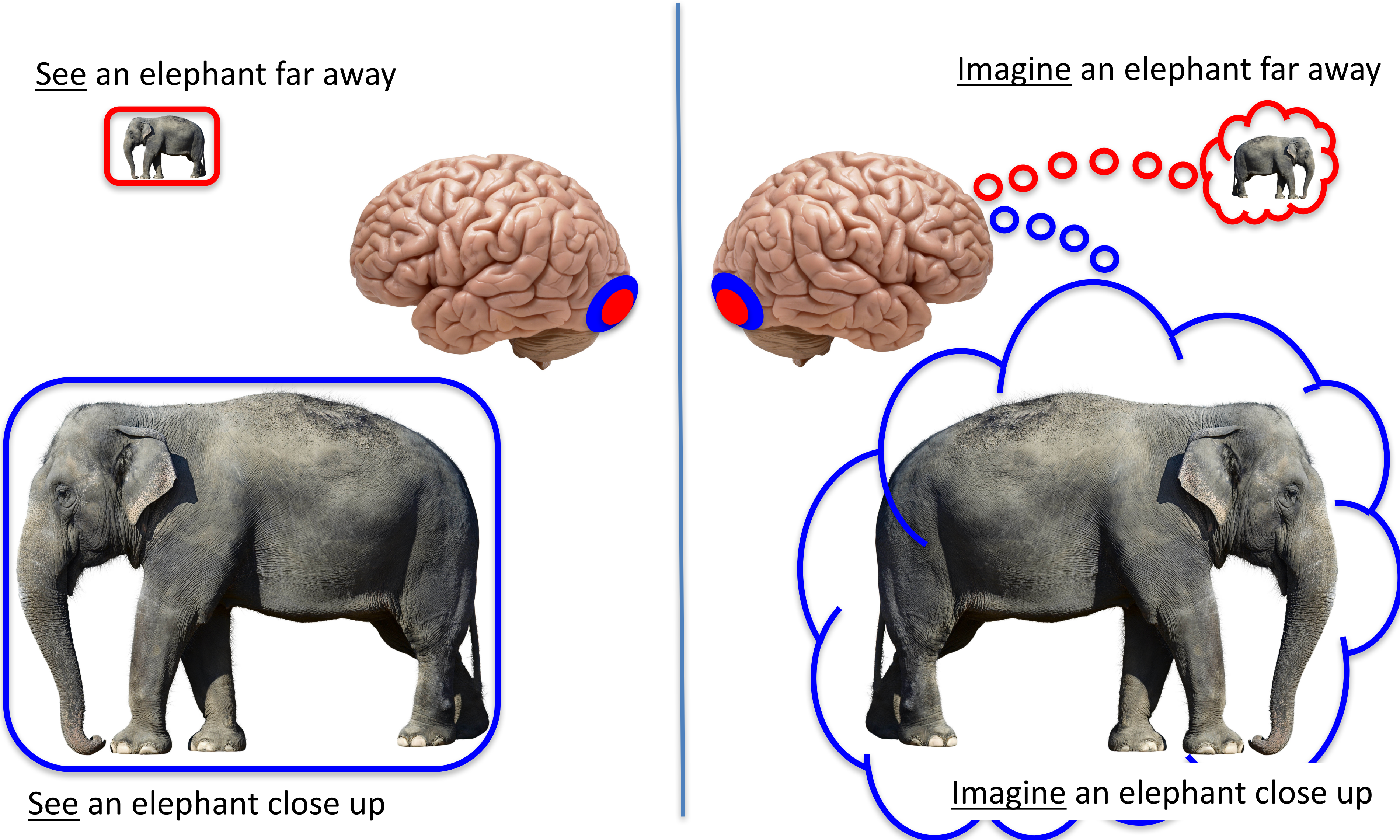
Map of input in V1

But ABSOLUTE size is not maintained

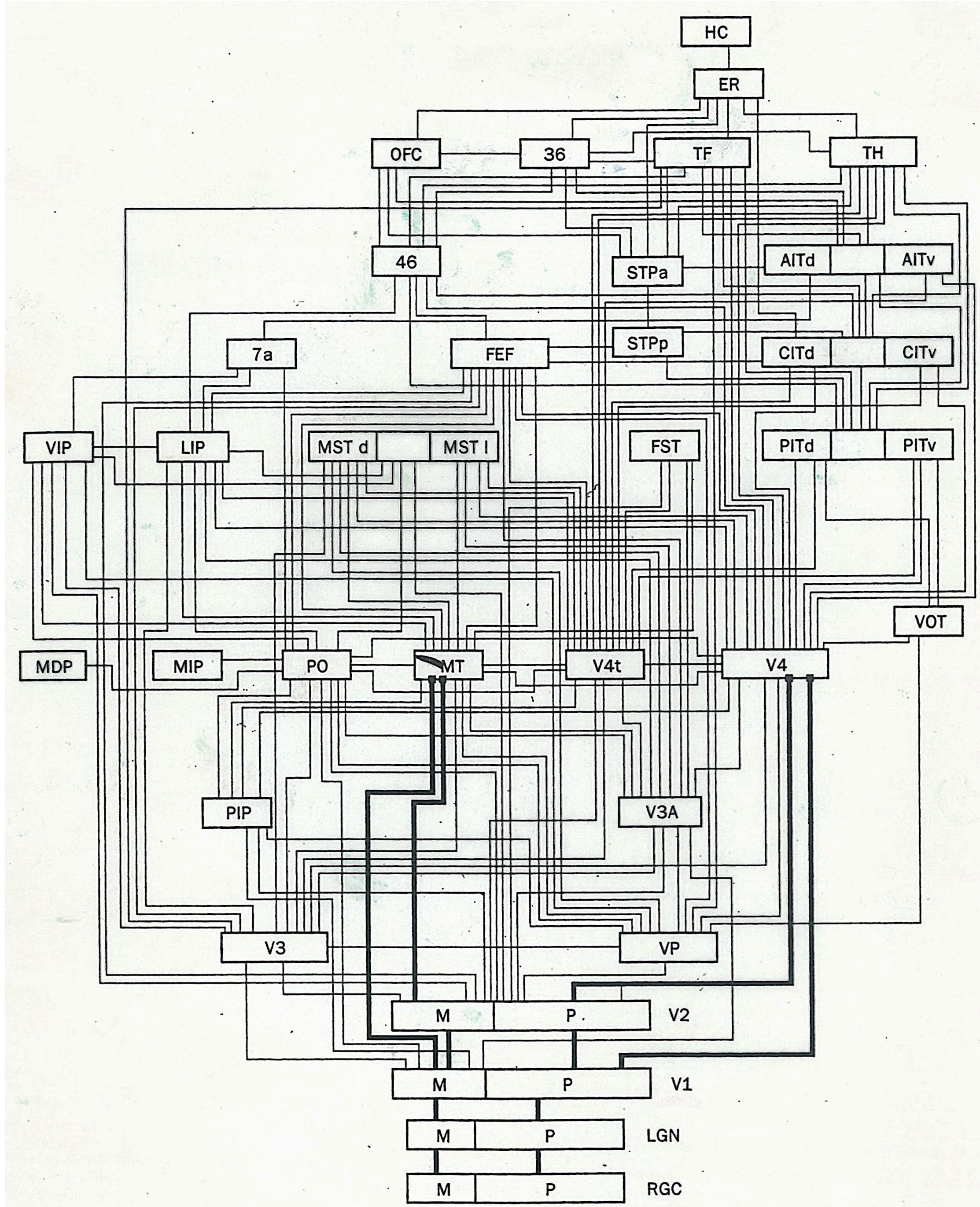
Fovea is greatly (80X) **Magnified**

Visual Imagery

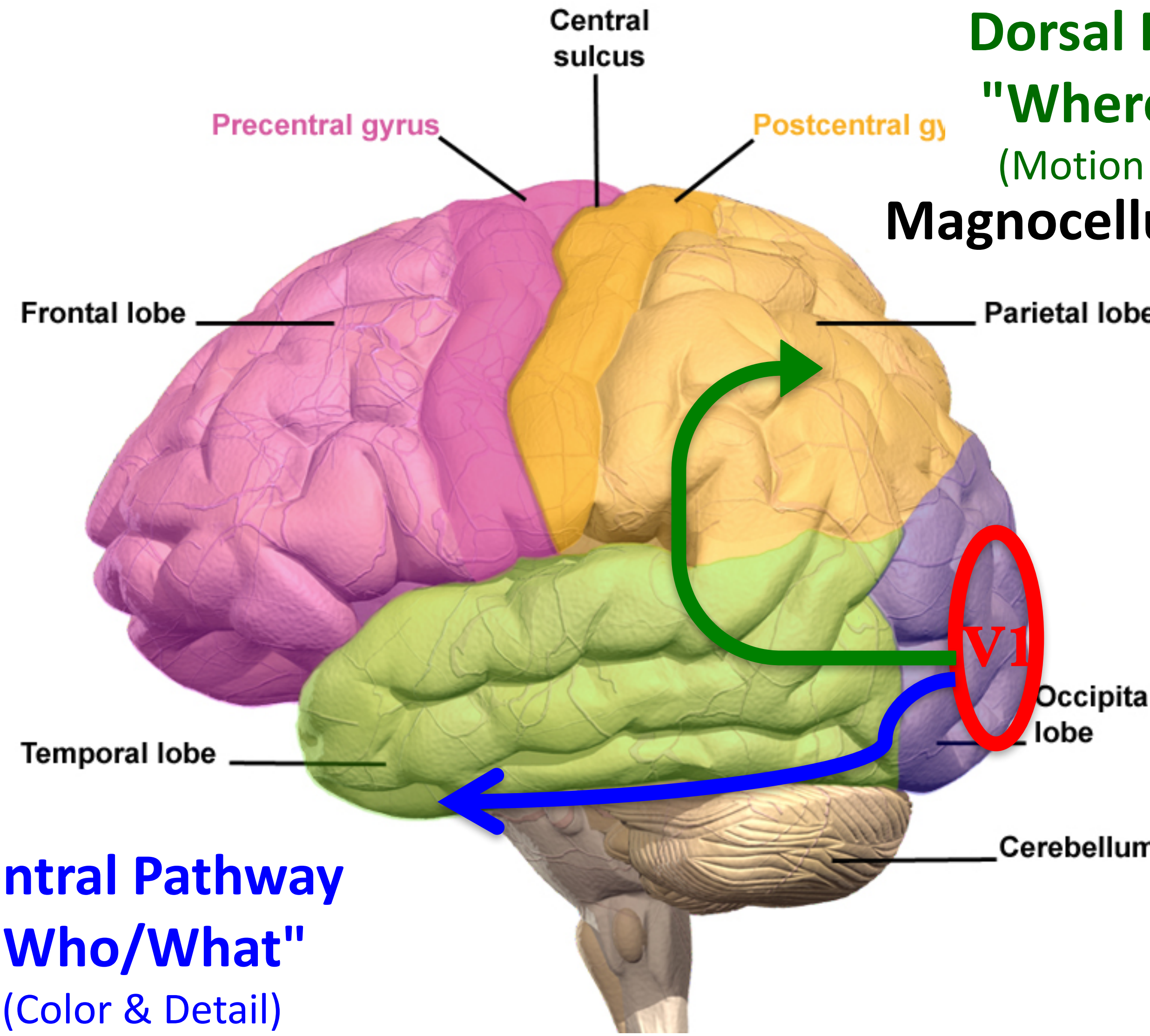
Activates some of the same areas as actual visual perception



Visual Pathways



Visual Pathways

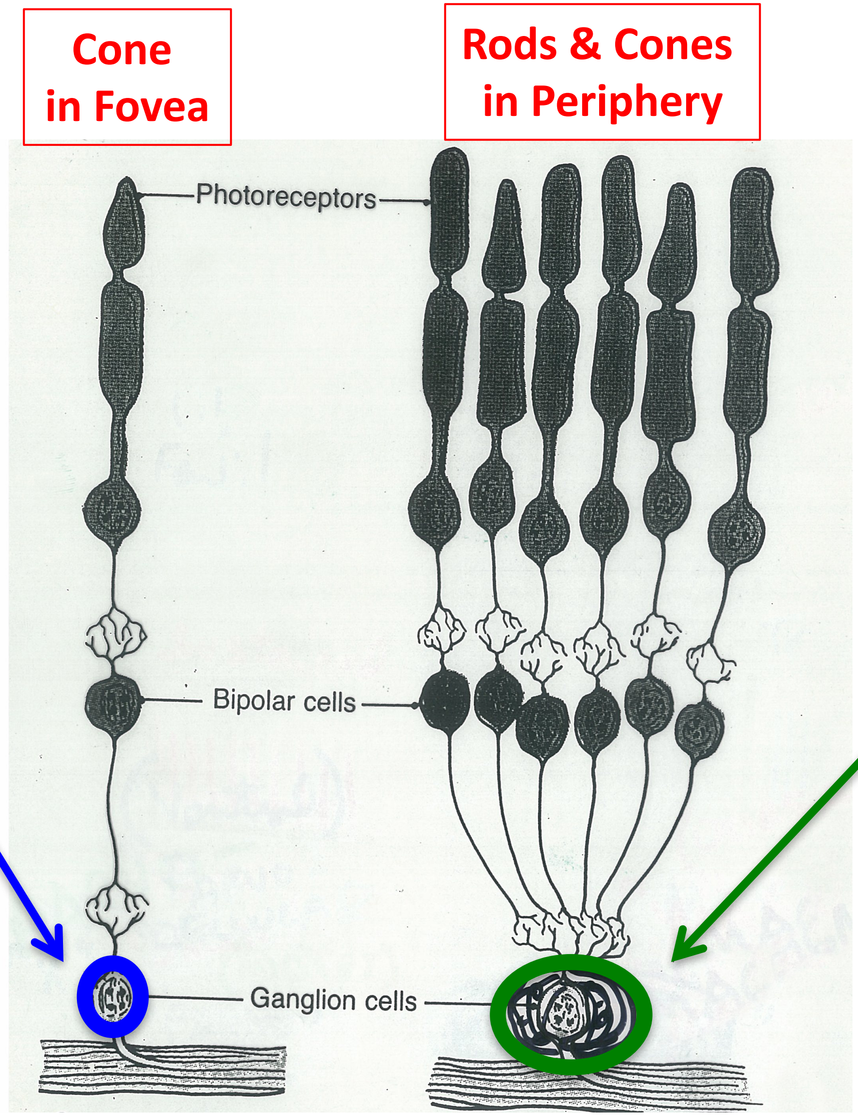


Dorsal Pathway
"Where/How"
(Motion & Depth)
Magnocellular Pathway

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

Visual Pathways

begin in Retina



Parvocellular Pathway

Magnocellular Pathway

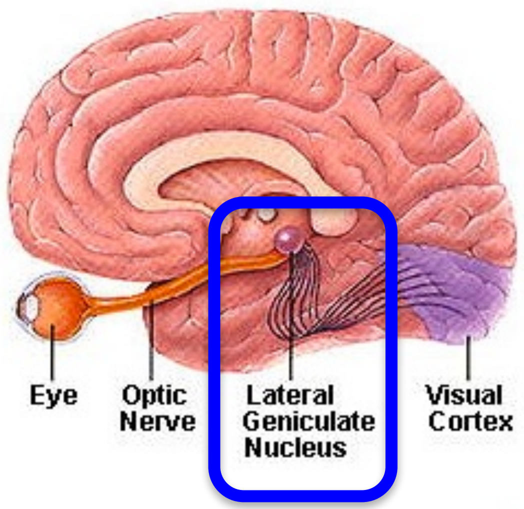
Parvocellular (SMALL) Ganglions

From Low Convergence (1:1) Cones

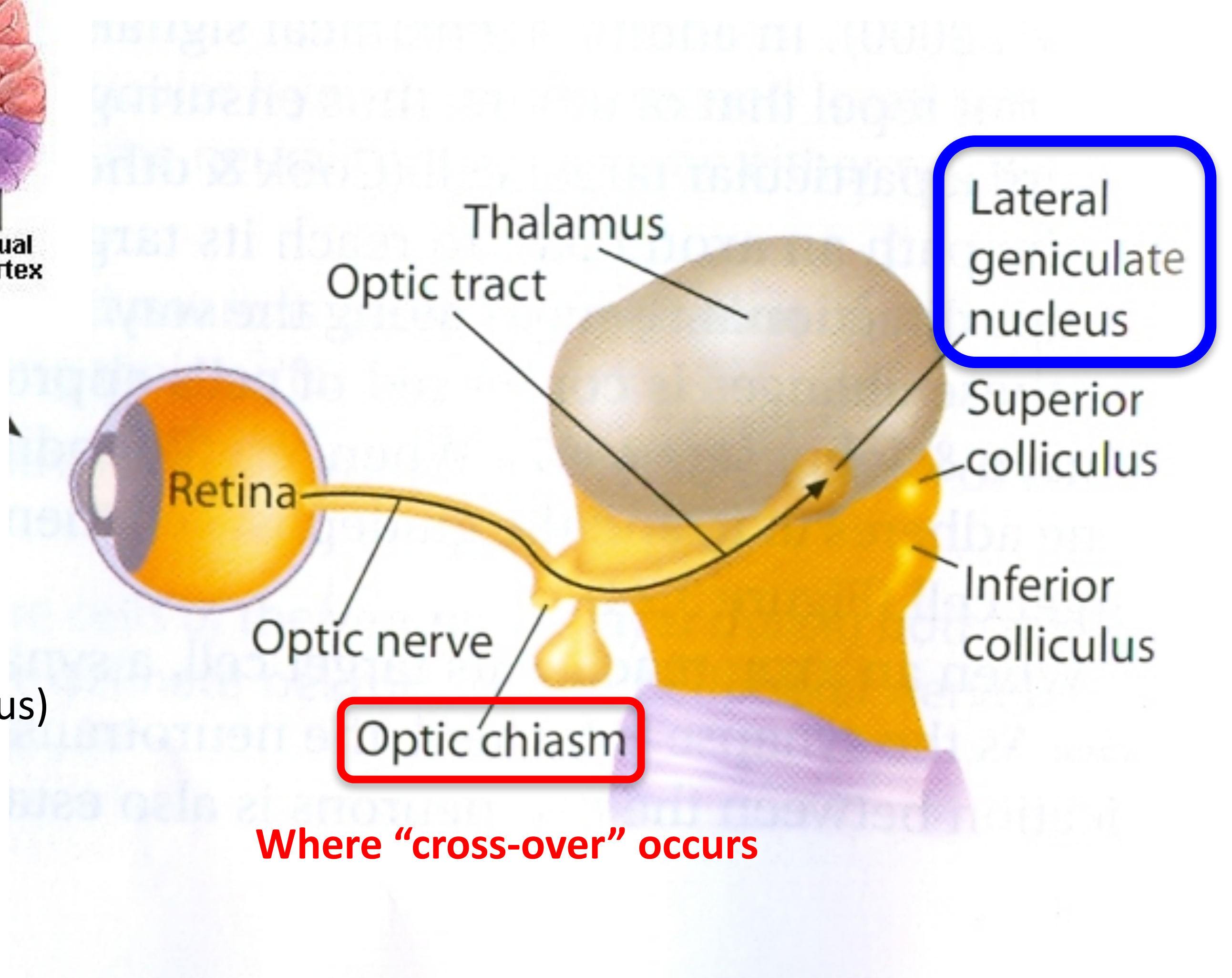
Magnocellular (LARGE) Ganglions

From High Convergence (Many:1) Rods

Visual Pathways



Optic Nerve
(Axons of Ganglions)
to **LGN**
(Lateral Geniculate Nucleus)
of Thalamus

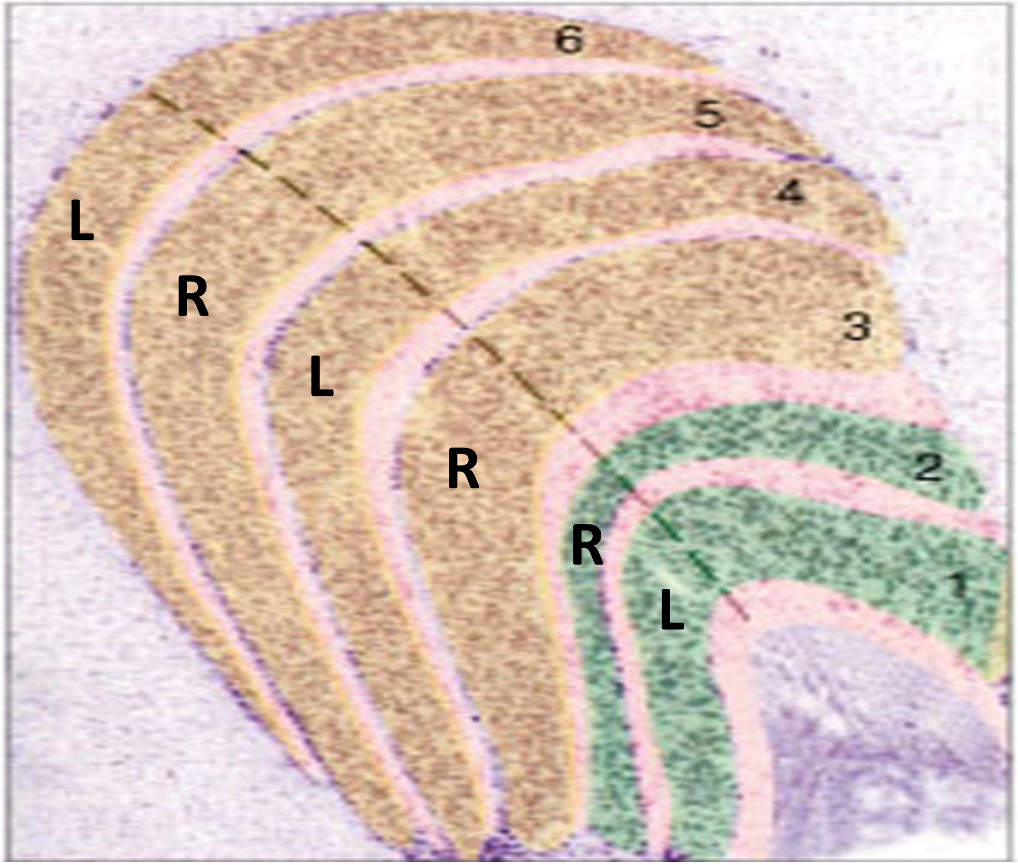


LGN

Lateral Geniculate Nucleus
of the Thalamus

6 layers

Parvocellular
Pathways
- Layers 3-6



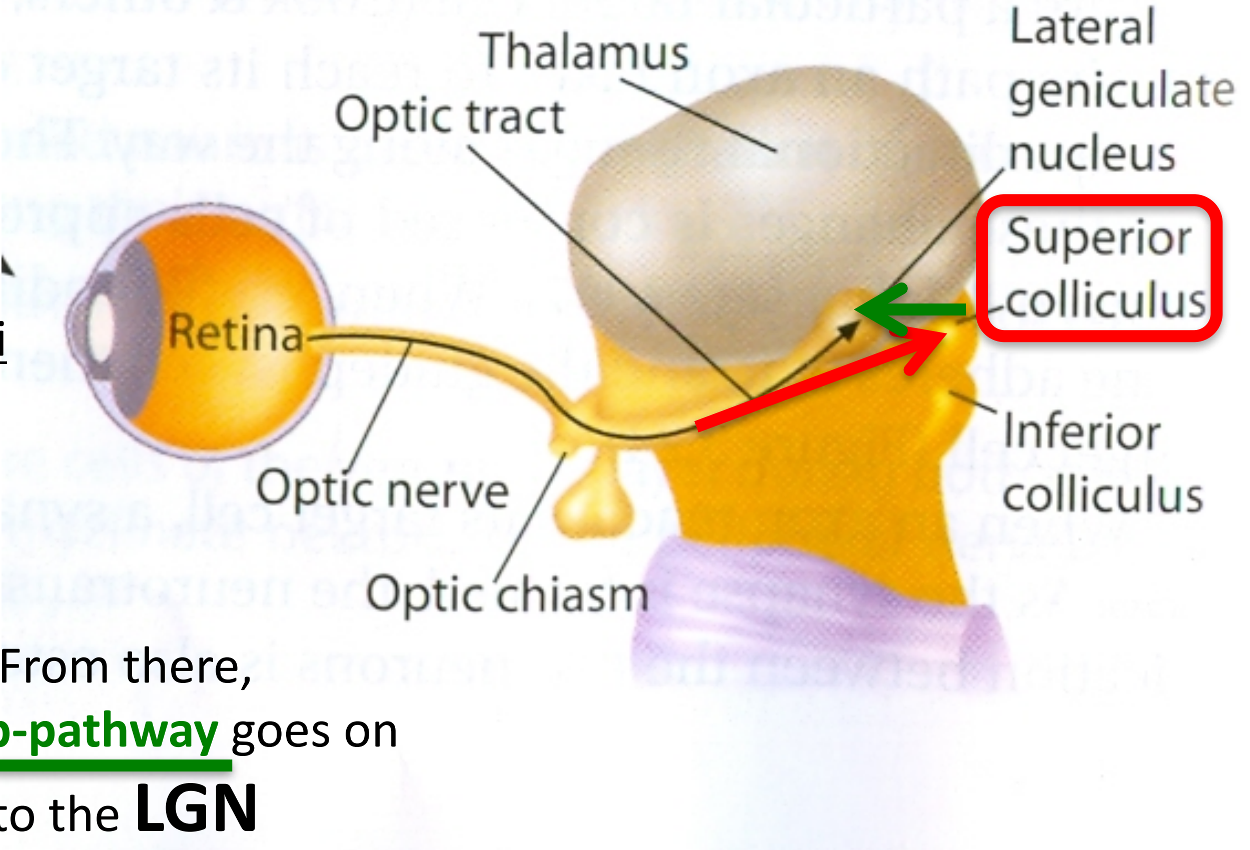
Magnocellular
Pathways
- Layers 1 & 2

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

Some axons along the Magnocellular Pathway go first to the

Superior Colliculus

in the Tectum of the Midbrain

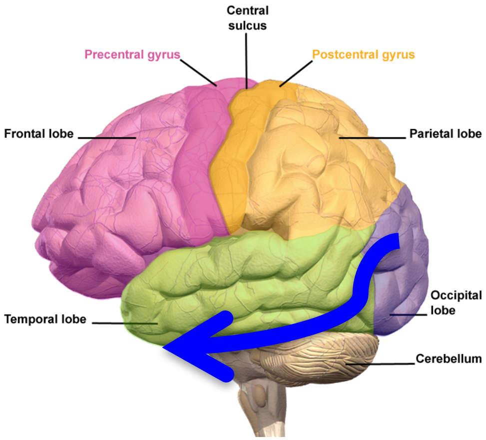


Used in Colliculi to map location of visually moving stimuli

Implicated in "Blindsight"

From there, this sub-pathway goes on to the **LGN**

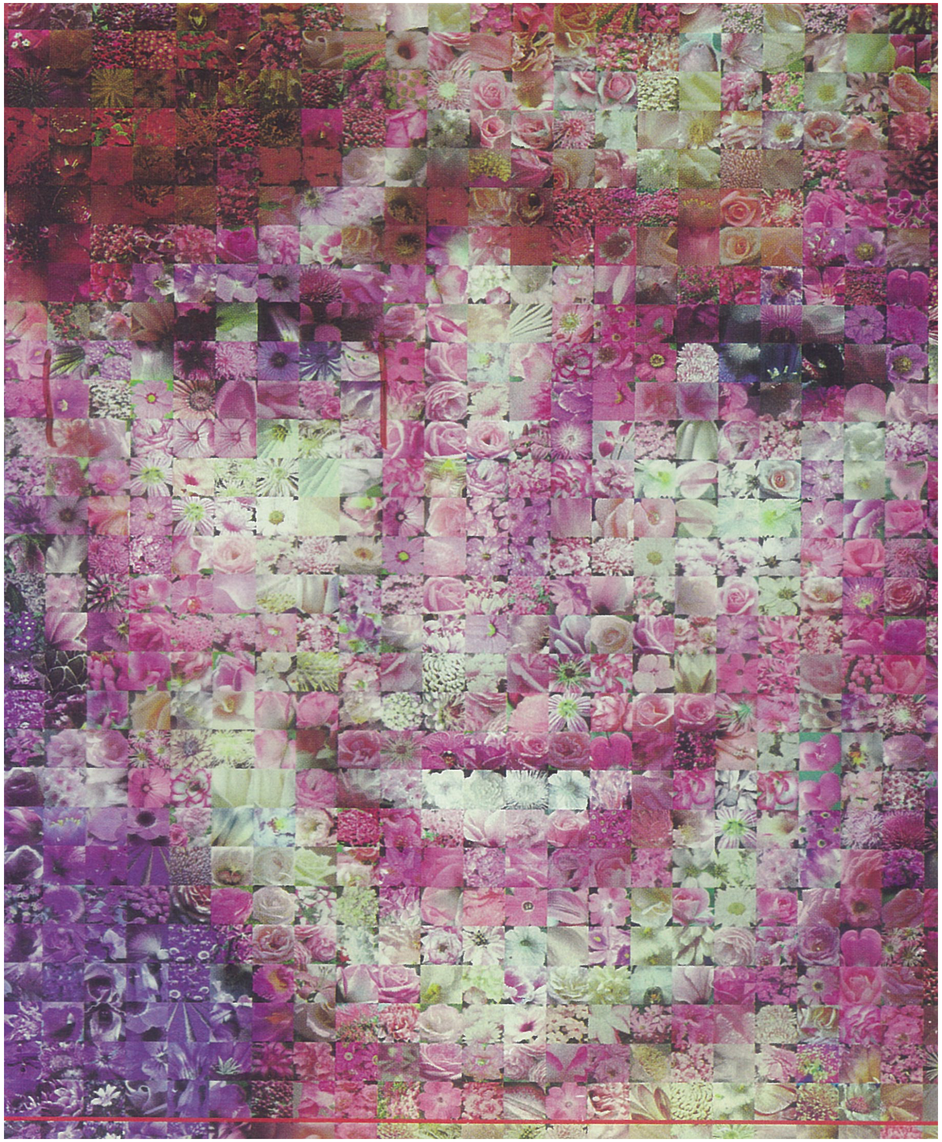
Parvocellular Pathway

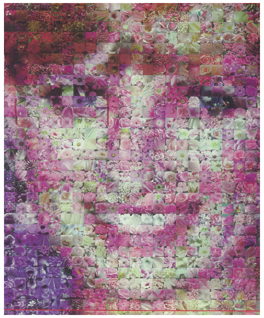


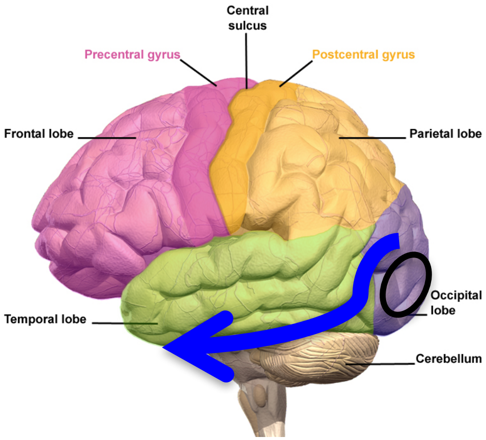
Color

&

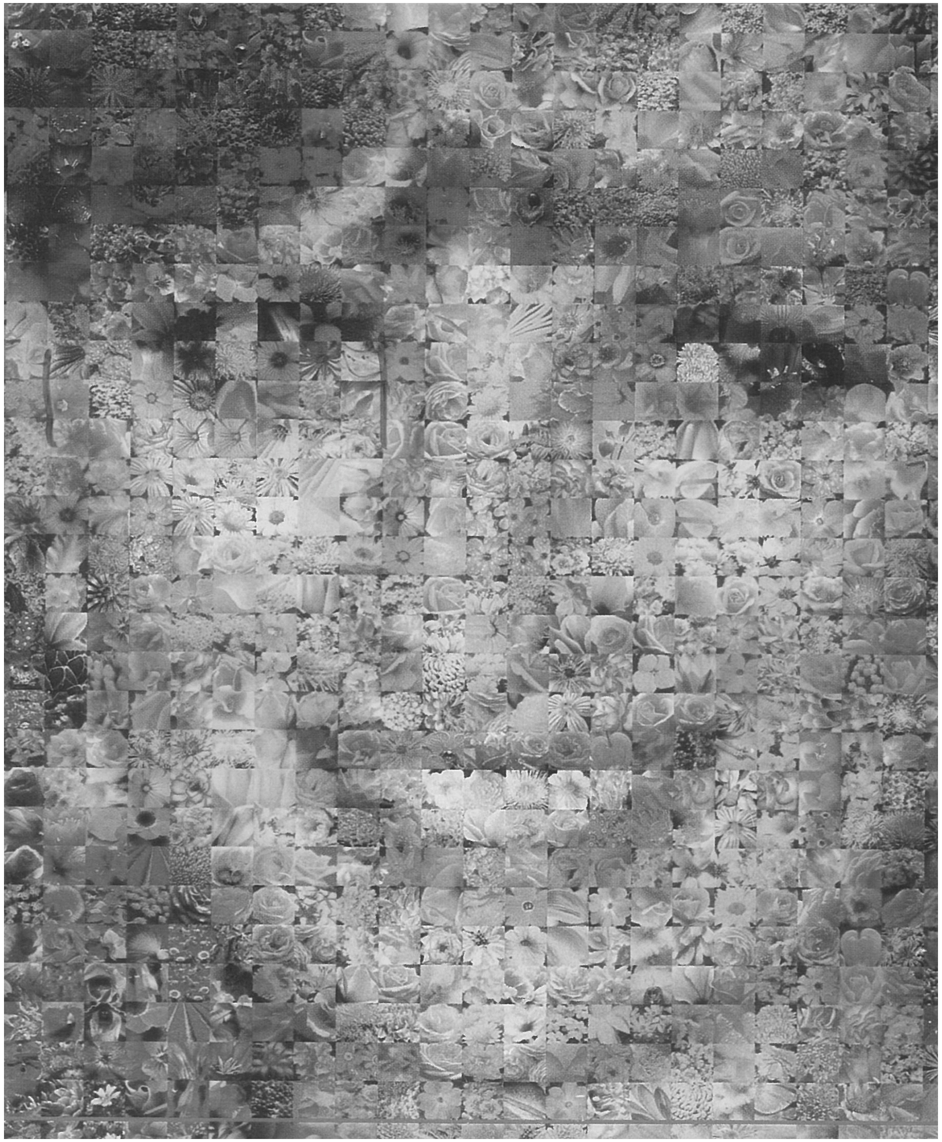
Detail







Parvocellular Pathway - **DETAIL**



Includes

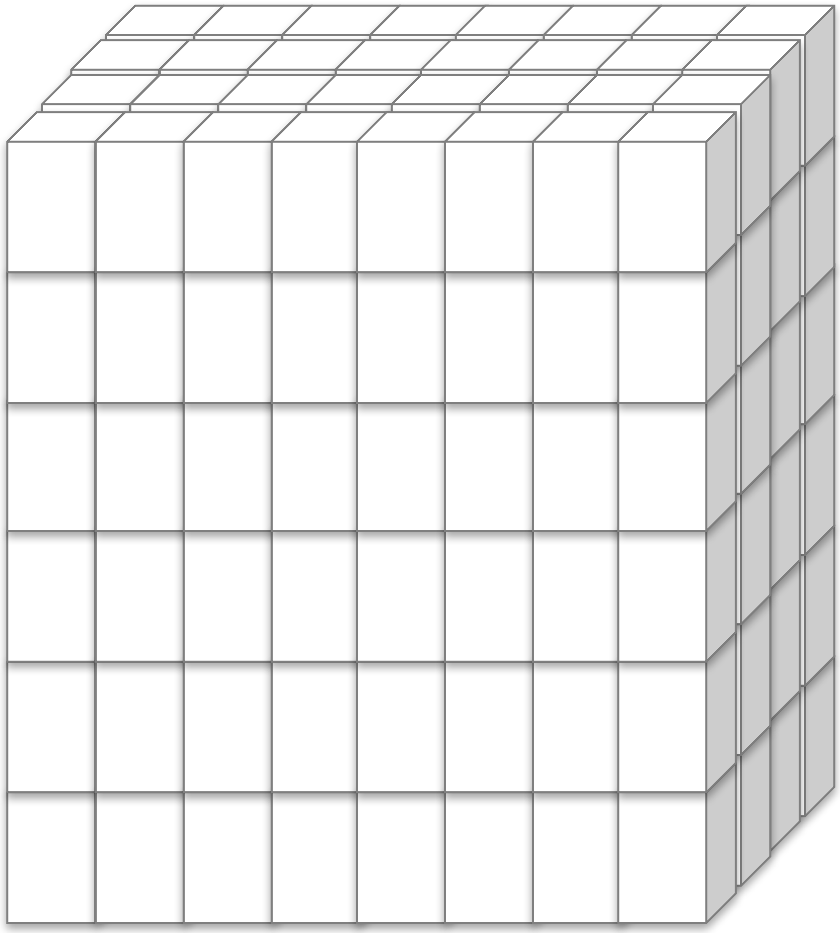
"Simple Cells"

(Bar Detectors)

In **V1**

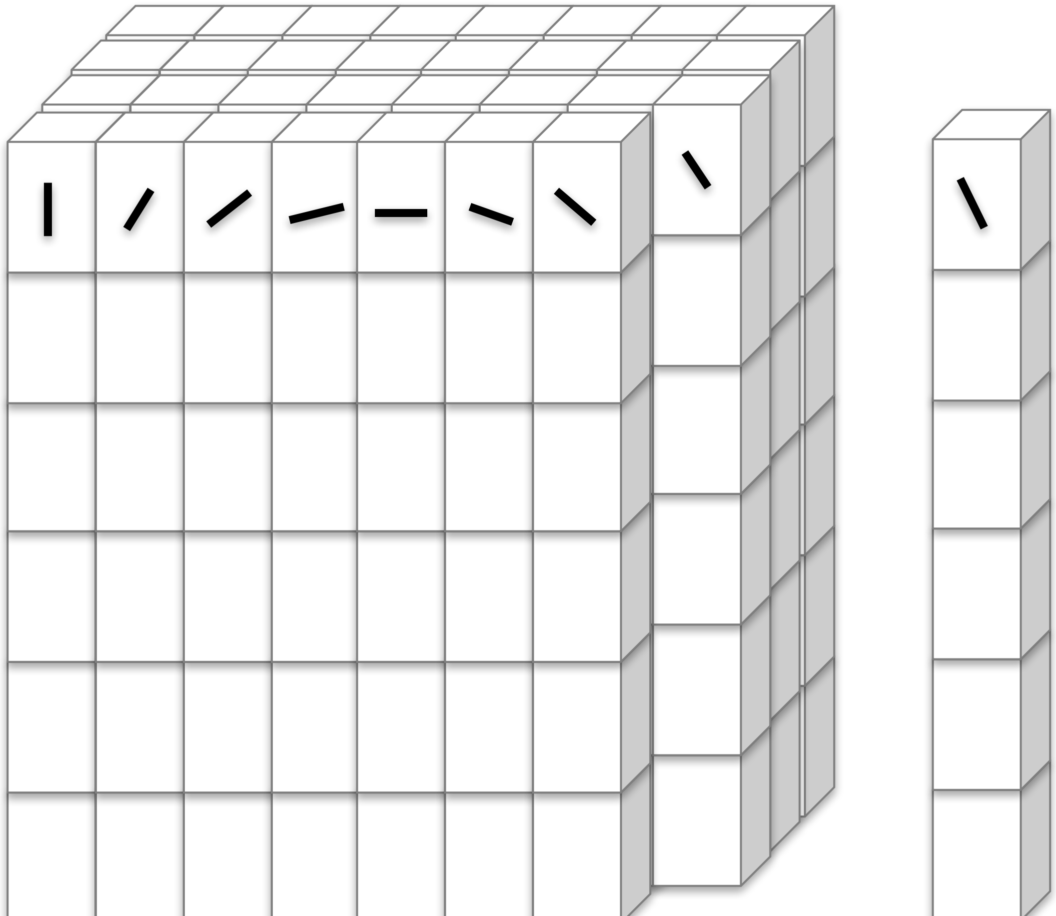
Columnar Organization in V1

6 Layered
Cortex



Columnar Organization in V1

6 Layered
Cortex

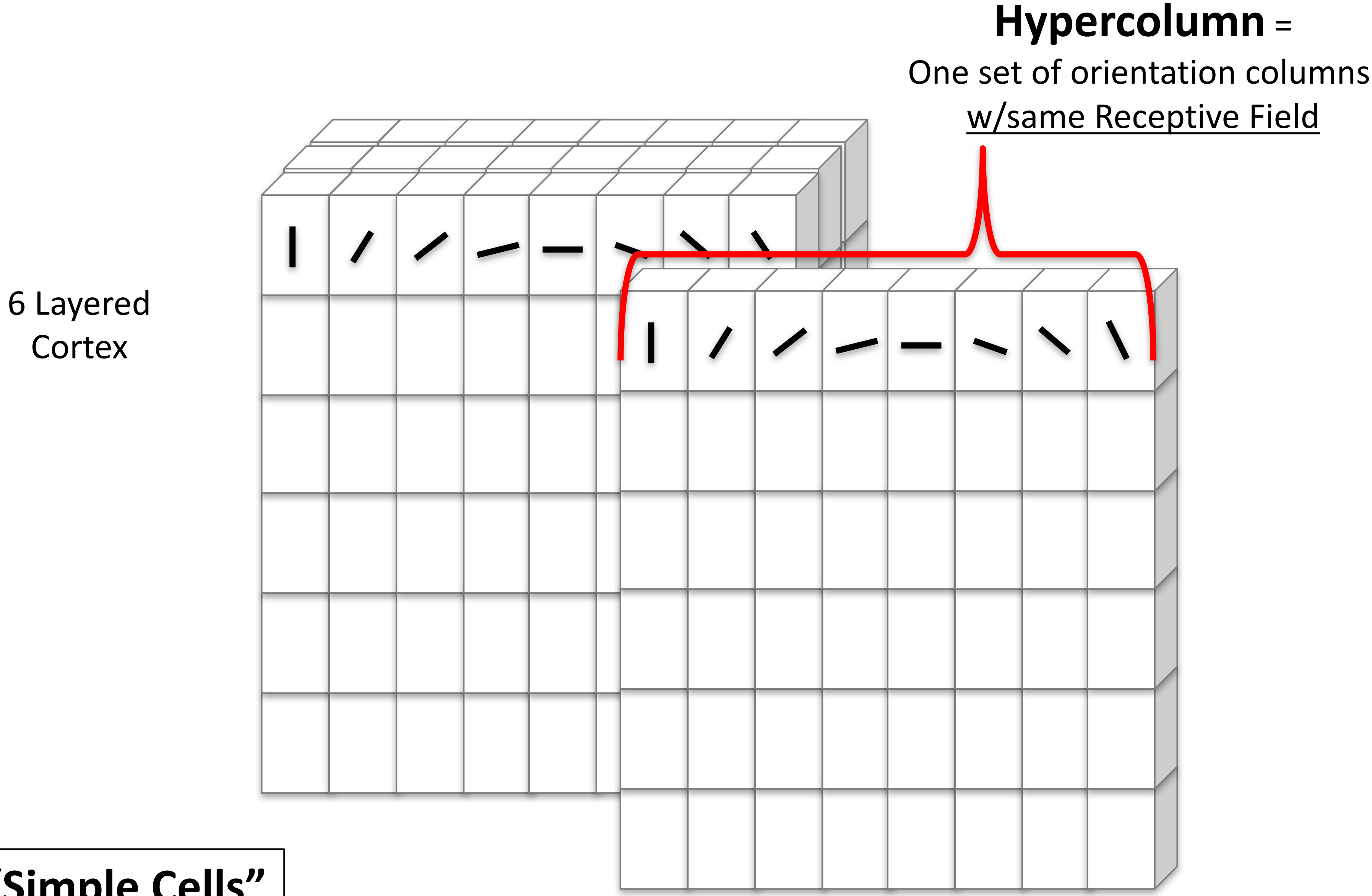


Column =
Cells in all
6 layers that
respond to same
"preferred" stimulus

In this case,
lines of a
particular
Orientation

"Simple Cells"

Columnar Organization in V1

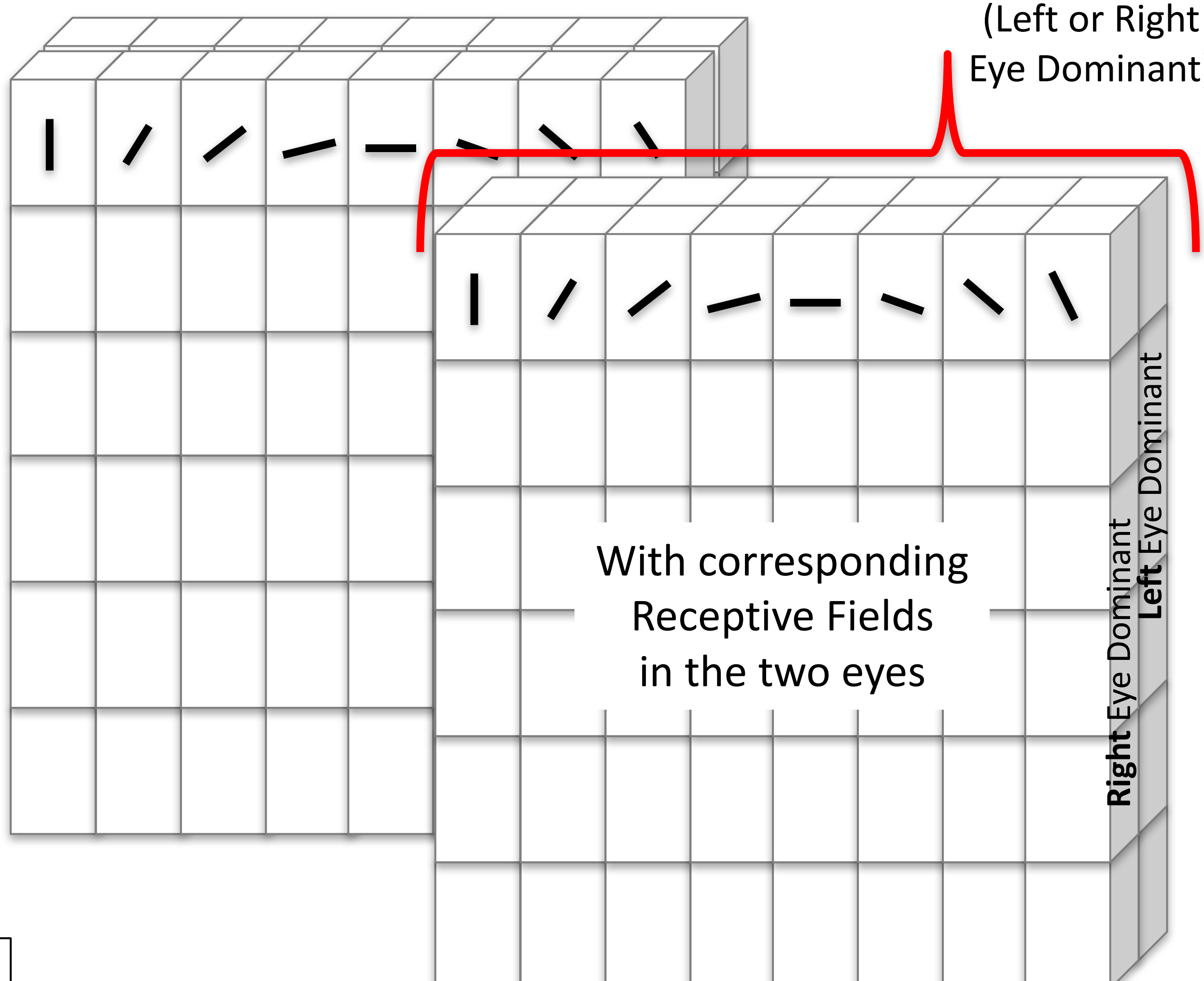


“Simple Cells”

Columnar Organization in V1

Hypercolumns
come in pairs
(Left or Right
Eye Dominant)

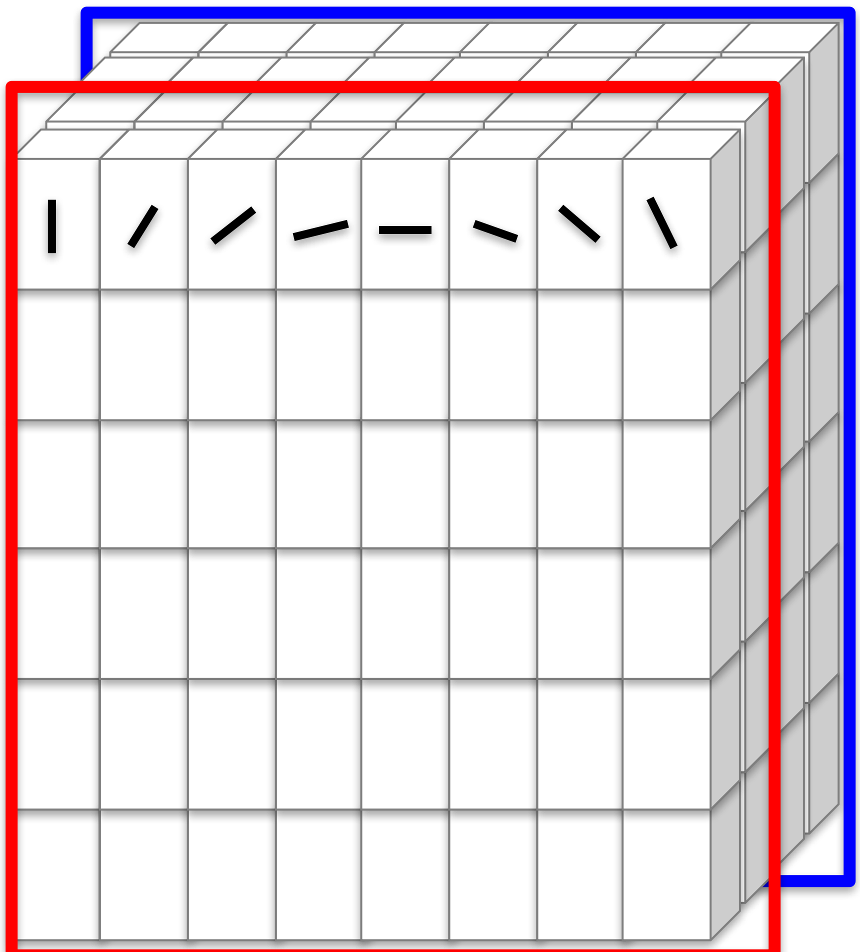
6 Layered
Cortex



“Simple Cells”

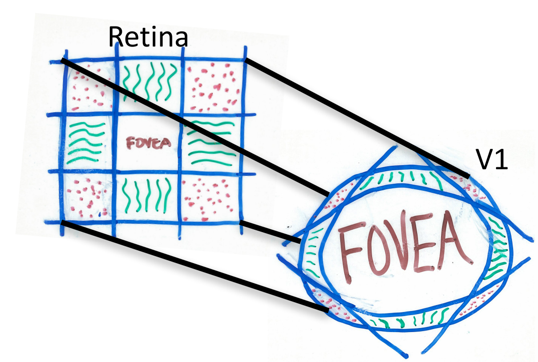
Columnar Organization in V1

6 Layered
Cortex



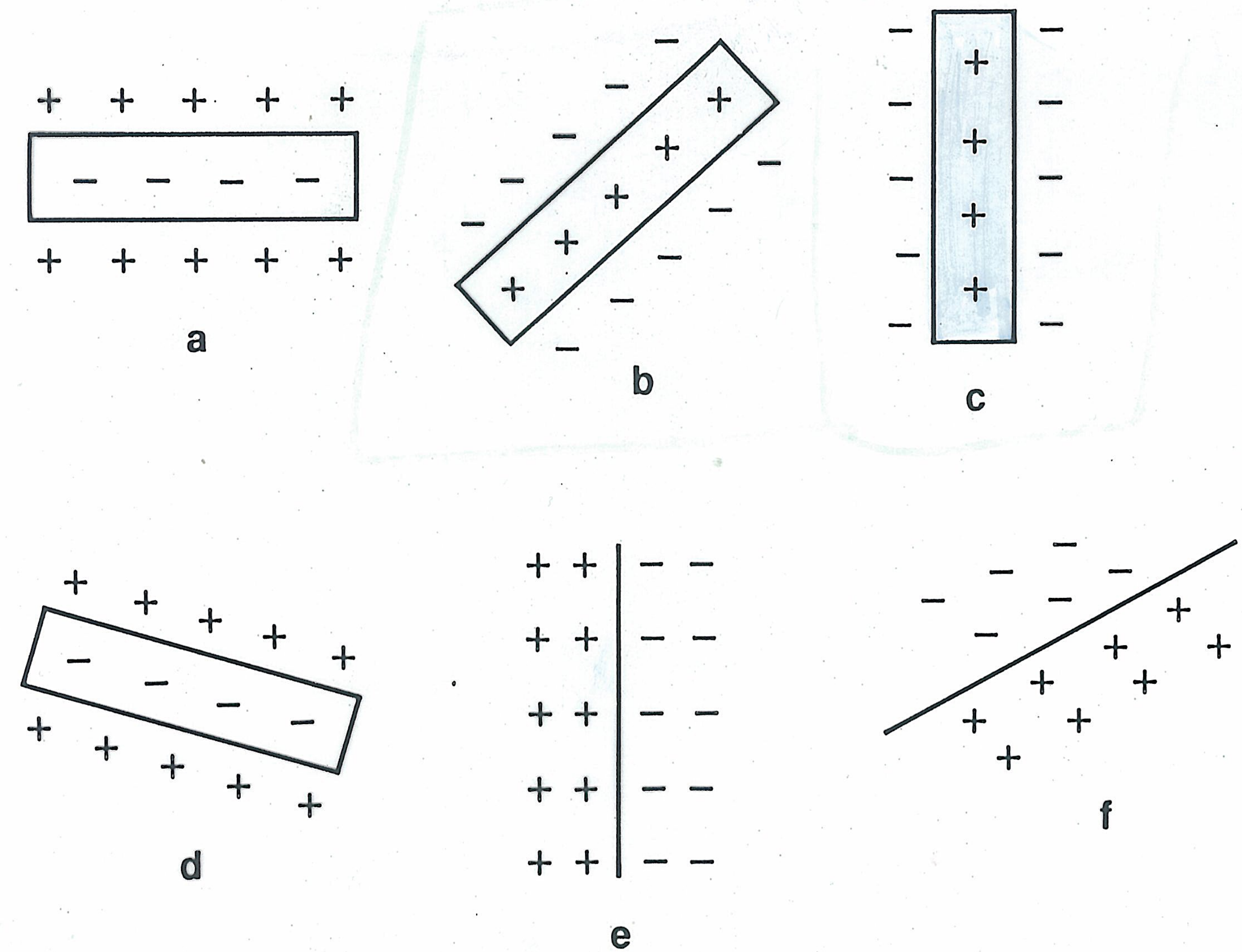
Adjacent Hypercolumn pairs
have adjacent
Receptive Fields in
Retina

= **Topological**
Map of the Retina
In V1



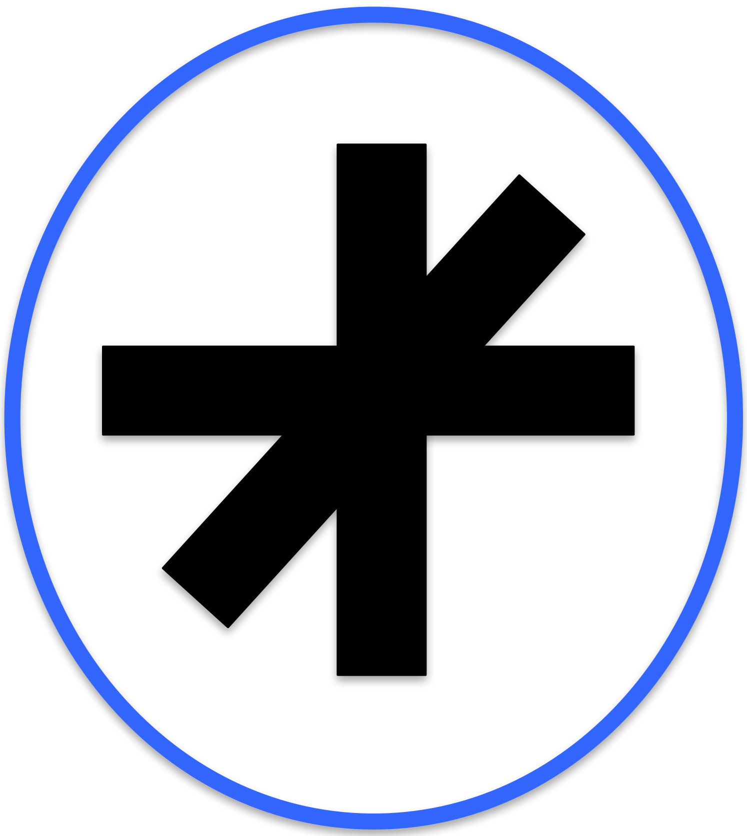
“Simple Cells”

"Simple Cells"
aka "Bar Detectors"



Simple Cells in V1

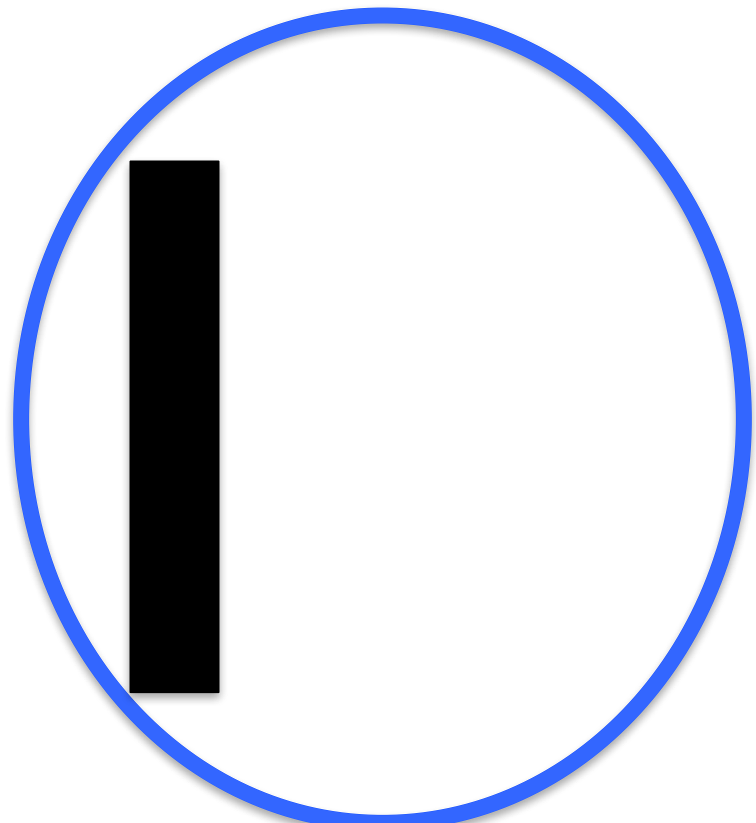
Respond to "bar" in a particular orientation in a given Receptive Field



Receptive Field of Simple Cell in Retina

"Complex" Cells in V2

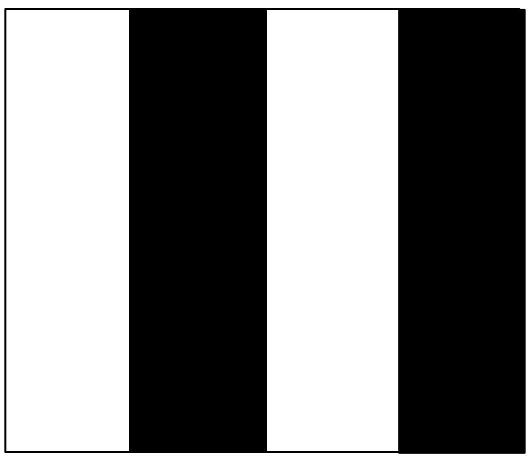
Respond to **moving** "bar" in particular orientation in given Receptive Field



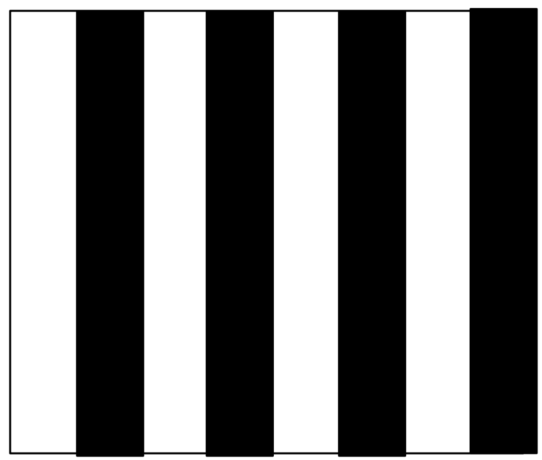
Receptive Field of Complex Cell in Retina

Spatial Frequency

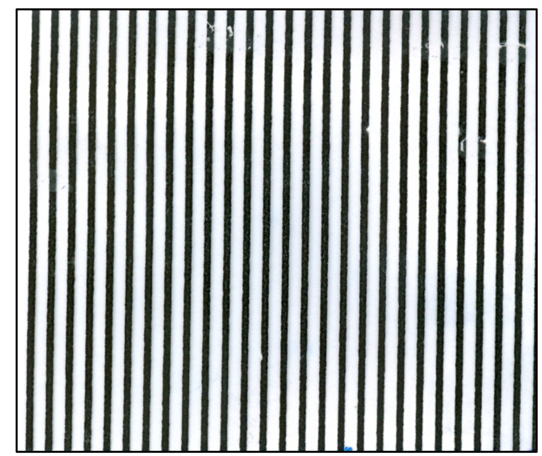
Changes in Contrast / Degree of Retinal Arc



LOW
Spatial Freq

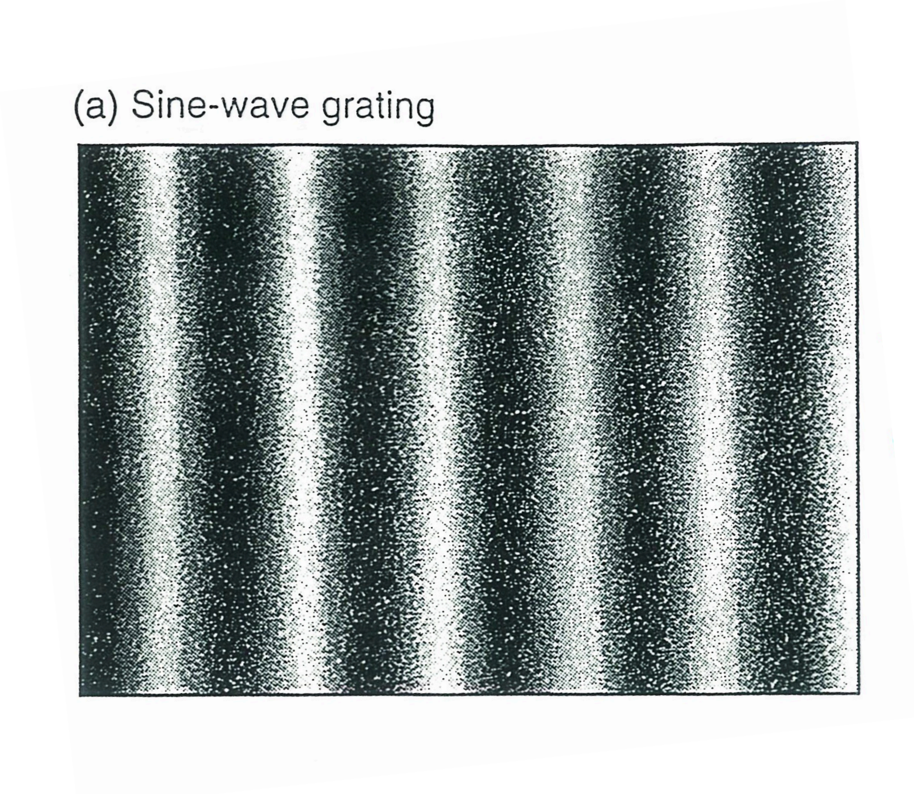


MEDIUM
Spatial Freq



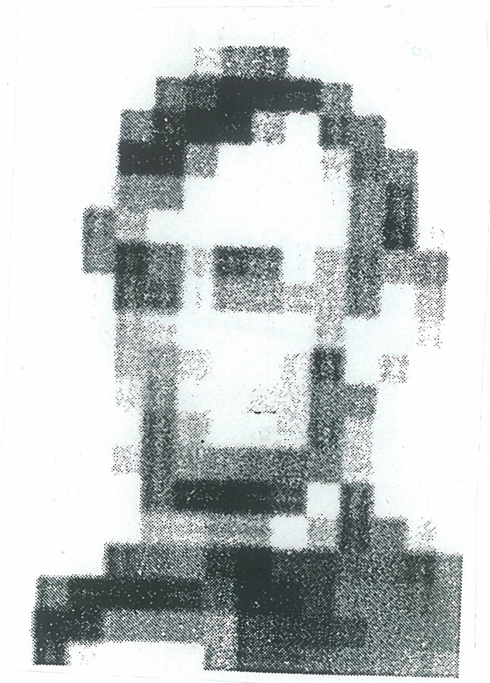
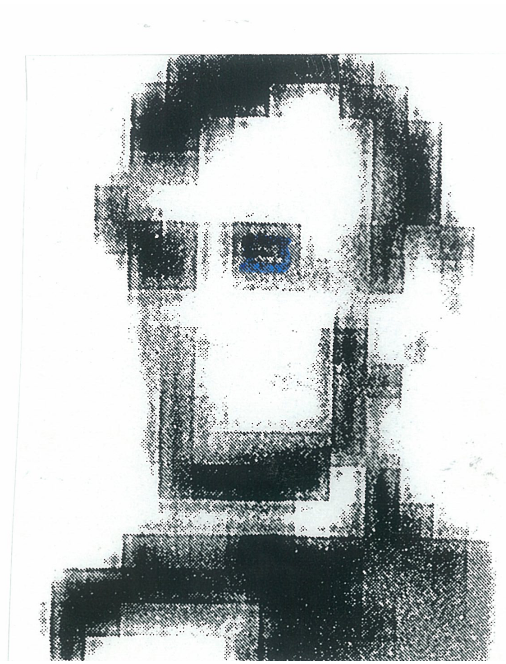
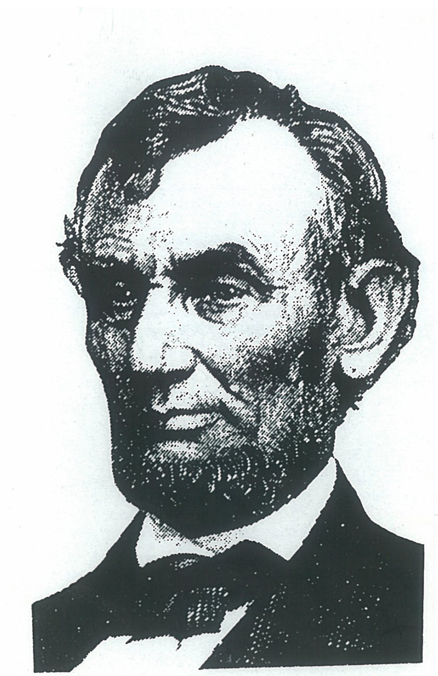
HIGH
Spatial Freq

Spatial Frequency



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???

Spatial Frequency Channels

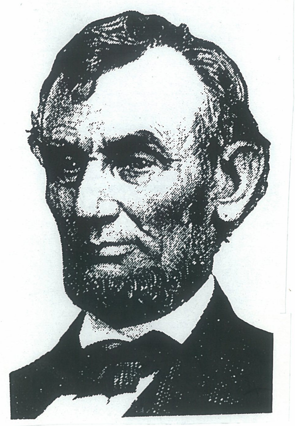
Given this stimulus...

<u>High</u>
Spatial
Frequency
gradients

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

Spatial Frequency Channels

Given this stimulus...



<u>Medium</u>
Spatial
Frequency
gradients

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

Given this stimulus...

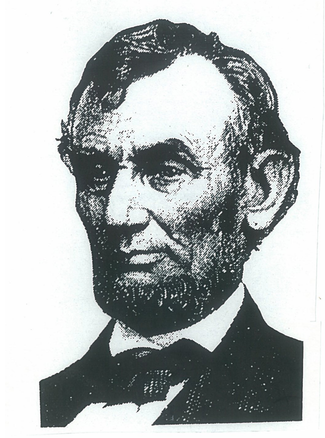
Spatial Frequency Channels

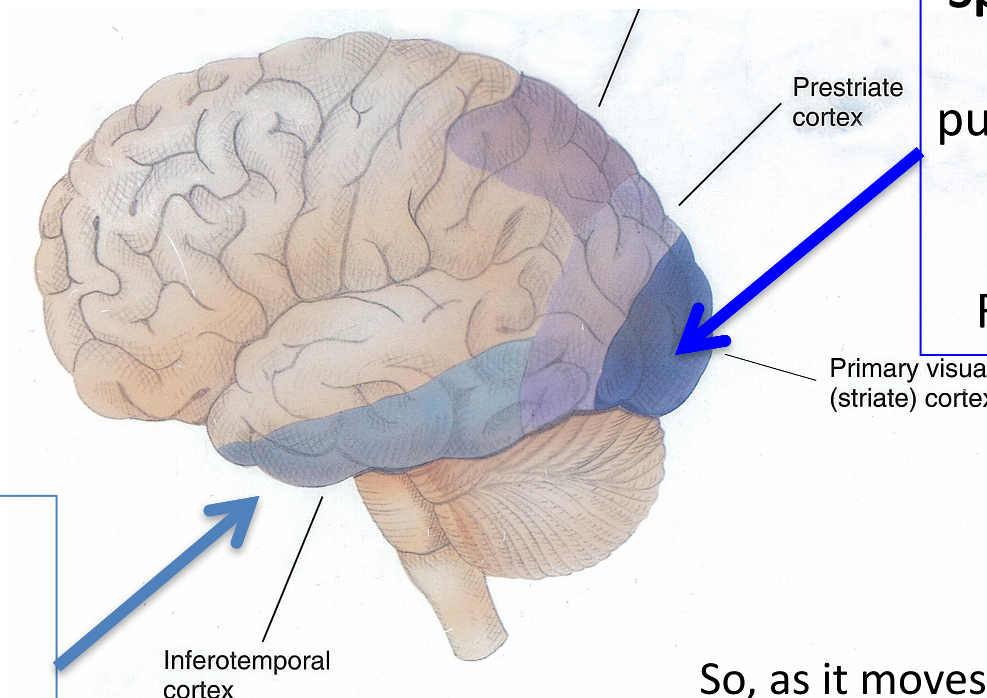
Low
Spatial
Frequency
gradients

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

Spatial Frequency Channels

Given this stimulus...

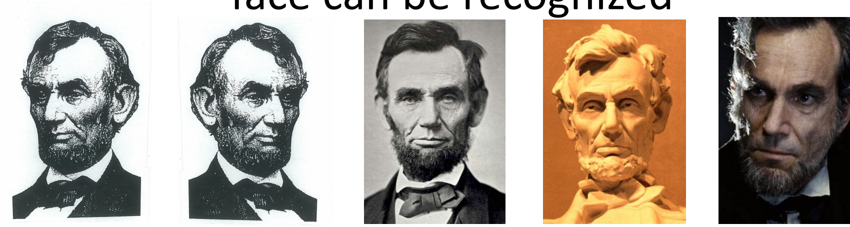




Spatial Frequency channels in V1 pull out sets of SFs, low to high, from affected Receptive Fields

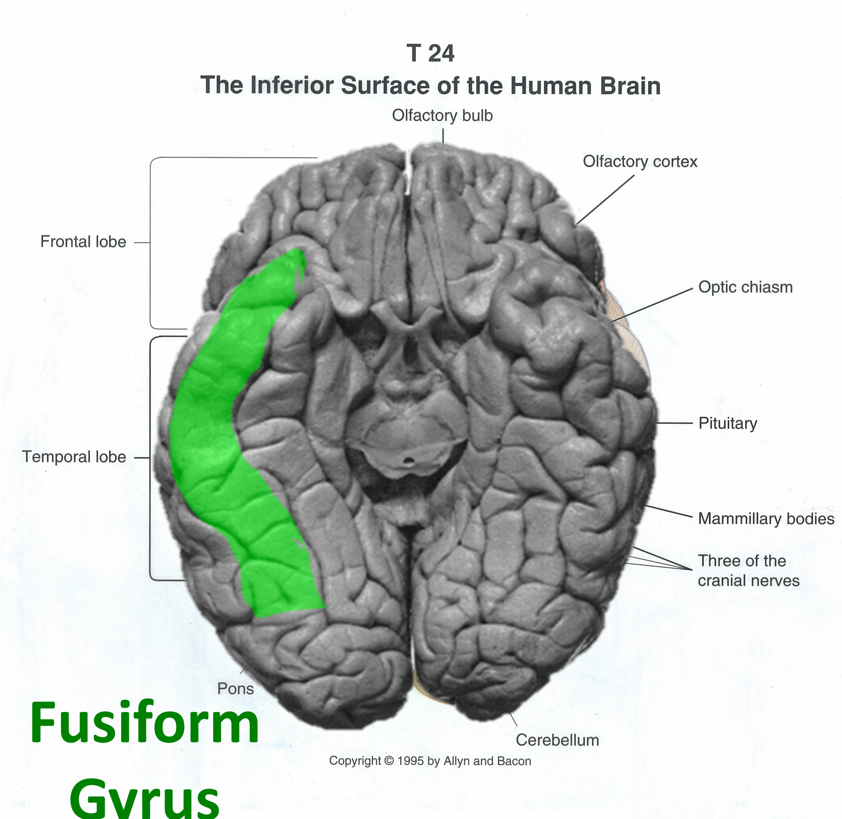
While circuits in **Inferior Temporal** respond to (enable recognition of) face as a whole.

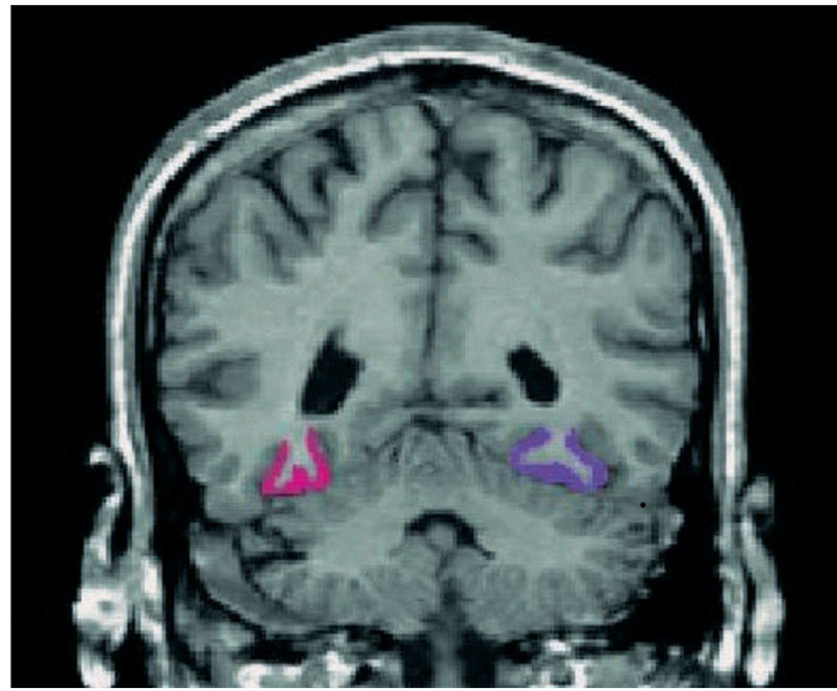
So, as it moves up pathway, info is "reassembled", but in an abstract (relational) way, so almost any version of face can be recognized



Fusiform Gyrus

Face recognition in Inferior Temporal (IT) Cortex





Posterior Coronal Section

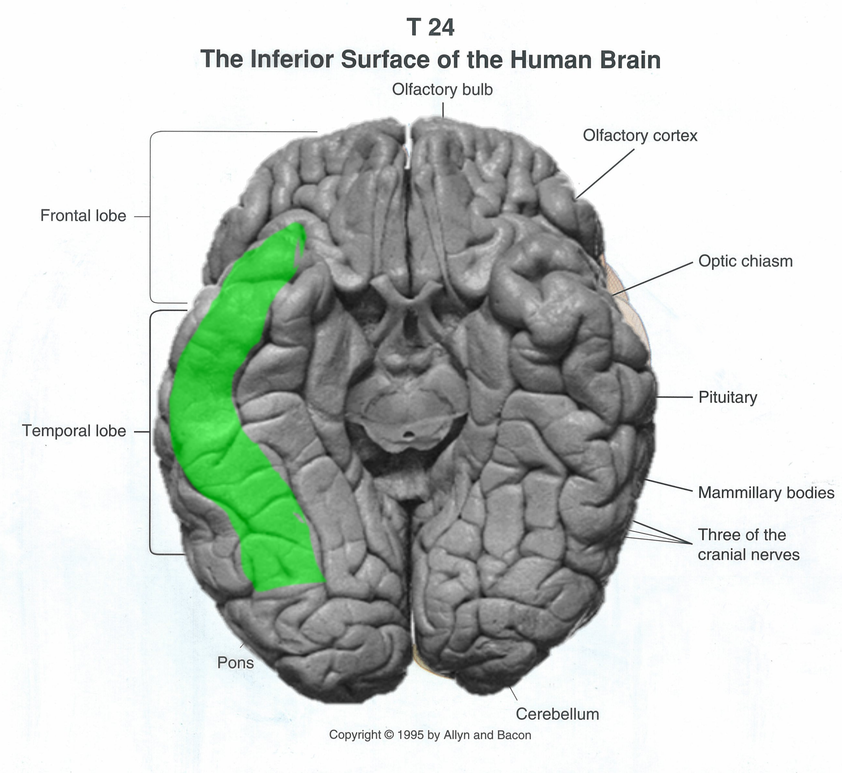
Damage to the Fusiform Gyrus can result in

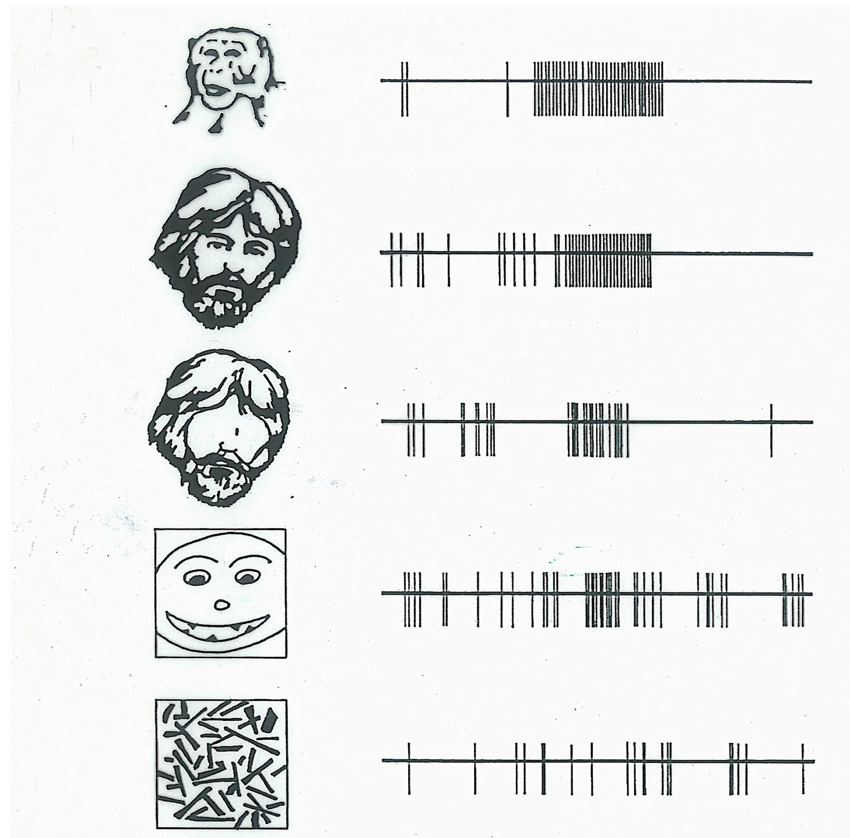
Prosopagnosia

- Inability to recognize faces

Fusiform Gyrus

Face recognition in Inferior Temporal (IT) Cortex



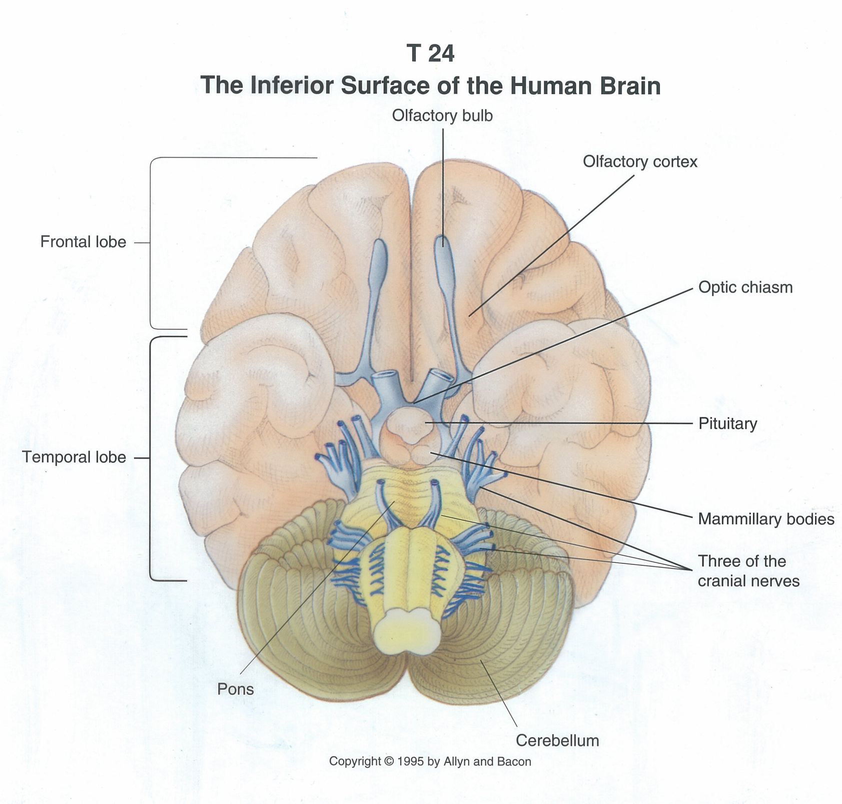


Damage to the Fusiform Gyrus can result in

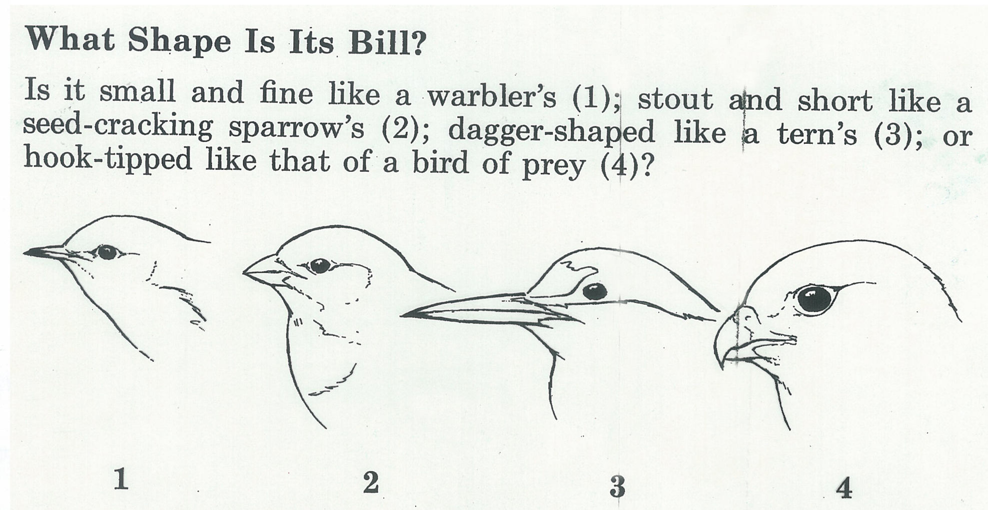
Prosopagnosia

- Inability to recognize faces

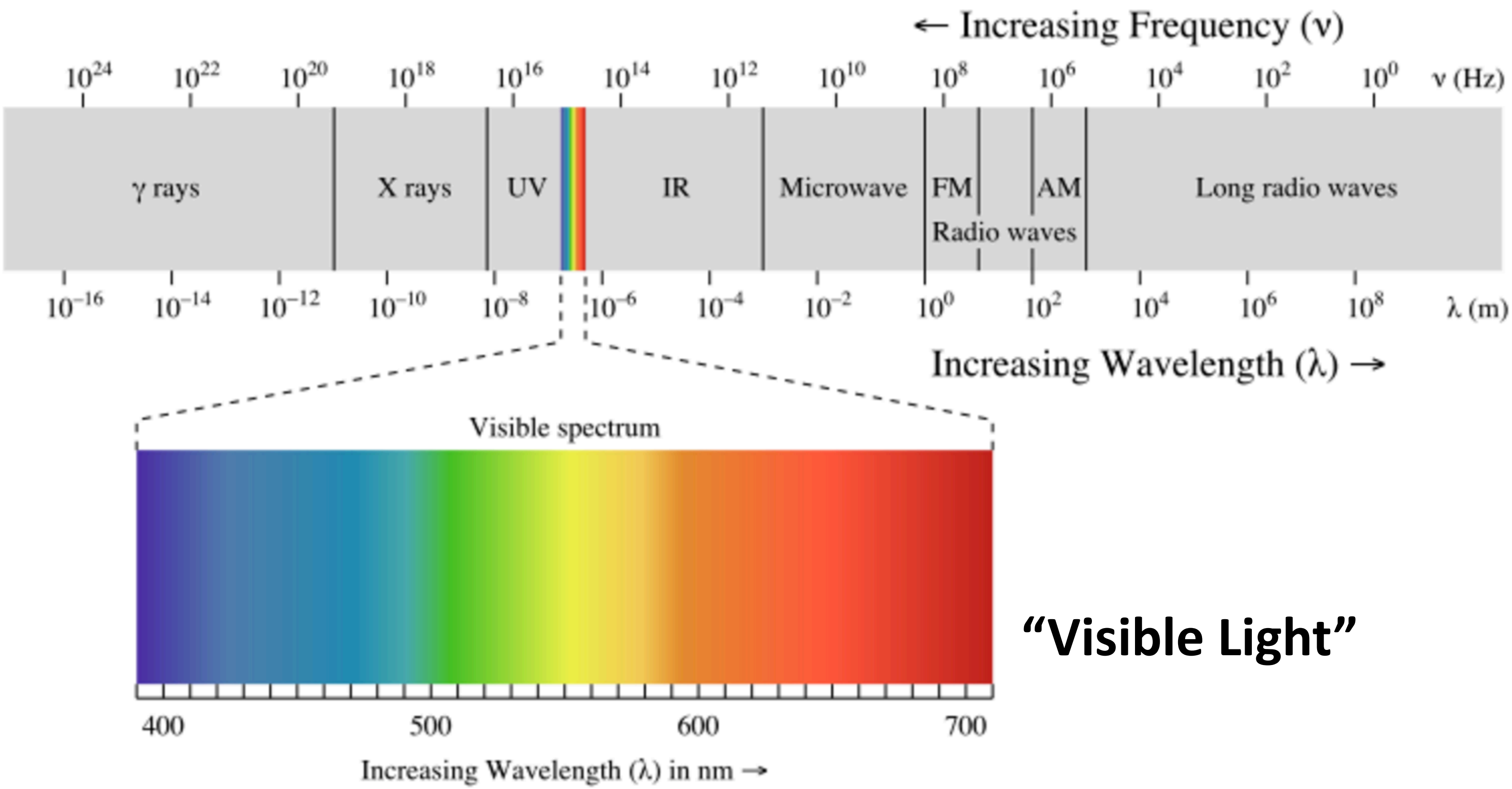
Other "Complex" Cells in Inferior Temporal



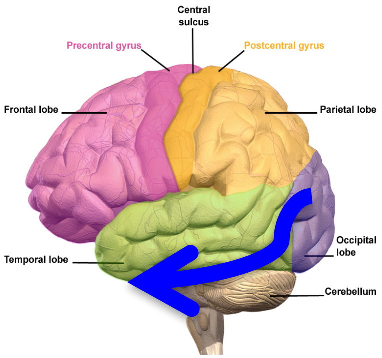
For visual recognition of other learned distinctions



Electromagnetic Radiation Spectrum



"Visible Light"

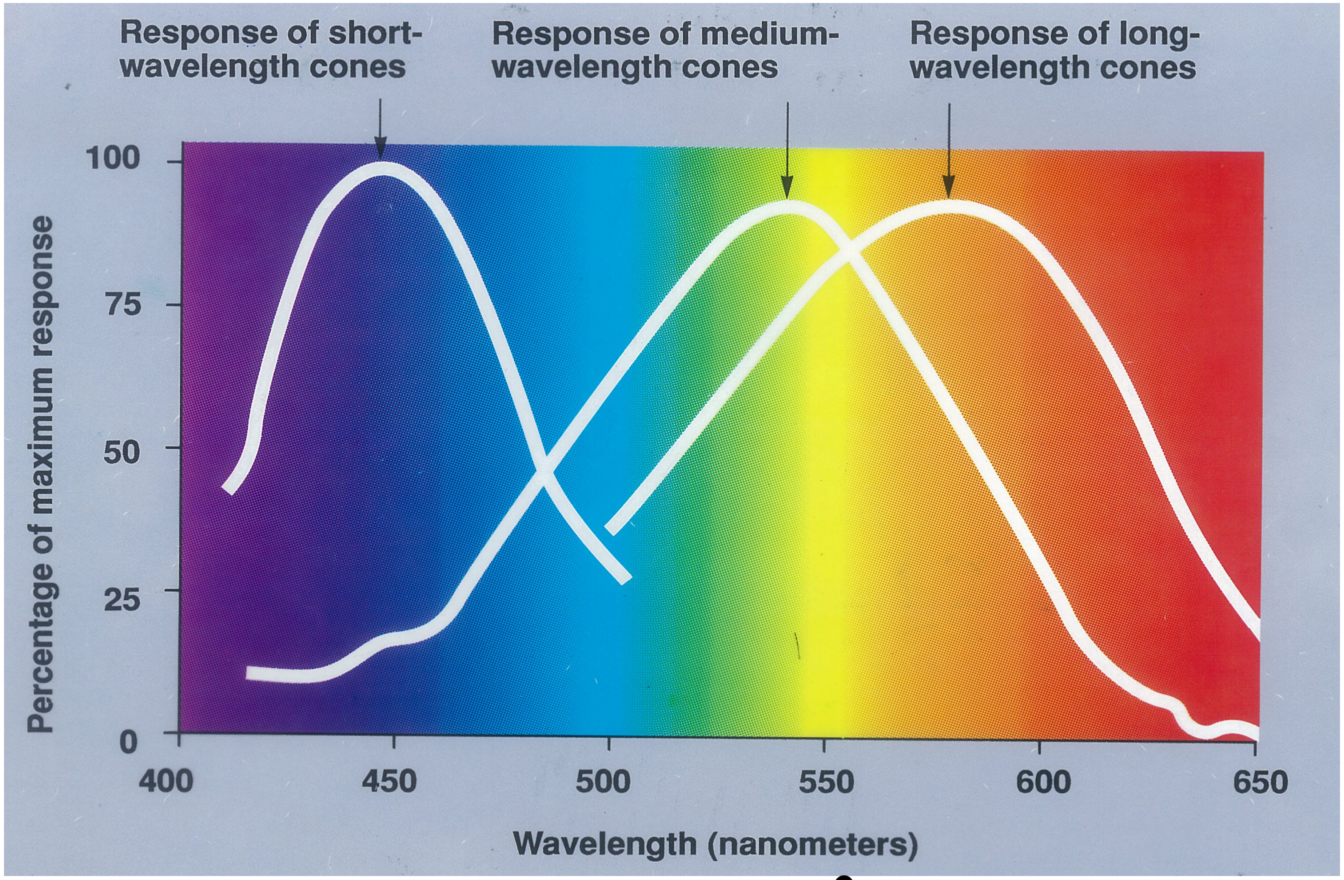


Trichromatic Color Vision

Three Cone Types

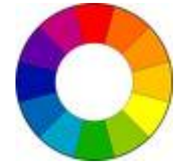
-- each with its own type of Opsin

-- each responsive to a different range of wavelengths



Wavelength = λ

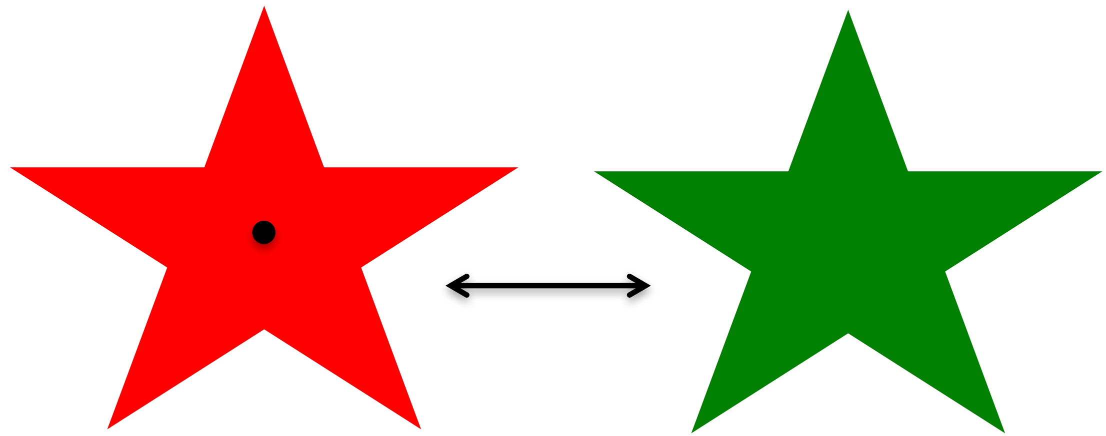
Color Opponency



After-Images

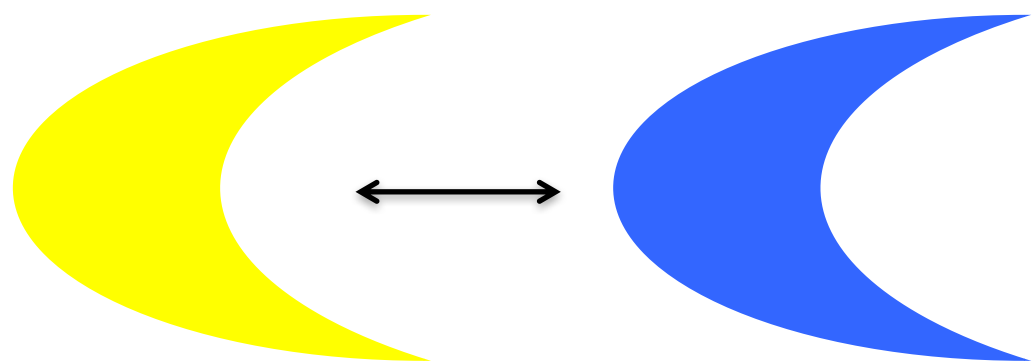
Adapt to **Red**,
will see **Green** afterimage

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



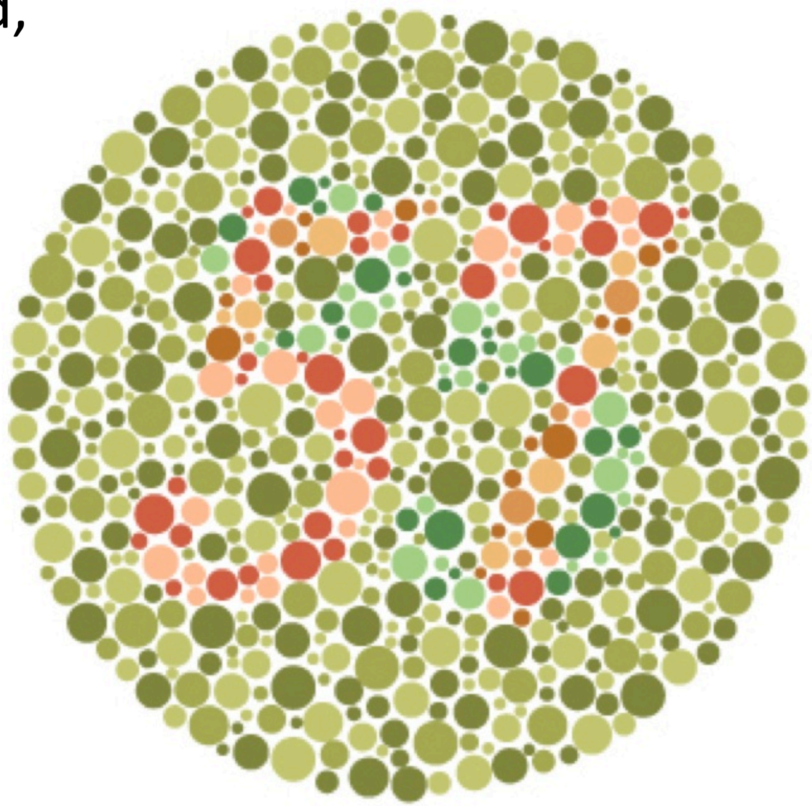
Adapt to **Yellow**,
will see **Blue** afterimage

Adapt to **Blue**,
See **Yellow**



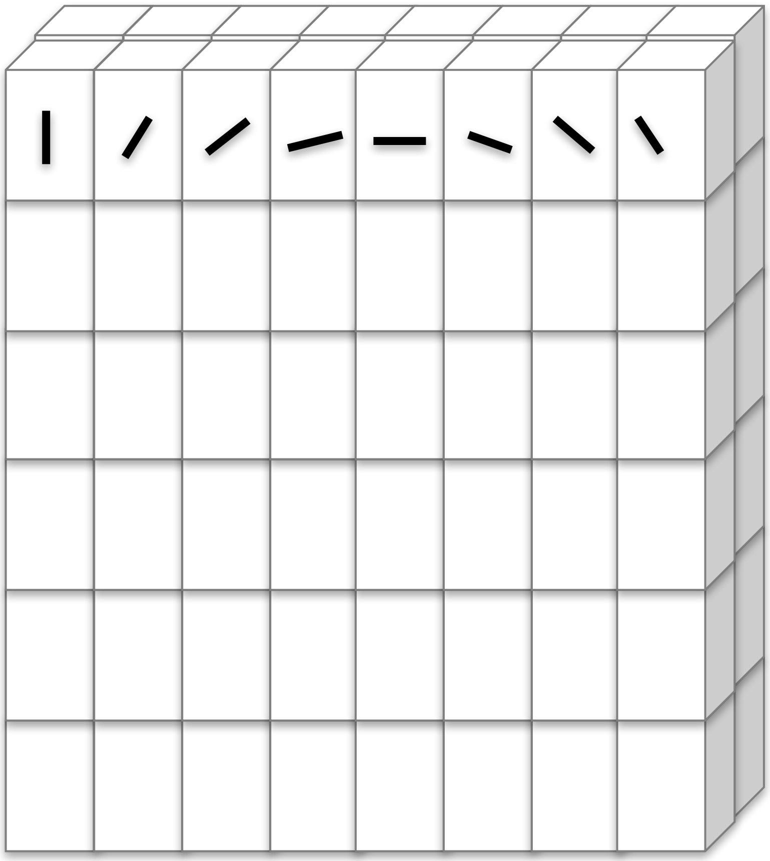
Color Opponency

When people are color blind,
they will be blind to
Red & **Green**
<u>or</u> to
Yellow & **Blue**



Color "**Blobs**" in V1

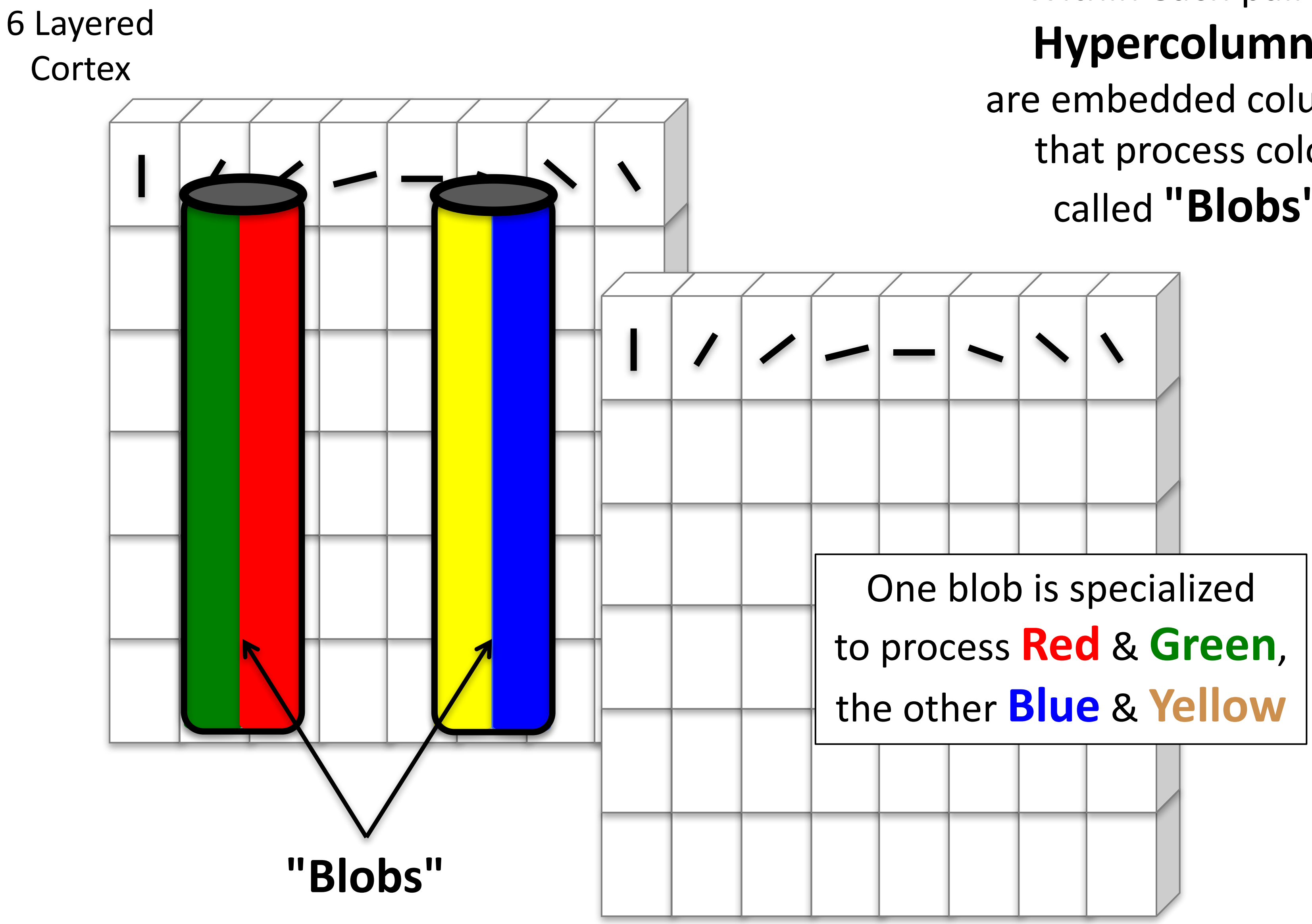
6 Layered
Cortex



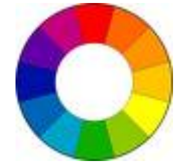
Within each pair of
Hypercolumns
are embedded columns
that process color
called "**Blobs**"

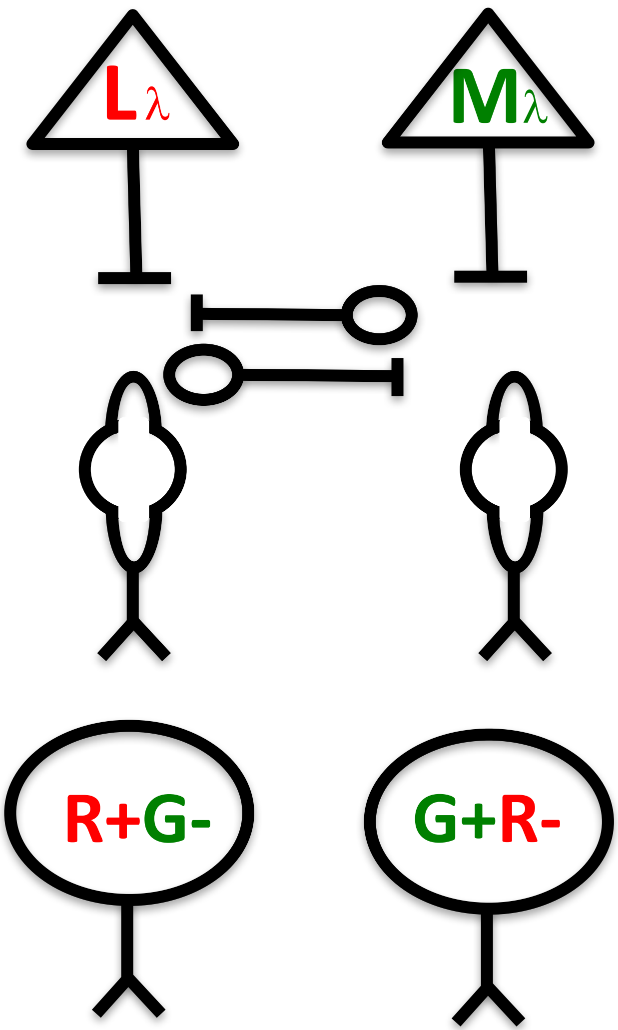
Color "**Blobs**" in V1

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



Color Opponency





Long/Medium Wavelength Cones

Horizontal "C" Cells
(Lateral Inhibitors)

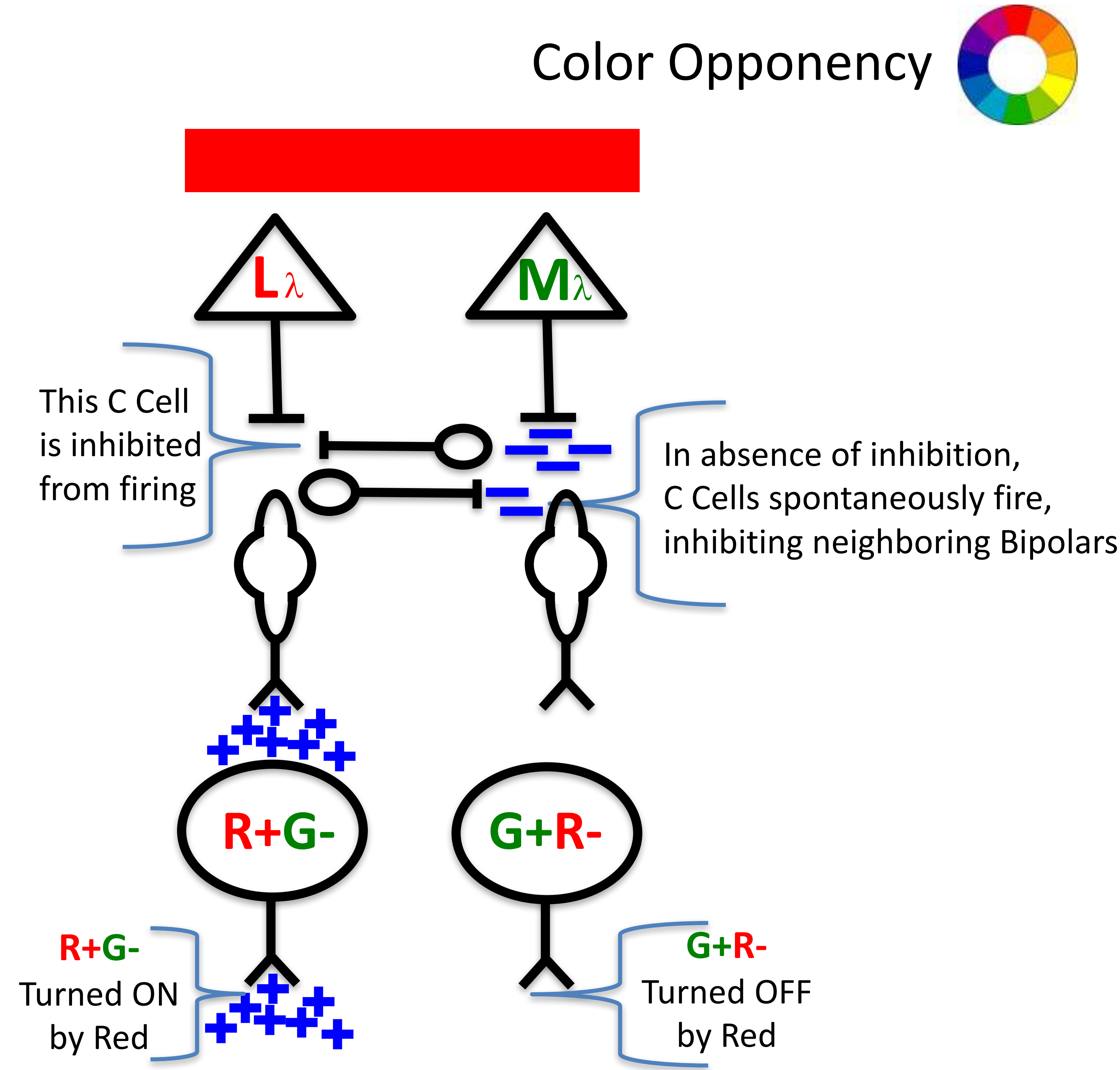
Bipolars

Opponent Cells
(Ganglions)

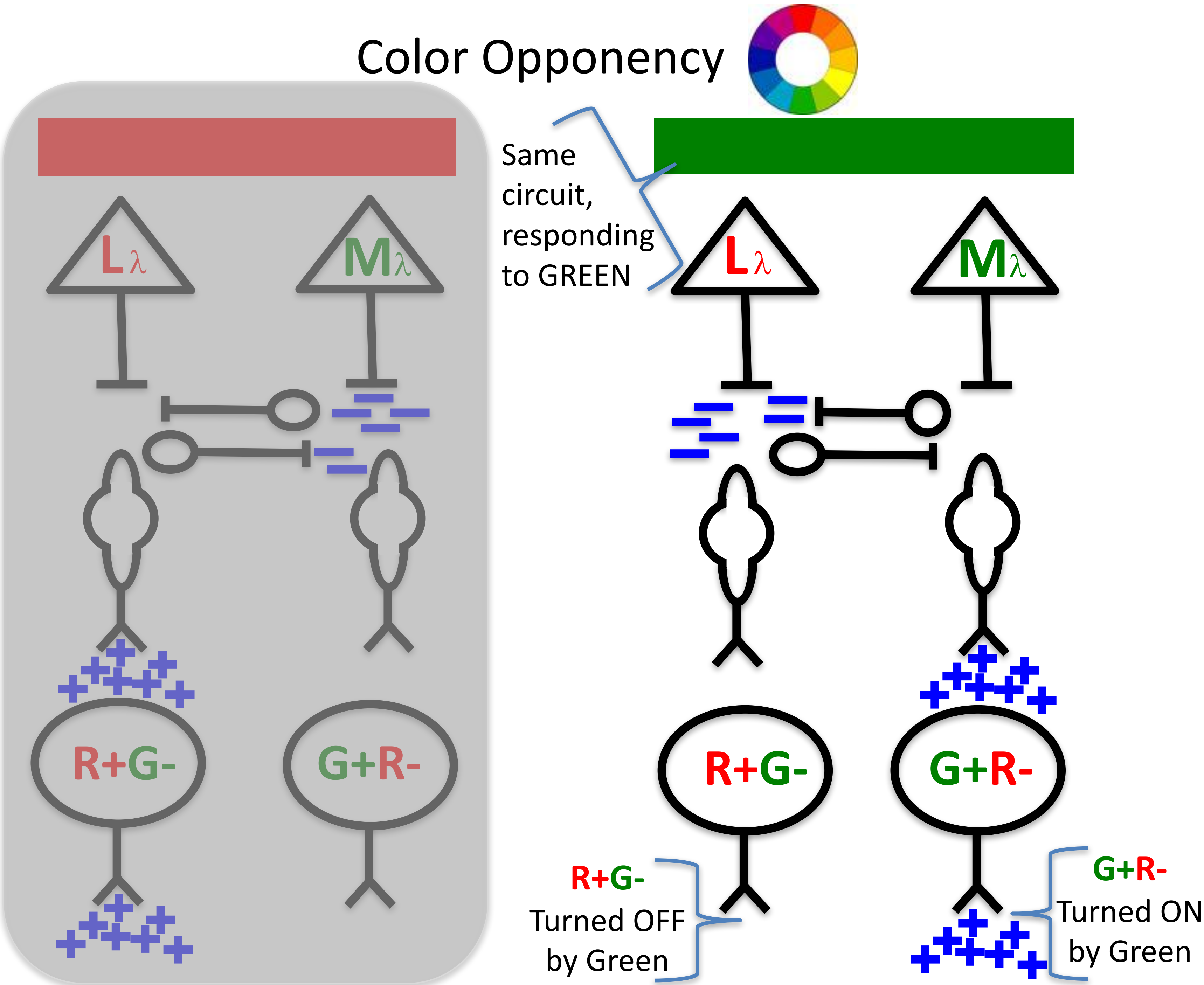
R+G-
Turned on by Red, off by Green

G+R-
Turned on by Green, off by Red

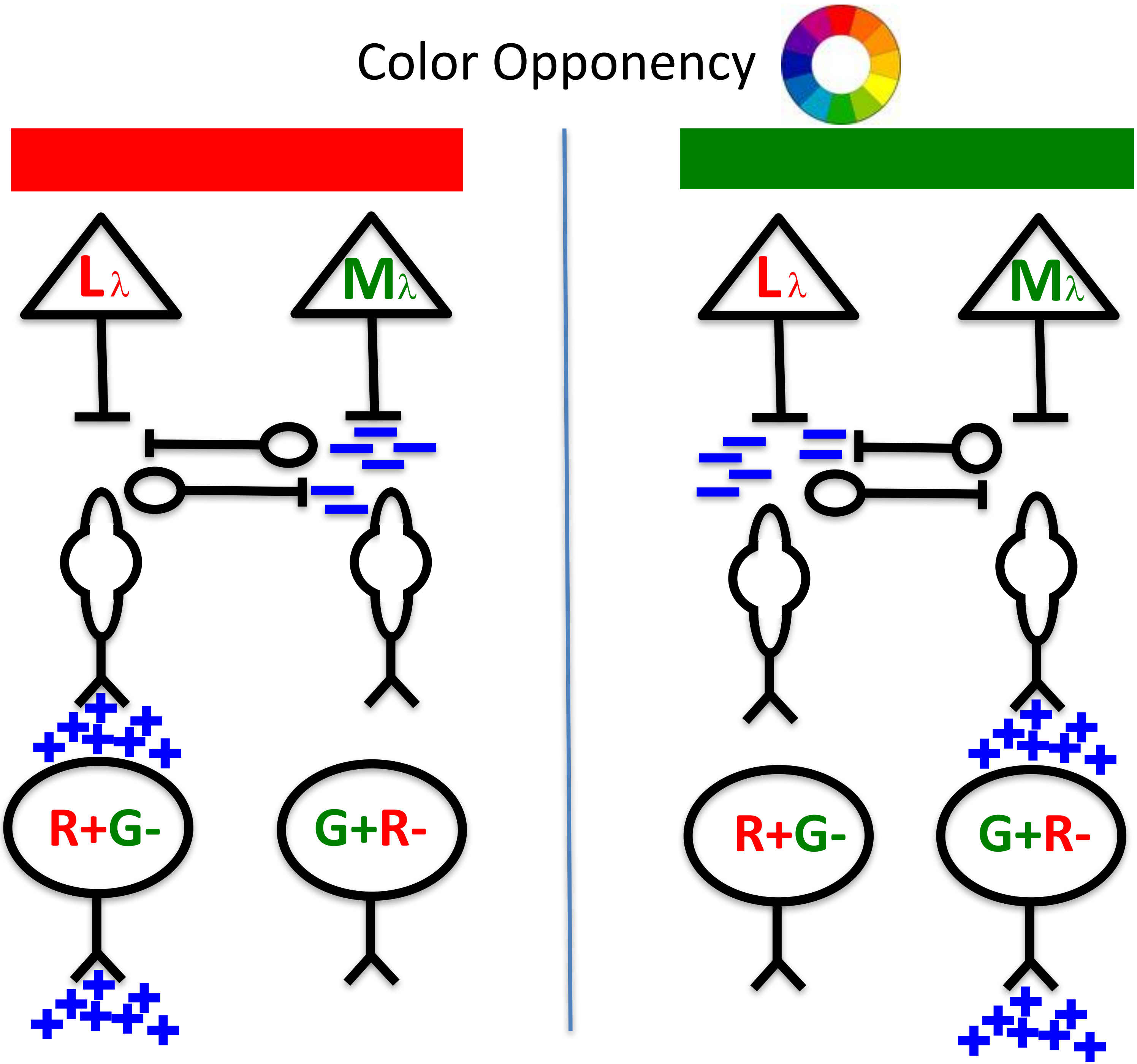
Color Opponency



Color Opponency

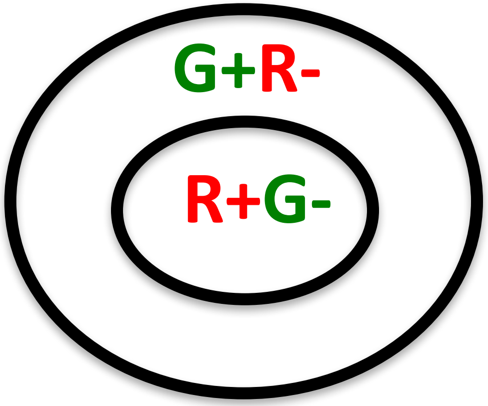


Color Opponency



Double Opponent Cell

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

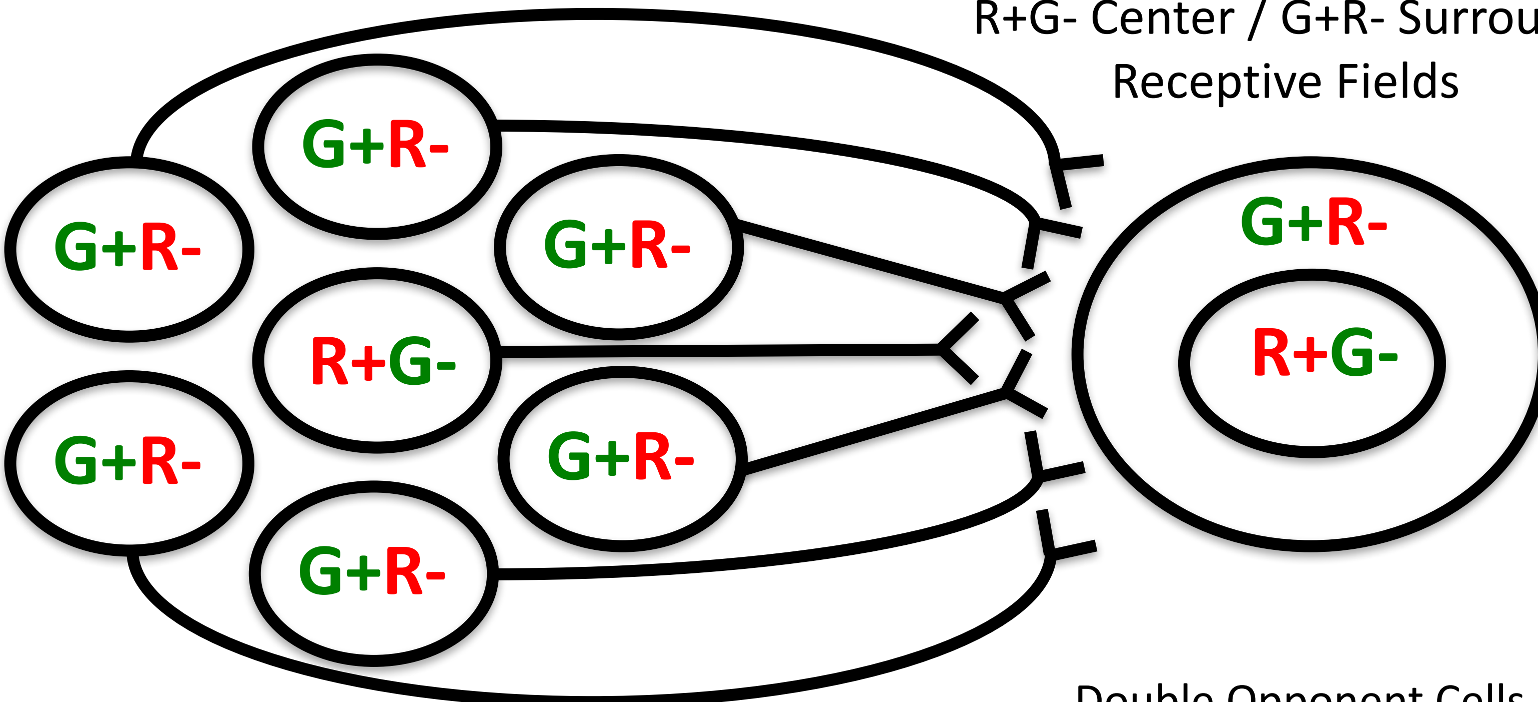


Double Opponent Cells
in Striate Cortex (V1)

Double Opponent Cell

Created by the convergence of
Opponent Cells from LGN

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

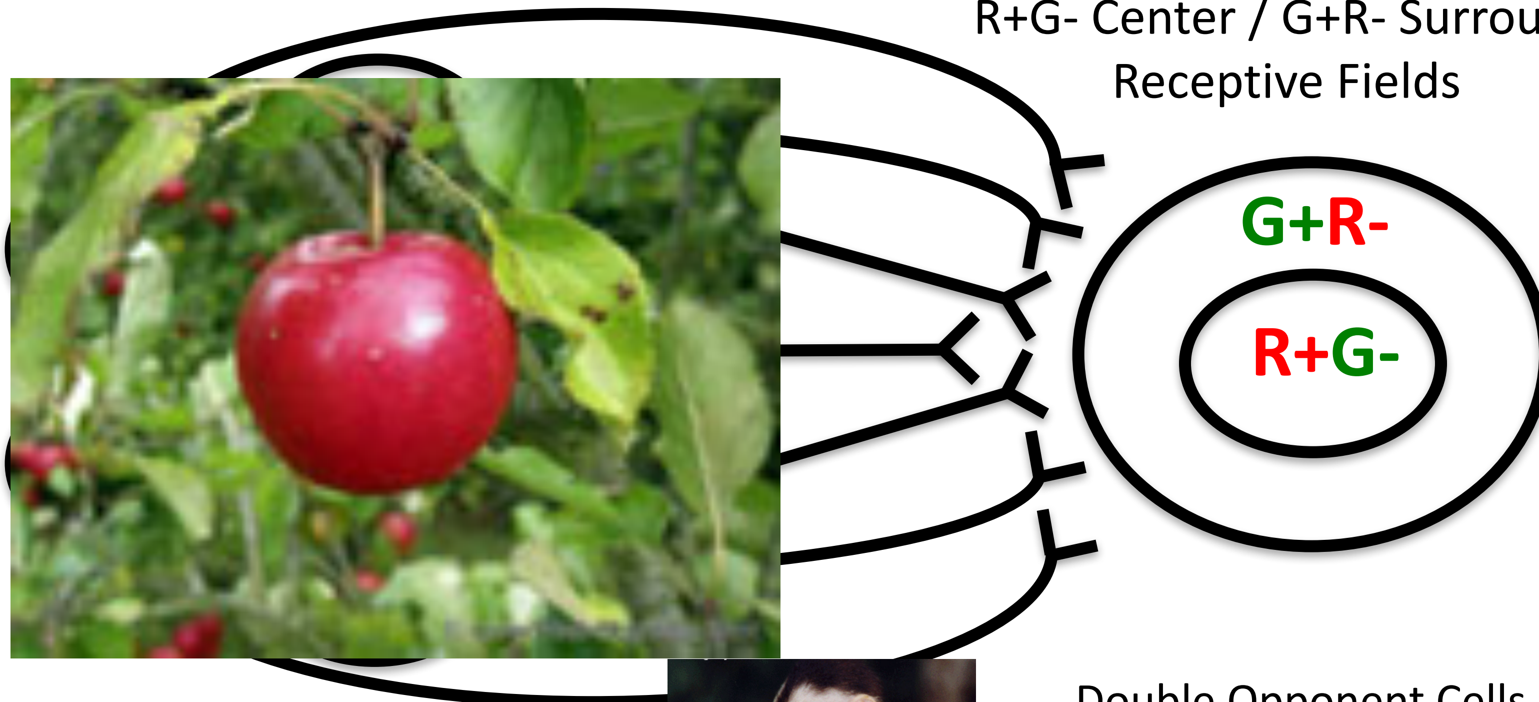


Double Opponent Cells
in Striate Cortex (V1)

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)

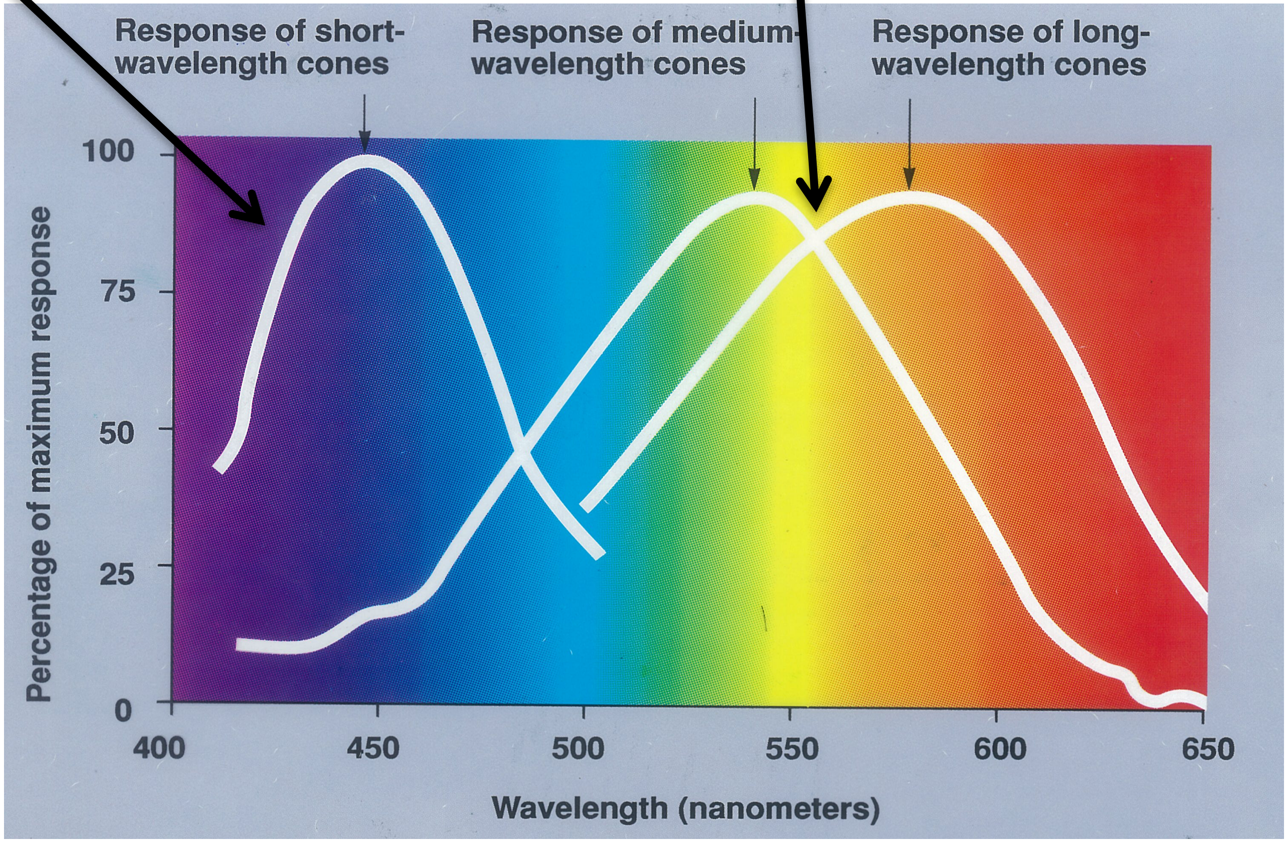
Optimal Stimulus – Ripe Fruit!

Color Opponency

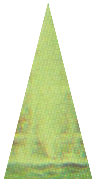
Blue / **Yellow** opponency works much the same way as **Red** /**Green**

Short wavelength cones
are set in opposition to. . .

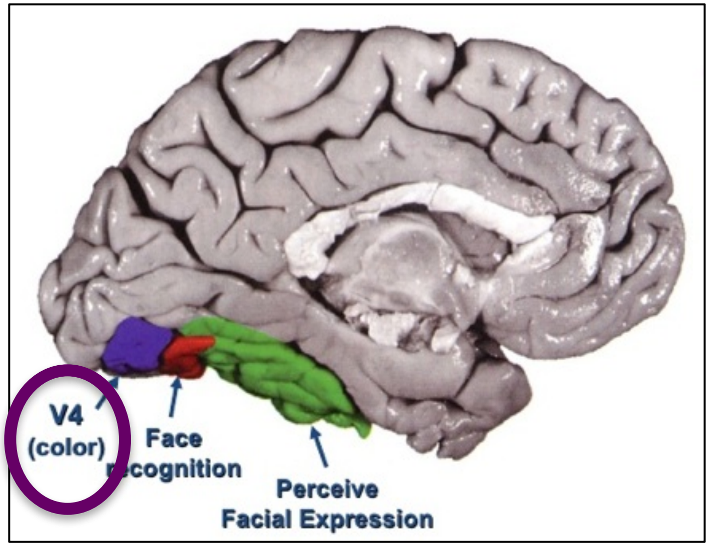
. . .**Medium+Long** wavelength cones
when they respond equally,
as they do to yellow light.



Color Constancy



Color Constancy



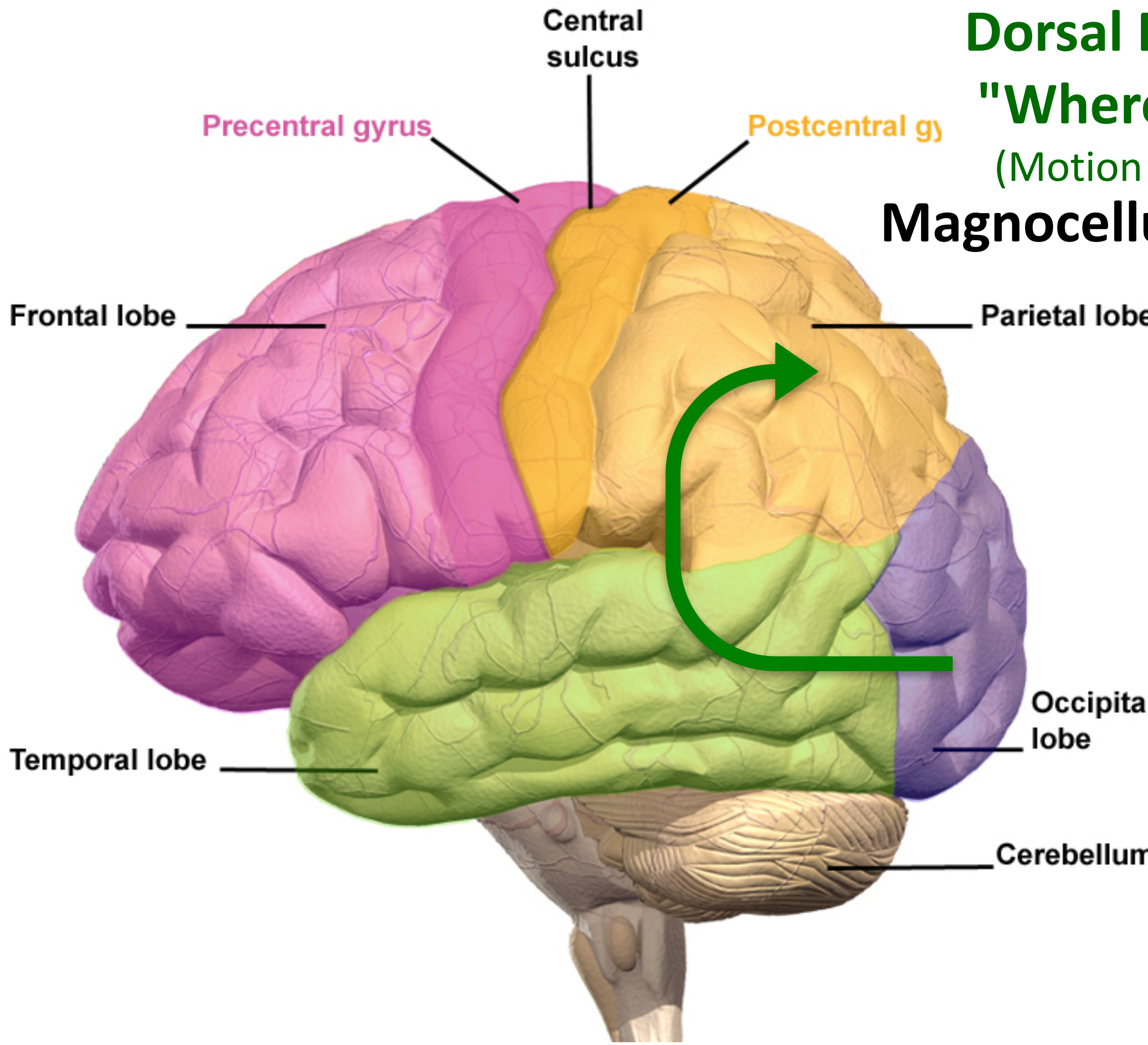
V4

detects & filters out overall tint of scene

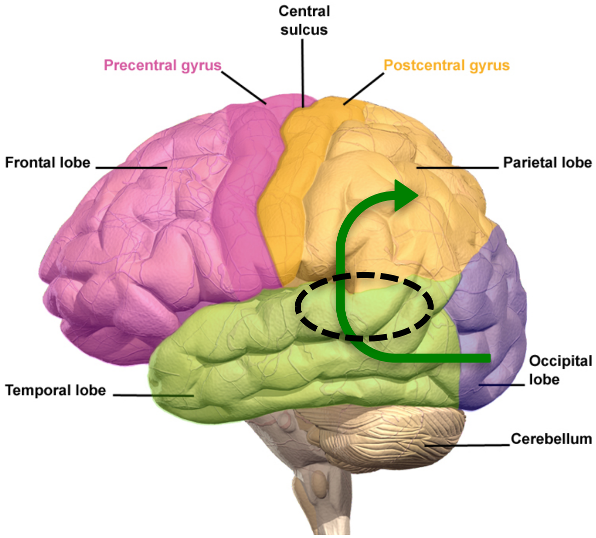
Enables recognition of color under varying lighting conditions

= Color Constancy

Magnocellular Pathway



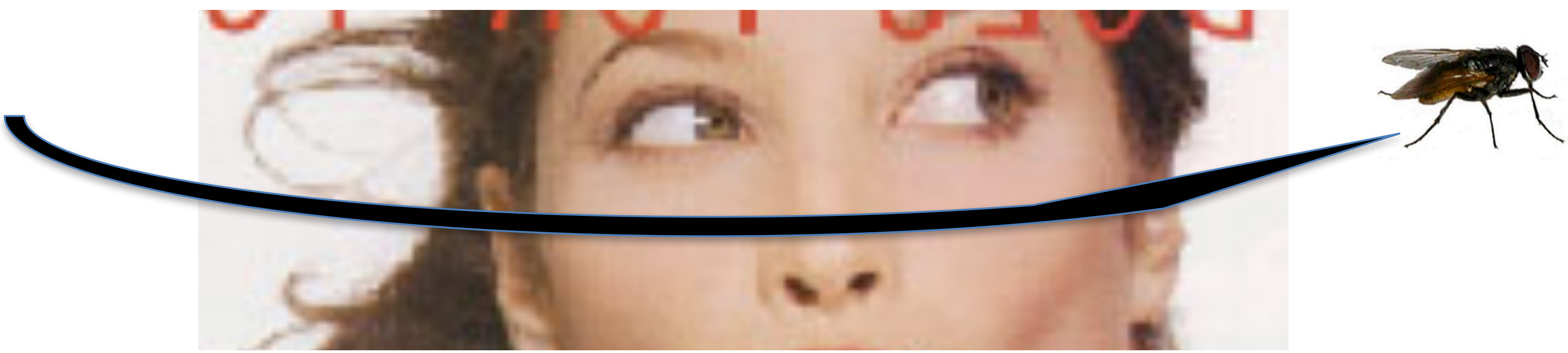
Dorsal Pathway
"Where/How"
(Motion & Depth)
Magnocellular Pathway



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

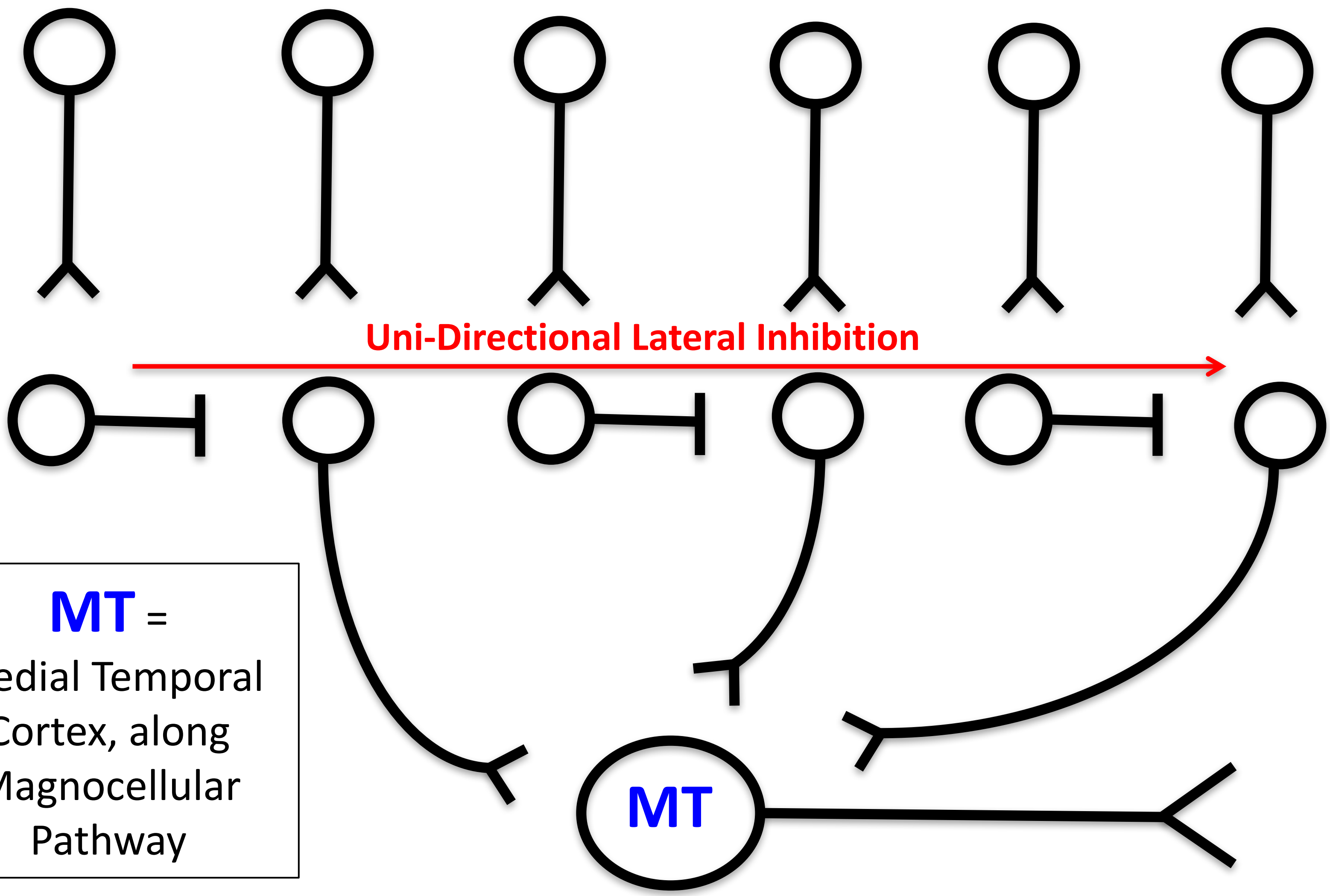
MT (Medial Temporal)

Along "*Where/How*"
Visual pathway to Parietal



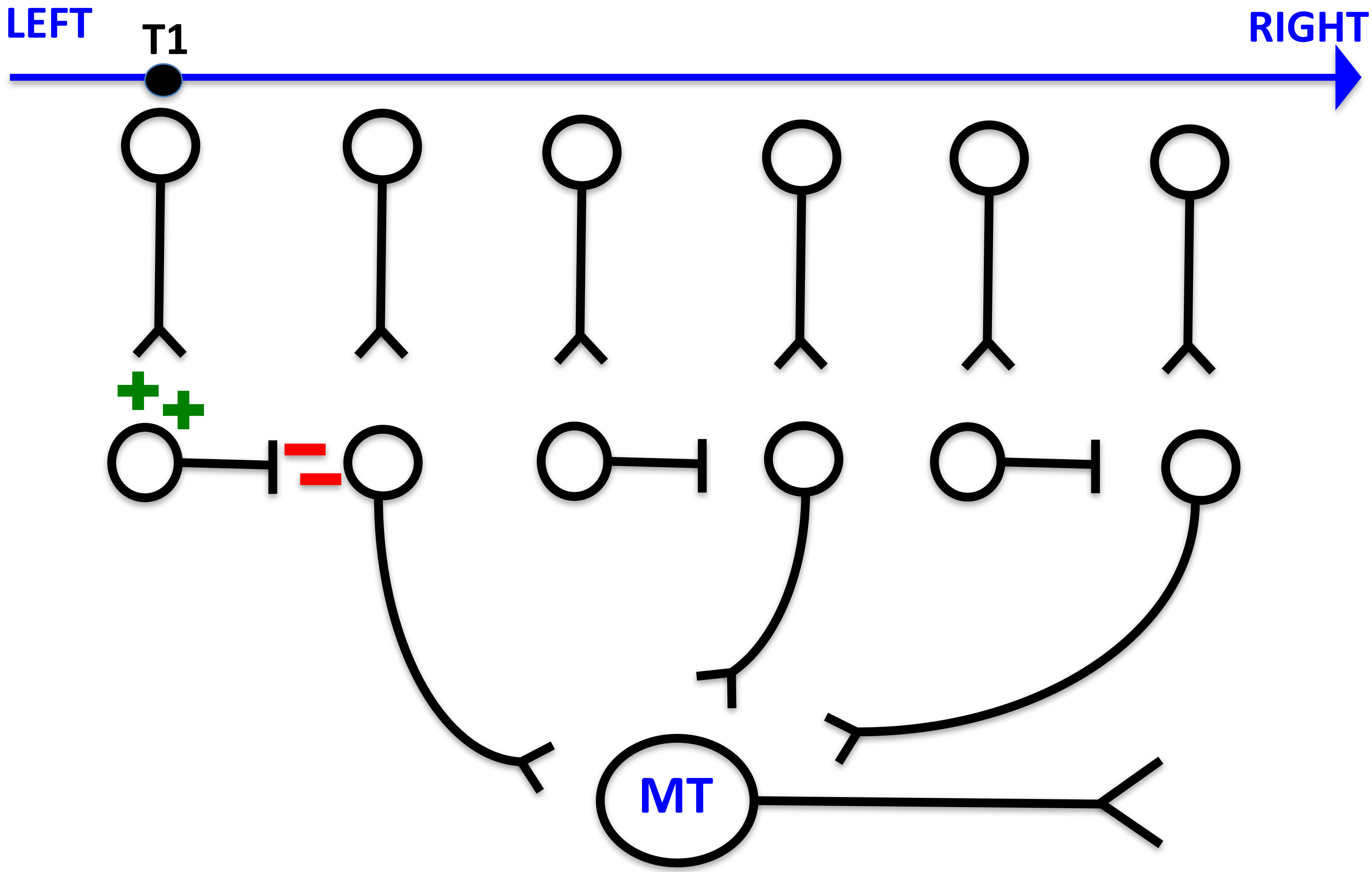
Includes Direction-Sensitive
Motion Detectors

Direction-Sensitive Motion Detector Circuit in MT

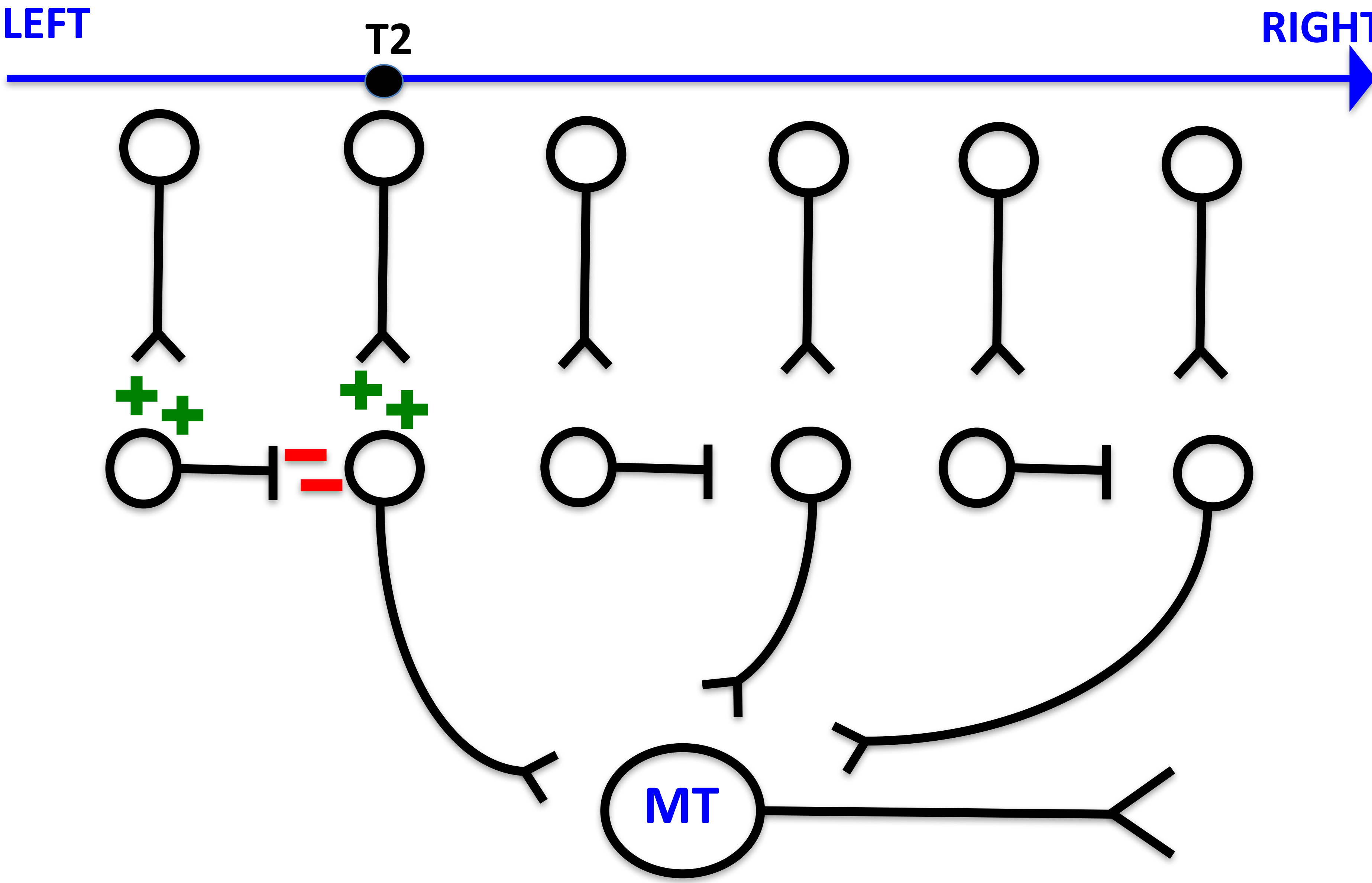


MT =
Medial Temporal
Cortex, along
Magnocellular
Pathway

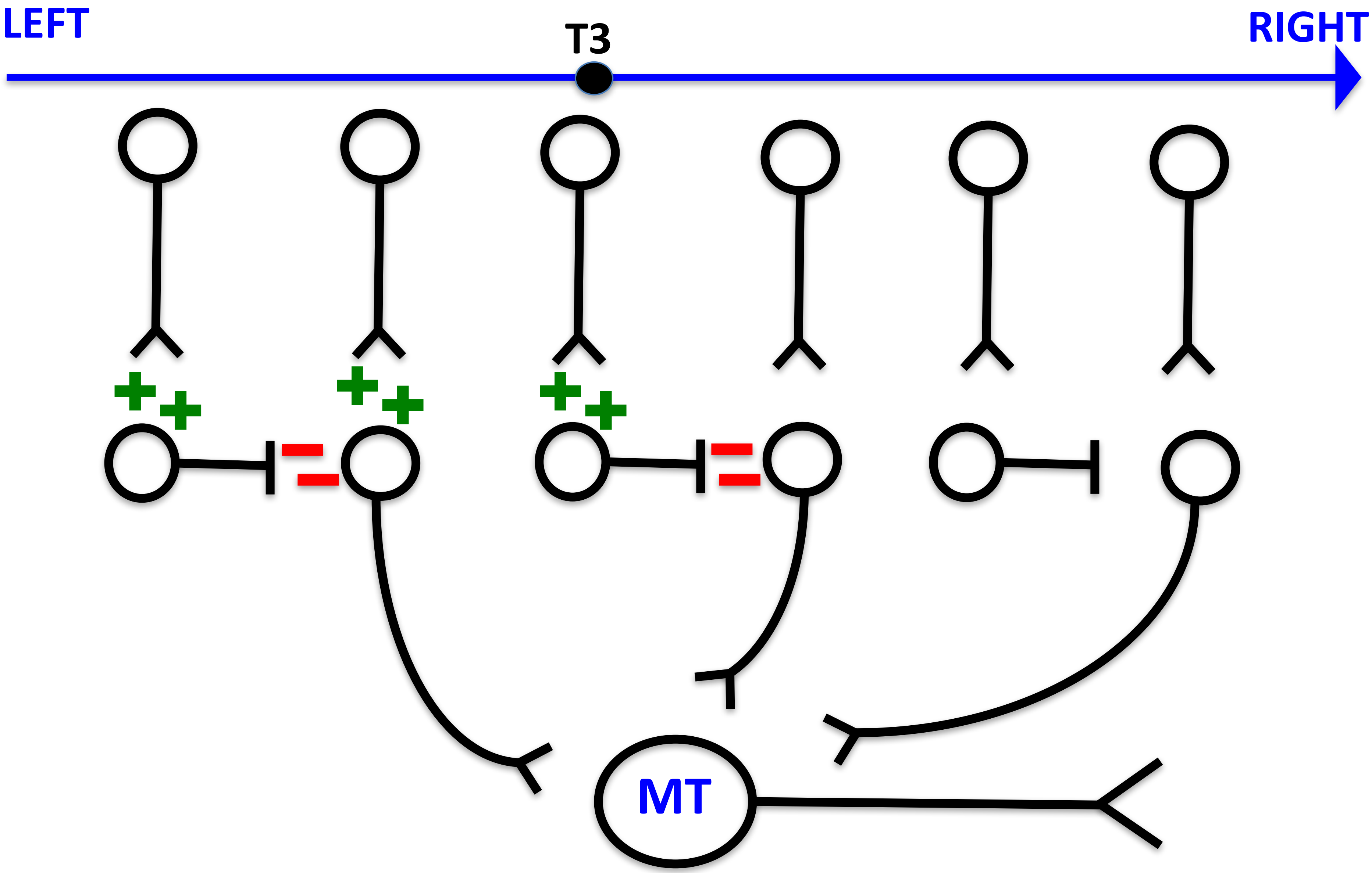
Direction-Sensitive Motion Detector Circuit in MT



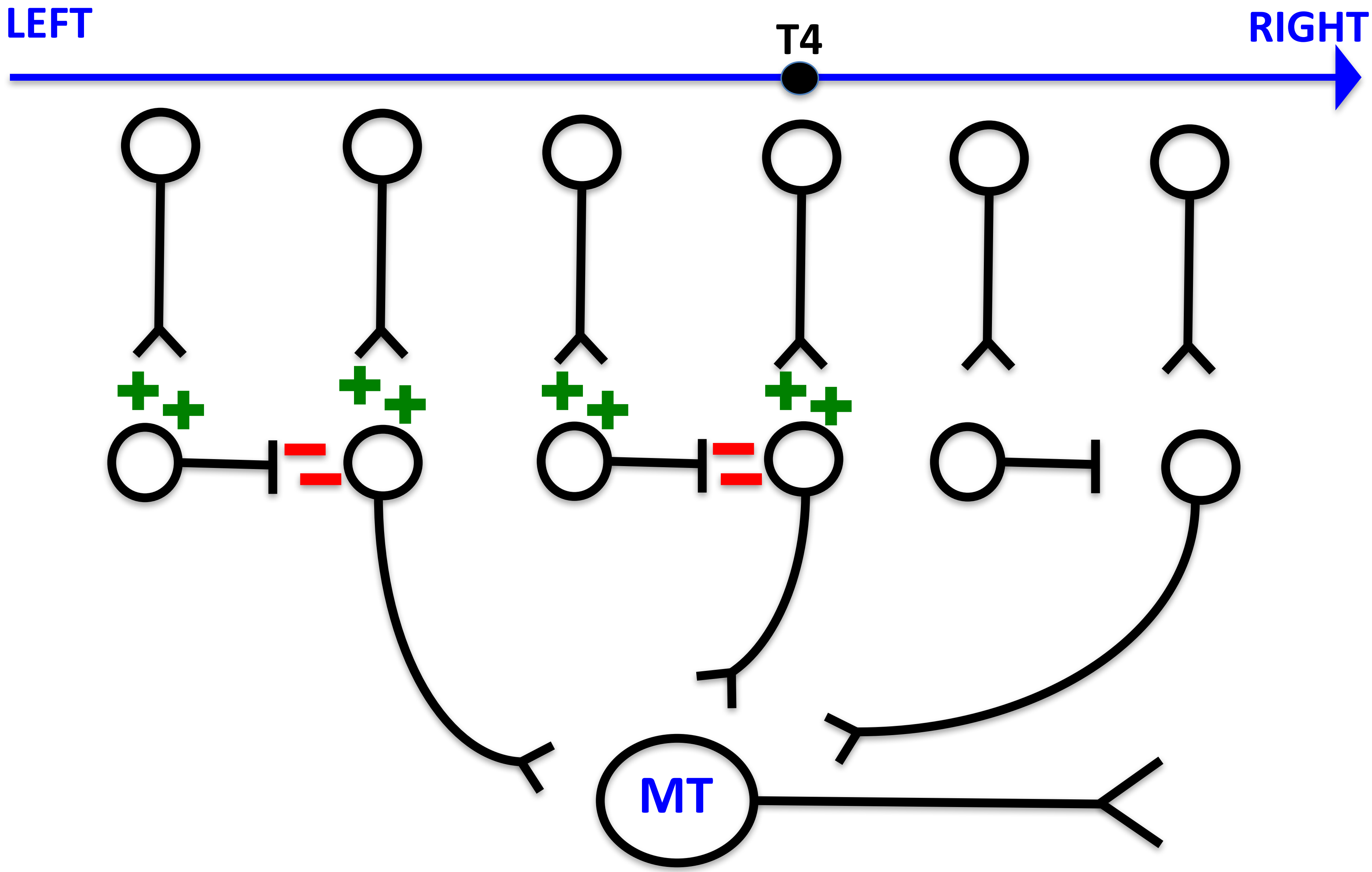
Direction-Sensitive Motion Detector Circuit in MT



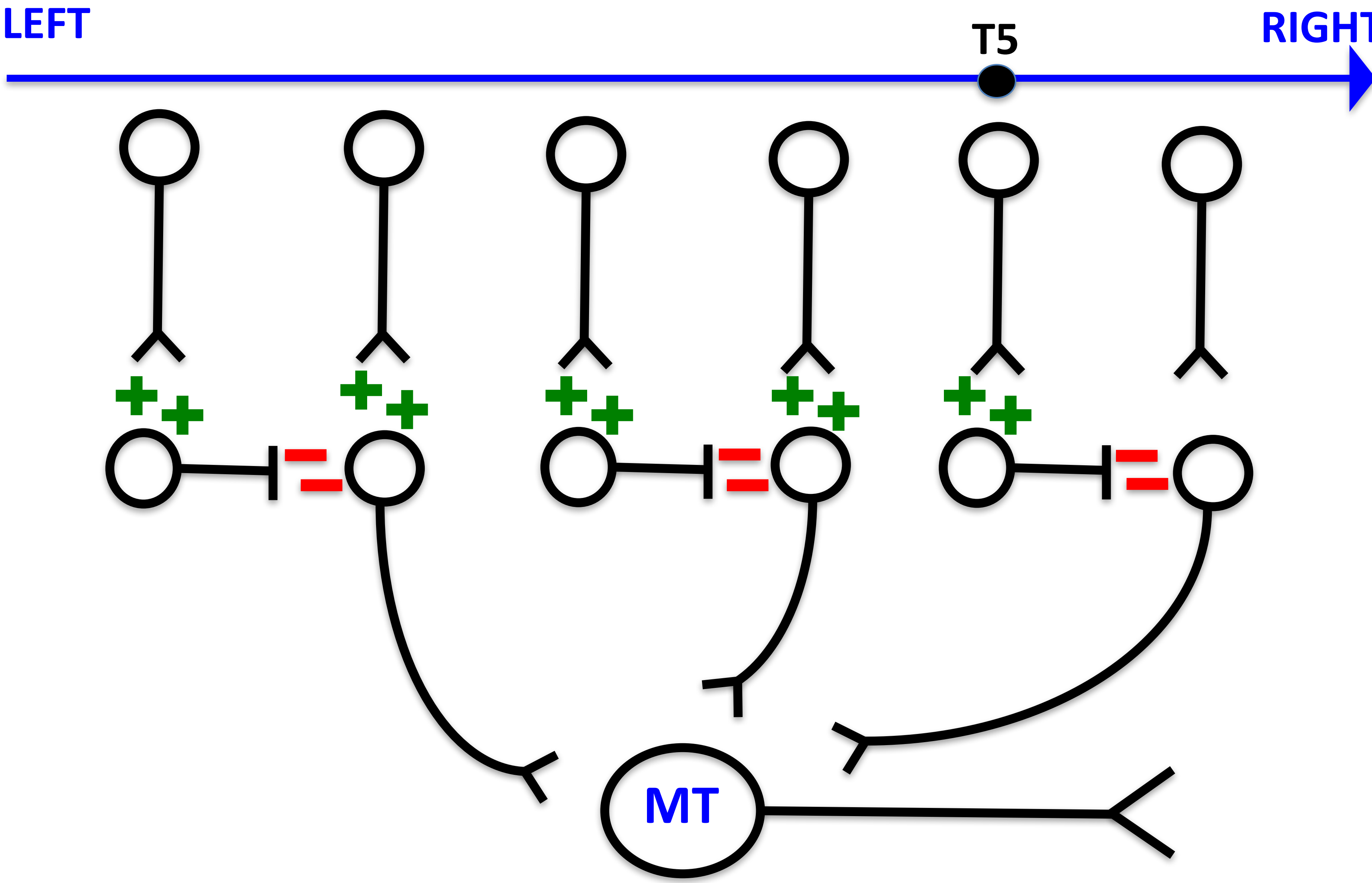
Direction-Sensitive Motion Detector Circuit in MT



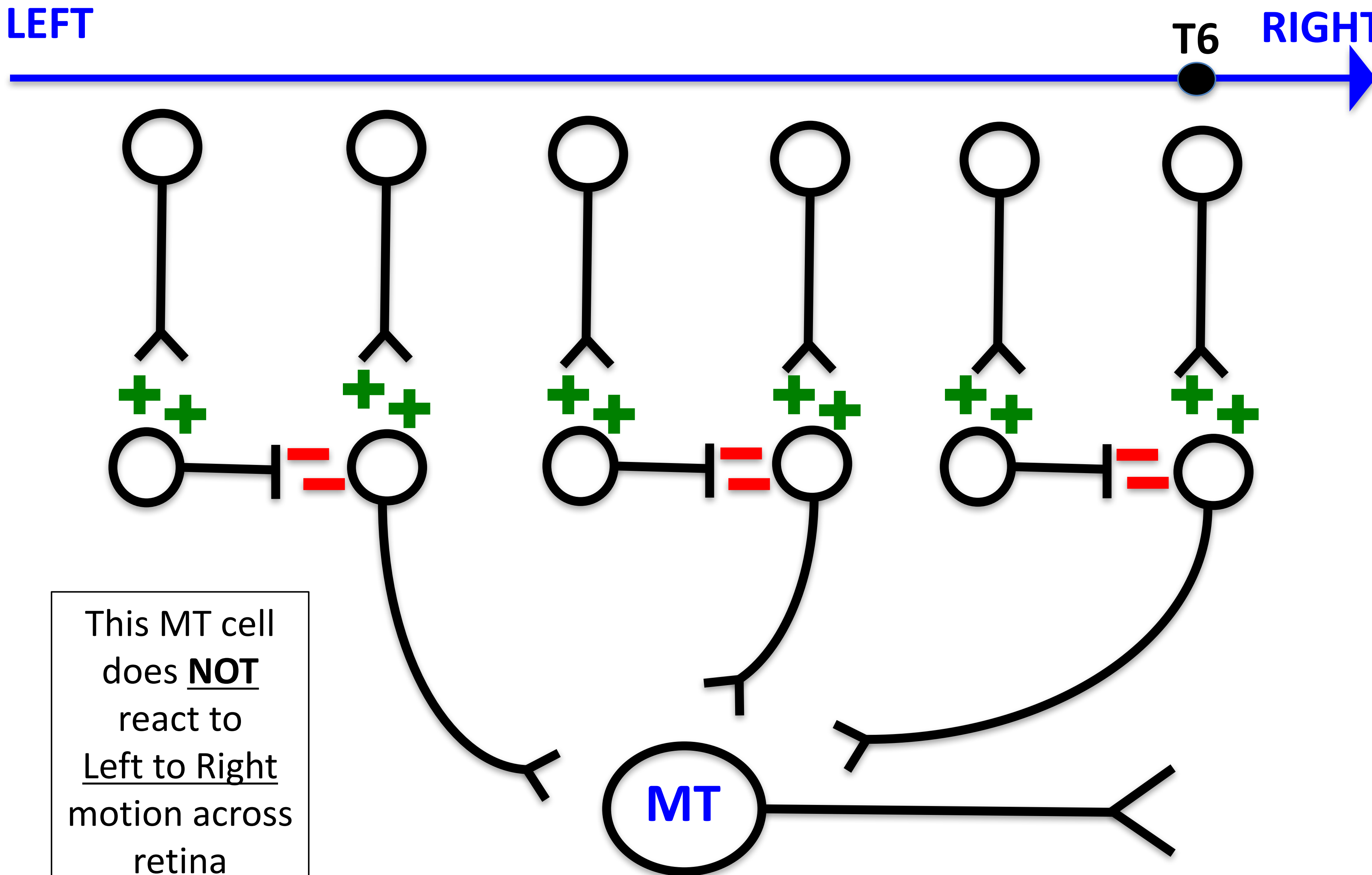
Direction-Sensitive Motion Detector Circuit in MT



Direction-Sensitive Motion Detector Circuit in MT

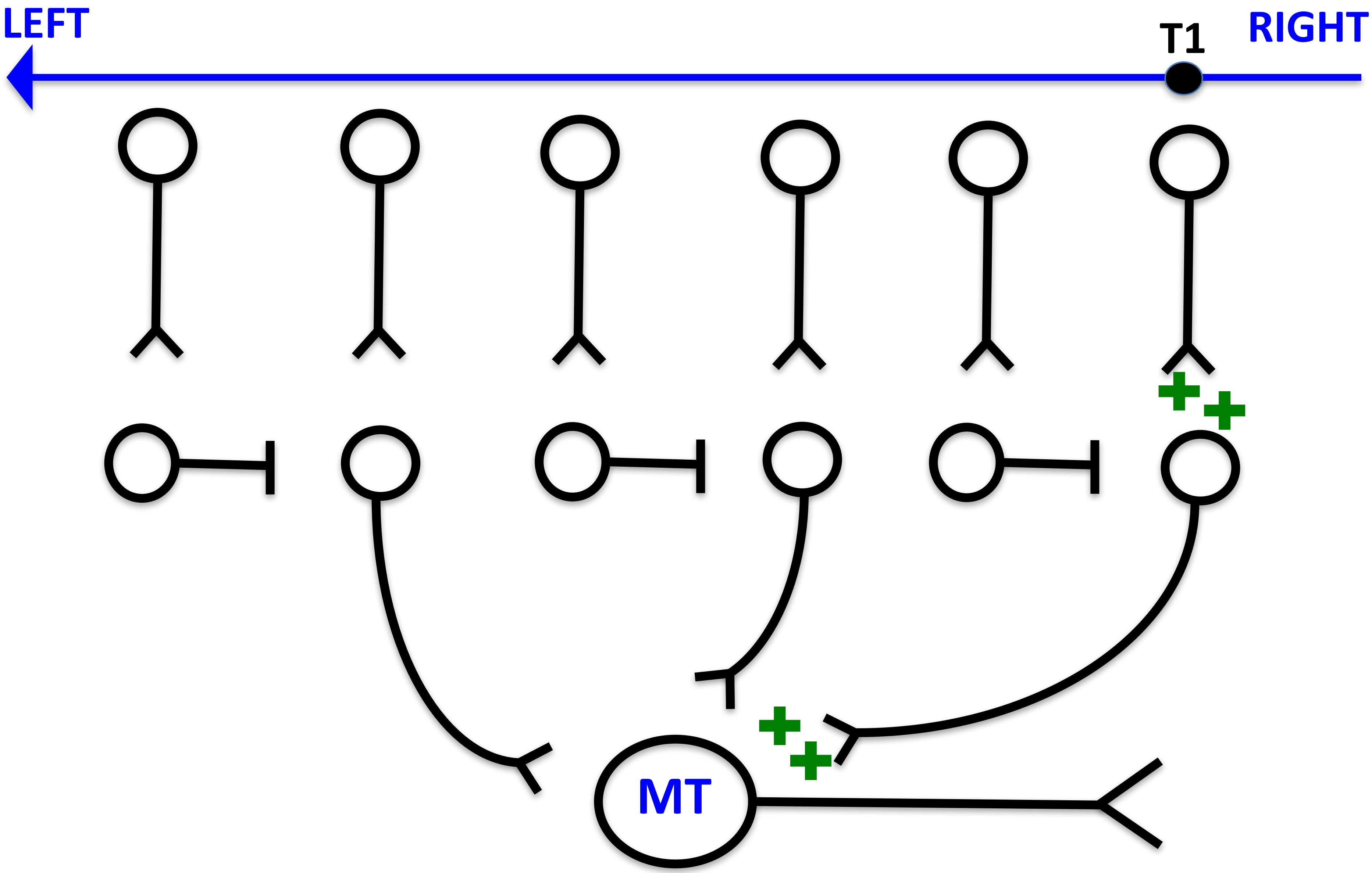


Direction-Sensitive Motion Detector Circuit in MT

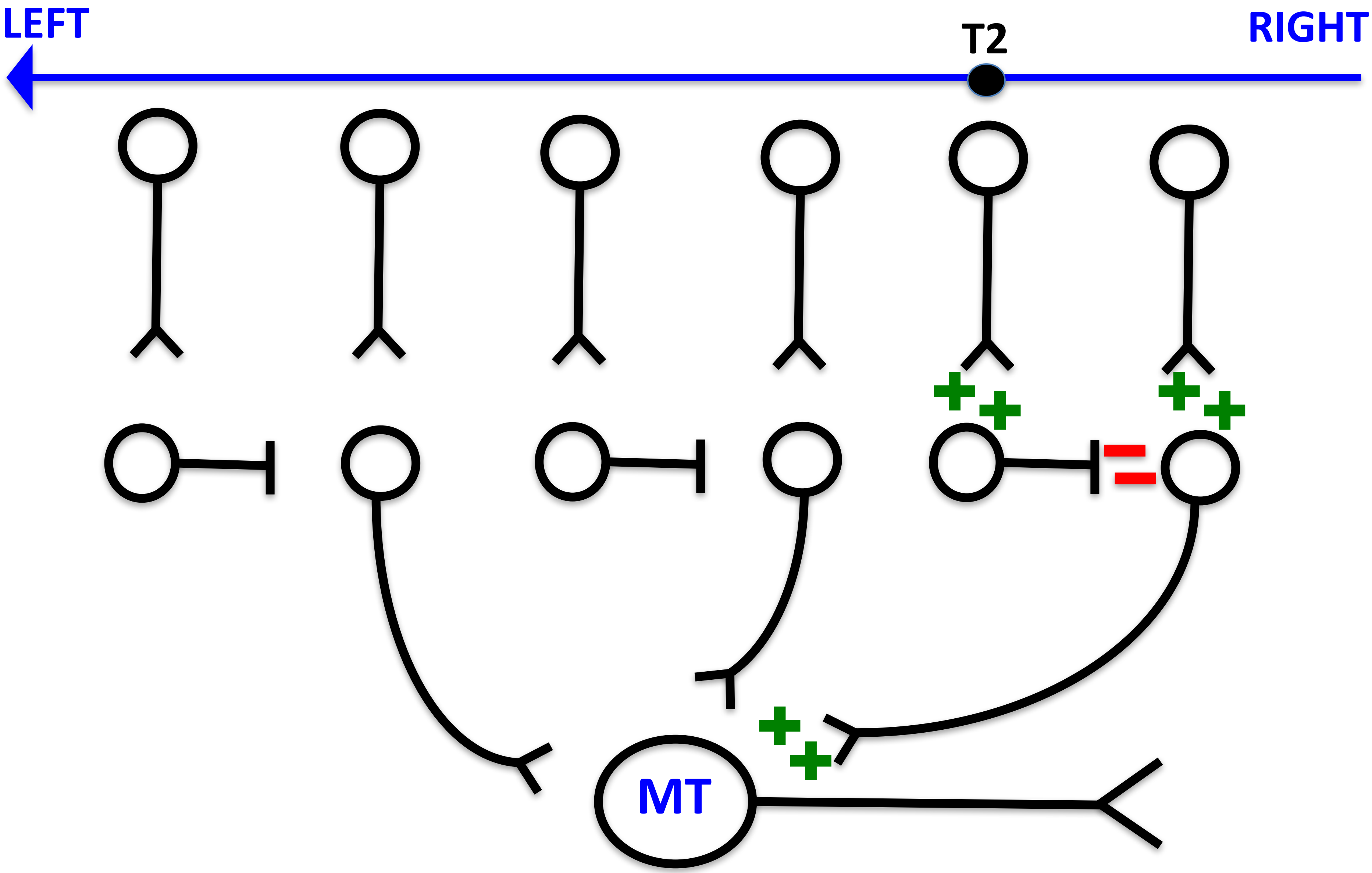


This MT cell does **<u>NOT</u>** react to <u>Left to Right</u> motion across retina

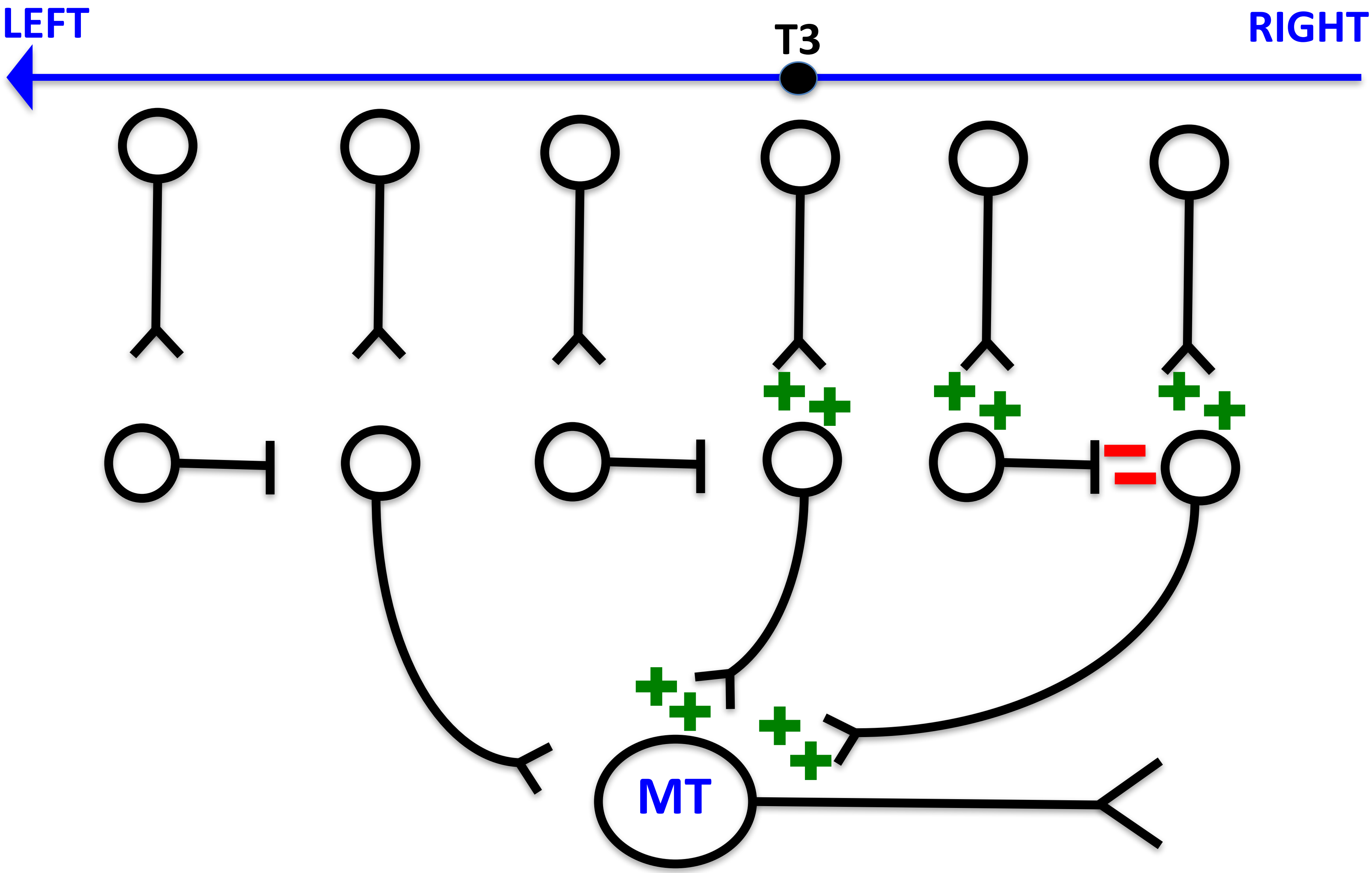
Direction-Sensitive Motion Detector Circuit in MT



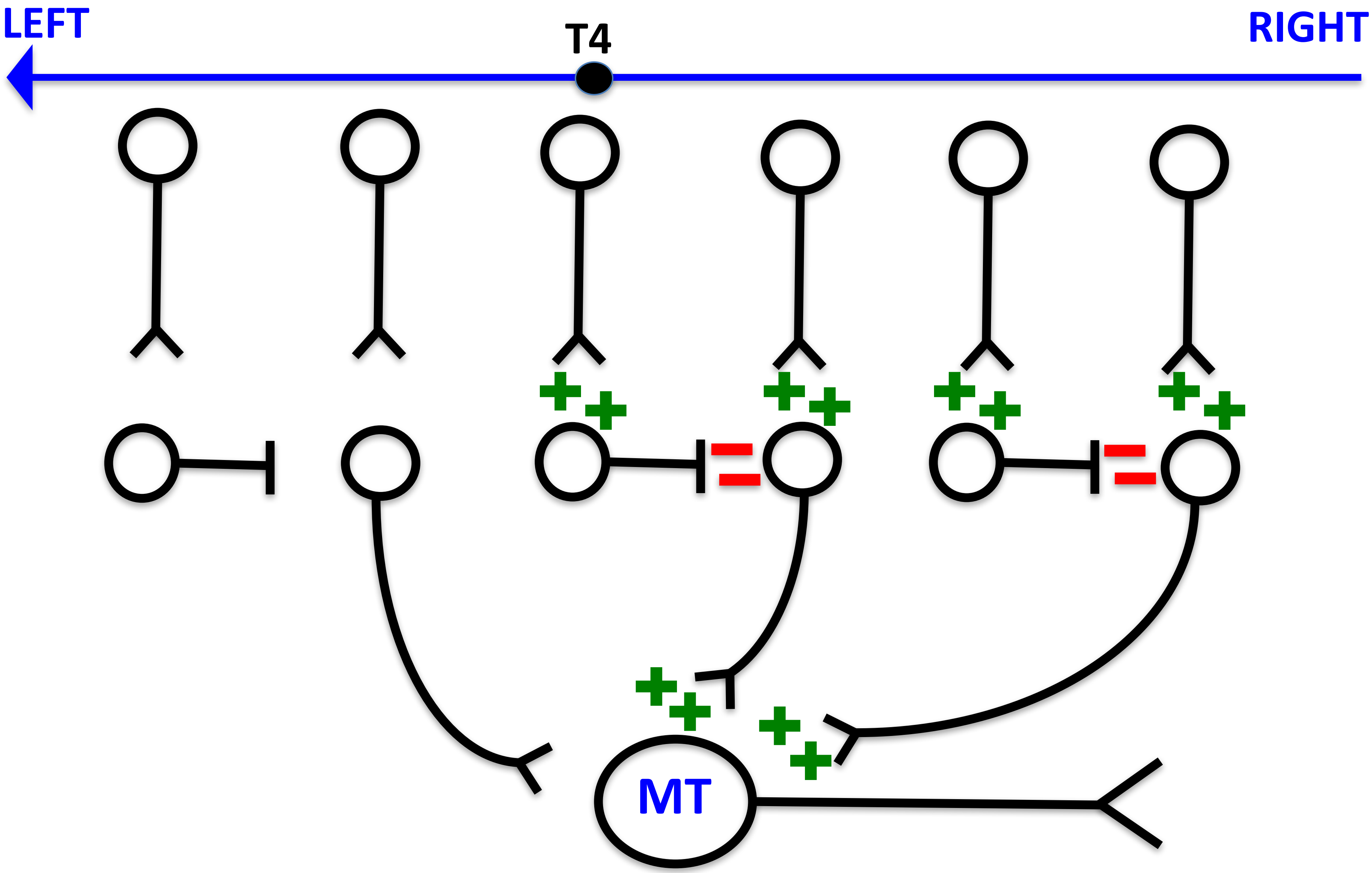
Direction-Sensitive Motion Detector Circuit in MT



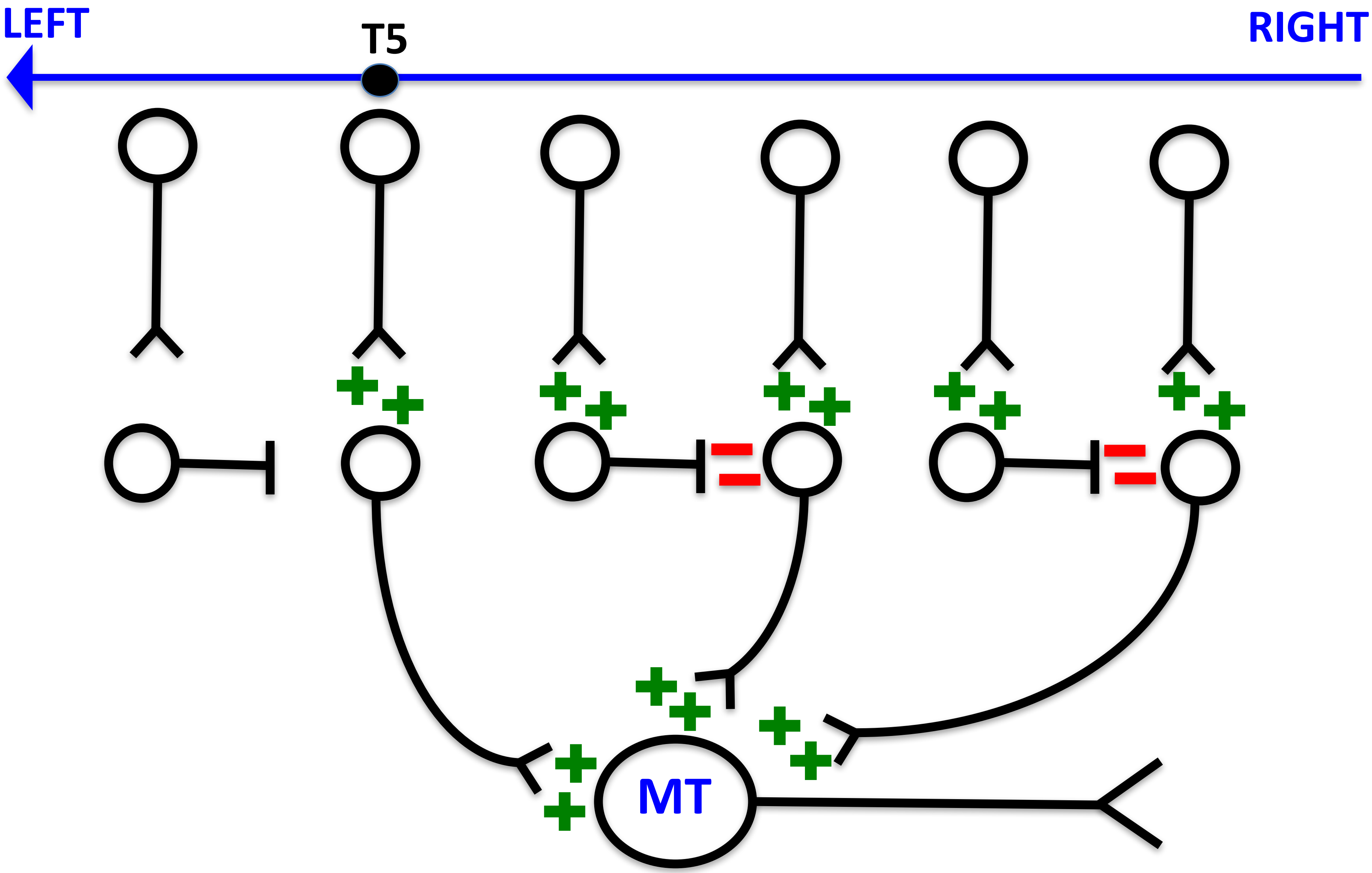
Direction-Sensitive Motion Detector Circuit in MT



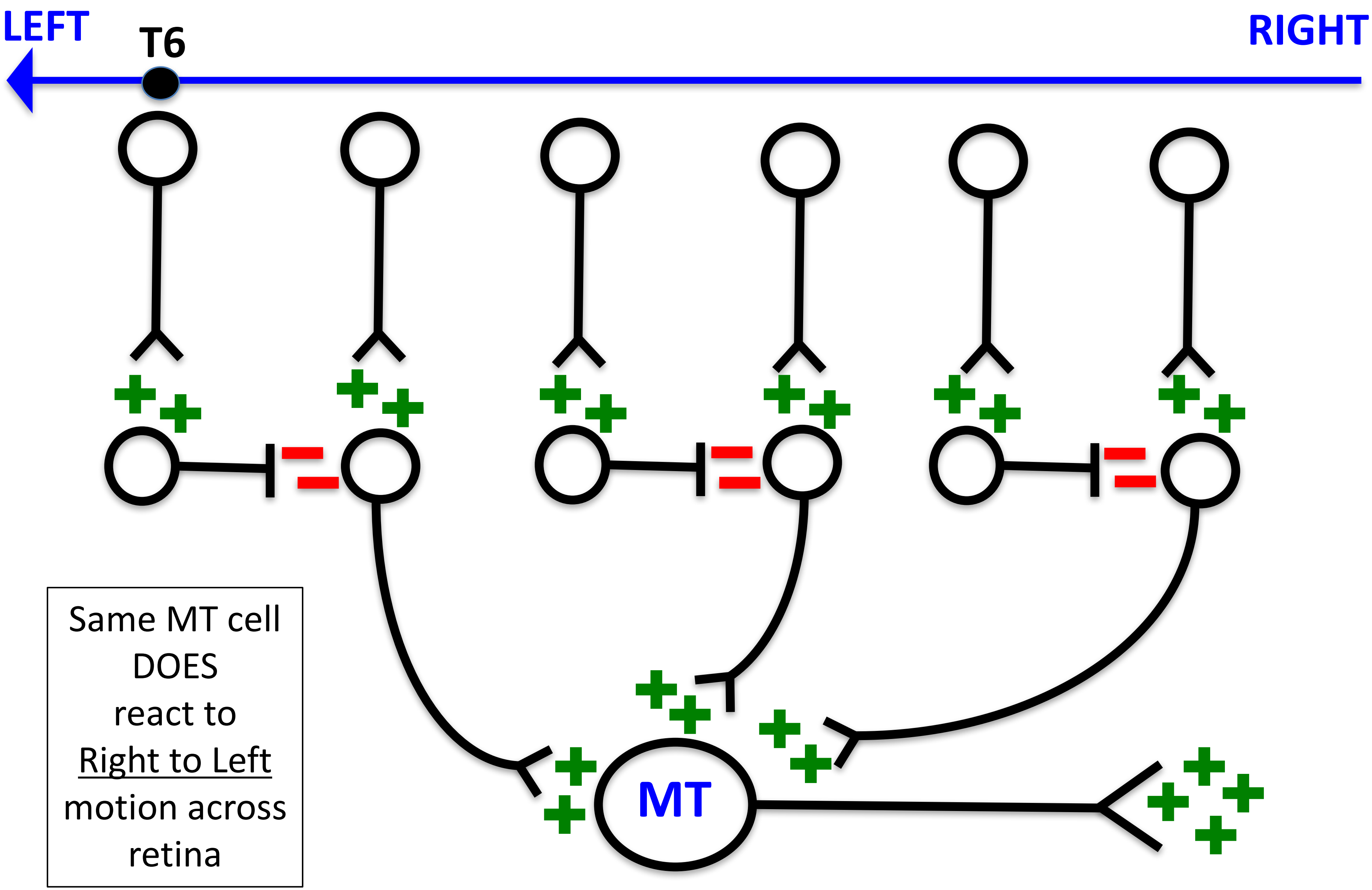
Direction-Sensitive Motion Detector Circuit in MT



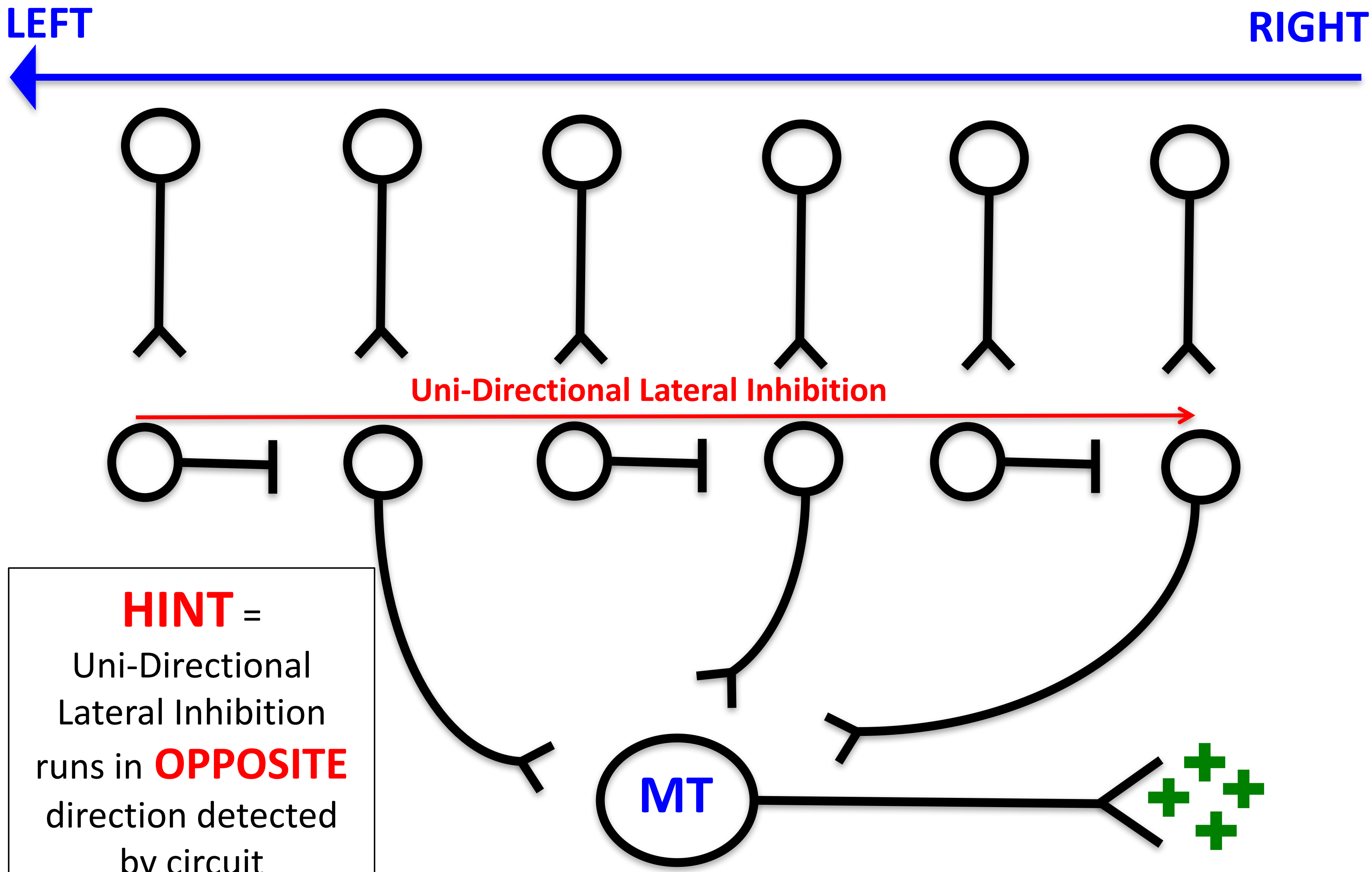
Direction-Sensitive Motion Detector Circuit in MT



Direction-Sensitive Motion Detector Circuit in MT

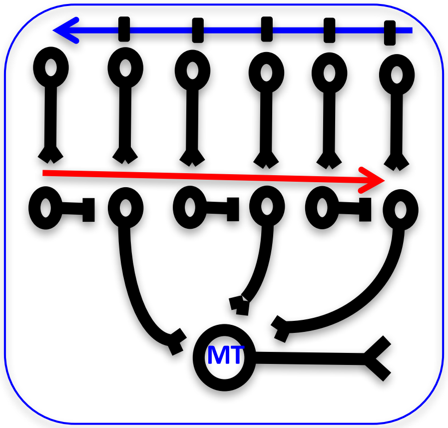


Direction-Sensitive Motion Detector Circuit in MT

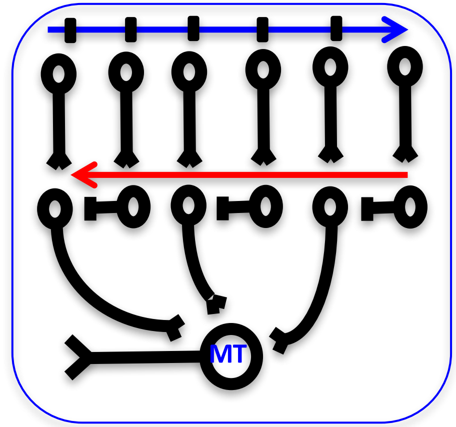


HINT =
Uni-Directional Lateral Inhibition runs in **OPPOSITE** direction detected by circuit

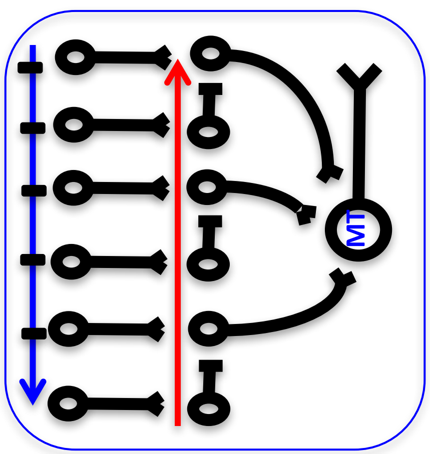
Direction-Sensitive Motion Detector Circuit in MT



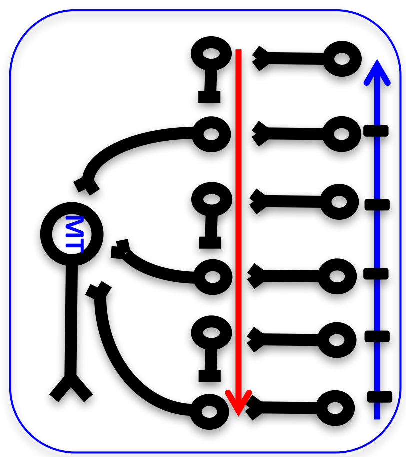
Detects motion RIGHT to LEFT



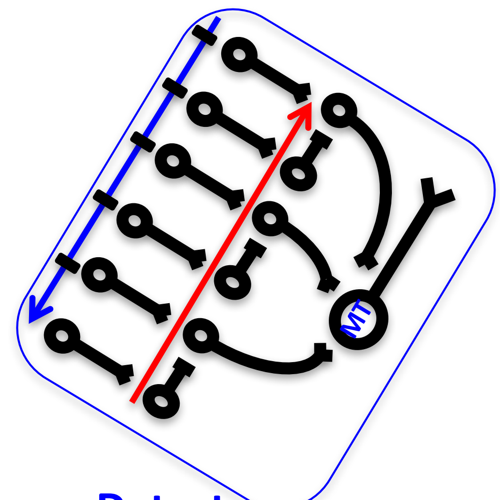
Detects motion LEFT to RIGHT



Detects motion DOWNWARD

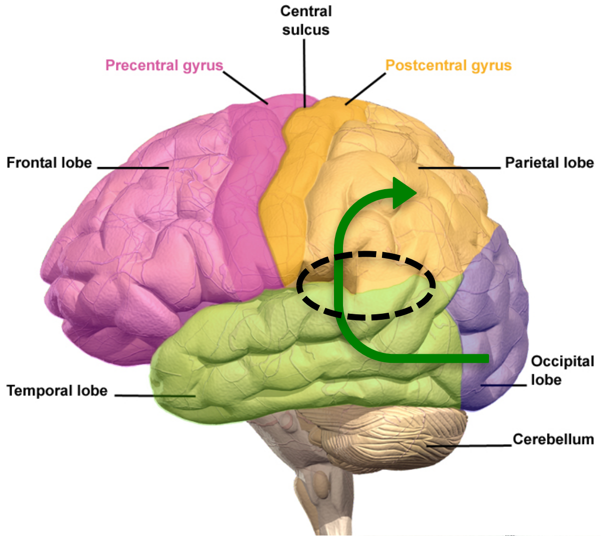


Detects motion UPWARD



Detects motion DIAGONALLY DOWN

Etc...



MST (Medial Superior Temporal)

Includes "Optic Flow" Detectors

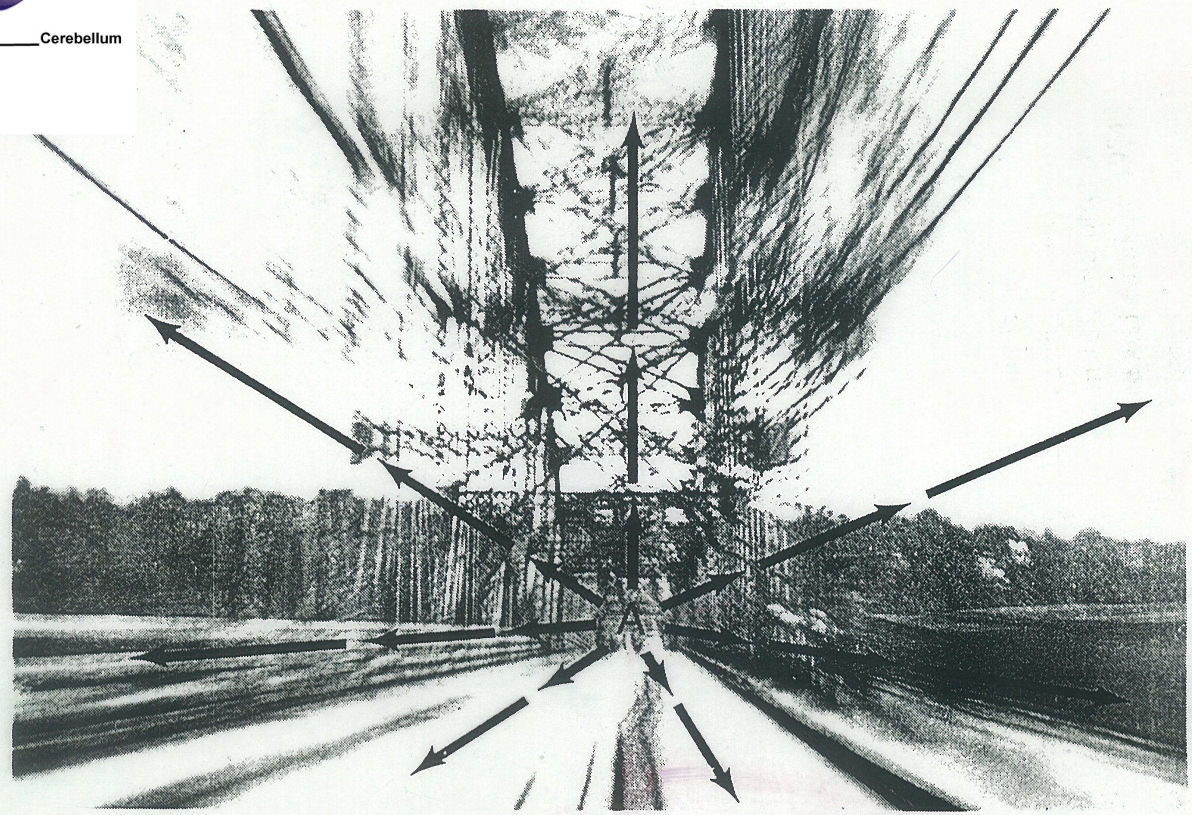
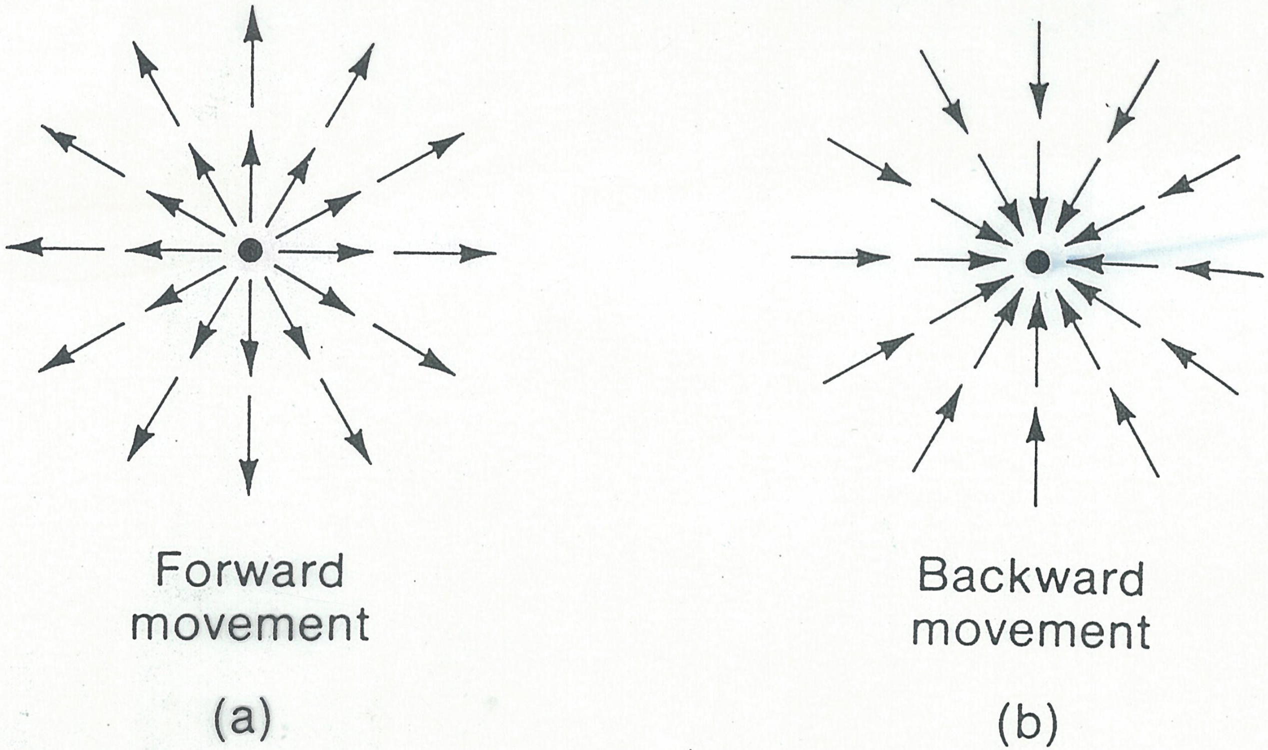


FIGURE 8.49 The flow of the environment as seen from a car speeding across a bridge toward point A. The flow, shown by the arrows, is more rapid closer to the car (as indicated by the increased blur) but occurs everywhere except A, the focus of expansion, toward which the car is moving. (Also see Figure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

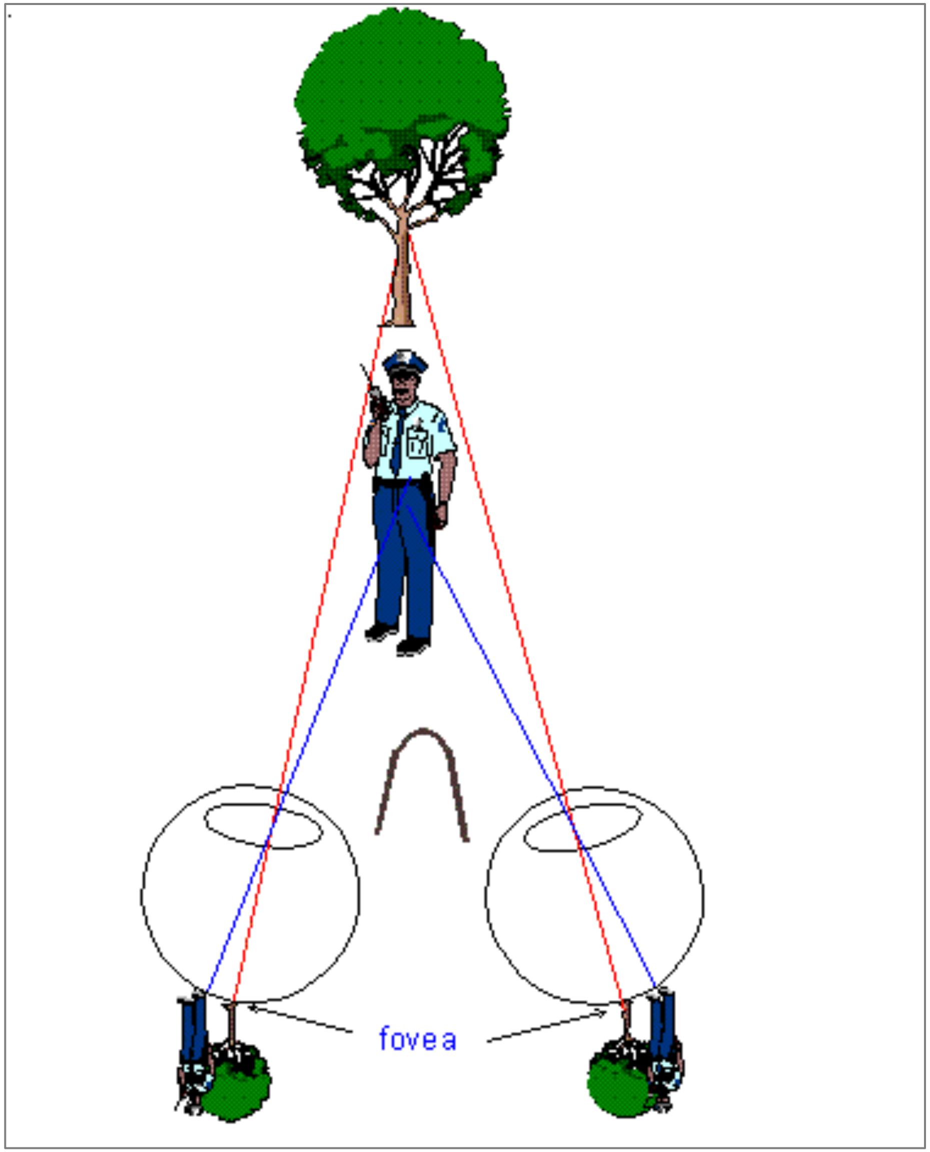
Optic Flow Detectors in **MST**



F I G U R E 8. 48 Flow patterns that occur (a) when we move forward and (b) when we move backward.

Binocular Disparity

Used for
Depth Perception

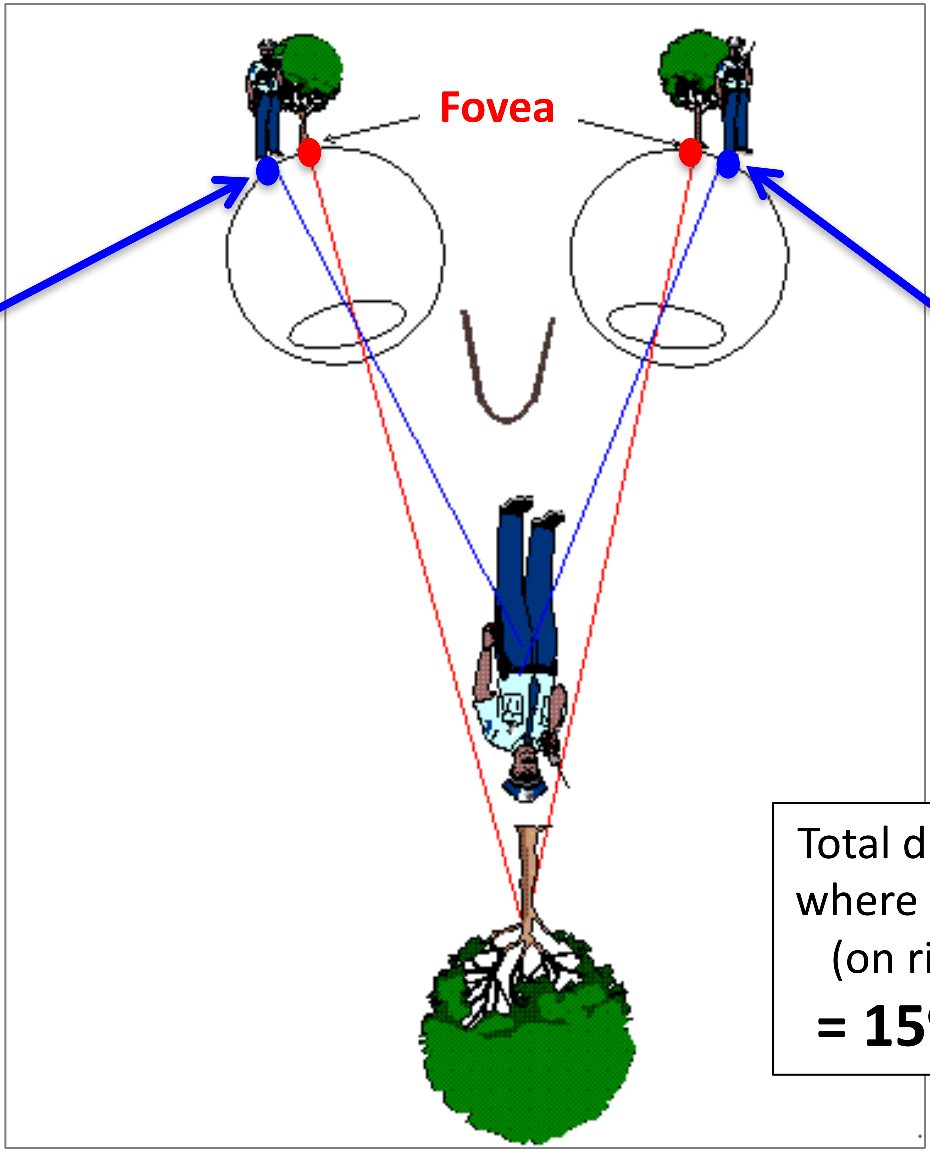


Part of WHERE
In the
"Where/How"
Pathway

Binocular Disparity

When focused on tree…

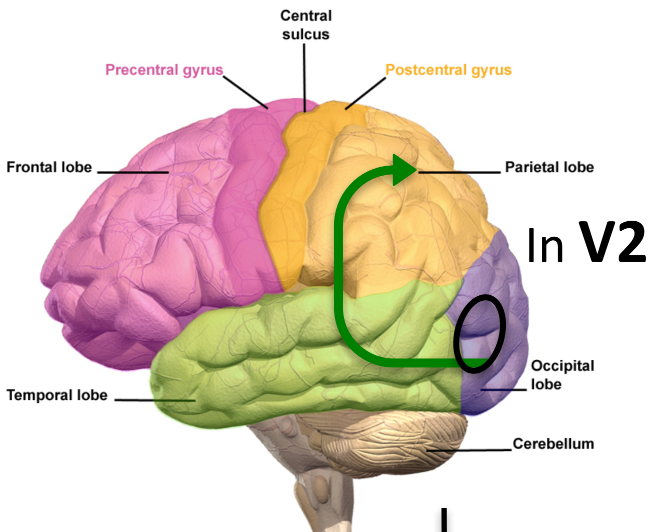
Closer policeman falls (~ 15°) to Right of Fovea in Left Eye



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

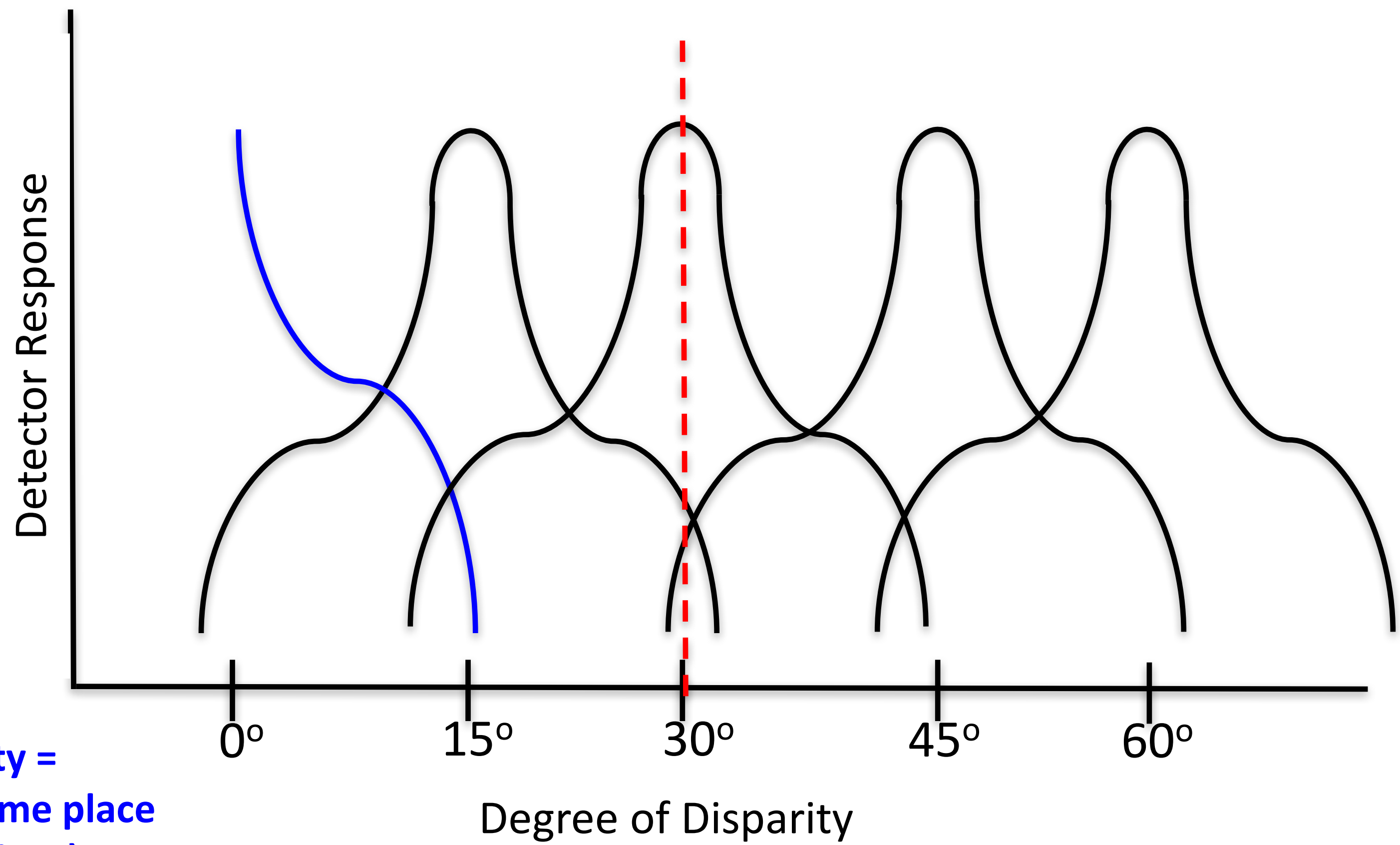
Total disparity between where closer object falls (on right vs. left eye)

= 15° + 15° = 30°



Disparity Detectors

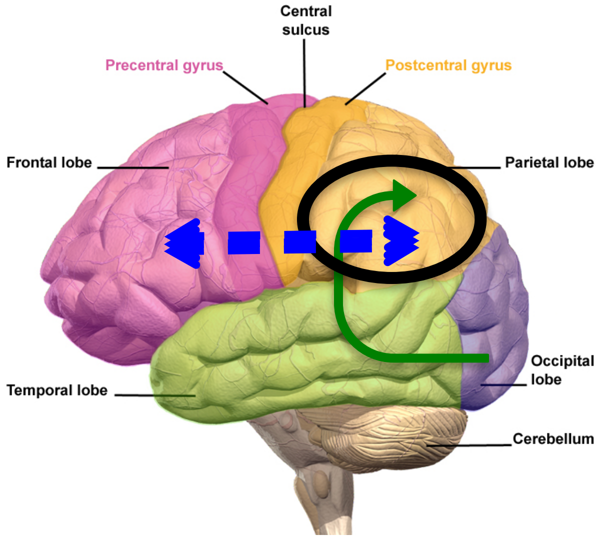
Each detector has a “preferred” disparity
to which it responds the most,
but also responds to other, overlapping disparities



**(0º disparity =
Images fall on same place
on both Retinas)**

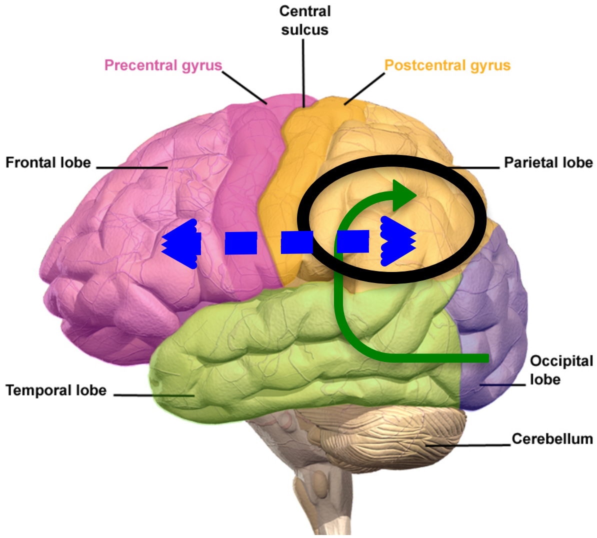
Higher Parietal Cortex

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



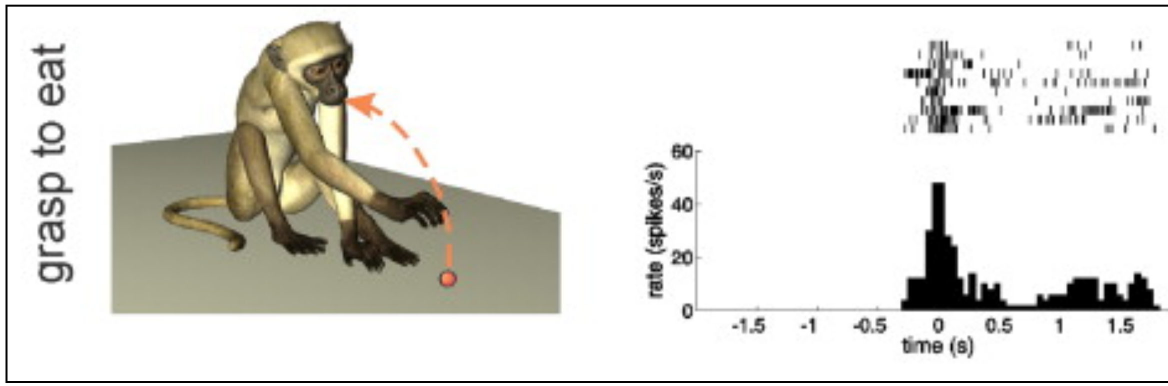
Higher Parietal Cortex

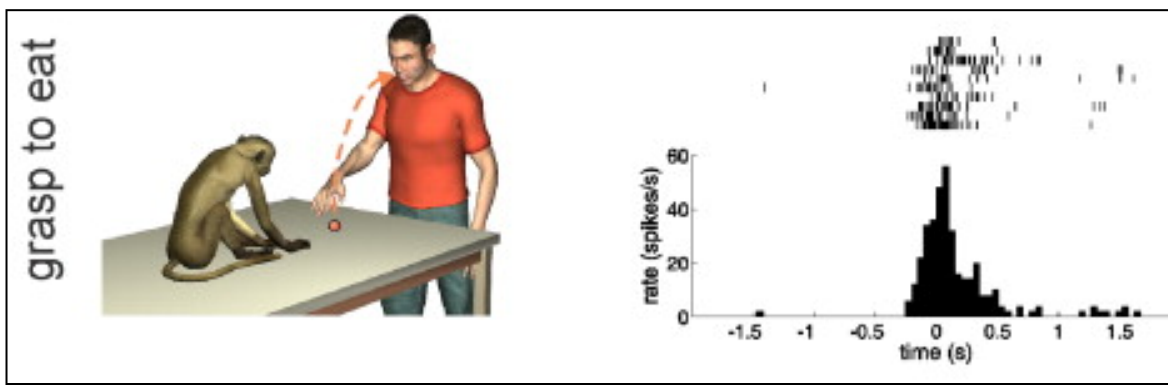
Mirror Cell System

Respond to seeing self,
or other,
perform and action.

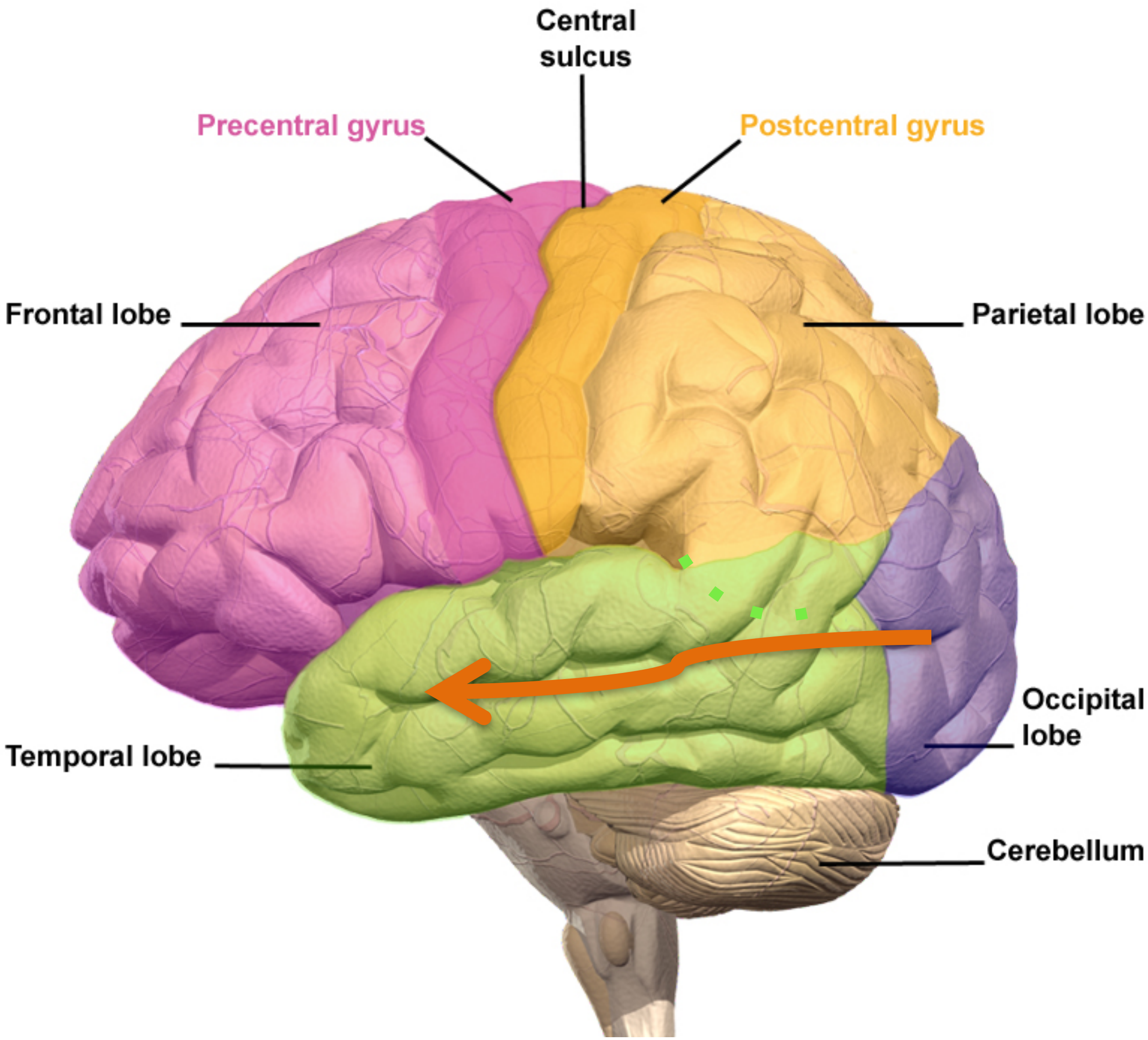
Activity reverberates with Mirror Cells in Premotor Cortex

Promotes Imitation





Visual Pathways

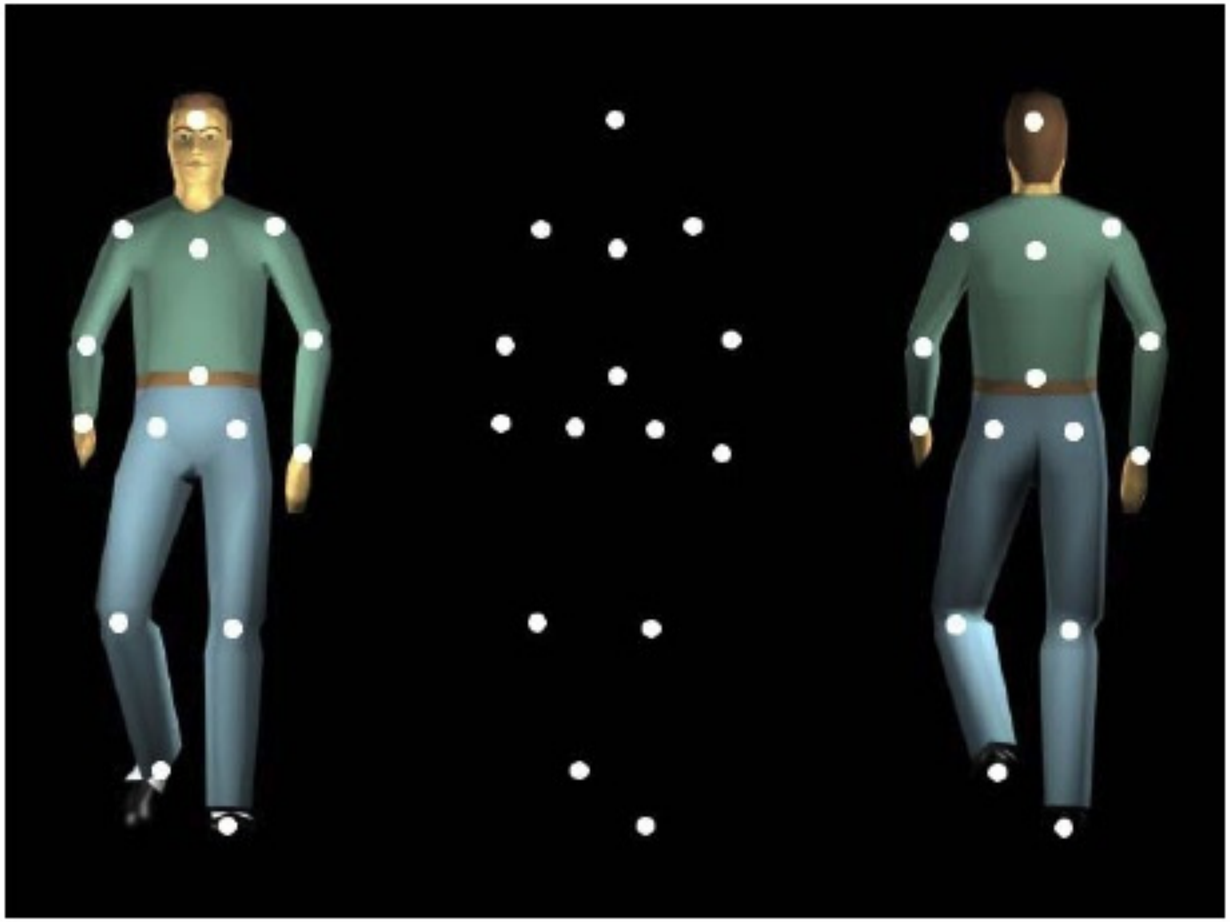


S T S

Superior Temporal Sulcus

(Biological Motion)

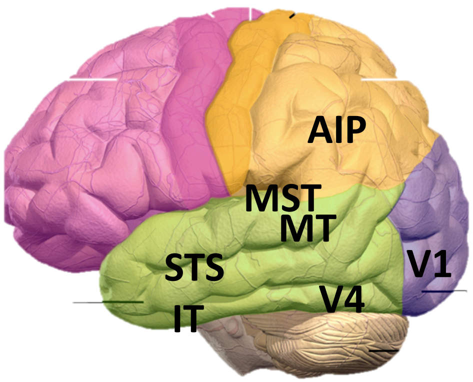
STS (Superior Temporal Sulcus)
Biological Motion



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