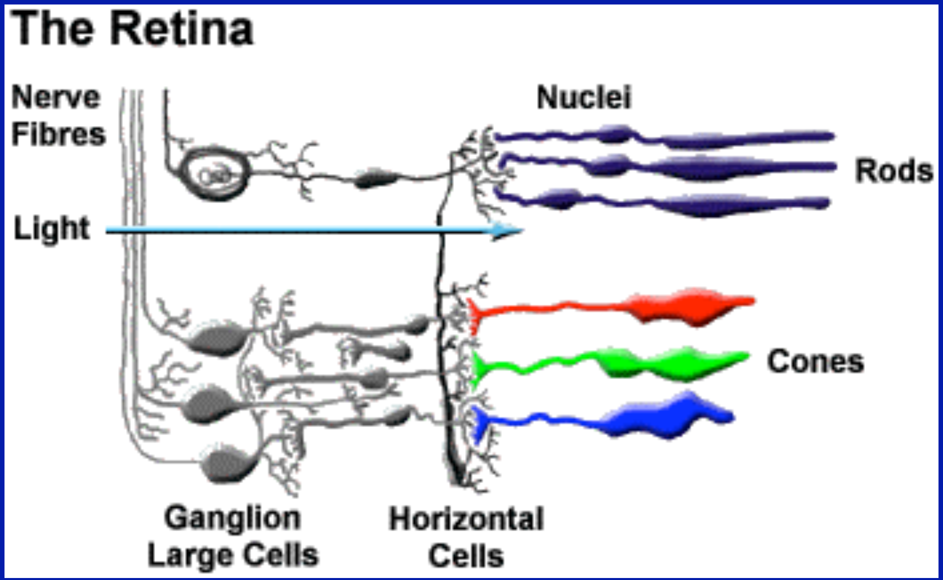
Photoreceptors

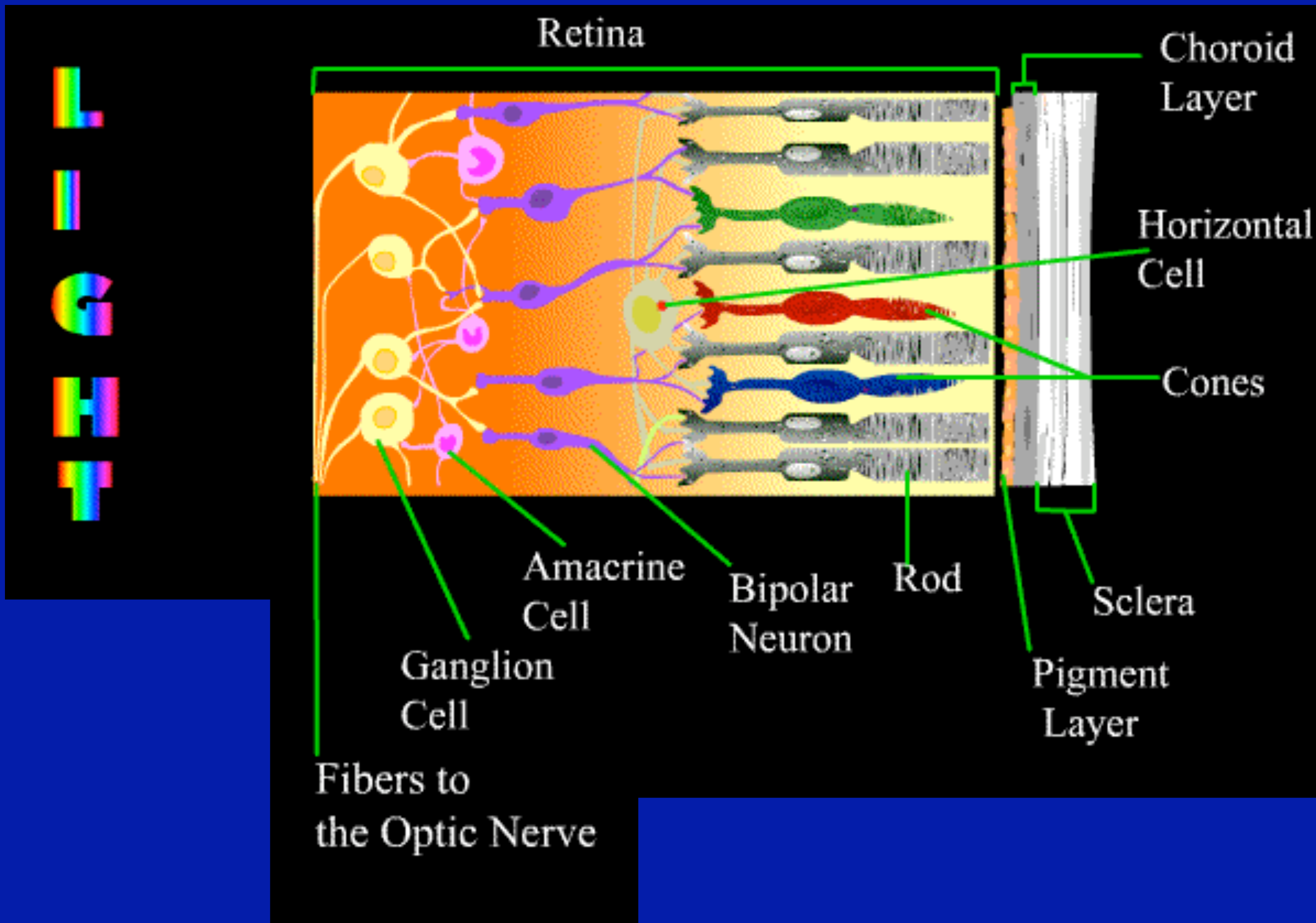
Rods

- 120 000 000
- Dim light
- Prefer wavelength of 505 nm
- Monochromatic
- Mainly in periphery of the eye

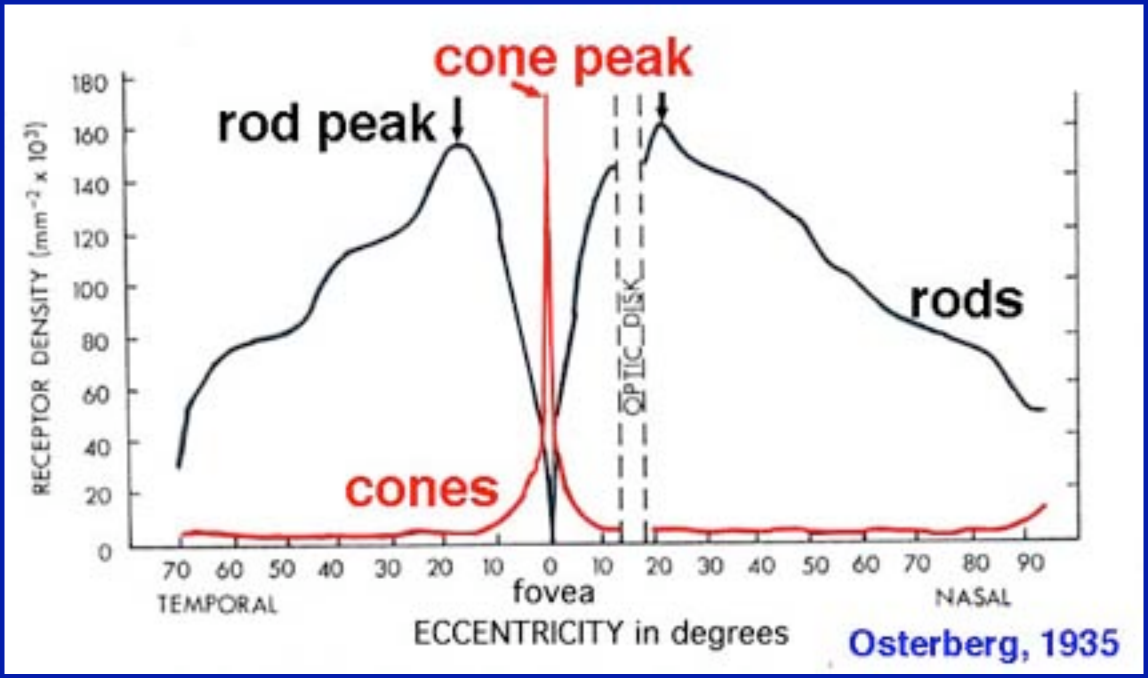
Cones

- 6 000 000
- More light
- Different spectral sensitivities
- Long-wave receptors (558 nm)
- Medium-wave receptors (531 nm)
- Short-wave receptors (419 nm)

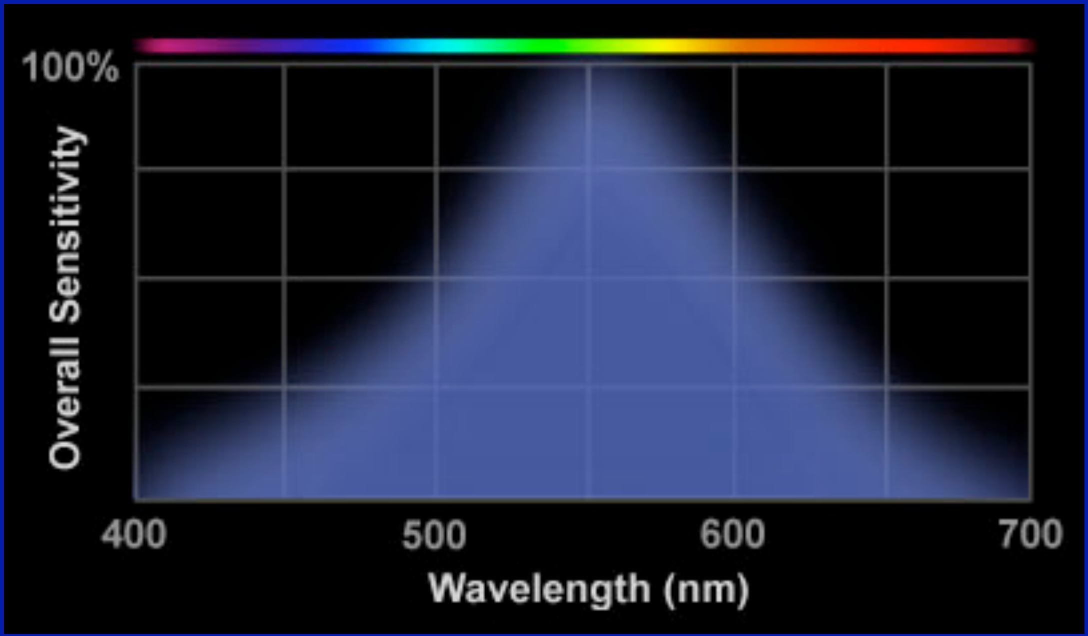

The Retina
Nerve
Fibres
Nuclei
Rods
Light
Cones
Ganglion
Large Cells
Horizontal
Cells


LIGHT
Retina
Choroid Layer
Horizontal Cell
Cones
Sclera
Pigment Layer
Rod
Bipolar Neuron
Amacrine Cell
Ganglion Cell
Fibers to the Optic Nerve

Distribution of rods and cones across the retina



Rod sensitivity



Prefer wavelength at around 505 nm

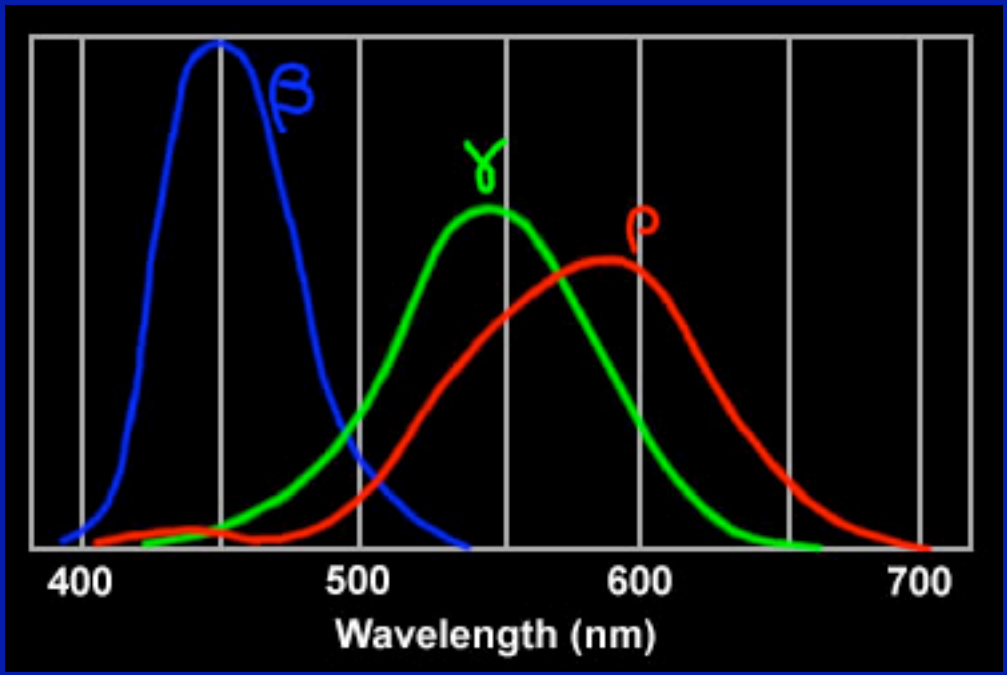
Cones sensitivity

Different spectral sensitivities

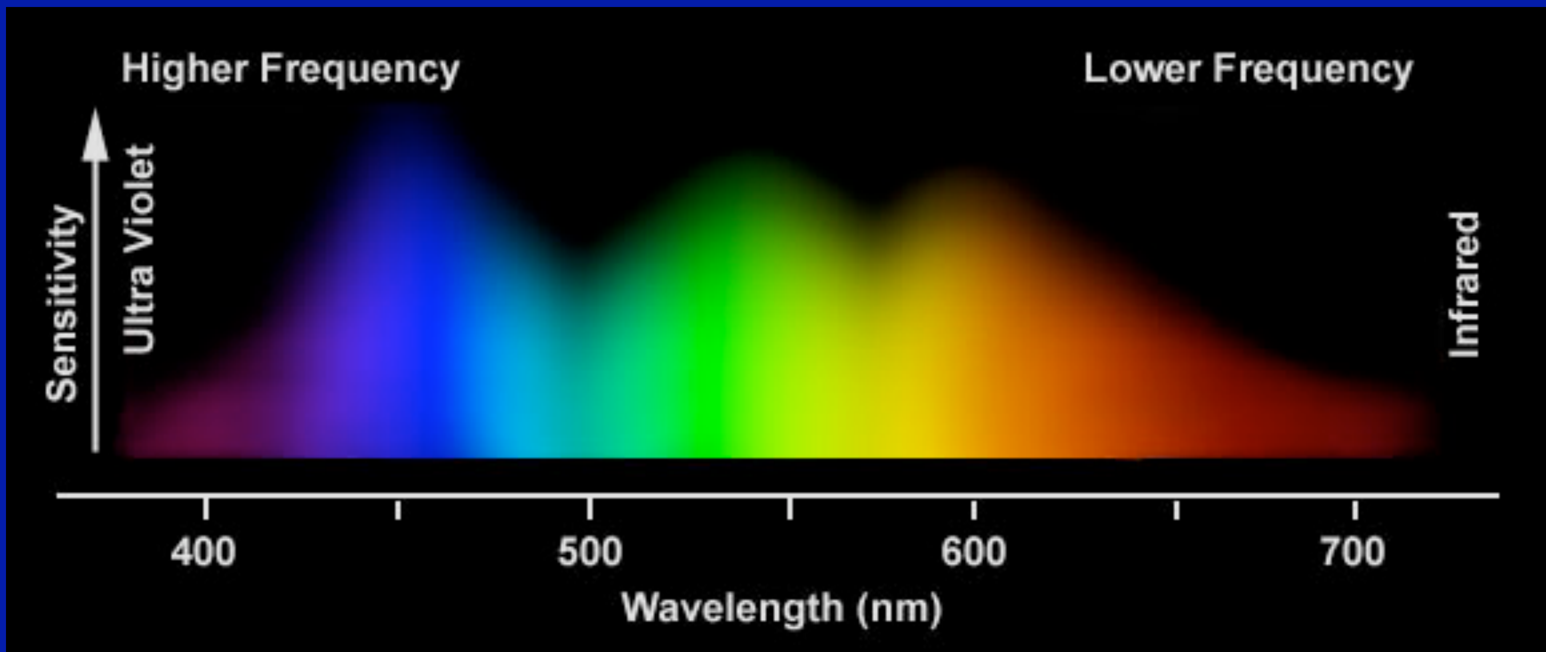
Long-wave receptors (558 nm)

Medium-wave receptors (531 nm)

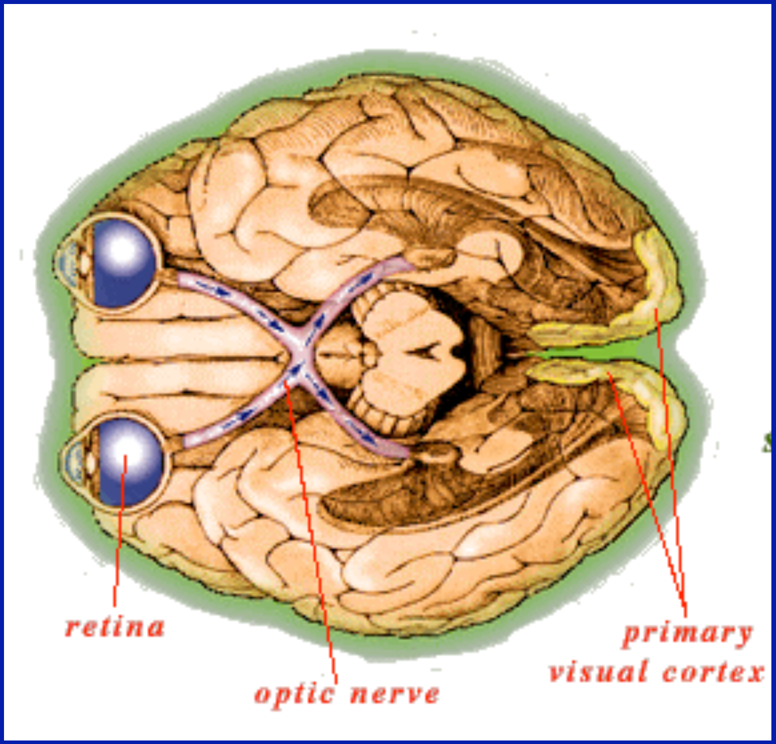
Short-wave receptors (419 nm)



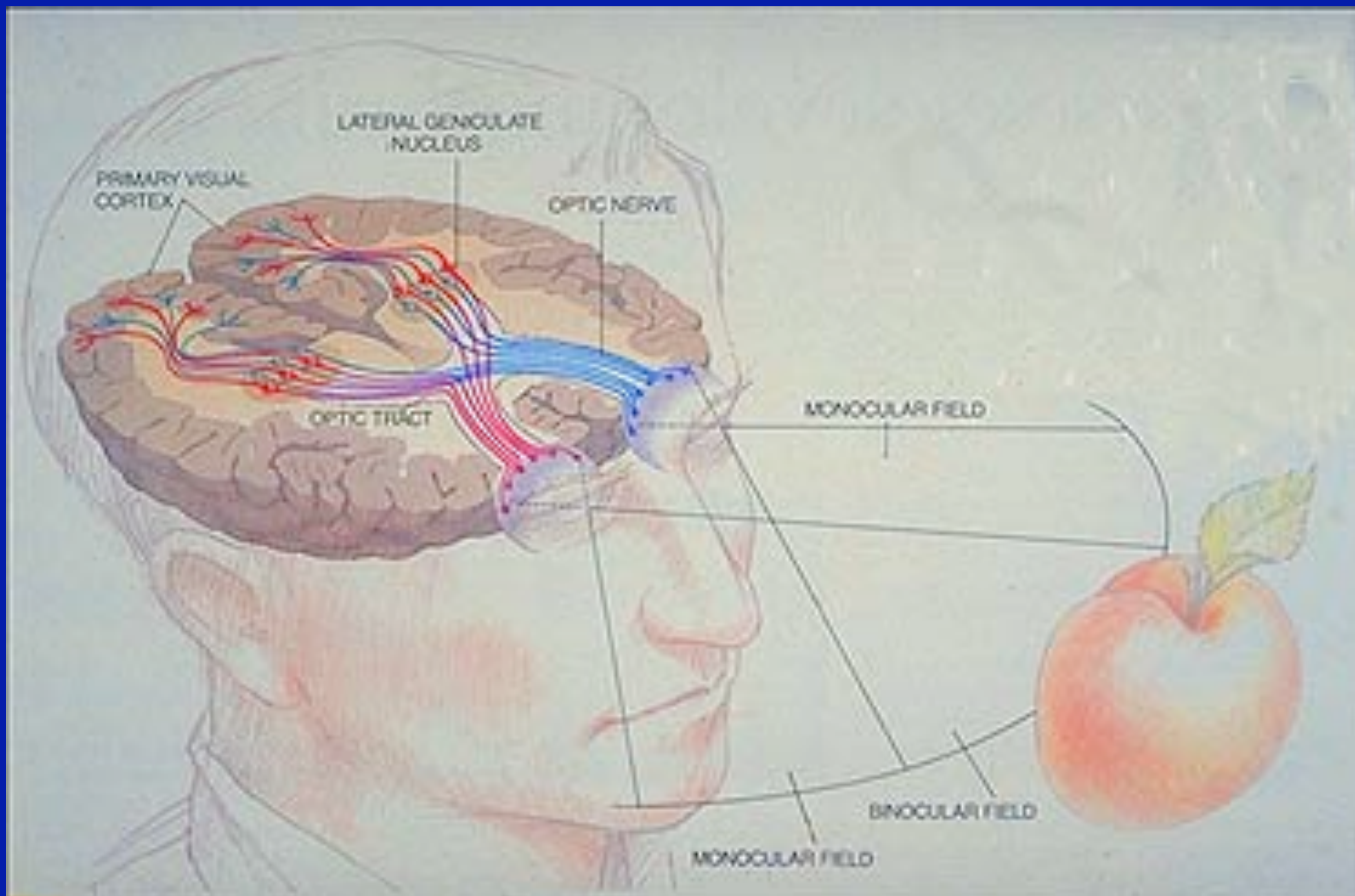
Cones sensitivity

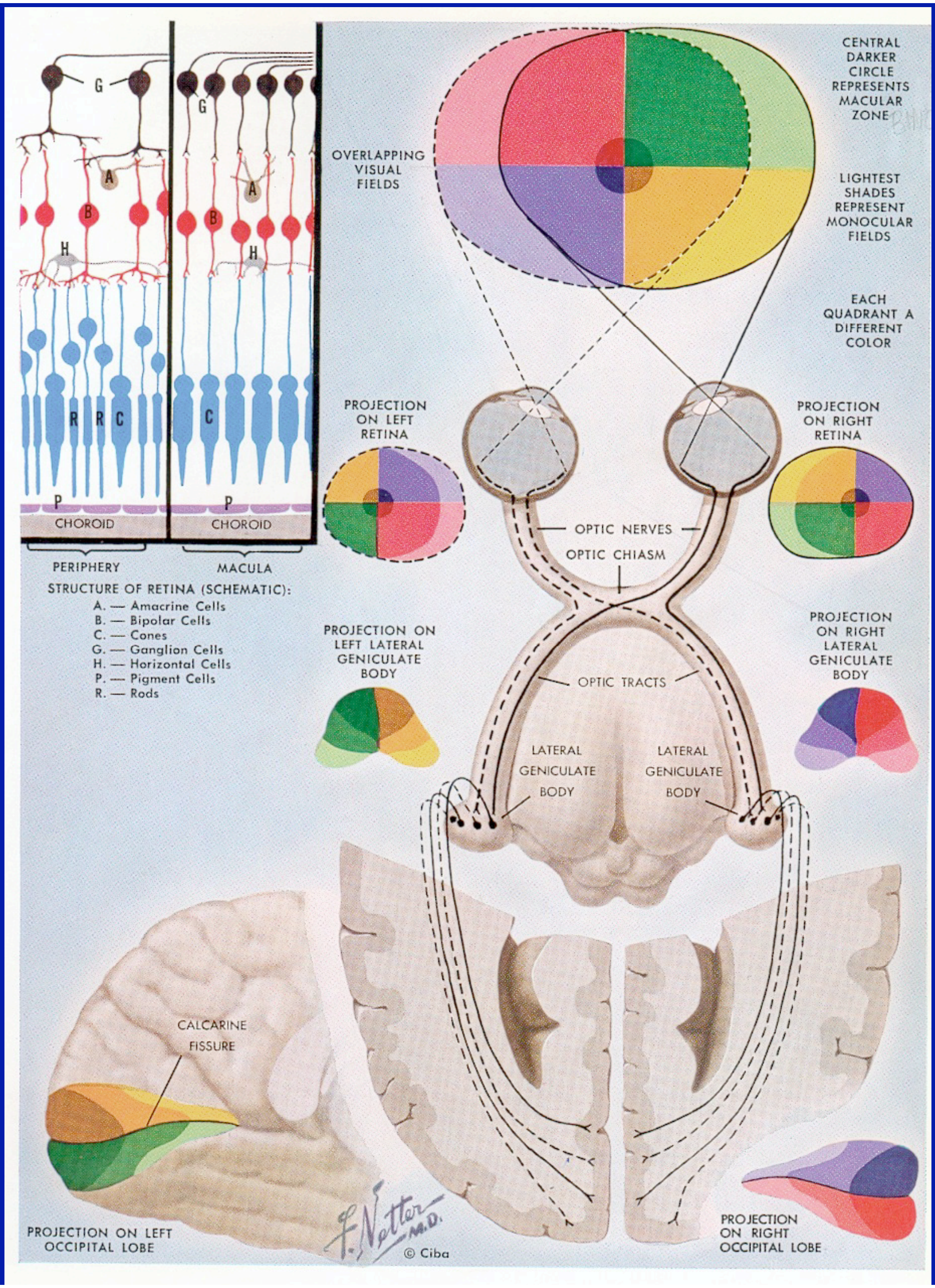


Visual Pathway



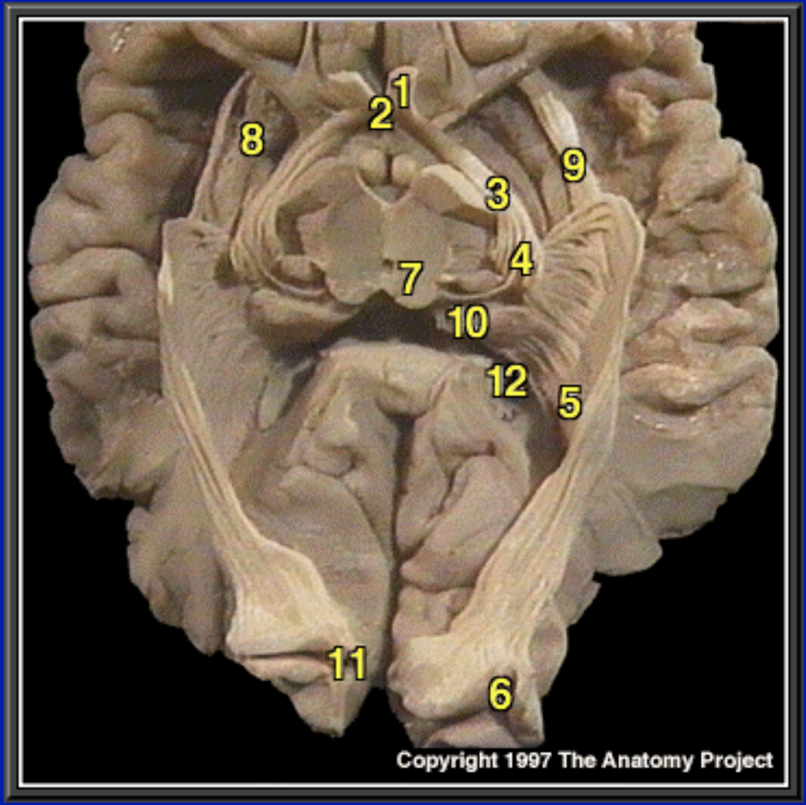
Visual Pathway



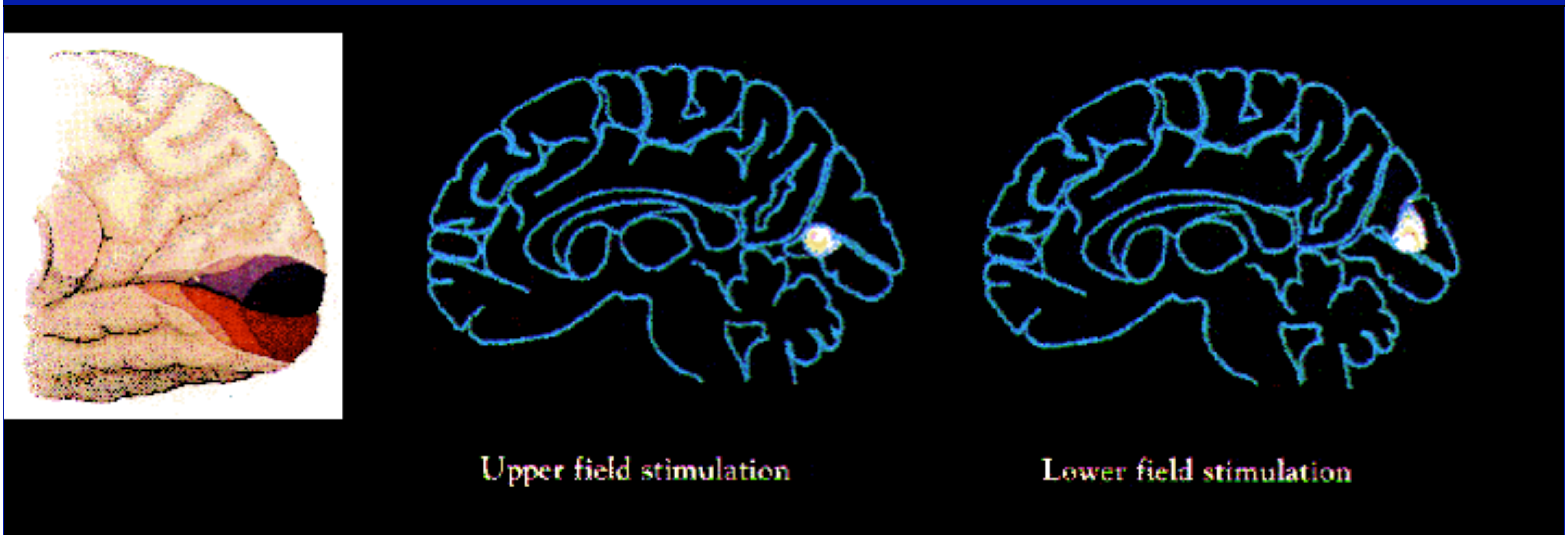


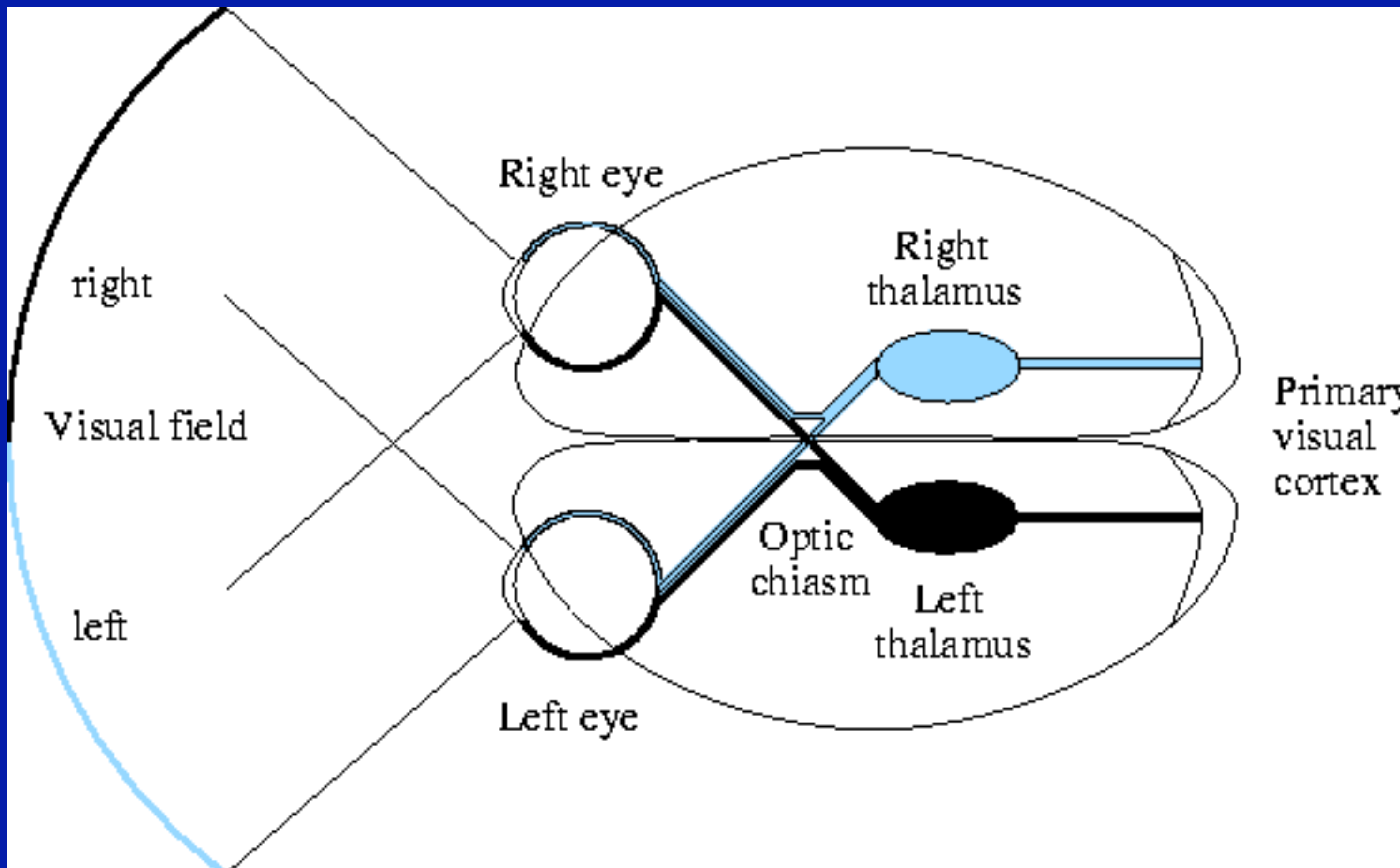
G
A
B
H
R
R
C
P
CHOROID
CHOROID
PERIPHERY
MACULA
STRUCTURE OF RETINA (SCHEMATIC):
A. — Amacrine Cells
B. — Bipolar Cells
C. — Cones
G. — Ganglion Cells
H. — Horizontal Cells
P. — Pigment Cells
R. — Rods
OVERLAPPING VISUAL FIELDS
CENTRAL DARKER CIRCLE REPRESENTS MACULAR ZONE
LIGHTEST SHADES REPRESENT MONOCULAR FIELDS
EACH QUADRANT A DIFFERENT COLOR
PROJECTION ON LEFT RETINA
PROJECTION ON RIGHT RETINA
OPTIC NERVES
OPTIC CHIASM
PROJECTION ON LEFT LATERAL GENICULATE BODY
PROJECTION ON RIGHT LATERAL GENICULATE BODY
OPTIC TRACTS
LATERAL GENICULATE BODY
LATERAL GENICULATE BODY
CALCARINE FISSURE
PROJECTION ON LEFT OCCIPITAL LOBE
PROJECTION ON RIGHT OCCIPITAL LOBE
F. Netter M.D.
© Ciba

Visual Pathway



1. optic nerve
2. optic chiasma
3. optic tract
4. thalamus (LGN)
5. optic radiation
6. visual cortex of occipital lobe

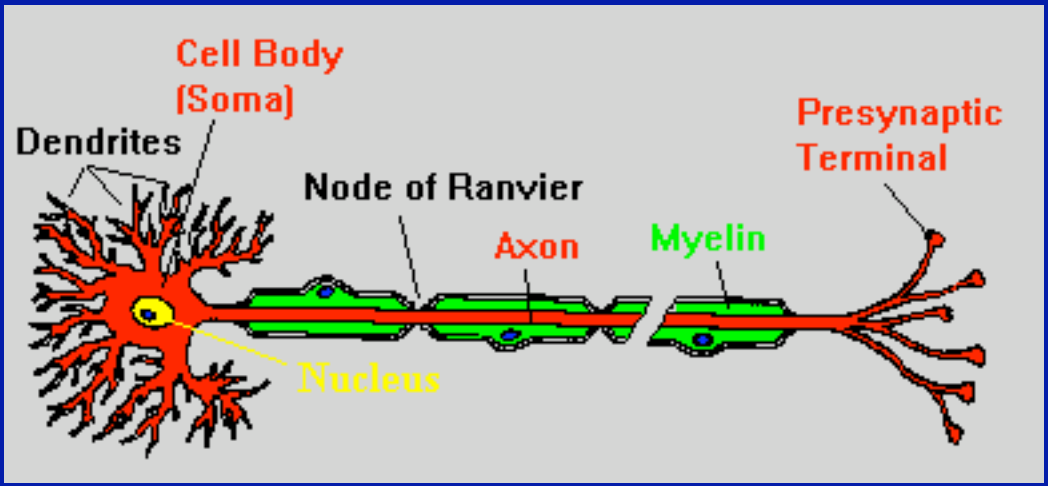

Upper field stimulation
Lower field stimulation

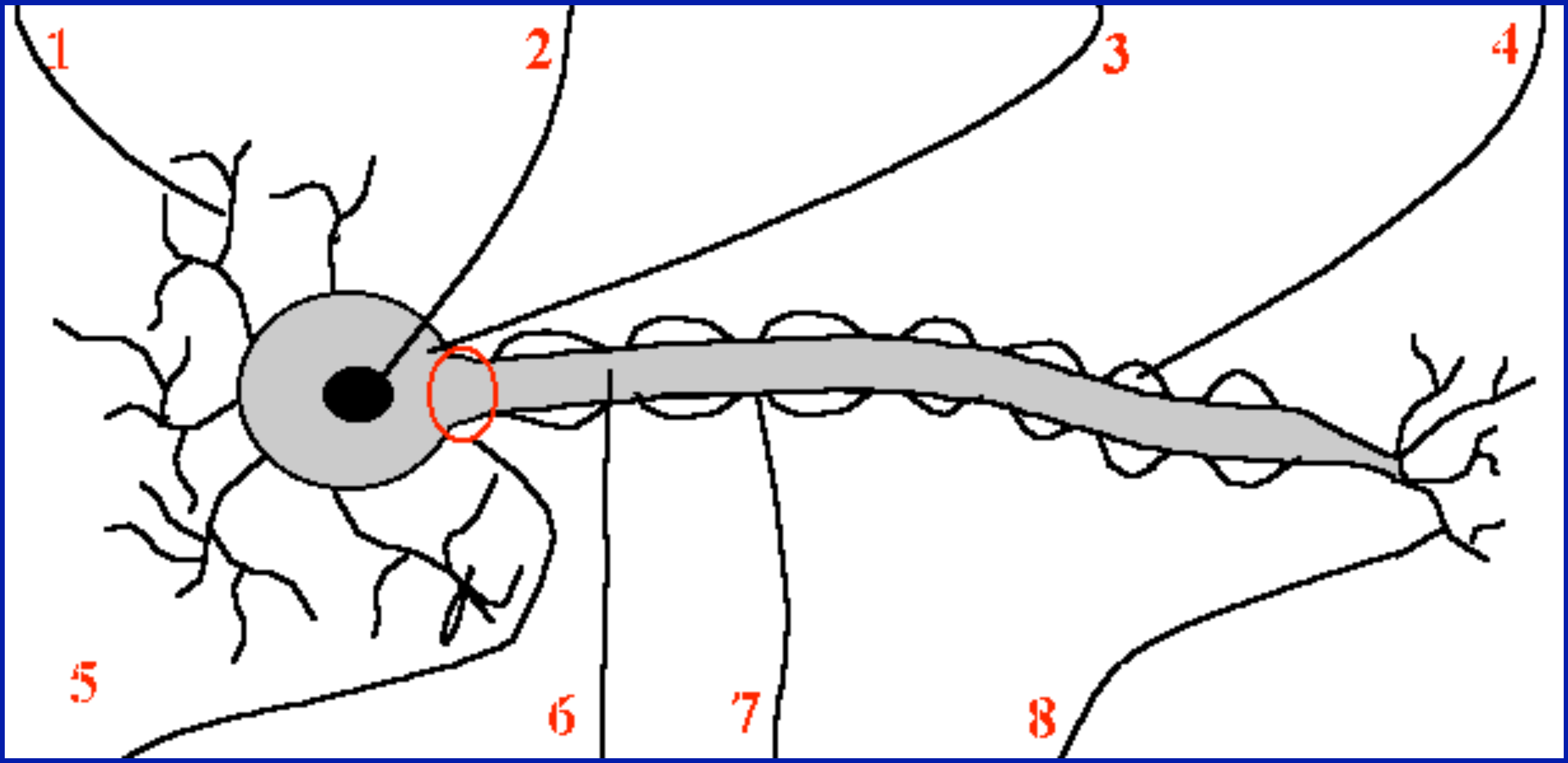


right
Visual field
left
Right eye
Left eye
Right
thalamus
Optic
chiasm
Left
thalamus
Primary
visual
cortex

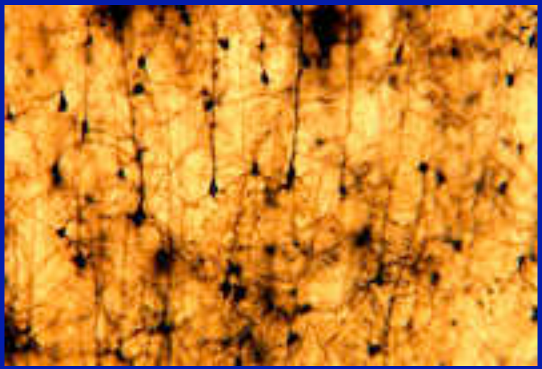
Neurons

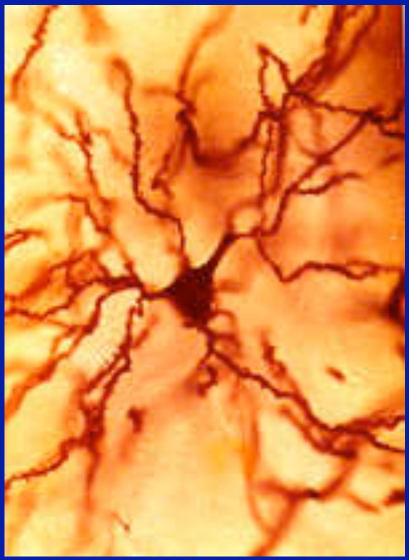
- Structure
- Electrical activity
- Action potential (nerve impulse)
  - **EPSP:**
    Excitatory post-synaptic potential)
  - **IPSP:**
    Inhibitory post synaptic potential)
- Neural circuits


Cell Body
(Soma)
Dendrites
Presynaptic
Terminal
Node of Ranvier
Axon
Myelin
Nucleus

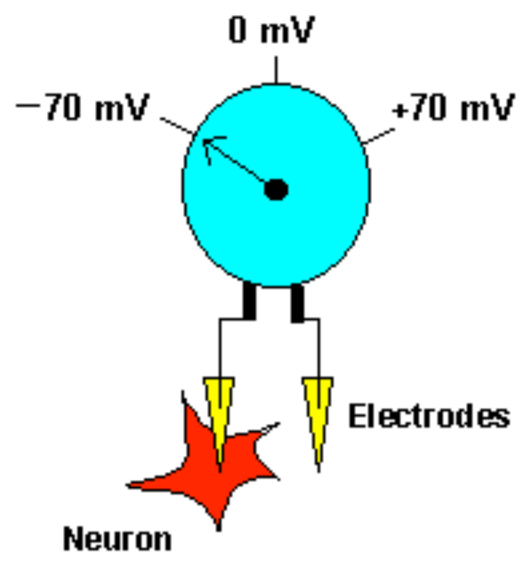


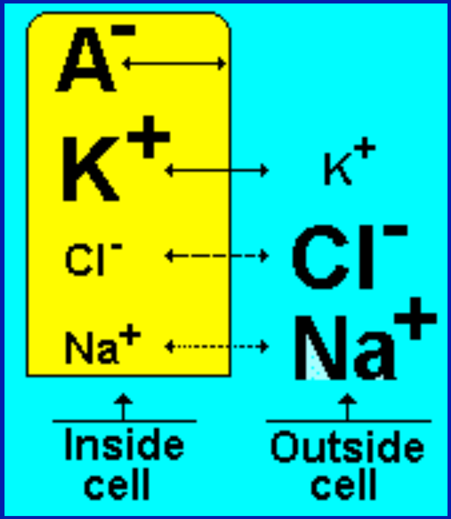
1. Dendrite
2. Nucleus
3. Soma
4. Myelin
5. Axon Hillock
6. Axon
7. Node of Ranvier
8. Axon Terminal

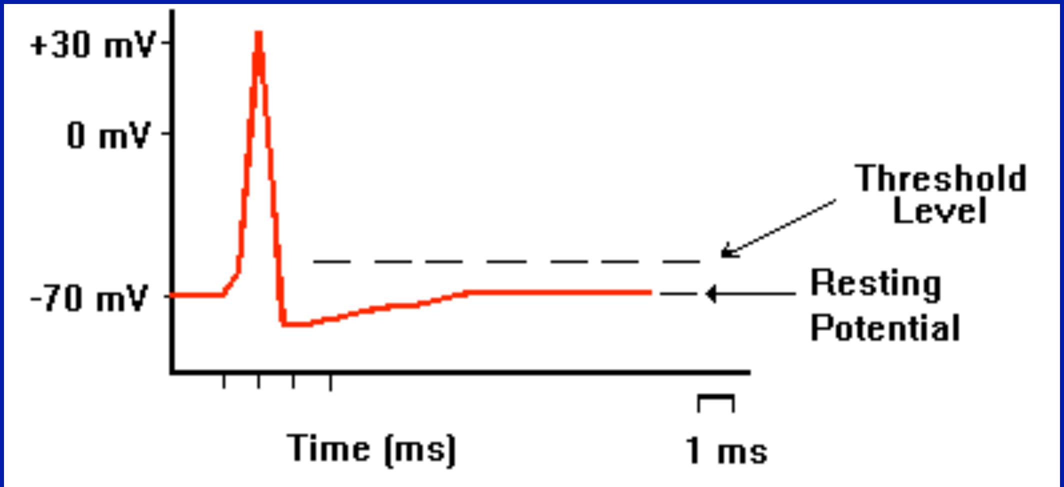




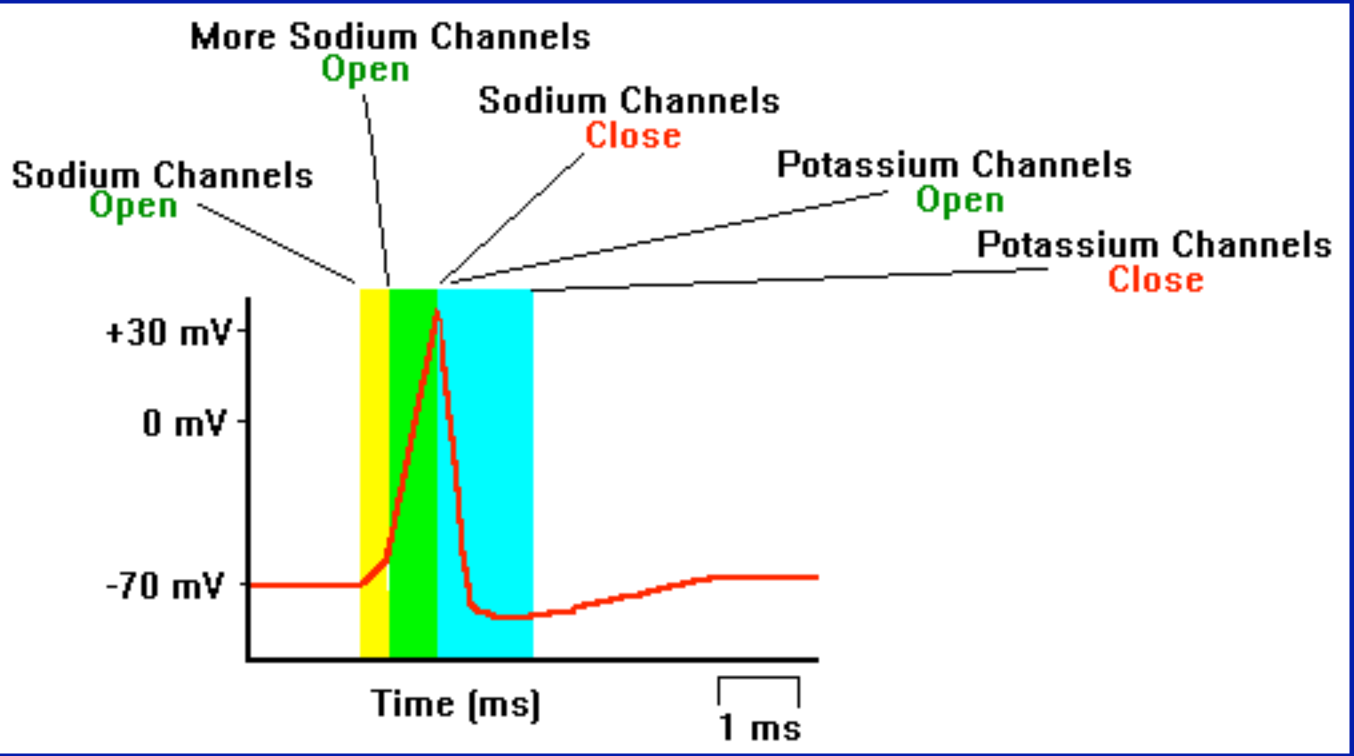
Neuron located in the cerebral cortex of the hamster. Golgi stain. (Image courtesy of Dr. James Crandall, Eunice Kennedy Shriver Center)


0 mV
−70 mV
+70 mV
Electrodes
Neuron

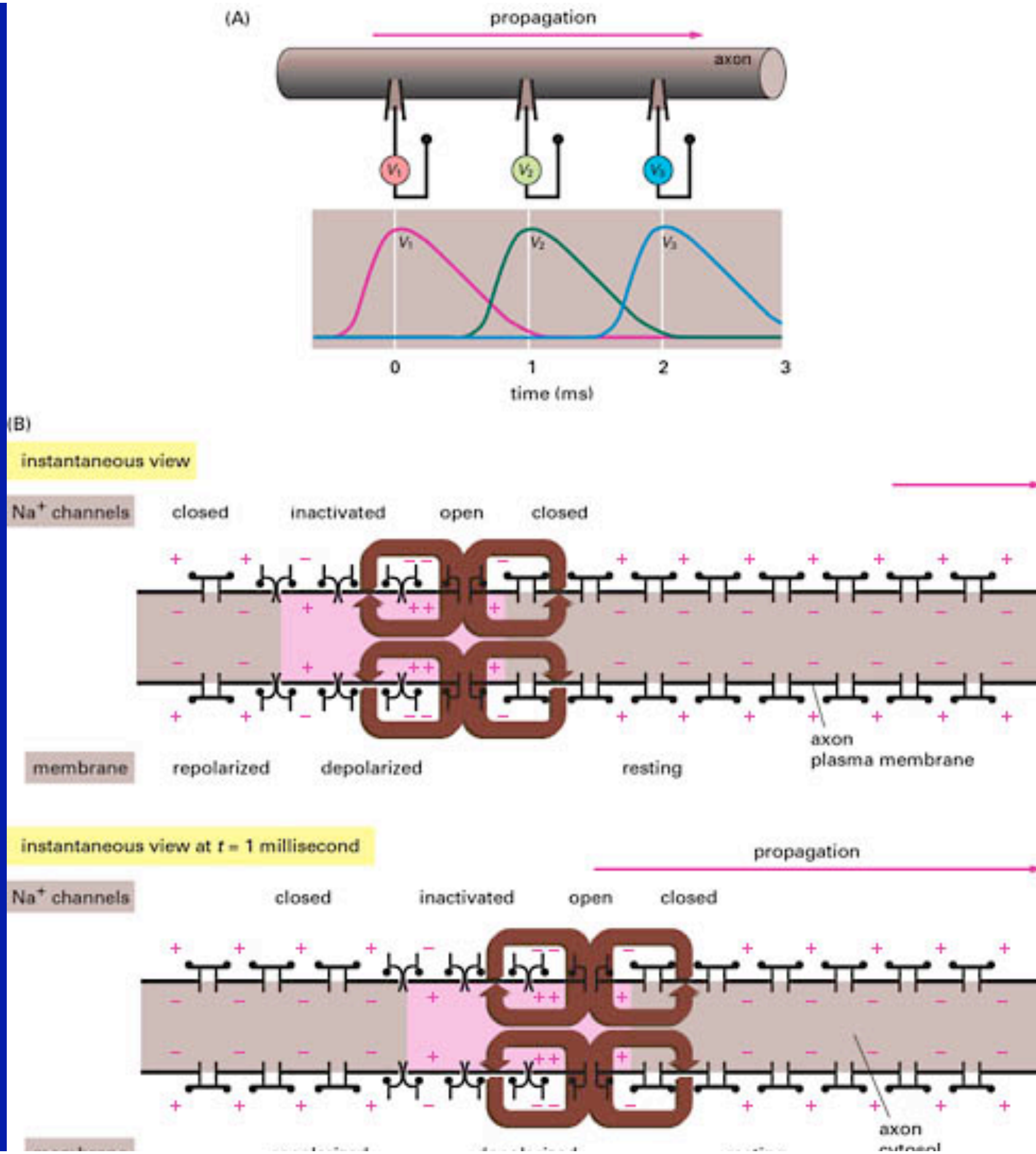

A⁻
K⁺
K⁺
Cl⁻
Cl⁻
Na⁺
Na⁺
Inside cell
Outside cell



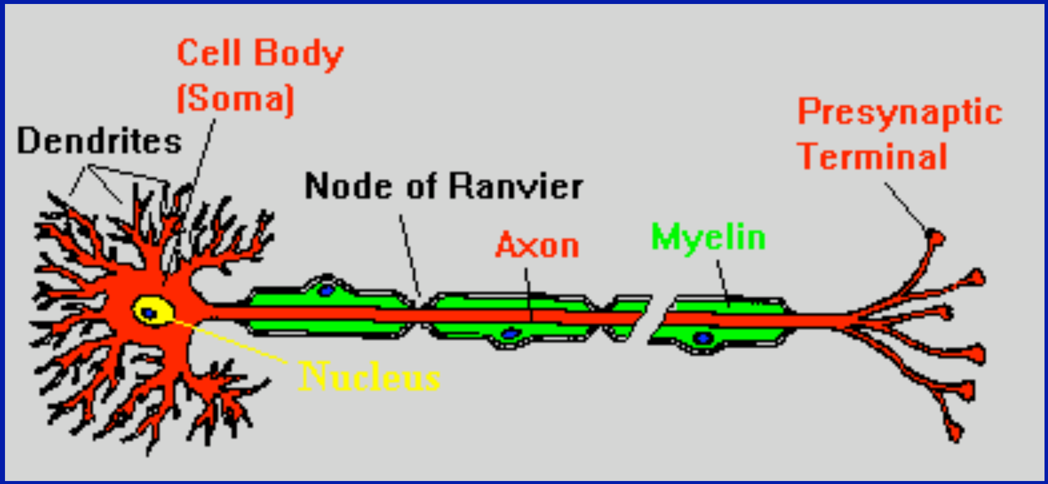
+30 mV
0 mV
-70 mV
Threshold Level
Resting Potential
Time (ms)
1 ms



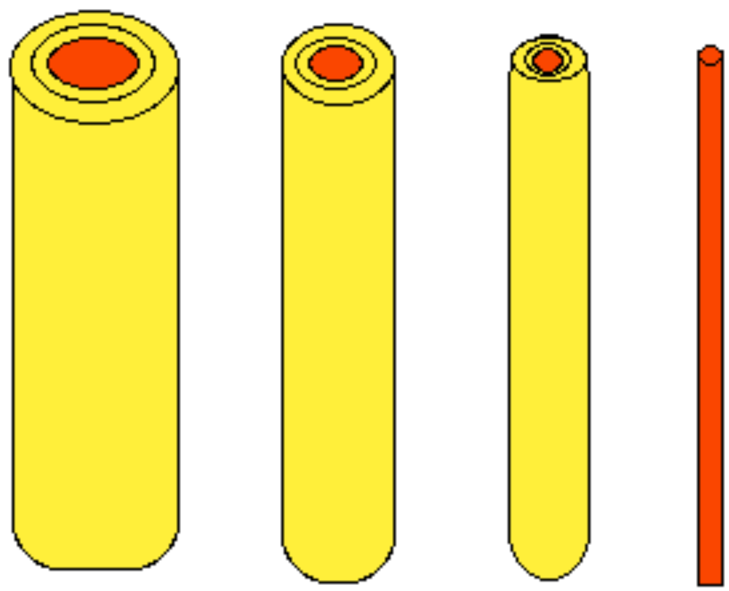
More Sodium Channels Open
Sodium Channels Close
Sodium Channels Open
Potassium Channels Open
Potassium Channels Close
+30 mV
0 mV
-70 mV
Time (ms)
1 ms



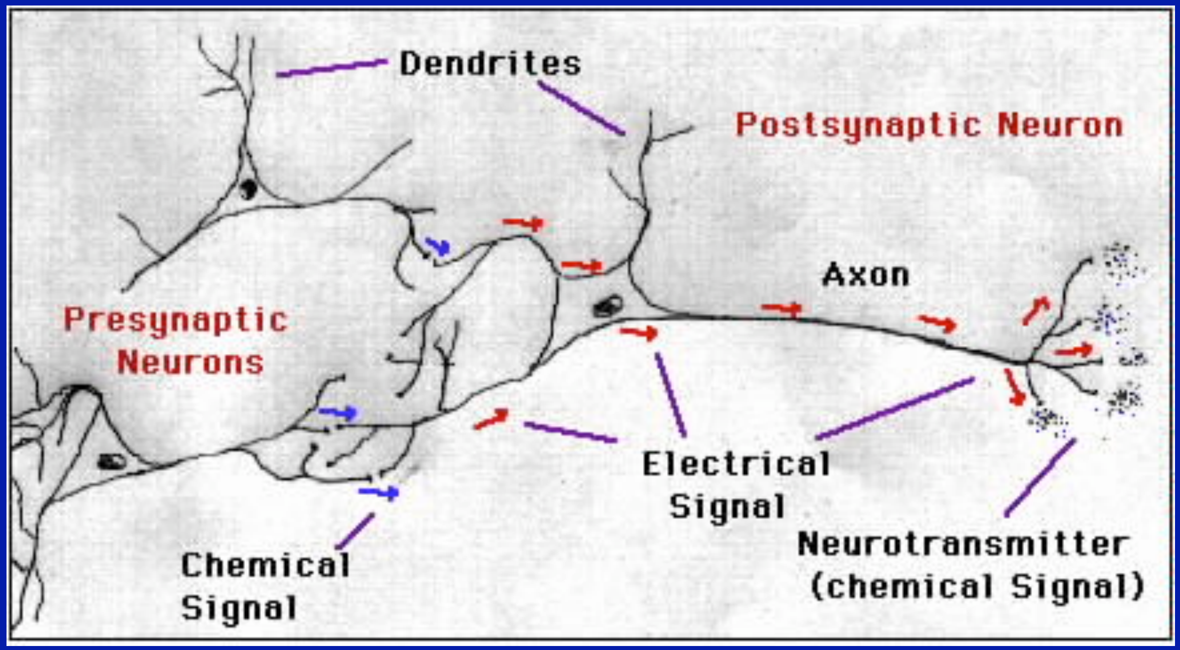
(A)
propagation
axon
0
1
2
3
time (ms)
(B)
instantaneous view
Na+ channels
closed
inactivated
open
closed
membrane
repolarized
depolarized
resting
axon
plasma membrane
instantaneous view at t = 1 millisecond
propagation
Na+ channels
closed
inactivated
open
closed
axon

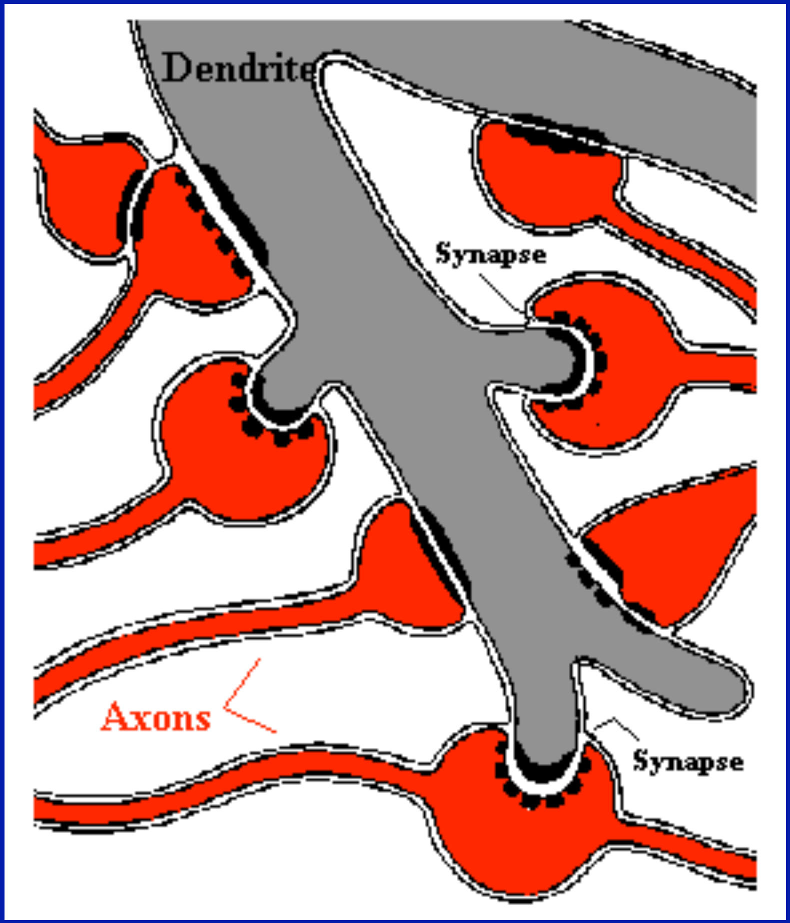


Primary Afferent Axons



Axon Type	Aα	Aβ	Aδ	C
Diameter (µm)	13-20	6-12	1-5	.2-1.5
Speed (m/s)	80-120	35-75	5-35	.5-2.0


Dendrites
Postsynaptic Neuron
Axon
Presynaptic
Neurons
Electrical
Signal
Neurotransmitter
(chemical Signal)
Chemical
Signal


Dendrite
Synapse
Axons
Synapse

Excitatory Post-Synaptic Potential

EPSP

Depolarization of the post-synaptic membrane

Increase the probability of nerve firing

Inhibitory Post-Synaptic Potential

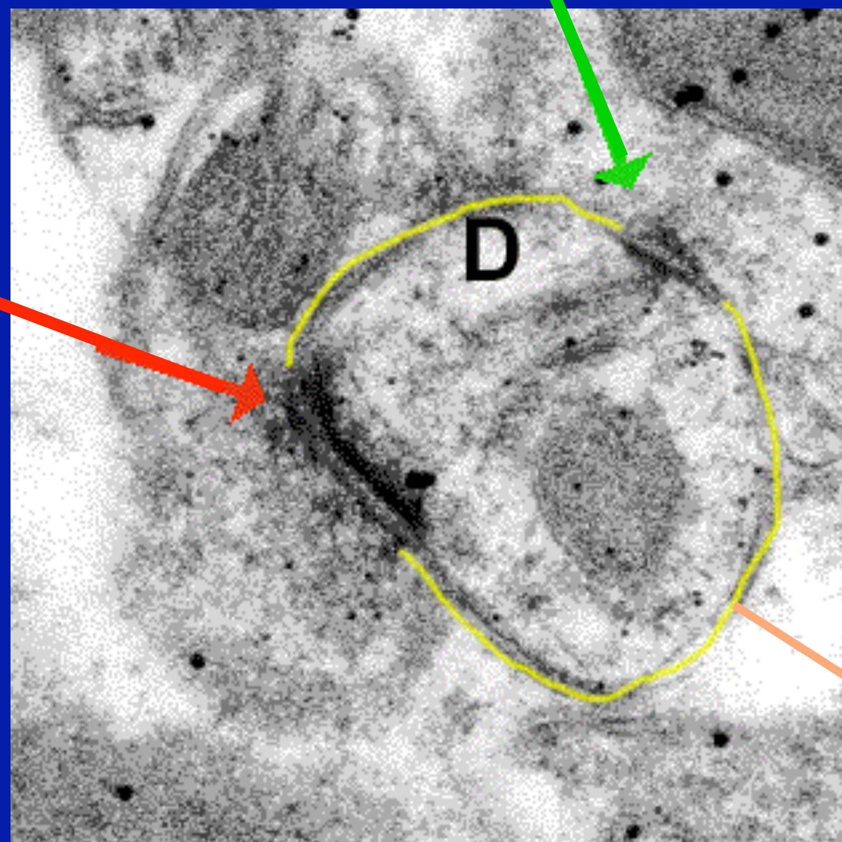
IPSP

Hyperpolarization of the post-synaptic membrane

Decrease the probability of nerve firing

Excitatory synapse

Inhibitory synapse



Dendrite

VISUAL PATHWAYS

Hubel and Wiesel:

***Receptive fields

- Retina: ganglion cells
- Lateral Geniculate Nucleus
- Visual cortex

Receptive fields

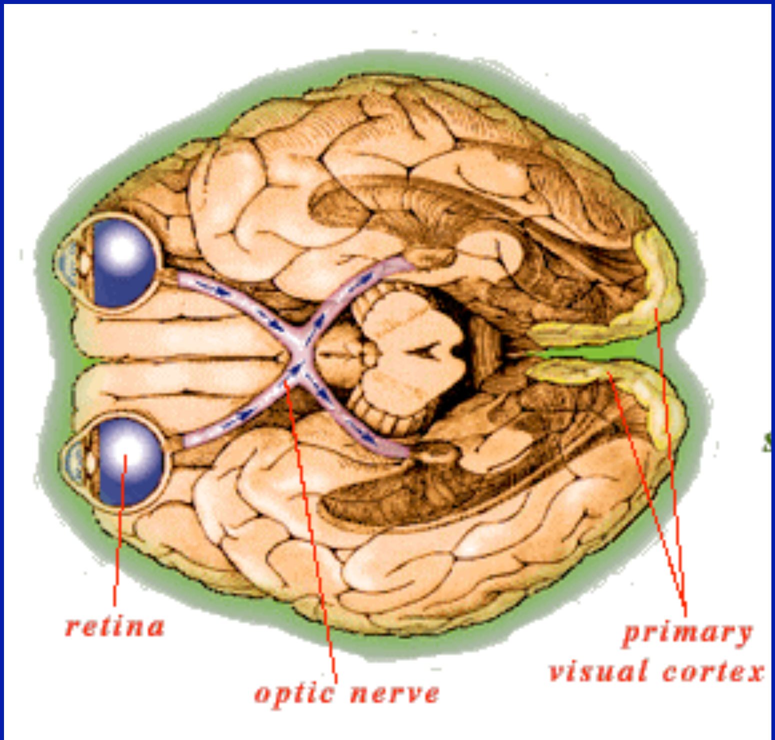
The regions of receptors on the retina which when stimulated make a neuron fires

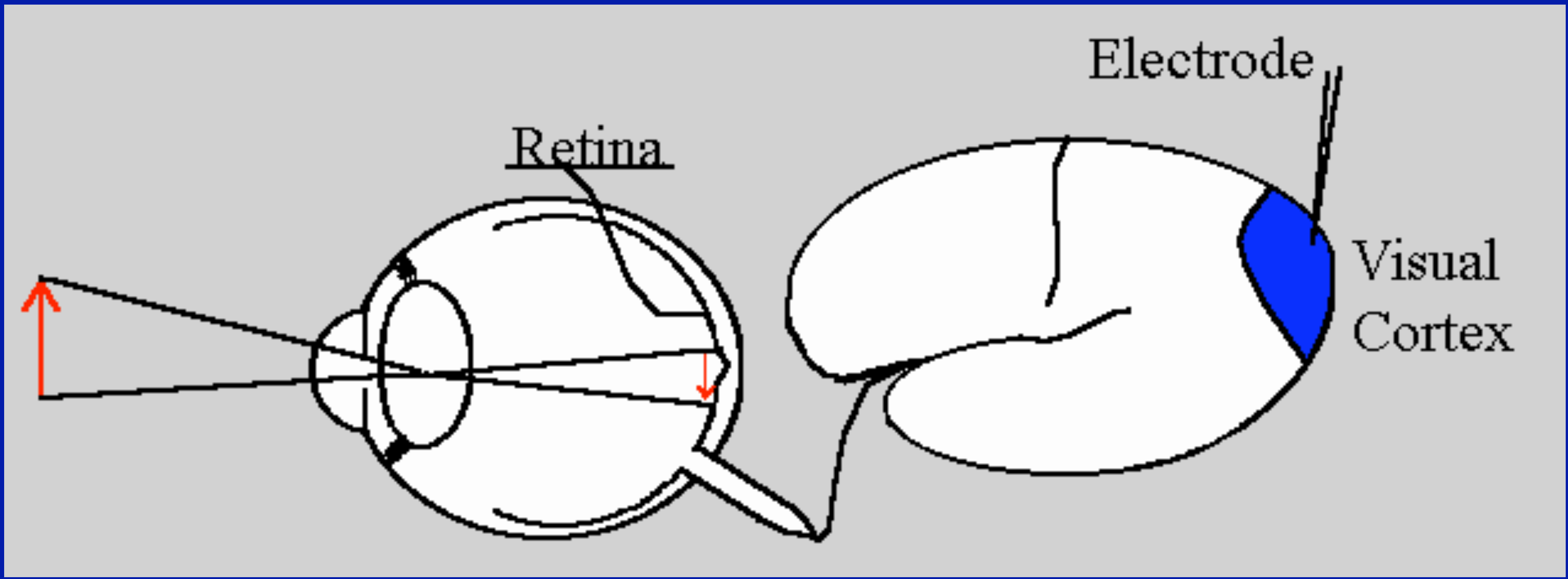
Psychophysics is the study of the quantitative relationship between environmental stimulation (the physical dimension) and sensory experience (the psychological dimension).

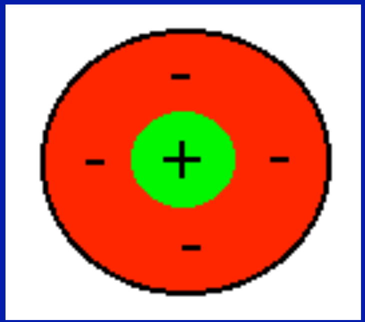
Two of the basic parameters of human performance that are measured using psychophysical methods are accuracy (i.e., validity) and precision (i.e., reliability). These two measures are closely related to concepts encountered in most psychology courses.

The package presented here consists of five independent modules. Three of the modules will give you hands-on experience learning about psychophysical methods typically used to measure accuracy and precision. These methods are the *Method of Limits*, the *Method of Constant Stimuli*, and the *Method of Adjustment*. The other two modules will give you hands-on experience learning about how to apply the concepts of accuracy and precision. This will be done by examining the *Mueller-Lyer Illusion* and *Weber's Law*. Within each of the modules you will be given (a) a clear description of the objectives of the module, (b) hands-on experience collecting and analyzing data pertinent to the module, (c) the opportunity to take an online quiz designed to test how well you understand the key concepts, and (d) the opportunity to vary the parameters of the program and thus design your own experiments.

Visual Pathway



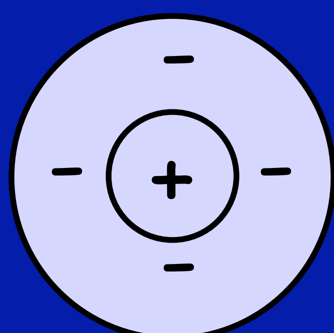

Electrode
Retina
Visual
Cortex



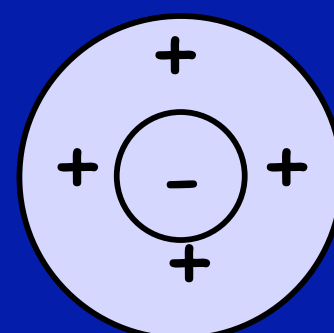
Receptive fields in the Retina and Lateral Geniculate Nucleus (LGN)

Center-Surround or concentric cells

Center-ON
Surround-OFF

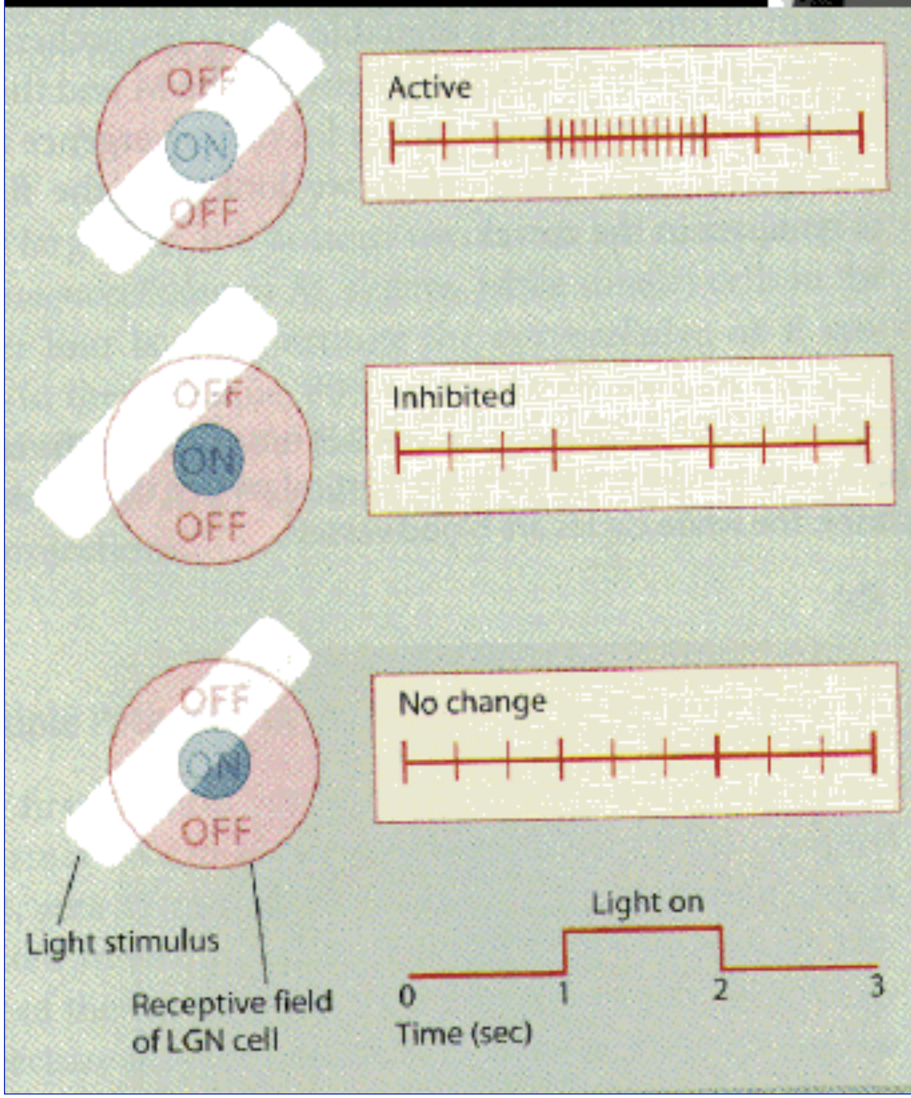


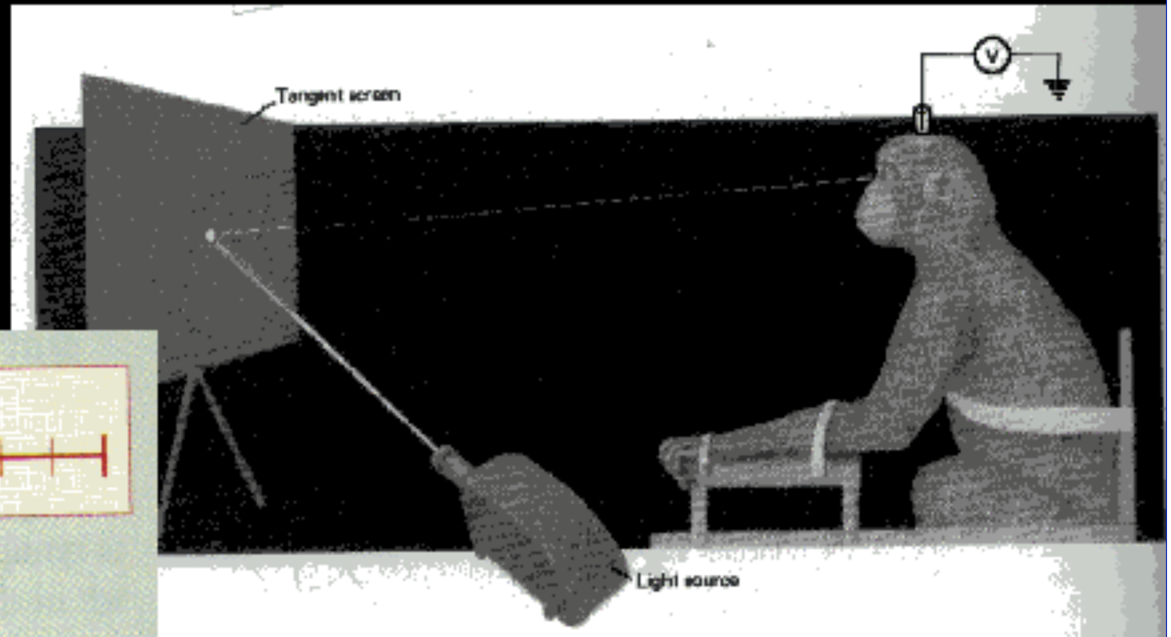
Center-OFF
Surround-ON

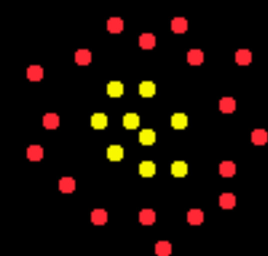


MacRetina:

- ganglion cells
- LGN cells



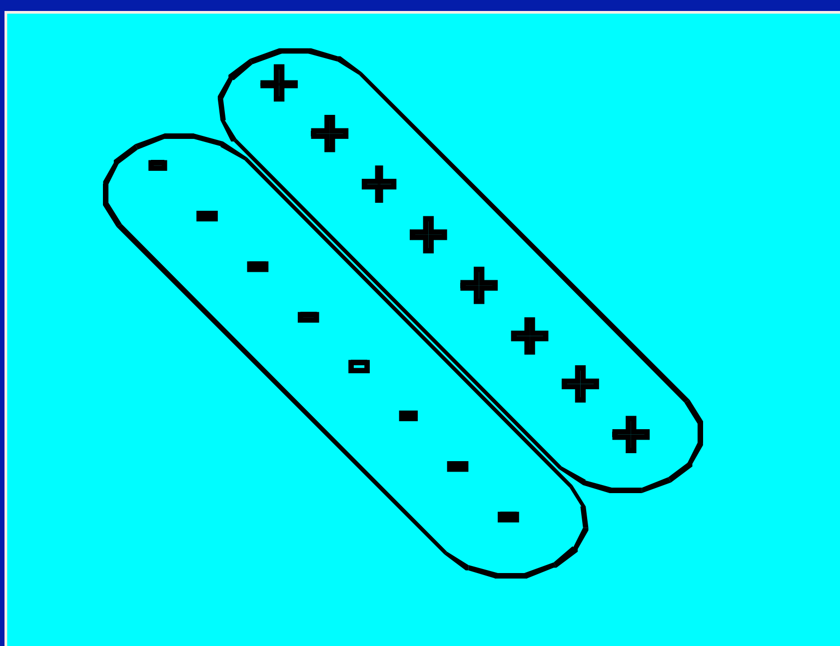


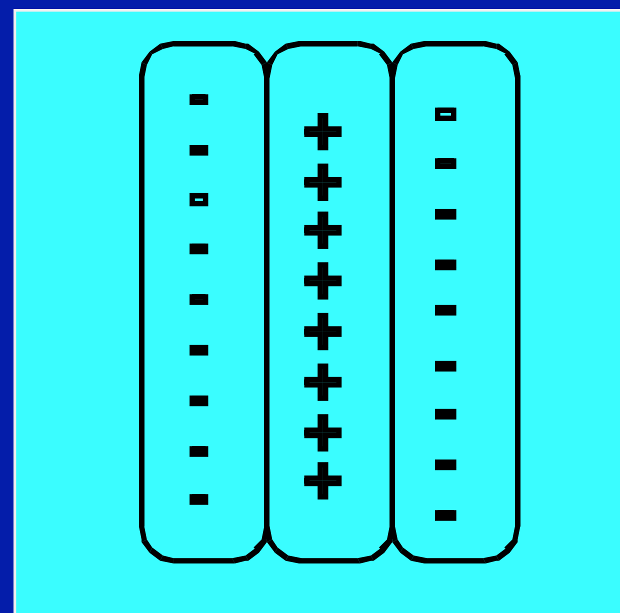


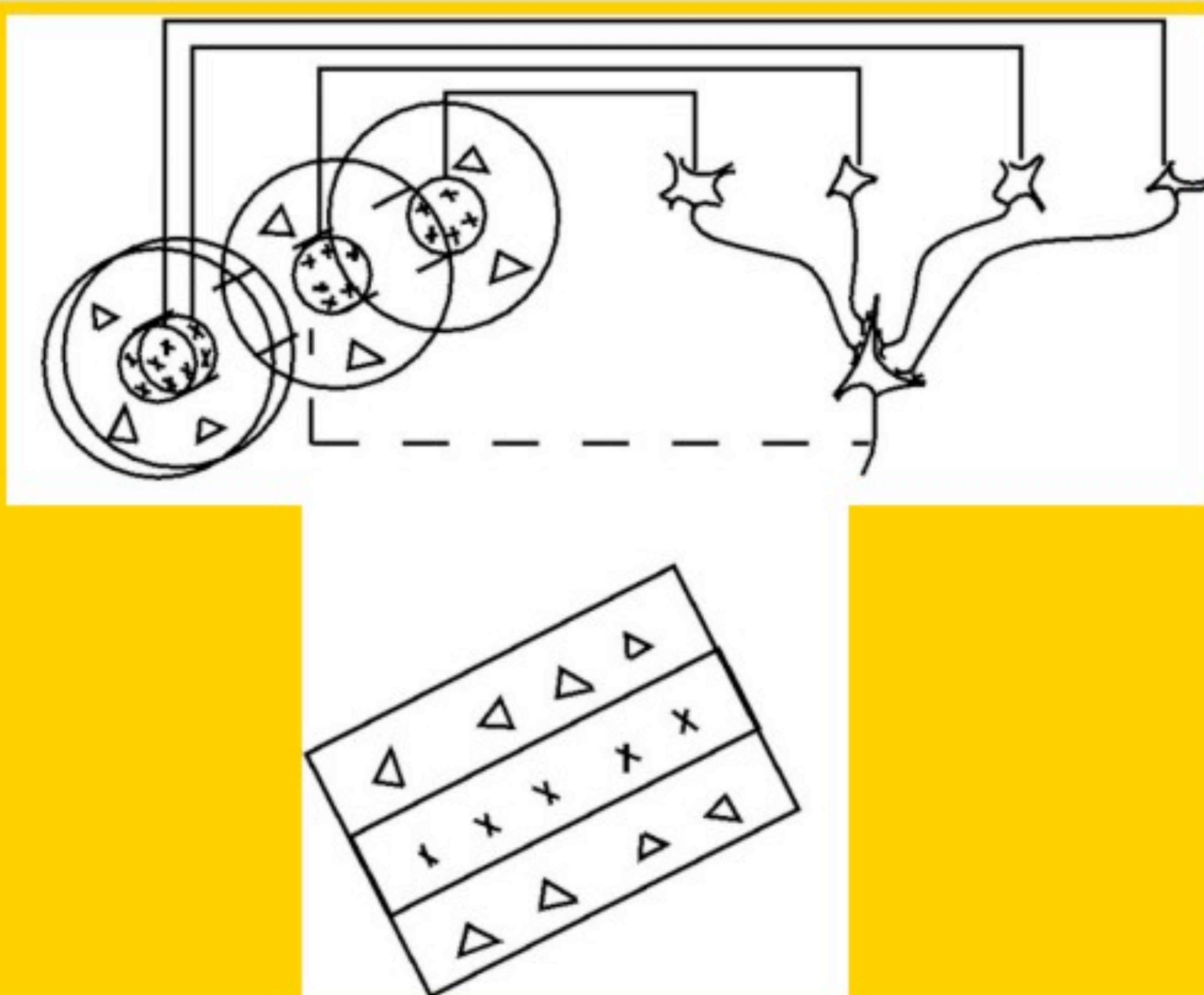
Receptive fields in the first visual area: V1, Striate Cortex, Area 17

Simple cells

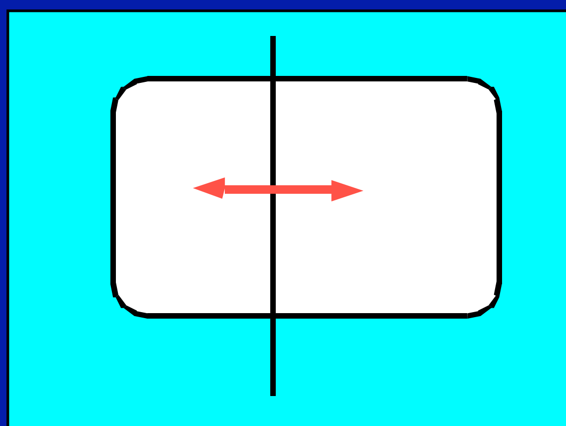
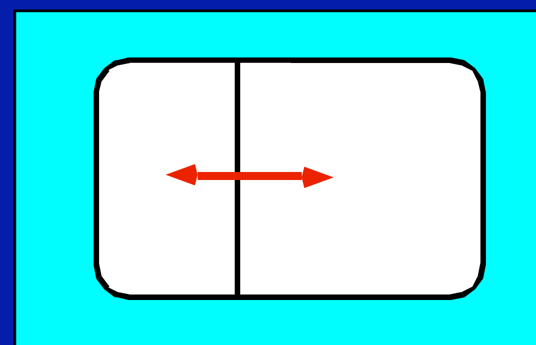
Orientation selective (Linear)





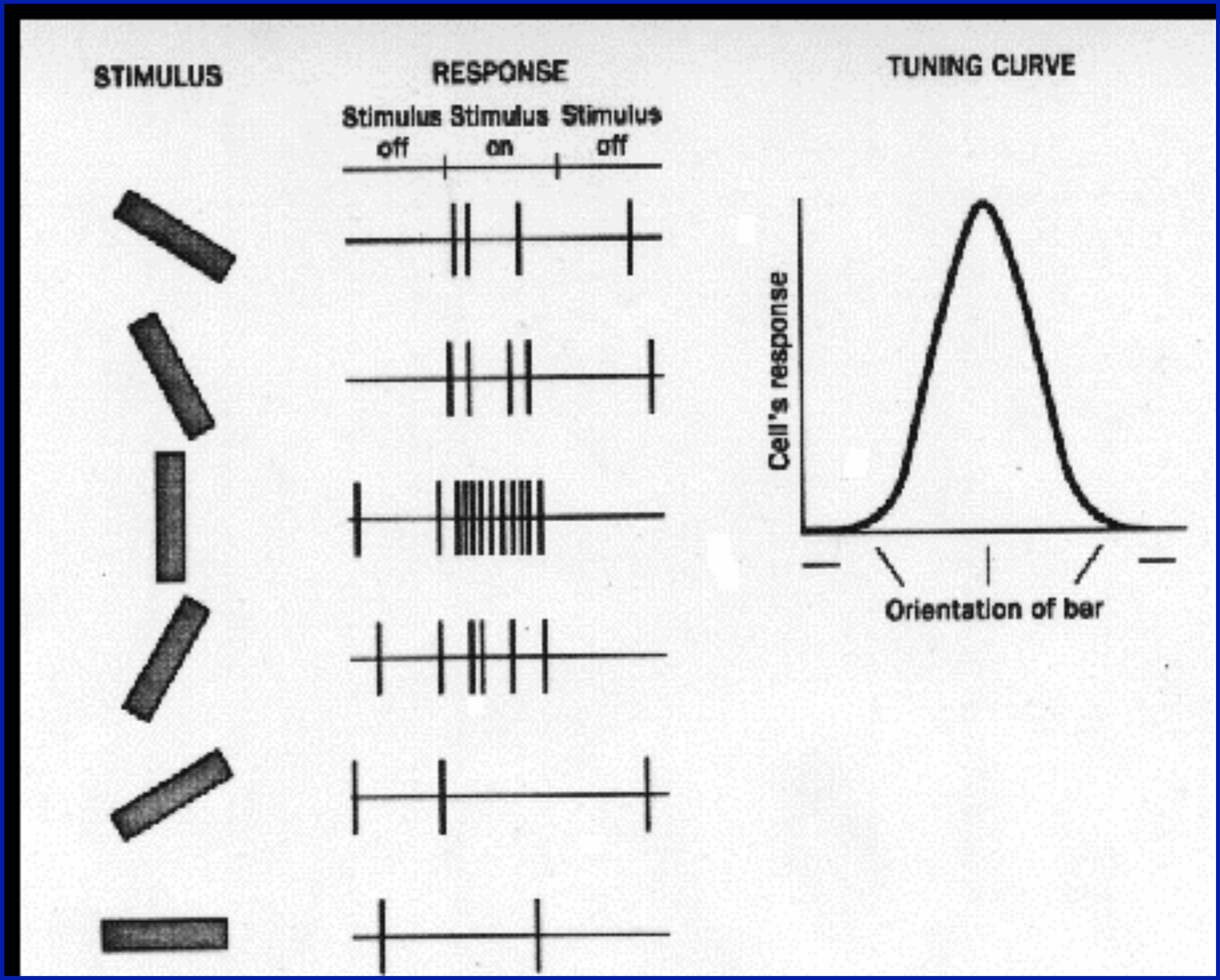


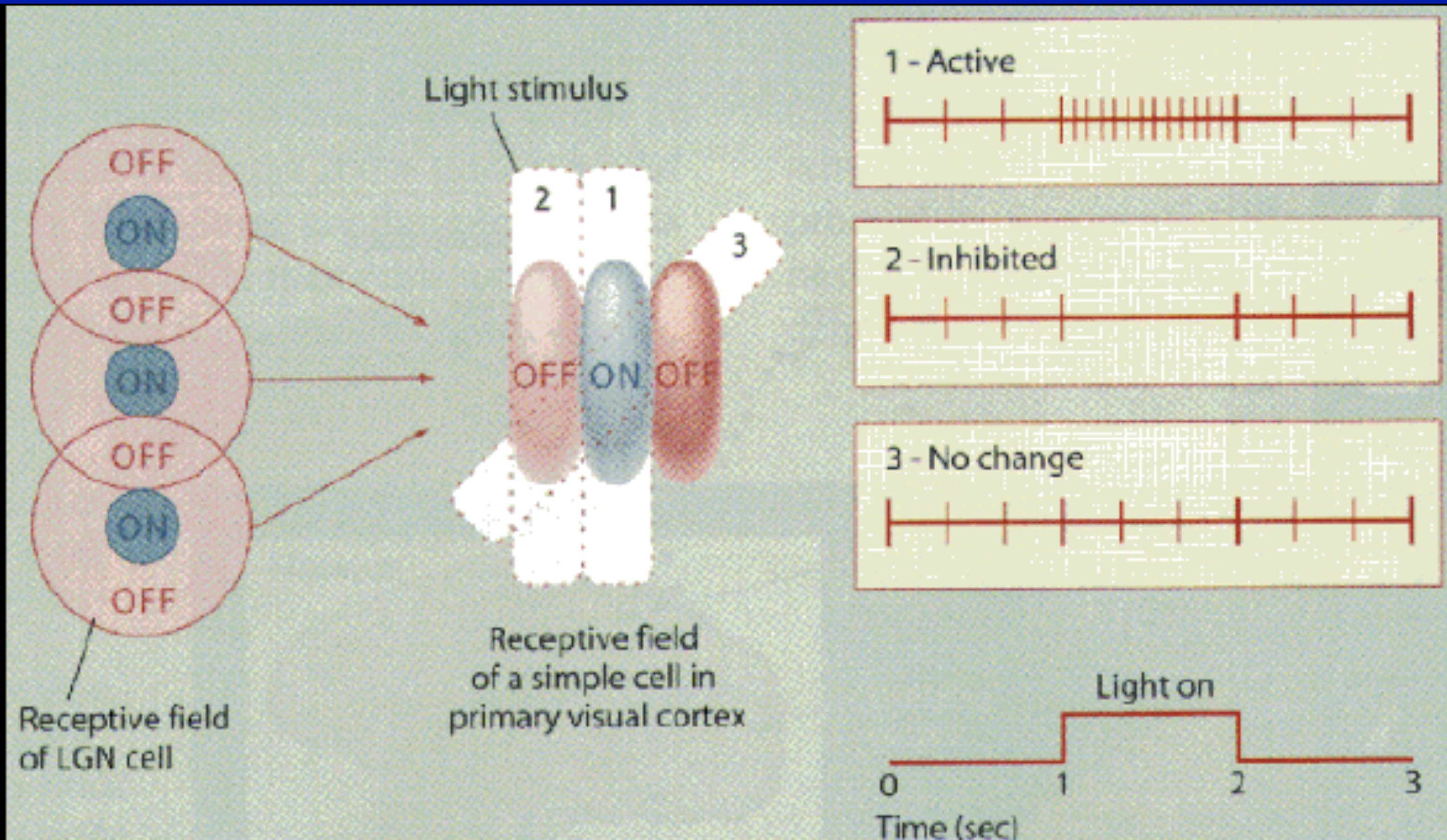
Receptive fields in the first visual area:
V1, Striate Cortex, Area 17

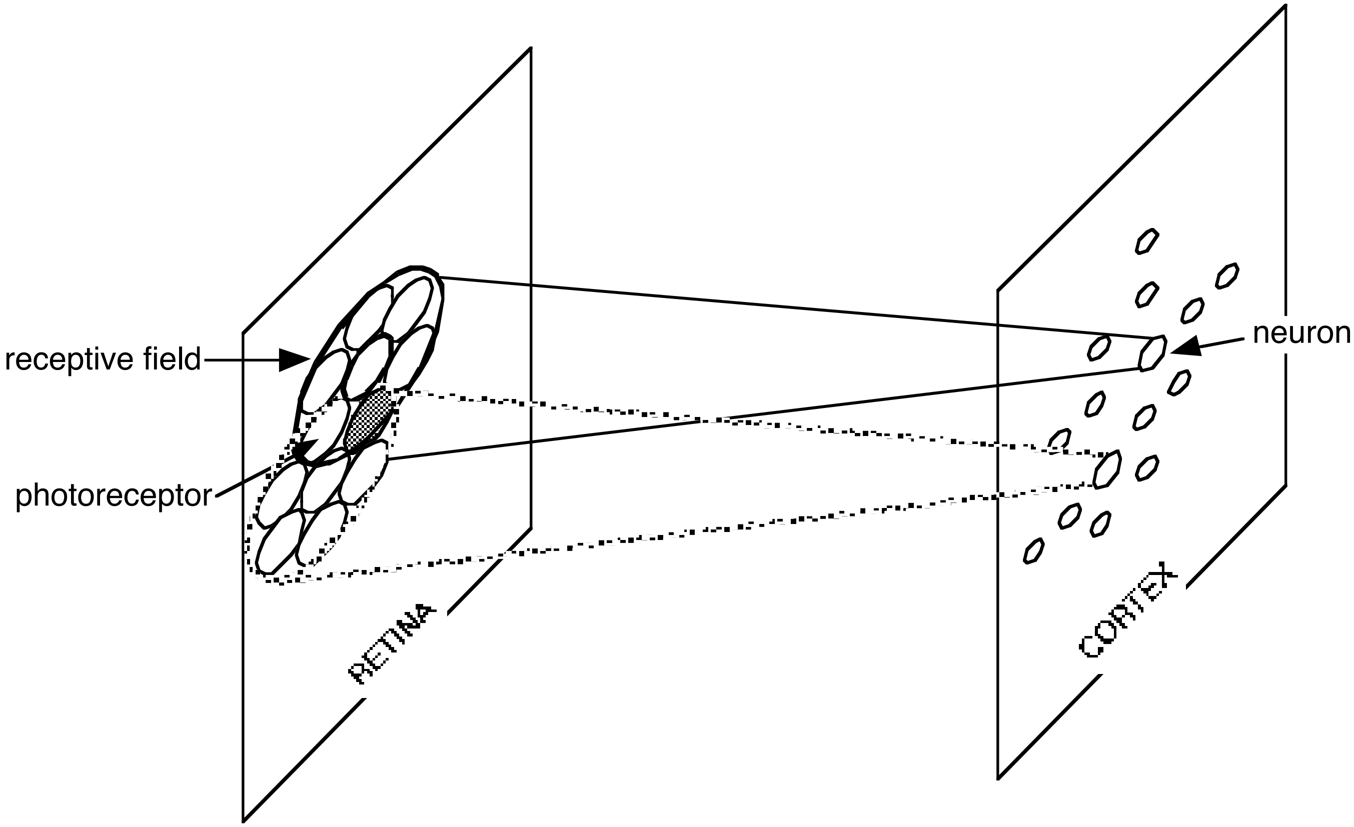
Complex cells	Hypercomplex cells
	
	END STOPPED
Orientation selective Motion selective Not position	Orientation selective Motion selective Not position

Orientation selective

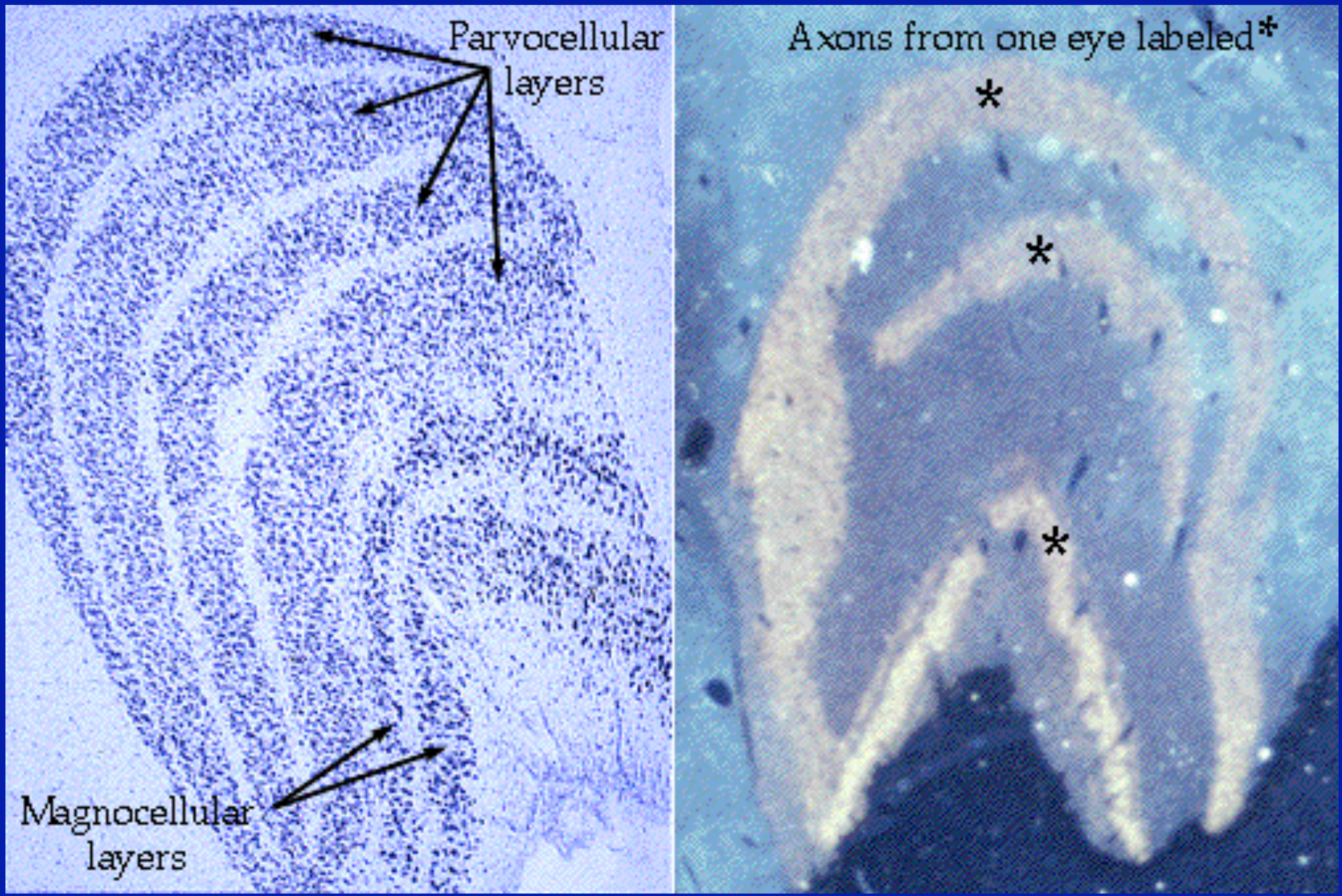
Tuning curve




Light stimulus
OFF
ON
OFF
ON
OFF
ON
OFF
Receptive field
of LGN cell
2
1
3
OFF ON OFF
Receptive field
of a simple cell in
primary visual cortex
1 - Active
2 - Inhibited
3 - No change
Light on
0
1
2
3
Time (sec)


receptive field
photoreceptor
neuron
RETINA
CORTEX

Lateral Geniculate Nucleus



ORGANIZATION
OF
THE VISUAL CORTEX

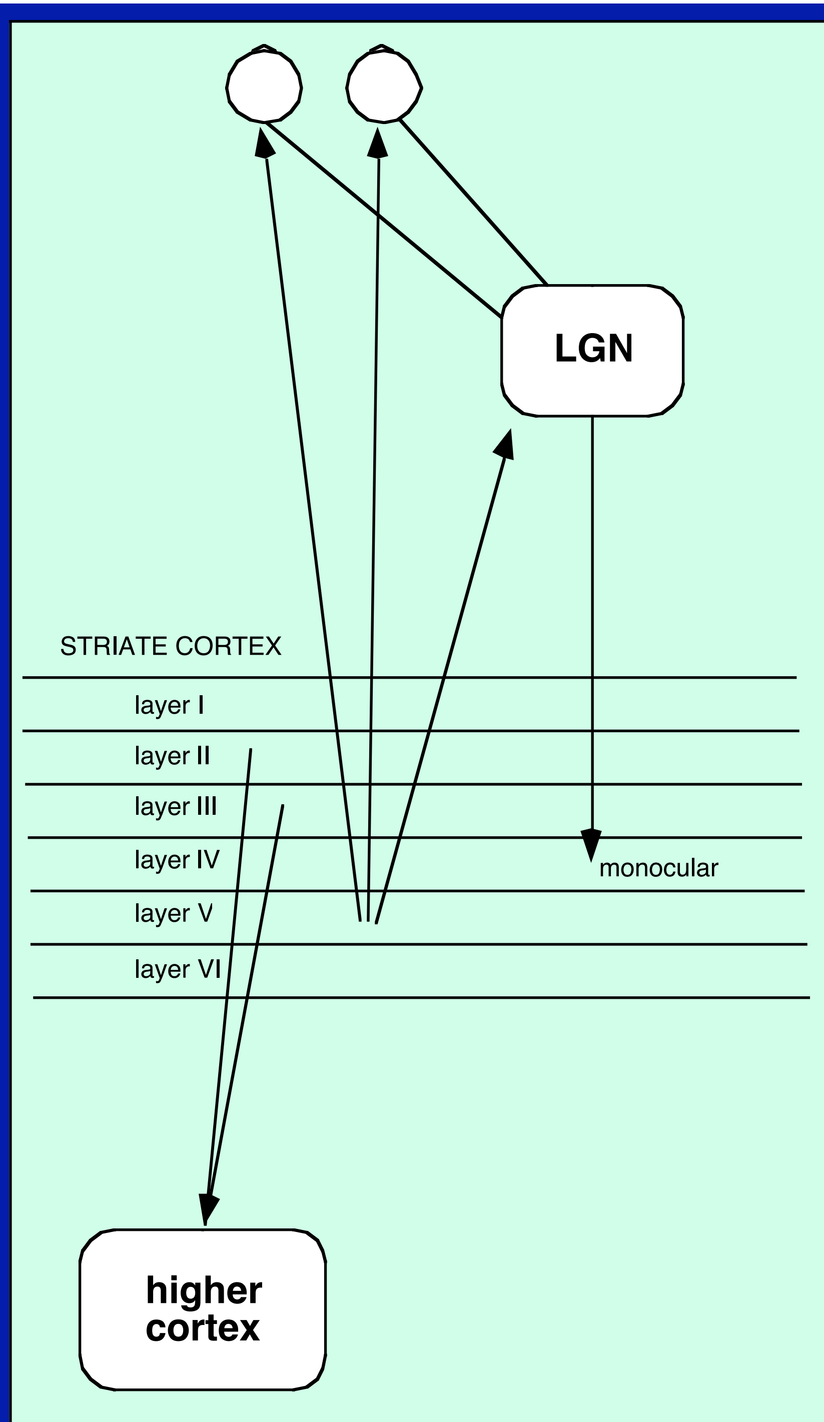
- Laminar organization
- Retinotopic
- Ocular dominance
- Orientation preference
- Color blob (in V4)

Primary Visual Cortex

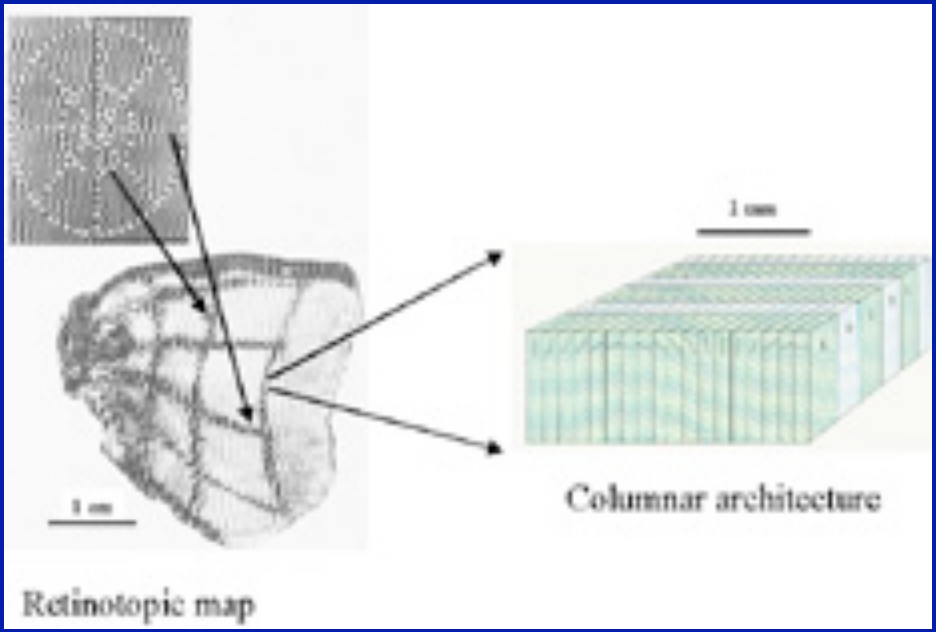
(V1, Brodmann area 17, striate cortex)

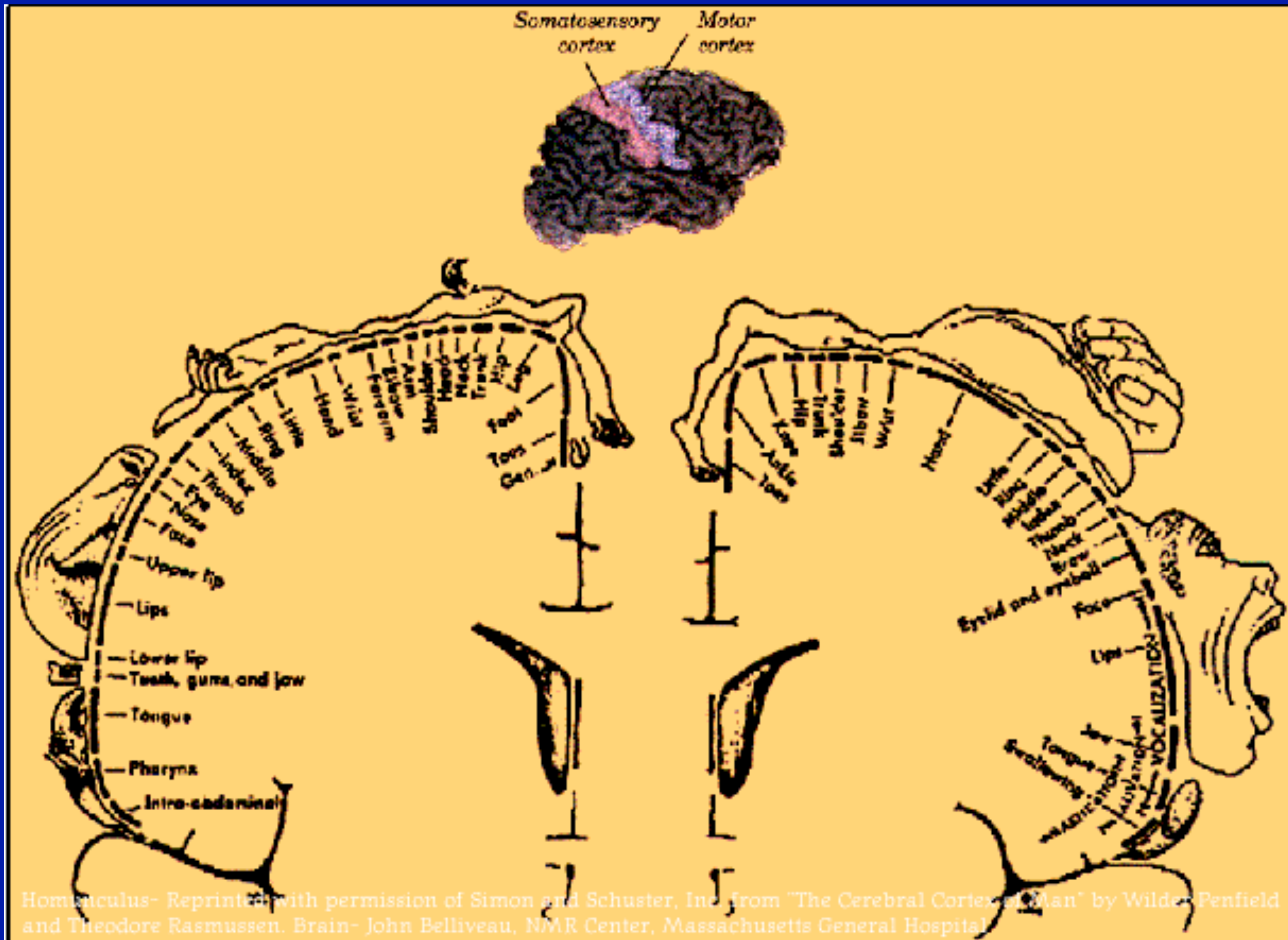
Laminar organization

layer 4: input layer
layers 2+3: output to other cortical areas
layer 5: output to the superior colliculus
layer 6: output to the LGN


LGN
STRIATE CORTEX
layer I
layer II
layer III
layer IV
monocular
layer V
layer VI
higher cortex

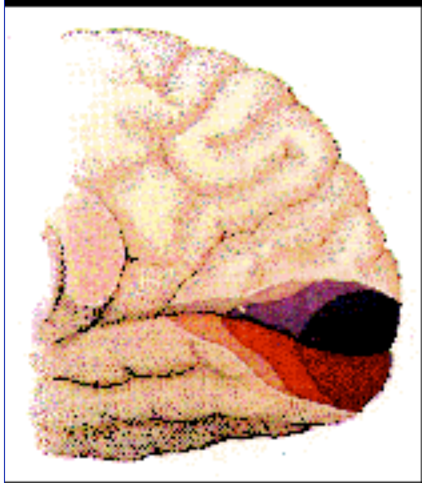
Tootel



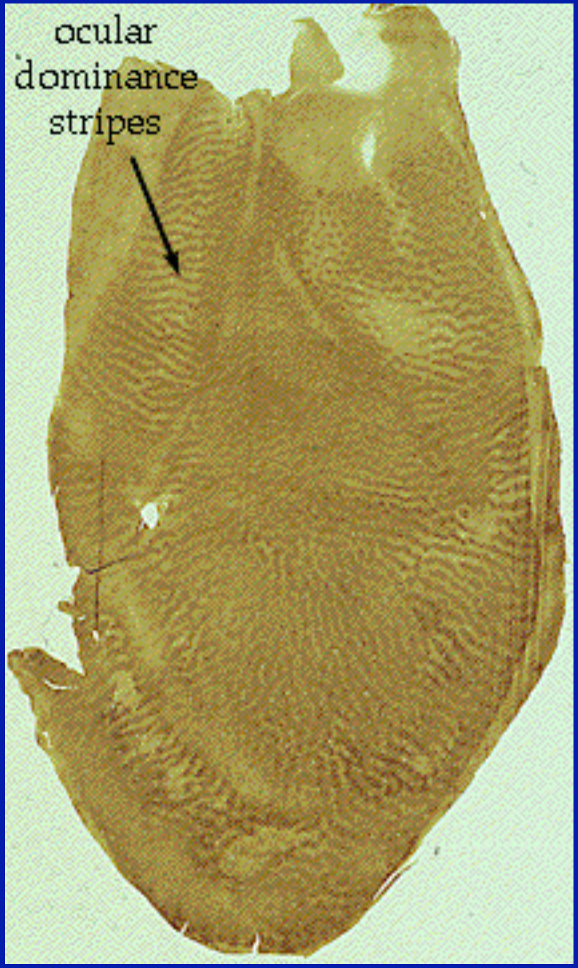


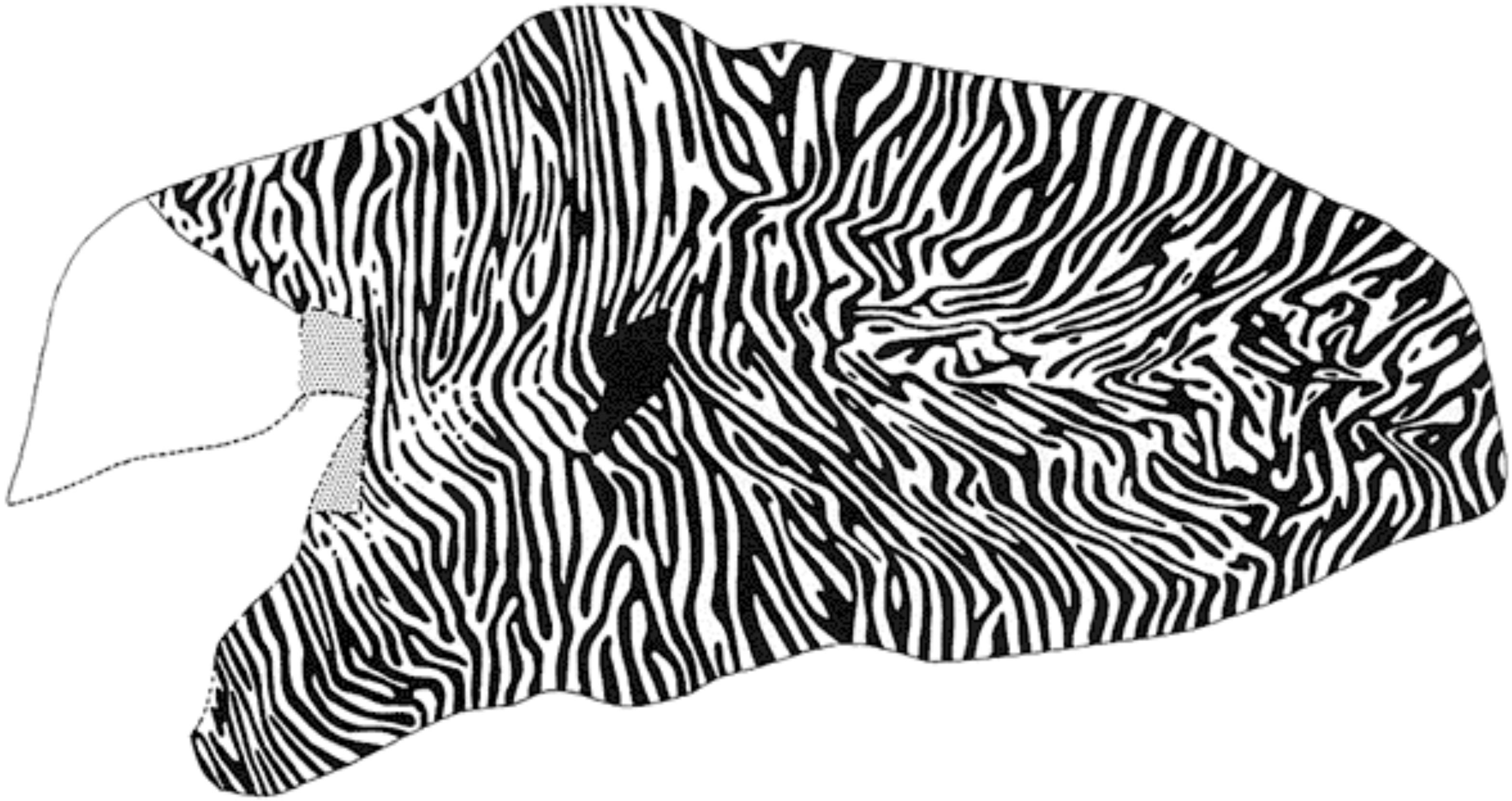
Wilder Penfield & Théodore Rasmussen

(Centre de recherche en neurophysiologie du Royal Victoria Hospital de Montréal, 1950)




Upper field stimulation
Lower field stimulation


ocular
dominance
stripes



Simon LeVay, The Journal of Neuroscience, Vol. 5, No. 2, Feb. 1985

LeVay, S., Hubel, D. H., and Wiesel, T. N. (1975).
The pattern of ocular dominance dominance columns in macaque visual cortex revealed by a reduced silver
J. Comp. Neurol., 159:559-576.

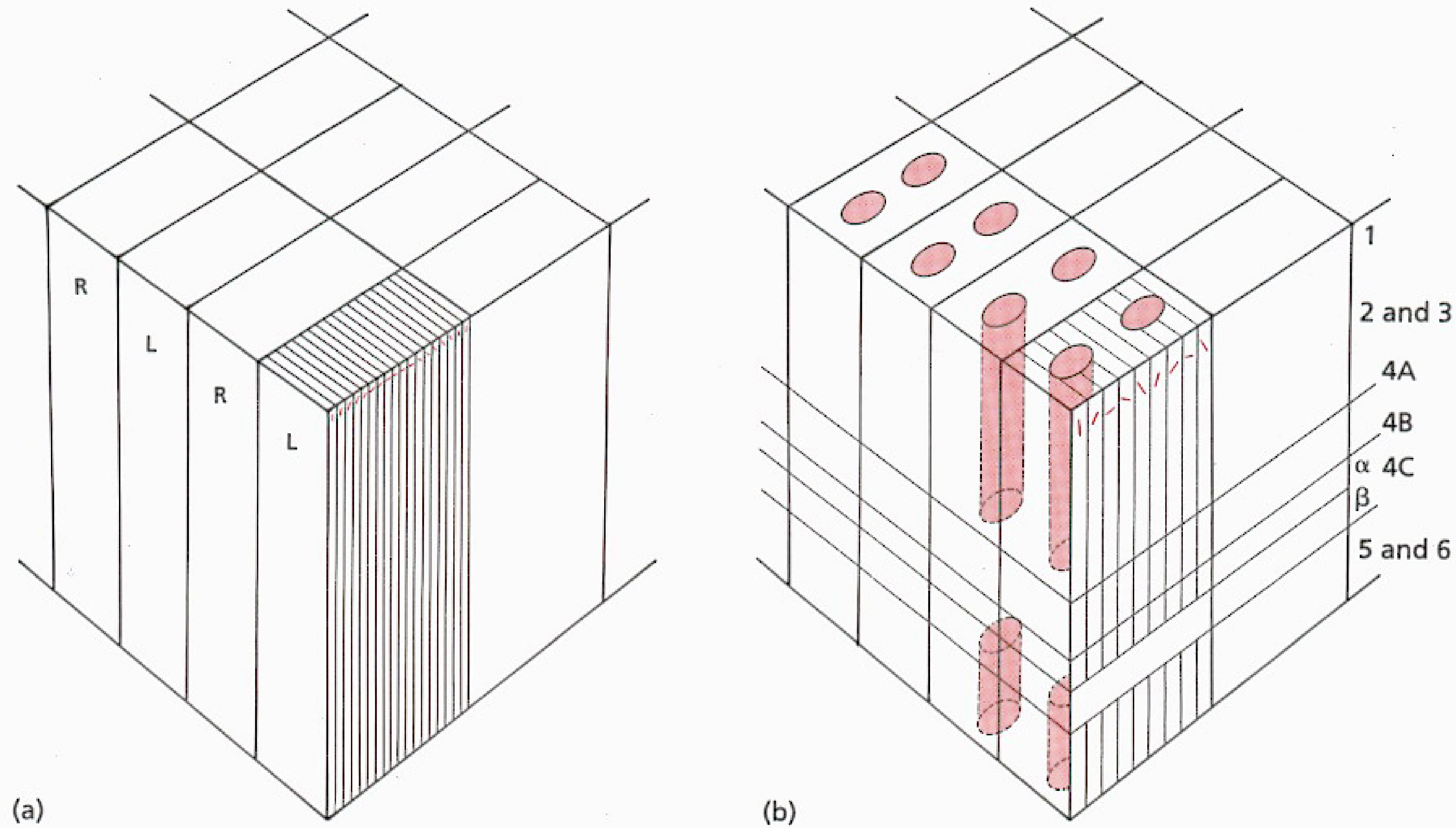
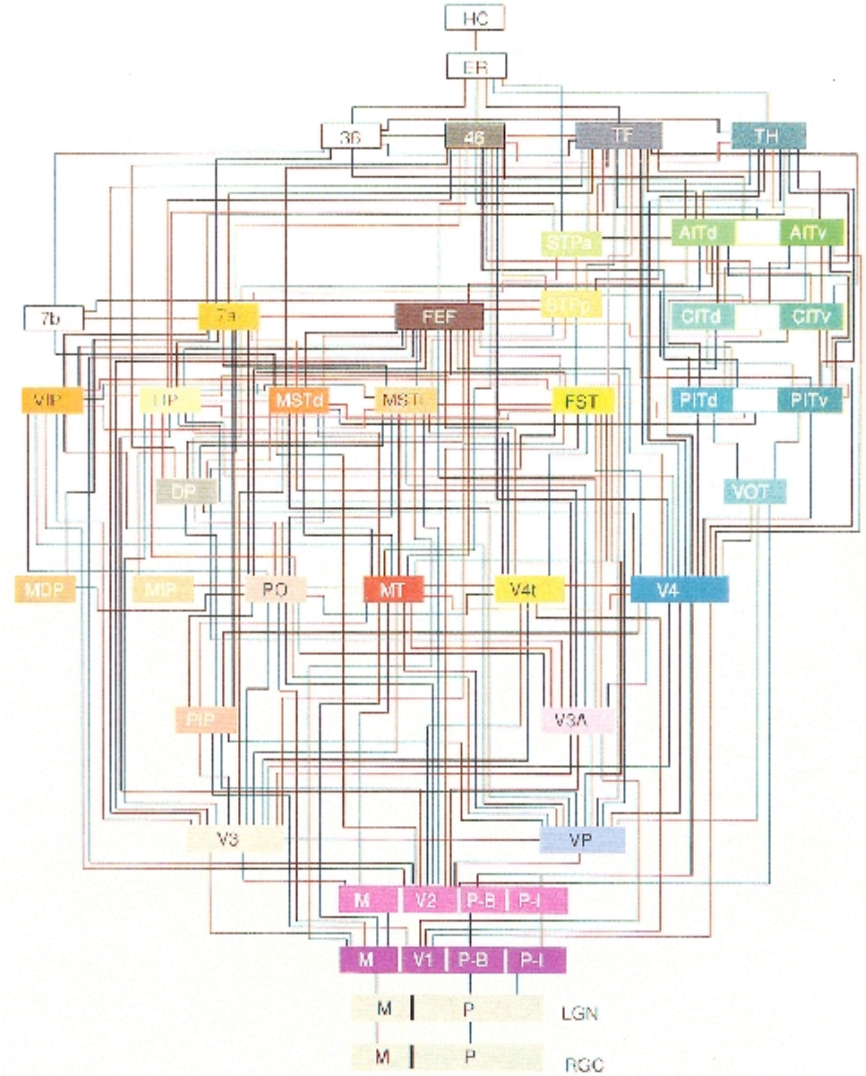
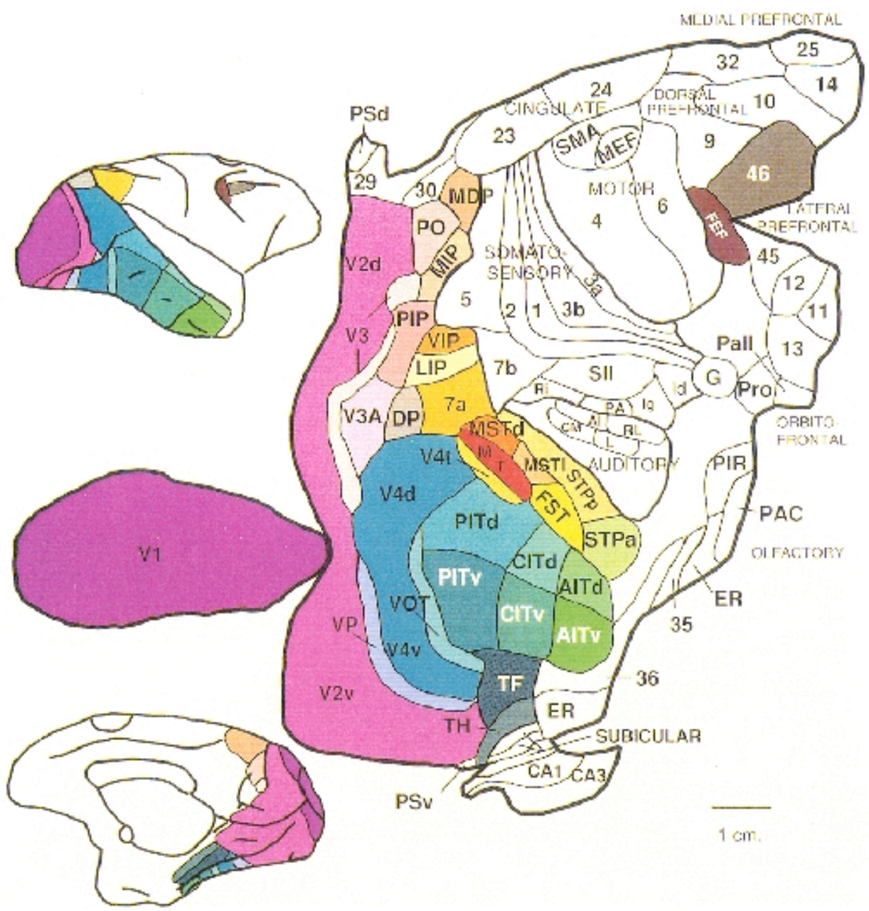


Fig. 19.2 (a) The model of the organization of area V1 proposed by Hubel and Wiesel and (b) its later modification by Livingstone and Hubel. (Redrawn from Hubel, D.H. & Wiesel, T.N. (1977). *Proc. R. Soc. Lond.* B **198**, 1–59 and Livingstone, M.S. & Hubel, D.H. (1984). *J. Neurosci.* **4**, 309–356.)

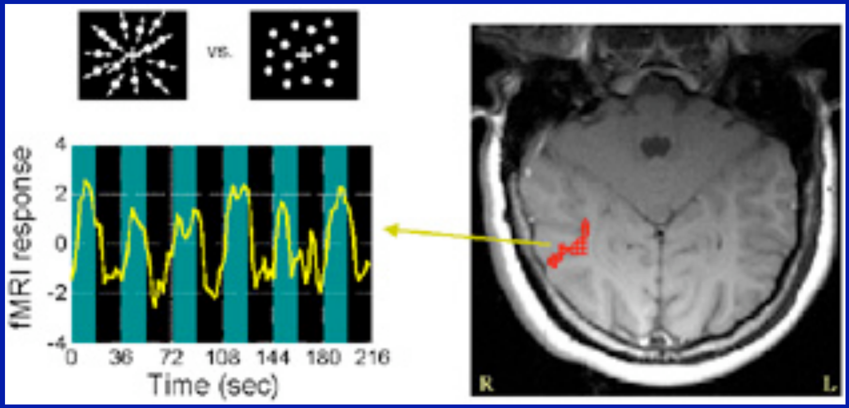
Visual hierarchy



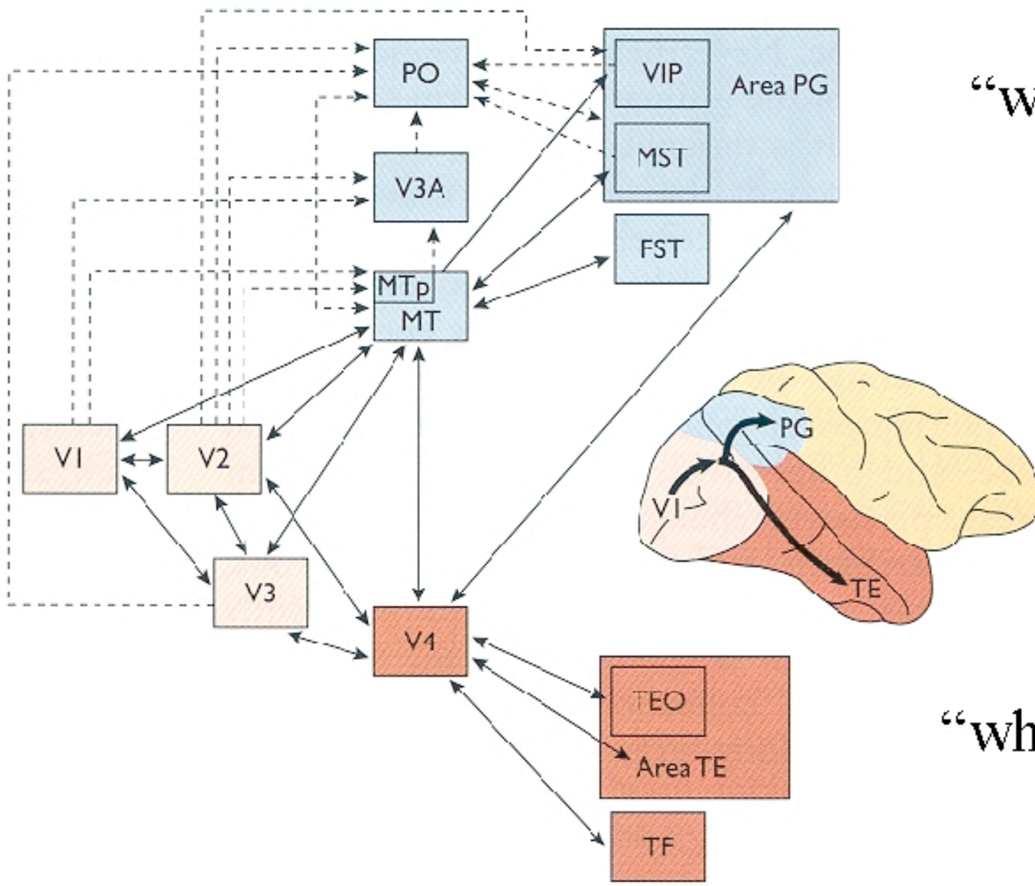
Cortical areas of macaque



Motion sensitivity in Middle Temporal Area (MT)



Dorsal and ventral streams



"where"

"what"

What & How systems
Goodale

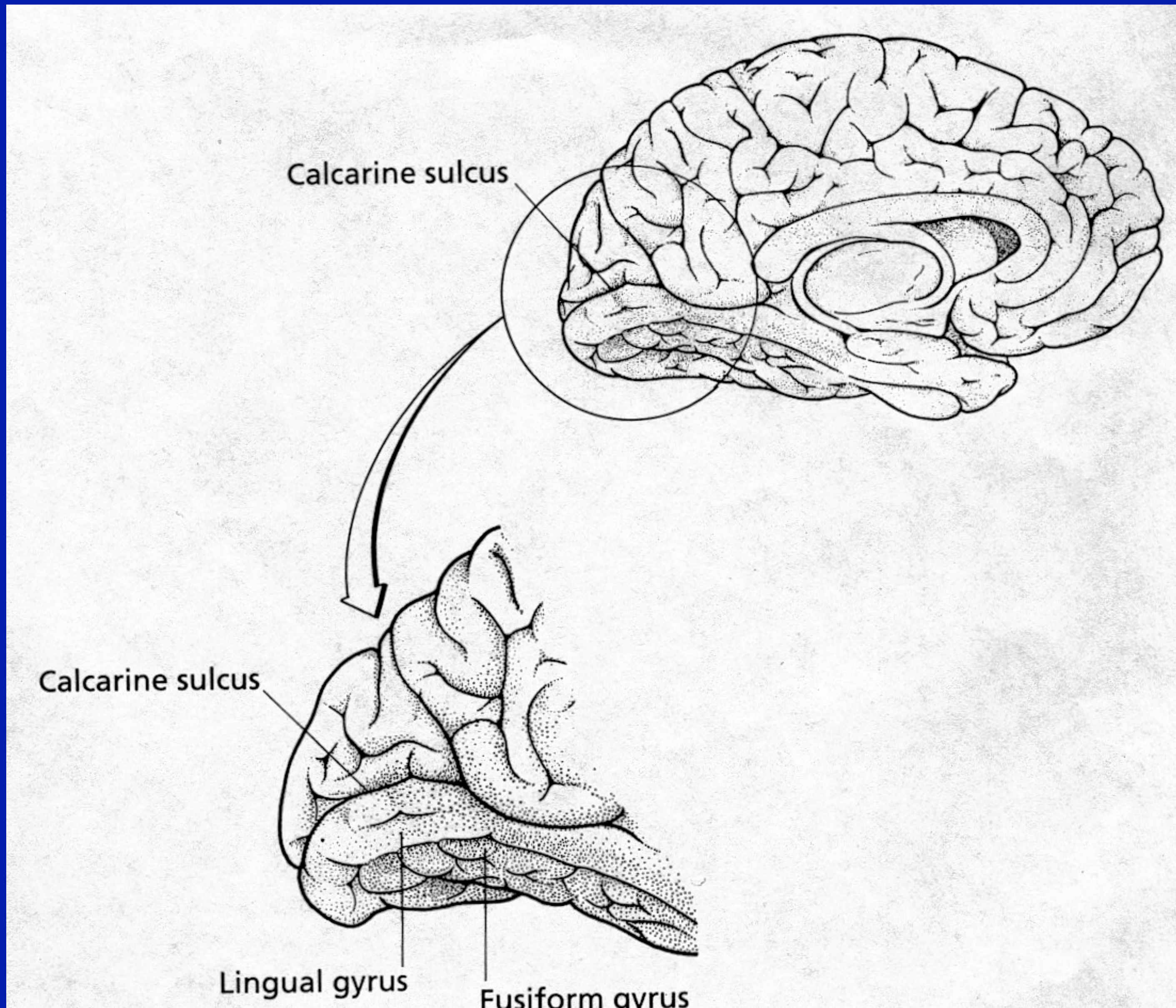
Double dissociation

	Visuo-motor orientation	Judging Visual orientation
Ventral Stream Damage	√	X
Dorsal Stream Damage	X	√

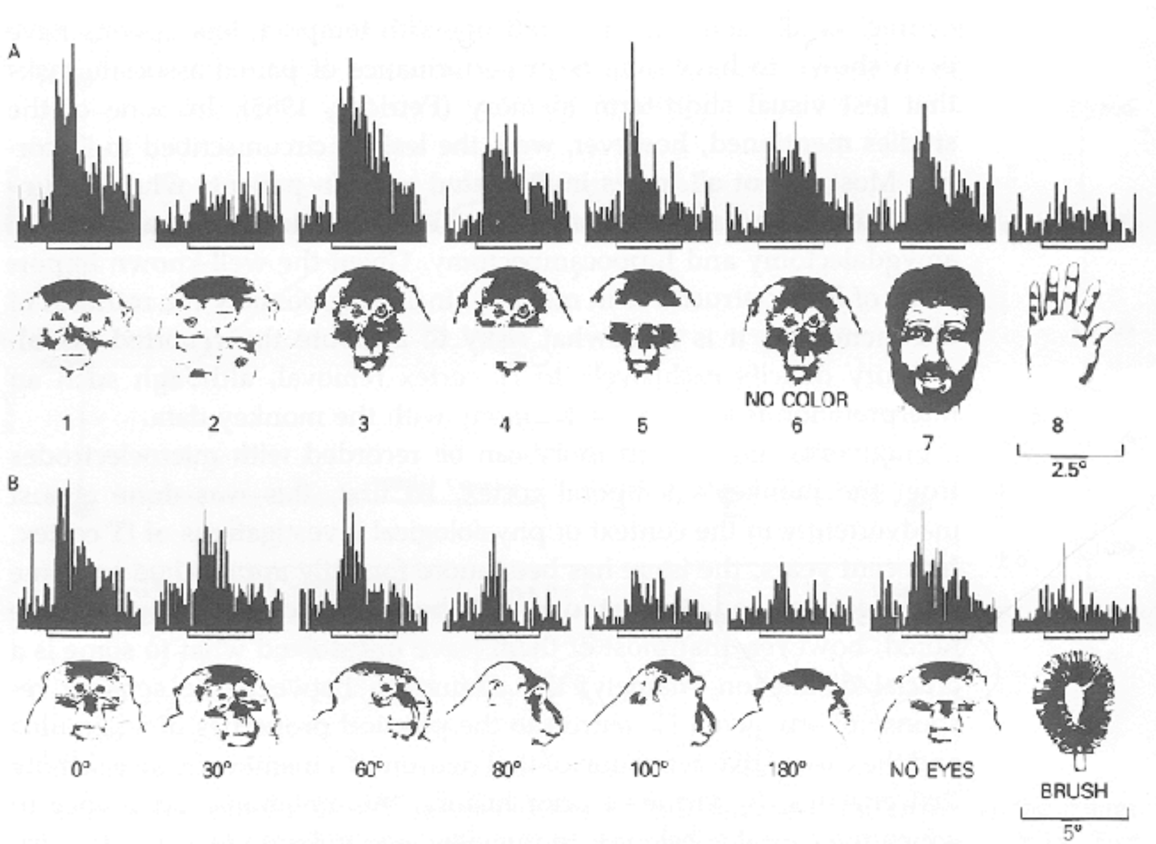
Ventral Stream

Properties of Infero-Temporal (IT) neurons

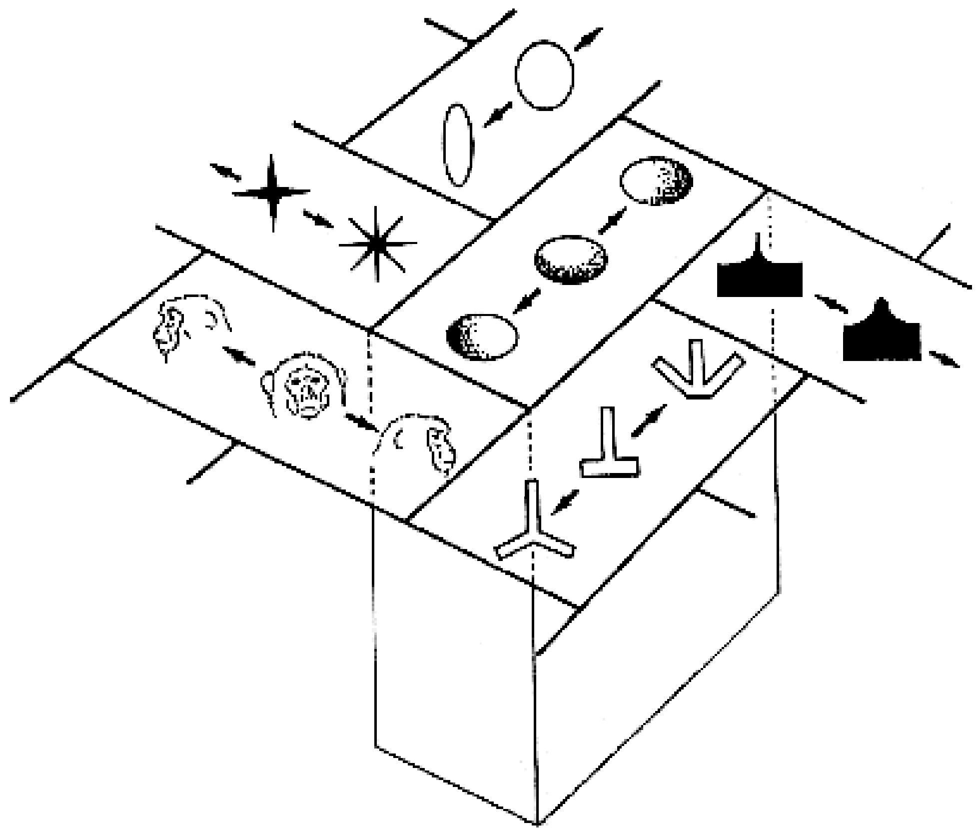
- receptive field size
- stimulus selectivity
- “attribute” invariance
- position invariance
- size invariance
- viewpoint invariance
- columnar organization


Calcarine sulcus
Calcarine sulcus
Lingual gyrus
Fusiform gyrus

“Face cells”

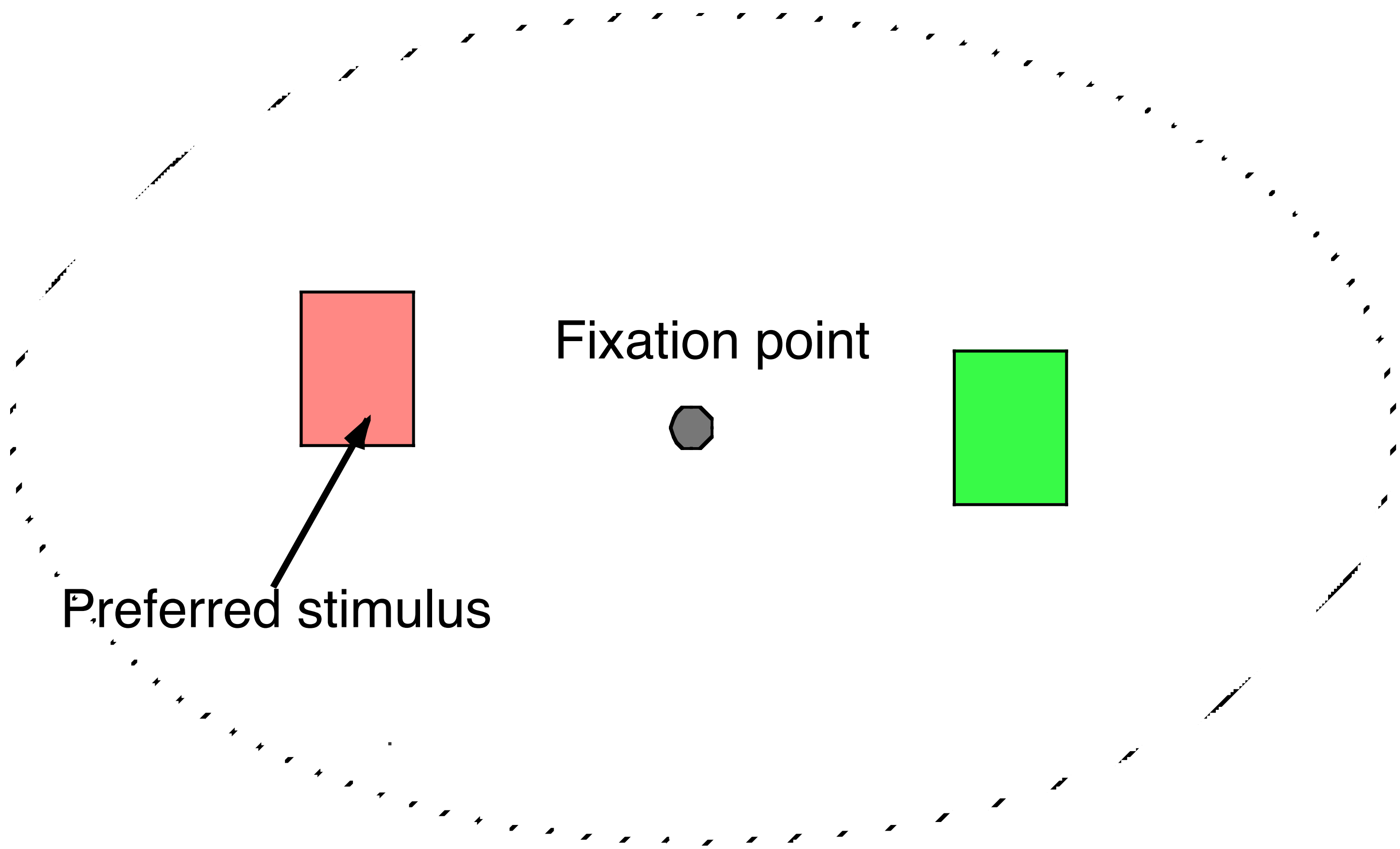


Columnar organisation in IT

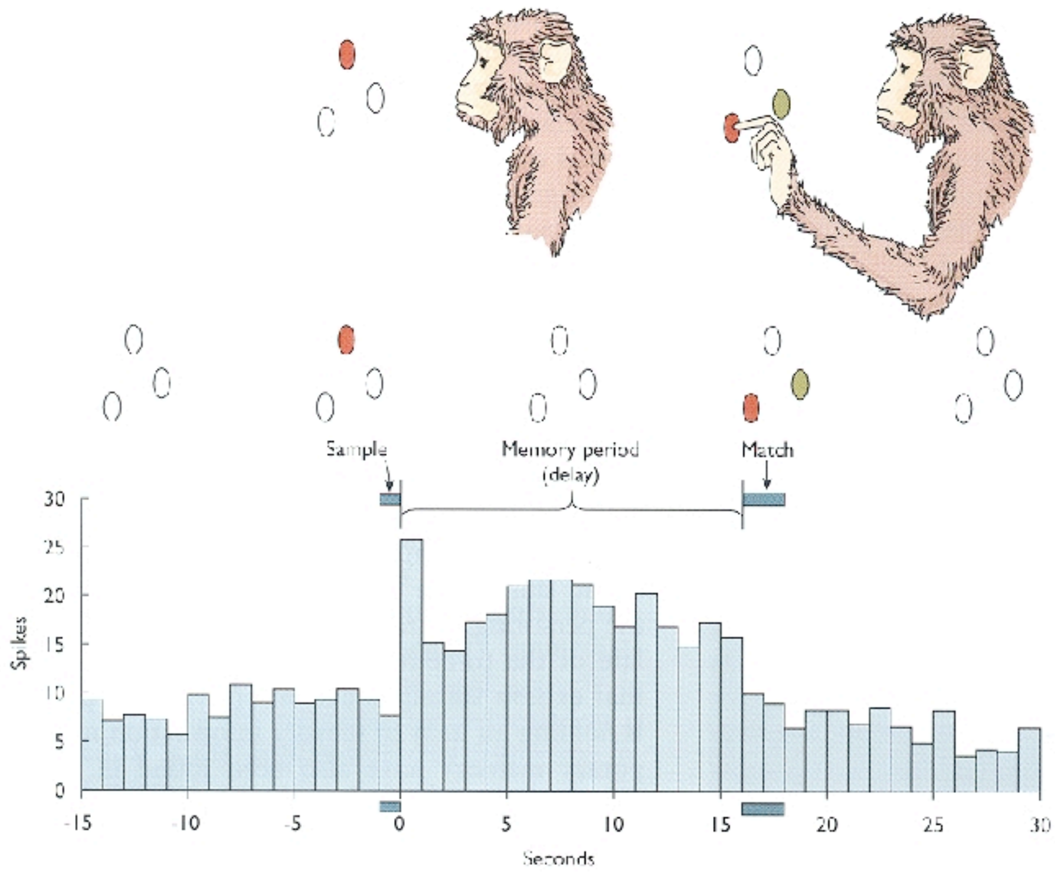


From Tanaka, 1996.

Attention in the ventral stream
Moran & Desimone (1985)



Delayed-match-to-sample task



Is cell firing related to perception?

- Logothetis et al.
- Newsome et al.