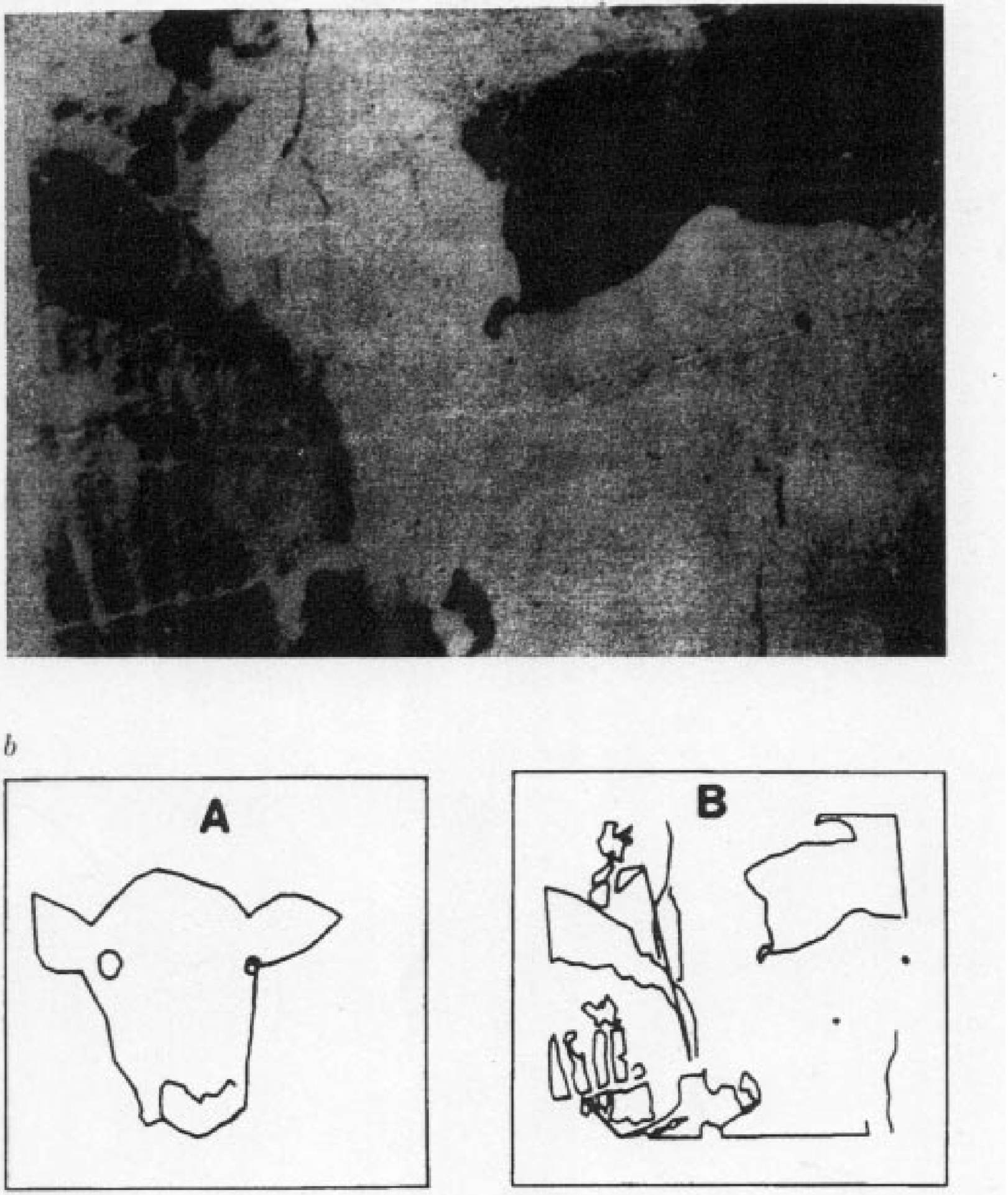
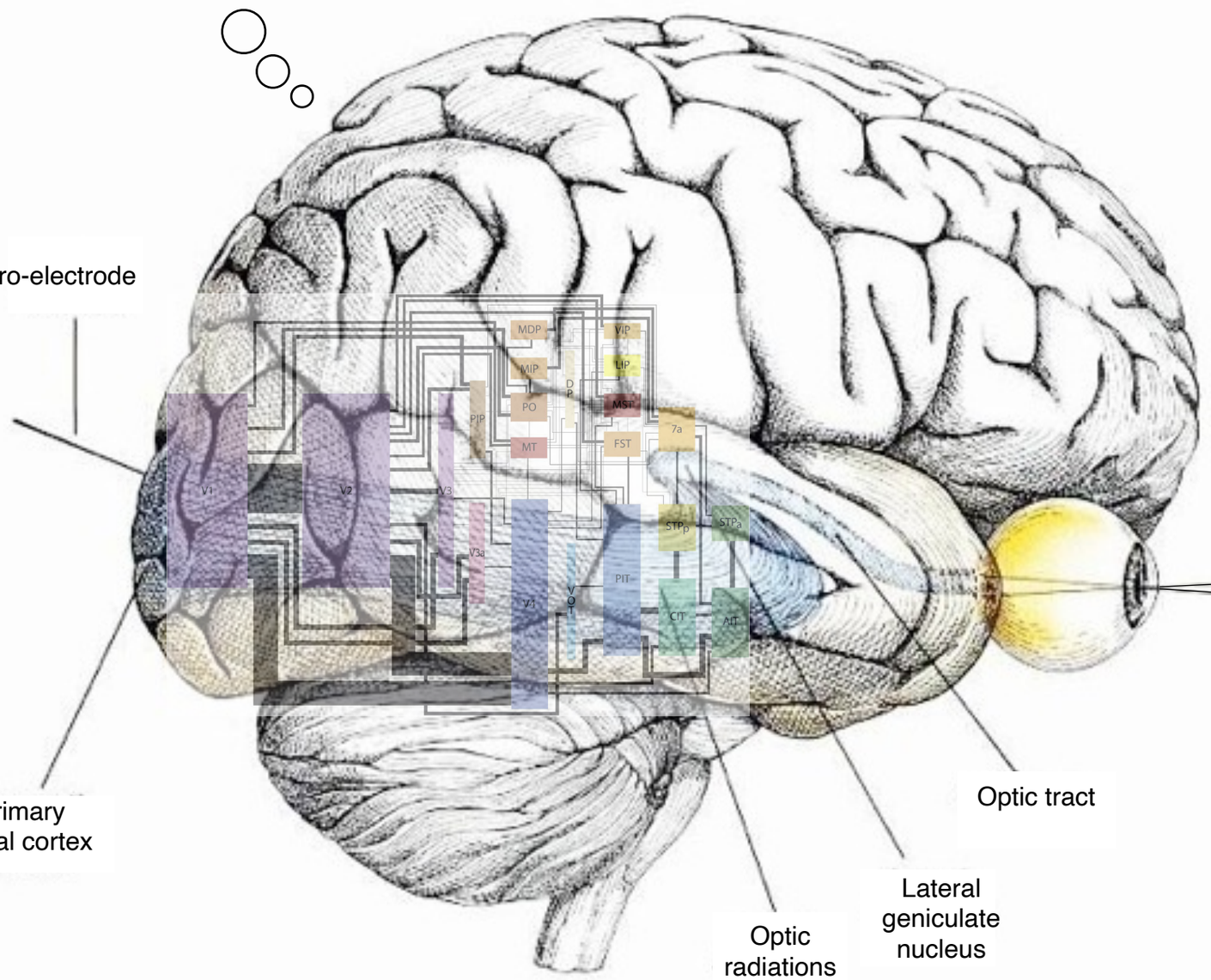
A ‘puzzle picture’
Dallenbach (1951)



*b*

micro-electrode

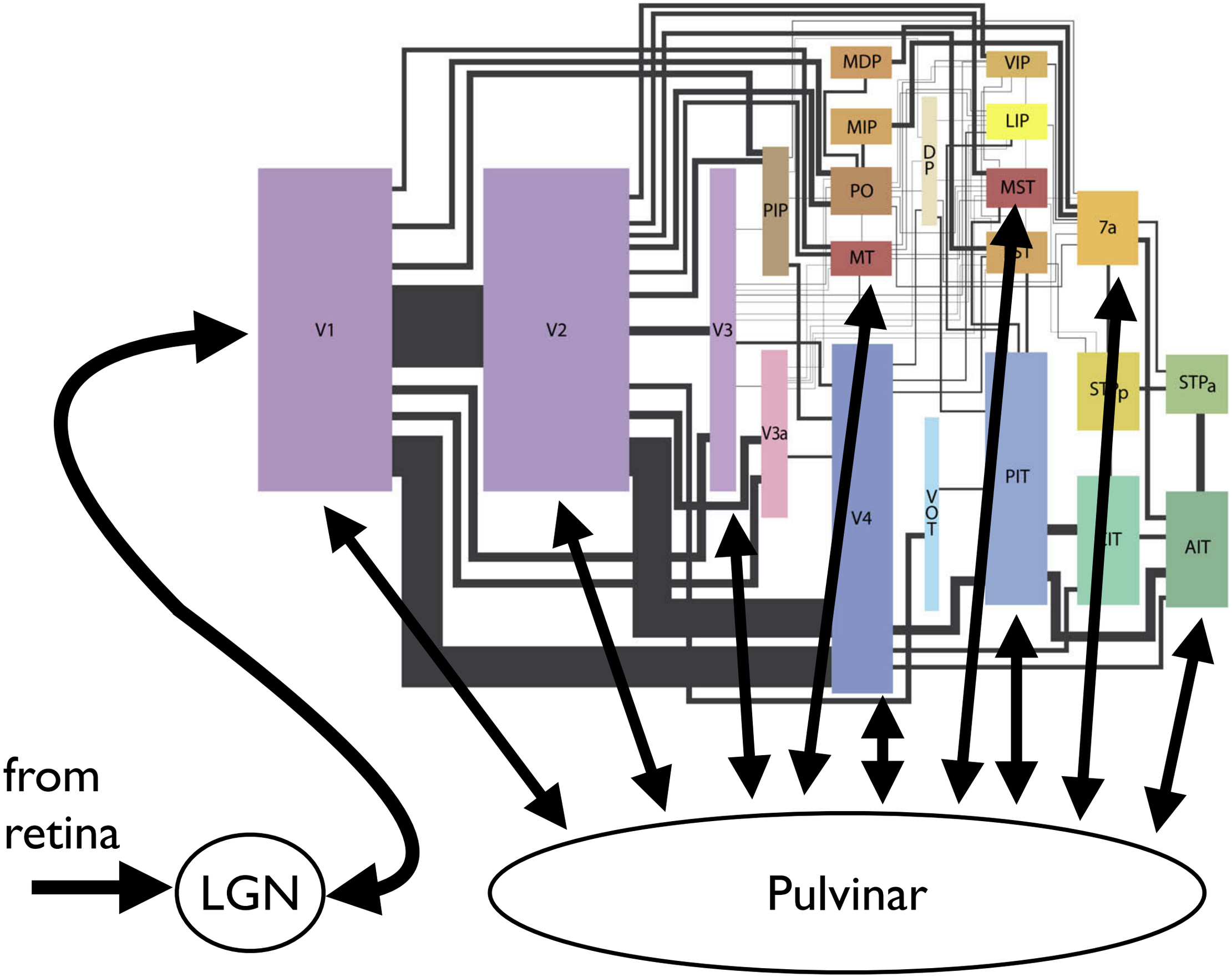


Primary visual cortex

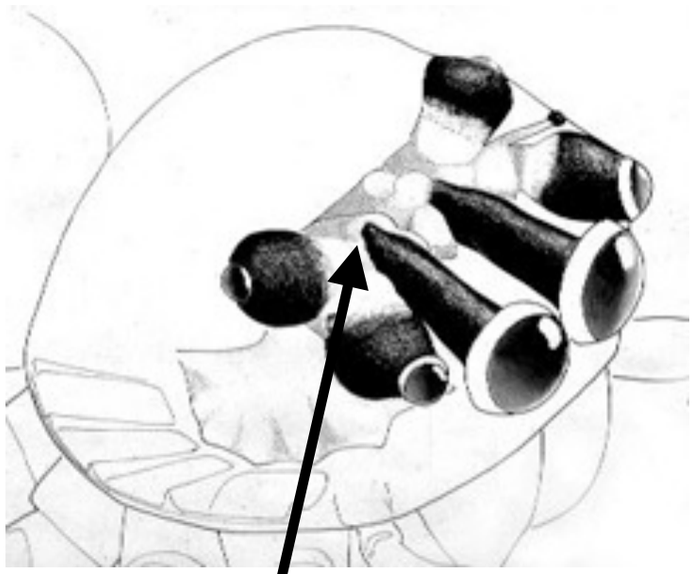
Optic radiations

Lateral geniculate nucleus

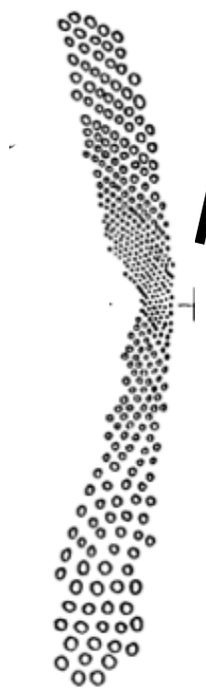
Optic tract


V1
V2
V3
V3a
PIP
MDP
MIP
PO
MT
DP
VIP
LIP
MST
7a
V4
VOT
PIT
STPa
AIT
from
retina
LGN
Pulvinar

# Vision in jumping spiders



(Wayne Maddison)

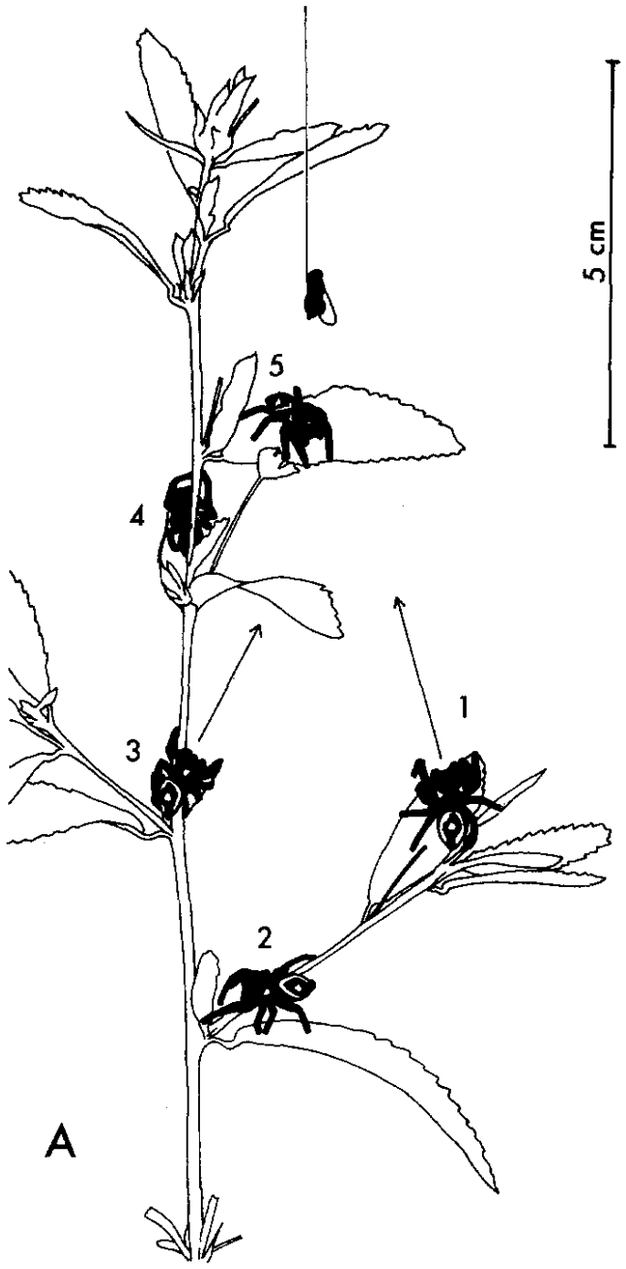


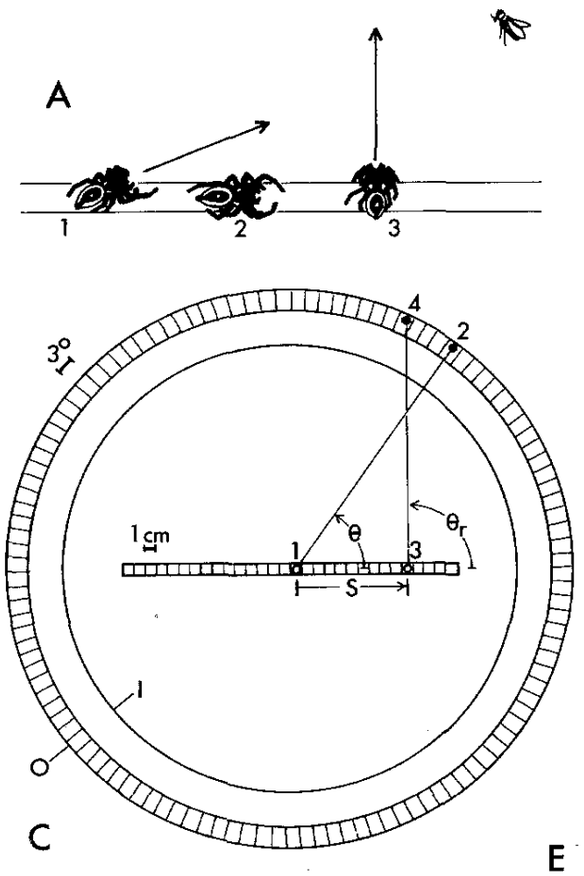
(Bair & Olshausen, 1991)

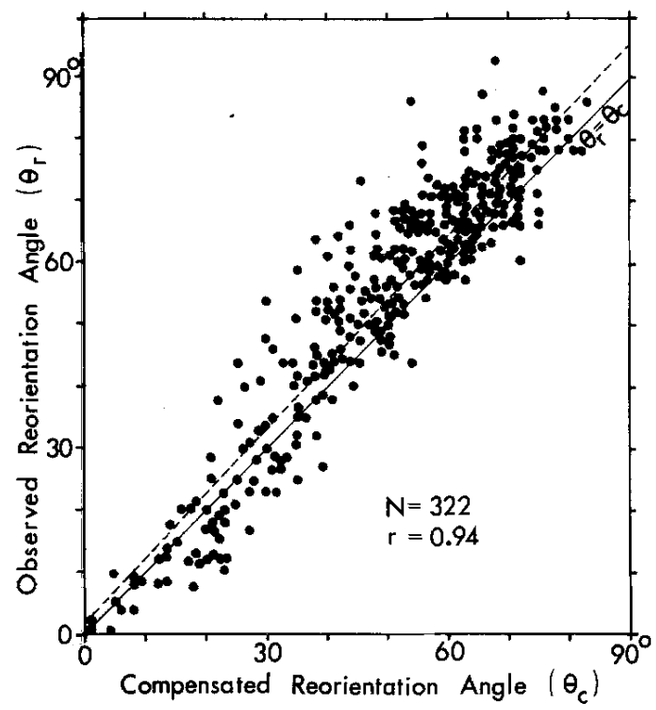
# One-day old jumping spider
## (filmed in the Bower lab, Caltech)

# Orientation by Jumping Spiders During the Pursuit of Prey

(D.E. Hill, 1979)



# Navigation

(Tarsitano & Jackson 1997)

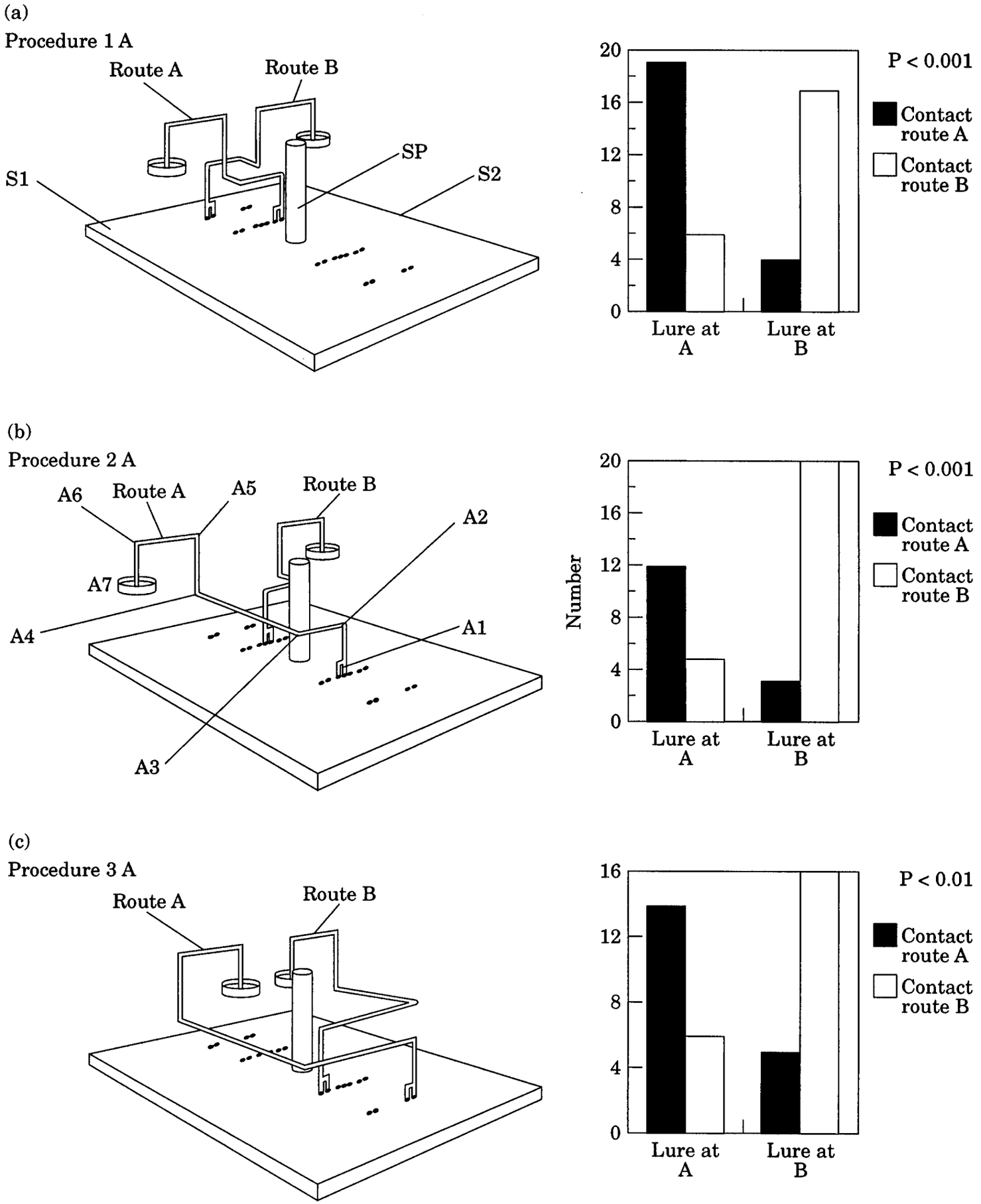
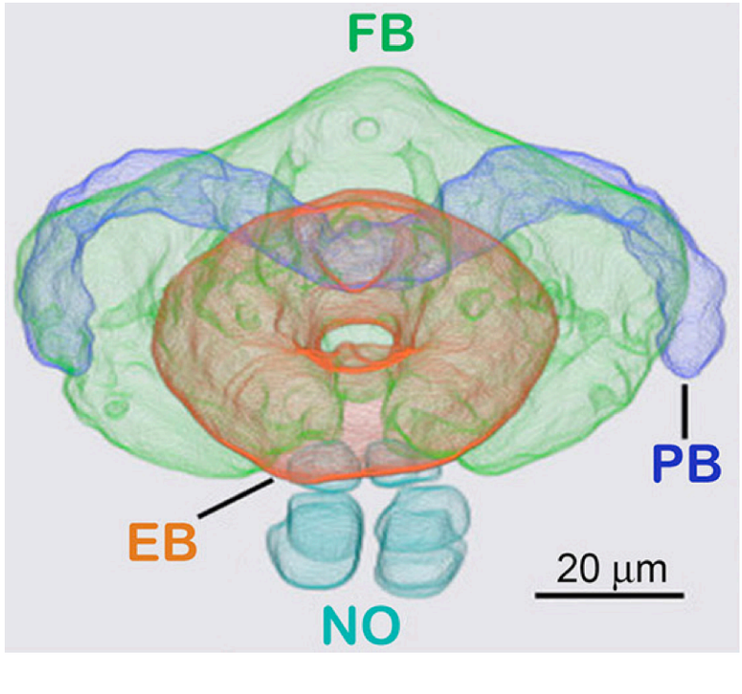
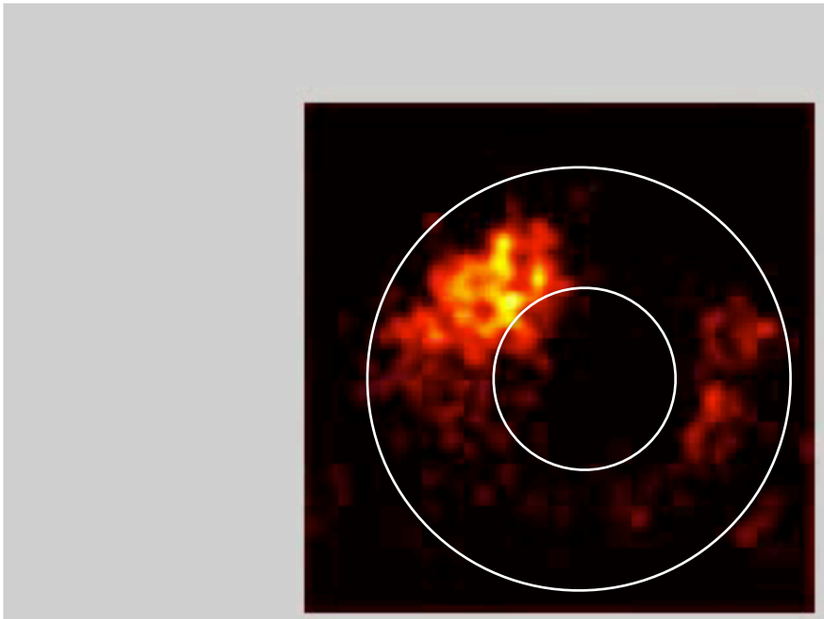



**Figure 1 a-c.**

# Head-direction cells in ellipsoid body of Drosophila

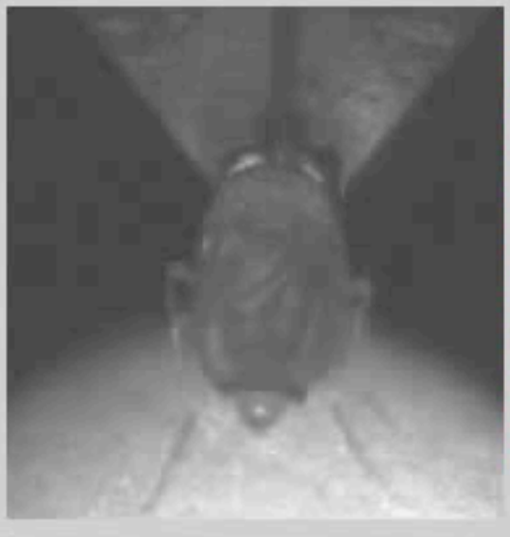
(Seelig & Jayaraman 2015)

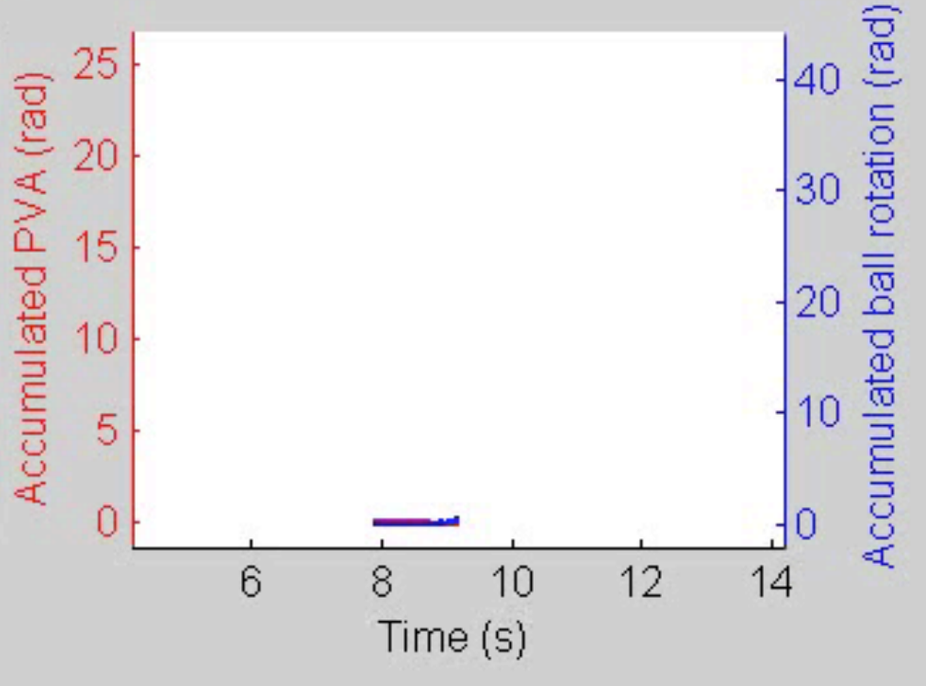


← Ellipsoid body activity (calcium imaging

Decoded vs. actual head dir.





# How to build a model of world from sensory data?

# Bayesian inference

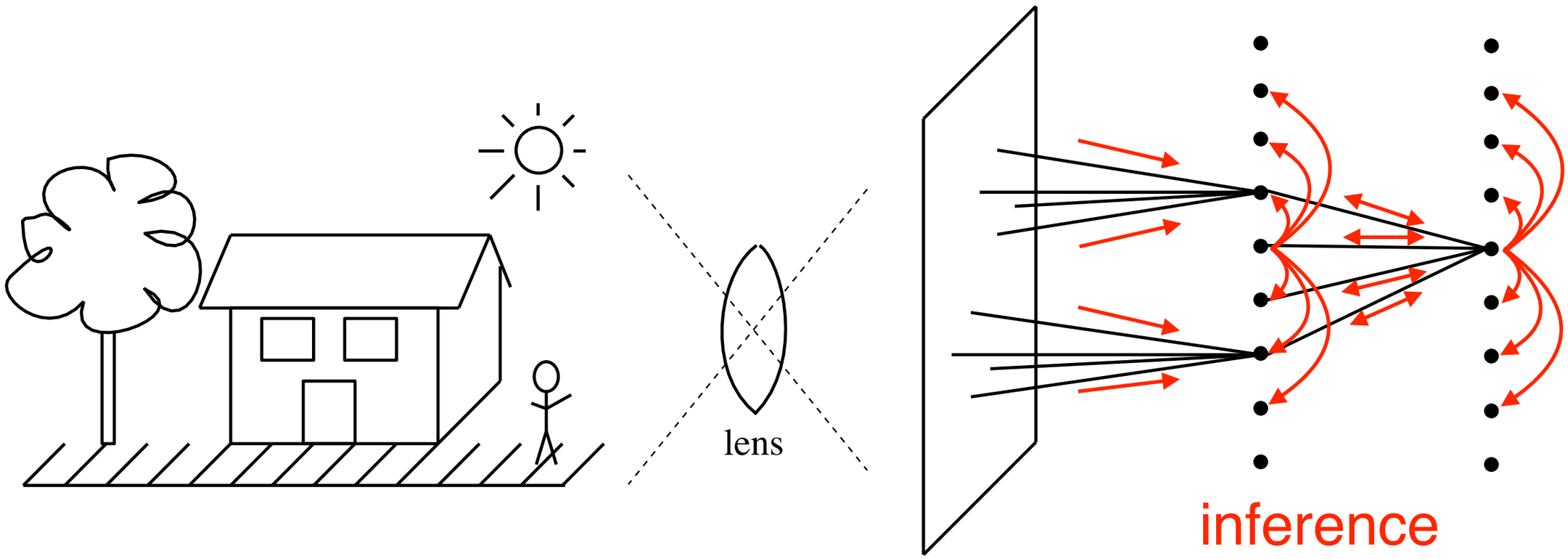
image generation

prior knowledge

$$P(H|D) = \frac{P(D|H)\,P(H)}{P(D)}$$

?

# Perception as inference



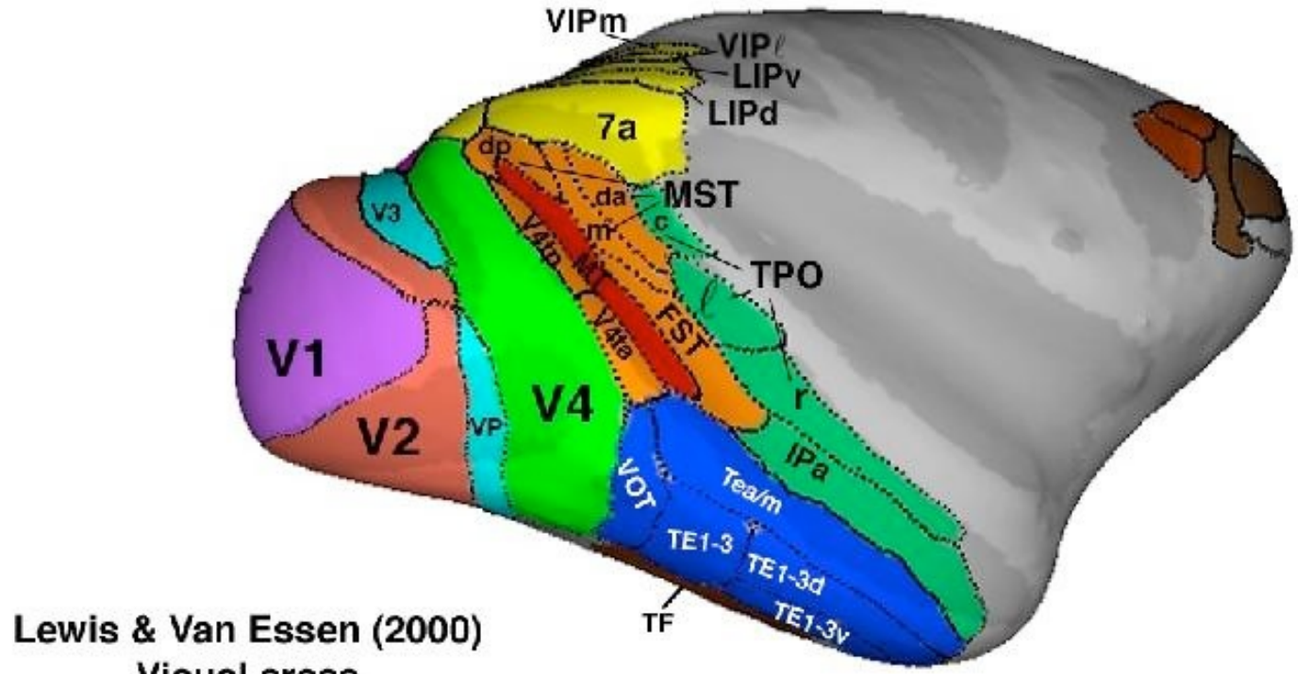

**World** → **Image** ← **Model**

$$P(I|H) \times P(H)$$

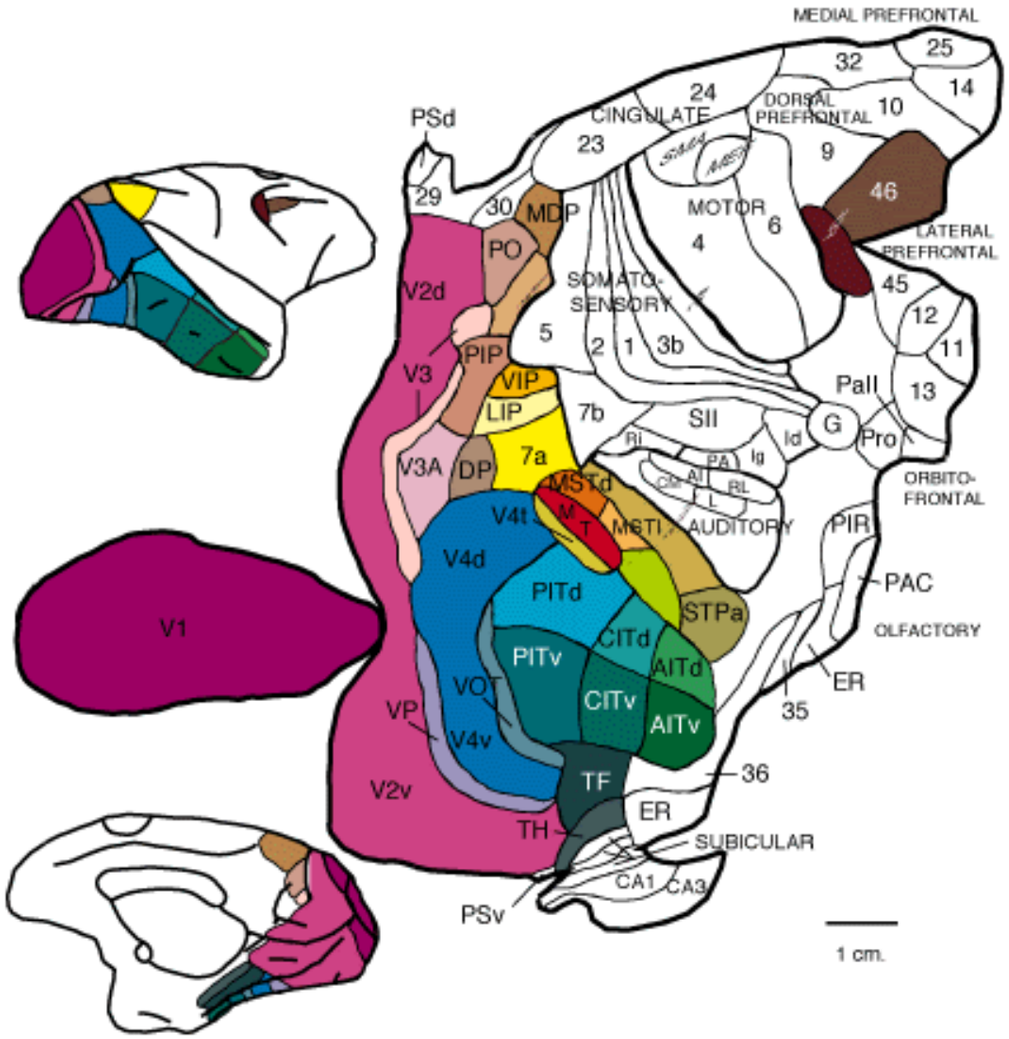
$$\propto P(H|I)$$

# Area V1

# Macaque visual cortex



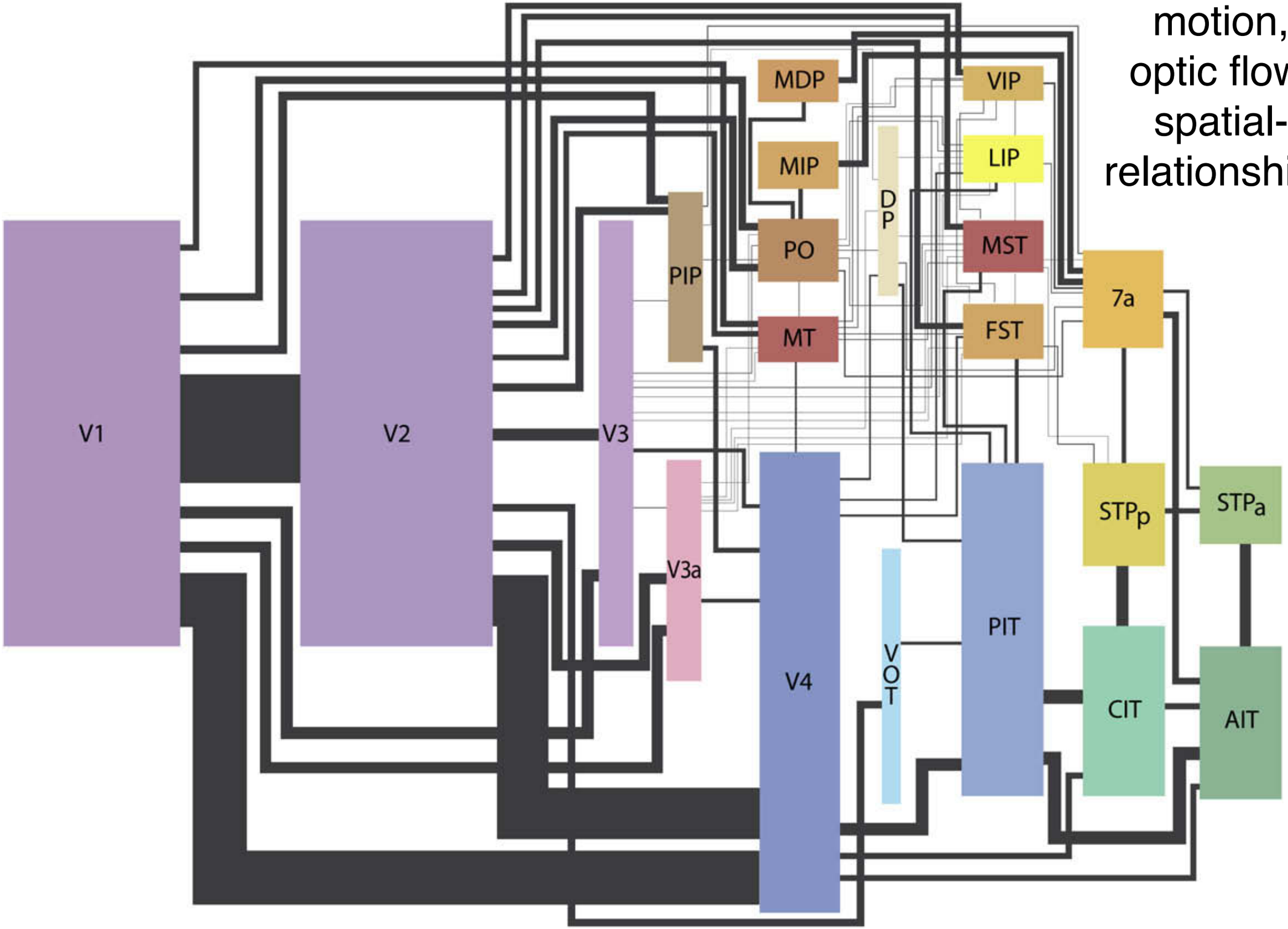

inflated




flattened

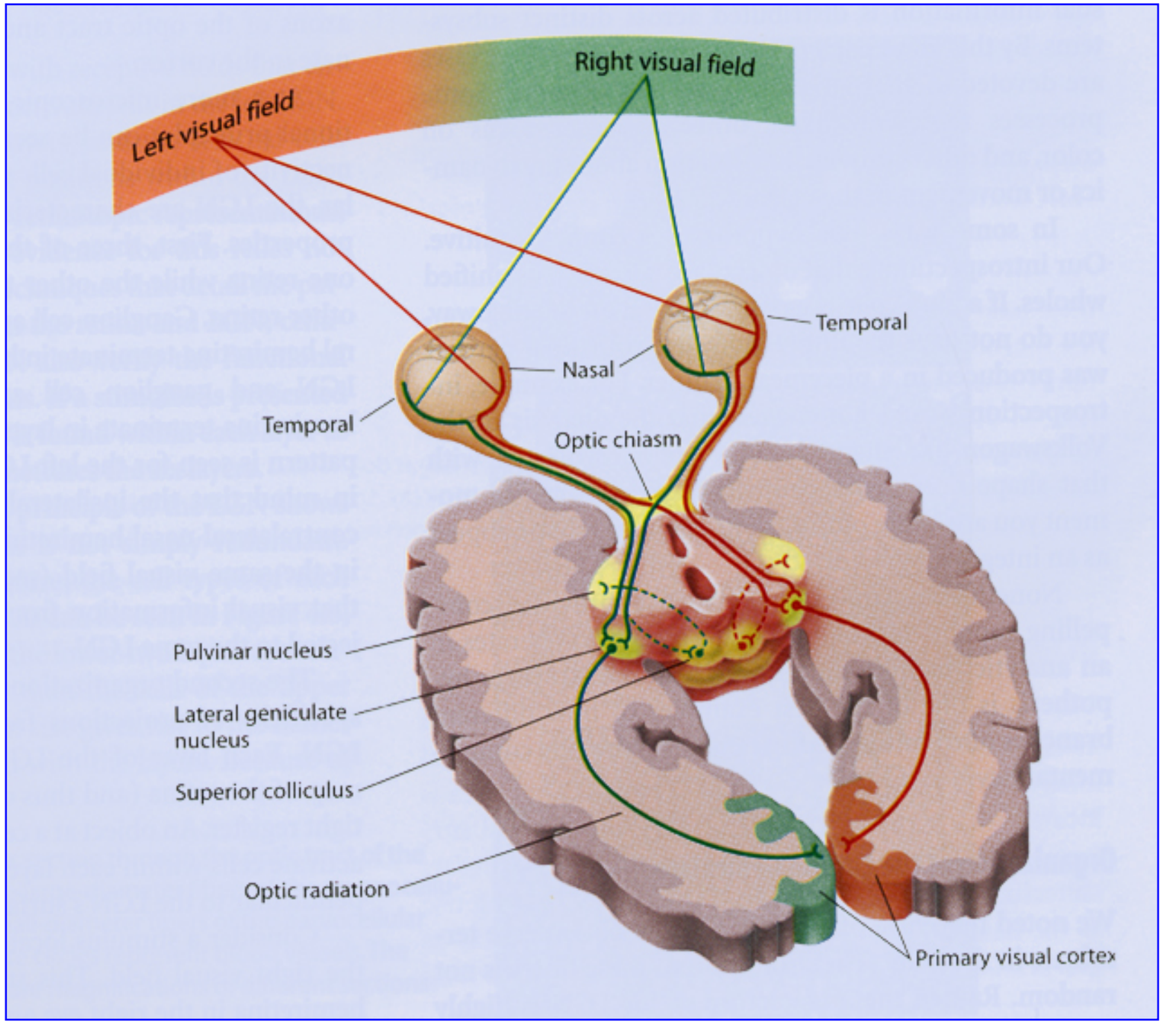
Wallisch & Movshon (2008)

motion,
optic flow,
spatial-
relationships




lines, edges surface boundaries ? objects faces

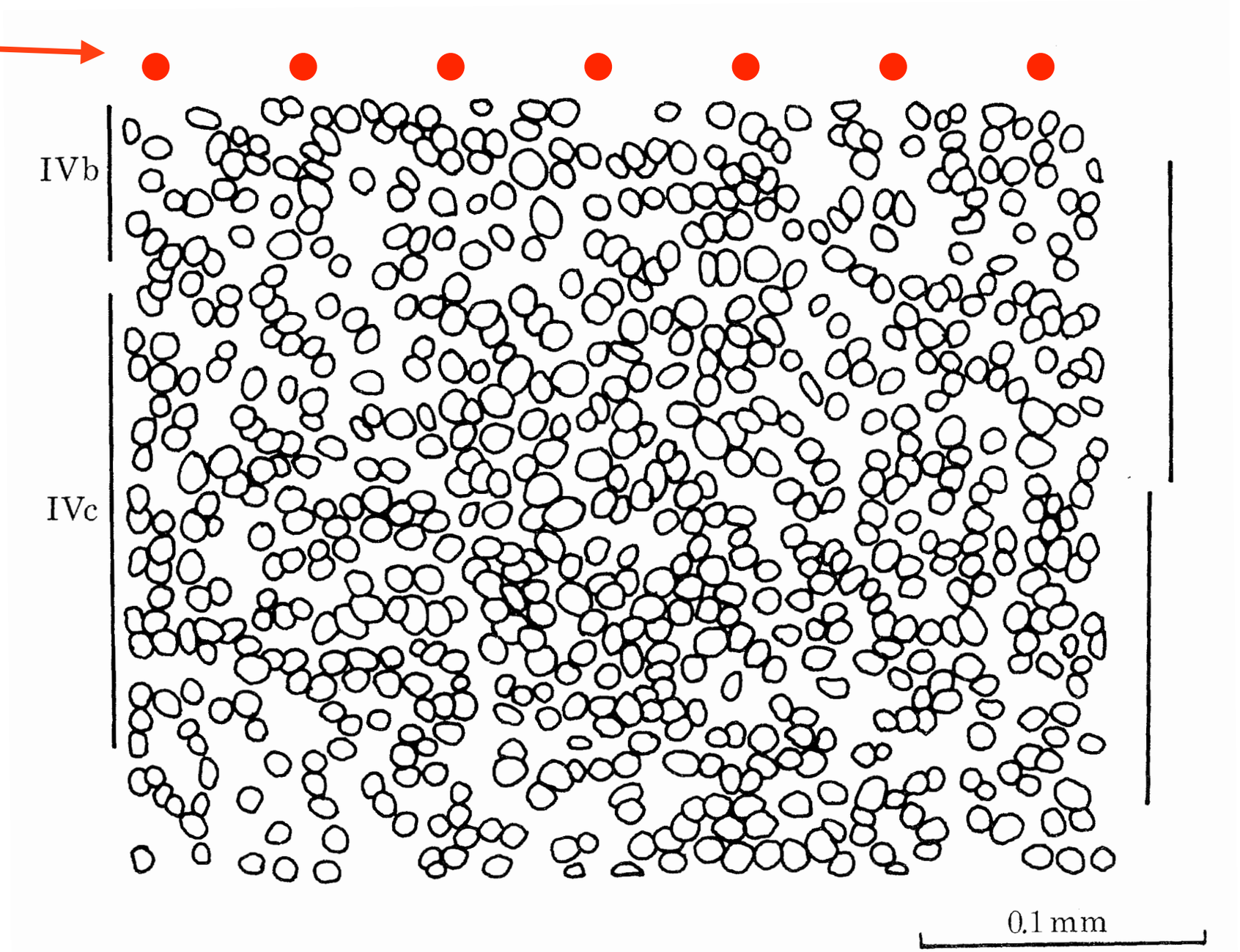
# Lateralization of the visual pathways



# V1 is highly overcomplete

LGN afferents

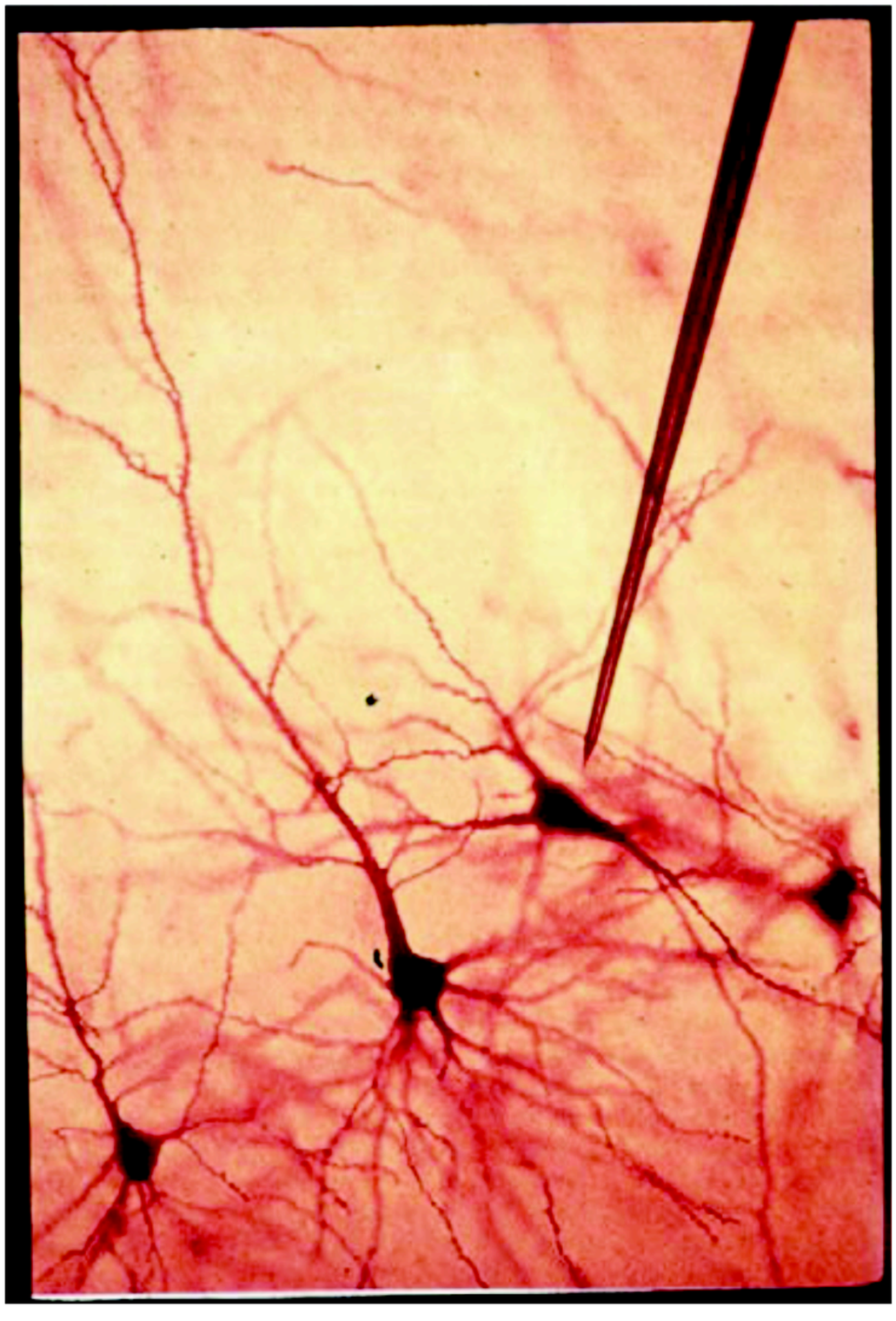
layer 4 cortex



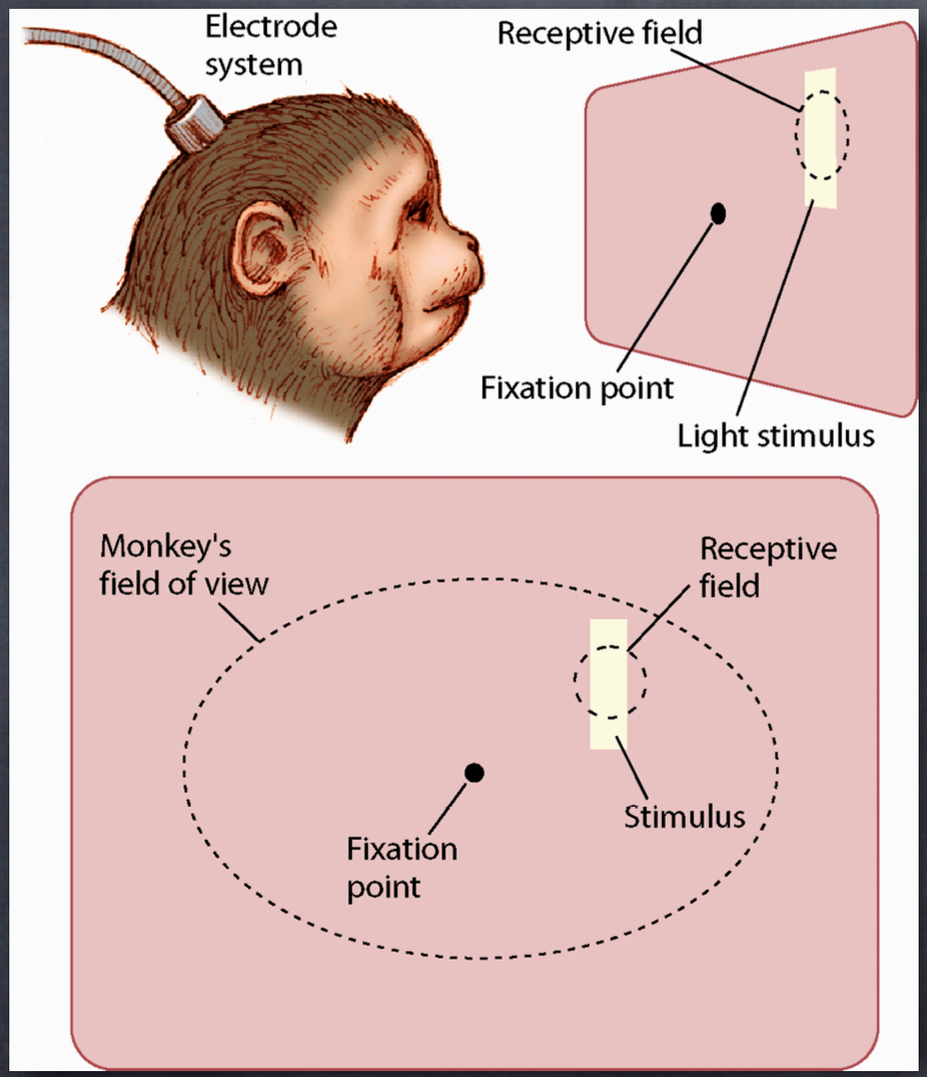

Barlow (1981)

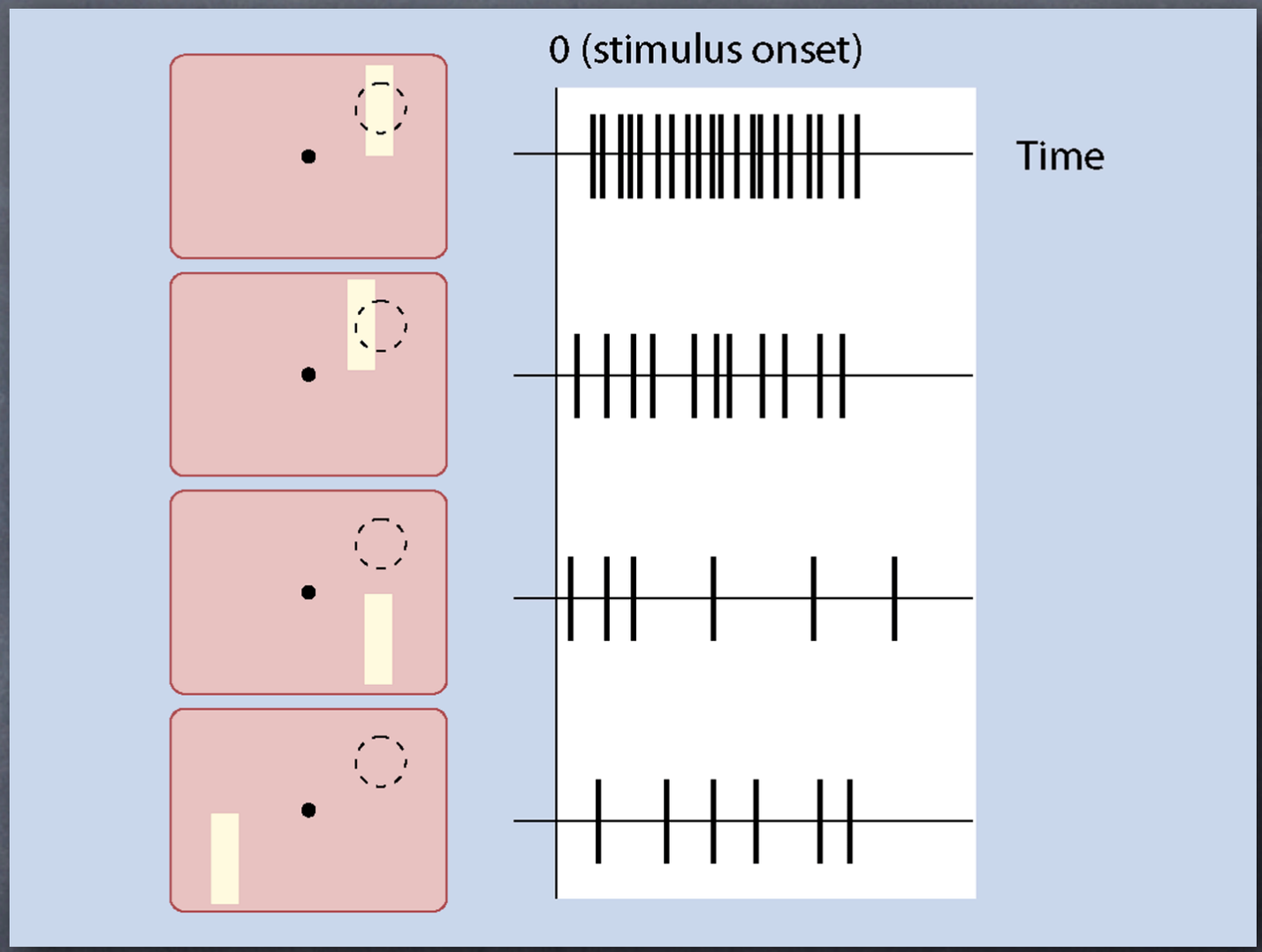
# 1 $mm^2$ of cortex contains 100,000 neurons and receives input from ~14x14 'pixels' in retina

# Single-unit electrophysiology

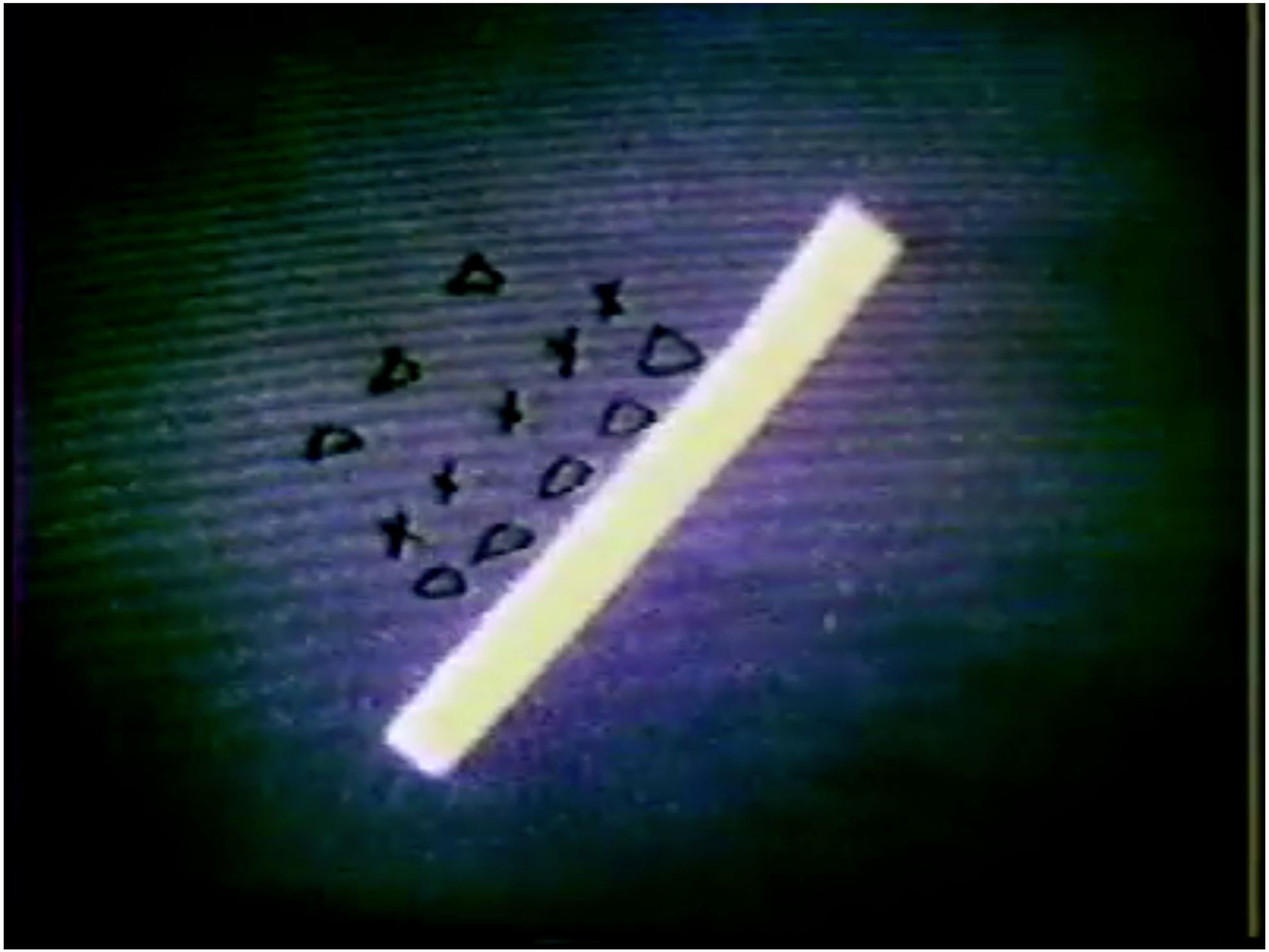


# Extracellular microelectrode recordings can be used to measure action potentials

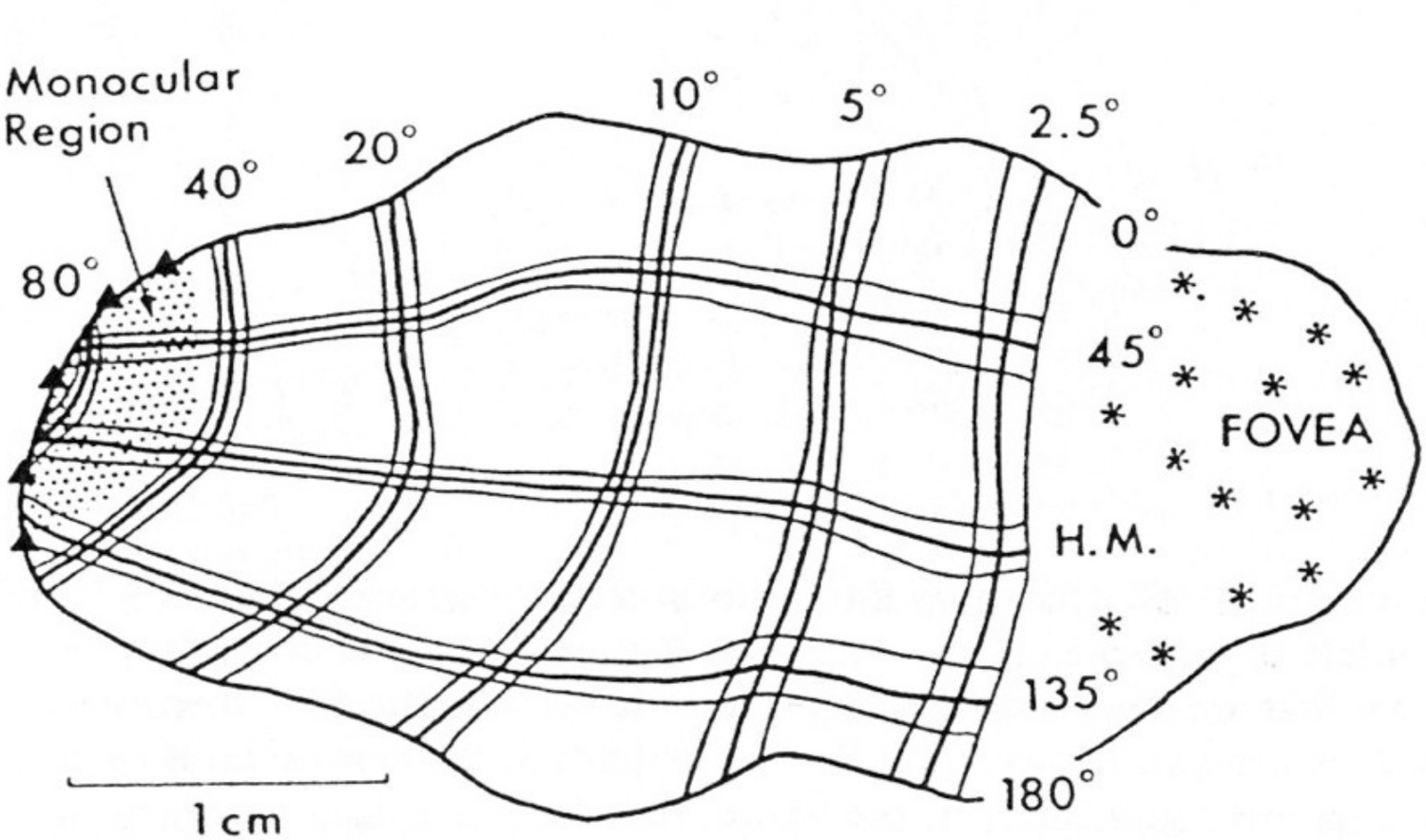


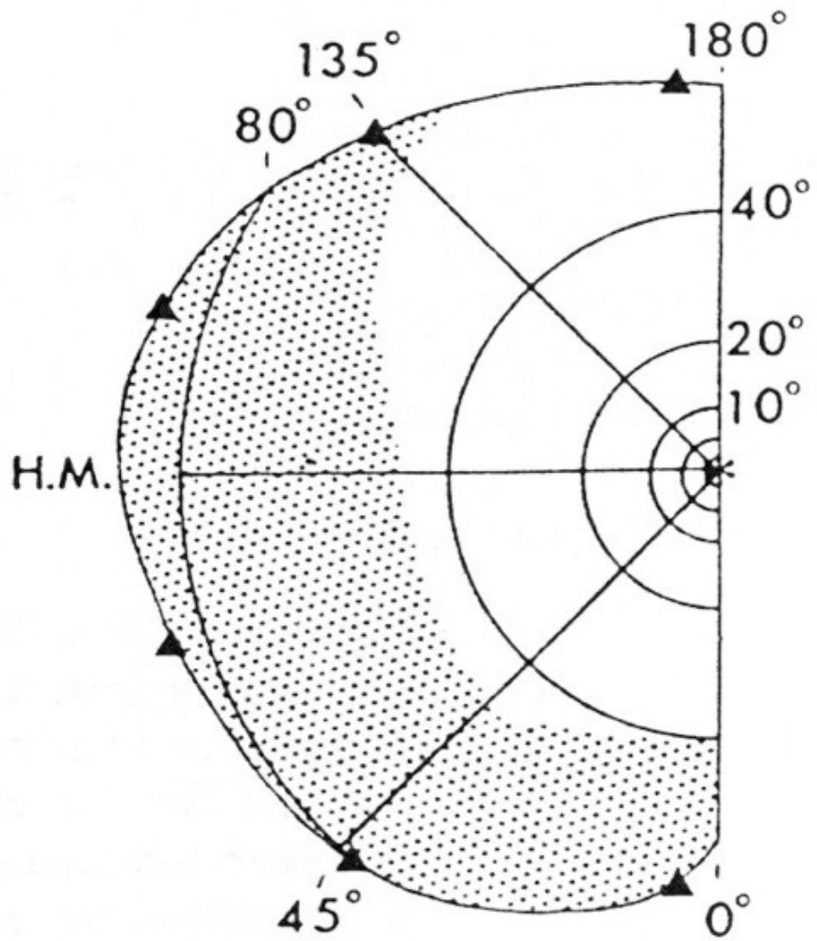



# Mapping of simple cell receptive field

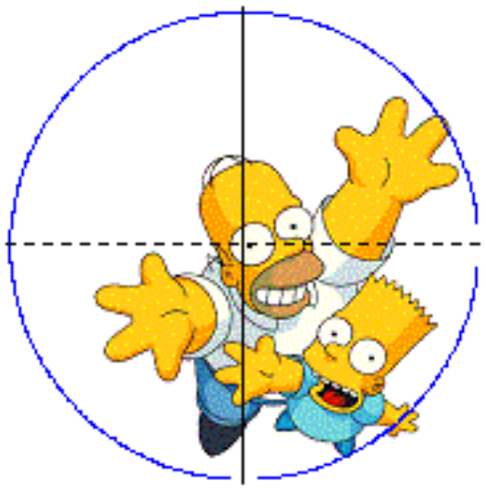


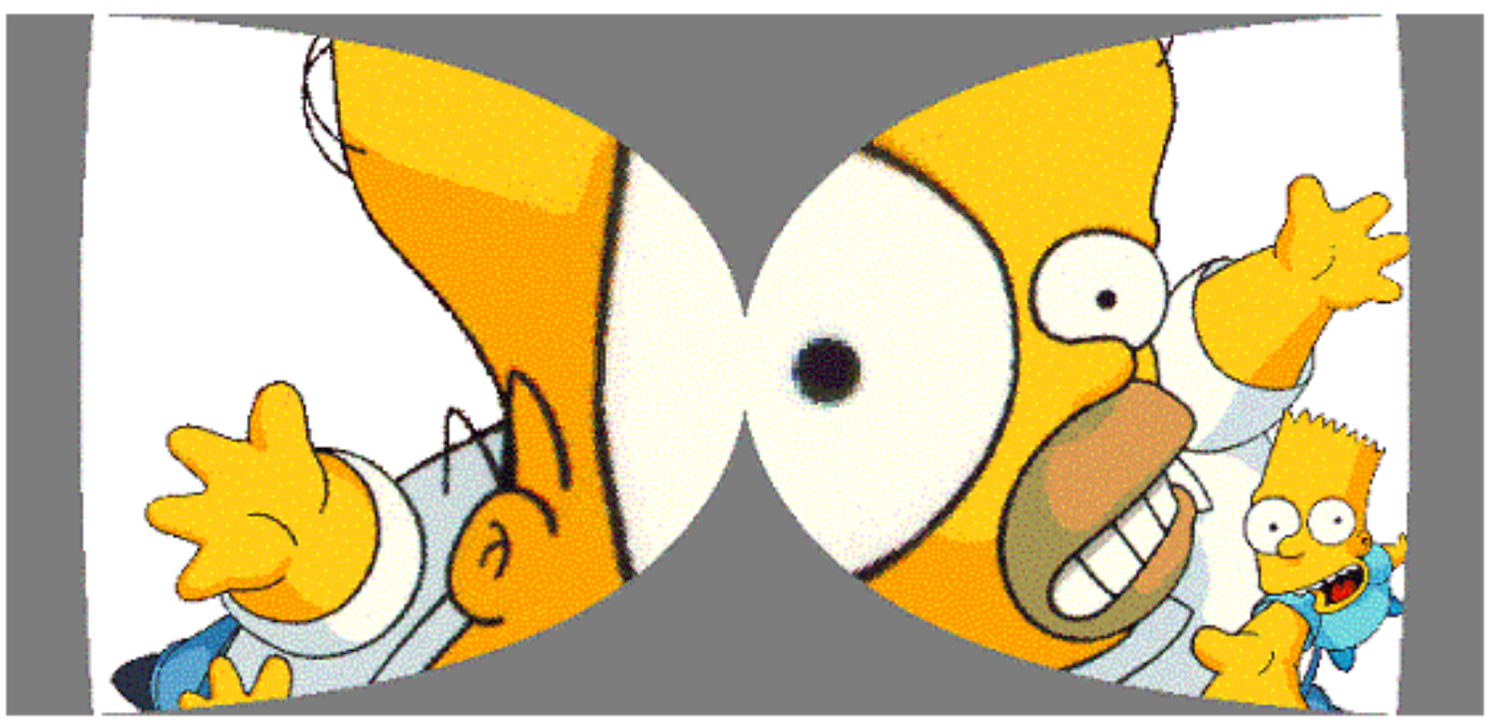
# V1 - topographic representation



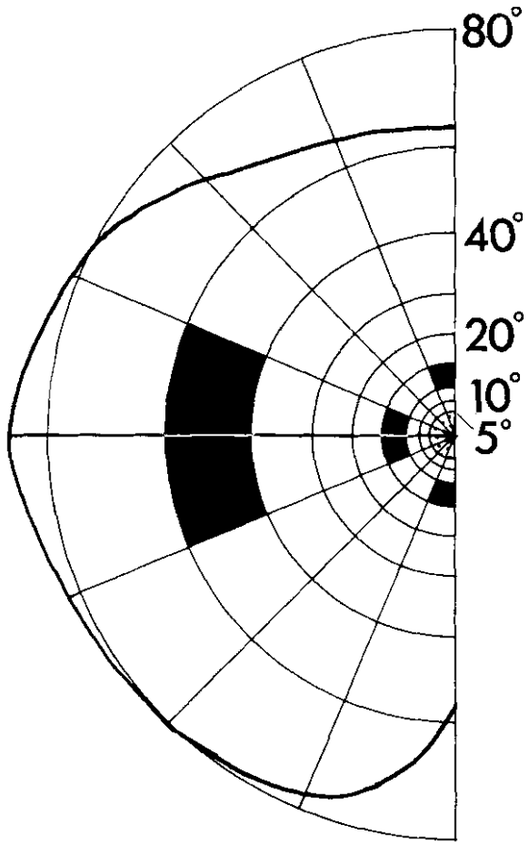
# Cortical magnification



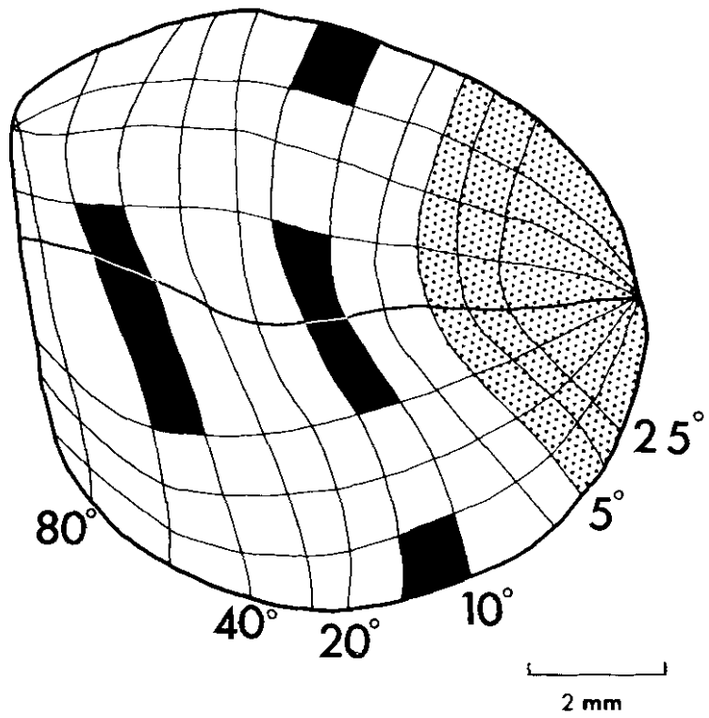


courtesy of Arash Fazl

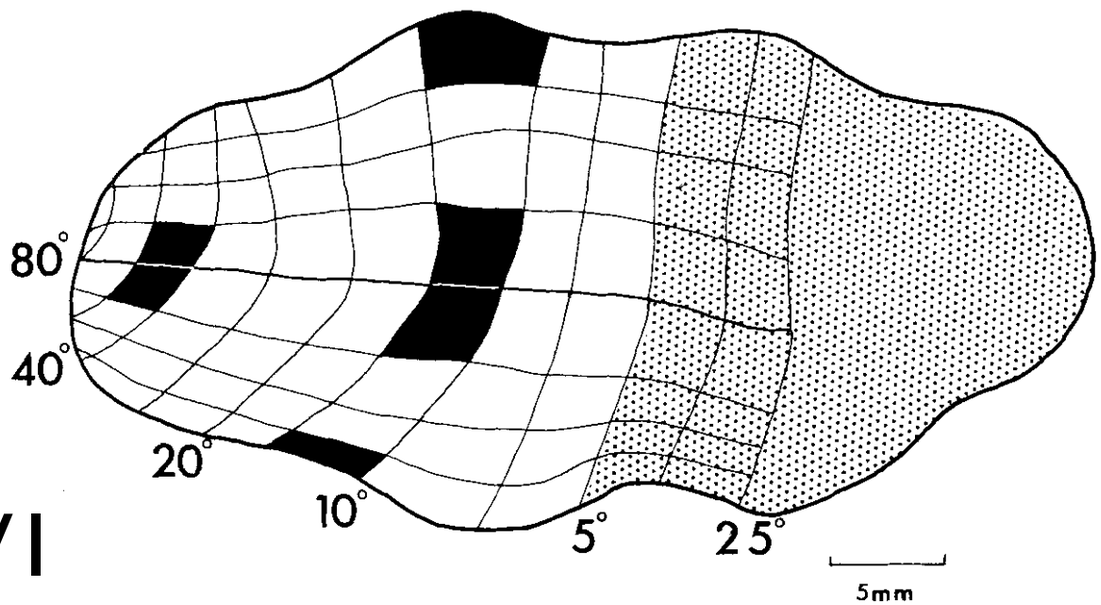
# Foveal oversampling in LGN and Cortex
## (Connolly & Van Essen, 1984)




LGN



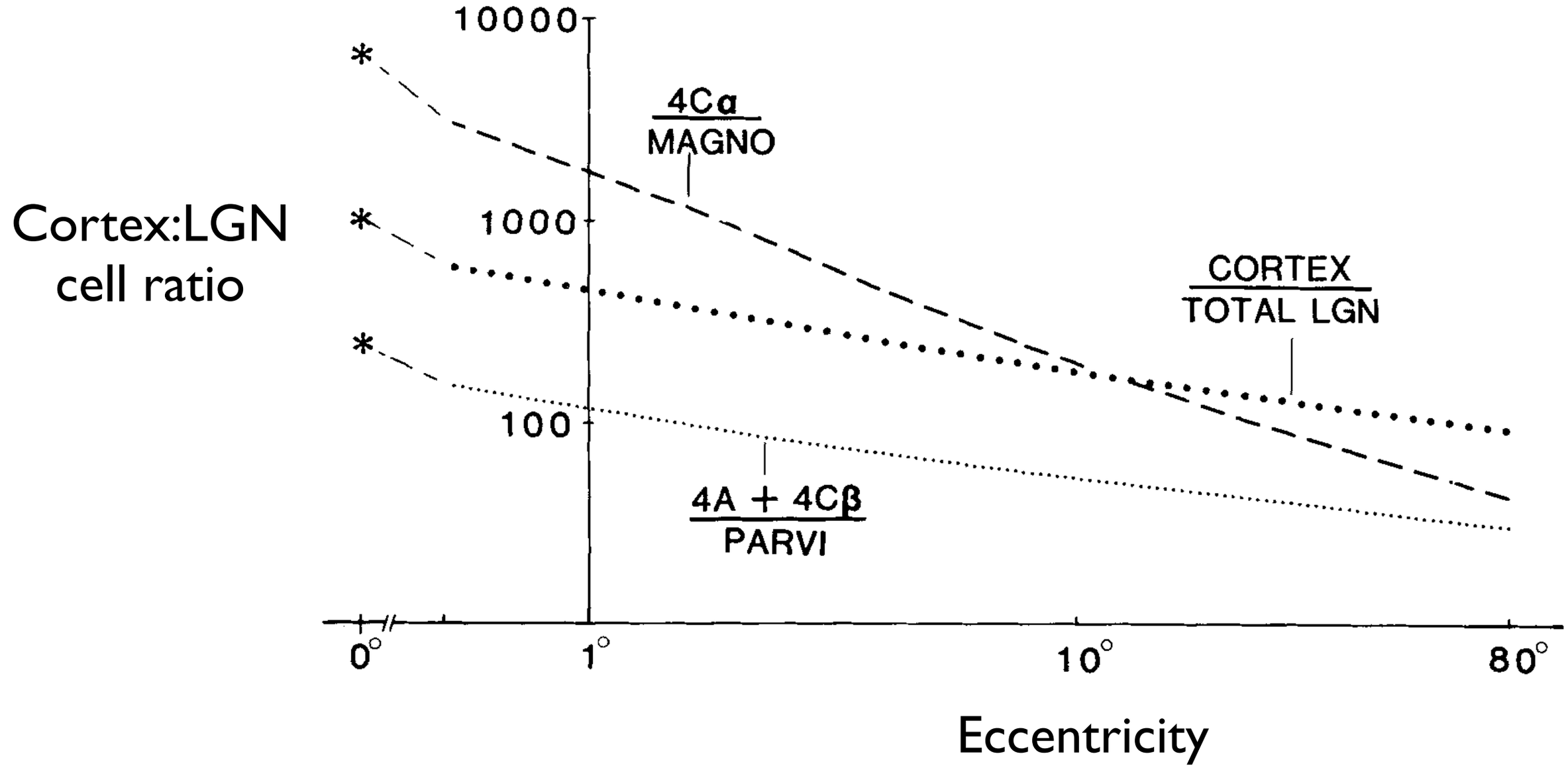

"…despite the fact that the estimated total number of LGN cells is similar to the total number of retinal ganglion cells, their ratio must vary from many LGN cells per retinal ganglion cell for the fovea to fewer than one LGN cell per retinal ganglion cell in the periphery."



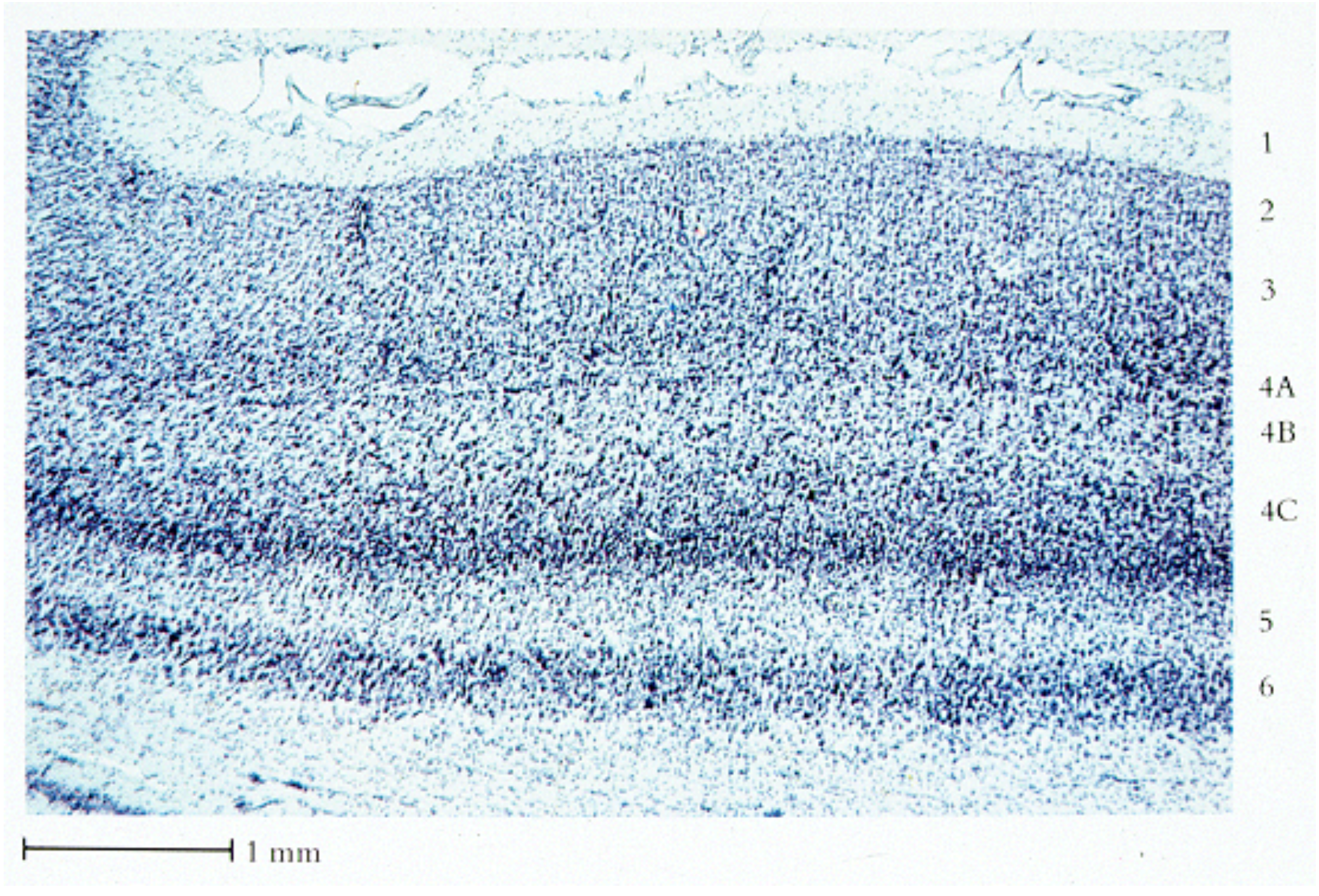

V1

# Cortex:LGN cell ratio ranges from 1000:1 in fovea to 100:1 in periphery

(Connolly & Van Essen, 1984)

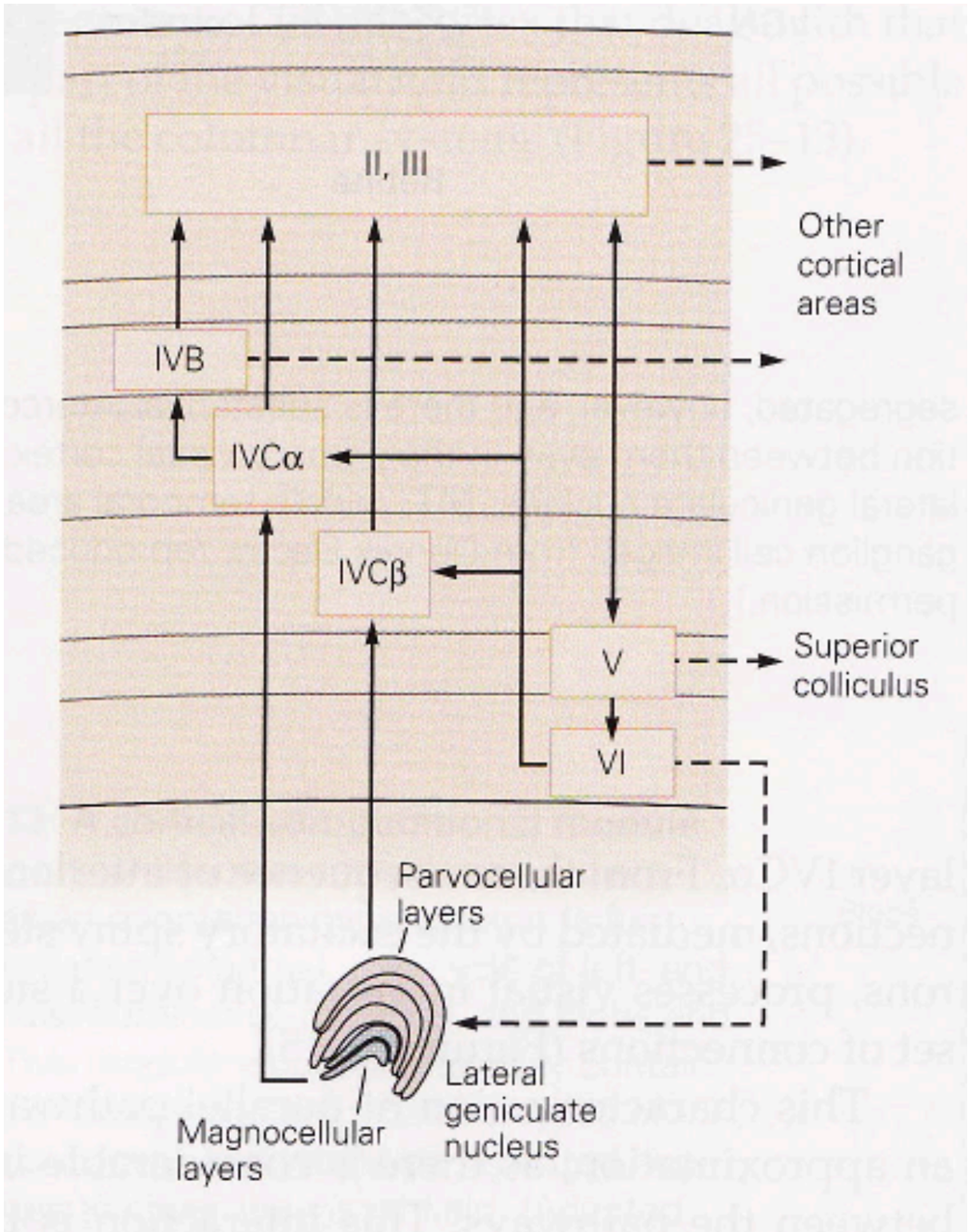


# Cortical layers

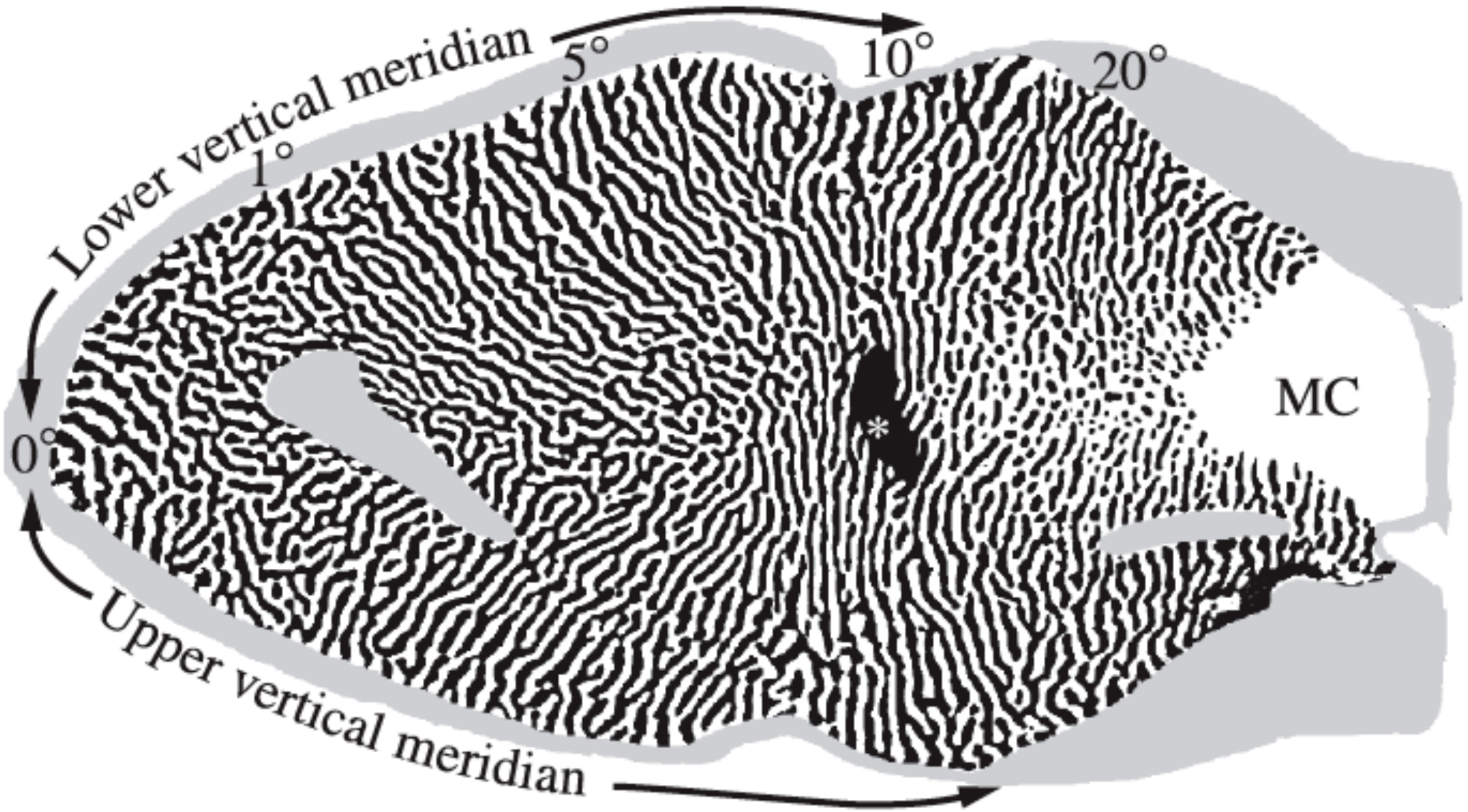
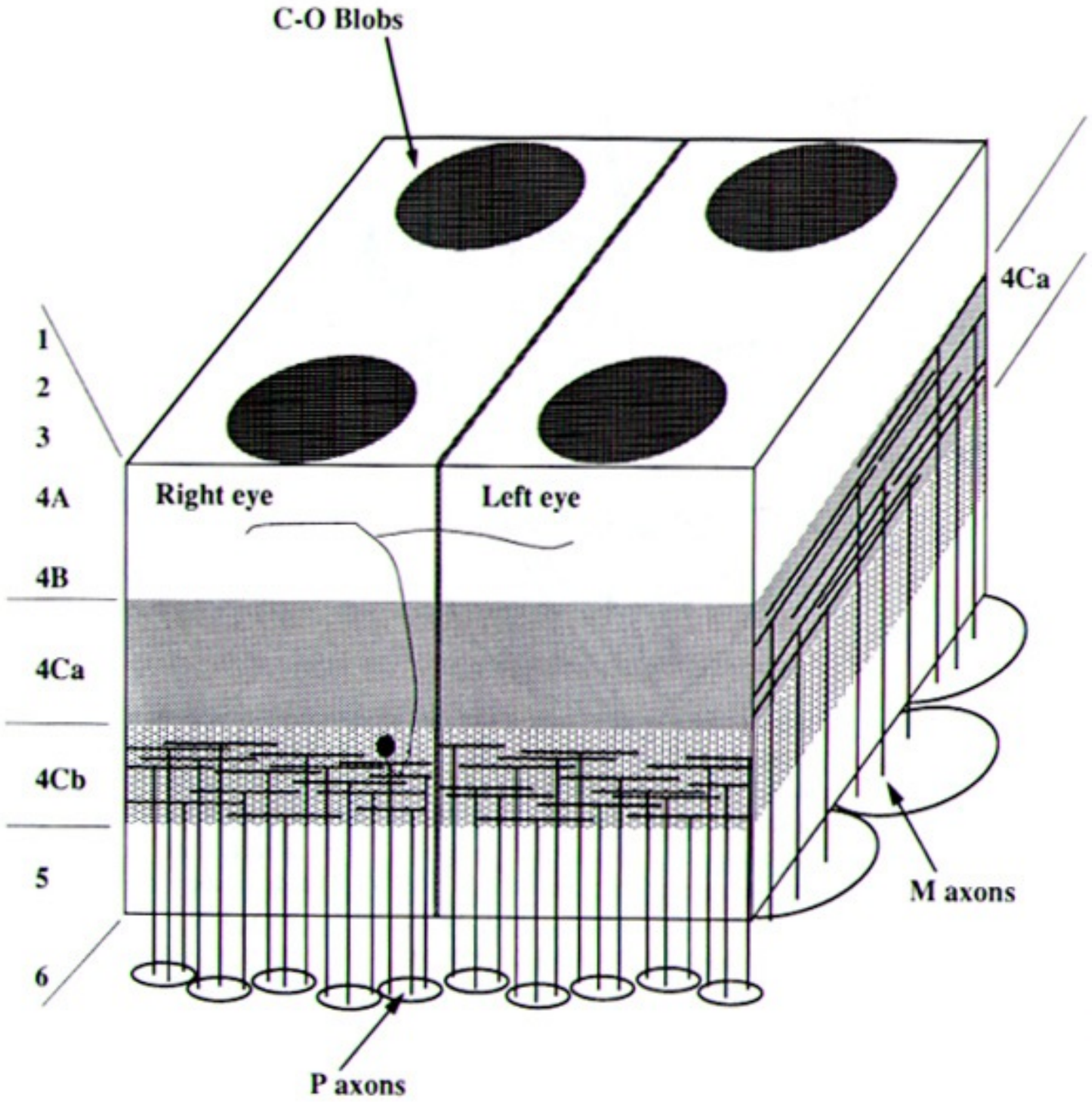



Primary visual cortex slice (Nissl stain)

# Connections of cortical layers in V1



# Ocular dominance columns
(Horton)



1 $mm^2$ of cortex analyzes ca. 14 x 14 array of retinal sample nodes and contains 100,000 neurons