Cortical Basis of Vision

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Visual Neuroscience Laboratory

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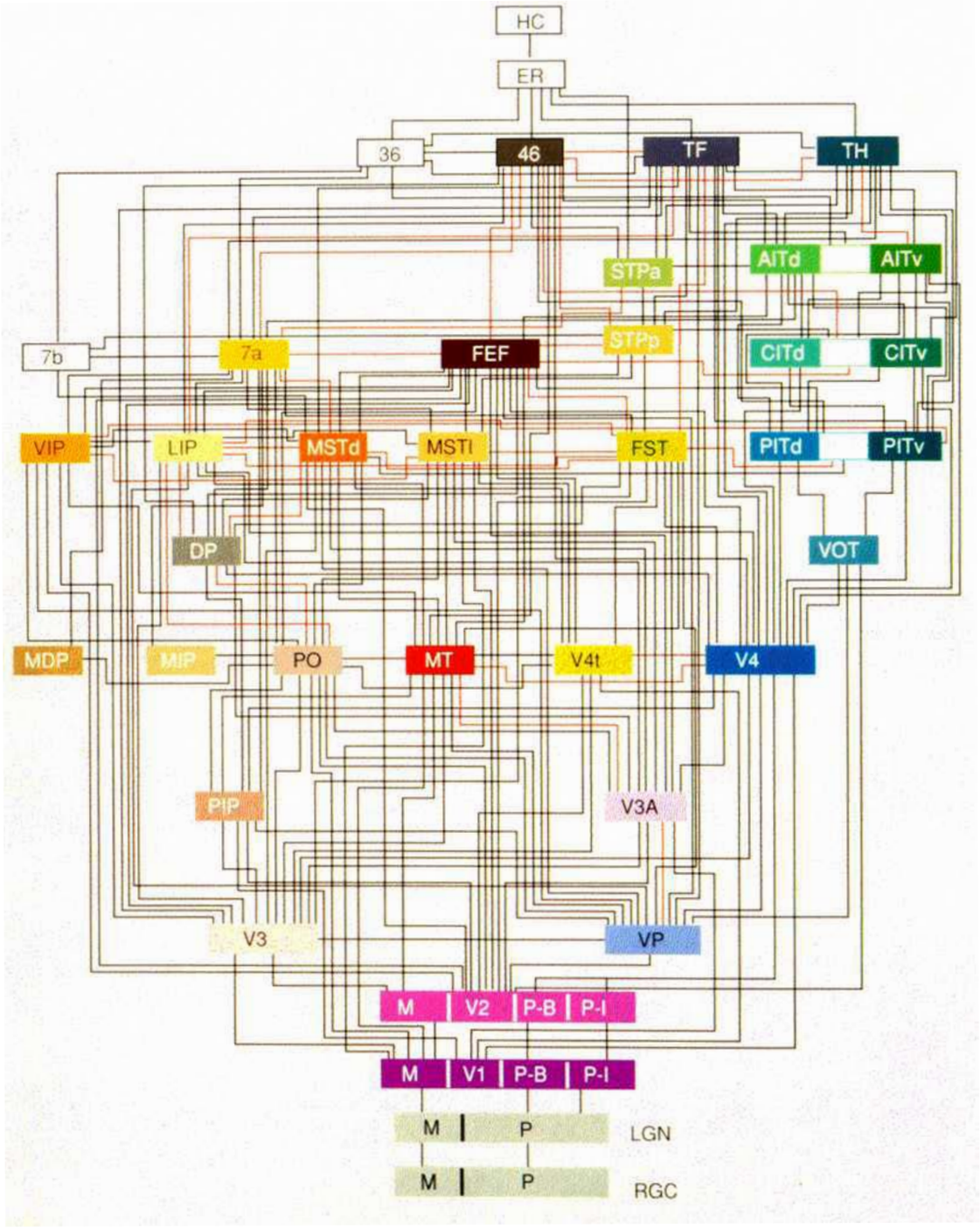
The visual system



Felleman & Van Essen (1991) Cereb Cortex 1:1-47

Eye and retina

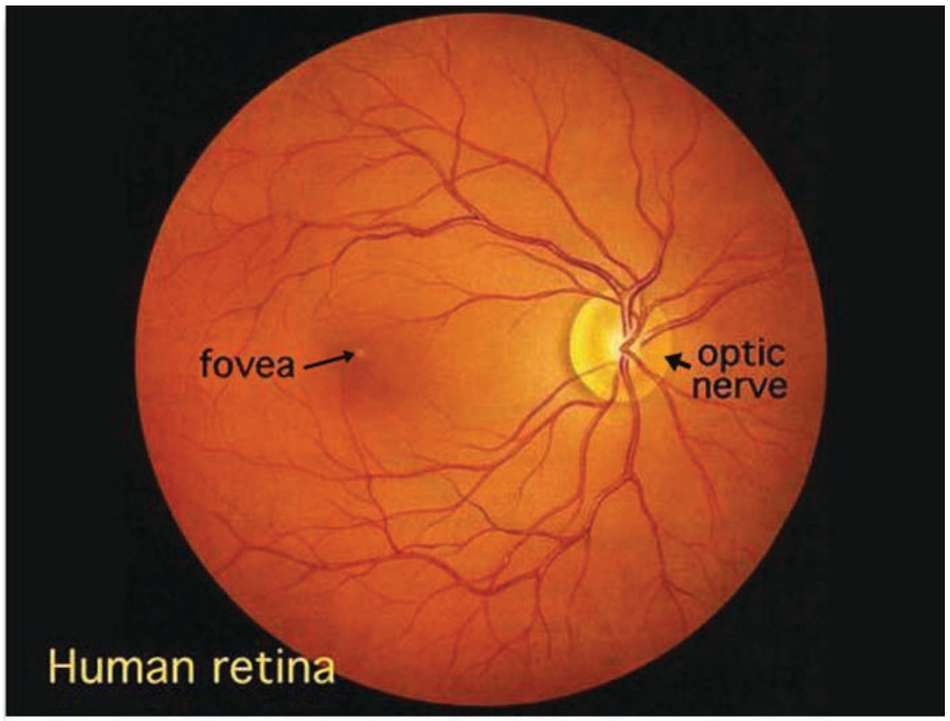


Fig. 1. Human retina as seen through an opthalmoscope.

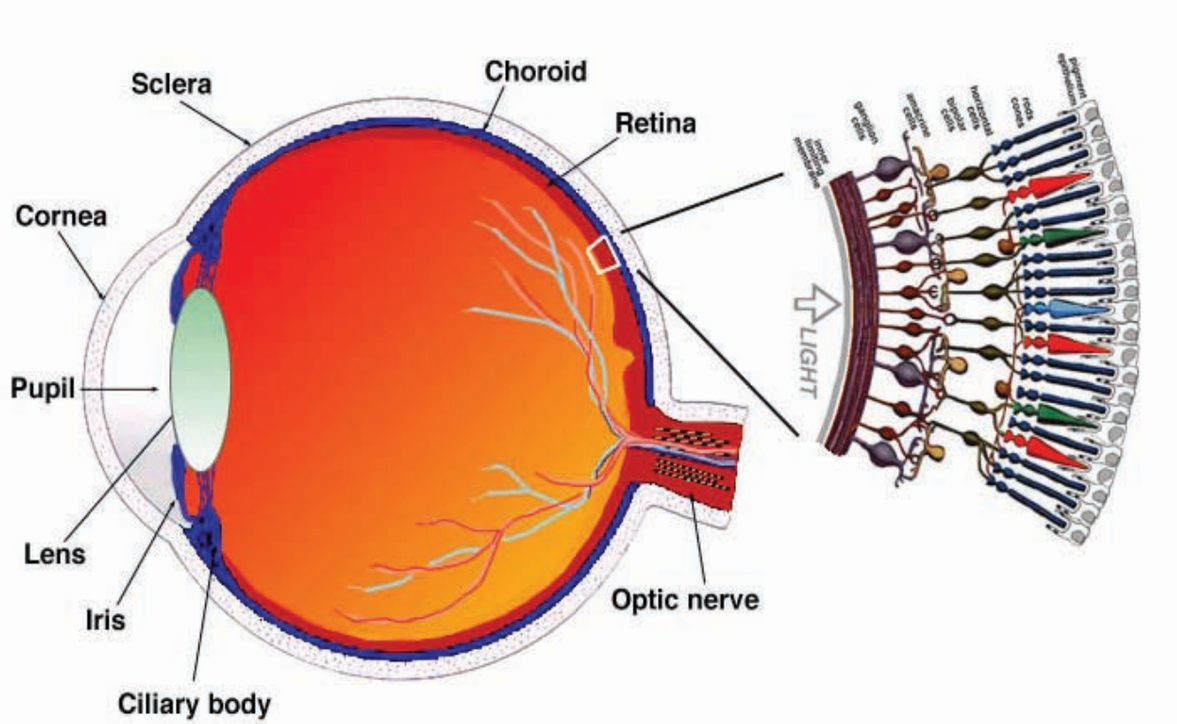
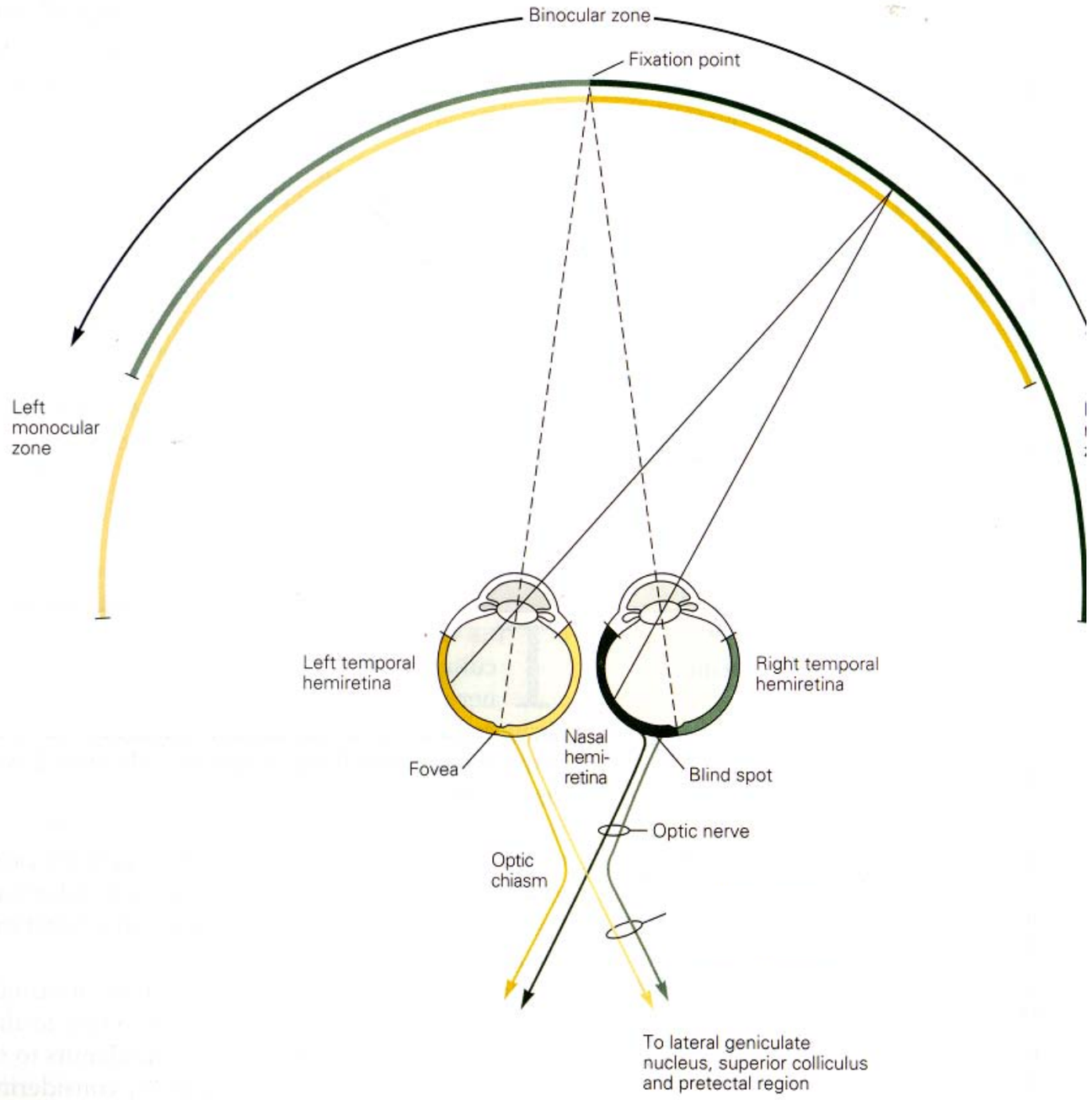
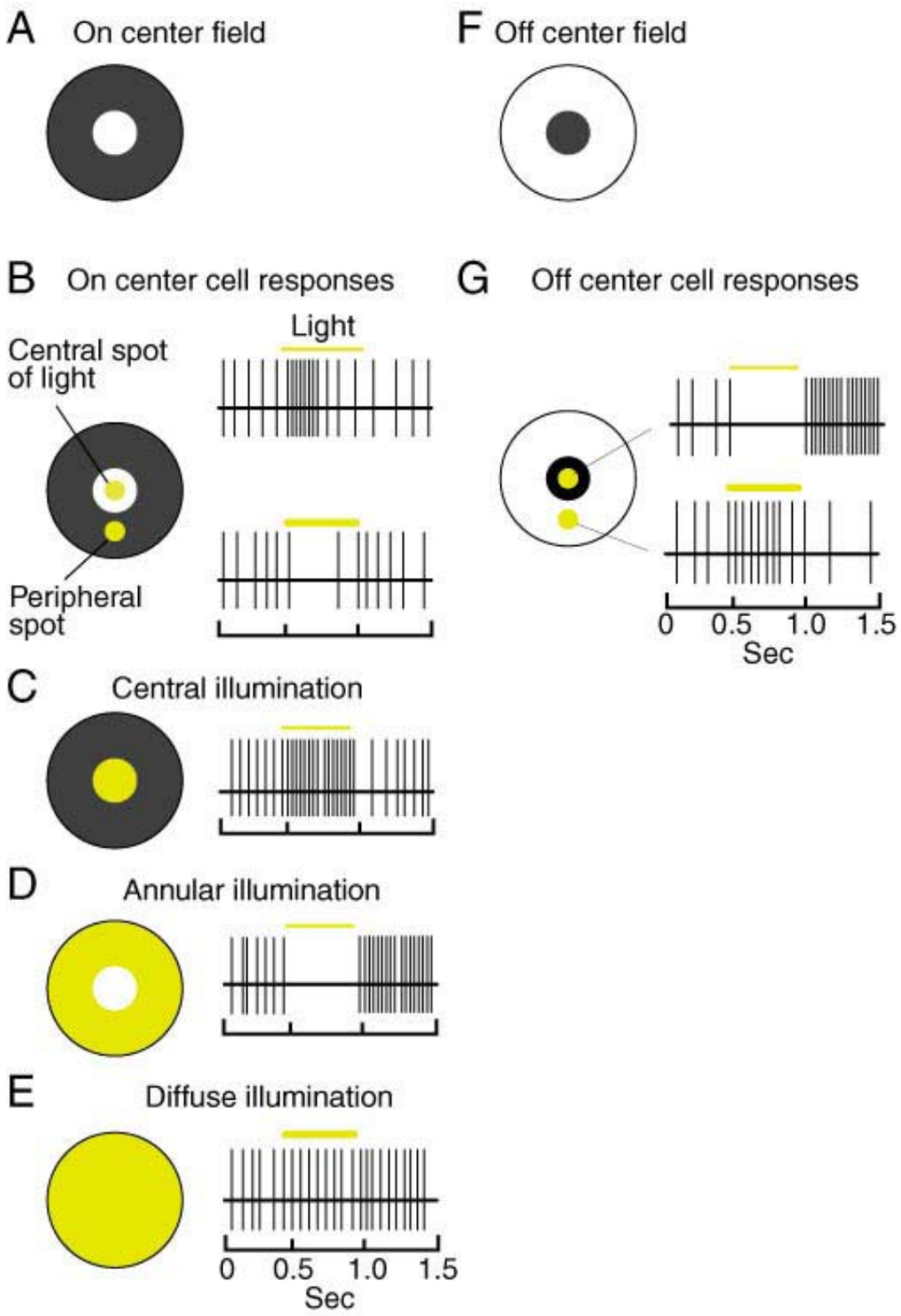


Fig. 1.1. A drawing of a section through the human eye with a schematic enlargement of the retina.

Representation of the visual world in the retina



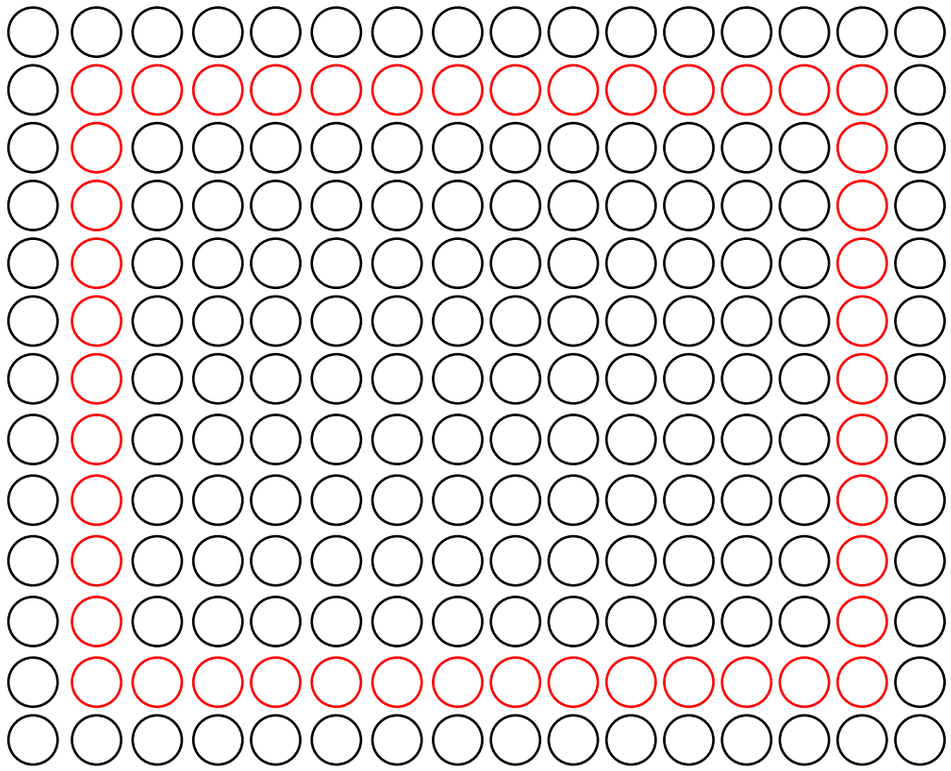
Receptive field properties of retinal ganglion cells



Retinal coding

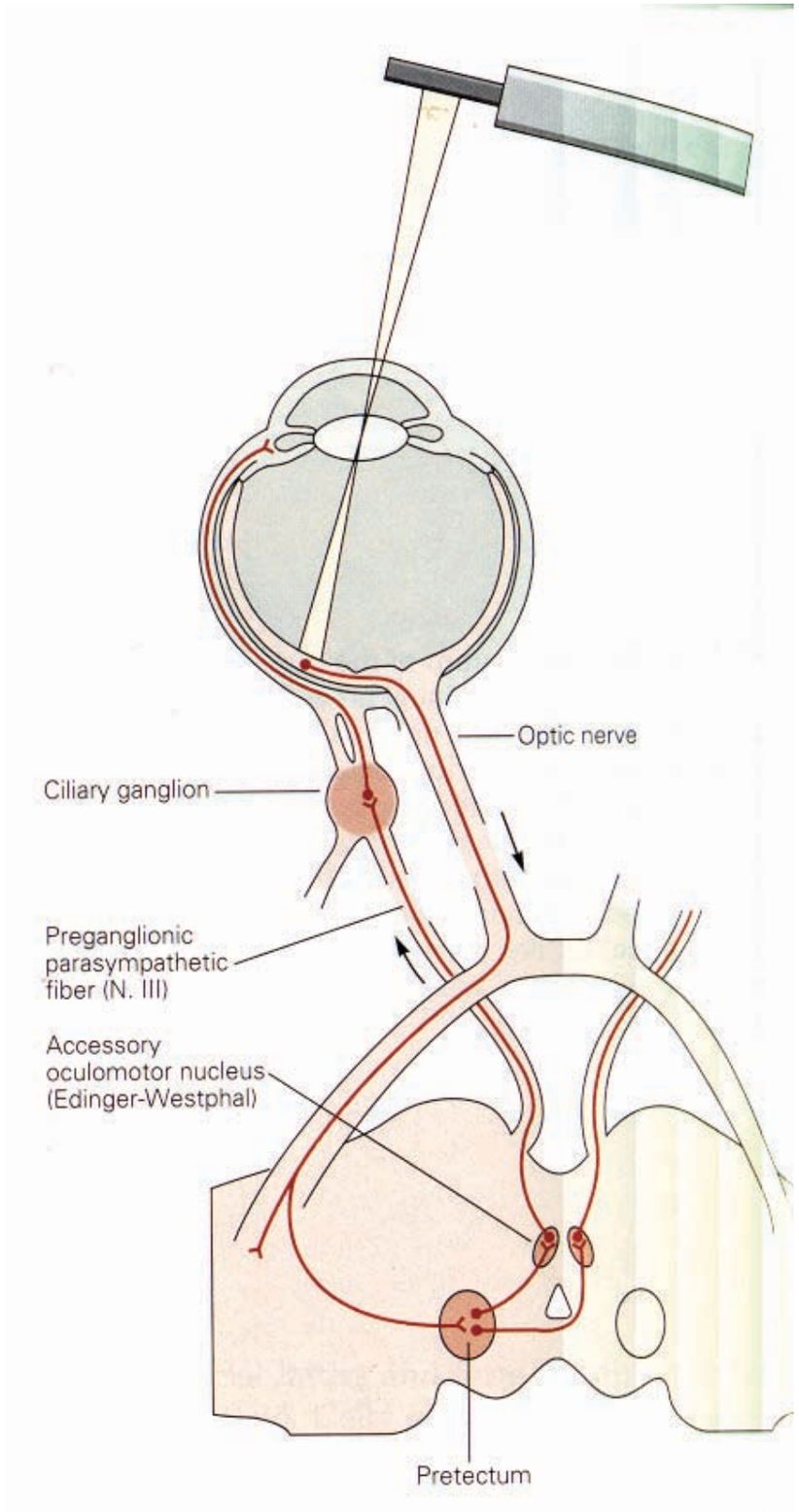
Visual object

Retina

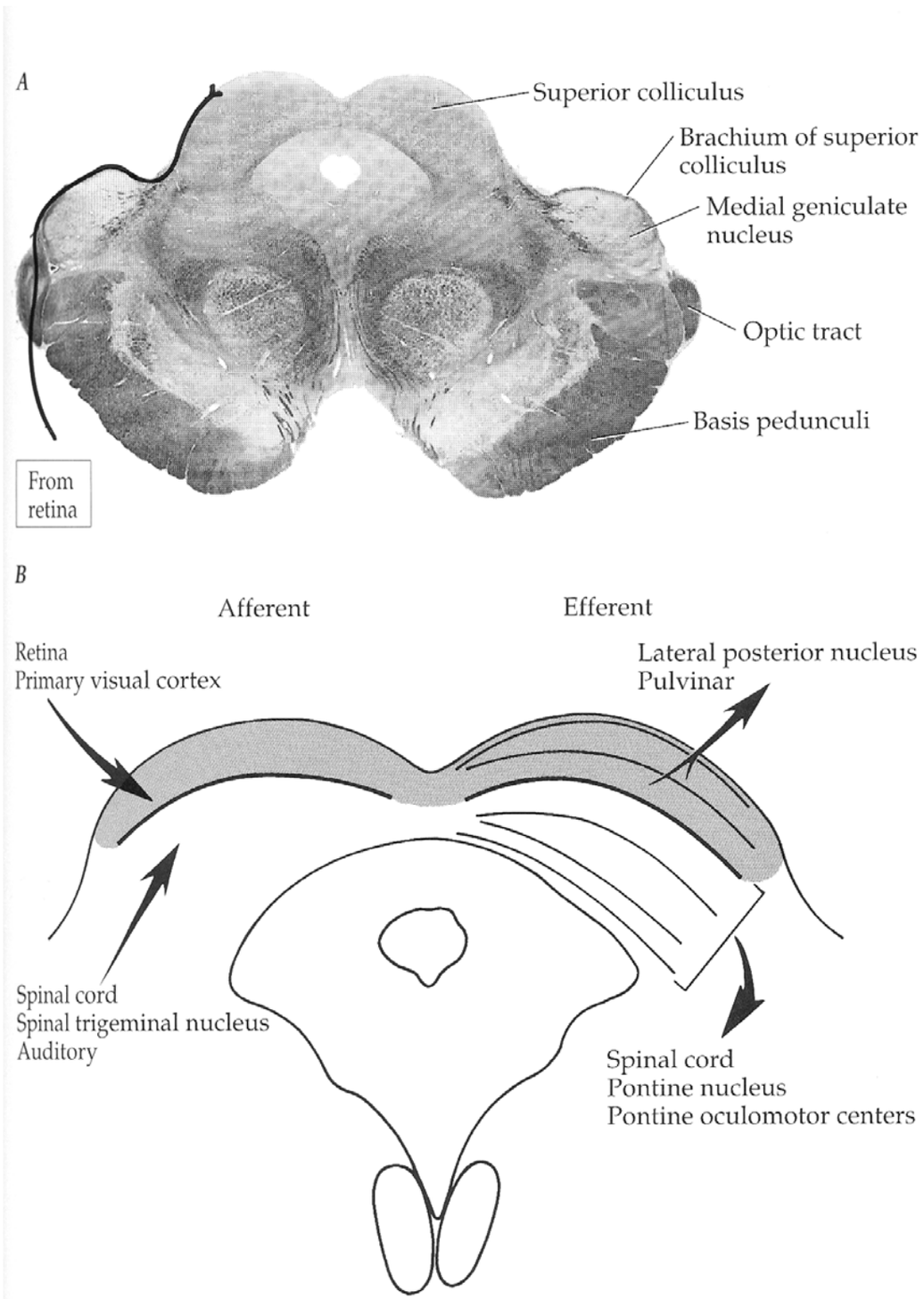


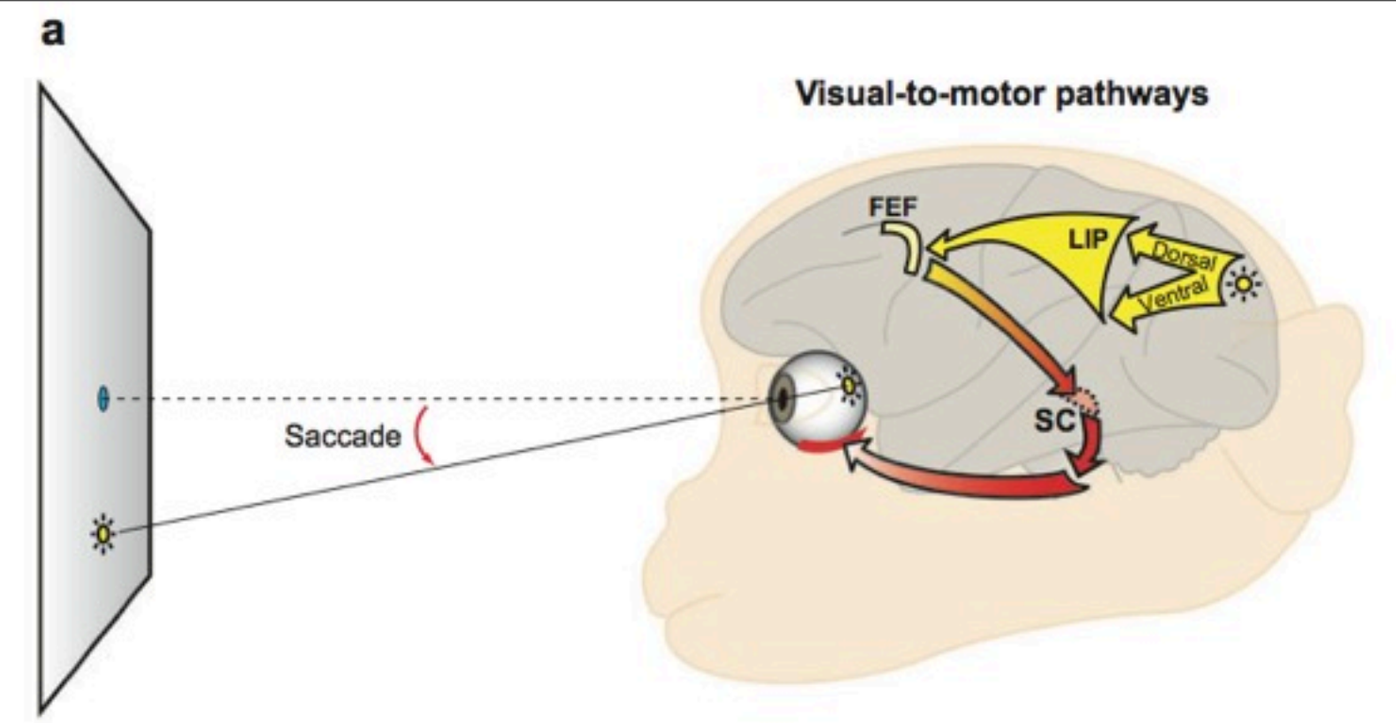
The retina encodes change/boundaries, not absolute value.

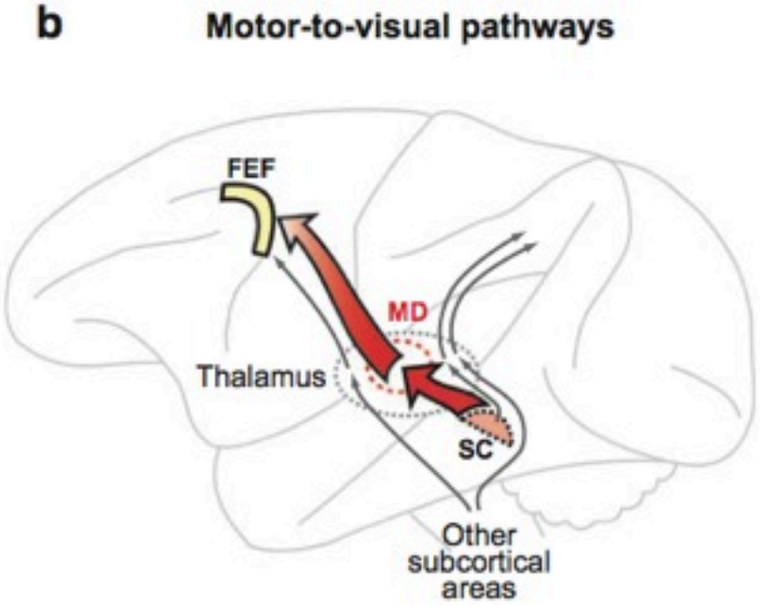
Pathway 1: Pretectum (pupillary reflex)

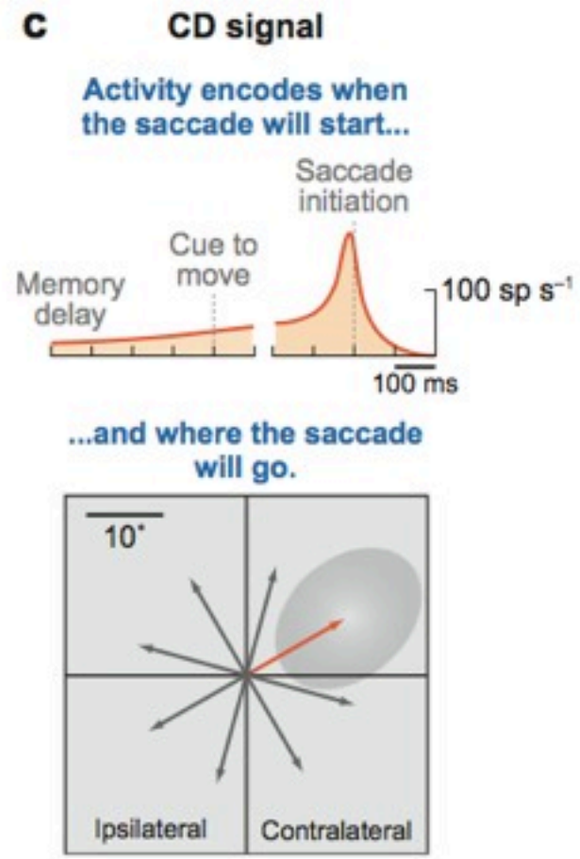


Pathway 2: Superior colliculus

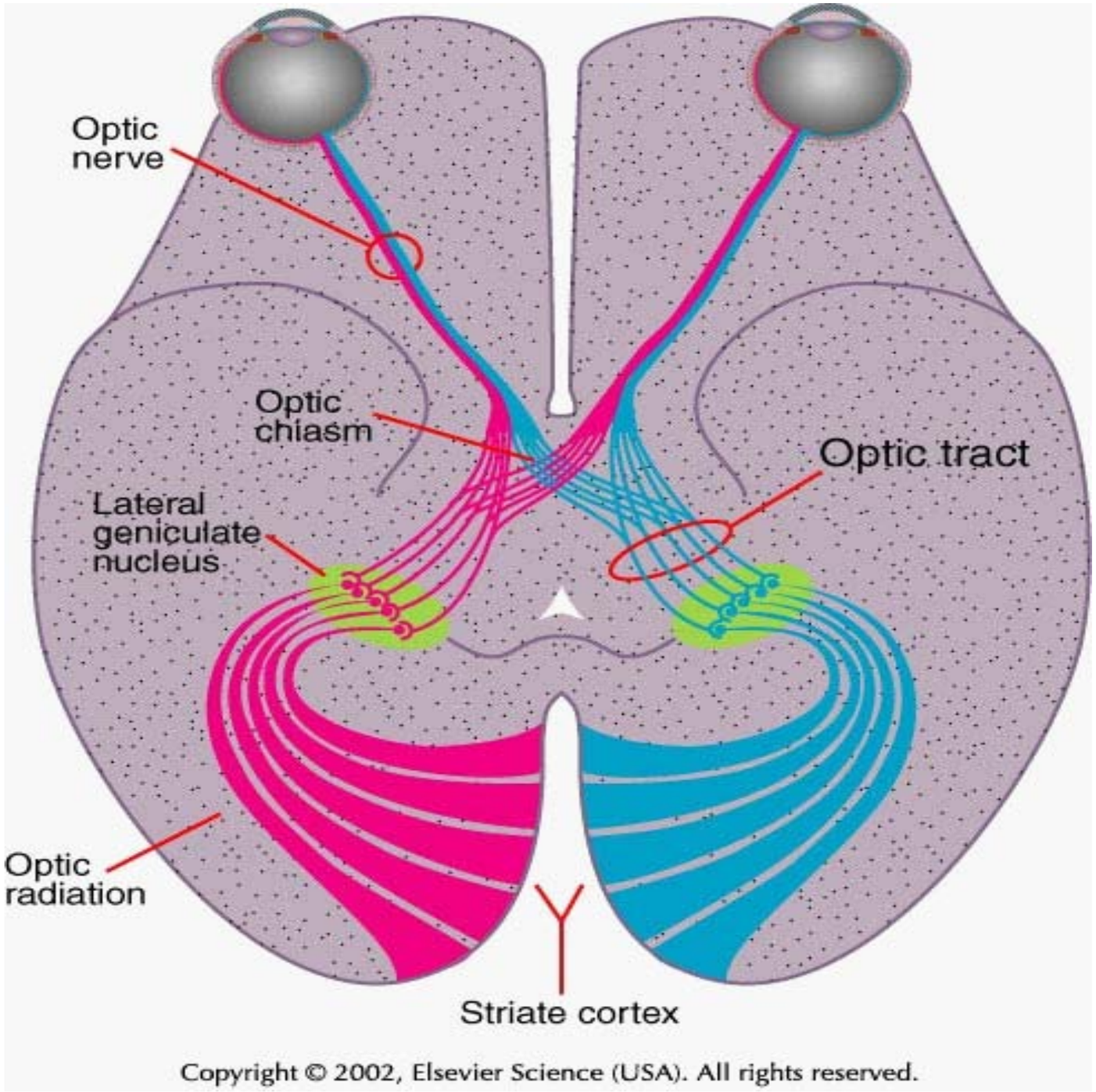



a
Visual-to-motor pathways
FEF
LIP
Dorsal
Ventral
SC
Saccade


b
Motor-to-visual pathways
FEF
MD
Thalamus
SC
Other
subcortical
areas

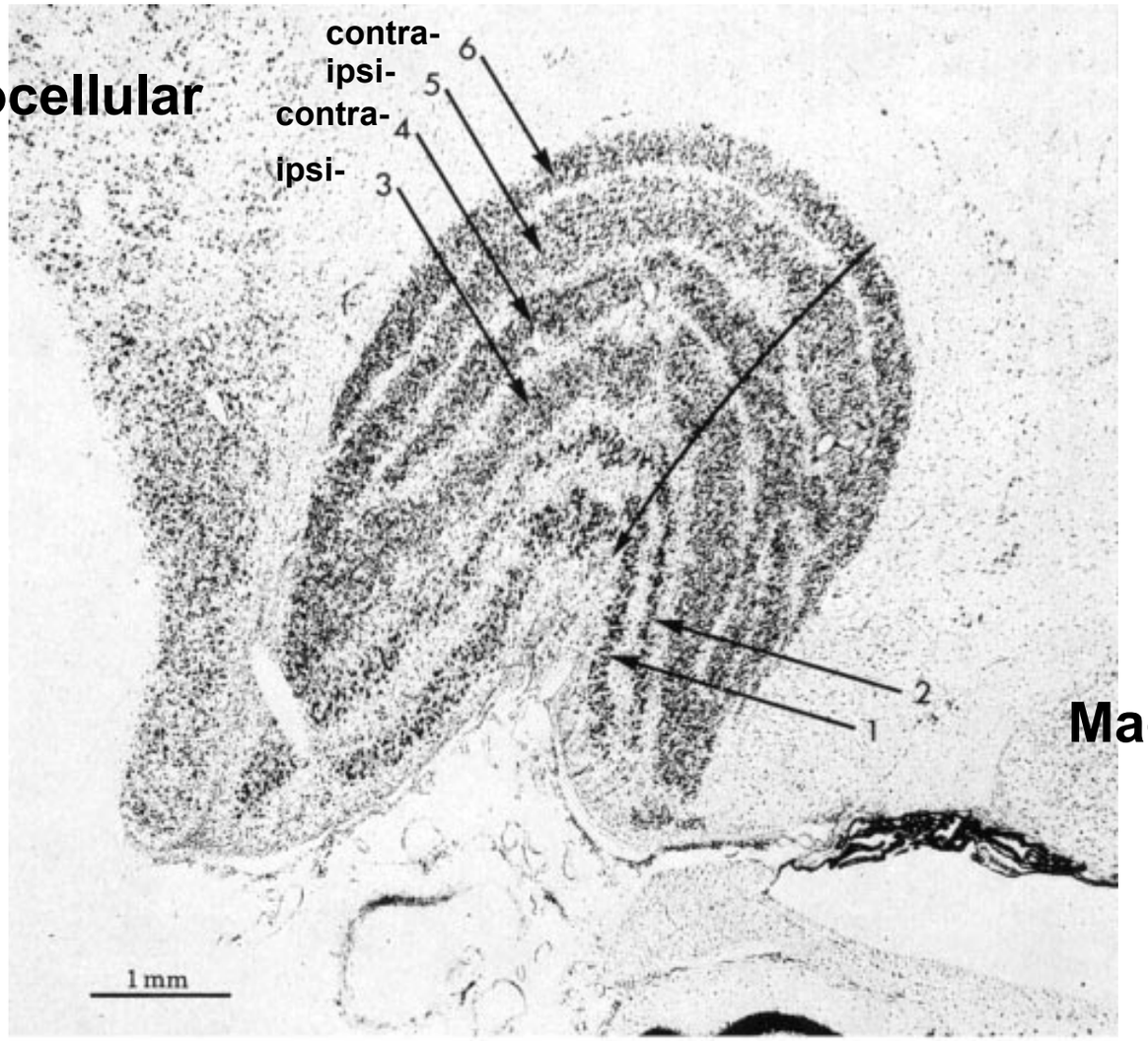

c
CD signal
Activity encodes when
the saccade will start...
Saccade
initiation
Cue to
move
Memory
delay
100 sp s⁻¹
100 ms
...and where the saccade
will go.
10°
Ipsilateral
Contralateral

Pathway 3: To LGN and visual cortex



Structure and organization of the lateral geniculate nucleus

Parvocellular

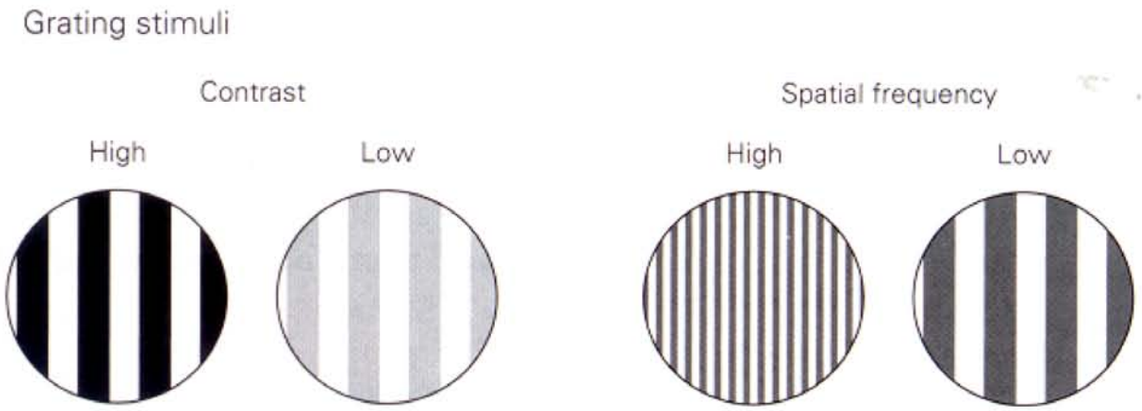


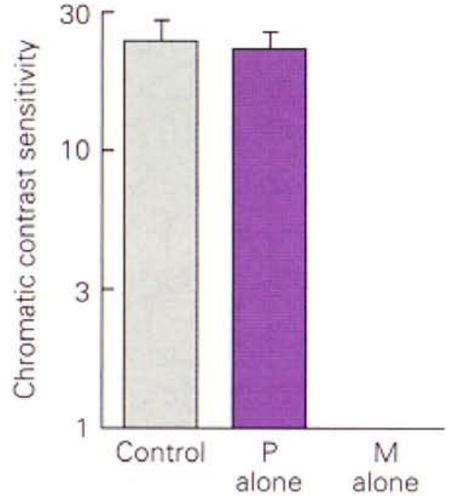
Magnocellular

Magnocellular vs. parvocellular pathways

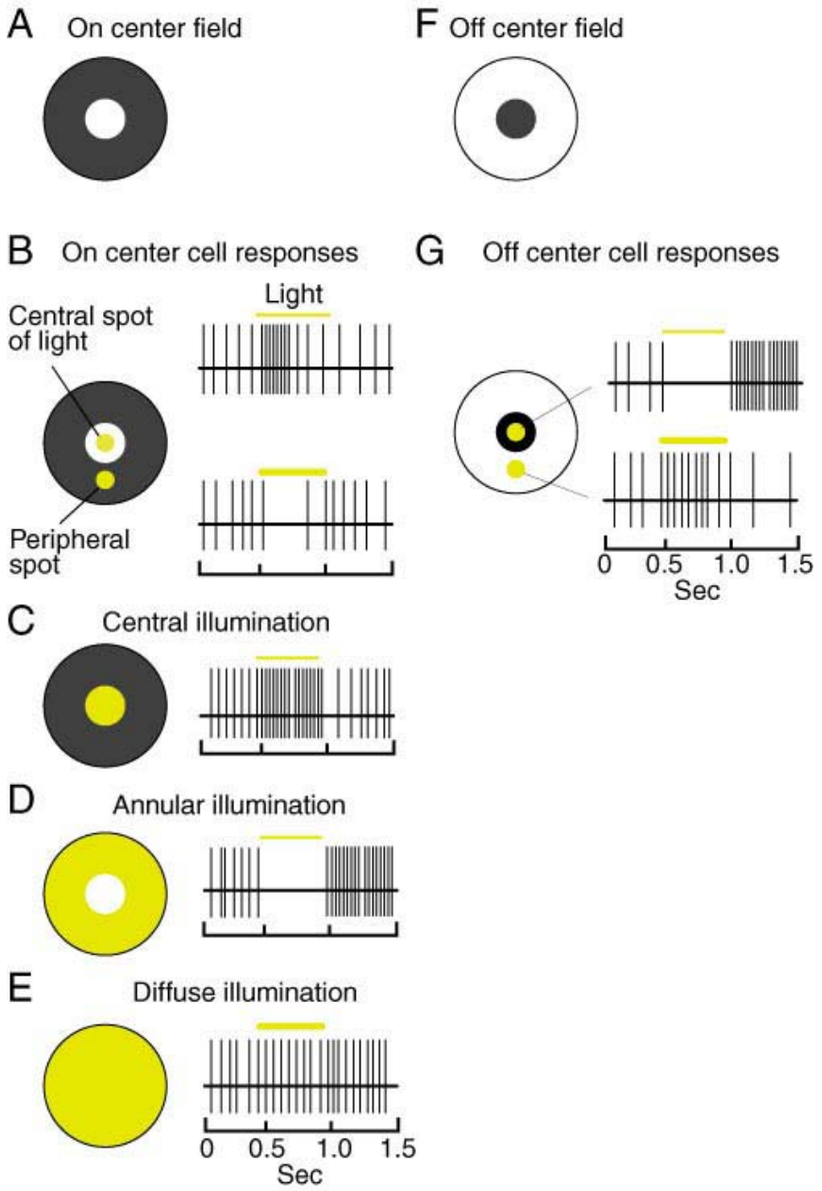
Magno:
- *higher contrast sensitivity*
- *low spatial freq.*
- *phasic/transient*

Parvo:
- *lower contrast sensitivity*
- *fine spatial freq.*
- *tonic*
- *color*

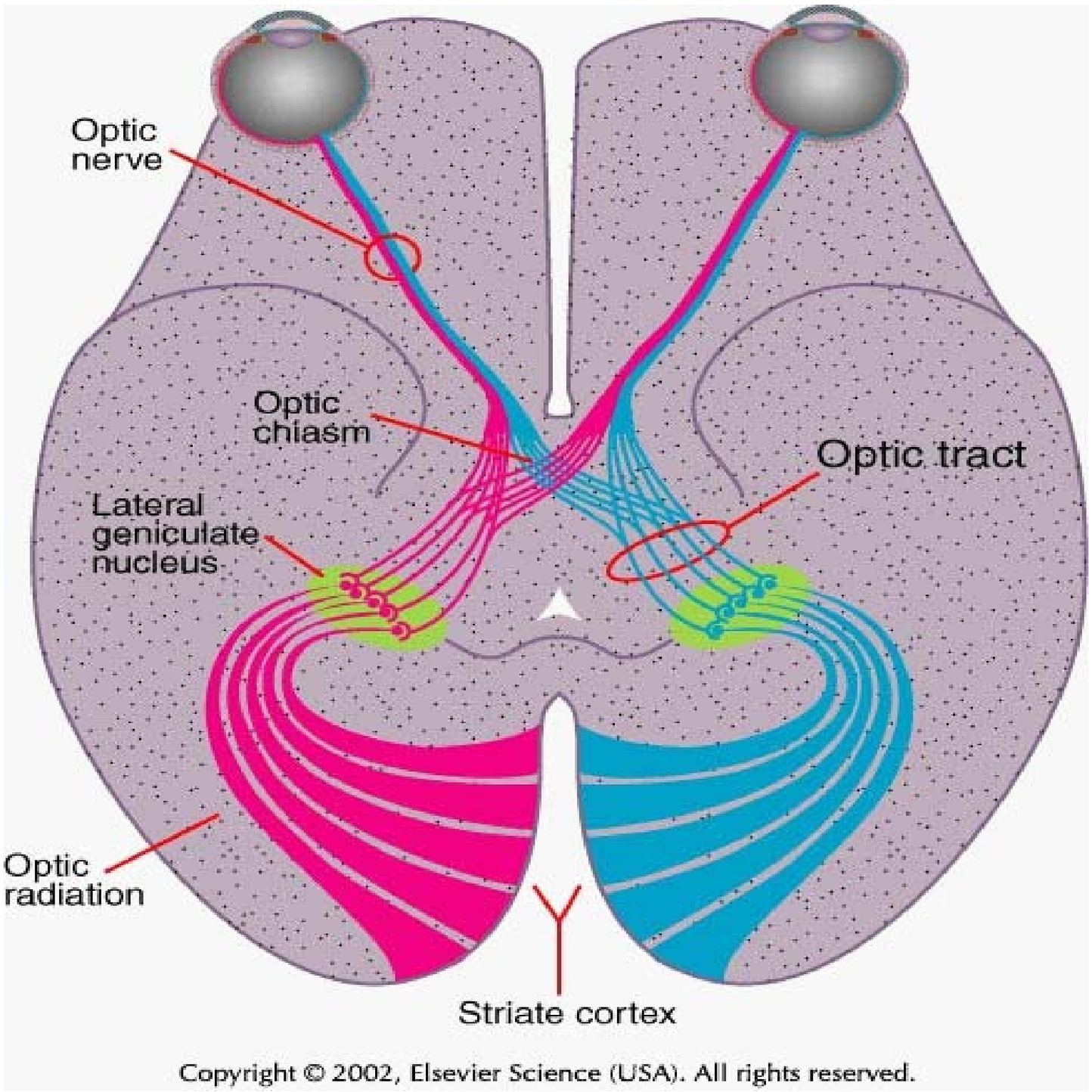




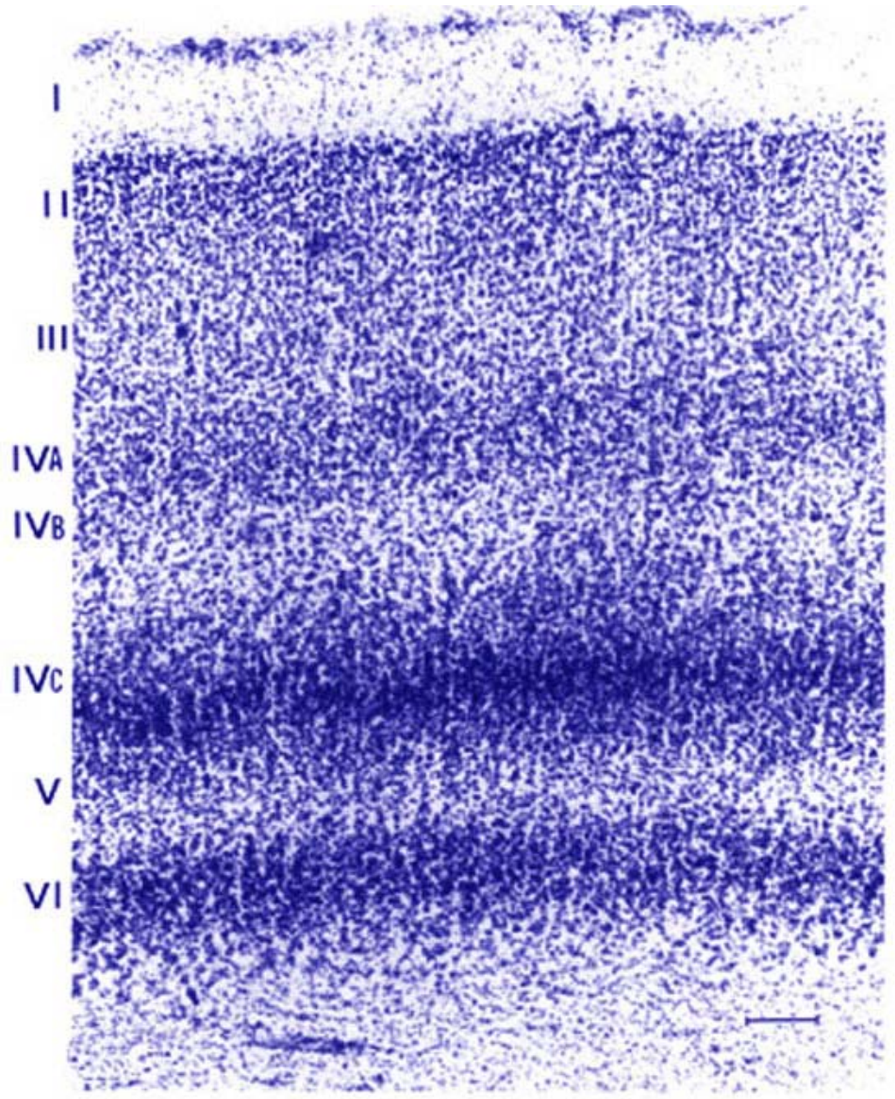
RF properties of LGN cells



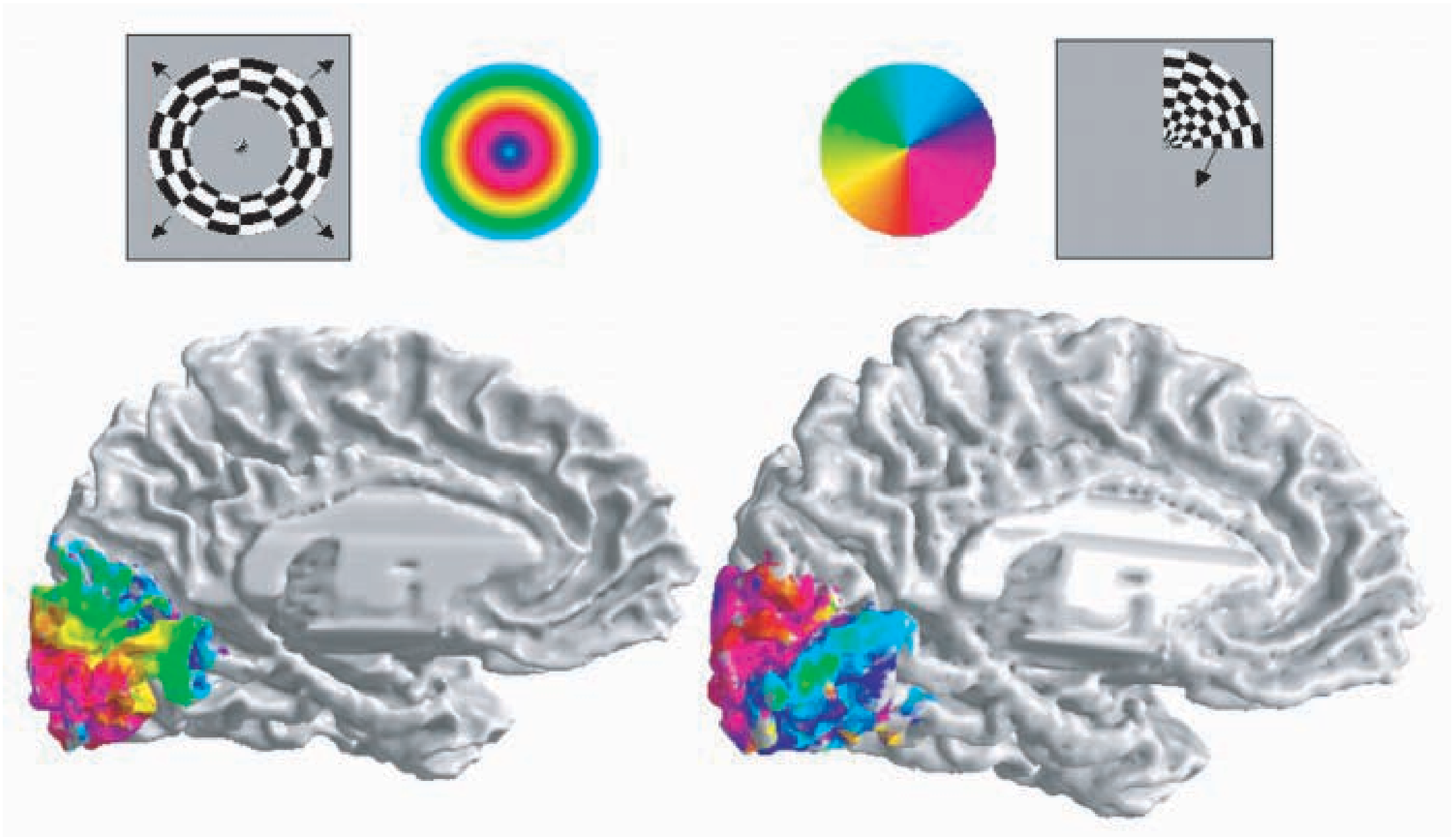
What is the LGN for?

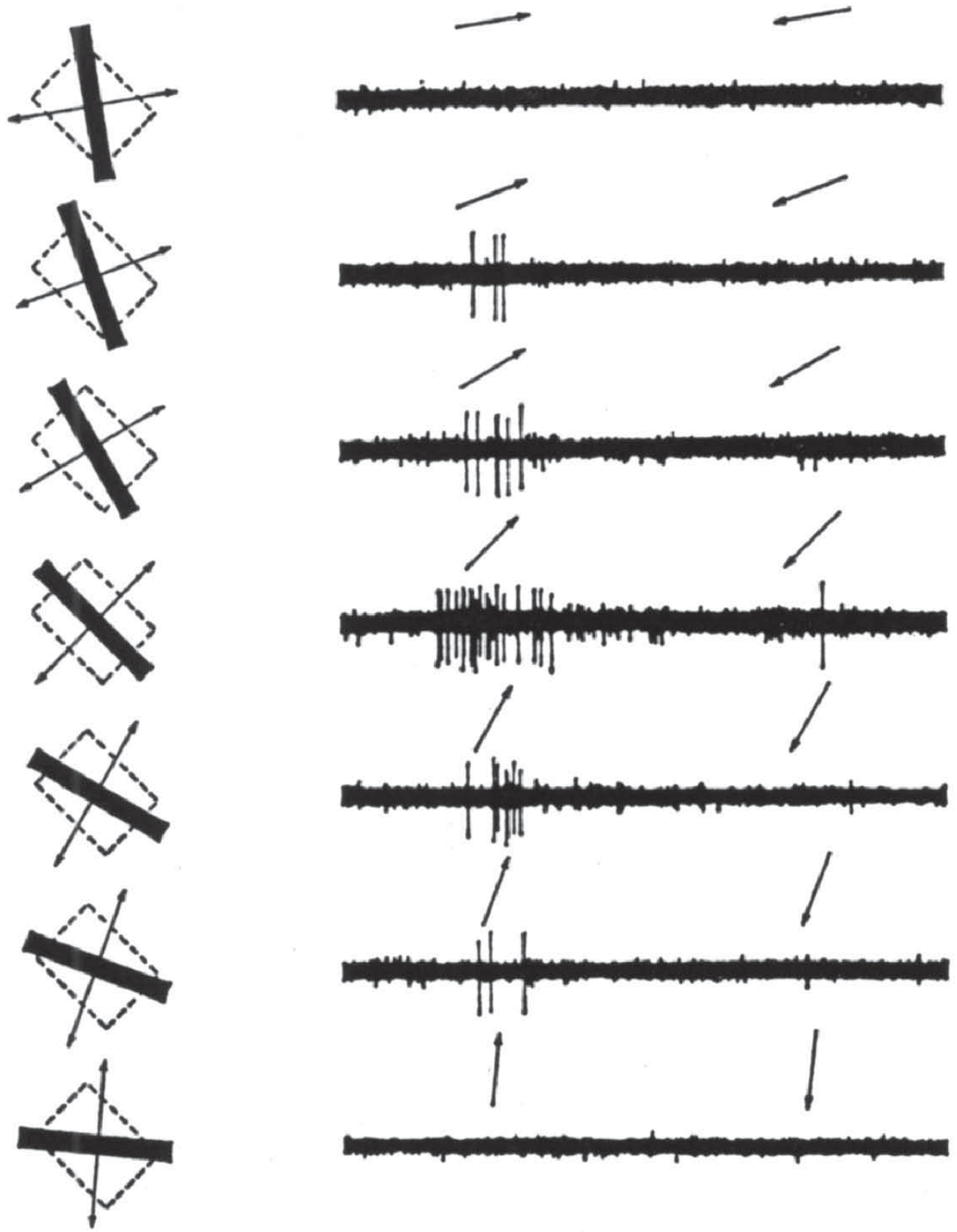


Anatomy of primary visual cortex

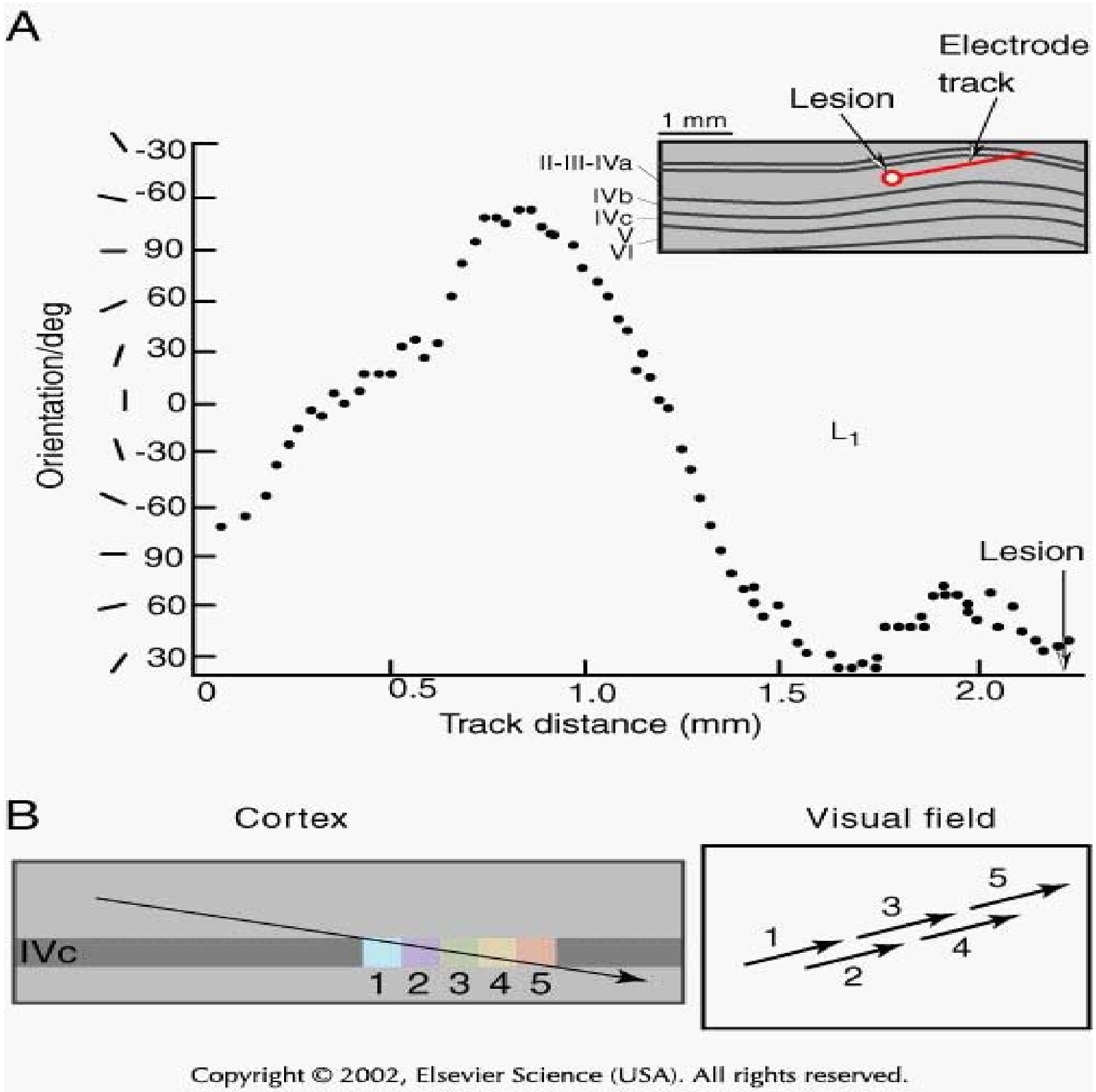


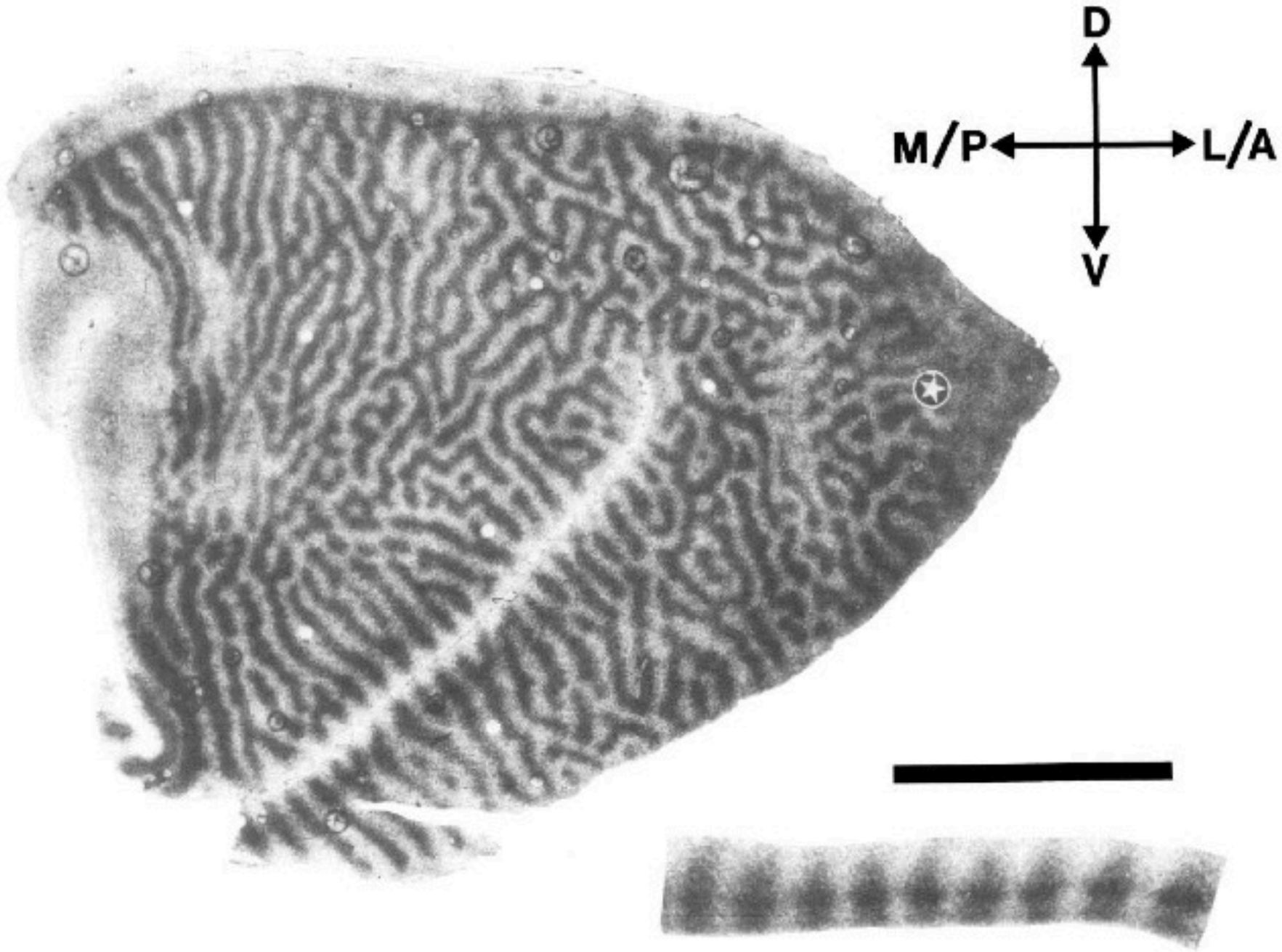
Retinotopic organization of V1





Spatial arrangement of orientation selectivity

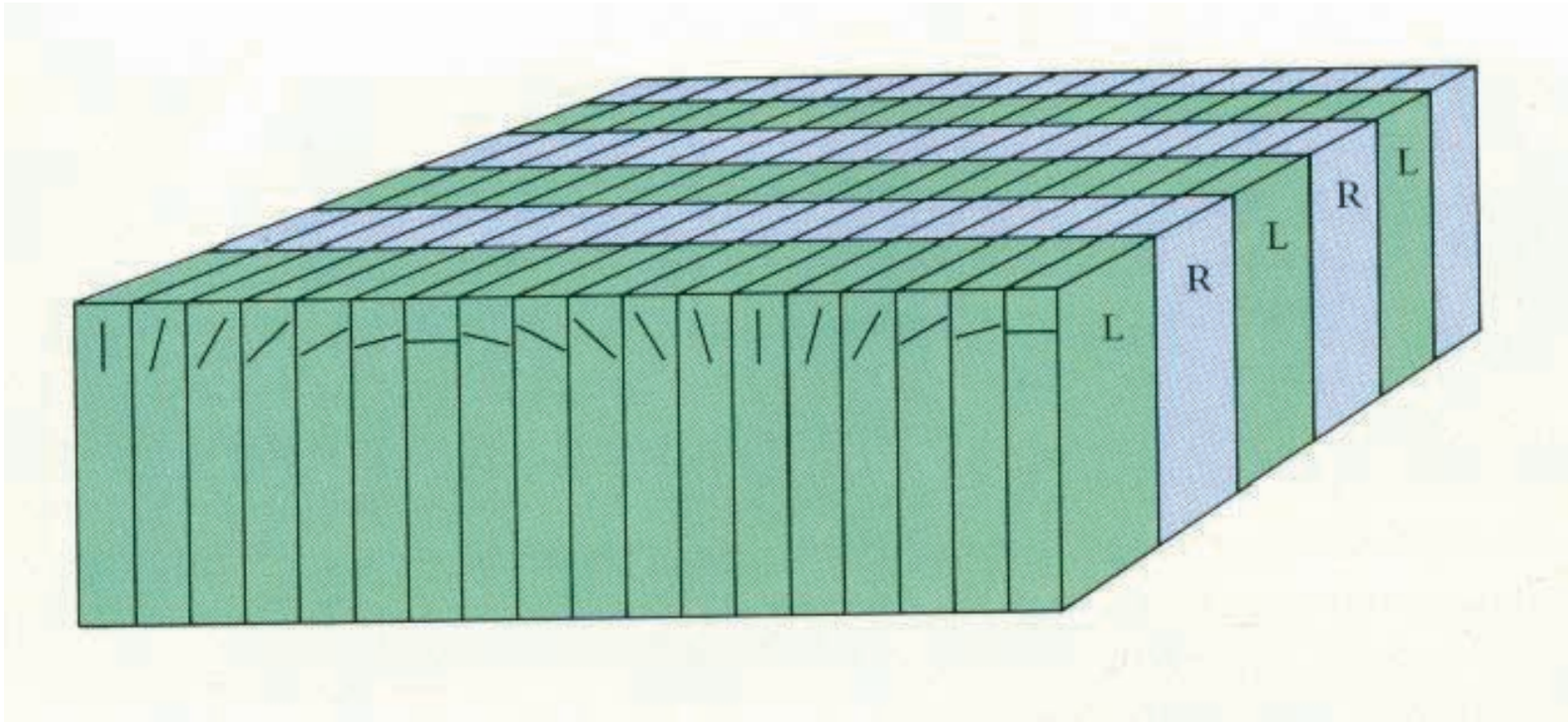




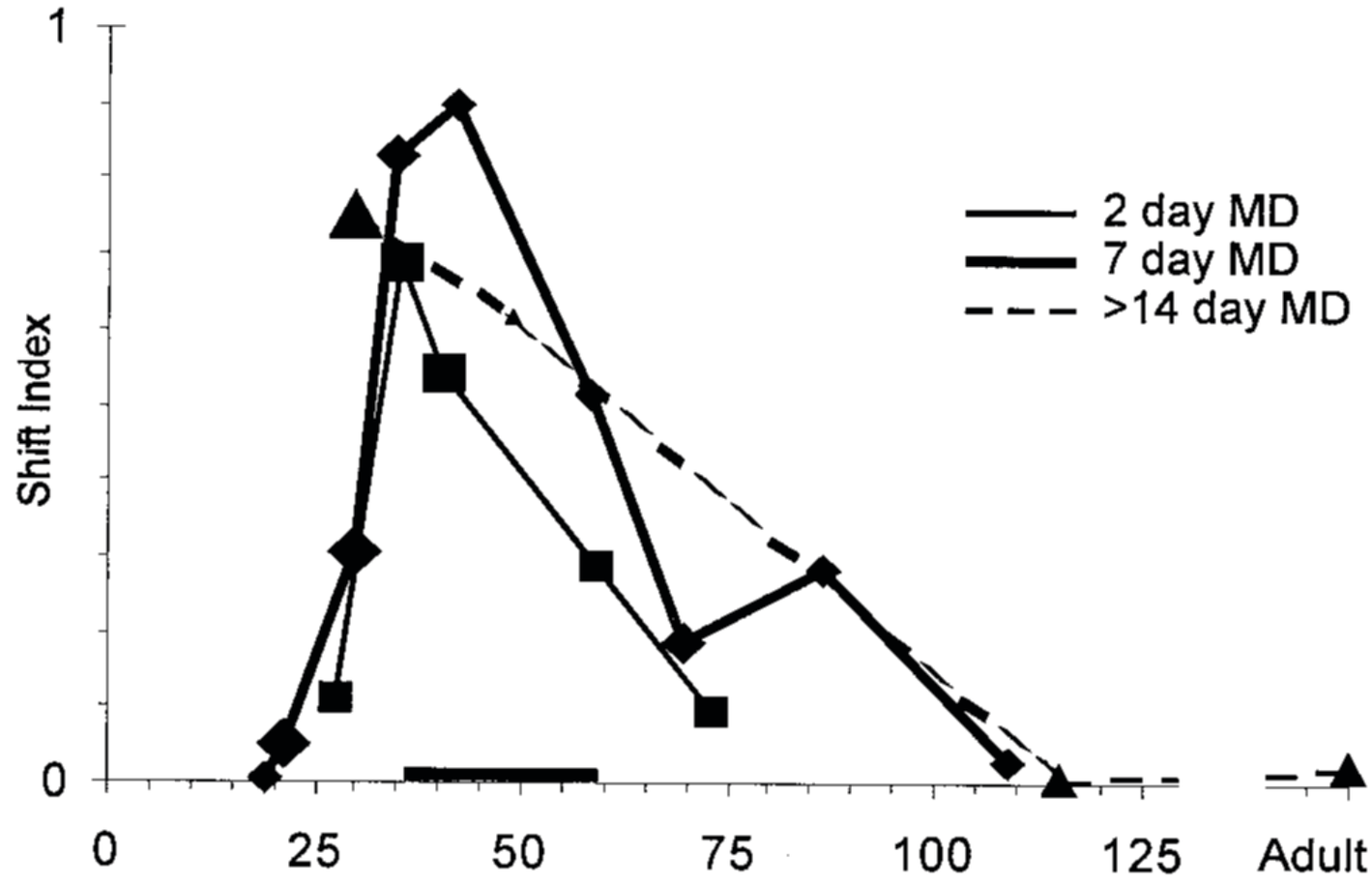
Tootell et al ,1988

“Ice Cube” model

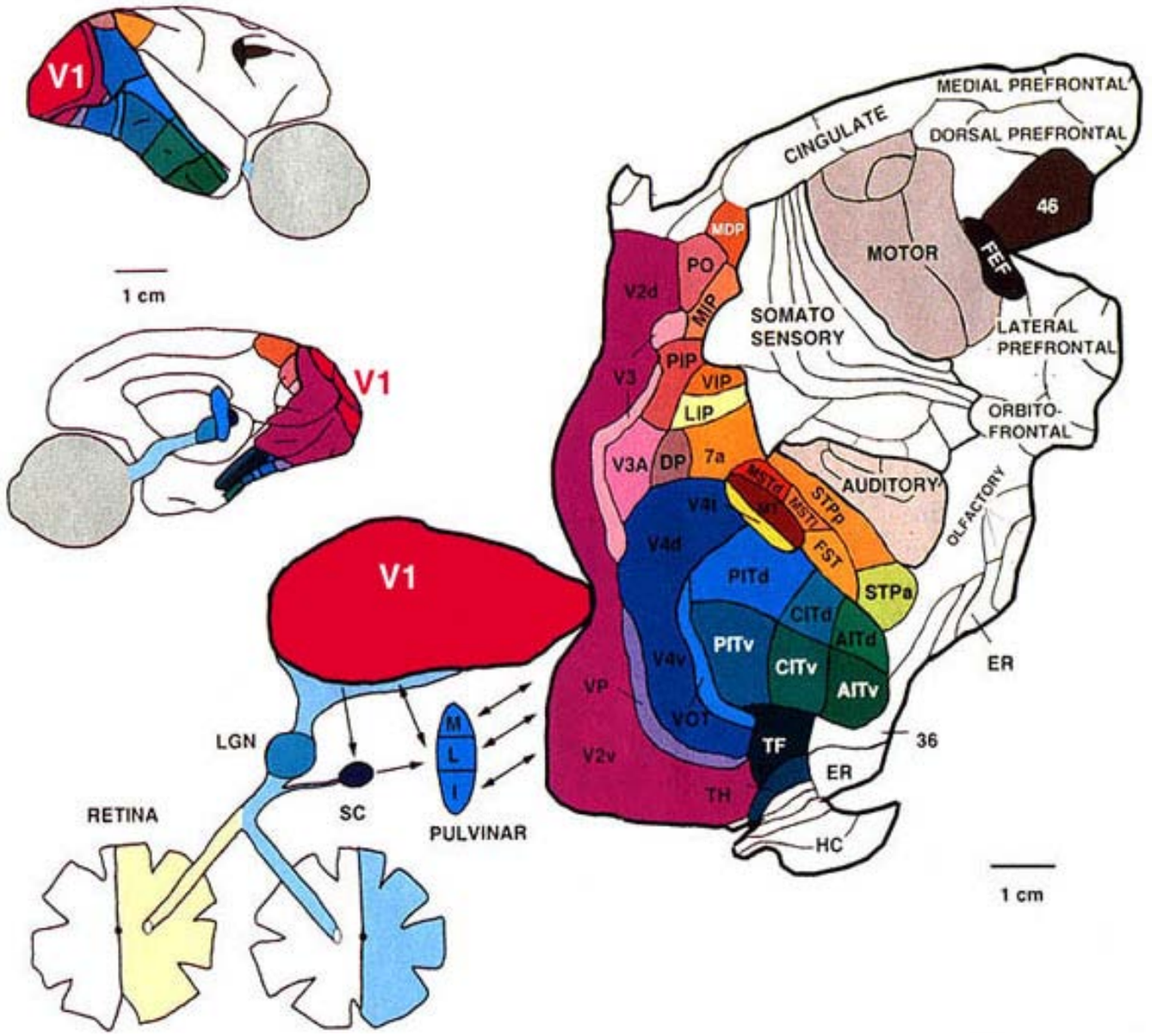
Ocular dominance columns



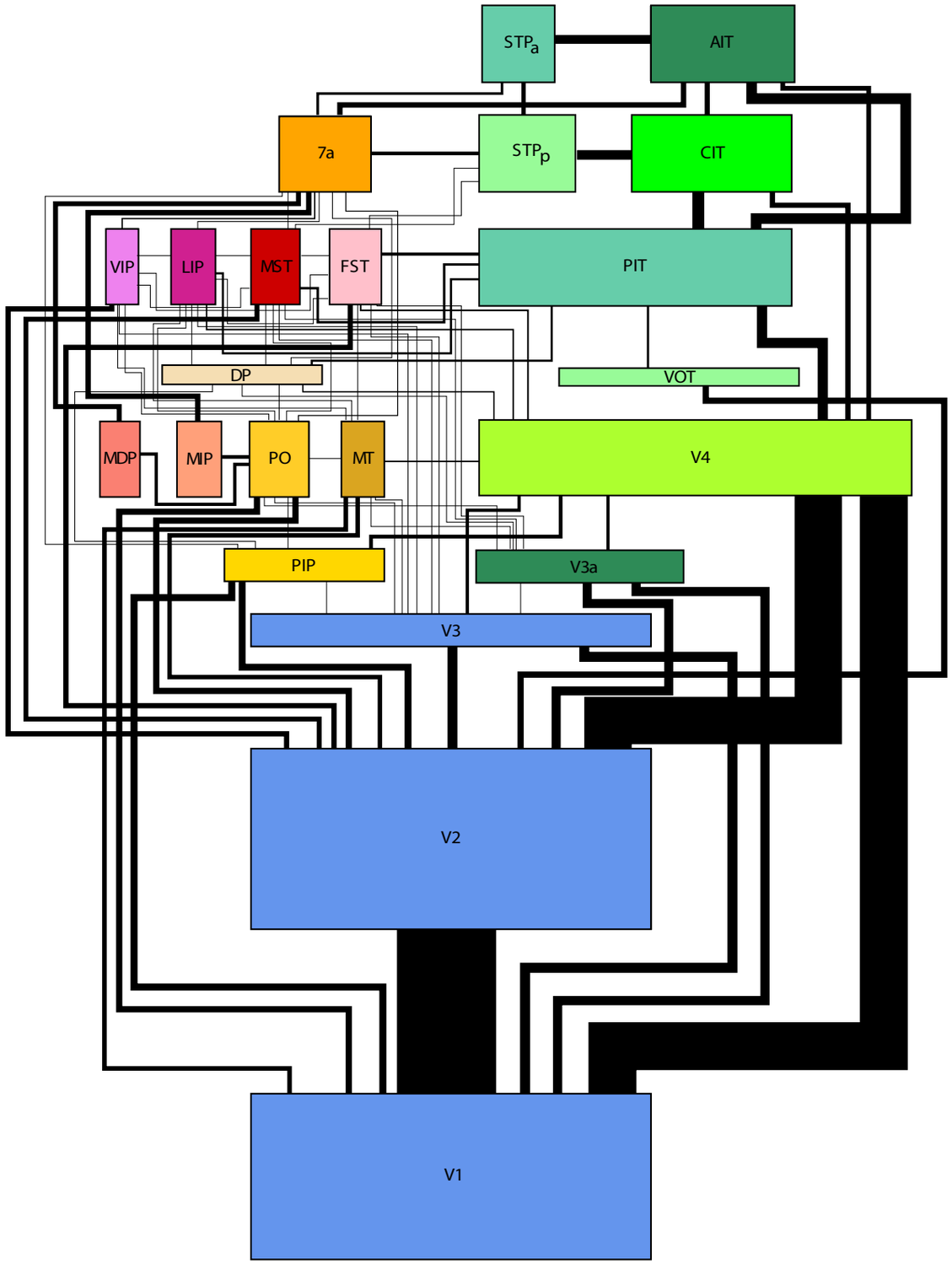
Critical period



Issa et al. (1999) J Neurosci. 1999 Aug 15;19(16):6965-78.



Felleman & Van Essen (1991) Cereb Cortex 1:1-47


STP$_a$
AIT
7a
STP$_p$
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V3
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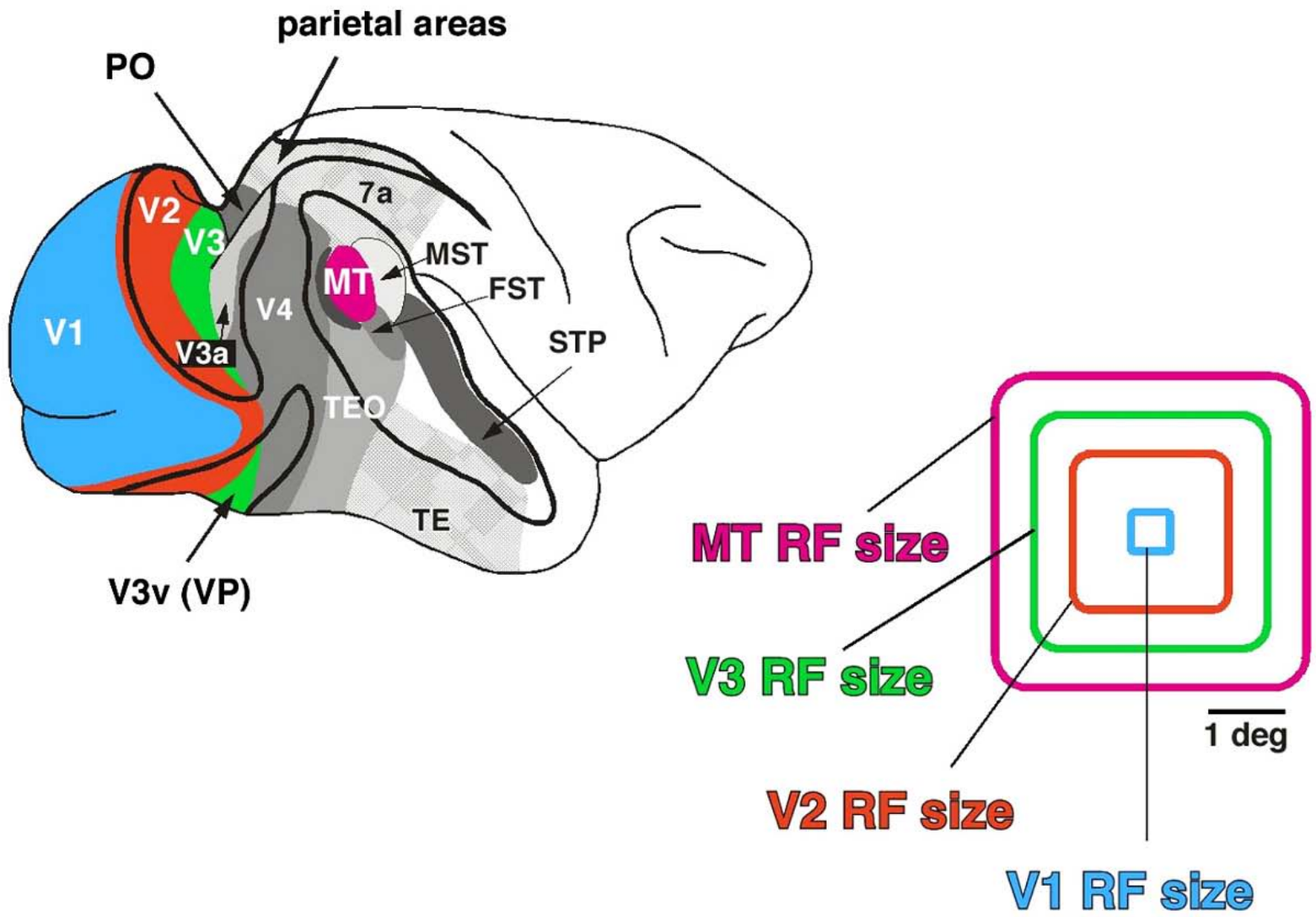
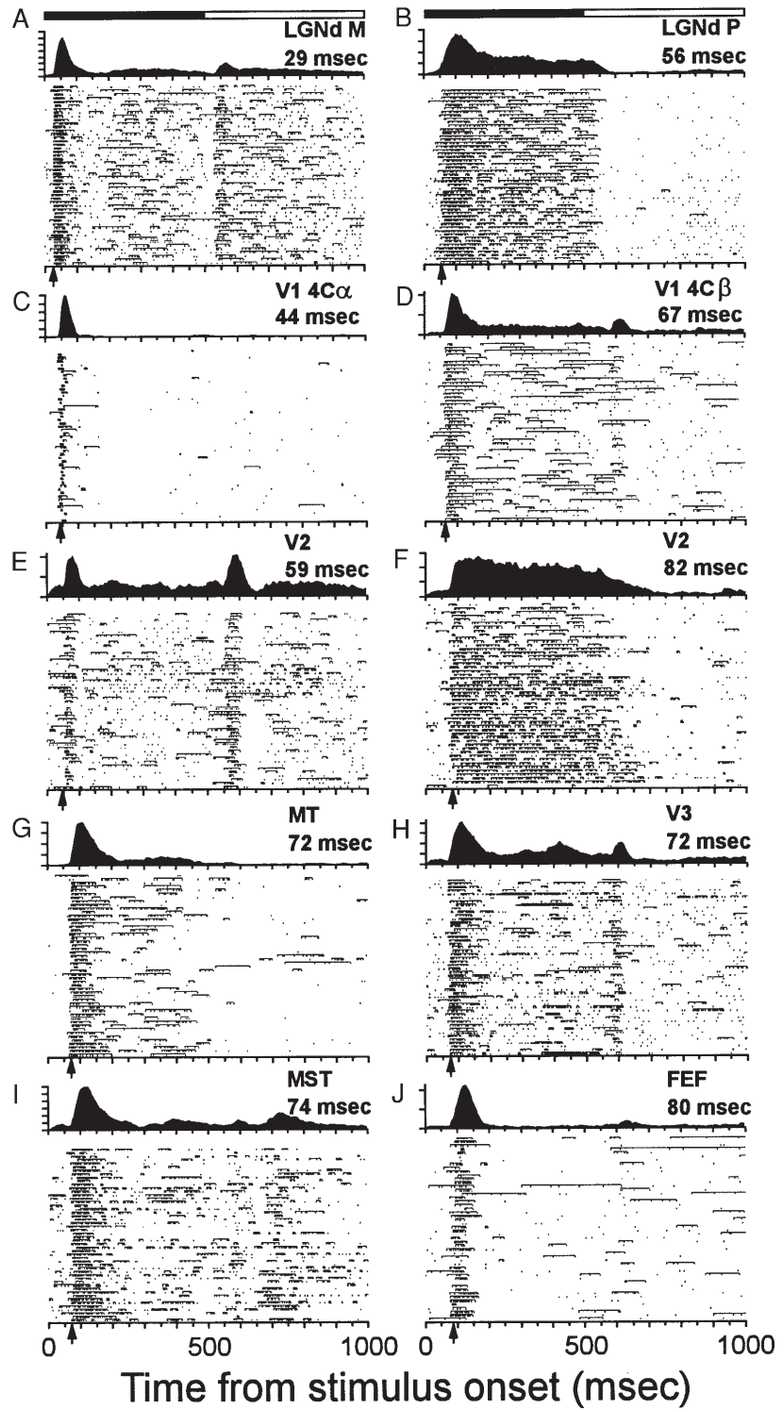
V1

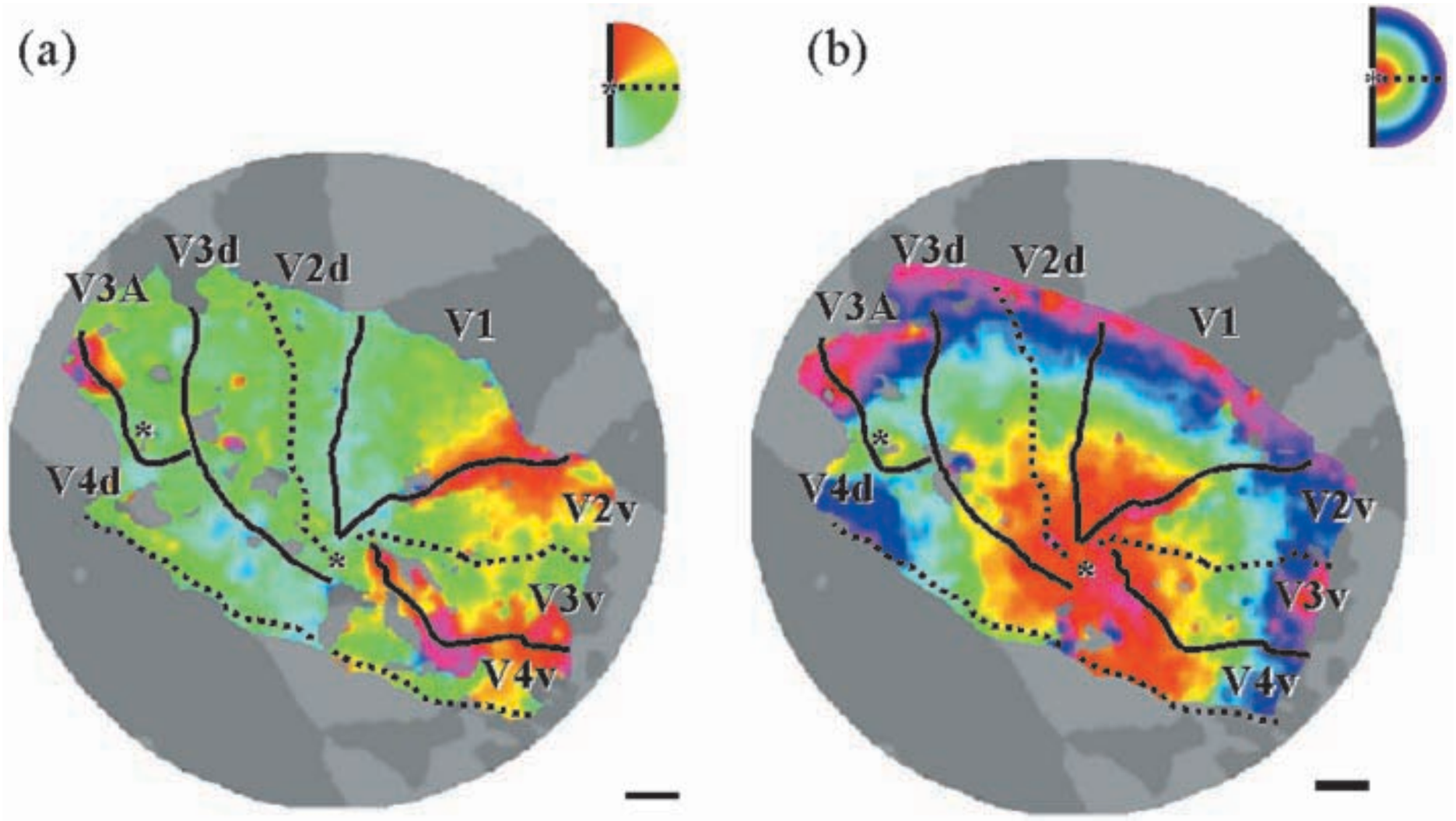
Principle 1: Receptive field size increases at higher levels



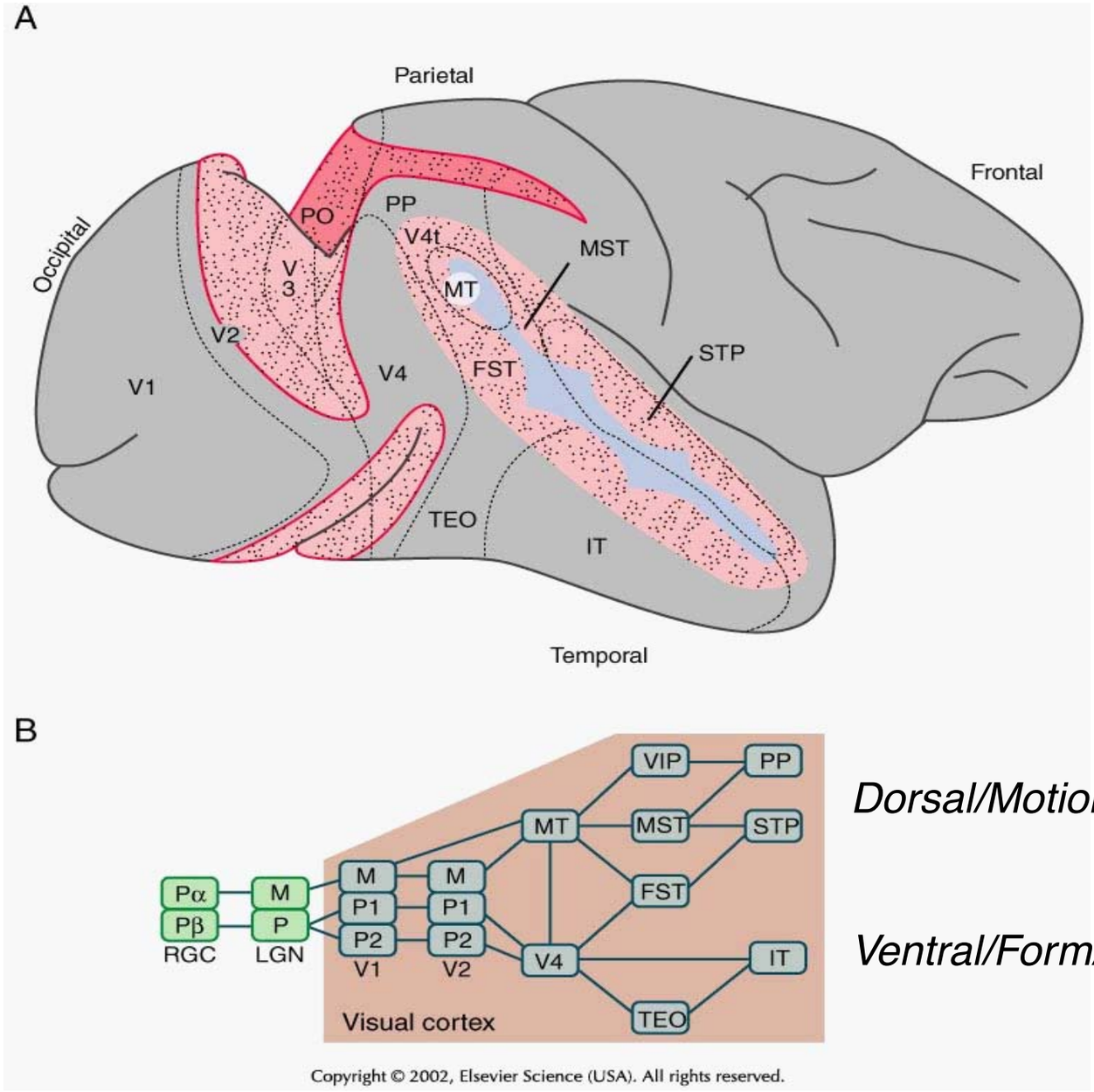
Principle 2: Responses in higher cortical areas occur later



Principle 3: Most areas contain a retinotopic map of the entire (contralateral) visual field

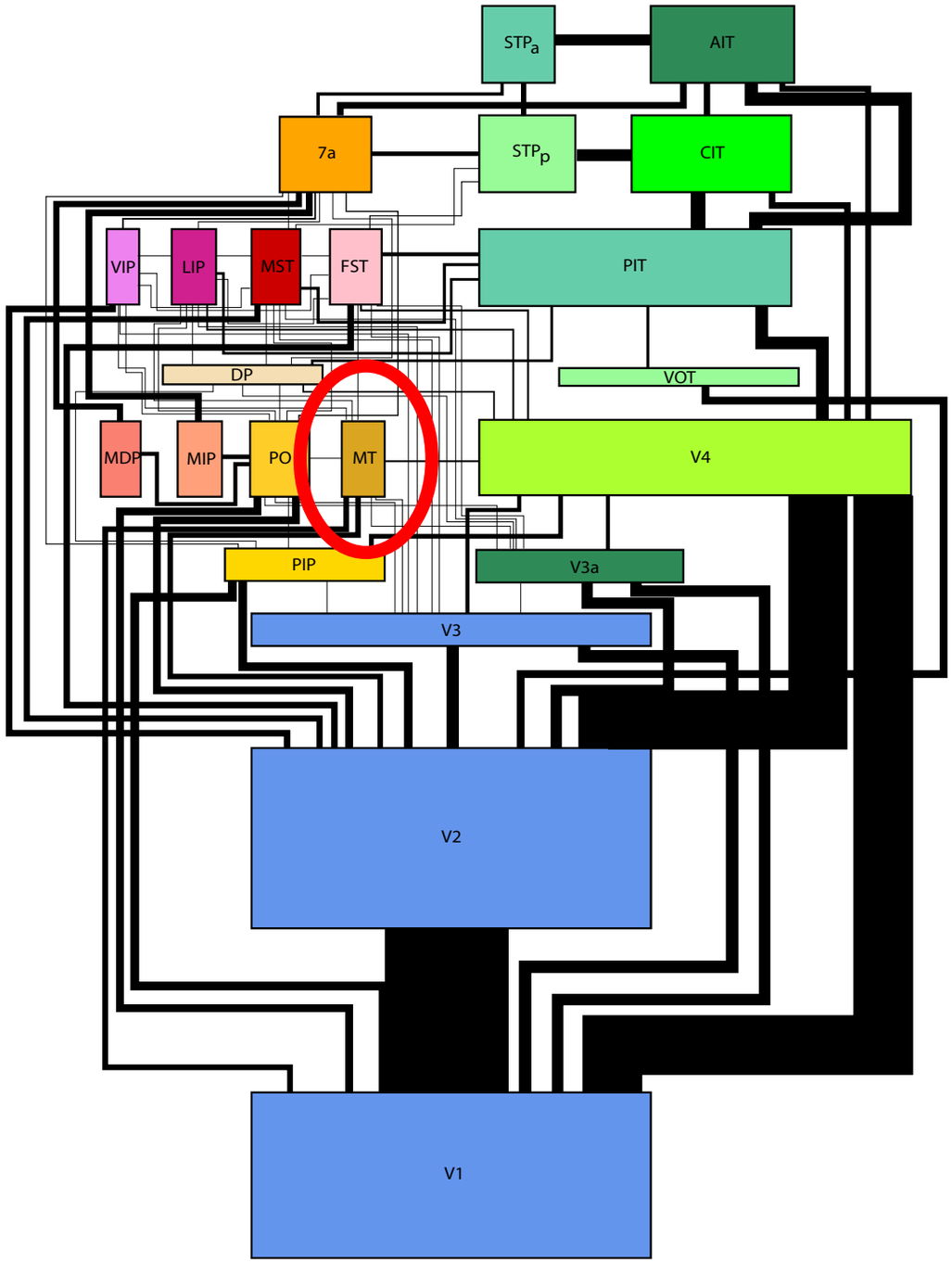


Two major "pathways" in the visual system



Dorsal/Motion/"Where"

Ventral/Form/"What"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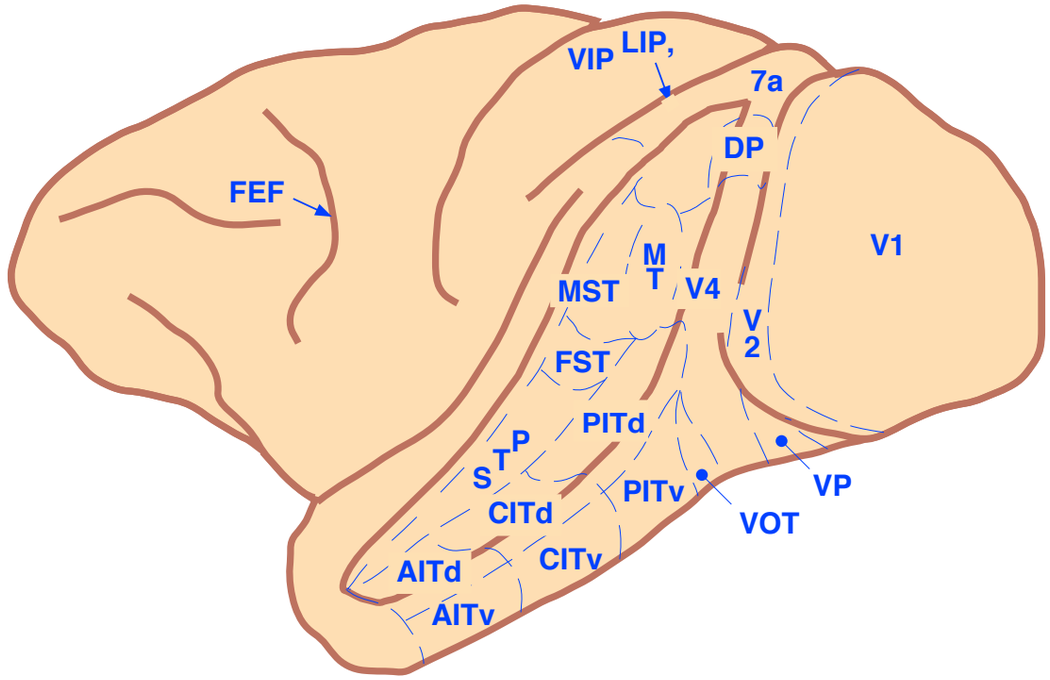
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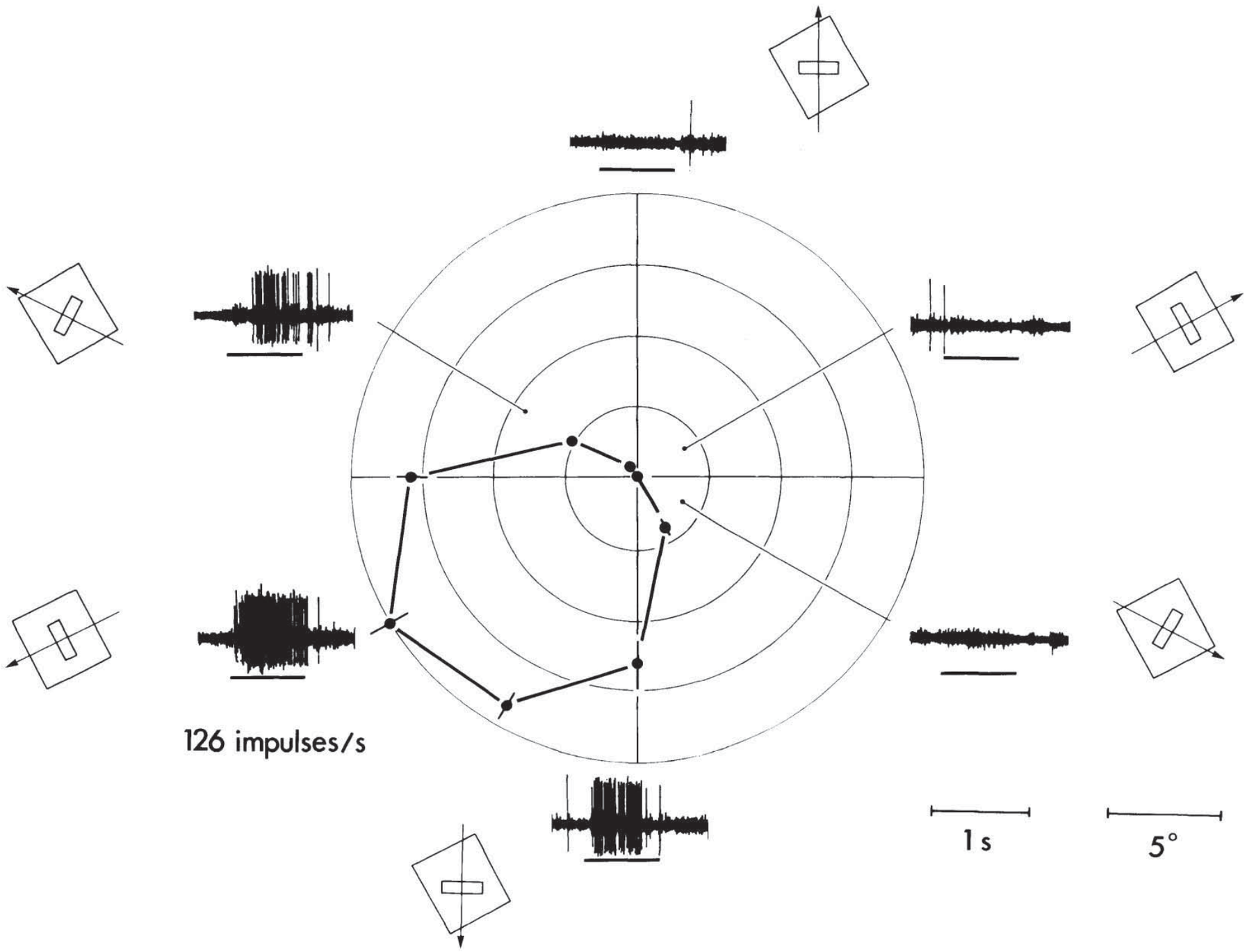
AITv

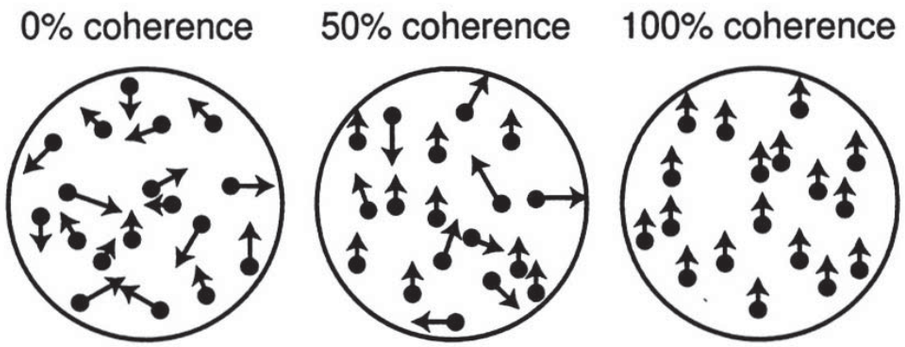
MT NEURONS ARE SELECTIVE FOR DIRECTION OF MOTION



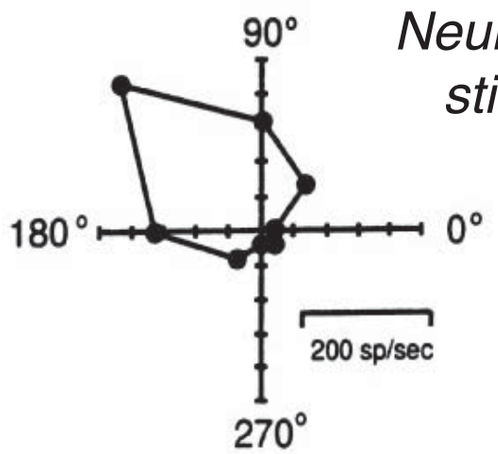
Maunsell & Van Essen (1983)

Linking MT activity to the perception of visual motion

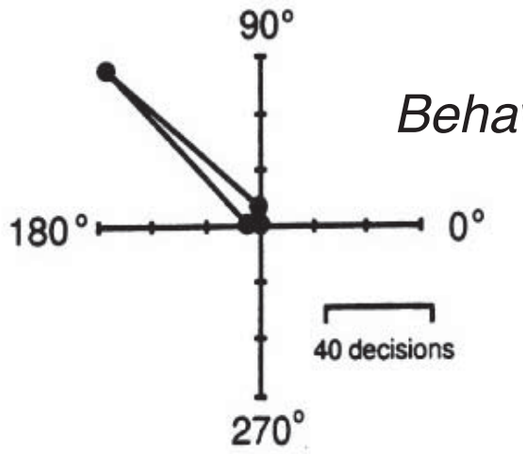
Stimulus



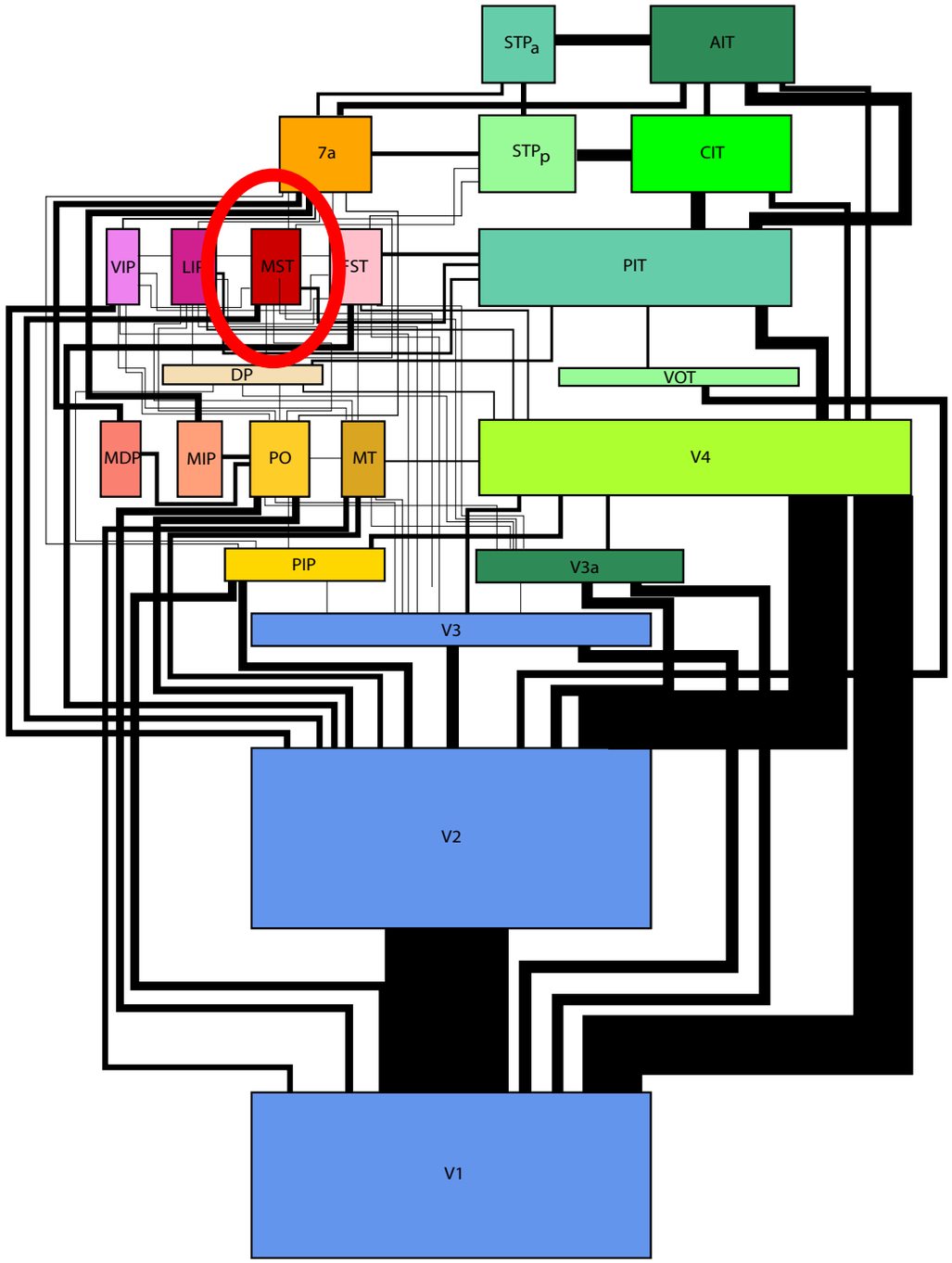
Neuronal tuning at stimulation site



Behavioral decision



Salzman et al. (1990) Nature 346: 174-177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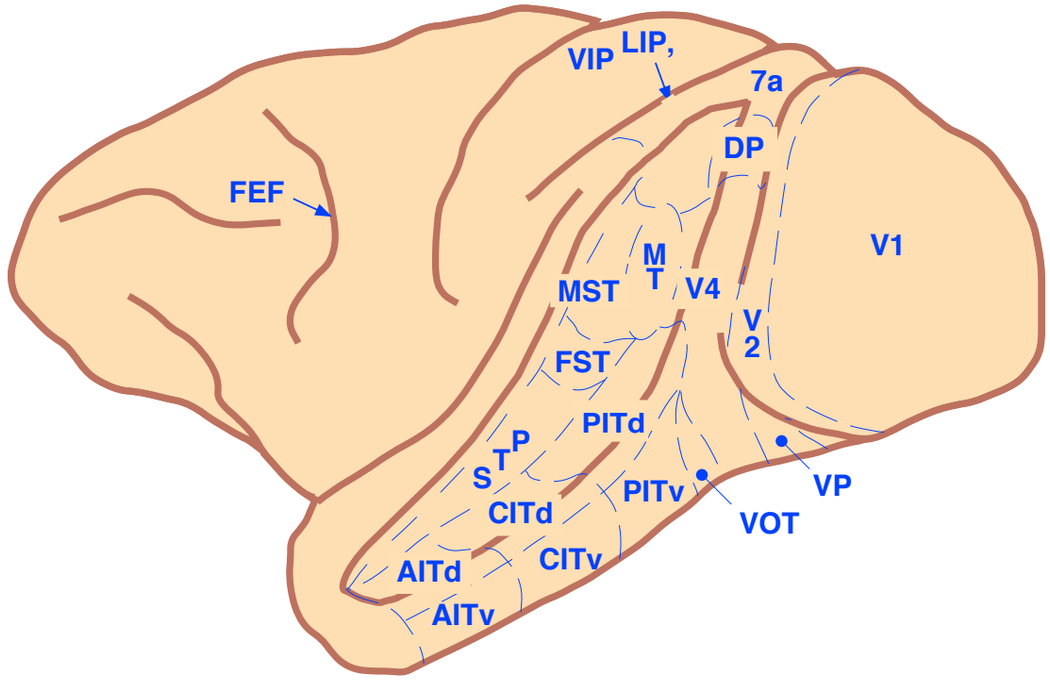
V1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CITd
PITv
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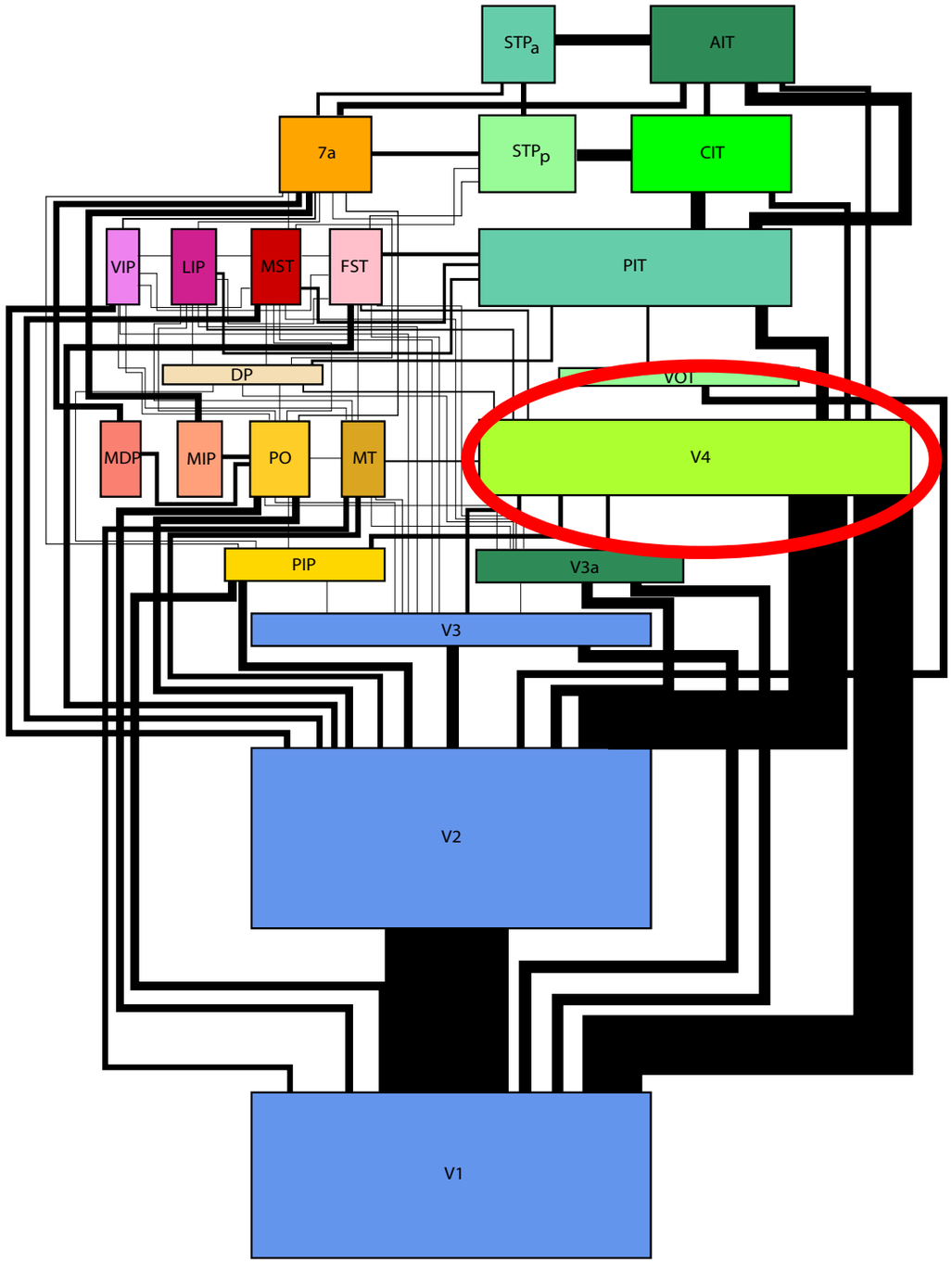
VOT
CITv
AITd
AITv

FIG. 3. Comparison between responses to the optic flow field motion stimuli and the shifted-center-of-motion combination stimuli in a neuron with similar responses to both sets of stimuli. *A*: squares along the top represent the 100□1 100□ stimulus screen, with the arrows depicting the direction of dot motion on each part of the screen. This set of 12 basic optic flow field stimuli includes 8 directions of planar motion, 2 directions of radial motion, and 2 directions of circular motion. The spike density histograms below each stimulus show the mean responses over 6 presentations of each stimulus. Vertical lines: stimulus onset; height of lines indicates the 100-spike/s discharge rate. Thick horizontal bar: 1-s stimulus period. The spike densities in bold outline are those in which the response was significantly different from control activity (*t*-test, $P \leq 0.01$). This neuron responded best to rightward planar and outward radial stimuli. *B*: polar plot of the planar responses shown in *A*; conventions are the same as in Fig. 2. *C*: patterns of motion in vector combination stimuli (*top*) and spike density histograms of the responses evoked by those stimuli (*bottom*), showing a preference for vector combination stimuli based on rightward planar motion. *D*: polar plot of the vector combination responses shown in *C*. This neuron shows good agreement between responses to planar and vector combination stimuli, preferring rightward planar motion and the vector combination stimulus containing rightward motion as the planar component.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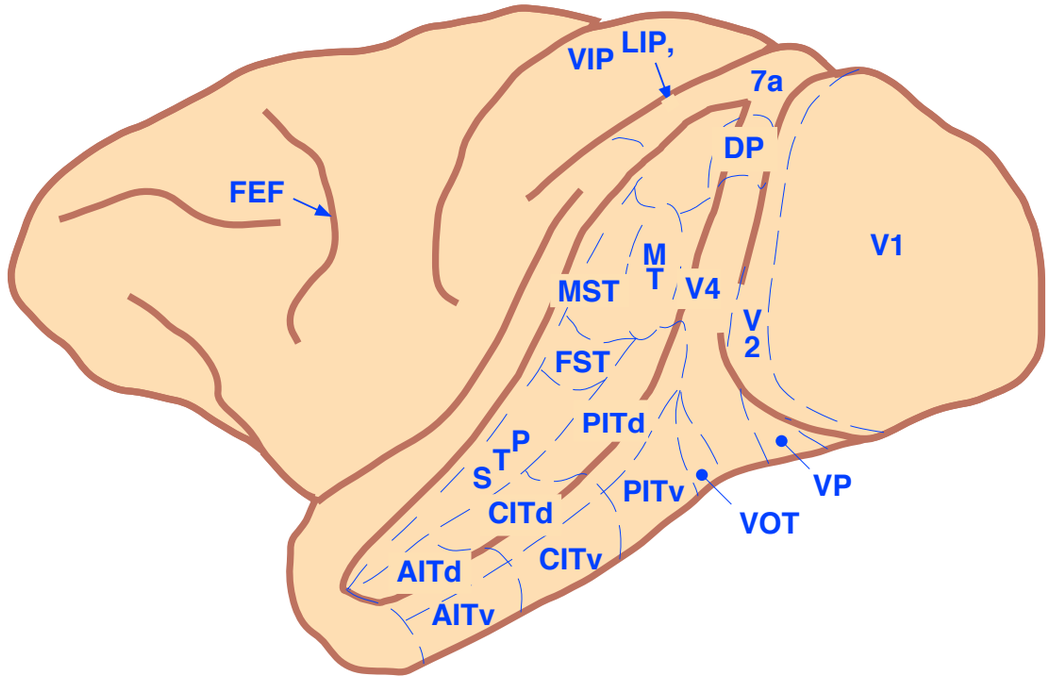
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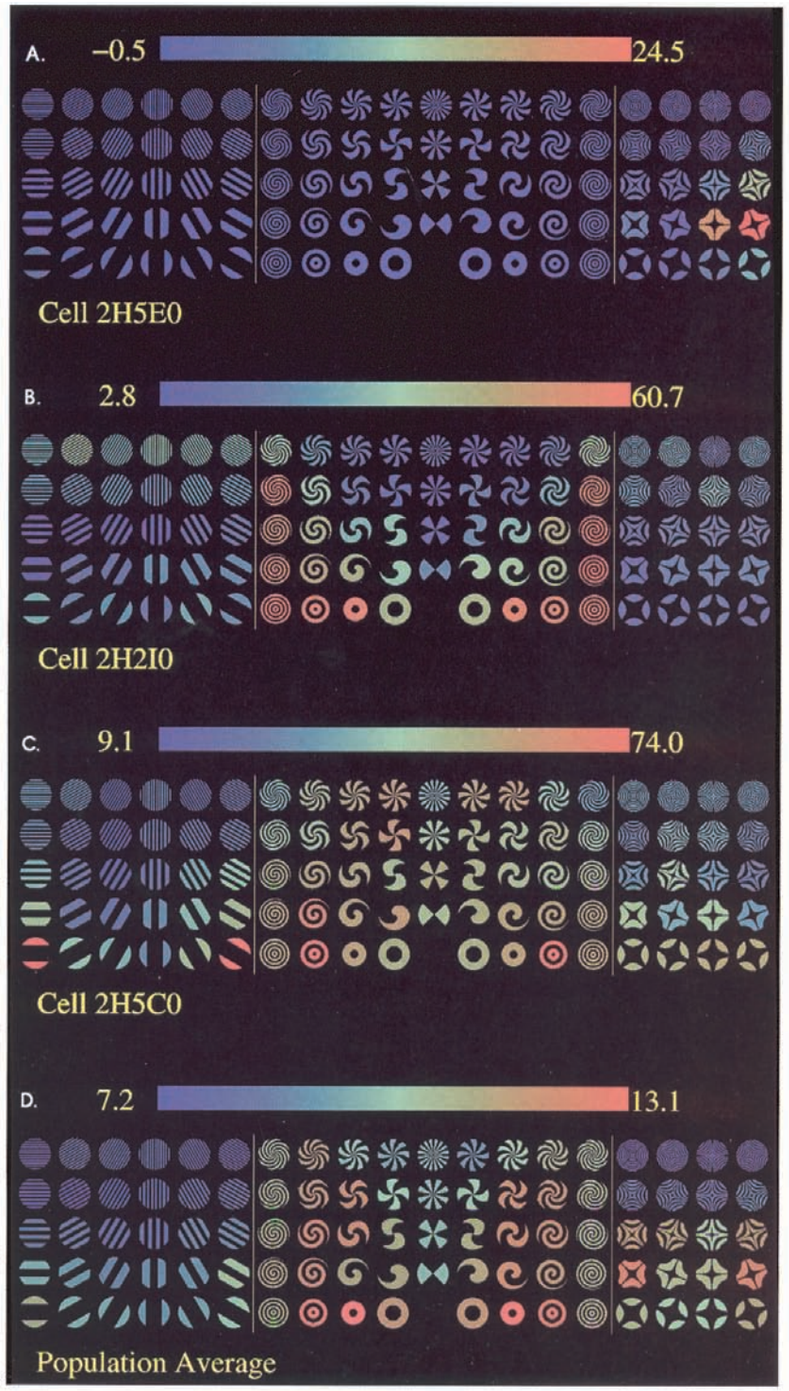
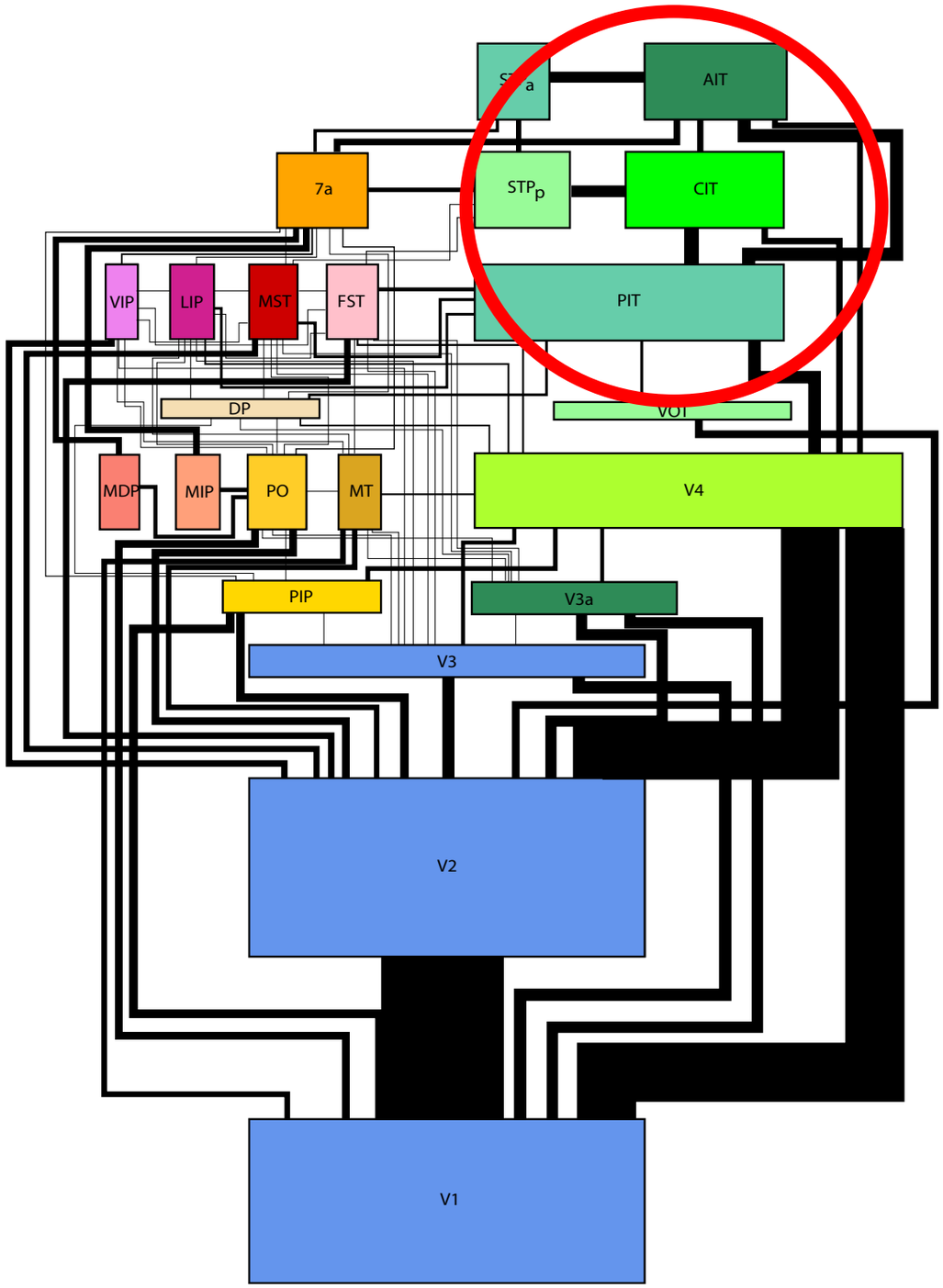
CITv
AITd
AITv

V4 responses: Tuning for form of intermediate complexity



Gallant et al, 1996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V2
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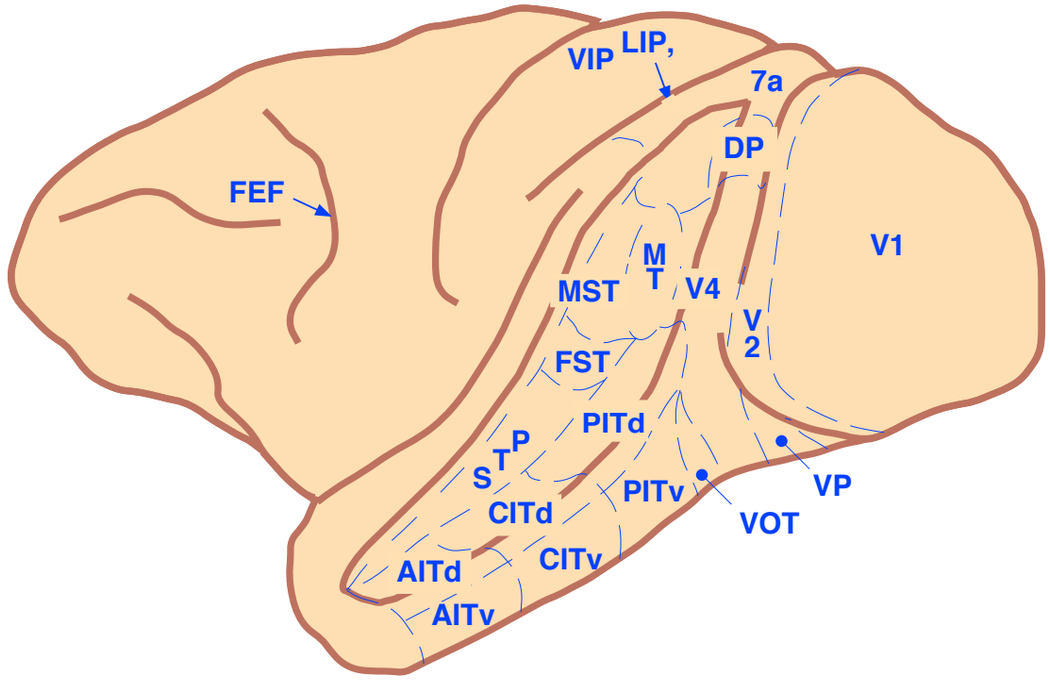
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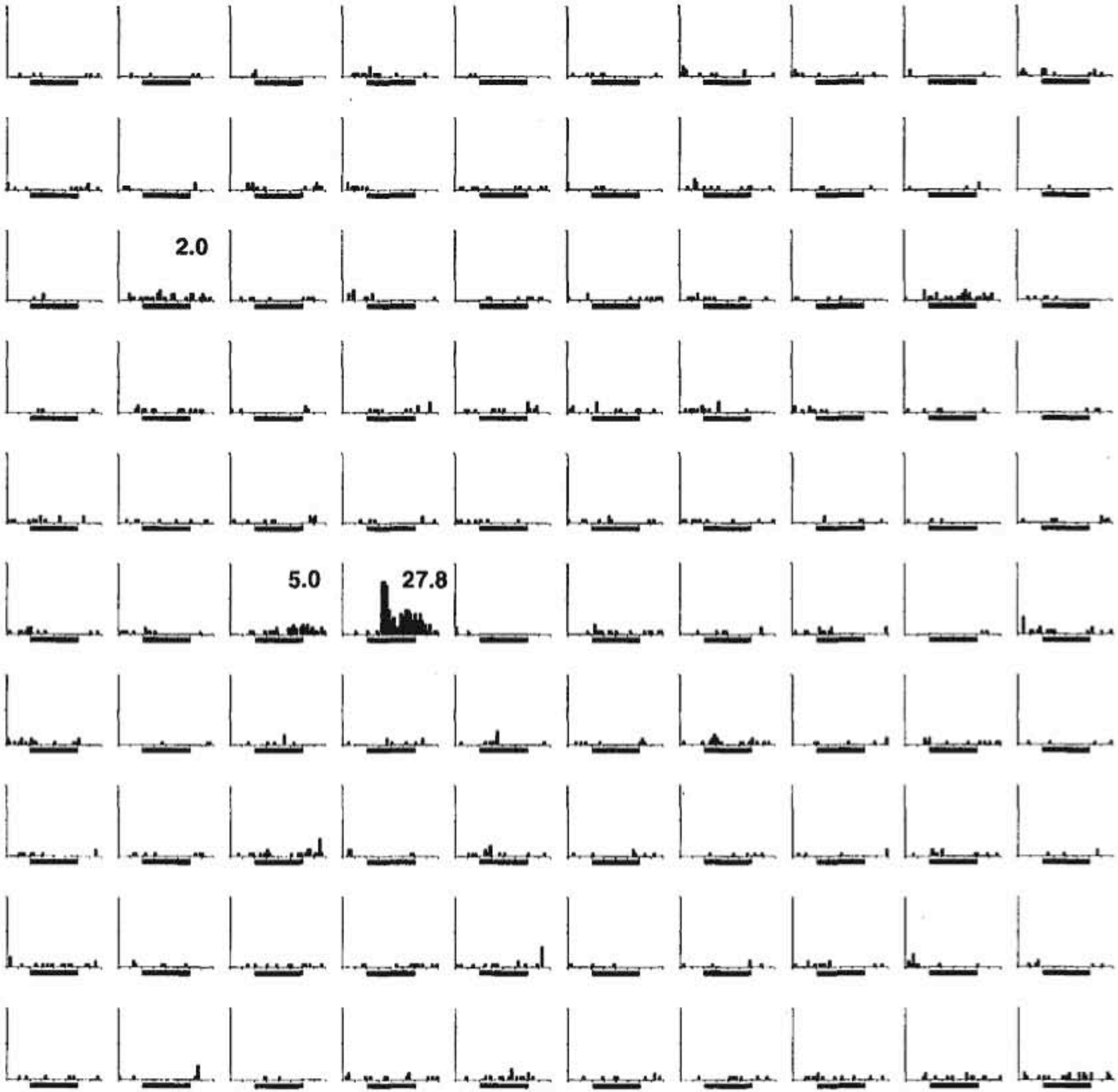
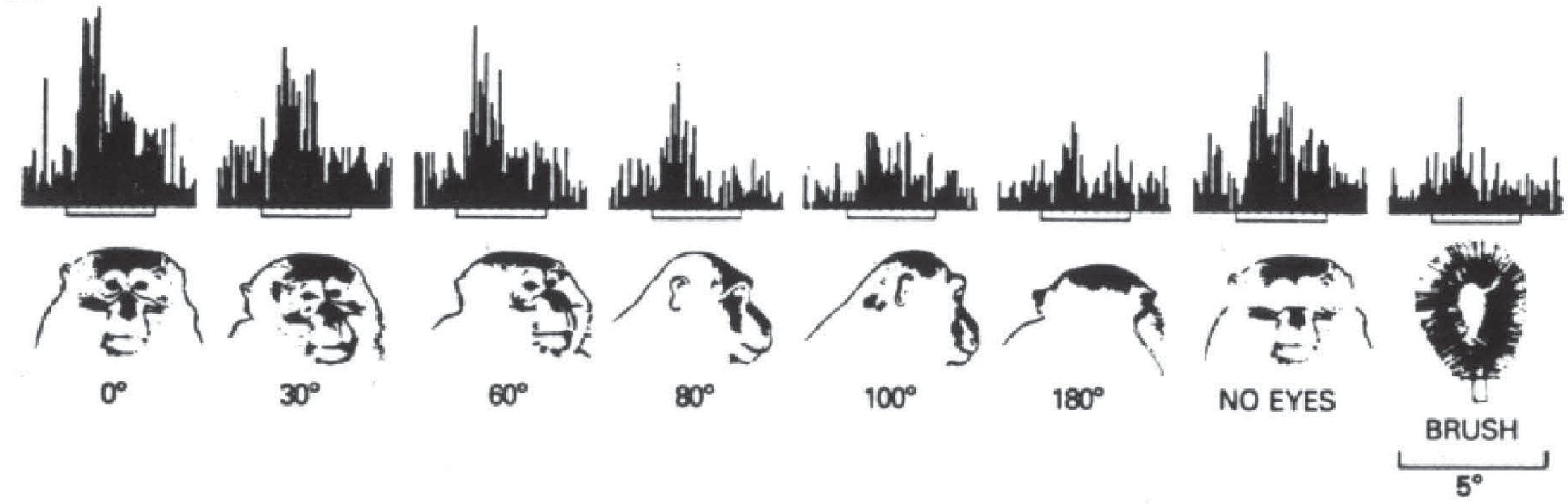
AITv

Tamura & Tanaka, 2001

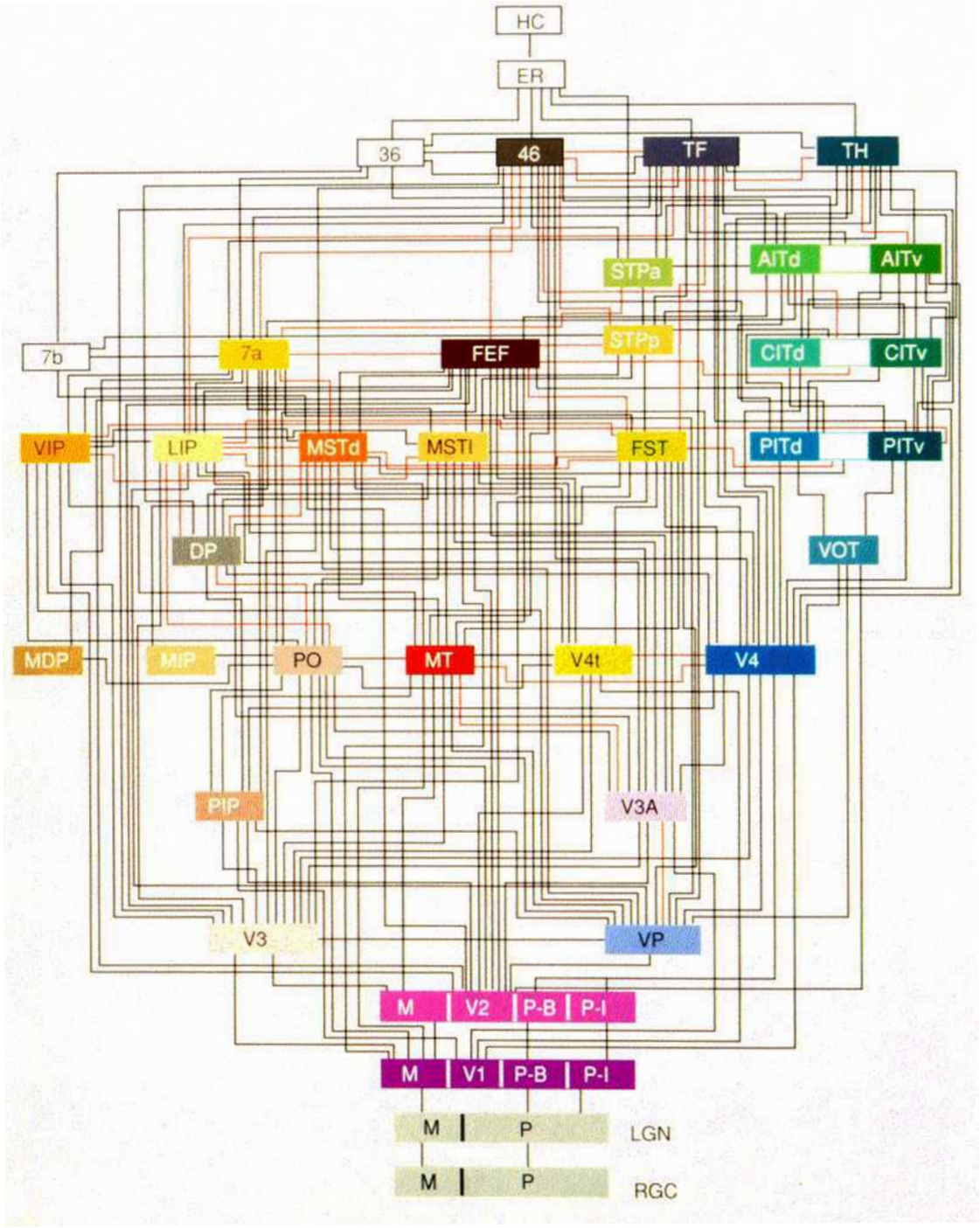


Tamura & Tanaka, 2001



Desimone et al, 1984

The visual system



Felleman & Van Essen (1991) Cereb Cortex 1:1-47