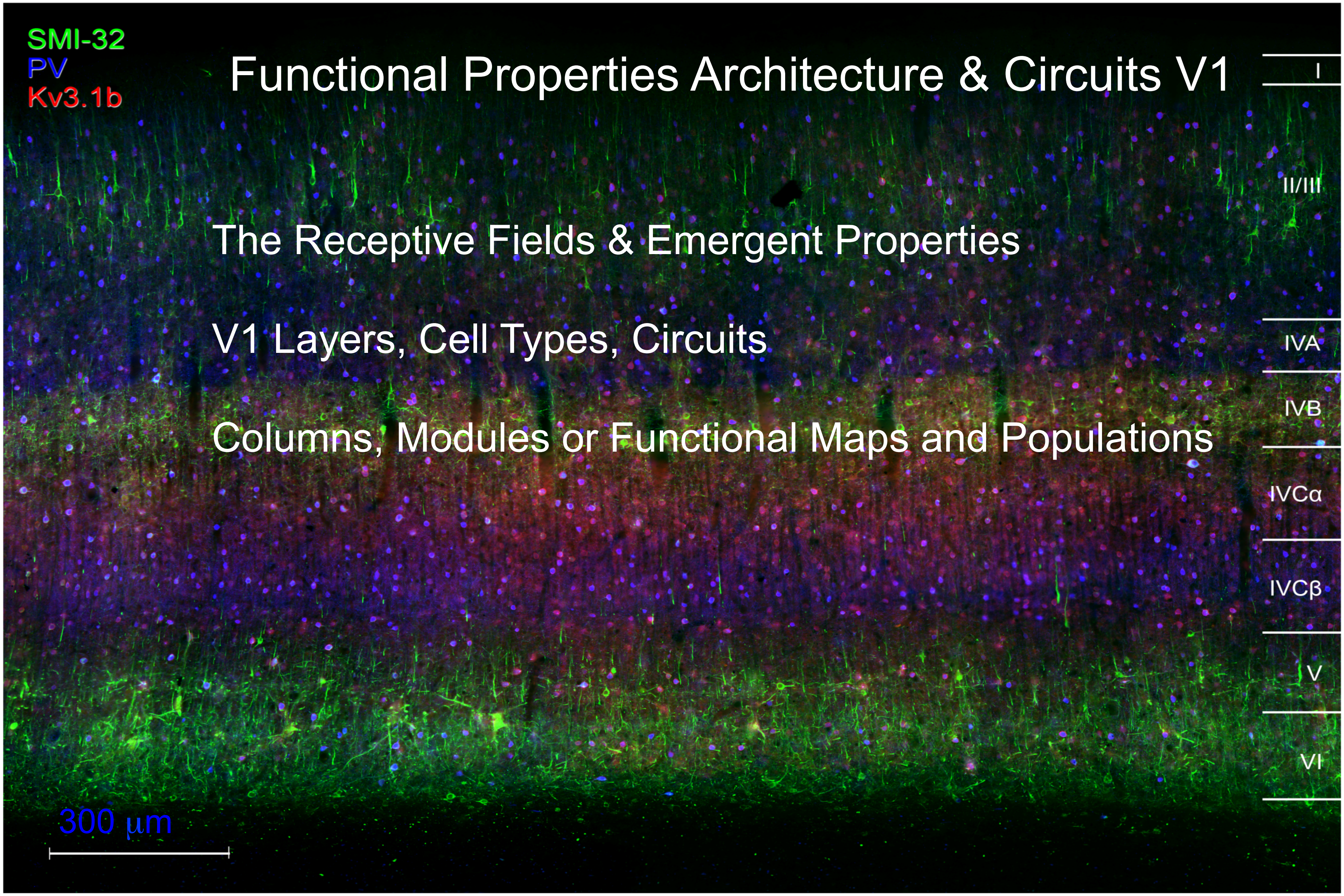
Functional Properties Architecture & Circuits V1

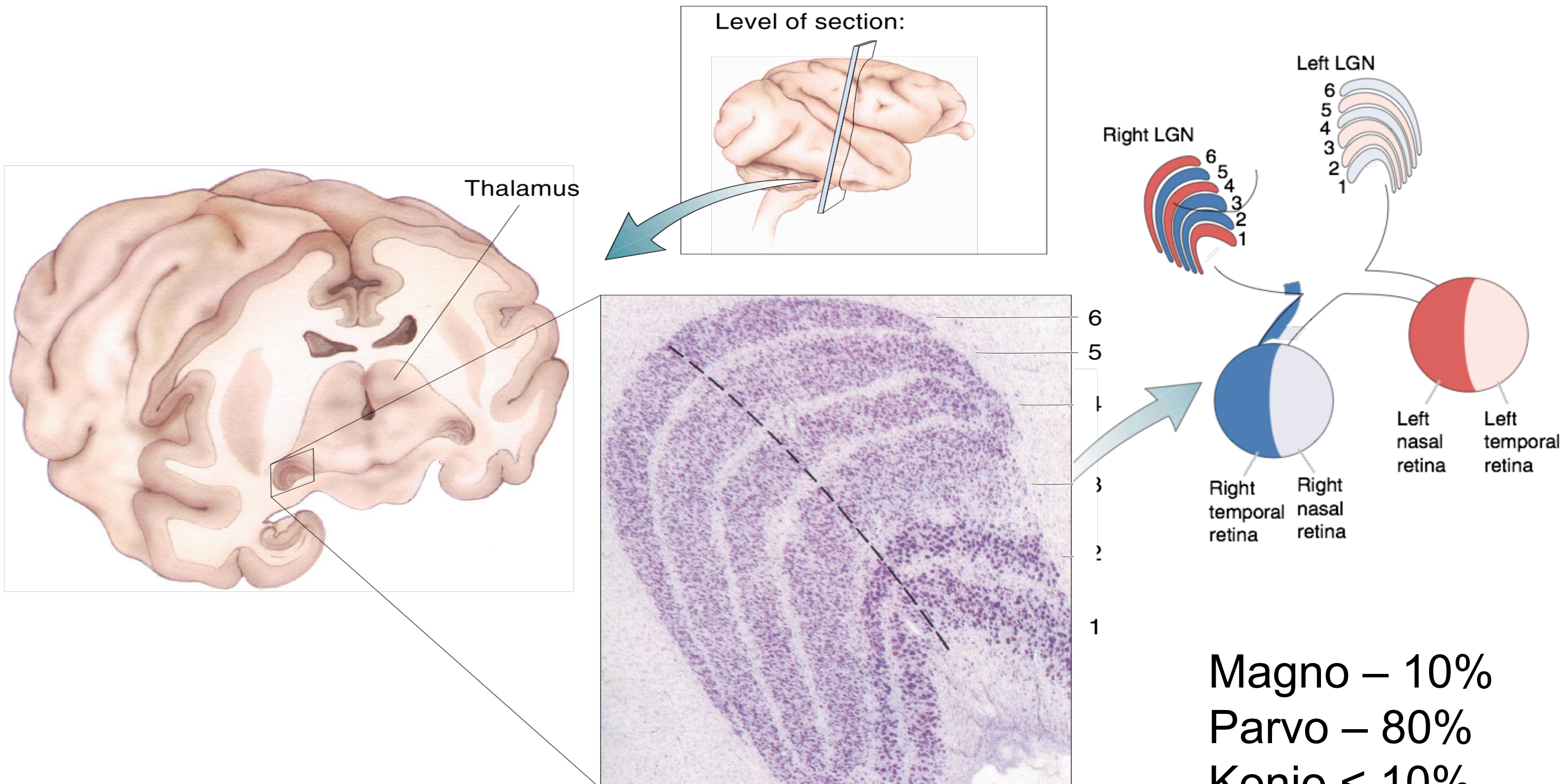
The Receptive Fields & Emergent Properties

V1 Layers, Cell Types, Circuits

Columns, Modules or Functional Maps and Populations



LGN of the macaque monkey. The tissue has been stained to show cell bodies, which appear as dots. Notice particularly the six layers and the larger size of the cells in the two ventral layers (layers 1 and 2). (Source: Adapted from Hubel, 1988, p. 65.)



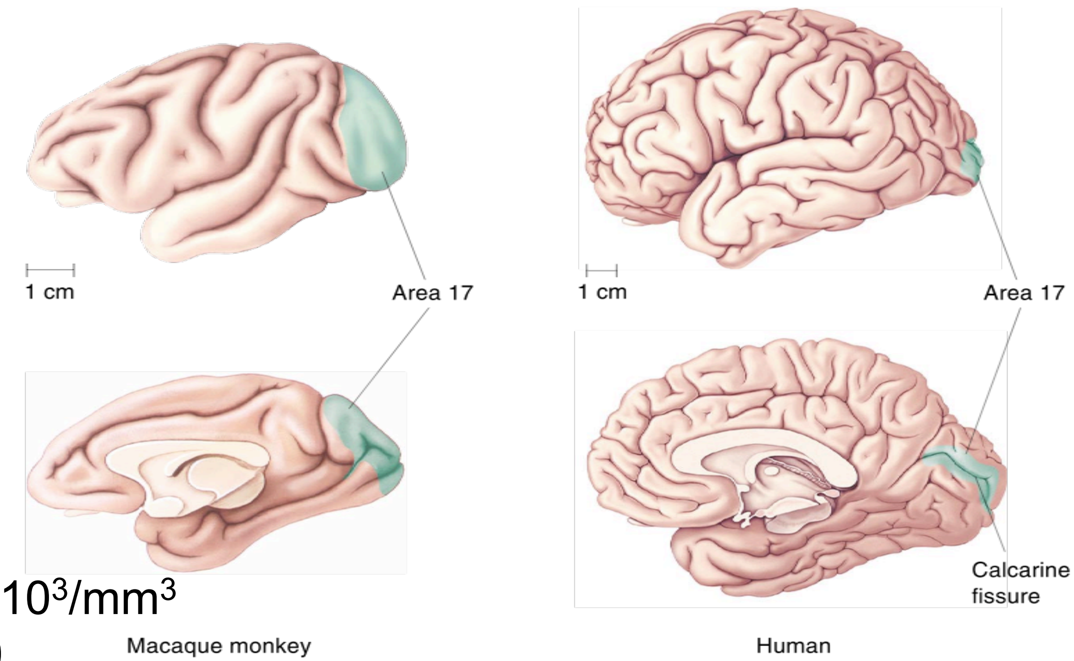
Magno – 10%
Parvo – 80%
Konio < 10%

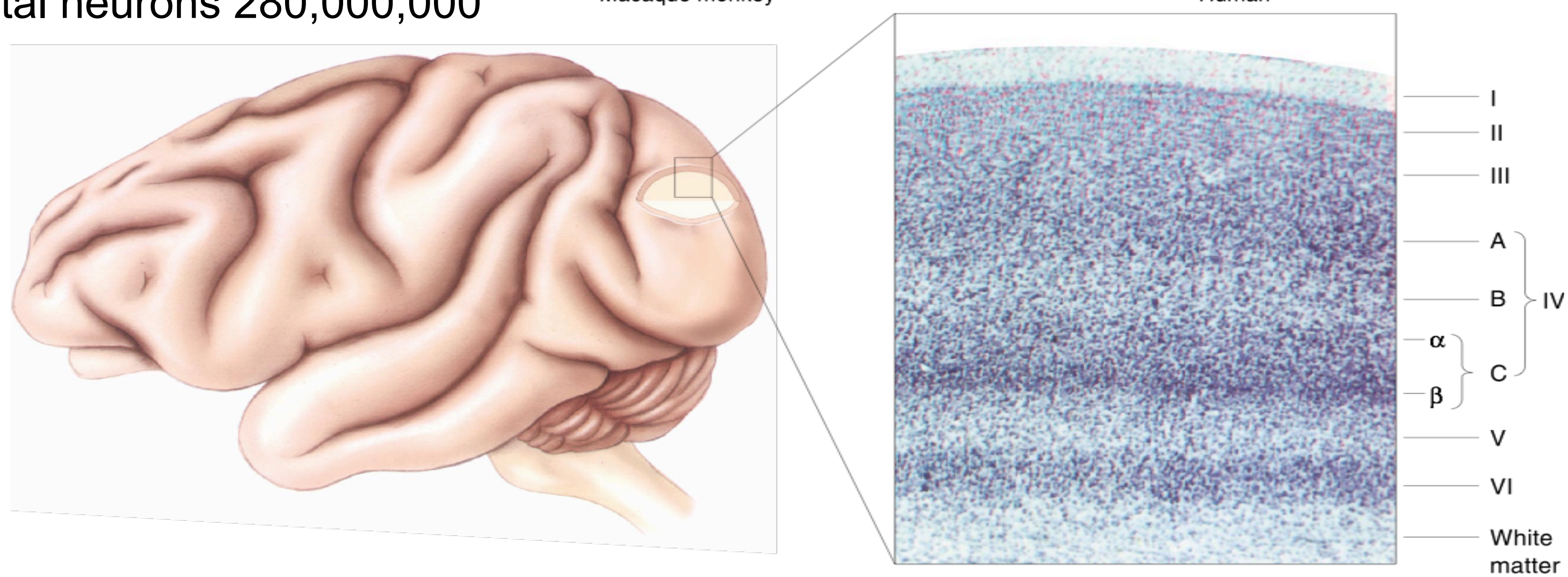
Total afferents > 1,000,000 per optic nerve consider V1

How are the inputs organized?

Is there segregation?

Volume ~ 1,400 mm^3
Density (neurons) ~ 200 x $10^3/mm^3$
Total neurons 280,000,000





Hubel & Wiesel 1976

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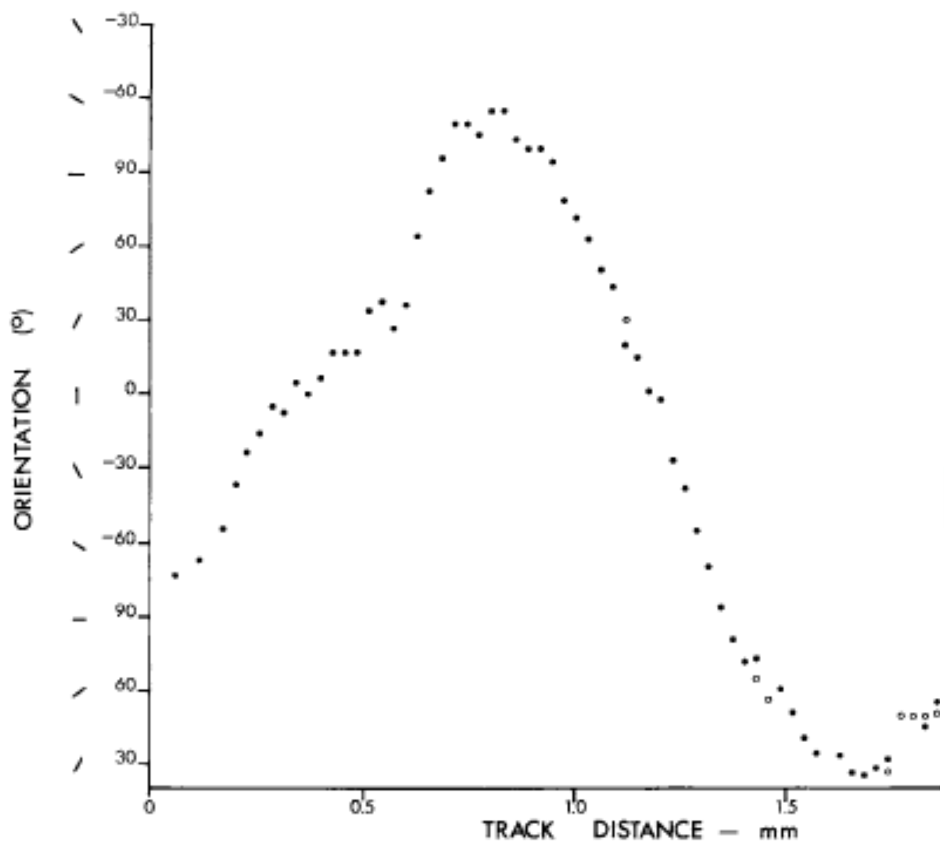
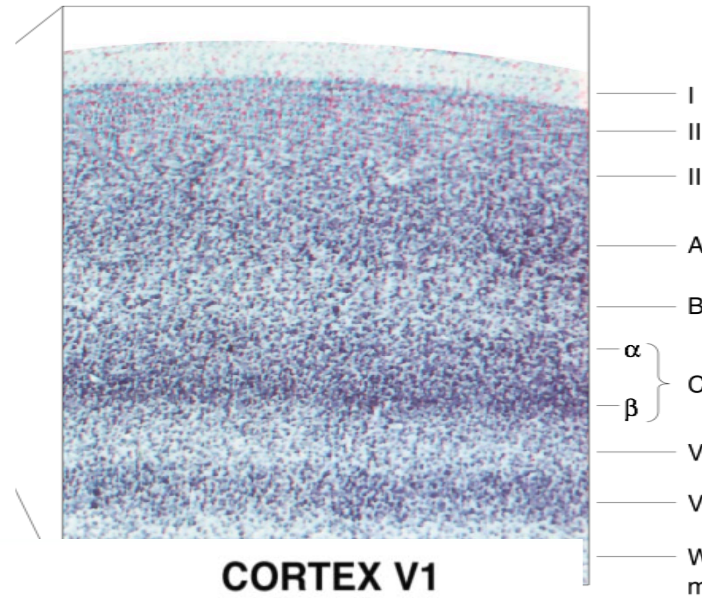
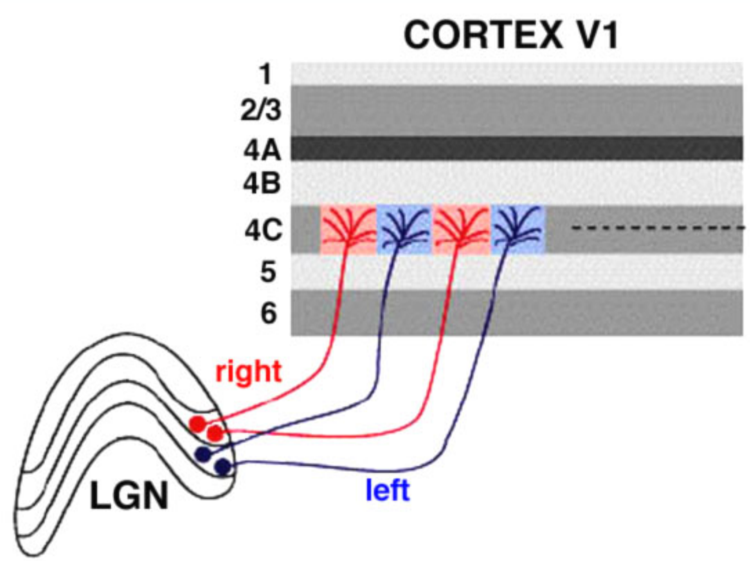


Fig. 2A Graph of orientation vs. track distance for an oblique penetration th
cortex in a normal monkey. Note the reversals in direction of orientation shifts, tl
which bracket a long sequence spanning 267°. (Experiment No. 7.)





LGN properties (primate)

Parvo/Magno/Konio distinctions

R-G opponent/non-opponent/B-Y opponent SF tuning

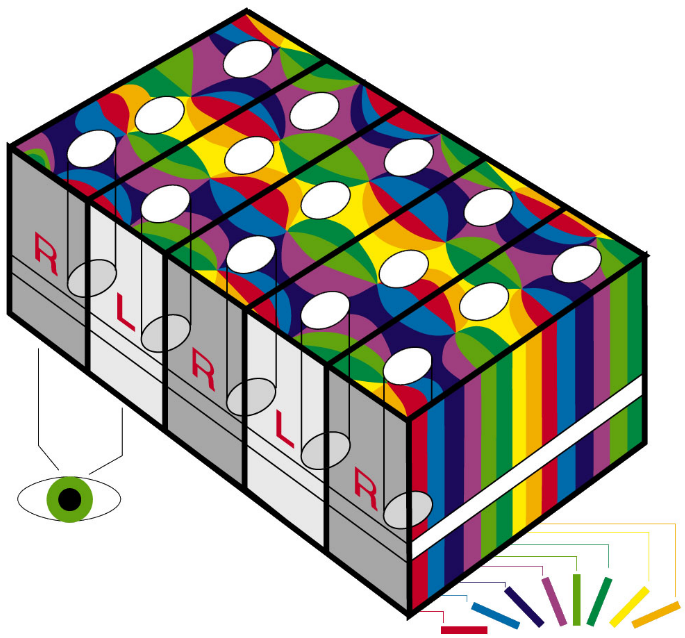
Low/High/? Achromatic Contrast gain

Long/short/Long latency and integration times

Sustained/transient/? – low/bandpass TF tuning

Selectivity

Unselective for orientation, direction, spatial freq (SF), temp Freq (TF)



V1 properties

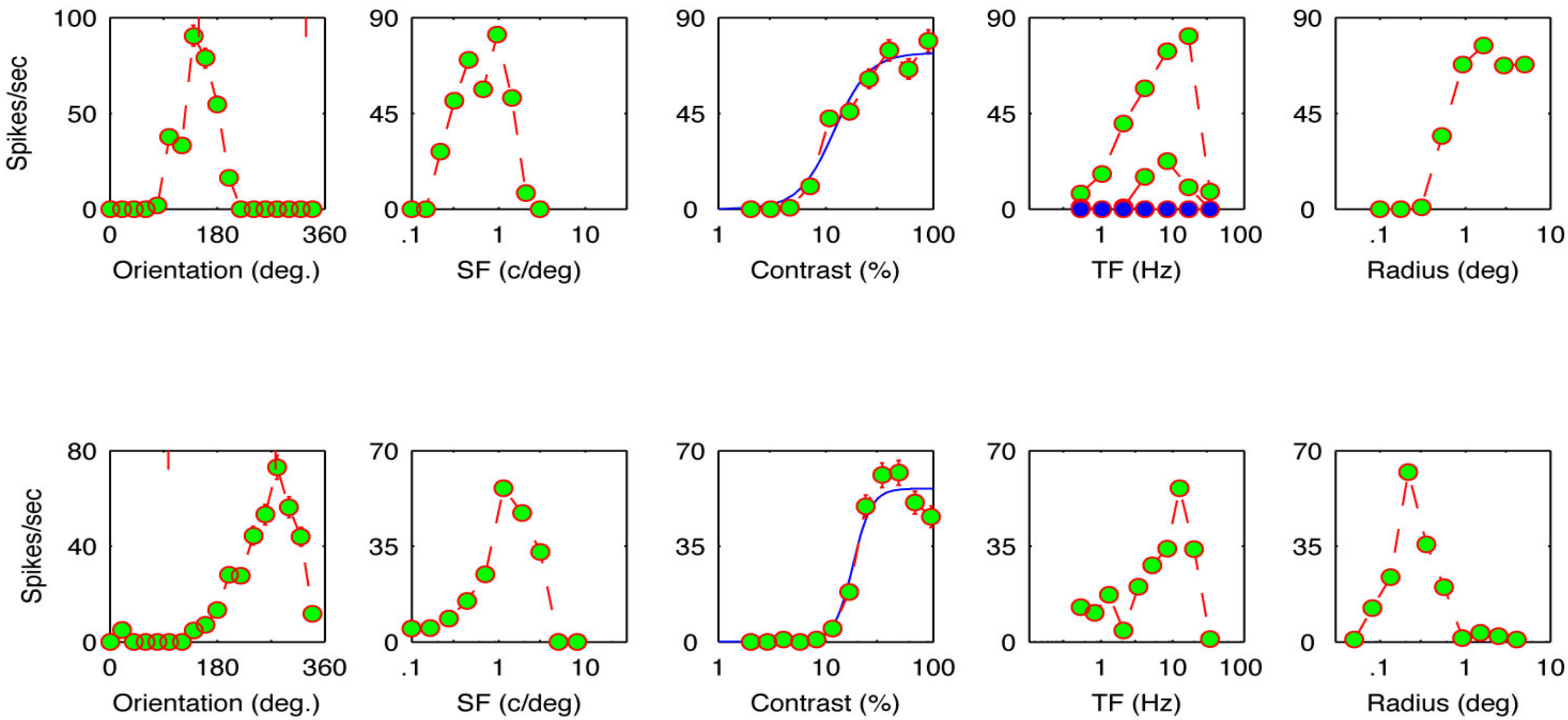
Selectivity

Orientation, direction, SF, TF, size (eCRF), binocular disparity, chromatically double opponent

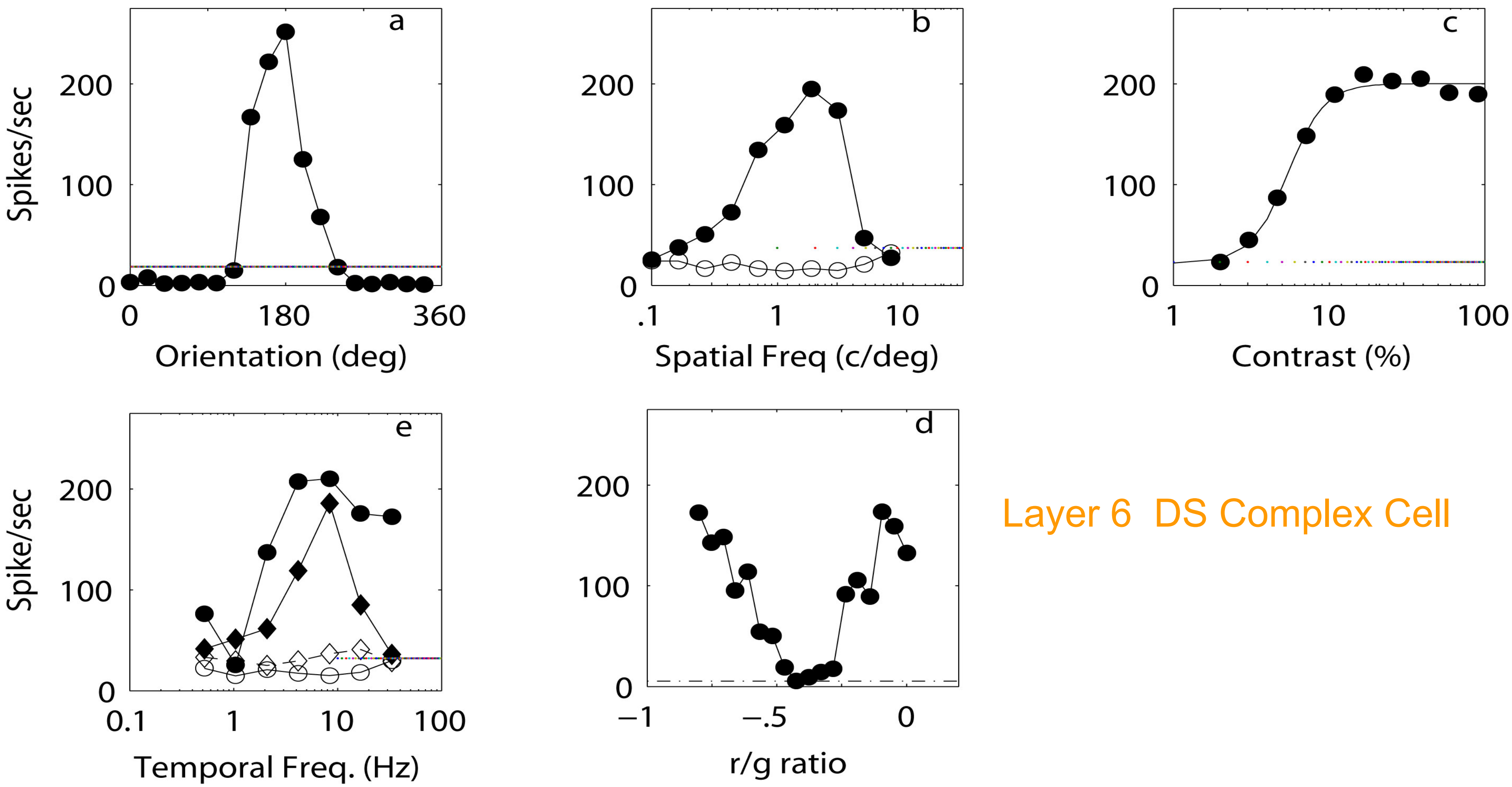
Different populations with different degrees of selectivity along a range of stimulus dimensions

Functional Characterization

Layer 4c alpha Simple Cells

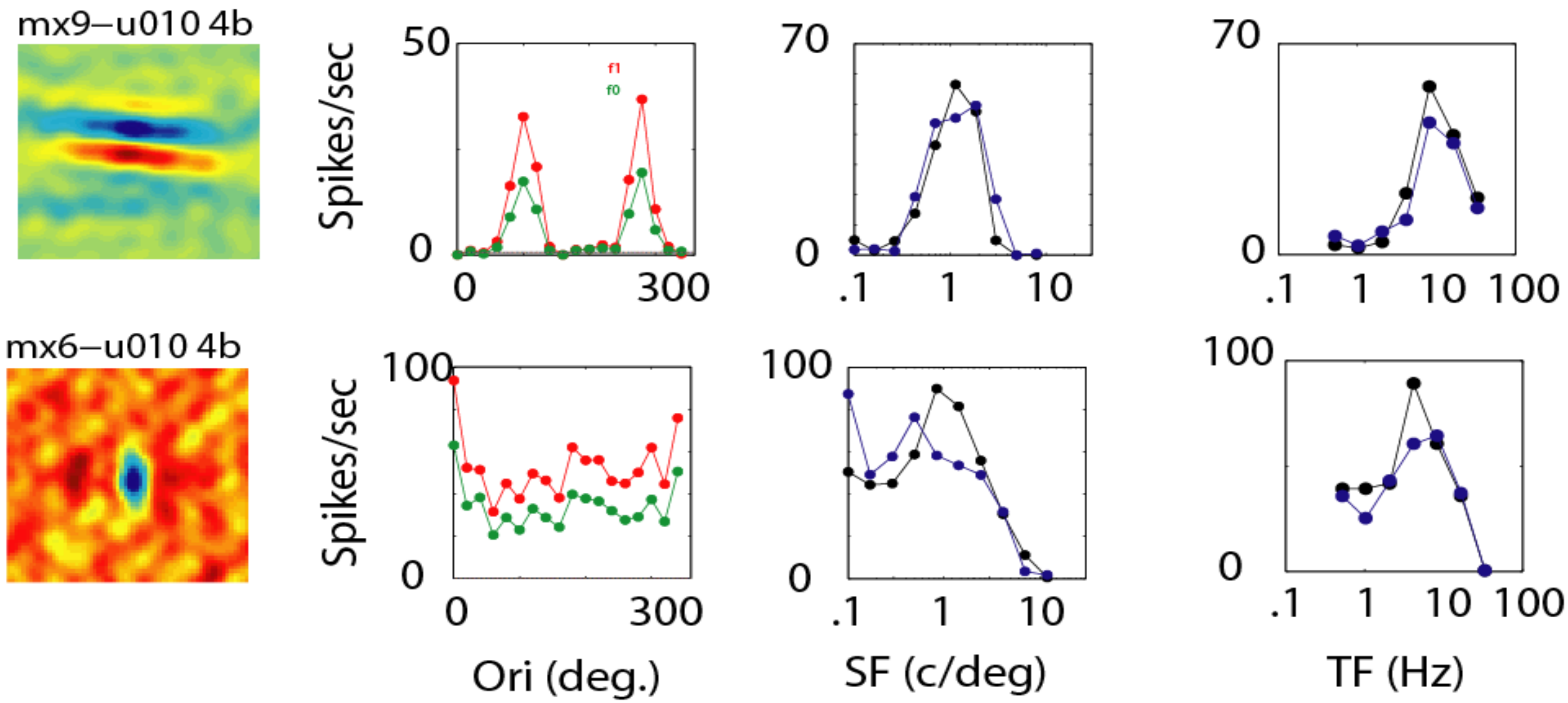


Functional Characterization

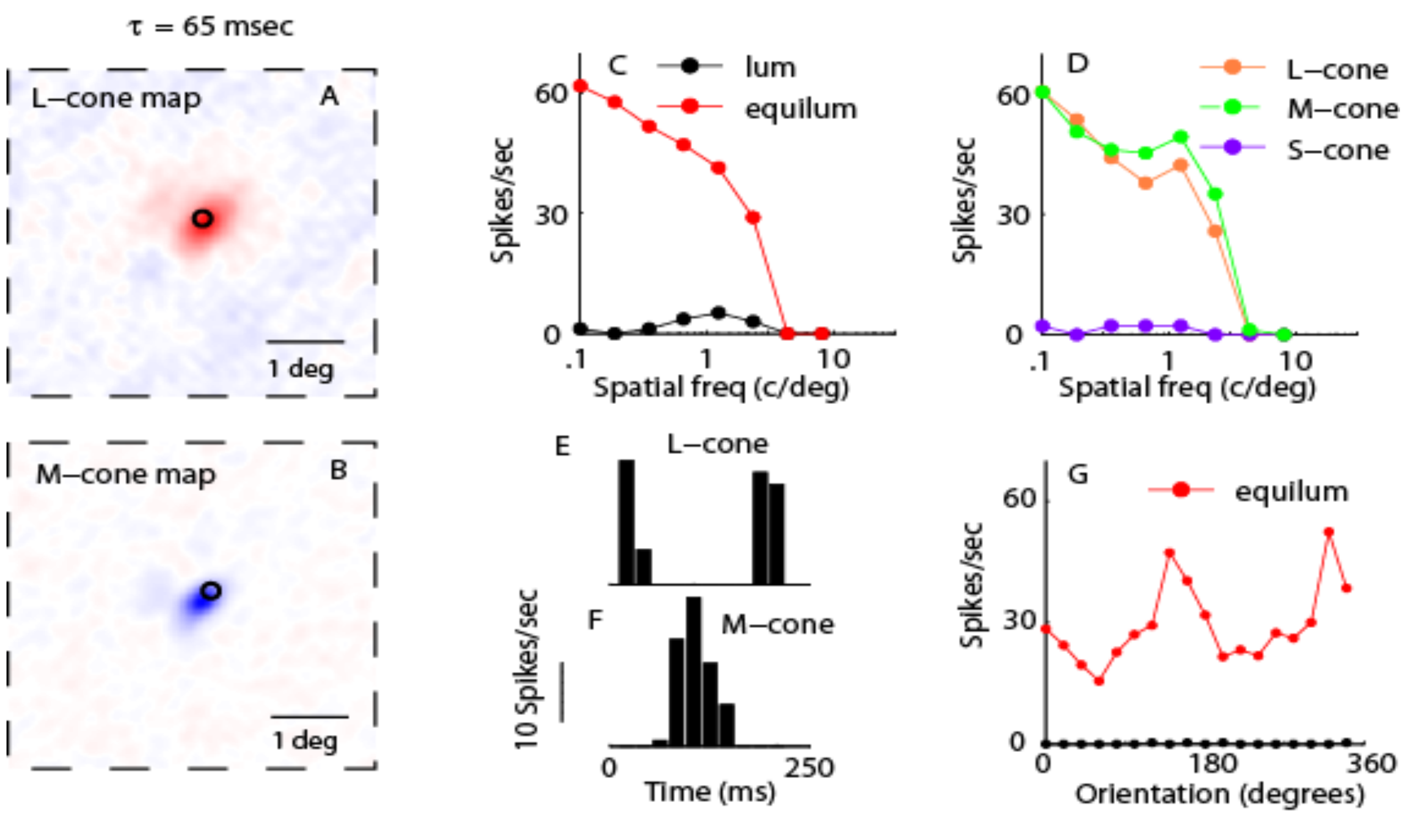


Layer 6 DS Complex Cell

RF Maps, orientation, SF and TF tuning: simple cells in layer 4b

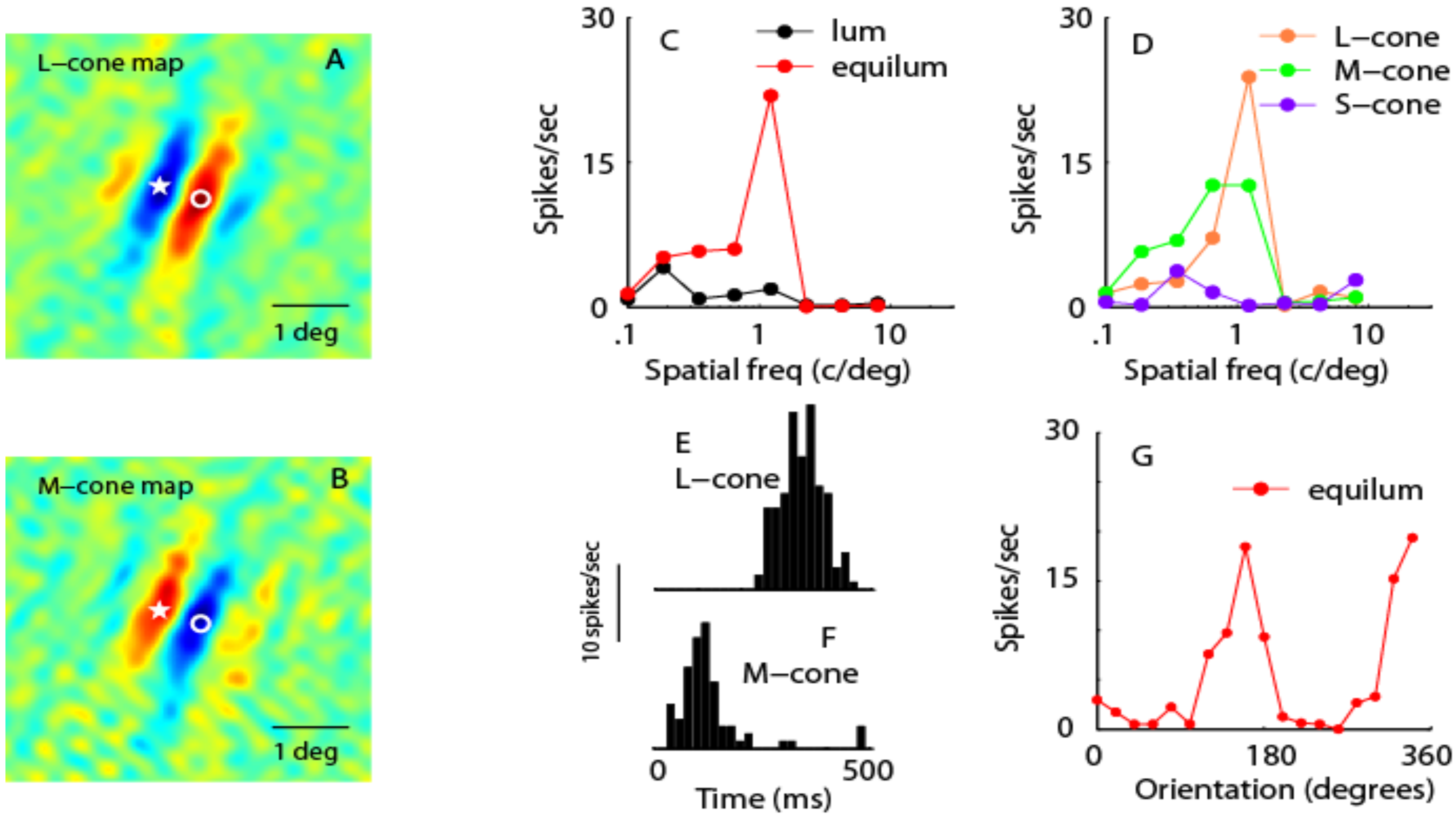


Maps, SF and Orientation Tuning for Single Color Opponent Neuron from L6



Johnson et al 2008

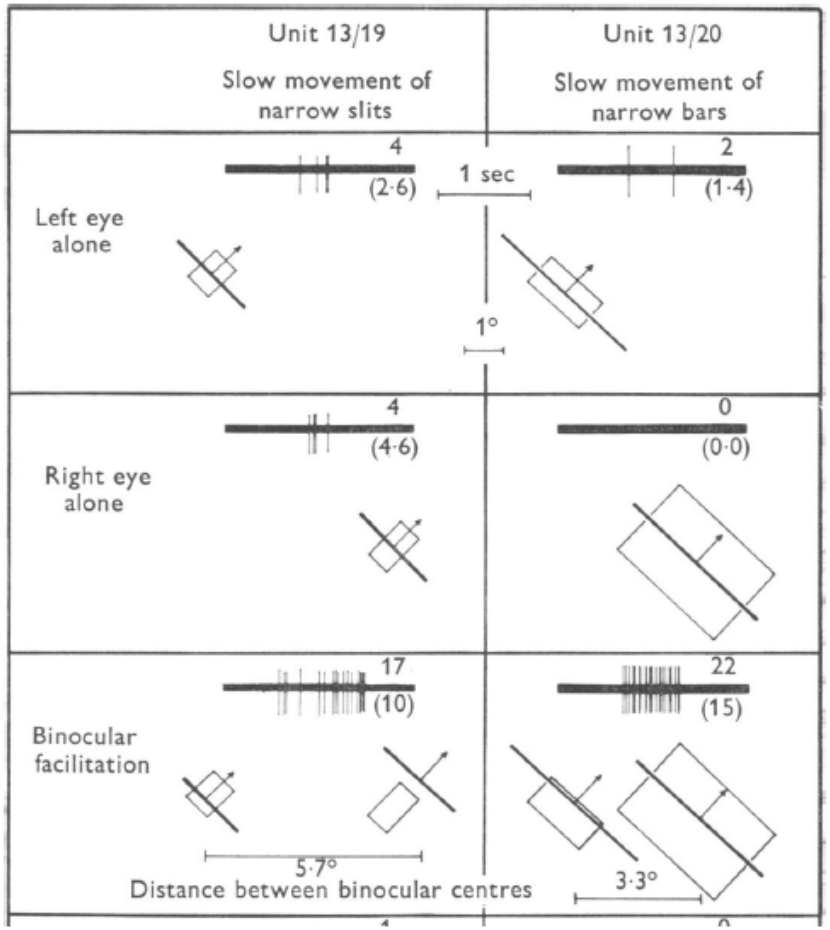
Maps, SF and Orientation Tuning for Double Color Opponent Neuron from L6



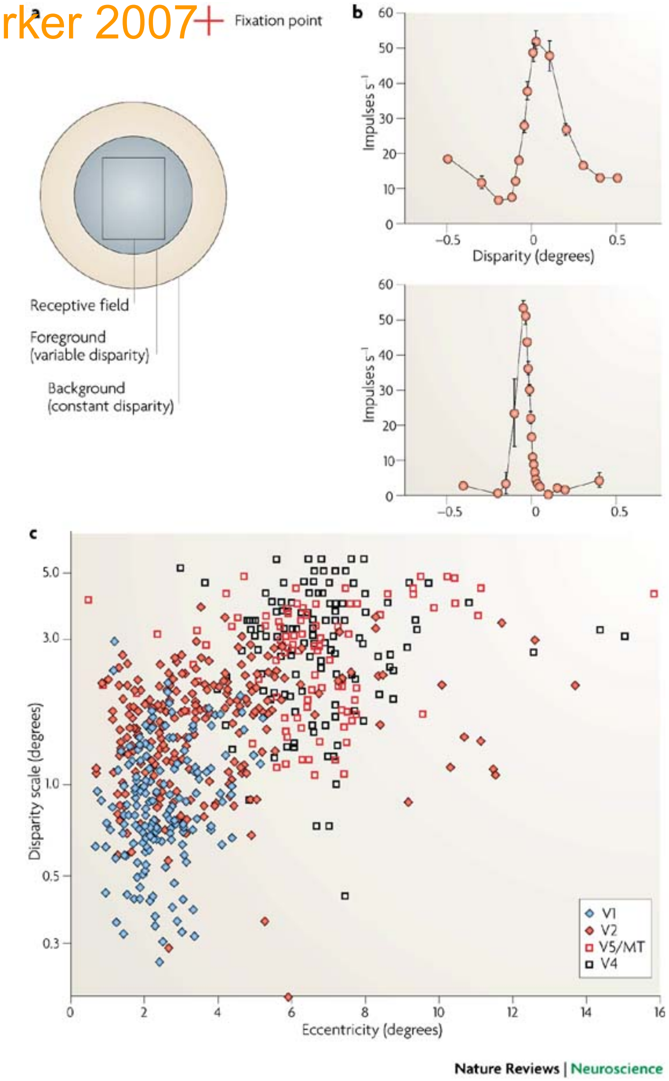
Johnson et al 2008

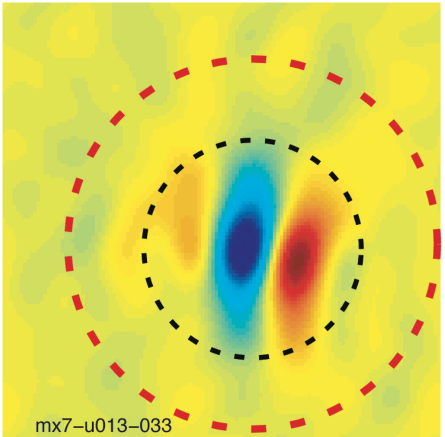
O/P ratio 0.2

Disparity Selectivity of Neurons Cat Area 17 : from Barlow, Blakemore and Pettigrew 1967



Disparity Selectivity of Neurons in Monkey V1, V2, MT & MST : from Parker 2007





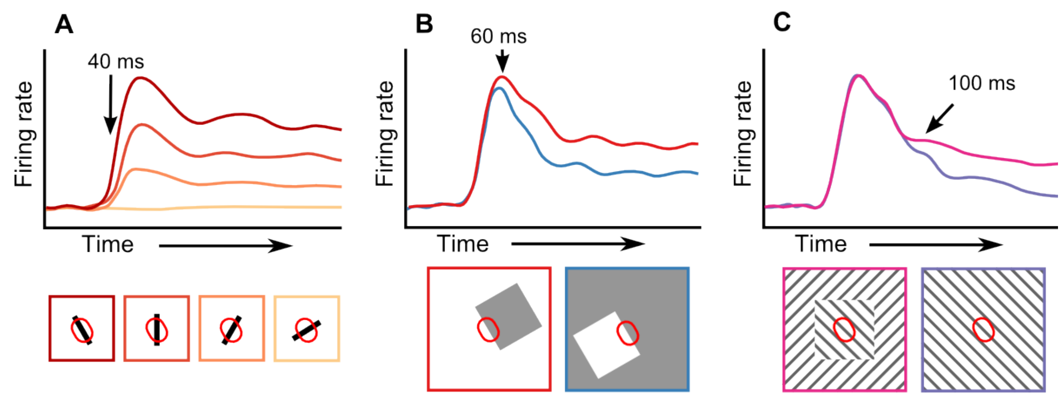
CRF
Classical Receptive Field

eCRF
Extra-Classical Receptive Field

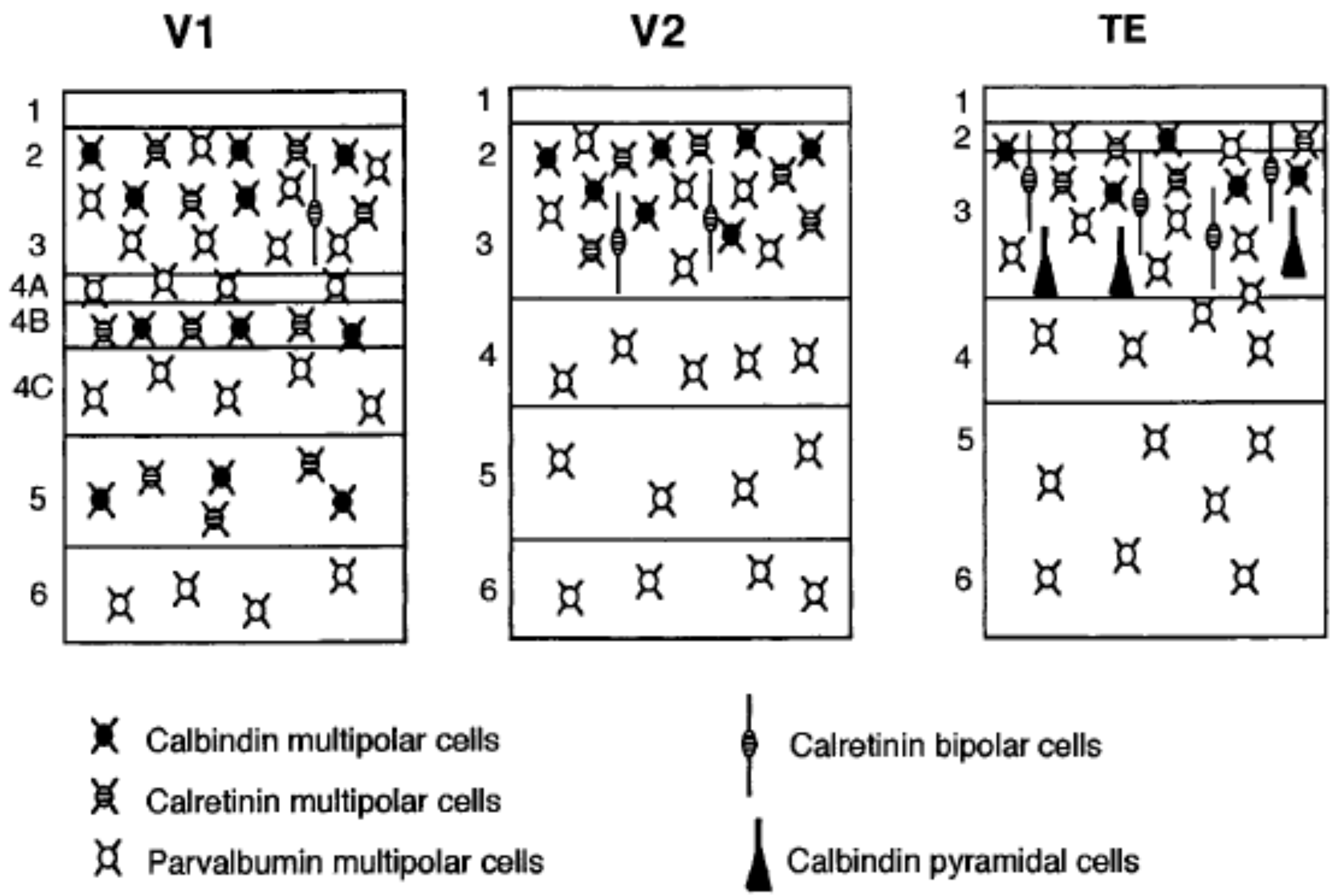
- **eCRF:** modulates the CRF responses -- influence that is the CONTEXT

Blakemore & Tobin	Allman et al
DeAngelis, Ozhawa, Freeman	Knierim & Van Essen
Sengpiel et al	Lamme, Ziper et al
Cavanaugh et al	

Williford & von der Heydt (2013)



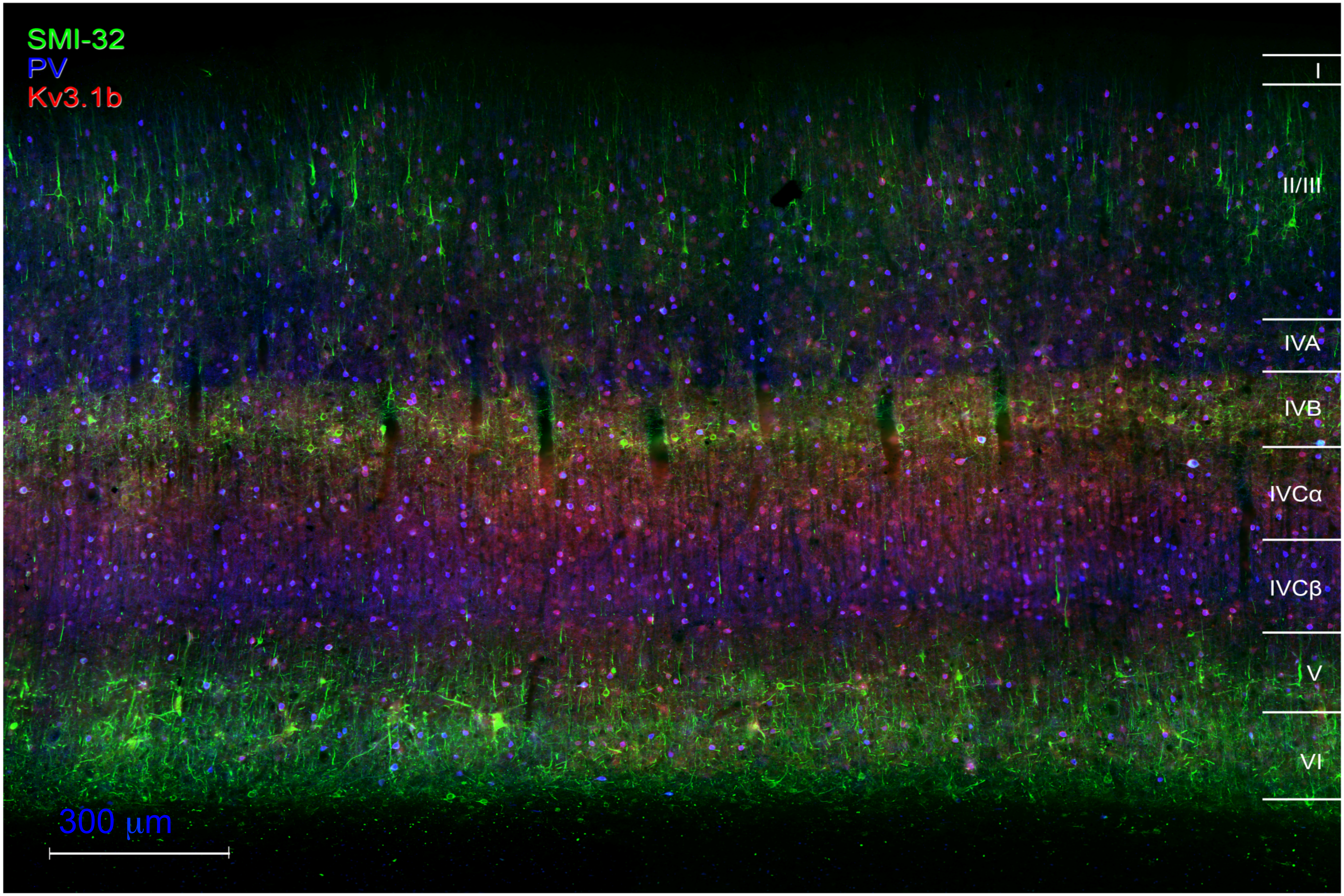
- What is the relationship to perception?



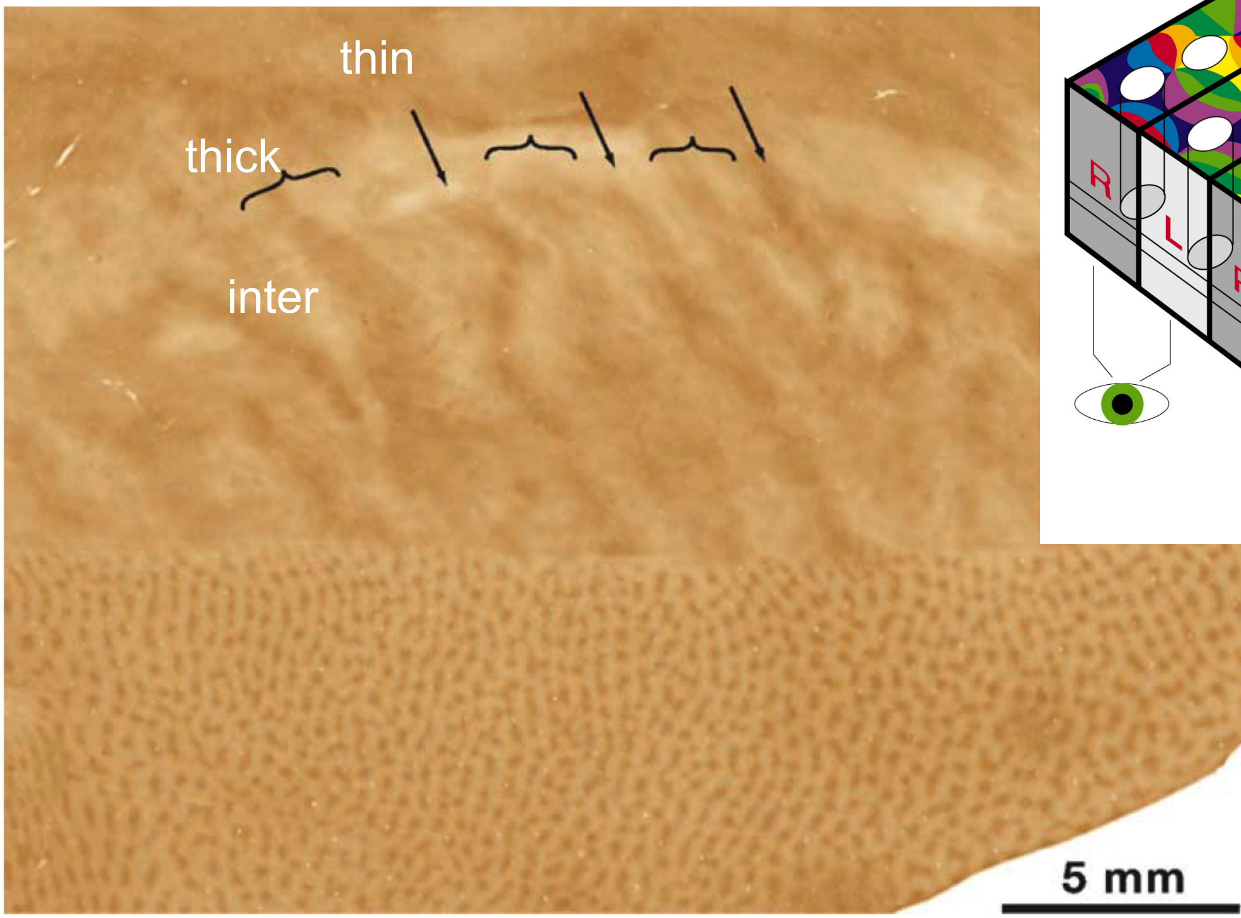
From DeFelipe, 2005

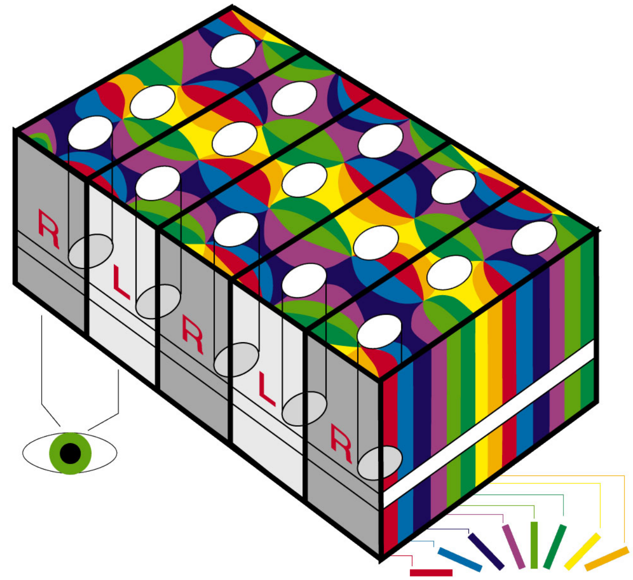
Layers, Columns, Cell Types and Circuits

- Laminar organization of cortex
- Ocular Dominance
- Cell Types, excitatory, inhibitory
- Circuits and projections


SMI-32
PV
Kv3.1b
I
II/III
IVA
IVB
IVCα
IVCβ
V
VI
300 μm

CO blobs and stripes (Sincich & Horton 2005)

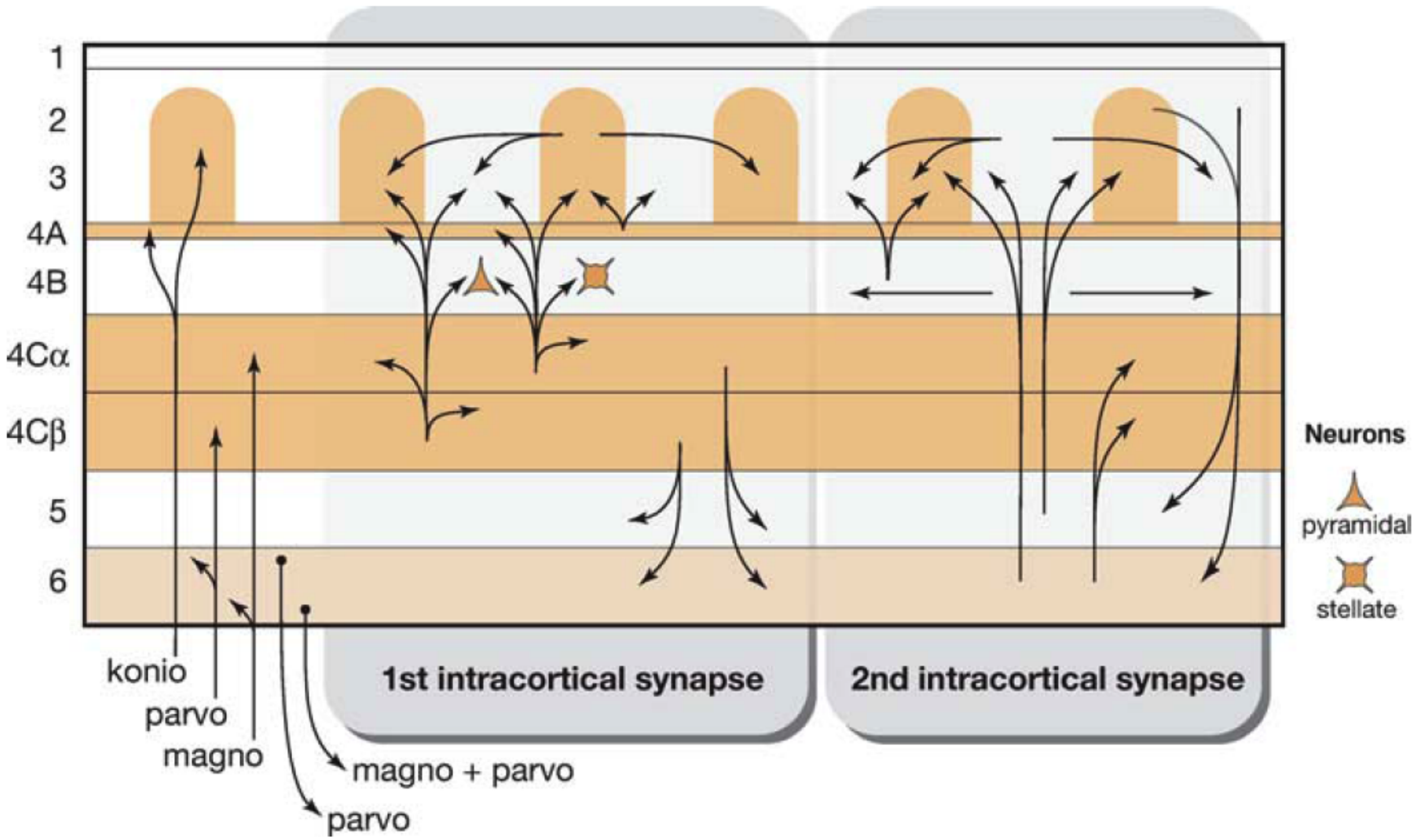




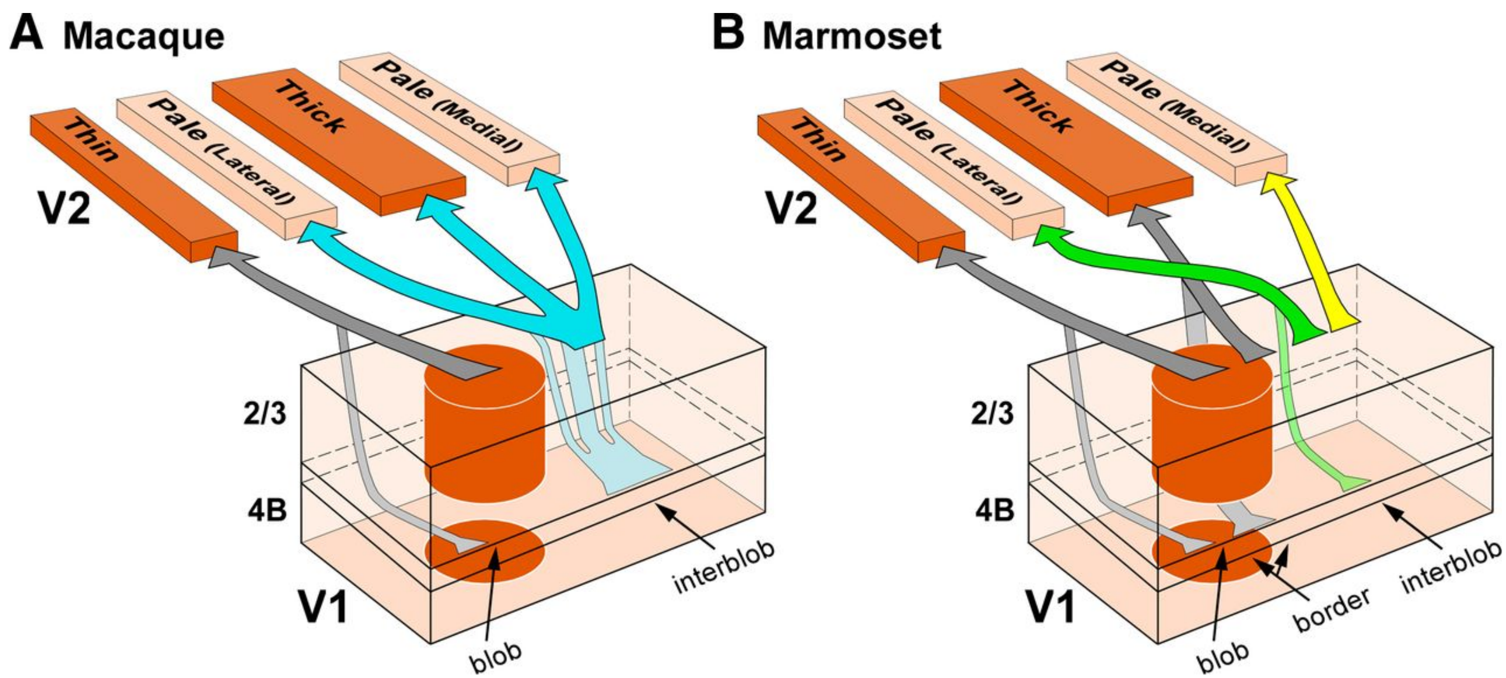
V1

Intracolumnar feedforward and feedback connections

(Sincich & Horton 2005)

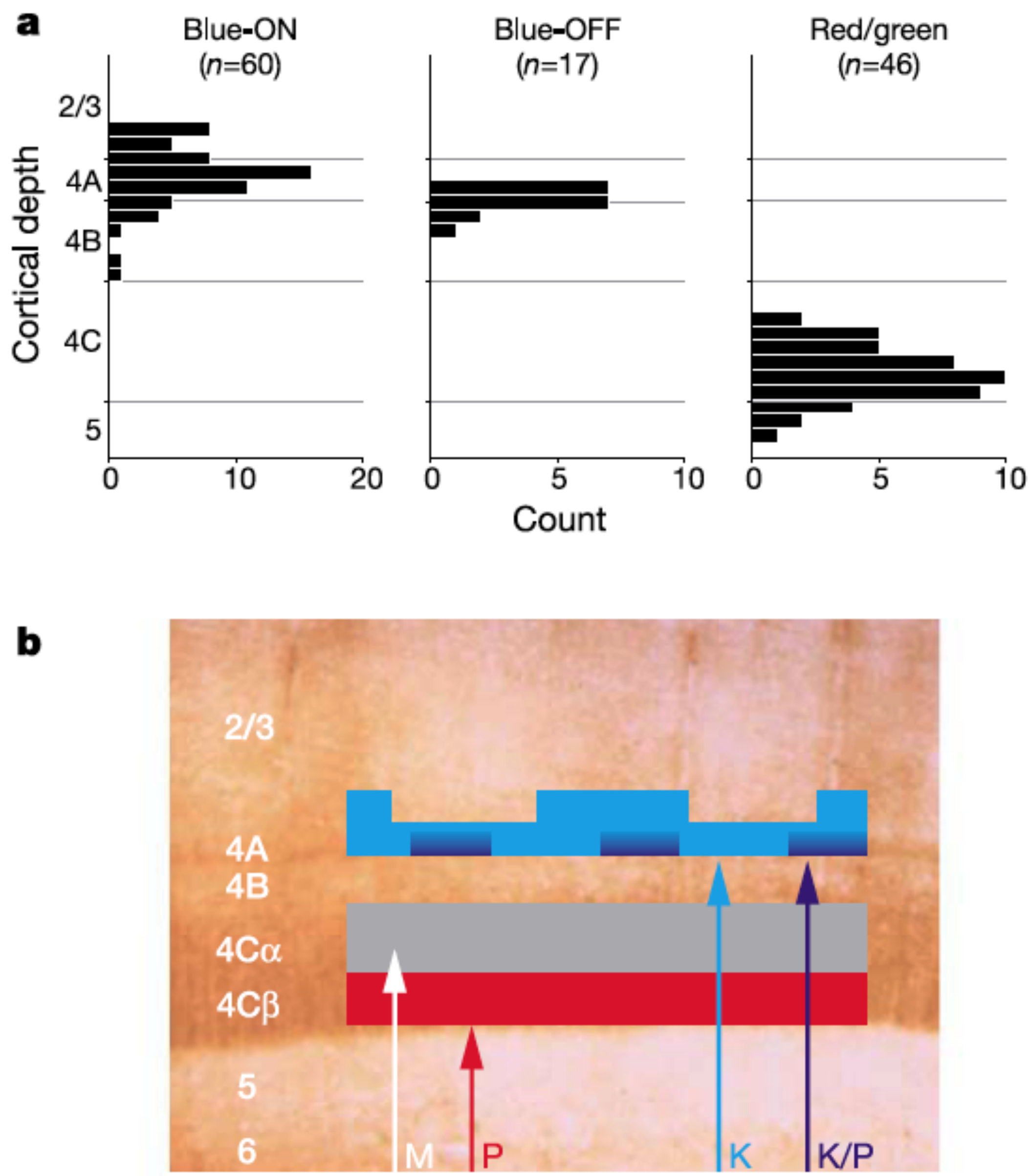


Projections from V1 to V2 in primate

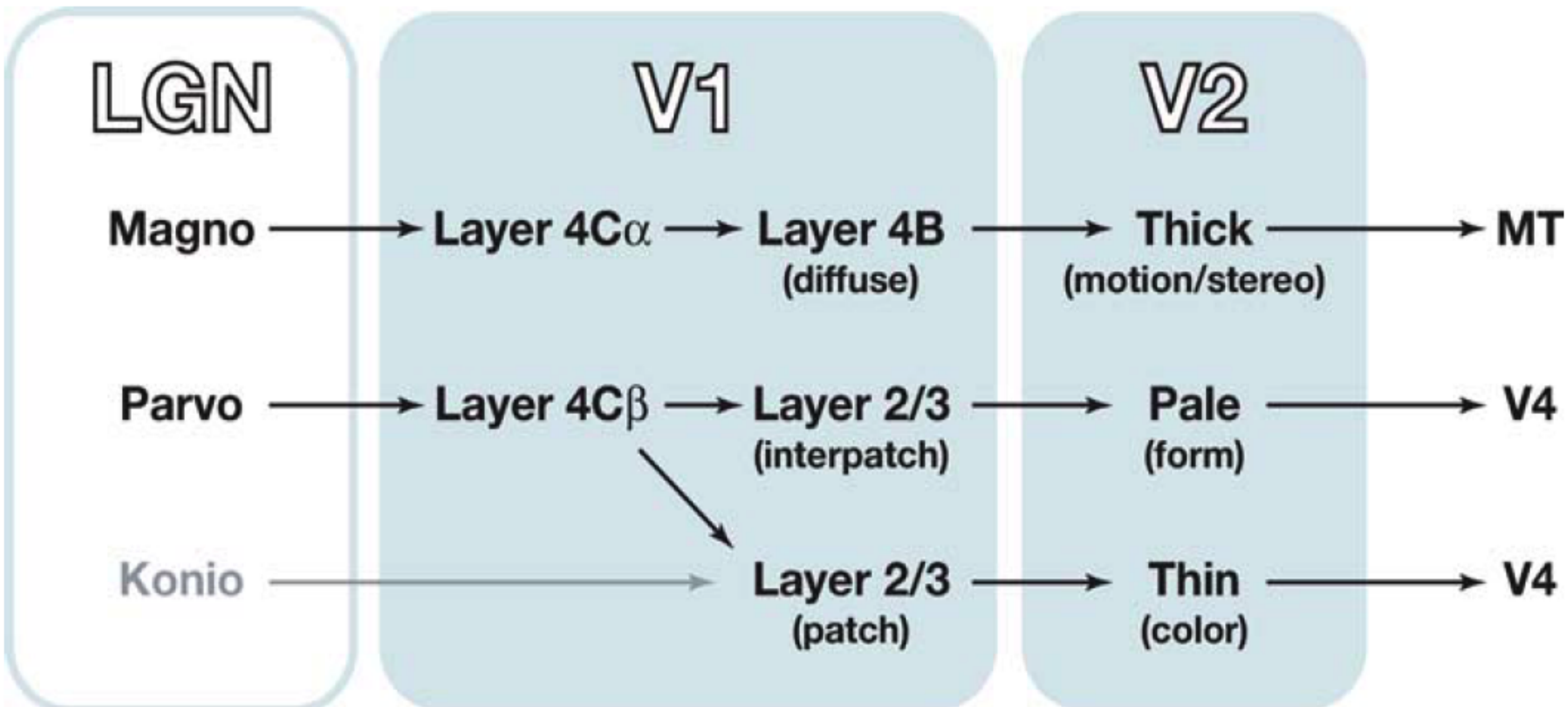


Federer et al 2013

Segregated color selective inputs (from Chatterjee & Callaway, 2003)



Tripartite view of V1--V2 (Livingstone-Hubel)



The canonical cortical micro-circuit

from Martin & Douglas 2010

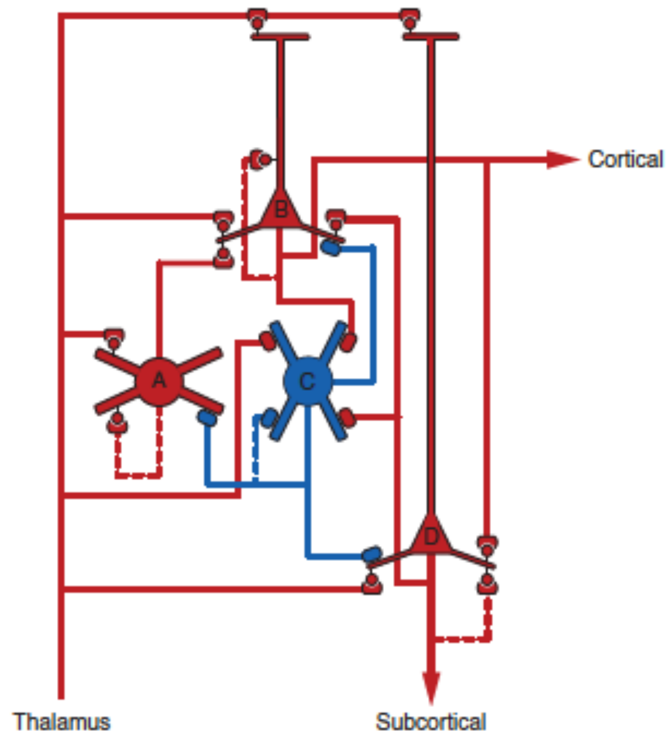
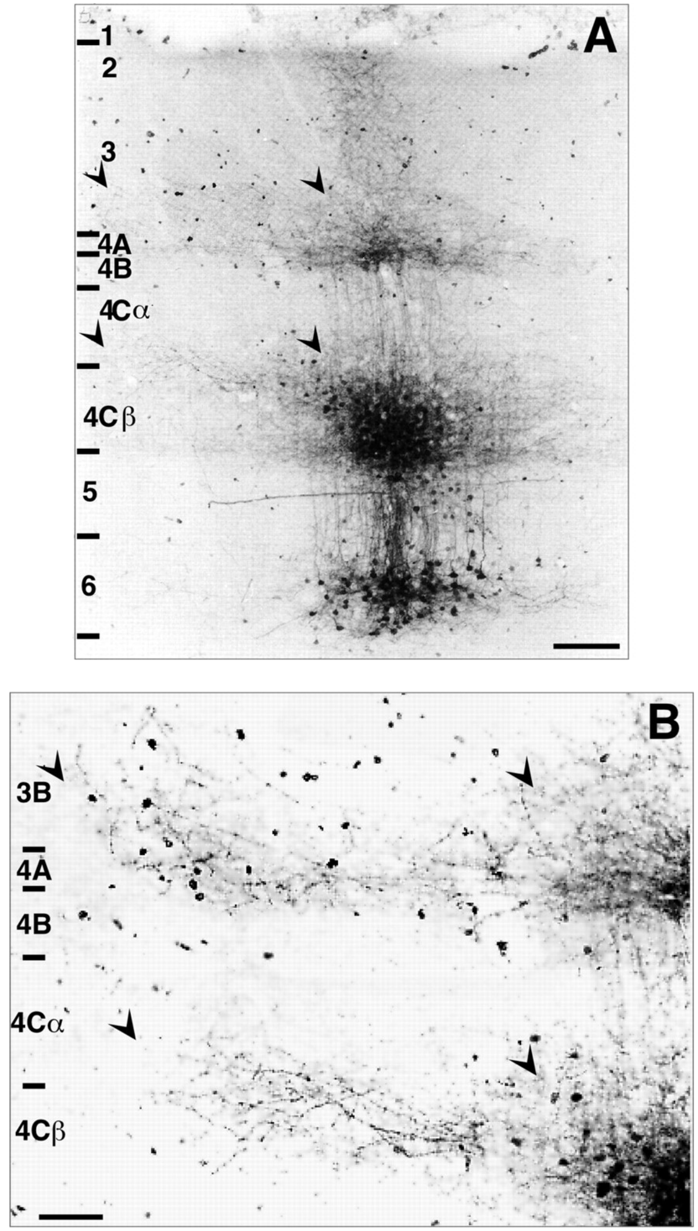
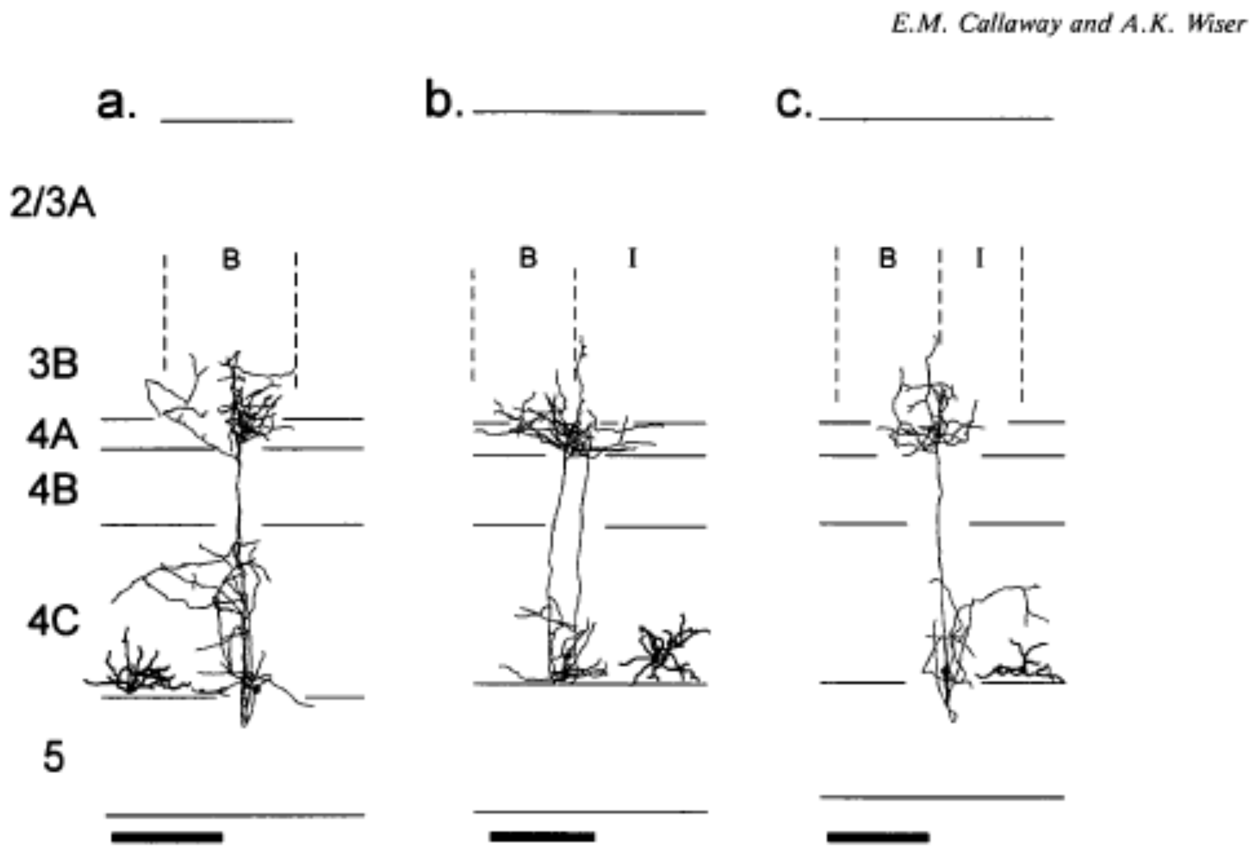


FIGURE 2–1. A canonical circuit for neocortex. Thalamic relay cells mainly form synapses in the middle layers of cortex, but they also form synapses with neurons in all six cortical layers, including the tufts of pyramidal cells in layer 1. In all layers the excitatory (red) and inhibitory (blue) neurons form recurrent connections with like cells within the same layer (dashed lines) and with other cell types (continuous lines). Layer 4 in some primary sensory cortical areas contain a specialist excitatory cell type, the spiny stellate cell (A), which projects to pyramidal cells and inhibitory cells in layer 4 and other layers. The superficial layer pyramidal cells (B) connect locally and project to other areas of cortex. Inhibitory neurons (C) are found in all layers (only one representative is shown here), and they constitute about 15% of the neurons in the neocortex. The deep layer pyramidal cells (D) also connect recurrently locally and project to subcortical nuclei in the thalamus, midbrain, and spinal cord.

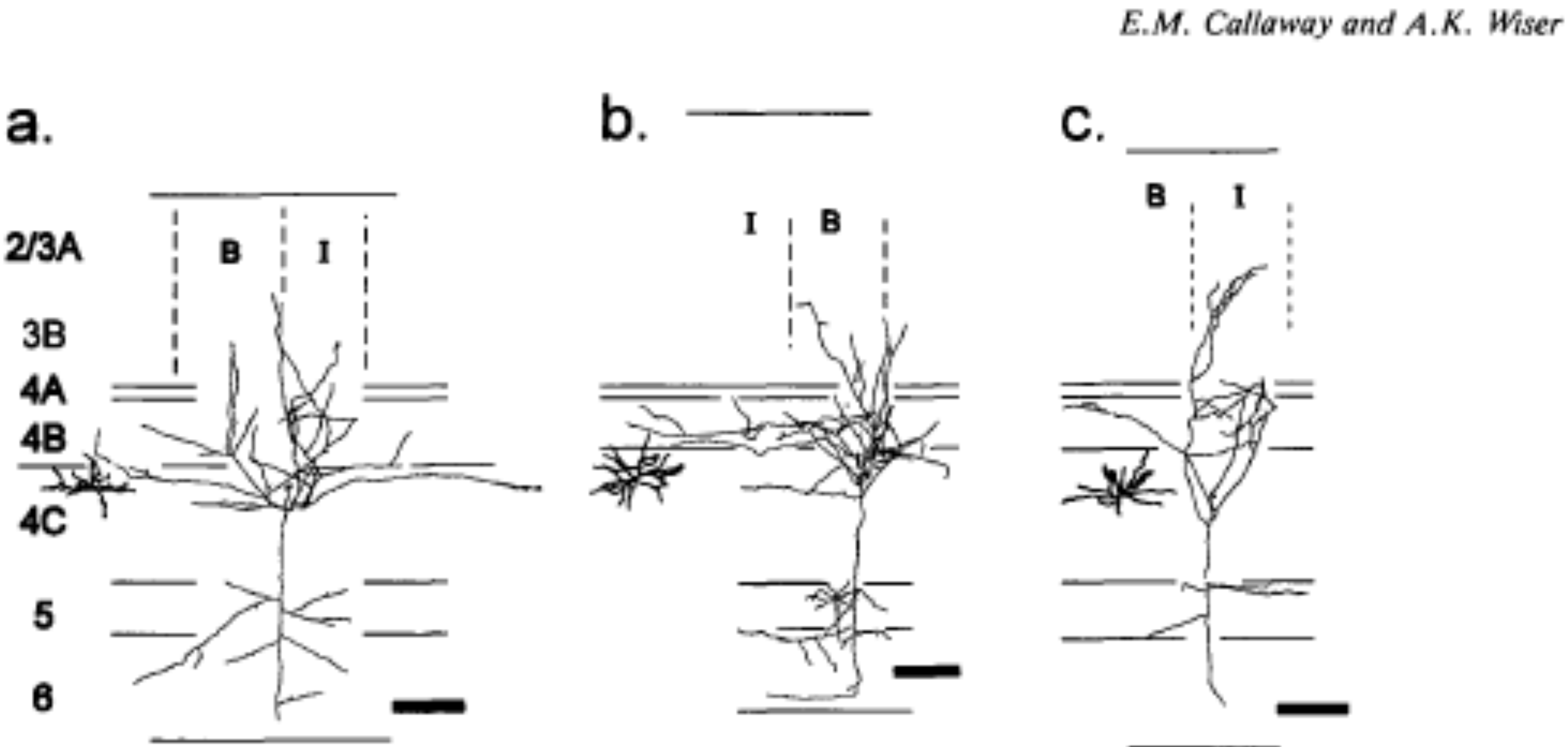
Radial and Lateral connections (from Lund et al 2003)



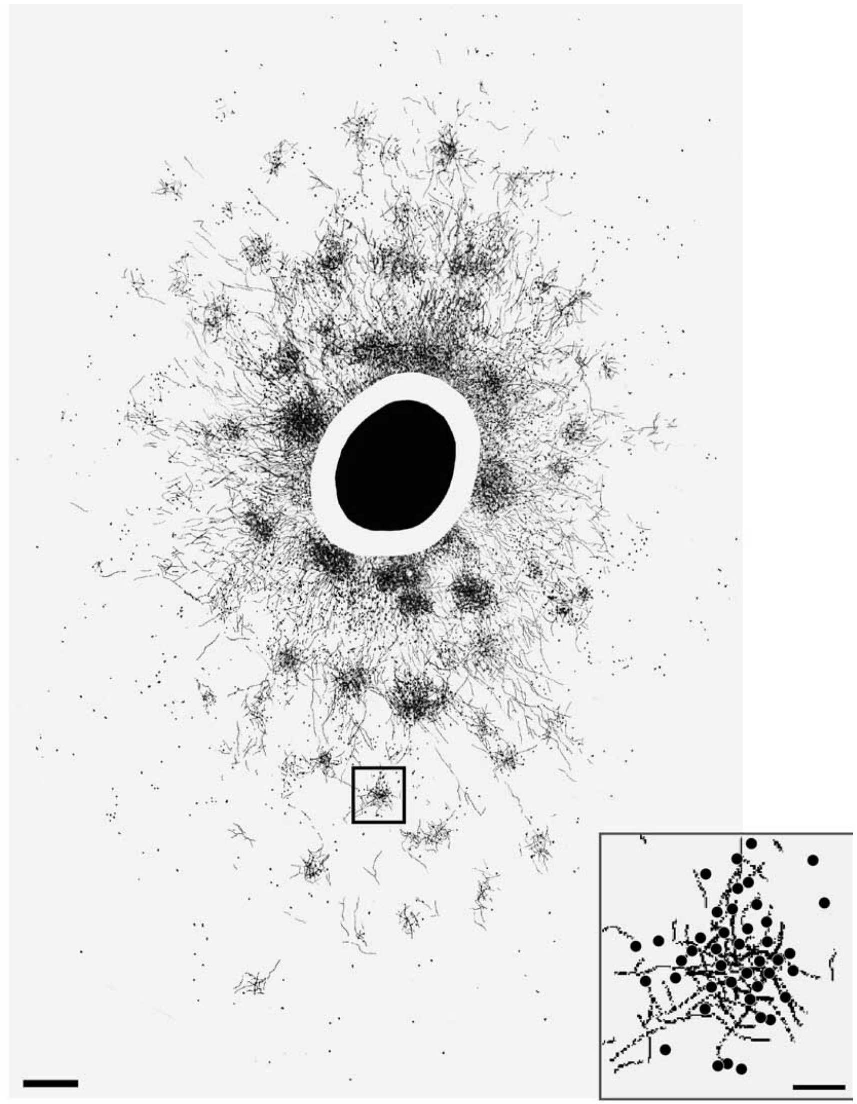
Layer 4cβ projections



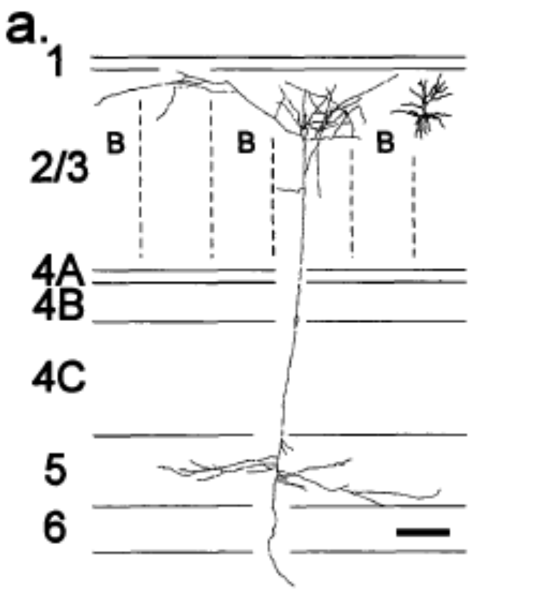
Layer 4cα projections

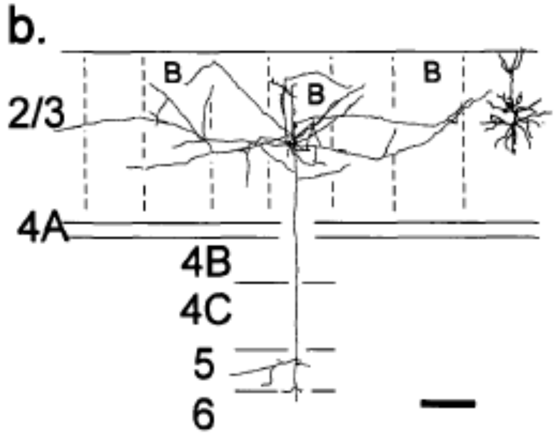


Lateral connections in layer 2/3

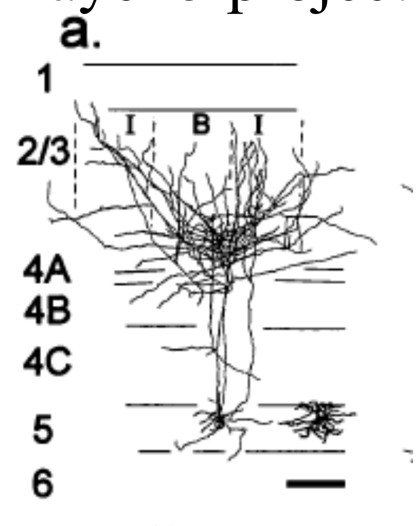


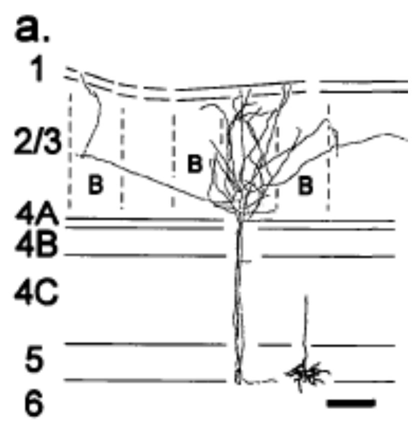
Layer 2 projections





Layer 5 projections

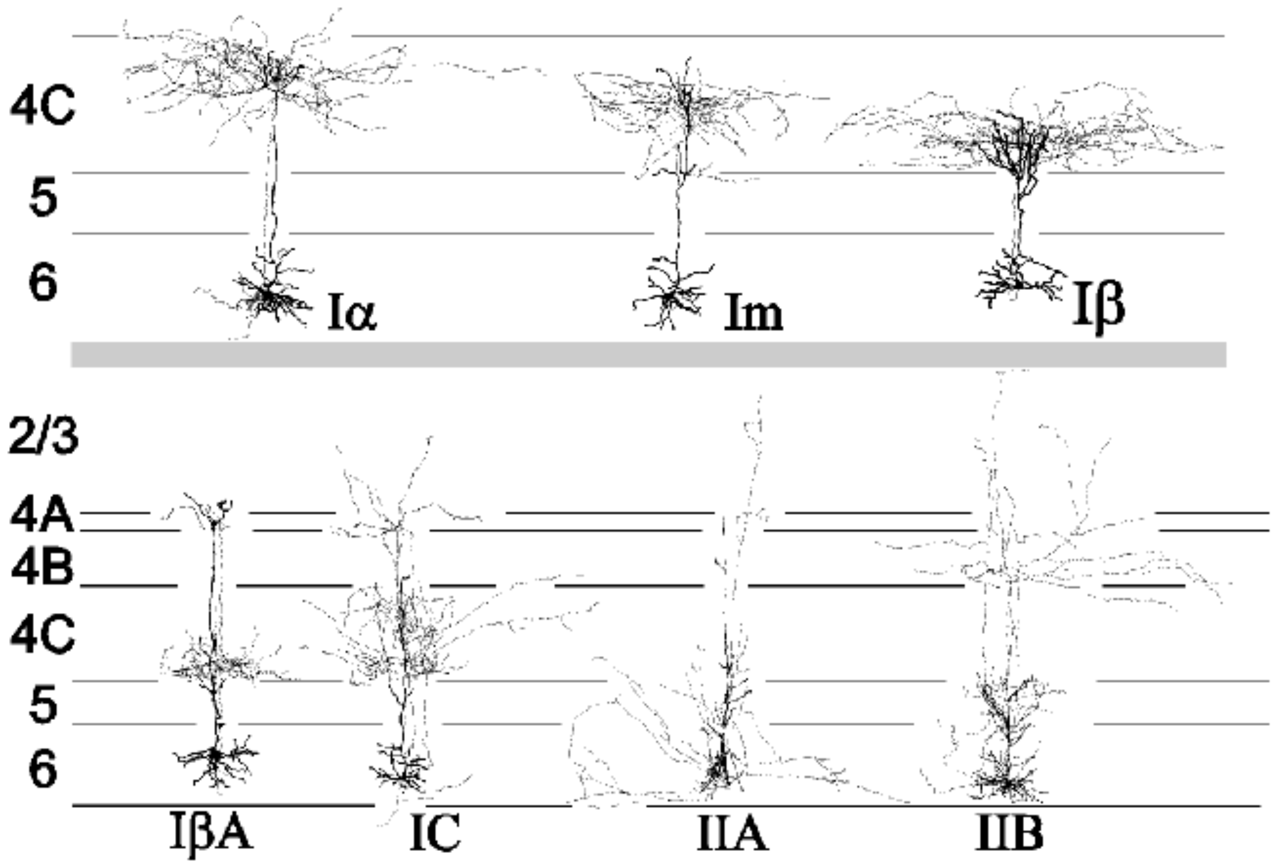


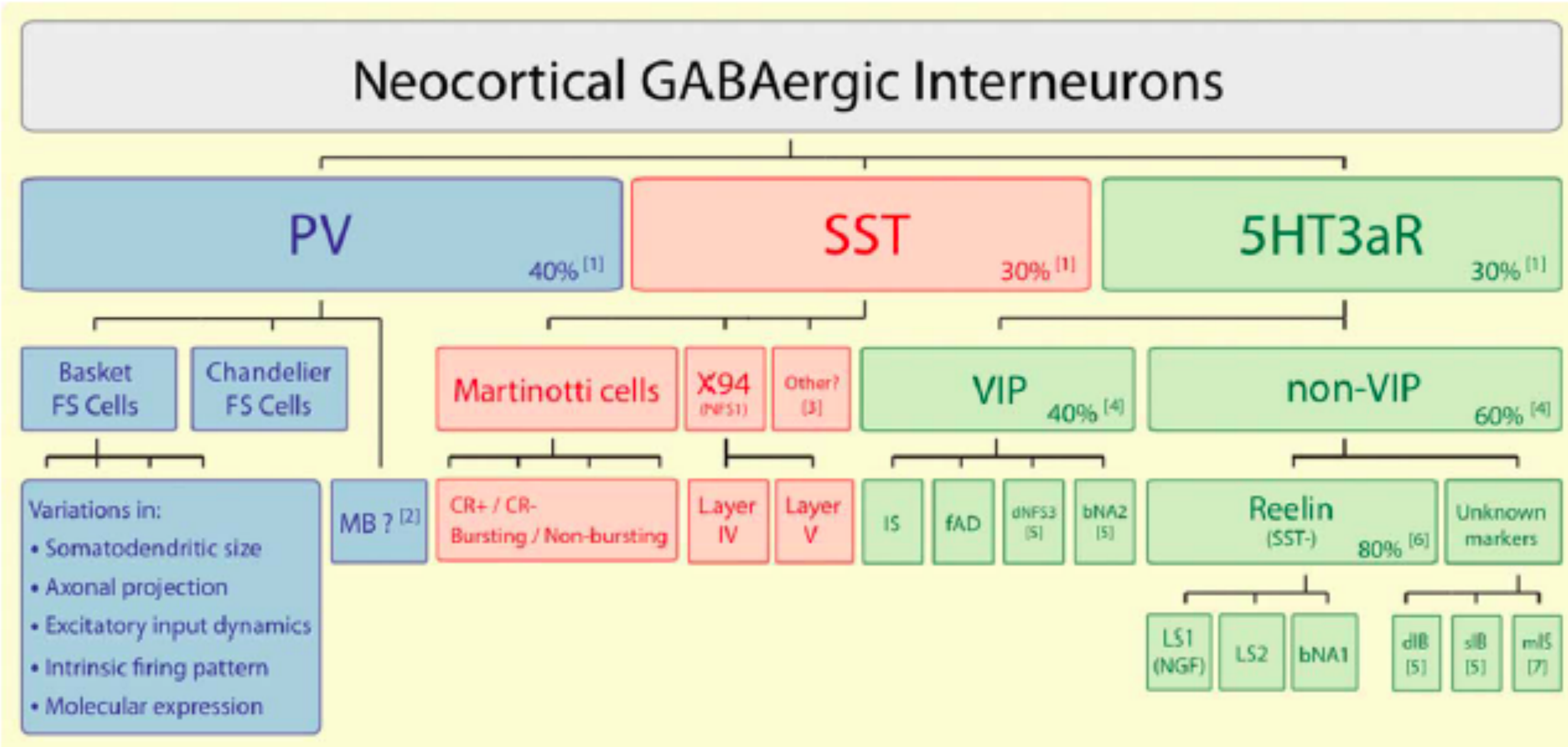


From
Wiser &
Callaway
1996

Layer 6 Classes and projections

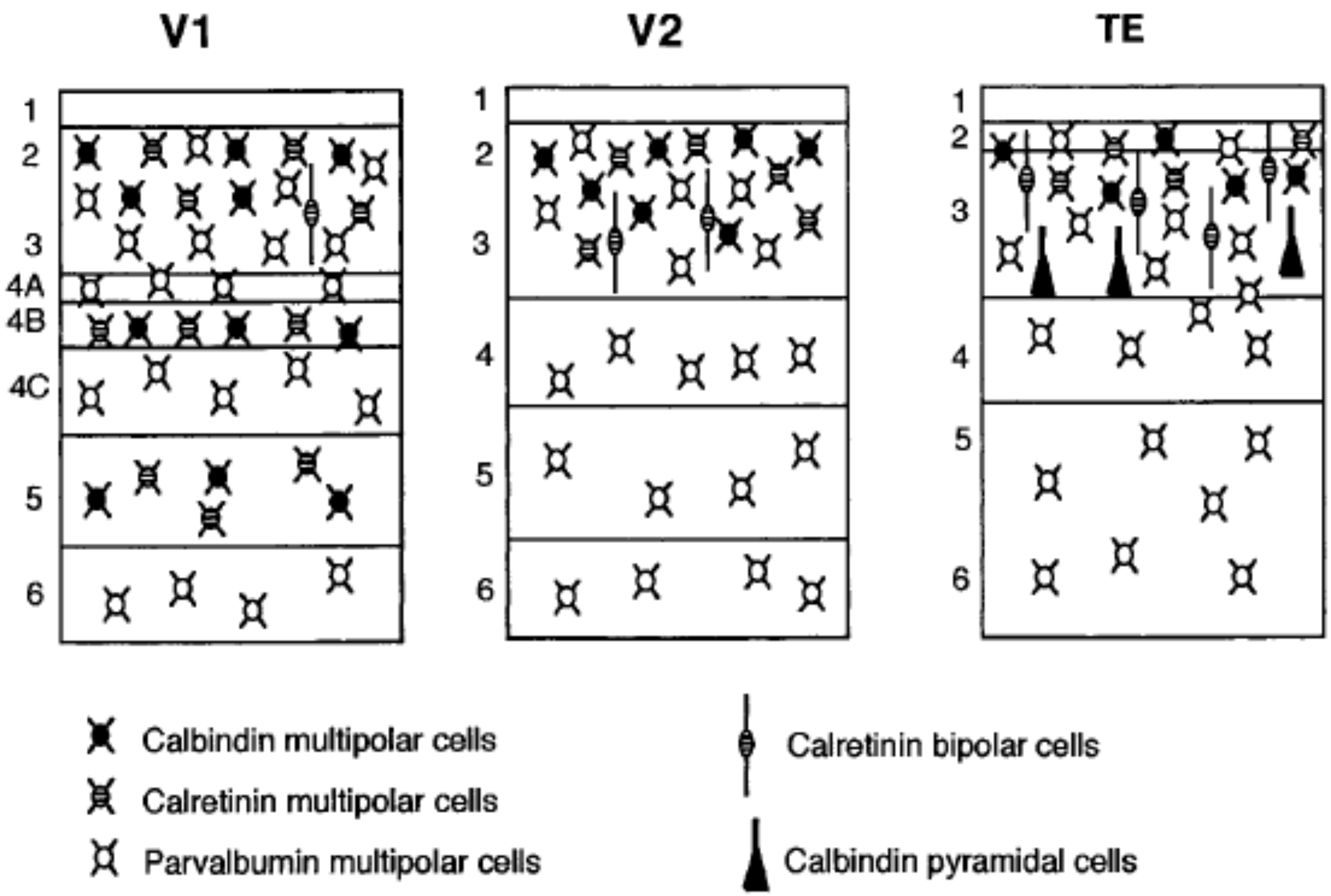
From Wiser & Callaway (1996): Fig. 12



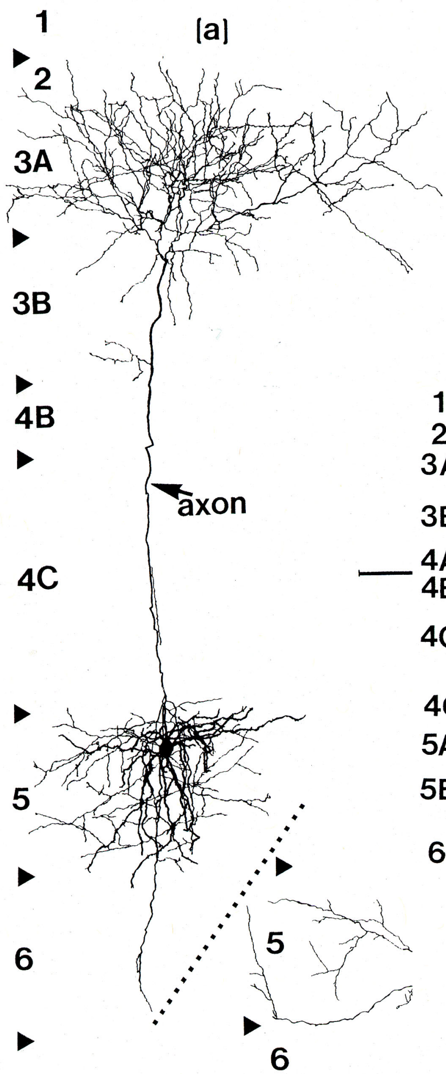


From Rudy et al 2010

Inhibitory interneurons in Primate V1



From Defelipe 1999



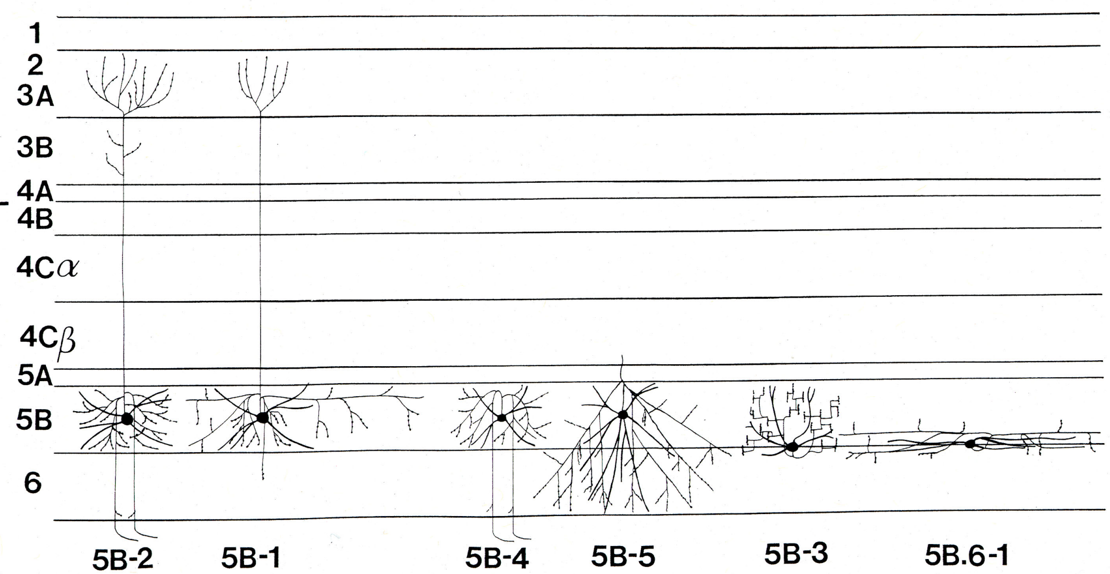


Fig. 21. Summary diagram illustrating the varieties of local circuit neuron described for lamina 5B and the 5B-6 border. Pyramidal neurons of the 5B lamina can either lack a well-developed apical dendrite or may have an apical dendrite with poorly developed (the smaller pyramids) or strongly developed (large pyramids) arbor in laminae 3A/2 and 1. The pyramids have recurrent axon collaterals that also show terminal arbors in the 3A/2 region (Lund and Boothe, '75). The 5B-1 and 5B-2 local circuit neuron axons can be seen to replicate this laminar pattern of dendritic and axonal distribution of the pyramidal neurons of the layer.