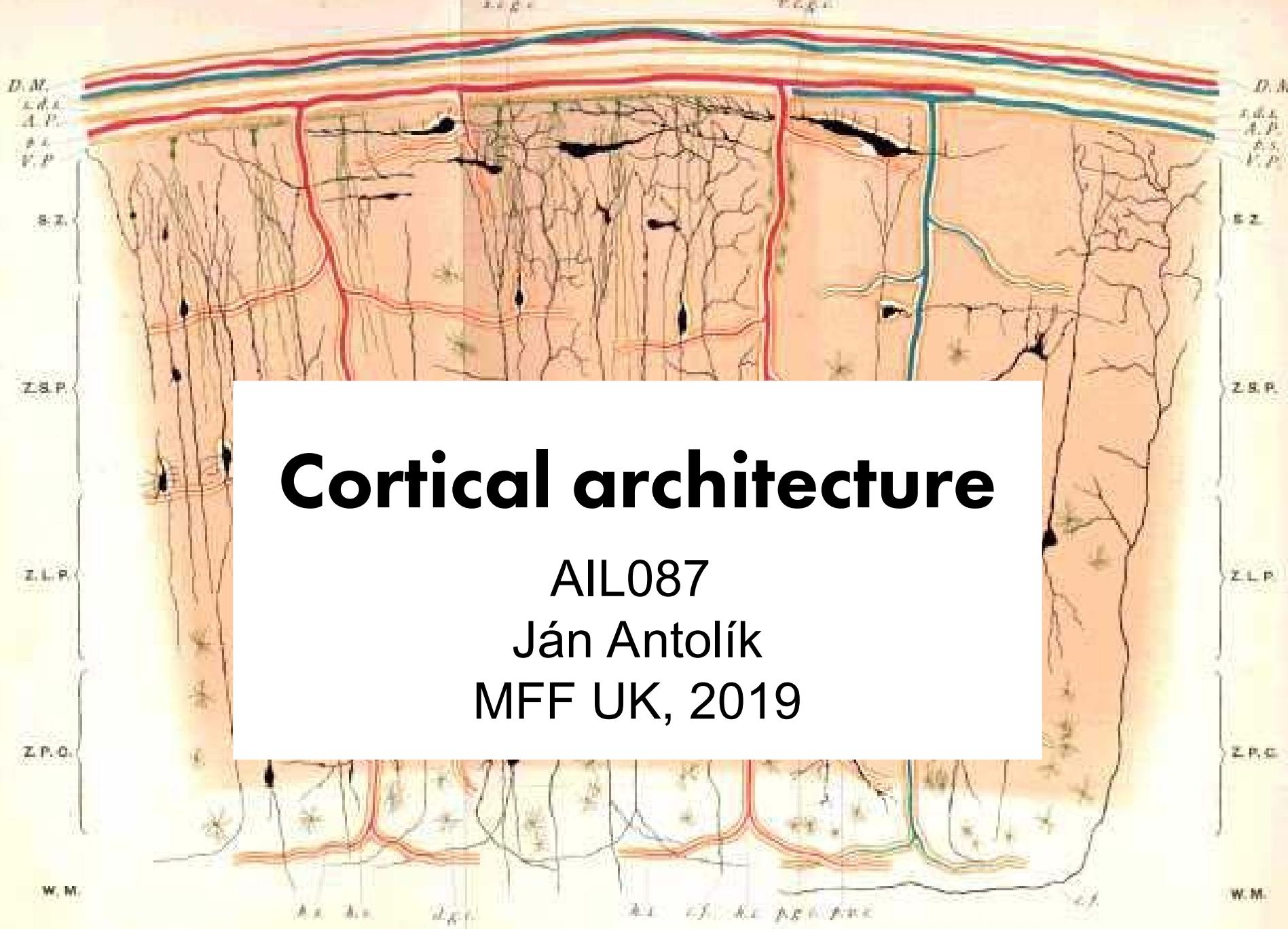
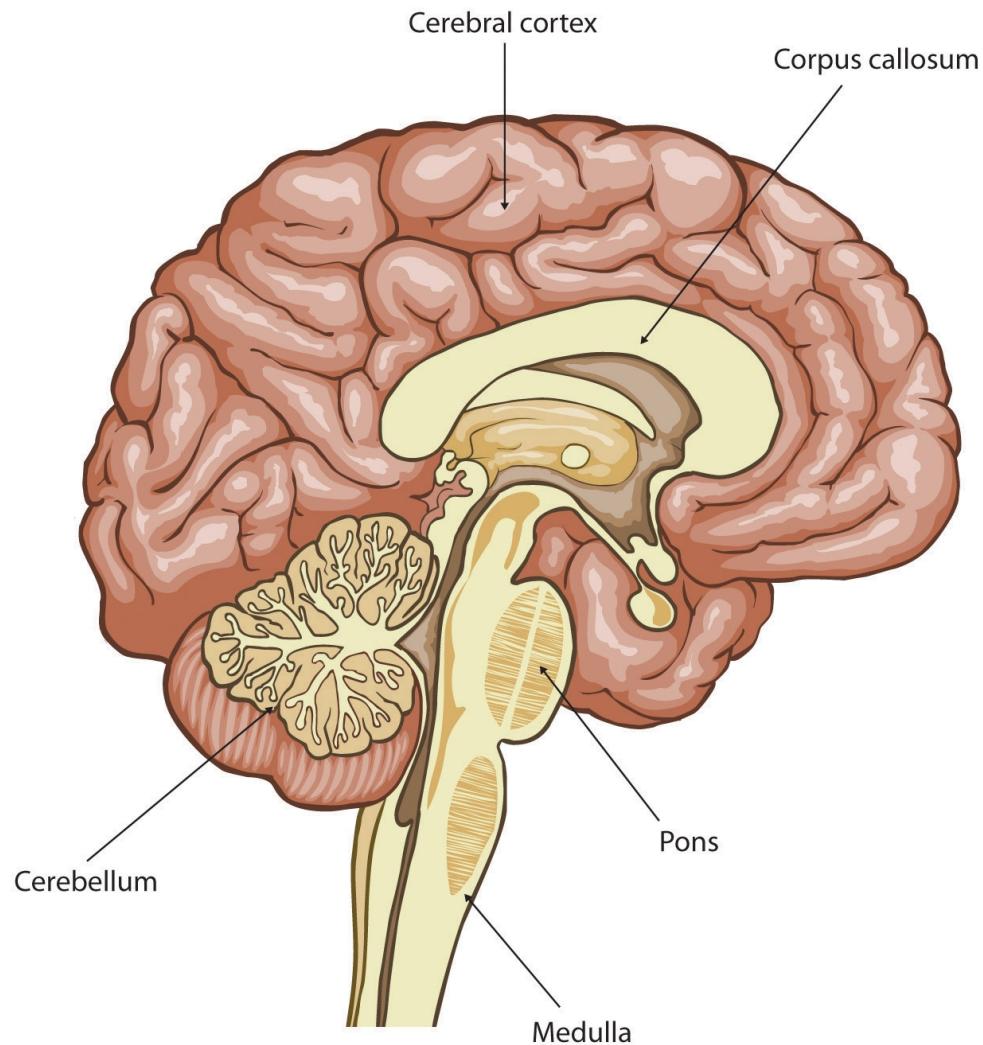


# Cortical architecture

AIL087  
Ján Antolík  
MFF UK, 2019

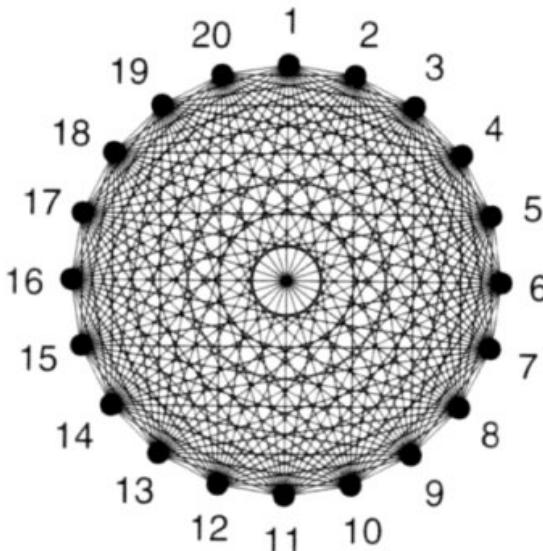




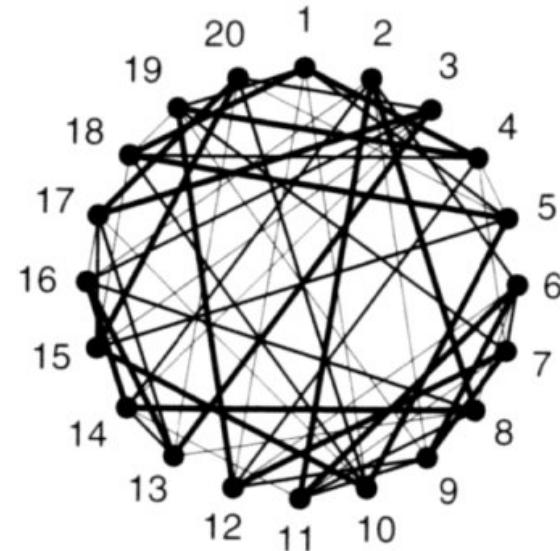
# Why isn't the brain “fully connected”?

- # neurons – say,  $10^9$
- # synapses – say,  $10^{12}$

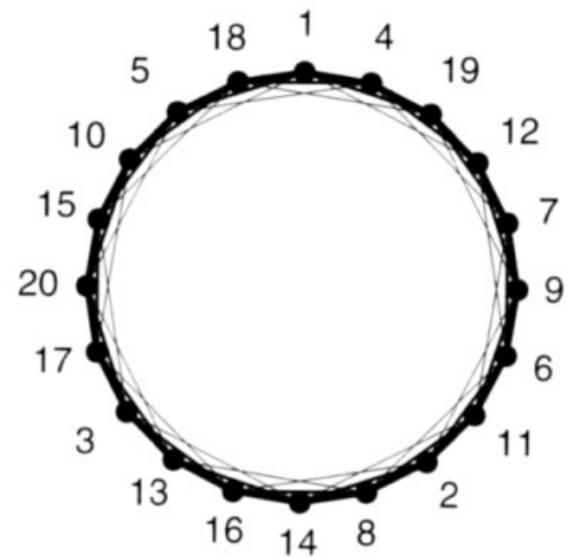
A.



B.

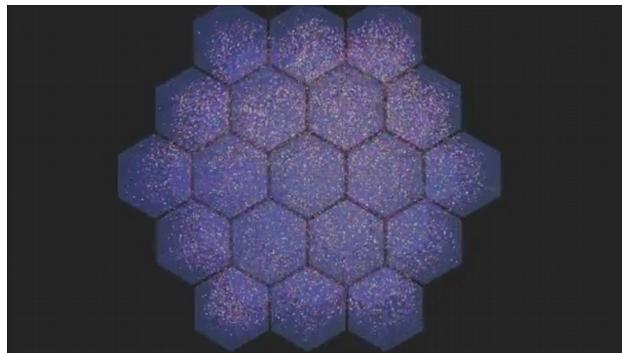
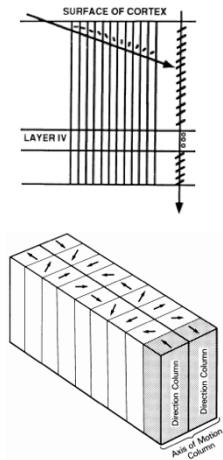


C.

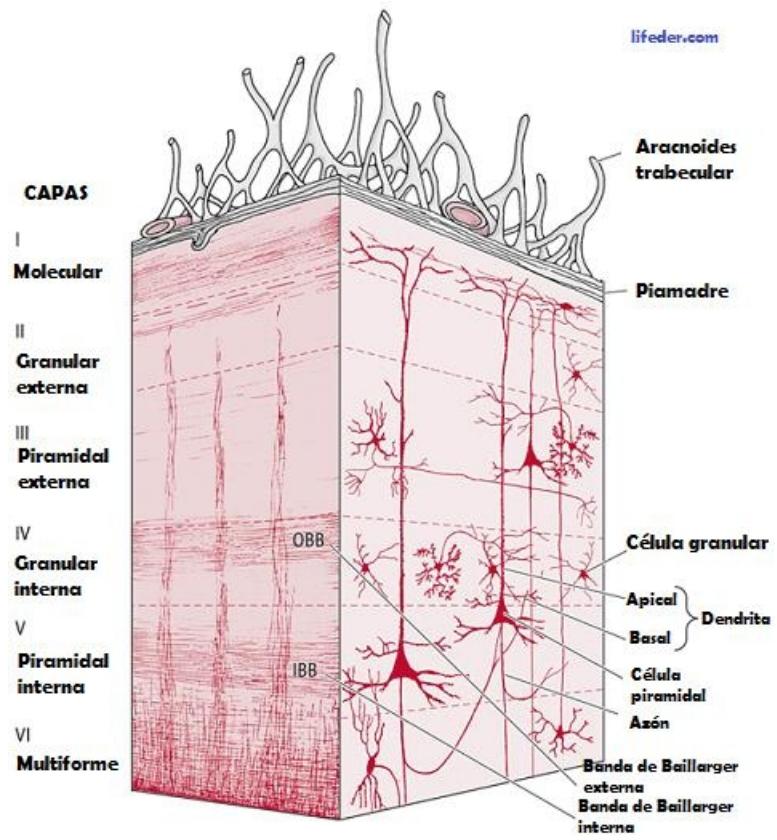


# Horizontal vs. vertical organization of the cortex

## Horizontal

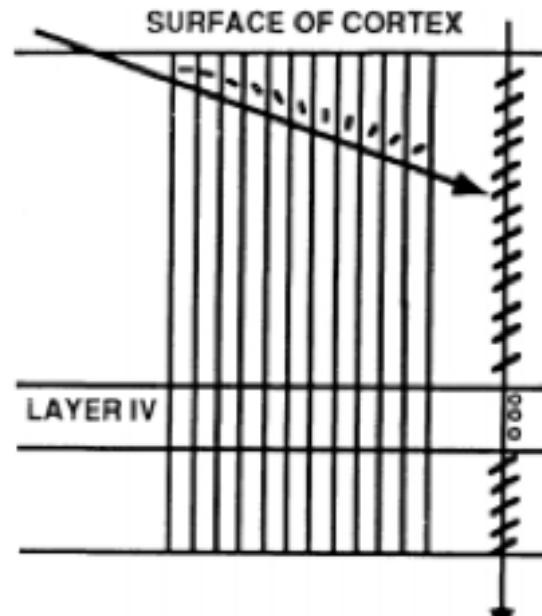


## Vertical



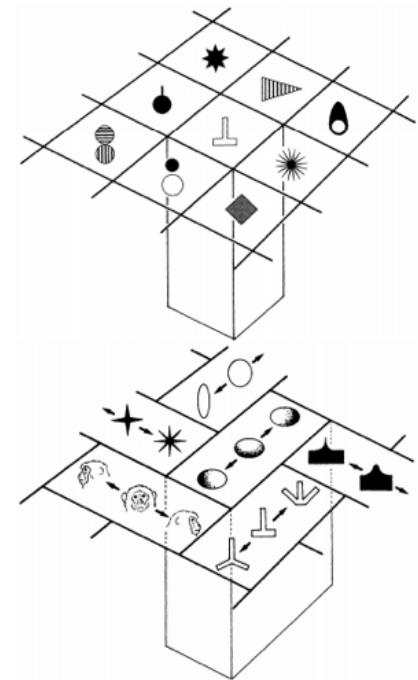
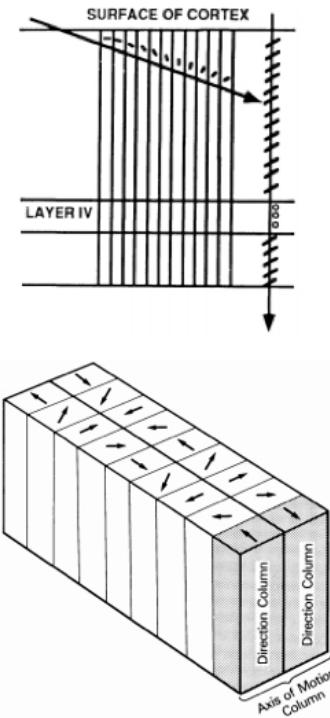
# The cortical column concept

- Introduced by Vernon Mountcastle in 50s



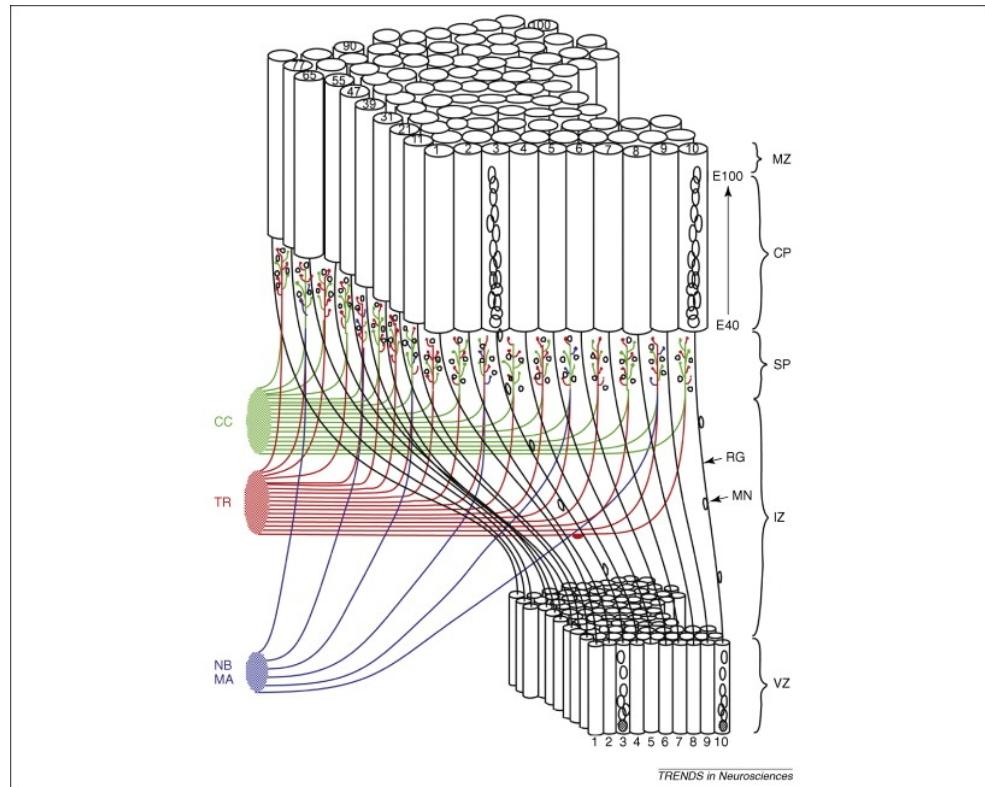
# The cortical column concept

- Introduced by Vernon Mountcastle in 50s
- Initially an idea of discrete modular organization



# The cortical column concept

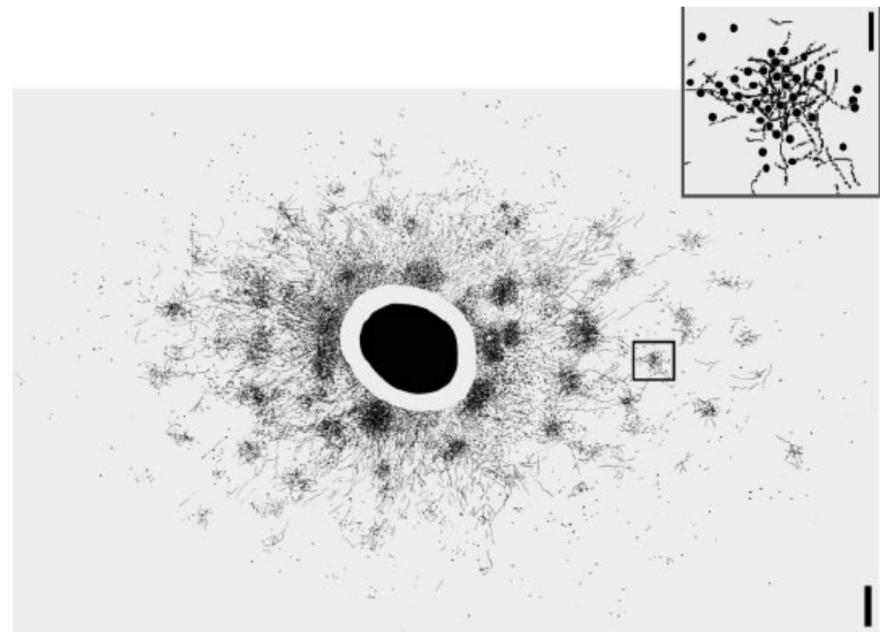
- Introduced by Vernon Mountcastle in 50s
- Initially an idea of discrete modular organization



# The cortical column concept

- Introduced by Vernon Mountcastle in 50s
- Initially an idea of discrete modular organization

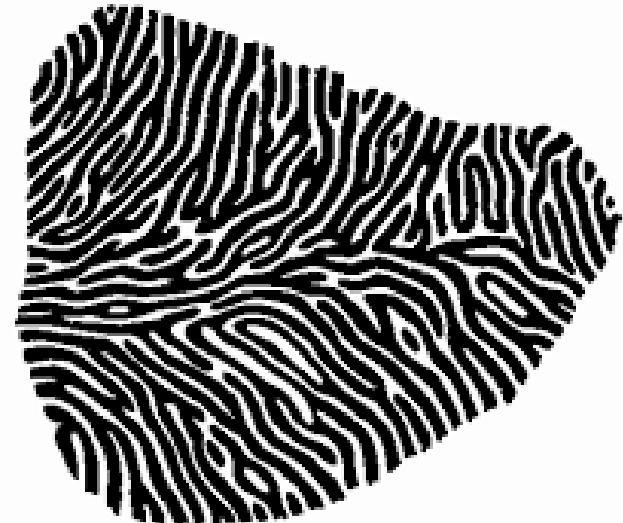
Daisy patterns of lateral connectivity



# The cortical column concept

- Introduced by Vernon Mountcastle in 50s
- Initially an idea of discrete modular organization

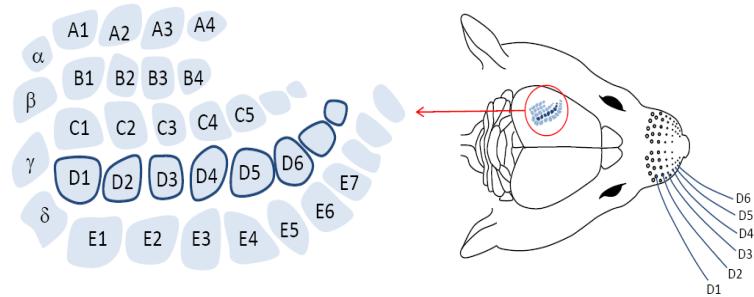
Occular dominance maps



# The cortical column concept

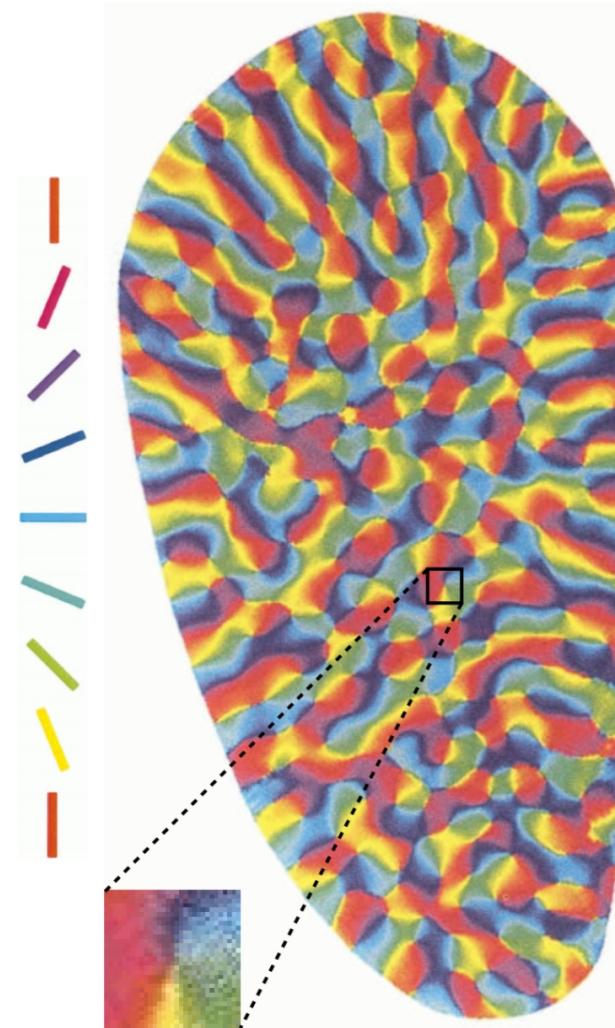
- Introduced by Vernon Mountcastle in 50s
- Initially an idea of discrete modular organization

Barrel cortex in rodents



# The cortical column concept

- Introduced by Vernon Mountcastle in 50s
- Initially an idea of discrete modular organization
- More evidence towards continuous mapping



# Cortical Layers

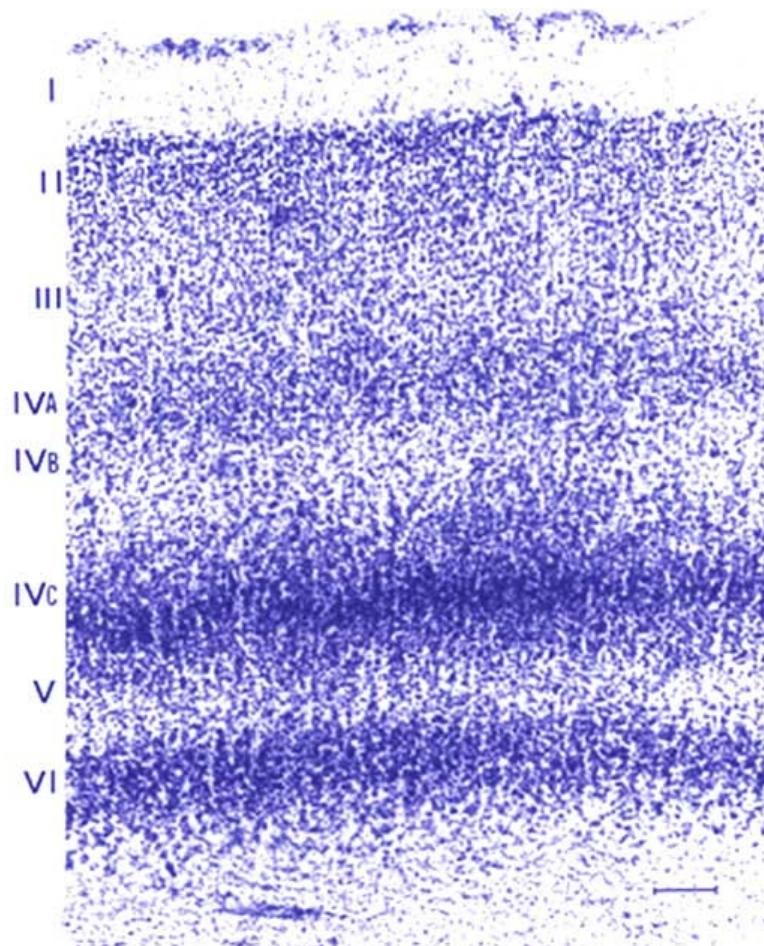
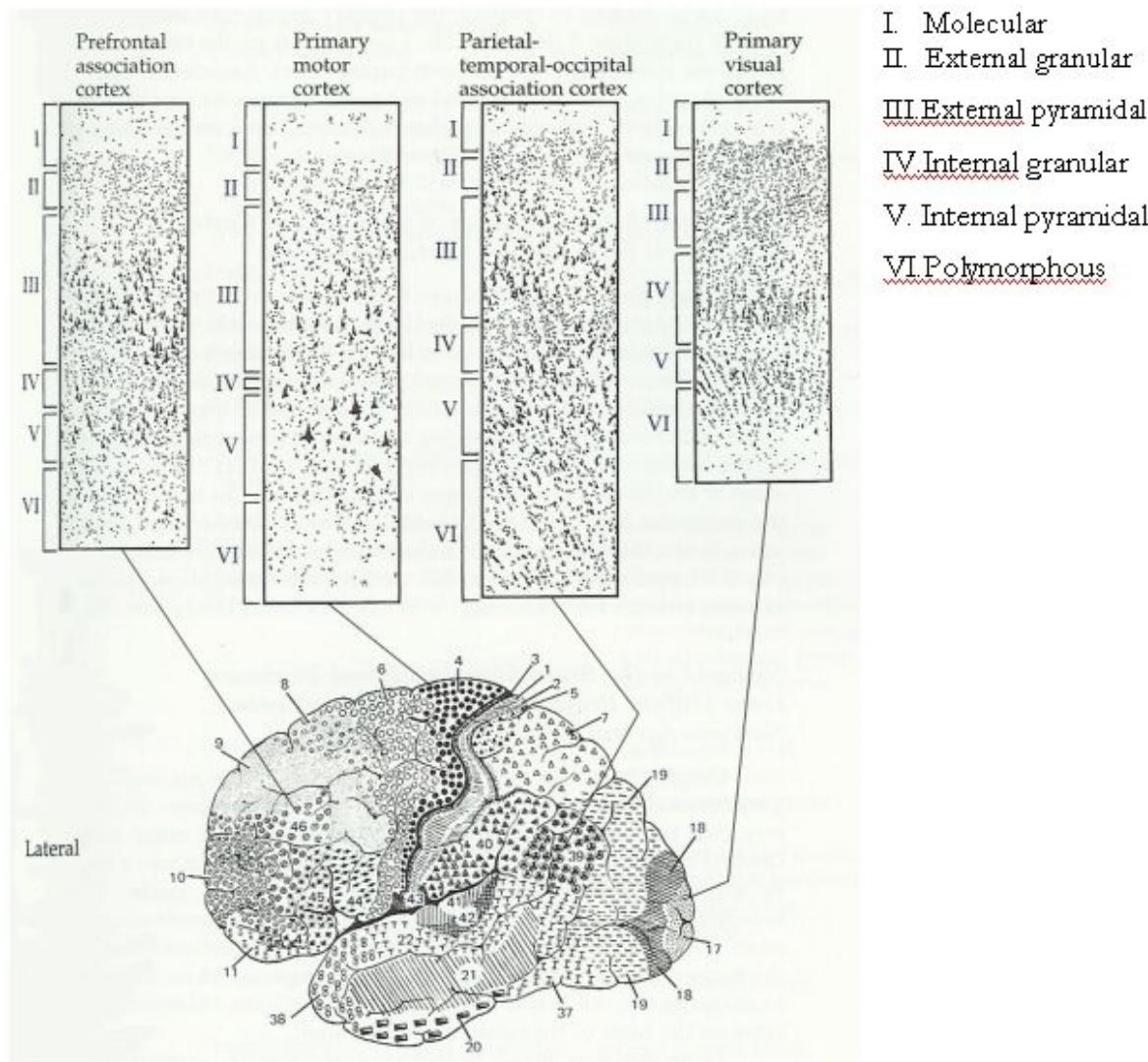
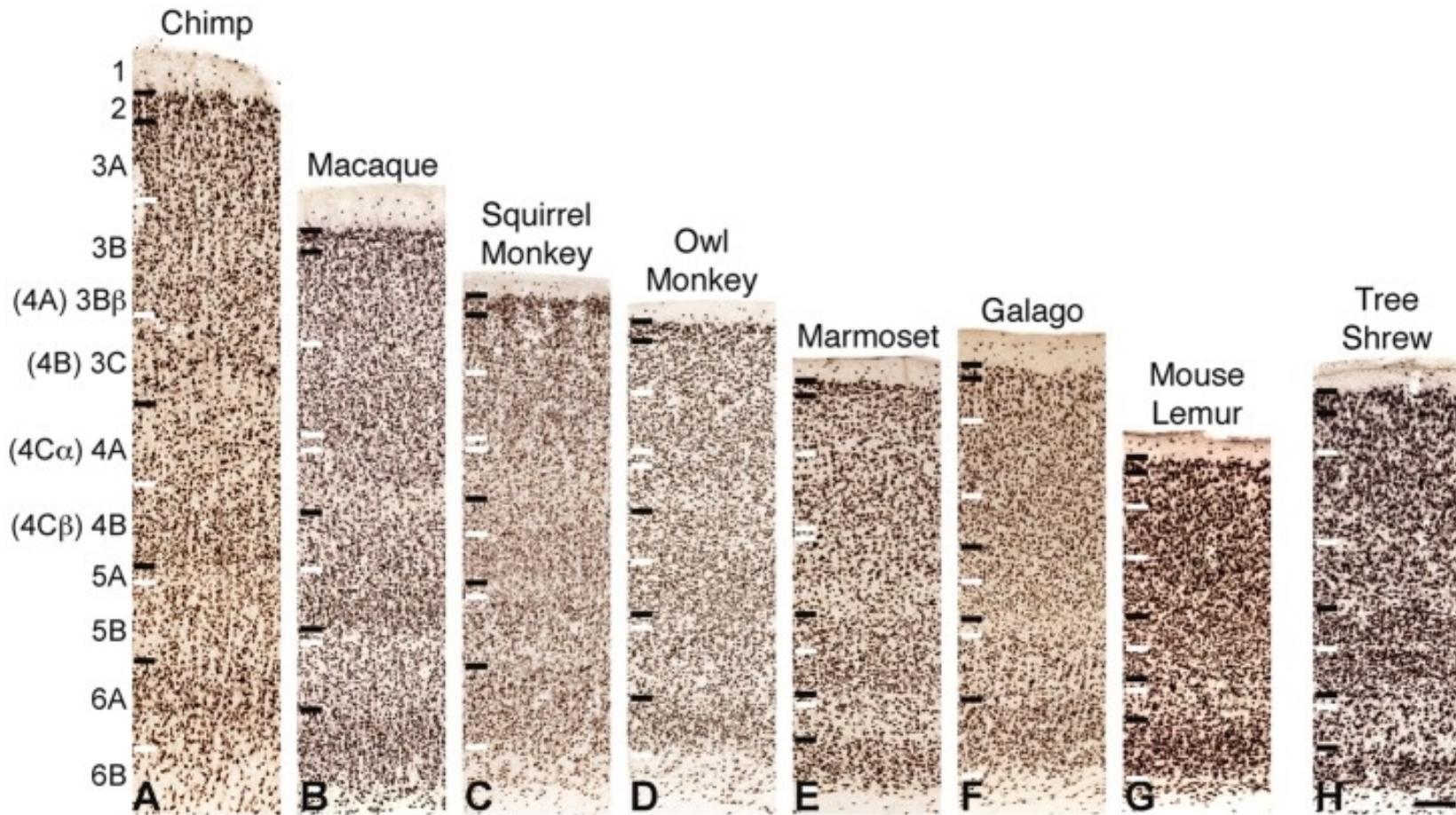


Figure 13. Nissl stain of the visual cortex reveals the different layers I through VI quite clearly.

# Cortical layers – across brain



# Cortical layers – across species



# Cortical layers – neural types

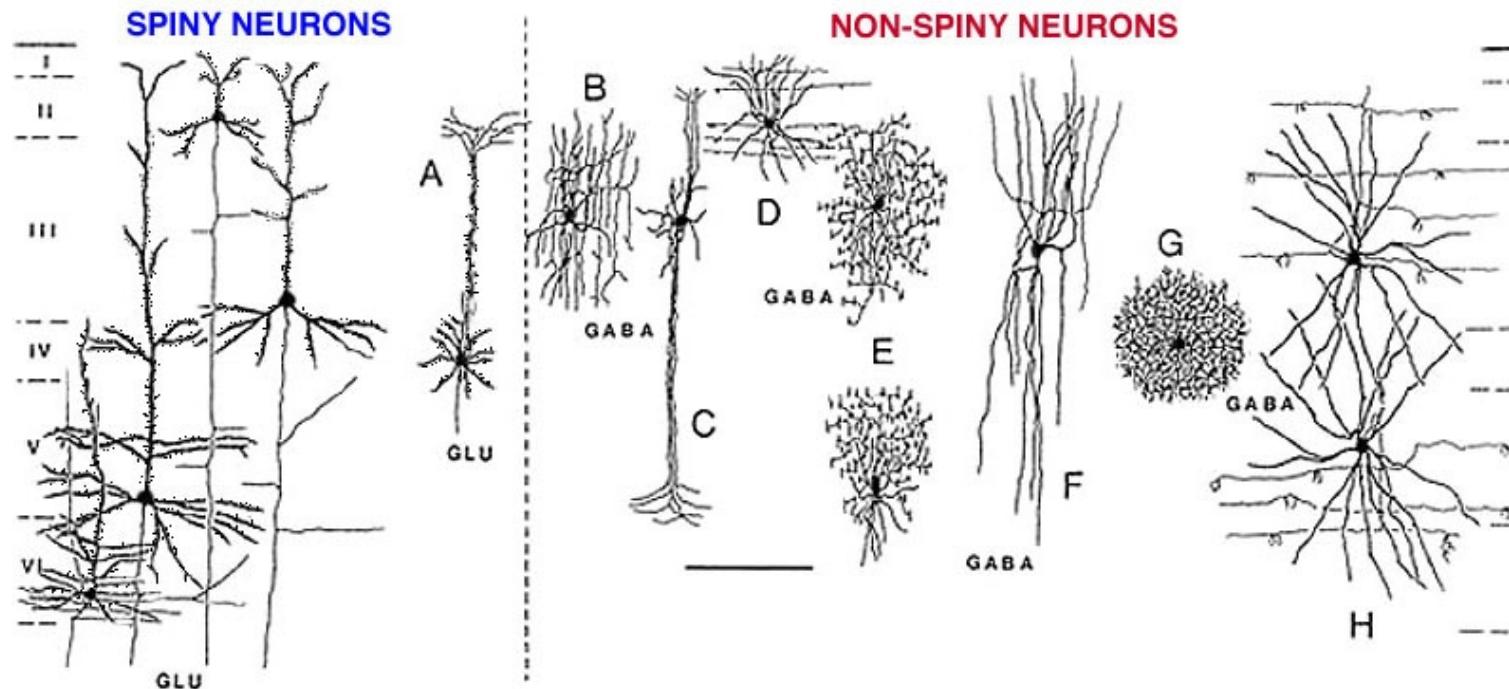
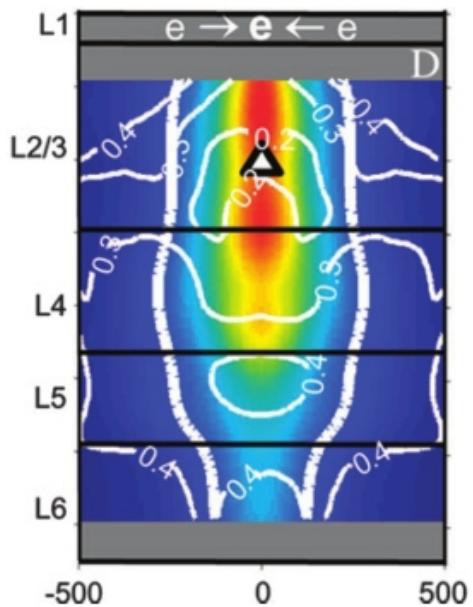
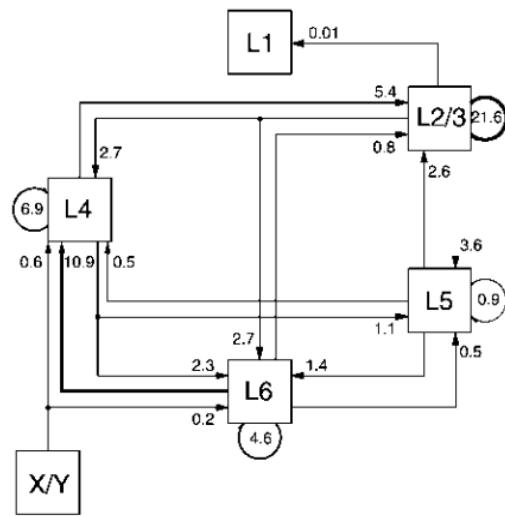


Figure 12. Basic cell types in the monkey cerebral cortex. Left: spiny neurons that include pyramidal cells and stellate cells (A). Spiny neurons utilize the neurotransmitter glutamate (Glu). Right: smooth cells that use the neurotransmitter GABA. B, cell with local axon arcades; C, double bouquet cell; D, H, basket cells; E, chandelier cells; F, bitufted, usually peptide-containing cell; G, neurogliaform cell.

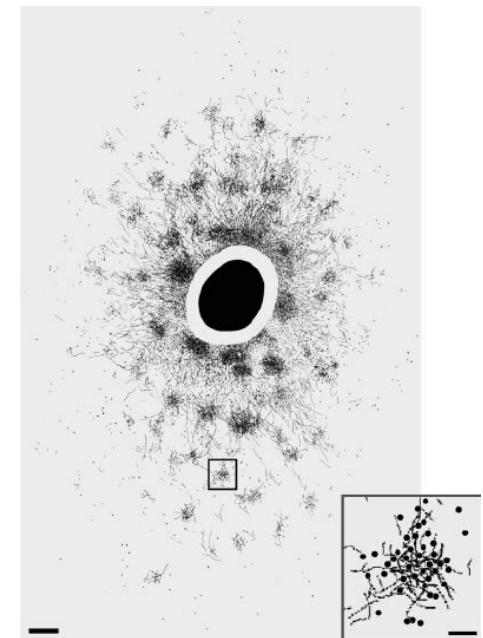
# Connectome of cortical column



Stepanyants et al., 2008, cat

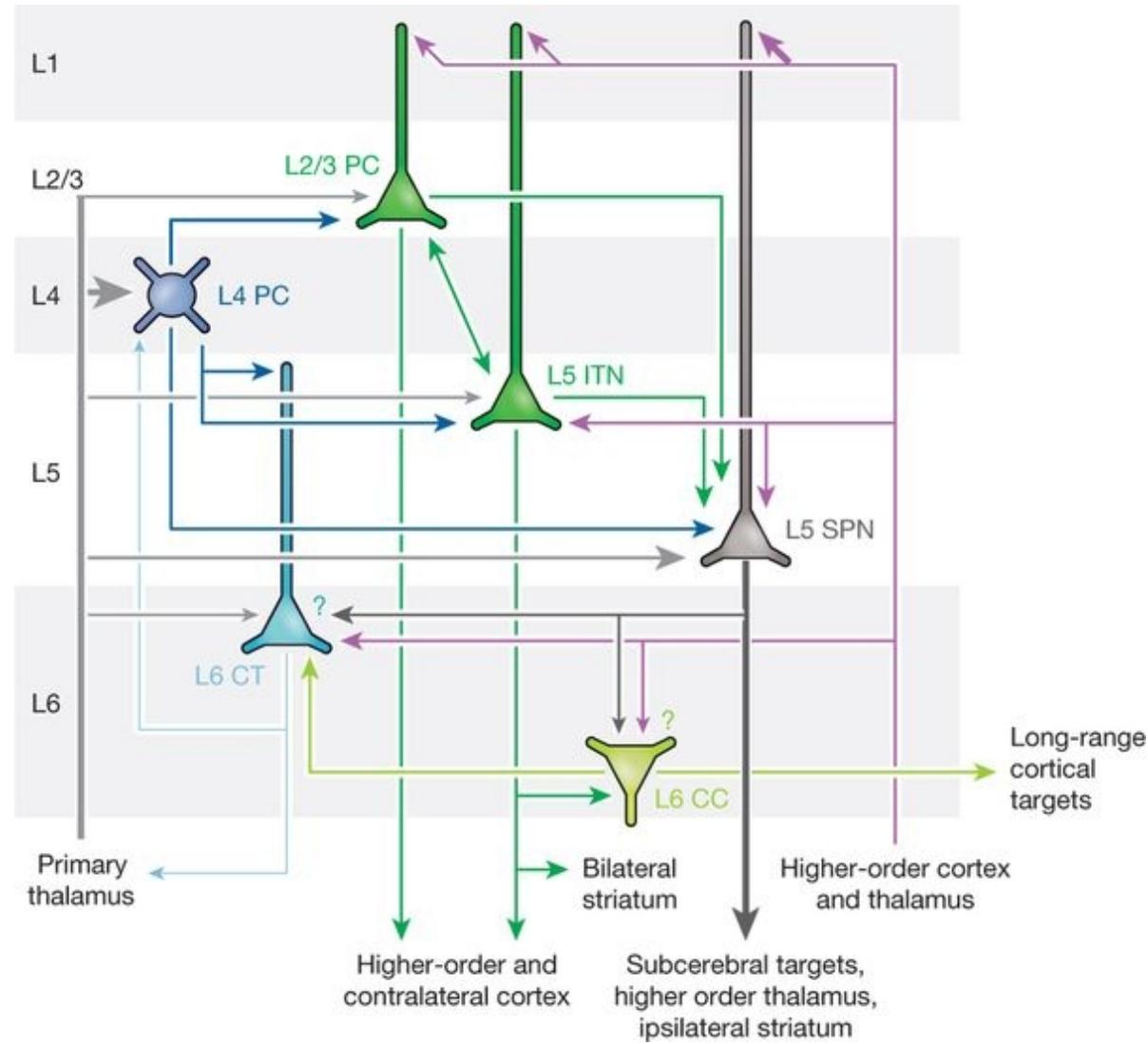


Binzegger et. al. 2004, cat

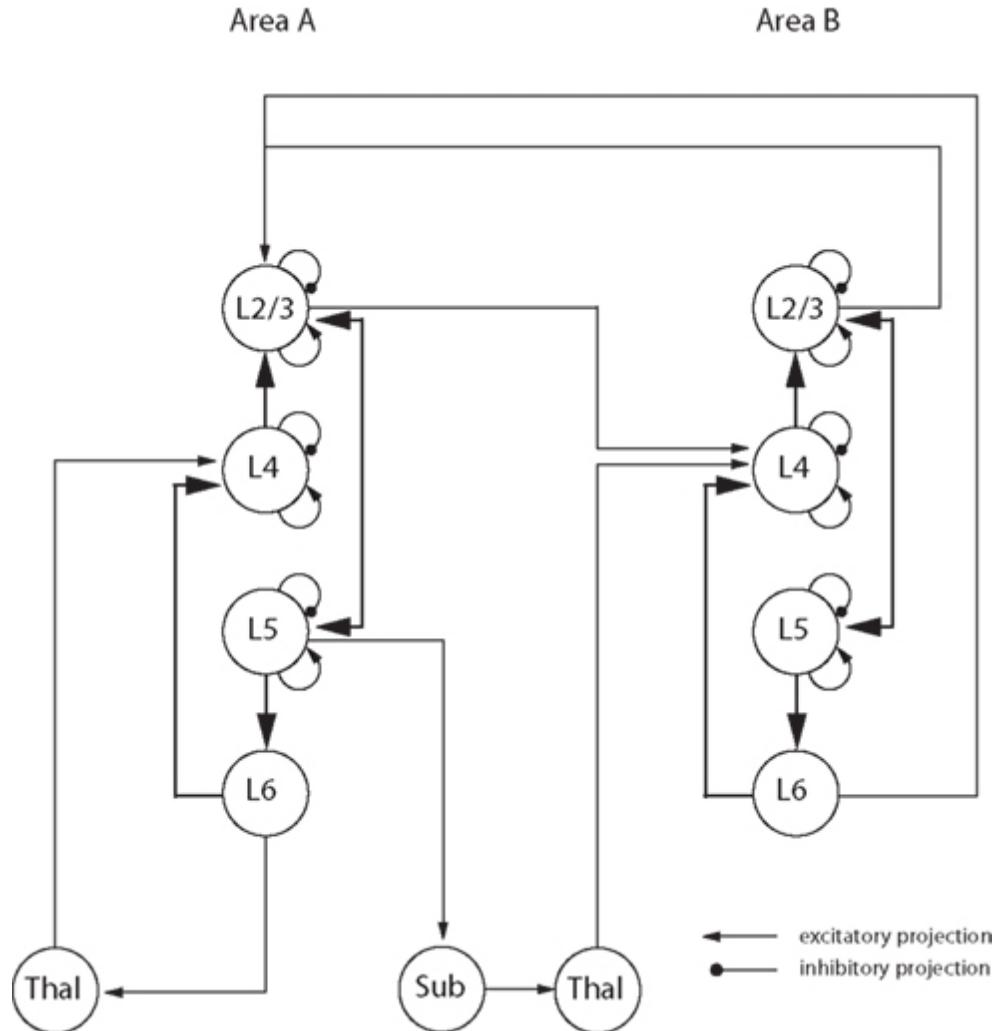


Angelucci lab

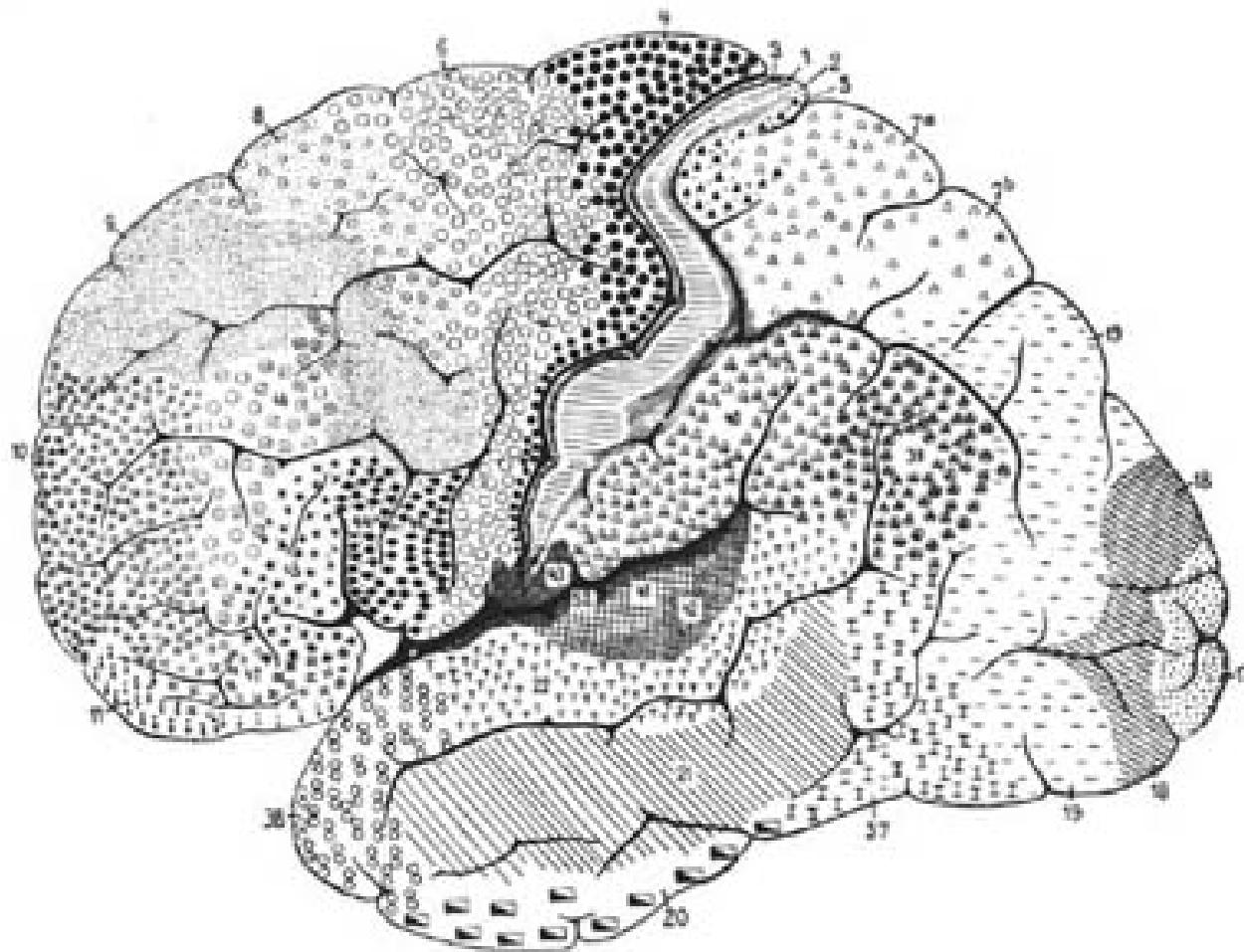
# Connectome of cortical column



# Connectome of cortical column



# Cortical area organization

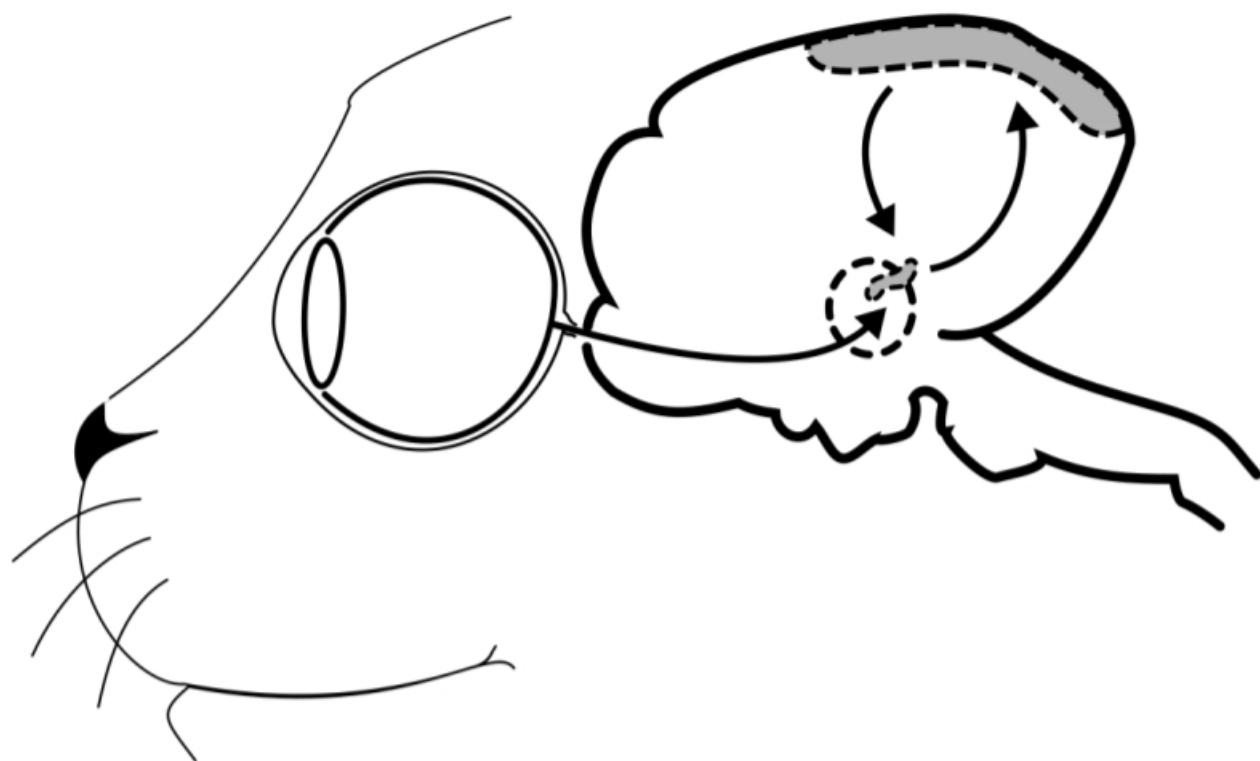


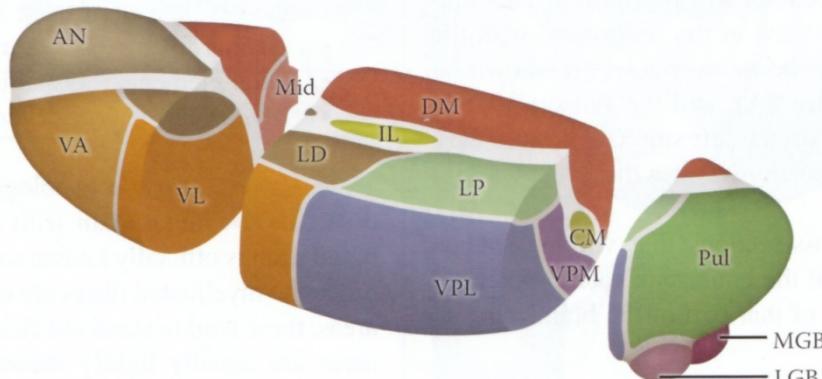
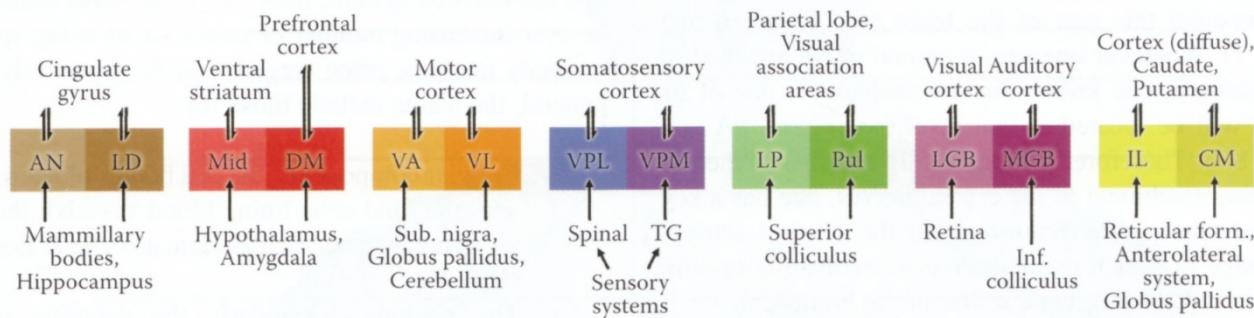
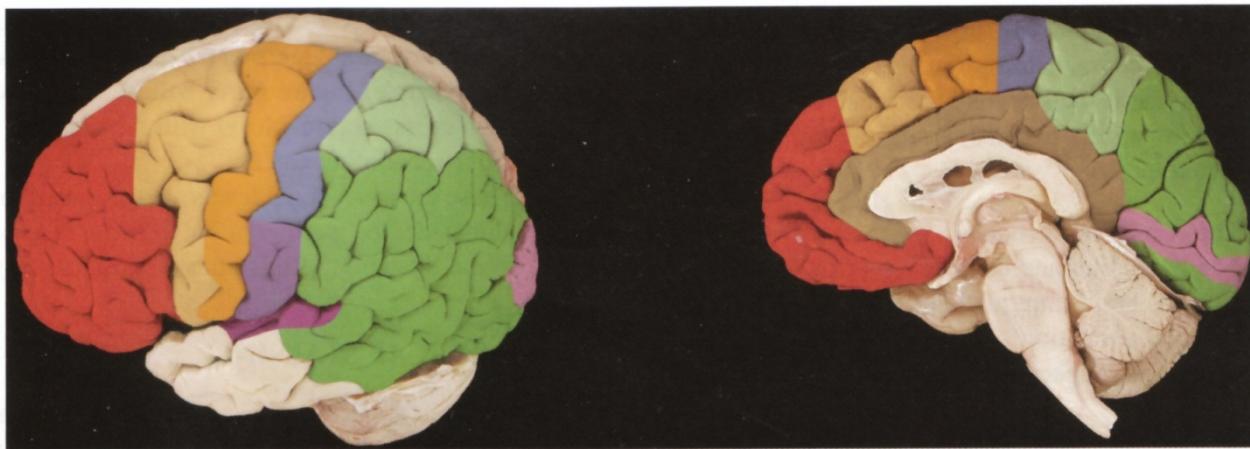
# **Inter-areal connectivity**

## **MRI Tractography**



# Cortico-thalamic connectivity





AN = Anterior nn.

LD = Lateral dorsal n.

LP = Lateral posterior n.

Pul = Pulvinar

DM = Dorsomedial n.

Mid = Midline nn.

VA = Ventral anterior n.

VL = Ventral lateral n.

VPL = Ventral posterolateral n.

VPM = Ventral posteromedial n.

LGB = Lateral geniculate body

MGB = Medial geniculate body

IL = Intralaminar nn.

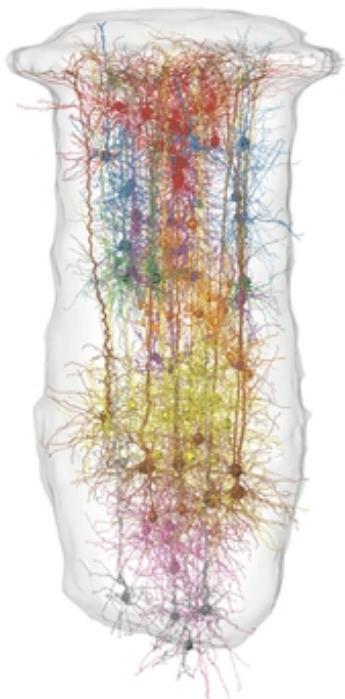
CM = Centromedian n.

# Cortical Architecture in Models

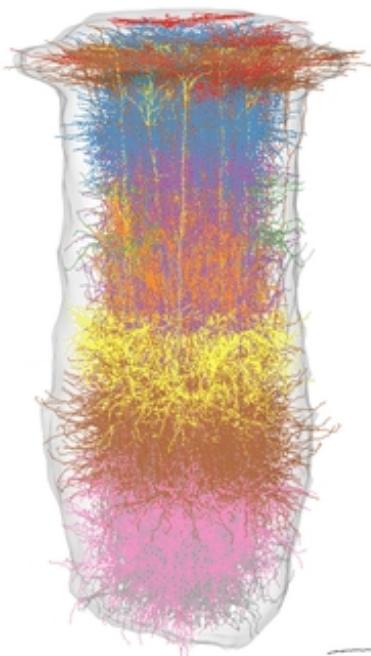
# Model types

- Approach
  - Data-driven
  - Hypothesis-driven
  - Function-driven
- Level-of-detail
  - Biophysical
  - Point neuron
  - Rate-models
  - Mean-field approximations

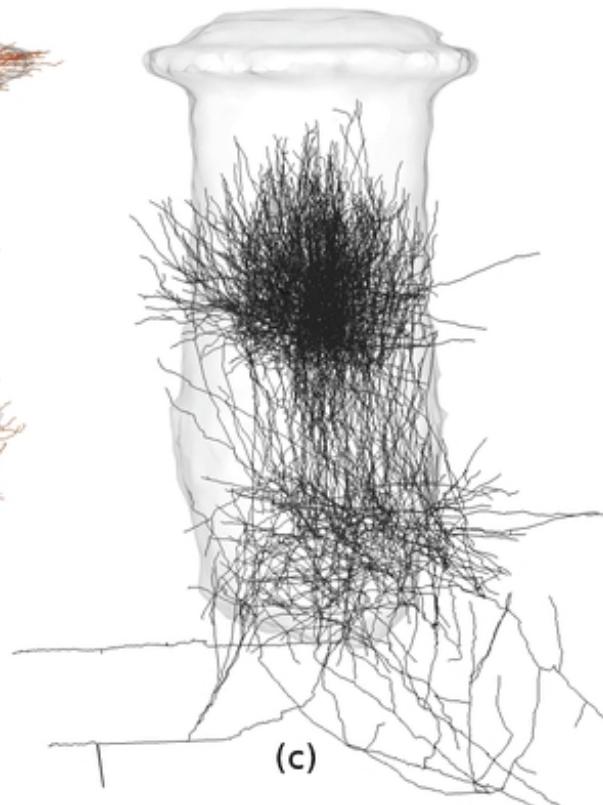
# Models of cortical column



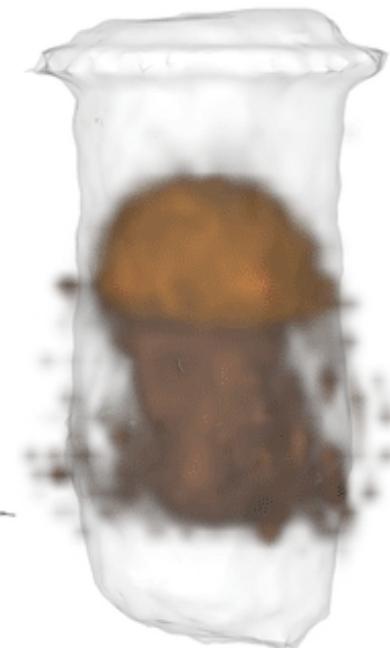
(a)



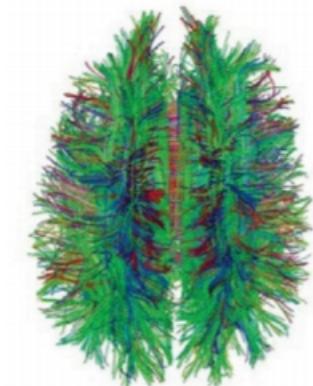
(b)



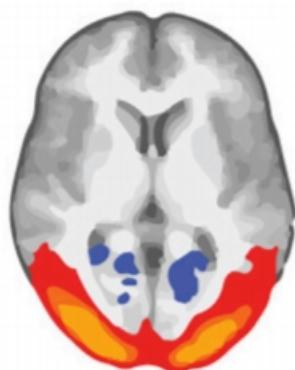
(c)



(d)

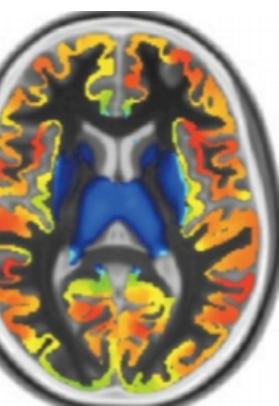
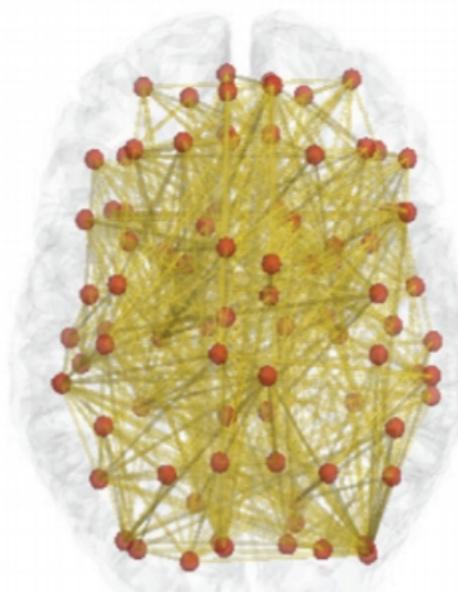


Connectivity  
(dMRI)



Functional brain dynamics  
(fMRI)

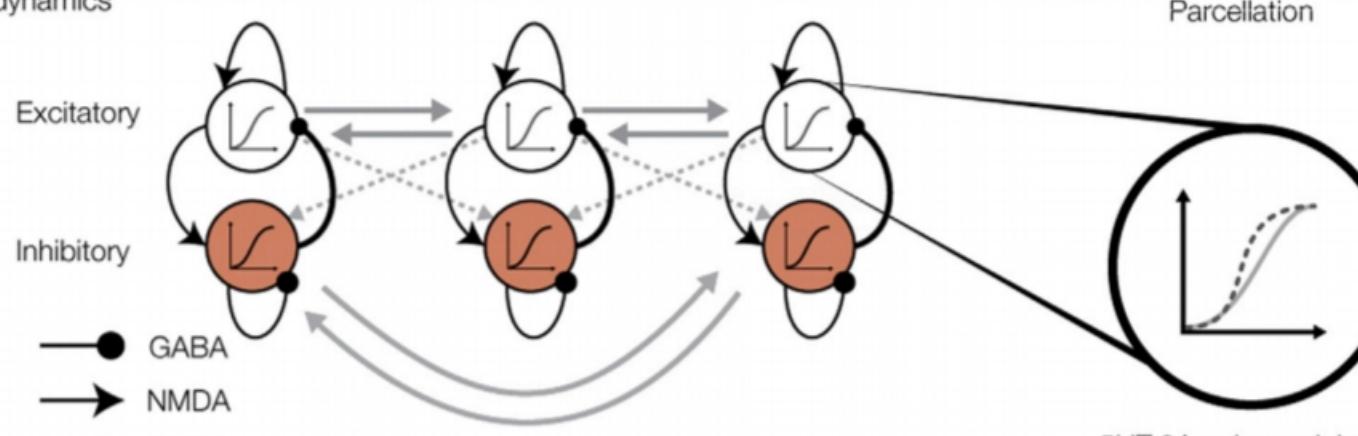
Whole-brain  
model



Neurotransmitter  
(PET)



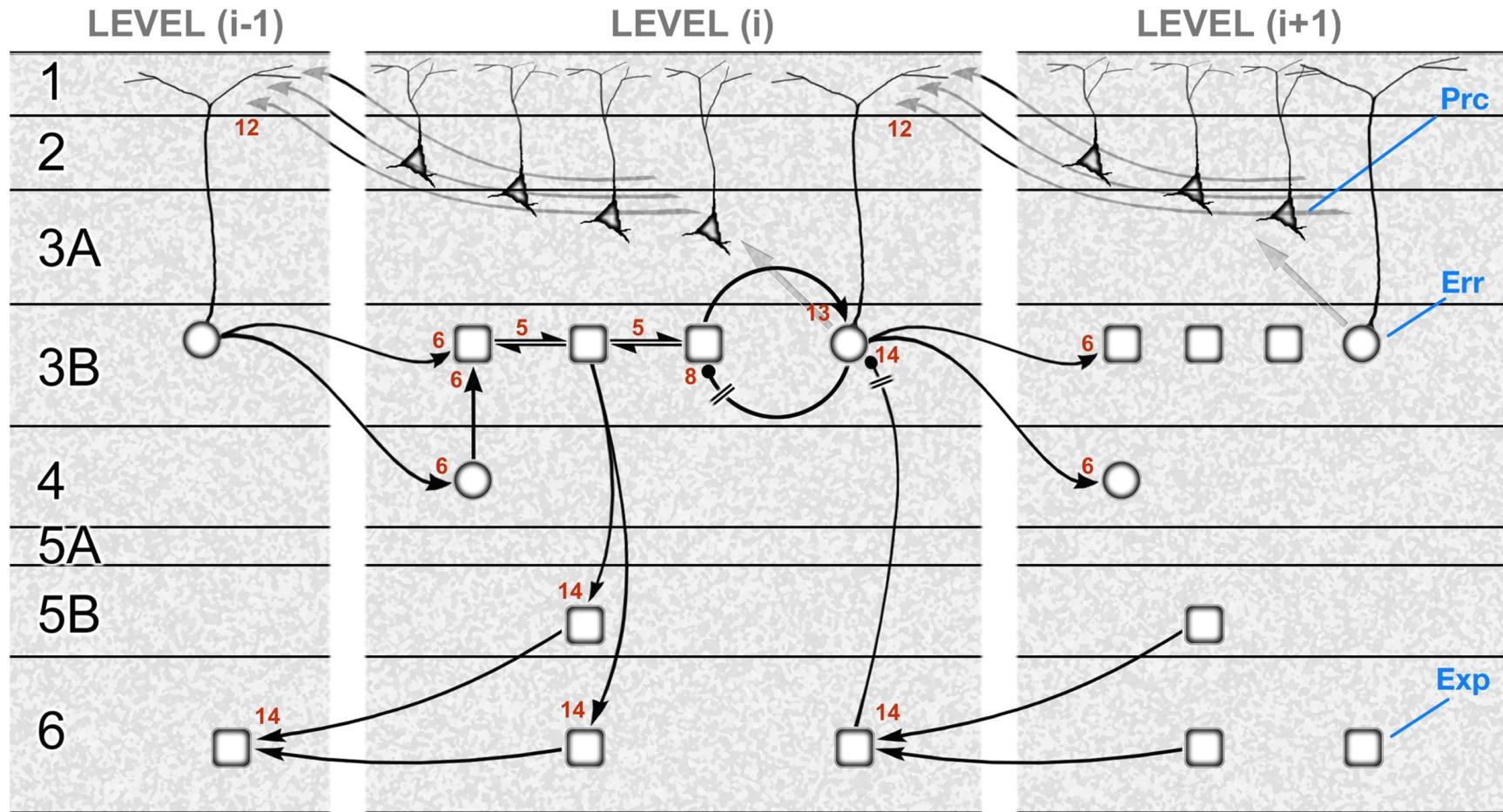
Parcellation



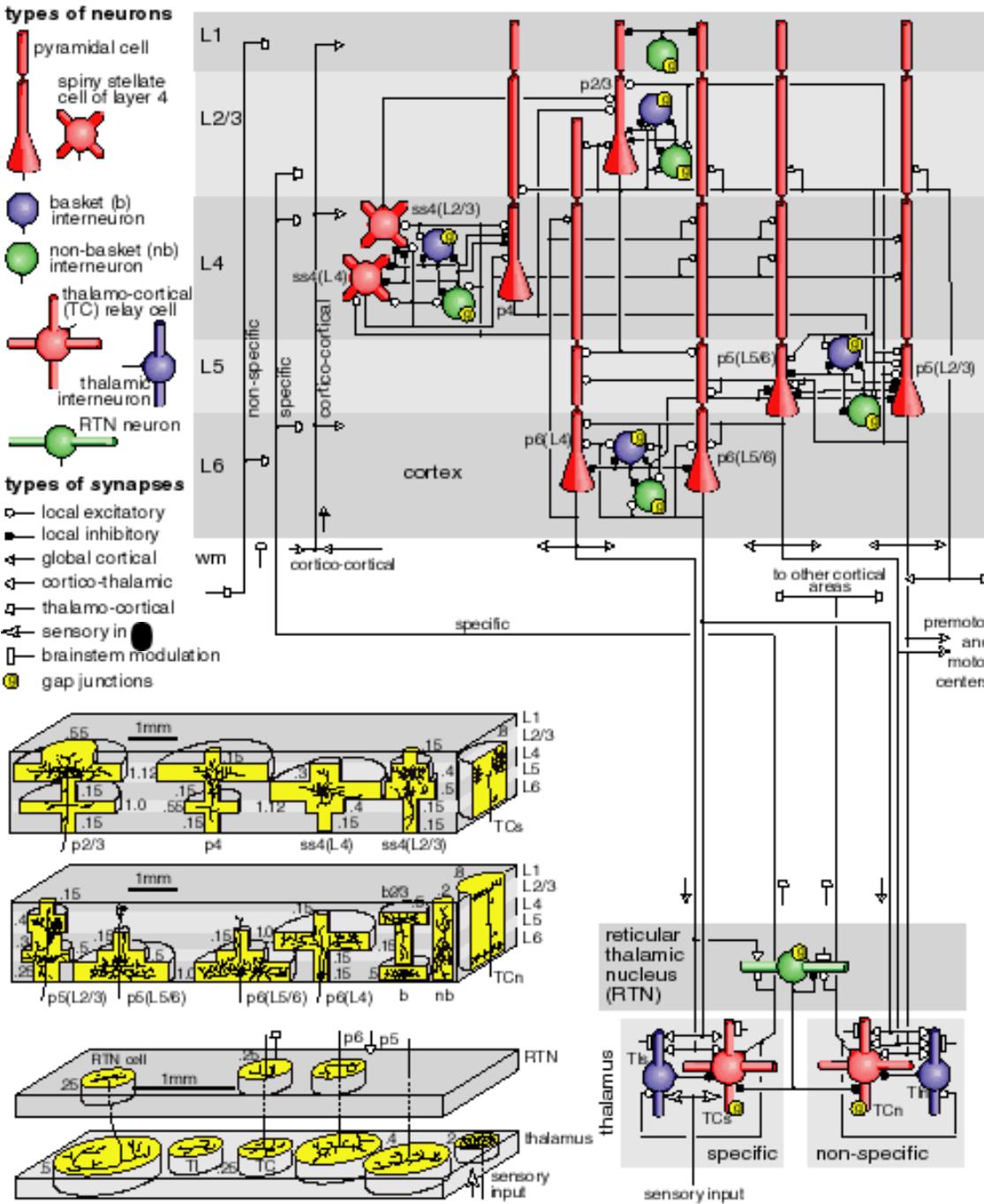
Balanced dynamic mean field model

5HT-2A gain modulation

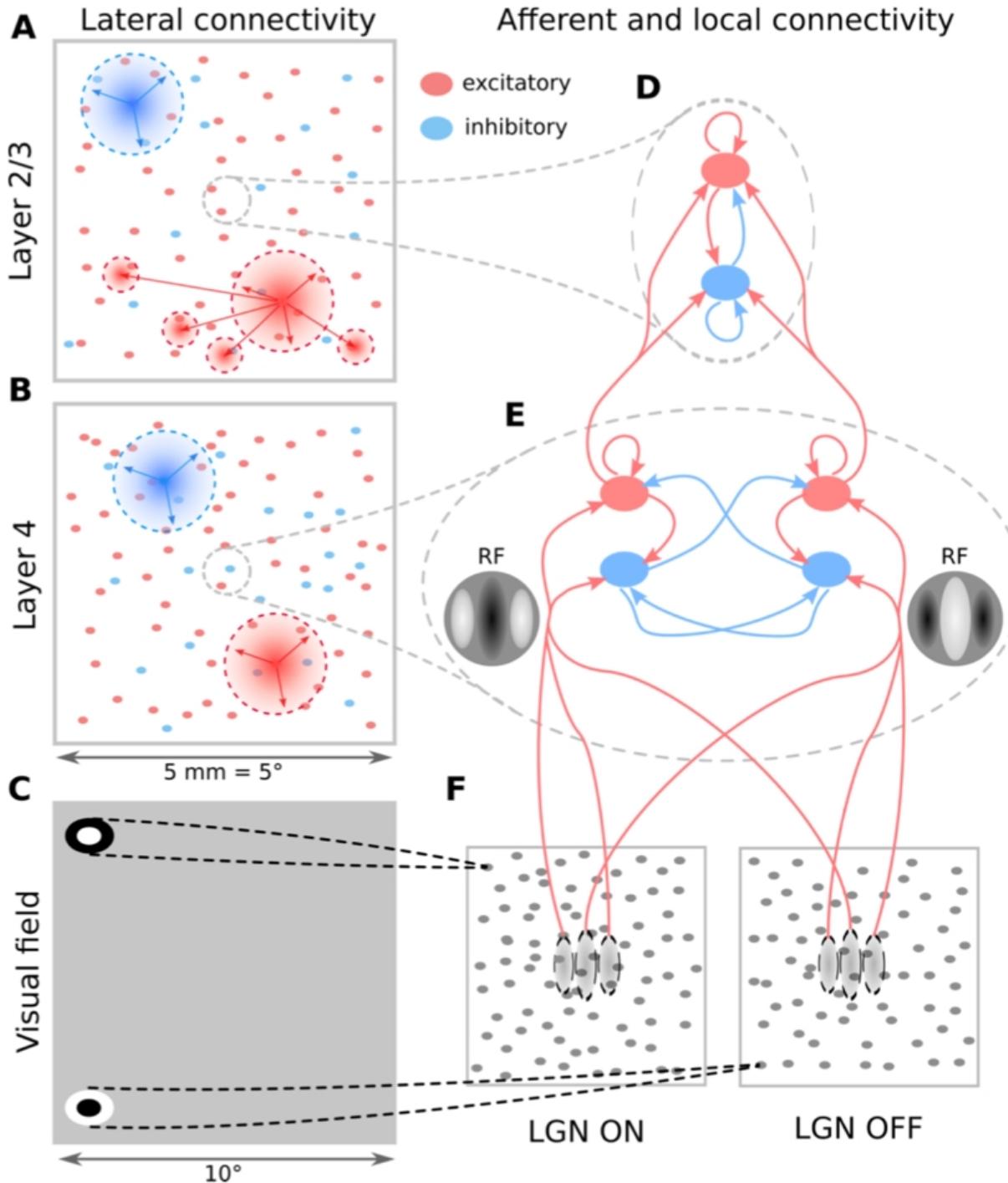
# Neural elements of predictive coding



# Izhikevich brain model



# Models of visual system in our group



**END**