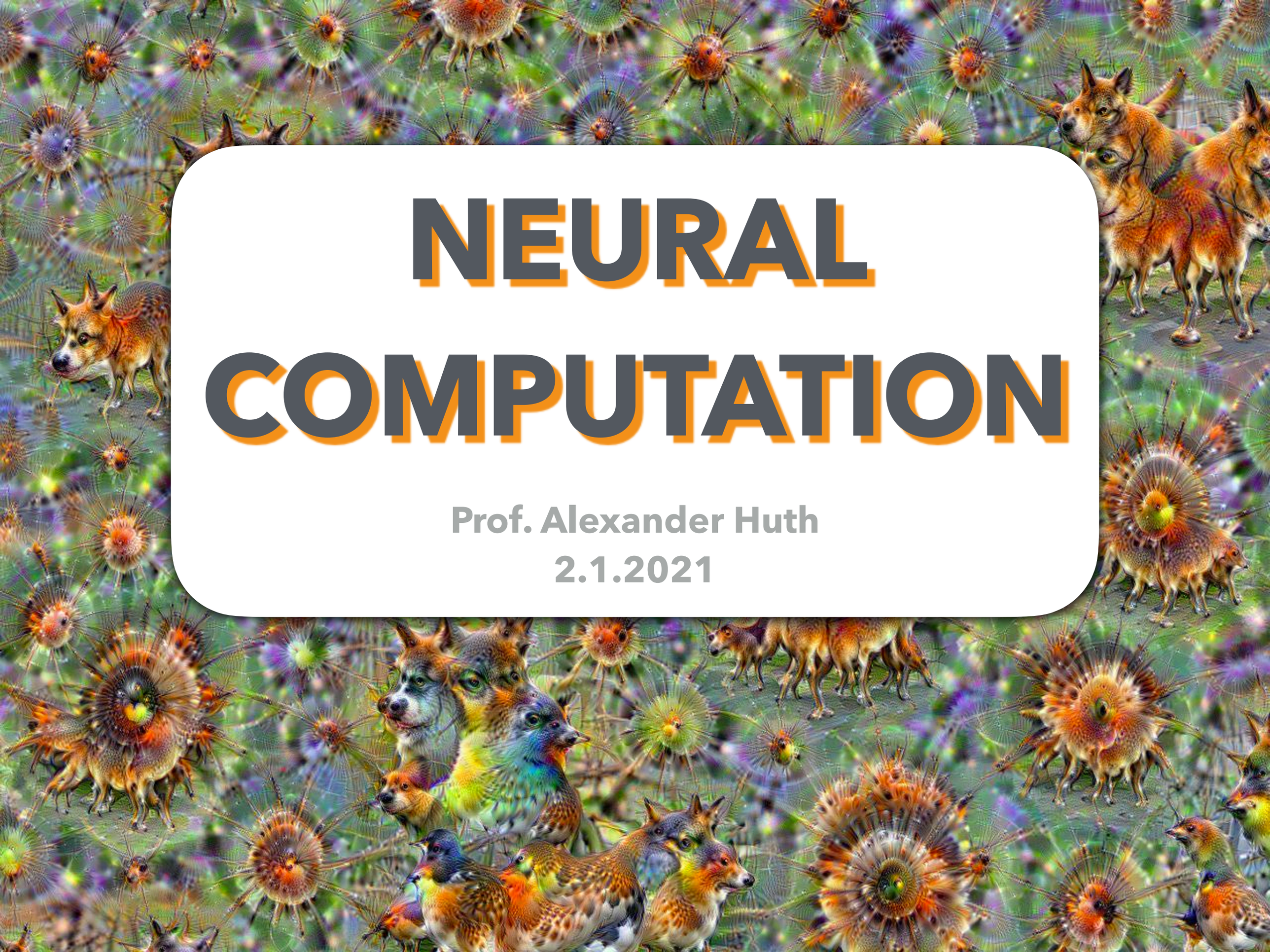


NEURAL COMPUTATION

Prof. Alexander Huth

2.1.2021

LAST TIME

* synaptic plasticity

* homeostasis

* hebbian learning & how to fix it

PAPER PRESENTATIONS :)

* For **Wednesday**, I'm asking for 1-2 volunteers to (briefly) present a paper to the class!

  * Presentation should be ≤2 slides and take ≤15 minutes total

* Two suggested papers are posted on Canvas

* If you want to volunteer, respond to the announcement on Canvas

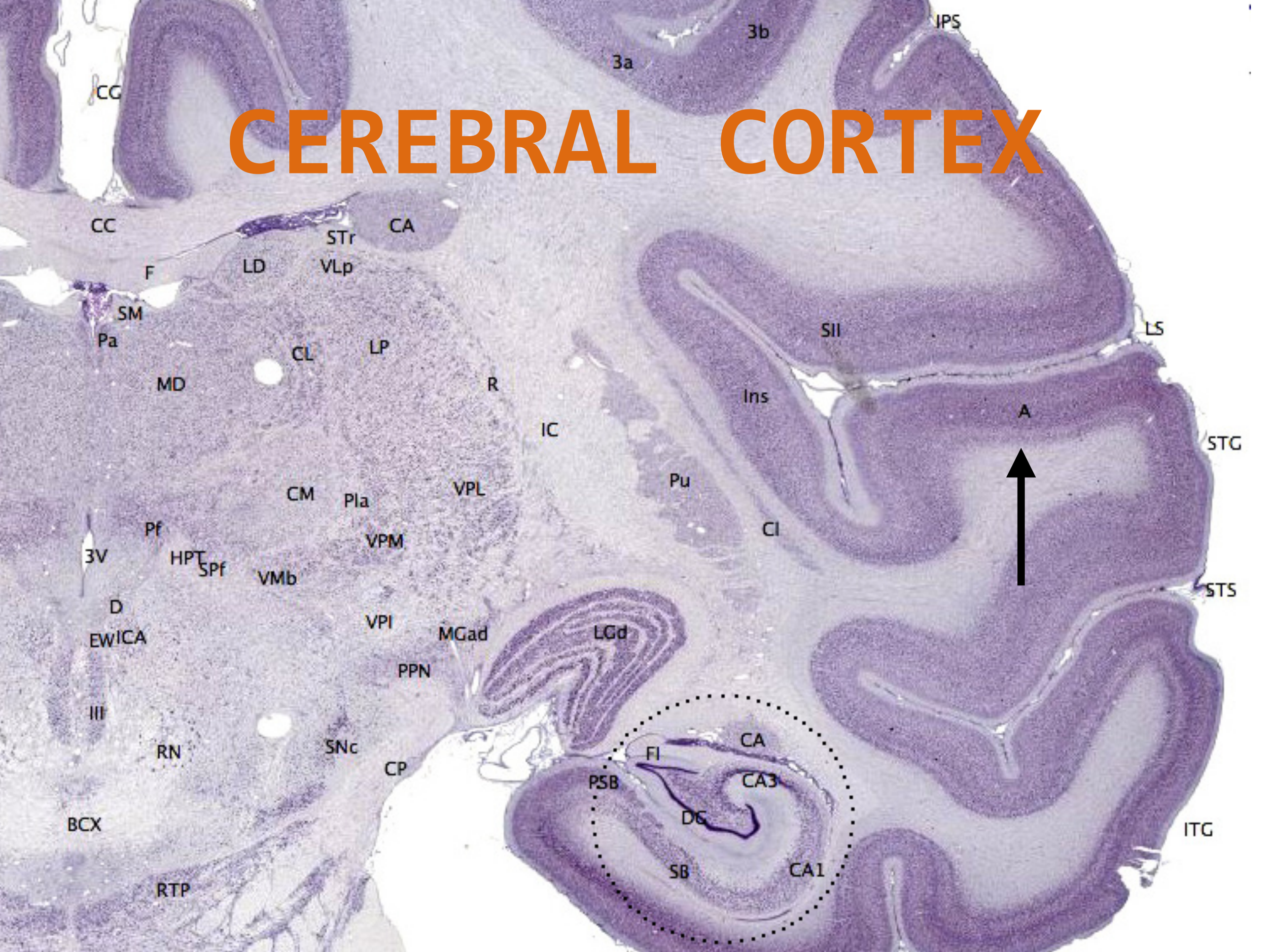
* If nobody volunteers, I'll volun-tell some folks at random

TODAY

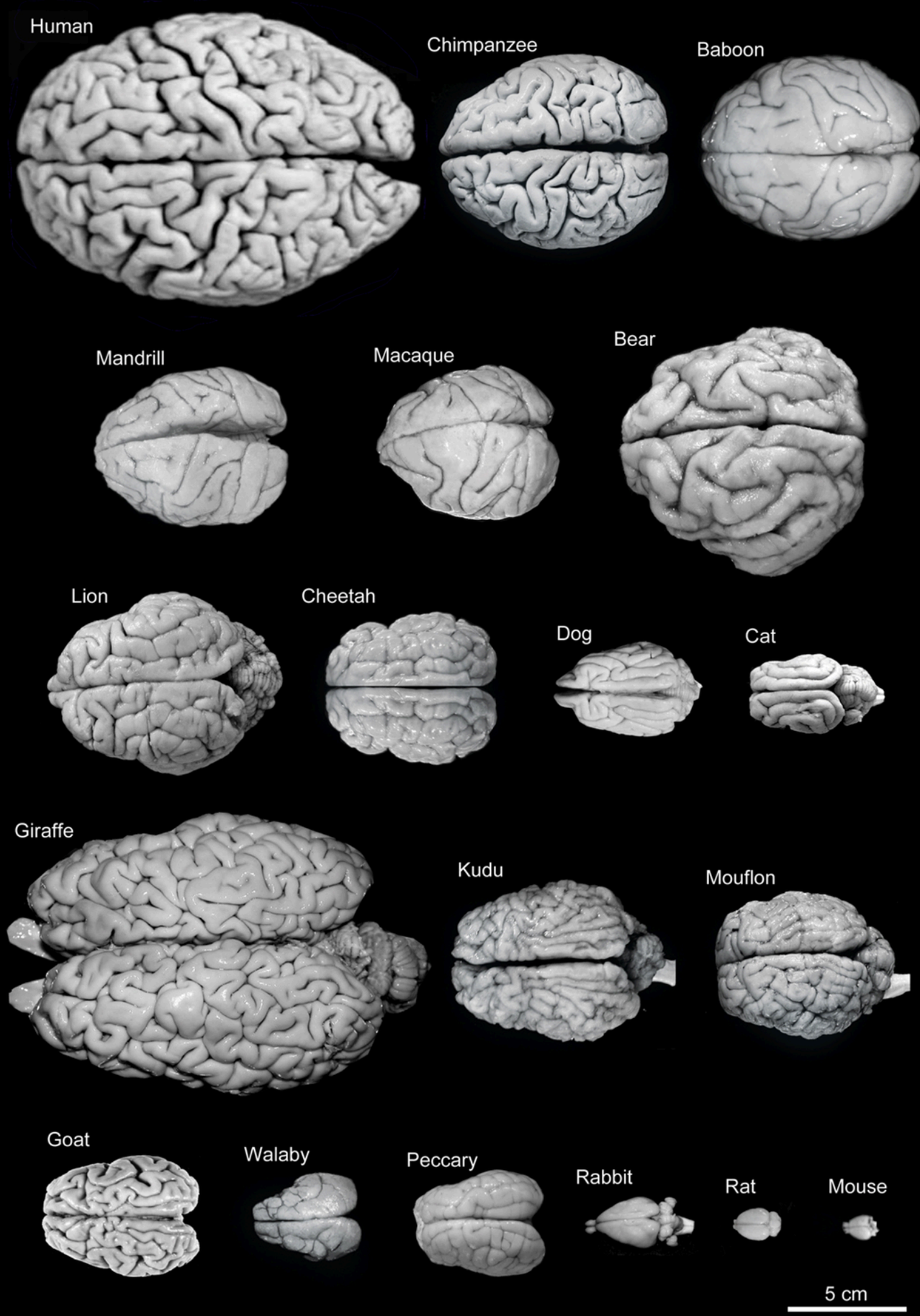
* cerebral cortex / neocortex

* cortical cell types

CEREBRAL CORTEX



CORTEX

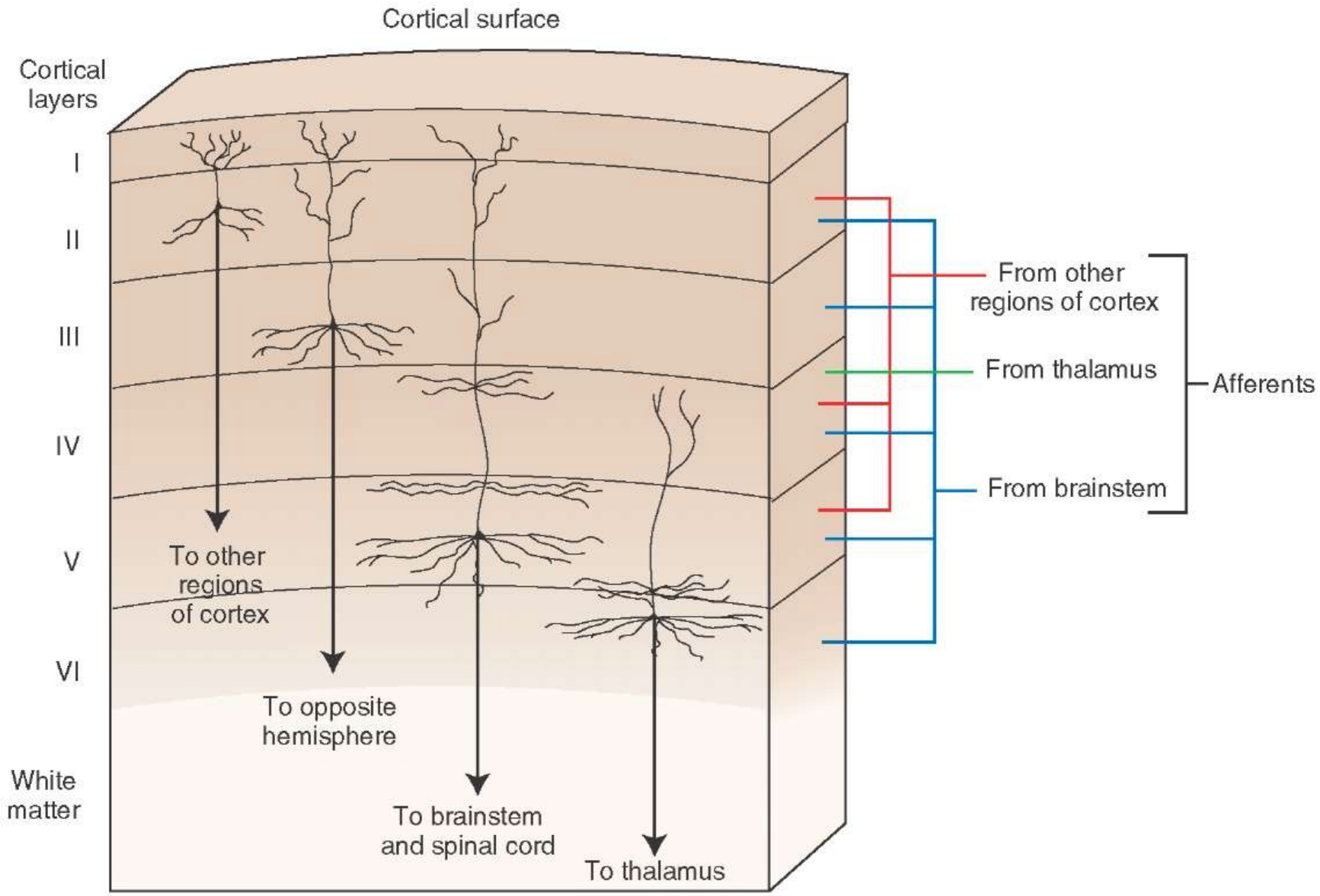

Human
Chimpanzee
Baboon
Mandrill
Macaque
Bear
Lion
Cheetah
Dog
Cat
Giraffe
Kudu
Mouflon
Goat
Walaby
Peccary
Rabbit
Rat
Mouse
5 cm

CEREBRAL CORTEX

* Common to all mammals
* Thin sheet of neural tissue (2-5 mm thick in humans)
* Each hemisphere of human cortex has surface area of ~1.3 sq ft (0.12 sq m)

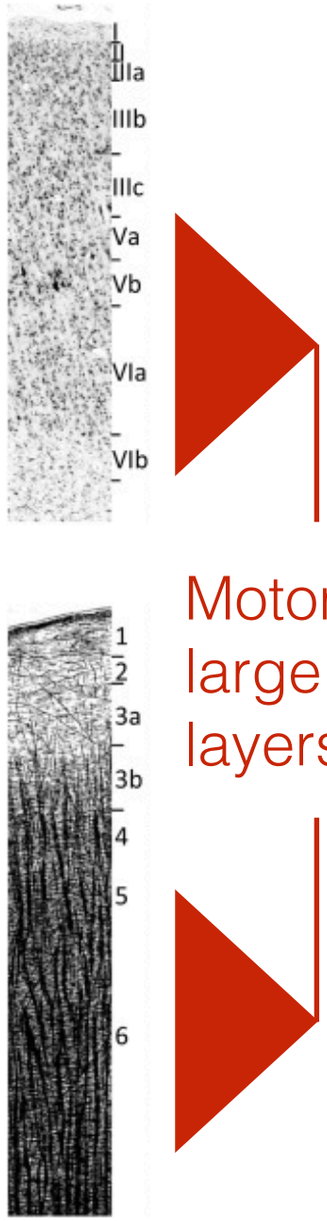
CEREBRAL CORTEX

* *Vaguely* stereotypical 6-layer structure



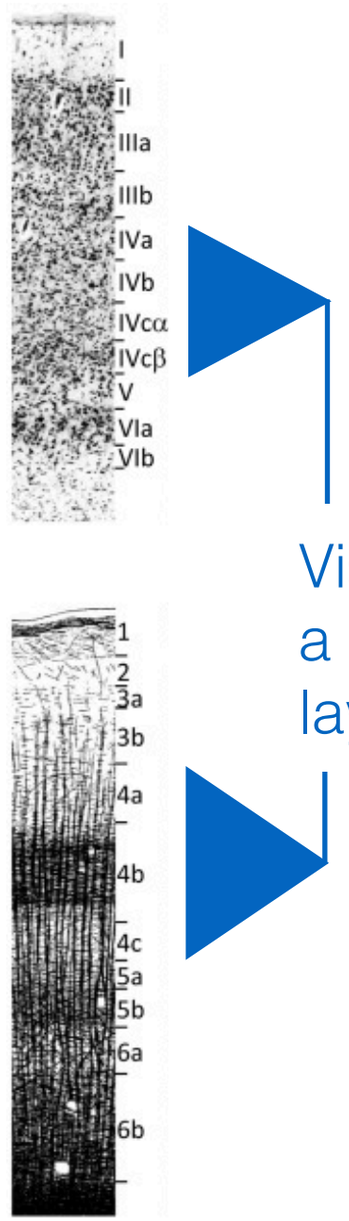
CEREBRAL CORTEX

* But layer structure differs across areas!



M1

Motor cortex has large output layers (V and VI)



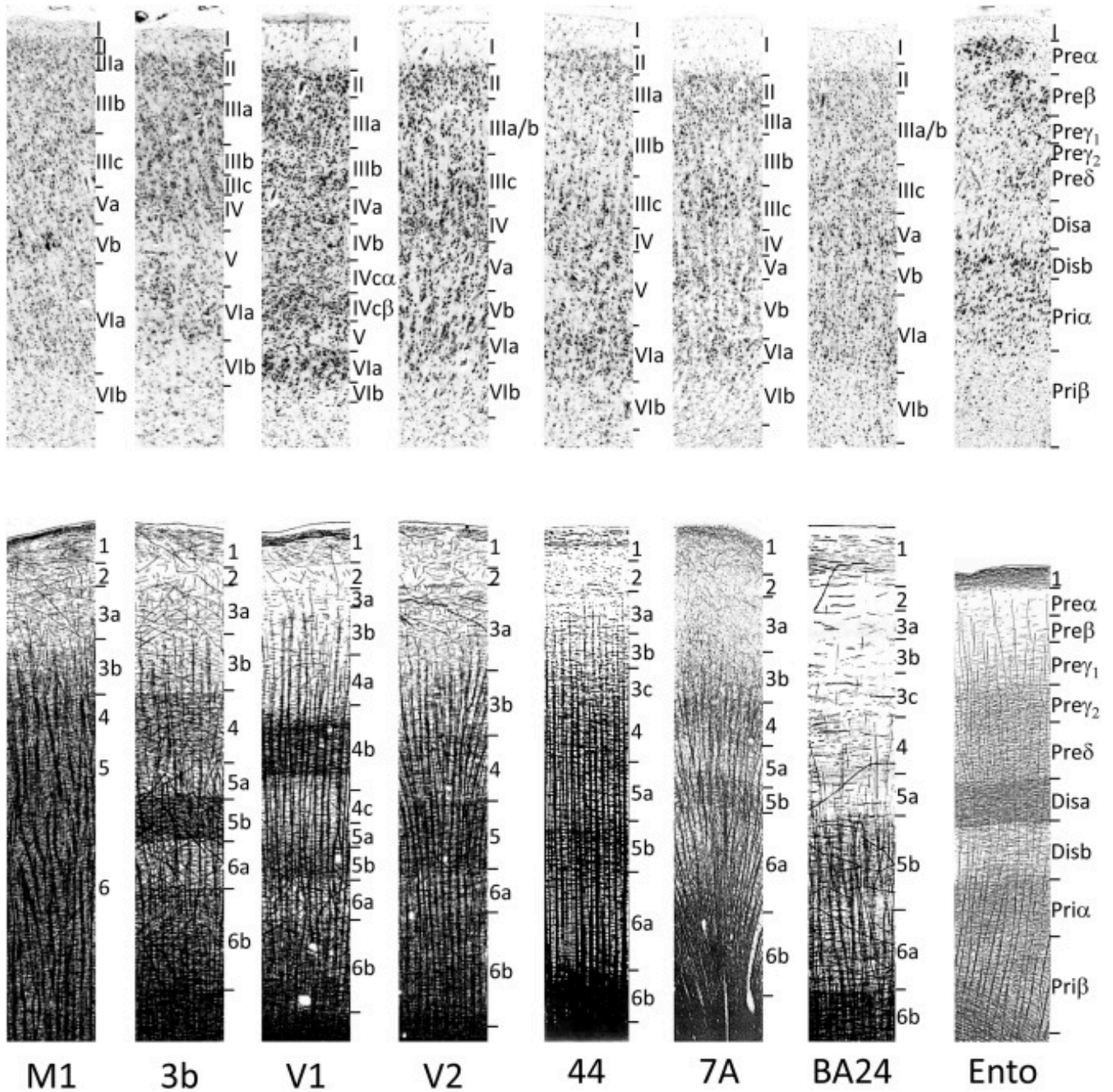
V1

Visual cortex has a larger *input* layer (IV)

From https://www.sciencedirect.com/science/article/pii/S1053811917306821

CEREBRAL CORTEX

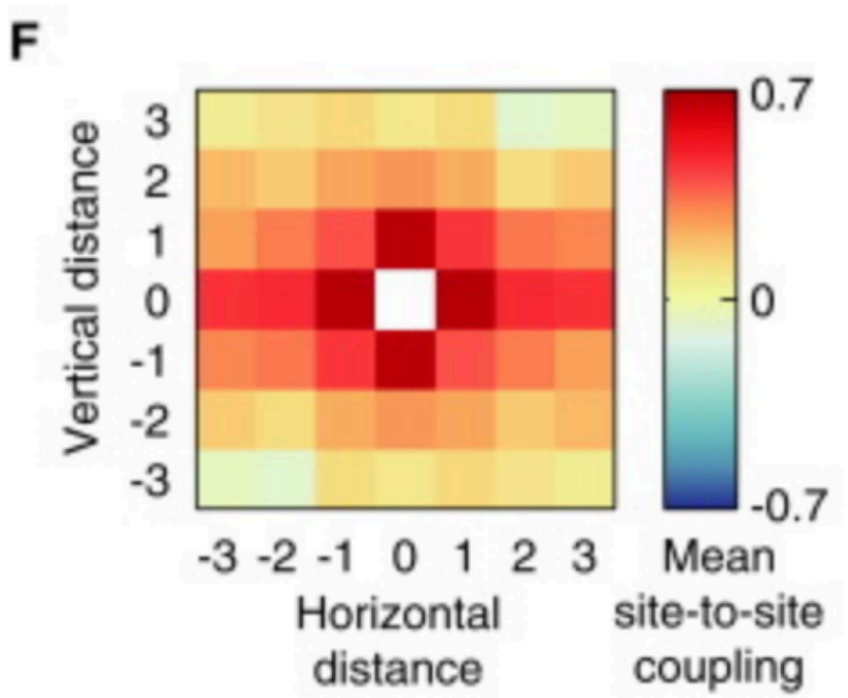
* There's a lot of diversity over the cortex!



From https://www.sciencedirect.com/science/article/pii/S1053811917306821

CEREBRAL CORTEX

* Neurons preferentially make connections *vertically* (i.e. with nearby neurons in other layers) and *horizontally* (i.e. with neurons in the same layer), but are less likely to make *diagonal* connections



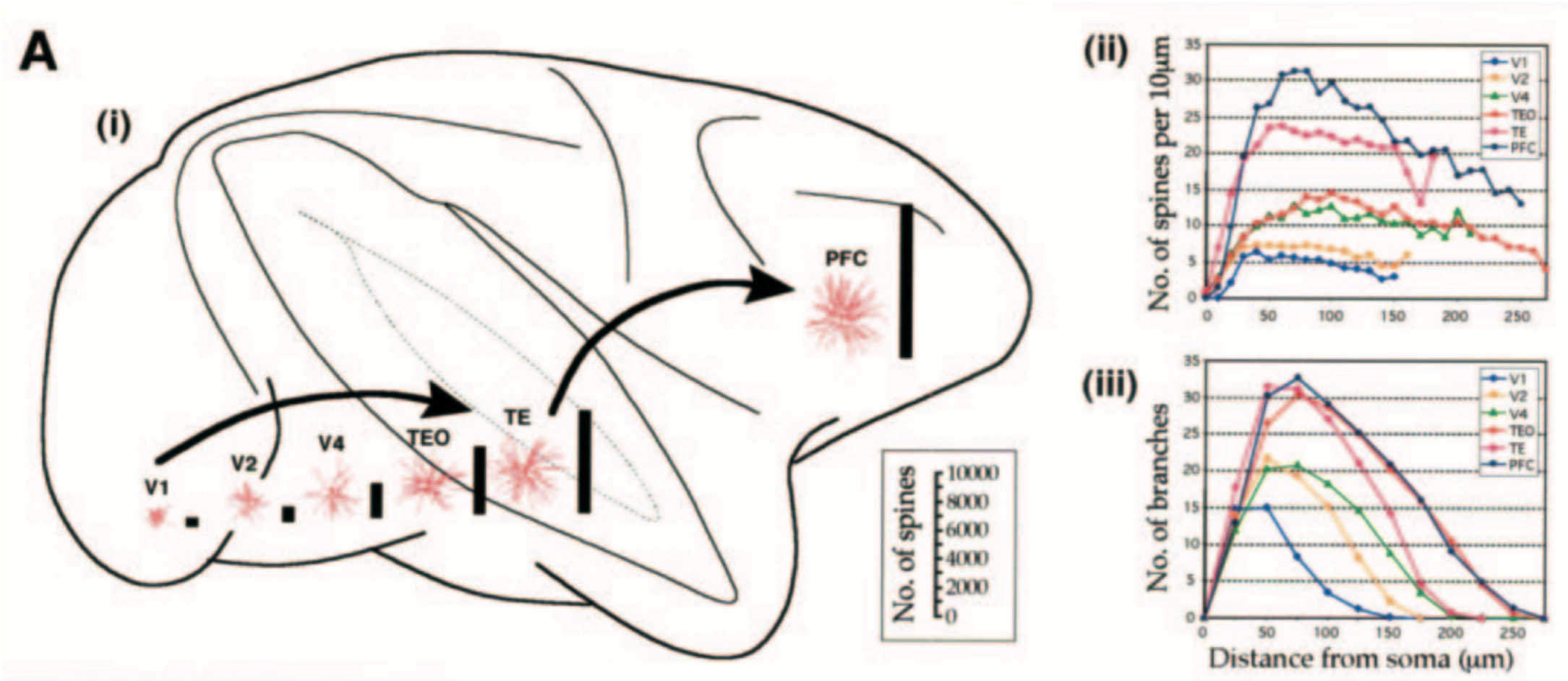
Hamilton, 2013

CEREBRAL CORTEX

* .. Leading some suggest that the “cortical column” (rather than the neuron) is the elementary unit of computation in mammalian brains (Mountcastle)

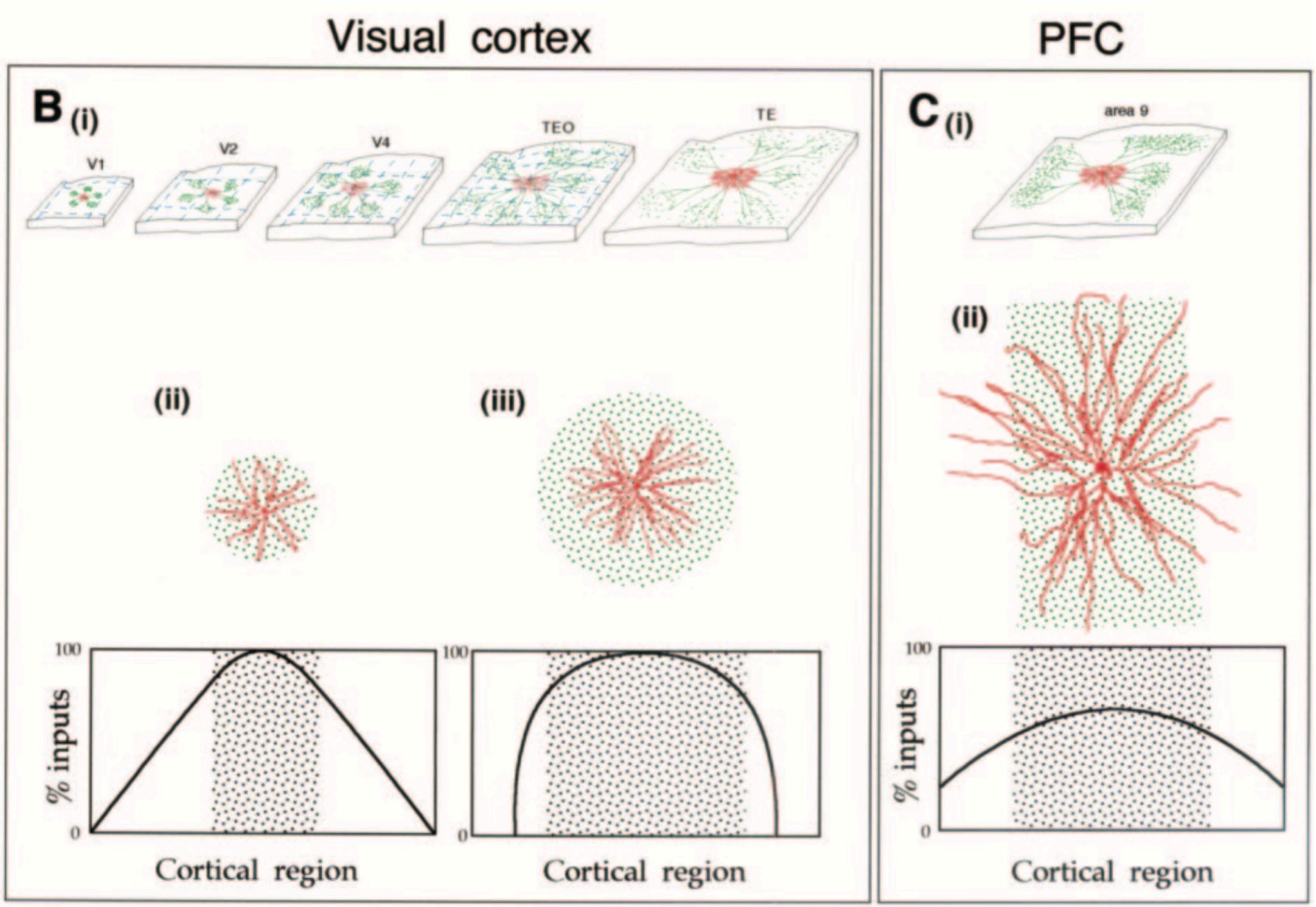
CEREBRAL CORTEX

* Dendritic arbor size varies across cortex



Elston, 2003

CEREBRAL CORTEX



Elston, 2003

CEREBRAL CORTEX

* Cortex is (roughly) a 2.5-D lattice of neurons

* Neurons in different areas have different connectivity patterns. *(Does this lead to different computational functions?)*

CELL TYPES

* Traditional idea:
  * ~1 type of excitatory cell (pyramidal), a few types of inhibitory cells (basket, chandelier, etc.)

CELL TYPES

* How do we know about different cell types?

* Physiological properties

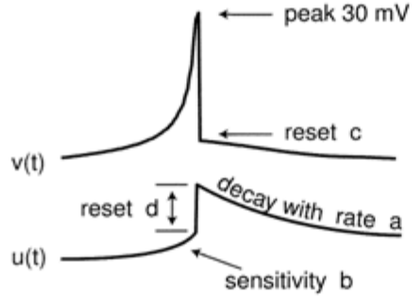
* Morphology (aka shape)

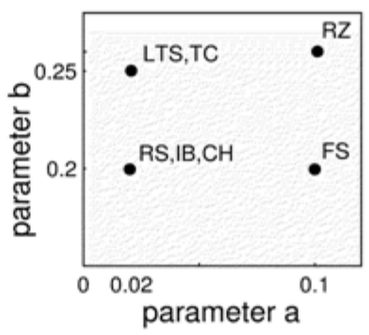
* …?

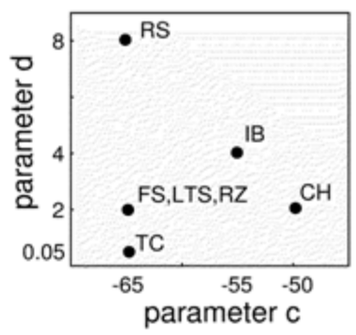
PHYSIOLOGICAL PROPERTIES

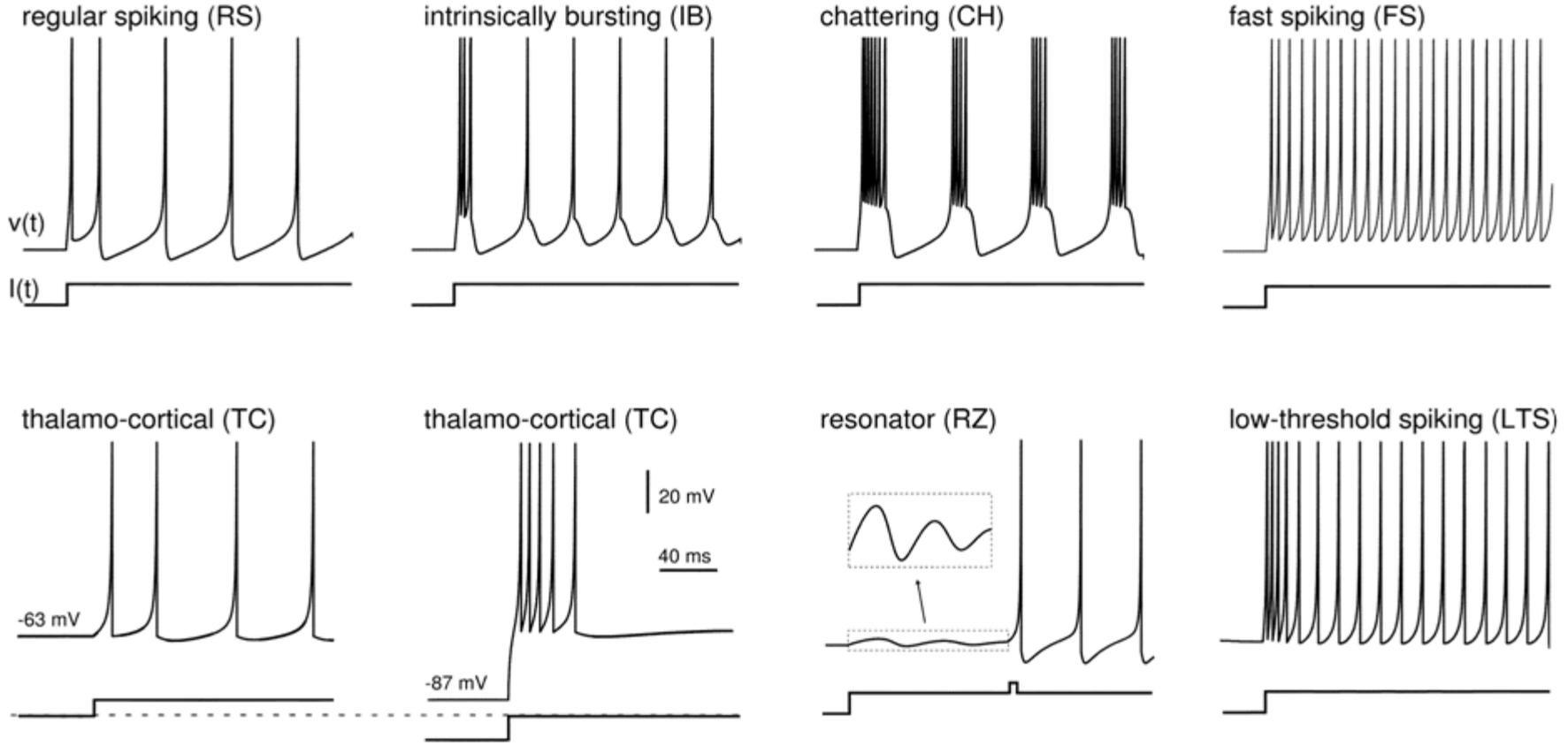
$$v' = 0.04v^2 + 5v + 140 - u + I$$
$$u' = a(bv - u)$$

if v = 30 mV,
then v ← c, u ← u + d



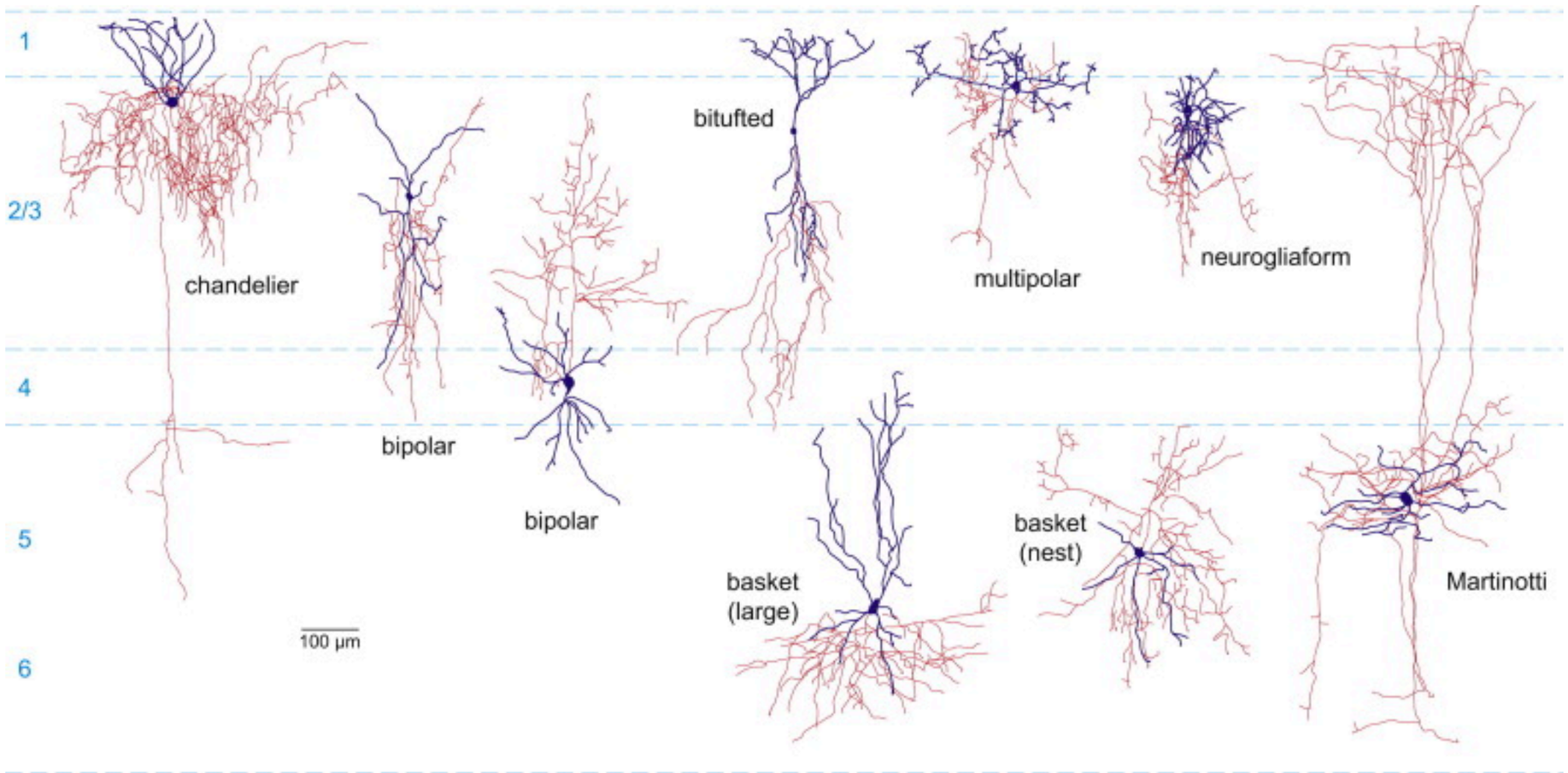






Izhikevich (2003) Simple model of spiking neurons

MORPHOLOGY



dendrite **axon**

The Mouse Nervous System (2012)

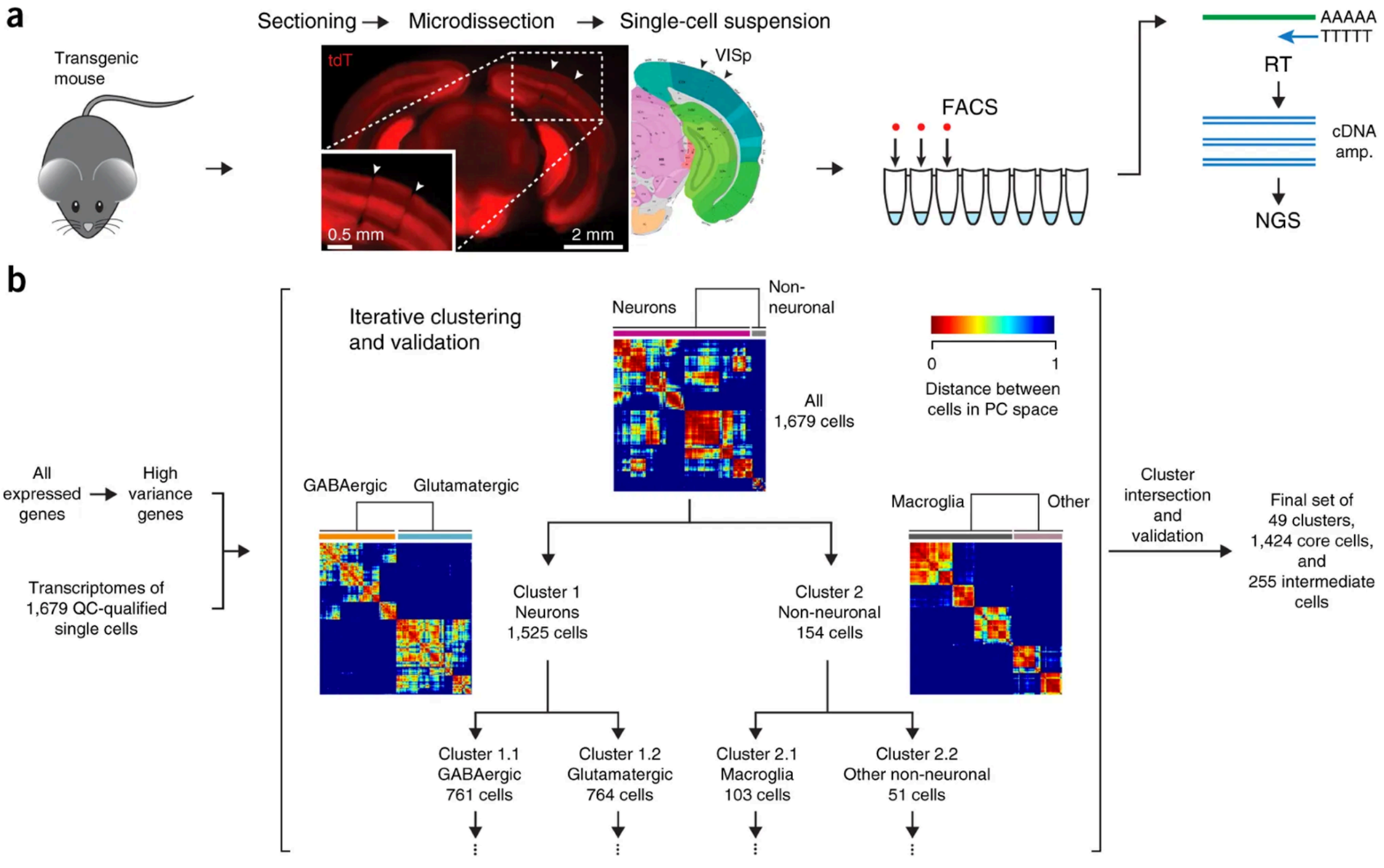
TRANSCRIPTOMICS

* ~Every cell in your body has the **same DNA**

* But different cells **express** different genes, leading to the production of different **proteins**

* We can see which genes are being expressed in a cell by ~sequencing all the messenger RNA (**mRNA**) in the cell

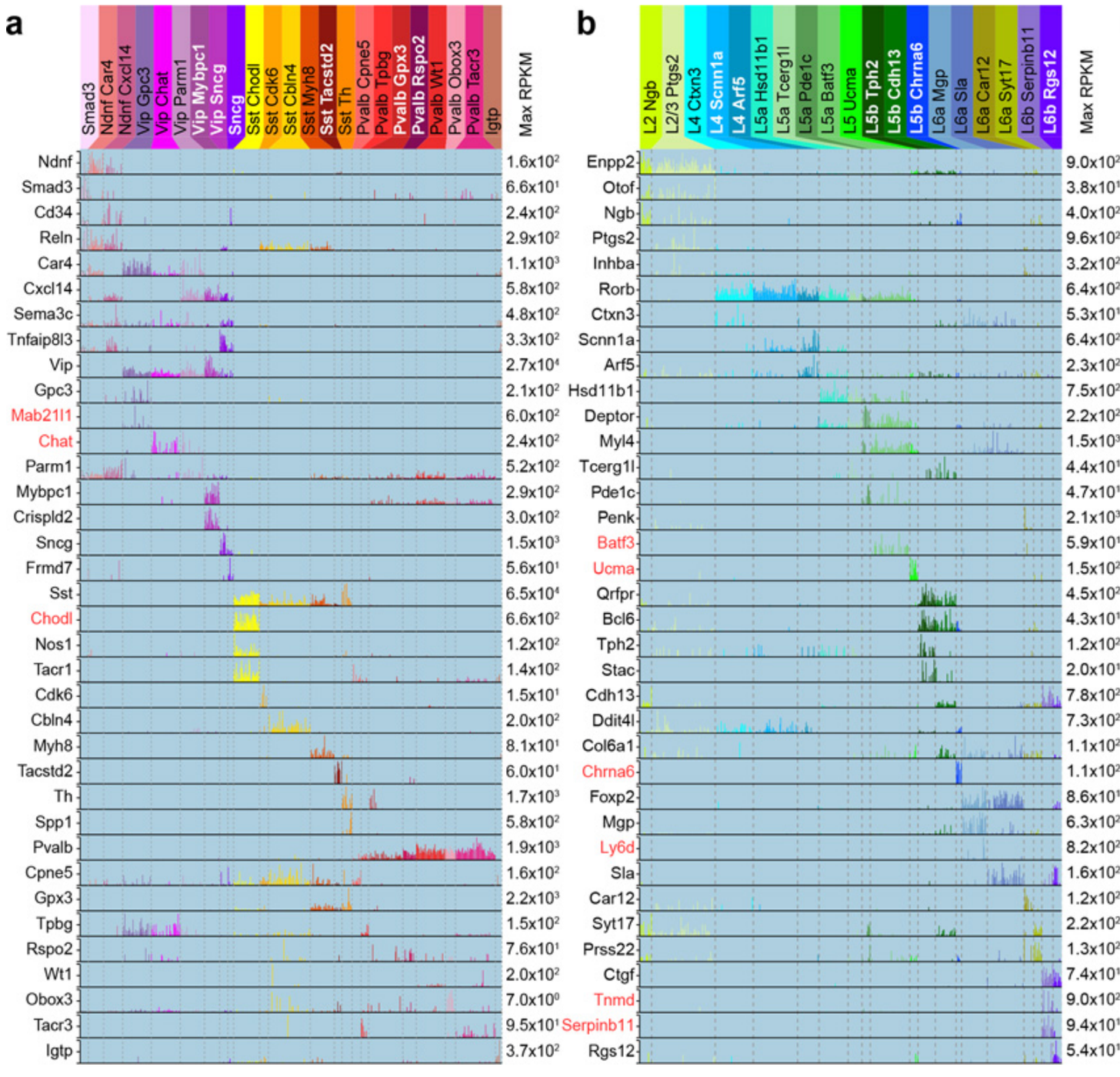
TRANSCRIPTOMICS



Tasic et al. (2016)

TRANSCRIPTOMICS

* Modern findings:
  * at least **23** excitatory types & **19** inhibitory types (in visual cortex alone!)



Tasic et al. (2016)

RECAP

* cortex

* layers

* cortical cell types

NEXT TIME

* neuroscience methods & limitations