511-2018-09-12-cells

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2018-09-11 15:22:27

Announcements

- **Quiz 1** Friday
    - 13 questions/15 points
    - Take-home, take 30 min

Today's Topics

- Wrap-up on neuroanatomy
- Cells of the nervous system
    - Glia
    - Neurons

Visualizing the microanatomy of the brain

How many neurons and glia?

- Old "lore": ~100 billion neurons
- New estimate (Azevedo et al., 2009):
  - ~86 +/- 8 billion neurons
  - 85 +/- 9 billion glia

How many neurons and glia?

"These findings challenge the common view that humans stand out from other primates in their brain composition and indicate that, with regard to numbers of neuronal and nonneuronal cells, the human brain is an isometrically scaled-up primate brain."
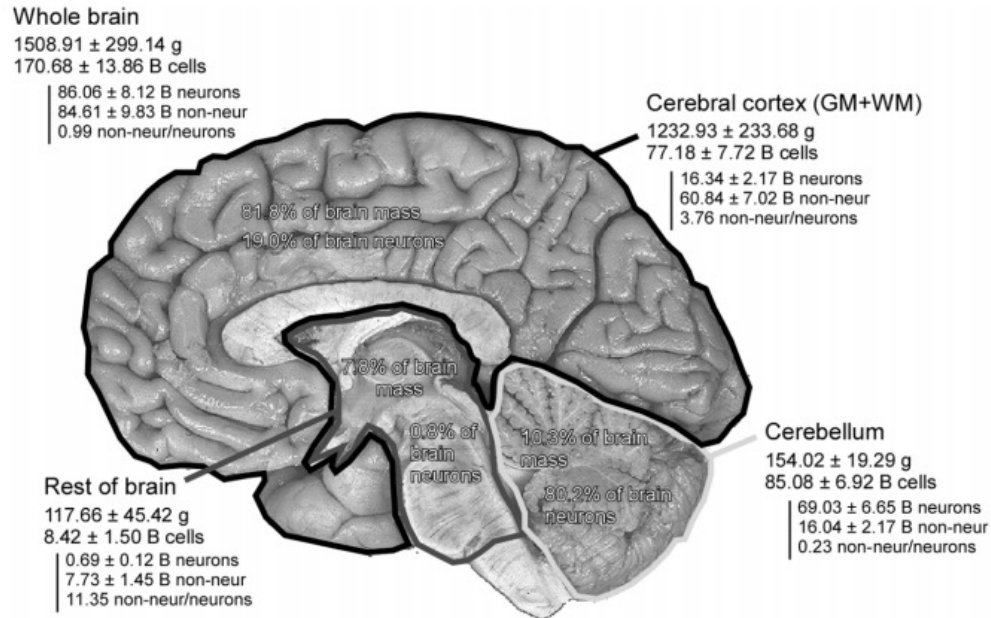
(Azevedo et al., 2009)

Mass, Neurons, Non-Neurons

The Journal of Comparative Neurology

536   F.A.C. AZEVEDO ET AL.

Whole brain
1508.91 ± 299.14 g
170.68 ± 13.86 B cells

    86.06 ± 8.12 B neurons
    84.61 ± 9.83 B non-neur
    0.99 non-neur/neurons

Cerebral cortex (GM+WM)
1232.93 ± 233.68 g
77.18 ± 7.72 B cells

    16.34 ± 2.17 B neurons
    60.84 ± 7.02 B non-neur
    3.76 non-neur/neurons

81.8% of brain mass
19.0% of brain neurons

7.8% of brain mass

0.8% of brain neurons

10.3% of brain mass

80.2% of brain neurons

Cerebellum
154.02 ± 19.29 g
85.08 ± 6.92 B cells

    69.03 ± 6.65 B neurons
    16.04 ± 2.17 B non-neur
    0.23 non-neur/neurons

Rest of brain
117.66 ± 45.42 g
8.42 ± 1.50 B cells

    0.69 ± 0.12 B neurons
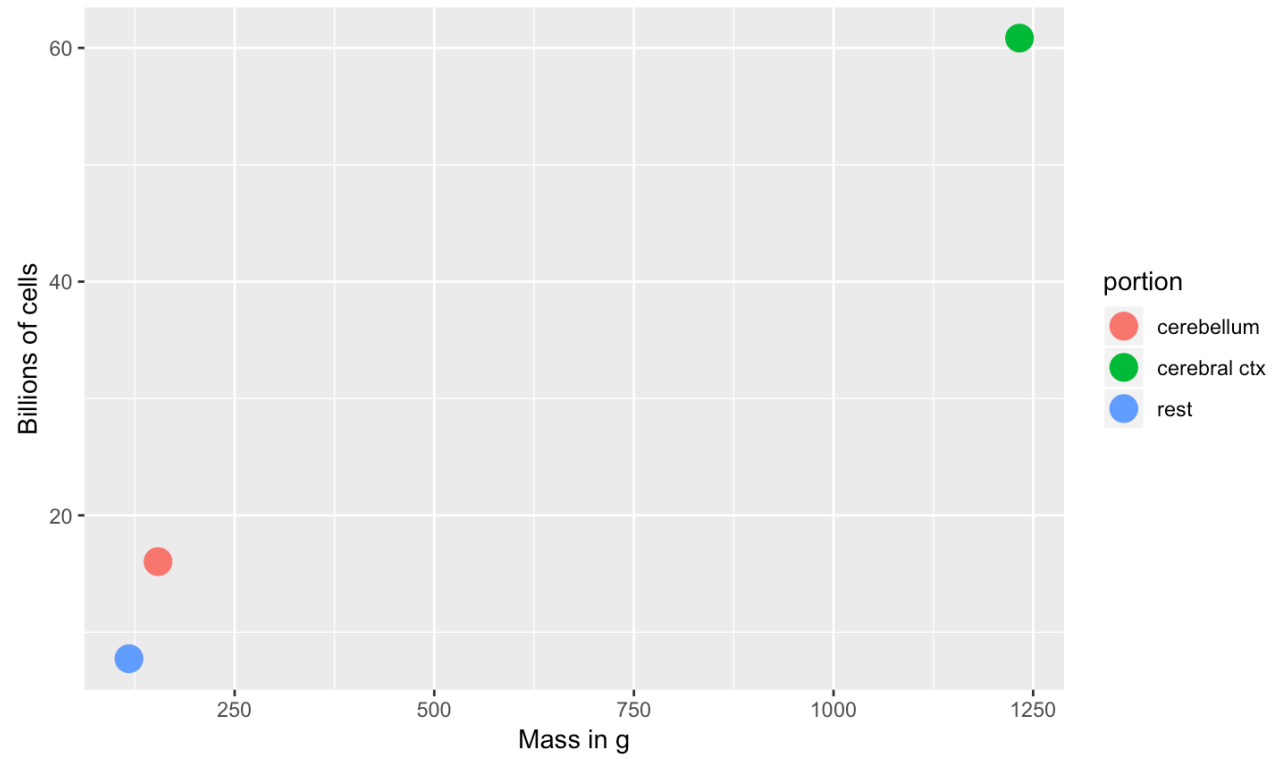   7.73 ± 1.45 B non-neur
    11.35 non-neur/neurons

Figure 2.
Absolute mass, numbers of neurons, and numbers of nonneuronal cells in the entire adult human brain. Values are mean ± SD and refer to the two hemispheres together. B, billion.

(Azevedo et al., 2009)

Neurons by brain mass
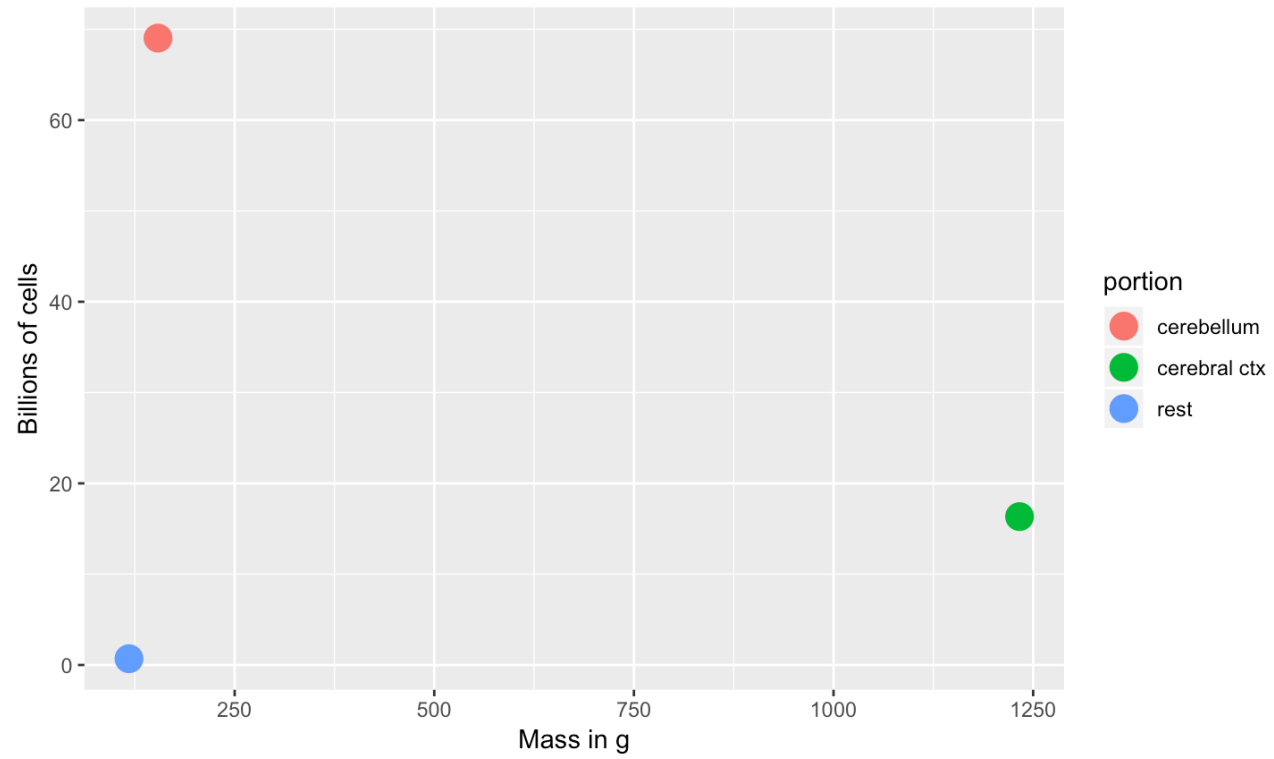
Non-neuronal cells by brain mass

The Human Advantage

Glia (neuroglia)

- Functions
   - Structural support
    - Metabolic support
    - Brain development

Astrocytes

- "Star-shaped"

- Most numerous cell type in CNS

- Physical and metabolic support

    - Blood/brain barrier

    - Ion (Ca++/K+) buffering

    - Neurotransmitter (e.g., glutamate) buffering

    - Regulate local blood flow

Astrocytes

- Shape brain development, synaptic plasticity

- Disruption linked to cognitive impairment, disease (Chung, Welsh, Barres, & Stevens, 2015)

Astrocytes
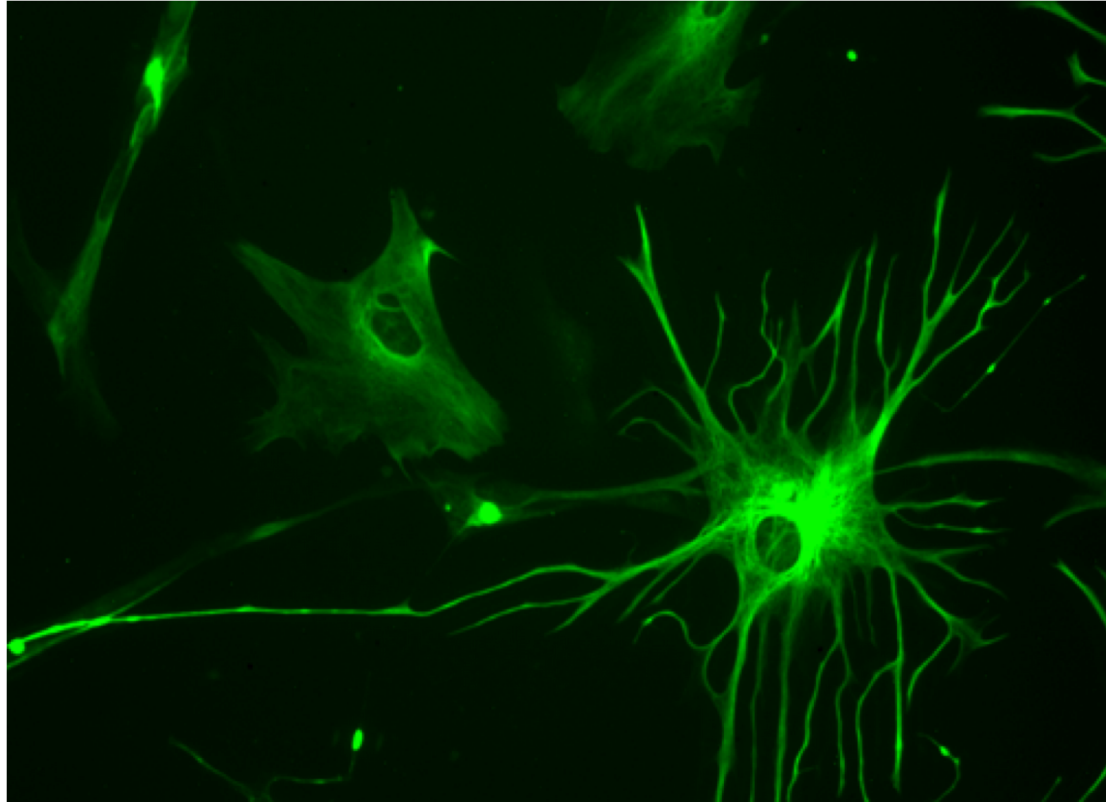
https://upload.wikimedia.org/wikipedia/commons/5/56/Human_astrocyte.

Myelinating cells

- *Oligodendrocytes*
    - In brain and spinal cord (CNS)
    - 1:many neurons
- *Schwann cells*
    - In PNS
    - 1:1 neuron
    - Facilitate neuro-regeneration
- Mnemonics: COPS/SPOC

Oligodendrocytes
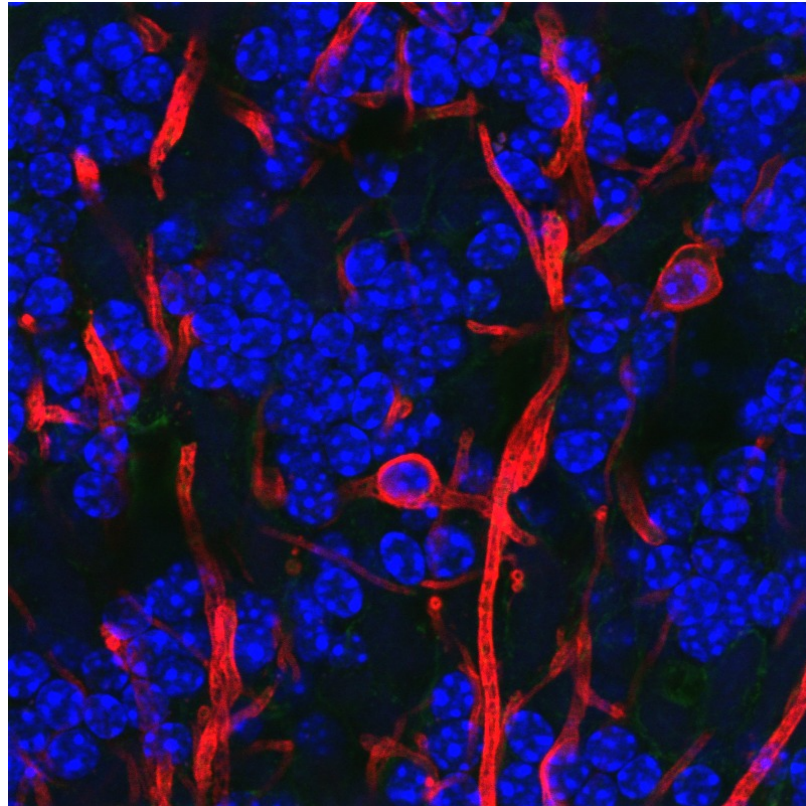
https://upload.wikimedia.org/wikipedia/commons/thumb/8/8a/Oligodende
page1-800px-Oligodendendrocytes_in_rat_brain.tif.jpg

Schwann Cells

http://www.sciencellonline.com/media/catalog/product/cache/1/image/a6f8fb4f61eb724cff40f184d1fbcab0/m/1
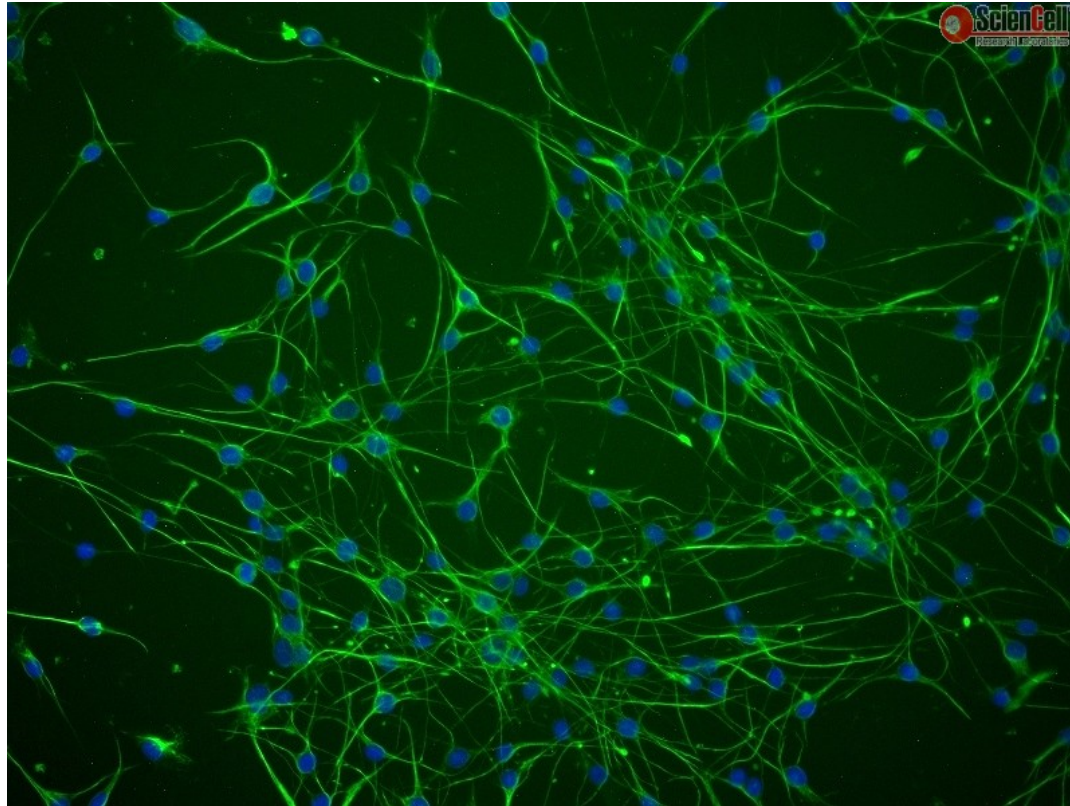
Microglia

- Phagocytosis
- Clean-up damaged, dead tissue
- Role in 'pruning' of synapses in normal development

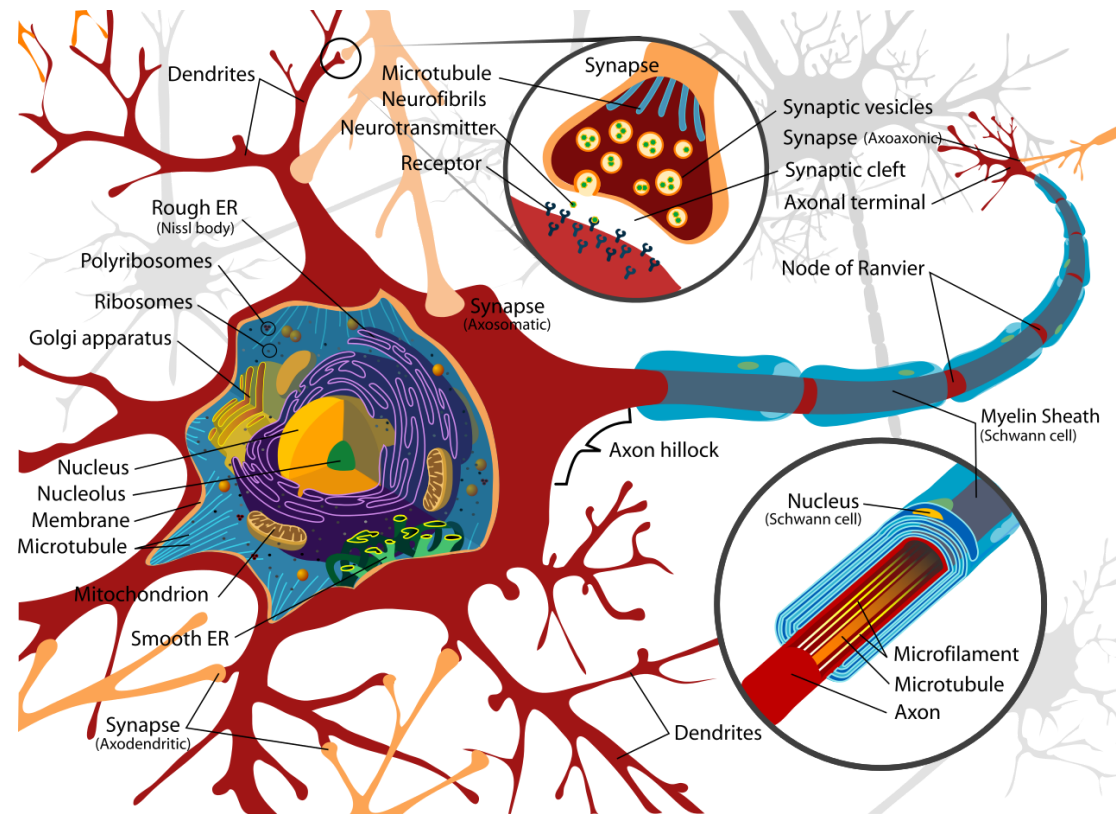# Microglia
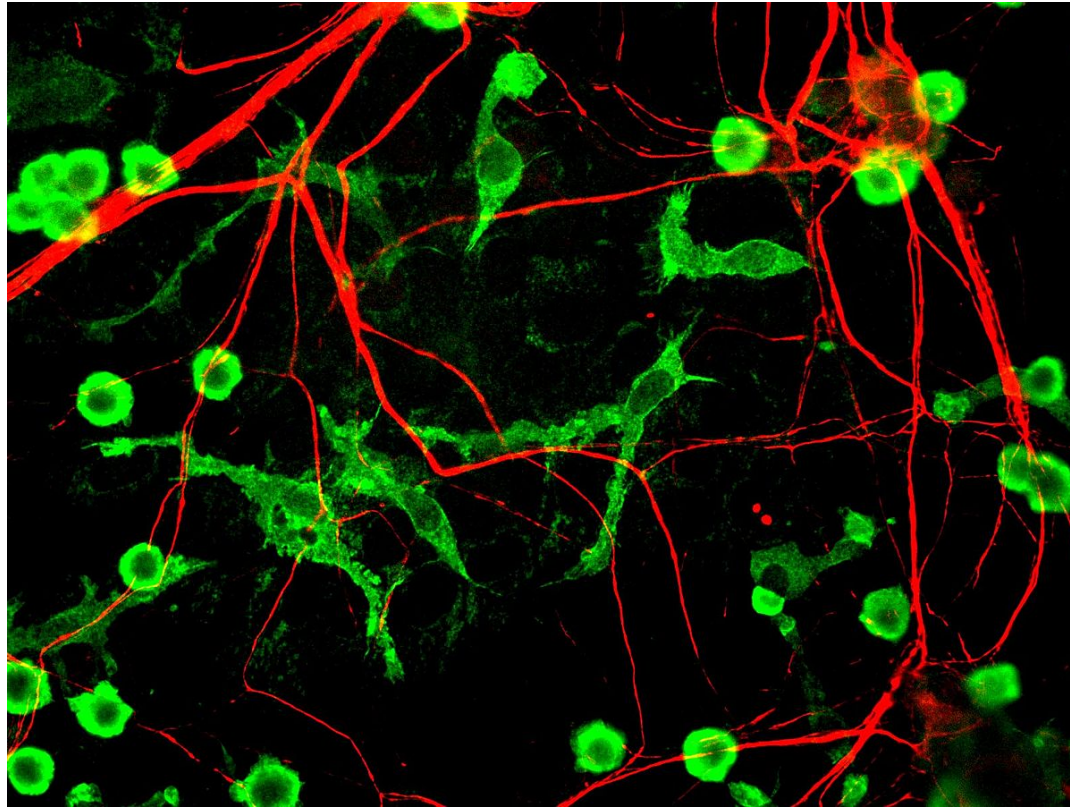
By GerryShaw - Own work, CC BY-SA 3.0, Link

What makes neurons "special"?

- Long-lived (most generated b/w 3-25 weeks gestational age)
- Extended branching (dendrites and axons)
- Electrically excitable
- Connect to small #s of other cells via synapses
- Release neurotransmitters

Macrostructure of neurons

- Dendrites

- Soma

- Axons

- Terminal buttons (boutons)

Structure of neurons

Dendrites

- Majority of input to neuron

- Passive vs. active

- Spines

Dendrites

http://i.livescience.com/images/i/000/058/588/original/brain-cell.jpg?1383065356
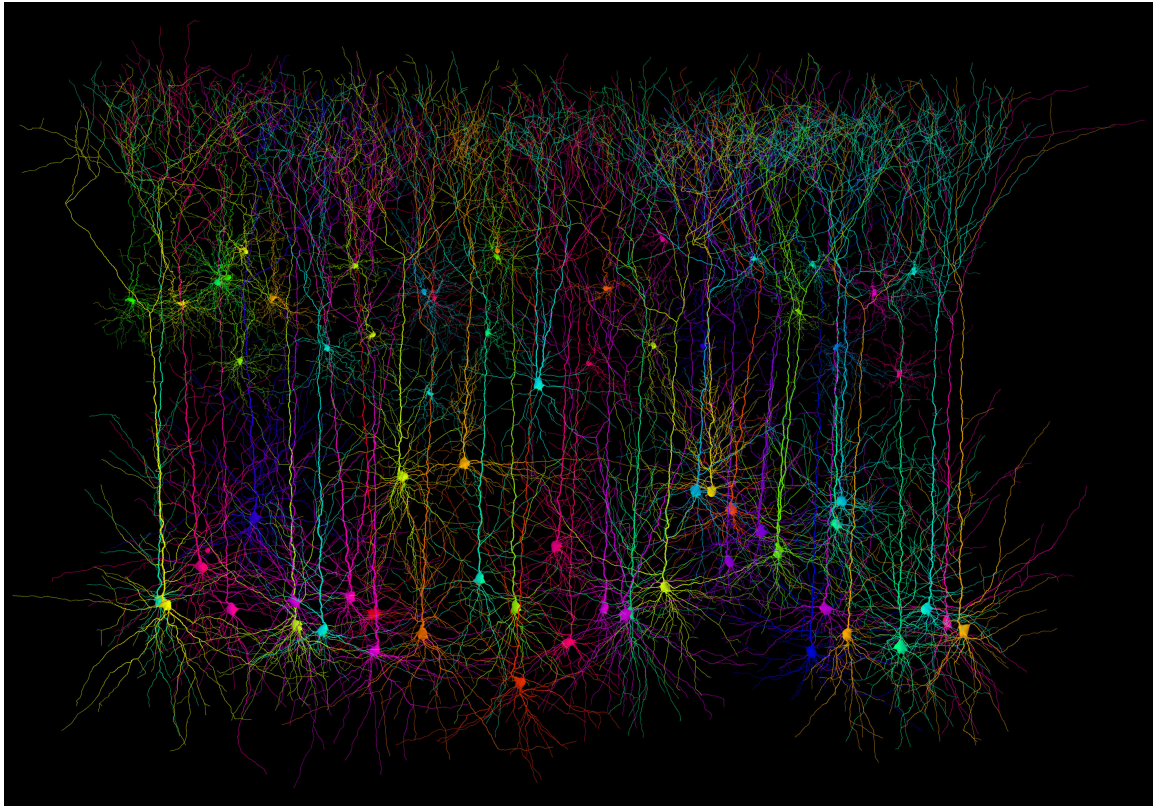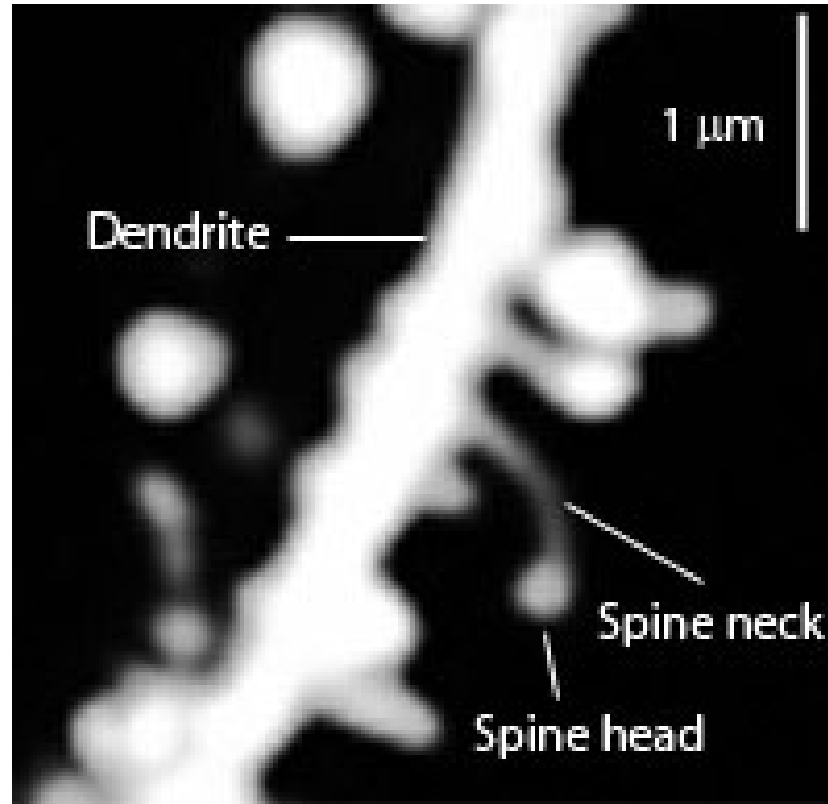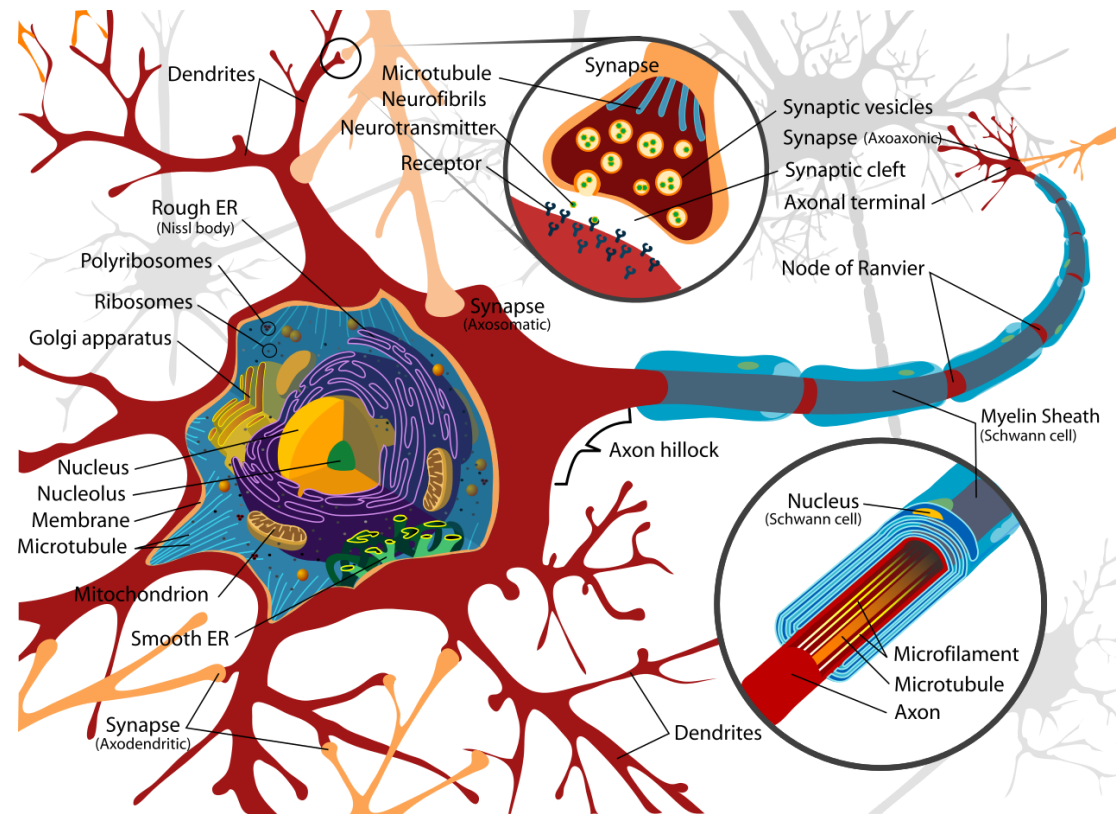
Dendritic Spines

https://upload.wikimedia.org/wikipedia/commons/b/b1/Dendritic_spines.jpg

Soma (cell body)

- Varied shapes
- Nucleus
    - Chromosomes
- Organelles
    - Mitochonrdria
    - Smooth and Rough Endoplasmic reticulum (ER)
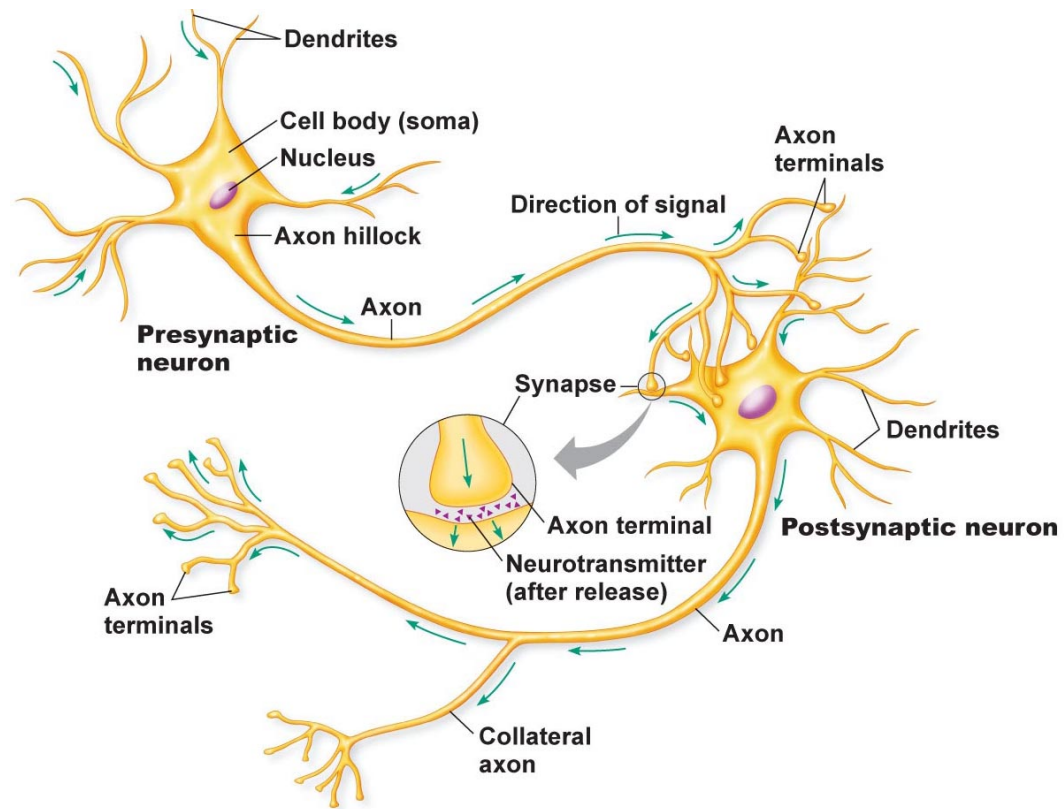
Soma

https://upload.wikimedia.org/wikipedia/commons/thumb/a/a9/Complete_neuron_cell_diagram_en.svg/1280px-Complete_neuron_cell_diagram_en.svg.png

Axons

- *Axon hillock*

- *Initial segment*

- *Nodes of Ranvier*

- *Axon Terminals*

Axons

http://droualb.faculty.mjc.edu/Course%20Materials/Physiology%20101/Chapter%20Notes/Fall%202007/figure_0

Synaptic bouton (terminal button)

- *Synapse* (~5-10K per neuron)
- Pre and postsynaptic membranes
- *Synaptic cleft*
- *Synaptic vesicles*
    - Store/release neurotransmitters
- *Autoreceptors* & *transporters*
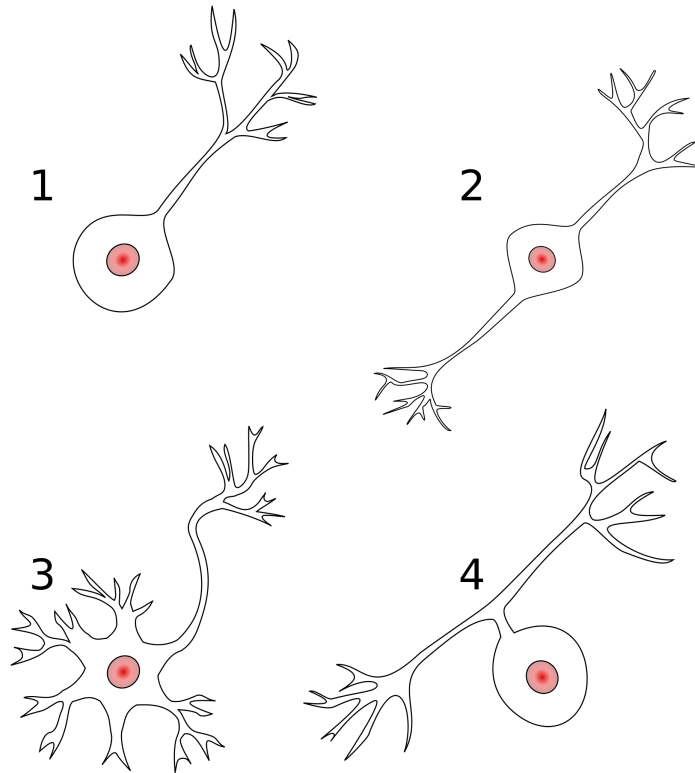
Synaptic bouton (terminal button)

http://antranik.org/wp-content/uploads/2012/04/synapse.jpg
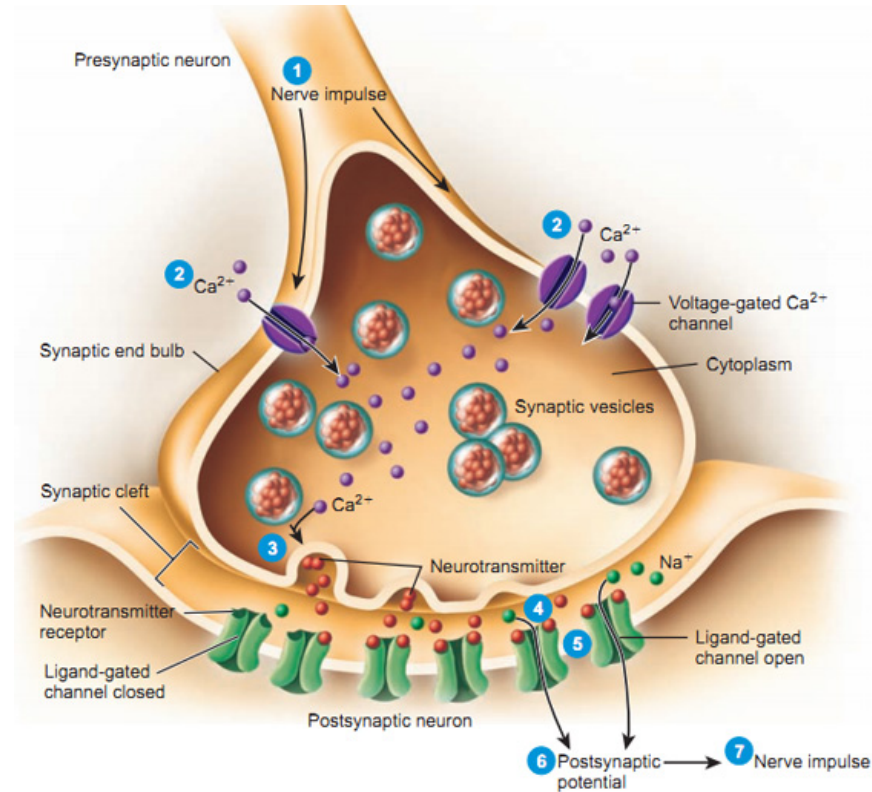
Classifying neurons

- Functional role

    - Input (sensory), output (motor/secretory), interneurons

- Anatomy

    - *Unipolar*
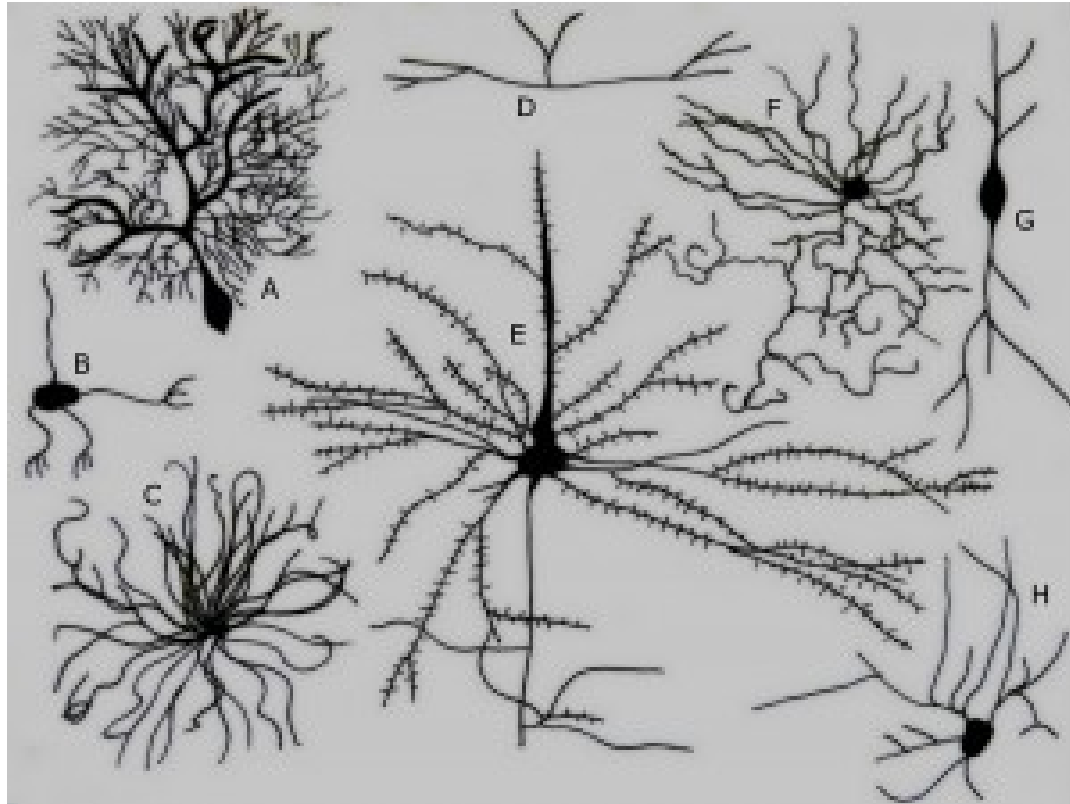
    - *Bipolar*

    - *Multipolar*

Branching types

1

2

3

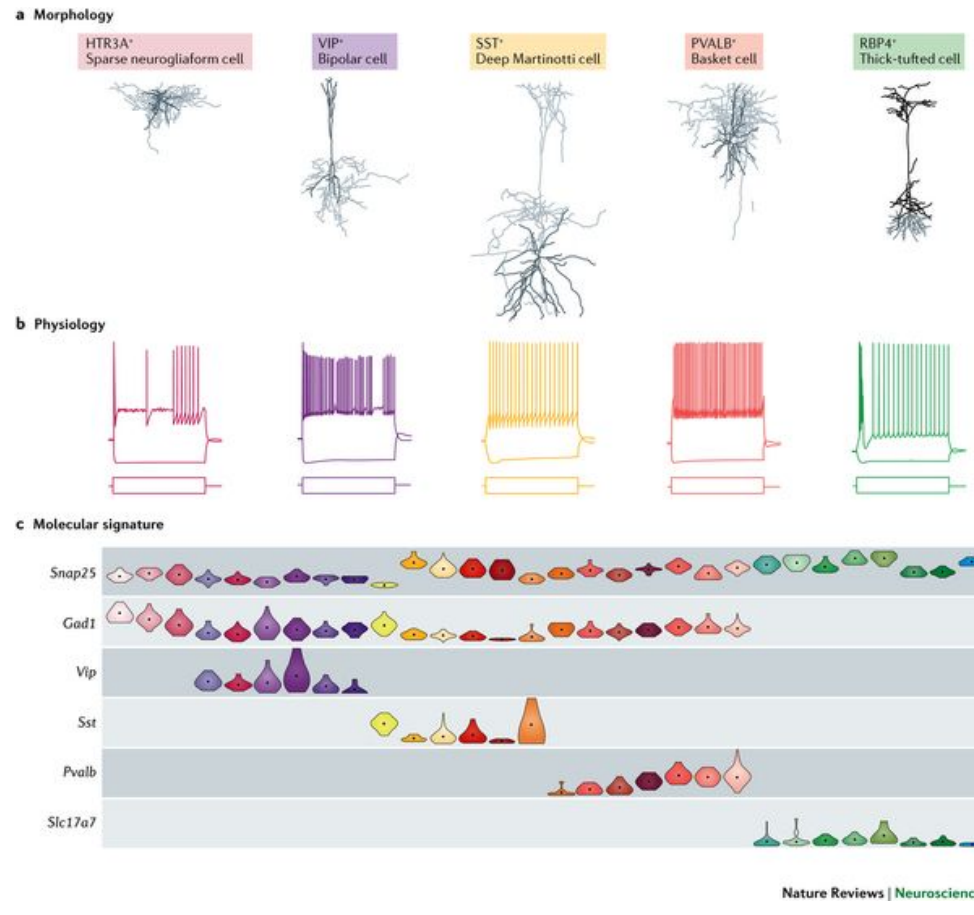4

Classifying neurons

- By specific anatomy

    - Pyramidal cells

    - Stellate cells

    - Purkinje cells

    - Granule cells
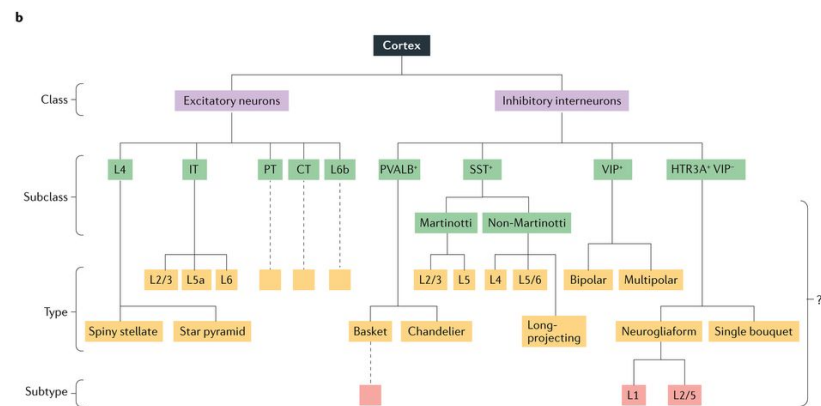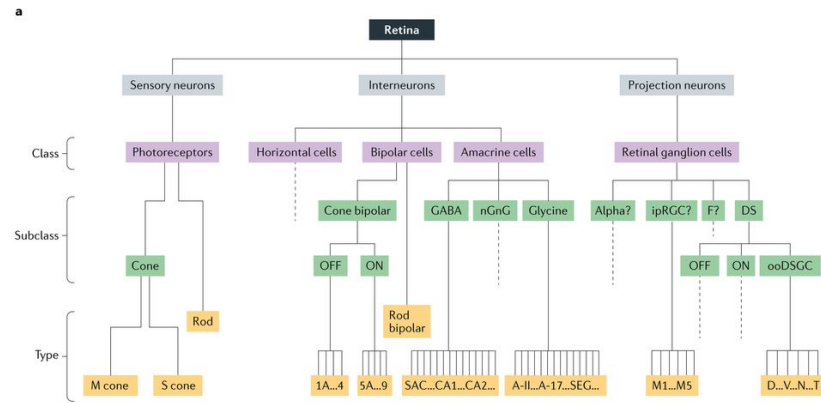
Neurons by type

http://blogs.scientificamerican.com/brainwaves/files/2012/05/selection-glamor-FINAL-300x225.jpg
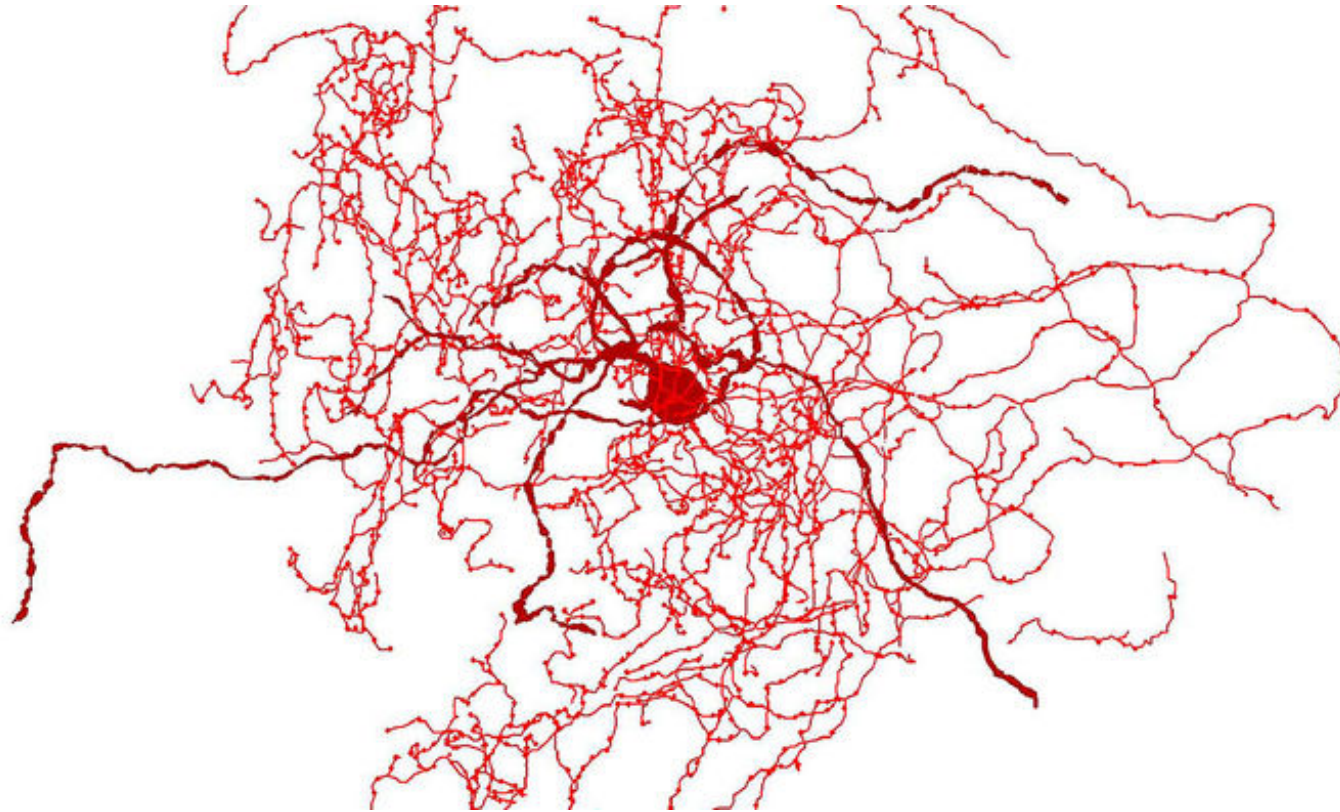
Morphology, physiology, gene transcription

Zeng & Sanes, 2017

Zeng & Sanes, 2017

(Boldog et al., 2018)

Next time

- **Quiz 1** (available after class)
- Neurophysiology

References

Azevedo, F. A., Carvalho, L. R., Grinberg, L. T., Farfel, J. M., Ferretti, R. E., Leite, R. E., … others. (2009). Equal numbers of neuronal and nonneuronal cells make the human brain an isometrically scaled-up primate brain. *Journal of Comparative Neurology*, *513*(5), 532–541. https://doi.org/10.1002/cne.21974

Boldog, E., Bakken, T. E., Hodge, R. D., Novotny, M., Aevermann, B. D., Baka, J., … Tamás, G. (2018). Transcriptomic and morphophysiological evidence for a specialized human cortical GABAergic cell type. *Nature Neuroscience*, *21*(9), 1185–1195. https://doi.org/10.1038/s41593-018-0205-2

Chung, W.-S., Welsh, C. A., Barres, B. A., & Stevens, B. (2015). Do glia drive synaptic and cognitive impairment in disease? *Nature Neuroscience*, *18*(11), 1539–1545. https://doi.org/10.1038/nn.4142