# Neurobiology

JI Shengjian

*Perhaps the major reason that neuroscience remains such an exciting field is the wealth of unanswered questions about the fundamental organization and function of the human brain…*

# Course assessment

**Attendance: 10%**

**Performance in class, JC peer-review and attitude: 10%**

**Article reading, presentation and discussion: 30%**

**Mid-term test: 20%**

**Final examination: 30%**

# Course contents, format

**Part 1, Structure and Organization of Nervous System**

**Part 2, Nervous System Development and Diseases**

**Part 3, Neural Signaling**

**Part 4, Sensory and Motor Systems**

**Part 5, Complex Brain Functions**

**Part 6, Neuroscience Article Reading, Presentation and Discussion**

# Neuroscience Article Reading, Presentation and Discussion

- Help understanding what you just learn in the class.
- Apply what you learn to real scientific research.
- Find your interests.
- Avoid the overwhelming paper reading if arranged together.
- Improve your scientific reading, critical thinking, and presentation skills.
- Pre-training for your graduate JC presentation to the whole lab and department.

- I will send the papers to the class at least one week before the presentation date.

# Neuroscience Article Reading, Presentation and Discussion

❖ **How to present:**

- Give a clear background for this study.
- Try to present all the important data, esp. figures and tables in the main text. If necessary, the supplementary information and data should also be explained.
- For every experiment, you should explain:
  - Why did they do this experiment? What questions did they want to ask?
  - What experiments and techniques did they use?
  - What are the results? Did the results answer the questions they asked?
  - Could they draw the conclusions from these experiments as they claimed?
  - If you did the same project, would you carry out the same experiments, or you have better ideas?

- How do you feel like about his paper? What are good and what are bad? Where should the paper have been published?
- If you follow up this paper, what will you do next?
  - You should be able to ask three important questions as your three future directions.

**Try your best and impress me and your classmates!**

# Get to know neuroscientists

## 1. Nobel prize laureates in Neuroscience

Ramón Cajal

Golgi

Sherrington

Kandel

Axel

Südhof

Mosers

# Get to know neuroscientists

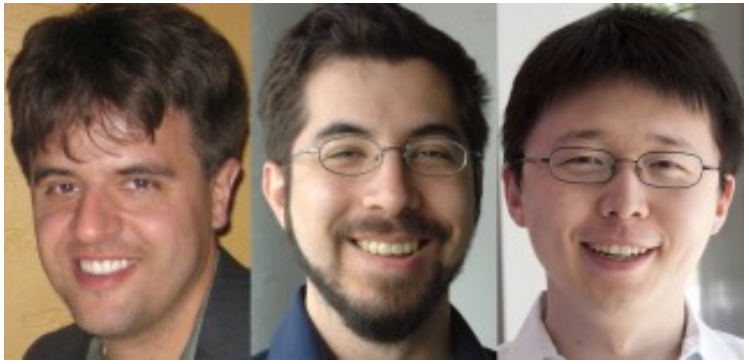
## 2. Neuroscientists who never won Nobel prize but contribute to modern neuroscience (research/education) a lot

Snyder

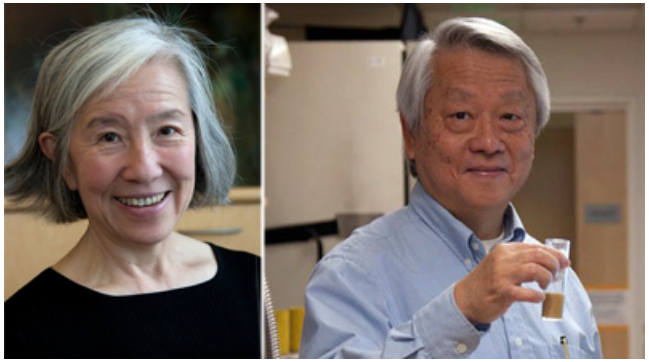
Jessell

Greenberg

Tessier-Lavigne



Deisseroth, Boyden, Zhang



Jans

# Get to know neuroscientists

## 3. Active neuroscientists whom you should know

Ginty

Bargmann

Barres

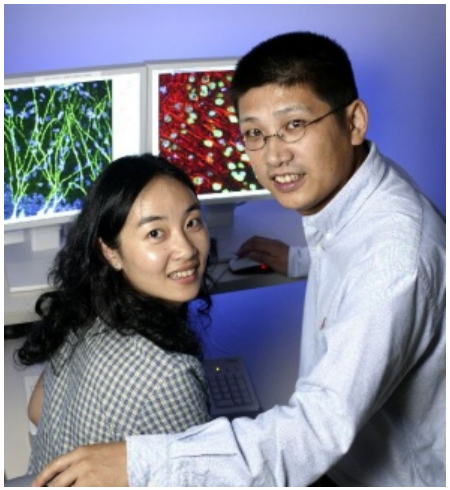
Huganir

Zoghbi

Poo

# Get to know neuroscientists

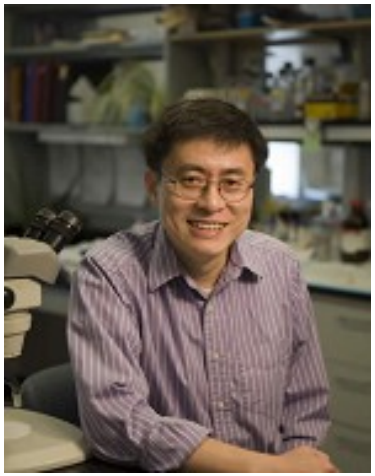
## 4. Chinese neuroscientists who are doing very well



Song & Ming

Sheng

Shen

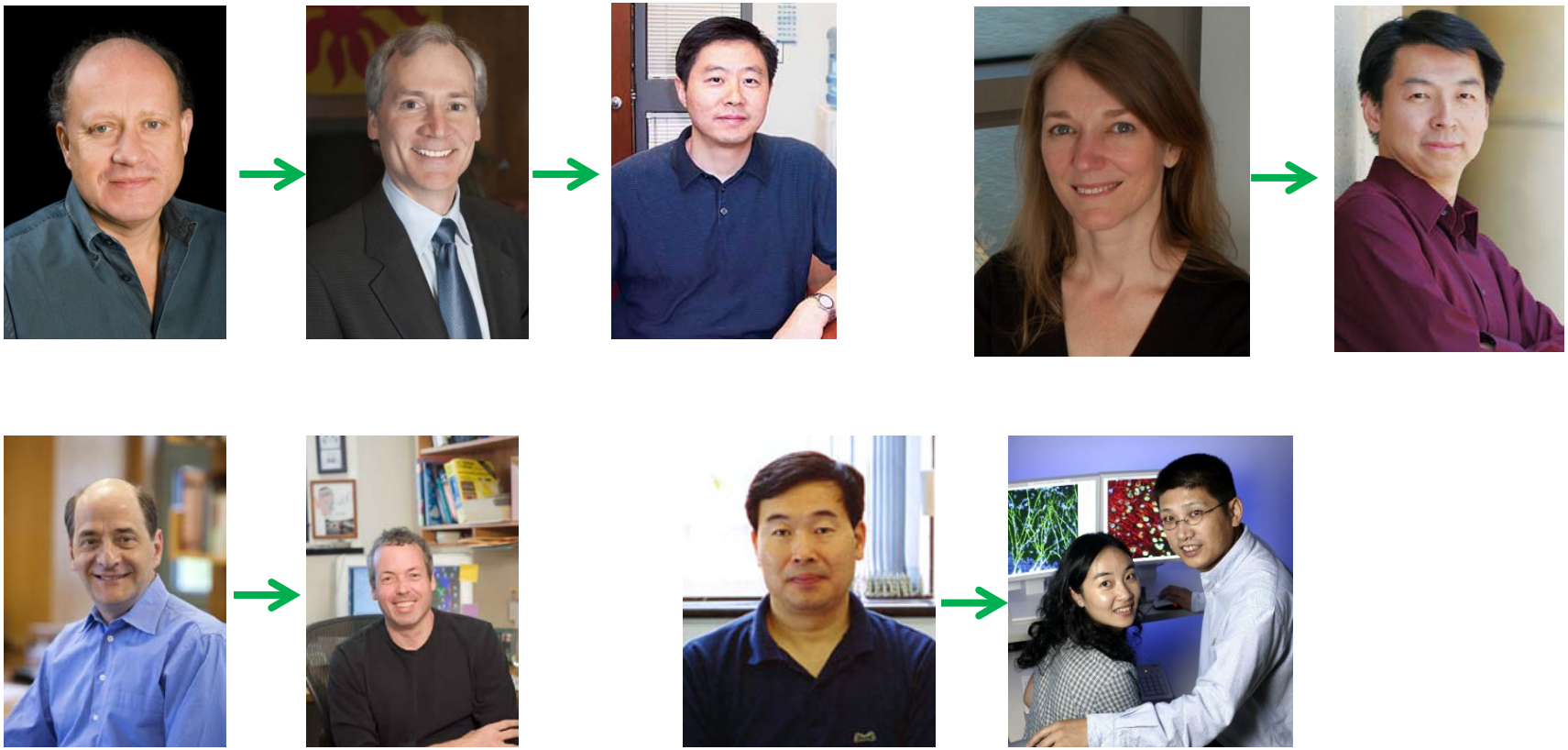


Dong

Zou

Jin

# Connections in neuroscience



# NeuroTree:

## Neuroscience academic family tree

Edward Kravitz
Harvard Medical School

Julius Axelrod
NIMH

?

Bernard Beryl Brodie
NIH

H. George Mandel
George Washington University(Chemistry Tree)

Leslie Iversen
Oxford

Gerald Fischbach
Columbia

Julius Axelrod
NIMH

Thomas M Jessell
Columbia

Solomon H Snyder
Johns Hopkins

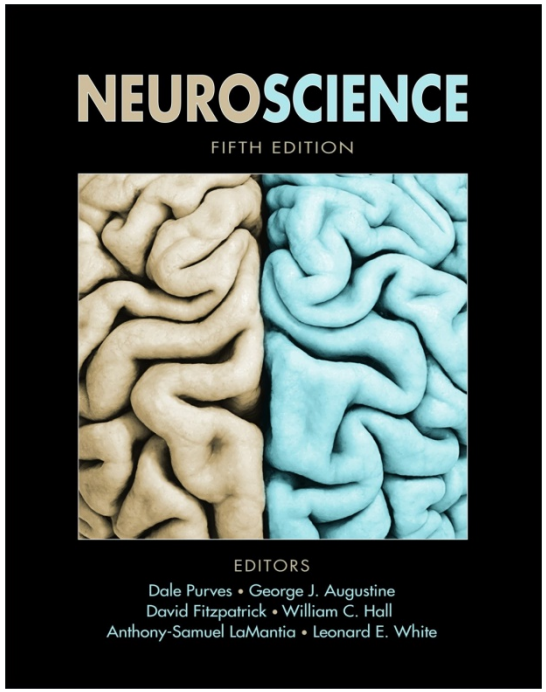
Shanthini Sockanathan
Johns Hopkins Medical School

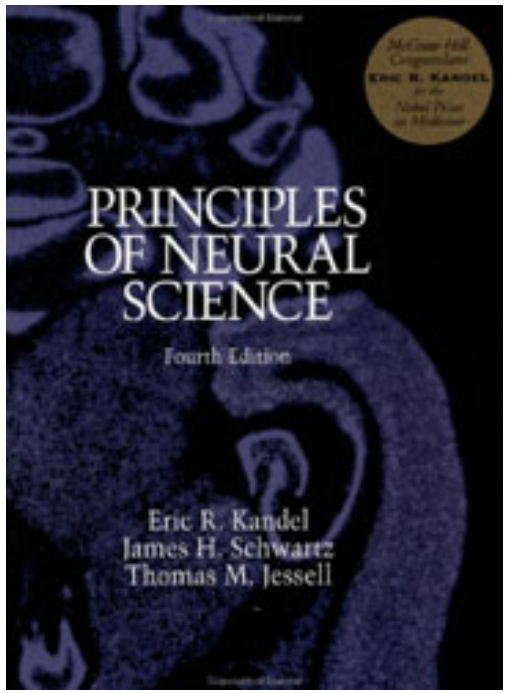
Samie R. Jaffrey
Weill Cornell Medical College

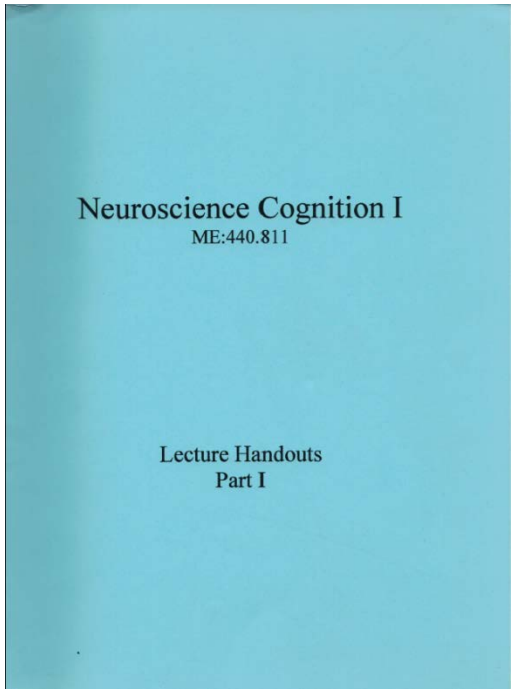
**Shengjian Ji**
South University of Science and Technology of China

# Textbooks, further Reading & references

- Neuroscience, 5th ed., Dale Purves et al., Sinauer Associates
- Principles of Neural Science, 5th ed., Eric Kandel et al. McGraw-Hill
- Neuroscience Cognition I, lecture handouts, Johns Hopkins University



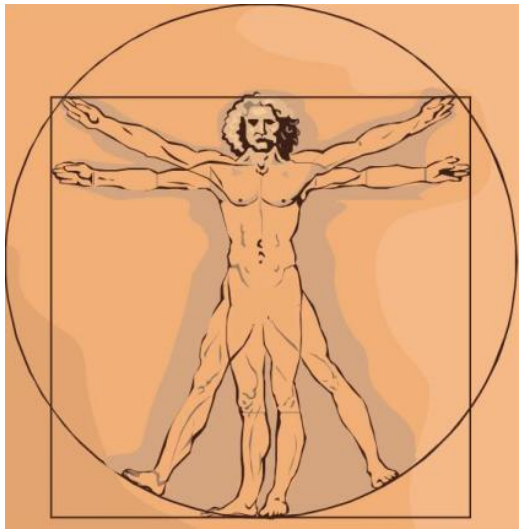




轴突中含微管、神经丝、线粒体、滑面内质网，但不存在尼氏体或核糖体等蛋白质合成装置

# Part 1, Structure and Organization of Nervous System

# Model organisms in neuroscience

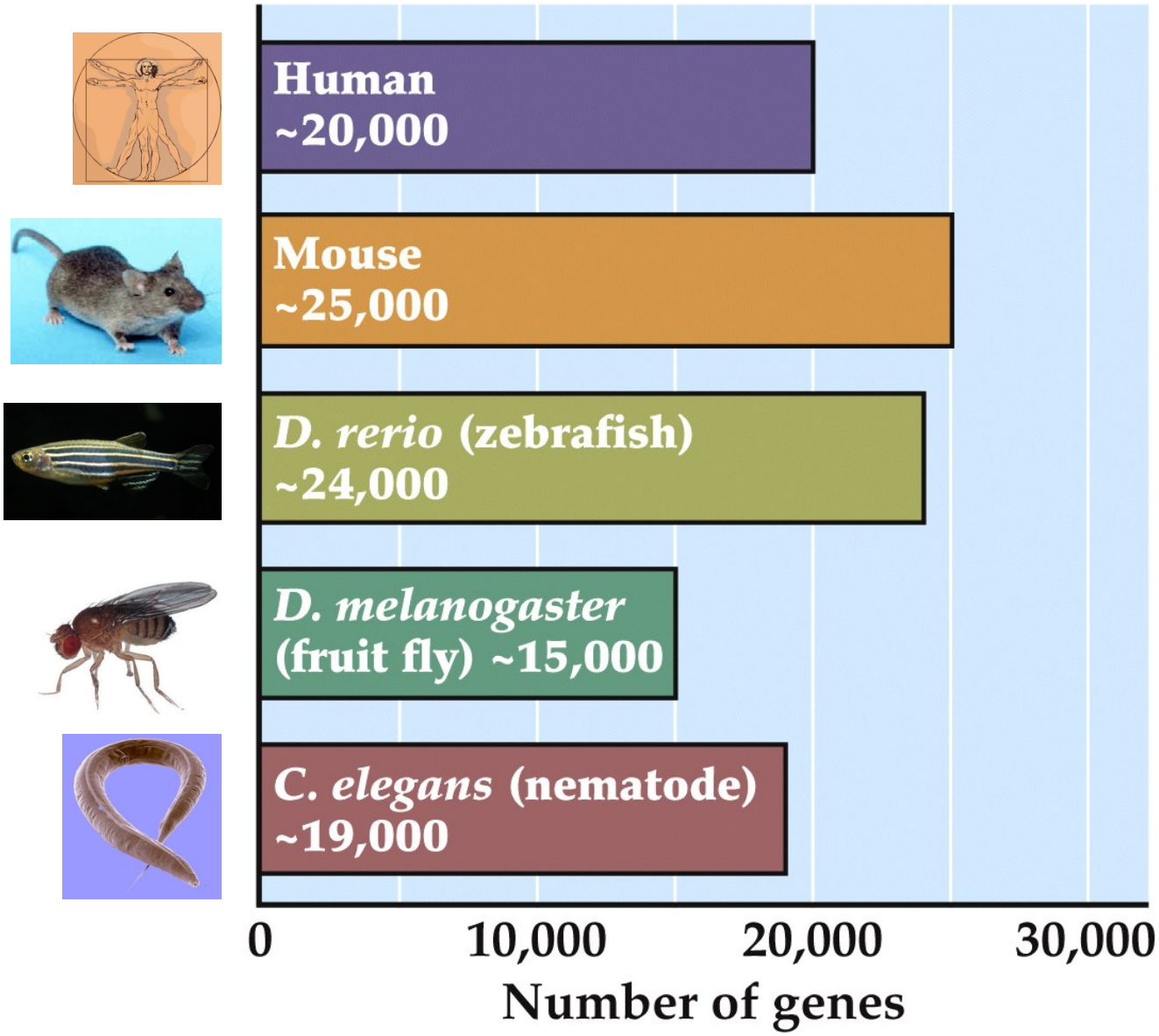


# Advantages of main model organisms

- Genetic and genomic information
- Forward screening by generating mutants
- Transgenic or knockout

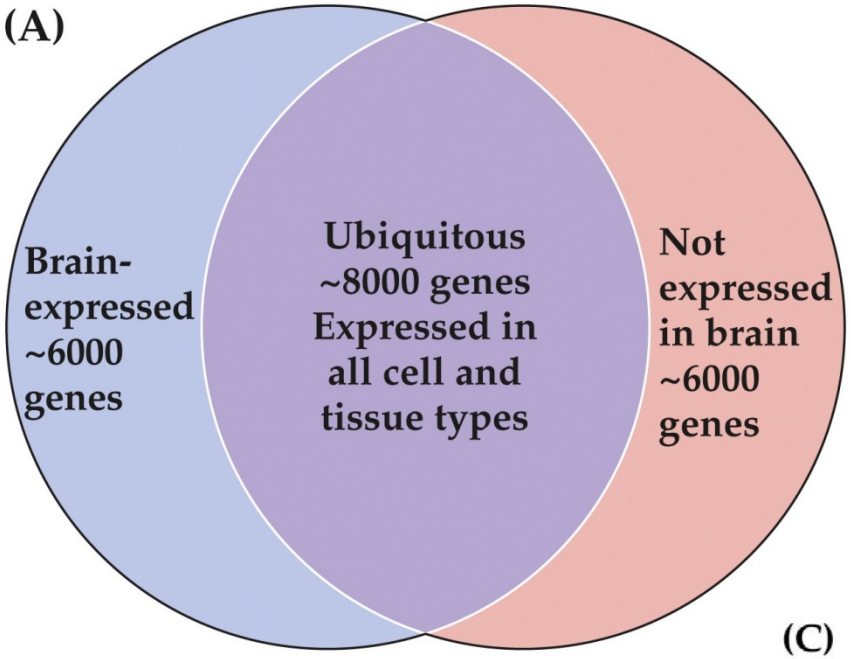
# Other model organisms in neuroscience

# Gene numbers *vs* organismal complexity



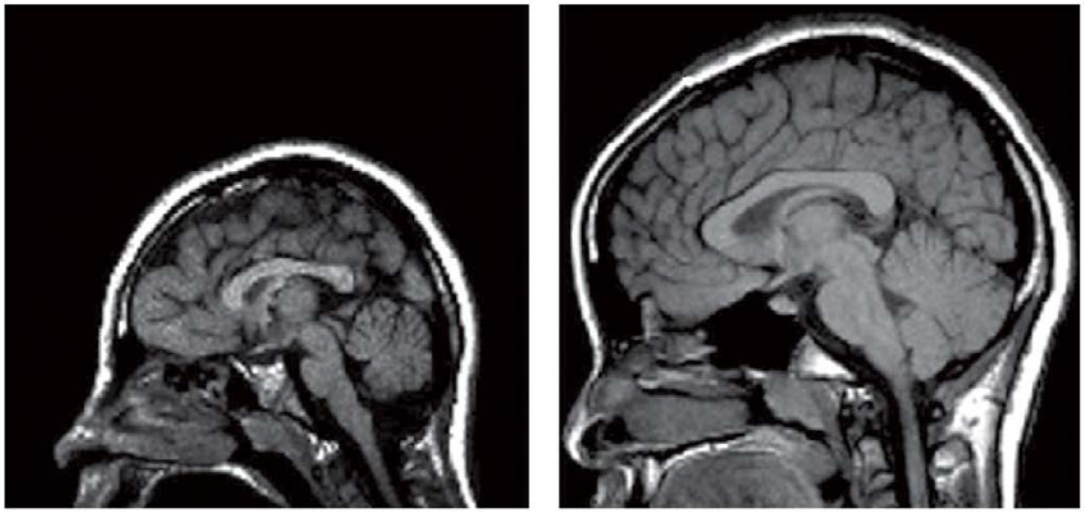

*NEUROSCIENCE 5e*, Box 1A

# The genome and the brain




*NEUROSCIENCE 5e*, Figure 1.1 (Part 1)

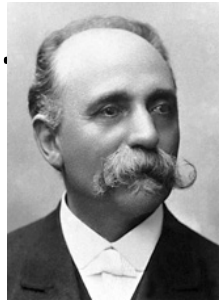

(C) Microcephaly: *ASPM*



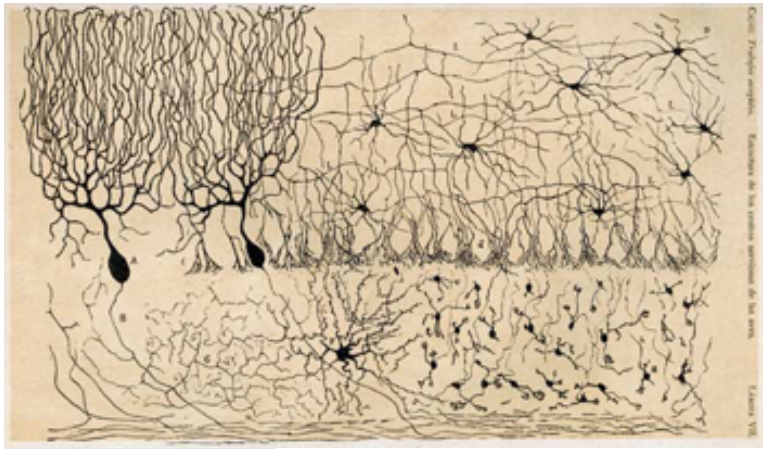
*NEUROSCIENCE 5e*, Figure 1.1 (Part 3)

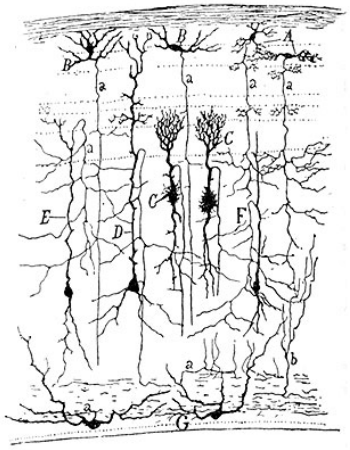
# The cellular components of the nervous system

- **Reticular theory (Camillo Golgi)**: each nerve cell was connected to its neighbors by protoplasmic links, forming a continuous nerve cell network, or *reticulum* (Latin for "net").
  - Golgi apparatus
  - Golgi stain or Golgi's method



- **Neuron doctrine (Santiago Ramón y Cajal & Charles Sherrington)**: nerve cells are discrete entities and they communicate with each other by means of specialized contacts-*synapses*.



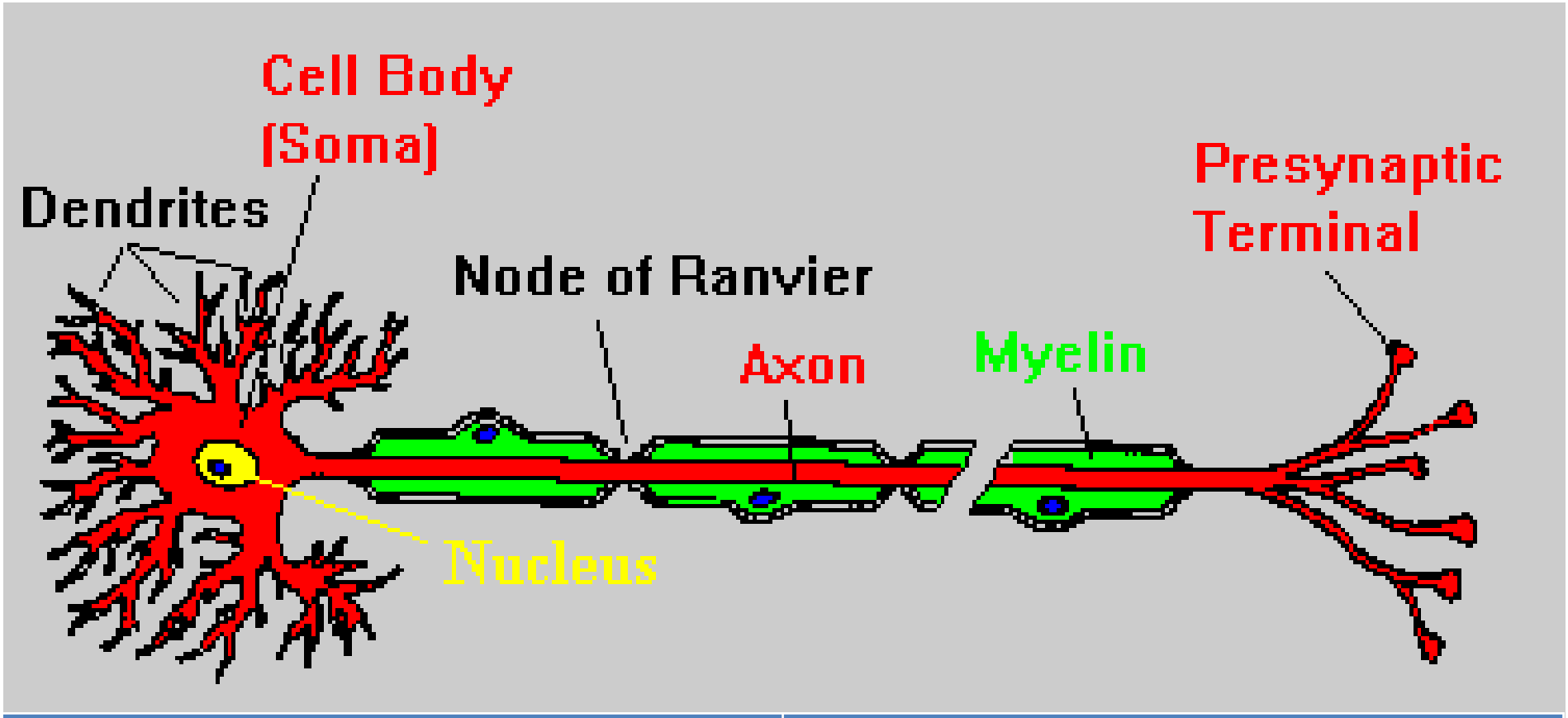


# Cells of the nervous system

- **Nerve cells (neurons)**: specialized for electrical signaling over long distances.

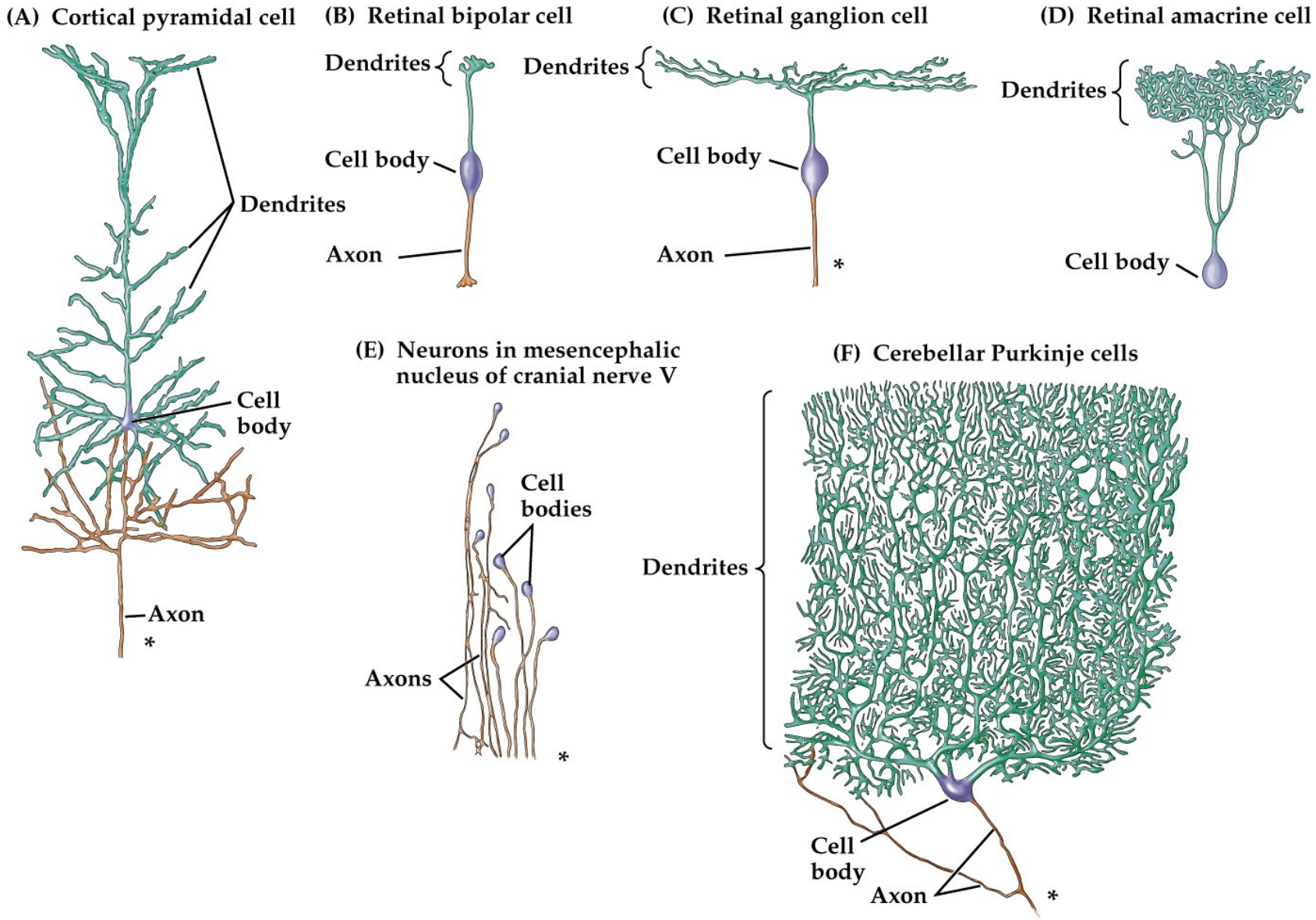
- **Glia cells (neuroglia, glia)**: supporting, rather than generating electrical signals. More numerous than neurons--3:1.

# Neurons



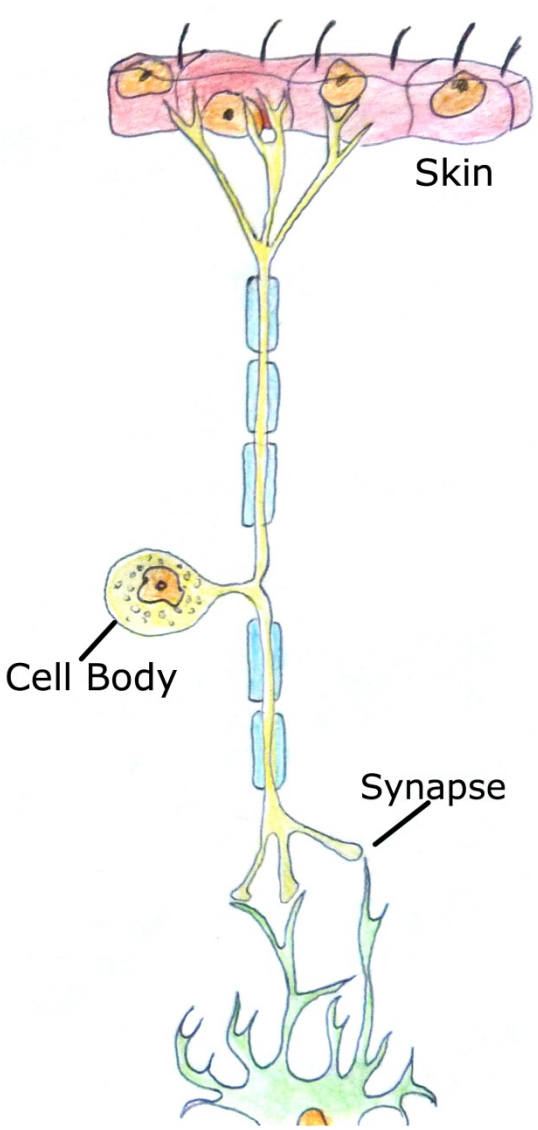

| Axons | Dendrite |
|---|---|
| Take information from neuronal soma | Bring information to neuronal soma |
| Smooth surface | Rough surface (dendritic spines) |
| Hundreds of micrometers to meters in length | Usually very short |
| Can have myelin | No myelin insulation |

# Some neuron morphologies found in the human nervous system

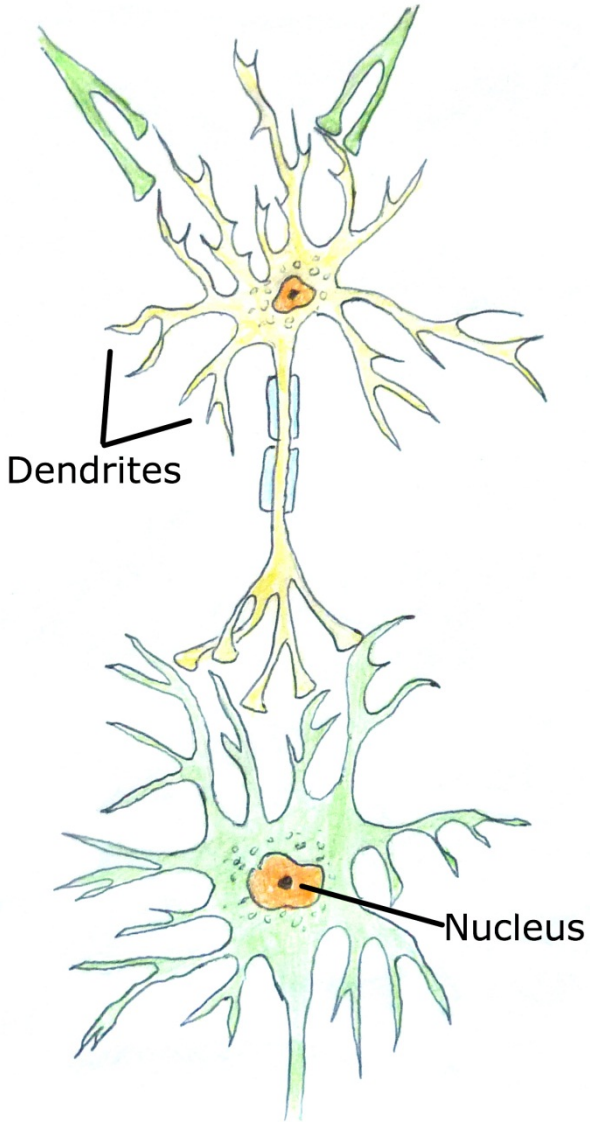



***NEUROSCIENCE 5e*, Figure 1.2**

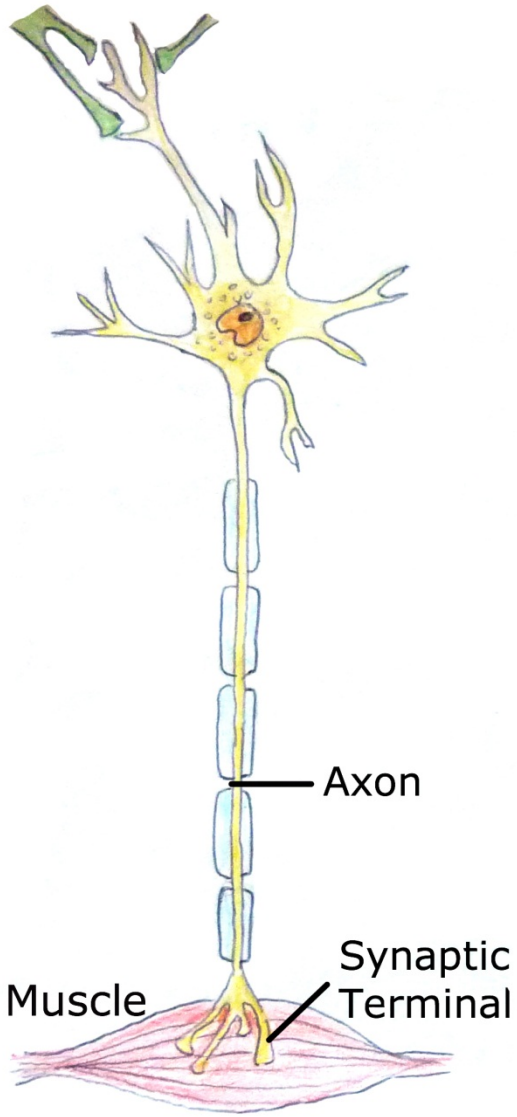
# Neurons classified by function




**Sensory neuron**




**Interneuron**



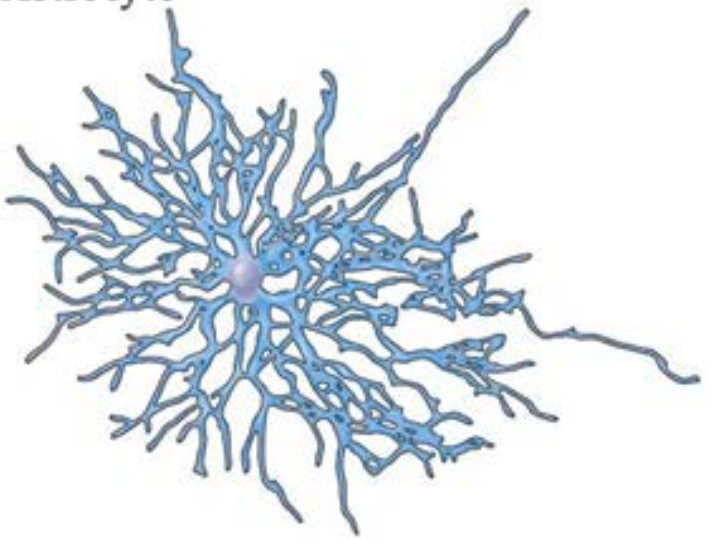

**Motor neuron**

# Glia: “glue” (*Greek*)

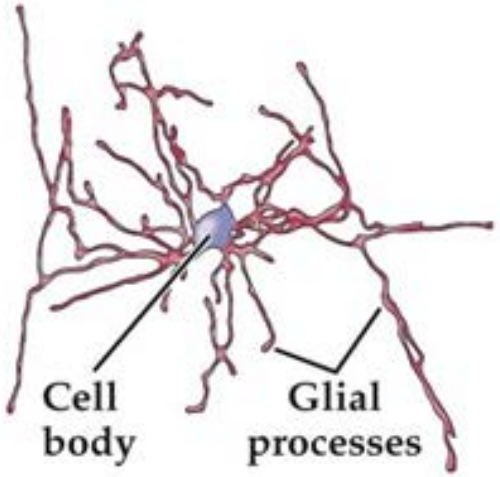
- Modulating the rate of nerve signal propagation.
- Modulating synaptic action by controlling the uptake and metabolism of neurotransmitters.
- Providing a scaffold for neural development.
- Aiding or inhibiting recovery from nerve injury.

# Glia

(A) Astrocyte

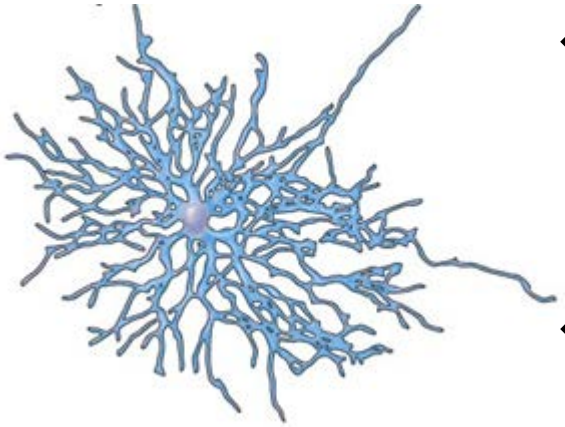


(B) Oligodendrocyte



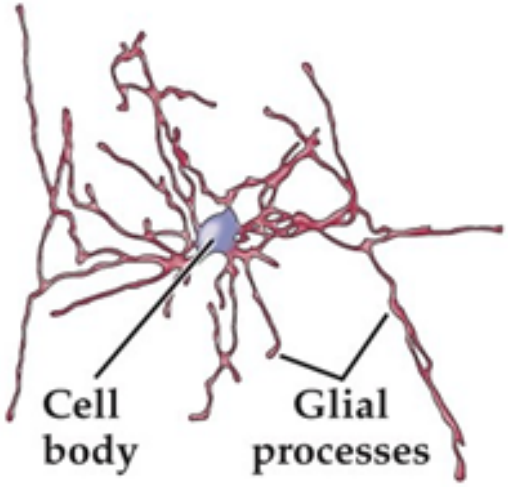

(C) Microglial cell

# Astrocyte



- **Location**: central nervous system (brain and spinal cord)
- **Morphology**: elaborate local processes; star-like (“astral”)
- **Function**: maintain an appropriate chemical environment for neuronal signaling; retain the characteristics of stem cells

# Oligodendrocyte

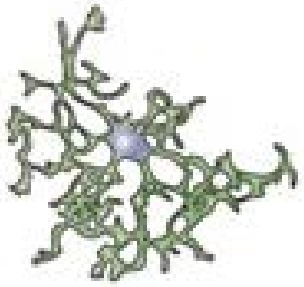



- **Location**: central nervous system
- **Myelin**: laminated, lipid-rich wrapping around some axons

- ***Peripheral nervous system**: Schwann cells*

- **Stem cell properties**

# Microglial cell



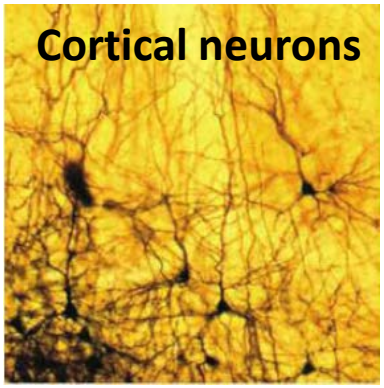
- Sharing properties with macrophages:

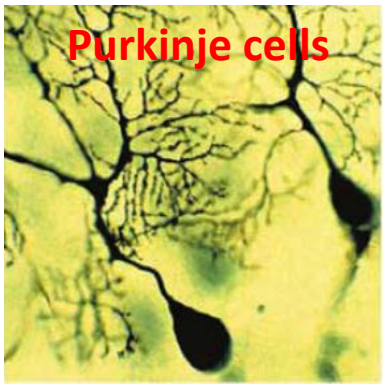
- Acting primarily as scavenger cells that remove cellular debris from sites of injury or normal cell turnover.

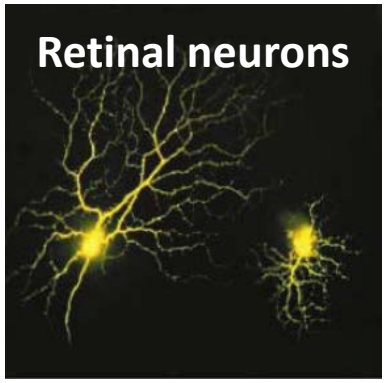
- Secreting signal molecules that can modulate local inflammation and influence cell survival or death.

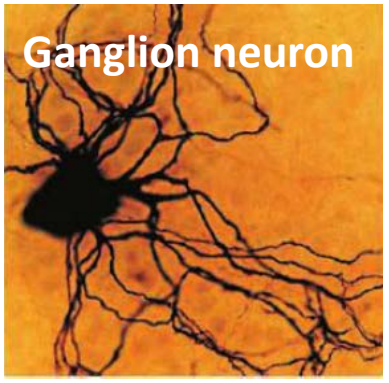
# Visualizing cells in nervous system

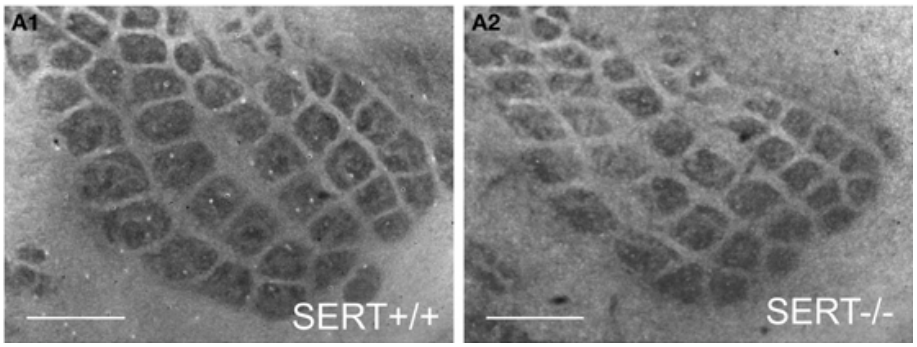
- **Golgi staining**: a limited number of cells at random in their entirety
- **Fluorescent dyes and other soluble molecules**
- **Nissl staining**: nucleolus, ribosomes et al.
- **Cytochrome oxidase staining**



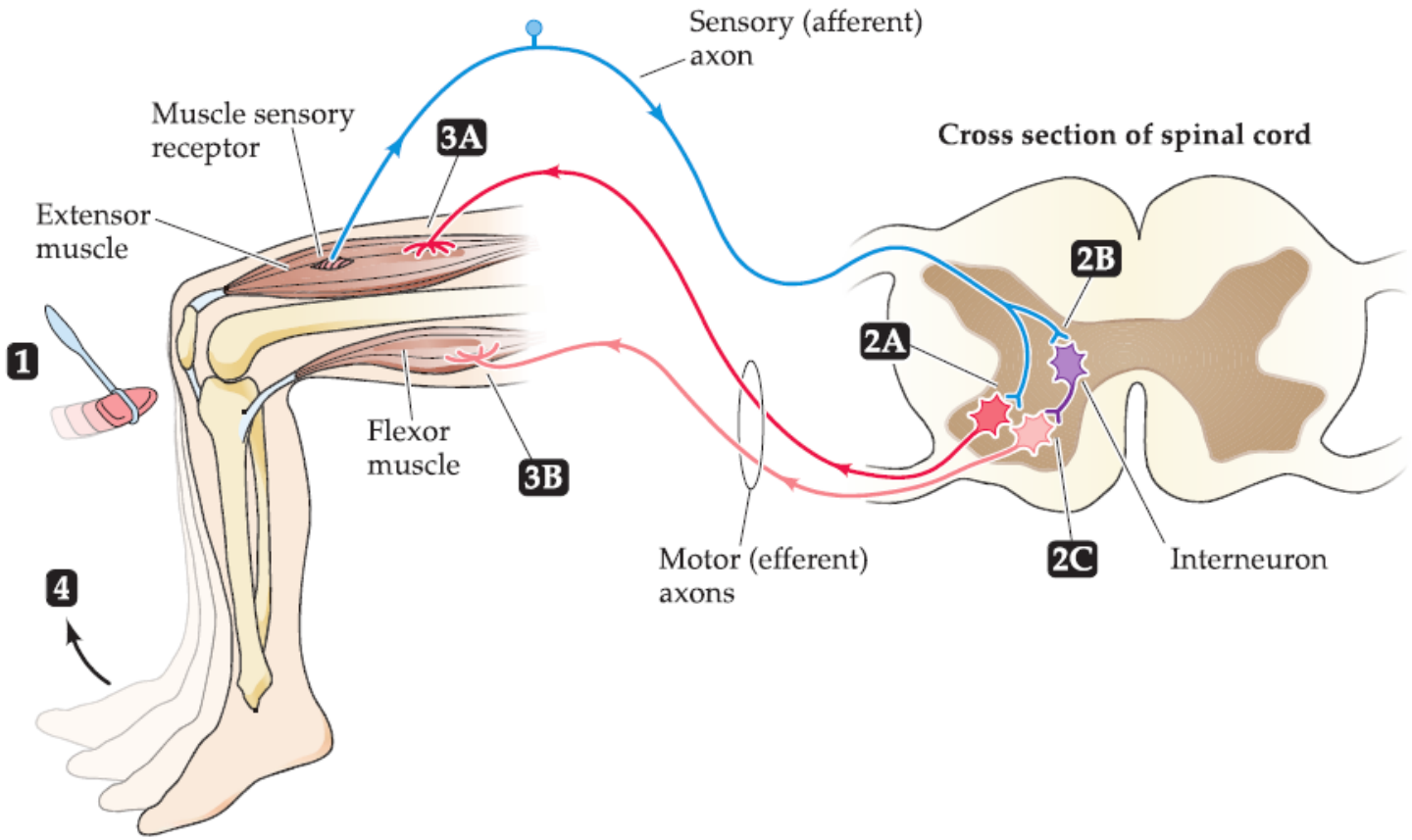





# Neural circuits

- Neurons never function in isolation.
- Neural circuits are the foundation of sensation, perception, movement, and behavior.
- Basic constituents:
  - **Afferent neurons**: carrying information from the periphery *toward* the brain or spinal cord
  - **Efferent neurons**: carrying information *away* from the brain or spinal cord
  - **Interneurons** (local circuit neurons): participate only in the local aspects of a circuit

# Myotatic reflex: "knee-jerk“ reflex




**1** Hammer tap stretches tendon, which, in turn, stretches sensory receptors in leg extensor muscle

**2A** Sensory neuron synapses with and excites motor neuron in the spinal cord

**2B** Sensory neuron also excites spinal interneuron

**2C** Interneuron synapse inhibits motor neuron to flexor muscles

**3A** Motor neuron conducts action potential to synapses on extensor muscle fibers, causing contraction

**3B** Flexor muscle relaxes because the activity of its motor neurons has been inhibited

**4** Leg extends

# Organization of human nervous system

- **By function:**
  - **Sensory systems**: acquiring and processing information from the environment, e.g., the visual system or the auditory system.
  - **Motor systems**: responding to such information by generating movements and other behavior.
  - **Associational systems**: mediating the most complex and least well characterized brain functions.

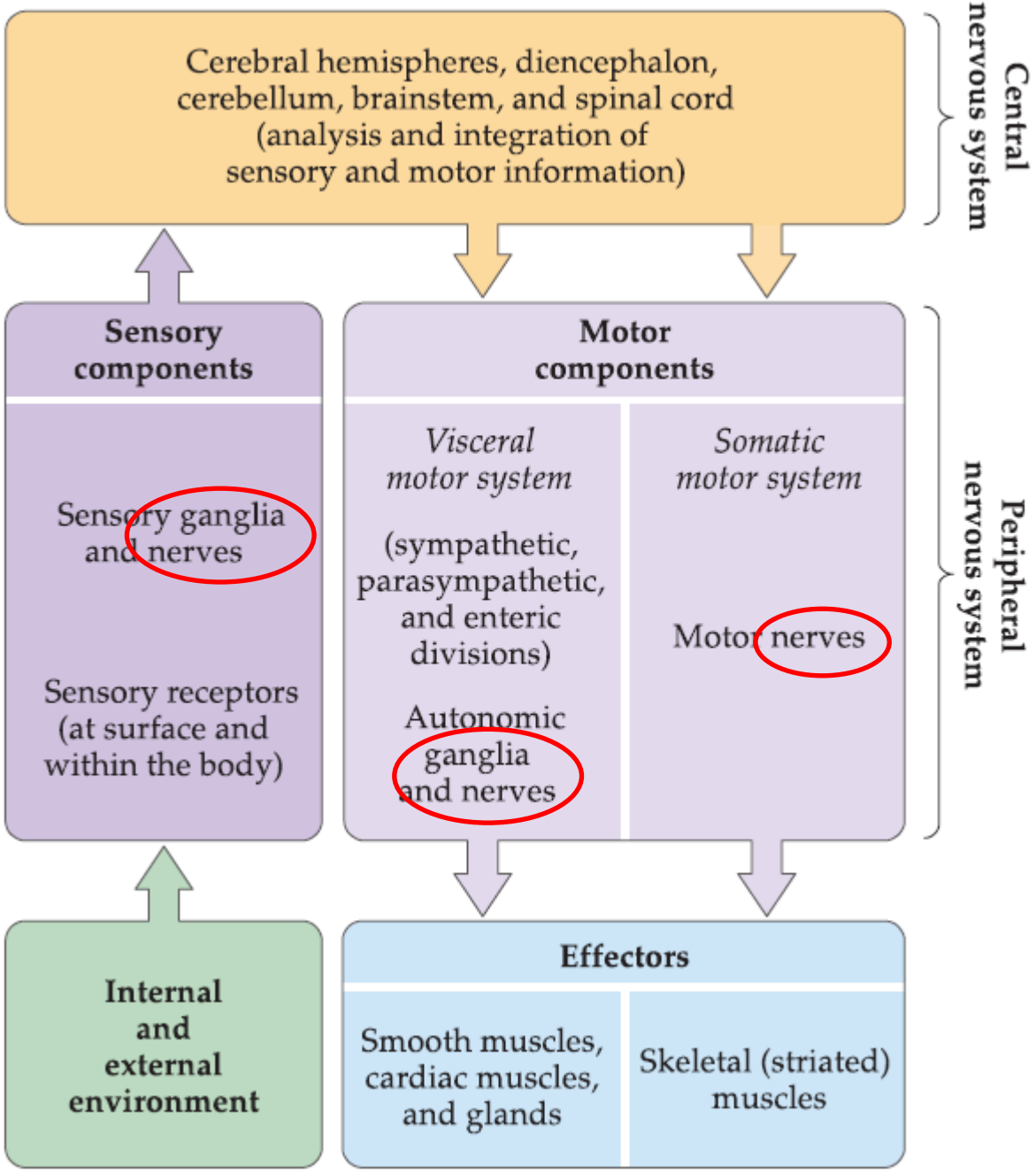
- **By anatomy:**
  - **Central nervous system (CNS)**: **brain** (cerebral hemispheres, diencephalon, cerebellum, and brainstem) and **spinal cord**.
  - **Peripheral nervous system (PNS)**

## ❖ CNS

- **Somas**:
  - **Nuclei**: local accumulations of neurons that have roughly similar connections and functions (cerebrum, brainstem and spinal cord)
  - **Cortex** (plural, *cortices)*: sheet-like arrays of nerve cells (cerebral hemispheres and cerebellum)
- **Axons**: tracts

## ❖ PNS

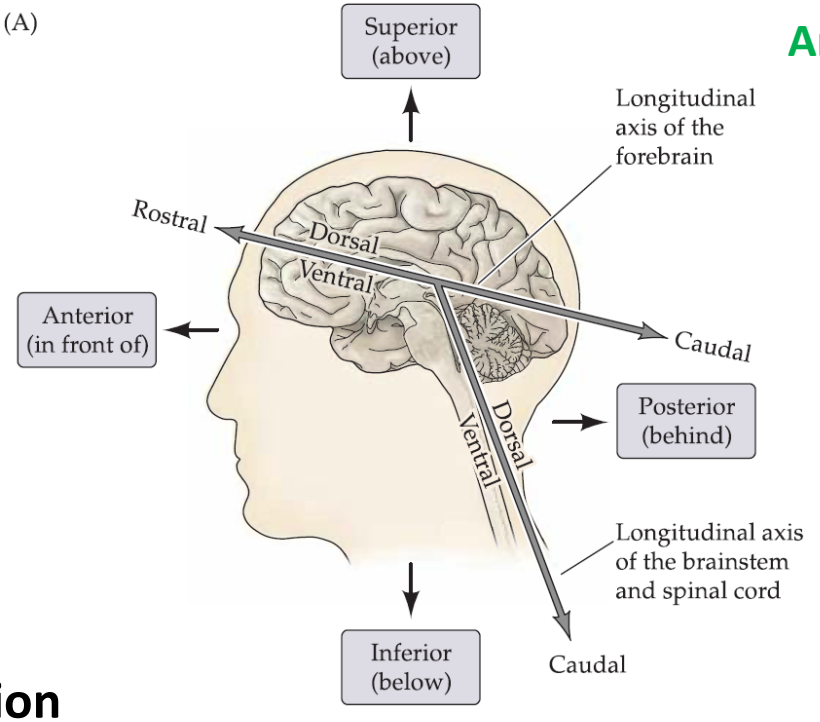
- **Somas**: ganglia
- **Axons**: nerves

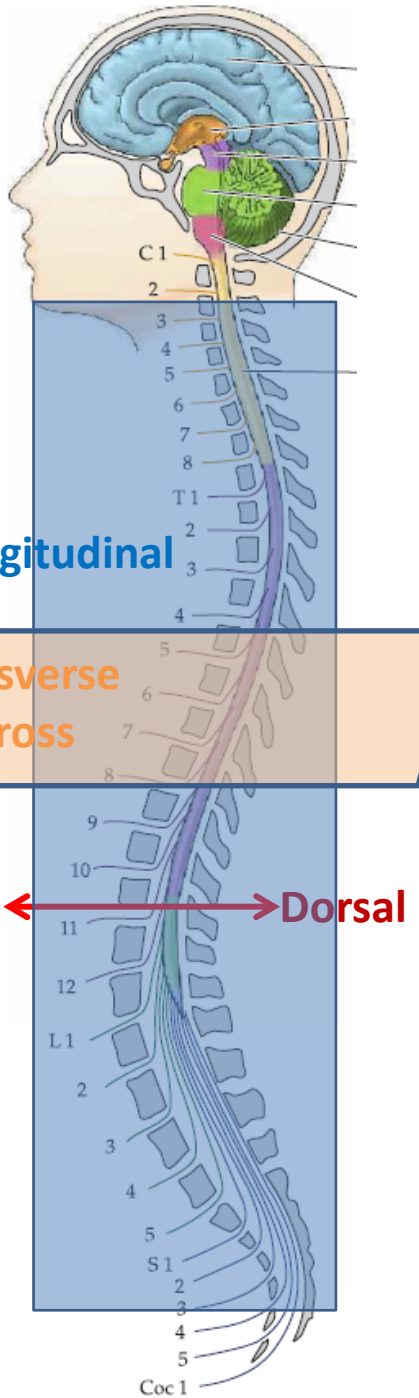


# Survey of human neuroanatomy

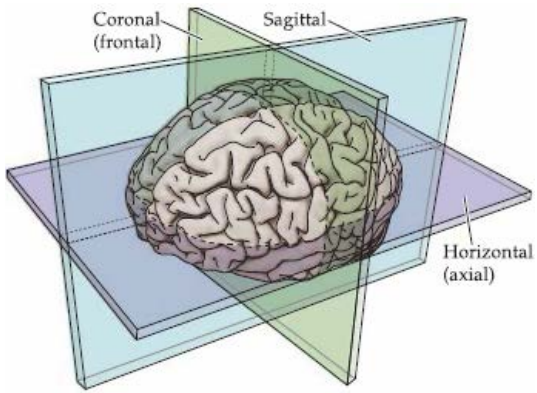
## ❖ Neuroanatomical terminology

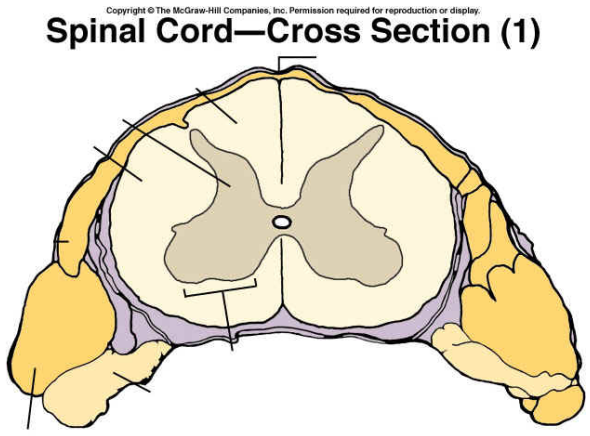
- **Axis**



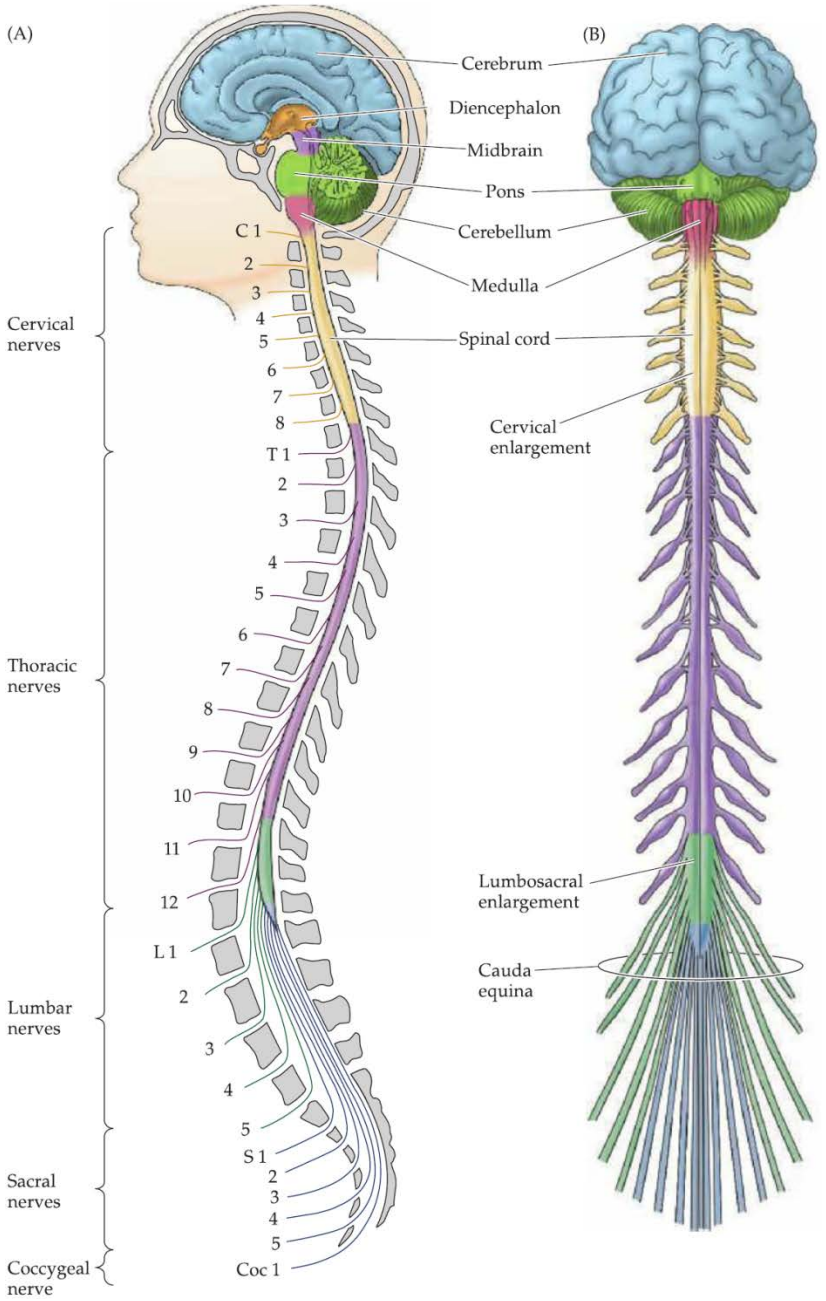




- **Planes of section**



# Basic subdivisions of central nervous system




**Forebrain**: diencephalon, cerebral hemispheres

**Hindbrain**: **brainstem**, cerebellum

**Brainstem**: medulla, pons, midbrain