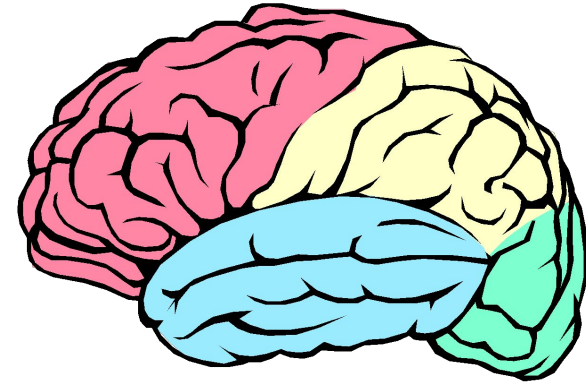


Overview of Nervous System

Dr R S Inamdar

The Nervous System



- A network of billions of nerve cells linked together in a highly organized fashion to form the rapid control center of the body.
- Functions include:
 - Integrating center for homeostasis, movement, and almost all other body functions.
 - The mysterious source of those traits that we think of as setting humans apart from animals

Basic Functions of the Nervous System

1. Sensation

- Monitors changes/events occurring in and outside the body. Such changes are known as *stimuli* and the cells that monitor them are *receptors*.

2. Integration

- The parallel processing and interpretation of sensory information to determine the appropriate response

3. Reaction

- Motor output.
 - The activation of muscles or glands (typically via the release of *neurotransmitters* (NTs))

Nervous vs. Endocrine System

- Similarities:

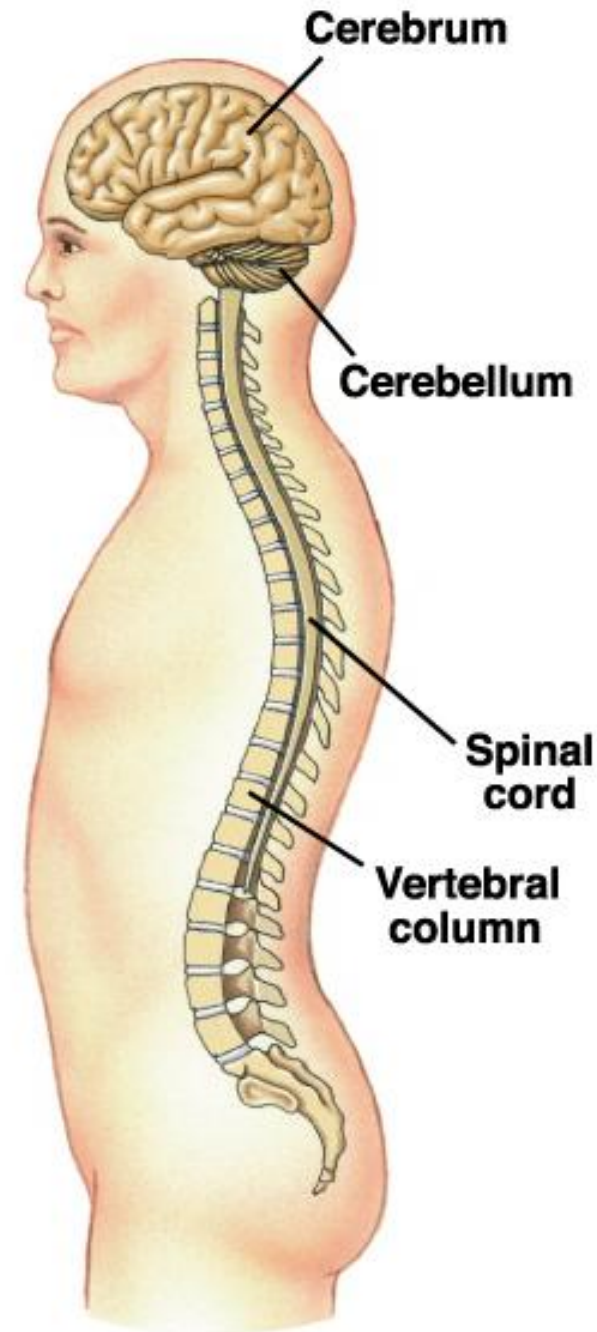
- They both monitor stimuli and react so as to maintain homeostasis.

- Differences:

- The NS is a rapid, fast-acting system whose effects do not always persevere.
- The ES acts slower (via blood-borne chemical signals called H _____) and its actions are usually much longer lasting.

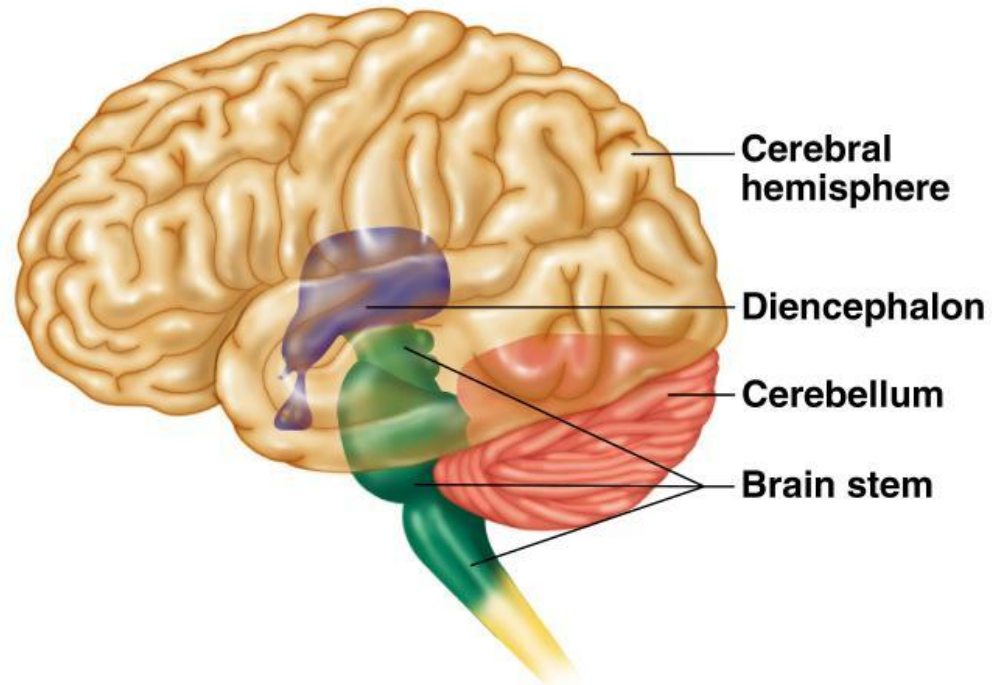
Organization of the Nervous System

- 2 big initial divisions:
 1. **Central Nervous System**
 - The brain + the spinal cord
 - The center of integration and control
 2. **Peripheral Nervous System**
 - The nervous system outside of the brain and spinal cord
 - Consists of:
 - 31 Spinal nerves
 - » Carry info to and from the spinal cord
 - 12 Cranial nerves
 - » Carry info to and from the brain



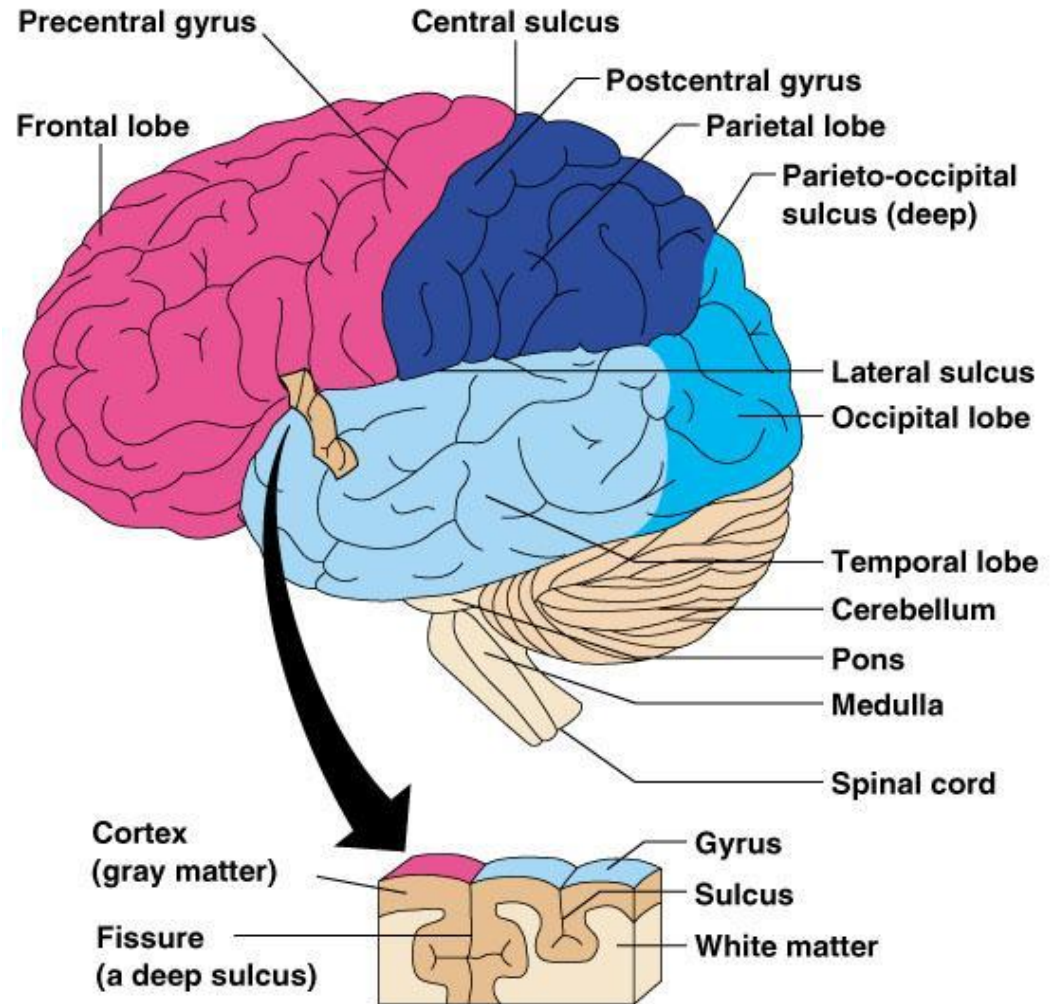
Regions of the Brain

- Cerebral hemispheres
- Diencephalon
- Brain stem
- Cerebellum



Cerebral Hemispheres (Cerebrum)

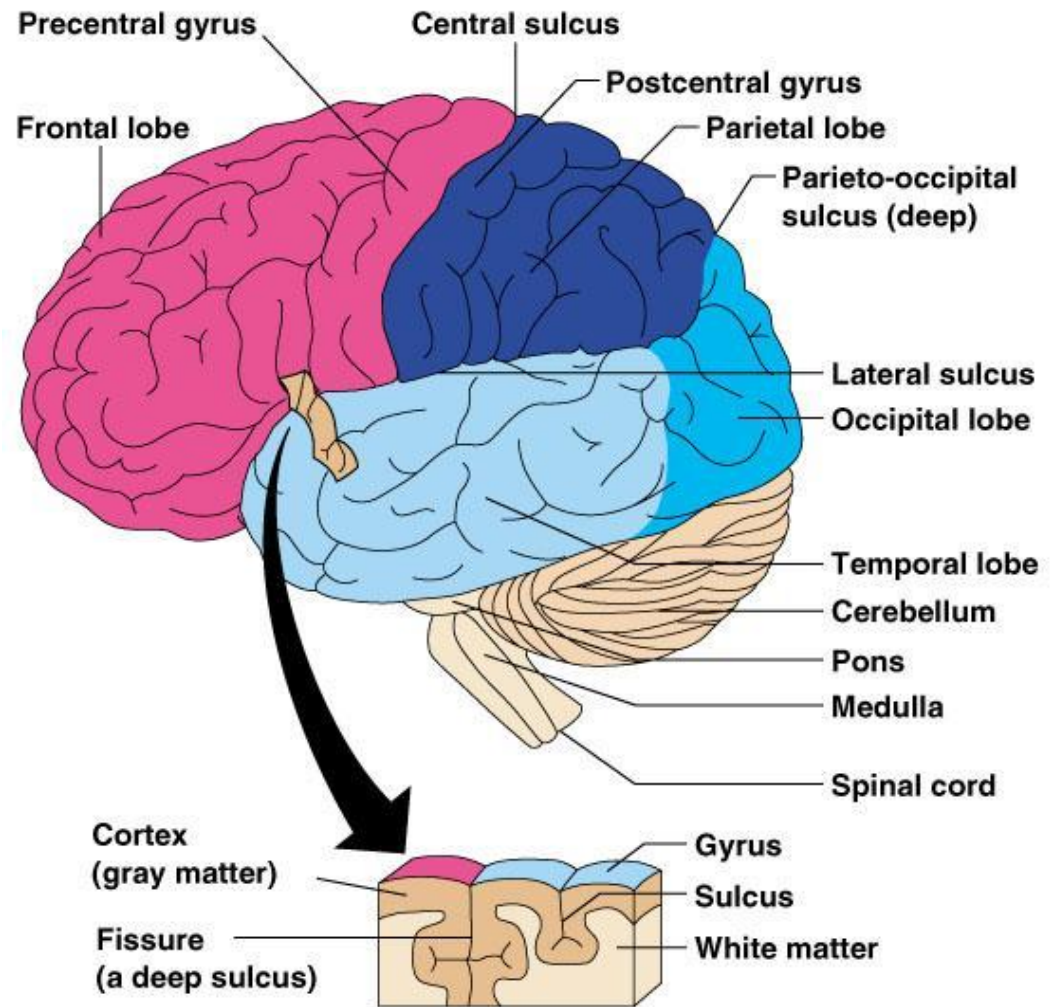
- Paired (left and right) superior parts of the brain
- Include more than half of the brain mass



(a)

Cerebral Hemispheres (Cerebrum)

- The surface is made of ridges (gyri) and grooves (sulci)



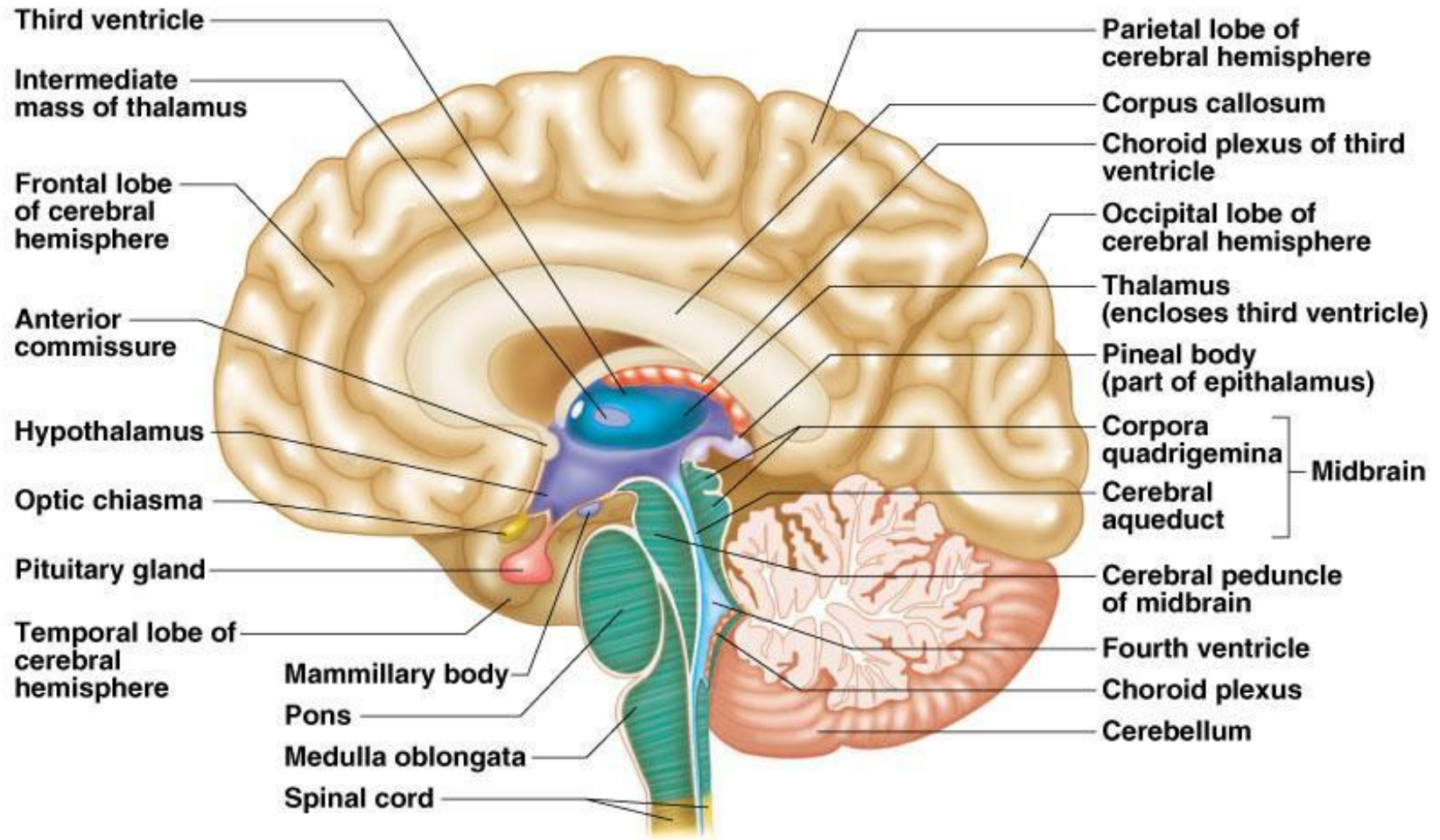
(a)

Figure 7.13a

Lobes of the Cerebrum

- Fissures (deep grooves) divide the cerebrum into lobes
- Surface lobes of the cerebrum
 - Frontal lobe
 - Parietal lobe
 - Occipital lobe
 - Temporal lobe

Lobes of the Cerebrum

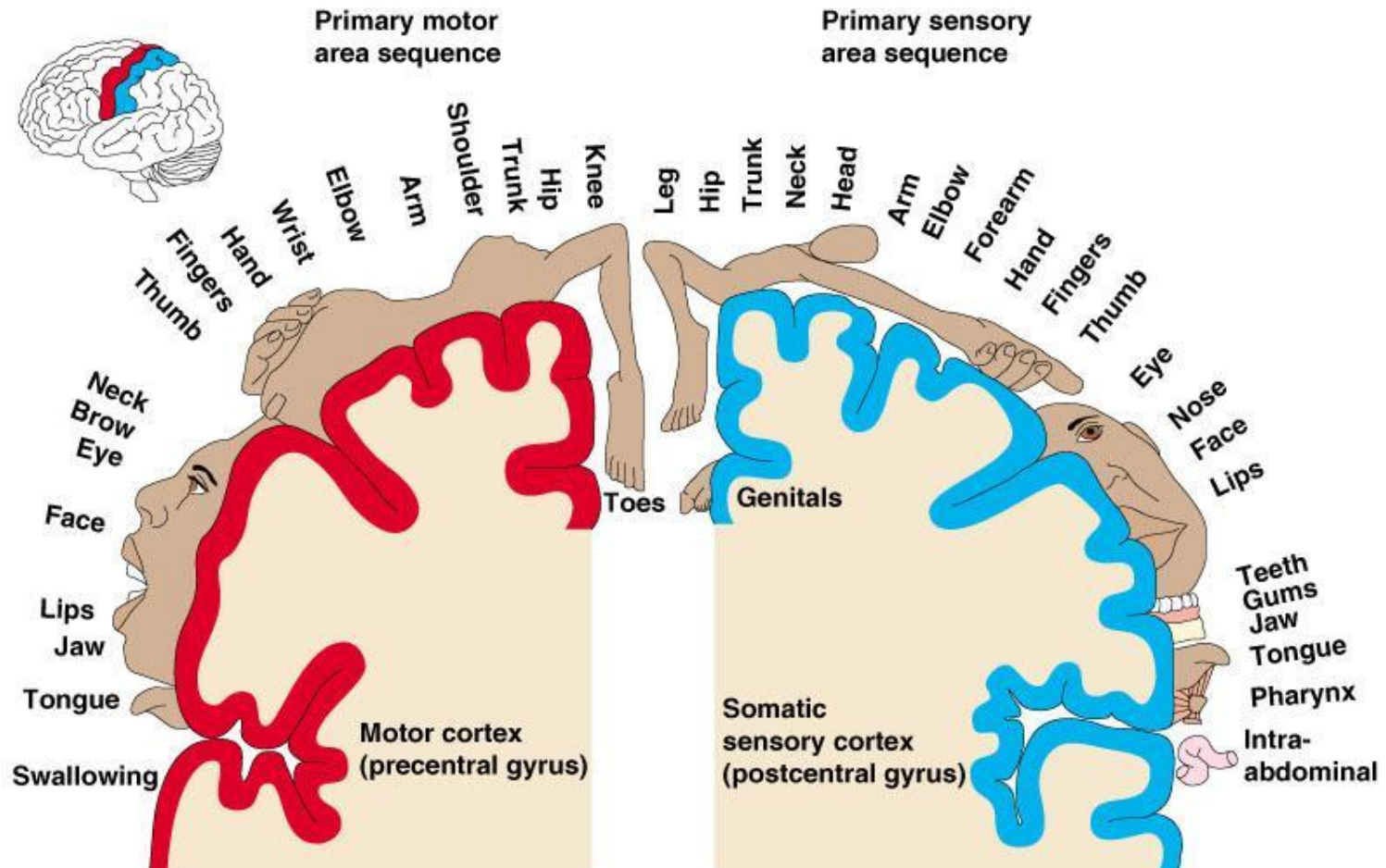


(a)

Specialized Areas of the Cerebrum

- Somatic sensory area – receives impulses from the body's sensory receptors
- Primary motor area – sends impulses to skeletal muscles
- Broca's area – involved in our ability to speak

Sensory and Motor Areas of the Cerebral Cortex



Specialized Area of the Cerebrum

- Cerebral areas involved in special senses
 - Gustatory area (taste)
 - Visual area
 - Auditory area
 - Olfactory area

Specialized Area of the Cerebrum

- Interpretation areas of the cerebrum
 - Speech/language region
 - Language comprehension region
 - General interpretation area

Specialized Area of the Cerebrum

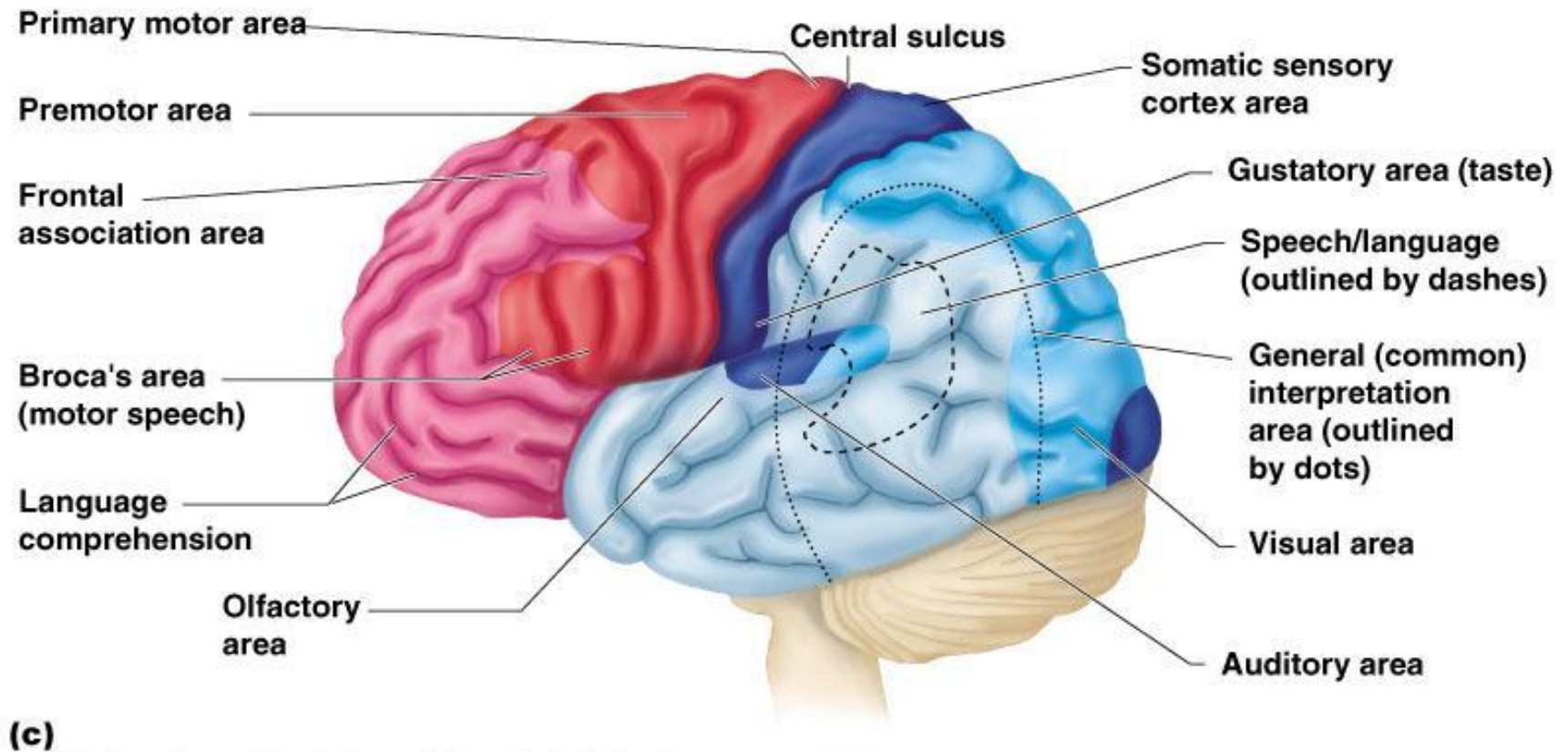
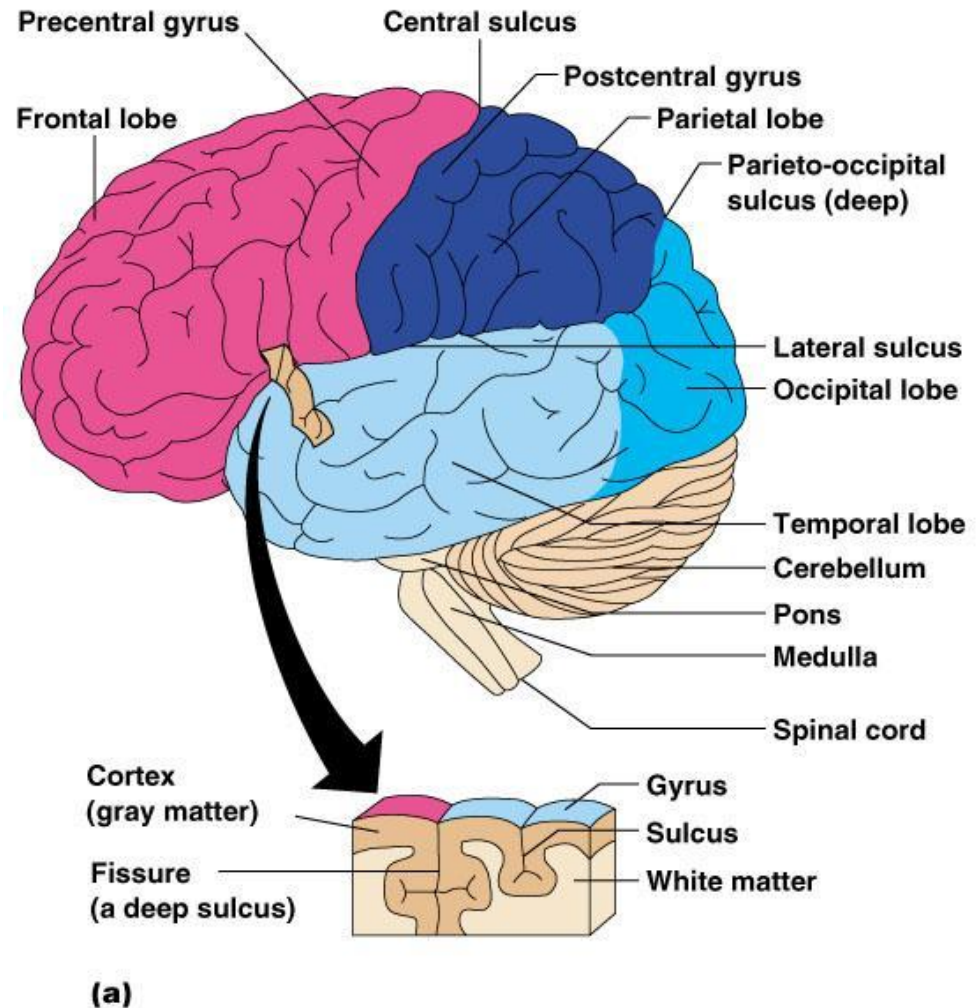


Figure 7.13c

Layers of the Cerebrum

- Gray matter
 - Outer layer
 - Composed mostly of neuron cell bodies



Layers of the Cerebrum

- White matter
 - Fiber tracts inside the gray matter
 - Example: corpus callosum connects hemispheres

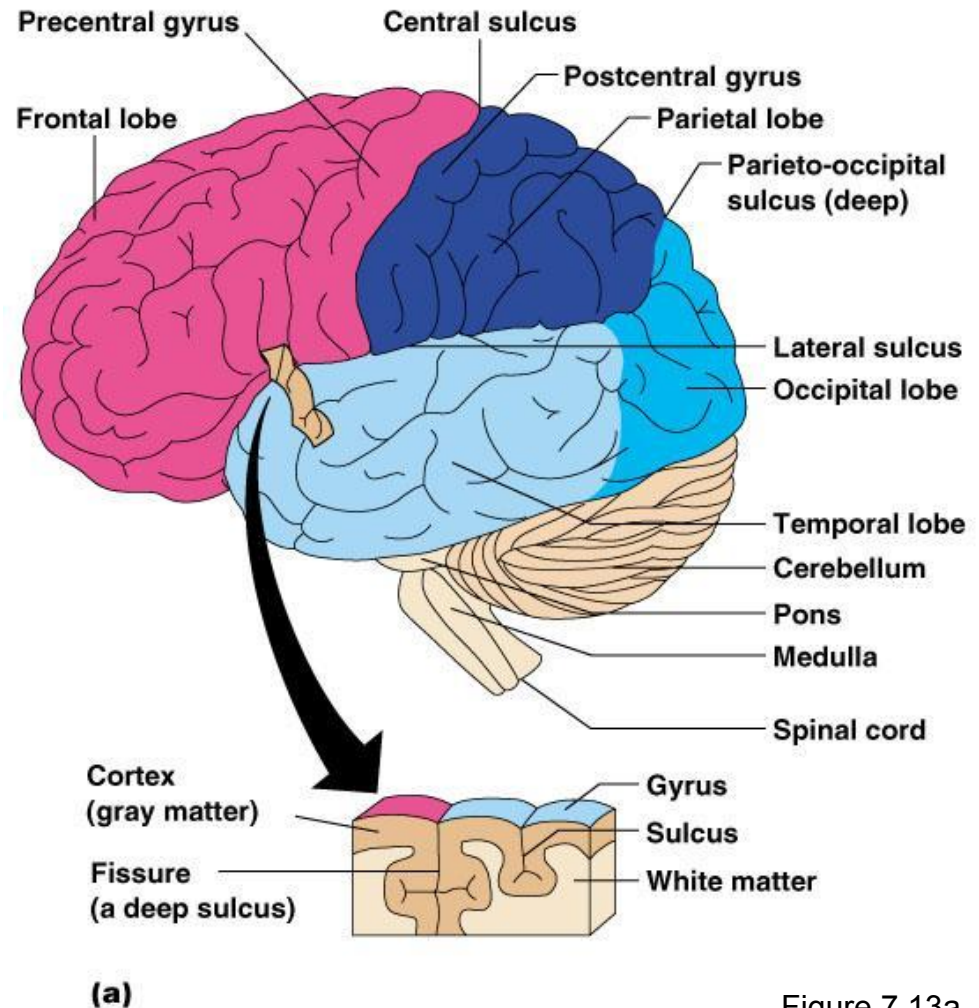
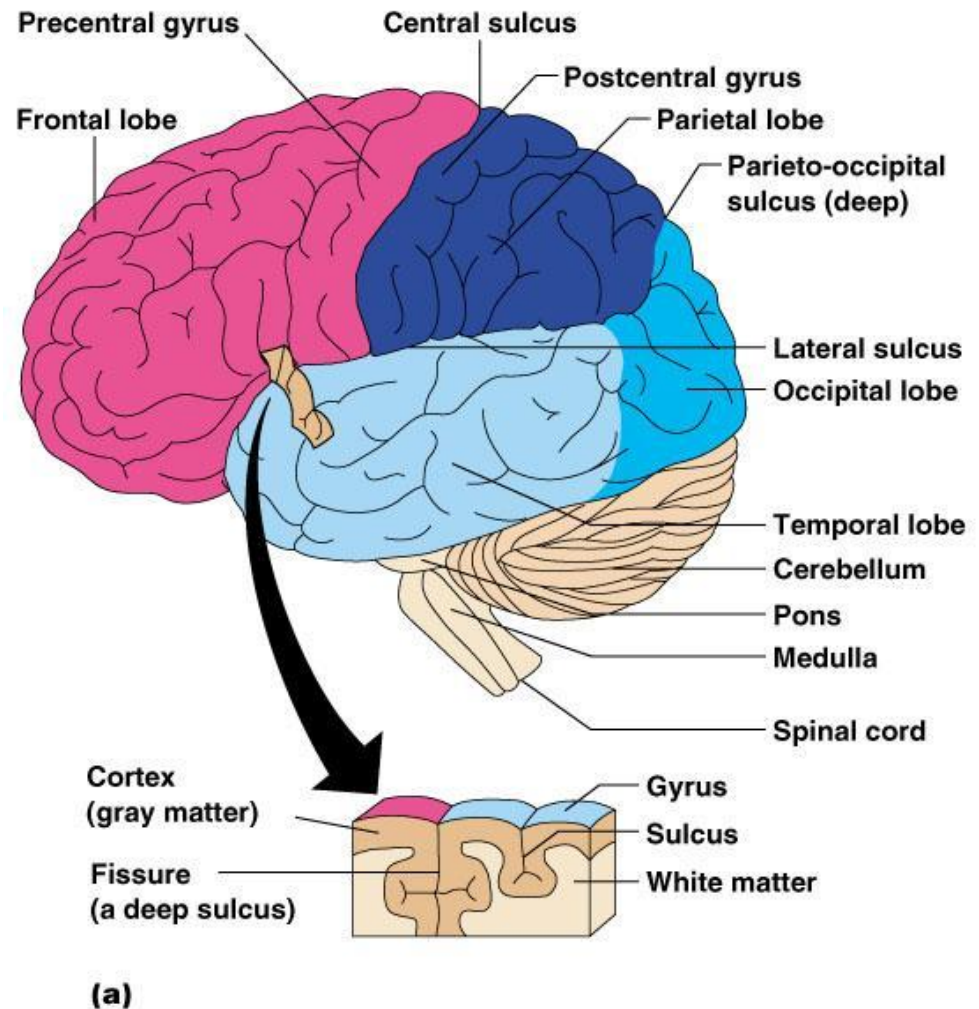


Figure 7.13a

Layers of the Cerebrum

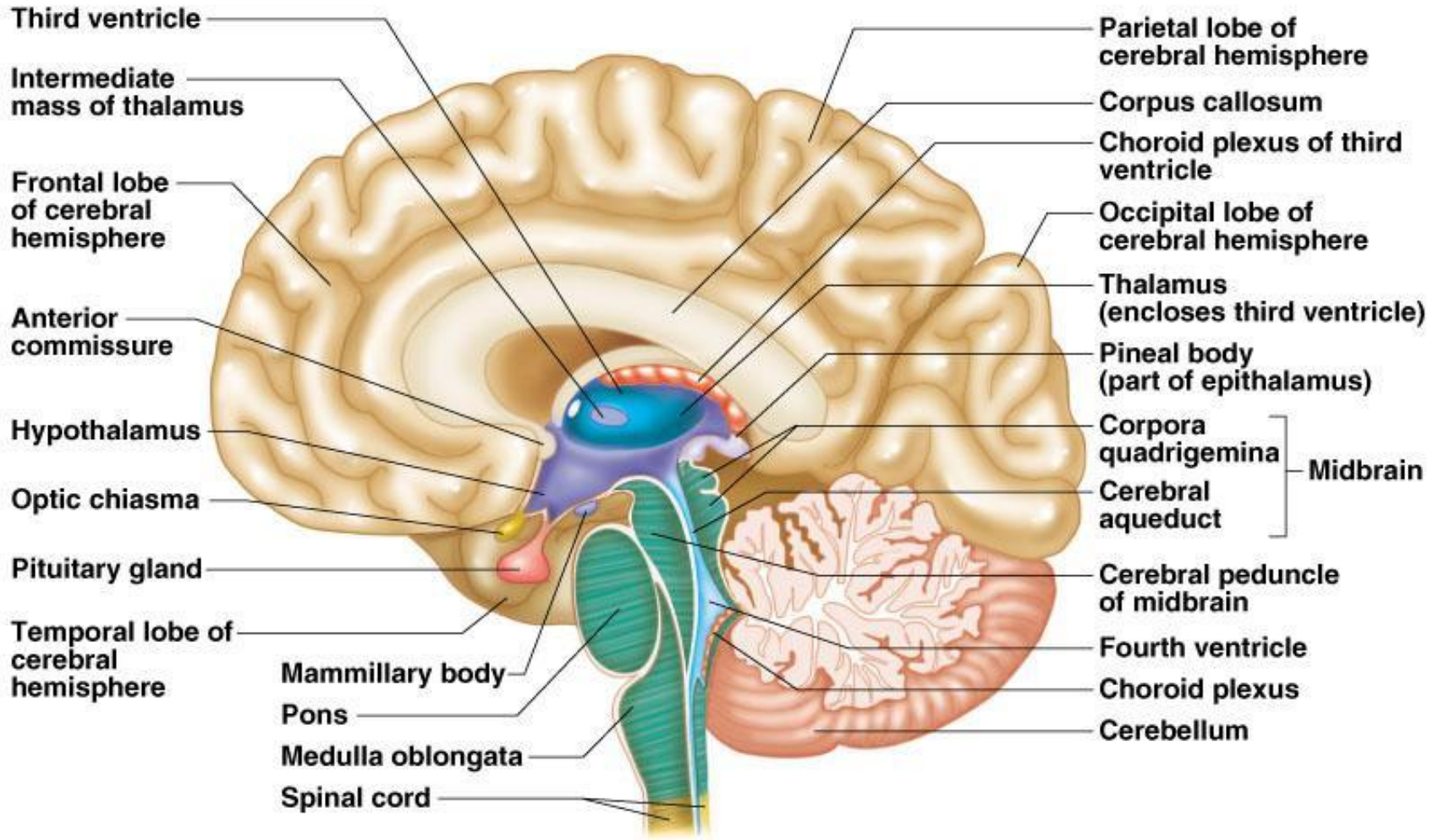
- Basal nuclei – internal islands of gray matter
- Regulates voluntary motor activities by modifying info sent to the motor cortex
- Problems = ie unable to control muscles, spastic, jerky
- Involved in Huntington's and Parkinson's Disease



Diencephalon

- Sits on top of the brain stem
- Enclosed by the cerebral hemispheres
- Made of three parts
 - Thalamus
 - Hypothalamus
 - Epithalamus

Diencephalon



(a)

Thalamus

- Surrounds the third ventricle
- The relay station for sensory impulses
- Transfers impulses to the correct part of the cortex for localization and interpretation

Hypothalamus

- Under the thalamus
- Important autonomic nervous system center
 - Helps regulate body temperature
 - Controls water balance
 - Regulates metabolism

Hypothalamus

- An important part of the limbic system (emotions)
- The pituitary gland is attached to the hypothalamus

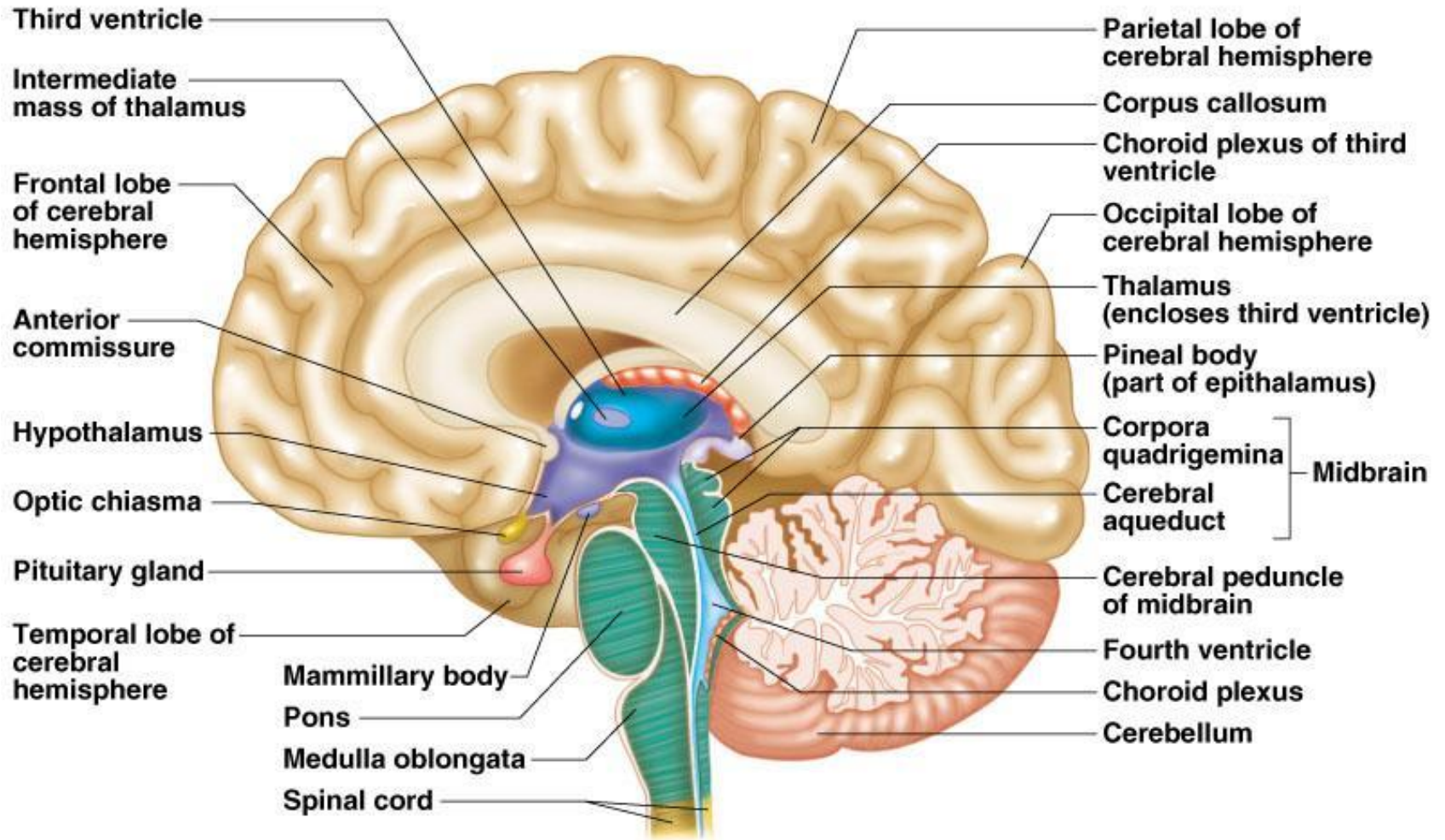
Epithalamus

- Forms the roof of the third ventricle
- Houses the pineal body (an endocrine gland)
- Includes the choroid plexus – forms cerebrospinal fluid

Brain Stem

- Attaches to the spinal cord
- Parts of the brain stem
 - Midbrain
 - Pons
 - Medulla oblongata

Brain Stem



(a)

Midbrain

- Mostly composed of tracts of nerve fibers
 - Reflex centers for vision and hearing
 - Cerebral aquaduct – 3rd-4th ventricles

Pons

- The bulging center part of the brain stem
- Mostly composed of fiber tracts
- Includes nuclei involved in the control of breathing

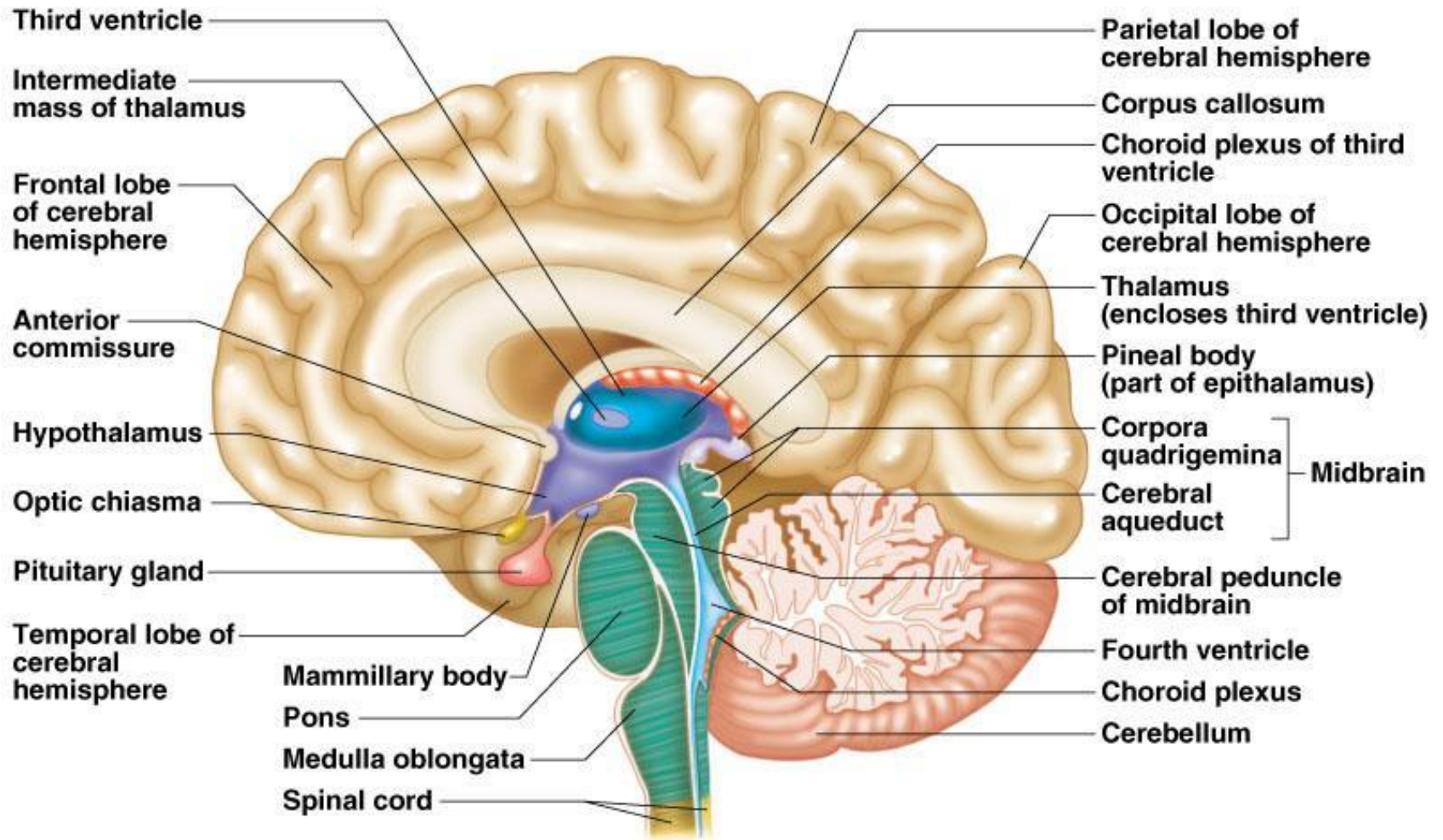
Medulla Oblongata

- The lowest part of the brain stem
- Merges into the spinal cord
- Includes important fiber tracts
- Contains important control centers
 - Heart rate control
 - Blood pressure regulation
 - Breathing
 - Swallowing
 - Vomiting

Cerebellum

- Two hemispheres with convoluted surfaces
- Provides involuntary coordination of body movements

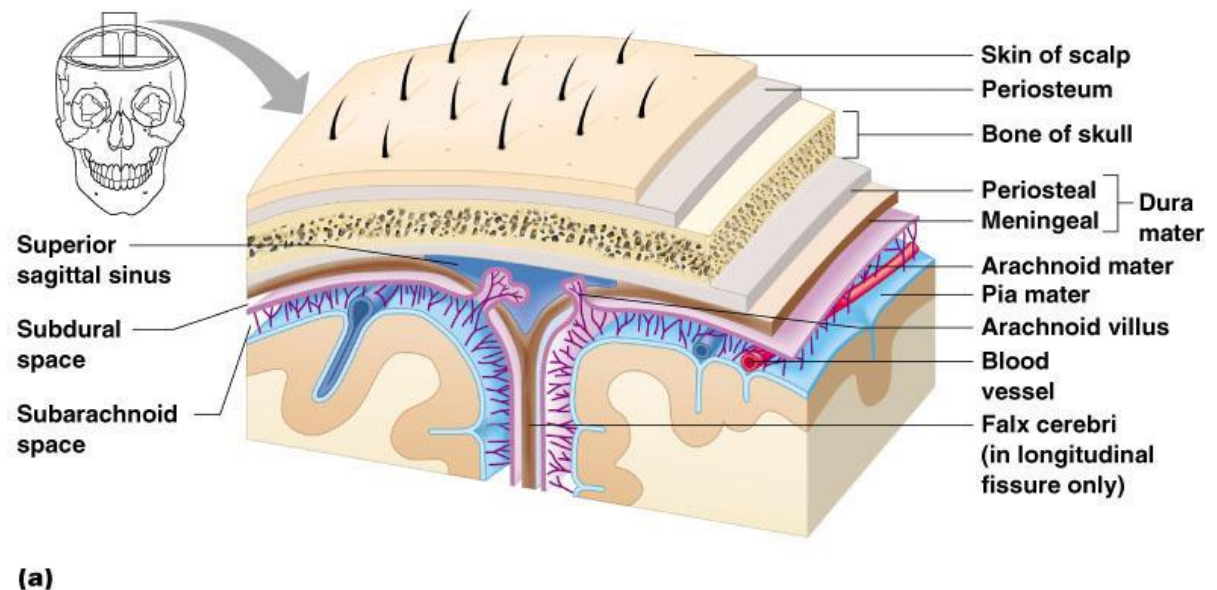
Cerebellum



(a)

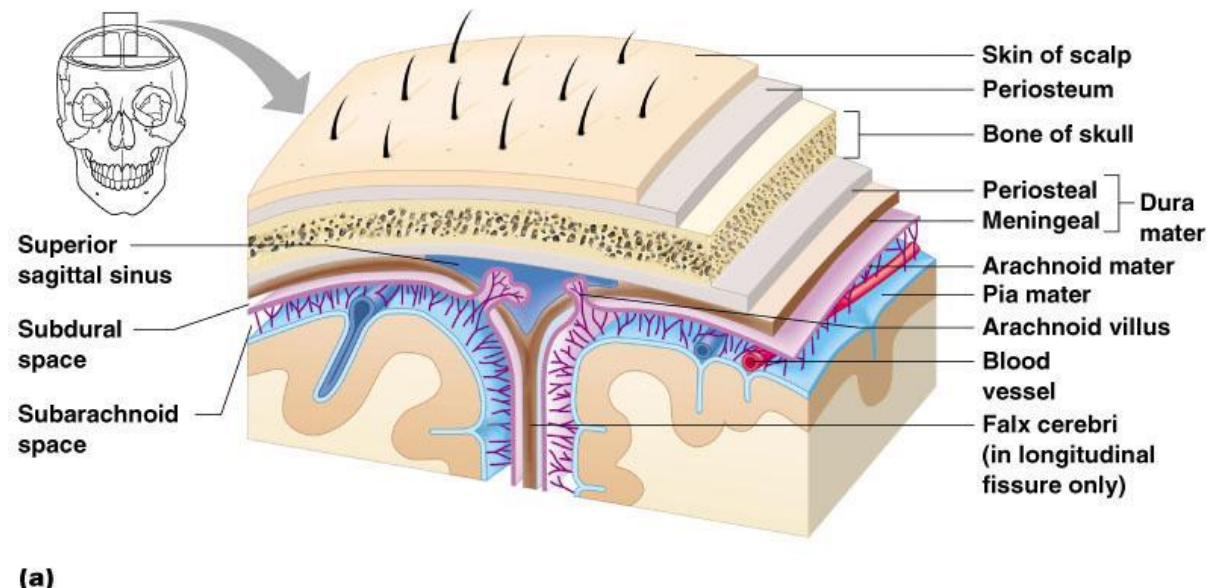
Protection of the Central Nervous System

- Scalp and skin
- Skull and vertebral column
- Meninges



Protection of the Central Nervous System

- Cerebrospinal fluid
- Blood brain barrier



Meninges

- Dura mater
 - Double-layered external covering
 - Periosteum – attached to surface of the skull
 - Meningeal layer – outer covering of the brain
 - Folds inward in several areas

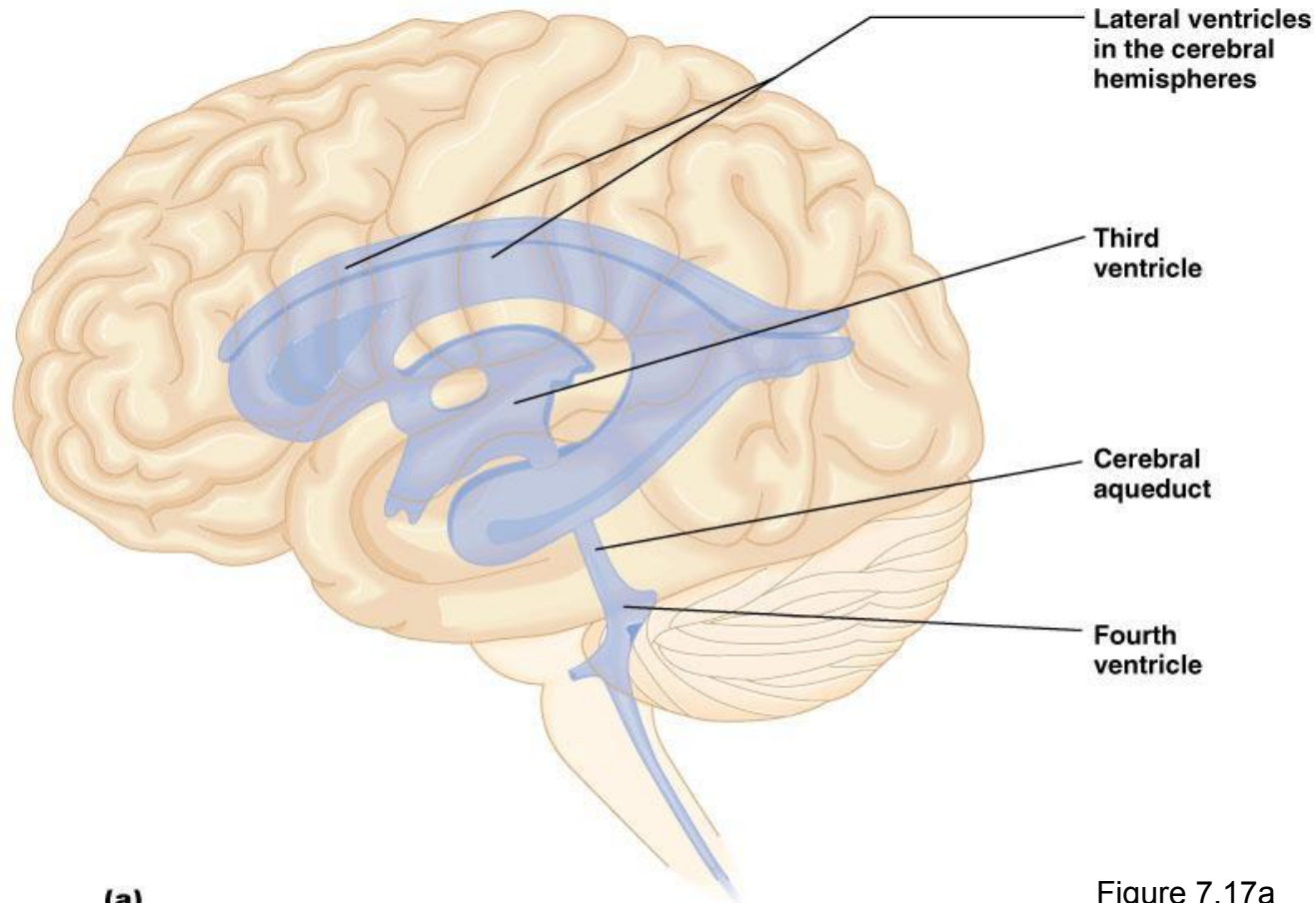
Meninges

- Arachnoid layer
 - Middle layer
 - Web-like
- Pia mater
 - Internal layer
 - Clings to the surface of the brain

Cerebrospinal Fluid

- Similar to blood plasma composition
- Formed by the choroid plexus
- Forms a watery cushion to protect the brain
- Circulated in arachnoid space, ventricles, and central canal of the spinal cord

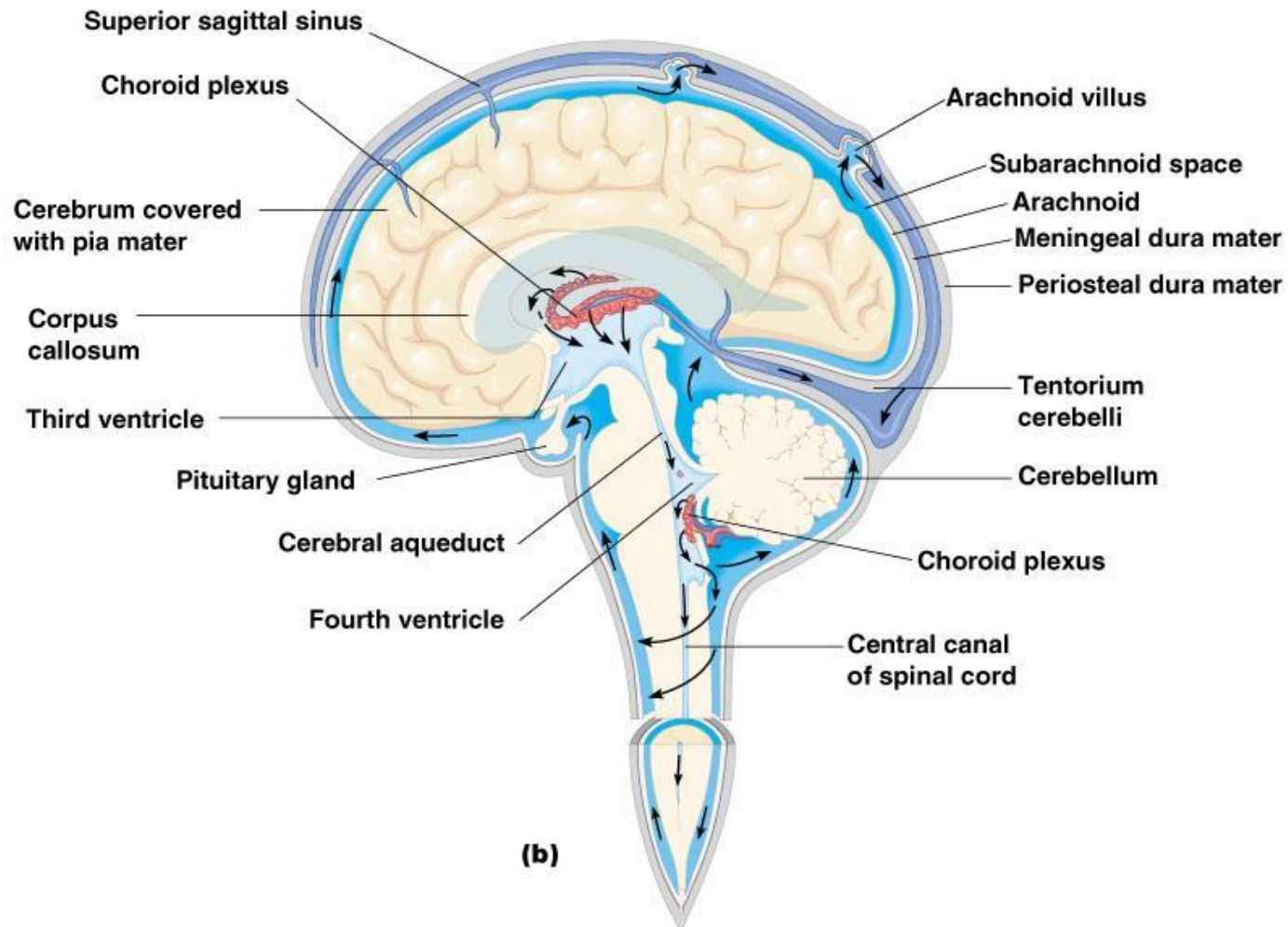
Ventricles and Location of the Cerebrospinal Fluid



(a)

Figure 7.17a

Ventricles and Location of the Cerebrospinal Fluid

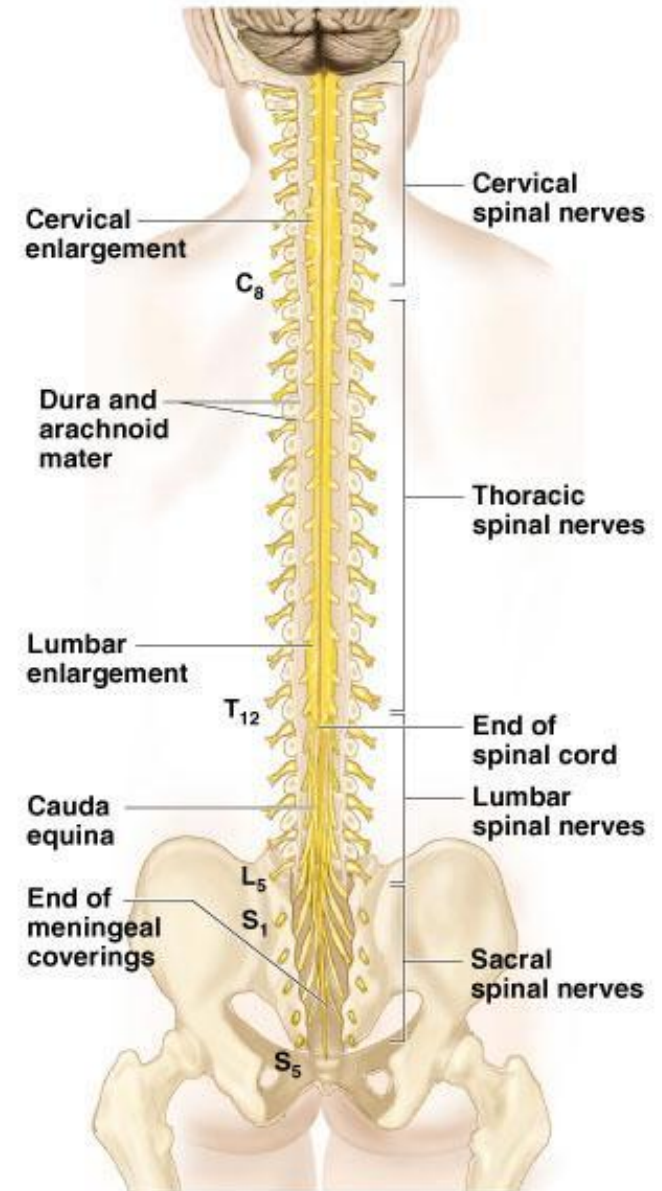


Blood Brain Barrier

- Includes the least permeable capillaries of the body
- Excludes many potentially harmful substances
- Useless against some substances
 - Fats and fat soluble molecules
 - Respiratory gases
 - Alcohol
 - Nicotine
 - Anesthesia

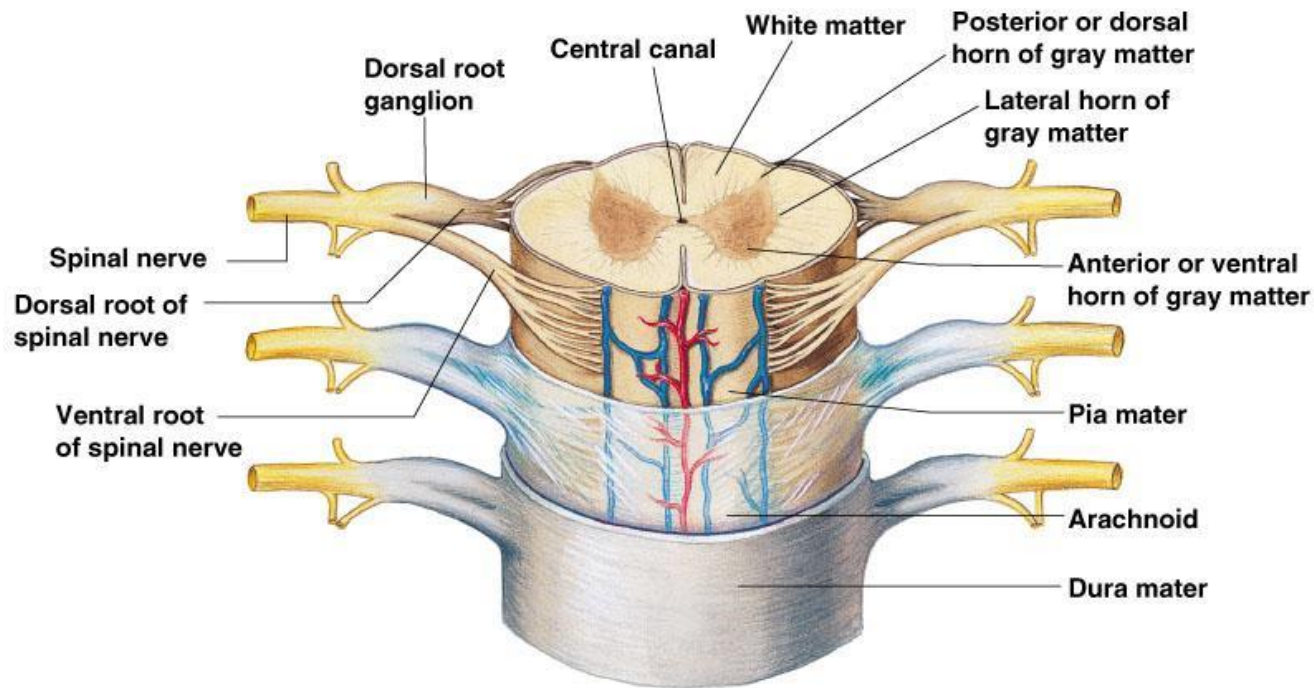
Spinal Cord

- Extends from the medulla oblongata to the region of T12
- Below T12 is the cauda equina (a collection of spinal nerves)
- Enlargements occur in the cervical and lumbar regions



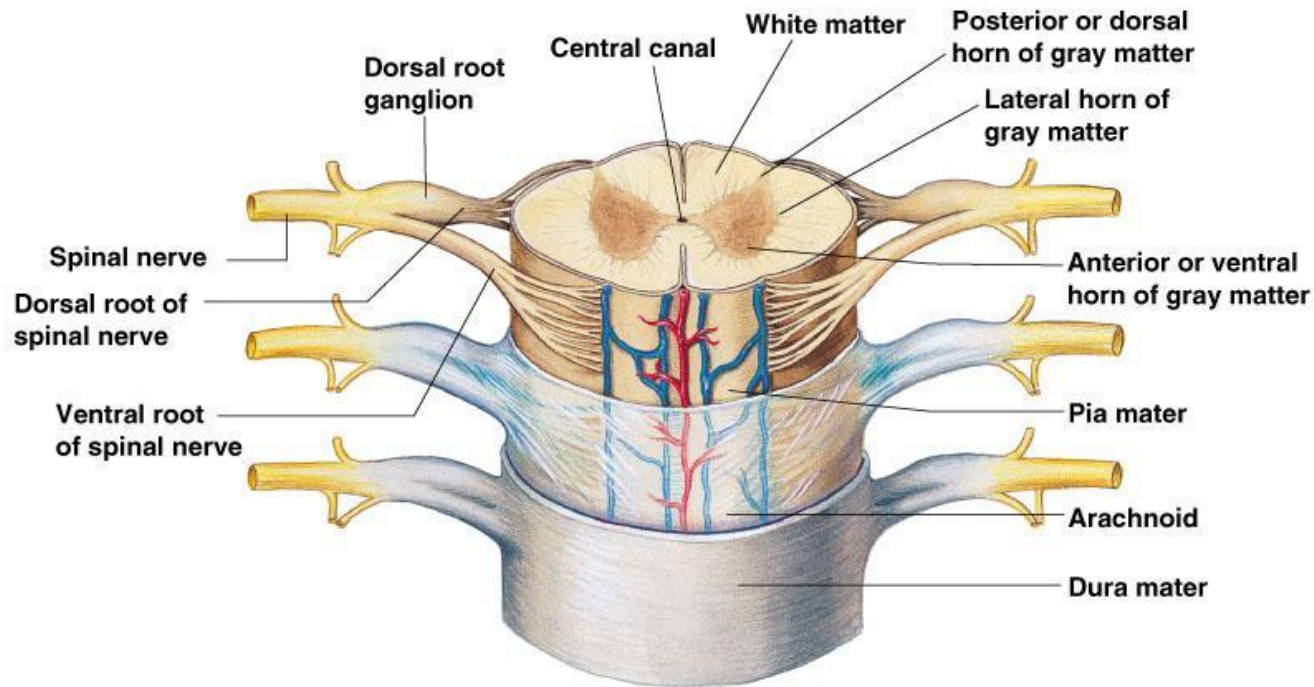
Spinal Cord Anatomy

- Exterior white matter – conduction tracts



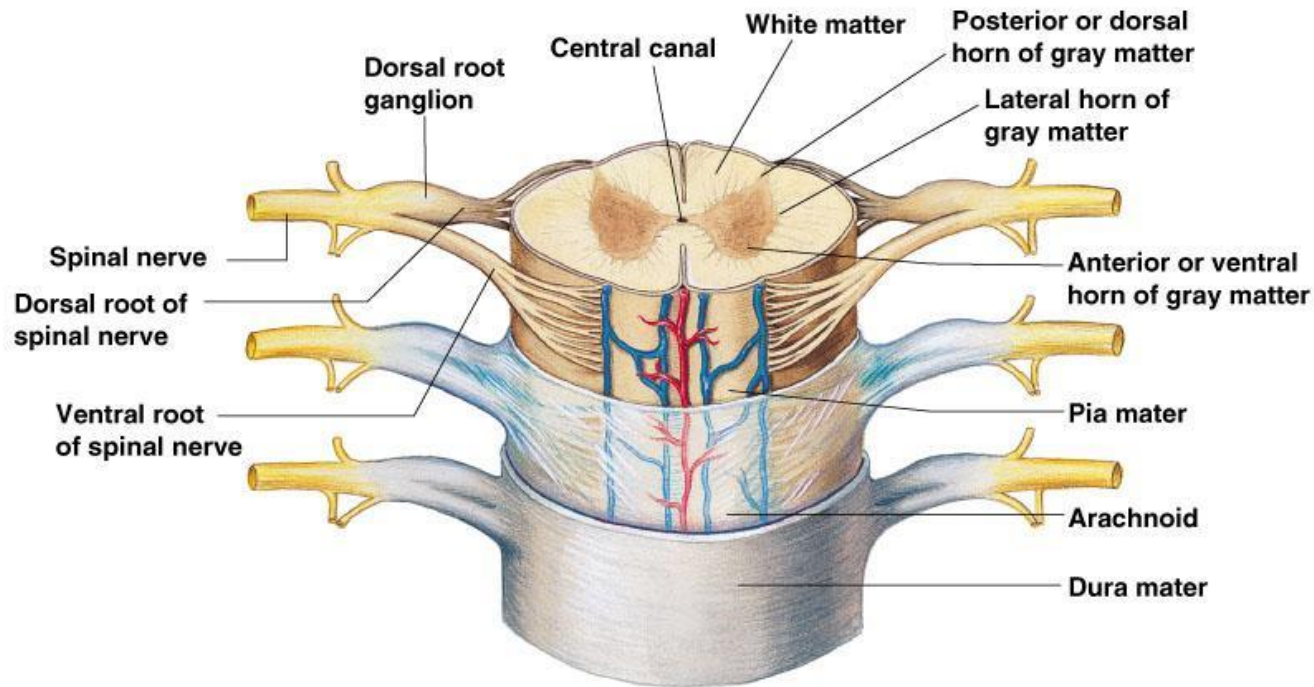
Spinal Cord Anatomy

- Internal gray matter - mostly cell bodies
 - Dorsal (posterior) horns
 - Anterior (ventral) horns



Spinal Cord Anatomy

- Central canal filled with cerebrospinal fluid



Spinal Cord Anatomy

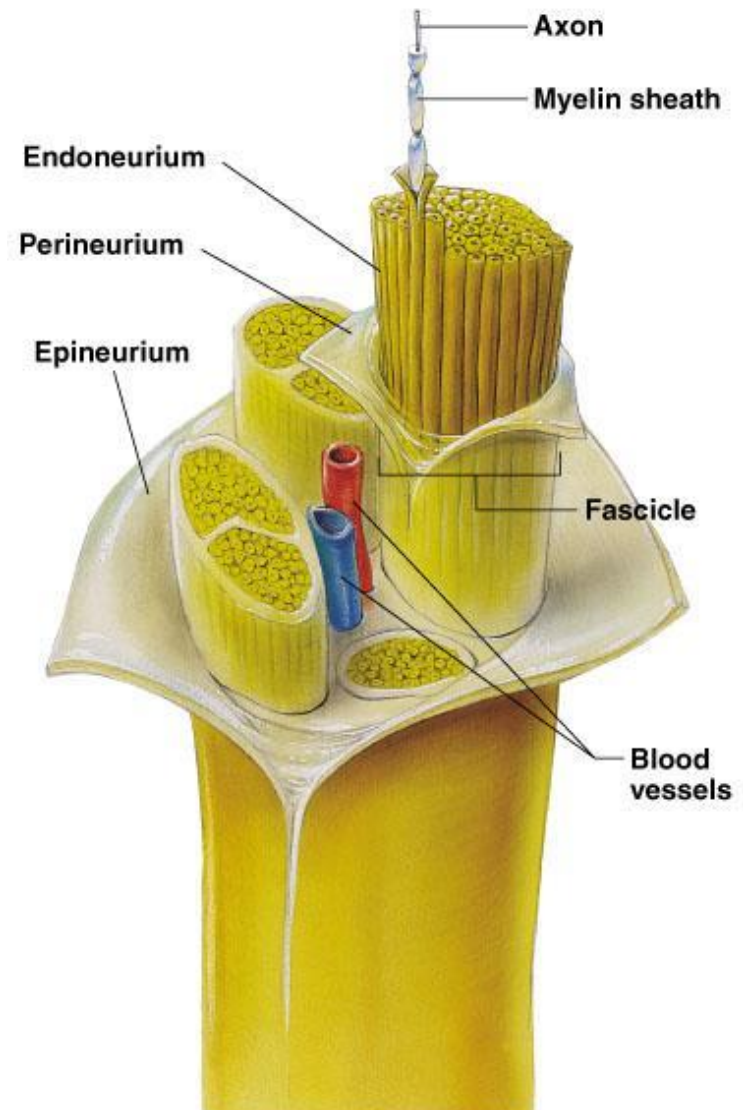
- Meninges cover the spinal cord
- Nerves leave at the level of each vertebrae
 - Dorsal root
 - Associated with the dorsal root ganglia – collections of cell bodies outside the central nervous system
 - Ventral root

Peripheral Nervous System

- Nerves and ganglia outside the central nervous system
- Nerve = bundle of neuron fibers
- Neuron fibers are bundled by connective tissue

Structure of a Nerve

- Endoneurium surrounds each fiber
- Groups of fibers are bound into fascicles by perineurium
- Fascicles are bound together by epineurium



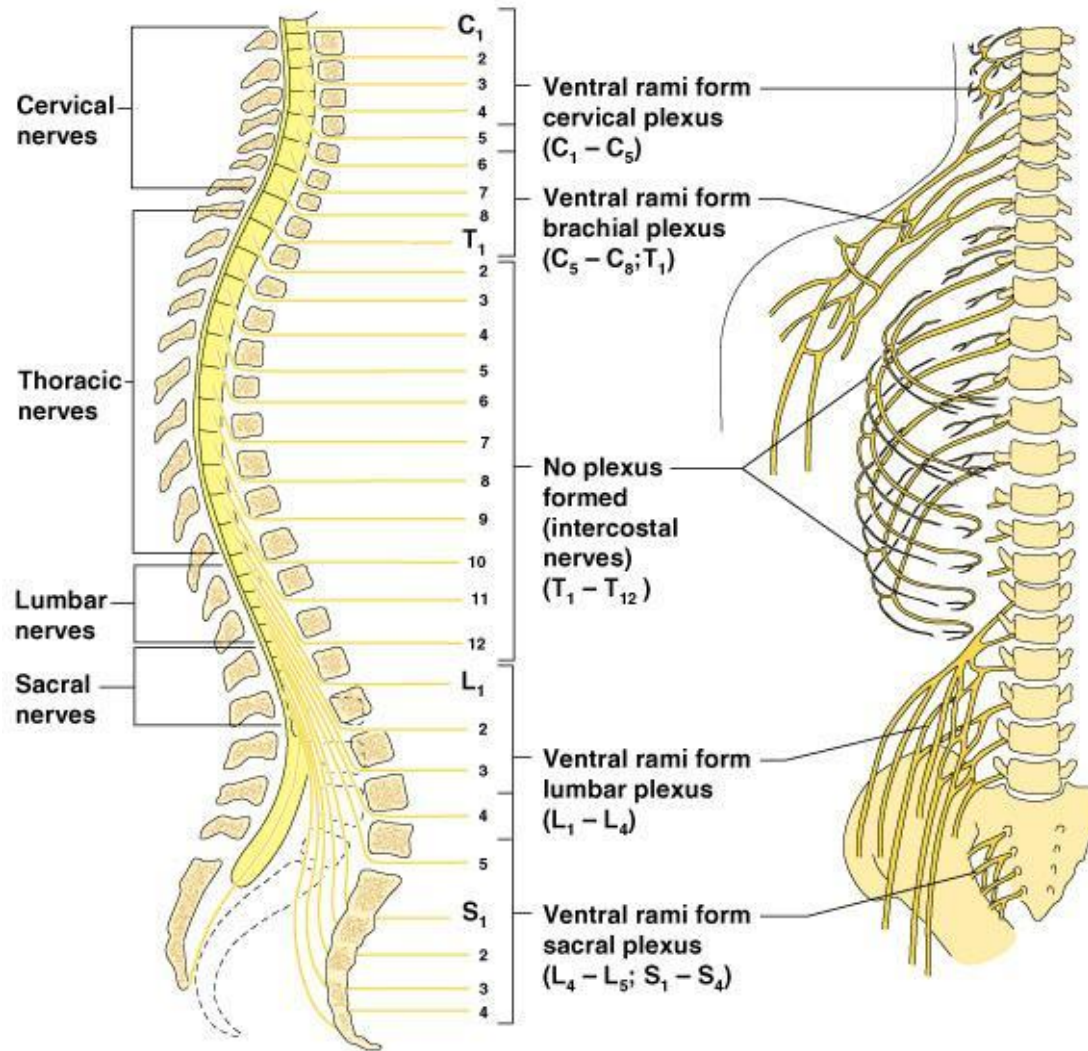
Classification of Nerves

- Mixed nerves – both sensory and motor fibers
- Afferent (sensory) nerves – carry impulses toward the CNS
- Efferent (motor) nerves – carry impulses away from the CNS

Spinal Nerves

- There is a pair of spinal nerves at the level of each vertebrae.

Spinal Nerves



(a)

Peripheral Nervous System

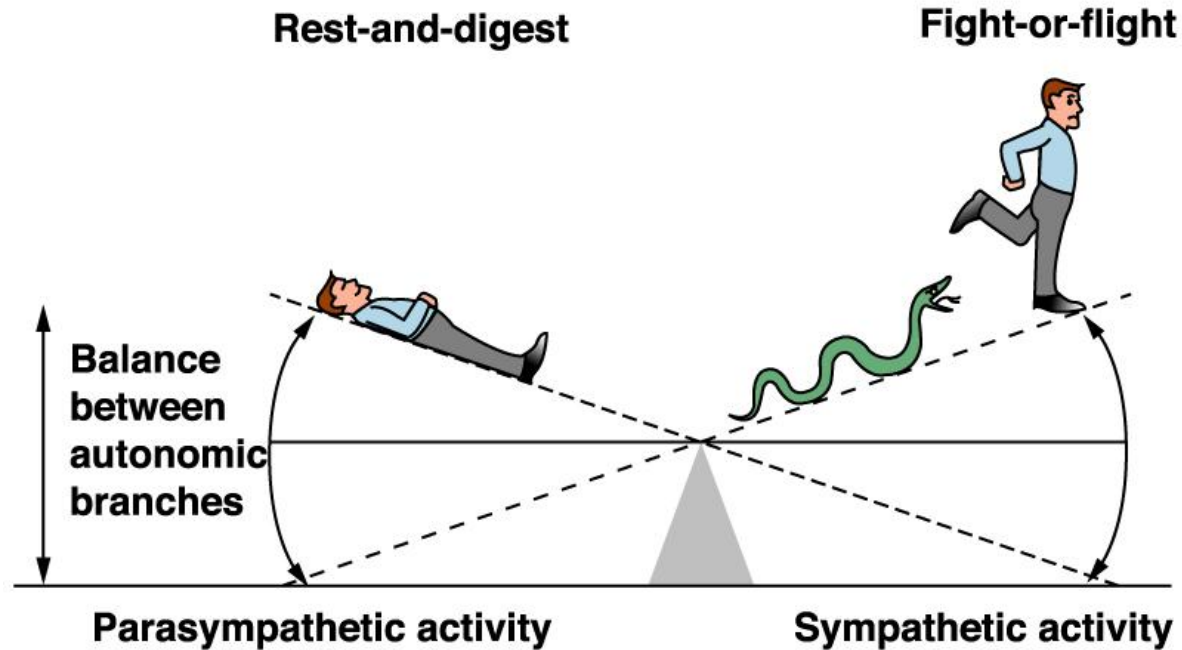
- Responsible for communication between the CNS and the rest of the body.
- Can be divided into:
 - **Sensory Division**
 - **Afferent division**
 - Conducts impulses from receptors to the CNS
 - Informs the CNS of the state of the body interior and exterior
 - Sensory nerve fibers can be **somatic**(from skin, skeletal muscles or joints) or **visceral** (from organs w/i the ventral body cavity)
 - **Motor Division**
 - **Efferent division**
 - Conducts impulses from CNS to effectors (muscles/glands)
 - Motor nerve fibers

Motor Efferent Division

- Can be divided further:
 - Somatic nervous system
 - VOLUNTARY (generally)
 - Somatic nerve fibers that conduct impulses from the CNS to skeletal muscles
 - Autonomic nervous system
 - INVOLUNTARY (generally)
 - Conducts impulses from the CNS to smooth muscle, cardiac muscle, and glands.

Autonomic Nervous System

- Can be divided into:
 - Sympathetic Nervous System
 - “Fight or Flight”
 - Parasympathetic Nervous System
 - “Rest and Digest”



These 2 systems are antagonistic.

Typically, we balance these 2 to keep ourselves in a state of dynamic balance.

We'll go further into the difference btwn these 2 later!

Nervous Tissue

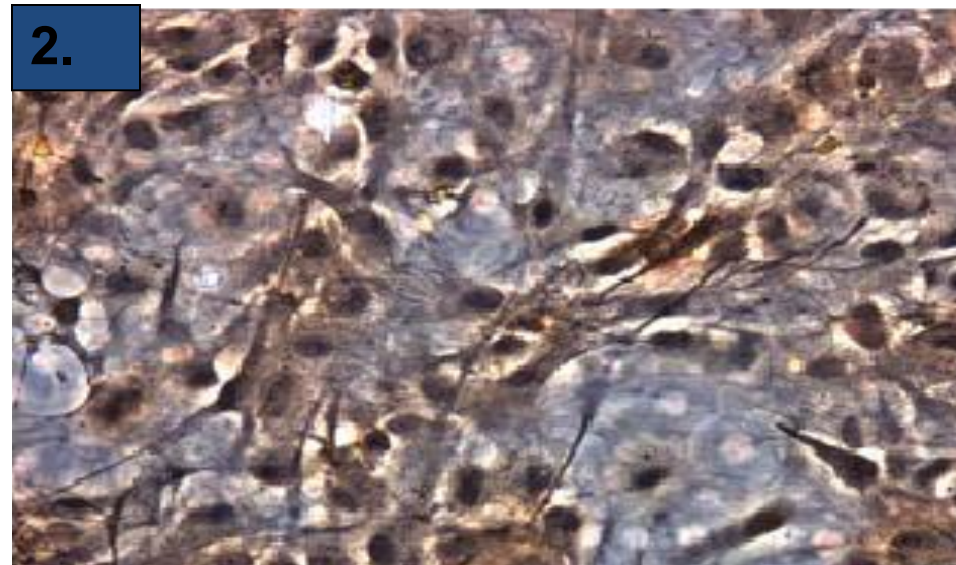
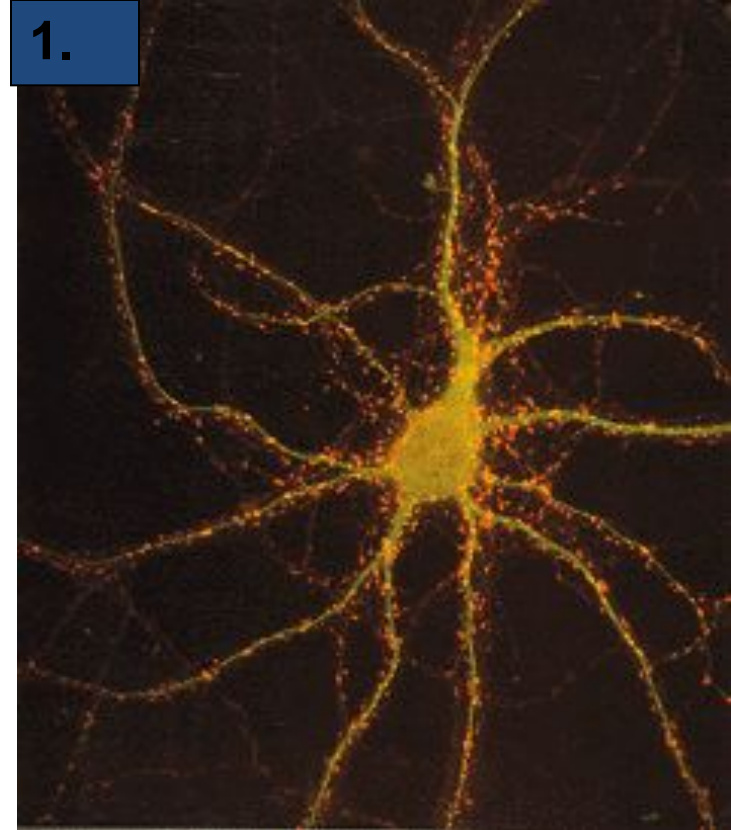
- Highly cellular
 - How does this compare to the other 3 tissue types?
- 2 cell types

1. Neurons

- Functional, signal conducting cells

2. Neuroglia

- Supporting cells

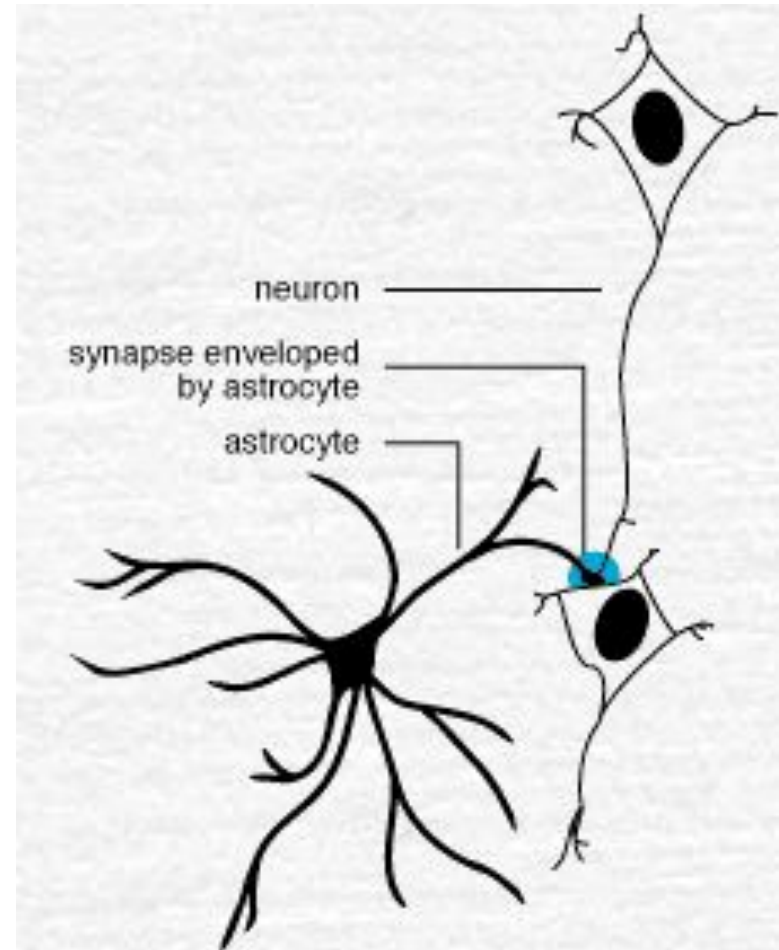


Neuroglia

- Outnumber neurons by about 10 to 1 (the guy on the right had an inordinate amount of them).
- 6 types of supporting cells
 - 4 are found in the CNS:

1. Astrocytes

- Star-shaped, abundant, and versatile
- Guide the migration of developing neurons
- Act as K^+ and NT buffers
- Involved in the formation of the blood brain barrier
- Function in nutrient transfer



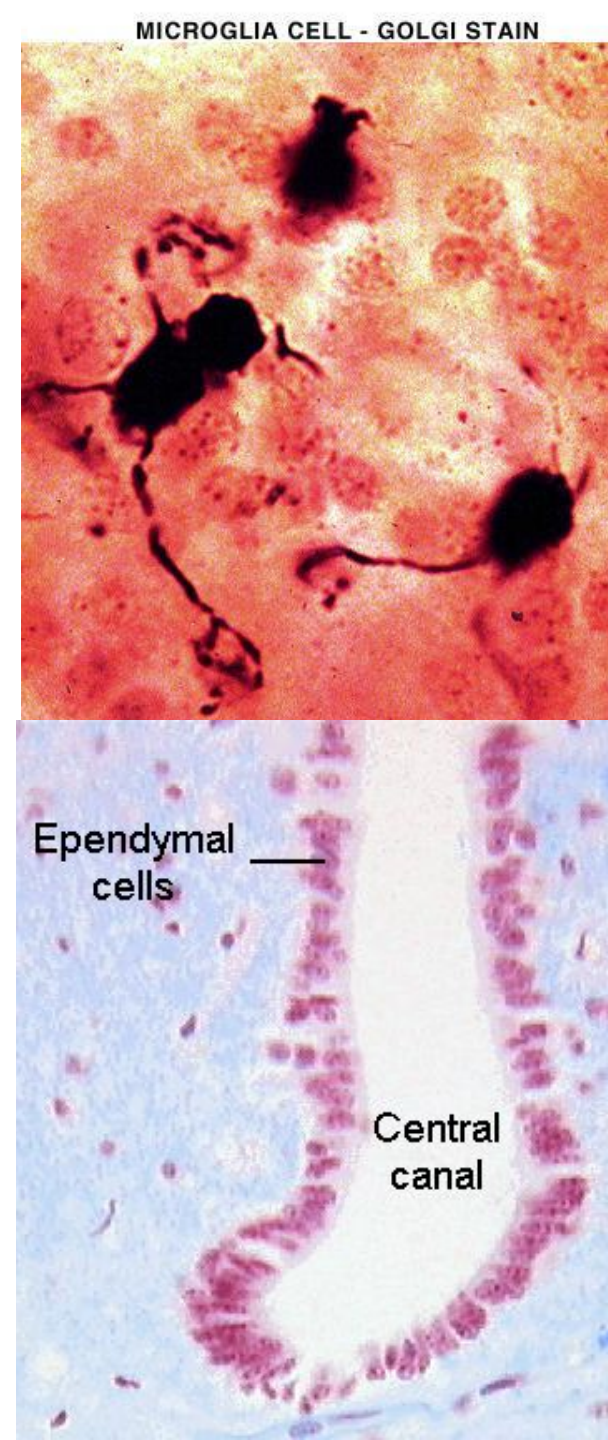
Neuroglia

2. Microglia

- Specialized immune cells that act as the macrophages of the CNS
- Why is it important for the CNS to have its own army of immune cells?

3. Ependymal Cells

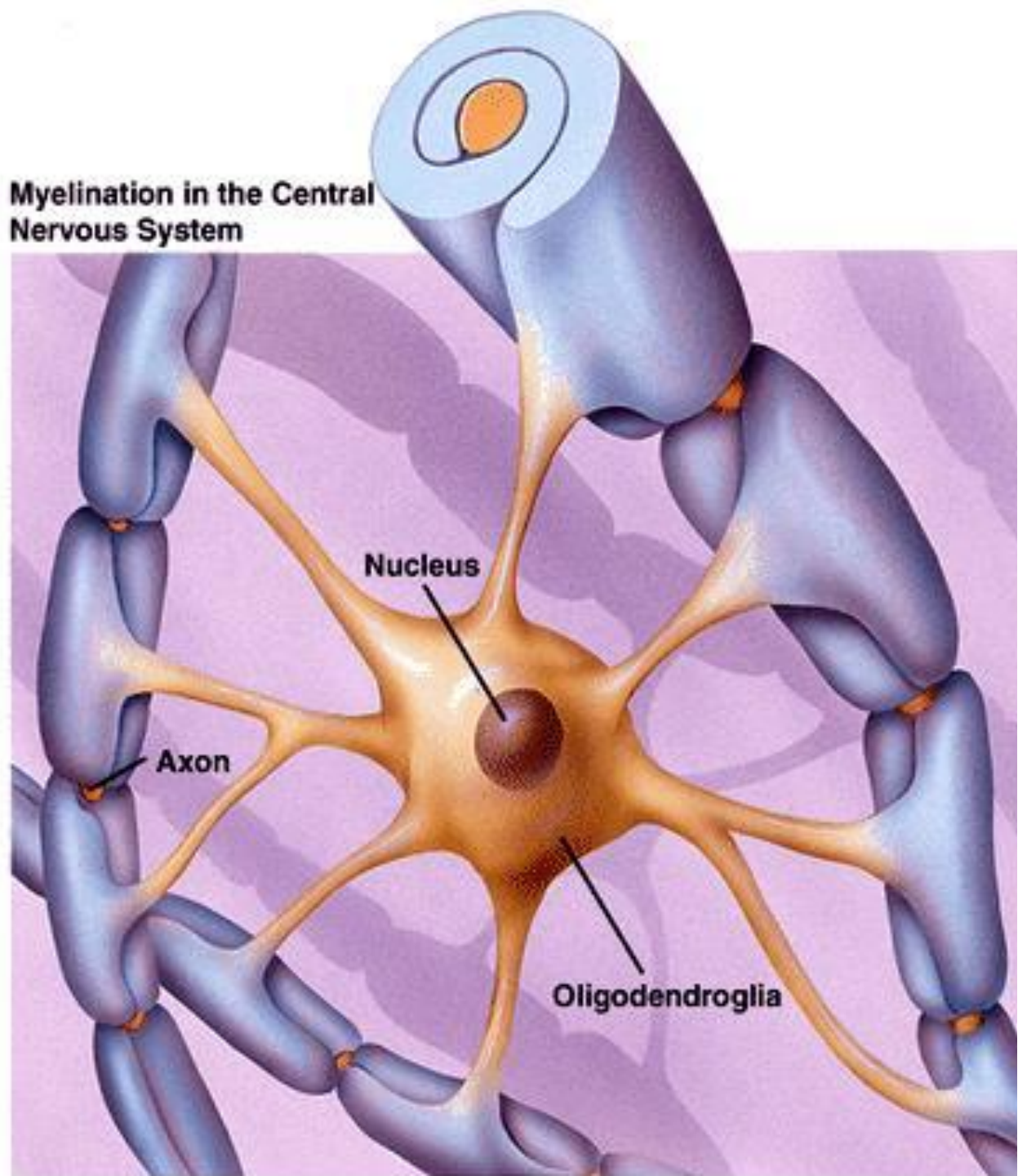
- Low columnar epithelial-esque cells that line the ventricles of the brain and the central canal of the spinal cord
- Some are ciliated which facilitates the movement of cerebrospinal fluid



Neuroglia

4. Oligodendrocytes

- Produce the **myelin sheath** which provides the electrical insulation for certain neurons in the CNS



Neuroglia

- 2 types of glia in the PNS

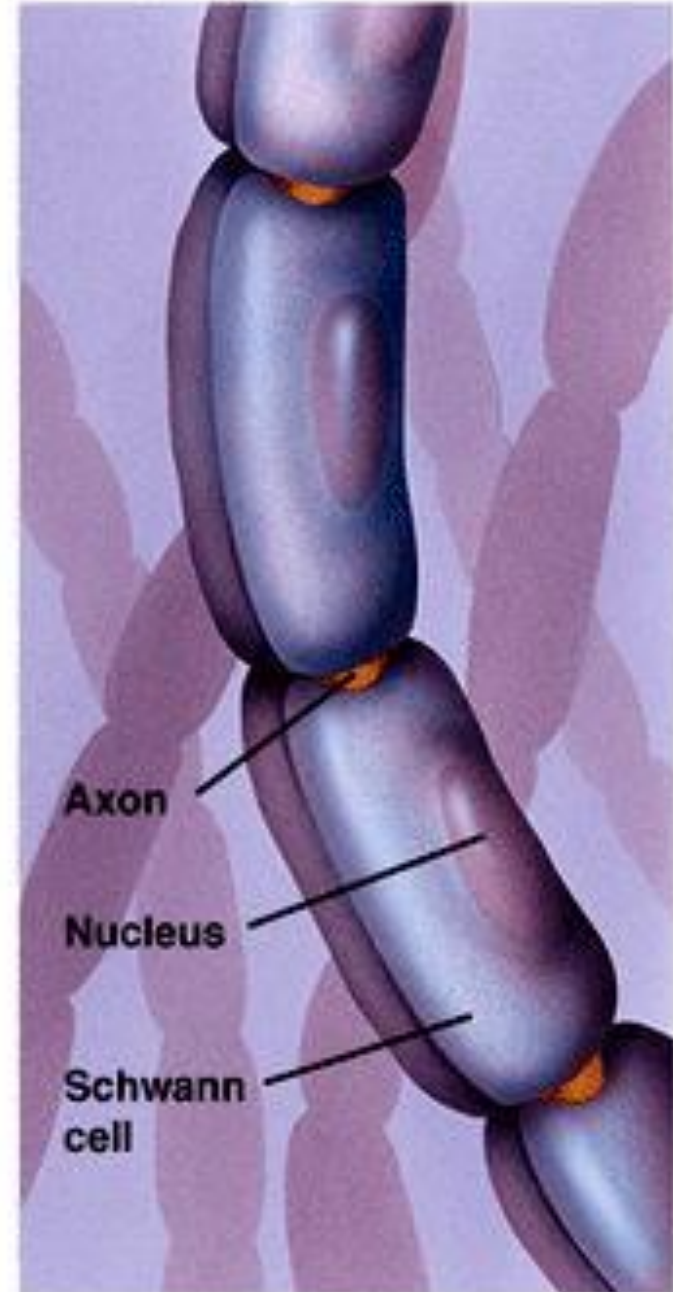
1. Satellite cells

- Surround clusters of neuronal cell bodies in the PNS
- Unknown function

2. Schwann cells

- Form myelin sheaths around the larger nerve fibers in the PNS.
- Vital to neuronal regeneration

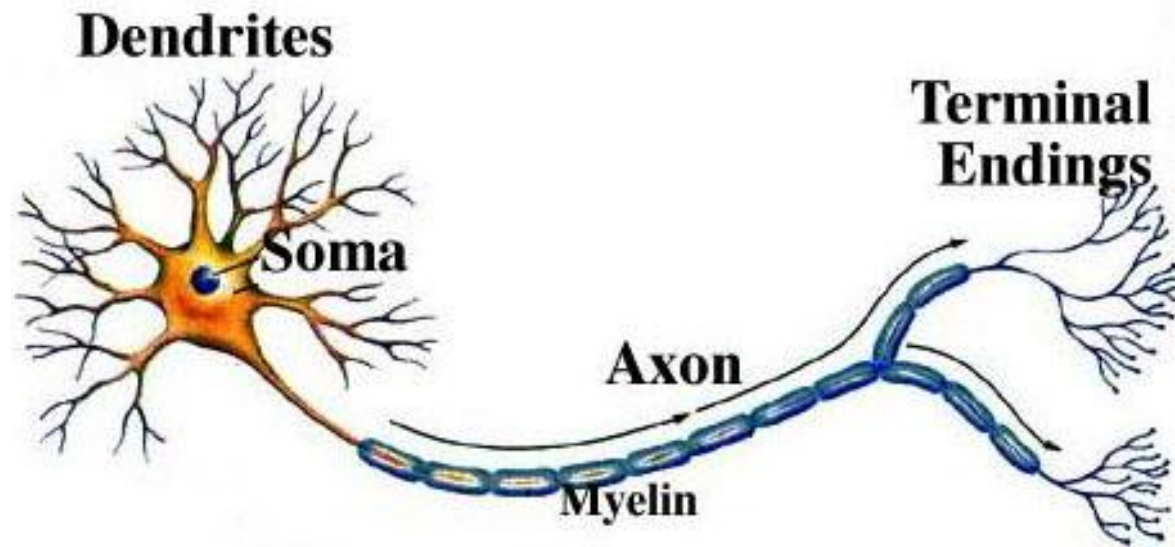
Myelination in the Peripheral Nervous System



Neurons

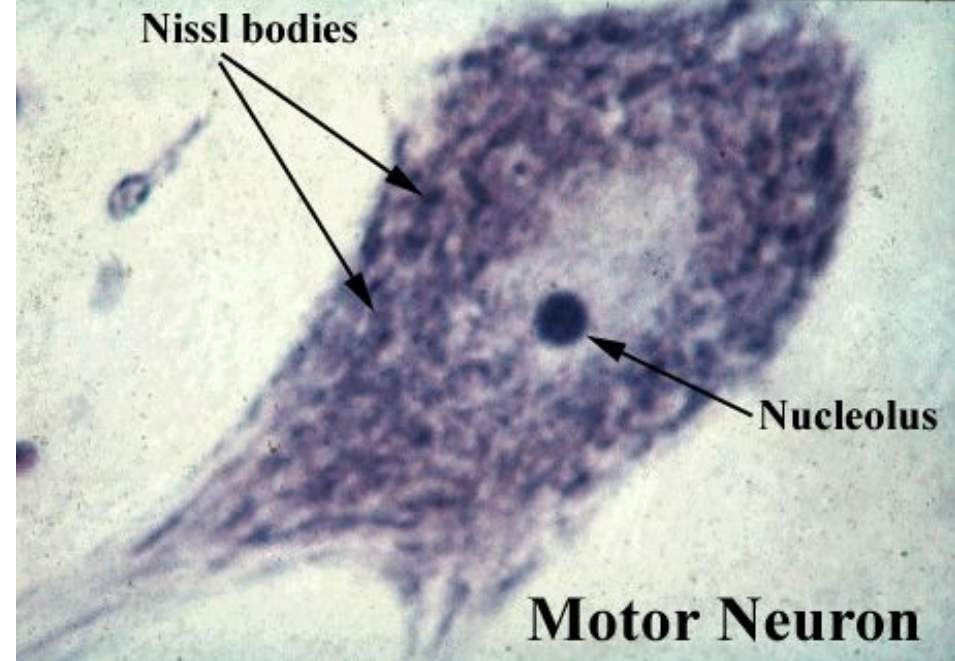
- The functional and structural unit of the nervous system
- Specialized to conduct information from one part of the body to another
- There are many, many different types of neurons but most have certain structural and functional characteristics in common:

- Cell body (**soma**)
- One or more specialized, slender processes (**axons/dendrites**)
- An input region (**dendrites/soma**)
- A conducting component (**axon**)
- A secretory (output) region (**axon terminal**)



Soma

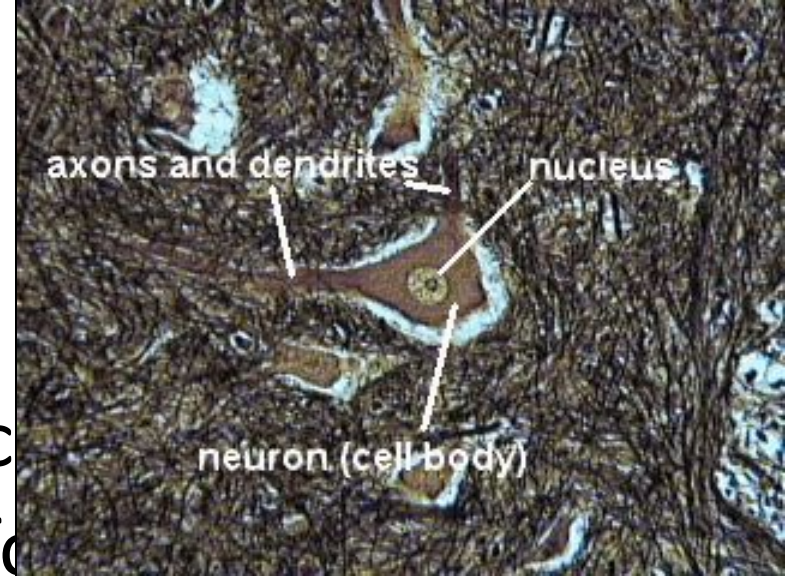
- Contains nucleus plus most normal organelles.
- Biosynthetic center of the neuron.
- Contains a very active and developed rough endoplasmic reticulum which is responsible for the synthesis of _____.
 - The neuronal rough ER is referred to as the **Nissl body**.
- Contains many bundles of protein filaments (**neurofibrils**) which help maintain the shape, structure, and integrity of the cell.



In the soma above, notice the small black circle. It is the **nucleolus**, the site of ribosome synthesis. The light circular area around it is the nucleus. The mottled dark areas found throughout the cytoplasm are the Nissl substance.

Somata

- Contain multiple mitochondria
- Acts as a receptive service for signals from other neurons.
- Most somata are found in the bony environs of the CNS. *Why?*
- Clusters of somata in the CNS are known as **nuclei**. Clusters of somata in the PNS are known as **ganglia**.

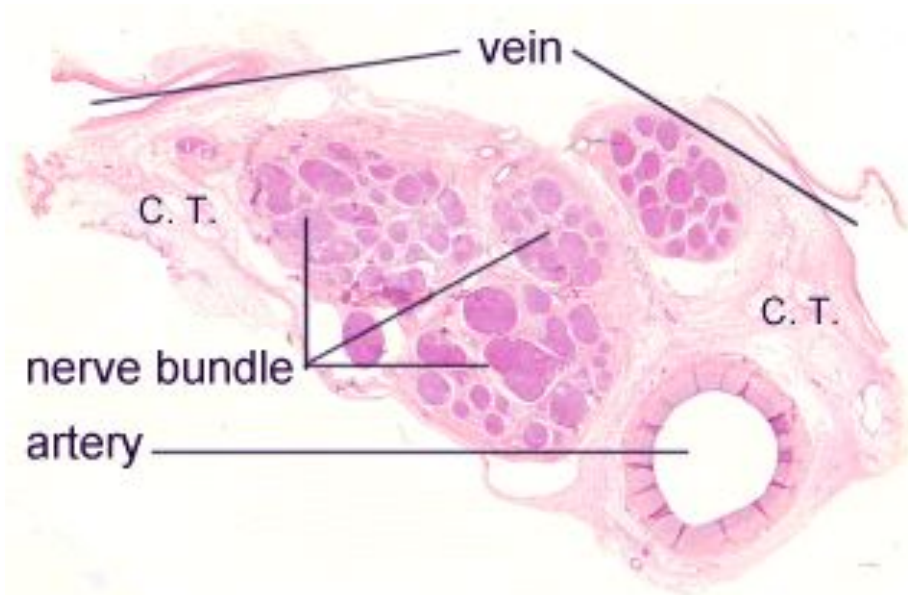


Neuronal Processes

- Armlike extensions emanating from every neuron.
- The CNS consists of both somata and processes whereas the bulk of the PNS consists of processes.
- **Tracts** = Bundles of processes in the CNS (**red arrow**)

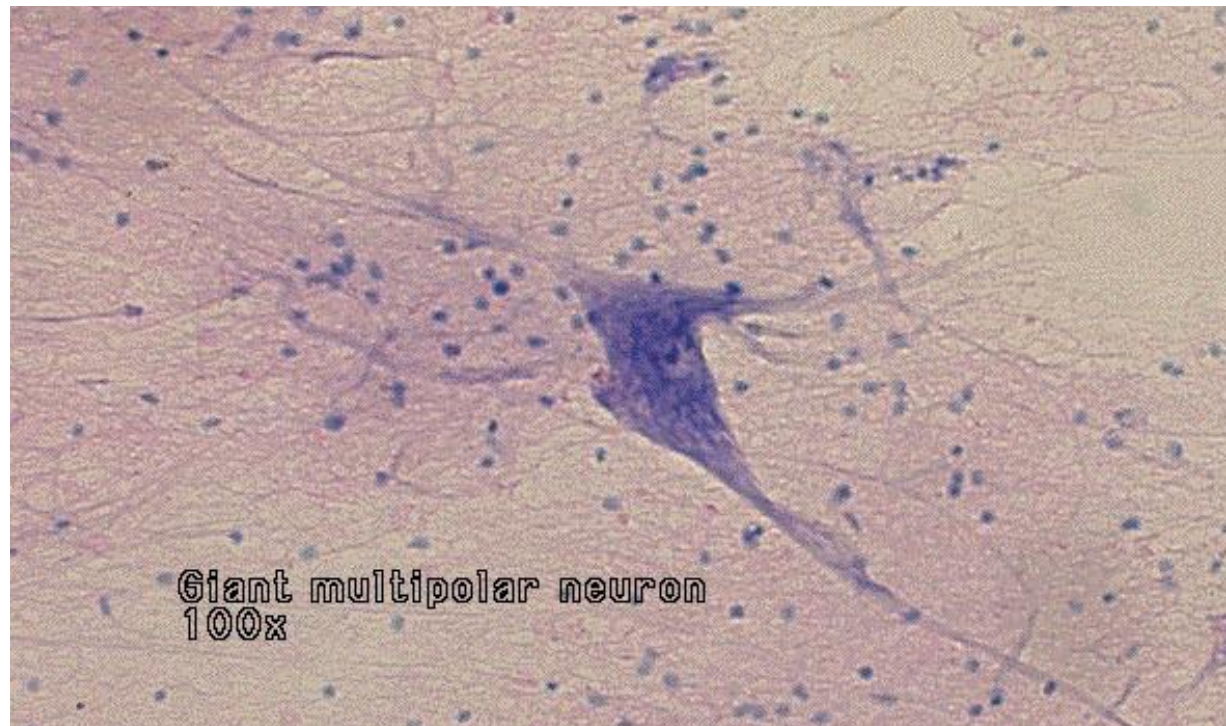
Nerves = Bundles of processes in the PNS

- 2 types of processes that differ in structure and function:
 - **Dendrites and Axons**

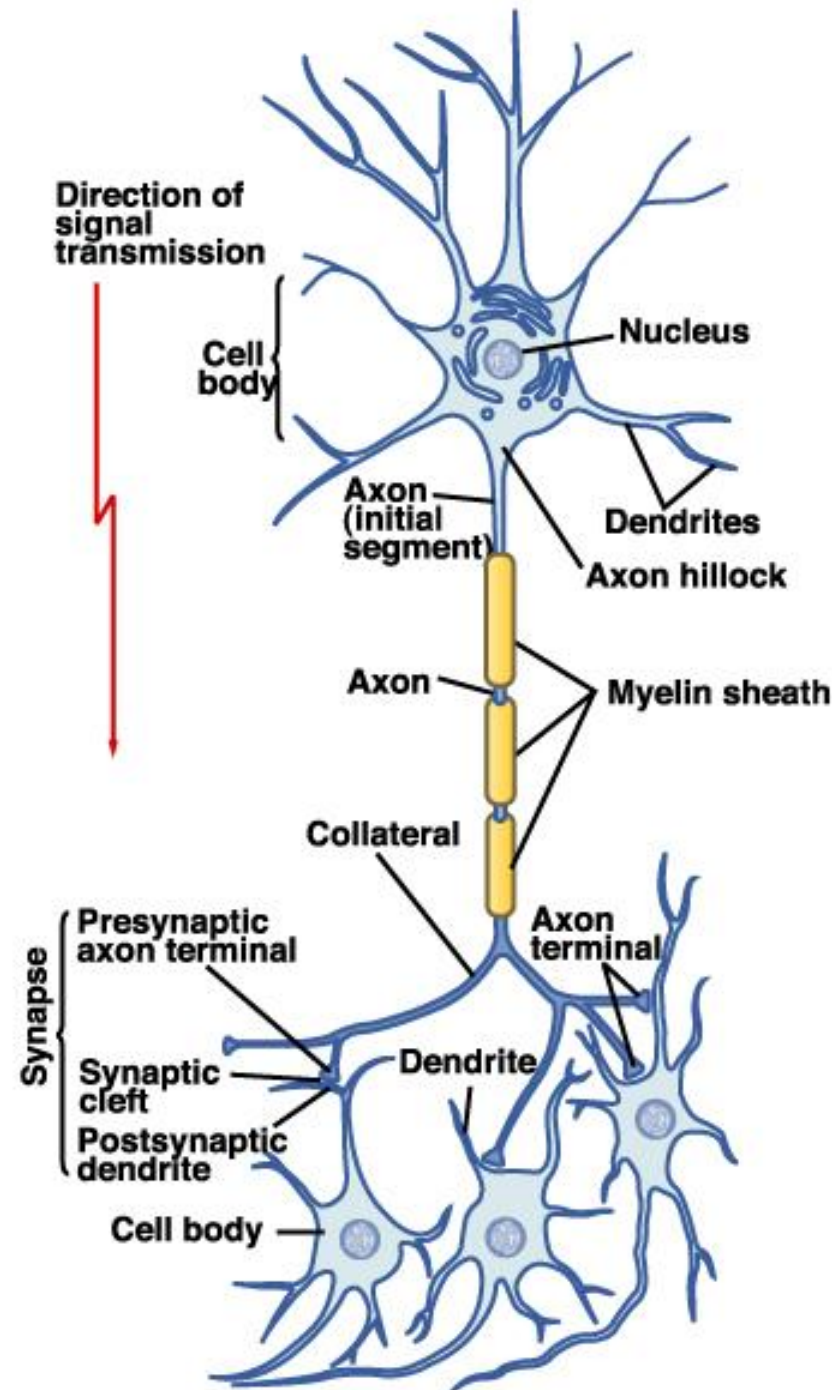


- Dendrites are thin, branched processes whose main function is to receive incoming signals.
- They effectively increase the surface area of a neuron to increase its ability to communicate with other neurons.
 - Small, mushroom-shaped **dendritic spines** further increase the SA
- Convey info towards the soma thru the use of **graded potentials** – which are somewhat similar to action potentials.

Notice the multiple processes extending from the neuron on the right. Also notice the multiple dark circular dots in the slide. They're not neurons, so they must be...

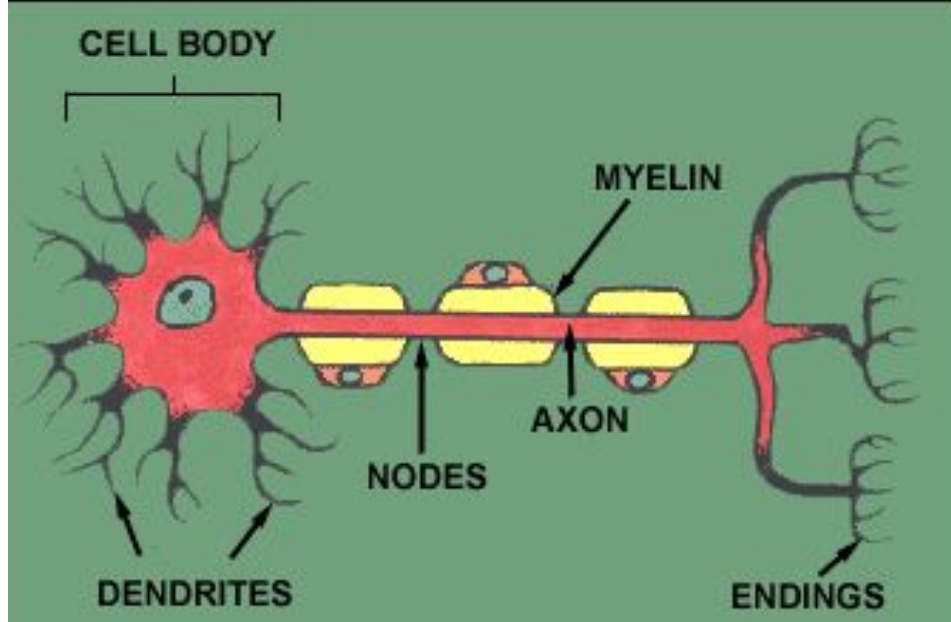


- Most neurons have a single axon – a long (up to 1m) process designed to convey info away from the cell body.
- Originates from a special region of the cell body called the **axon hillock**.
- Transmit APs from the soma toward the end of the axon where they cause NT release.
- Often branch sparsely, forming **collaterals**.
- Each collateral may split into **telodendria** which end in a **synaptic knob**, which contains **synaptic vesicles** – membranous bags of NTs.

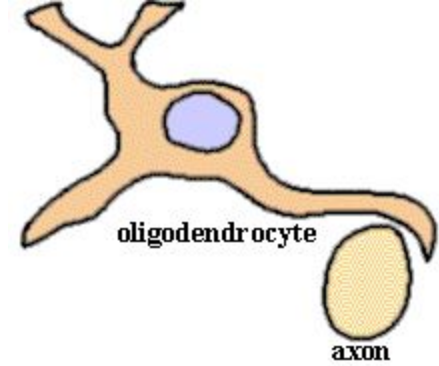


Axons

- **Axolemma** = axon membrane.
- Surrounded by a **myelin** wrapping of lipid
 - Protects the axon and electrically isolates it
 - Increases the rate of AP transmission
- The myelin sheath is made by _____ in the CNS and by _____ in the PNS.
- This wrapping is never complete. Interspersed along the axon are gaps where there is no myelin – these are **nodes of Ranvier**.
- In the PNS, the exterior of the Schwann cell surrounding an axon is the **neurilemma**

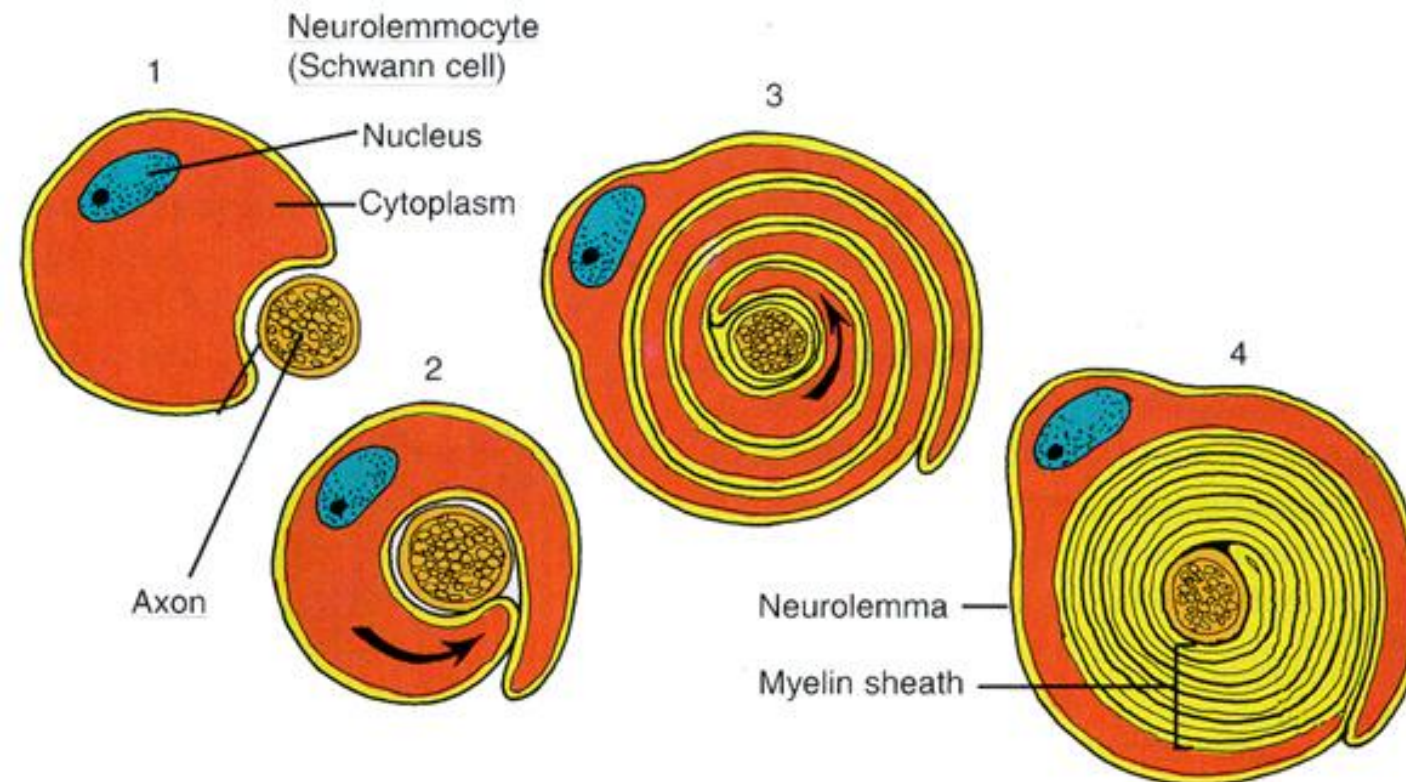


Myelination in the CNS



The Process of Myelination

Myelination in the PNS



- A bundle of processes in the PNS is a **nerve**.
- Within a nerve, each axon is surrounded by an **endoneurium** (*too small to see on the photomicrograph*) – a layer of loose CT.

- Groups of fibers are bound together into bundles (**fascicles**) by a **perineurium** (red arrow).
- All the fascicles of a nerve are enclosed by a **epineurium** (black arrow).

