



■ The Nervous System

Functions of the Nervous System

1. Sensory input – gathering information

- To monitor changes occurring inside and outside the body (changes = stimuli)

2. Integration –

- to process and interpret sensory input and decide if action is needed.

3. Motor output

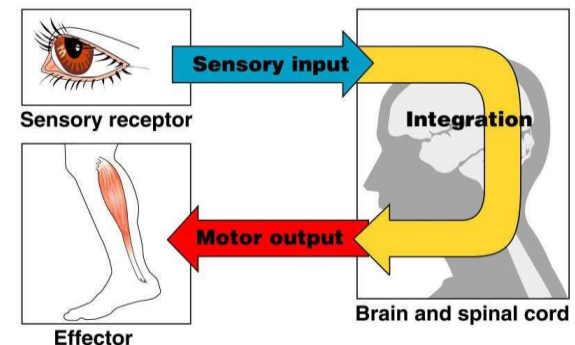
- A response to integrated stimuli
- The response activates muscles or glands

Structural Classification of the Nervous System

- Central nervous system (CNS)
 - Brain
 - Spinal cord
- Peripheral nervous system (PNS)
 - Nerve outside the brain and spinal cord

Functional Classification of the Peripheral Nervous System

- Sensory (afferent) division
 - Nerve fibers that carry information *to* the central nervous system
 - Motor (efferent) division
 - Nerve fibers that carry impulses away from the central nervous system
- Motor (efferent) division
 - Two subdivisions
 - Somatic nervous system = voluntary
 - Autonomic nervous system = involuntary



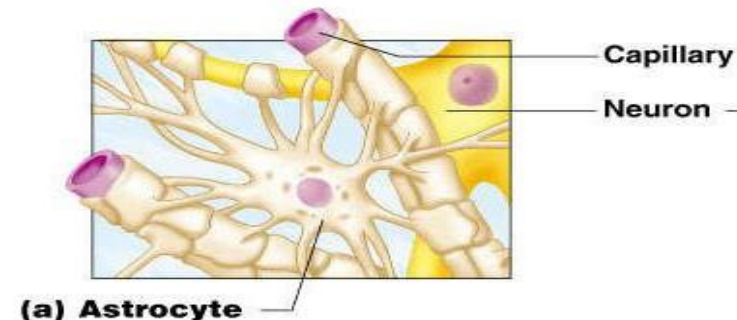
Nervous Tissue: Support Cells (Neuroglia or Glia)

- **Astrocytes**

- Abundant, star-shaped cells
- Form barrier between capillaries and neurons
- Control the chemical environment of the brain (CNS)

- **Microglia (CNS)**

- Spider-like phagocytes
- Dispose of debris



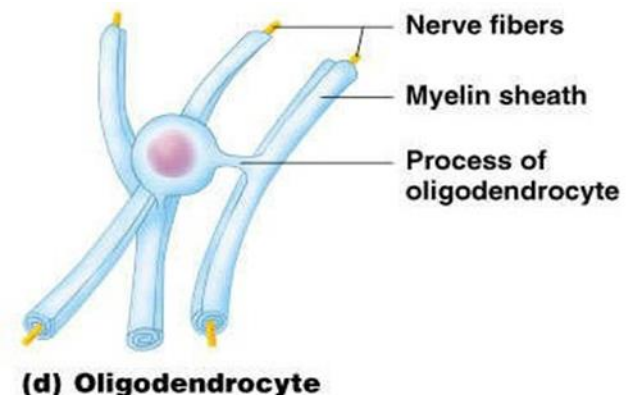
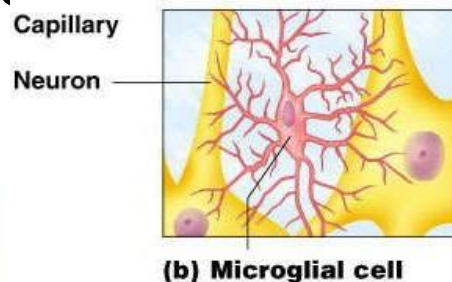
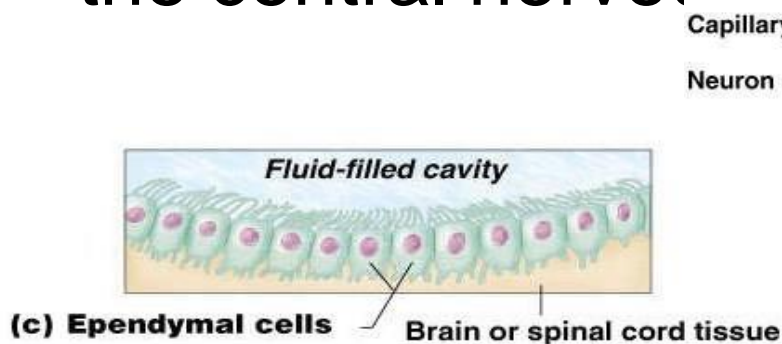
Nervous Tissue: Support Cells

- **Ependymal cells (CNS)**

- Line cavities of the brain and spinal cord
- Circulate cerebrospinal fluid

- **Oligodendrocytes (CNS)**

- Produce myelin sheath around nerve fibers in the central nervous system

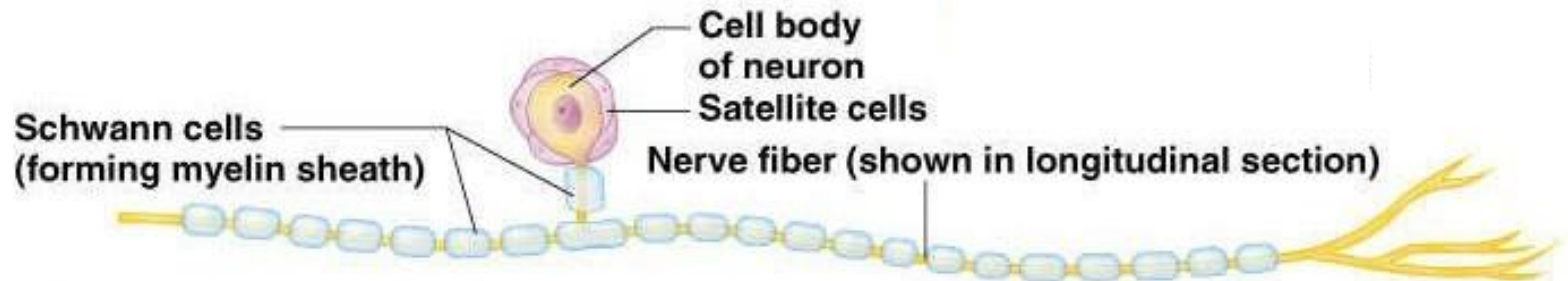


Neuroglia vs. Neurons

- Neuroglia divide.
- Neurons do not.
- Most brain tumors are “gliomas.”
- Most brain tumors involve the neuroglia cells, not the neurons.
- Consider the role of cell division in cancer!

Support Cells of the PNS

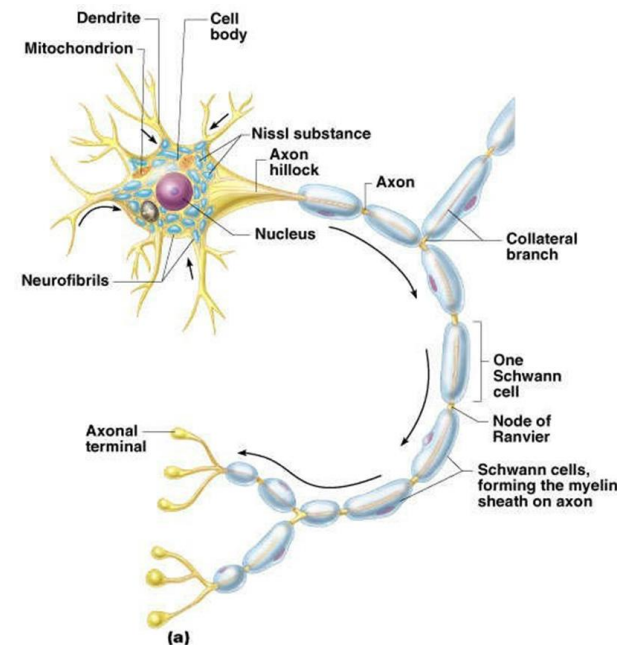
- Satellite cells
 - Protect neuron cell bodies
- Schwann cells
 - Form myelin sheath in the peripheral nervous system



(e) Sensory neuron with Schwann cells and satellite cells

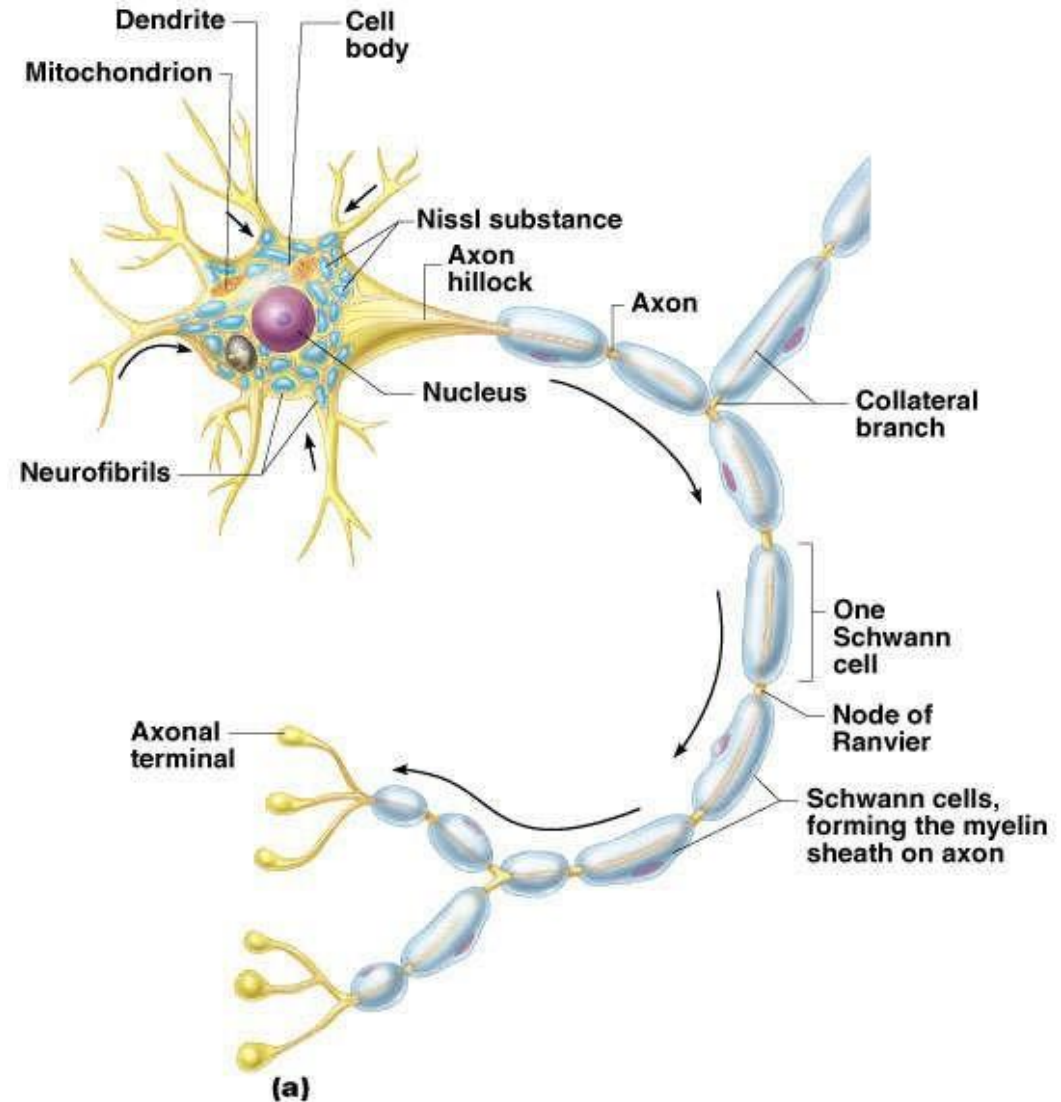
Nervous Tissue: Neurons

- Neurons = nerve cells
 - Cells specialized to transmit messages
 - Major regions of neurons
 - Cell body – nucleus and metabolic center of the cell
 - Processes – fibers that extend from the cell body (dendrites and axons)
 - Cell body, Nucleus, Large nucleolus



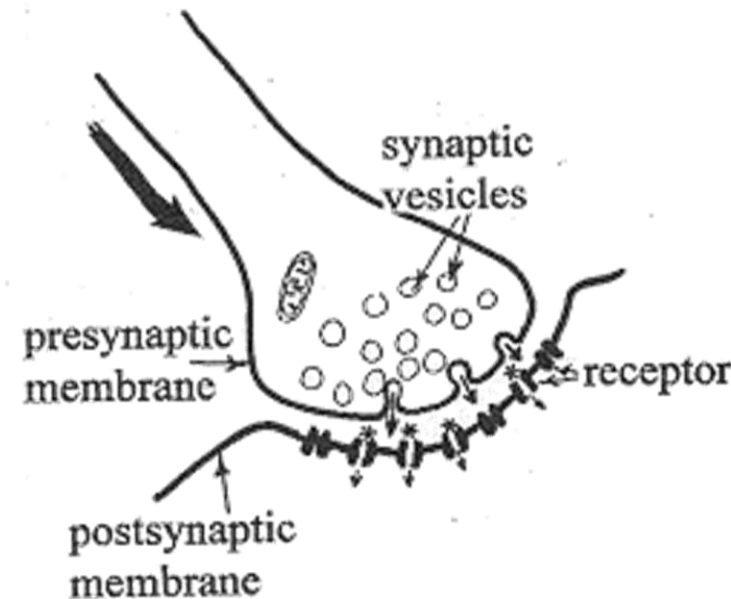
Neuron Anatomy

- Extensions outside the cell body
 - Dendrites – conduct impulses toward the cell body
 - Axons – conduct impulses away from the cell body (only 1!)



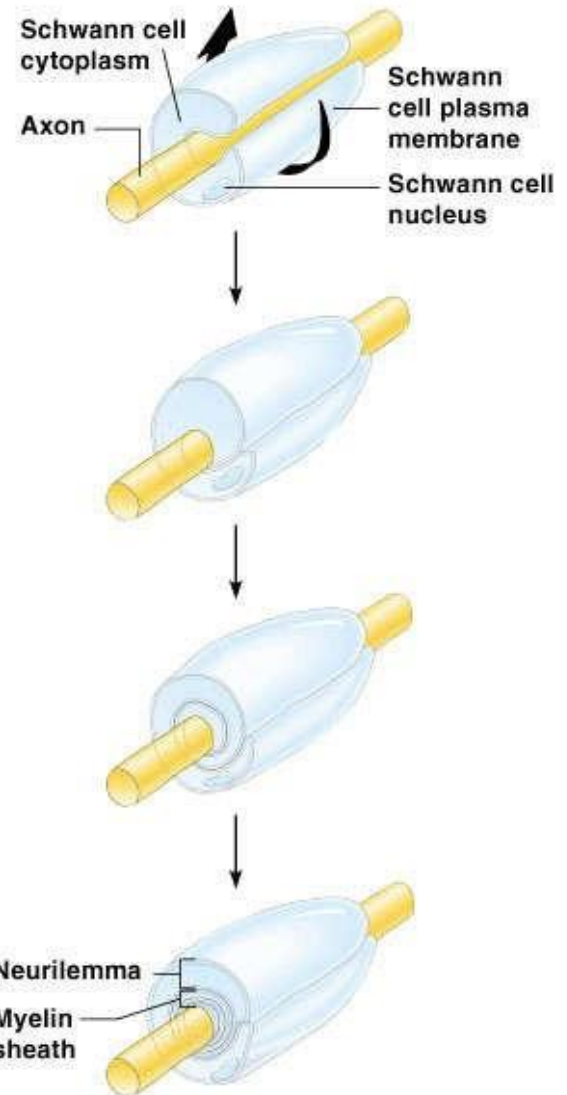
Axons and Nerve Impulses

- Axons end in axonal terminals
- Axonal terminals contain vesicles with neurotransmitters
- Axonal terminals are separated from the next neuron by a gap
 - Synaptic cleft – gap between adjacent neurons
 - Synapse – junction between nerves



Nerve Fiber Coverings

- Schwann cells – produce myelin sheaths in jelly-roll like fashion
- Nodes of Ranvier – gaps in myelin sheath along the axon



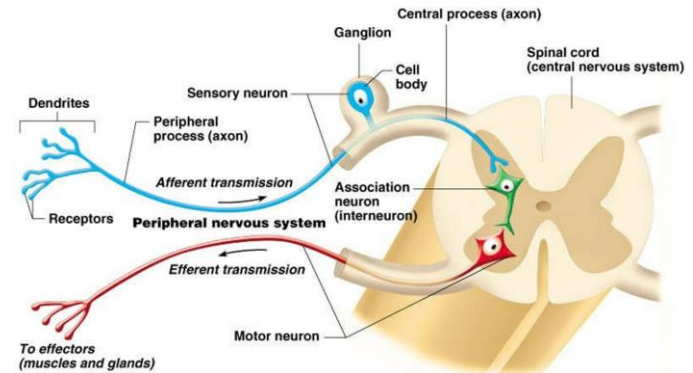
- Clinical Application
- In Multiple Scleroses the myelin sheath is destroyed.
- The myelin sheath hardens to a tissue called the scleroses.
- This is considered an autoimmune disease.
- Why does MS appear to affect the muscles?

Neuron Cell Body Location

- Most are found in the central nervous system
 - Gray matter – cell bodies and unmyelinated fibers
 - Nuclei – clusters of cell bodies within the white matter of the central nervous system
- Ganglia – collections of cell bodies outside the central nervous system

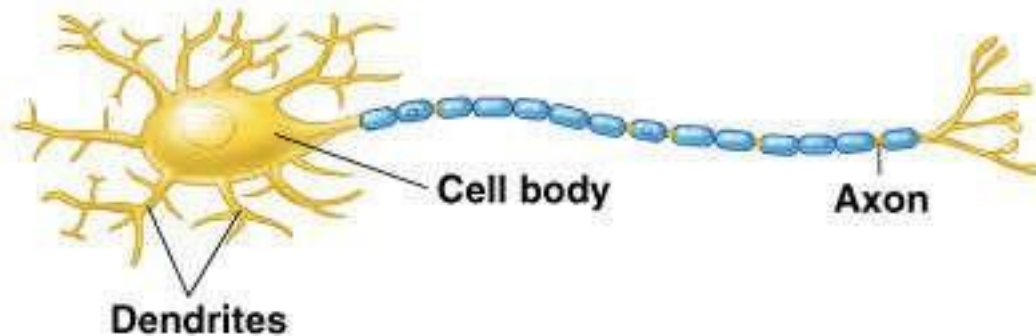
Functional Classification of Neurons

- Sensory (afferent) neurons
 - Carry impulses from the sensory receptors
 - Cutaneous sense organs
 - Proprioceptors – detect stretch or tension
- Motor (efferent) neurons
 - Carry impulses from the central nervous system
 - Interneurons (association neurons)
 - Found in neural pathways in the central nervous system, Connect sensory and motor neurons



Structural Classification of Neurons

- Multipolar neurons – many extensions from the cell body



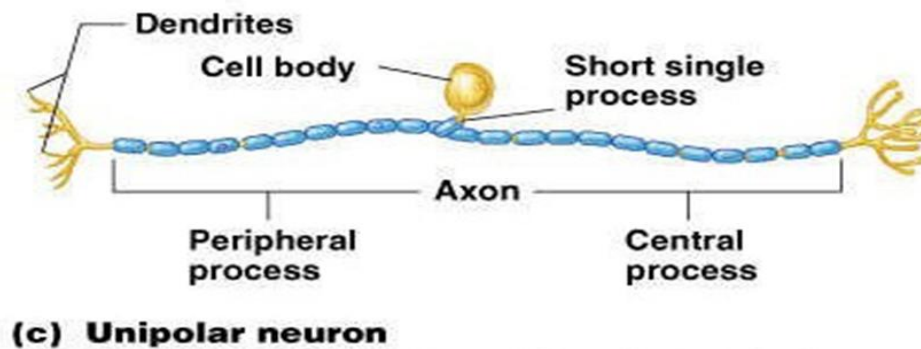
(a) Multipolar neuron

Structural Classification of Neurons

- Bipolar neurons – one axon and one dendrite



Unipolar neurons – have a short single process leaving the cell body



How Neurons Function (Physiology)

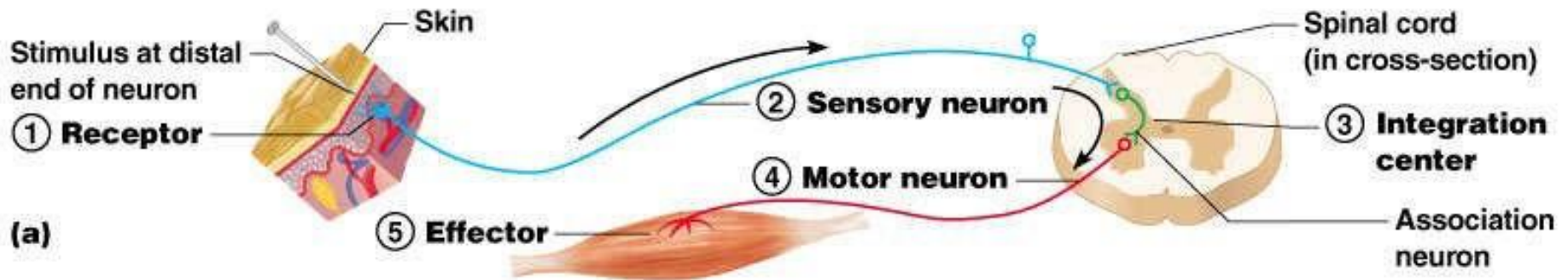
- Irritability – ability to respond to stimuli
- Conductivity – ability to transmit an impulse
- The plasma membrane at rest is polarized
 - Fewer positive ions are inside the cell than outside the cell

Continuation of the Nerve Impulse between Neurons

- Impulses are able to cross the synapse to another nerve
 - Neurotransmitter is released from a nerve's axon terminal
 - The dendrite of the next neuron has receptors that are stimulated by the neurotransmitter

The Reflex Arc

- Reflex – rapid, predictable, and involuntary responses to stimuli
- Reflex arc – direct route from a sensory neuron, to an interneuron, to an effector

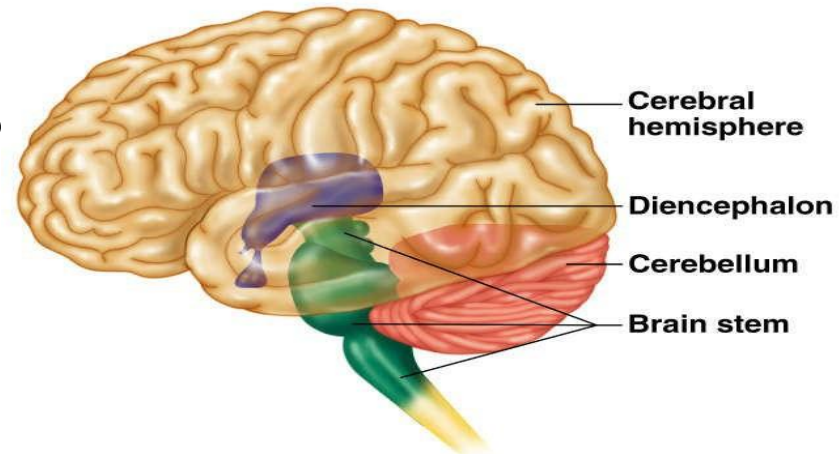


Types of Reflexes and Regulation

- Autonomic reflexes
 - Smooth muscle regulation
 - Heart and blood pressure regulation
 - Regulation of glands
 - Digestive system regulation
- Somatic reflexes
 - Activation of skeletal muscles

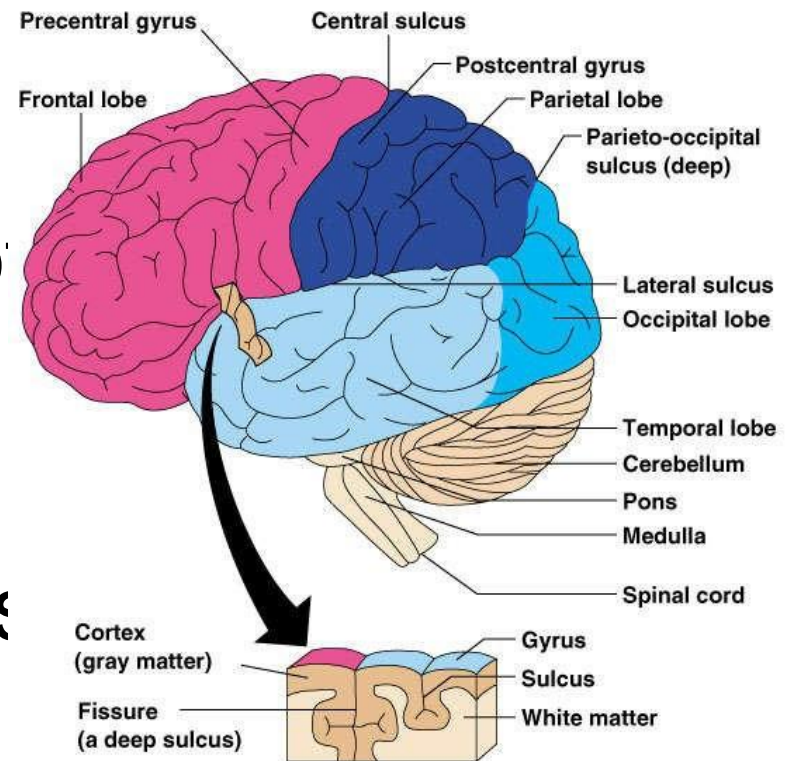
Regions of the Brain

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



(a)

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

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

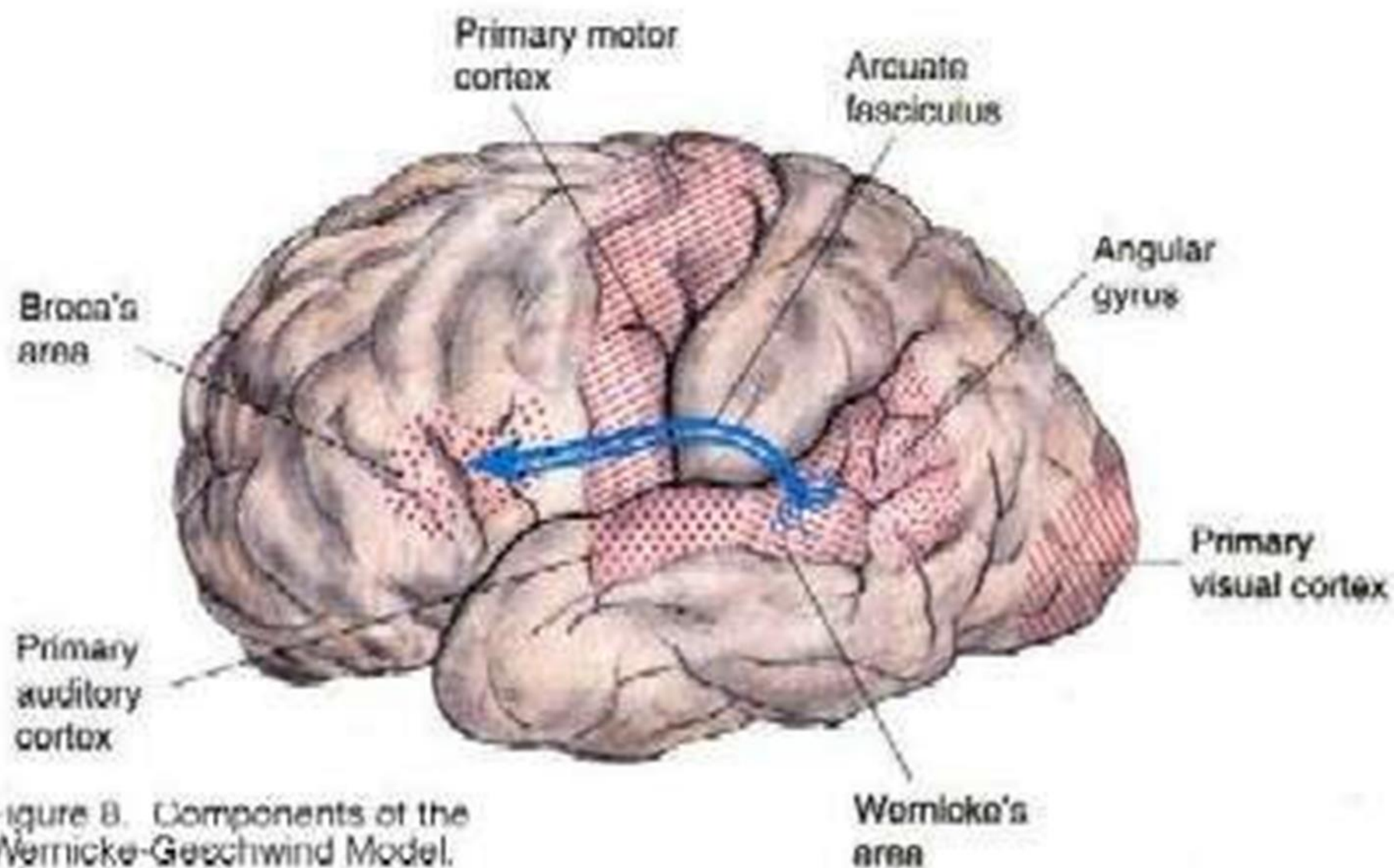
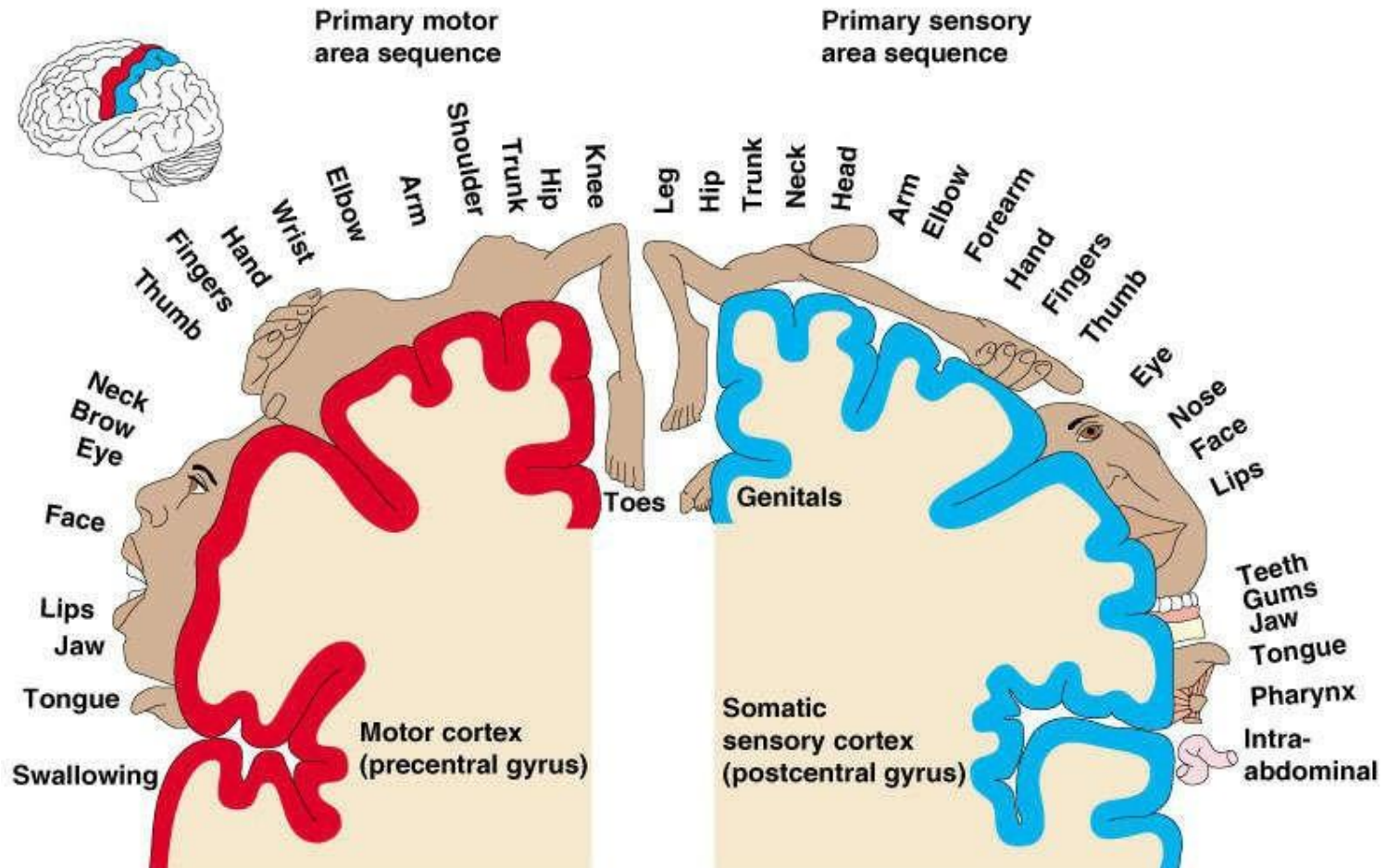


Figure 8. Components of the Wernicke-Geschwind Model.

Sensory and Motor Areas of the Cerebral Cortex



Specialized Area of the Cerebrum

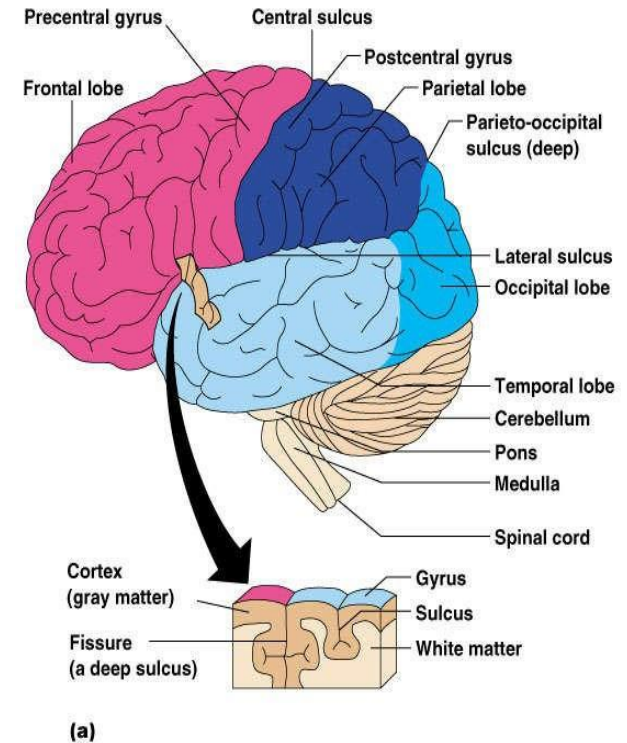
- Cerebral areas involved in special senses
 - Gustatory area (taste)
 - Visual area
 - Auditory area
 - Olfactory area

Specialized Area of the Cerebrum

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

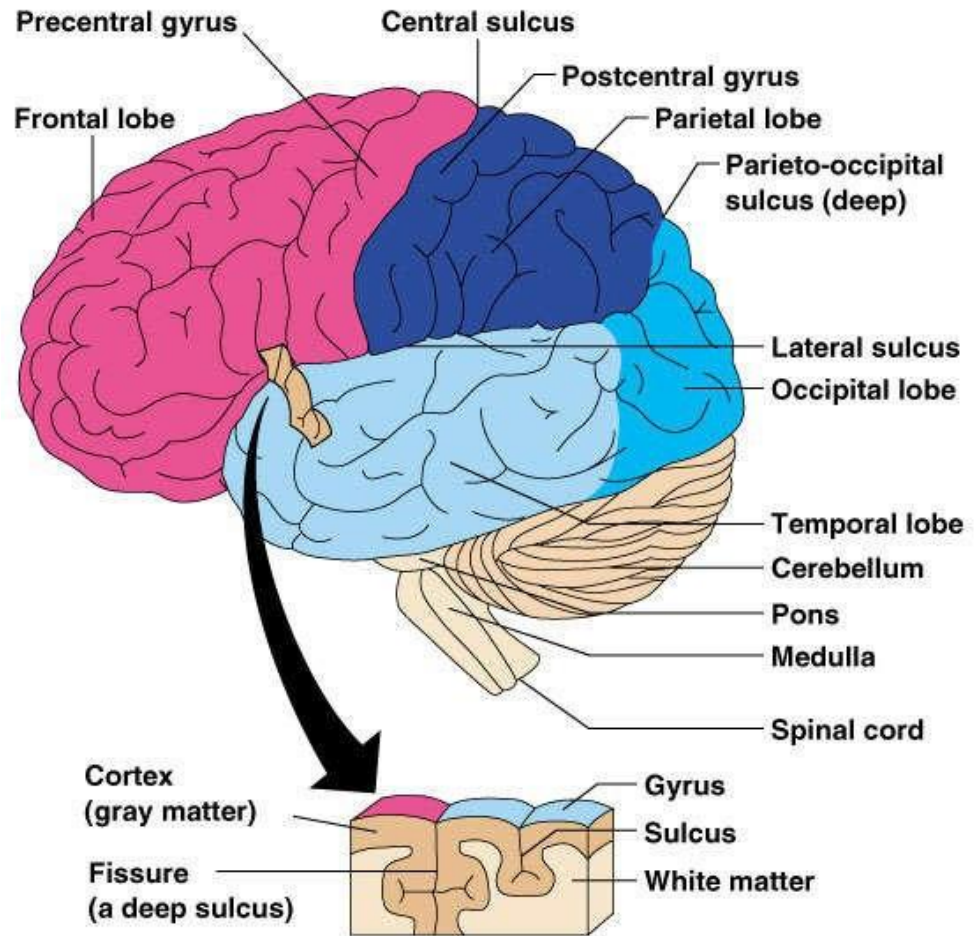
Layers of the Cerebrum

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



Layers of the Cerebrum

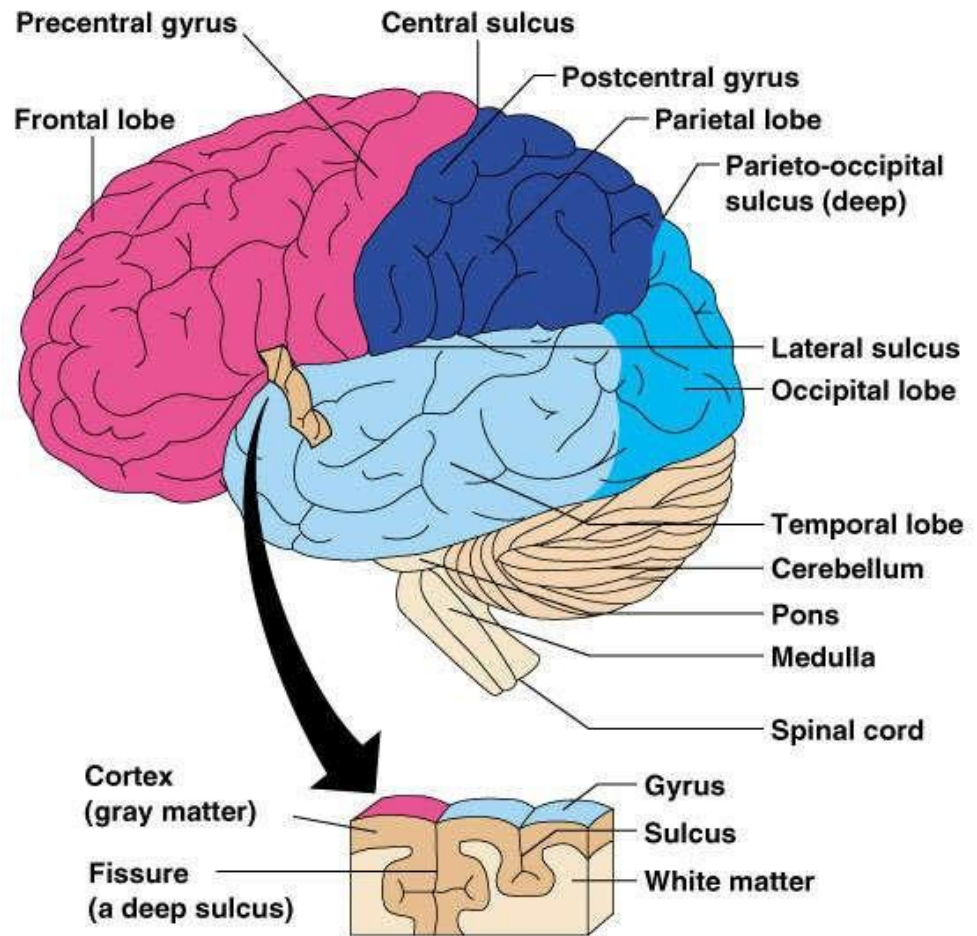
- White matter
 - Fiber tracts inside the gray matter
 - Example: corpus callosum connects hemispheres



(a)

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

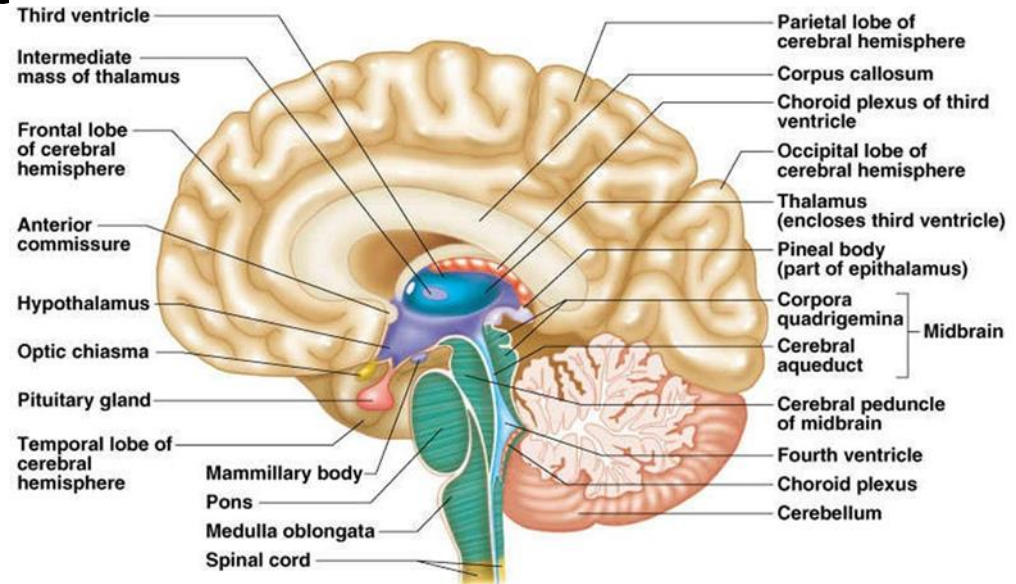


(a)

Diencephalon

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

- Thalamus
- Hypothalamus
- Epithalamus



(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

Midbrain

- Mostly composed of tracts of nerve fibers
 - Reflex centers for vision and hearing
 - Cerebral aqueduct – 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

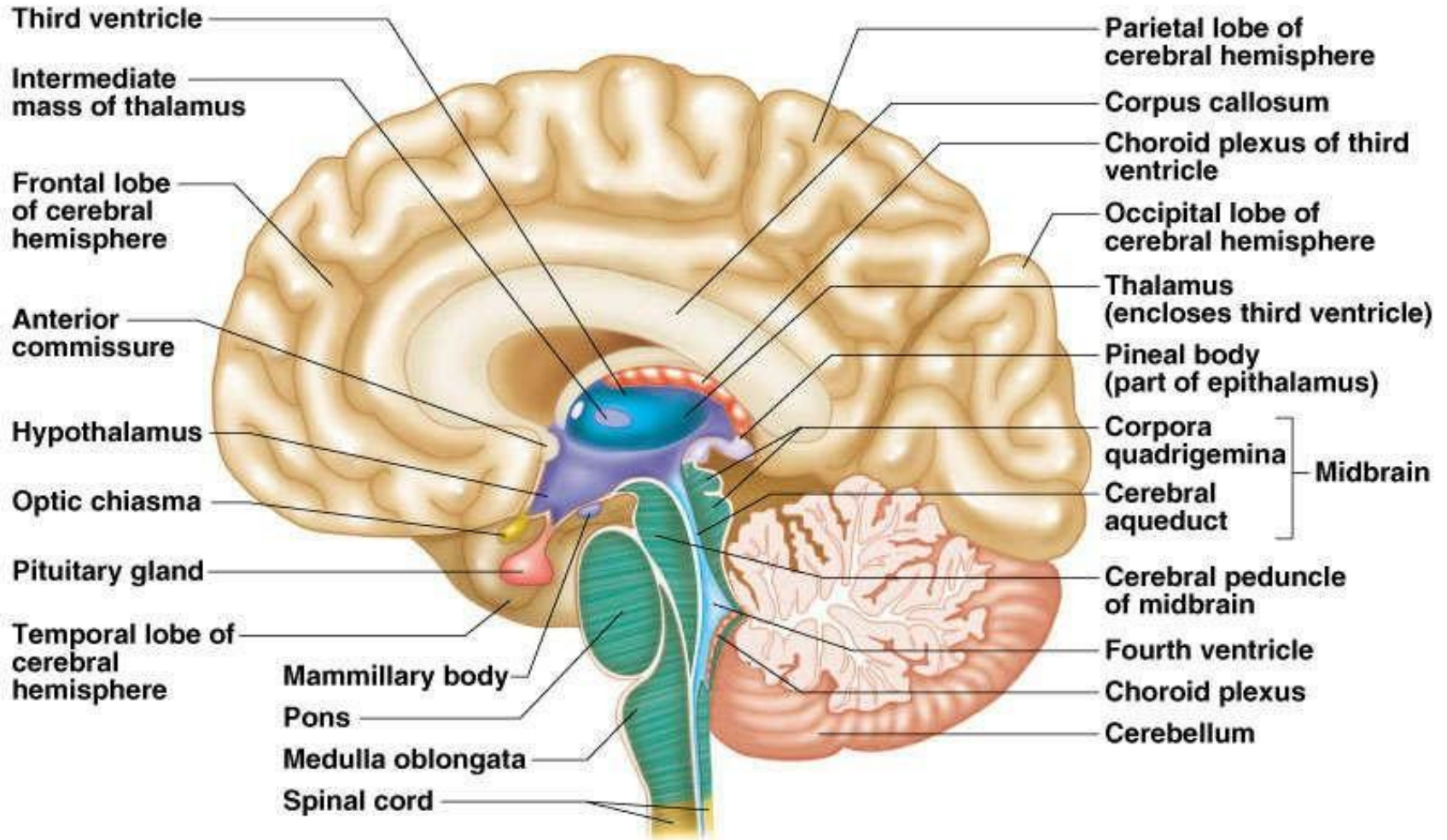
Medulla Oblongata

- 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

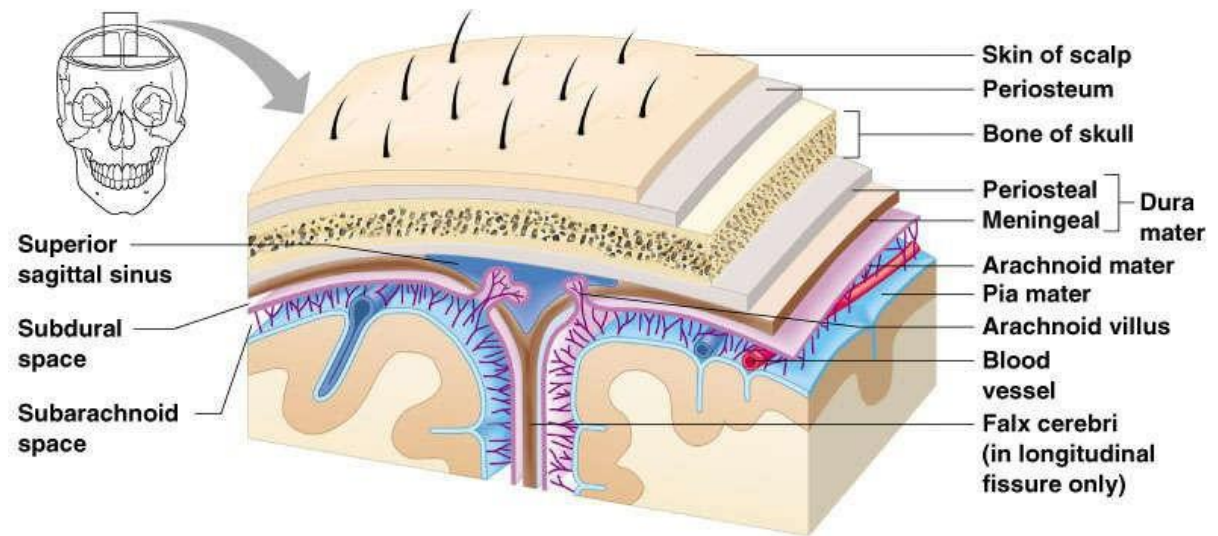
Cerebellum



(a)

Protection of the Central Nervous System

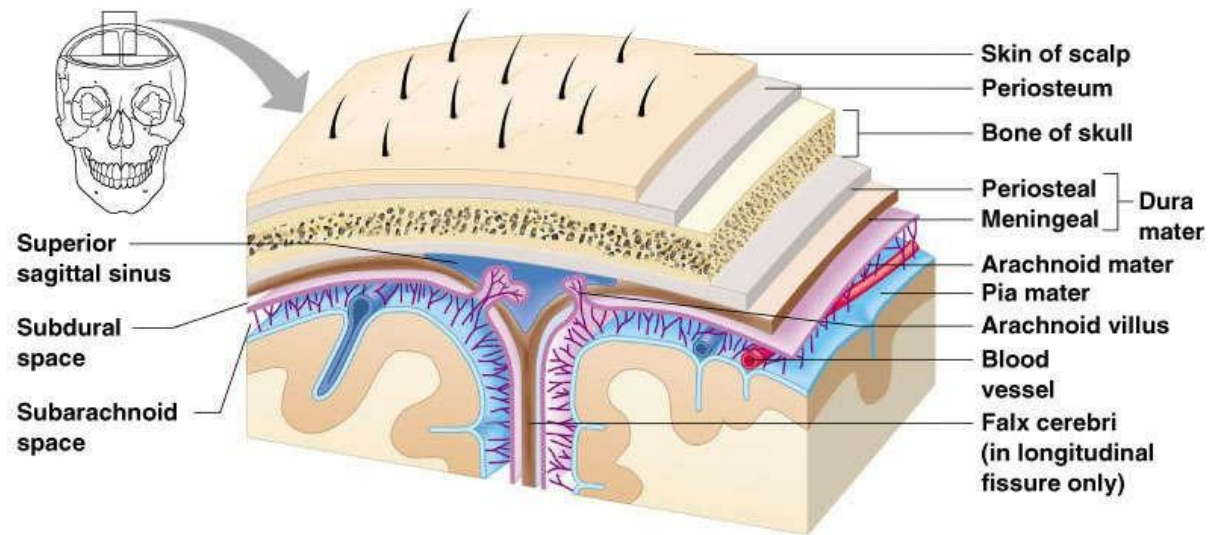
- Scalp and skin
- Skull and vertebral column
- Meninges



(a)

Protection of the Central Nervous System

- Cerebrospinal fluid
- Blood brain barrier



(a)

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

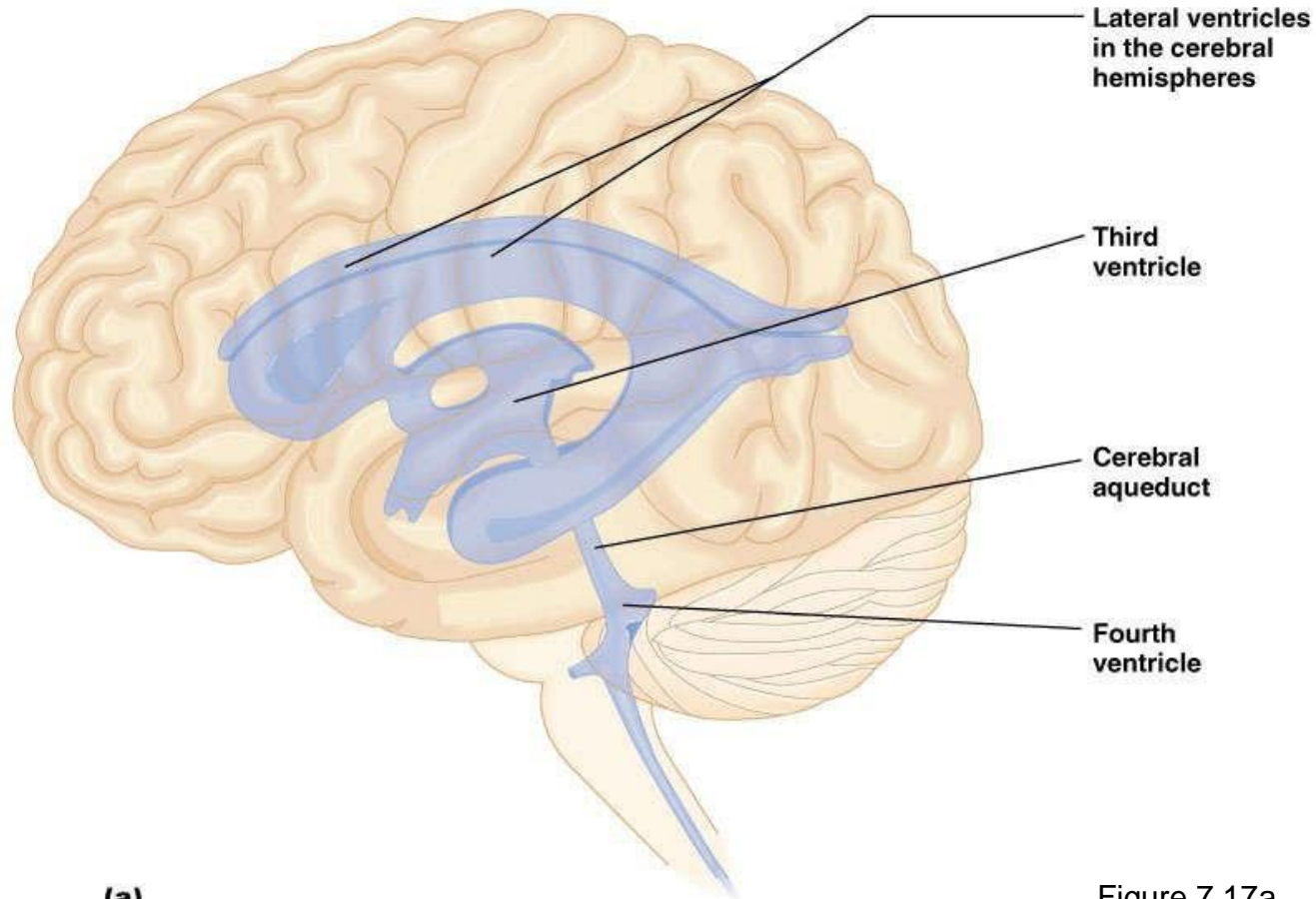
Meninges

- 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

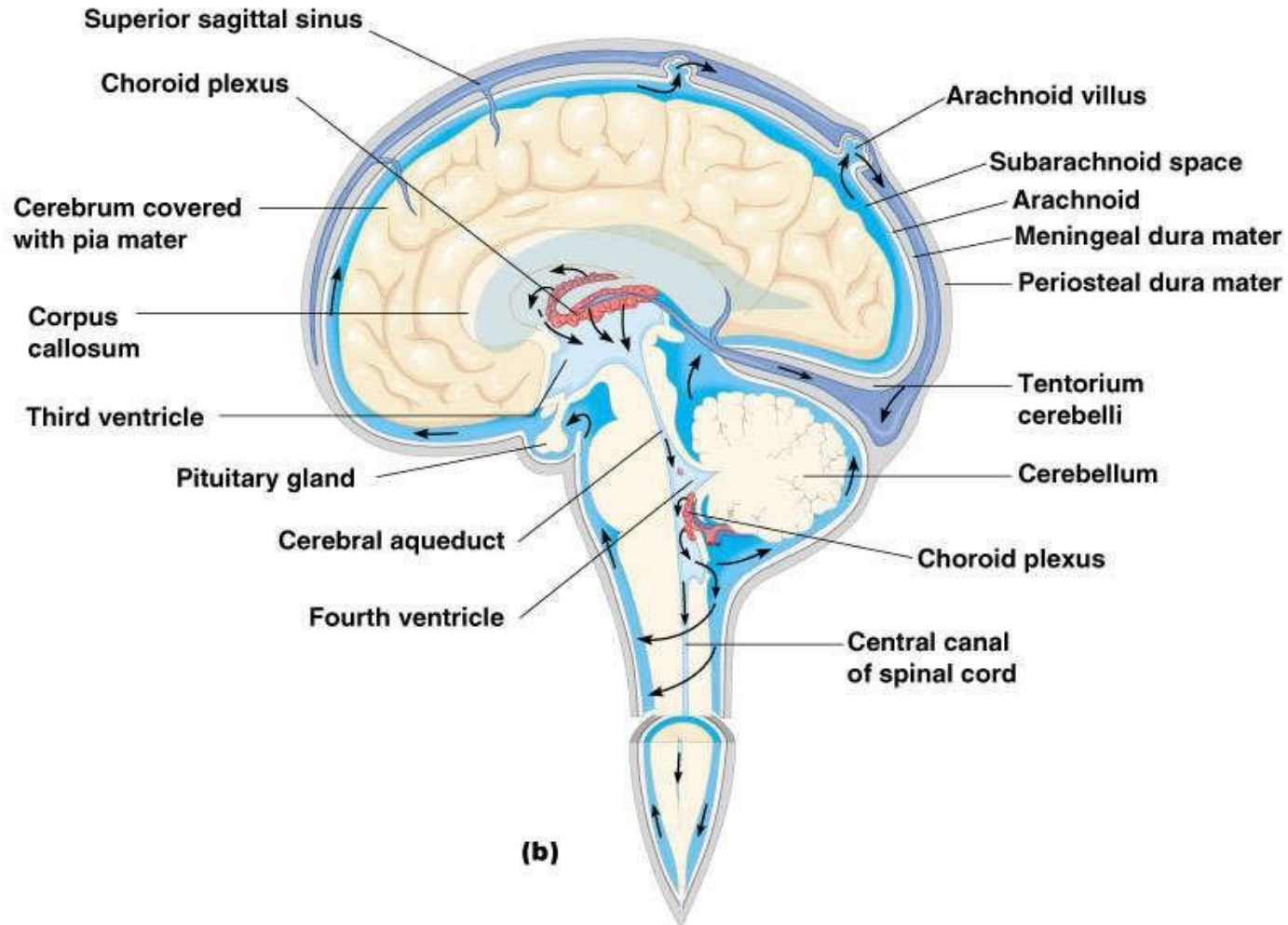
Ventricles and Location of the Cerebrospinal Fluid



(a)

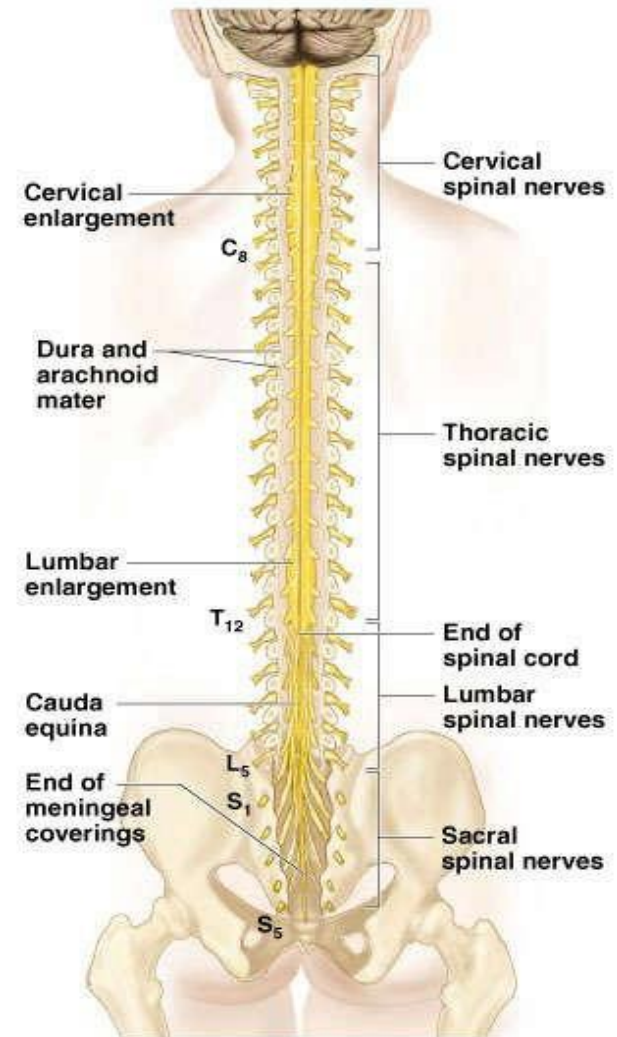
Figure 7.17a

Ventricles and Location of the Cerebrospinal Fluid



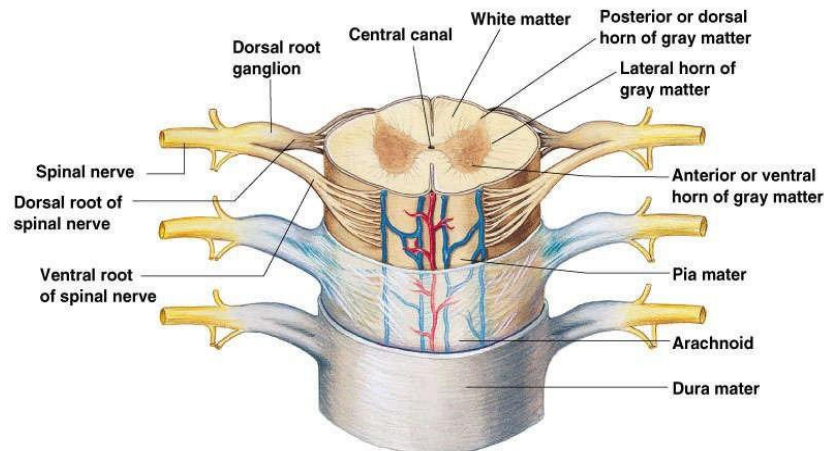
Spinal Cord

- 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 mater – conduction tracts
- Internal gray matter - mostly cell bodies
 - Dorsal (posterior) horns
 - Anterior (ventral) horns
- 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

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.

