Nervous System: Tissue & Brain

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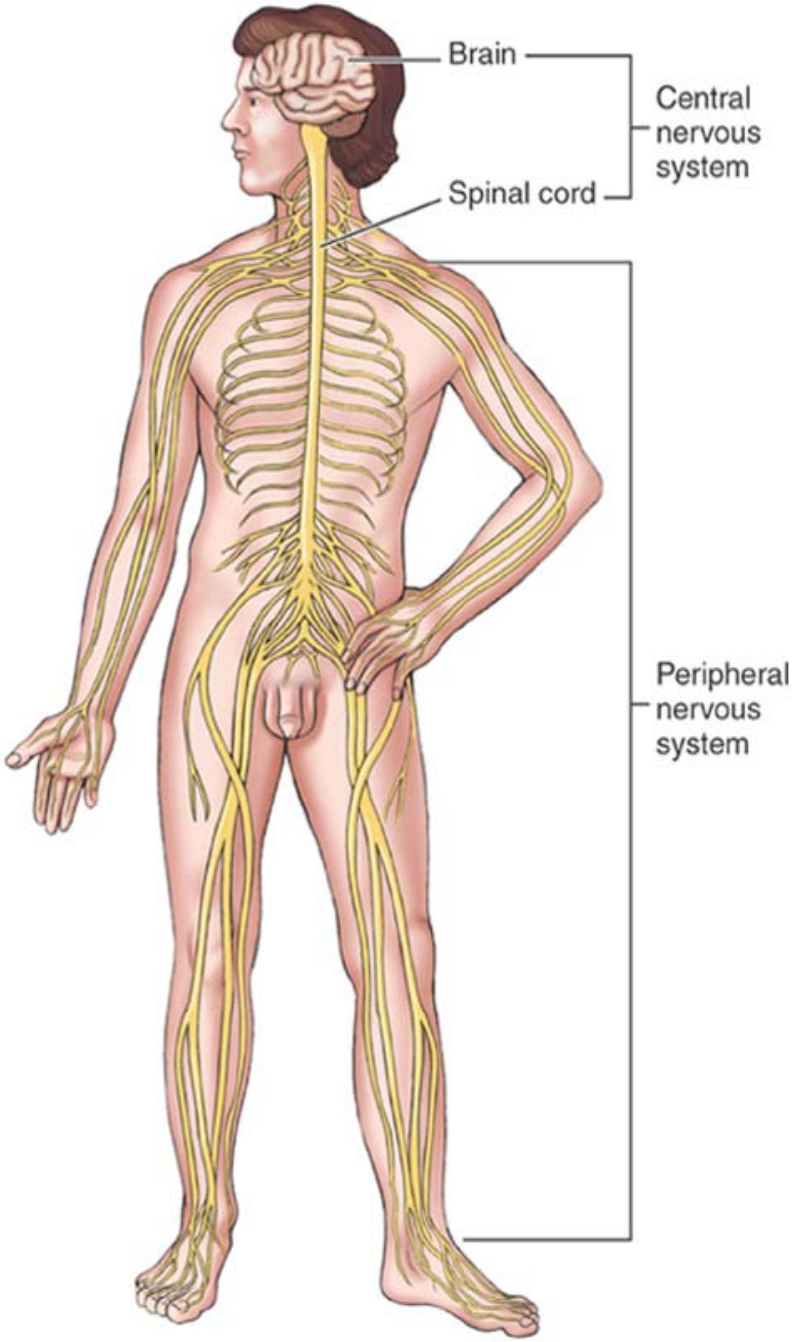
- The Nervous System is divided into two divisions:
  - The Central Nervous System which includes the brain & spinal cord
  - The Peripheral Nervous System located outside the CNS & consists of the nerves


Brain
Central nervous system
Spinal cord
Peripheral nervous system

Function of the Nervous System

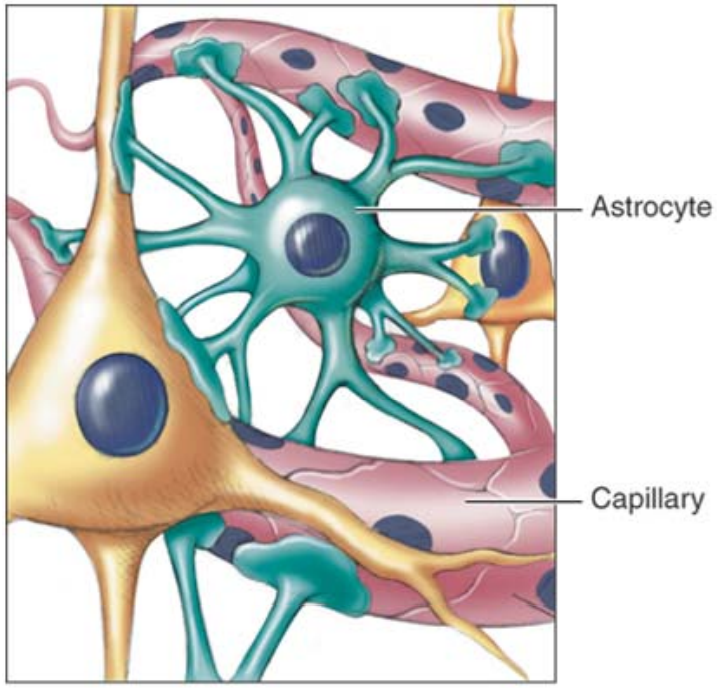
- Sensory function: nerves that gather information from inside & outside the body & carry it to the CNS
- Integrative function: sensory information is brought to the CNS & interpreted
- Motor function: nerves carry message from CNS to muscles & glands in the body

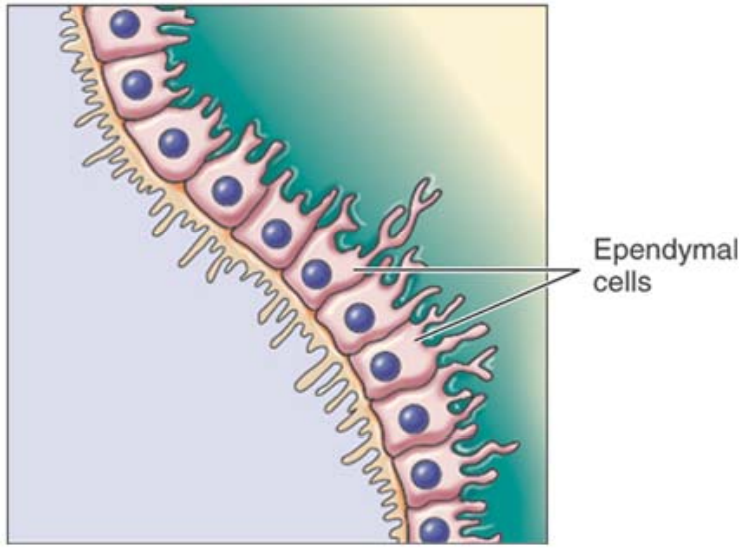
Cells of the Nervous System

- Neuroglia: AKA glial cell
  - Most abundant of nerve cells
  - Supports, protects, insulates & nourishes neurons
  - Does not conduct an impulse

Types of Neuroglia

- Astrocytes: form protective barrier around neuron blocking toxins in blood from entering the CNS
- Ependymal: line inside cavity of brain & assist with formation of CSF
- Microglia: participates in phagocytosis of pathogens
- Oligodendrocytes: form CNS myelin sheath


Astrocyte
Capillary

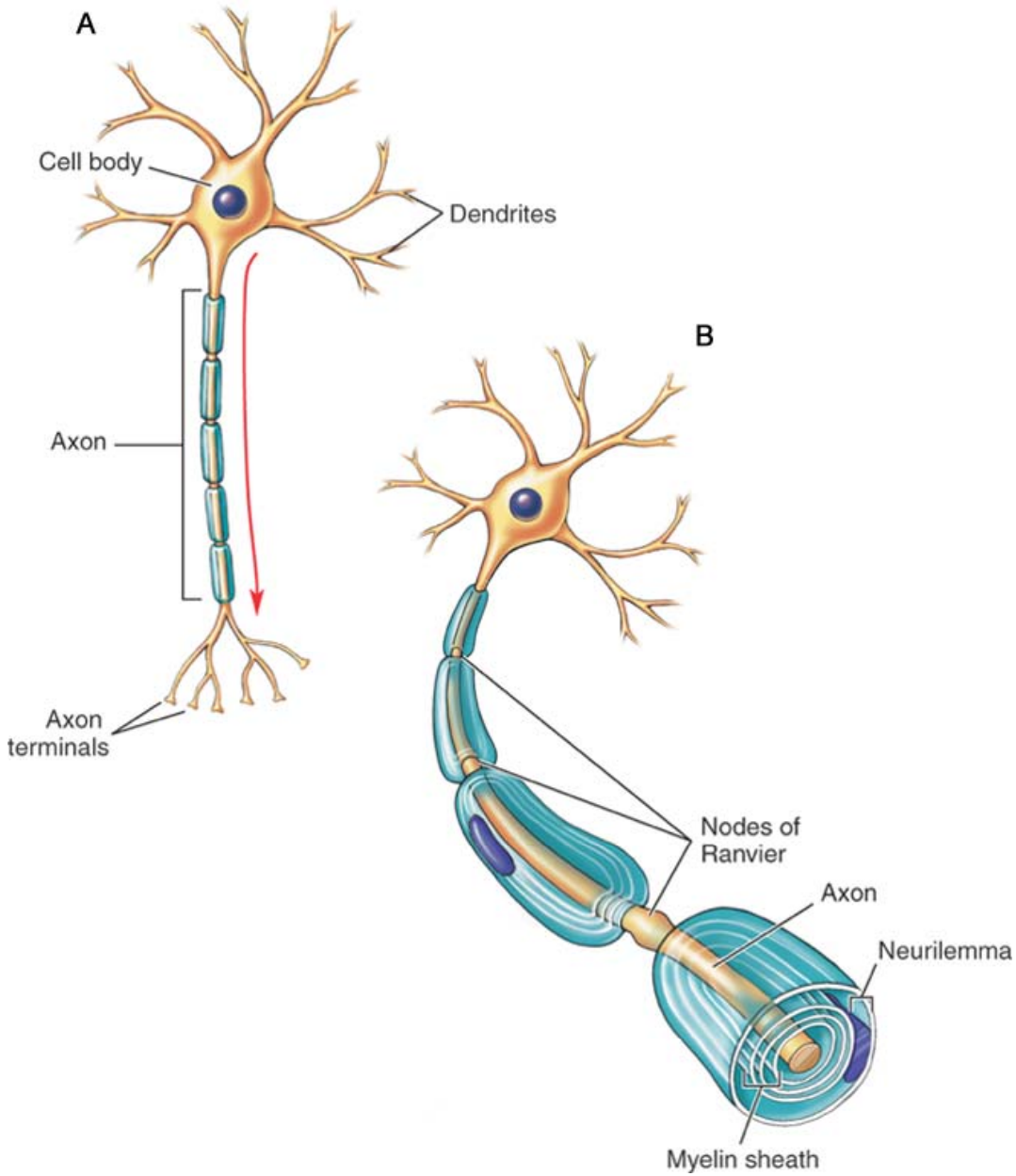

Ependymal
cells

Cells of the Nervous System

- Neuron
  - Most important for transmission of information
  - Vary in shape & size
  - Three parts:
    - Dendrite: tree like projections receives information from other neurons & sends impulse to body
    - Body: contains nucleus
    - Axon: long extension that transmits information away from the cell body which branch off to axon terminals

Structure of an Axon

- Myelin sheath: layer of white fatty material which encases the axon to protect & insulate
- CNS & PNS differ in development of myelin sheath
  - PNS: Schwann cells form the myelin sheath (Cytoplasm & nuclei lie outside the myelin sheath called neurilemma which plays key role in nerve regeneration)
  - CNS: oligodendrocytes form myelin sheath
- Nodes of Ranvier: areas along axon not covered with myelin


A
Cell body
Dendrites
Axon
Axon terminals
B
Nodes of Ranvier
Axon
Neurilemma
Myelin sheath

Three types of Neurons

- Sensory neuron:
  - carries information from the periphery to CNS
  - AKA afferent neuron
  - Found in CNS & PNS
- Motor neuron:
  - carries information from the CNS to the periphery
  - AKA efferent neuron
  - Found in CNS & PNS
- Interneuron:
  - form connections between sensory & motor neurons
  - Only located in the CNS
  - Play role in thinking, learning & memory

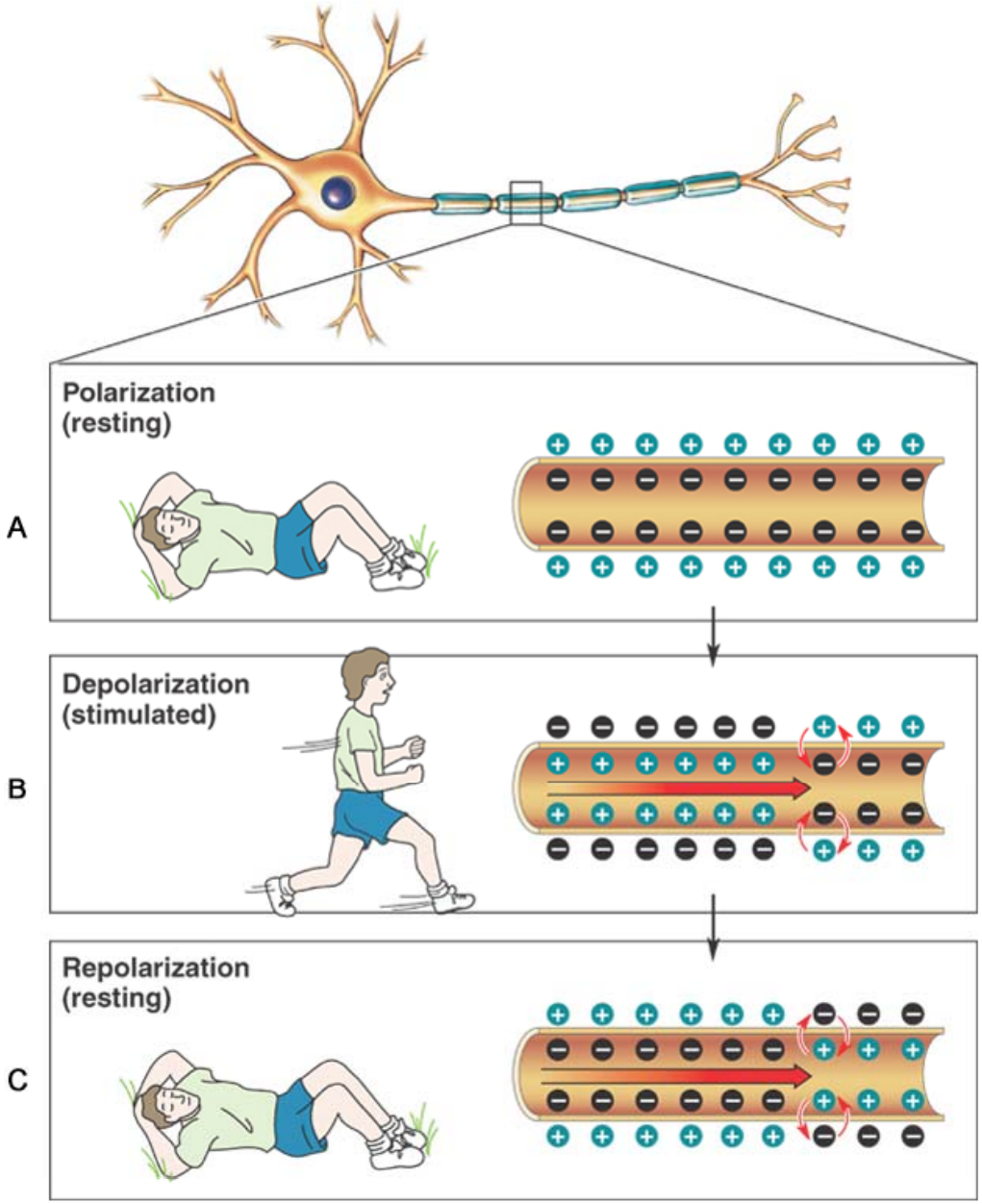
Tissue of the CNS

- White matter:
  - White because myelinated
  - Gathered together in tracts according to function
- Gray matter:
  - Composed of cell bodies, interneurons & unmyelinated fibers
- Cell bodies appear in clusters
  - In CNS clusters are called nuclei (nucleus)
  - In PNS clusters are called ganglia (ganglion)

- Neurons carrying information
  - Nerve impulse is an electrical impulse or signal that conveys information along a neuron
  - Occurs as a result of the movement of ions across the cell membrane
  - Series of events causes electrical charge

Nerve Impulse

- Polarization:
  - resting state of the neuron; cell quiet & resting
  - inside of neuron is negative charge & outside is positive
  - No nerve impulse is transmitted
- Depolarization:
  - Neuron is stimulated
  - Change inside cell to positive charge
- Repolarization:
  - Quick change inside cell back to negative charge
  - Need to repolarize in order to be stimulated again
- Refactory period is the unresponsive period before repolarization

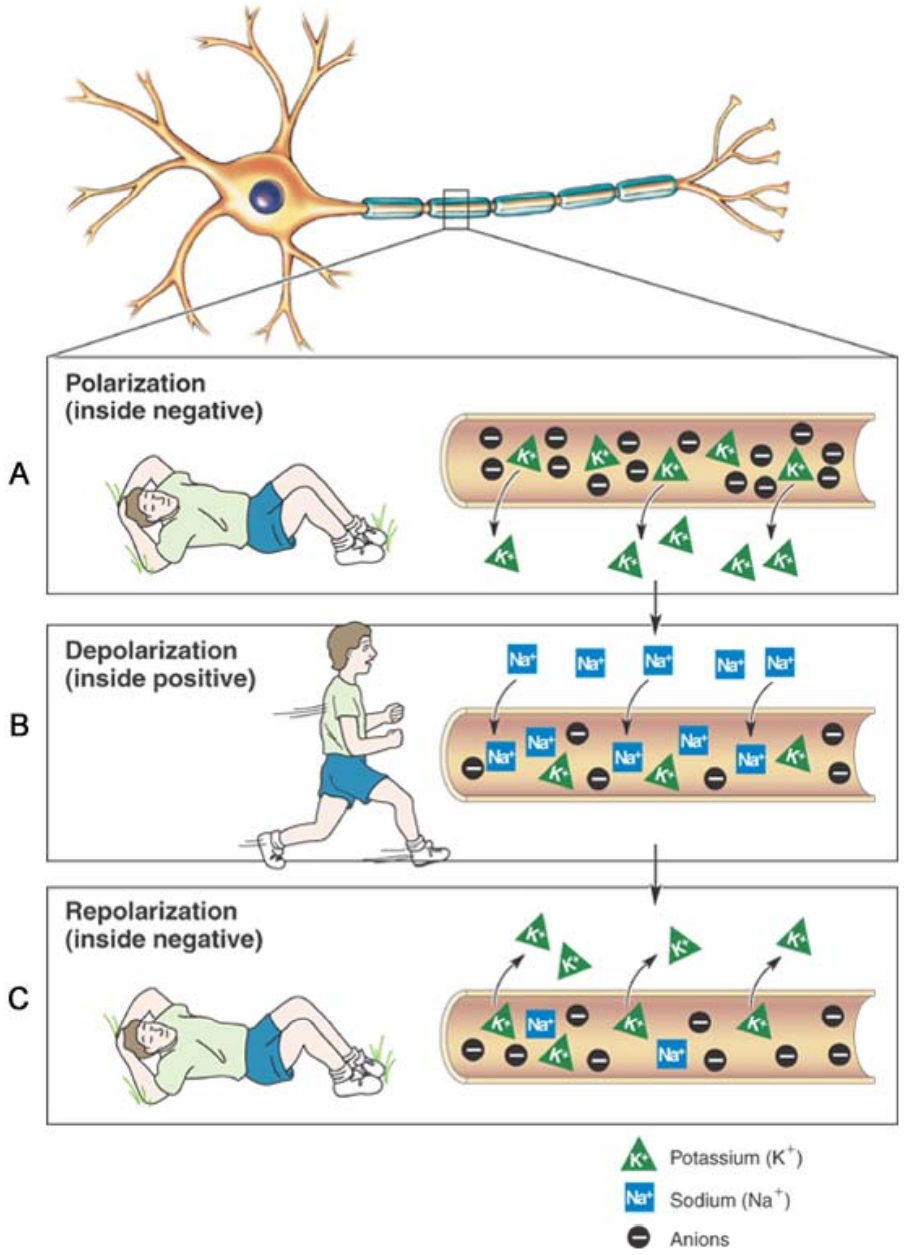

Polarization
(resting)
A
Depolarization
(stimulated)
B
Repolarization
(resting)
C

Cause of Nerve Impulse

- Nerve impulse is due to movement of ions across the cell membrane of the neuron
  - Polarization (resting state): excessive anoins remain in the cell while potassium (cation) leaks out during rest period creating a negative environment
  - Depolarization (stimulated state): when stimulated, neuronal membrane changes occur allowing soduim (cation) to cross the membrane carrying a positive charge into the cell

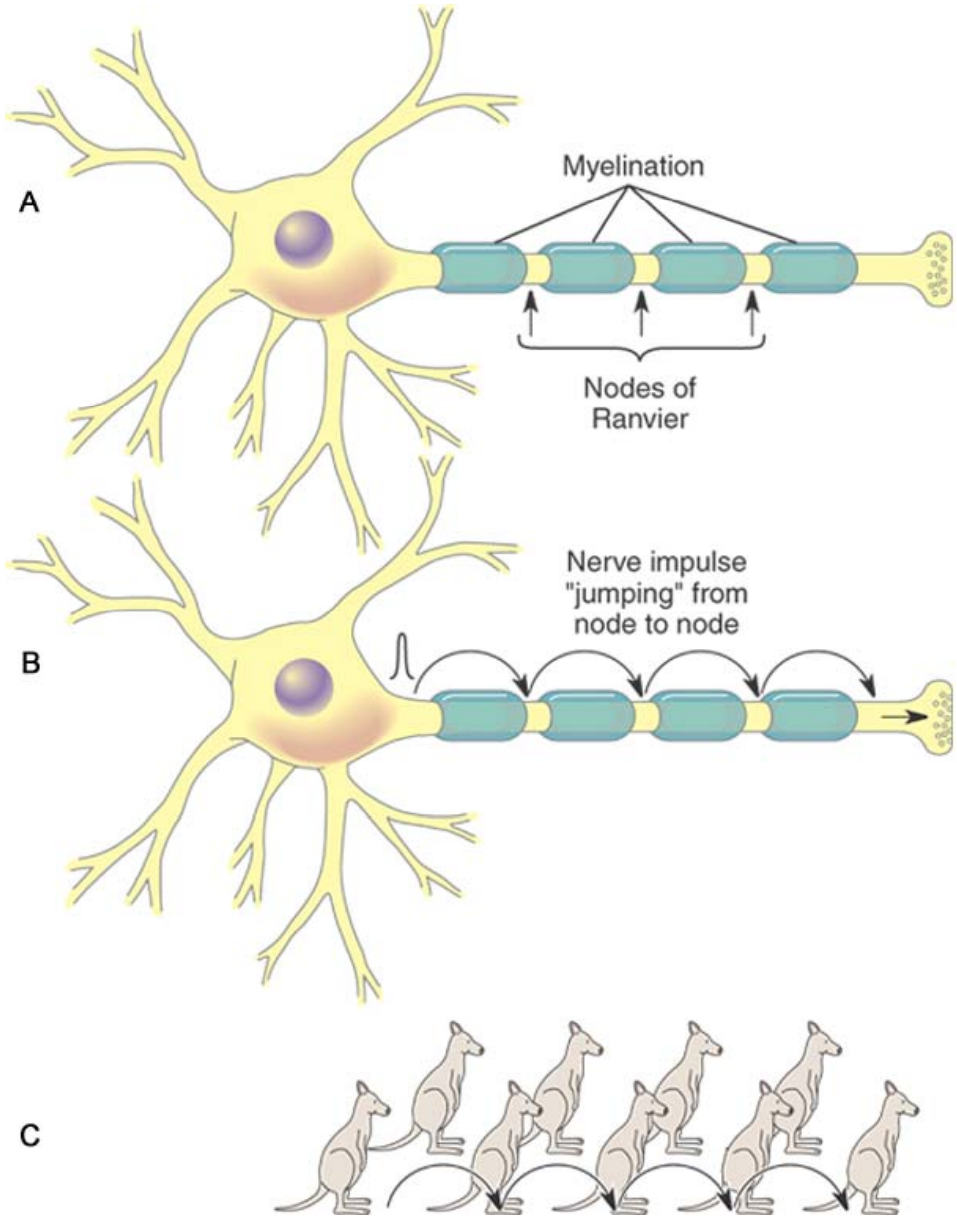
Cause of Nerve Impulse

– Repolarization (return to resting): soon after depolarization, the neuronal membrane undergoes another change stopping the diffusion of sodium (cation) into the cell & allows diffusion of potassium (cation) out of the cell leaving the remaining anions thus creating a negative charge


A
Polarization
(inside negative)
B
Depolarization
(inside positive)
C
Repolarization
(inside negative)
Potassium (K^+)
Sodium (Na^+)
Anions

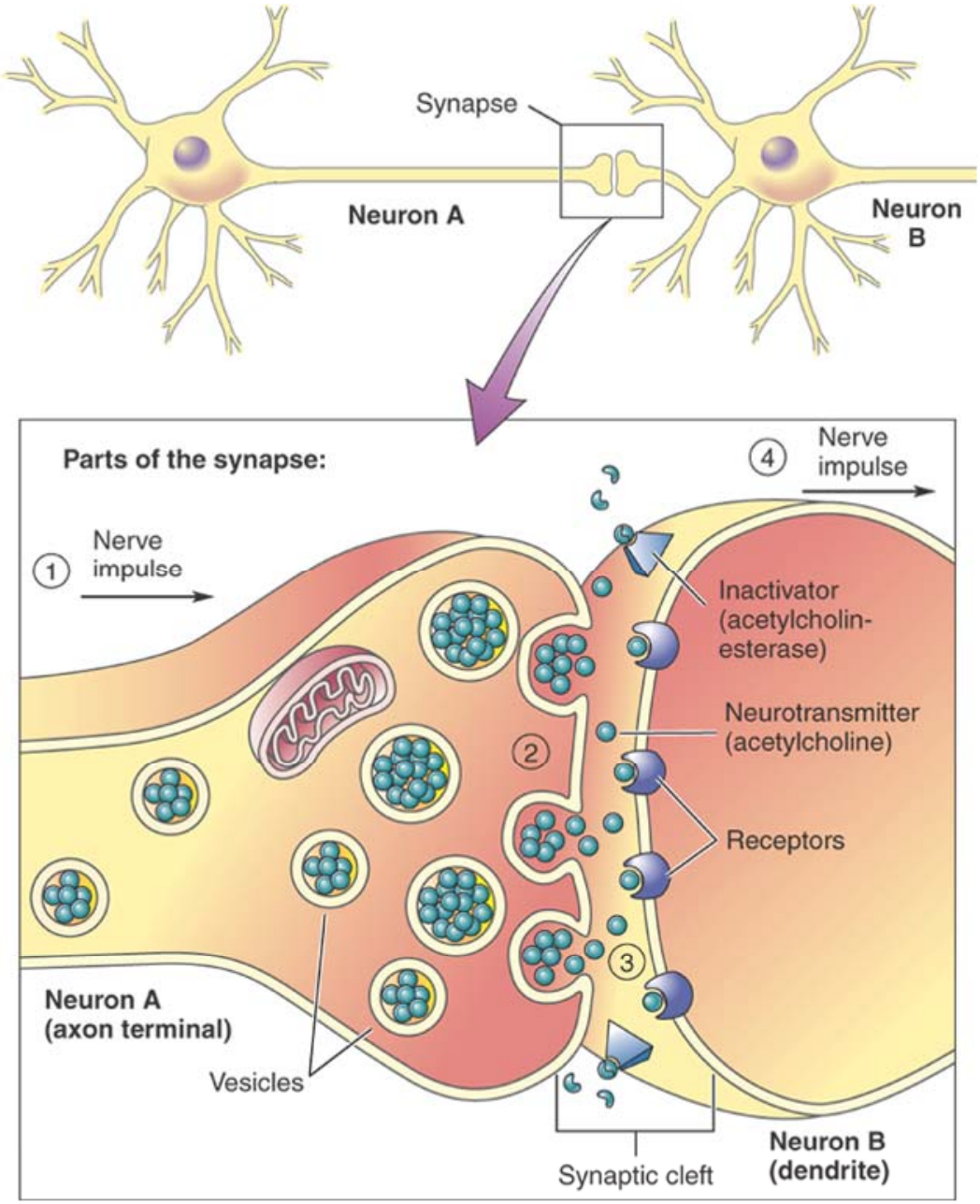
Nerve Impulse

- The impulse moves along the axon by stimulating segments of the membrane like a wave
- Nerve impulse cannot stimulate areas that are myelinated
- Nodes of Ranvier are not myelinated therefore the impulse jumps from node to node called saltatory conduction
- Saltatory conduction is fast mode of transmission


A
Myelination
Nodes of
Ranvier
B
Nerve impulse
"jumping" from
node to node
C

Nerve Impulse

- Synapse is a junction or space between two neurons which information is transmitted across
- Process:
  - The impulse travels along first neuron to its end at the axon terminal
  - Neurotransmitters diffuse across the synapse & binds with the receptor site on the dendrite of the next neuron (new neuron now stimulated)
  - Once the neurotransmitter has stimulated the neuron it is terminated by inactivator substance (acetylcholinesterase) on the dendrite


Synapse
Neuron A
Neuron B
Parts of the synapse:
1 Nerve impulse
2
3
4 Nerve impulse
Inactivator (acetylcholin-esterase)
Neurotransmitter (acetylcholine)
Receptors
Neuron A (axon terminal)
Vesicles
Synaptic cleft
Neuron B (dendrite)

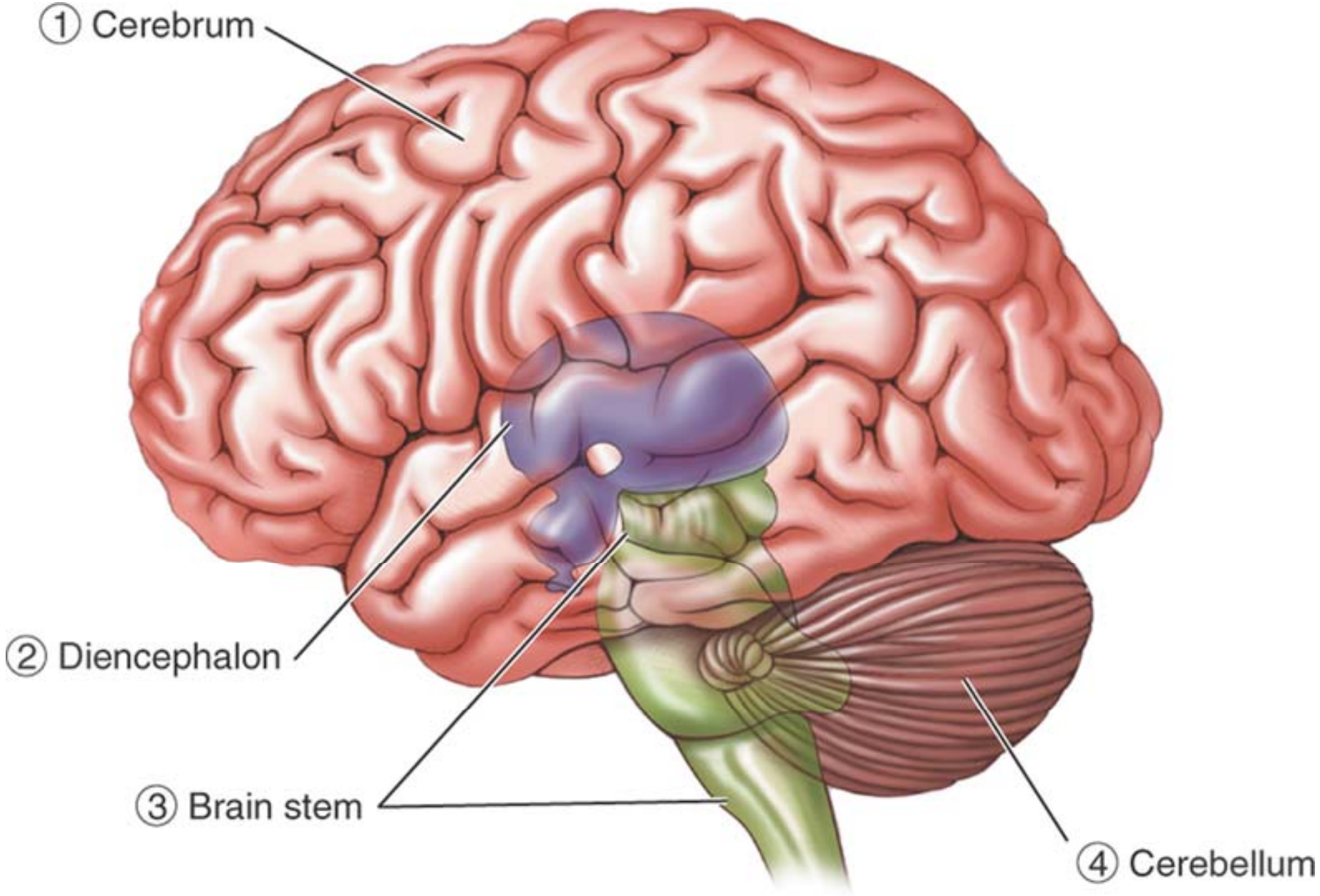
Nerve Impulse

Neurotransmitters

- Two most common:
  - Acetycholine
  - Norepinephrine
- Others include:
  - Serotonin
  - Gamma-aminobutyric acid (GABA)
  - Endorphins

Brain Structure & Function

- 4 Major areas:
  - Cerebrum
  - Diencephalon
  - Brain stem
  - Cerebellum


① Cerebrum
② Diencephalon
③ Brain stem
④ Cerebellum

Cerebrum

- Largest part of brain
- Contains right & left hemisheres
- Joined together by corpus callosum
- Each hemisphere has 4 major lobes
  - Frontal
  - Parietal
  - Temporal
  - Occipital

Cerebrum

- Contains both gray & white matter
- Gray matter forms outer layer called cerebral cortex & is composed of cell bodies & interneurons. This allows us to perform higher mental tasks such as reasoning, learning, language & memory
- White matter is located below the cortex & is composed of myelinated axons that form connections between spinal cord & brain
- There are patches of gray matter scattered throughout

Cerebrum

- Structures of the surface of cerebrum:
  - Convolutions or gyri: elevations along the surface of the cerebrum
  - The more convolutions the greater the intelligences
  - Sulci: grooves that separate gyri
  - Fissures: deep sulcus
  - Sulcus & Fissures seperate the lobes of the brain

Cerebrum

- Ventricles
  - Four cavities in the brain
    - Two lateral
    - Third
    - Fourth
  - Each contains a capillary network called choroid plexus which forms CSF from blood plasma

Cerebral Lobes

- Frontal lobe:
  - Located at front of cranium
  - Controls voluntary motor activity
  - Personality
  - Emotions
  - Behavior
  - High level tasks such as learning & thinking
  - Motor speech called Broca's area

Cerebral Lobes

- Parietal Lobe:
  - Located behind central sulcus
  - Primarily receives sensory information from the body esp. Skin & muscle
  - Allows you to experience pain, touch, temperature & proprioception
  - AKA primary somatosensory area
  - Because of crossover fibers has role in reading, speech & taste

Cerebral Lobes

- Temporal:
  - Located inferior to lateral fissure in an area above the ear
  - Auditory area controls hearing
  - Olfactory area controls smell
  - Taste is interpreted
  - Wernicke's area is located in the posterior temporal lobe & controls comprehension of speech

Cerebral Lobes

- Occipital Lobe:
  - Located at the back of head
  - Contains the visual cortex which interprets sight
  - Allows us to read, interpret what we see, judge distance or see in three dimension

Cerebral Lobe Function

- Each lobe may have specific function but many functions depend on more than one lobe.
- Example: speech area is located in an area of three lobes: temporal, parietal, occipital

Cerebrum

- Association Area:
  - Large area of cerebral cortex
  - Area of analyzing, interpreting & integrating information
  - Has large stores of knowledge to help interpret information received in an area of the brain.

Cerebrum

- Patches of Gray:
  - Located throughout the cerebral white matter
  - Called Basal Nuclei
  - Helps regulate body movement & facial expression
  - Dopamine is neurotransmitter responsible for activity

Diencephalon

- Located beneath the cerebrum & above the brain stem
- Contains the thalamus & hypothalamus
- Thalamus sorts out sensory information from lower brain & spinal cord and sends it to the appropriate area in the cerebrum
- Hypothalamus is located below the thalamus & helps regulate temperature, water balance & metabolism
- Also affects autonomic nerves that control BP, HR & respirations

Diencephalon

- Pituitary gland
  - located under the hypothalamus
  - affects hormones in the body
  - hypothalamus controls pituitary function therefore controls endocrine function

Brain Stem

- Connects the spinal cord with higher brain structures
- Three parts:
    - Midbrain—Pons—Medulla Oblongata
- Midbrain
  – relays sensory & motor information
  – reflex center for vision

Brain Stem

- Pons:
  - Acts as bridge for information to travel to and from brain structures
  - Regulates respiratory rate & rhythm
- Medulla Oblongata:
  - Connects spinal cord with pons
  - Relay for sensory & motor information
  - Called vital center because of control of HR, BP & respiration
  - Area is sensitive to narcotics

Cerebellum

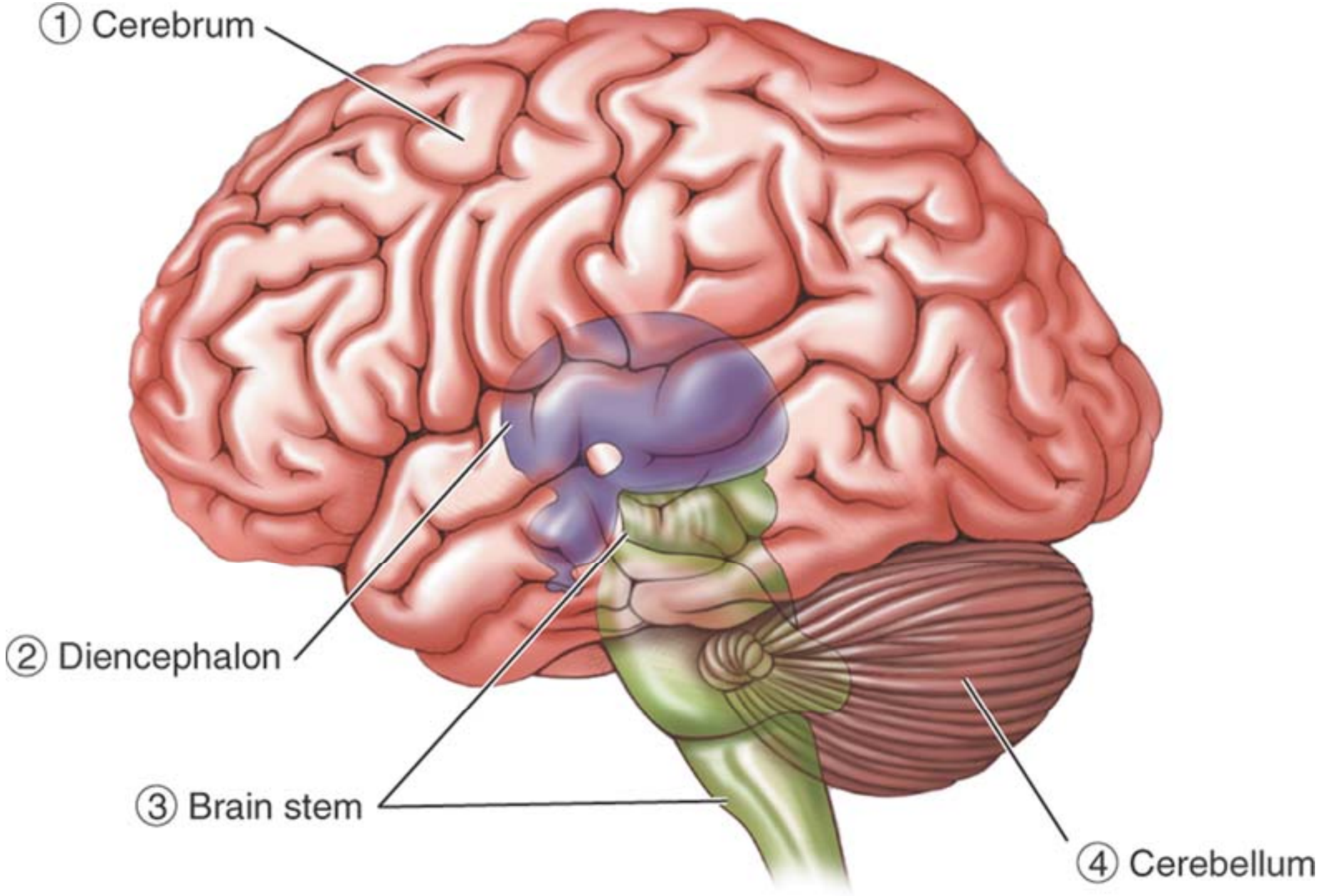
- Protrudes under the occipital lobe at the base of the skull
- Concerned with coordinated voluntary movements
- Receives information from many areas of body, integrates & produces smooth coordinated muscle response
- Trauma to this area results in jerky muscle movement, staggering unsteady gait

Limbic System

- One of two overlapping structures
- AKA: Emotional Brain
- Parts of cerebrum & diencephalon that form wishbone shape
- Contributes to memory
- Functions in emotional behavior & states

Reticular Formation

- Second structure to overlap in the brain
- Extends the entire brain stem and connect to cerebral cortex
- Special mass of gray matter
- Concerned with sleep/wake cycle & consciousness
- Sensitive to the effects of certain drugs & alcohol


① Cerebrum
② Diencephalon
③ Brain stem
④ Cerebellum

Consciousness, Sleep & Coma

- Consciousness:
  - state of wakefulness that depends on information from the body to the reticular activating system
  - Different levels of consciousness: attentiveness, alertness, relaxation & inattentivenss
- Sleep:
  - occurs when RAS is inhibited or slowed
  - Cause is unknown
- Coma:
  - Several stages from light to deep

Stages of Sleep

- Two types:
  - Non-rapid eye movements sleep (NREM)
    - 4 stages of NREM from light to deep in cycles from light to deep then deep to light
  - Rapid eye movement sleep (REM)
    - Averages 90 – 120 minutes per night
    - Just as name there is rapid movement of eyes
    - Fluctuating BP, resp rate & rhythm
    - Dreaming occurs in REM
    - Associated with mental & physical distress

Protection of the CNS

- Bone:
  - First layer of protection
  - Brain in cranium & spinal cord in vertebral column
- Meninges:
  - Second layer
  - Contains three layers of connective tissue

Protection of the CNS

- Meninges:
  - Dura Mater:
    - outermost layer
    - thick & tough
  - Arachnoid layer
    - middle layer
    - Resembles a spider web
    - Contain arachnoid villi which are specialized projections
  - Pia Mater:
    - Innermost layer
    - Soft layer containing many blood vessels

Protection of the CNS

- Subarachnoid space:
  - Located between arachnoid layer & pia mater
  - CSF circulates in this space forming a cushion around the brain & spinal cord
- Inflammation or infection of the meninges is causes meningitis

Protection of the CNS

- Cerebrospinal fluid:
  - Third layer of protection
  - Formed from blood within brain within the ventricles by the choroid plexus
  - Clear fluid containing water, glucose, protein & several ions (Na & Cl)
  - Adult circulate ½ cup of CSF

Protection of the CNS

- Cerebrospinal fluid flows in two ways:
  - Through hole in the spinal cord called central canal draining into the subarachnoid space at the base of the spinal cord
  - Rest flows from the 4th ventricle through tiny holes (foramina) into the subarachnoid space that encircles the brain. It leaves the space & drains into the blood stream & returns to the heart
  - If drains less increased intracranial pressure develops

Protection of the CNS

- Blood-Brain Barrier:
  - Arrangement of cells associated with blood vessels that supply the brain & spinal cord
  - Selects substances that are allowed to enter the CNS
  - Prevents certain harmful substances from entering
  - Not all toxic substances are blocked. i.e alcohol
  - Some antibiotics do not cross the barrier