ANATOMY, PHYSIOLOGY, AND DISEASE

Ch. 9: The Nervous System:

The Body's Control Center

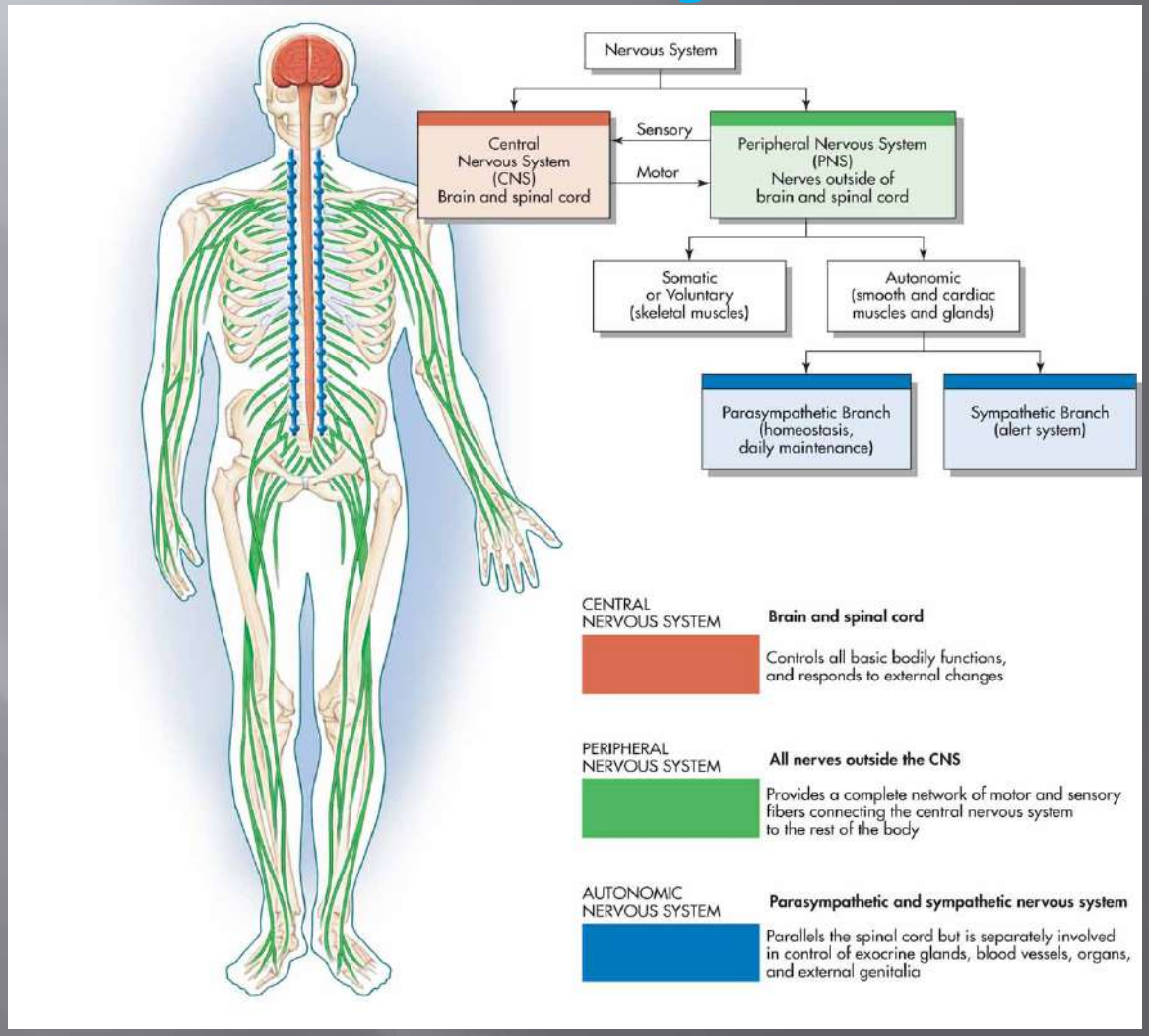
Basic Operations

- Central Nervous System (CNS): Brain and spinal cord; controls total nervous system
- Peripheral Nervous System (PNS): Everything outside brain and spinal cord, ie. nerves and neurons
- Sensory System: input side of nervous system
- Motor System: output side of nervous system

Basic Operations (cont.)

- Somatic Nervous System: controls skeletal muscle and mostly voluntary movements
- Autonomic Nervous System: controls smooth muscle, cardiac muscle, and several glands
- Autonomic system is divided into 2 systems: Parasympathetic system- deals with normal body functioning and maintenance of homeostasis
- Sympathetic nervous system controls “fight or flight” response system

Organization of the Nervous System



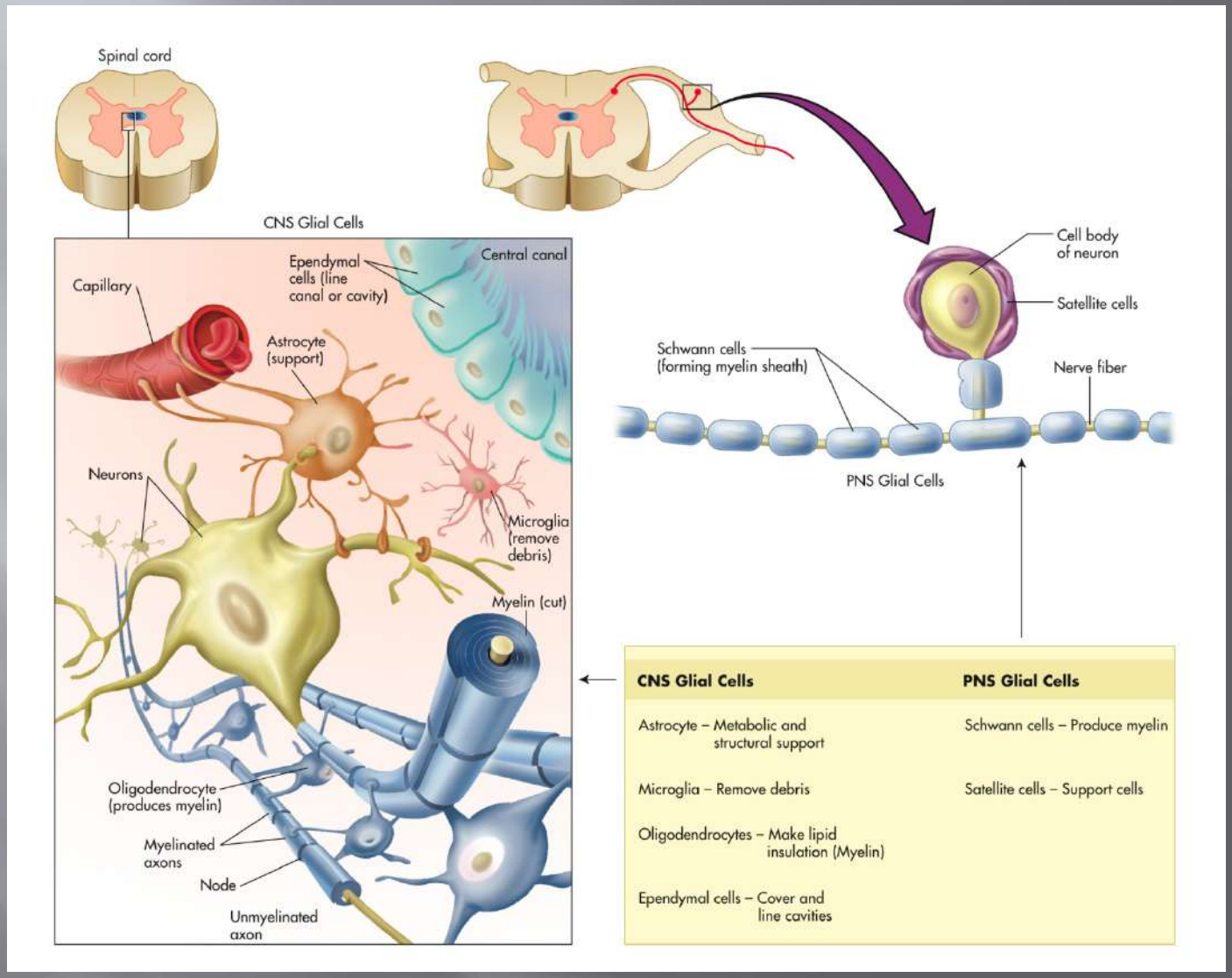
Nervous Tissue

- Specialized cells called neuroglia, or glial cells, perform specialized functions
  - CNS has four types of glial cells:
    - Astrocytes: metabolic and structural support cells
    - Microglia: remove debris
    - Ependymal cells: cover and line cavities of nervous system
    - Oligodendrocytes: make lipid insulation called myelin

Specialized Cells (cont.)

- PNS has two types of glial cells:
  - Schwann cells: make myelin for the PNS
  - Satellite cells: support cells

Glial cells and their functions.

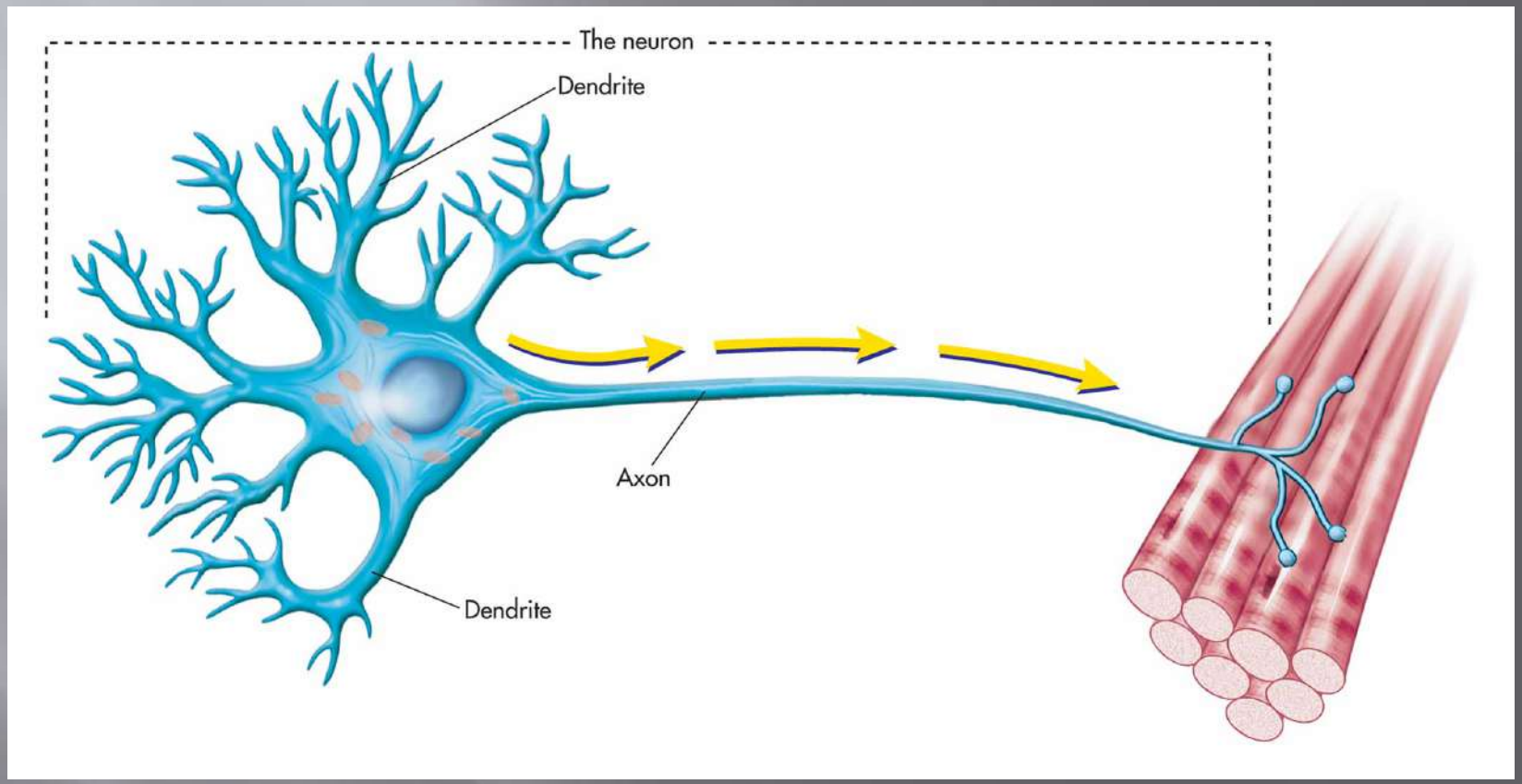


CNS Glial Cells	PNS Glial Cells
Astrocyte – Metabolic and structural support	Schwann cells – Produce myelin
Microglia – Remove debris	Satellite cells – Support cells
Oligodendrocytes – Make lipid insulation (Myelin)	
Ependymal cells – Cover and line cavities	

Neurons

- All control functions of nervous system carried out by group of cells called neurons
- Each part of neuron has specific function:
  - Body: cell metabolism
  - Dendrites: receive information from the environment
  - Axon: generates and sends signals to other cells
  - Axon terminal: where signal leaves cell
  - Synapse: where axon terminal and receiving cell combine

Neuron connecting to skeletal muscle.



Neurons (cont.)

- Neurons are classified by how they look (structure) or what they do (function)
- Input neurons = sensory neurons
- Output neurons = motor neurons
- Neurons which carry information between neurons are called interneurons

How Neurons Work

- Neurons are called excitable cells that can carry a small electrical charge
- Each time charged particles flow across cell membrane, a tiny charge is generated
- All 3 muscle types and gland cells are excitable cells
- Cells are able to generate tiny currents by changing permeability of their membranes

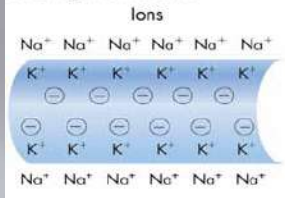
How Neurons Work (cont.)

- An unstimulated cell= a resting cell; it is said to be polarized; it is more negative inside than outside the cell
- When stimulated, sodium gates in cell membrane open, allowing sodium to travel across membrane
- Sodium (Na+) is positively charged, so cell becomes more positive as they enter

How Neurons Work (cont.)

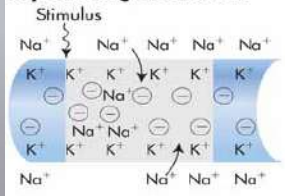
- A more positive cell = depolarized
- Sodium gates close and potassium gates open; potassium (K+) leaves cell, taking its positive charge with it
- This is called repolarization
- Action potential (AP) = cell moving through depolarization, repolarization, and hyperpolarization
- Cell cannot accept another stimulus until it returns to its resting state; this is called refractory period

Resting Membrane



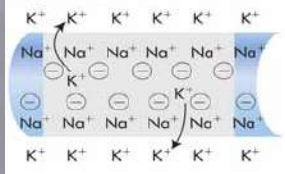
Na^+ ions are concentrated on the outside of the membrane, while K^+ ions are on the inside of the membrane. However, the inside of the membrane has enough negative ions so that the inside is more negatively charged than the outside.

Depolarizing Membrane

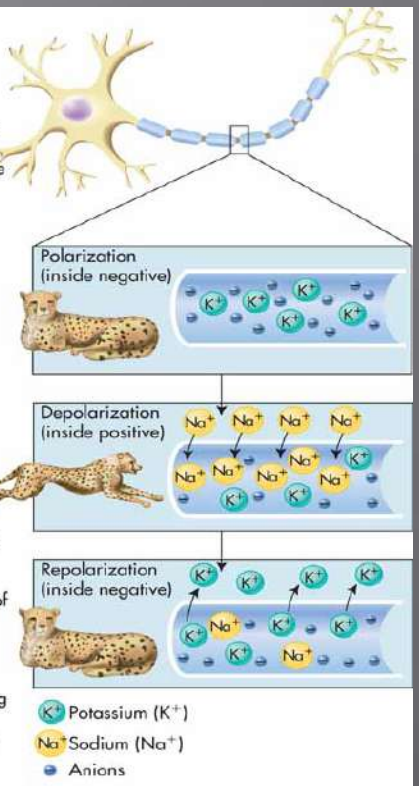


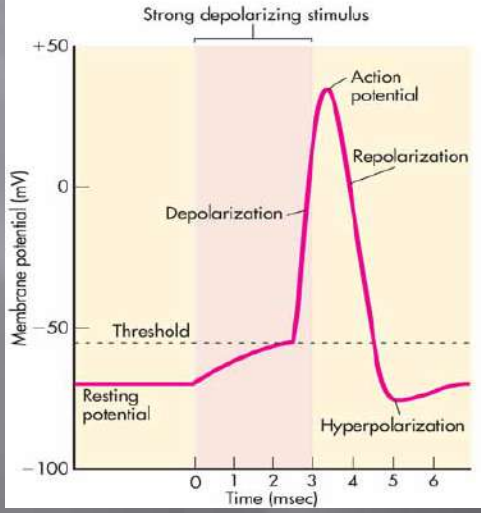
This occurs when a stimulus makes the membrane permeable to Na^+, allowing sodium to enter the cell and make it more positive inside.

Repolarization



Na^+ channels now close, and K^+ channels open. Now K^+ can diffuse out of the cell. By this diffusion, the polarity of the membrane is restored. Active transport moves Na^+ and K^+ back to where they belong, re-establishing the resting membrane. The resting membrane can now receive another stimulus to cause this process to repeat.





How Neurons Work (cont.)

- Neurons can send, receive, and interpret signals
- Ex. You hit your thumb with a hammer
- Dendrites are stimulated
- Na+gates open
- Na+ flows into dendrites and cell becomes depolarized
- # of cells affected depends on how hard you hit your thumb

How Neurons Work (cont.)

- Dendrites carry depolarization to sensory neuron cell body
- Speed of impulse conduction is determined by amount of myelin and diameter of axon
- Myelinated nerves are white
- Unmyelinated nerves are gray

How Neurons Work (cont.)

- Myelin is essential for speedy flow of AP's down axons
- Unmyelinated axon: impulse travels slower
- Myelinated axons: impulse travels quickly

Pathology Connection: Myelin Disorders

- Multiple Sclerosis (MS): disorder where myelin in CNS is destroyed
  - Less myelin= slow or no impulse conduction
  - Damaged myelin often have plaques or scarred areas
  - Etiology: probably auto-immune attack
  - S/S: vary depending on where patient's myelin has been damaged; include disturbances in vision, balance, speech, and movement

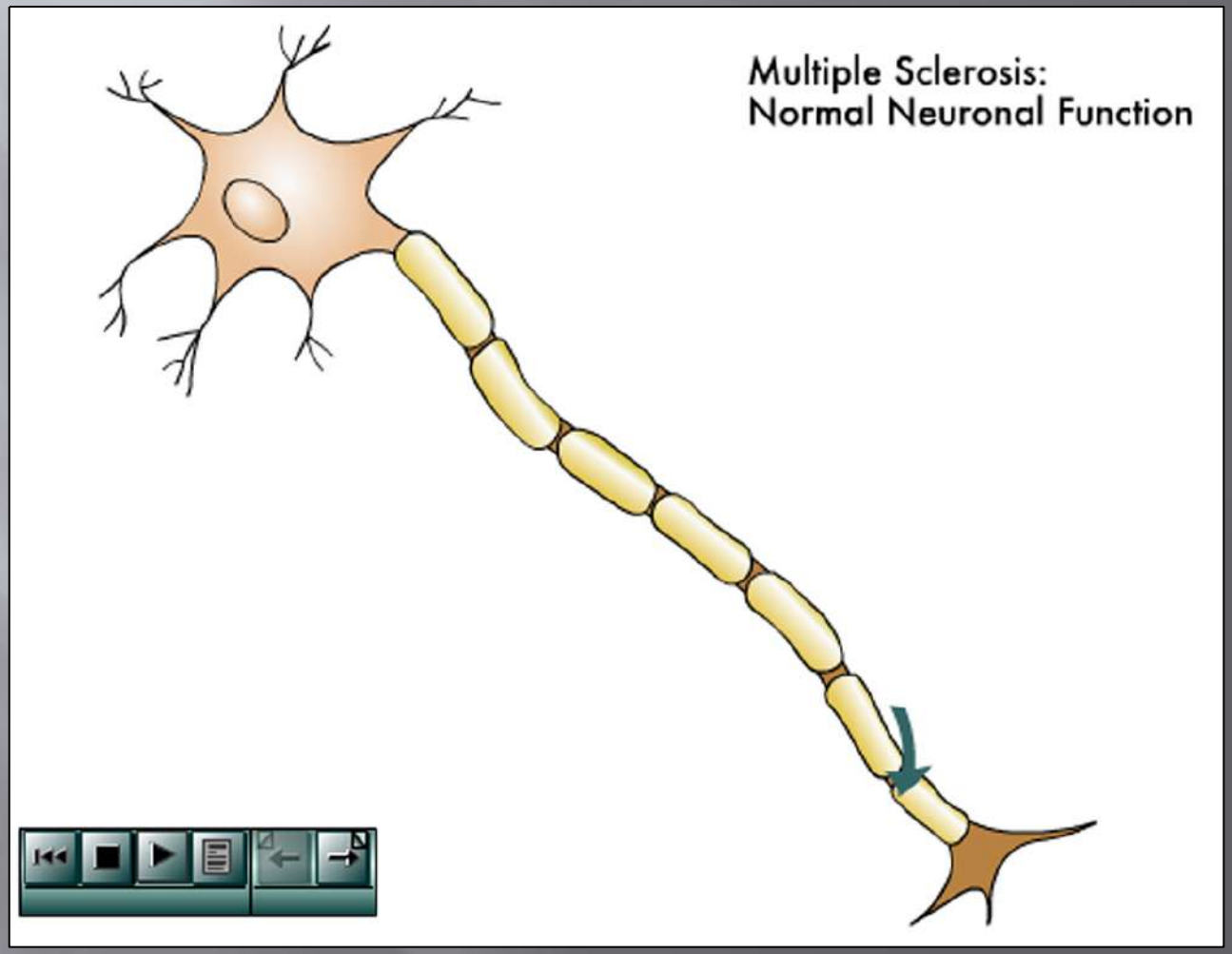
Multiple Sclerosis (cont.)

- Epidemiology: more common in women; diagnosed most often in people under age 50
- DX: based upon hx of s/s flare-ups, and presence of plaques on MRI; no definitive diagnosis
- TX: no cure; TX used to slow progression and control symptoms in acute flare: steroids, plasma exchange, or IV immunoglobulin G; immunosuppressant drugs.

Types of MS

- Relapsing-remitting: has symptomatic flare-ups (called relapses), followed by periods of no symptoms (called remissions)
- Chronic progressive: has no remission periods; patients become steadily more disabled
- Most patients initially diagnosed with relapsing-remitting, but at least 50% will progress to chronic progressive form

MS Animation



Guillain-Barré Syndrome

- Etiology: unknown, may be from viral infection; autoimmune attack on myelin and/or axons in PNS.
- S/S: weakness and ascending paralysis of limbs, face and diaphragm
- DX: based hx of ascending paralysis after viral infection: Electromyography (EMG) and Cerebral Spinal fluid (CSF) shows high protein and no WBC
- TX: supportive care until symptoms improve/resolve; ventilation support, prevention of blood clots and bed sores, pain meds; PT after their PNS recovers

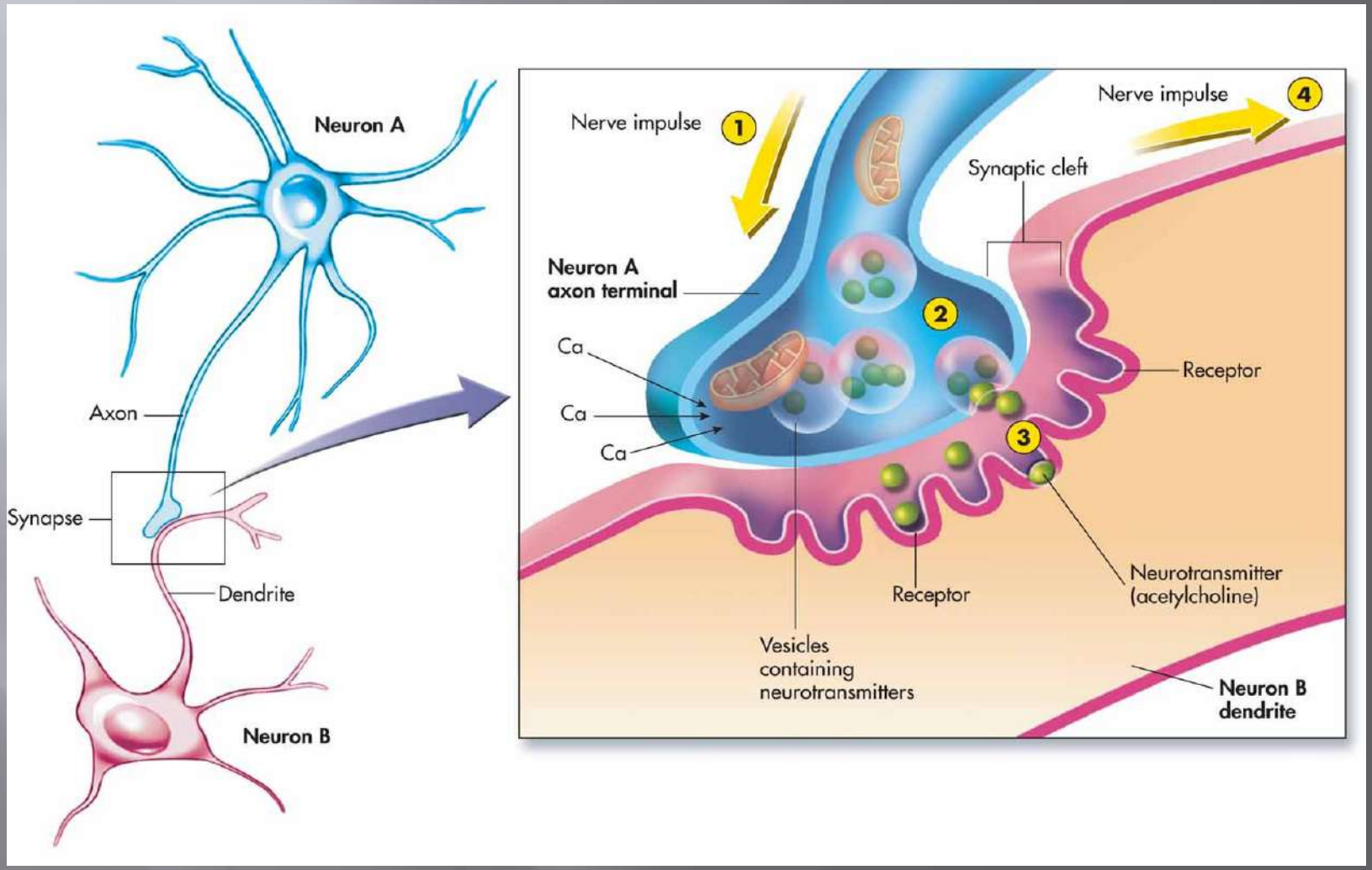
Guillain-Barré Syndrome (cont.)

- Course of disease has three phases
  - Acute phase: initial onset of disease; pt becomes steadily worse
  - Plateau phase: period of days to weeks; pt condition is stable
  - Recovery phase: period of time that pt recovers function; can take up to 2 years and may not recover fully

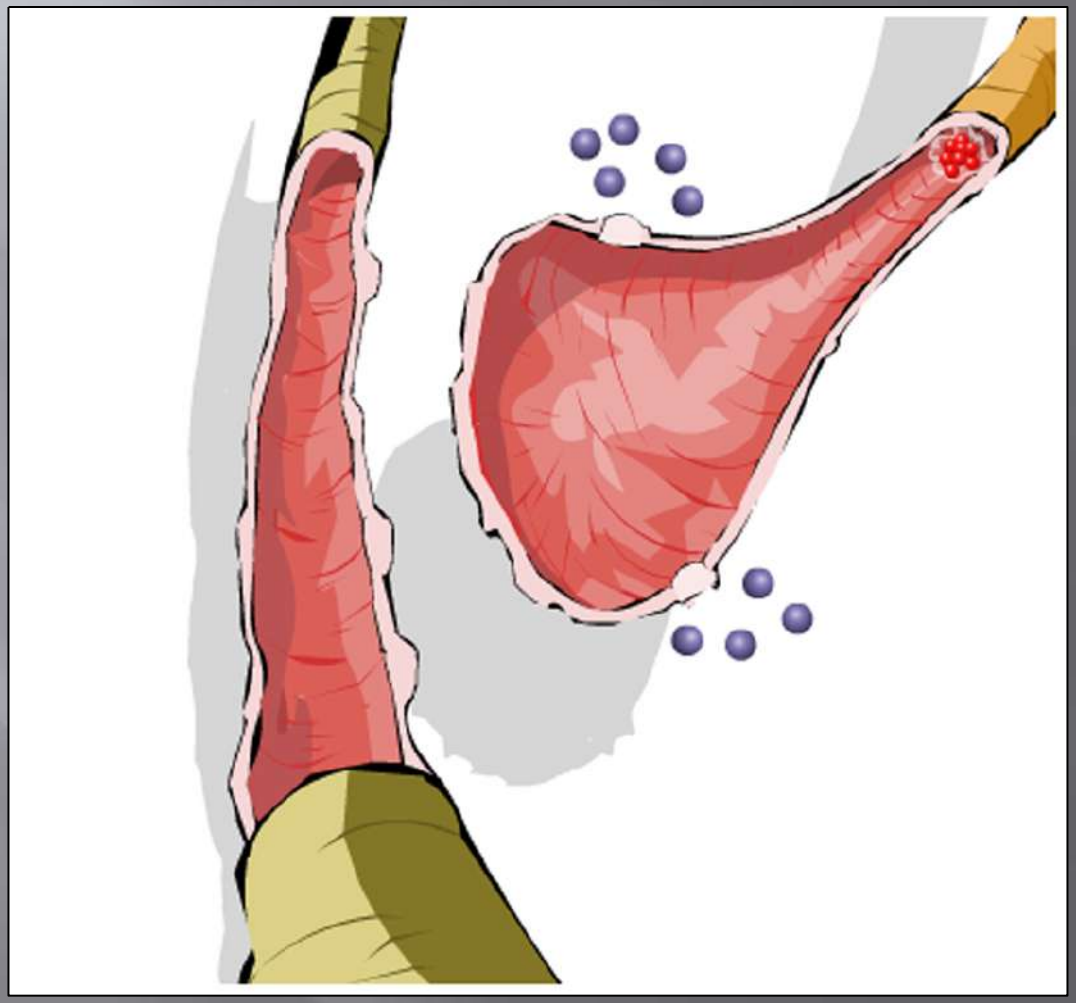
How Synapses Work

- When AP arrives at axon terminal, terminal depolarizes, Calcium (Ca+) gates open; Ca+ flows into cell
- Tiny sacs in terminal called vesicles release their contents from cell when calcium flows in
- Vesicles contain molecules called neurotransmitters that send signals from neuron to neuron
- Neurotransmitters can excite the cell or calm it down

Synapses


Neuron A
Axon
Synapse
Dendrite
Neuron B
Nerve impulse
1
Nerve impulse
4
Synaptic cleft
Neuron A
axon terminal
2
Ca
Ca
Ca
Receptor
3
Receptor
Neurotransmitter
(acetylcholine)
Vesicles
containing
neurotransmitters
Neuron B
dendrite

Neurosynapses Animation



Common Neurotransmitters

TABLE 9-1 Selected Common Neurotransmitters

NEUROTRANSMITTER	LOCATION	FUNCTION	COMMENTS
Acetylcholine	CNS* and PNS*	Generally excitatory but is inhibitory to some organs and glands	Found in skeletal neuromuscular junctions and in many ANS* synapses
Norepinephrine	CNS and PNS	May be excitatory or inhibitory depending on the receptors	Found at visceral and cardiac muscle synapses, ANS
Epinephrine	CNS and PNS	May be excitatory or inhibitory depending on the receptors	Found in pathways concerned with behavior and mood
Serotonin	CNS	Generally inhibitory	Found in pathways that regulate temperature, sensory perception, mood, onset of sleep
Endorphins	CNS	Generally inhibitory	Inhibit release of pain neurotransmitters

*CNS = central nervous system; PNS = peripheral nervous system; ANS = autonomic nervous system.

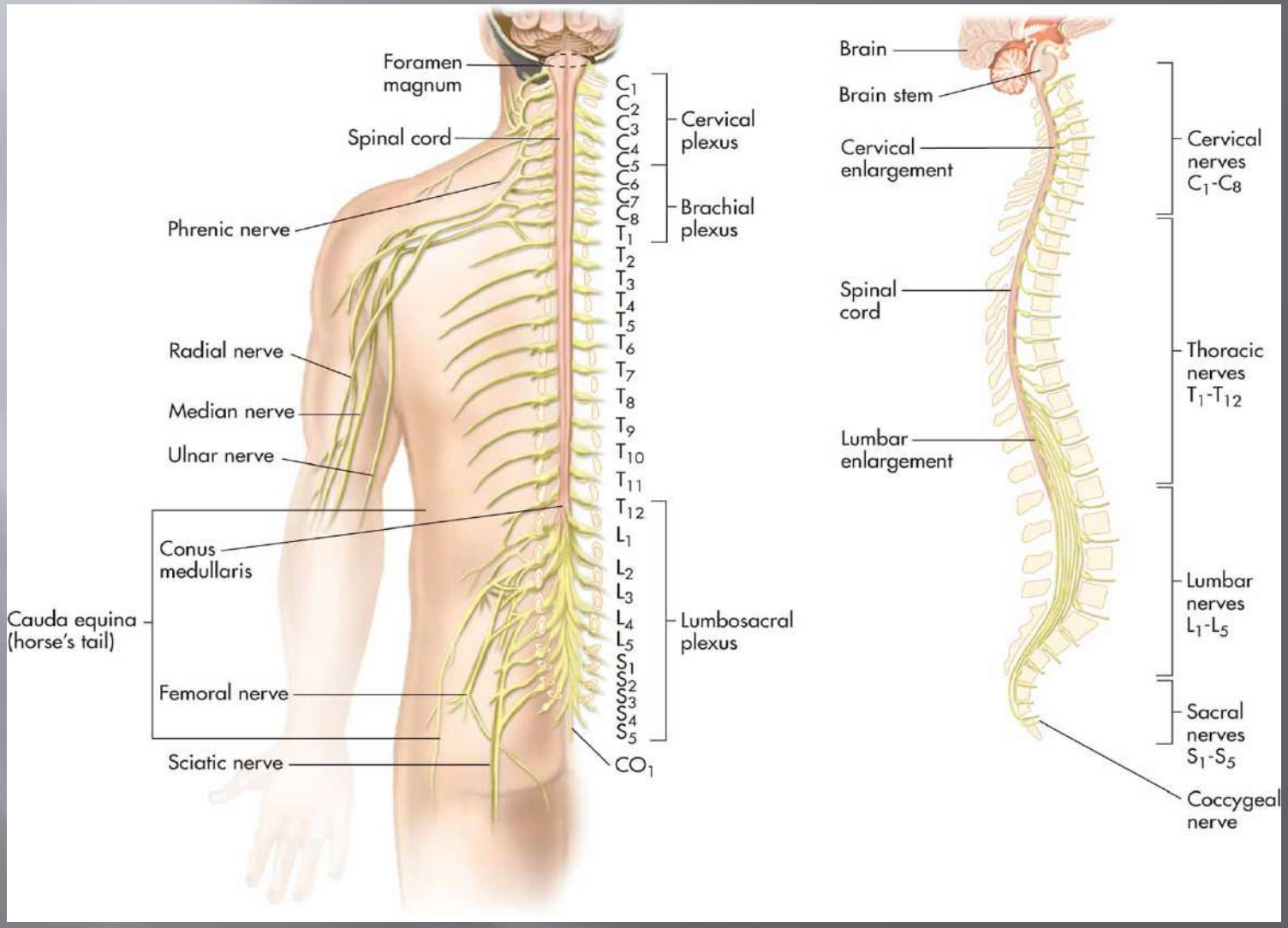
Electrical Synapses

- Do not need chemicals to transmit info from one cell to another
- Called electrical synapses: transfers info freely through connections called gap junctions
- Found in intercalated disks between cardiac muscle fibers

Spinal Cord and Spinal Nerves

- Hollow tube running inside vertebral column, from foramen magnum to the 2nd lumbar vertebrae
- Has 31 segments, each with pair of spinal nerves, named for corresponding vertebrae
- Ends at L2 in pointed structure called conus medullaris; hanging from conus medullaris is cauda equine (horses tail), which dangles loosely and floats in bath of cerebral spinal fluid (CSF)
- Has 2 widened areas, cervical and lumbar enlargements; contain neurons for upper and lower limbs

Spinal Cord


Foramen magnum
Spinal cord
Phrenic nerve
Radial nerve
Median nerve
Ulnar nerve
Conus medullaris
Cauda equina (horse's tail)
Femoral nerve
Sciatic nerve
C1
C2
C3
C4
C5
C6
C7
C8
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5
CO1
Cervical plexus
Brachial plexus
Lumbosacral plexus
Brain
Brain stem
Cervical enlargement
Spinal cord
Lumbar enlargement
Cervical nerves C1-C8
Thoracic nerves T1-T12
Lumbar nerves L1-L5
Sacral nerves S1-S5
Coccygeal nerve

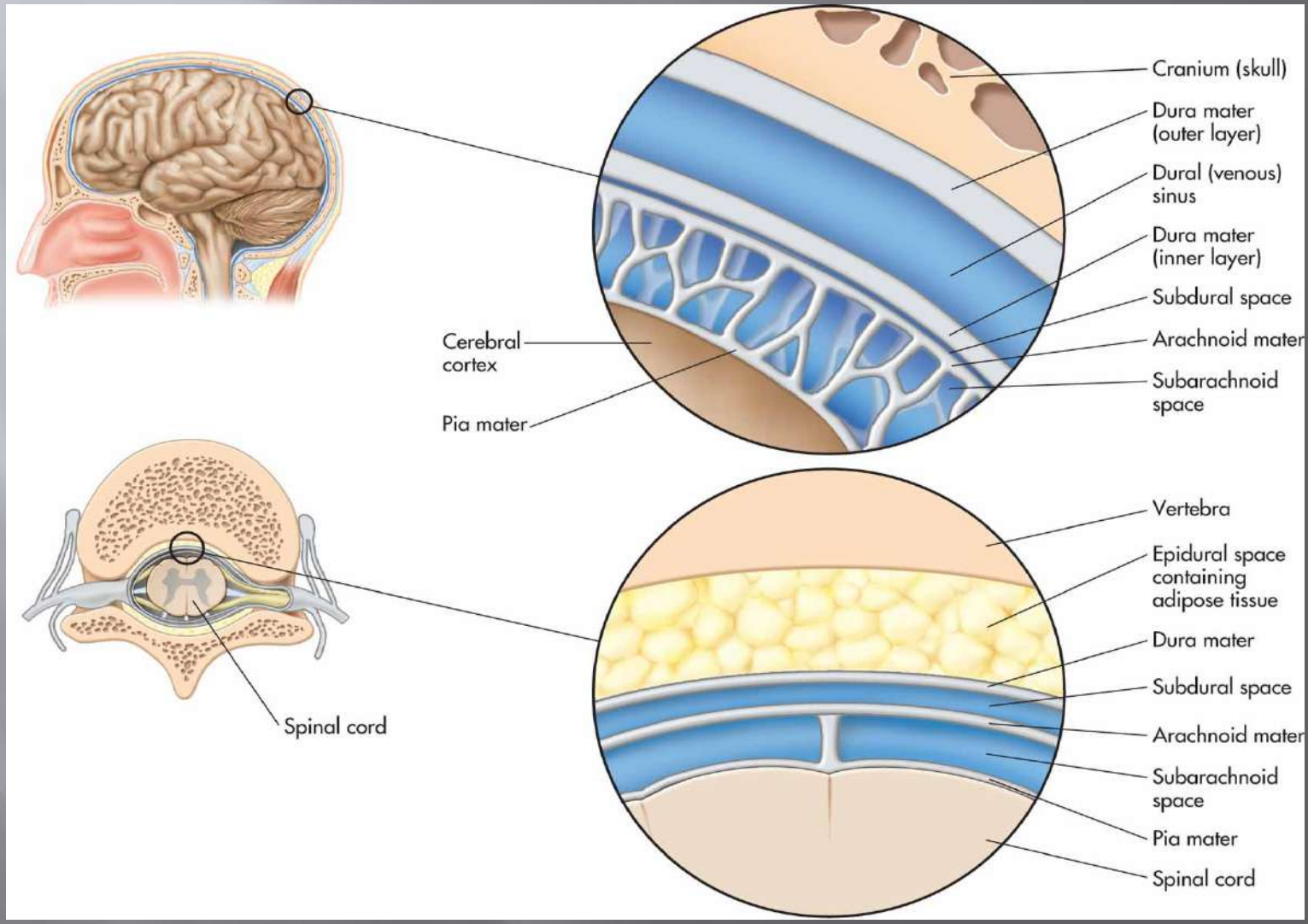
Meninges

- Protective covering of brain and spinal cord
- Act as cushioning and shock absorbers
- 3 layers
  - Outer layer is thick fibrous tissue called dura mater
  - Middle layer is delicate, resembles spider web= arachnoid mater, composed of collagen and elastic fibers, acts as shock absorber, transports gases, nutrients, chemical messengers and waste products
  - Innermost layer, fused to neural tissue= pia mater, contain blood vessels that serve brain and spinal cord

Meninges

- Spaces associated with meninges
  - Between dura mater and vertebral column= space filled with fat and blood vessels called epidural space
  - Between dura mater and arachnoid mater = subdural space filled with tiny bit of fluid
  - Between arachnoid mater and pia mater = large subarachnoid space filled with CSF that acts as fluid cushion

Meninges


Cranium (skull)
Dura mater (outer layer)
Dural (venous) sinus
Dura mater (inner layer)
Subdural space
Arachnoid mater
Subarachnoid space
Cerebral cortex
Pia mater
Vertebra
Epidural space containing adipose tissue
Dura mater
Subdural space
Arachnoid mater
Subarachnoid space
Pia mater
Spinal cord
Spinal cord

Epidural Placement Video

Spinal Cord

- Divided in half by anterior median fissure and posterior median sulcus
- Interior of spinal cord is then divided into: sections of white matter columns and gray matter horns
- Types of horns (regions where neuron's cell bodies reside)
  - Dorsal horn: involved in sensory functions
  - Ventral horn: involved in motor function
  - Lateral horn: dealing with autonomic functions

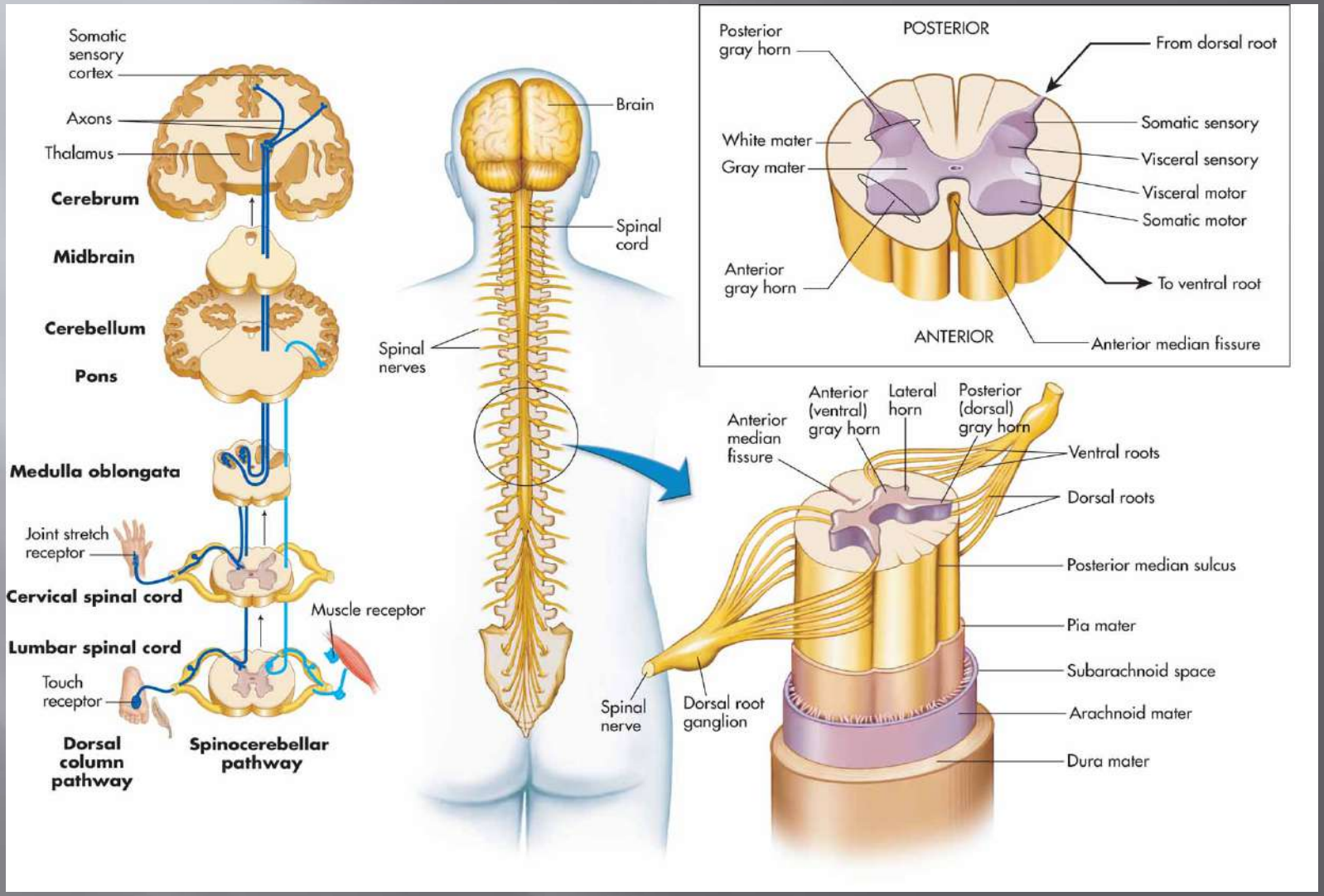
Spinal Cord (cont.)

- Columns: areas of white matter (which contain axons running up and down spinal cord, to and from brain)
- Ascending pathways: carry sensory info up to brain
- Descending pathways: carry motor information down from brain
- Left and rt. halves of spinal cord connected by commissures (gray and white); allows two sides of CNS to communicate
- Center of spinal cord is CSF-filled cavity called central canal

Spinal Cord (cont.)

- Spinal roots project from both sides of spinal cord in pairs; fuse to form spinal nerves
- Dorsal root: collection of sensory neurons that carry sensory information
- Ventral root is motor

Spinal Cord


Somatic sensory cortex
Axons
Thalamus
Cerebrum
Midbrain
Cerebellum
Pons
Medulla oblongata
Joint stretch receptor
Cervical spinal cord
Muscle receptor
Lumbar spinal cord
Touch receptor
Dorsal column pathway
Spinocerebellar pathway
Brain
Spinal cord
Spinal nerves
Spinal nerve
Dorsal root ganglion
Posterior gray horn
POSTERIOR
From dorsal root
Somatic sensory
Visceral sensory
Visceral motor
Somatic motor
White mater
Gray mater
Anterior gray horn
To ventral root
ANTERIOR
Anterior median fissure
Anterior median fissure
Anterior (ventral) gray horn
Lateral horn
Posterior (dorsal) gray horn
Ventral roots
Dorsal roots
Posterior median sulcus
Pia mater
Subarachnoid space
Arachnoid mater
Dura mater

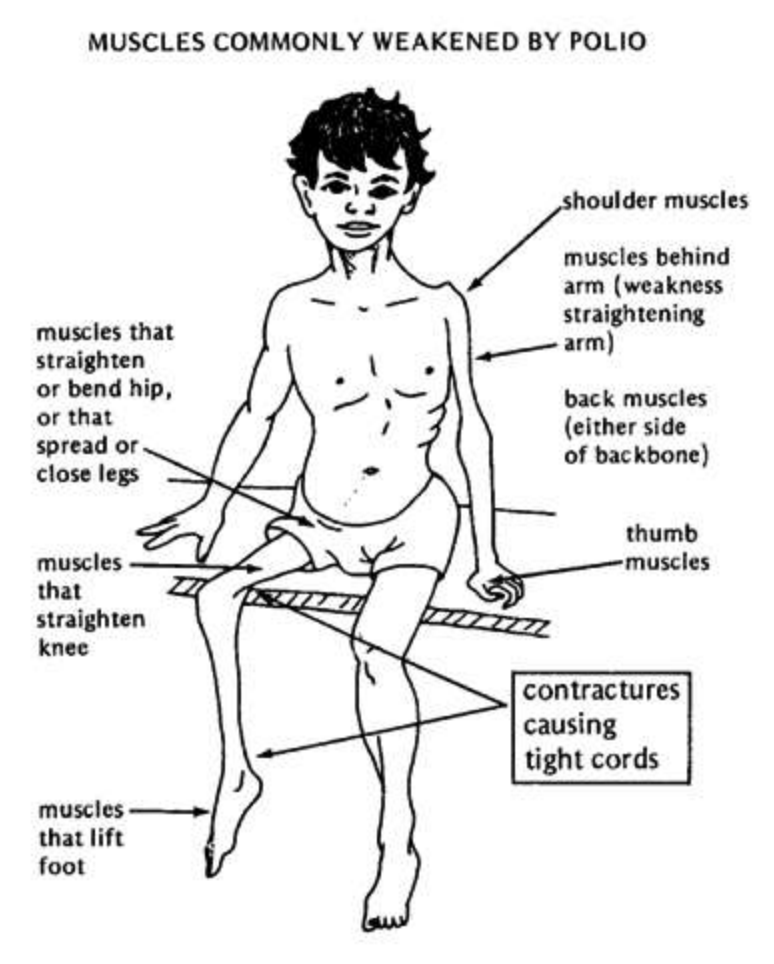
Pathology Connection: Polio

- Paralysis caused by poliomyelitis virus
- Epidemiology: common prior to large-scale vaccinations in the 1950s; now rare
  - S/S
    - 99% of patients have mild upper resp. or digestive illness for a few days
    - 1% of patients develop paralytic form; virus kills motor neurons in ventral horn of spinal cord; cell death = paralysis; sensory neurons unaffected = sensation remains

Polio (cont.)

- RX
  - No cure; if pt. survives, needs extensive rehab. (PT)
  - 25% of patients with paralytic polio suffer permanent disability

Polio


MUSCLES COMMONLY WEAKENED BY POLIO
shoulder muscles
muscles behind arm (weakness straightening arm)
back muscles (either side of backbone)
thumb muscles
muscles that straighten or bend hip, or that spread or close legs
muscles that straighten knee
contractures causing tight cords
muscles that lift foot

Polio


All Local Teams
Journal American
SALK'S VACCINE WORKS!
Official Count
All Local Teams Are Raised Out

Post-Polio Syndrome

- Post-polio syndrome (PPS): progressive weakness that appears several decades after polio infection
  - Affects 25-40% of patients with paralytic polio
  - Cause may be related to damage left by polio virus
    - Areas of spinal cord damaged by original infection, neurons are destroyed
    - Patients recover function by using few surviving motor neurons to power all muscles
    - Surviving neurons are overworked and begin to die themselves

Post-Polio Syndrome (cont.)

- DX: rule out other causes of progressive muscle weakness in polio survivors
- RX:
  - Unable to stop progression
  - Exercise can improve muscle function in some patients

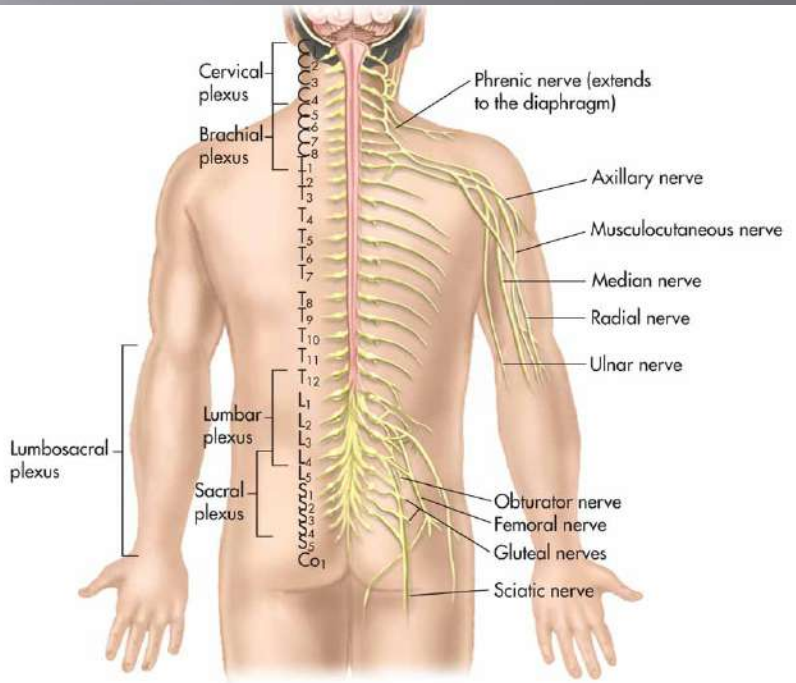
Spinal Nerves

- Part of PNS
- Consist of bundles of axon, blood vessels, and connective tissue
- Run between CNS and organs or tissues, carrying information into and out of CNS
- Connected to spinal cord; named for spinal cord segment where they are attached
- Carry both sensory and motor info

Spinal Nerves (cont.)

- Nerves from thoracic spinal column project to thoracic body wall without branching
- All other nerves branch extensively; are called plexuses

Spinal Cord Plexuses



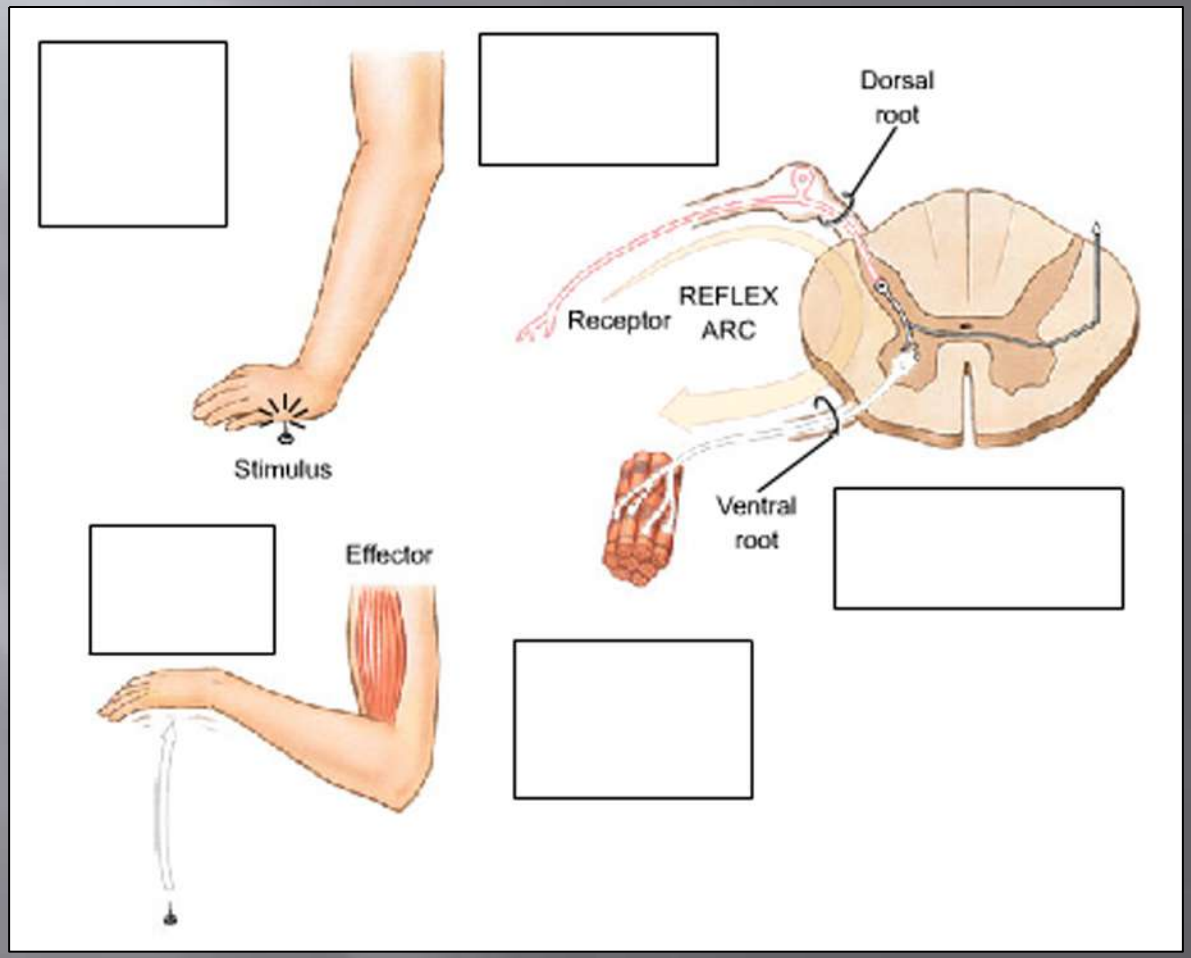
SPINAL NERVE PLEXUSES

PLEXUS	LOCATION	SPINAL NERVES INVOLVED	REGION SUPPLIED	MAJOR NERVES LEAVING PLEXUS
Cervical	Deep in the neck, under the sternocleidomastoid muscle	C_1-C_4	Skin and muscles of neck and shoulder; diaphragm	Phrenic (Diaphragm)
Brachial	Deep to the clavicle, between the neck and the axilla	C_5-C_8, T_1	Skin and muscles of upper extremity	Musculocutaneous Ulnar Median Radial Axillary
Lumbosacral	Lumbar region of the back	T_{12}, L_1-L_5, S_1-S_4	Skin and muscles of lower abdominal wall, lower extremity, buttocks, external genitalia	Obturator Femoral Sciatic Pudendal

Reflexes

- Simplest form of motor output you can make
- Protective, keeping you from harm
- Involuntary
- Can occur without brain being involved, involving only spinal cord

Reflex Animation



Pathology Connection: Peripheral Neuropathy

- Caused by damage to peripheral nerves
- S/S
  - Because peripheral nerves are involved in sensory, motor, and autonomic functions, s/s can vary
  - Muscle weakness, decreased reflexes, numbness, tingling, paralysis, pain, difficulty controlling blood pressure, abnormal sweating, digestive abnormalities
- Causes
  - Trauma

Peripheral Neuropathy (cont.)

- Systemic disease
  - Diabetes (most common systemic cause of peripheral neuropathy)
  - Kidney disorders
  - Hormonal imbalance
  - Alcoholism
  - Vascular damage
  - Repetitive stress
  - Chronic inflammation
  - Toxins
  - Tumors

Peripheral Neuropathy (cont.)

- Infection & autoimmune causes
  - Shingles
  - Epstein-Barr virus
  - Herpes
  - HIV
  - Lyme disease
  - Polio
- Genetic: Charcot Marie Tooth

Peripheral Neuropathy (cont.)

- DX: hx of s/s
  - Diagnostic tests: CT, MRI, electromyogram (EMG)
- RX: underlying cause is treated; symptoms are managed with meds and therapy

Spinal Cord Injury

- Causes
  - Car accidents
  - Violence
  - Falls
  - Work injuries
  - Disease
- Epidemiology
  - 50% of spinal cord injuries occur in people between ages 16 and 30
  - Most injuries are in males
  - 10,000 spinal cord injuries occur in U.S. per year

Spinal Cord Injury (cont.)

- Types of injury
  - Severing of spinal cord (partial or complete)
  - Crushing
  - Bruising
- Expected outcome
  - Bruises may resolve with time and rehab
  - Severed or crushed spinal cord usually results in permanent injury

Spinal Cord Injury (cont.)

- Mechanism of tissue injury
  - Initial injury traumatizes spinal cord
  - Body's response to injury causes further tissue damage
    - Spinal cord swells, decreasing its blood flow
    - Immune system removes and demyelinates some of surviving tissue
    - Excess neurotransmitter release kills cells
    - Damaged neurons self-destruct

Spinal Cord Injury (cont.)

- S/S
  - Paralysis and sensory loss below injury
  - Extent of body affected depends on location of injury
    - Cervical: pts become quadriplegic (paralyzed in all four limbs); some can have paralysis of diaphragm, and require assistance to breathe (ventilator)
    - Thoracic and lumbar injuries: pts become paraplegic (paralyzed in legs); if paralysis of abd. muscles may have difficulty coughing or taking deep breaths

Spinal Cord Injury (cont.)

- DX
  - Neurological exam testing sensory and motor function
  - Imaging studies
    - MRI
    - X-ray
    - CT scan
    - Myelography (X-ray of spinal cord using dye)

Spinal Cord Injury (cont.)

- RX
  - Acute stage: prevent further damage
    - Immobilization
    - Respiration is aided
    - Low blood pressure or cardiac problems are treated
    - Steroids to reduce damage caused by inflammation
  - Stabilize injury using surgical techniques

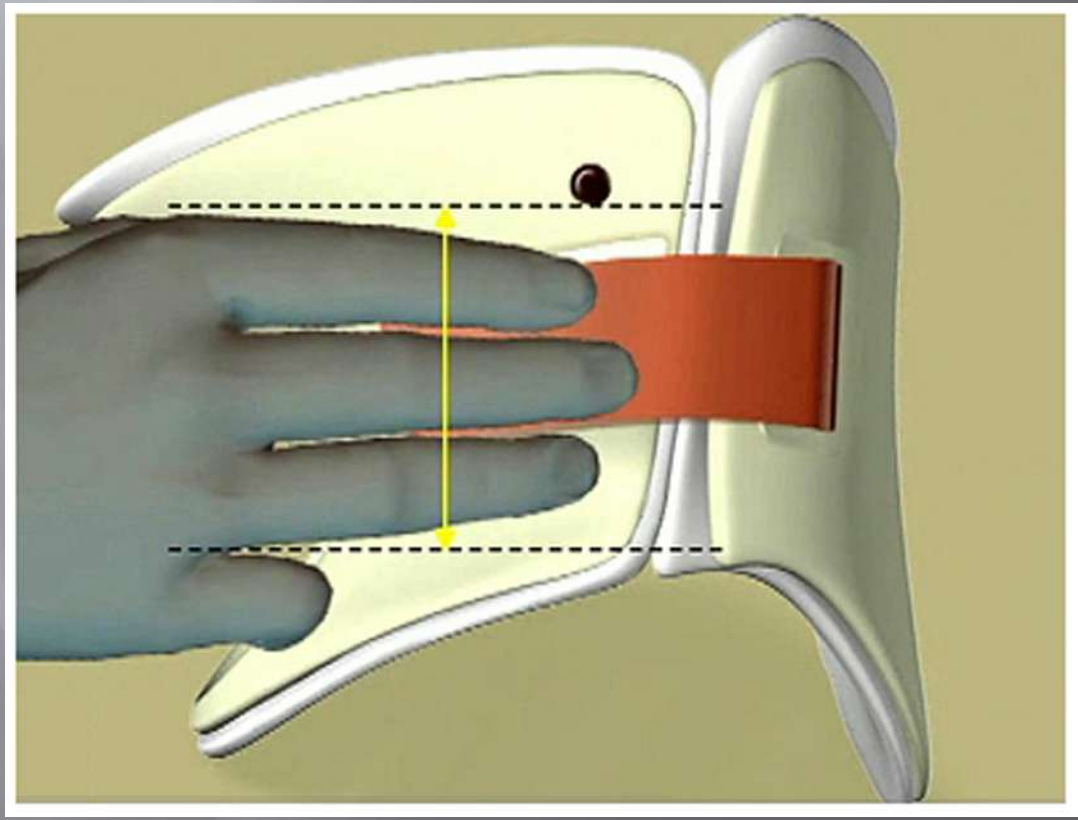
Spinal Cord Injury (cont.)

- After acute stage: treat or prevent long term problems such as:
  - Respiratory difficulties
  - Blood pressure abnormalities
  - Pneumonia
  - Blood clots
  - Organ dysfunction
  - Pressure sores
  - Pain
  - Bladder and bowel dysfunction

Spinal Cord Injury (cont.)

- Rehab
  - Extensive rehab can help spinal cord injury patients recover some function
  - Other aspects of rehab include learning to cope with the injury

Spinal Injury Video



Brain

- Main processor and director of nervous system
- At top of spinal cord, beginning at level of foramen magnum and filling skull
- Divided into several anatomical and functional sections
- Brain consists of:
  - Cerebrum
  - Cerebellum
  - Brain stem

Cerebrum

- Largest part of brain
  - Divided into right and left hemispheres by longitudinal fissure and divided from cerebellum by transverse fissure
  - Surface not smooth; broken by ridges (gyri) and grooves (sulci) collectively known as convolutions
  - Convolutions increase surface area of brain, so you can pack more brain in smaller space

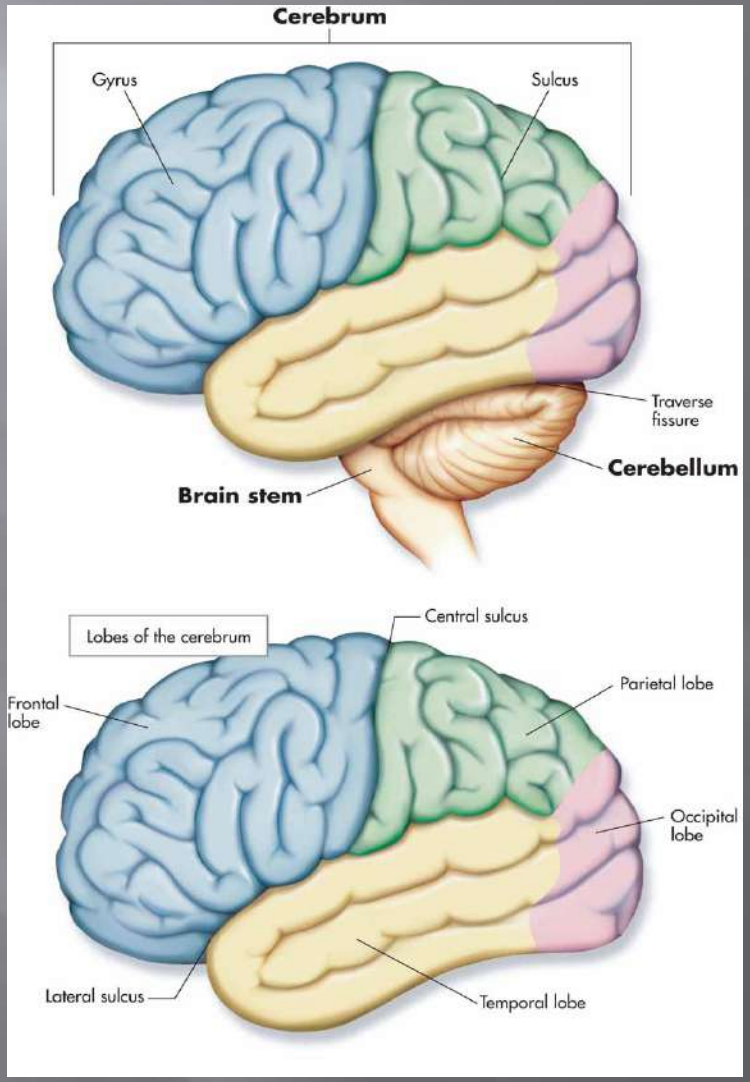
Cerebrum: Lobes

- Lobes named for skull bones that cover them, occur in pairs (one in each hemisphere)
  - Anterior lobes, separated from the rest of brain by central sulci = frontal lobes; responsible for motor activities, conscious thought, and speech
  - Posterior to frontal lobes = parietal lobes; involved with body sense perception, primary taste, and speech
  - Posterior to parietal lobes = occipital lobes, responsible for vision

Lobes (cont.)

- Most inferior lobes, separated by lateral sulci = temporal lobes; involved in hearing and integration of emotions
- Information coming into brain is contralateral = the right side of body is controlled by left side of cerebral cortex and left side of body is controlled by right side of cerebral cortex

The Brain


Cerebrum
Gyrus
Sulcus
Traverse fissure
Cerebellum
Brain stem
Lobes of the cerebrum
Central sulcus
Frontal lobe
Parietal lobe
Occipital lobe
Lateral sulcus
Temporal lobe

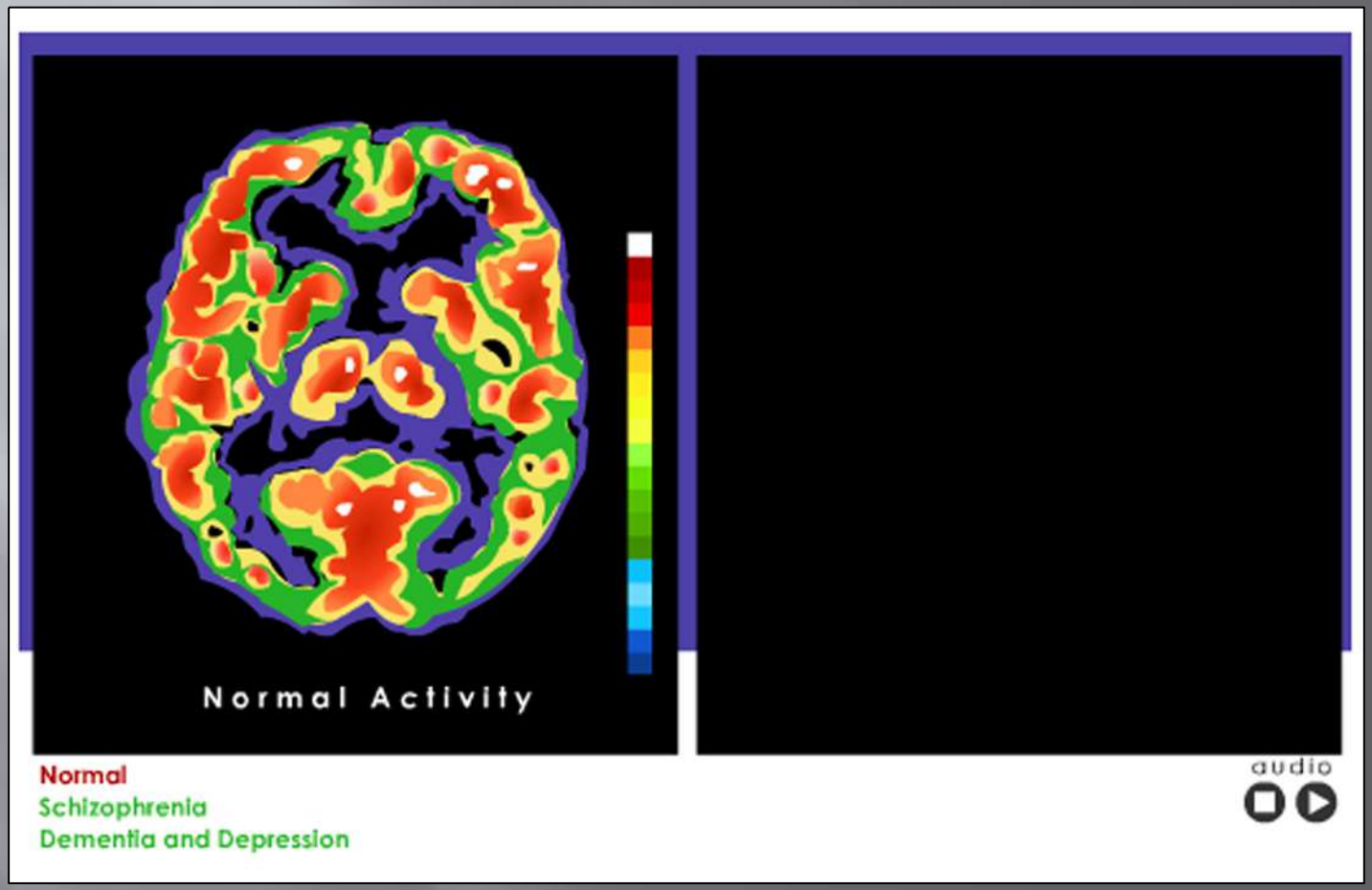
Cerebellum

- Posterior to cerebrum
  - Divided into hemispheres by raised ridge called vermis
  - Surface is convoluted like the cerebrum
  - Involved in sensory collection, motor coordination, and balance

TABLE 9-2 Cerebral Lobes and Cerebellum

STRUCTURE	MAJOR FUNCTIONS
Cerebral Lobes	
Frontal lobe	Motor function, behavior and emotions, memory storage, thinking, smell
Parietal lobe	Body sense, perception, and speech
Occipital lobe	Vision
Temporal lobe	Hearing, taste, language comprehension, integration of emotions
Insula	Autonomic functions
Cerebellum	Sensory and motor coordination and balance

PET Scan Animation



Brain Stem

- Stalk-like structure inferior to, and partially covered by cerebrum
  - Divided into three sections
    - Medulla oblongata: continuous with spinal cord, responsible for heartbeat, respirations, and blood vessel diameter
    - Pons: just superior to medulla oblongata
    - Midbrain: most superior portion of brain stem and is completely covered by cerebrum

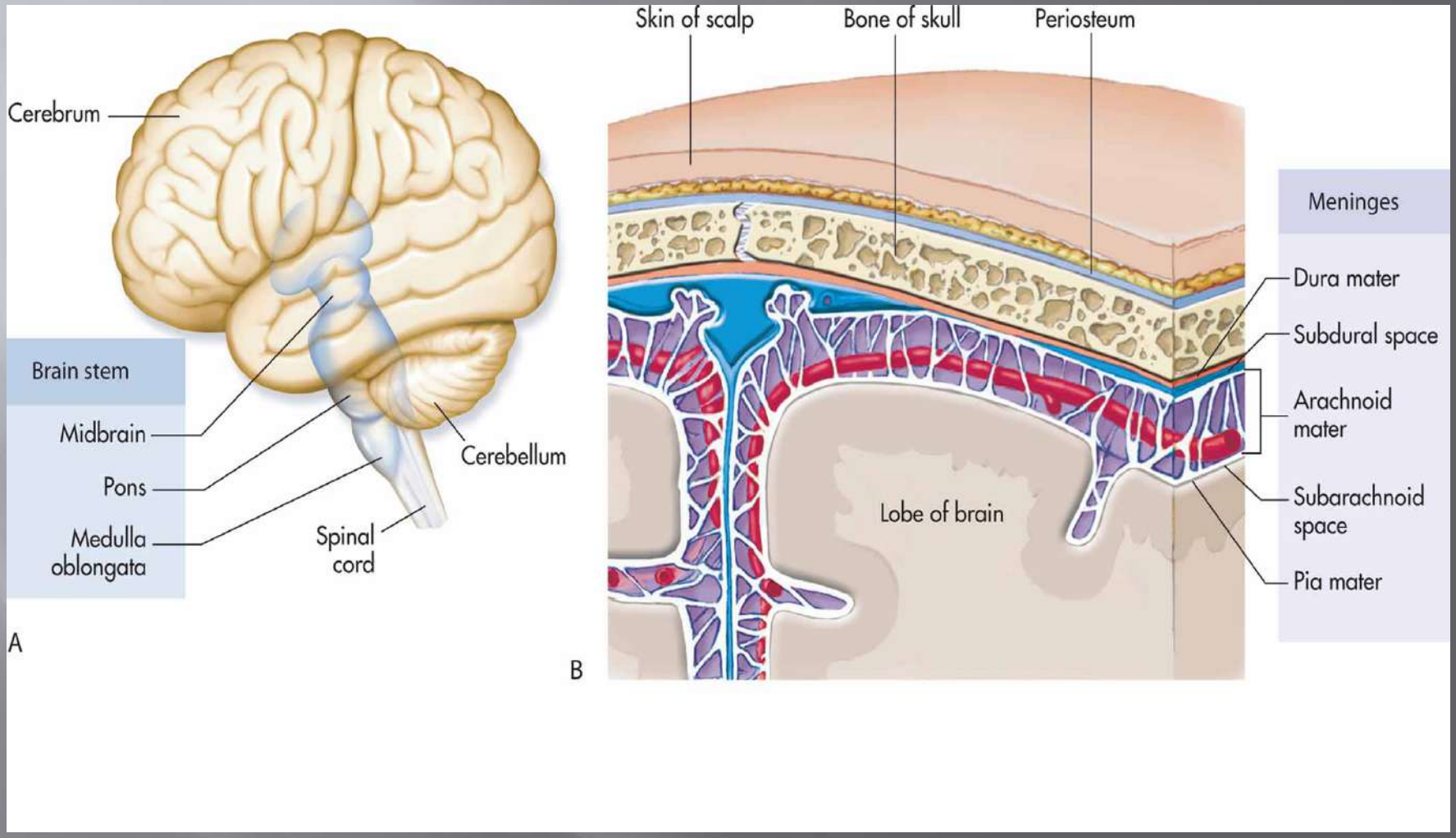
TABLE 9-3 The Brain Stem

STRUCTURE	FUNCTION
Midbrain	Relays sensory and motor information
Pons	Relays sensory and motor information; role in breathing
Medulla oblongata	Regulates vital functions of heart rate, blood pressure, breathing, and reflex center for coughing, sneezing, swallowing and vomiting

Brain Stem (cont.)

- Contains reticular system; responsible for "waking up" cerebral cortex
  - General anesthesia inhibits reticular system, causing unconsciousness
  - Injury to reticular system can lead to coma

Brain Stem and Meninges



Brain and Meninges

- Covered with protective membranes = *meninges*
- Meninges continuous with spinal cord meninges
- Meningitis is infection of meninges; possibly fatal condition; can rapidly spread; affects brain and spinal cord

Pathology Connection: Brain Injury

- Traumatic Brain Injury (TBI)
  - Occurs when force is applied to skull, causing damage to brain tissue
  - Common causes
    - Vehicle accidents (most common cause)
    - Falls
    - Violence
    - Sports injuries
  - Other causes: lack of oxygen to brain, strokes, or hemorrhage

Pathology Connection: Brain Injury (cont.)

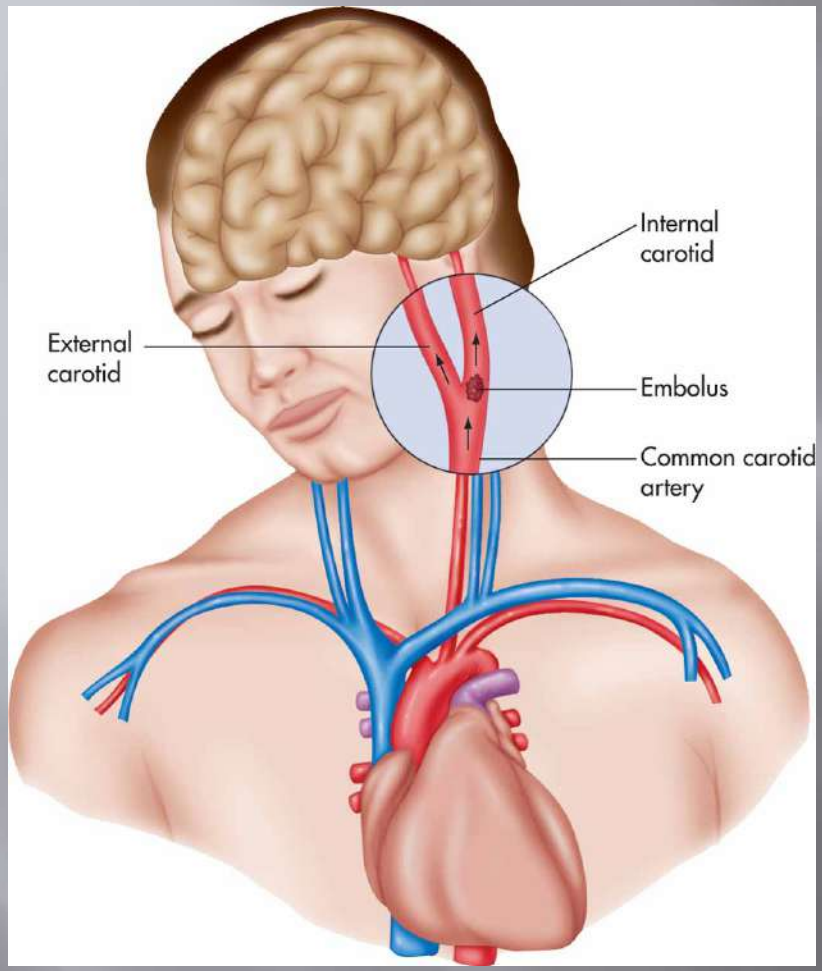
- Epidemiology
  - 100 cases per 100,000 people in U.S. each year
  - 50% of TBIs involve alcohol
  - Riskiest ages for TBI are under 5, 15-24 (males), over 75
  - Types of TBI
    - Closed: skull is not open
    - Penetrating: skull is punctured by an object

Brain Injury: Stroke

- Stroke (CVA)
  - Etiology: disruption of blood flow to portion of brain; if oxygen disrupted for long enough, brain tissue will die
  - S/S: occur suddenly and vary depending on location involved; can include sensory, language, motor, and memory difficulties; can be permanent; unilateral weakness or paralysis, aphasia, slurred speech, confusion, numbness
  - DX: S/S, CT, MRI
  - RX: possible surgery, blood thinners (if clot based), PT, OT, ST

Brain Injury: TIA

- Transient Ischemic Attack (TIA)
  - Known as "mini-stroke"
  - Pts have stroke-like symptoms that are temporary
  - Can be precursor to major stroke



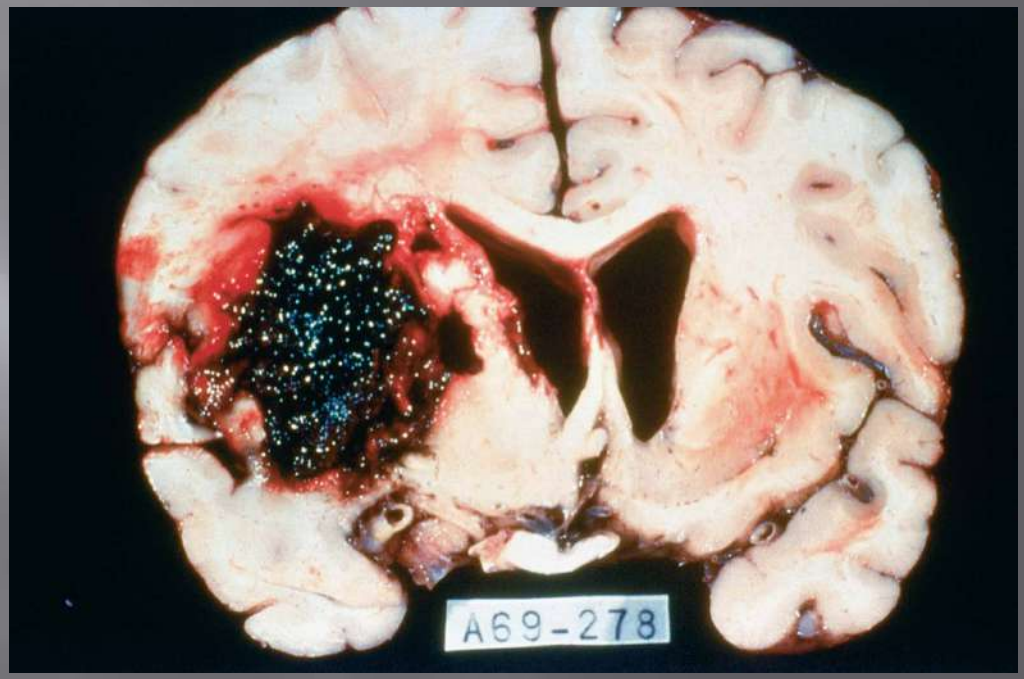


Figure 9-13 (A) Embolus traveling to the brain and (B) cross-section of brain showing cerebrovascular accident (CVA).

Brain Injury: Hematoma

- Etiology
  - Pool of blood between any of layers of meninges and skull
  - Common locations: epidural (between dura mater and skull), subdural (between dura mater and arachnoid mater) and subarachnoid (in subarachnoid space)
  - Blow to head can rupture blood vessels in skull, causing them to bleed into space
  - Stroke or ruptured aneurysm (weak spot in blood vessel inside skull) can cause hematoma

Hematoma (cont.)

- DX
  - Glascow Coma Scale: scale from 3-15 based on patient's ability to open their eyes on command, respond verbally to questions, move limbs when requested; lower number indicates more severe injury
  - CT, MRI and PET scanning: used to pinpoint location and severity of injury and to monitor its progression

Hematoma (cont.)

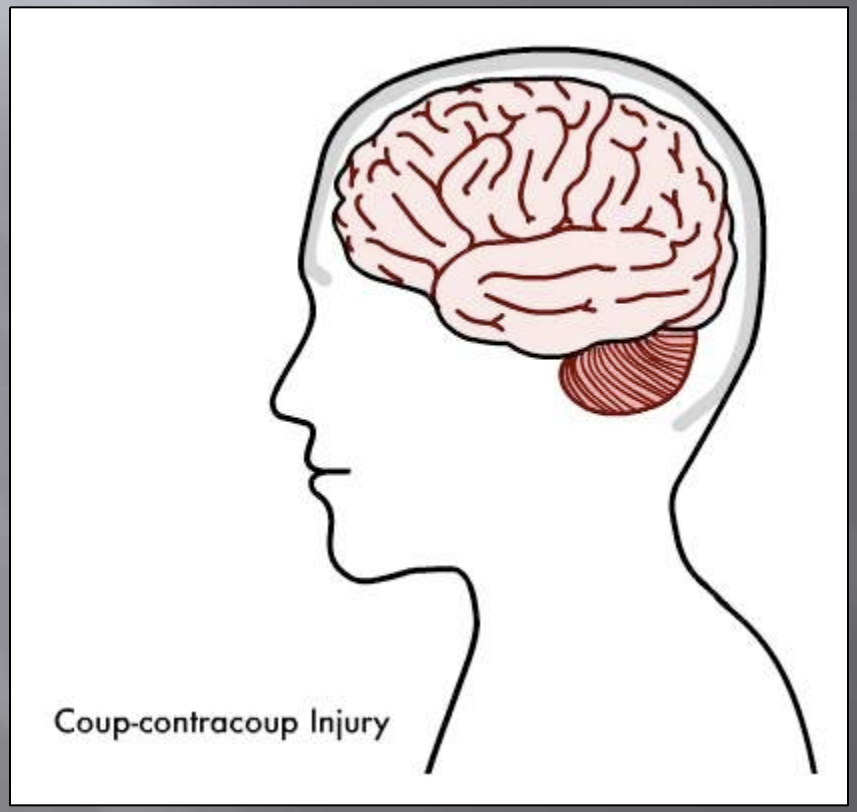
- RX:
- Decrease swelling to prevent further damage
- Acute care
  - Immobilization of head
  - Stabilization of cardiovascular and respiratory functions
  - Monitor intracranial pressure
  - Meds to decrease intracranial pressure
  - Surgery to remove clots, blood or foreign objects (for example, bullet or bone fragments) from brain

Post-Concussion Syndrome

- Occurs several days or weeks after injury in 40% of pts.
- S/S: dizziness, headache, memory and concentration problems, irritability, disordered sleep, and anxiety and depression; S/S usually temporary

Glasgow Coma Scale Video

Contracoup Injury Animation



Internal Anatomy of the Brain

- Inside of brain has white and gray matter, and hollow cavities containing CSF (cerebral spinal fluid)
- White matter surrounded by gray matter
- Layer of gray matter surrounding white matter = cortex
  - In cerebrum = cerebral cortex
  - In cerebellum = cerebellar cortex

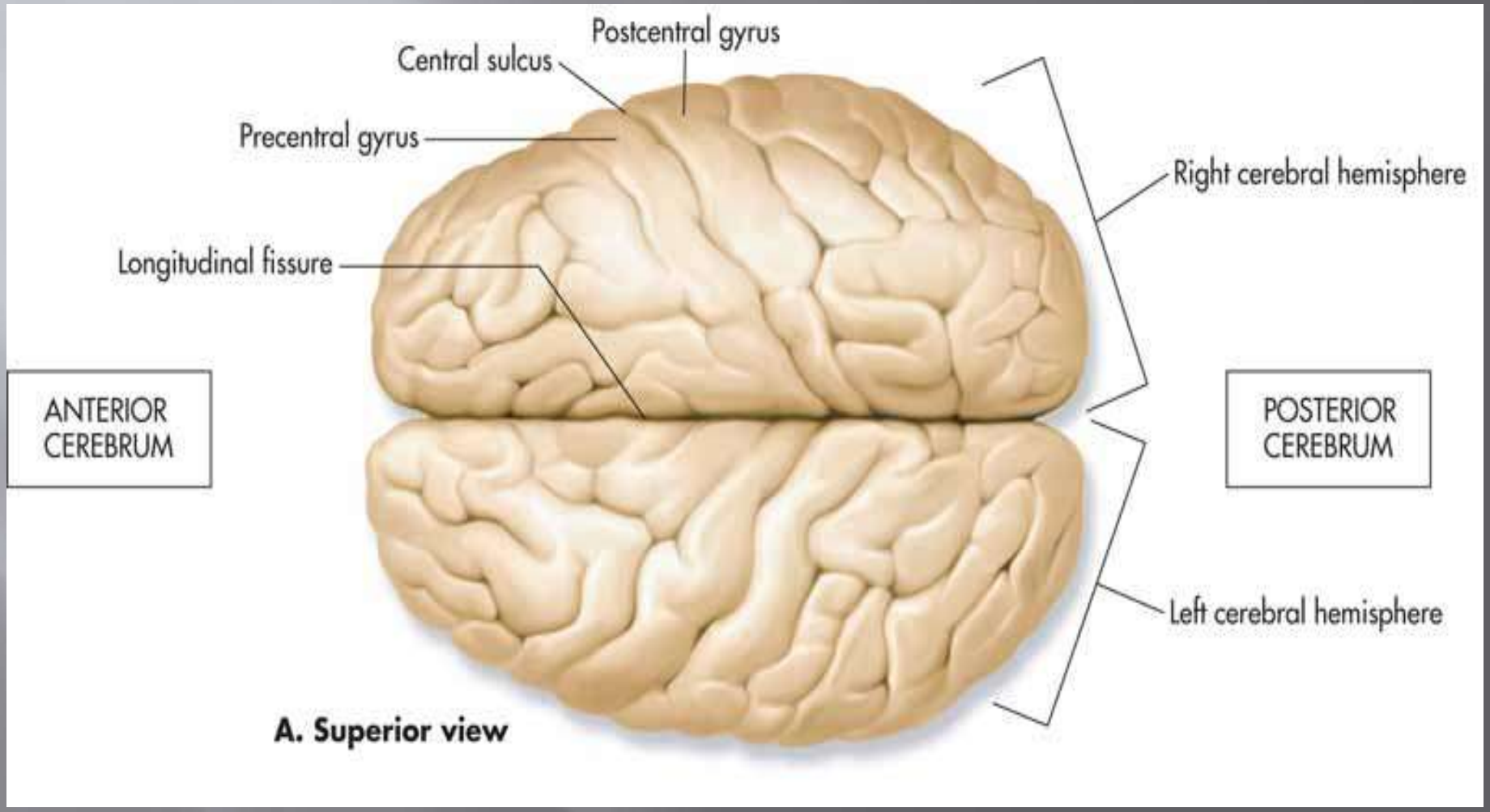
Internal Anatomy of the Brain (cont.)

- There are "islands" of grey matter deep inside brain called nuclei
- Examples of nuclei
  - Basal nuclei: motor coordination system
  - Limbic system: controls emotion, mood, and memory

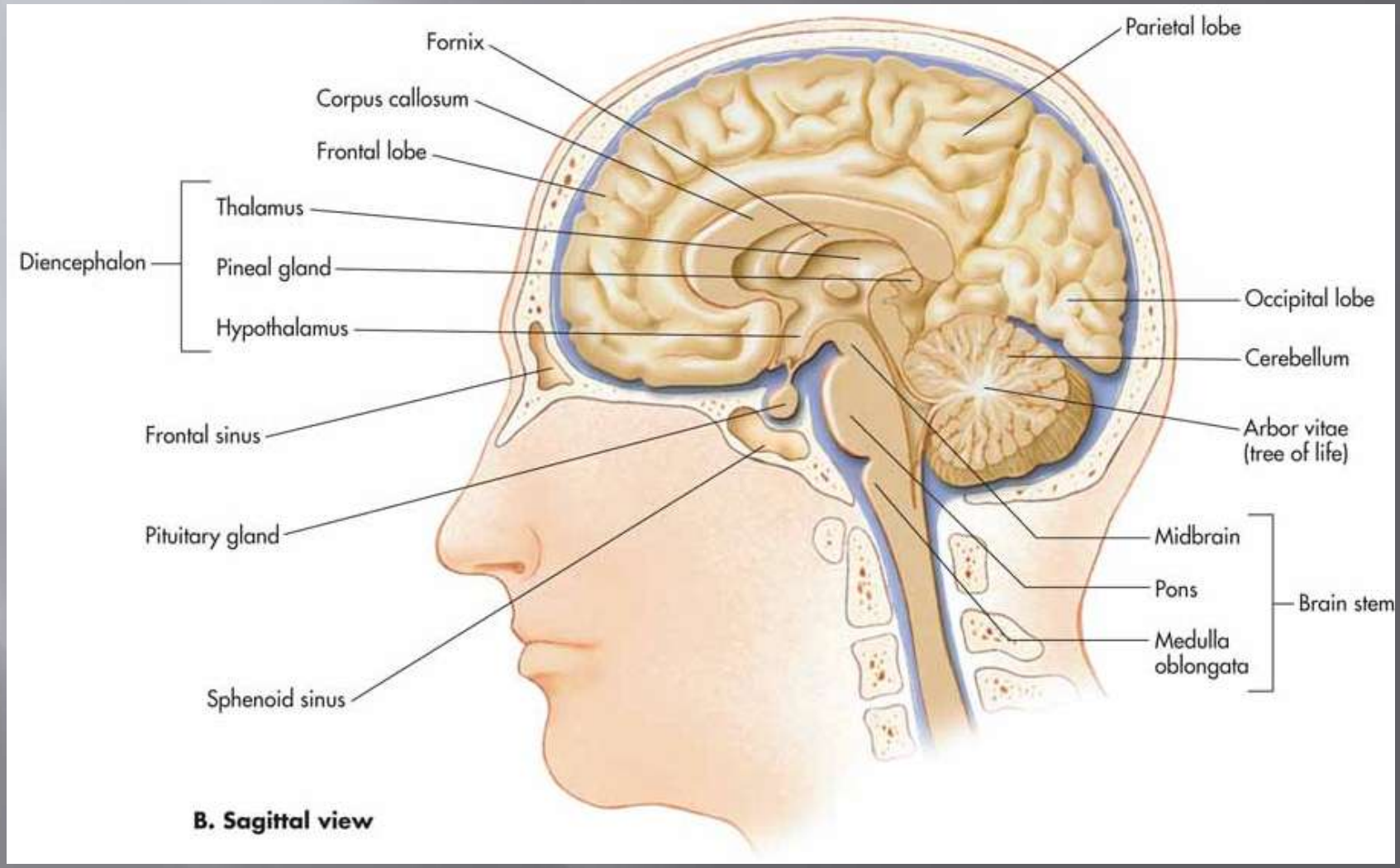
Internal Anatomy of the Brain (cont.)

- Inside of cerebrum reflects external lobes (frontal, parietal, temporal, and occipital) = clearly visible
- On either side of central sulcus are two gyri
  - Precentral gyrus anterior to central sulcus
  - Postcentral gyrus posterior to central sulcus

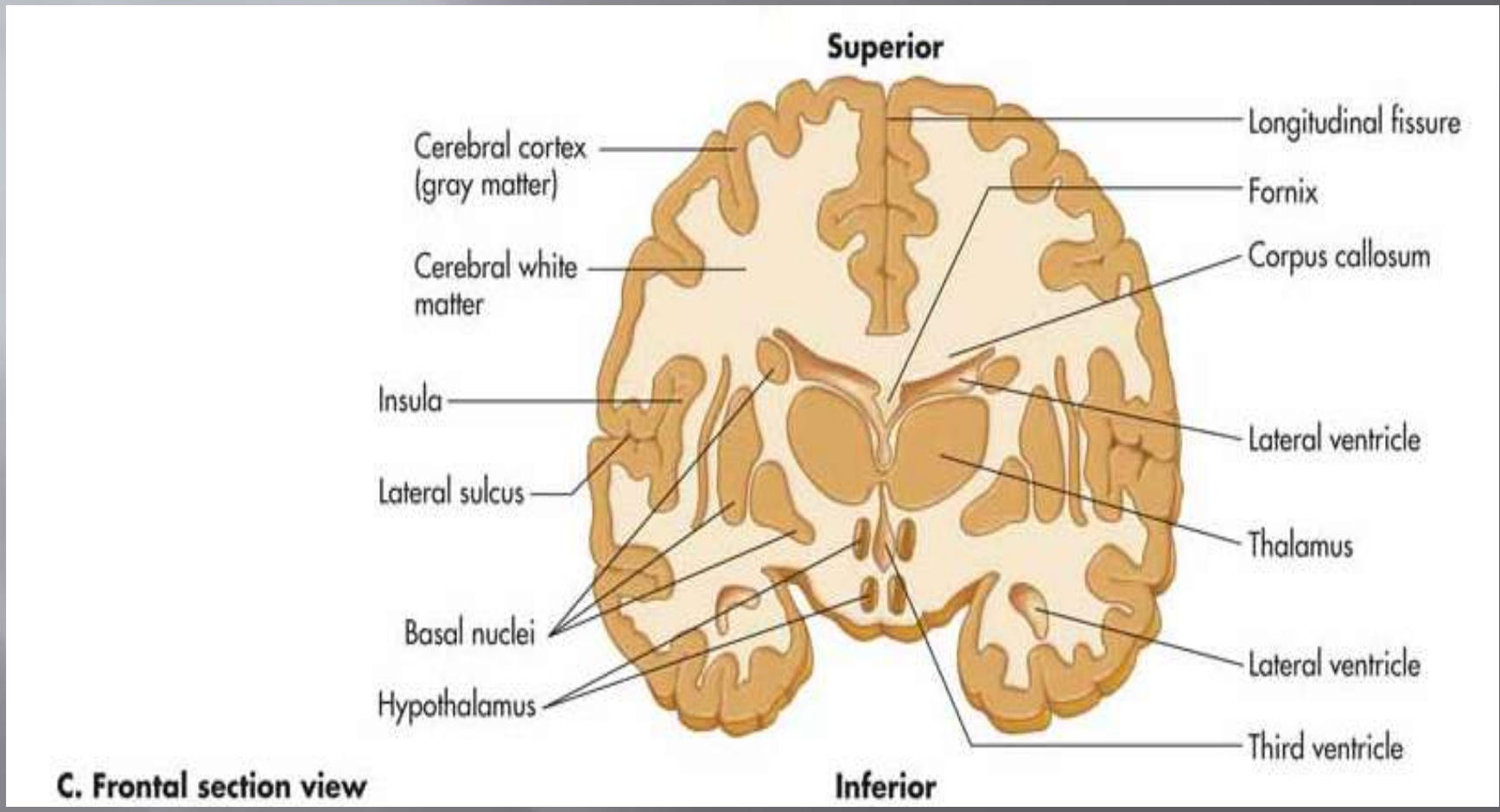
Superior View of Brain



Sagittal View of Brain



Superior and Sagittal View of Brain



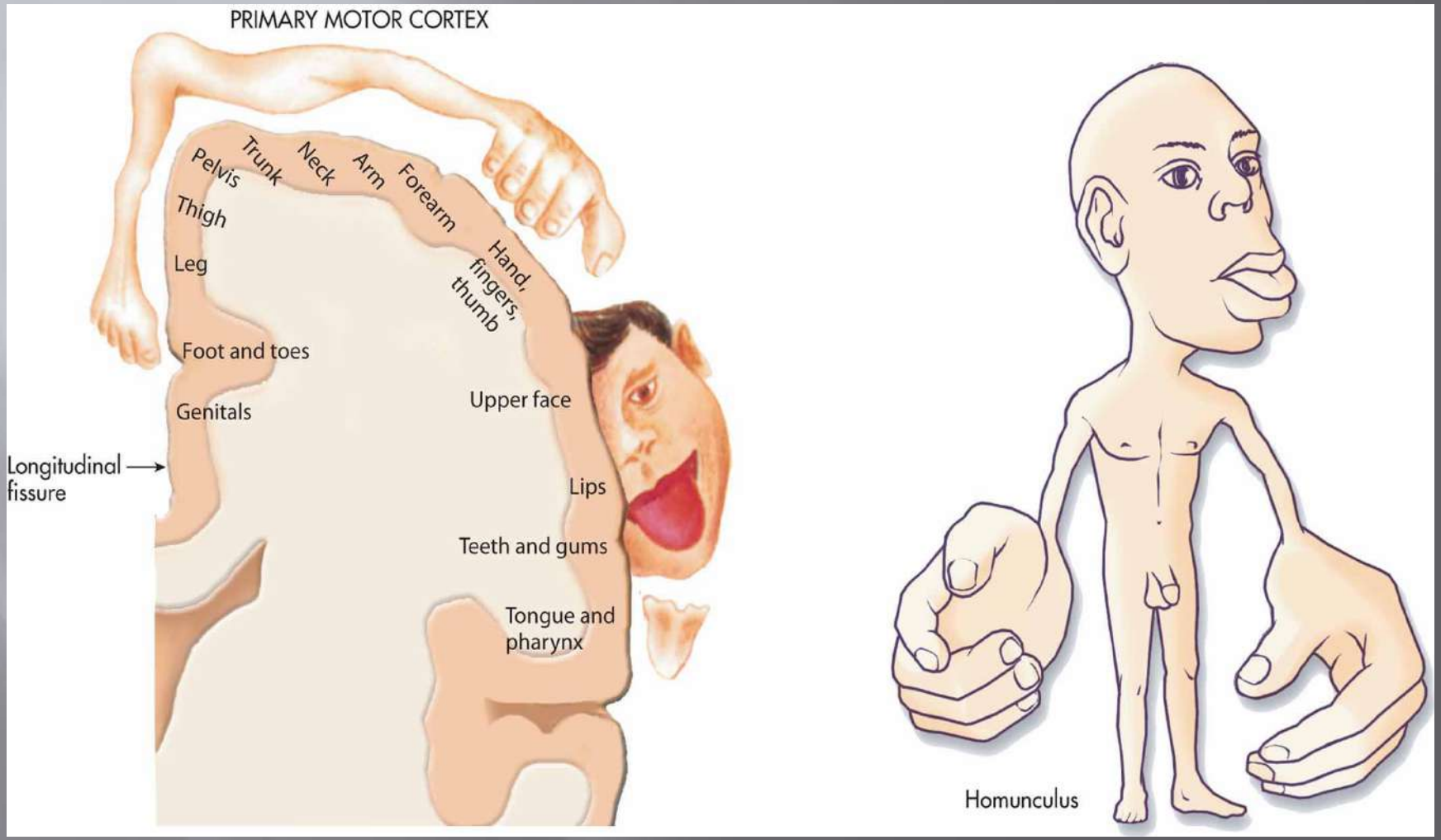
Internal Anatomy of the Brain (cont.)

- Precentral gyrus
  - Location: frontal lobe
  - Function: contains primary motor cortex (region that controls body movements)
    - Each portion controls specific area of body
    - This creates "map" of body on brain called motor "homunculus" (little man)
    - Body parts that perform more finely coordinated movements (like hands and lips) require larger area on "map"

Internal Anatomy of the Brain (cont.)

- Other frontal lobe structures
  - Premotor area: plans movements before they occur
  - Broca's area: controls movements associated with speech

Primary Motor Cortex and Homunculus



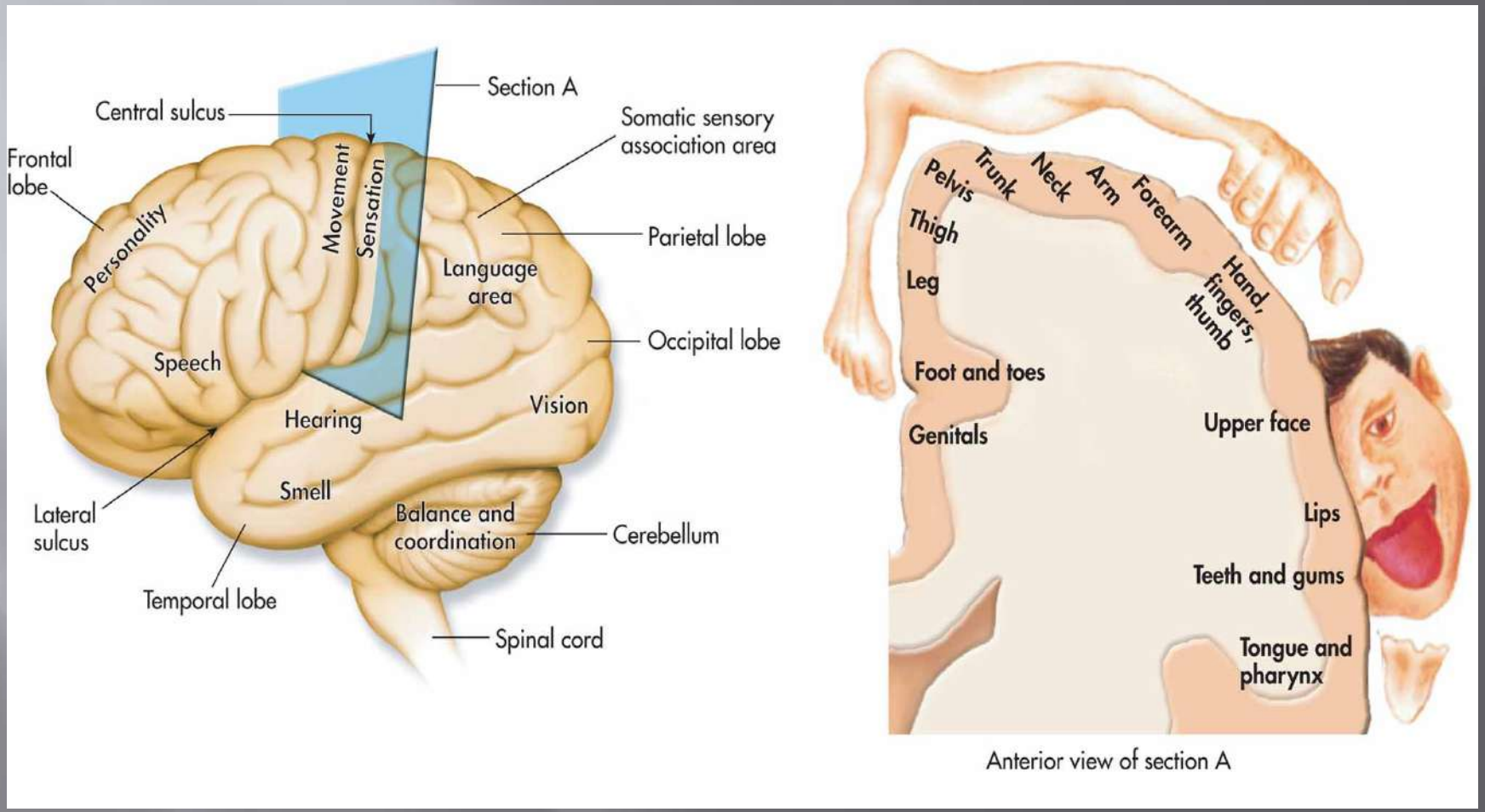
Internal Anatomy of the Brain (cont)

- Postcentral gyrus
  - Location: parietal lobe
  - Function: contains primary somatosensory cortex (center for processing sensory information)
    - Each portion gets sensory input from specific area of body
    - Also creates "map" of body on brain
    - Size of body parts on "map" is proportional to amount of sensory input provided

Internal Anatomy of the Brain (cont.)

- Other areas of parietal lobe
  - Somatic sensory association area: allows understanding and interpretation of sensory information
  - Wernicke's area: controls understanding of speech

Primary Somatic Sensory Area



Internal Anatomy of the Brain (cont.)

- Corpus callosum
  - Collection of white matter that connects left and right hemispheres
  - Allows for cross-communication between rt. and left sides of brain
  - Many activities, like walking or driving, require both sides of body, and therefore both sides of brain, to be well coordinated

Internal Anatomy of the Brain (cont.)

- Inferior to cerebrum is section of brain not visible from exterior, called diencephalon
  - Consists of thalamus, hypothalamus, pineal body, and pituitary gland
  - Glands that interface with endocrine system

TABLE 9-4 Diencephalon

STRUCTURE	FUNCTION
Thalamus	Relays and processes information going to the cerebrum
Hypothalamus	Regulates hormone levels, temperature, water-balance, thirst, appetite, and some emotions (pleasure and fear); regulates the pituitary gland and controls the endocrine system
Pineal body	Responsible for secretion of melatonin (body clock)
Pituitary gland	Secretes hormones for various functions (explained in Chapter 10)

Cerebellum

- Has gray matter cortex and white matter center
- Fine tunes voluntary skeletal muscle activity and helps in maintenance of balance

Pathology Connection: Alzheimer's Disease

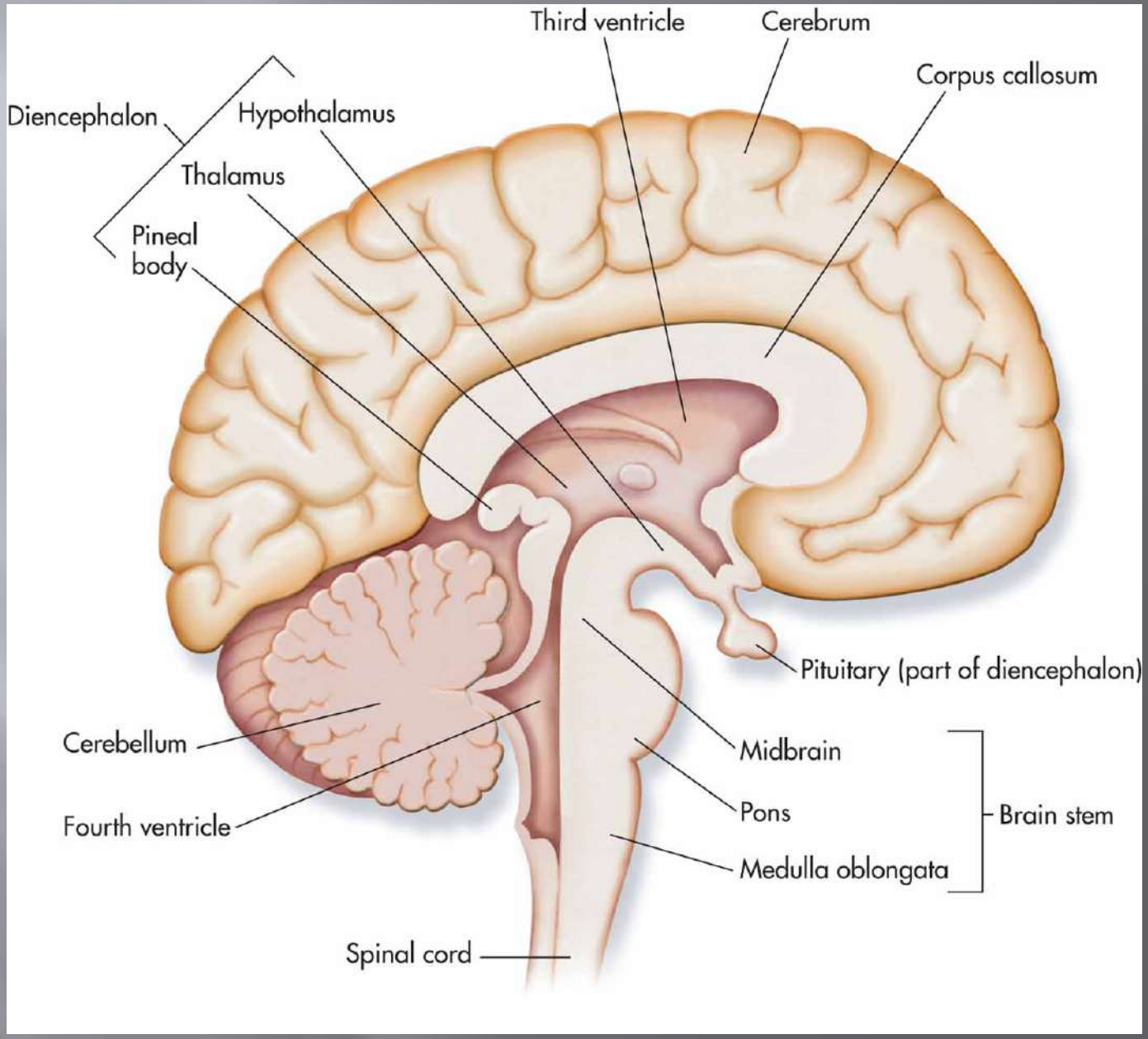
- Progressive degenerative disease, causing memory loss and diminishing cognitive function (dementia)
- Etiology: unknown, age is most important risk factor
- DX: S/S and history, may do CT or MRI

Alzheimer's (cont.)

- S/S: begin gradually with mild forgetfulness; progresses to severe forgetfulness (such as getting lost in familiar location), and difficulty speaking, reading, writing, and maintaining personal hygiene; patient may experience personality changes, anxiety, and aggressiveness
- RX: no cure; some meds may help slow progression of early and middle stages of disease

Cerebrospinal Fluid and Ventricles

- Ventricles
  - Cavities inside brain that are filled with CSF; continuous with central canal of spinal cord, and subarachnoid space
  - Four ventricles:
    - Lateral ventricles (ventricles 1 and 2) in cerebrum
    - Third ventricle is in diencephalon
    - Fourth ventricle is in inferior part of brain between medulla oblongata and cerebellum


Third ventricle
Cerebrum
Corpus callosum
Diencephalon
Hypothalamus
Thalamus
Pineal body
Pituitary (part of diencephalon)
Cerebellum
Midbrain
Pons
Brain stem
Fourth ventricle
Medulla oblongata
Spinal cord

CSF and Ventricles (cont.)

- CSF circulation
  - Filtered from blood in ventricles by tissue called choroid plexus
  - Made in lateral ventricles
  - Flows third and fourth ventricle through tiny opening
  - Flows into central canal of spinal cord and subarachnoid space
  - Returned to blood via ports between subarachnoid space and blood spaces in dura mater

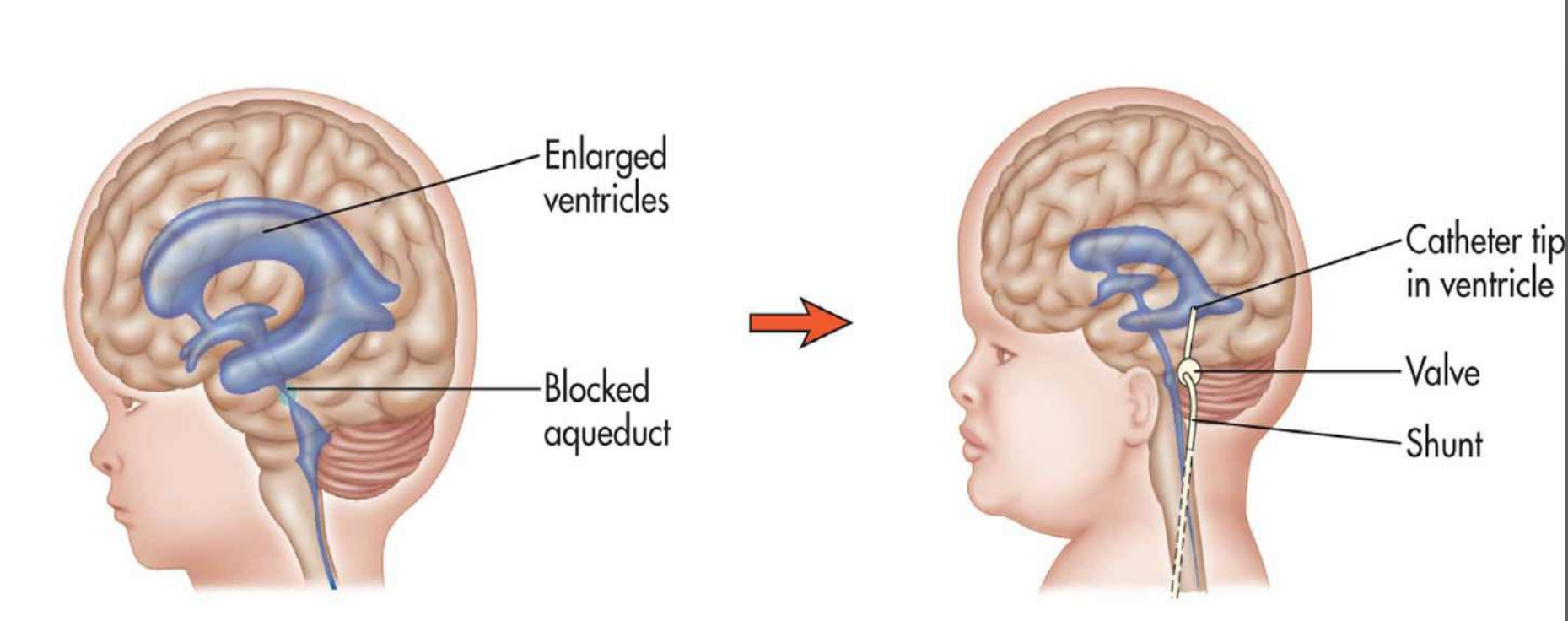
Pathology Connection: Hydrocephalus

- Condition of too much CSF in skull
- Etiology: blockage of narrow passages due to trauma, birth defect, tumor, or decreased reabsorption of CSF
- Can cause increased intracranial pressure
- S/S
  - Expansion of skull (in infants whose skulls have not fully hardened)
  - Nausea/vomiting
  - Irritability
  - Seizures
  - Headache
  - Blurred Vision
  - Sleepiness

Hydrocephalus (cont.)

- S/S
  - Balance and coordination problems
  - Personality changes
  - Dementia
- DX
  - CT or MRI shows enlarged ventricles
  - Monitoring of intracranial pressure
- RX
  - Medications
  - Surgical placement of shunt to drain fluid to heart or abdominal cavity

Hydrocephalus



Cranial Nerves

- Spinal cord has spinal nerves; brain has cranial nerves
- Both are similar in that they are input and output pathways for brain
- 12 pairs of cranial nerves
- some are sensory, some are motor, and some are both

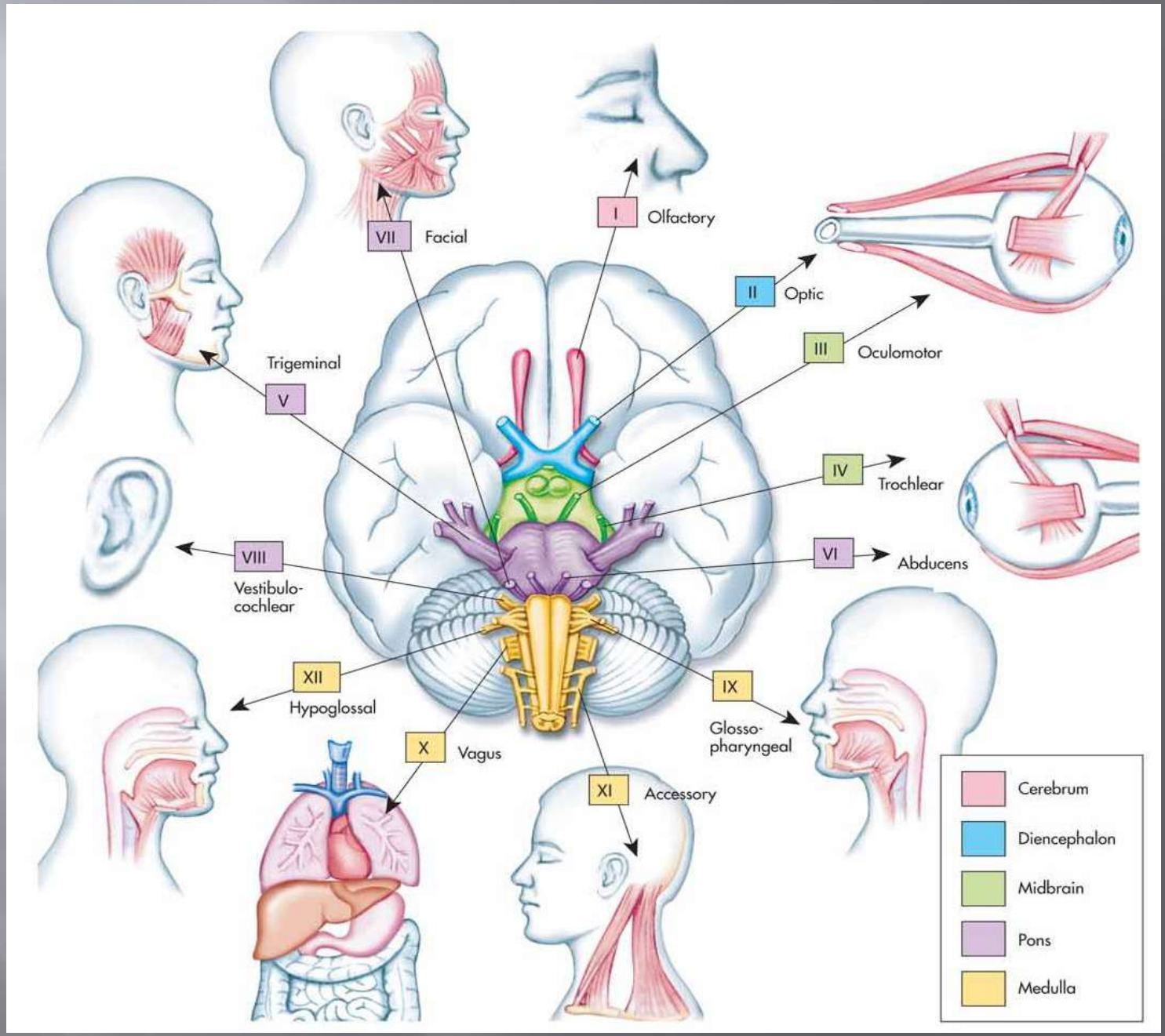
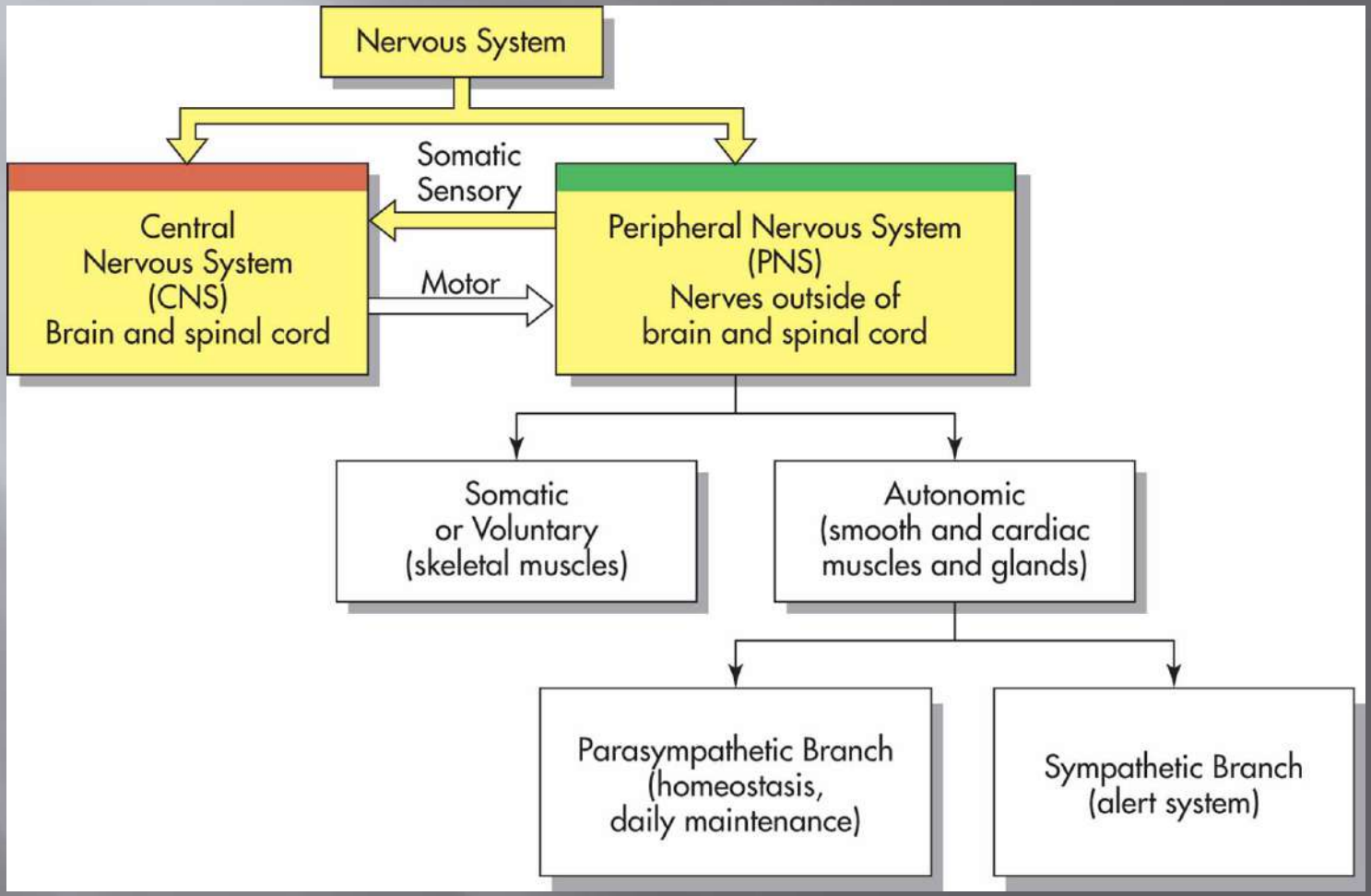

I Olfactory
II Optic
III Oculomotor
IV Trochlear
V Trigeminal
VI Abducens
VII Facial
VIII Vestibulo-cochlear
IX Glosso-pharyngeal
X Vagus
XI Accessory
XII Hypoglossal
Cerebrum
Diencephalon
Midbrain
Pons
Medulla

TABLE 9-5 Cranial Nerves and Functions

NERVE	FUNCTION
Olfactory (I)	Sensory (smell)
Optic (II)	Sensory (vision)
Oculomotor (III)	Mixed, chiefly motor for eye movements
Trochlear (IV)	Mixed, chiefly motor for eye movements
Trigeminal (V)	Mixed, sensory for face, motor for chewing
Abducens (VI)	Mixed, chiefly motor for eye movements
Facial (VII)	Motor for facial expression
Vestibulocochlear (VIII)	Sensory, hearing, and balance
Glossopharyngeal (IX)	Mixed, motor for throat muscles; sensory for taste
Vagus (X)	Mixed, motor for autonomic heart, lungs, viscera; sensory for viscera, taste buds, and so on
Accessory (XI)	Mixed, chiefly motor; motor and sensory for larynx, soft palate, trapezius, and sternocleidomastoid muscles
Hypoglossal (XII)	Chiefly motor for tongue muscles

Nervous System Flowchart



The Somatic Sensory System

- Provides sensory input
- Includes: fine touch, crude touch, vibration, pain, temperature, and body position
- Special senses (sight, hearing) are carried on cranial nerves
- Somatic sensation comes into both brain and spinal cord
- To attach meaning to sensation, it must get to brain for interpretation

Somatic Sensory System (cont.)

- Sensory info coming into brain from skin join to portion of cerebrum known as primary somatic sensory cortex
- Located in postcentral gyrus of parietal lobe
- Info is transported to specific parts of SS cortex that correspond to parts of body

The Motor System

- Somatic motor system controls voluntary movements under orders from cerebral cortex
- In frontal lobe are premotor and prefrontal areas, which plan movements
- Orders are sent to spinal cord and to number of coordination centers, including thalamus, basal nuclei, and cerebellum

Motor System (cont.)

- Thalamus, basal nuclei, and cerebellum are part of complicated motor coordination loop
- Without this loop, movement would be, at best, jerky and inaccurate, and some impossible
- After movement info is processed, it moves to spinal cord and brain stem via corticospinal and corticobulbar tracts

Motor System (cont.)

- Function of spinal cord pathways is to send orders from brain to motor neurons in spinal cord and brainstem
- Motor neurons in spinal cord connect to skeletal muscles, sending orders to skeletal muscles to carry out movement
- Second function of pathways is fine tuning of reflexes

Cerebral Palsy (CP)

- Permanent, non-progressive set of motor deficits dx in infants and young children
- Etiology: thought to be due to damage to motor cortex
- Risk factors: low birth weight, premature birth, multiple births, infection during pregnancy, developmental abnormalities, brain hemorrhage, perinatal brain injury, lack of oxygen, childhood illness

Cerebral Palsy (cont.)

- S/S
  - Increased muscle tone
  - Overactive reflexes
  - Lack of coordination of voluntary movements
  - Foot drag
  - Drooling
  - Speech difficulties
  - Fine motor problems
  - Tremor or other uncontrollable movements
- Many pts. with CP have normal or above normal intelligence

Cerebral Palsy (cont.)

- DX
  - Observing motor skills and developmental milestones
  - Imaging (CT or MRI)
  - R/O other causes of motor deficits
- RX
  - PT and OT
  - Assistive devices
  - Drugs to control symptoms
  - No cure

Parkinson's Disease (PD)

- Etiology: Caused by disappearance of dopamine neurons in one of basal nuclei, which later spreads to cerebral cortex; why they disappear is unknown, though toxins, mitochondrial malfunctions, viruses, and genetics may be cause
- S/S: Chronic progressive motor disorder
- resting tremor
- slow movement
- impaired balance
- rigidity
- emotional and cognitive disturbances

Parkinson's (cont.)

- DX based on history and physical exam
  - Common findings
    - Shuffling gate
    - Cogwheel rigidity (muscles that seem to catch and release when moved)
    - Tremors
  - Imaging is not helpful, since most early-stage cases of PD will have perfectly normal scans

Parkinson's (cont.)

- RX
  - Dopamine-enhancing drugs (like L-dopa)
    - Side effects may include hallucinations and excessive uncontrollable movements
    - L-dopa treated patients may have "on" and "off" periods that are unpredictable

Parkinson's Video

Amyotrophic Lateral Sclerosis (ALS)

- Etiology
- Rapidly progressive, fatal degeneration of motor system
- Motor neurons in cerebral cortex, brainstem, and spinal cord self-destruct
- Also called Lou Gehrig's disease
- Pts. usually die within 5 years of diagnosis; often due to respiratory failure
- Cause is unknown, but toxins, damage from free radicals, and mitochondrial problems may be involved

ALS (cont.)

- S/S: Usually begins between ages 40 and 60; first S/S: muscle weakness, twitching, and cramping; progress to complete paralysis including difficultly speaking and swallowing
- Eventually diaphragm becomes paralyzed; pt. becomes ventilator-dependant; eye movements, bladder, and bowel control usually retained

ALS (cont.)

- DX
  - No definitive test
  - Pts. often have both spastic and flaccid paralysis
  - Imaging, EMG, and blood and urine tests can help rule out other disorders
  - Neural biopsy may also be helpful to check for increase glutamate

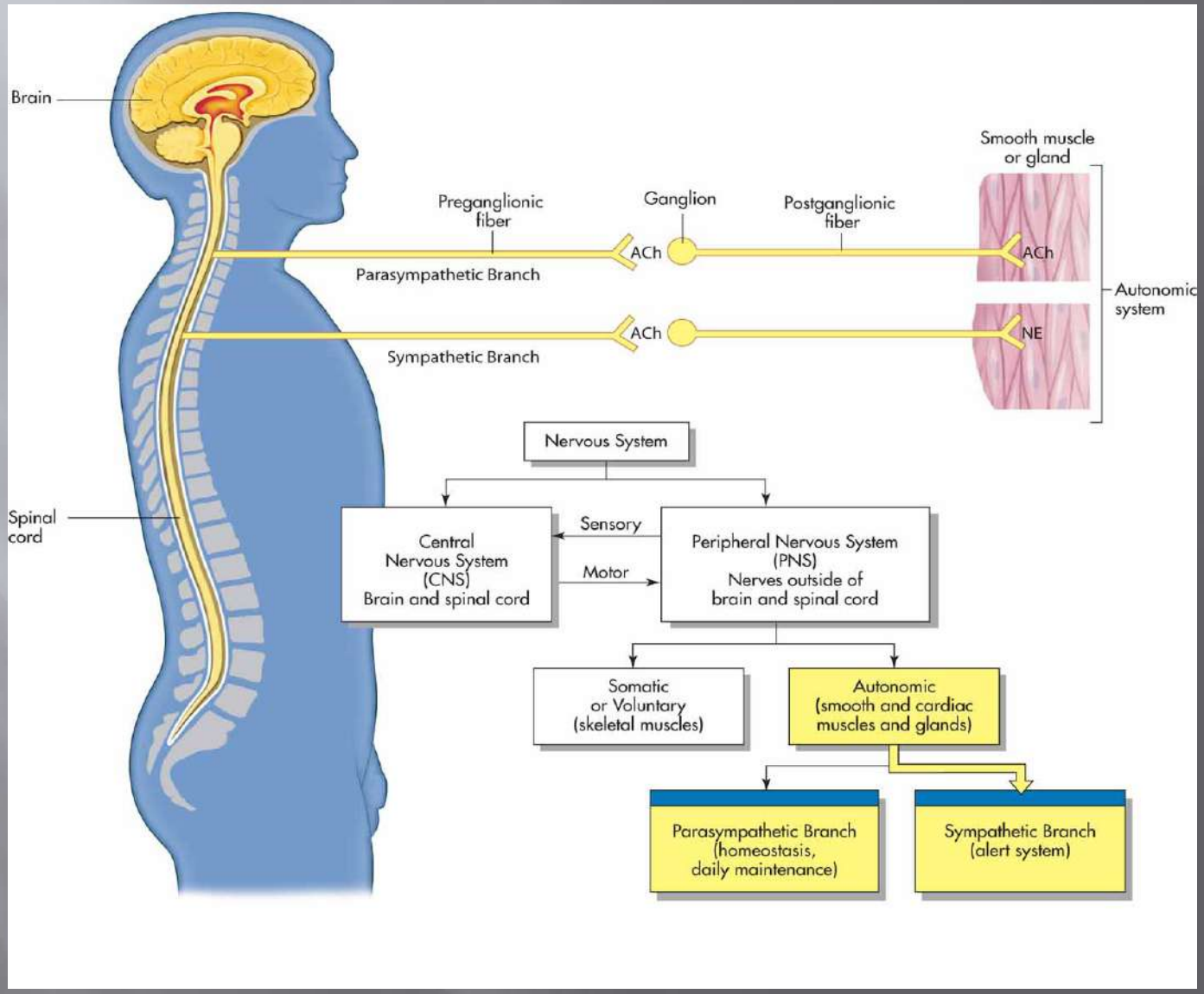
ALS (cont.)

- RX
  - No cure
  - The medication riluzole can be used to slow progression of disease; drug decreases neurotransmitter glutamate, thereby decreasing cell death

Autonomic Nervous System

- Controls blood pressure, heart rate, respiratory rate, digestion, and sweating
- Unlike somatic motor neurons, autonomic neurons do not project directly to muscles
- There are no autonomic neurons in cervical spinal cord
- ANS is divided into two subdivisions:
  - Sympathetic division
  - Parasympathetic division

Autonomic Nervous System



The Sympathetic Branch

- Controls "flight or fight" response
- Effects increase heart rate, BP, and sweating, also causes dry mouth, symptoms of adrenaline rush
- Neurons secrete acetylcholine and norepineprine
- SNS stimulates adrenal glands to release epinephrine that causes adrenaline rush

The Parasympathetic Branch

- Often called "resting and digesting" as it has opposite effect of sympathetic division
- Effects include decreased heart rate, respiration, and BP, and increased digestive activity including salivation and stomach activity

Myasthenia Gravis

- Etiology: autoimmune attack of acetylcholine receptor at neuromuscular junction
- S/S: progressive fluctuating muscle weakness, often starting with facial or eye muscles
- DX: blood tests, EMG
- RX: steroids, immunosuppressant drugs, plasma exchange, acetylchoinesterase inhibitors

Huntington's Disease

- Etiology: genetic; progressive loss of neurons from basal nuclei and cerebral cortex
- S/S: mid-life onset of chorea, mood swings and memory loss, progressing to dementia and paralysis
- DX: family history will show pattern of disease, imaging, genetic testing
- RX: no cure; meds to control emotional and motor symptoms, no drug treatment for dementia

Charcot Marie Tooth Disorder

- Etiology: genetic destruction of PNS myelin and/or axons
- S/S: ascending muscle weakness and atrophy, decreased sensation in affected limbs
- DX: history, EMG, biopsy, genetic testing
- RX: PT, OT, surgery, pain medication, symptom management, no treatment to stop deterioration