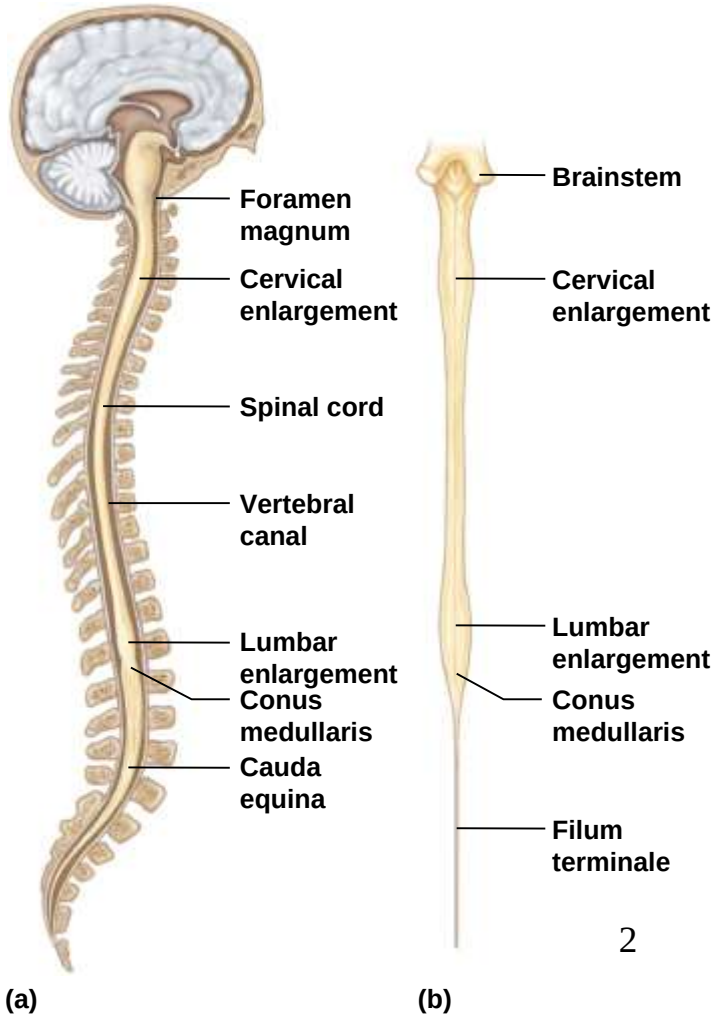
11.1: Introduction

- The central nervous system (CNS) consists of the brain and spinal cord.
- The brainstem connects the brain to the spinal cord.
- Communication to the peripheral nervous system (PNS) is by way of the spinal cord.

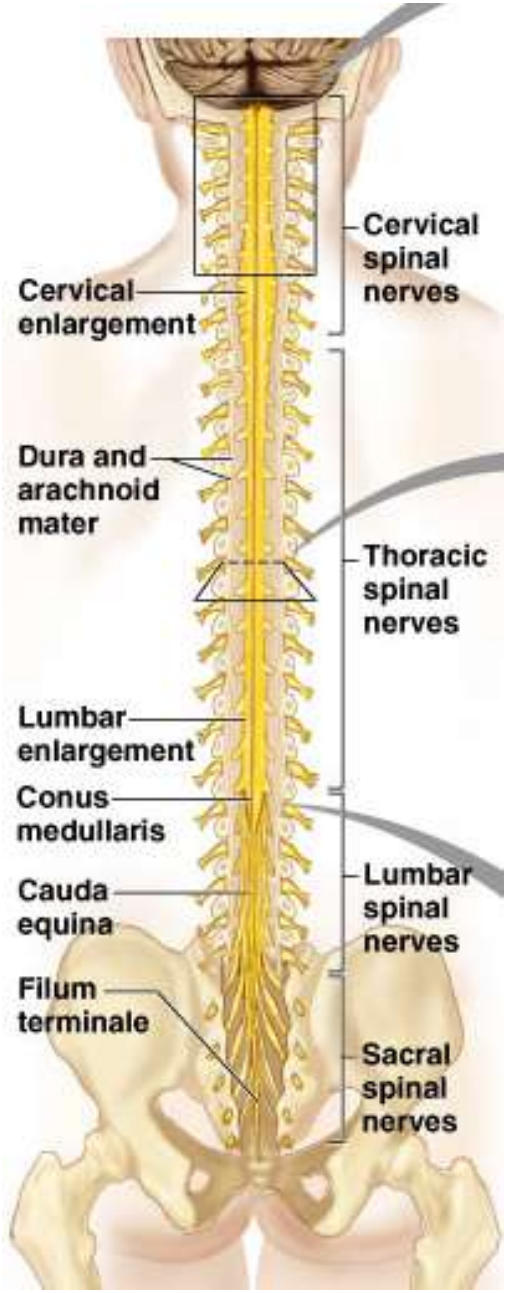
11.4: Spinal Cord

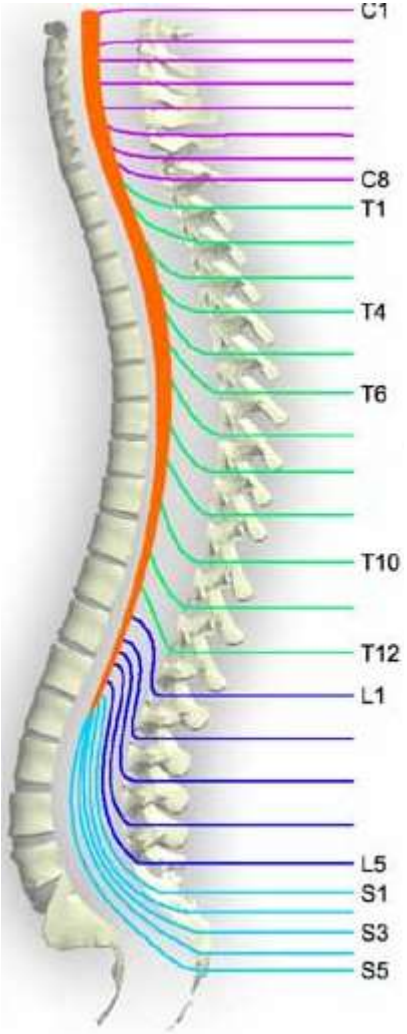
- Slender column of nervous tissue continuous with brain and brainstem
- Extends downward through vertebral canal
- Begins at foramen magnum and ends at L1/L2 interspace
- Conduit for nerve impulses to and from brain and brainstem
- Center for spinal reflexes



Spinal cord

- Fetal 3rd month: ends at coccyx
- Birth: ends at L3
- Adult position at approx L1-2 during childhood
- End: *conus medullaris*
  - This tapers into *filum terminale* of connective tissue, tethered to coccyx
- Spinal cord segments are superior to where their corresponding spinal nerves emerge through intervetebral foramina.
- *Denticulate ligaments*: lateral shelves of pia mater anchoring to dura (meninges: more later)

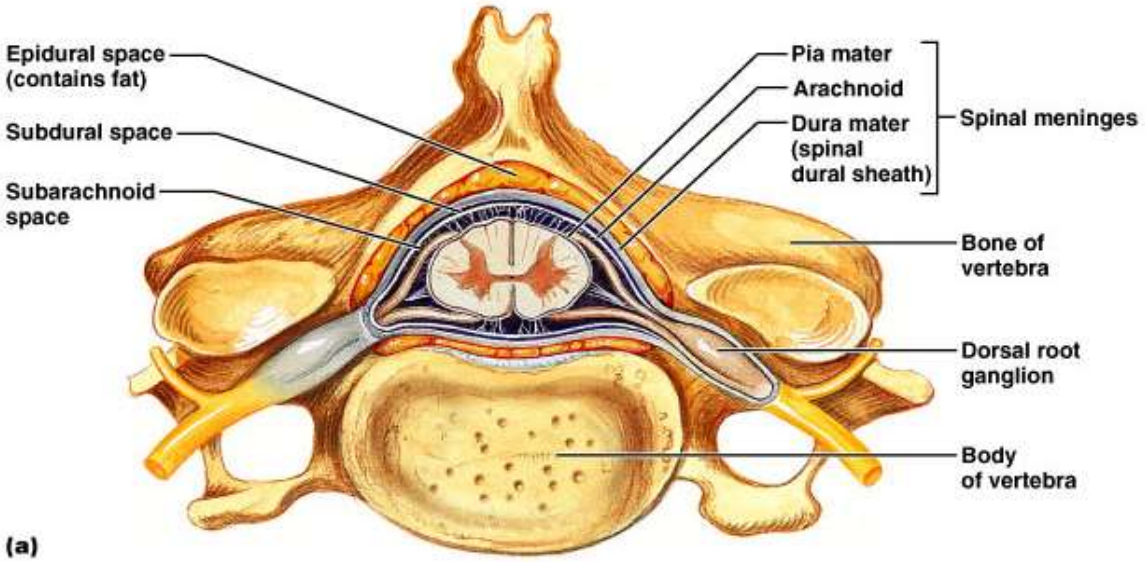


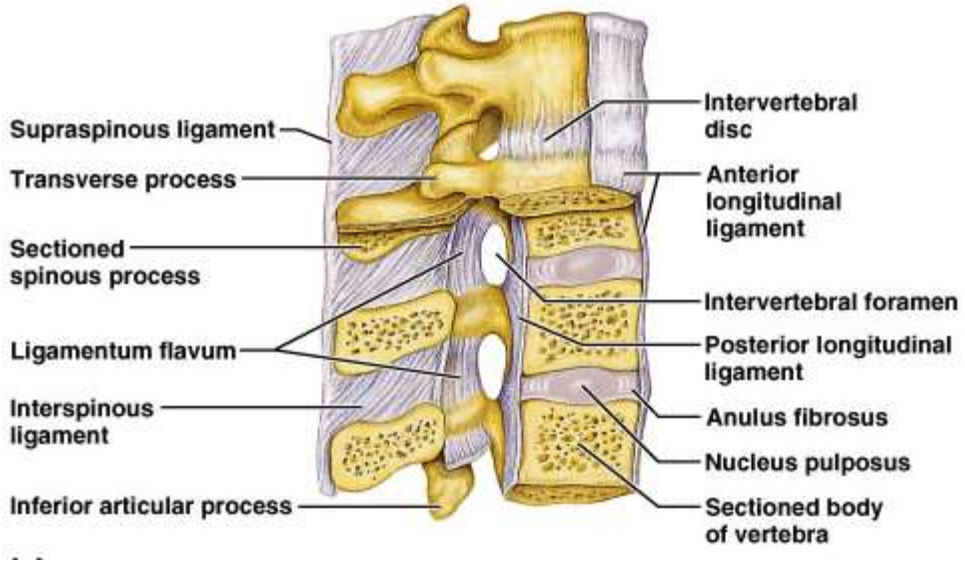


http://www.apparelyzed.com/spinalcord.html

Spinal nerves

- Part of the peripheral nervous system
- 31 pairs attach through dorsal and ventral nerve roots
- Lie in intervertebral foramina



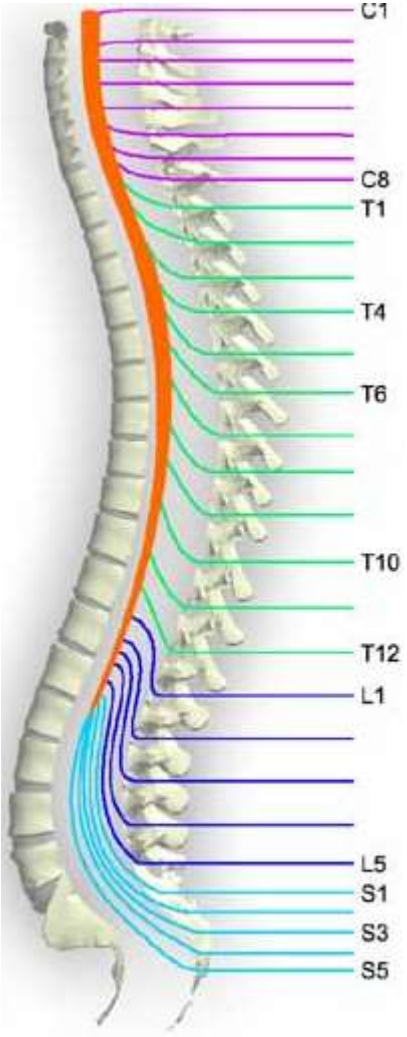


Spinal nerves continued

- Divided based on vertebral locations
- 8 cervical
- 12 thoracic
- 5 lumbar
- 5 sacral
- 1 coccygeal
- *Cauda equina* (“horse’s tail”): collection of nerve roots at inferior end of vertebral canal

Spinal nerves continued

- Note: cervical spinal nerves exit from *above* the respective vertebra
  - Spinal nerve root 1 from above C1
  - Spinal nerve root 2 from between C1 and C2, etc.
- Clinically, for example when referring to disc impingement, both levels of vertebra mentioned, e.g. C6-7 disc impinging on root 7
- Symptoms usually indicate which level

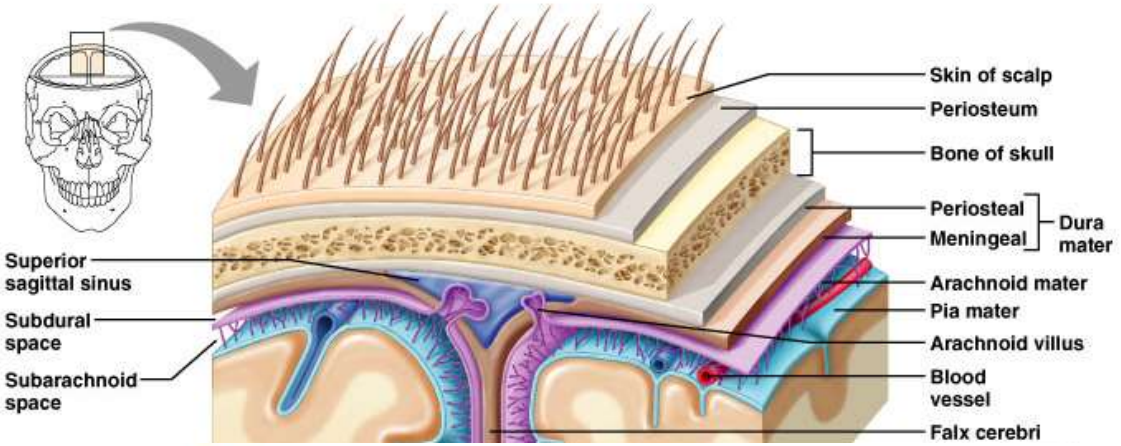


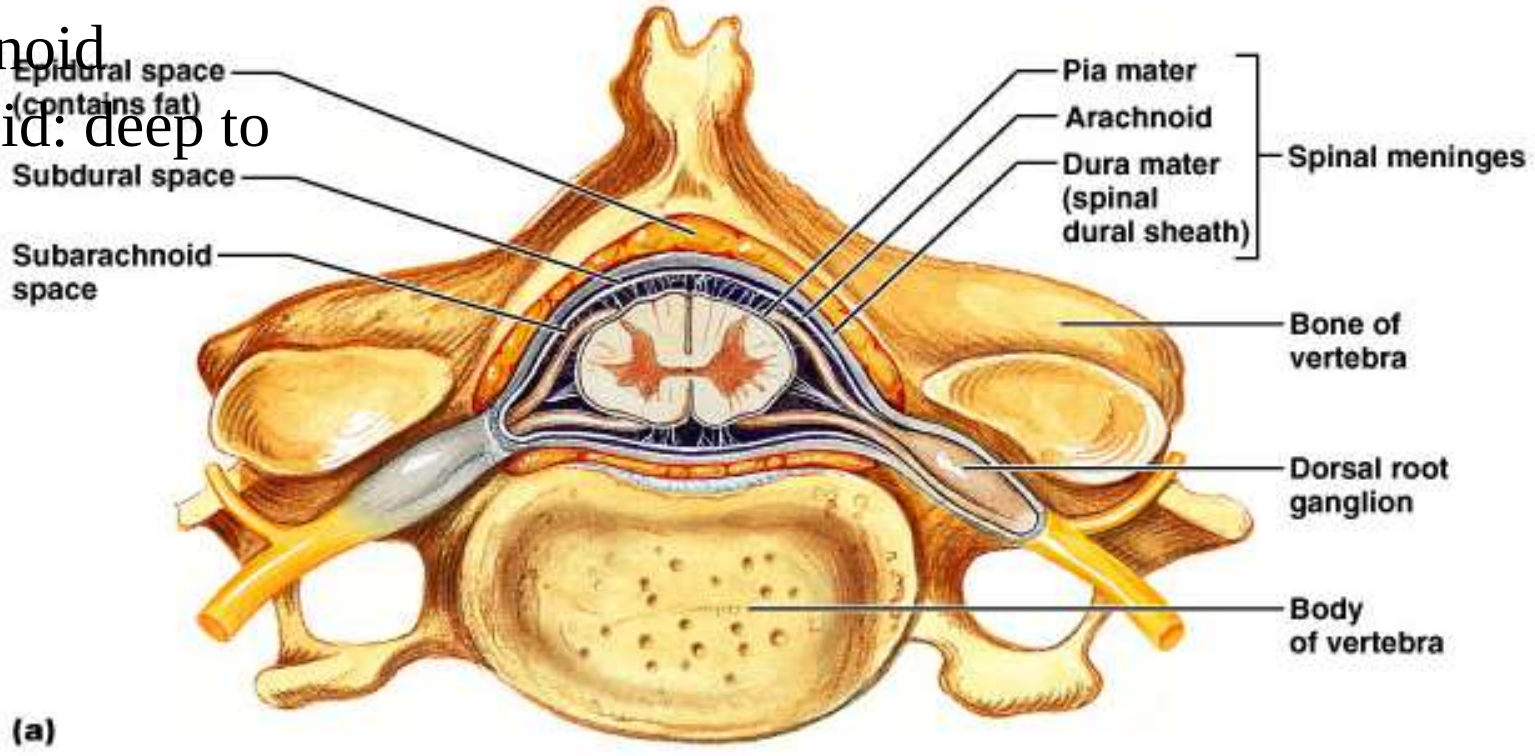
Protection:

Bone
Meninges
CSF (cerebrospinal fluid)

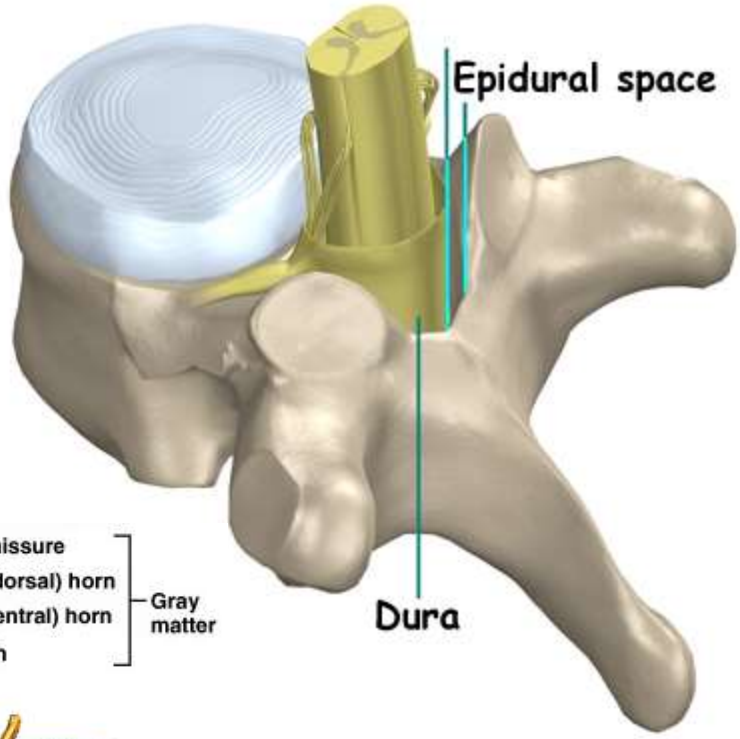
3 meninges:
- dura mater (outer)
- arachnoid mater (middle)
- pia mater (inner)

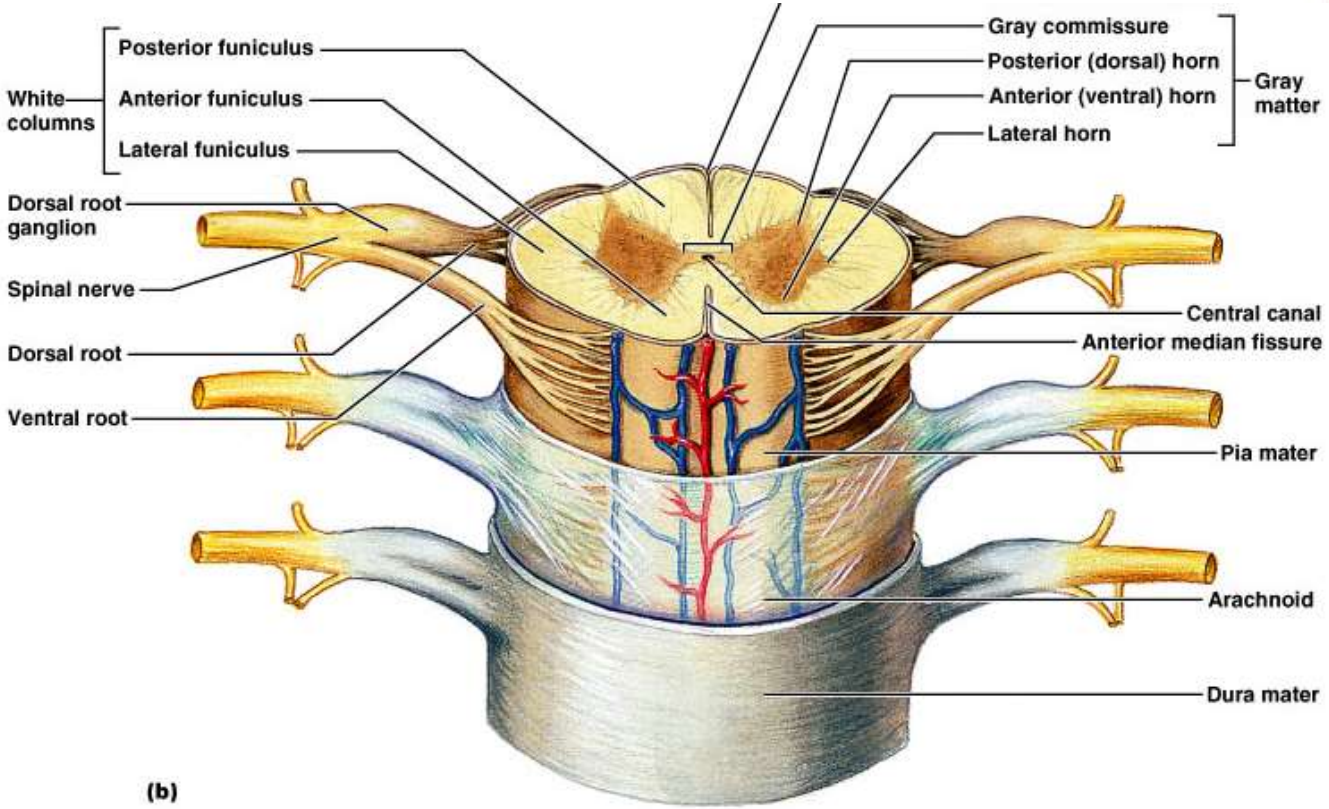
3 potential spaces
- epidural: outside dura
- subdural: between dura & arachnoid
- subarachnoid: deep to arachnoid





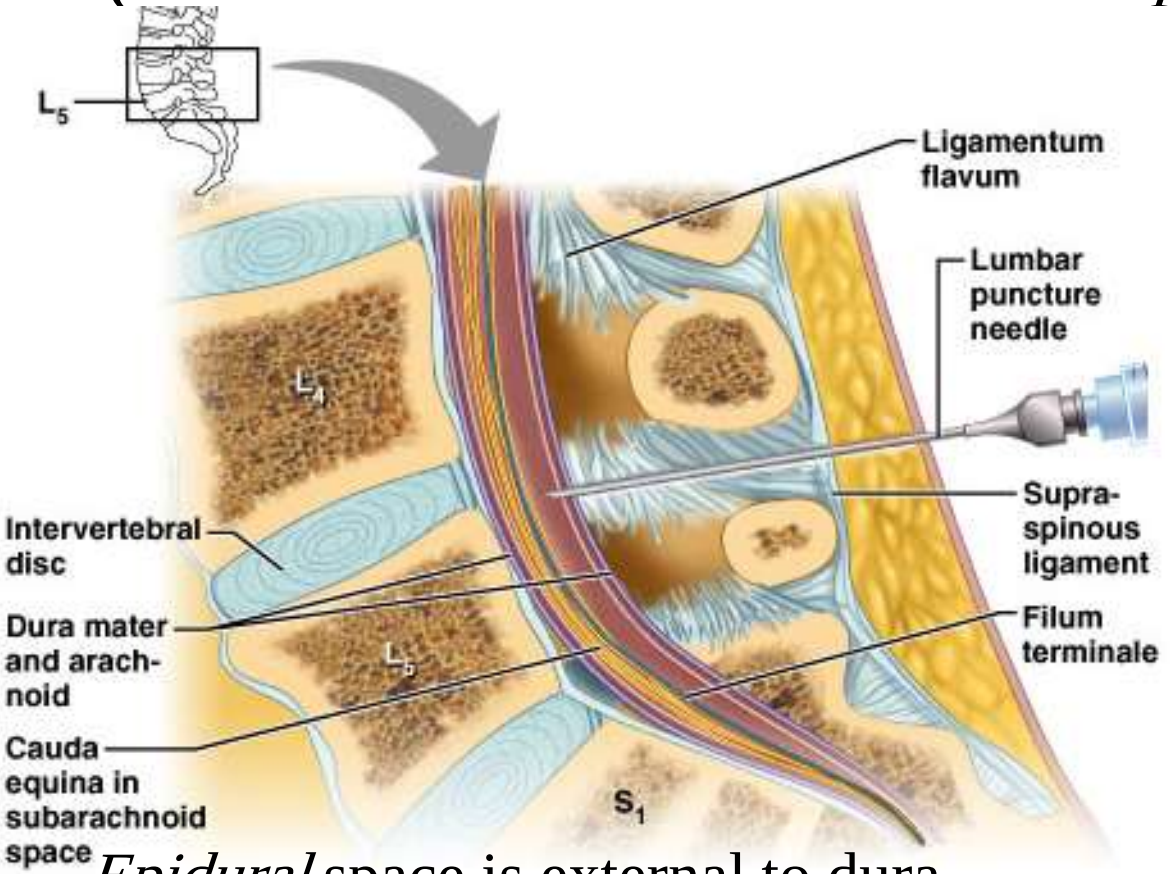
Spinal cord coverings and spaces





LP (lumbar puncure) = spinal tap

*(needle introduced into **subdural** space to collect CSF)*



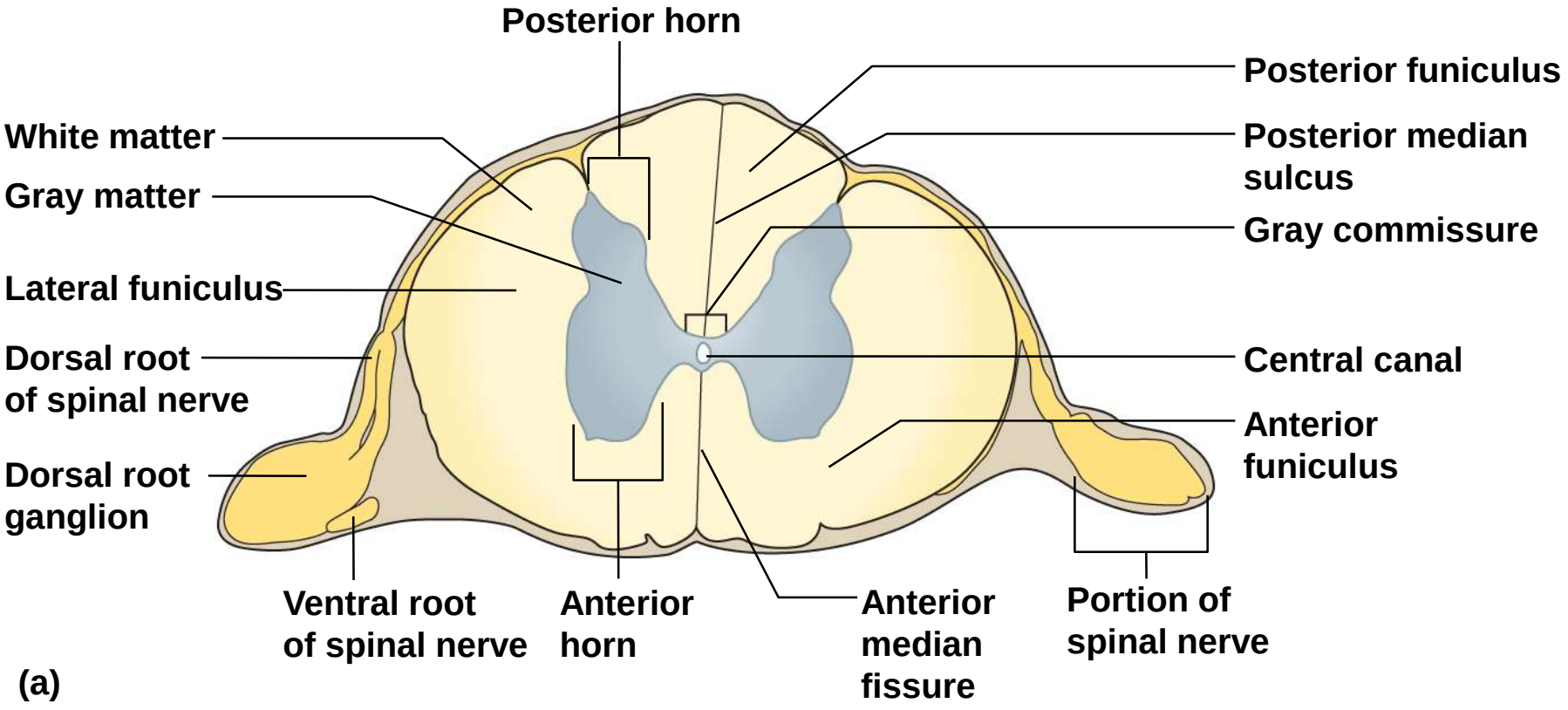
Lumbar spine needs to be flexed so can go between spinous processes

Epidural space is external to dura

Anesthestics are often injected into epidural space

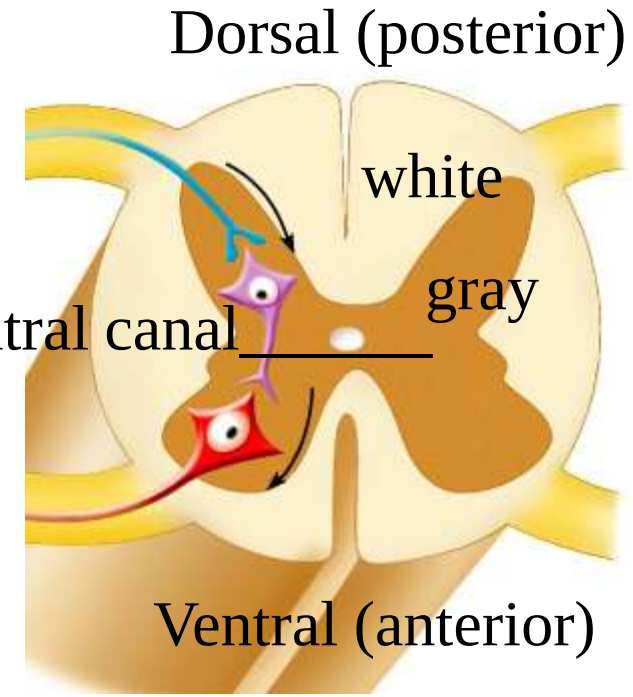
Injection into correct space is vital; mistakes can be lethal

Structure of the Spinal Cord



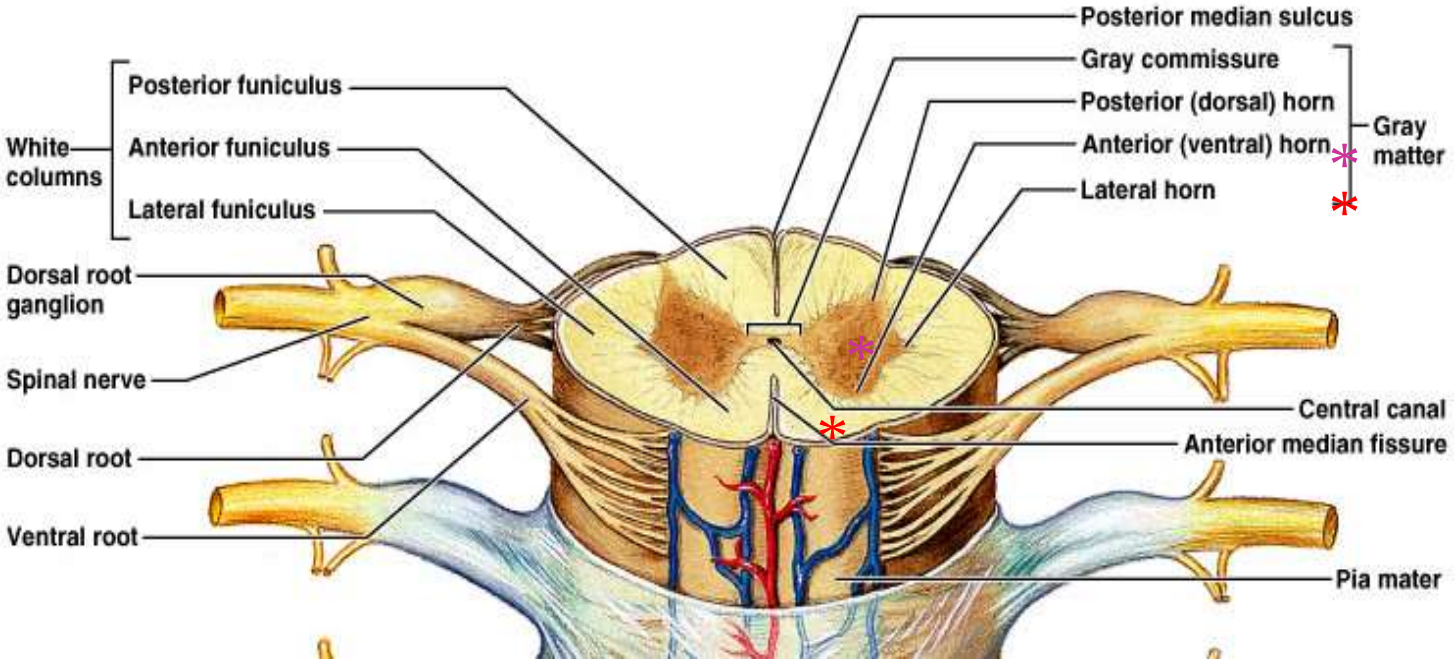
Gray/White in spinal cord

- Hollow central cavity (“central canal”)
- Gray matter surrounds cavity
- White matter surrounds gray matter (white: ascending and descending tracts of axons)
- “H” shaped on cross section
- Dorsal half of “H”: cell bodies of interneurons
- Ventral half of “H”: cell bodies of motor neurons
- No cortex (as in brain)



Spinal cord anatomy

- Gray commissure with central canal
- Columns of gray running the length of the spinal cord
  - Posterior (dorsal) horns *(cell bodies of interneurons)*
  - Anterior (ventral) horns *(cell bodies of motor neurons)*
- Lateral horns in thoracic and superior lumbar cord



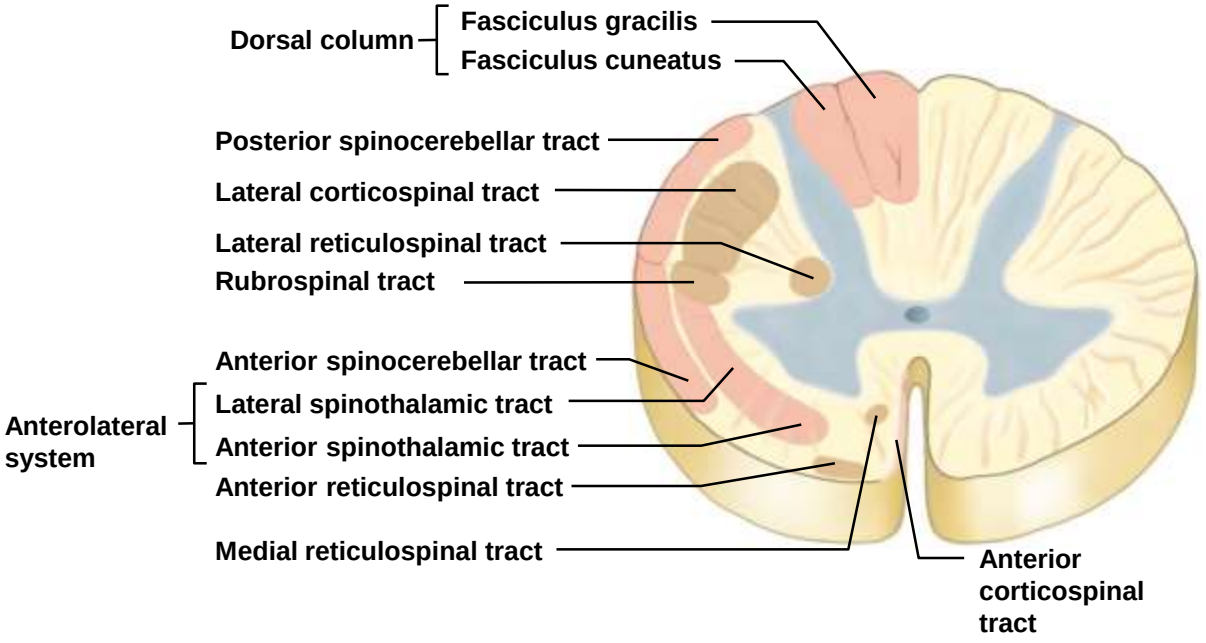
White matter of the spinal cord

(myelinated and unmyelinated axons)

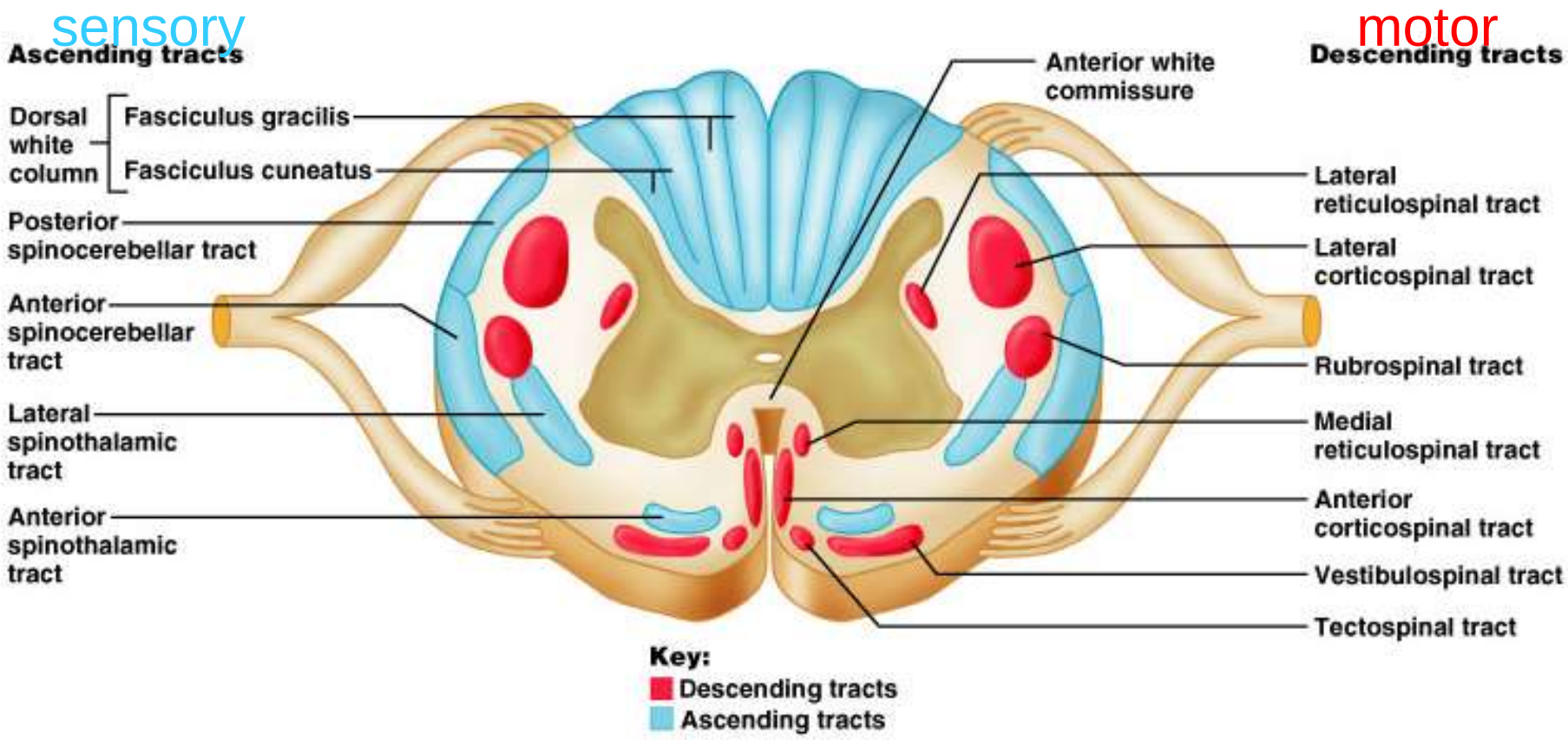
- ***Ascending*** fibers: sensory information from sensory neurons of body up to brain
- ***Descending*** fibers: motor instructions from brain to spinal cord
  - Stimulates contraction of body's muscles
  - Stimumulates secretion from body's glands
- ***Commissural*** fibers: white-matter fibers crossing from one side of cord to the other
- Most pathways cross (or ***decussate***) at some point
- Most synapse two or three times along the way, e.g. in brain stem, thalamus or other

Tracts of the Spinal Cord

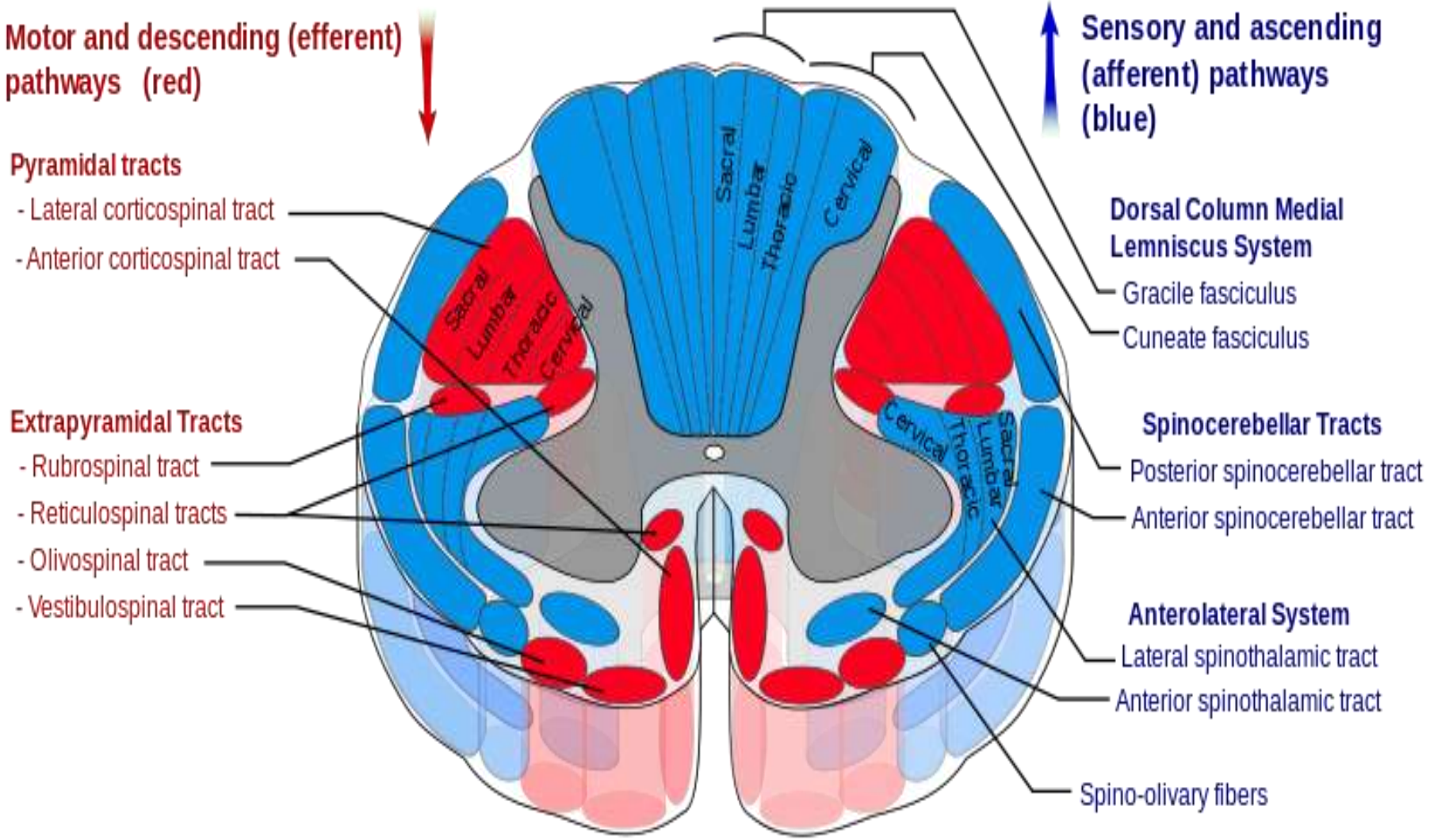
- Ascending tracts (dorsal) conduct sensory impulses to the brain
- Descending tracts (ventral) conduct motor impulses from the brain to motor neurons reaching muscles and glands



Major fiber tracts in white matter of spinal cord



Damage: to motor areas – paralysis
to sensory areas - paresthesias


Motor and descending (efferent) pathways (red)
Pyramidal tracts
- Lateral corticospinal tract
- Anterior corticospinal tract
Extrapyramidal Tracts
- Rubrospinal tract
- Reticulospinal tracts
- Olivospinal tract
- Vestibulospinal tract
Sensory and ascending (afferent) pathways (blue)
Dorsal Column Medial Lemniscus System
Gracile fasciculus
Cuneate fasciculus
Spinocerebellar Tracts
Posterior spinocerebellar tract
Anterior spinocerebellar tract
Anterolateral System
Lateral spinothalamic tract
Anterior spinothalamic tract
Spino-olivary fibers
Sacral
Lumbar
Thoracic
Cervical

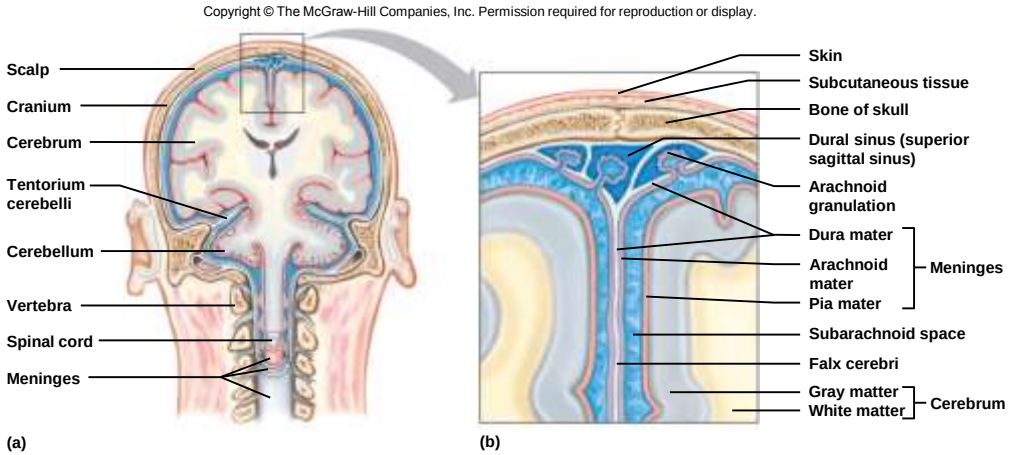
Nerve Tracts of the Spinal Cord

TABLE 11.3 | Nerve Tracts of the Spinal Cord

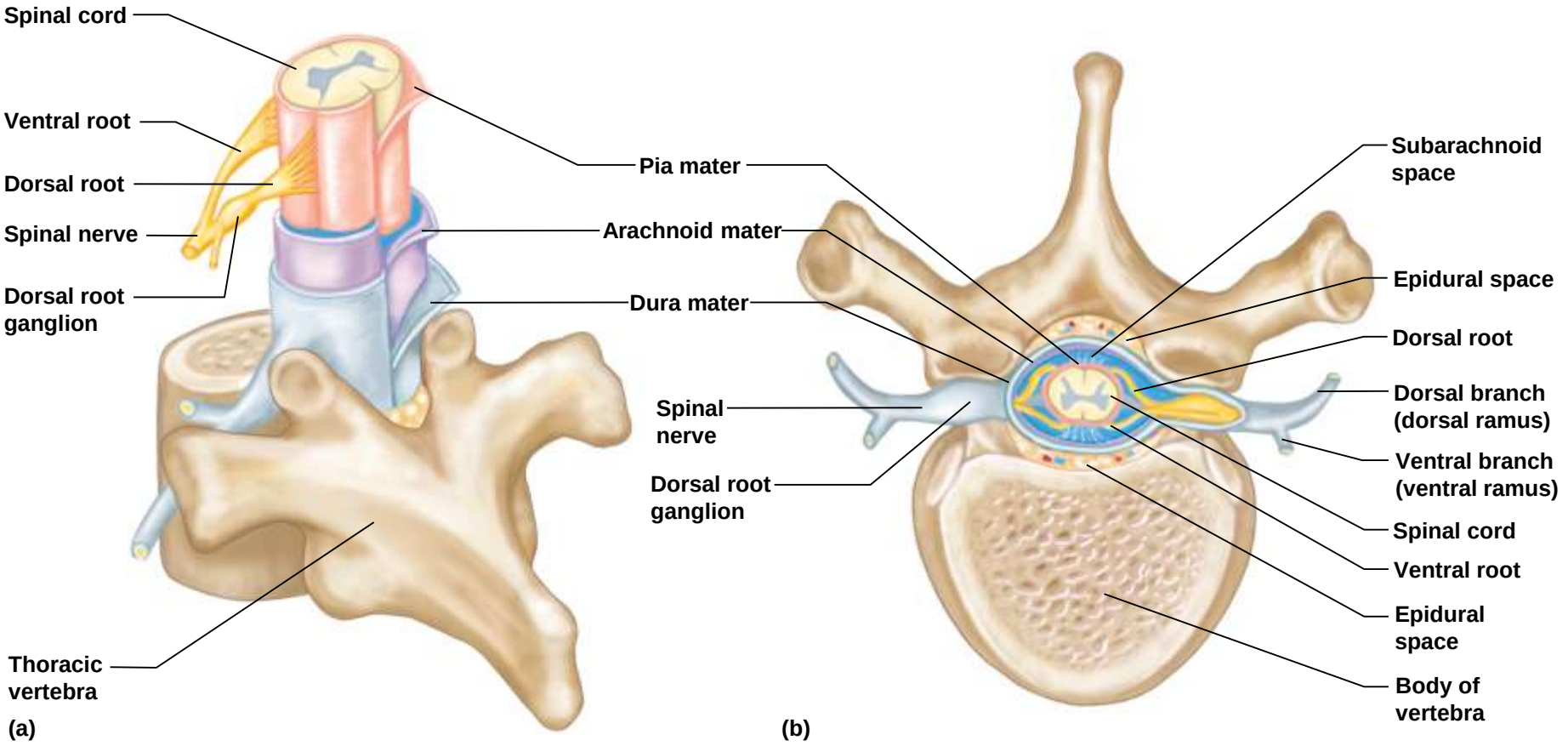
Tract	Location	Function
Ascending Tracts		
1. Fasciculus gracilis and fasciculus cuneatus	Posterior funiculi	Conduct sensory impulses associated with the senses of touch, pressure, and body movement from skin, muscles, tendons, and joints to the brain
2. Spinothalamic tracts (lateral and anterior)	Lateral and anterior funiculi	Conduct sensory impulses associated with the senses of pain, temperature, touch, and pressure from various body regions to the brain
3. Spinocerebellar tracts (posterior and anterior)	Lateral funiculi	Conduct sensory impulses required for the coordination of muscle movements from muscles of the lower limbs and trunk to the cerebellum
Descending Tracts		
1. Corticospinal tracts (lateral and anterior)	Lateral and anterior funiculi	Conduct motor impulses associated with voluntary movements from the brain to skeletal muscles
2. Reticulospinal tracts (lateral, anterior, and medial)	Lateral and anterior funiculi	Conduct motor impulses associated with the maintenance of muscle tone and the activity of sweat glands from the brain
3. Rubrospinal tracts	Lateral funiculi	Conduct motor impulses associated with muscular coordination and the maintenance of posture from the brain

11.2: Meninges

- The meninges
  - Membranes of CNS
  - Protect the CNS
  - Three (3) layers:
    - Dura mater
      - "Tough mother"
      - Venous sinuses
    - Arachnoid mater
      - "Spider mother"
      - Space contains cerebrospinal fluid (CSF)
    - Pia mater
      - "Little mother"
      - Encapsulates blood vessels



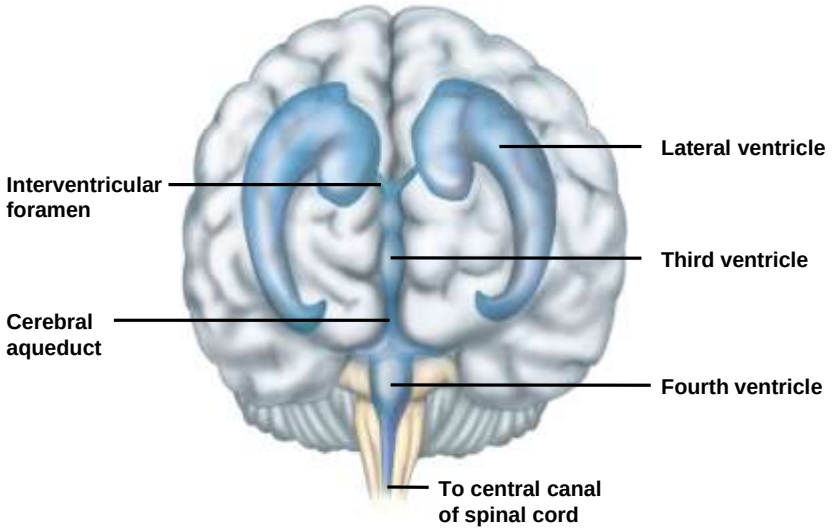
Meninges of the Spinal Cord

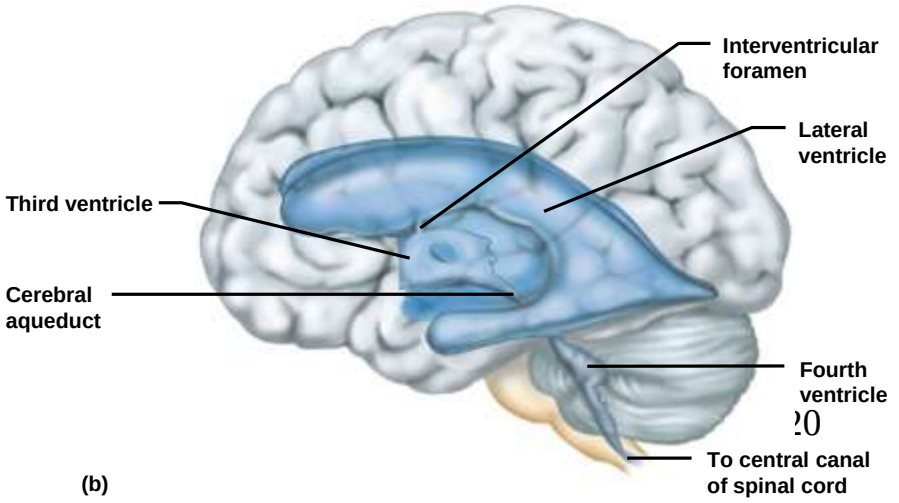


11.3: Ventricles and Cerebrospinal Fluid

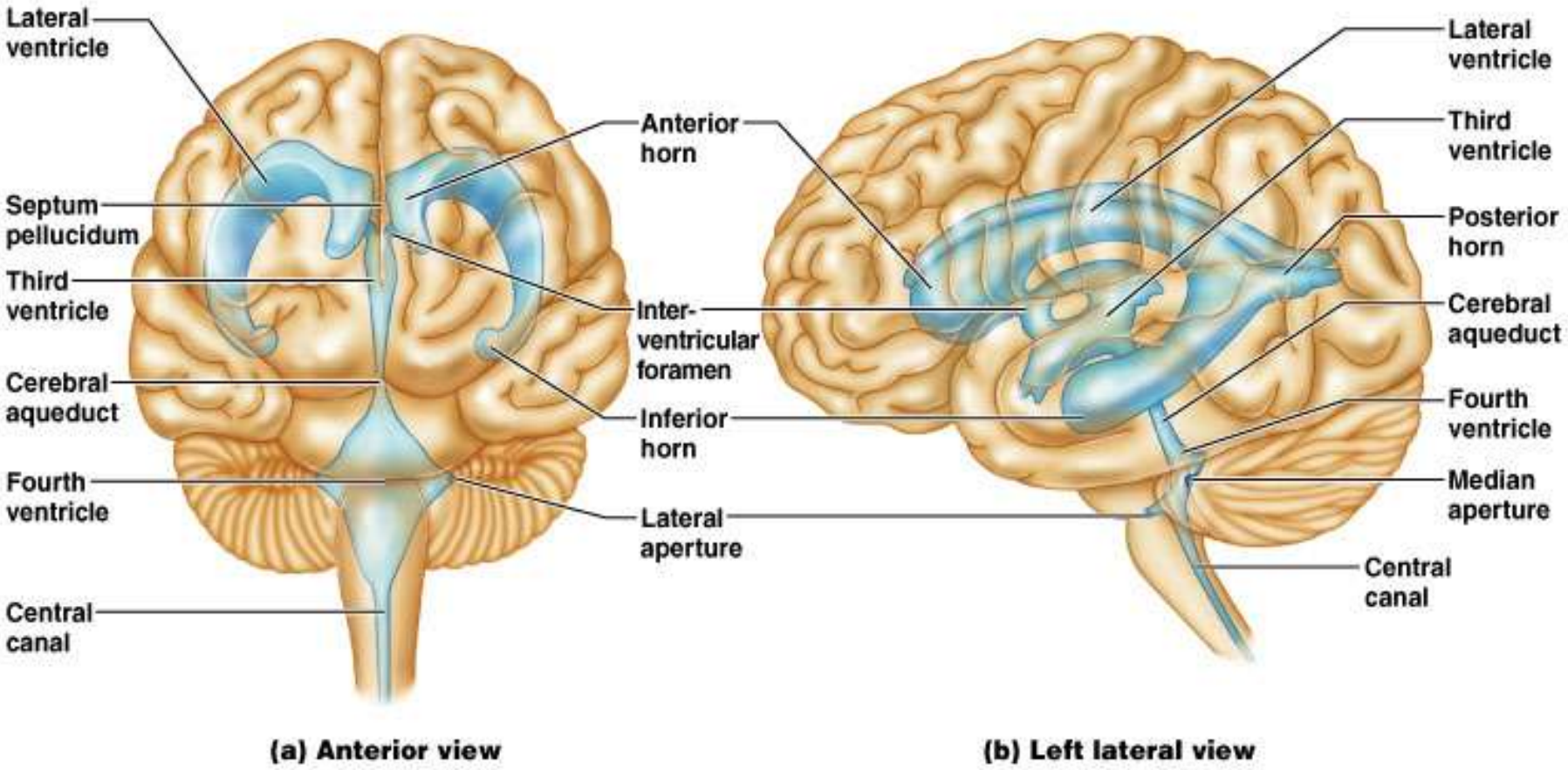
- There are four (4) ventricles
- The ventricles are interconnected cavities within cerebral hemispheres and brain stem
- The ventricles are continuous with the central canal of the spinal cord
- They are filled with cerebrospinal fluid (CSF)

- The four (4) ventricles are:
  - Lateral ventricles (2)
    - Known as the first and second ventricles
  - Third ventricle
  - Fourth ventricle
- Interventricular foramen
- Cerebral aqueduct

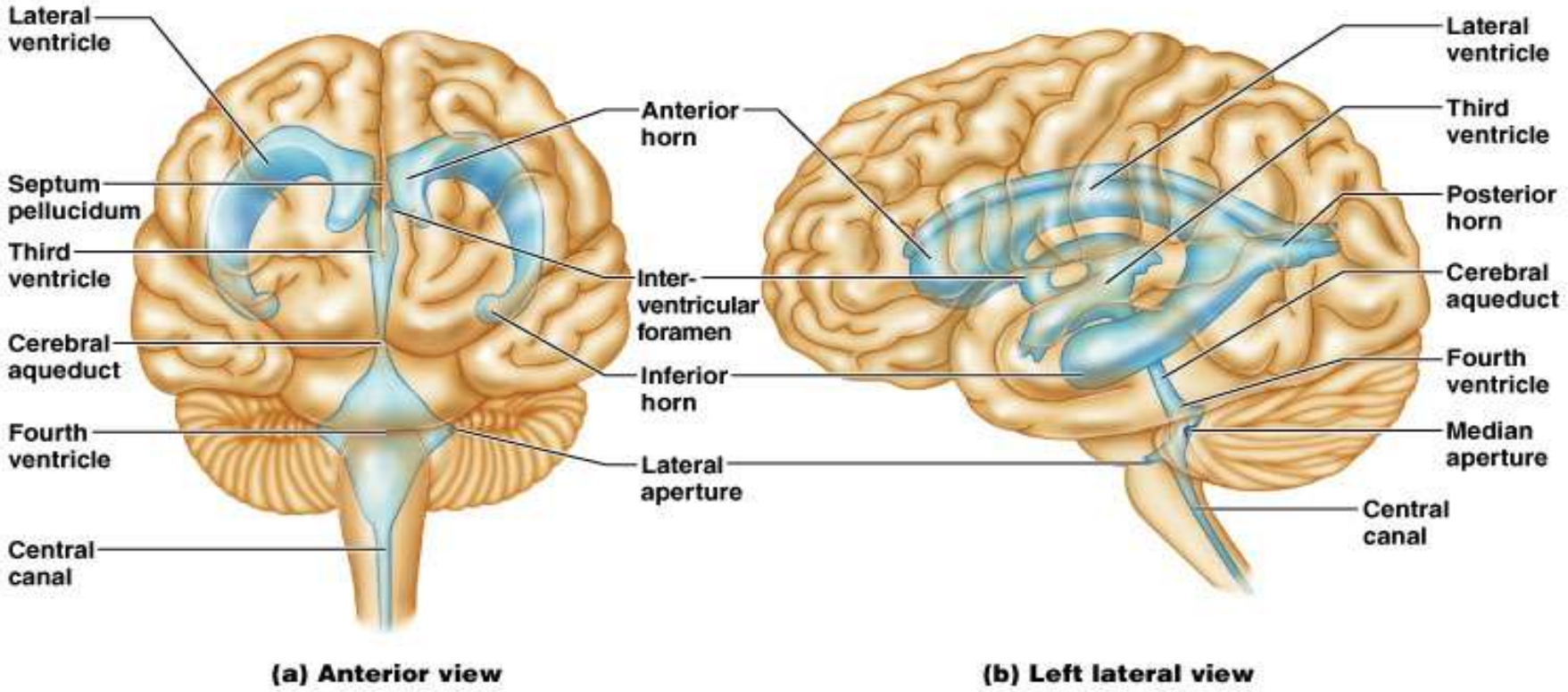




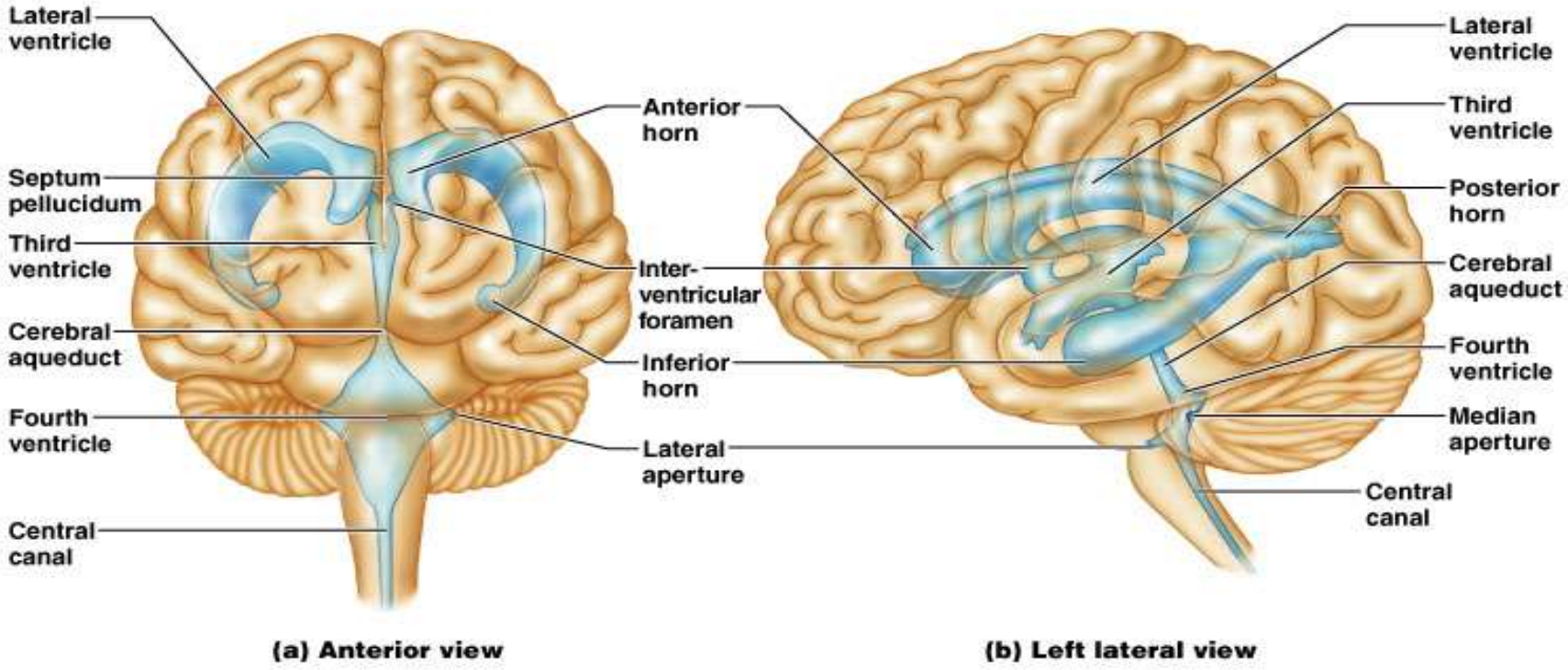
- Lateral ventricles
  - Paired, horseshoe shape
  - In cerebral hemispheres
  - Anterior are close, separated only by thin *Septum pellucidum*



- Third ventricle
  - In diencephalon
  - Connections
    - Interventricular foramen
    - Cerebral aqueduct

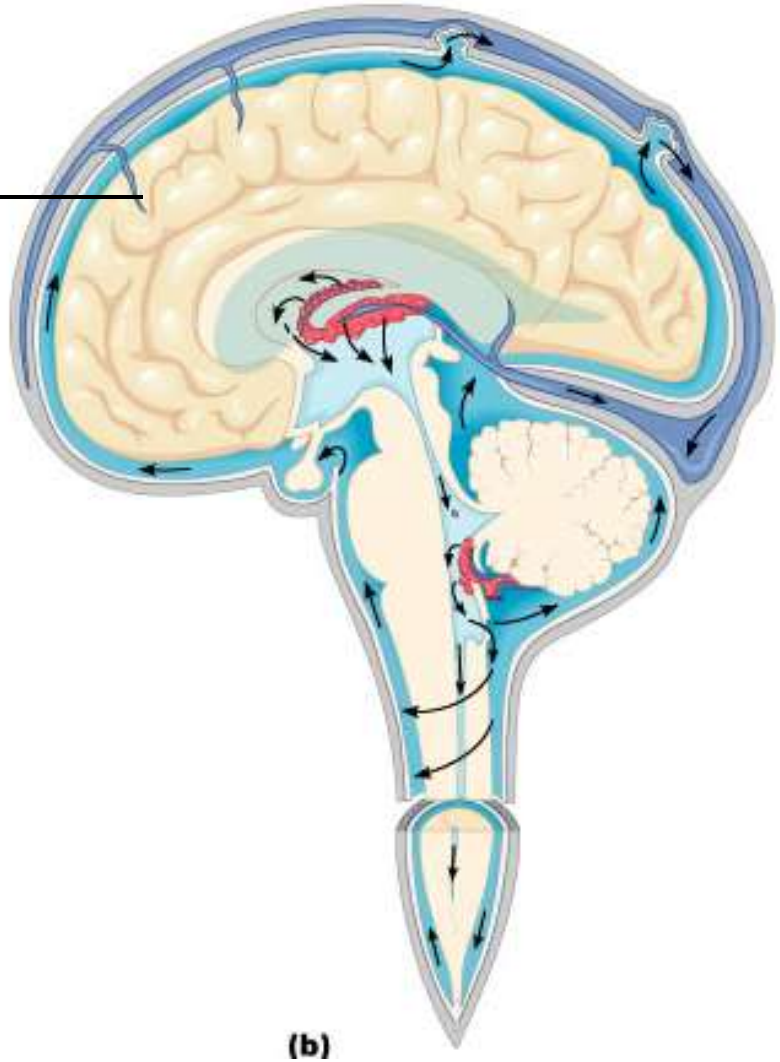


- Fourth ventricle
  - In the brainstem
  - Dorsal to pons and top of medulla
  - Holes connect it with subarachnoid space



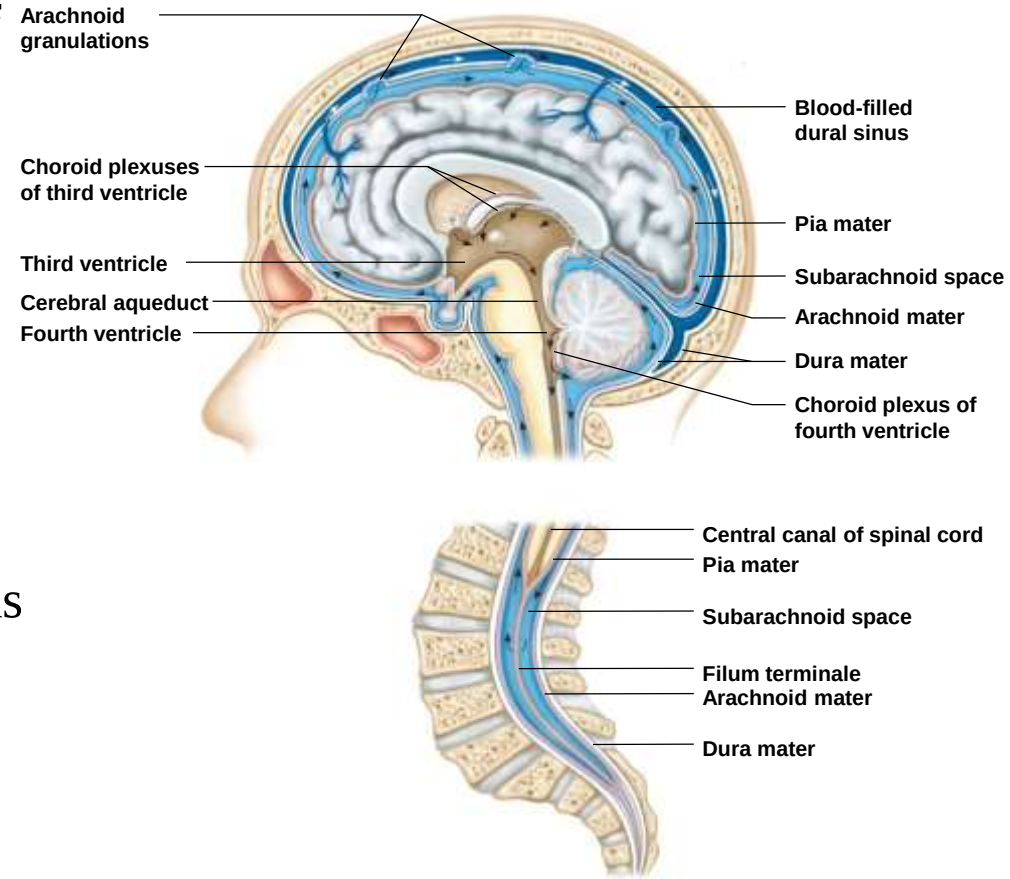
Subarachnoid space

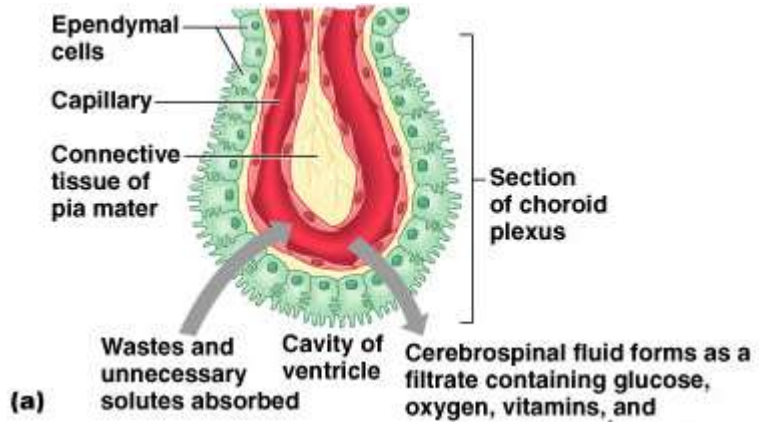
- Aqua blue in this pic
- Under thick coverings of brain
- Filled with CSF also
- Red: choroid plexus



Cerebrospinal Fluid

- Secreted by the choroid plexus
- Circulates in ventricles, central canal of spinal cord, and the subarachnoid space
- Completely surrounds brain & spinal cord
- Excess or wasted CSF is absorbed by arachnoid villi .
- Clear fluid similar to blood plasma
- Volume is only about 120 ml.
- Nutritive and protective
- Helps maintain stable ion concentrations in the CNS

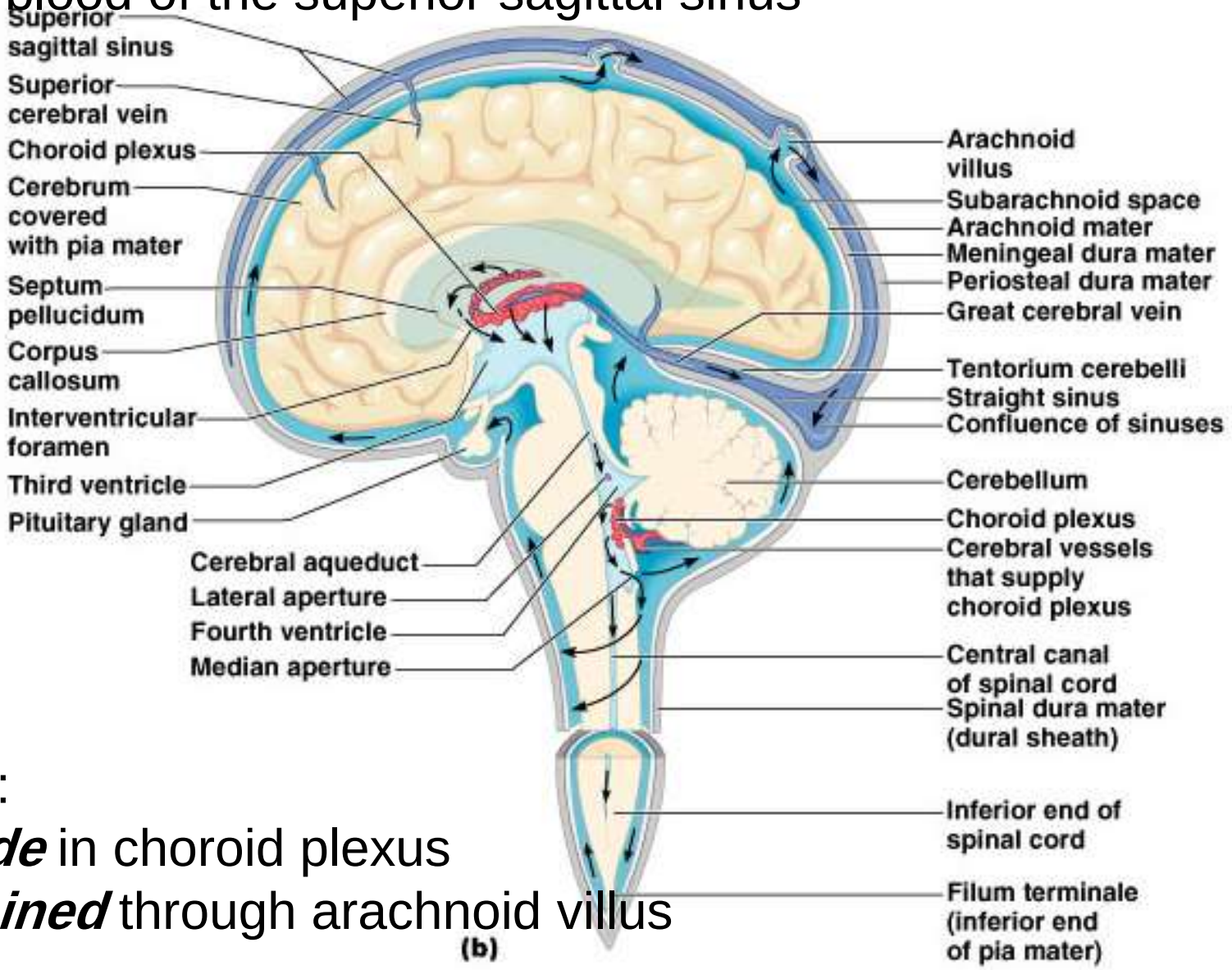




Cerebrospinal Fluid CSF

- Made in choroid plexuses (roofs of ventricles)
  - Filtration of plasma from capillaries through ependymal cells (electrolytes, glucose)
- 500 ml/d; total volume 100-160 ml (1/2 c)
- Cushions and nourishes brain
- Assayed in diagnosing meningitis, bleeds, MS
- Hydrocephalus: excessive accumulation

CSF circulation: through ventricles, median and lateral apertures, subarachnoid space, arachnoid villi, and into the blood of the superior sagittal sinus



CSF:

-***Made*** in choroid plexus

-***Drained*** through arachnoid villus

Blood-Brain Barrier

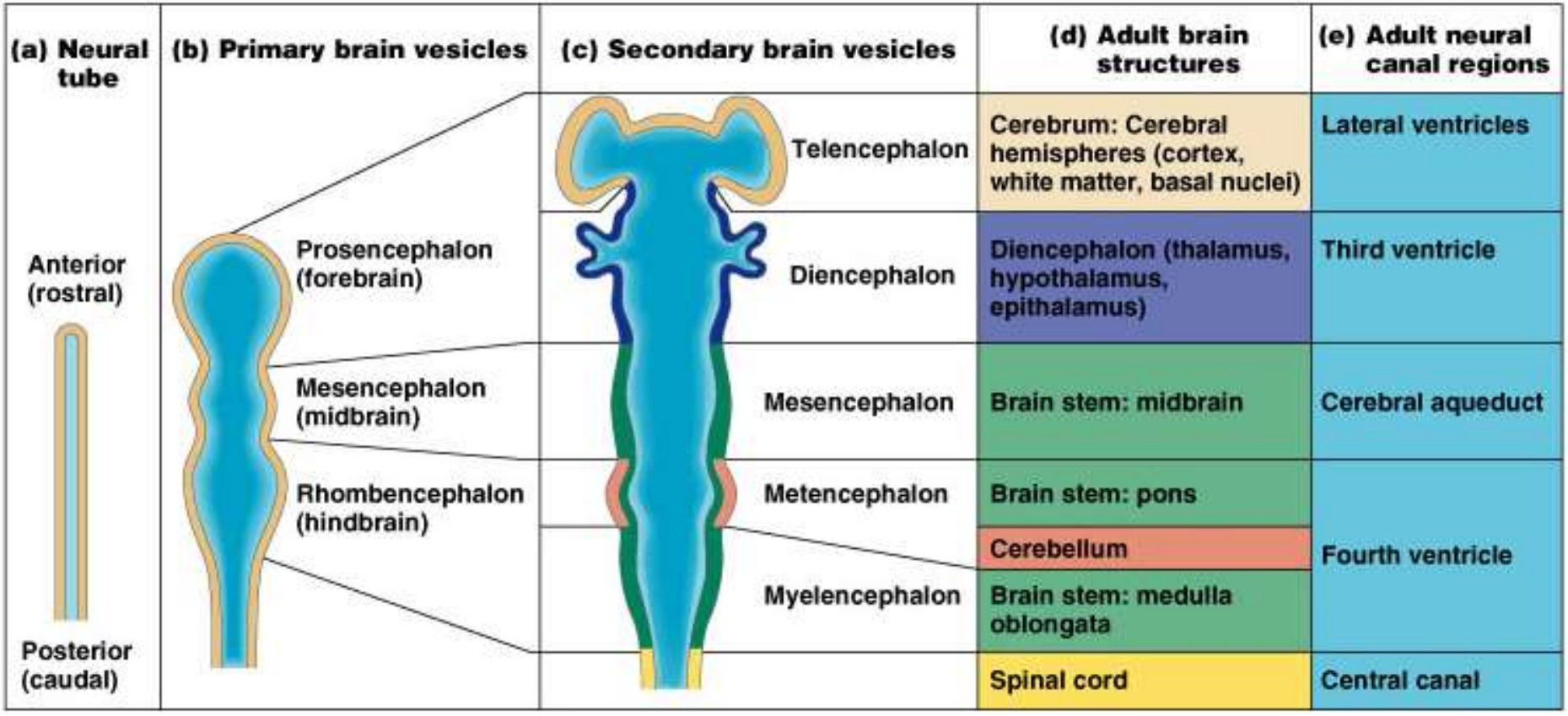
- Tight junctions between endothelial cells of brain capillaries, instead of the usual permeability
- Highly selective transport mechanisms
- Allows nutrients, O2, CO2
- ***Not*** a barrier against uncharged and lipid soluble molecules; allows alcohol, nicotine, and some drugs including anesthetics

The Brain: embryonic development

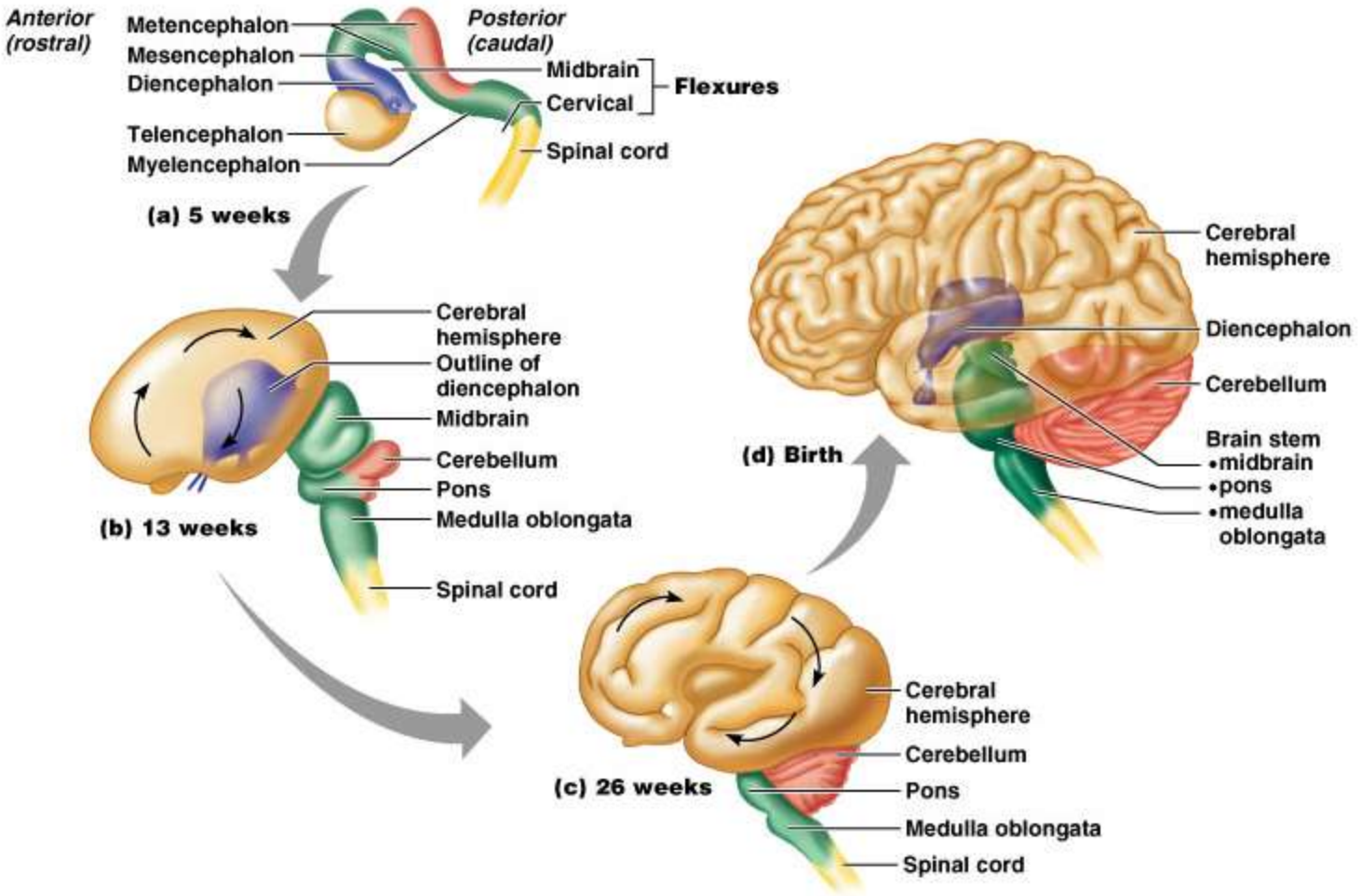
- Develops from neural tube
- Brain subdivides into
  - Forebrain
  - Midbrain
  - Hindbrain
- These further divide, each with a fluid filled region: ventricle, aqueduct or canal
  - Spinal cord also has a canal
- Two major bends, or flexures, occur (midbrain and cervical)

Brain development

- Learn forebrain, midbrain and hindbrain in (b)
- See next color coded pics in reference to (d)
- Learn (e)
- *Encephalos* means brain (otherwise you don't need to learn "c")



- Space restrictions force cerebral hemispheres to grow posteriorly over rest of brain, enveloping it
- Cerebral hemispheres grow into horseshoe shape (b and c)
- Continued growth causes creases, folds and wrinkles

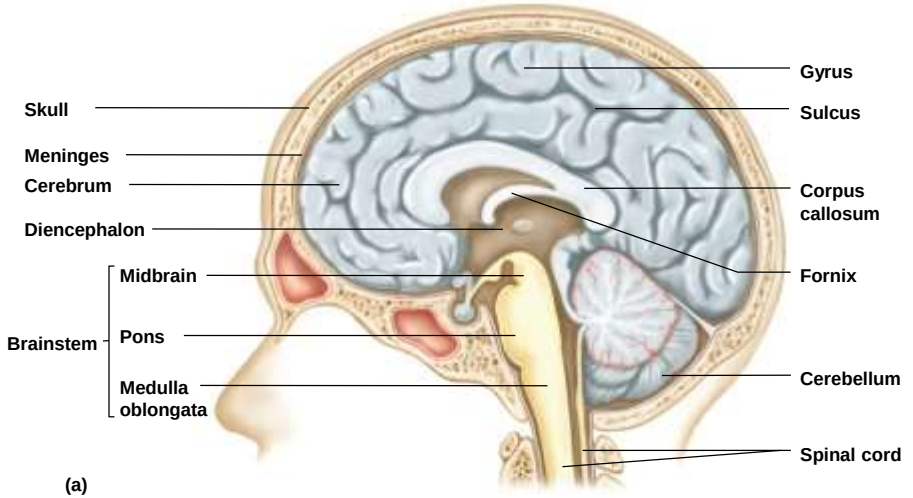


11.5: Brain

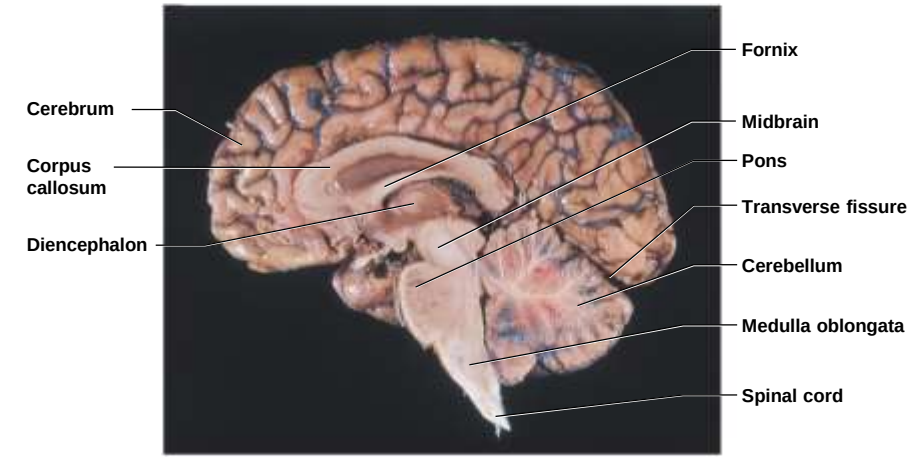
- Functions of the brain:
  - Interprets sensations
  - Determines perception
  - Stores memory
  - Reasoning
  - Makes decisions
  - Coordinates muscular movements
  - Regulates visceral activities
  - Determines personality

- Major parts of the brain:
  - Cerebrum
    - Frontal lobes
    - Parietal lobes
    - Occipital lobes
    - Temporal lobes
    - Insula
  - Diencephalon
  - Cerebellum
  - Brainstem
    - Midbrain
    - Pons
    - Medulla oblongata

The Brain



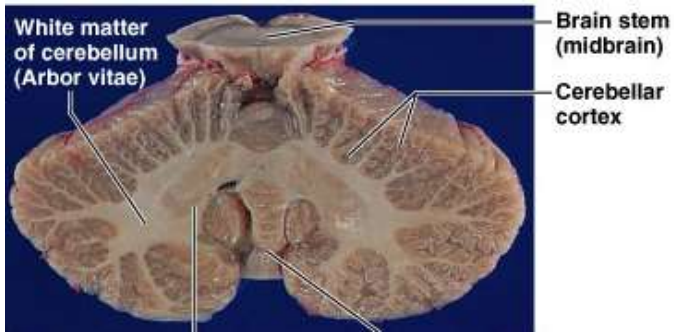
(a)



(b)

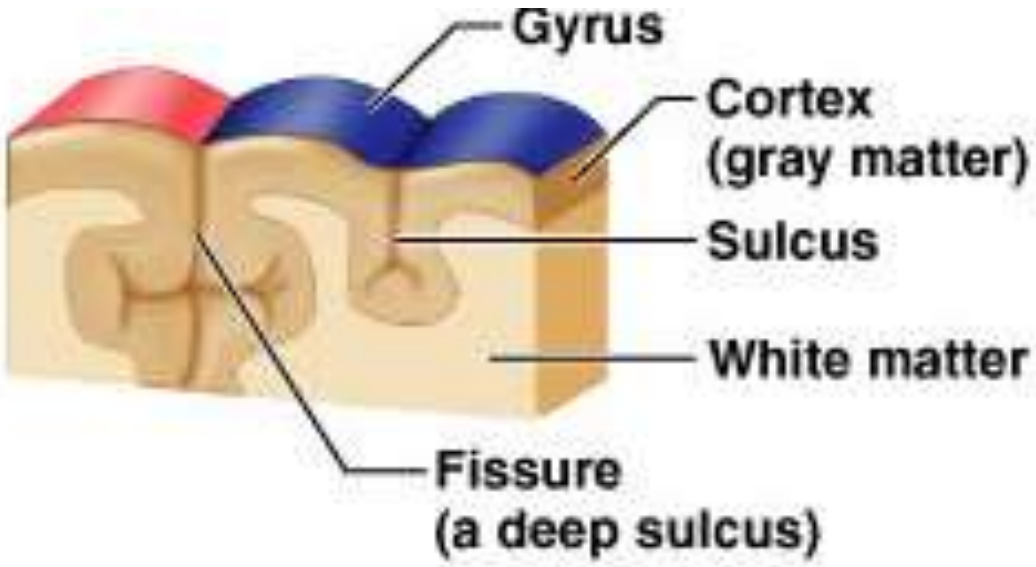
Usual pattern of gray/white in CNS

- White exterior to gray
- Gray surrounds hollow central cavity
- Two regions with additional gray called “cortex”
  - Cerebrum: “cerebral cortex”
  - Cerebellum: “cerebellar cortex”



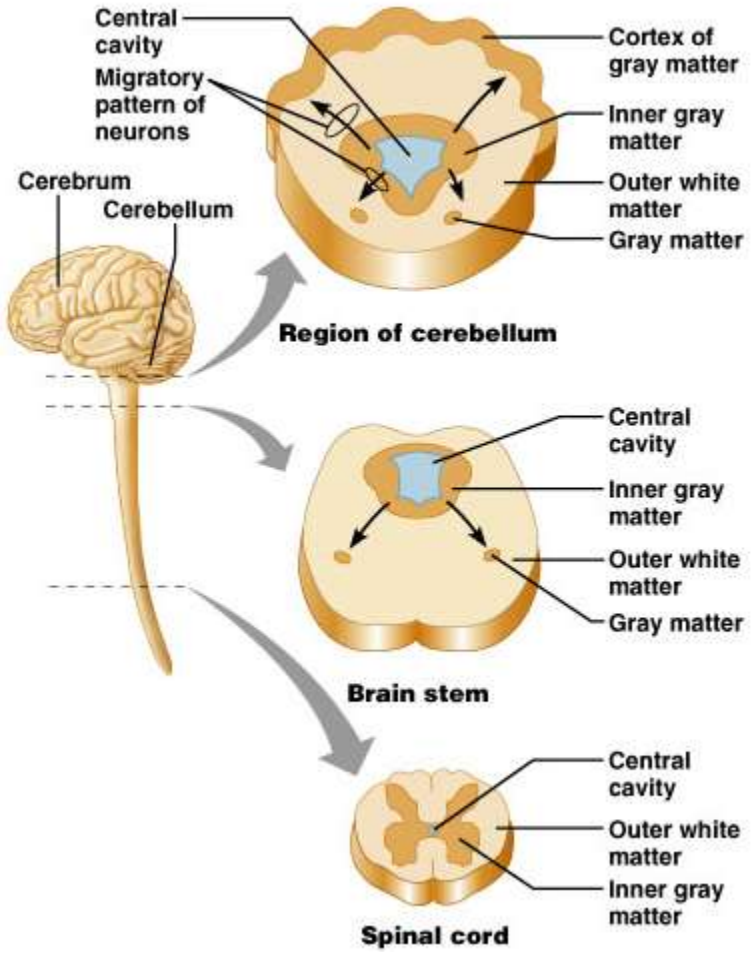
Surface anatomy

- ***Gyri*** (plural of ***gyrus***)
  - Elevated ridges
  - Entire surface
- Grooves separate gyri
  - A ***sulcus*** is a shallow groove (plural, ***sulci***)
  - Deeper grooves are ***fissures***



Gray and White Matter

- Like spinal cord but with another layer of gray outside the white
  - Called **cortex**
  - Cerebrum and cerebellum have
- Inner gray: "**brain nuclei**" (not cell nuclei)
  - Clusters of cell bodies

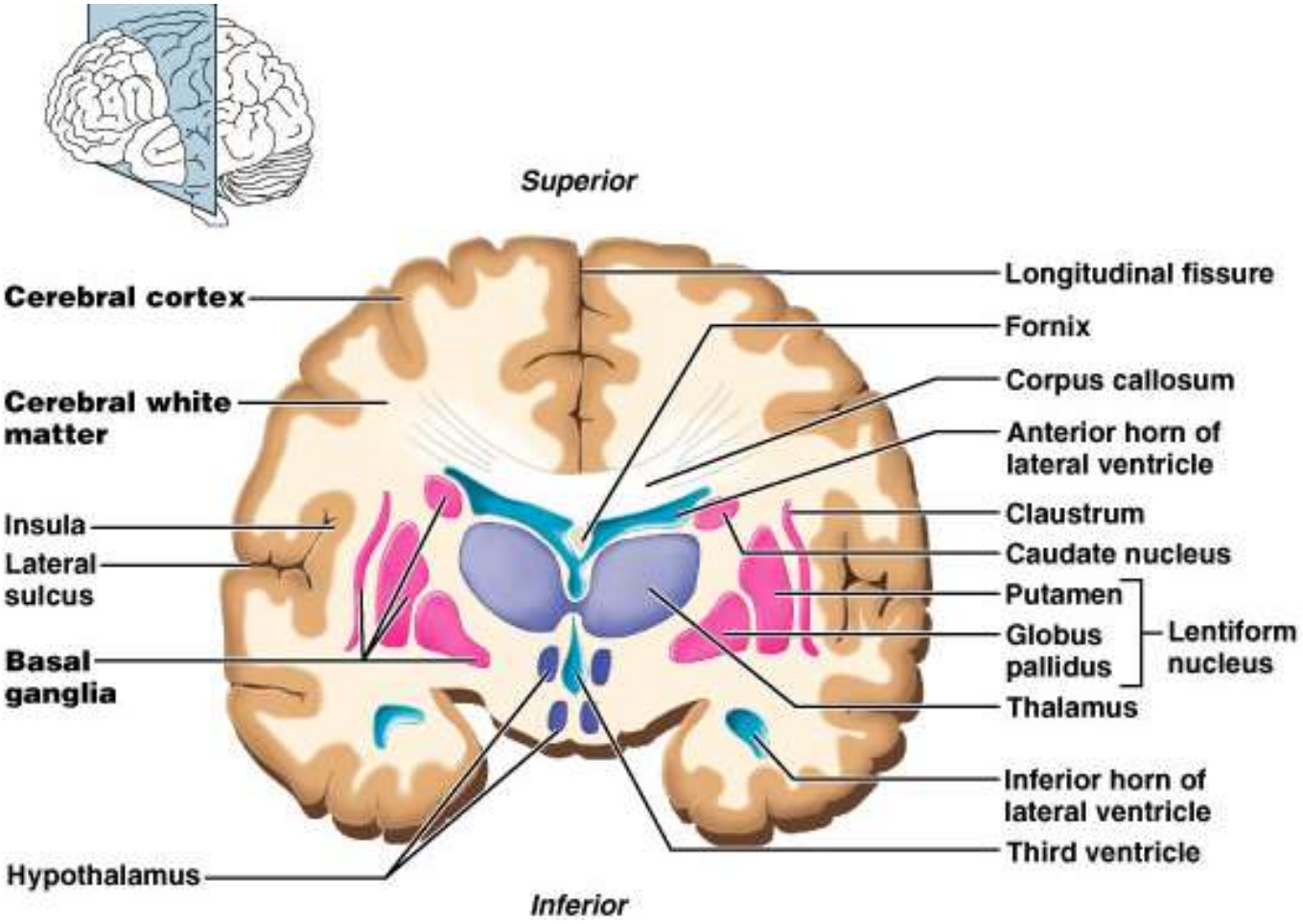


Remember, in PNS clusters of cell bodies were called "ganglia"

More words: brains stem is *caudal* (toward tail) to the more rostral (nose ward) cerebrum

coronal section

- Note: longitudinal fissure, lateral sulcus, insula
- Note: cerebral cortex (external sheet of gray), cerebral white, deep gray (basal ganglia)



Cerebral cortex

- Executive functioning capability
- Gray matter: of neuron cell bodies, dendrites, short unmyelinated axons
  - 100 billion neurons with average of 10,000 contacts each
- No fiber tracts (would be white)
- 2-4 mm thick (about 1/8 inch)
- Brodmann areas (historical: 52 structurally different areas given)

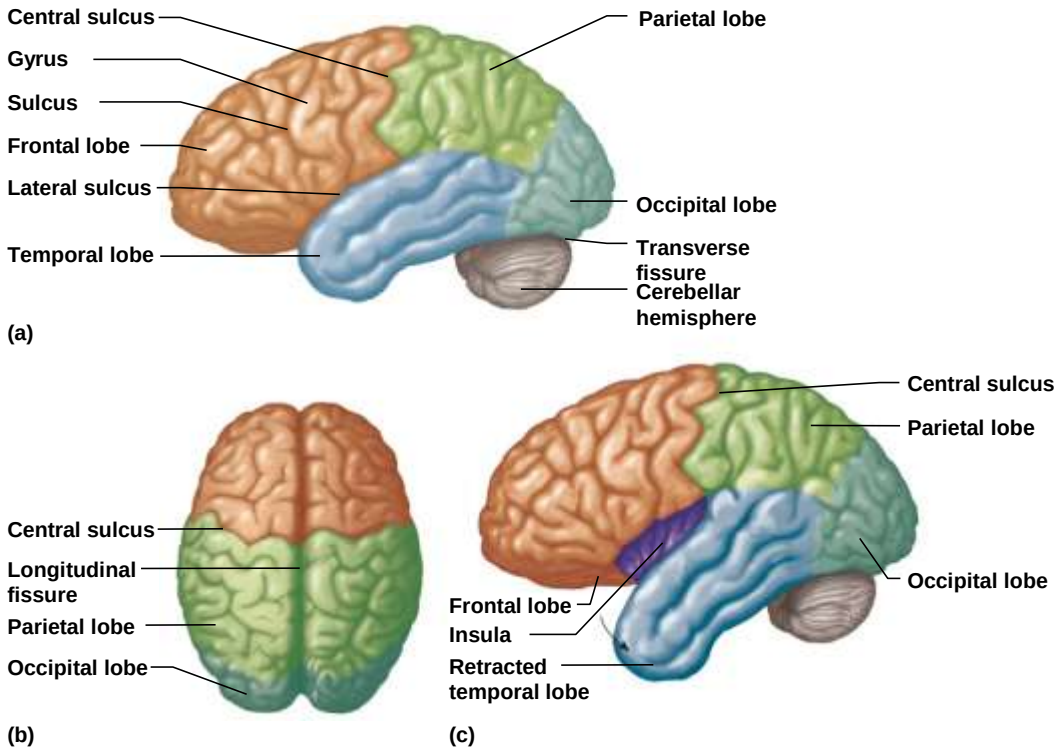
- Prenatal life: genes are responsible for creating the architecture of the brain
  - Cortex is the last to develop and very immature at birth
- Birth: excess of neurons but not inter-connected
  - 1st month of life: a million synapses/sec are made; this is genetic
- 1st 3 years of life: synaptic overgrowth (connections)
  - After this the density remains constant though some grow, some die
- Preadolescence: another increase in synaptic formation
- Adolescence until 25: brain becomes a reconstruction site
  - Connections important for self-regulation (in prefrontal cortex) are being remodeled: important for a sense of wholeness
  - Causes personal turbulence
  - Susceptible to stress and toxins (like alcohol and drugs) during these years; affects the rest of one's life
- The mind changes the brain (throughout life)
  - Where brain activation occurs, synapses happen
  - When pay attention & focus mind, neural firing occurs and brain structure changes (synapses are formed)
  - Human connections impact neural connections (ongoing experiences and learning include the interpersonal ones)

Cerebral cortex

- All the neurons are ***interneurons***
  - By definition confined to the CNS
  - They have to synapse somewhere before the info passes to the peripheral nerves
- Three kinds of functional areas
  - ***Motor*** areas: movement
  - ***Sensory*** areas: perception
  - ***Association*** areas: integrate diverse information to enable purposeful action

Structure of the Cerebrum

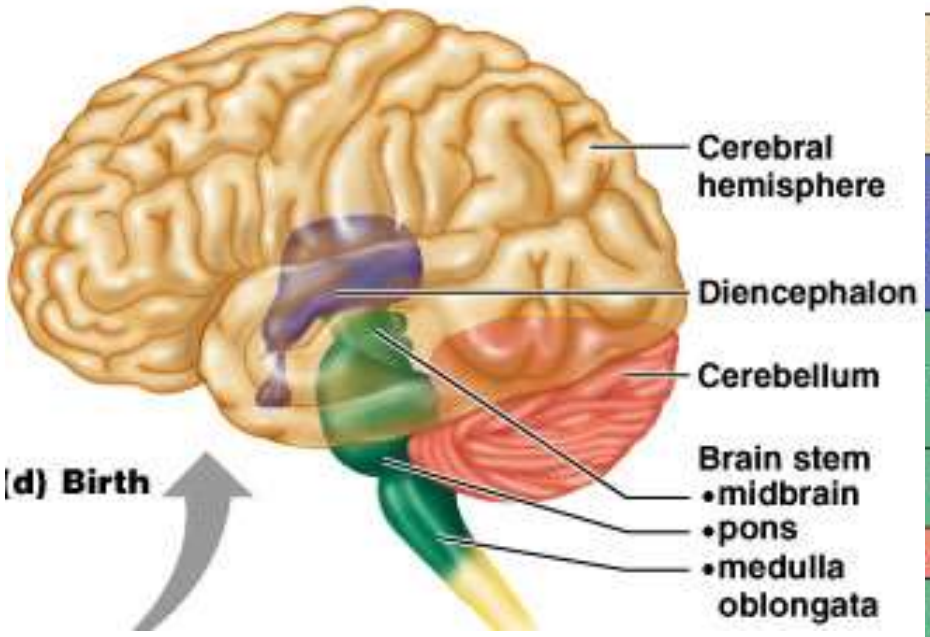
- Corpus callosum
  - Connects cerebral hemispheres (a commissure)
- Gyri
  - Bumps or convolutions
- Sulci
  - Grooves in gray matter
    - Central sulcus of Rolando
- Fissures
  - Longitudinal: separates the cerebral hemispheres
  - Transverse: separates cerebrum from cerebellum
  - Lateral fissure of Sylvius



Anatomical classification

- Cerebral hemispheres
- Diencephalon
  - Thalamus
  - Hypothalamus
- Brain stem
  - Midbrain
  - Pons
  - Medulla
- Cerebellum

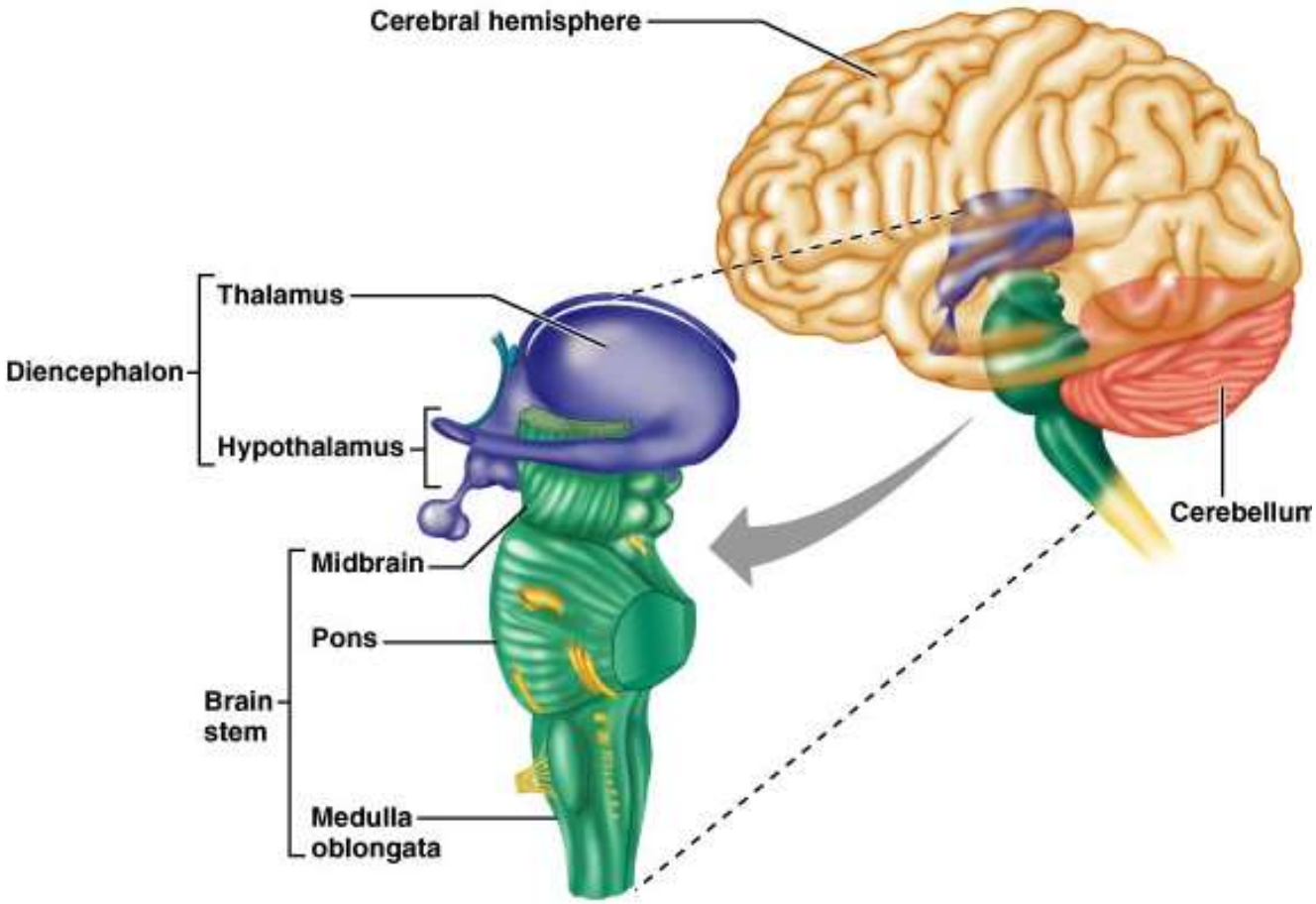
- Spinal cord



(d) Adult brain structures
Cerebrum: Cerebral hemispheres (cortex, white matter, basal nuclei)
Diencephalon (thalamus, hypothalamus, epithalamus)
Brain stem: midbrain
Brain stem: pons
Cerebellum
Brain stem: medulla oblongata
Spinal cord

(d) Adult brain structures
Cerebrum: Cerebral hemispheres (cortex, white matter, basal nuclei)
Diencephalon (thalamus, hypothalamus, epithalamus)
Brain stem: midbrain
Brain stem: pons
Cerebellum
Brain stem: medulla oblongata
Spinal cord

Parts of Brain



Cerebrum
Diencephalon
Brainstem
Cerebellum

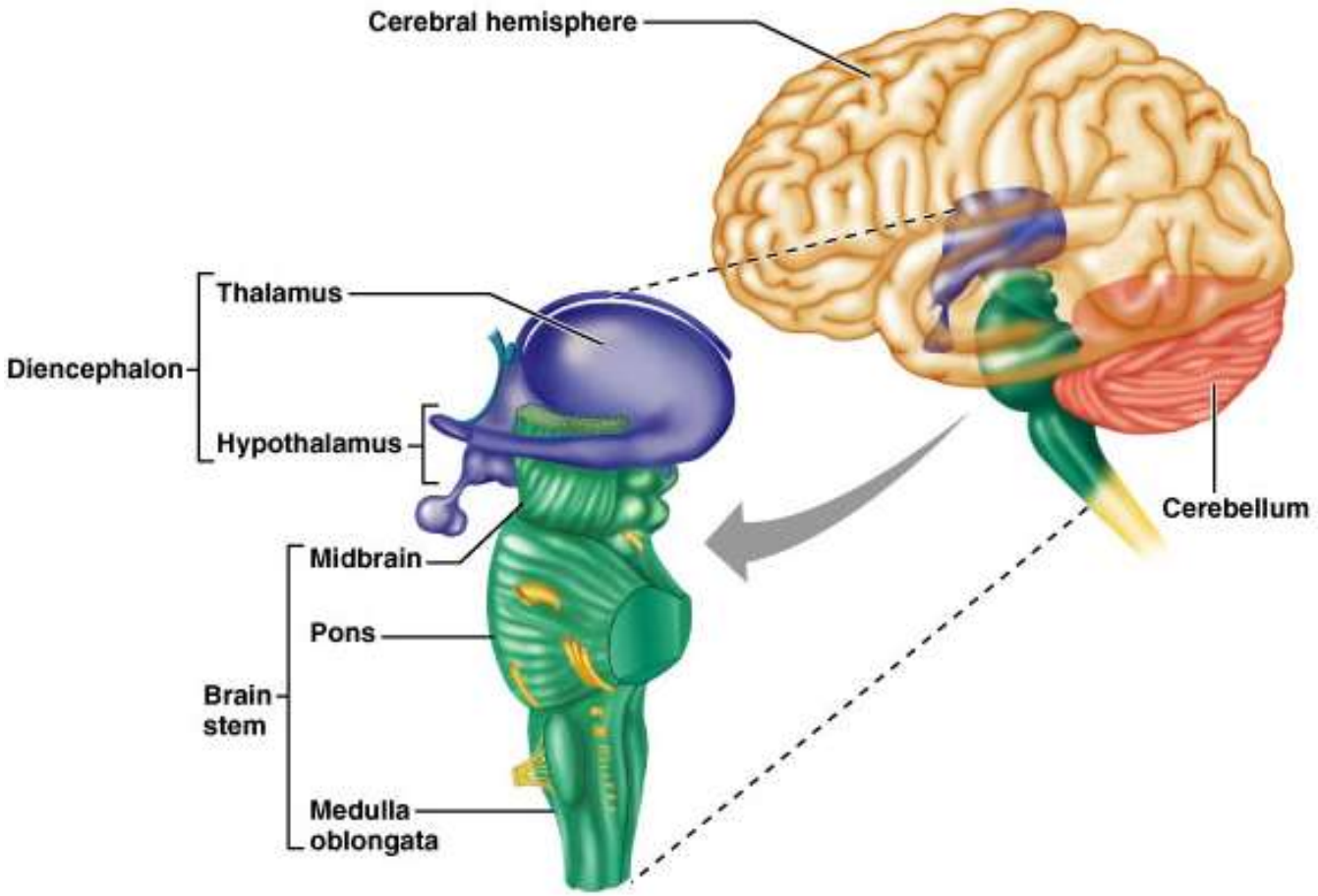
Parts of Brain

Cerebrum

Diencephalon

Brainstem

Cerebellum

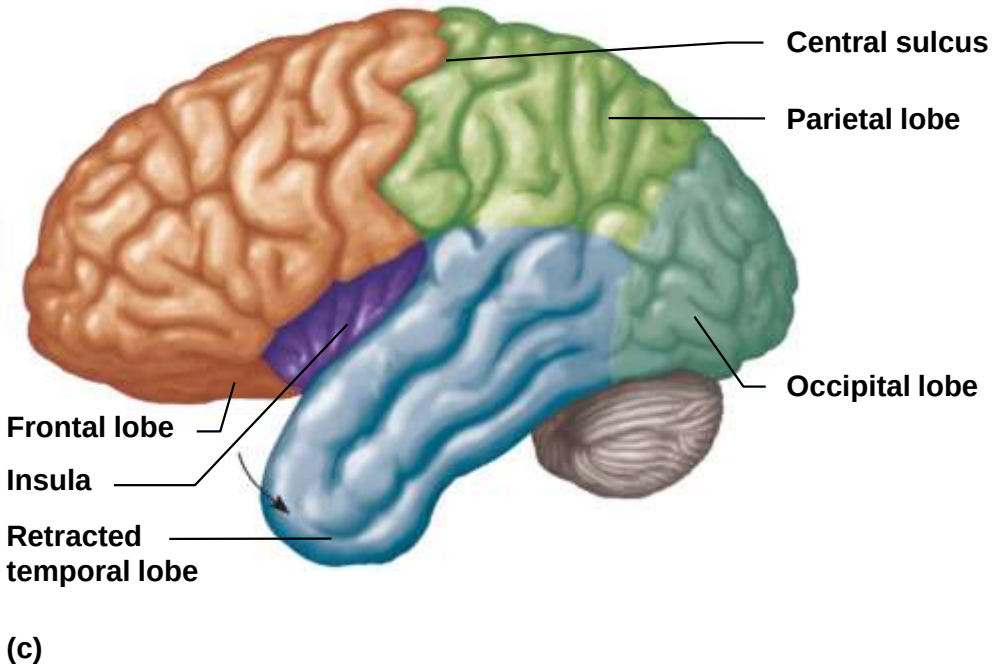


simplified…

- Back of brain: perception
- Top of brain: movement
- Front of brain: thinking

Lobes of the Cerebrum

- Five (5) lobes bilaterally:
  - Frontal lobe
  - Parietal lobe
  - Temporal lobe
  - Occipital lobe
  - Insula aka 'Island of Reil' (functions in interoceptive awareness & judging intensity of pain, among other things)

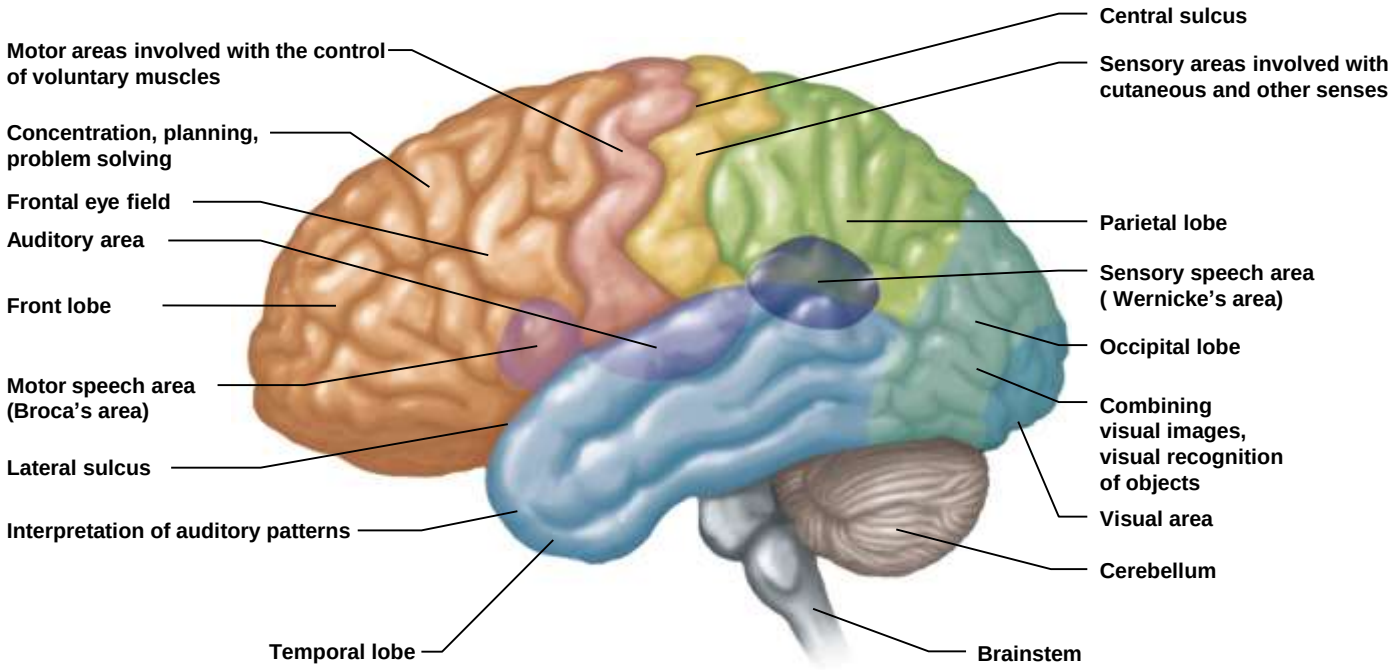


Functions of the Cerebrum

- Interpreting impulses
- Initiating voluntary movements
- Storing information as memory
- Retrieving stored information
- Reasoning
- Seat of intelligence and personality

Functional Regions of the Cerebral Cortex

- Cerebral cortex
  - Thin layer of gray matter that constitutes the outermost portion of cerebrum
  - Contains 75% of all neurons in the nervous system



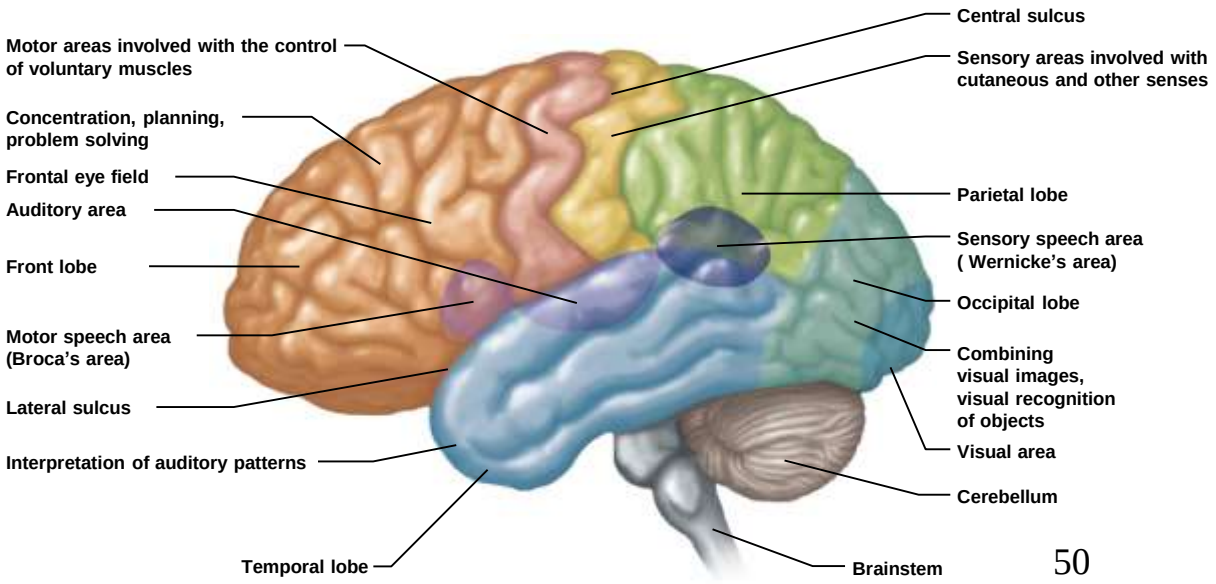
Functions of the Cerebral Lobes

TABLE 11.5 | Functions of the Cerebral Lobes

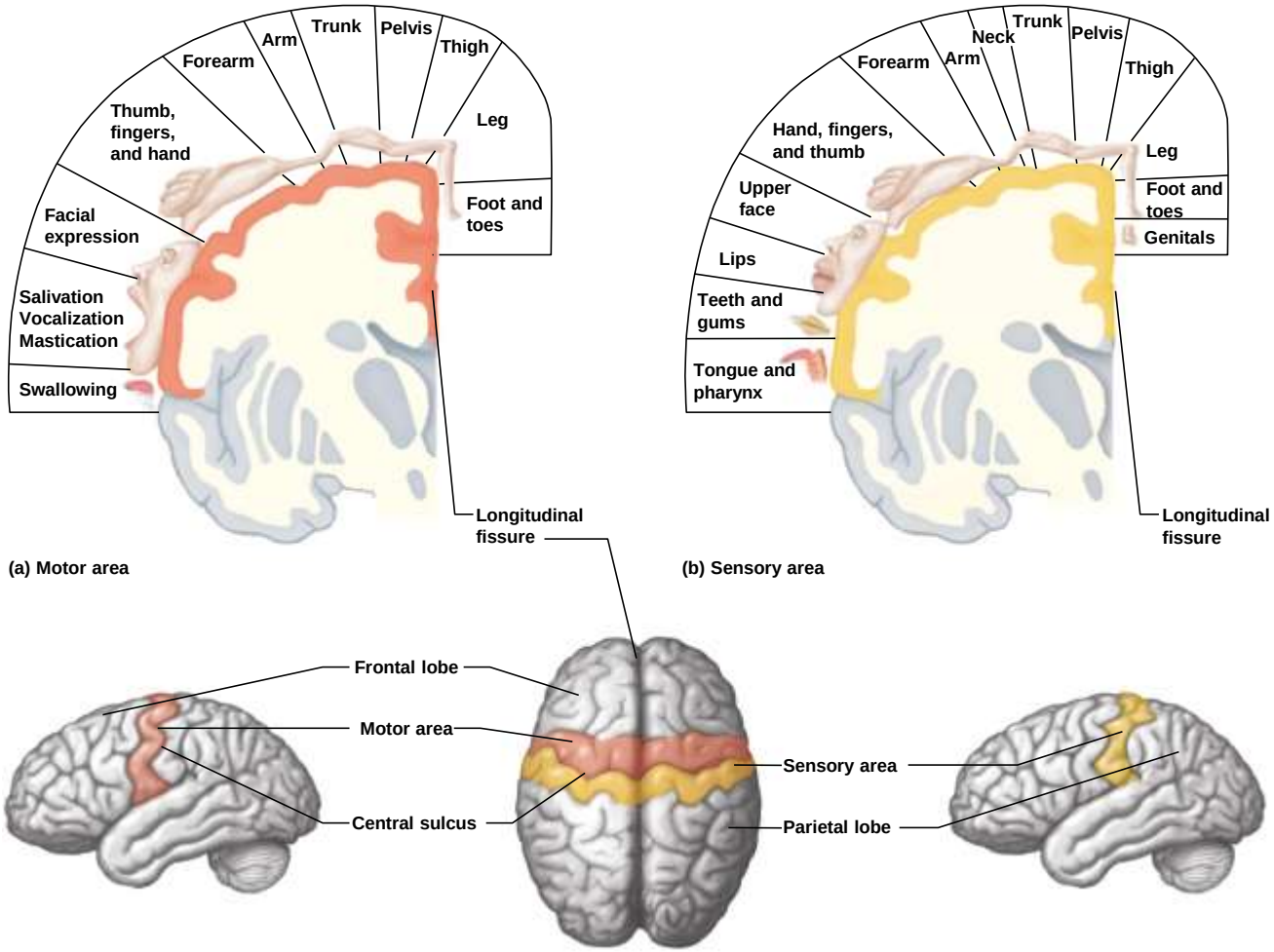
Lobe	Functions
Frontal lobes	Association areas carry on higher intellectual processes for concentrating, planning, complex problem solving, and judging the consequences of behavior. Motor areas control movements of voluntary skeletal muscles.
Parietal lobes	Sensory areas provide sensations of temperature, touch, pressure, and pain involving the skin. Association areas function in understanding speech and in using words to express thoughts and feelings.
Temporal lobes	Sensory areas are responsible for hearing. Association areas interpret sensory experiences and remember visual scenes, music, and other complex sensory patterns.
Occipital lobes	Sensory areas are responsible for vision. Association areas combine visual images with other sensory experiences.

Sensory Areas (post-central sulcus)

- Cutaneous sensory area
  - Parietal lobe
  - Interprets sensations on skin
- Visual area
  - Occipital lobe
  - Interprets vision
- Auditory area
  - Temporal lobe
  - Interprets hearing
- Sensory area for taste
  - Near base of the central sulcus
- Sensory area for smell
  - Arises from centers deep within the cerebrum

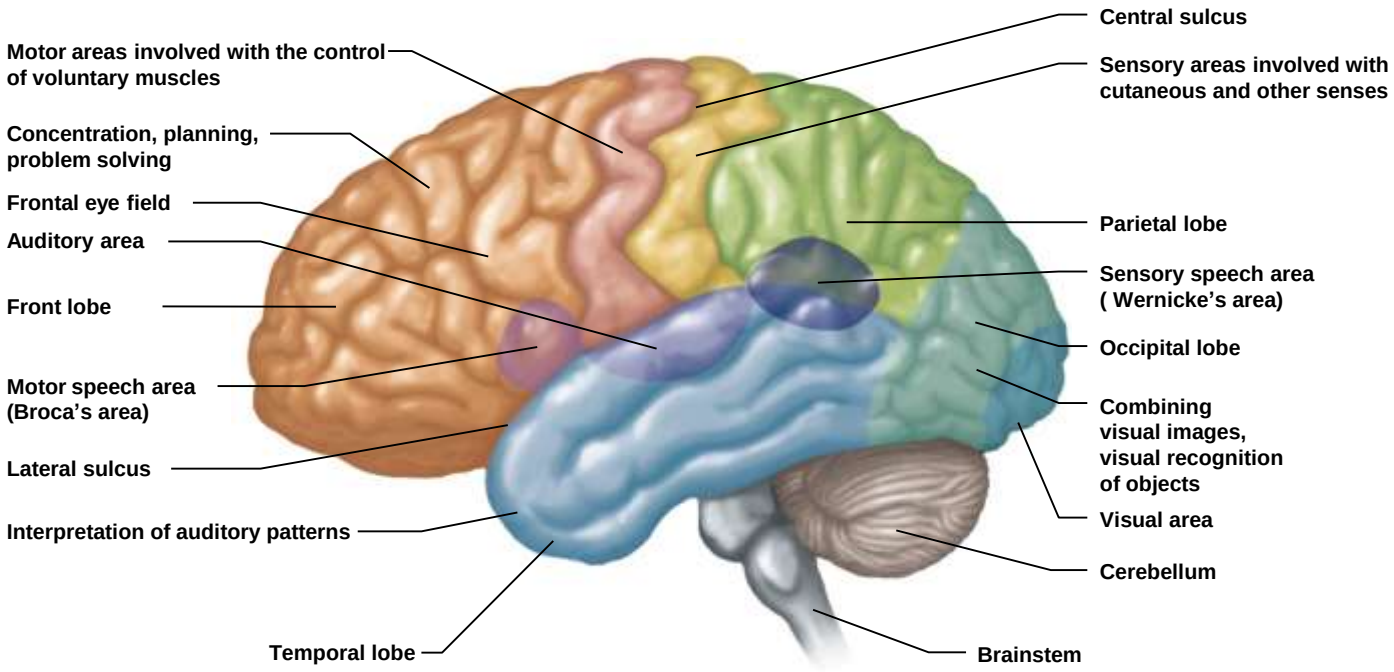


Motor & Sensory Areas



Association Areas

- Regions that are not primary motor or primary sensory areas
- Widespread throughout the cerebral cortex
- Analyze and interpret sensory experiences
- Provide memory, reasoning, verbalization, judgment, emotions

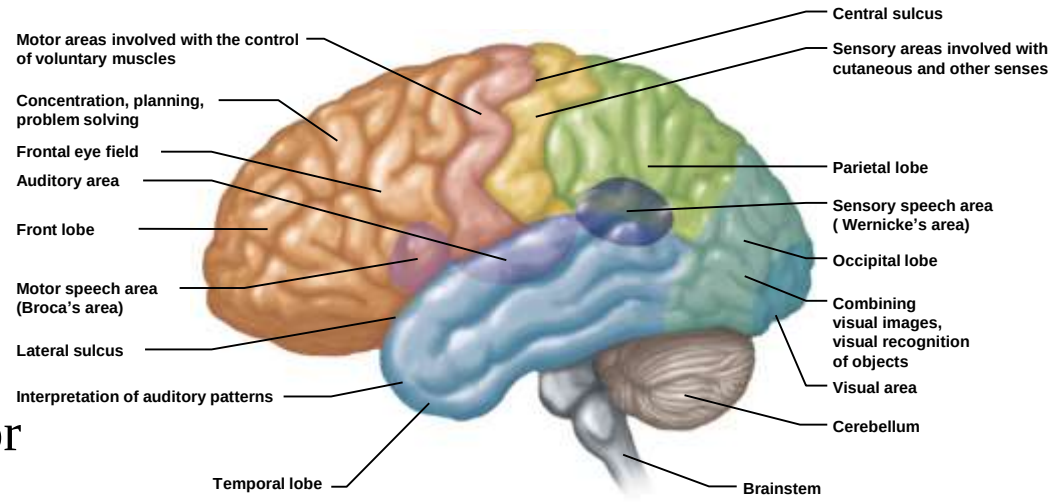


Association Areas

- Frontal lobe association areas
  - Concentrating
  - Planning
  - Complex problem solving
- Parietal lobe association areas
  - Understanding speech
  - Choosing words to express thought
- Temporal lobe association areas
  - Interpret complex sensory experiences
  - Store memories of visual scenes, music, and complex patterns
- Occipital lobe association areas
  - Analyze and combine visual images with other sensory experiences

Motor Areas (pre-central sulcus)

- Primary motor areas
  - Frontal lobes
  - Control voluntary muscles
- Broca's area
  - Anterior to primary motor cortex
  - Usually in left hemisphere
  - Controls muscles needed for speech
- Frontal eye field
  - Above Broca's area
  - Controls voluntary movements of eyes and eyelids

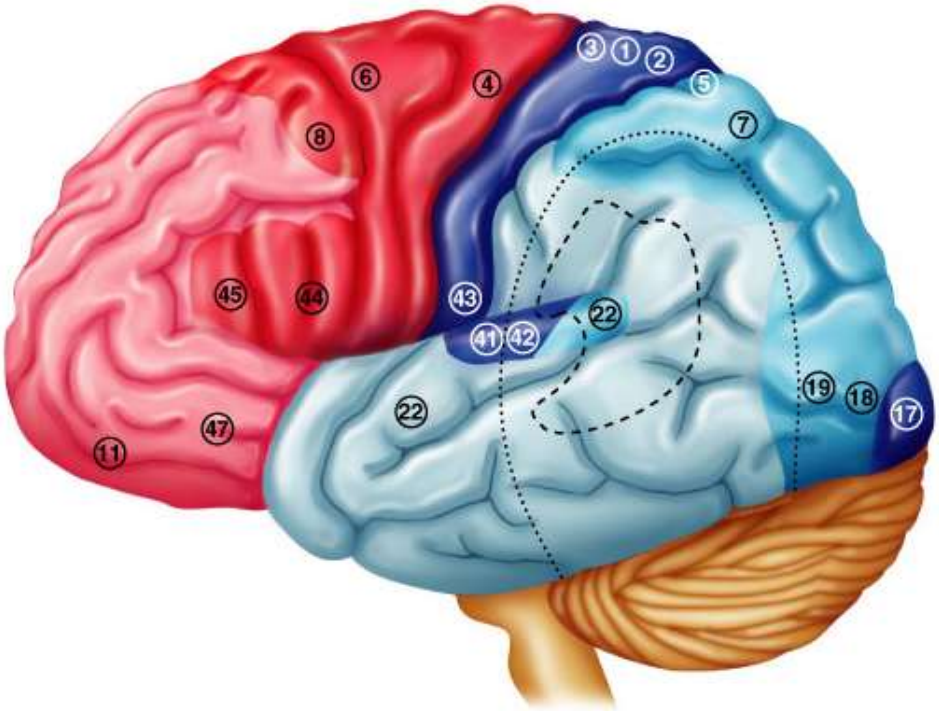


Sensory areas

Posterior to central sulcus

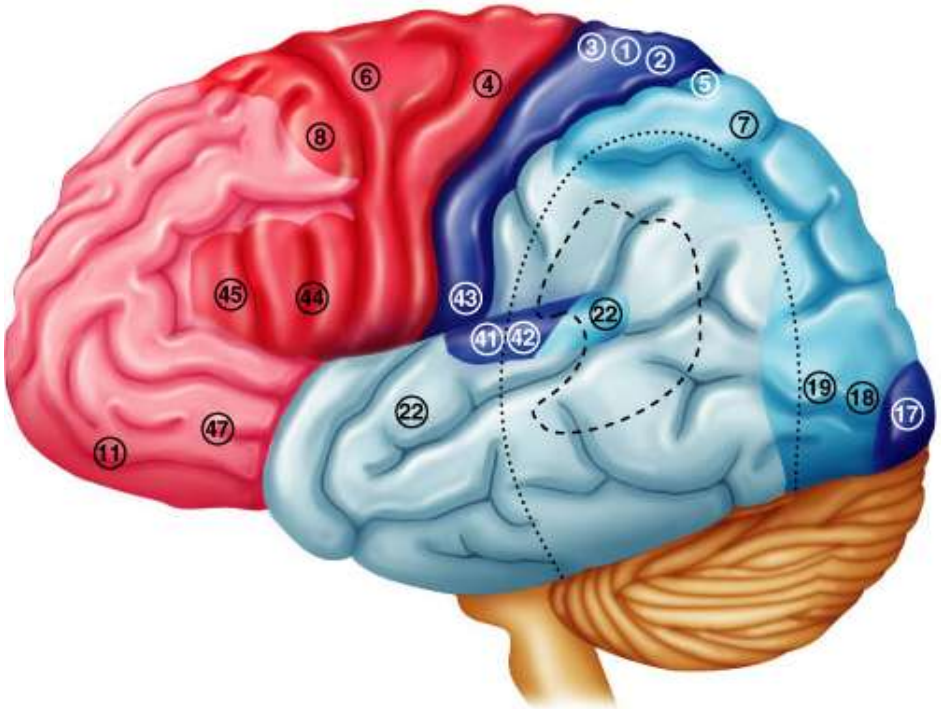
- Primary somatosensory cortex: postcentral gyrus of parietal lobe (allows conscious awareness of sensation and the ability to localize it: *where* the sensation is from)

- Somatosensory association area: behind it (understanding of what is being felt: the *meaning* of it)



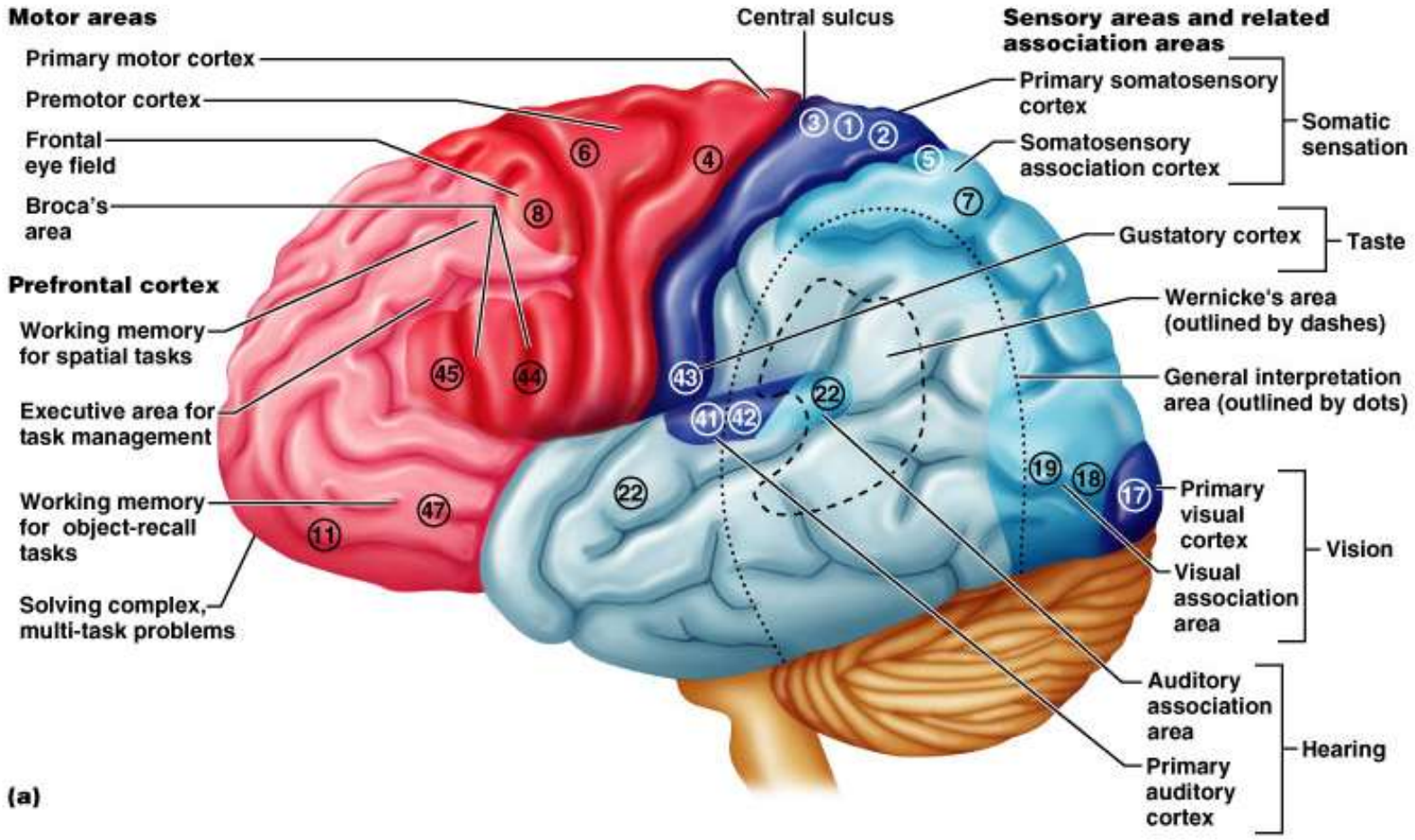
From special sense organs

- Sight: occipital lobe
  - Primary visual cortex (17)
    - Handles info from contralateral retina (right ½ of visual field is on left side)
    - Map of visual space
    - If damaged: functionally blind because no conscious awareness of sight
  - Visual association area (18 & 19)
    - Face recognition is usually on the right side

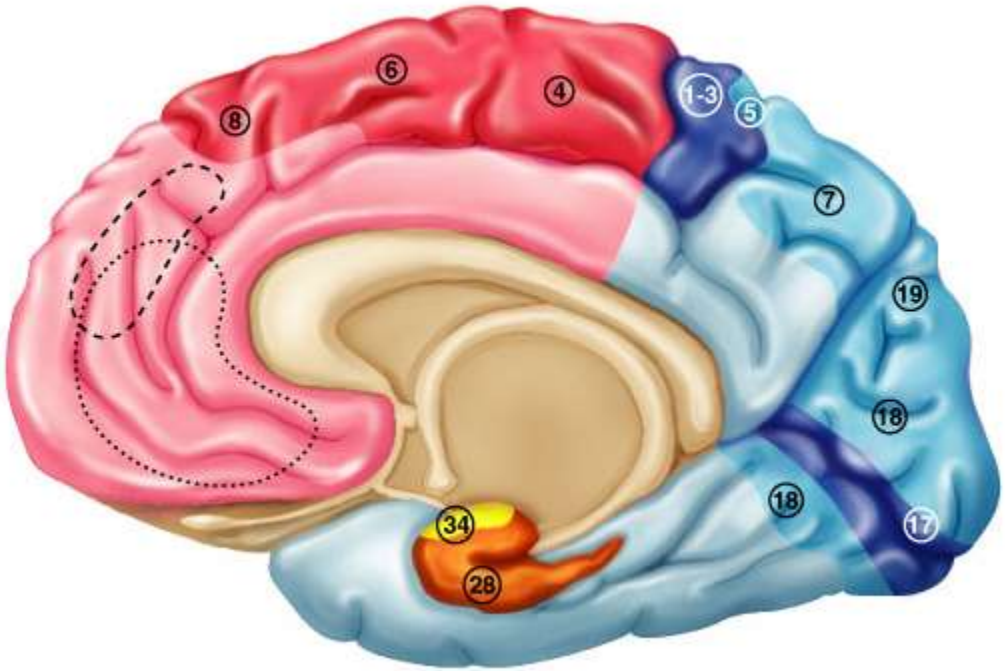


- Hearing: temporal lobe
  - Primary auditory area (41)
  - Auditory association area (22)

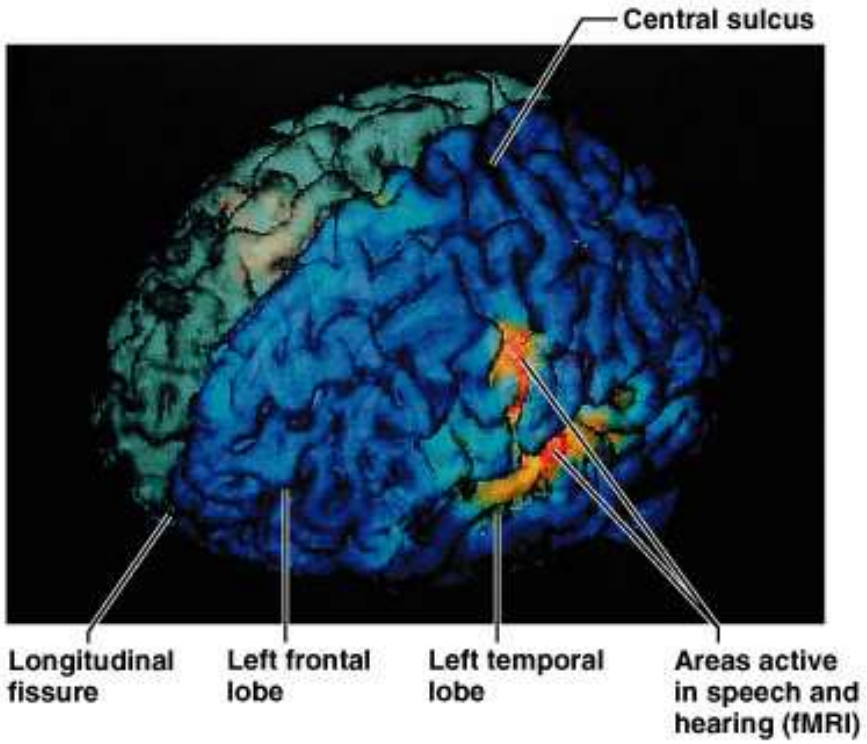
Refer back to this labeled version as needed



- Smell (olfactory sense): uncus
  - Deep in temporal lobe along medial surface



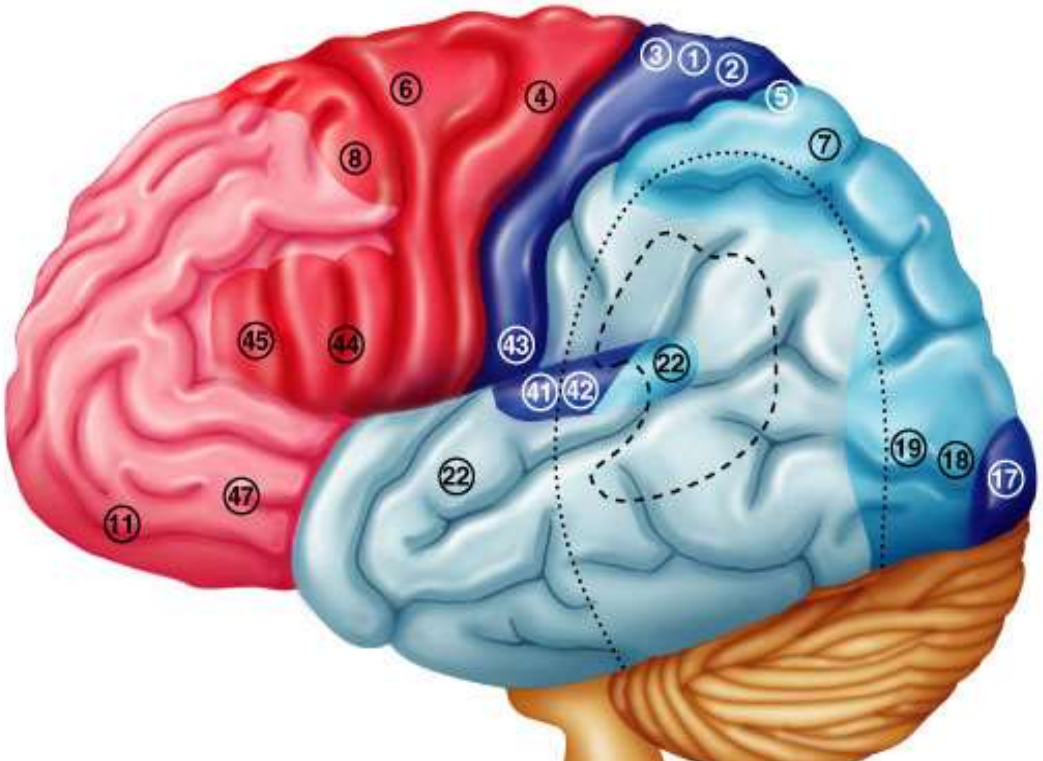
- fMRI: functional magnetic resonance imaging
- Cerebral cortex of person speaking & hearing
- Activity (blood flow) in posterior frontal and superior temporal lobes respectively



Motor areas

Anterior to central sulcus

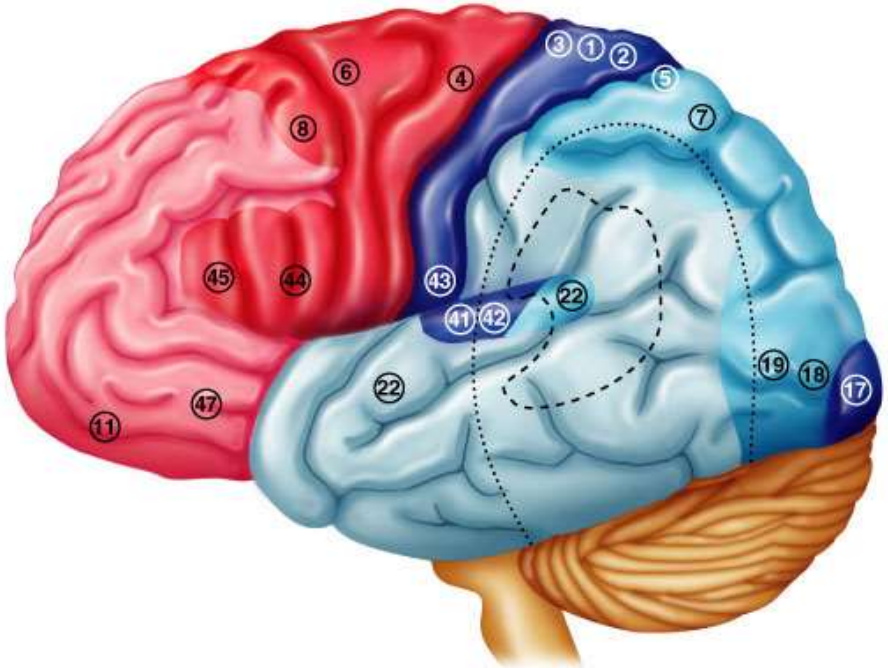
- Primary motor area
  - Precentral gyrus of frontal lobe (4)
  - Conscious or voluntary movement of skeletal muscles



- Primary motor area continued
  - Precentral gyrus of frontal lobe
  - Precise, conscious or voluntary movement of skeletal muscles
  - Large neurons called ***pyramidal cells***
  - Their axons: form massive ***pyramidal*** or ***corticospinal tracts***
    - Desend through brain stem and spinal cord
    - **Cross to contralateral (the other) side** in brainstem
    - Therefore: ***right side of the brain controls the left side of the body, and the left side of the brain controls the right side of the body***

Motor areas – continued

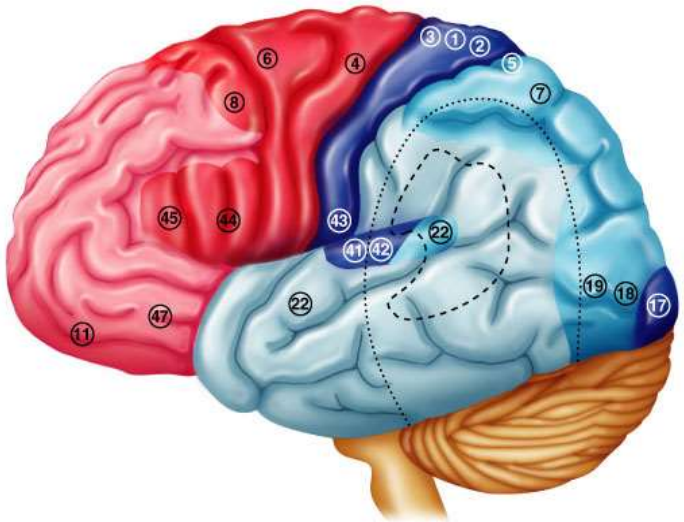
- Broca's area (44): specialized motor speech area
  - Base of precentral gyrus just above lateral sulcus in only one hemisphere, usually left
  - Word articulation: the movements necessary for speech
  - Damage: can understand but can't speak; or if can still speak, words are right but difficult to understand

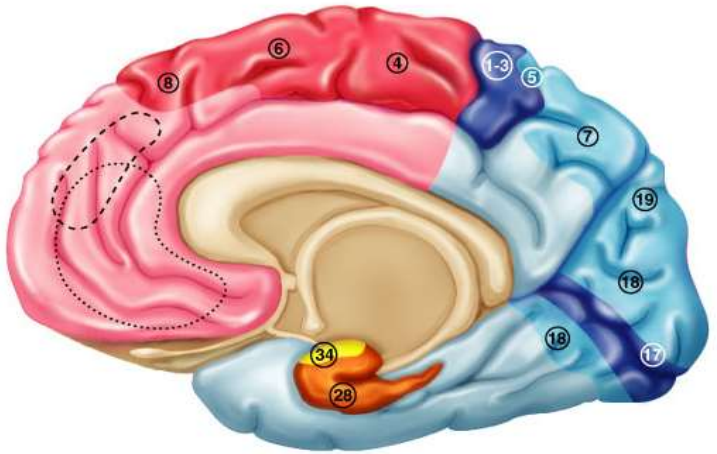


(a)

Motor areas – continued

- Premotor cortex (6): complex movements asociated with highly processed sensory info; also planning of movements
- Frontal eye fields (inferior 8): voluntary movements of eyes





(a)

Association Areas

Remember…

- Three kinds of functional areas (cerebrum)
  1. ***Motor*** areas: movement
  2. ***Sensory*** areas: perception
  3. ***Association*** areas: everything else

Association Areas

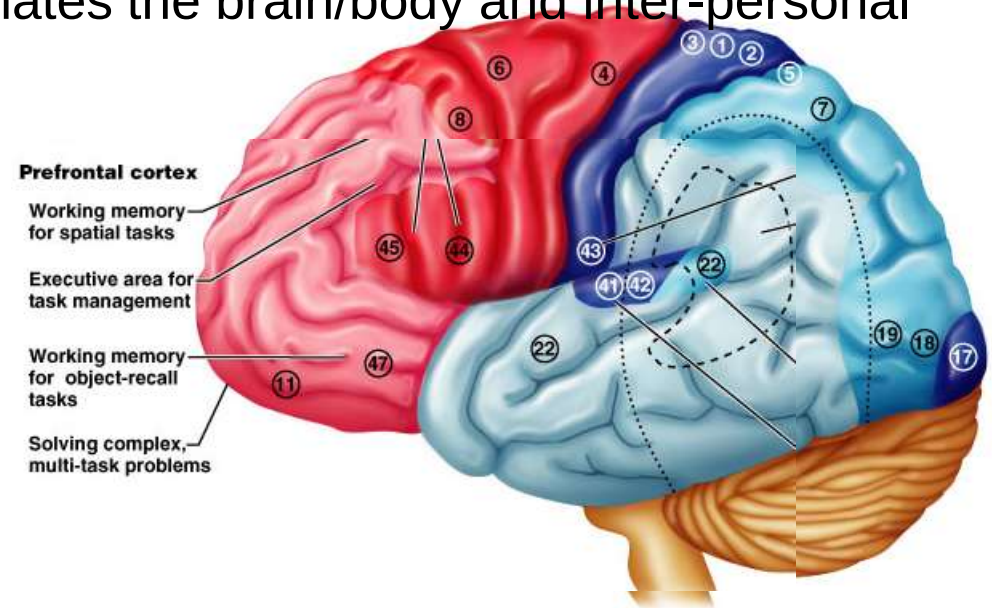
- Tie together different kinds of sensory input
- Associate new input with memories
- Is to be renamed ***“higher-order processing“ areas***

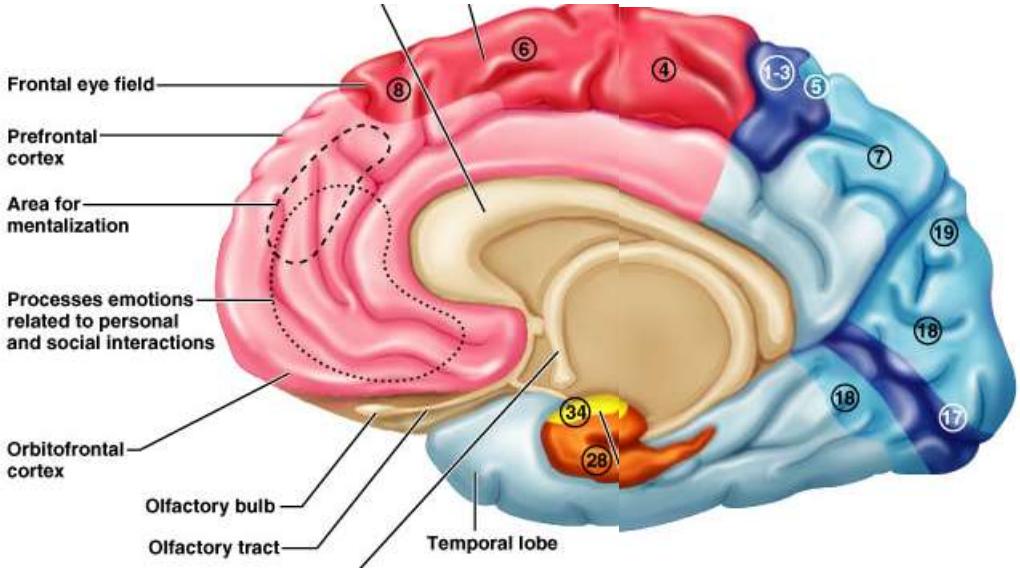
Prefrontal cortex: cognition

This area is remodeled during adolescence until the age of 25 and is very important for well-being; it coordinates the brain/body and inter-personal world as a whole

Intellect
Abstract ideas
Judgment
Personality
Impulse control
Persistence
Complex
Reasoning
Long-term
planning

Social skills
Appreciating
humor
Conscience
Mood
Mental
flexibility
Empathy





Executive functioning
e.g. multiple step problem solving
requiring temporary storage of infc
(working memory)

Wernicke's area

Region involved in recognizing and understanding spoken words

- Junction of parietal and temporal lobes
- One hemisphere only, usually left
- (Outlined by dashes)
- Pathology: comprehension impaired for written and spoken language: output fluent and voluminous

  but incoherent

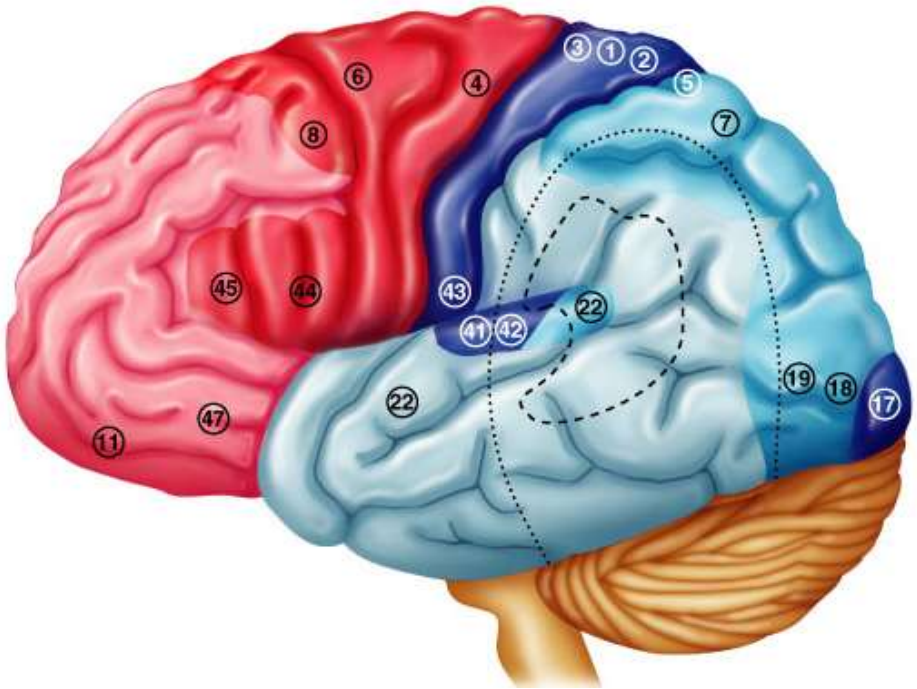
  (words understandable

  but don't make sense;

  as opposed to the

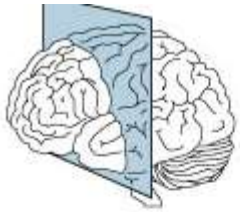
  opposite with Broca's

  area)

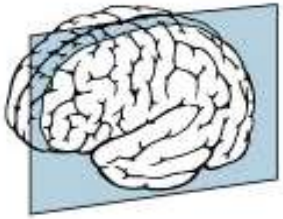


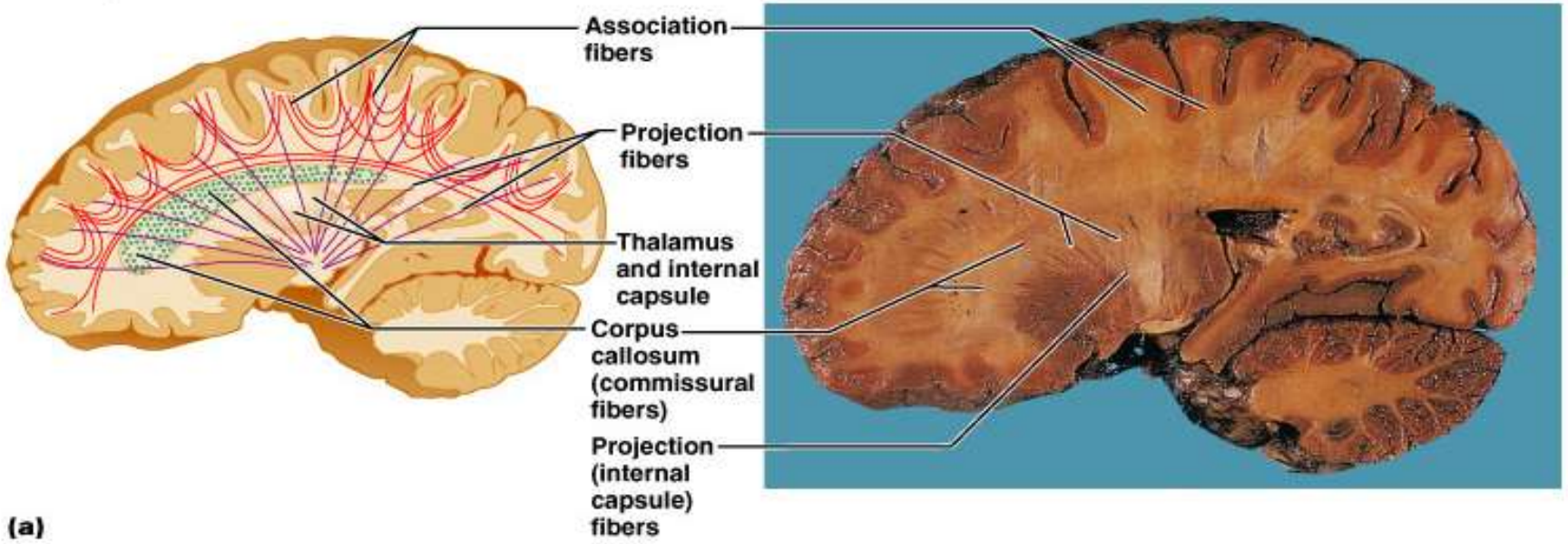
Cerebral white matter

- Extensive communication
  - Areas of cortex with each other
  - Areas of cortex with brain stem and spinal cord
- Via (mostly) myelinated axon fibers bundled into tracts
  - Commissures
  - Association fibers
  - Projection fibers

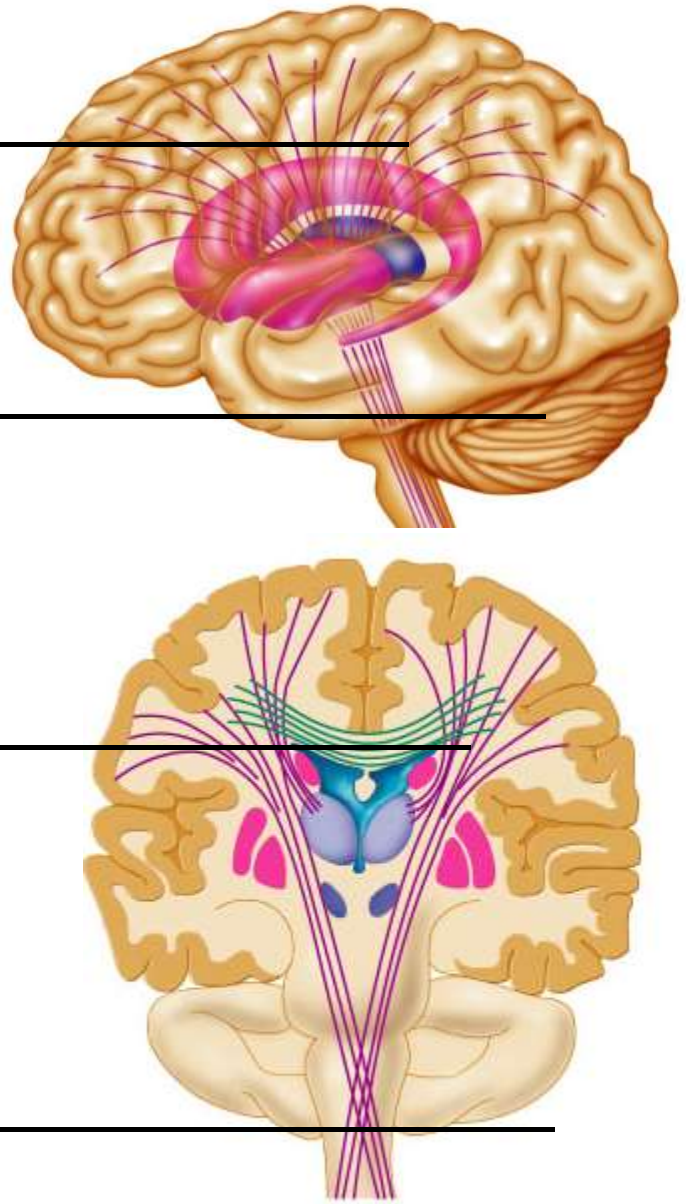


- **Commissures**: interconnect right and left hemispheres so can act as a whole
  - ***Corpus callosum*** is largest
- **Association fibers**: connect different parts of the *same* hemisphere; can be long or short
- **Projection fibers:** run *vertically*
  - Cerebral cortex running down (with motor instructions)
  - Or ascend to cerebral cortex from below (sensory info to cortex)



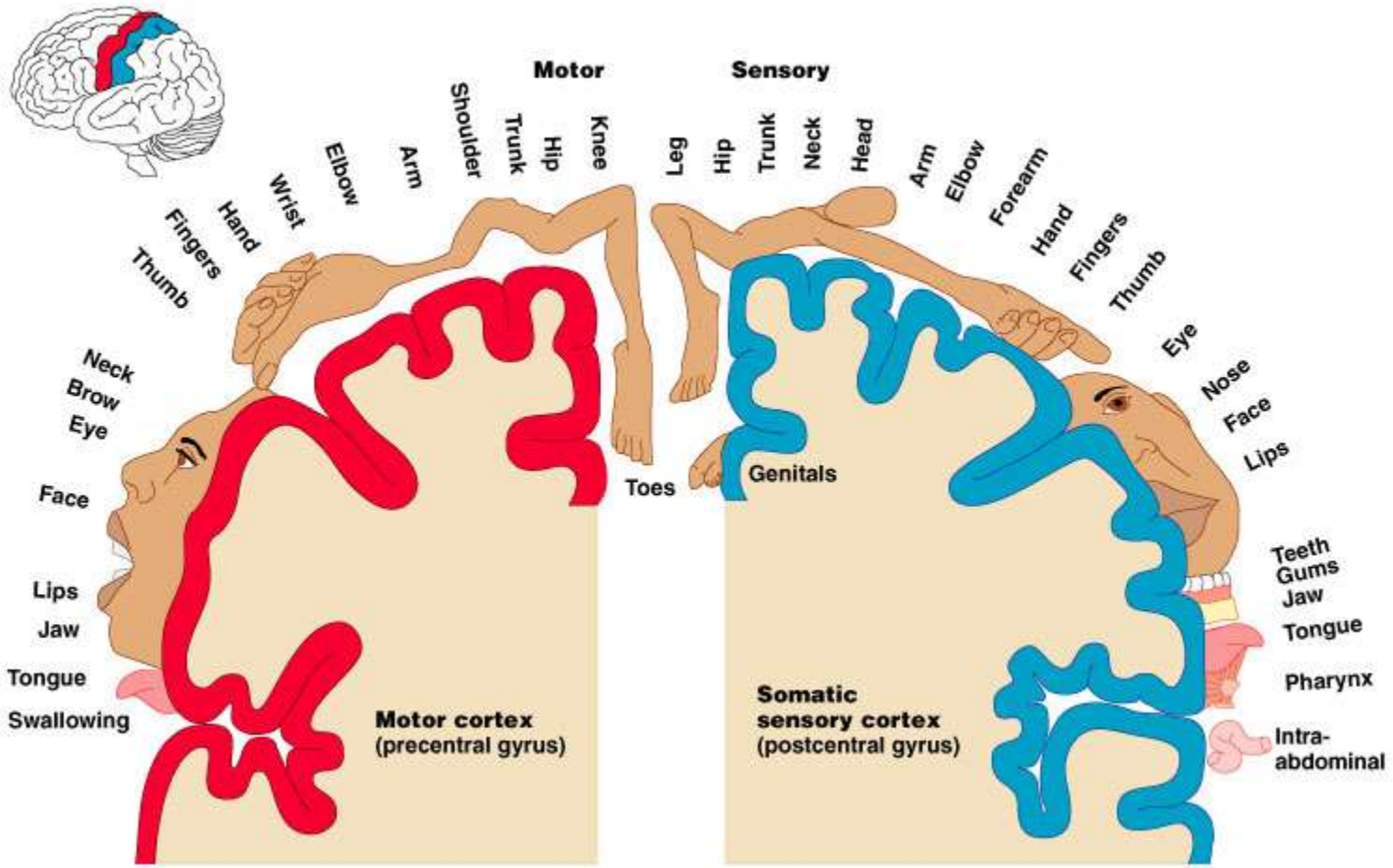


- Projection fibers
  - Corona radiata: fanning out of the fibers
  - Internal capsule: bundled, pass down
- Commisure
  - Corpus callosum: connects right and left hemispheres
- Decussation: crossing of pyramidal tracts



Homunculus – “little man”

- Body map: human body spatially represented
  - Where on cortex; upside down



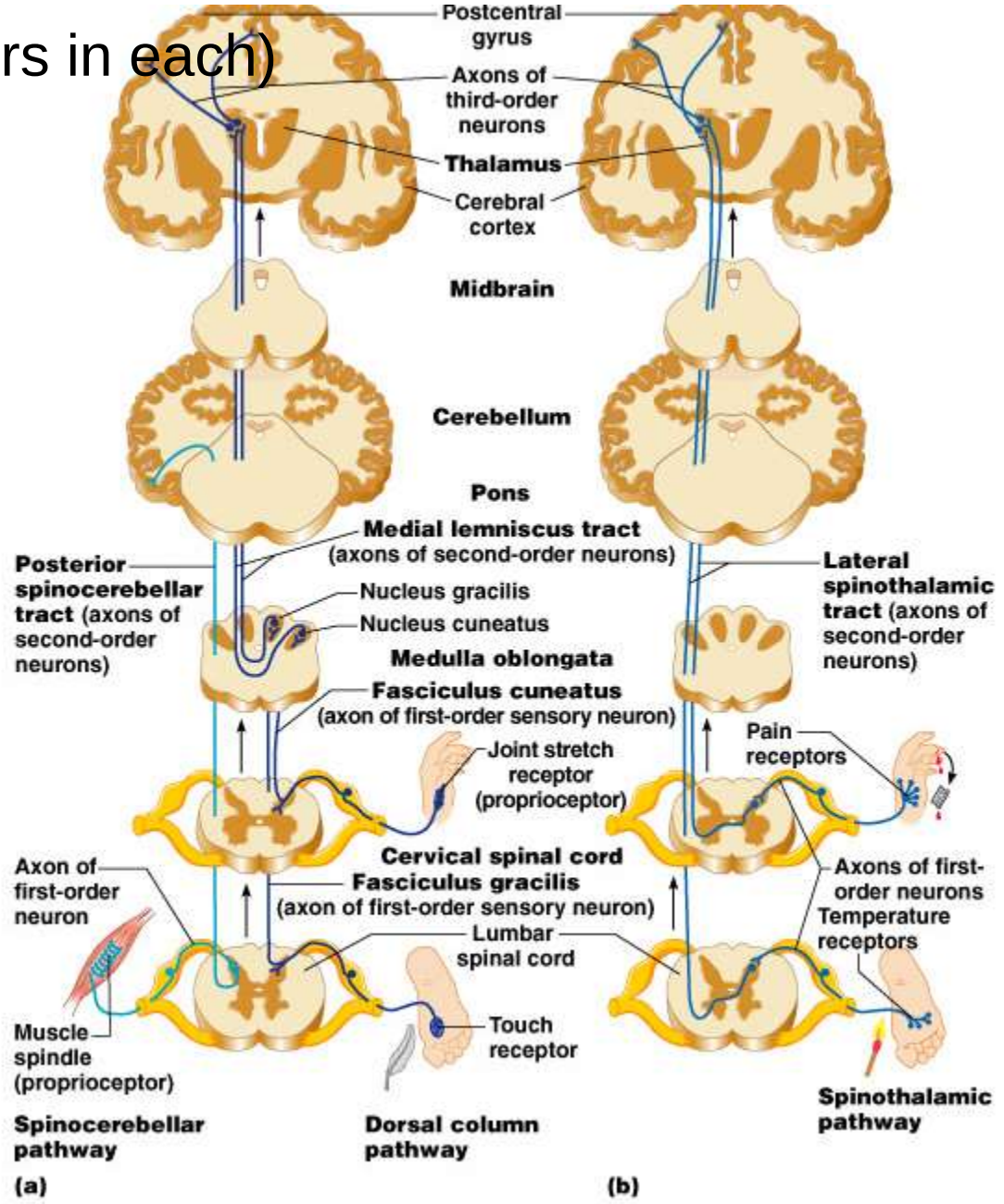
Major ascending pathways for the somatic senses

(thousands of nerve fibers in each)

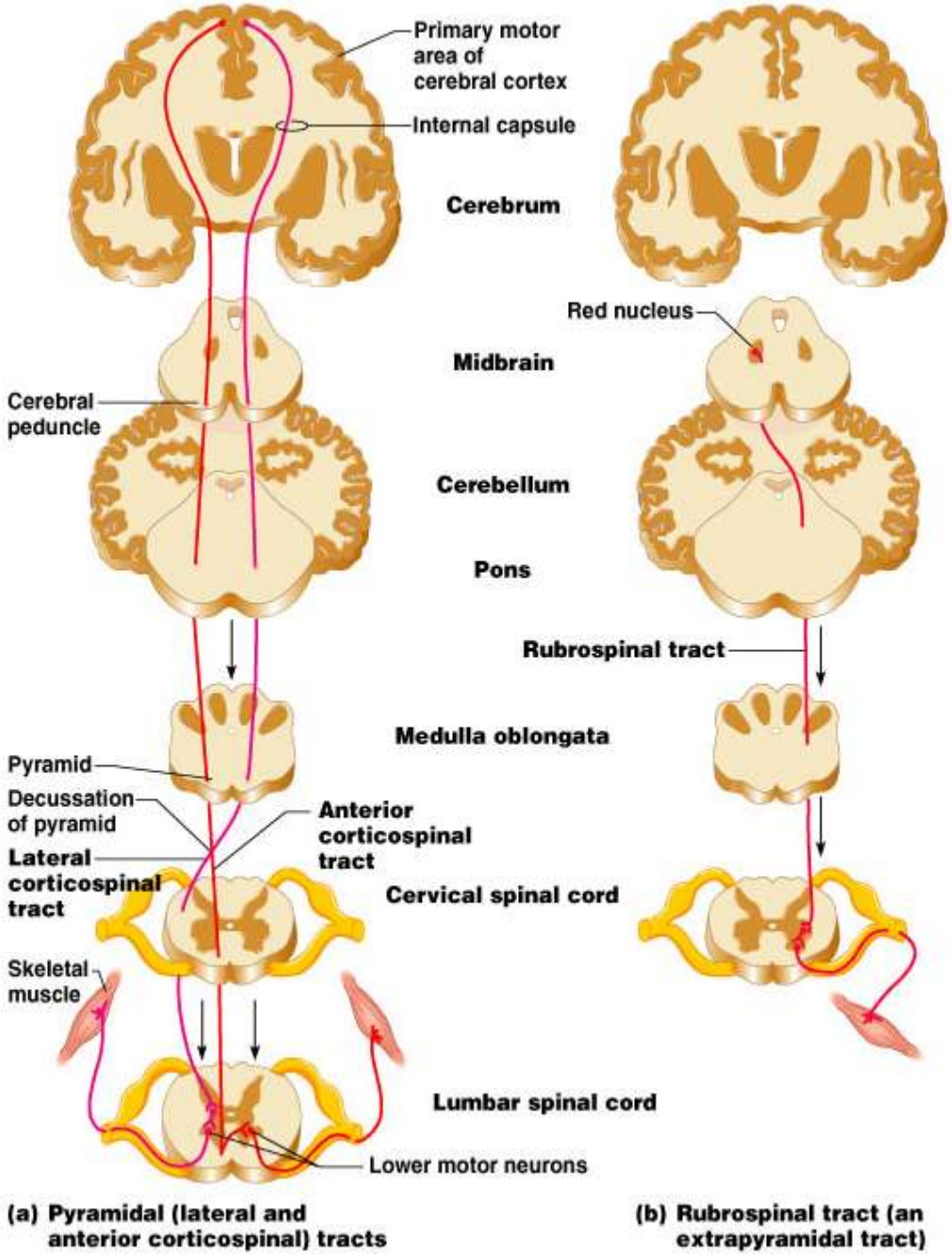
Spinocerebellar: proprioception from skeletal muscles to cerebellum of same side (don't cross)

Dorsal column: discriminative touch sensation through thalamus to somatosensory cortex (cross in medulla)

Spinothalamic: carries non discriminate sensations (pain, temp, pressure) through the thalamus to primary somatosensory cortex (cross in spinal cord before ascending)



Some Descending Pathways



Synapse with ventral (anterior) horn interneurons

Pyramidal tracts:
Lateral corticospinal – cross in pyramids of medulla; voluntary motor to limb muscles
Ventral (anterior) corticospinal – cross at spinal cord; voluntary to axial muscles

***"Extrapyramidal" tracts*:** one example

Hemisphere Dominance

- The left hemisphere is dominant in most individuals

- Dominant hemisphere controls:
  - Speech
  - Writing
  - Reading
  - Verbal skills
  - Analytical skills
  - Computational skills

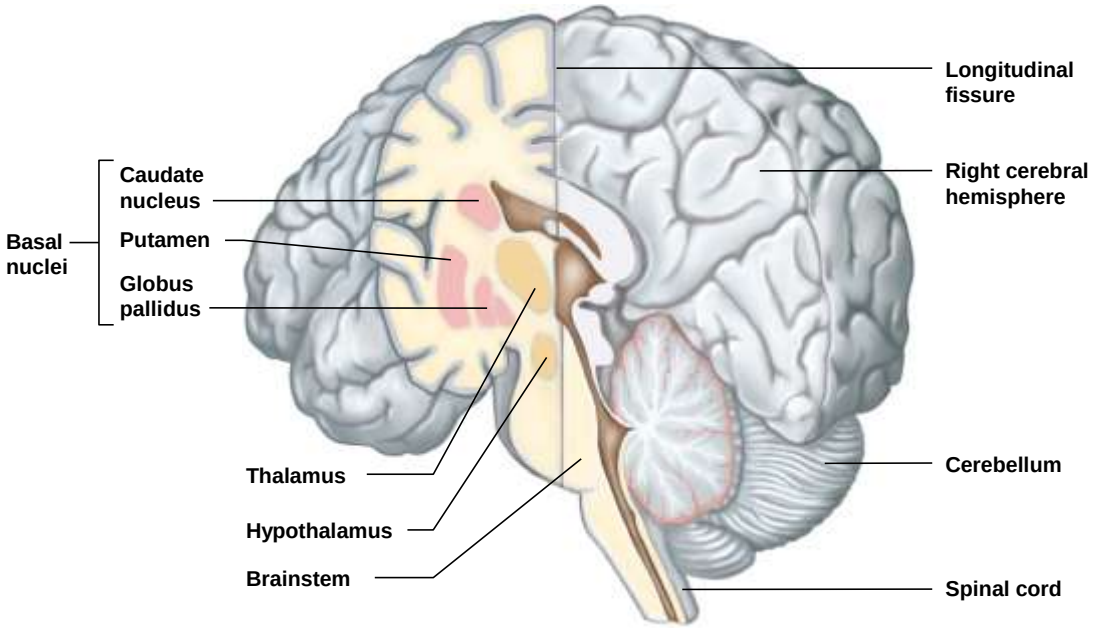
- Nondominant hemisphere controls:
  - Nonverbal tasks
  - Motor tasks
  - Understanding and interpreting musical and visual patterns
  - Provides emotional and intuitive thought processes

Memory

- Short term memory
  - Working memory
  - Closed neuronal circuit
  - Circuit is stimulated over and over
  - When impulse flow ceases, memory does also unless it enters long-term memory via memory consolidation
  - Limited to 7 bits of information
- Long term memory
  - Changes structure or function of neurons
  - Enhances synaptic transmission

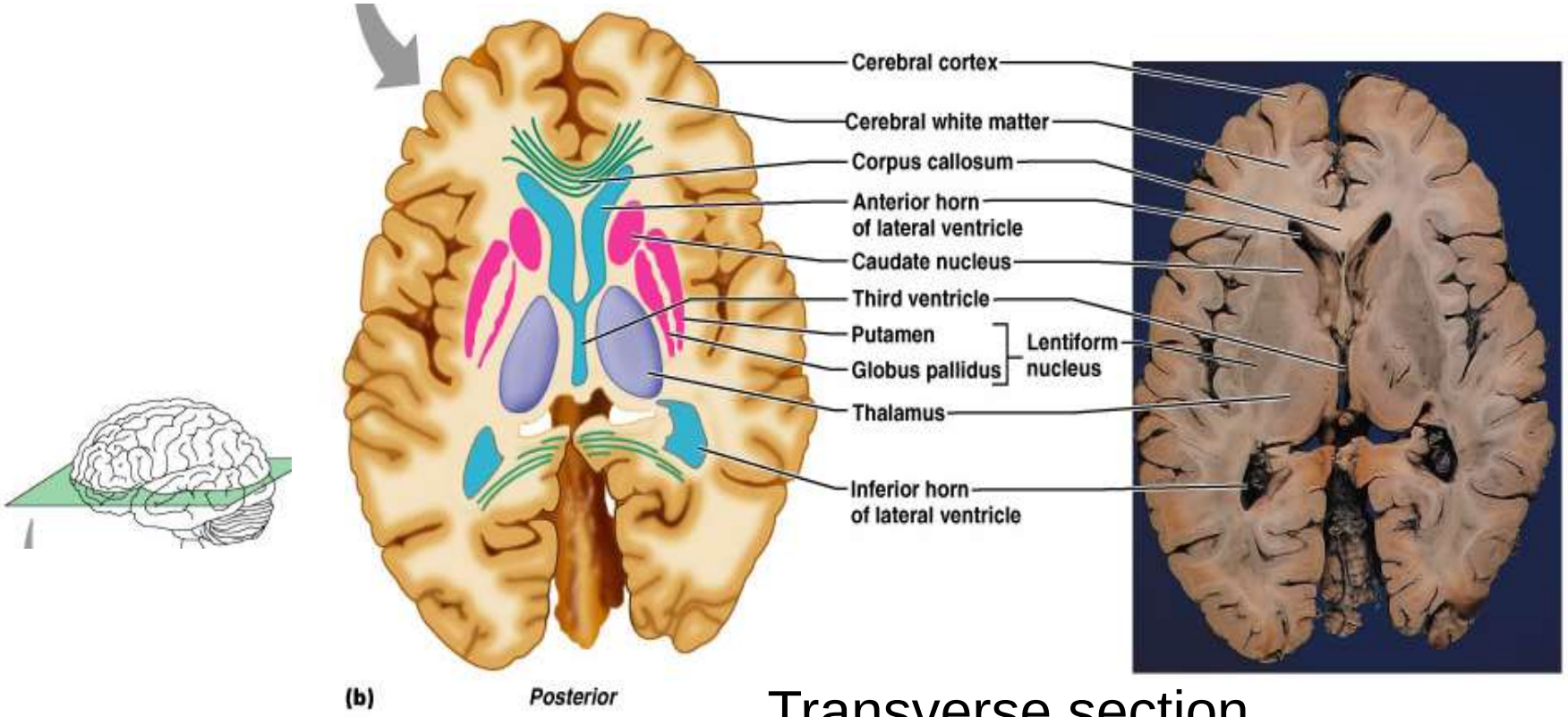
Basal Nuclei

- Masses of gray matter
- Deep within cerebral hemispheres
- Produce dopamine
- Control certain muscular activities
- Primarily by inhibiting motor functions



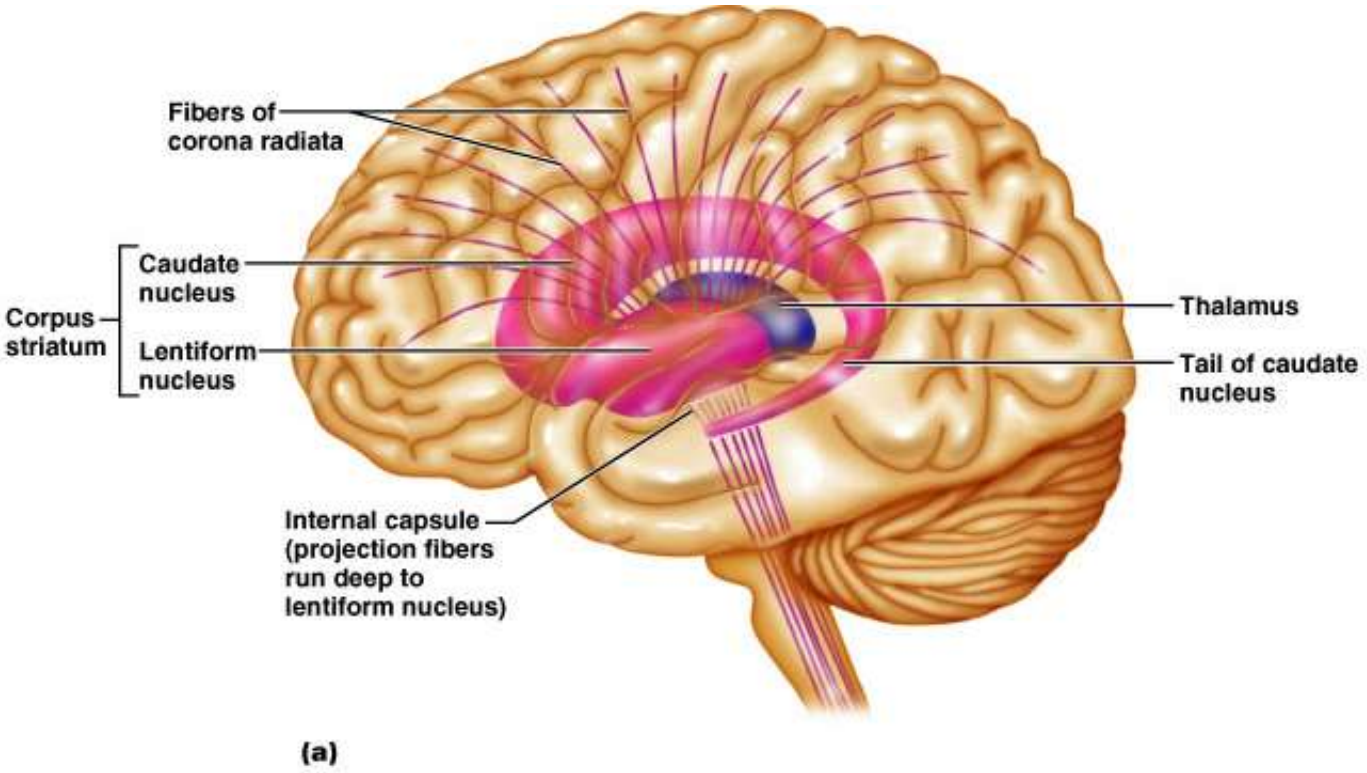
Basal ganglia

- Subcortical ***motor*** nuclei
- Part of “extrapyramidal system”
- Cooperate with cerebral cortex in controlling movements
- Most important ones: ***caudate nucleus***, ***lentiform nucleus*** composed of ***putamen*** and ***globus pallidus***



Transverse section

- Internal capsule passes between diencephalon and basal ganglia to give them a striped appearance
  - Caudate and lentiform sometimes called ***corpus striatum*** because of this



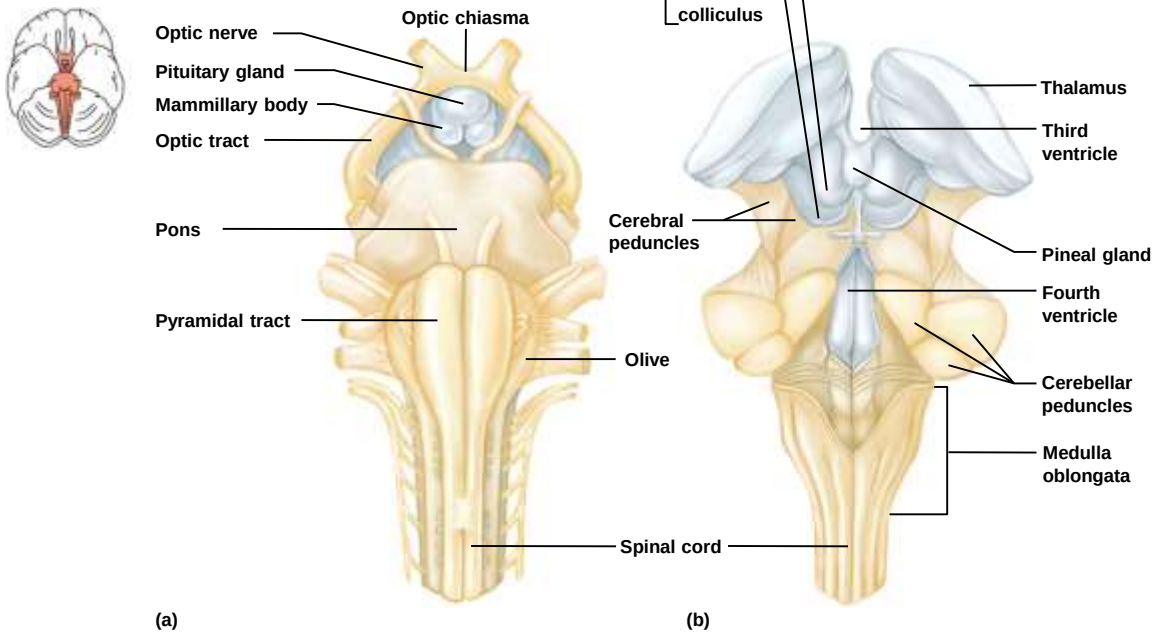
Basal ganglia

- Cooperate with cerebral cortex in controlling movements
- Communicate with cerebral cortex, receive input from cortical areas, send most of output back to motor cortex through thalamus
- Involved with stopping/starting & intensity of movements
- “Dyskinesias” – “bad movements”
  - Parkinson’s disease: loss of inhibition from substantia nigra of midbrain – everything slows down
  - Huntington disease: overstimulation (“choreoathetosis”) – degeneration of corpus striatum which inhibits; eventual degeneration of cerebral cortex (AD; genetic test available)
  - Extrapyramidal drug side effects: “tardive dyskinesia”
    - Can be irreversible; haloperidol, thorazine and similar drugs

Diencephalon

- Between cerebral hemispheres and above the brainstem
- Surrounds the third ventricle

- Thalamus
- Epithalamus
- Hypothalamus
- Optic tracts
- Optic chiasm
- Infundibulum
- Posterior pituitary
- Mammillary bodies
- Pineal gland

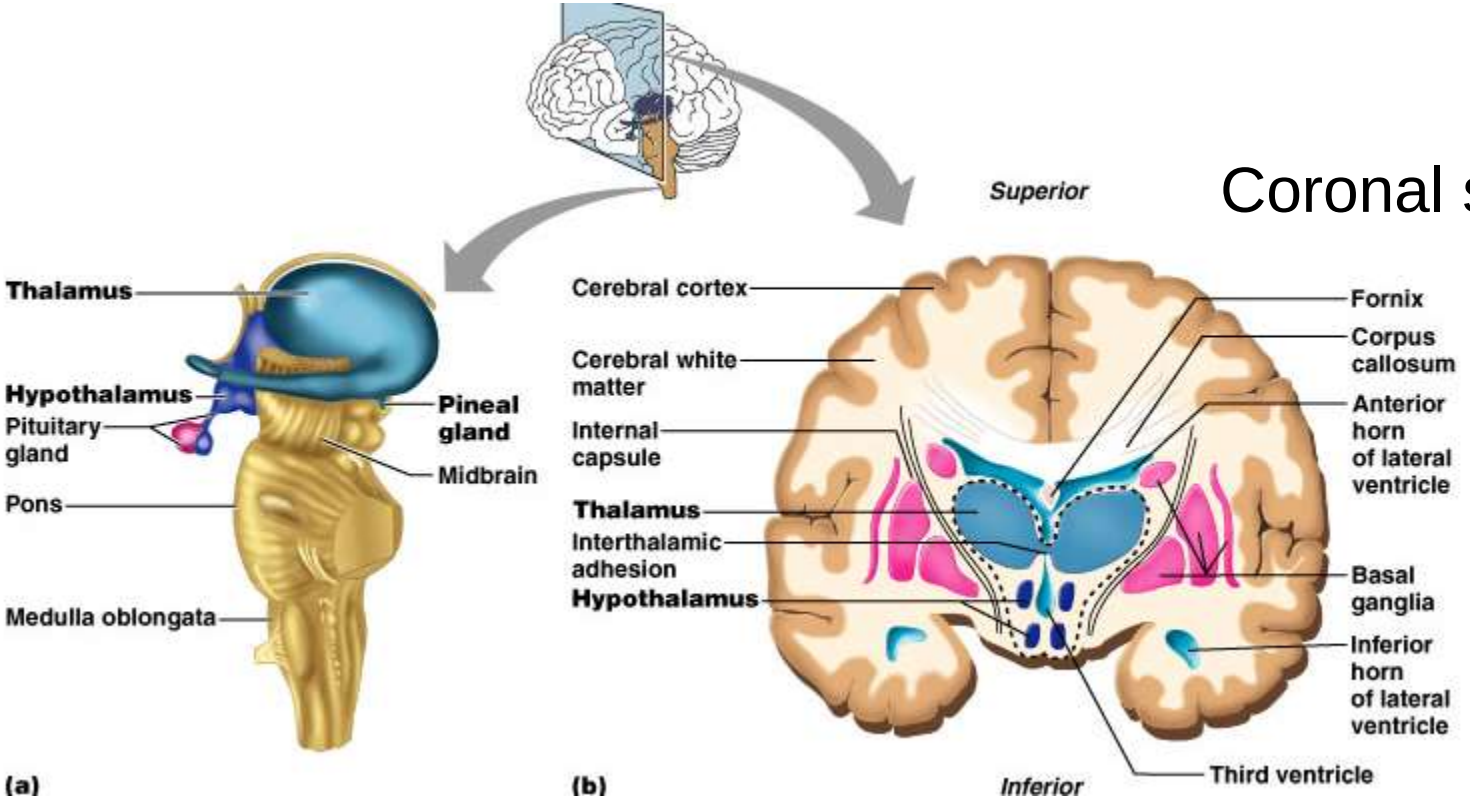


Diencephalon

- Thalamus
  - Gateway for sensory impulses heading to cerebral cortex
  - Receives all sensory impulses (except smell)
  - Channels impulses to appropriate part of cerebral cortex for interpretation
- Epithalamus
  - Functions to connect the limbic system to other parts of the brain.
- Hypothalamus
  - Maintains homeostasis by regulating visceral activities
  - Links nervous and endocrine systems (hence some say the neuroendocrine system)

Thalamus (egg shaped; means inner room)

- Two large lobes of gray matter (over a dozen nuclei)
- Laterally enclose the 3rd ventricle
- Gateway to cerebral cortex: ***every part of brain that communicates with cerebral cortex relays signals through a nucleus in the thalamus*** (e.g. certain nucleus for info from retina another from ears, etc.)
- Processing (editing) occurs also in thalamus



Coronal section

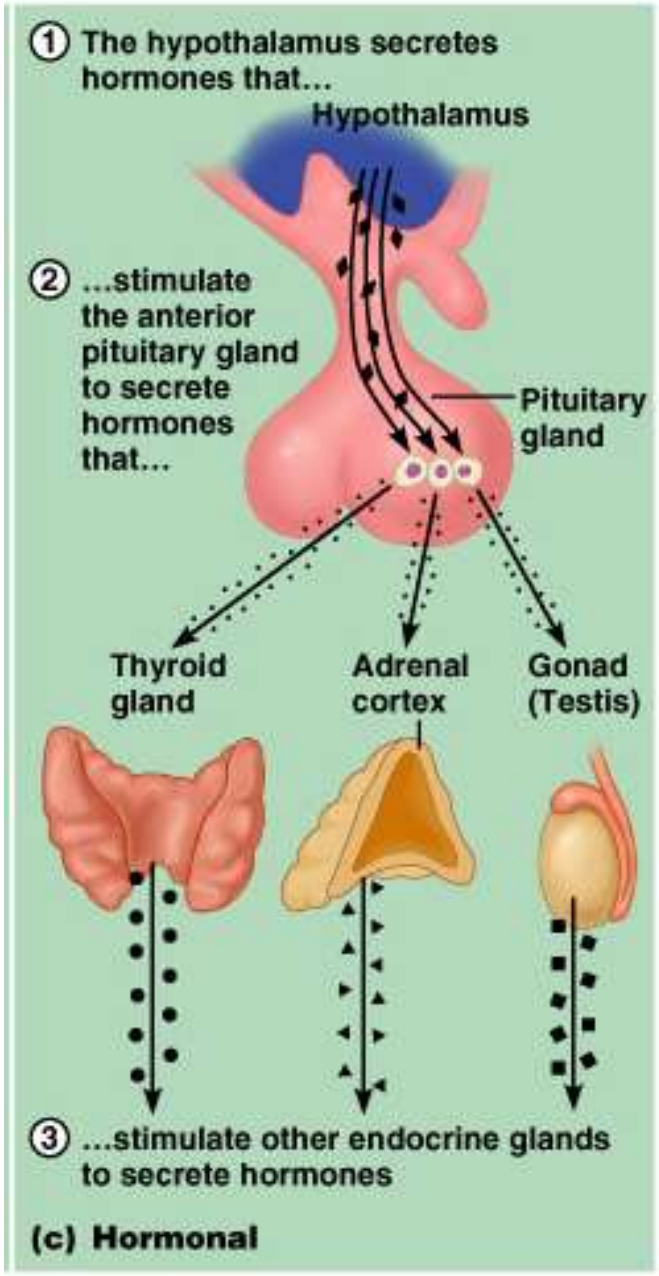
Hypothalamus

- “Below thalamus”
- Main visceral control center
  - Autonomic nervous system (peripheral motor neurons controlling smooth and cardiac muscle and gland secretions): heart rate, blood pressure, gastrointestinal tract, sweat and salivary glands, etc.
  - Emotional responses (pleasure, rage, sex drive, fear)
  - Body temp, hunger, thirst sensations
  - Some behaviors
  - Regulation of sleep-wake centers: circadian rhythm (receives info on light/dark cycles from optic nerve)
  - Control of endocrine system through pituitary gland
  - Involved, with other sites, in formation of memory

Hypothalamus

(one example of its functioning)

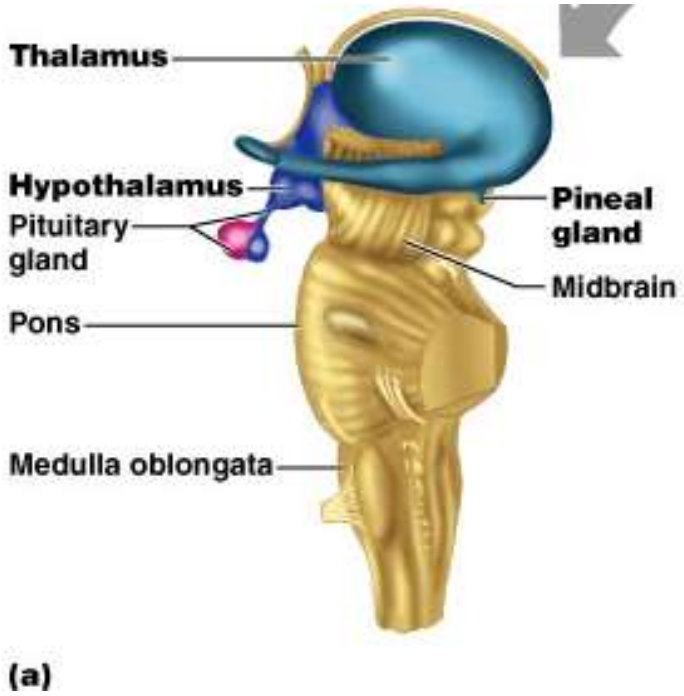
Control of endocrine system through pituitary gland

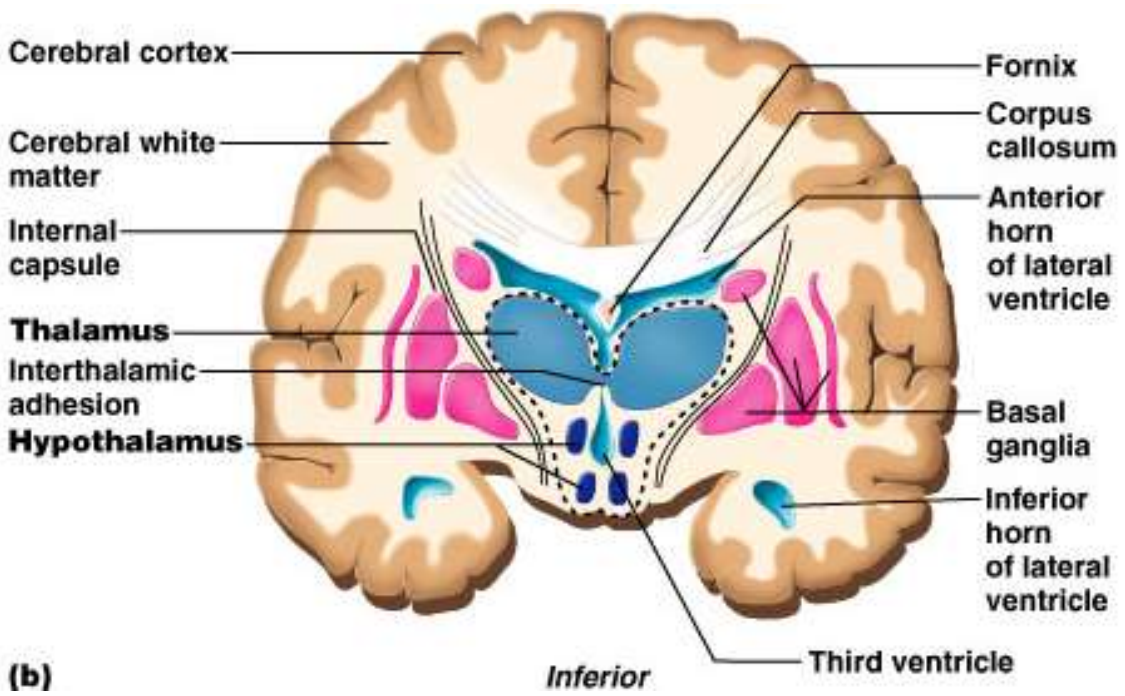


Epithalamus

- Third and most dorsal part of diencephalon
- Part of roof of 3rd ventricle
- Pineal gland or body (unpaired): produces melatonin signaling nighttime sleep
- Also a tiny group of nuclei

Coronal section





Diencephalon

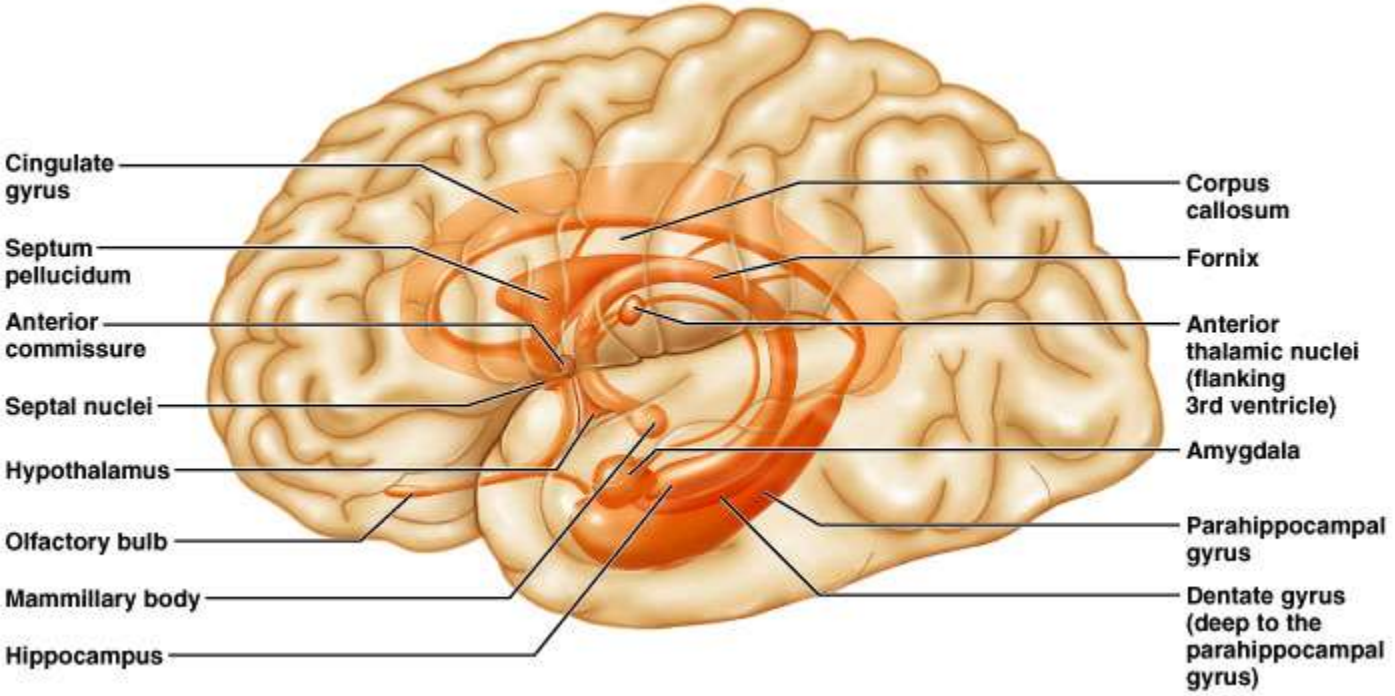
The Limbic System

- Consists of:
  - Portions of frontal lobe
  - Portions of temporal lobe
  - Hypothalamus
  - Thalamus
  - Basal nuclei
  - Other deep nuclei
- Functions:
  - Controls emotions
  - Produces feelings
  - Interprets sensory impulses

Limbic system

(not a discrete structure - includes many brain areas)

- Most important parts:
  - Hipocampus
  - Amygdala
  - Cingulate gyrus
  - Orbitofrontal cortex (not labeled; is behind eyes - part of the prefrontal cortex but connects closely)



Limbic system continued

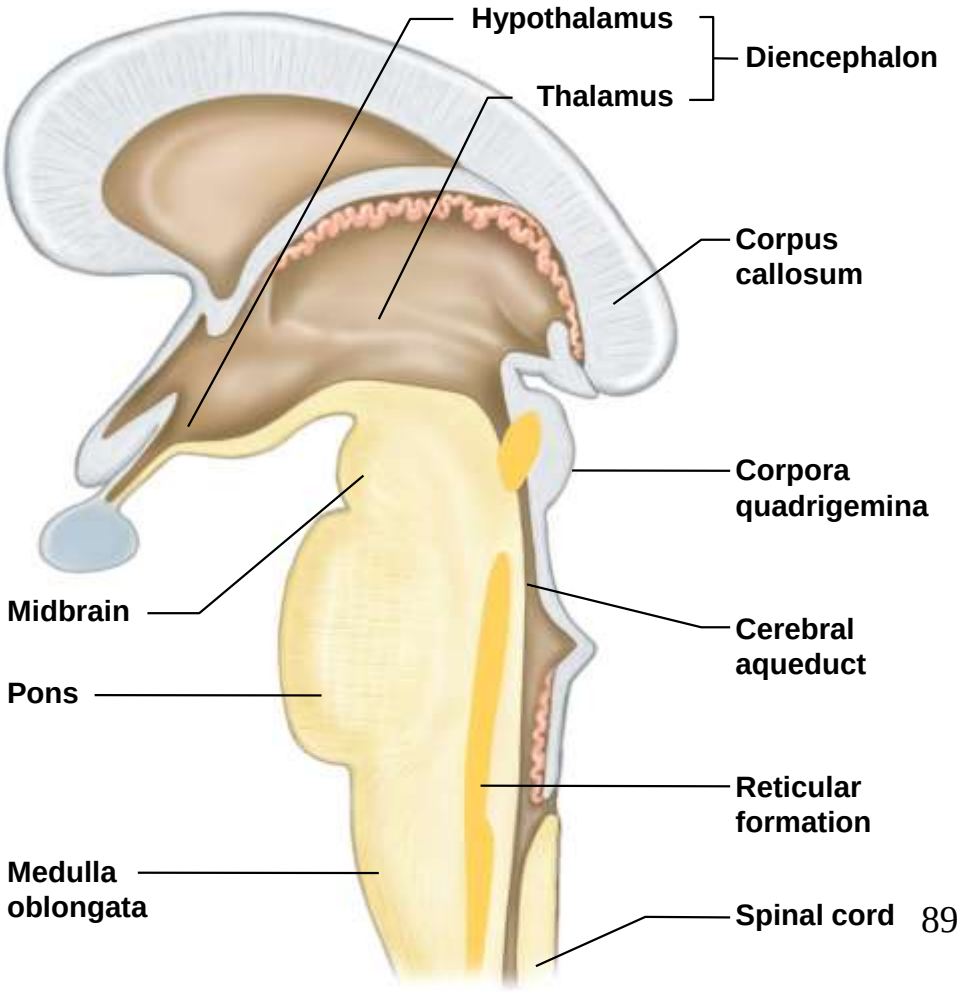
- Called the “emotional” brain
- Links different areas so integration can occur

- Necessary for emotional balance, adaptation to environmental demands (including fearful situations, etc.), for creating meaningful connections with others (e.g. ability to interpret facial expressions and respond appropriately), and more…

Brainstem

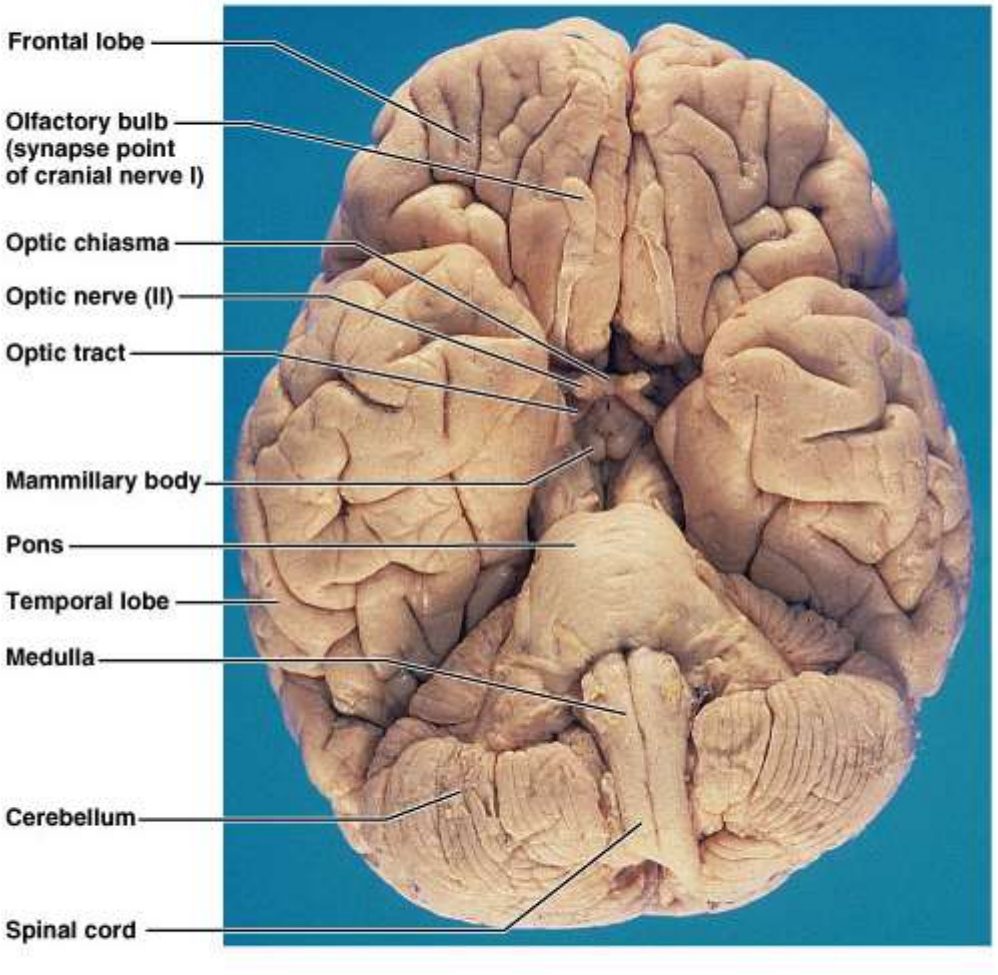
Three parts:

1. Midbrain
2. Pons
3. Medulla Oblongata



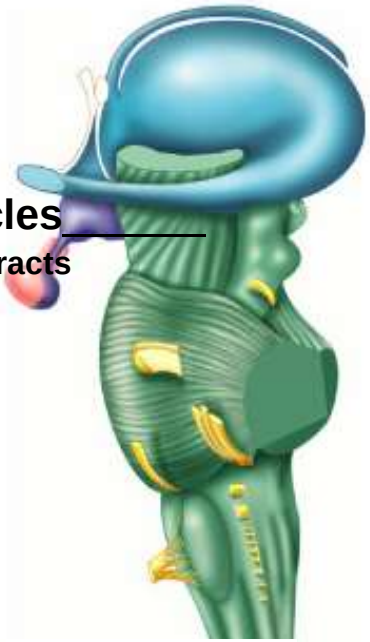
Brain stem

- Midbrain
- Pons
- Medulla oblongata

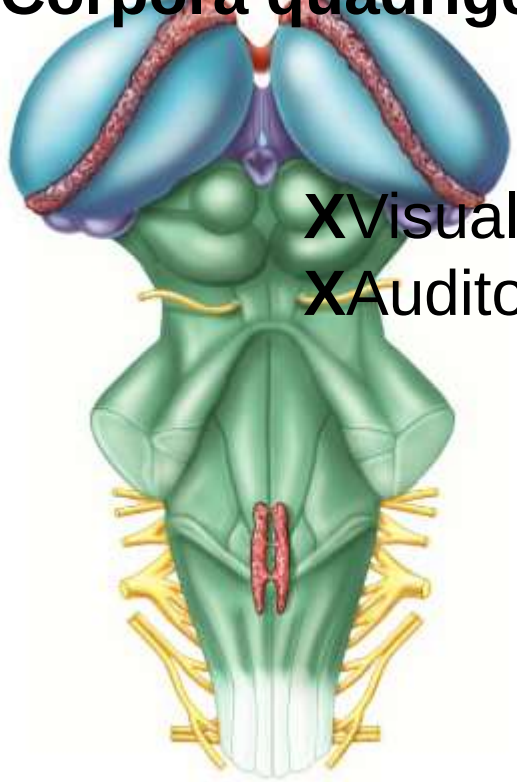


Midbrain

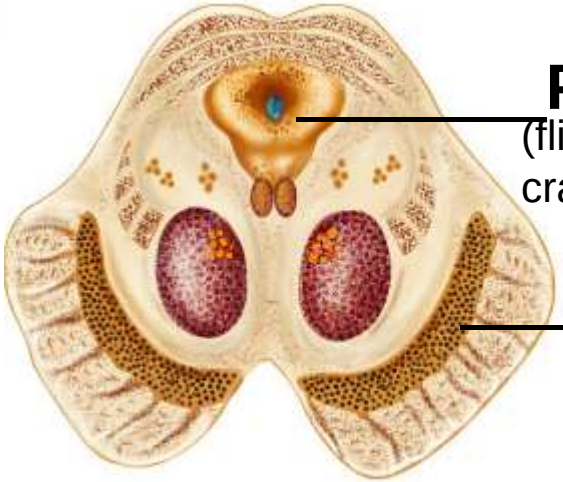
Cerebral peduncles
Contain pyramidal motor tracts



Corpora quadrigemina:



XVisual reflexes
XAuditory reflexe

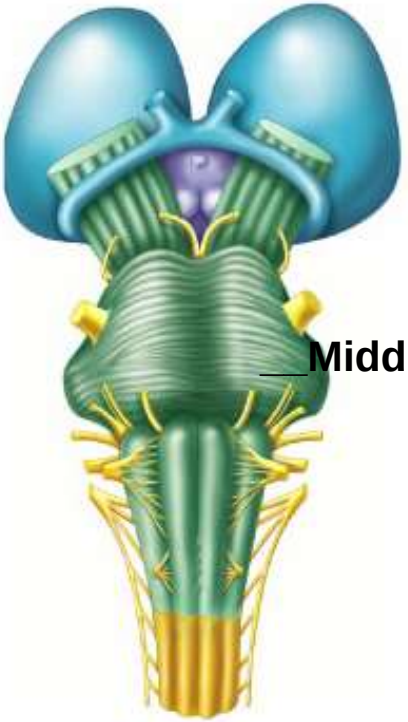


Periaqueductal gray
(flight/flight; nausea with visceral pain; some cranial nerve nuclei)

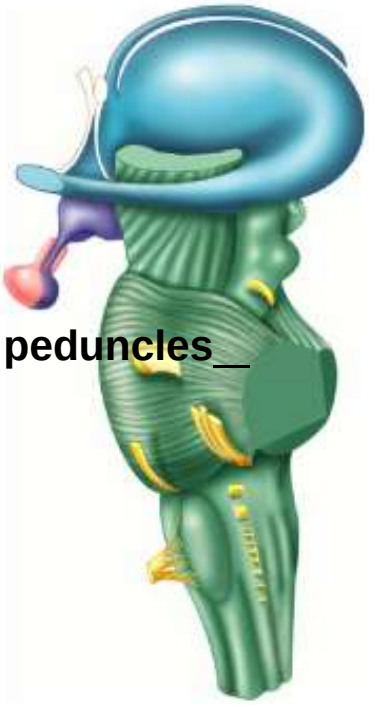
Substantia nigra
(degeneration causes Parkingson's disease)

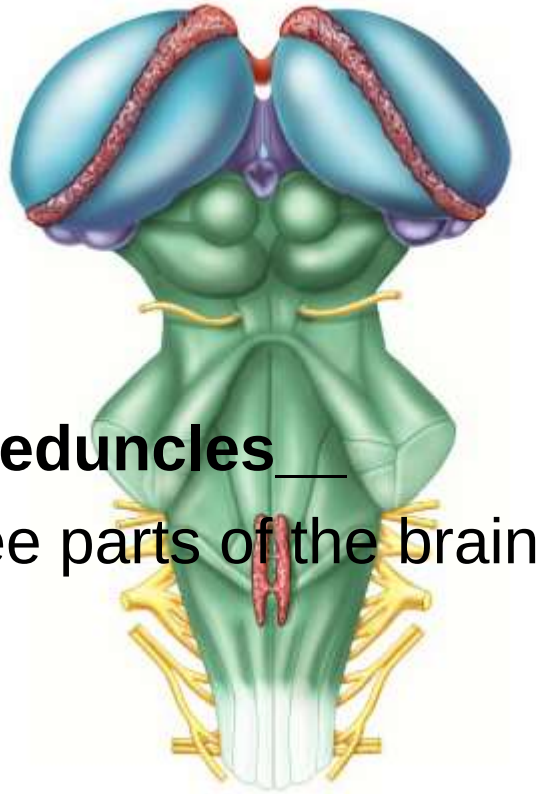
Pons

Also contains several CN and other n



__Middle cerebellar peduncles__





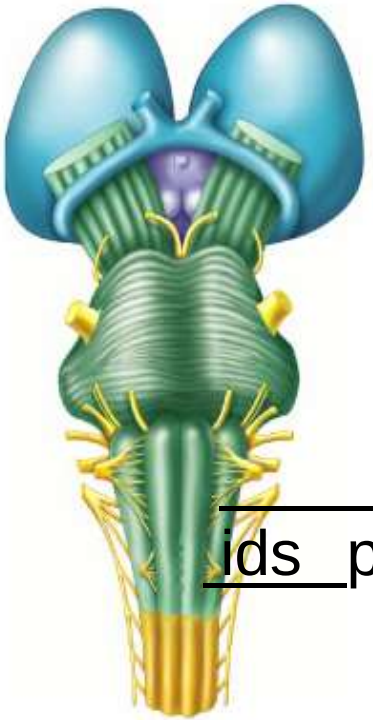
Dorsal view

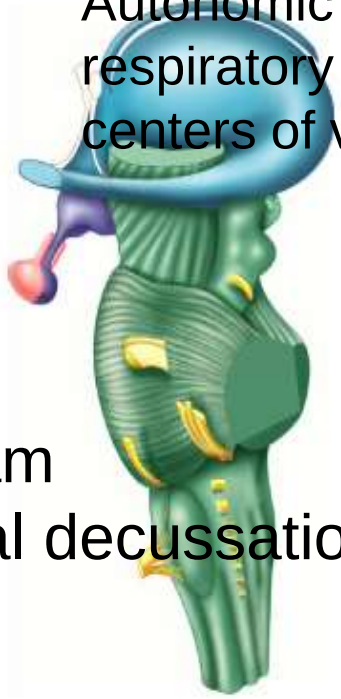
3 cerebellar peduncles__

(one to each of the three parts of the brain stem)

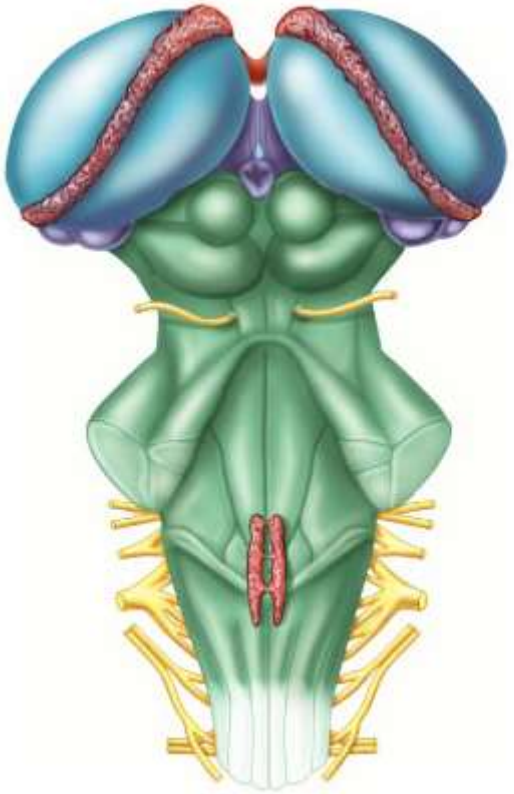
Medulla oblongata

Relays sensory info to cerebral cortex & cerebellum
Contains many CN and other nuclei
Autonomic centers controlling heart rate, respiratory rhythm, blood pressure; involuntary centers of vomiting, swallowing, etc.





_____Pyram
_ids_pyramidal decussation

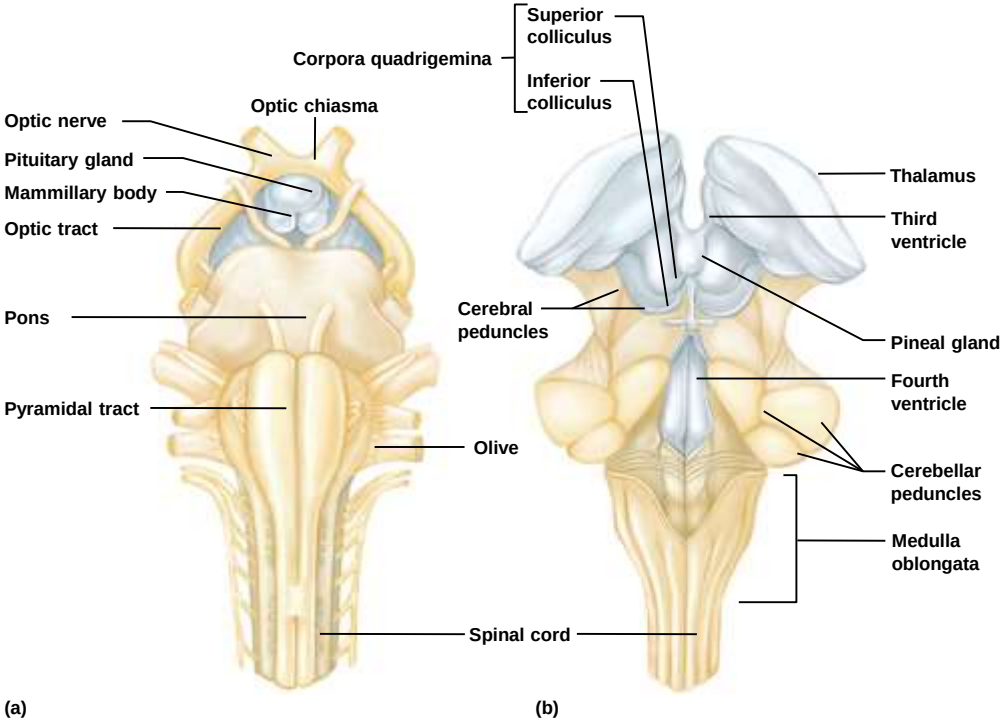


Dorsal view

"Pyramidal"=corticospinal tracts; these are motor tracts which cross over in the decussation. They are named pyramids because they supposedly look like them, and also they originate from "pyramidal" neurons in the motor cortex. tracts have the name of origin 1st, therefore "corticospinal" tells you they go from cortex ("cortico-") to spinal cord ("-spinal")

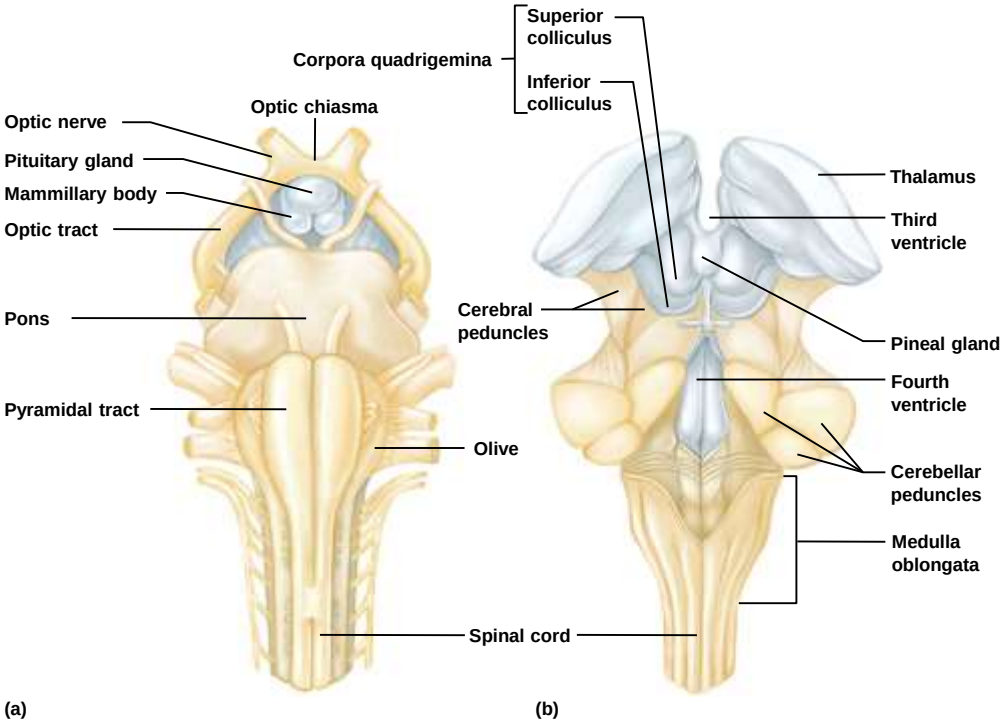
Midbrain

- Between diencephalon and pons
- Contains bundles of fibers that join lower parts of brainstem and spinal cord with higher parts of the brain
- Cerebral aqueduct
- Cerebral peduncles (bundles of nerve fibers)
- Corpora quadrigemina (centers for visual and auditory reflexes)



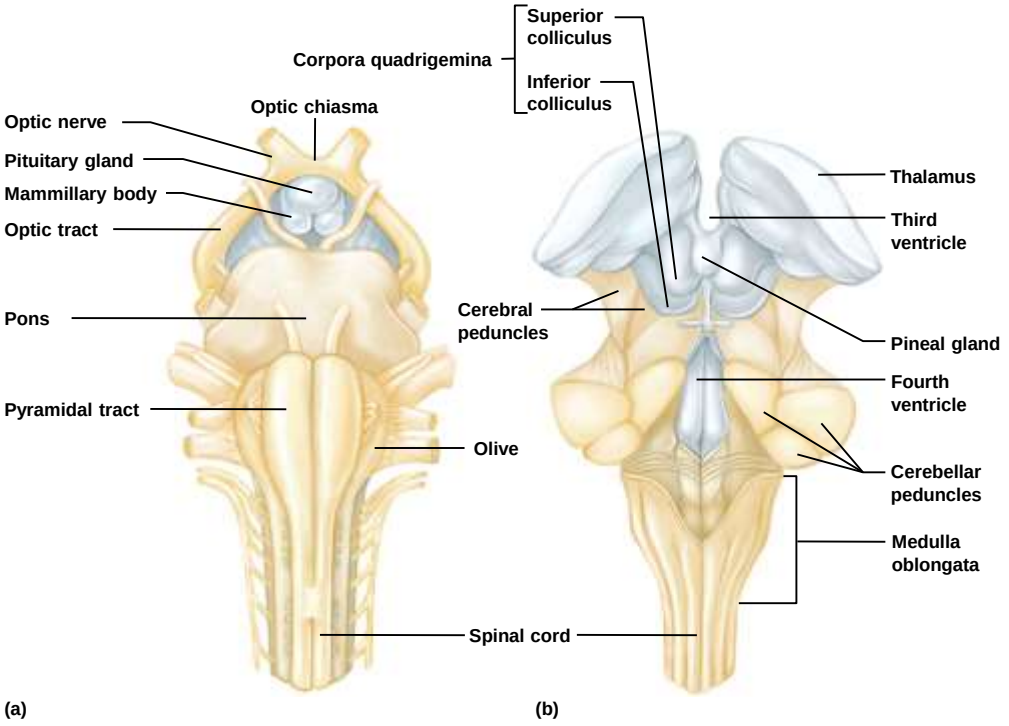
Pons

- Rounded bulge on underside of brainstem
- Between medulla oblongata and midbrain
- Helps regulate rate and depth of breathing
- Relays nerve impulses to and from medulla oblongata and cerebellum (bridge)



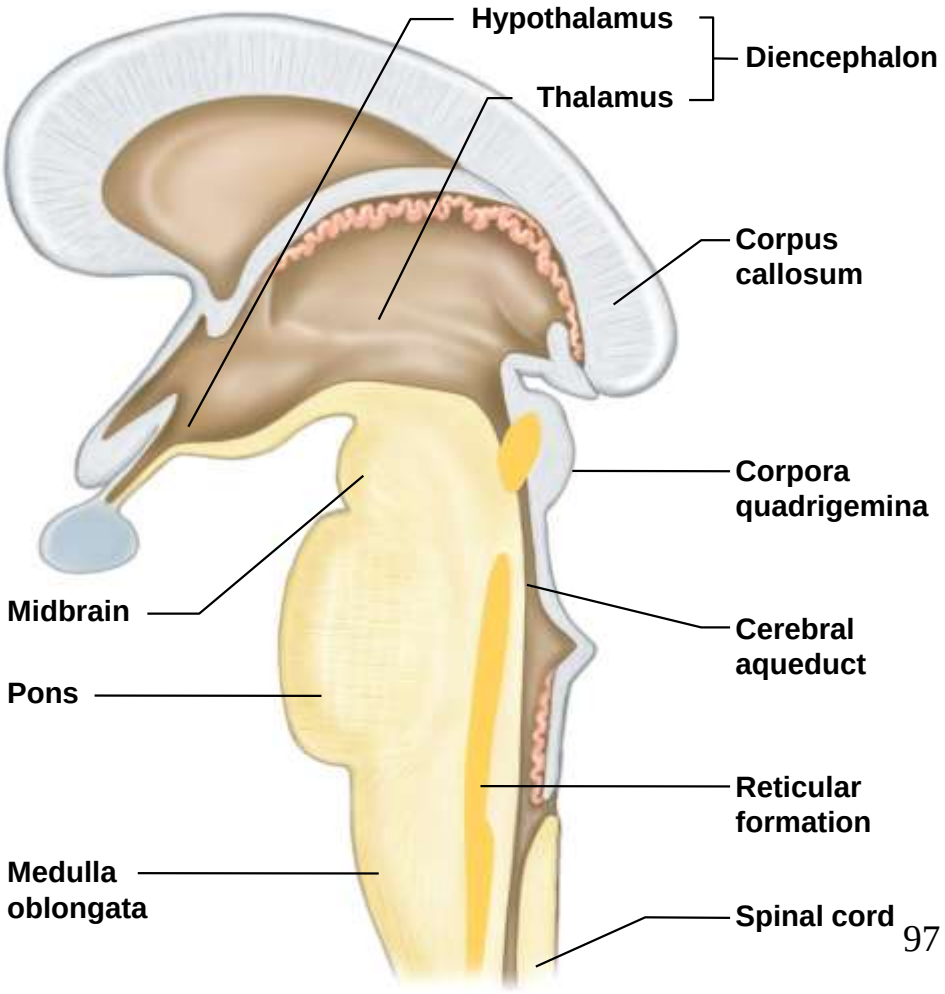
Medulla Oblongata

- Enlarged continuation of spinal cord
- Conducts ascending and descending impulses between brain and spinal cord
- Contains cardiac, vasomotor, and respiratory control centers
- Contains various nonvital reflex control centers (coughing, sneezing, swallowing, and vomiting)



Reticular Formation

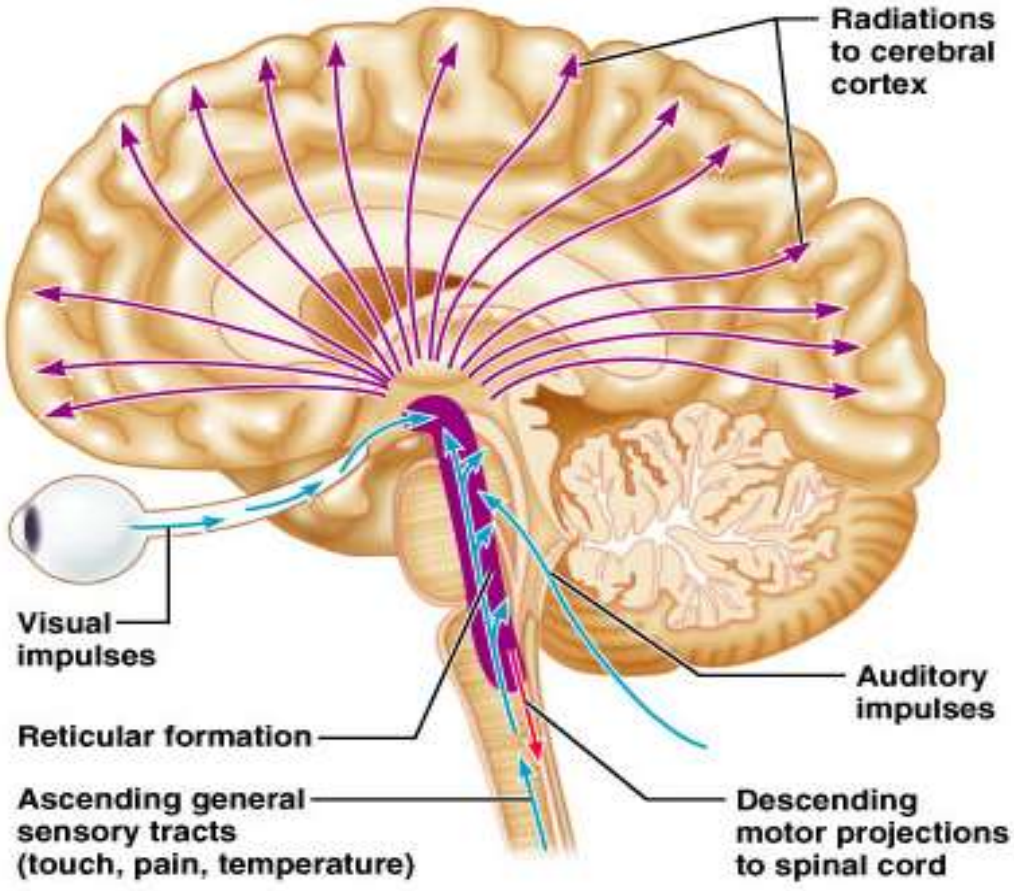
- Complex network of nerve fibers scattered throughout the brain stem
- Extends into the diencephalon
- Connects to centers of hypothalamus, basal nuclei, cerebellum, and cerebrum
- Filters incoming sensory information
- Arouses cerebral cortex into state of wakefulness



Reticular formation

Runs through central core of medulla, pons and midbrain

- Reticular activating system (RAS): keeps the cerebral cortex alert and conscious
- Some motor control

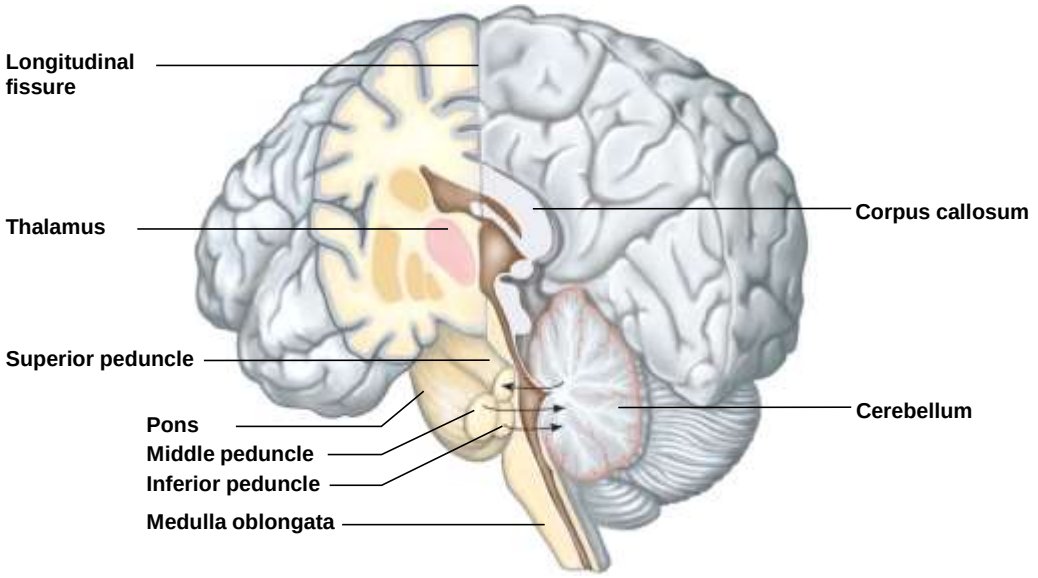


Types of Sleep

- Slow wave
  - Non-REM sleep
  - Person is tired
  - Decreasing activity of reticular system
  - Restful
  - Dreamless
  - Reduced blood pressure and respiratory rate
  - Ranges from light to heavy
  - Alternates with REM sleep
- Rapid Eye Movement (REM)
  - Paradoxical sleep
  - Some areas of brain active
  - Heart and respiratory rates irregular
  - Dreaming occurs

Cerebellum

- Inferior to occipital lobes
- Posterior to pons and medulla oblongata
- Two hemispheres like cerebrum
- Vermis connects hemispheres
- Cerebellar cortex (gray matter)
- Arbor vitae (white matter)
- Cerebellar peduncles (nerve fiber tracts)
- Dentate nucleus (largest nucleus in cerebellum)



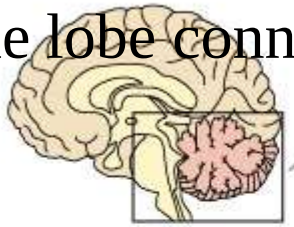
Cerebellum

Two major hemispheres: three lobes each

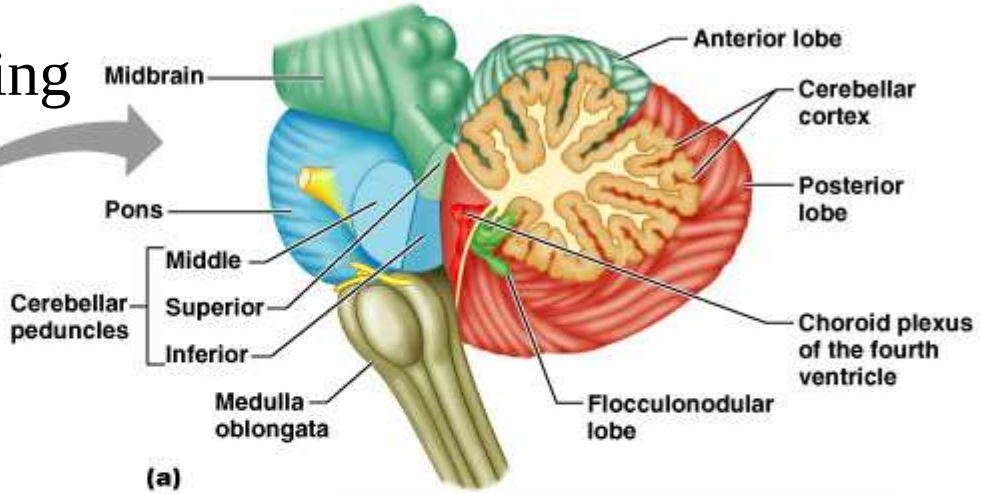
- Anterior
- Posterior
- Floculonodular

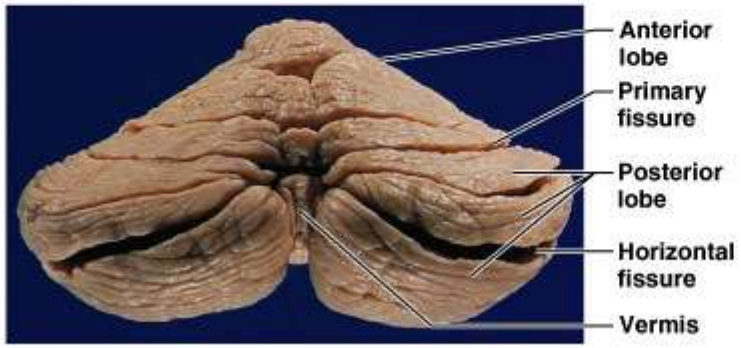
Separated from brain stem by 4th ventricle

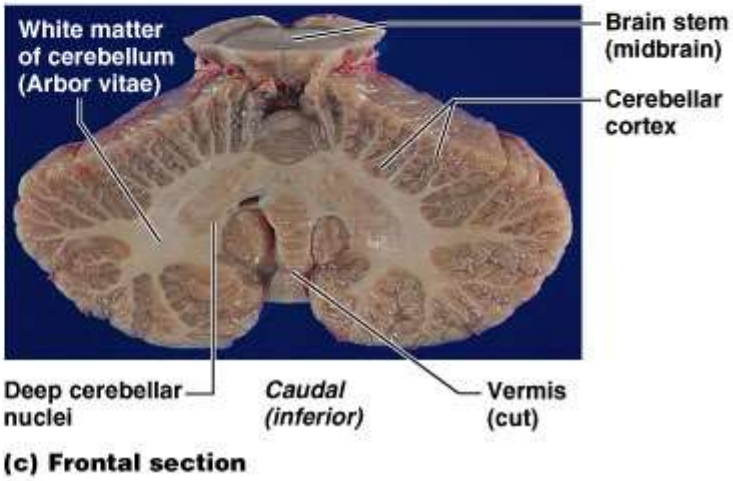
Vermis: midline lobe connecting hemispheres



Outer cortex of gray/
Inner branching white matter, called “arbor vitae”







Functions of cerebellum

- Smooths, coordinates & fine tunes bodily movements
- Helps maintain body posture
- Helps maintain equilibrium
- How?
  - Gets info from cerebrum re: movements being planned
  - Gets info from inner ear re: equilibrium
  - Gets info from proprioceptors (sensory receptors informing where the parts of the body actually are)
  - Using feedback, adjustments are made
- Also some role in cognition

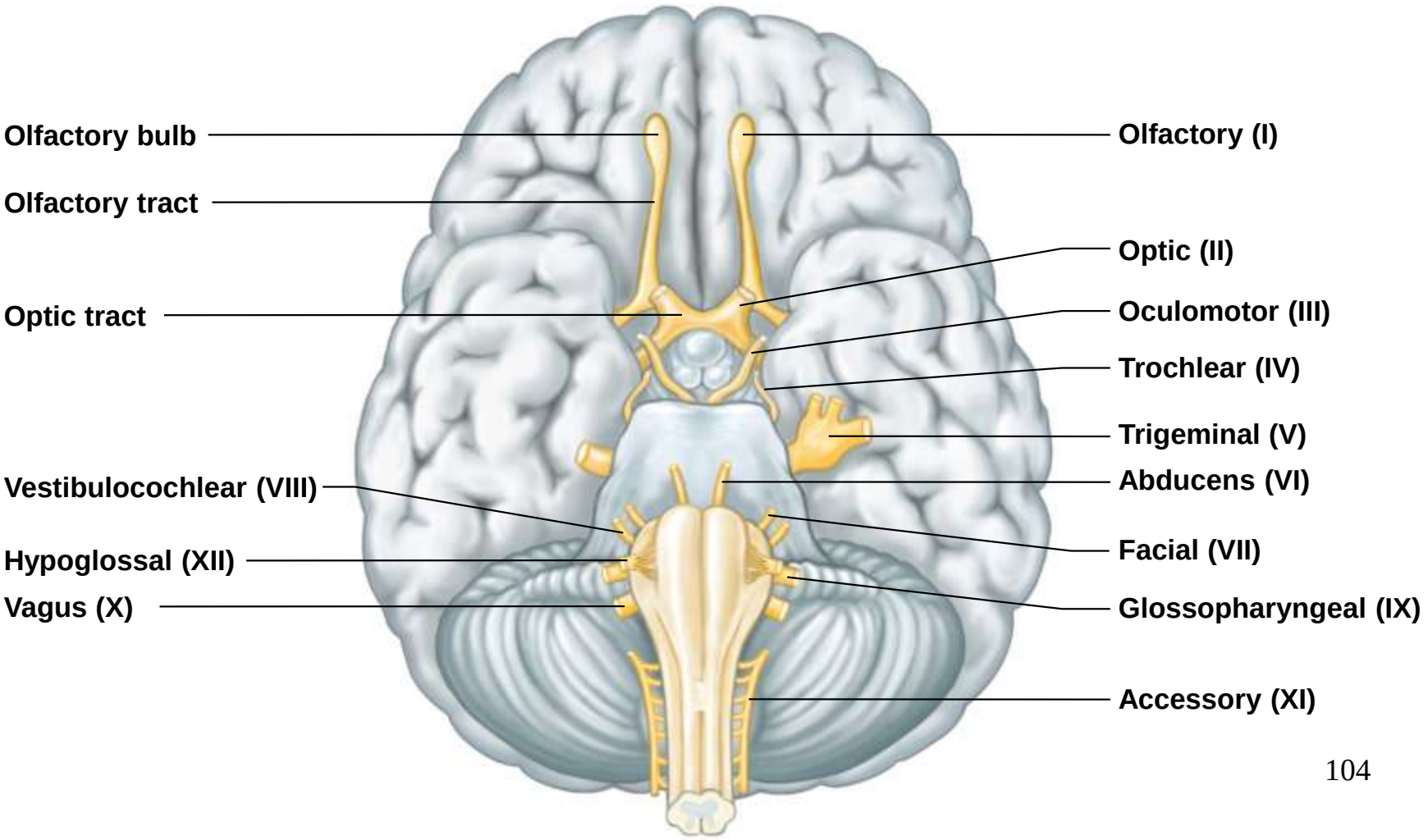
- Damage: ataxia, incoordination, wide-based gait, overshooting, proprioception problems

Major Parts of the Brain

TABLE 11.7 | Major Parts of the Brain

Part	Characteristics	Functions
1. Cerebrum	Largest part of the brain; two hemispheres connected by the corpus callosum	Controls higher brain functions, including interpreting sensory impulses, initiating muscular movements, storing memory, reasoning, and determining intelligence
2. Basal nuclei (ganglia)	Masses of gray matter deep within the cerebral hemispheres	Relay stations for motor impulses originating in the cerebral cortex and passing into the brainstem and spinal cord
3. Diencephalon	Includes masses of gray matter (thalamus and hypothalamus)	The thalamus is a relay station for sensory impulses ascending from other parts of the nervous system to the cerebral cortex; the hypothalamus helps maintain homeostasis by regulating visceral activities and by linking the nervous and endocrine systems
4. Brainstem	Connects the cerebrum to the spinal cord	
a. Midbrain	Contains masses of gray matter and bundles of nerve fibers that join the spinal cord to higher regions of the brain	Contains reflex centers that move the eyes and head, and maintains posture
b. Pons	A bulge on the underside of the brainstem that contains masses of gray matter and nerve fibers	Relays nerve impulses to and from the medulla oblongata and cerebrum; helps regulate rate and depth of breathing
c. Medulla oblongata	An enlarged continuation of the spinal cord that extends from the foramen magnum to the pons and contains masses of gray matter and nerve fibers	Conducts ascending and descending impulses between the brain and spinal cord; contains cardiac, vasomotor, and respiratory control centers and various nonvital reflex control centers
5. Cerebellum	A large mass of tissue inferior to the cerebrum and posterior to the brainstem; includes two lateral hemispheres connected by the vermis	Communicates with other parts of the CNS by nerve tracts; integrates sensory information concerning the position of body parts; and coordinates muscle activities and maintains posture

Cranial Nerves



Cranial Nerves I and II

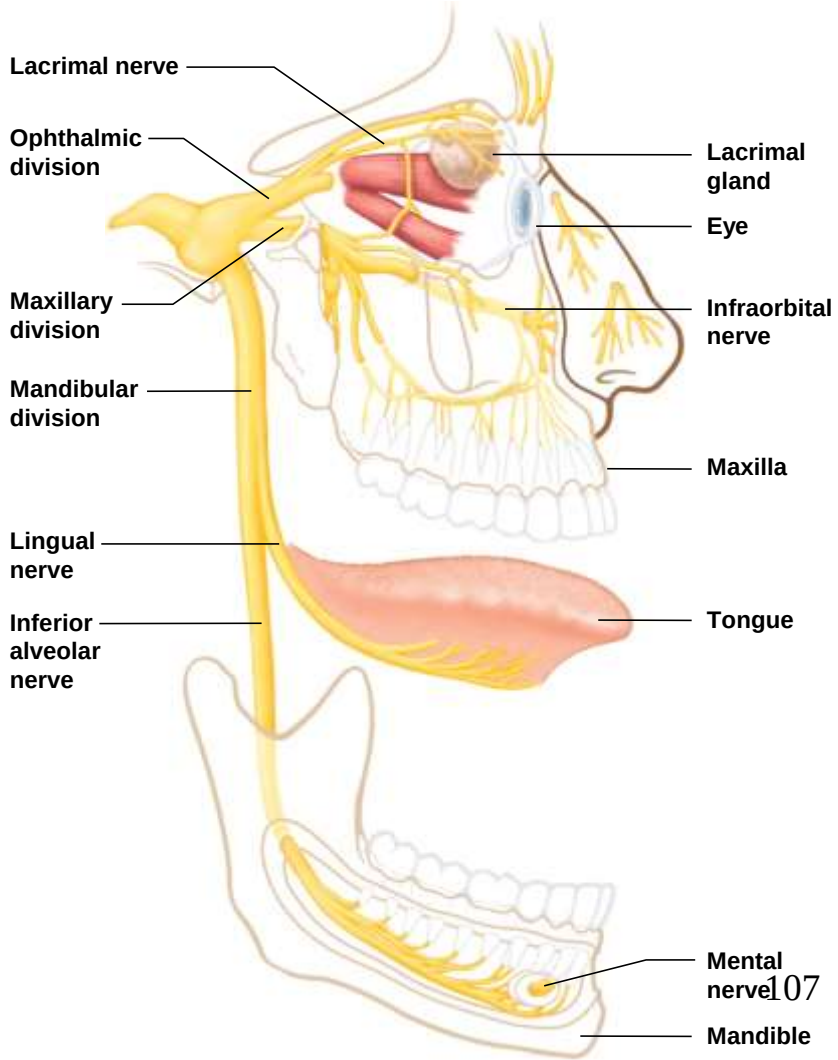
- Olfactory nerve (CN I)
  - Sensory nerve
  - Fibers transmit impulses associated with smell
- Optic nerve (CN II)
  - Sensory nerve
  - Fibers transmit impulses associated with vision

Cranial Nerves III and IV

- Oculomotor nerve (CN III)
  - Primarily motor nerve
  - Motor impulses to muscles that:
    - Raise eyelids
    - Move the eyes
    - Focus lens
    - Adjust light entering eye
  - Some sensory
    - Proprioceptors
- Trochlear nerve (CN IV)
  - Primarily motor nerve
  - Motor impulses to muscles that move the eyes
  - Some sensory
    - Proprioceptors

Cranial Nerve V

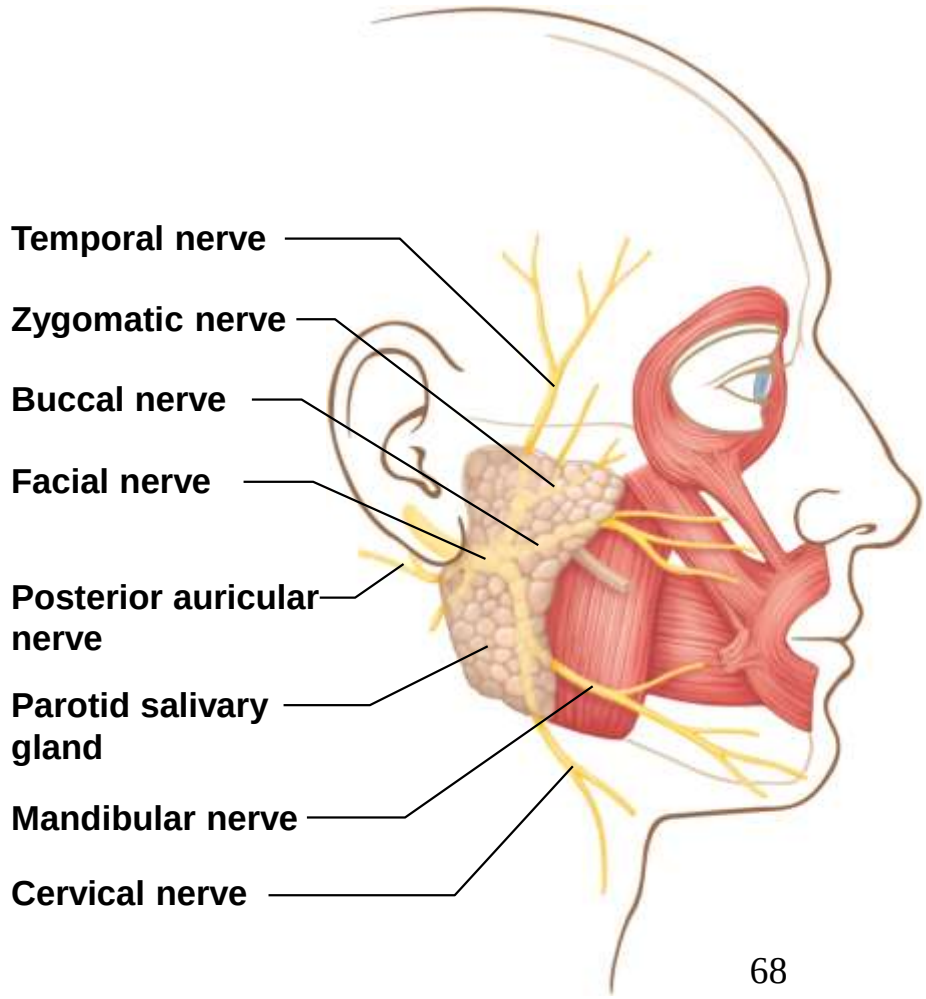
- Trigeminal nerve (CN V)
  - Mixed nerve
  - "Three (3) sisters"
  - (1) Ophthalmic division
    - Sensory from surface of eyes, tear glands, scalp, forehead, and upper eyelids
  - (2) Maxillary division
    - Sensory from upper teeth, upper gum, upper lip, palate, and skin of face
  - (3) Mandibular division
    - Sensory from scalp, skin of jaw, lower teeth, lower gum, and lower lip
    - Motor to muscles of mastication and muscles in floor of mouth



Cranial Nerves VI and VII

- Abducens nerve (CN VI)
  - Primarily motor nerve
  - Motor impulses to muscles that move the eyes
  - Some sensory
    - Proprioceptors

- Facial nerve (CN VII)
  - Mixed nerve
  - Sensory from taste receptors
  - Motor to muscles of facial expression, tear glands, and salivary glands



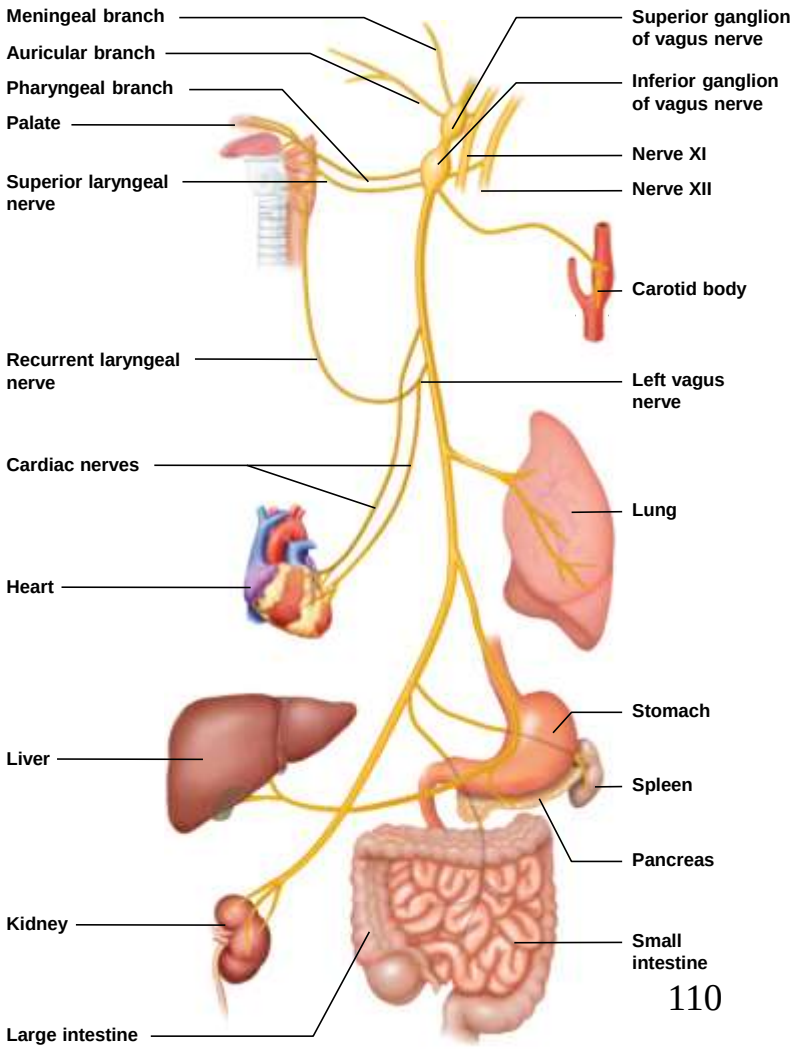
Cranial Nerves VIII and IX

- Vestibulocochlear nerve (CN VIII)
  - Aka acoustic or auditory nerve
  - Sensory nerve
  - Two (2) branches:
    - Vestibular branch
      - Sensory from equilibrium receptors of ear
    - Cochlear branch
      - Sensory from hearing receptors

- Glossopharyngeal nerve (CN IX)
  - Mixed nerve
  - Sensory from pharynx, tonsils, tongue and carotid arteries
  - Motor to salivary glands and muscles of pharynx

Cranial Nerve X

- Vagus nerve (CN X)
  - Mixed nerve
  - Somatic motor to muscles of speech and swallowing
  - Autonomic motor to viscera of thorax and abdomen
  - Sensory from pharynx, larynx, esophagus, and viscera of thorax and abdomen

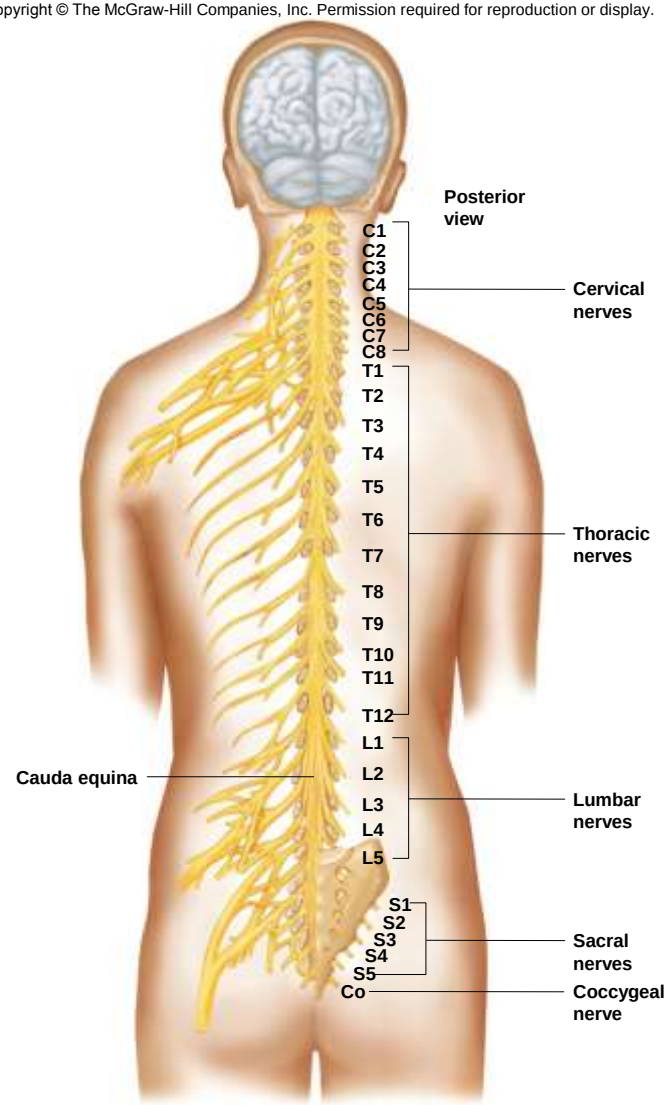


Cranial Nerves XI and XII

- Accessory nerve (CN XI)
  - Primarily motor nerve
  - We called this “Spinal” Accessory because:
    - Cranial branch
      - Motor to muscles of soft palate, pharynx and larynx
    - Spinal branch
      - Motor to muscles of neck and back
      - Some sensory
        - Proprioceptor
- Hypoglossal nerve (CN XII)
  - Primarily motor
  - Motor to muscles of the tongue
  - Some sensory
    - Proprioceptor

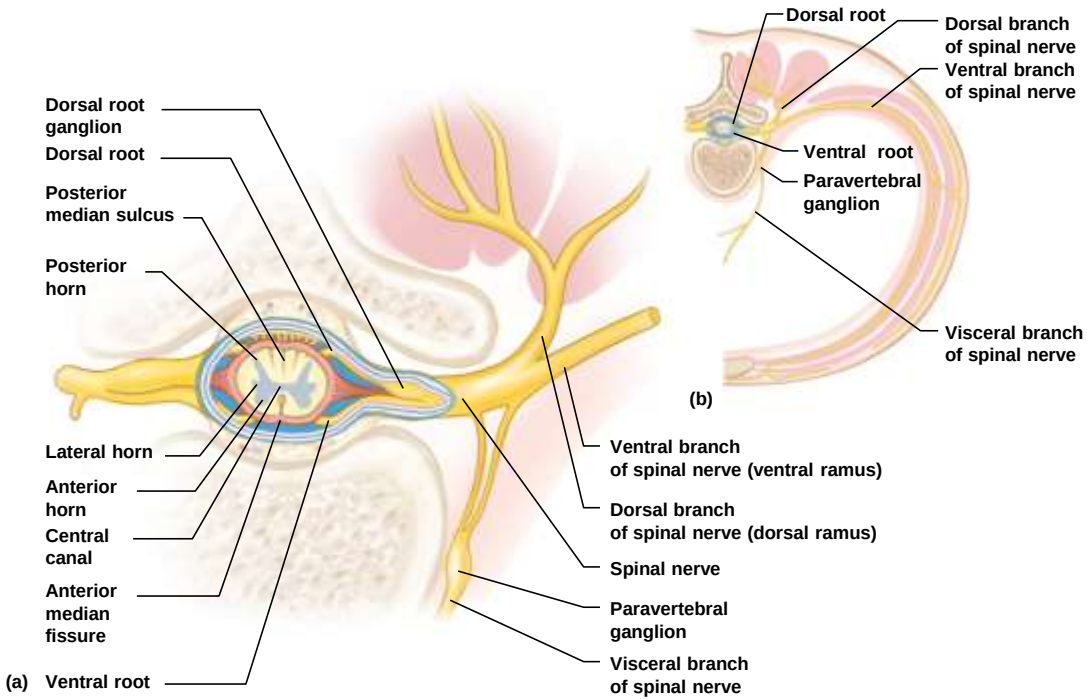
Spinal Nerves

- ALL are mixed nerves (except the first pair)
- 31 pairs of spinal nerves:
  - 8 cervical nerves
    - (C1 to C8)
  - 12 thoracic nerves
    - (T1 to T12)
  - 5 lumbar nerves
    - (L1 to L5)
  - 5 sacral nerves
    - (S1 to S5)
  - 1 coccygeal nerve
    - (Co or Cc)



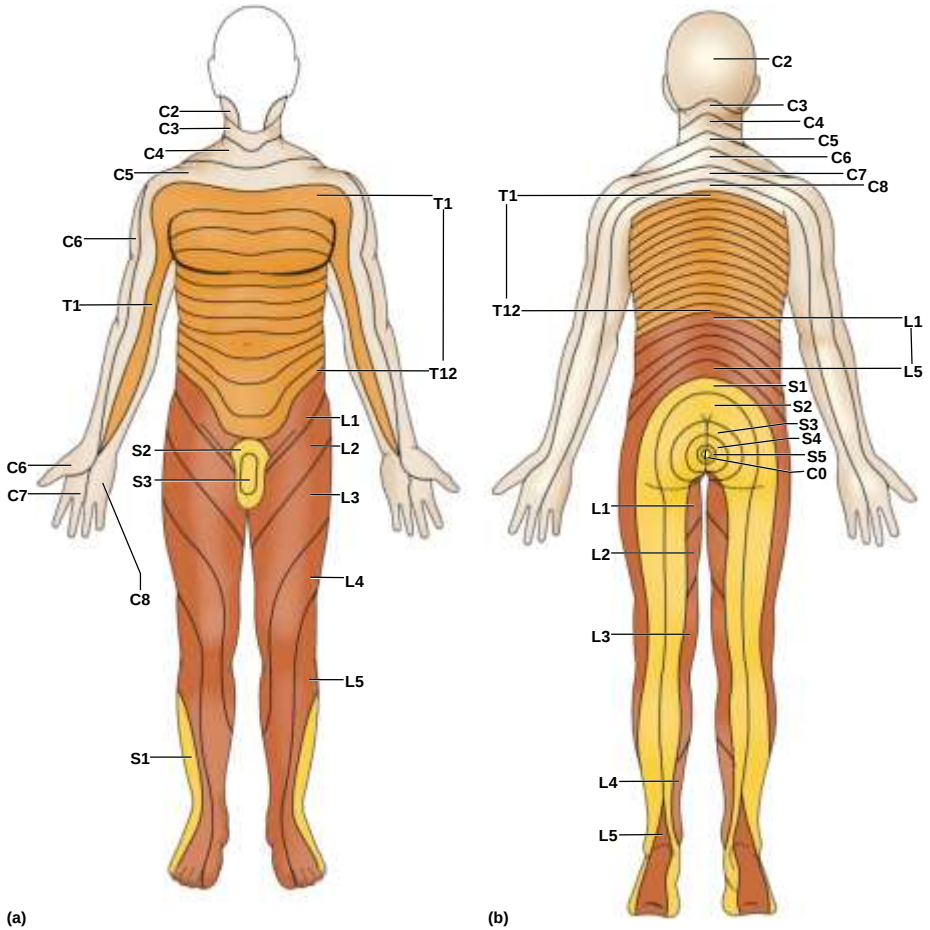
Spinal Nerves

- Dorsal root (aka posterior root)
  - Sensory root
  - Axons of sensory neurons are in the dorsal root ganglion
- Dorsal root ganglion
  - Aka DRG
  - Cell bodies of sensory neurons whose axons conduct impulses inward from peripheral body parts



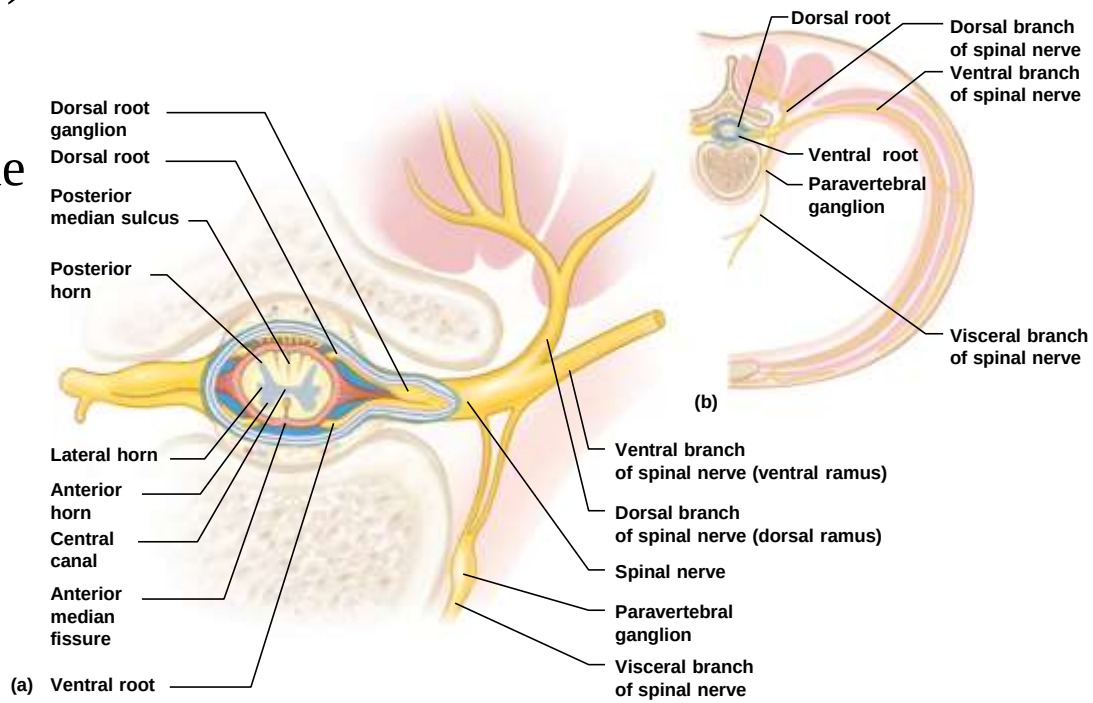
Dermatome

- An area of skin that the sensory nerve fibers of a particular spinal nerve innervate

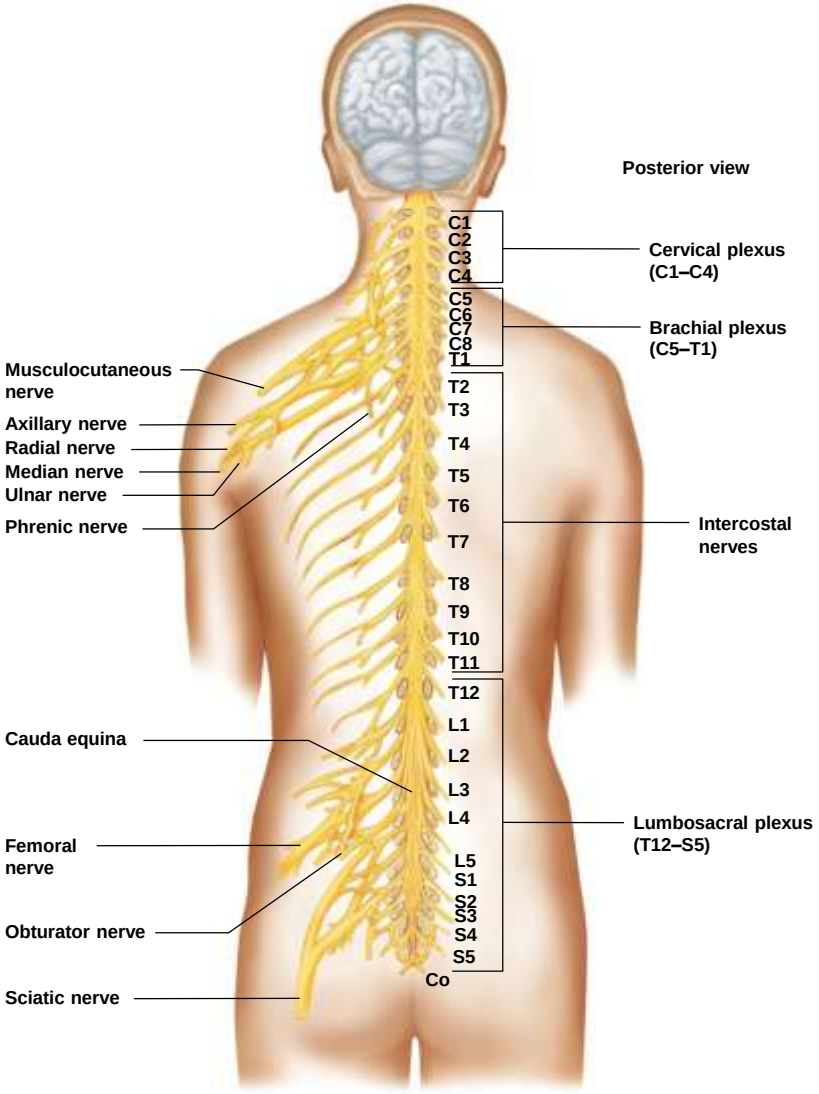


Spinal Nerves

- Ventral root (aka anterior root)
  - Motor root
  - Axons of motor neurons whose cell bodies are in the spinal cord
- Spinal nerve
  - Union of ventral root and dorsal roots
  - Hence we now have a "mixed" nerve



Plexuses



11.8: Lifespan Changes

- Brain cells begin to die before birth
- Over average lifetime, brain shrinks 10%
- Most cell death occurs in temporal lobes
- By age 90, frontal cortex has lost half its neurons
- Number of dendritic branches decreases
- Decreased levels of neurotransmitters
- Fading memory
- Slowed responses and reflexes
- Increased risk of falling
- Changes in sleep patterns that result in fewer sleeping hours