Chapter 14

Brain Function of the Medulla Oblongata, Pons, Mid-Brain, Thalamus, Hypothalamus, Cerebellum, Cerebrum, and Cranial Nerves

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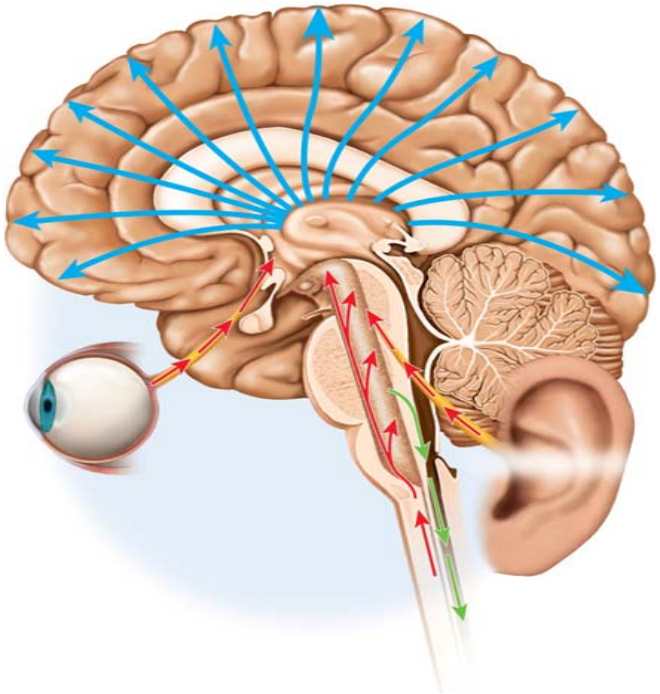
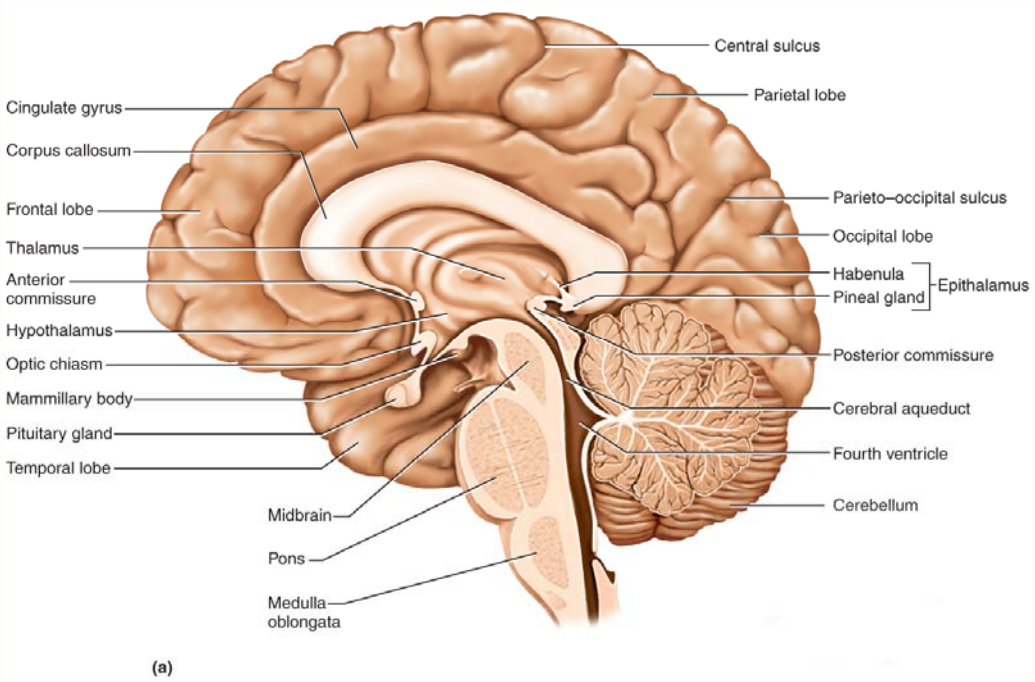
Motor Control as a Higher Brain Function



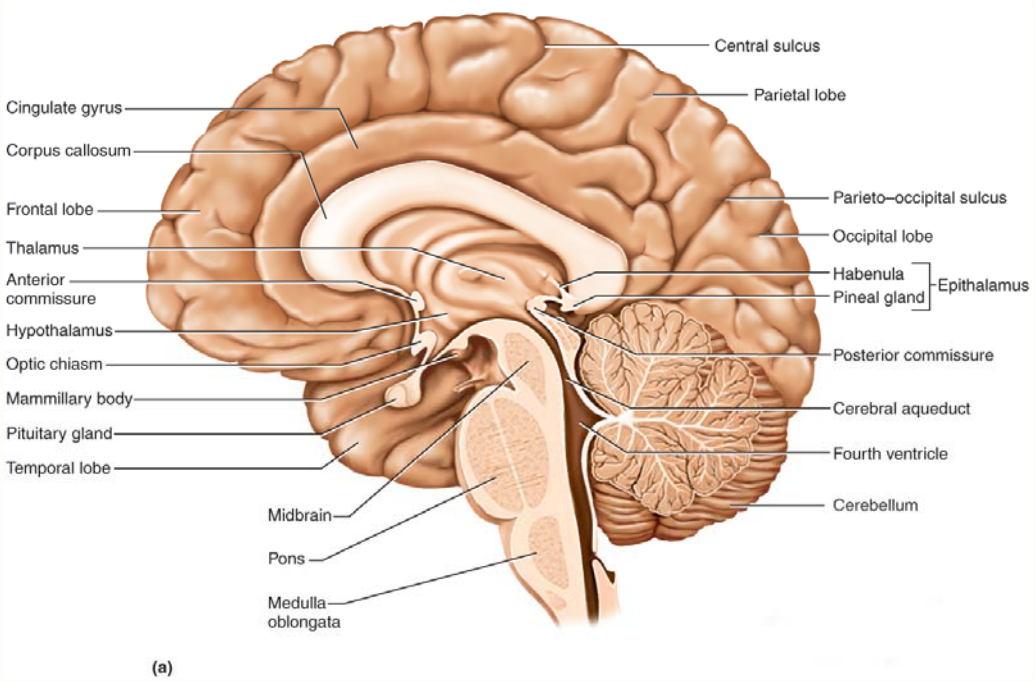
Medulla Oblongata

- Brain stem includes medulla oblongata, pons, midbrain, and diencephalon
- The medulla oblongata begins at foramen magnum of the skull
- extends for about 3 cm rostrally
- ends at a groove between the medulla and pons
- slightly wider than deep
- **pyramids** – pair of external ridges on anterior surface // resembles side-by-side baseball bats

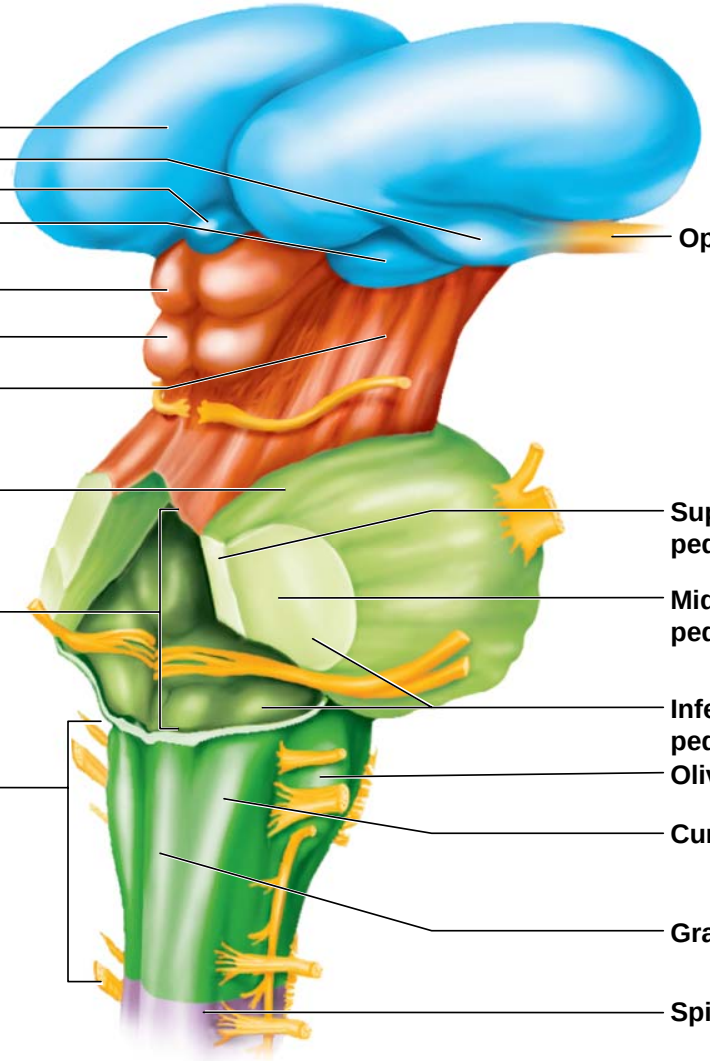


Medulla Oblongata

- **olive** – a prominent bulge lateral to each pyramid
- posteriorly, **gracile** and **cuneate fasciculi** of the spinal cord continue as two pair of ridges on the medulla
- all nerve fibers connecting the brain to the spinal cord pass through the medulla
- **four pairs of cranial nerves** begin or end in medulla - IX, X, XI, XII



Posterolateral View of Brainstem

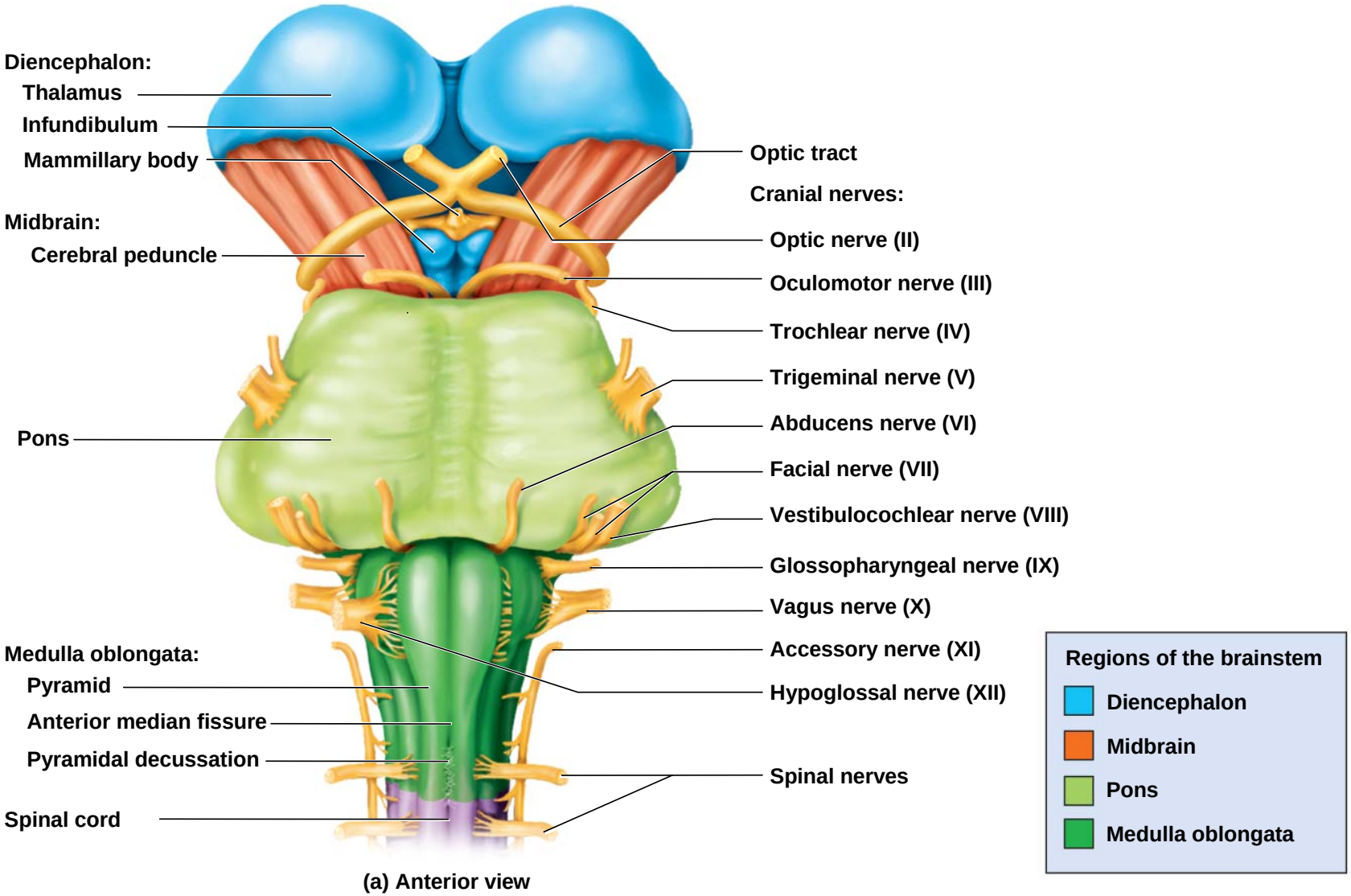


(b) Posterolateral view

Regions of the brainstem

- Diencephalon
- Midbrain
- Pons
- Medulla oblongata

Ventral View of Brainstem

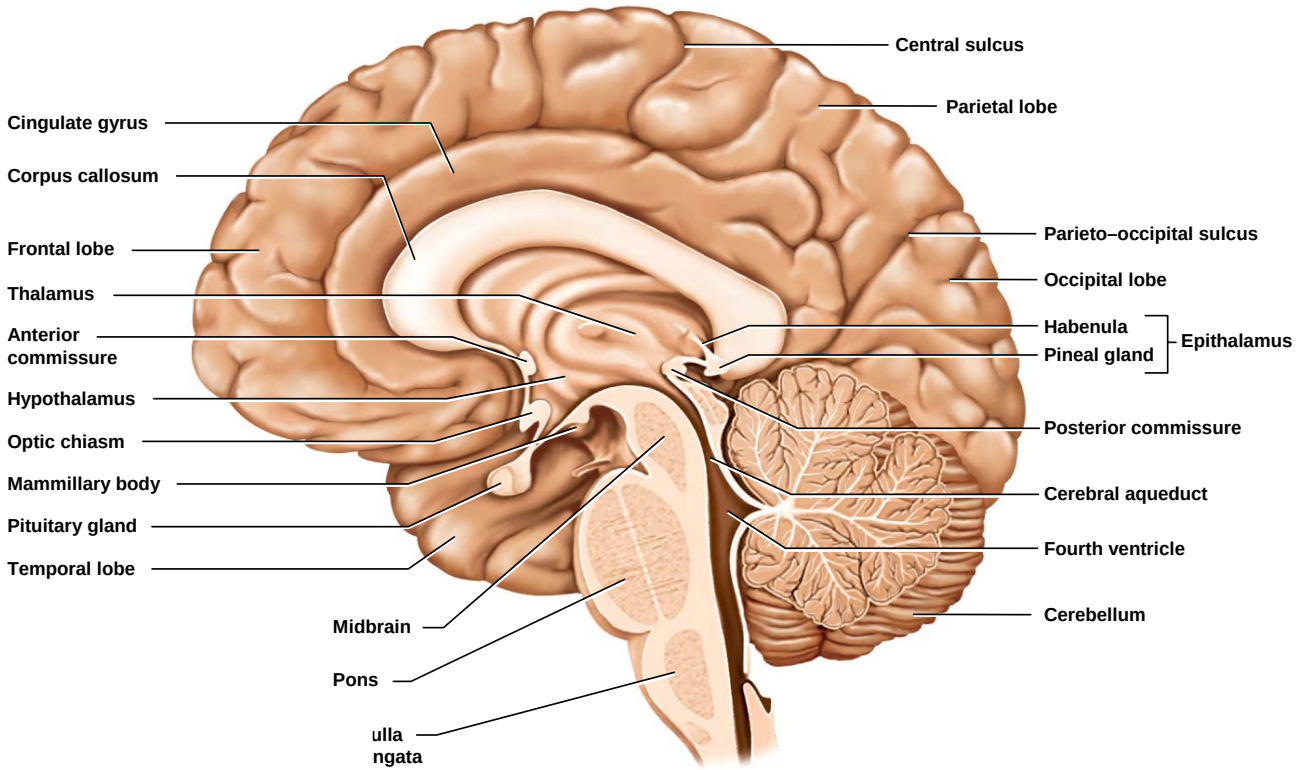


(a) Anterior view

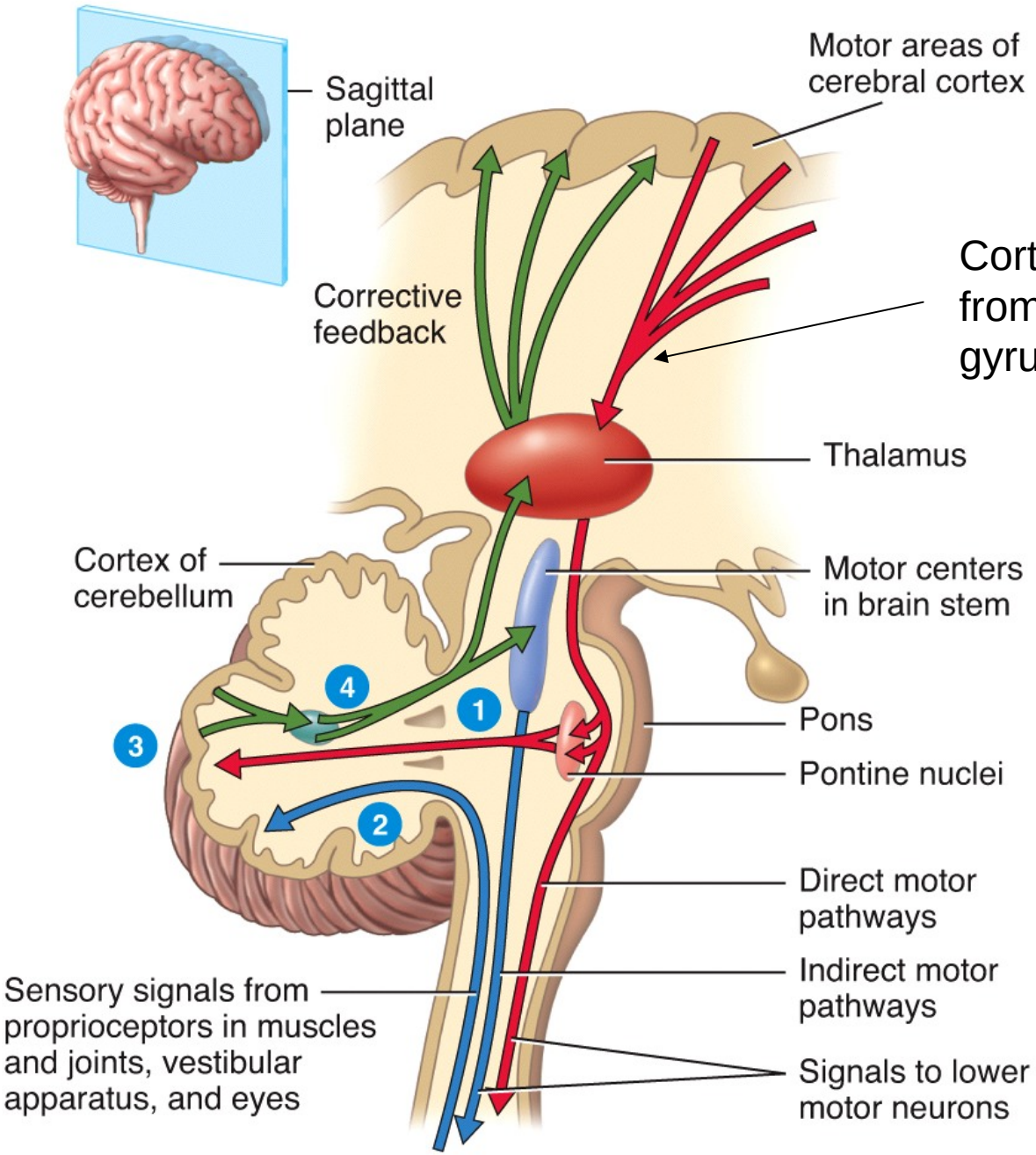
Functions Located in Medulla Oblongata

- cardiac center // adjusts rate and force of heart
- vasomotor center // adjusts blood vessel diameter
- respiratory centers // control rate and depth of breathing
- reflex centers // coughing, sneezing, gagging, swallowing, vomiting, salivation, sweating, movements of tongue and head

Pons

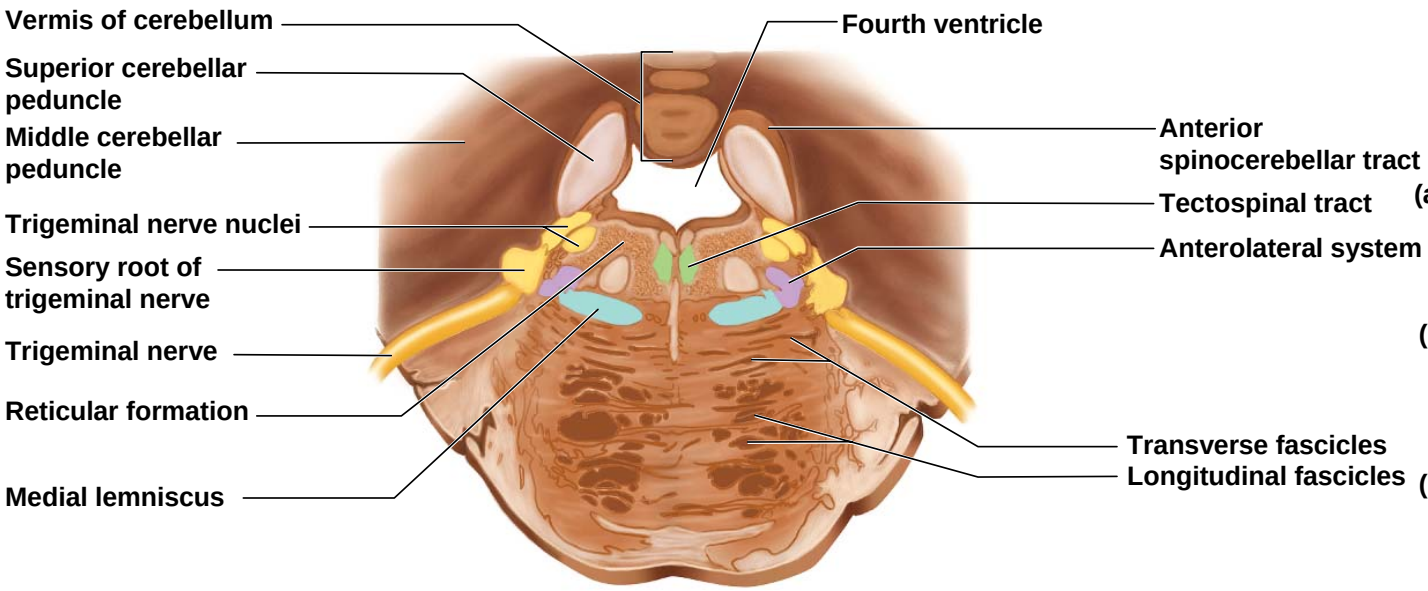


- **Pons** – anterior bulge in brainstem, rostral to medulla
- **Cerebellar peduncles** – tracts that connect cerebellum to brainstem /// tracks flow in and out of cerebellum
  - inferior peduncles = inflow from spinal cord
  - middle peduncles = inflow from all other areas of brain
  - superior peduncles = outflow to red nucleus-thalamus-cerebrum

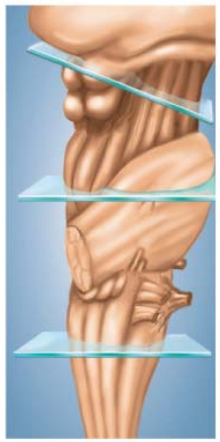


Sagittal section through brain and spinal cord

Cross-section of Pons

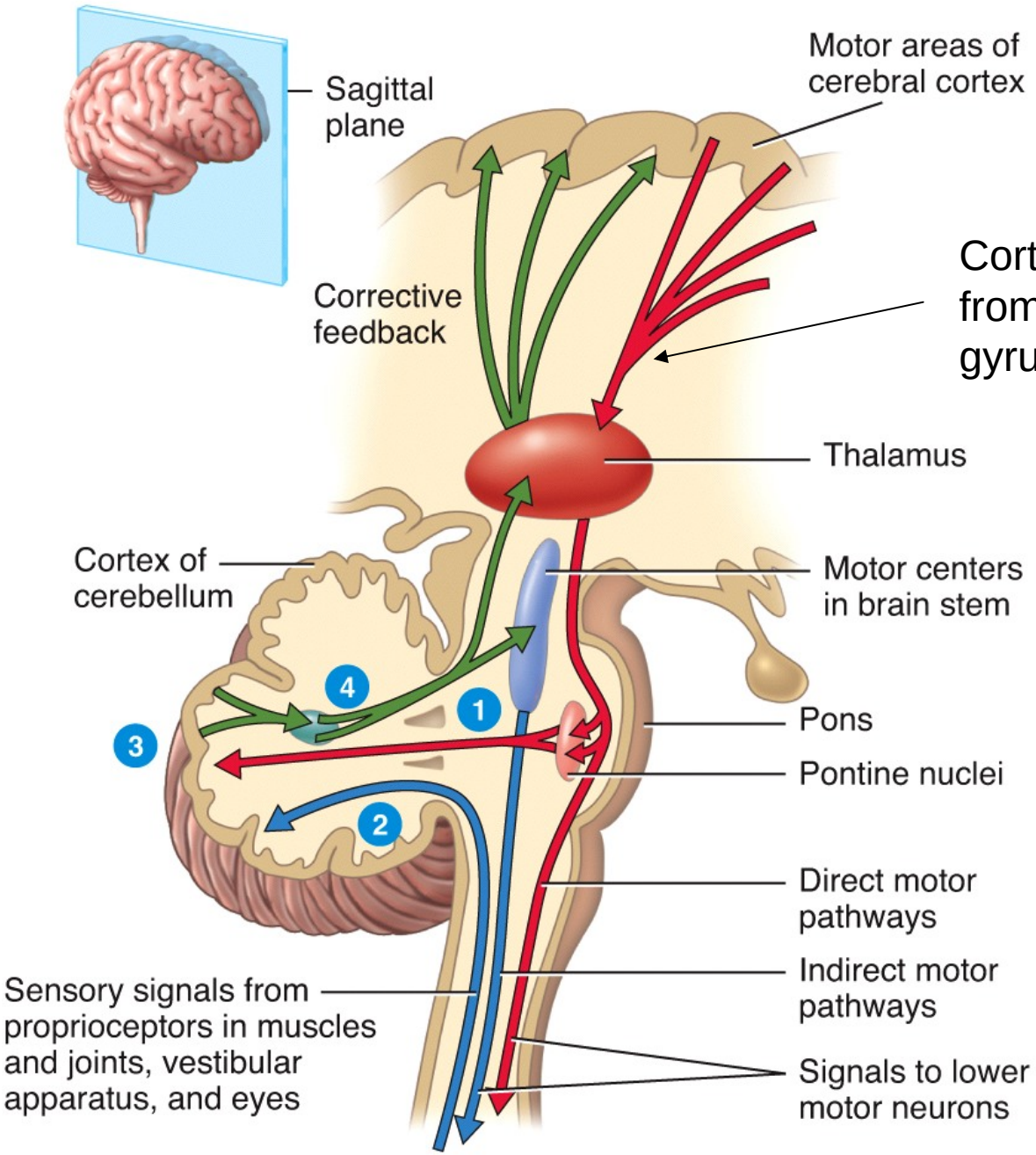


(b) Pons



Pons

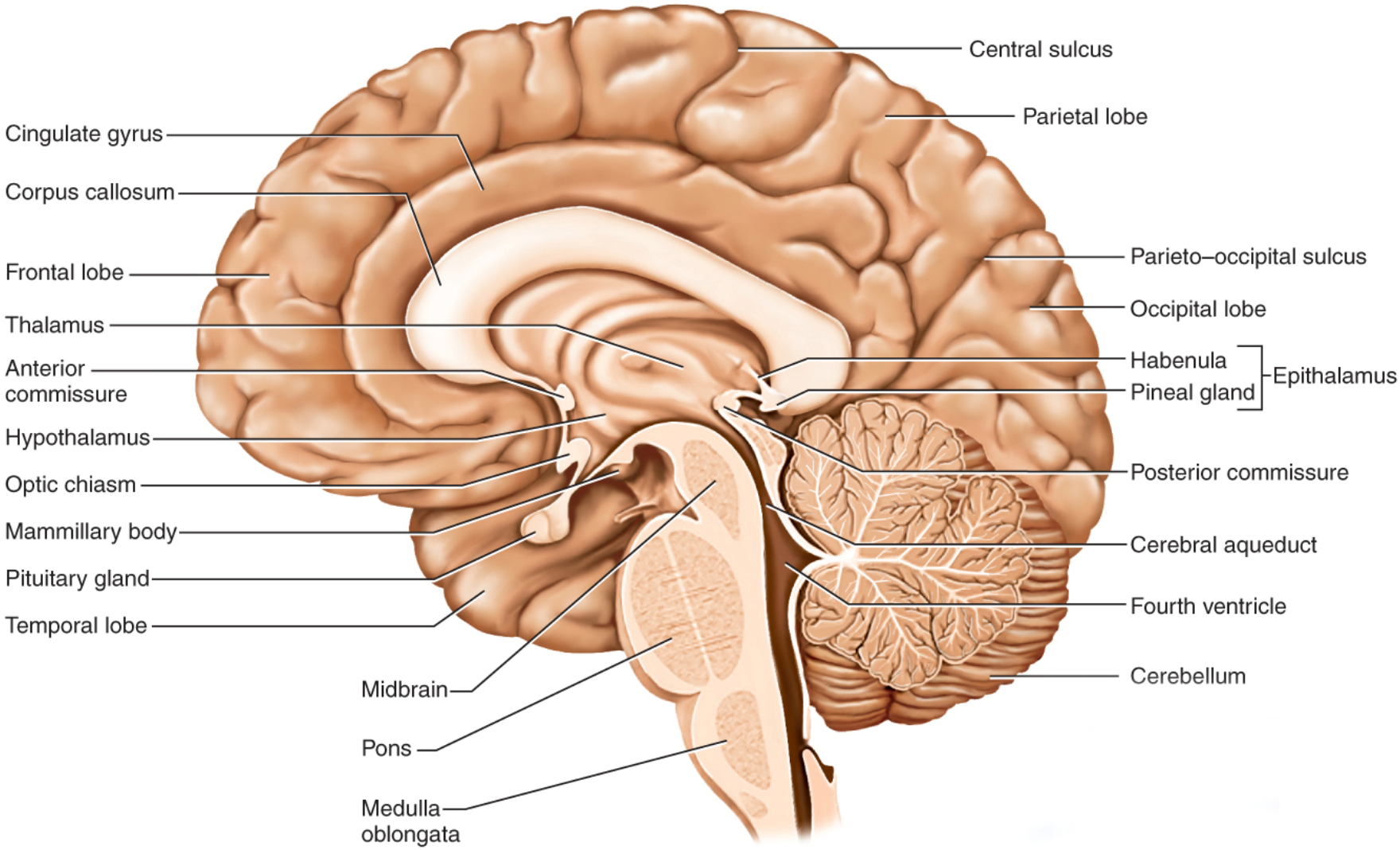
- ascending sensory tracts
- descending motor tracts
- pathways in and out of cerebellum
- **cranial nerves V, VI, VII, and VIII originate within Pons**
  - **sensory roles** – hearing, equilibrium, taste, facial sensations
  - **motor roles** – eye movement, facial expressions, chewing, swallowing, urination, and secretion of saliva and tears
- **reticular formation** in pons contains additional nuclei concerned with // *sleep, respiration, analgesic descending tract, and posture*



Sagittal section through brain and spinal cord

Midbrain

- Short segment of brainstem that connects the hindbrain to the forebrain
  - contains cerebral aqueduct
  - contains continuations of the medial lemniscus and reticular formation
  - contains the motor nuclei of two cranial nerves that control eye movements – CN III (oculomotor) and CN IV (trochlear)


Central sulcus
Parietal lobe
Cingulate gyrus
Corpus callosum
Parieto–occipital sulcus
Frontal lobe
Occipital lobe
Thalamus
Habenula
Epithalamus
Anterior commissure
Pineal gland
Hypothalamus
Posterior commissure
Optic chiasm
Mammillary body
Cerebral aqueduct
Pituitary gland
Fourth ventricle
Temporal lobe
Cerebellum
Midbrain
Pons
Medulla oblongata

(a)

Midbrain

- tectum – roof-like part of the midbrain posterior to cerebral aqueduct
  - exhibits four bulges, the corpora quadrigemina
  - upper pair, the superior colliculi function in visual attention, tracking moving objects, and some reflexes
  - lower pair, the inferior colliculi receives signals from the inner ear /// relays them to other parts of the brain, especially the thalamus
  - these two structures with input from eyes and ear and output to skeletal muscles in head/neck are responsible for the **startle reflex**
- cerebral peduncles – fiber tracts // two stalks that anchor the cerebrum to the brainstem anterior to the cerebral aqueduct

Midbrain // Cerebral Peduncles

- each consists of three main components // tegmentum, substantia nigra, and cerebral crus

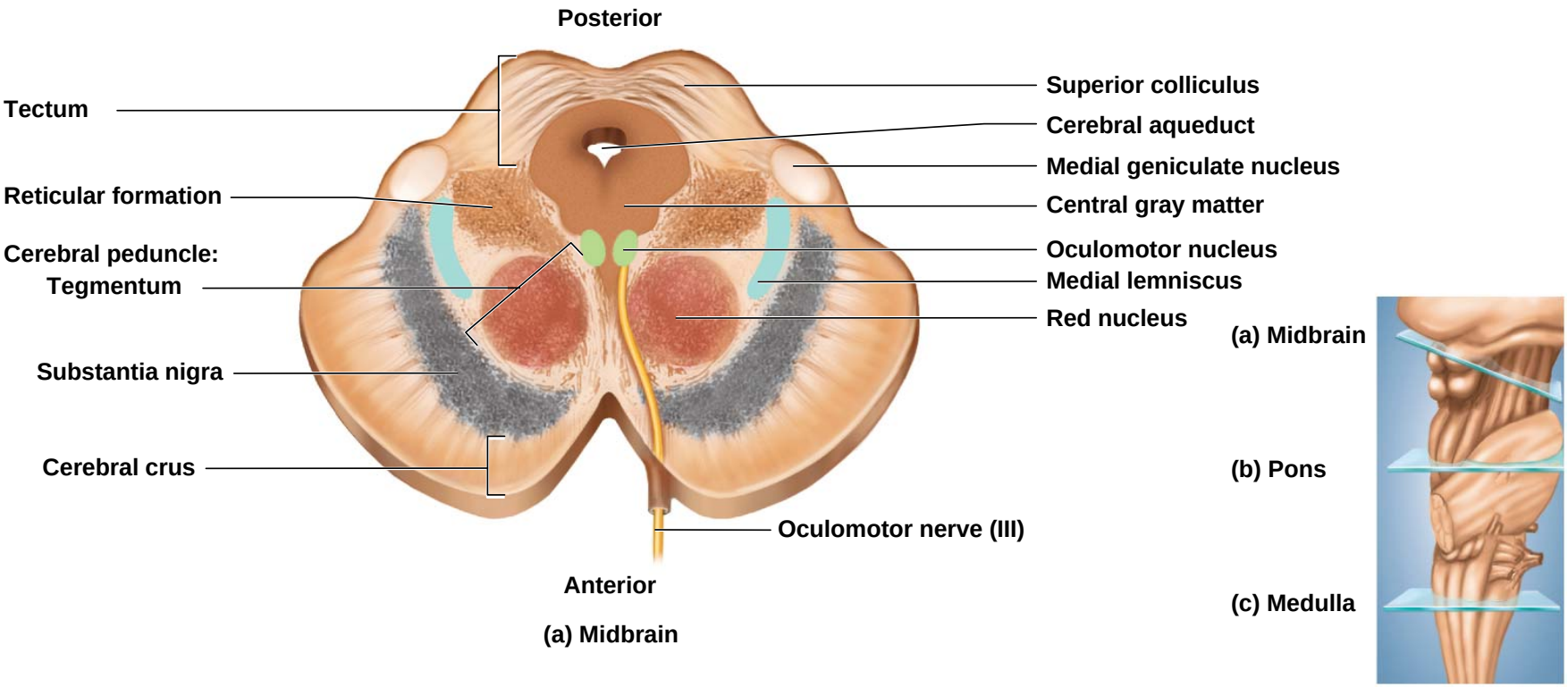
- Tegmentum // dominated by the red nucleus // pink color due to high density of blood vessels // connections go to and from cerebellum // collaborates with cerebellum for fine motor control

- substantia nigra // dark gray to black nucleus pigmented with melanin // motor center that <u>relays inhibitory signals to thalamus & basal nuclei preventing unwanted body movement</u>

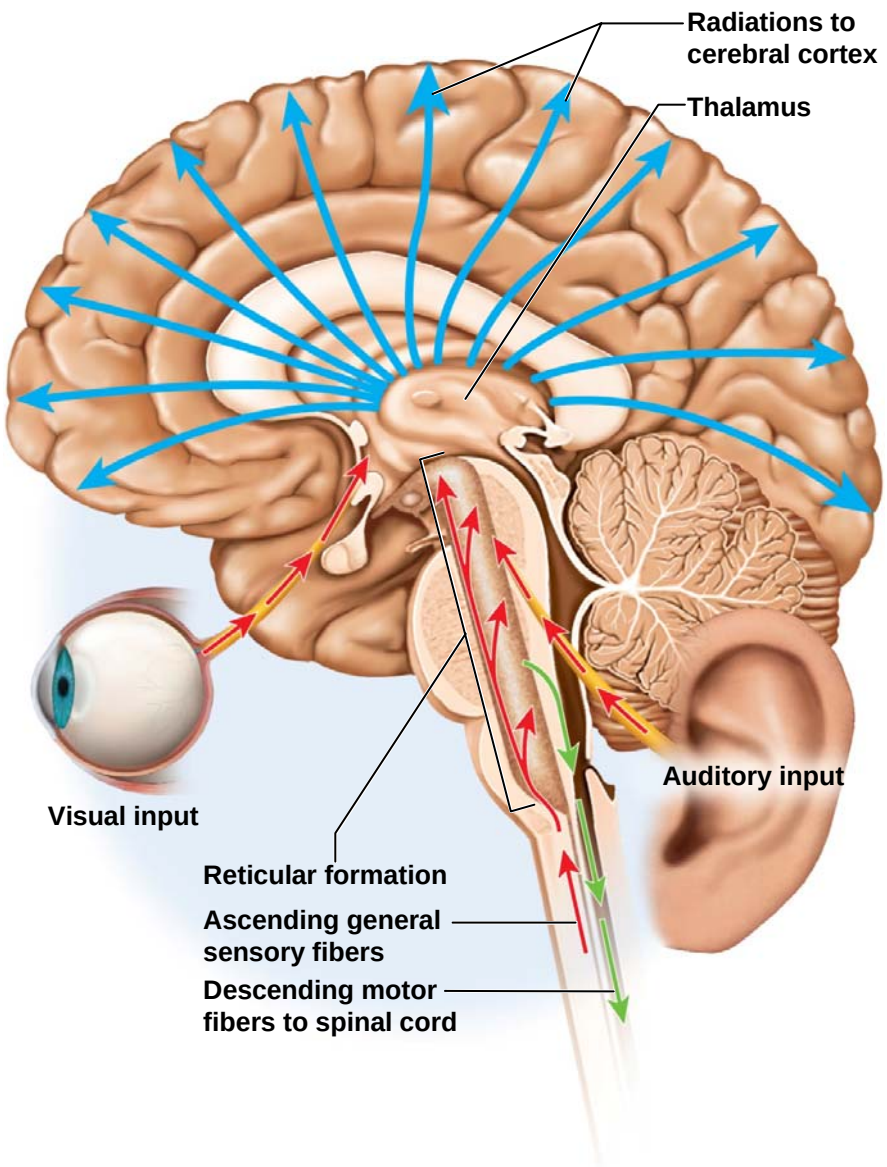
  - degeneration of neurons leads to tremors of Parkinson disease (reduced amount of dopamine secretion from substantia nigra to basal nuclie // reduced inhibitory signals to anterior horn's LMN = more unwanted contractions = increase muscle "tremors")

- cerebral crus // bundle of nerve fibers that connect the cerebrum to the pons // carries corticospinal tracts

Midbrain / Cross Section

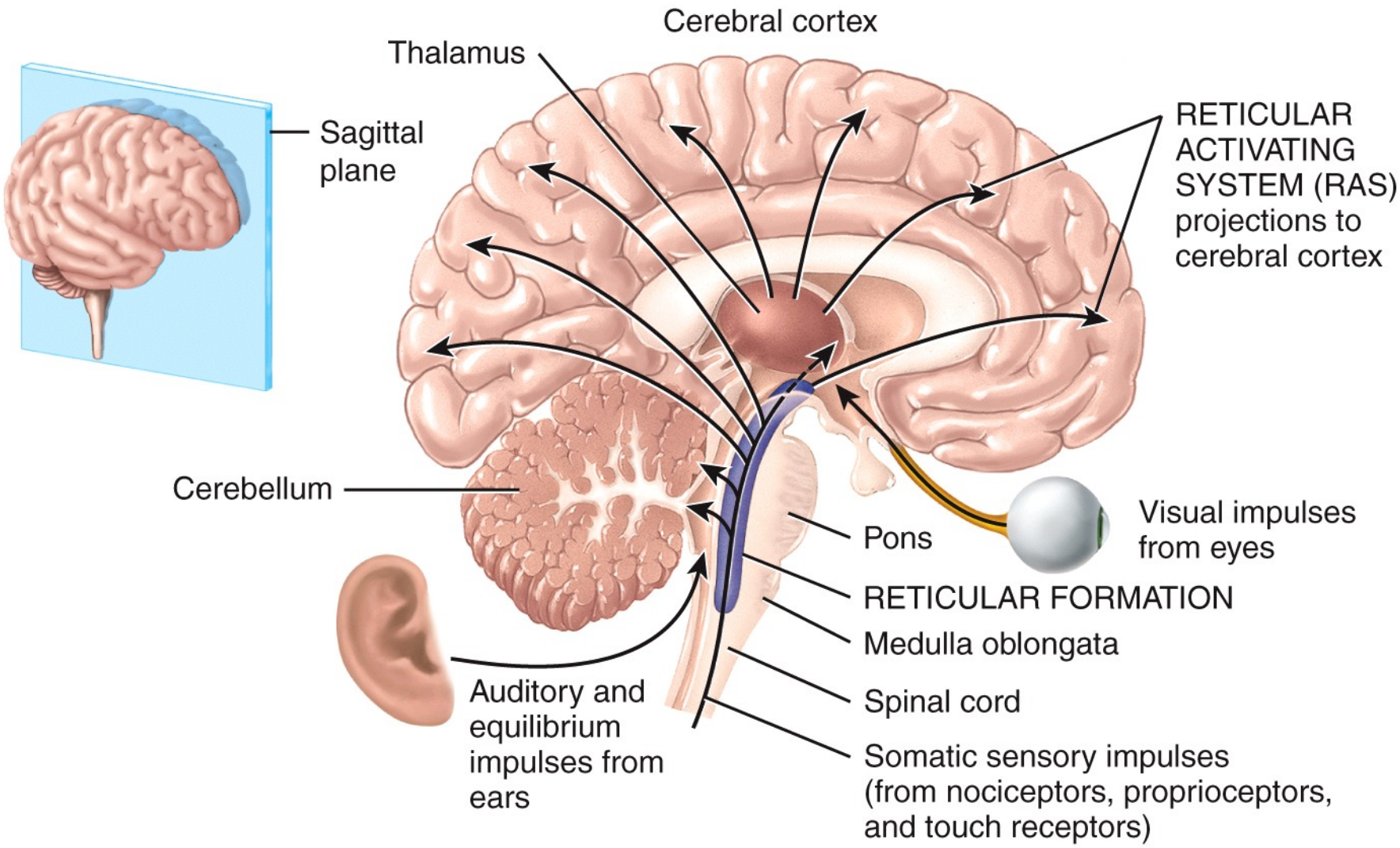


Reticular Formation



- loosely organized web of gray matter that runs vertically through all levels of the brainstem
- clusters of gray matter scattered throughout pons, midbrain and medulla
- occupies space between white fiber tracts and brainstem nuclei
- has connections with many areas of cerebrum
- more than 100 small neural networks without distinct boundary

Reticular Formation



(c) Sagittal section through brain and spinal cord showing the reticular formation

Functions of Reticular Formation Networks

- somatic motor control
  - adjust muscle tension to maintain tone, balance, and posture // especially during body movements
  - relays signals from eyes and ears to the cerebellum // integrates visual, auditory, and balance and motion stimuli into motor coordination
- gaze center – allow eyes to track and fixate on objects
- central pattern generators – (examples) neural pools that produce rhythmic signals to the muscles of breathing and swallowing
- cardiovascular control ***//*** includes cardiac and vasomotor centers of medulla oblongata

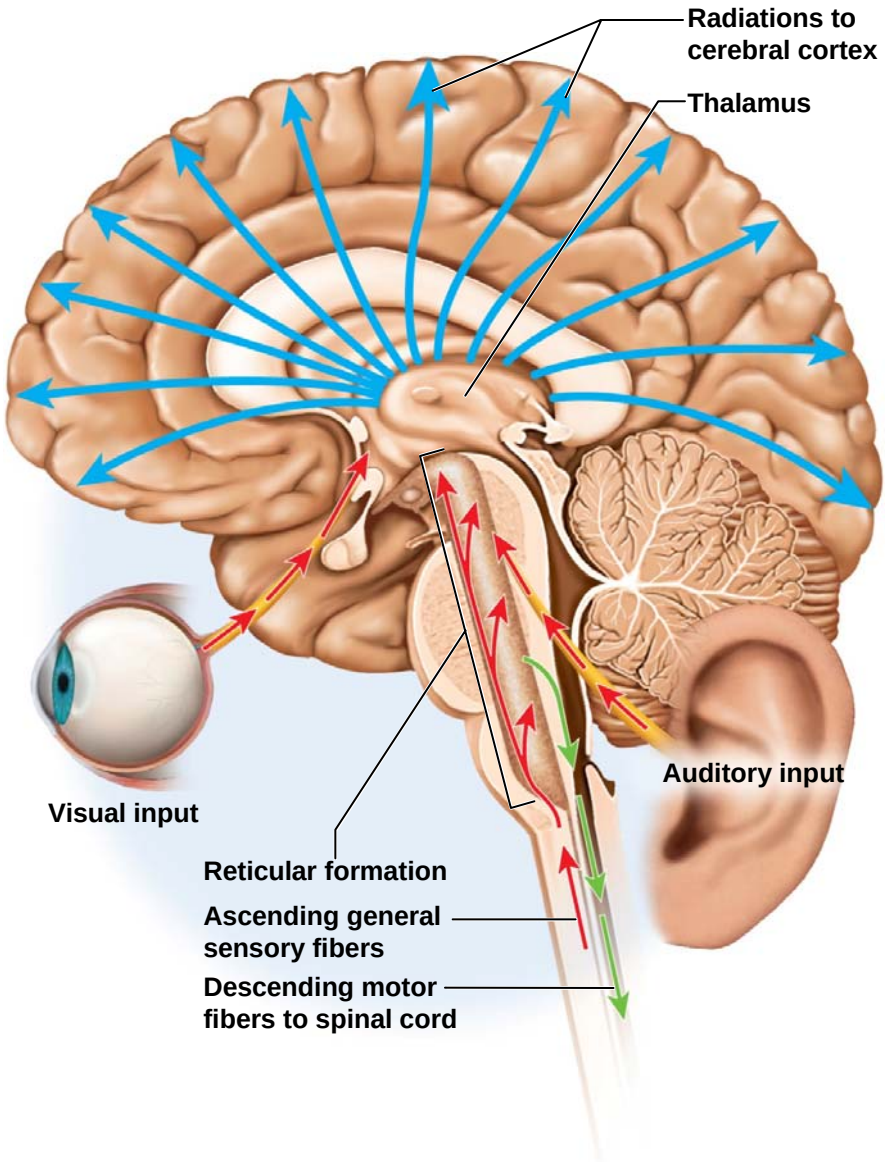
Functions of Reticular Formation Networks

- pain modulation
  - one route by which pain signals from the lower body reach the cerebral cortex
  - origin of descending analgesic pathways // fibers act in the spinal cord to block transmission of pain signals to the brain
- sleep and consciousness
  - plays central role in states of consciousness, such as alertness and sleep
  - injury to reticular formation can result in irreversible coma

Functions of Reticular Formation Networks

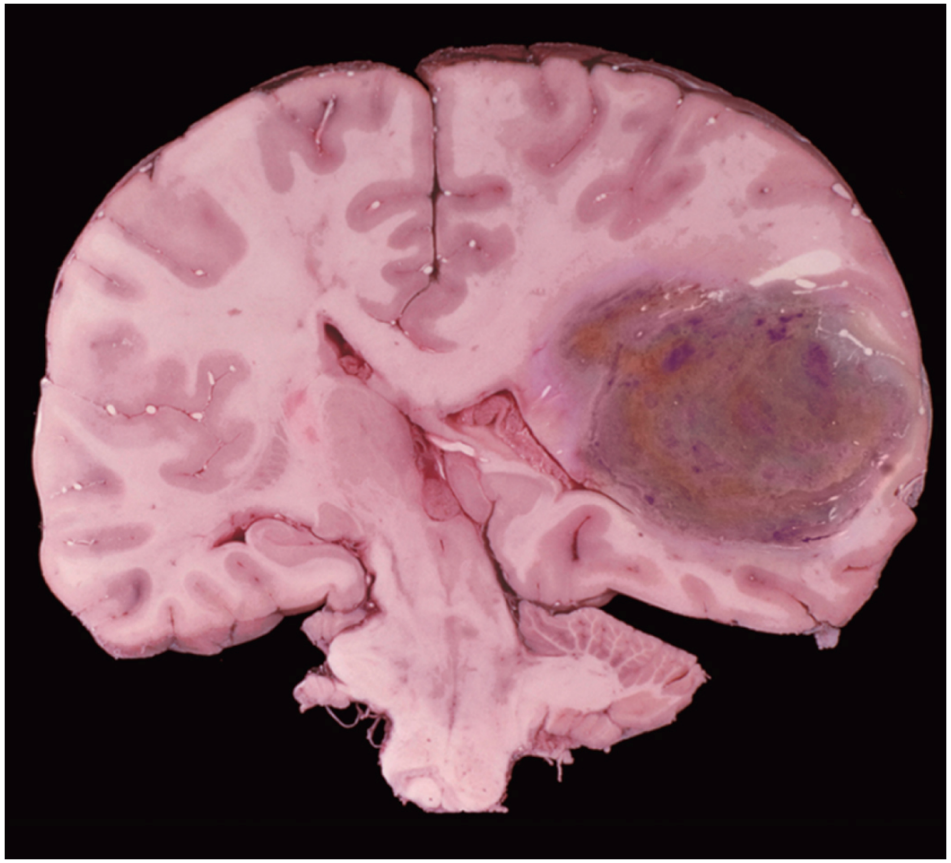
- Habituation
  - process in which the brain learns to ignore repetitive stimuli
  - inconsequential stimuli ignored while remaining sensitive to other “important stimuli”

Reticular Formation



The Diencephalon

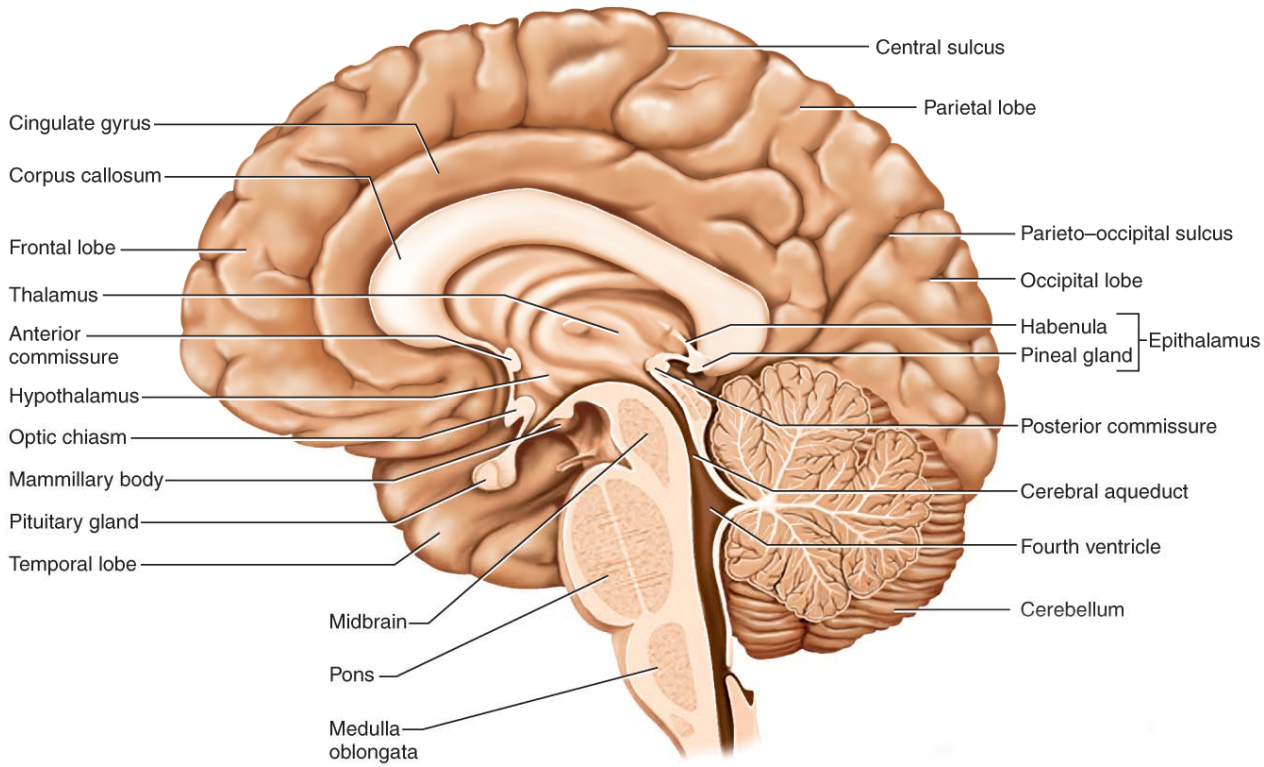
(Thalamus / Hypothalamus / Epithalamus)



The Forebrain

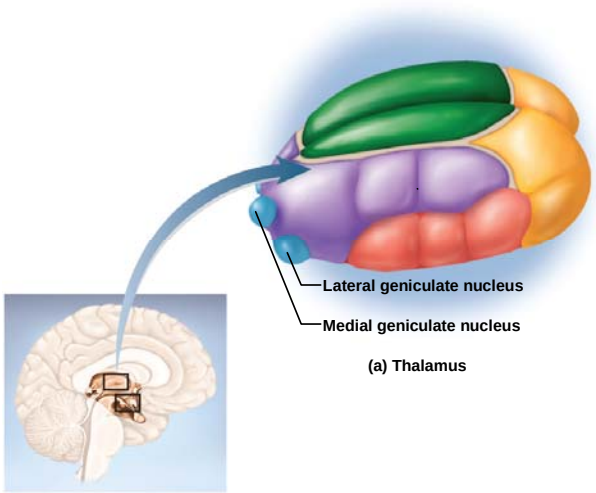
(two "mature structures" developed from embryonic tissues)

- the diencephalon // three major sub-derivatives
    - thalamus
    - hypothalamus
    - epithalamus
  - encloses the third ventricle
  - most rostral part of the brainstem
- the cerebrum // developed from telencephalon



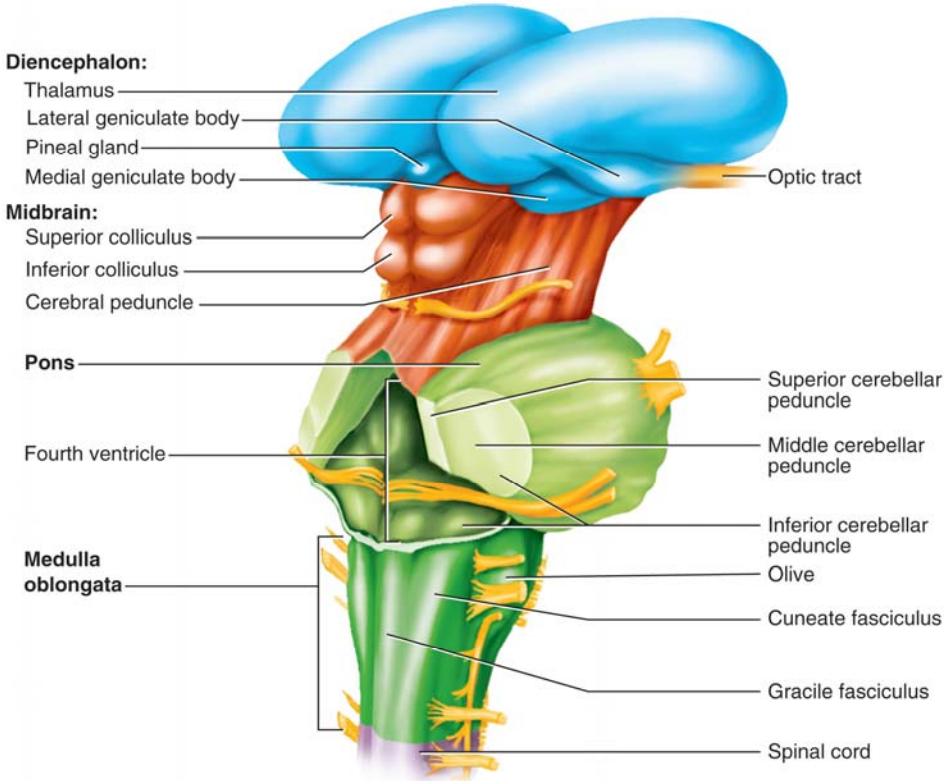
(a)

The Thalamus



(a) Thalamus

Thalamic Nuclei	
Anterior group	Part of limbic system; memory and emotion
Medial group	Emotional output to prefrontal cortex; awareness of emotions
Ventral group	Somesthetic output to postcentral gyrus; signals from cerebellum and basal nuclei to motor areas of cortex
Lateral group	Somesthetic output to association areas of cortex; contributes to emotional function of limbic system
Posterior group	Relay of visual signals to occipital lobe (via lateral geniculate nucleus) and auditory signals to temporal lobe (via medial geniculate nucleus)



(b) Dorsolateral view

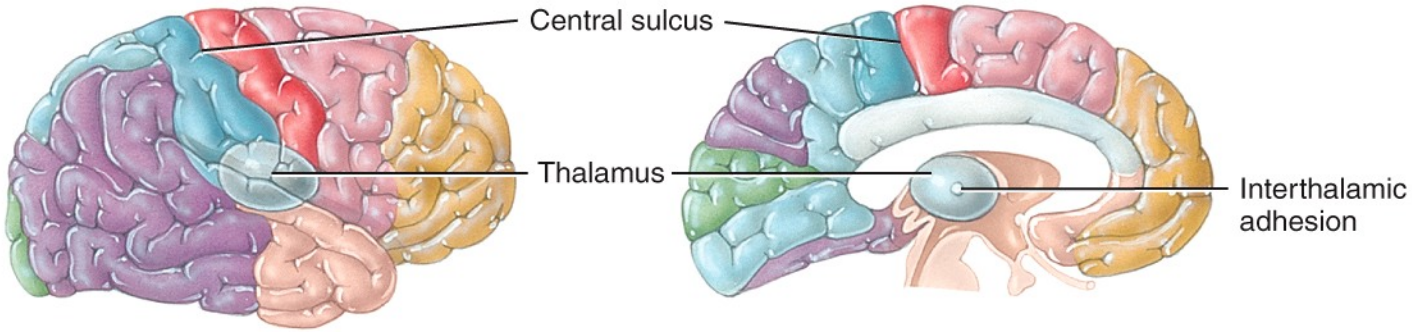
- An ovoid mass on each side of the brain
- perched at the superior end of the brainstem beneath the cerebral hemispheres

The Thalamus

- constitutes about four-fifths of the diencephalon
- two thalami are joined medially by a narrow intermediate mass
- composed of at least 23 nuclei – we will consider five major functional groups
- the **gateway to the cerebral cortex (Grand Central Station)**
  - nearly all sensory and motor signals to the cerebrum passes by way of synapses in the thalamic nuclei (exception is olfaction)
  - filters information on its way to cerebral cortex // split signal to share signal with limbic structures
  - Ascending signal synapse in thalamus then two pathway continue to ascend
    - One pathway goes to primary sensory area then passes onto association
    - Second pathway goes directly to the association area!!!

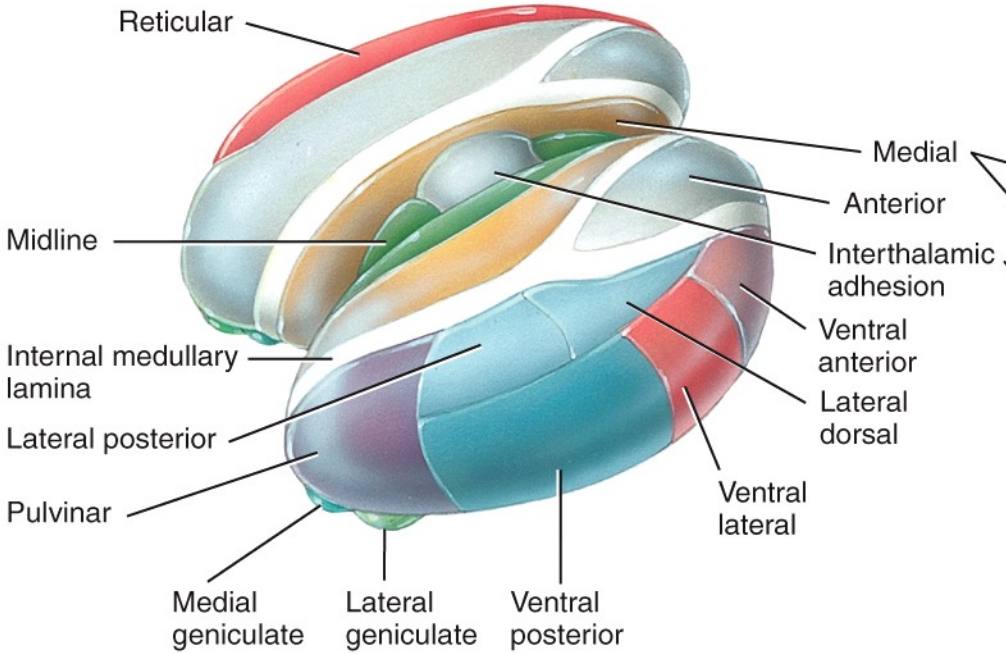
The Thalamus

- Plays key role in motor control
  - many spinal ascending tracts synapse with nuclei of the thalamus
  - also relaying signals between cerebellum to cerebrum
  - as well as providing the pathway for a feedback loop between the cerebral cortex, basal nuclei, and thalamus
  - We will look at these pathways when we study motor control as an example of one of the brain's higher functions

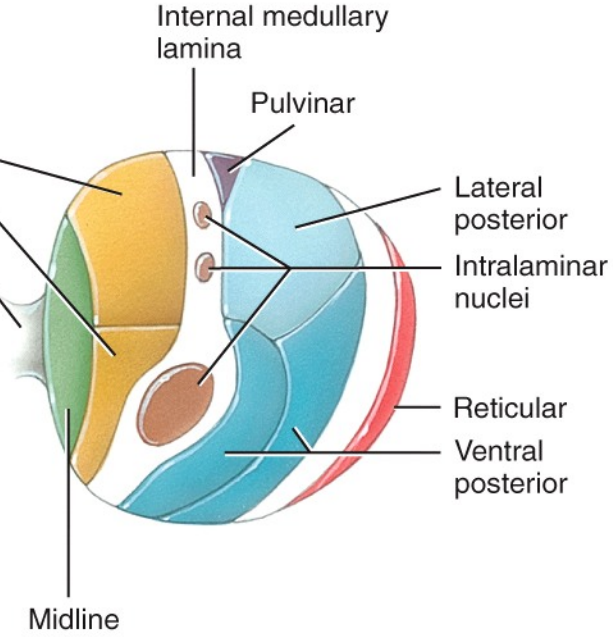


(a) Lateral view of right cerebral hemisphere

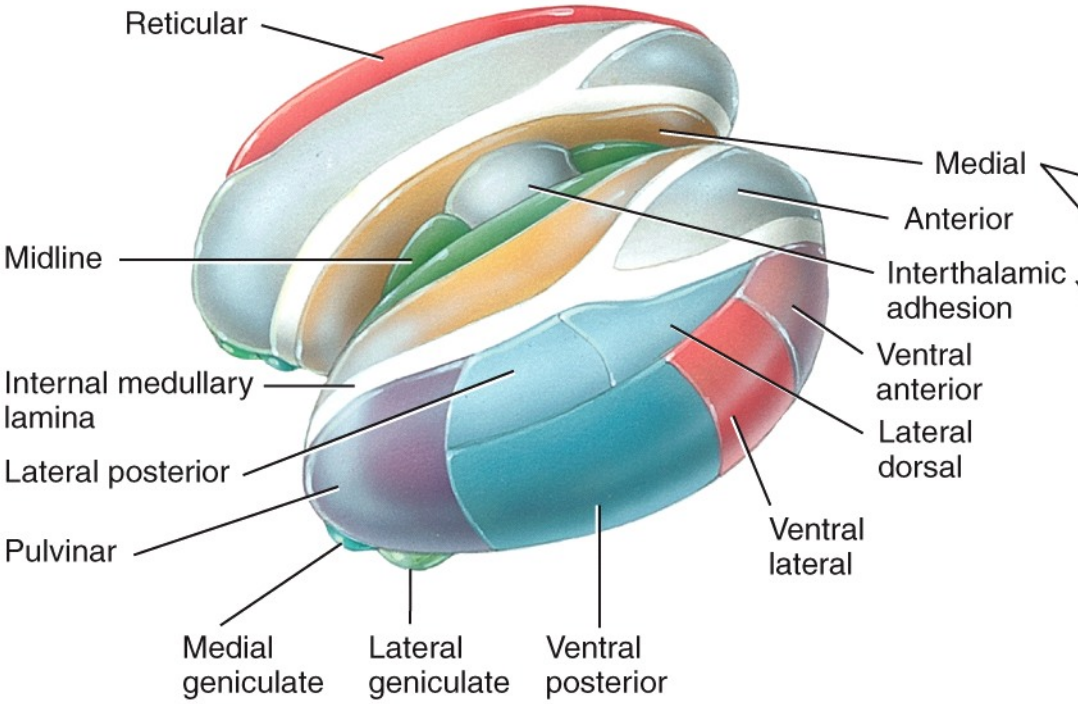
(b) Medial view of left cerebral hemisphere



(c) Superolateral view of thalamus showing locations of thalamic nuclei (reticular nucleus is shown on the left side only; all other nuclei are shown on the right side)



(d) Transverse section of right side of thalamus showing locations of thalamic nuclei



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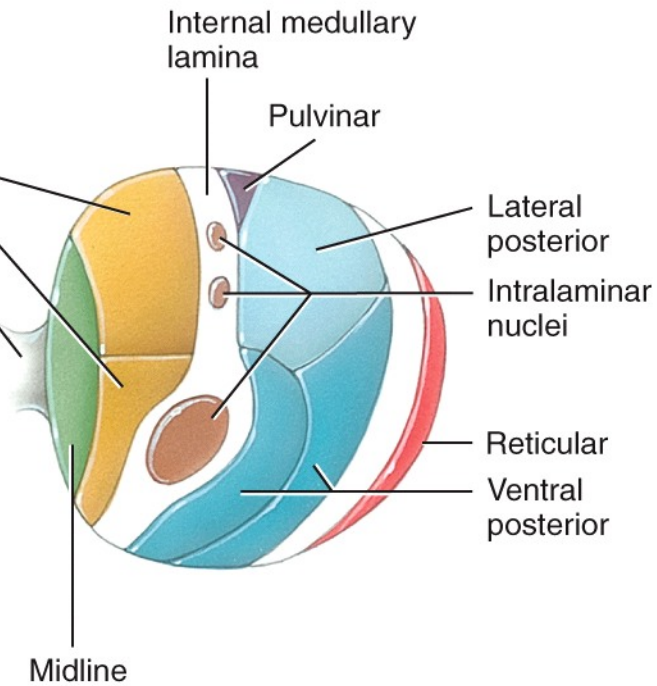


(d) Transverse section of right side of thalamus showing locations of thalamic nuclei

The Thalamus and the Limbic System

- Thalamus involved in emotional functions because the thalamus has fiber tracts which connects the thalamus to the limbic system

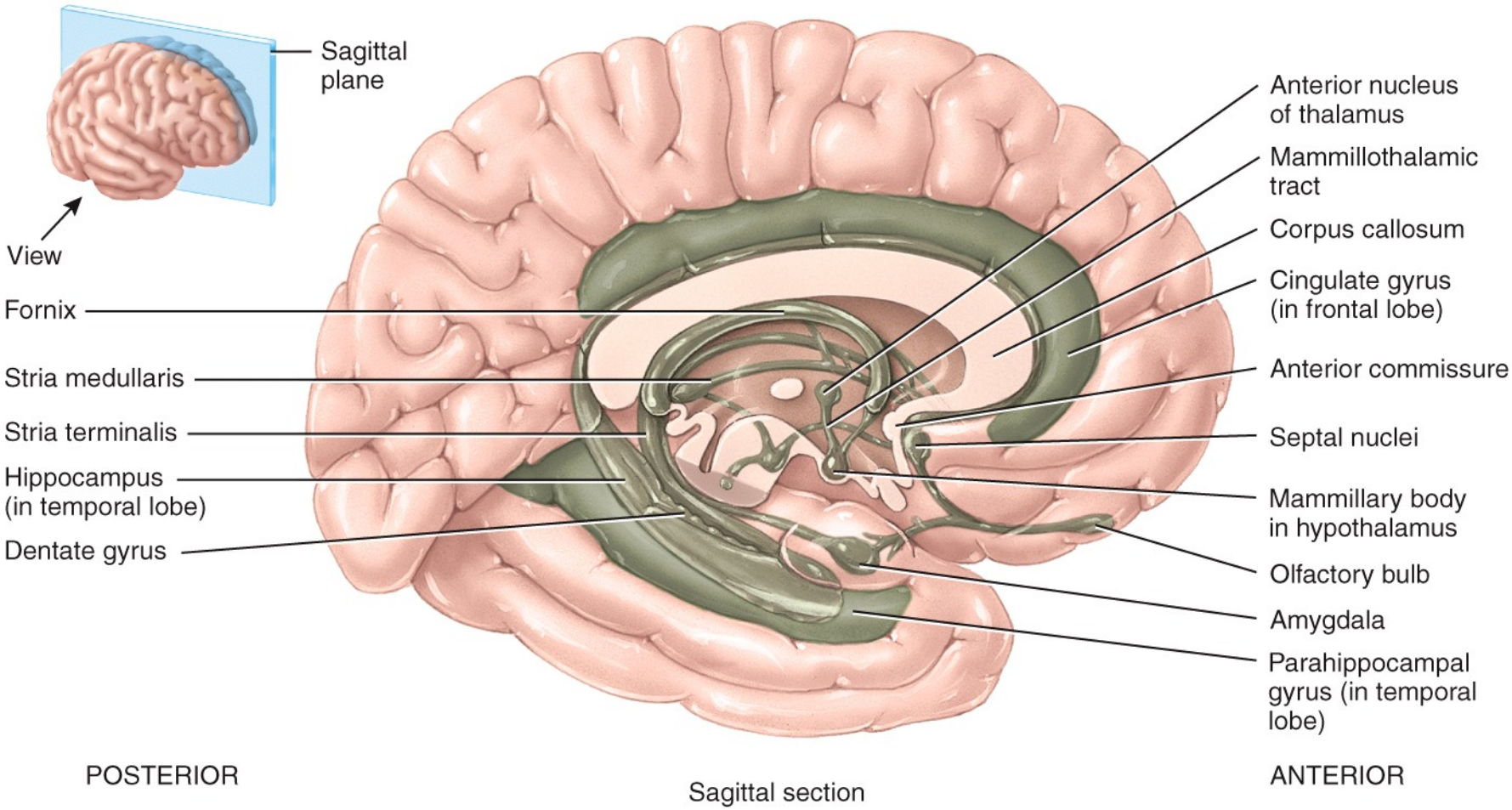
- LS plays key role in

  – the formation (consolidation) of new memory
  – providing a motivational system
  – site for innate emotions

- Limbic system = "primitive emotional brain" // a complex of structures that include some areas of cerebral cortex in the temporal and frontal lobes and some of the anterior thalamic nuclei

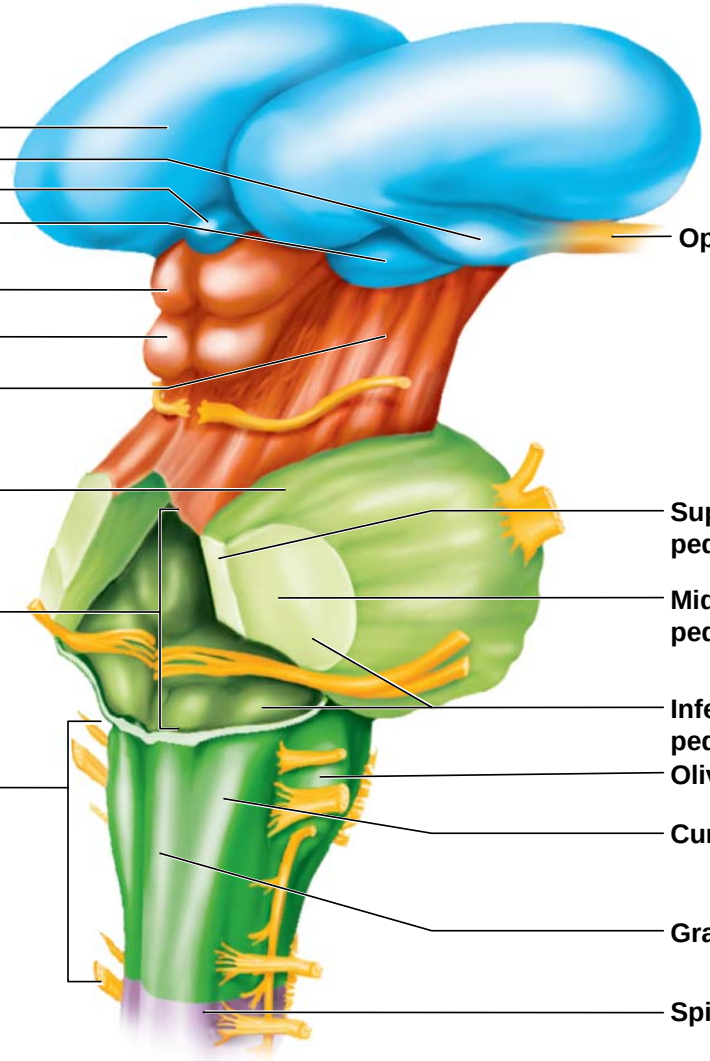
  – LS (paleomammalian brain formation) // first evolved at the end of the reptilian and beginning of the mammalian periods.

Limbic System = The Primitive Brain



Sagittal section

Posterolateral View of Brainstem

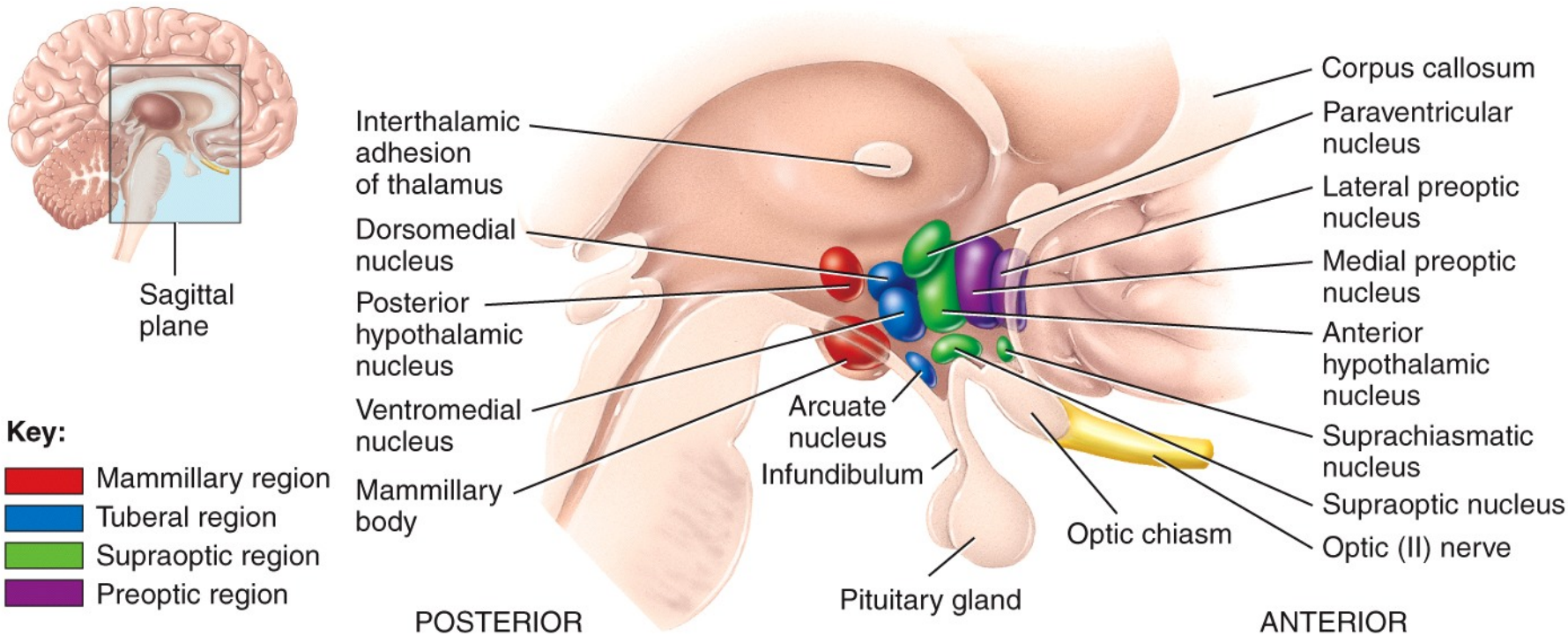


(b) Posterolateral view

Regions of the brainstem

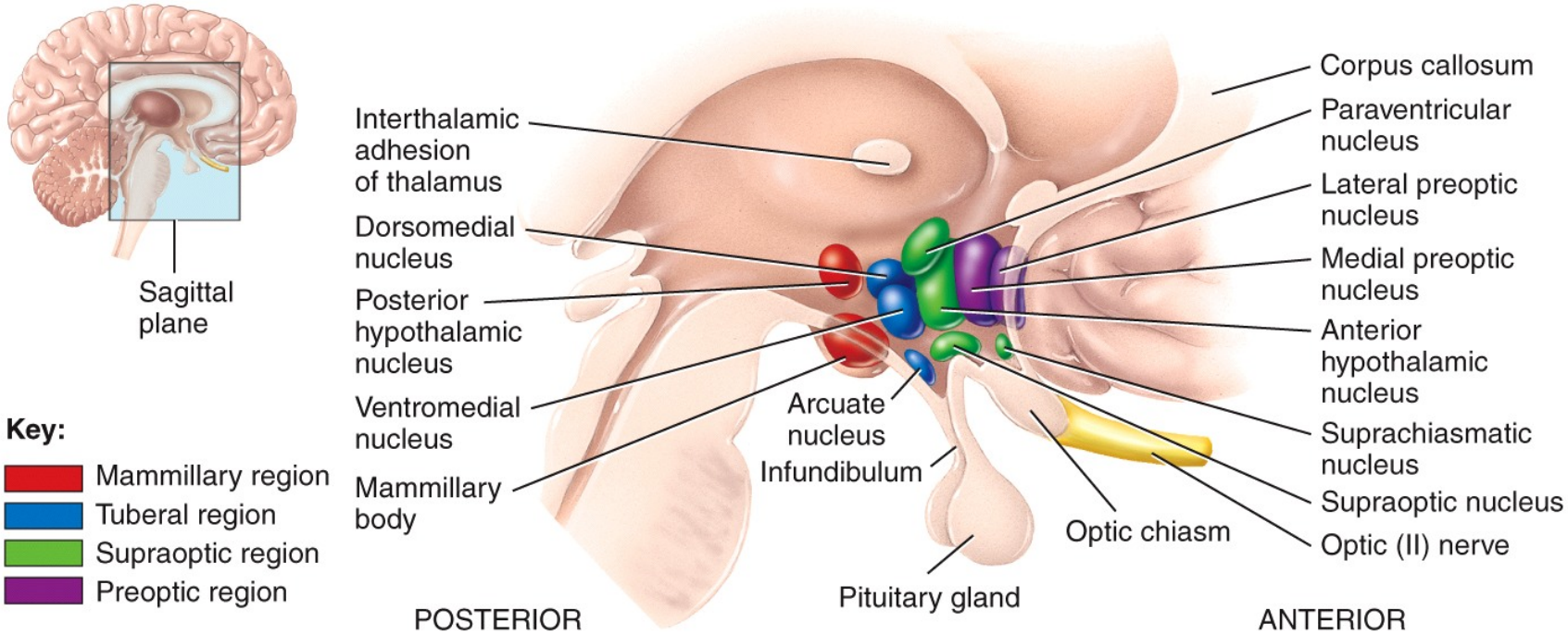
- Diencephalon
- Midbrain
- Pons
- Medulla oblongata

Hypothalamus



Sagittal section of brain showing hypothalamic nuclei

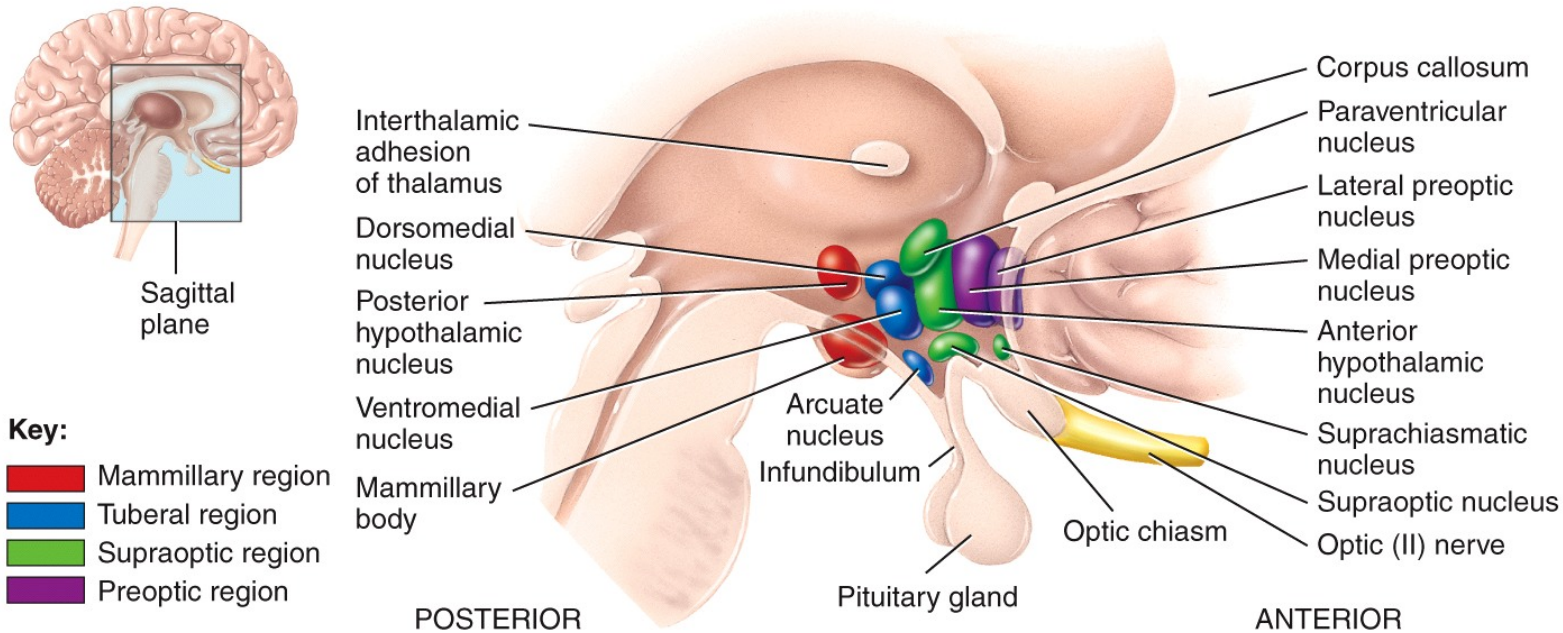
Hypothalamus



Sagittal section of brain showing hypothalamic nuclei

- forms part of the walls and floor of the third ventricle
- tissue boundry // anteriorly to optic chiasm // posteriorly to the paired mammillary bodies
- each mammillary body contains three or four mammillary nuclei // relay signals from the limbic system to the thalamus

Hypothalamus



Sagittal section of brain showing hypothalamic nuclei

- infundibulum – a stalk that attaches the pituitary gland to the hypothalamus
- control center // **it's the boss of autonomic nervous system & endocrine system**
- plays essential roll in homeostatic regulation of all body systems

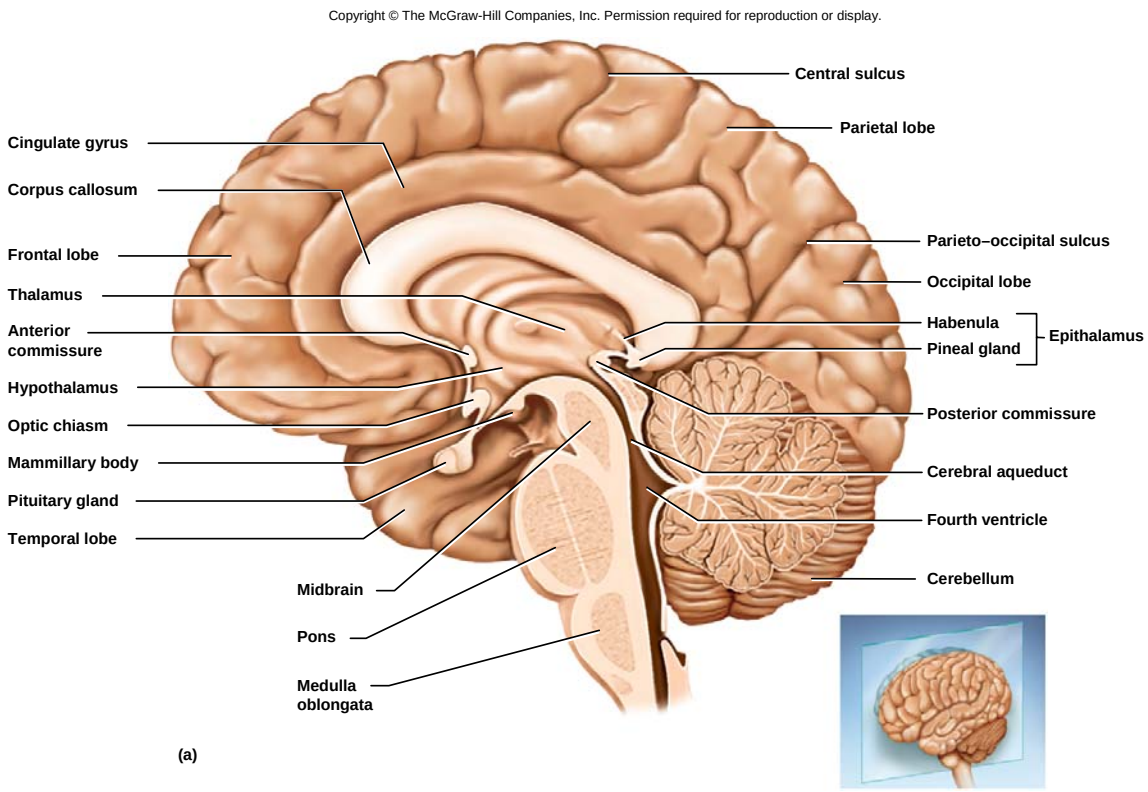
Functions of Hypothalamic Nuclei

- **hormone secretion**
  - controls anterior pituitary // secrete molecules which release hormones from anterior pituitary
  - Anterior pituitary hormones regulates growth, metabolism, reproduction,and stress responses
- **autonomic effects**
  - major integrating center for the autonomic nervous system
  - nerve tracks between hypothalamus and medulla oblongata
  - influences heart rate, blood pressure, gastrointestinal secretions and motility, and others
- **thermoregulation**
  - hypothalamic thermostat monitors body temperature
  - activates heat-loss center when temp is too high
  - activates heat-promoting center when temp is too low

Functions of Hypothalamic Nuclei

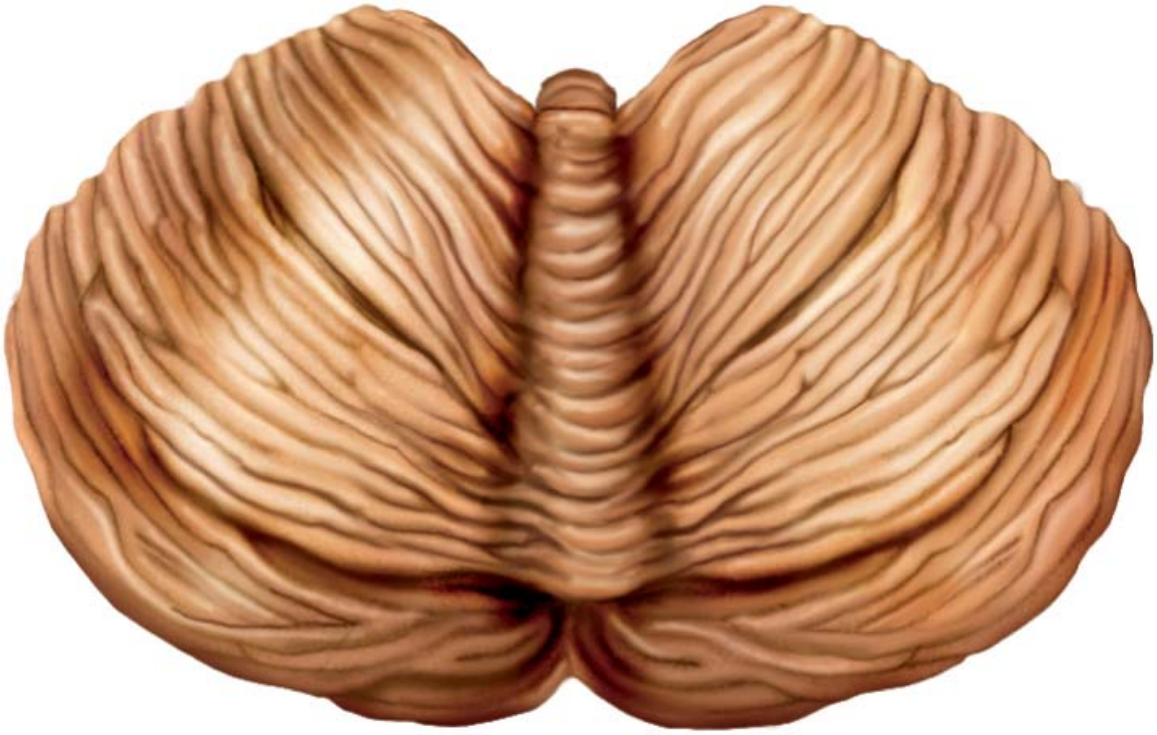
- **food and water intake**
  - hunger and satiety centers monitor blood glucose and amino acid levels // produce sensations of hunger and satiety
  - thirst center monitors osmolarity of the blood
- **rhythm of sleep and waking** // controls 24 hour circadian rhythm of activity
- **memory** // mammillary nuclei receive signals from hippocampus
- **emotional behavior** // anger, aggression, fear, pleasure, and contentment // as part of limbic system

Epithalamus

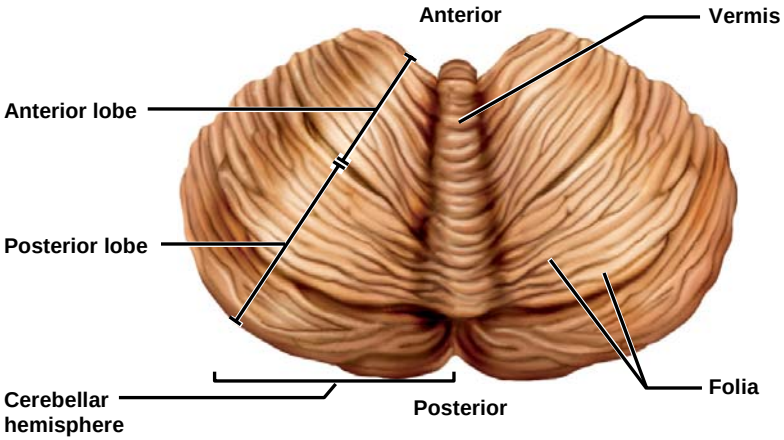


- epithalamus – thin roof over the third ventricle // very small mass of tissue composed of
  - pineal gland – endocrine gland
  - habenula – relay from the limbic system to the midbrain

The Cerebellum



Cerebellum



(b) Superior view

consists of right and left cerebellar hemispheres connected by **vermis**

cortex of gray matter with folds (**folia**) and four deep nuclei in each hemisphere

granule cells and **Purkinje cells** synapse on deep nuclei

white matter branching pattern is called **arbor vitae**

- the largest part of the hindbrain and the <u>second largest part of the brain as a whole</u>
- Only 10% total mass of brain
  - contains 50% or more of all brain neurons
  - 60% surface area of the cerebrum
  - cerebellum has 100 billion neurons
  - Cerebellum's soma have more synapses than soma of the cerebrum
  - 100,000 synapses per soma compared to 10,000 for other cortical soma

Functions of the Cerebellum

- In the 1950s we did not understand all the functions of cerebellum
- In the 1970s developed understanding that cerebellum coordinated skeletal muscle performance
- Today we understand the full range of cerebellum's functions:
- The cerebellum can be thought to simply "compares stuff"
- Receives and integrates sensory signals then sends efferent signals to other areas of the brain…..

Functions of the Cerebellum

- comparing textures of two objects without looking at them
- spatial perception
- comprehension of different views of 3D objects belonging to the same object
- motor function // monitor muscle performance vs intent
- cognitive role (information processing)
  - note: children with attention-deficit disorder have unusually small cerebellum

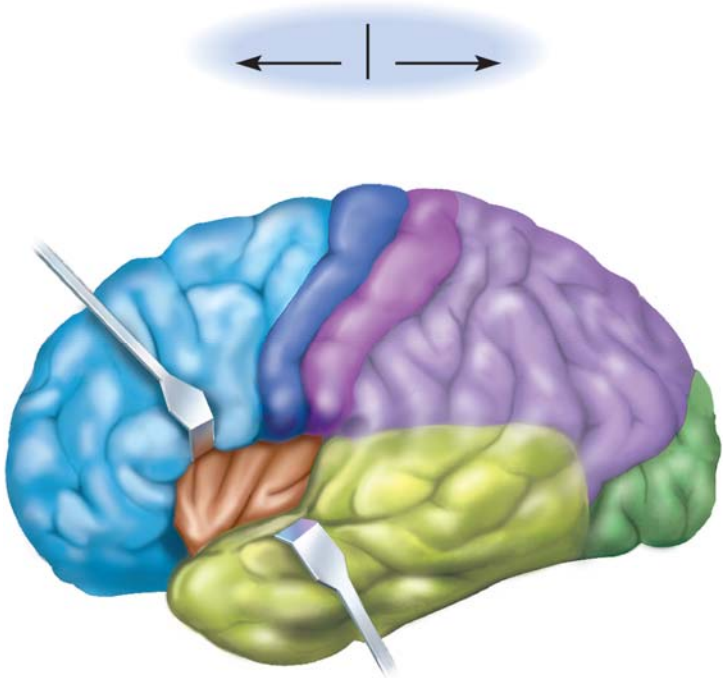
Functions of the Cerebellum

- Timekeeping center // Judge lapse time between two stimuli
  - predicting movement of objects
  - helps predict how much the eyes must move in order to compensate for head movements and remain fixed on an object
  - Coordinates fixed eye vision as head/body moves
  - Allows predator to catch prey or baseball player to catch a ball
- Hearing // distinguish between different pitches // distinguish between similar sounding words (rapid vs rabbit)

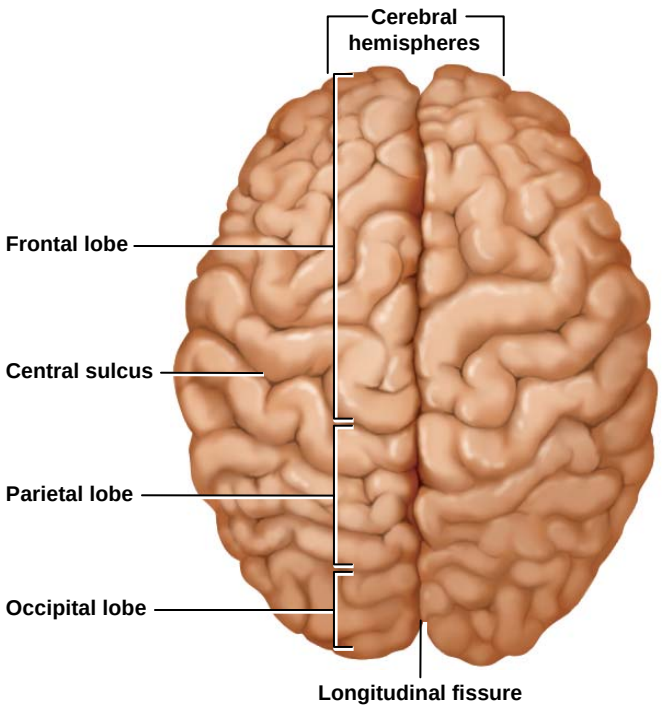
Functions of the Cerebellum

- language output // Relate word “apple” to verb “eat”
- planning and scheduling tasks
- cerebellar’s lesions may result in emotional overreactions and trouble with impulse control
- *We will examine the cerebellum’s function in “motor control” in detail as an example of a “higher brain function”.*

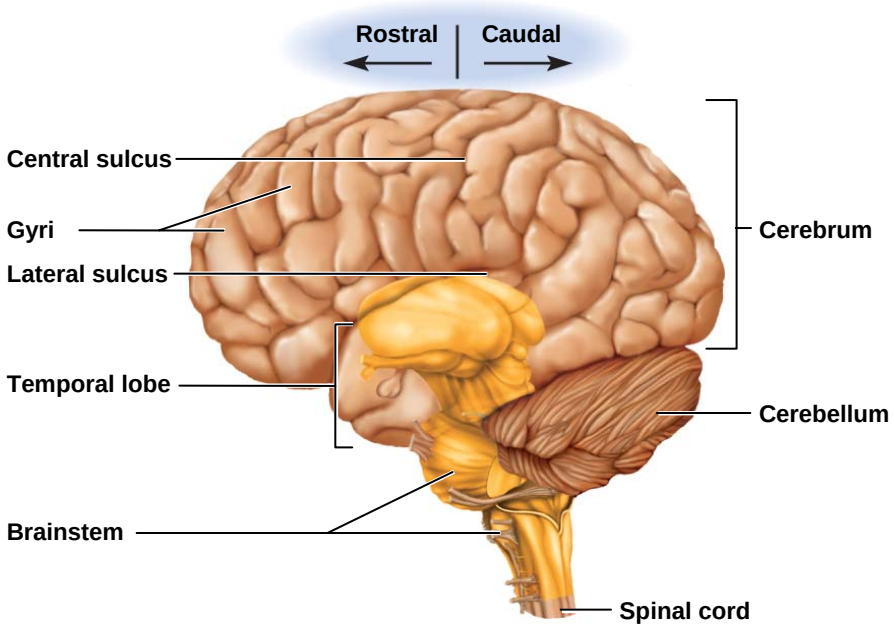
The Cerebrum



Cerebrum - Gross Anatomy



(a) Superior view

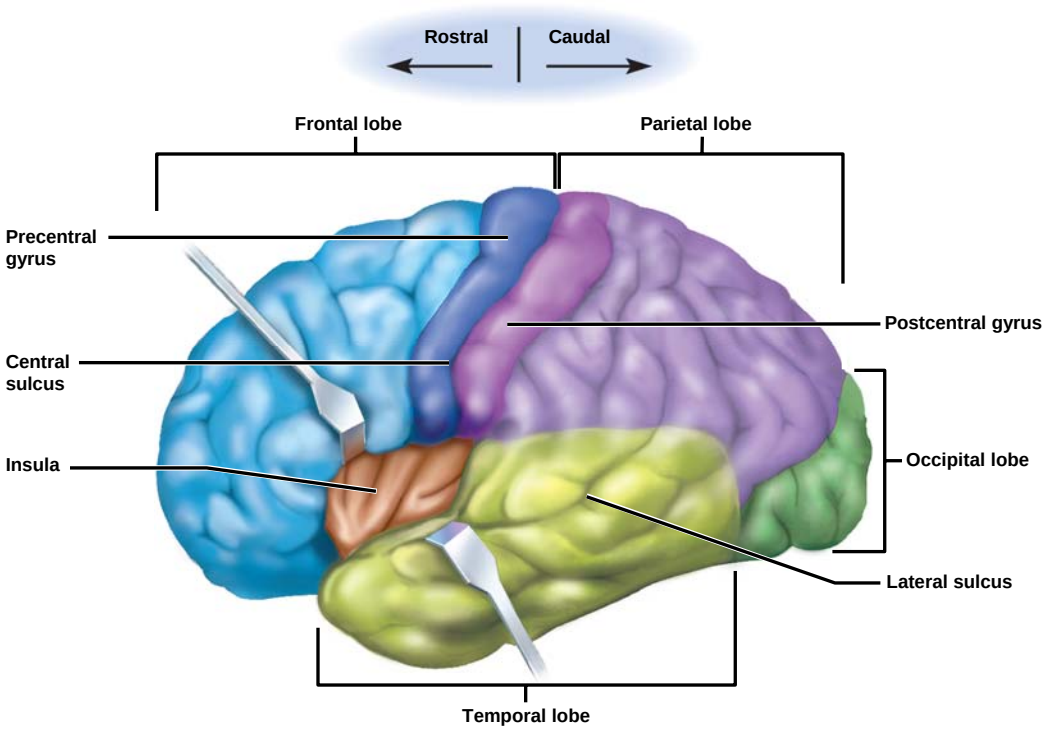


(b) Lateral view

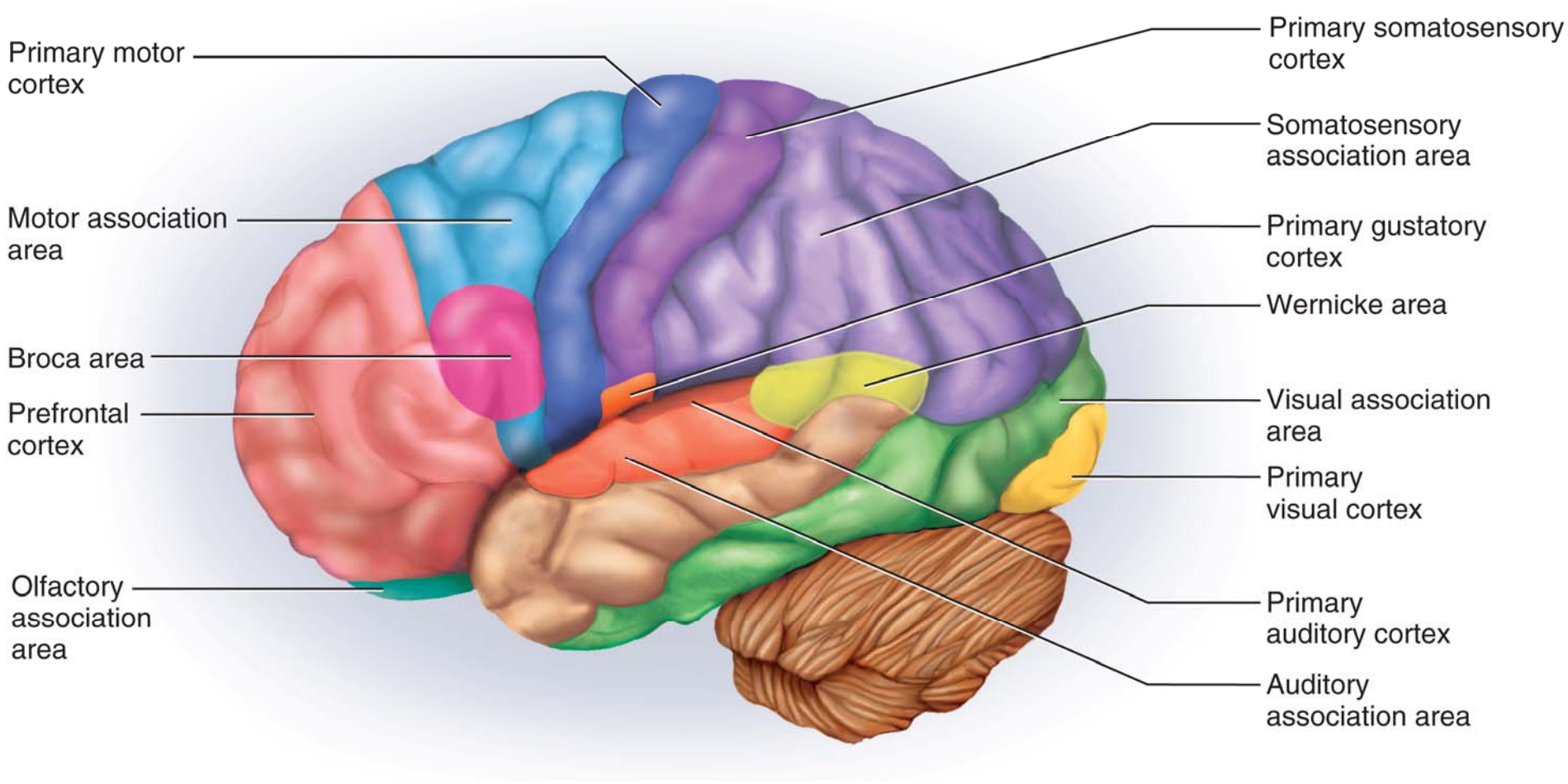
- two **cerebral hemispheres** // divided by **longitudinal fissure**
  - connected by white fibrous tract the **corpus callosum**
  - **gyri** and **sulci** – increases amount of cortex in the cranial cavity
  - gyri increases surface area for information processing capability
  - some sulci divide each hemisphere into **five lobes** named for the cranial bones that overly them

Cerebrum's Functions Isolated in "Lobes"

- **frontal lobe**
  - voluntary motor functions
  - motivation, foresight, planning, memory, mood, emotion, social judgment, and aggression
- **parietal lobe**
  - receives and integrates general sensory information, taste and some visual processing
- **occipital lobe**
  - primary visual center of brain
- **temporal lobe**
  - areas for hearing, smell, learning, memory, and some aspects of vision and emotion
- **insula** (hidden by other regions)
  - understanding spoken language, taste and sensory information from visceral receptors



Functional Map of the Cerebrum

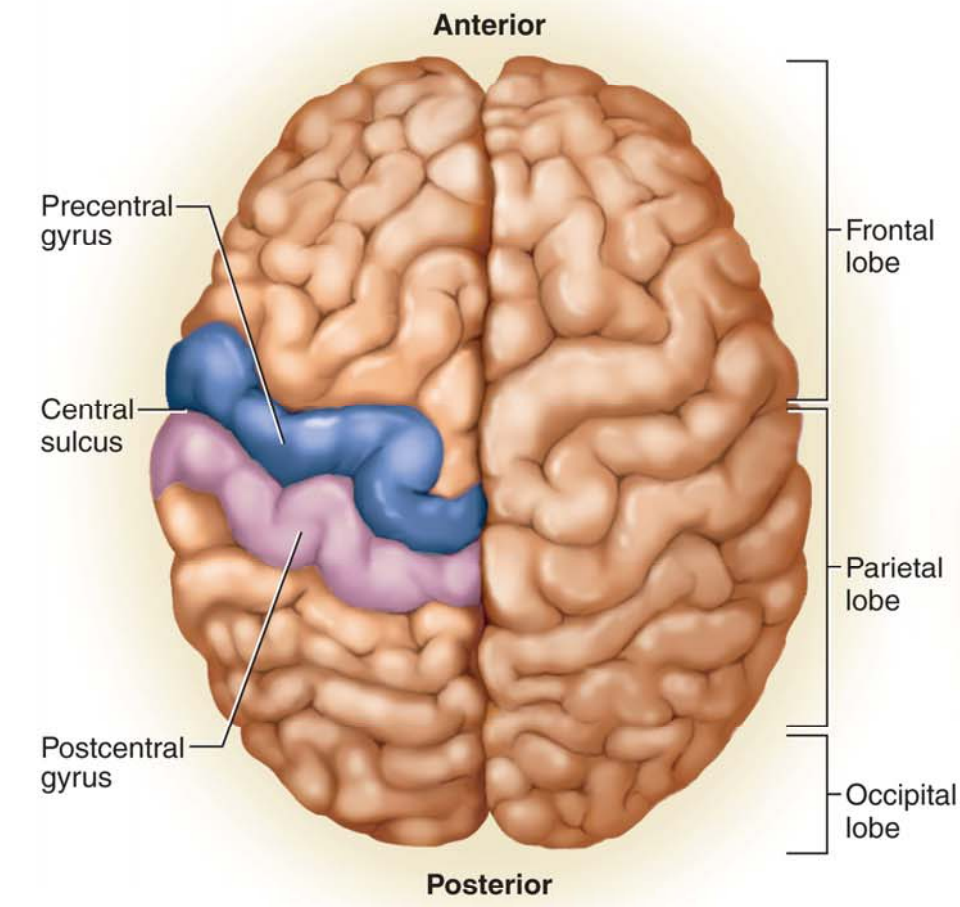


Note: key surface margins (longitudinal fissure / central sulcus / lateral sulcus)

Somatotopy of the Precentral and Postcentral Gyrus

- precentral gyrus = “motor strip” // corticospinal tract = upper motor neuron
- postcentral gyrus = “somatosensory strip” // receives spinalcortico tract
- somatotopy – point-for-point correspondence between an area of the body and an area on either the primary motor or sensory gyrus
- motor and sensory neurons for toe are deep in the longitudinal fissure of the medial side of the gyrus
- the summit of the gyrus controls the trunk, shoulder, and arm /// the inferolateral region controls the facial muscles
- motor homunculus is a distorted projection of the body image onto the motor or sensory gyri to show proportional mapping of muscle/sensory functions to body region

The Homunculus



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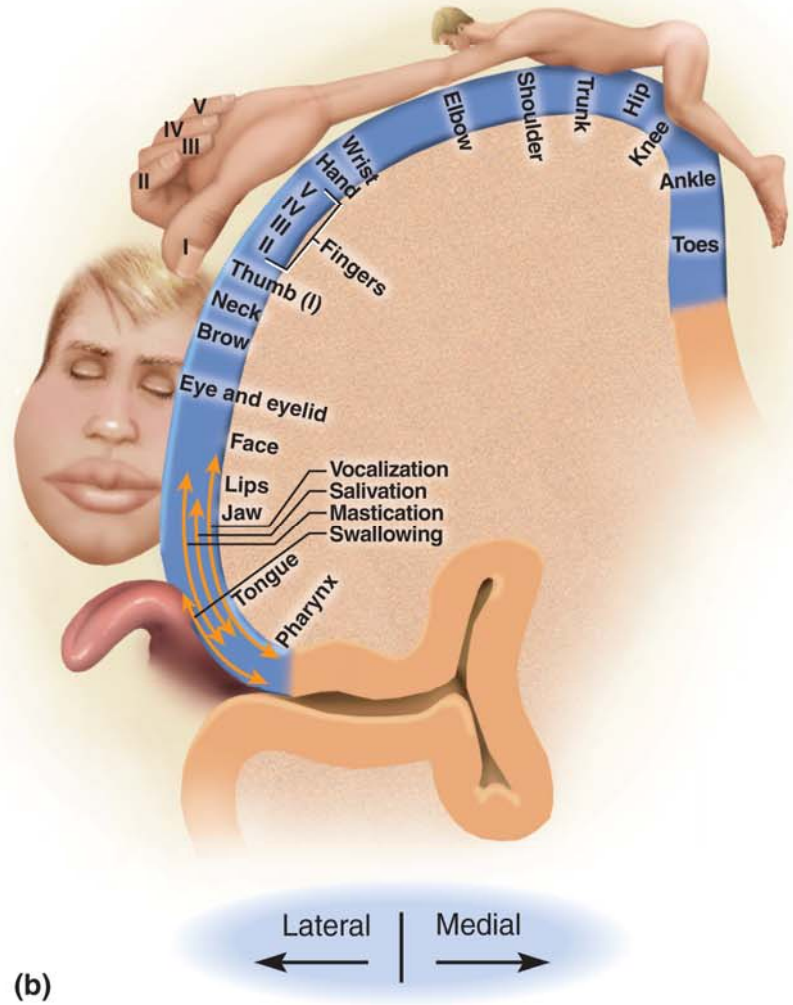


(b)

Higher Brain Functions of the Cerebrum

- HBF includes sleep, memory, cognition, emotions, special sensation, language, and *motor control of muscles*

- All these HBF require integrative functions between different areas of the brain located mainly the cerebrum but often with nerve curcuits between brainstem and cerebellum /// *involves combined action of multiple brain levels*

  - **motor control involves neural networks between cerebral cortex, basal nuclei, motor nuclei in brainstem and cerebellum**

  - note: spinal cord's **central pattern generators** also play a role in motor control // located in anterior horns

  - note: central pattern generators are also called motor programs or local motor neurons

- *All **Higher Brain Functions** (unlike the structure of the brain) do not have easily defined anatomical boundaries*

Motor Control of Skeletal Muscles

(This is a Type of Higher Brain Function)

- The intention to contract a muscle begins in prefrontal cortex
  - Prefrontal cortex sends action potential to the motor association (premotor) area of the frontal lobes
  - frontal cortex is where we plan our behavior (the idea to move)
  - motor association area = where neurons compile and store programs (neural circuits for different motor program) // degree and sequence of muscle contraction required for an action /// (e.g. how to tie your shoes)

Motor Control

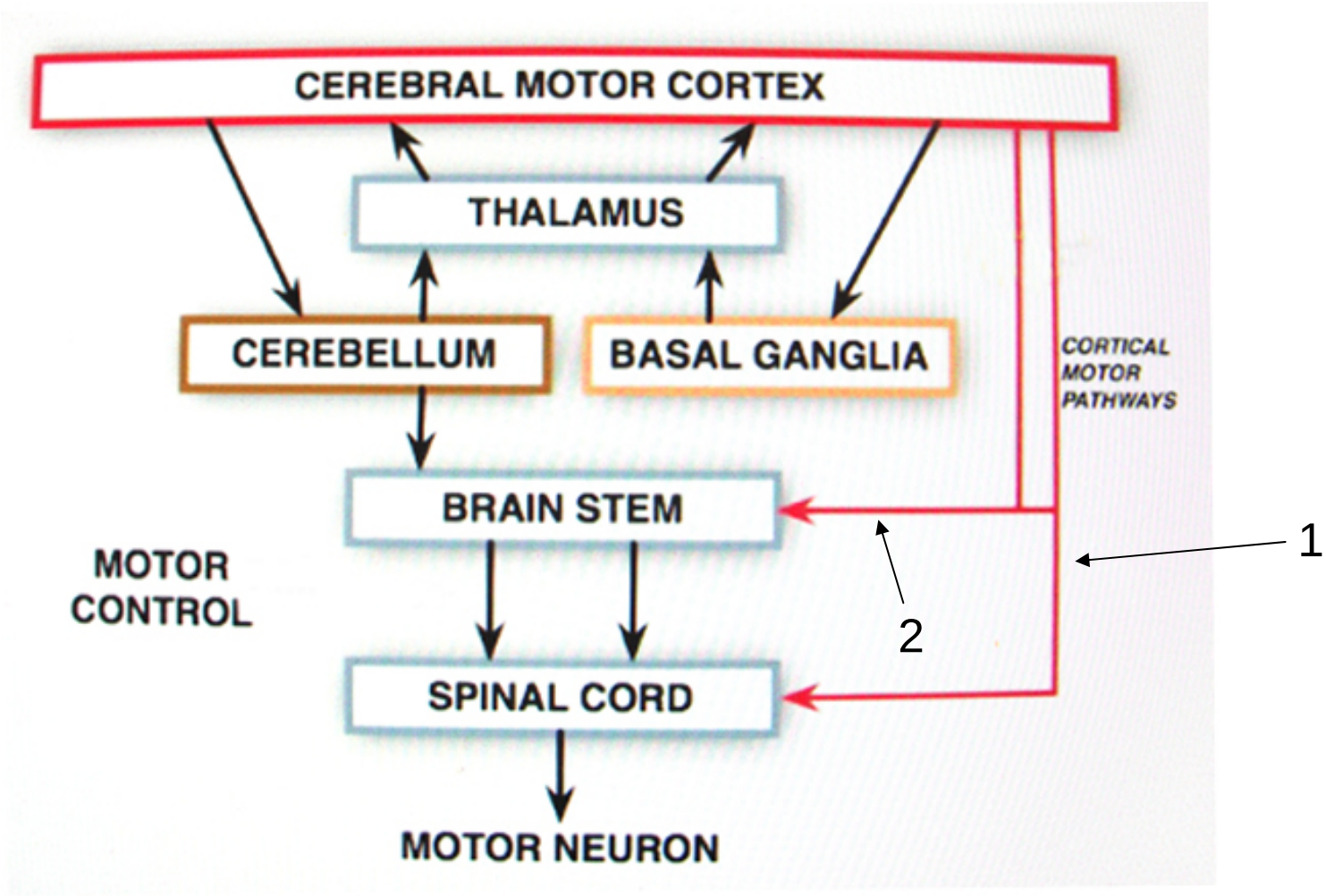
- Motor Programs (directions for specific muscle contractions) located in motor association area are relayed to neurons in precentral gyrus (the primary motor area --- also called the “motor strip”)

- Precentral Gyrus (Primary Motor Area) is where soma of the corticospinal tract (an upper motor neurons) originate /// they then descend to synapse on lower motor neurons (their soma in anterior horns of spinal cord) // LMN = common pathway to skeletal muscles

- Precentral Gyrus also have somas which form the corticobulbar tract (upper motor neuron track) // they decend to synapse on motor nuclei in brain stem (crainial nerves) // these are = to lower motor neurons

  – both CST & CBT synapse with LMN // LMN are the pathways or circuits that connect CNS to skeletal muscles

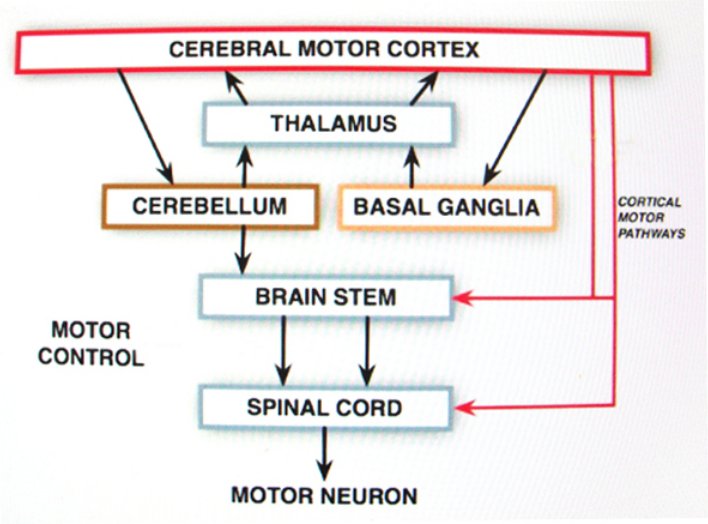
Understanding Motor Control Function



Notes:

1. Corticospinal tracts primarily innervate skeletal muscles of hand and feet
2. Corticospinal tracts have colateral fibers to Brain Stem Motor Nuclei
3. Brain Stem Motor Nuclei / muscle tone / modulate effects of gravity

Understanding Motor Control Function



Corticospinal tract sends Action Potentials to skeletal muscle (Direct pathway)

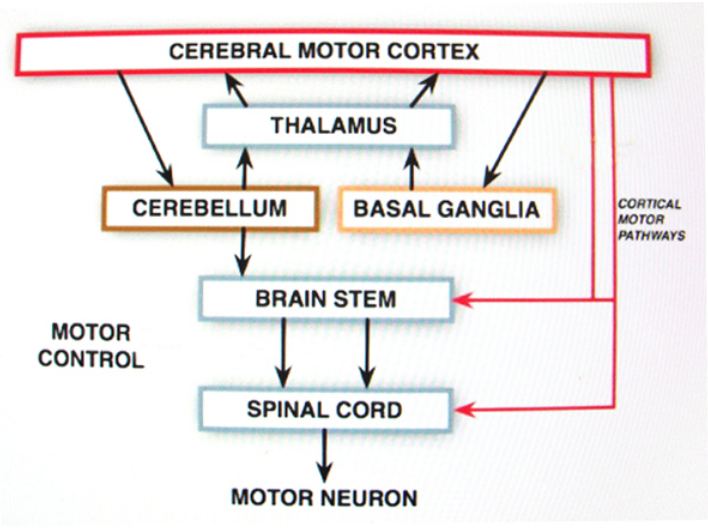
Corticospinal tract also influence brain stem's motor nuclei // these motor nuclei are the indirect pathway to skeletal muscles

Brain stem sends unconscious signals via indirect pathway to skeletal muscles to set muscle tone and inhibit skeletal muscle reflexes

Cerebellum able to communicate with both cerebrum and brain stem motor areas // compares intent and performance – provides corrective action

Basal nuclei also stores motor programs // e.g. regulate start-stop of rhythmic motions // stores implicit memory (procedural memory = the knowing how type of memory)

Understanding Motor Control Function



Somatic reflexes have their own circuits and if left unregulated they cause muscles to contract which would eventually result in a spastic contraction

---

Indirect pathway (brain stem motor nuclei) must provide descending inhibitory signals to prevent reflex spastic paralysis

---

Therefore – if you cut upper motor neurons you get spastic paralysis

---

But – if you cut the lower motor neurons you get flaccid paralysis

The Three Levels of Motor Control

- Cerebellum and basal nuclei are the ultimate planners and coordinators of complex motor activities // (local circuit neurons / motor programs/ central pattern generators)

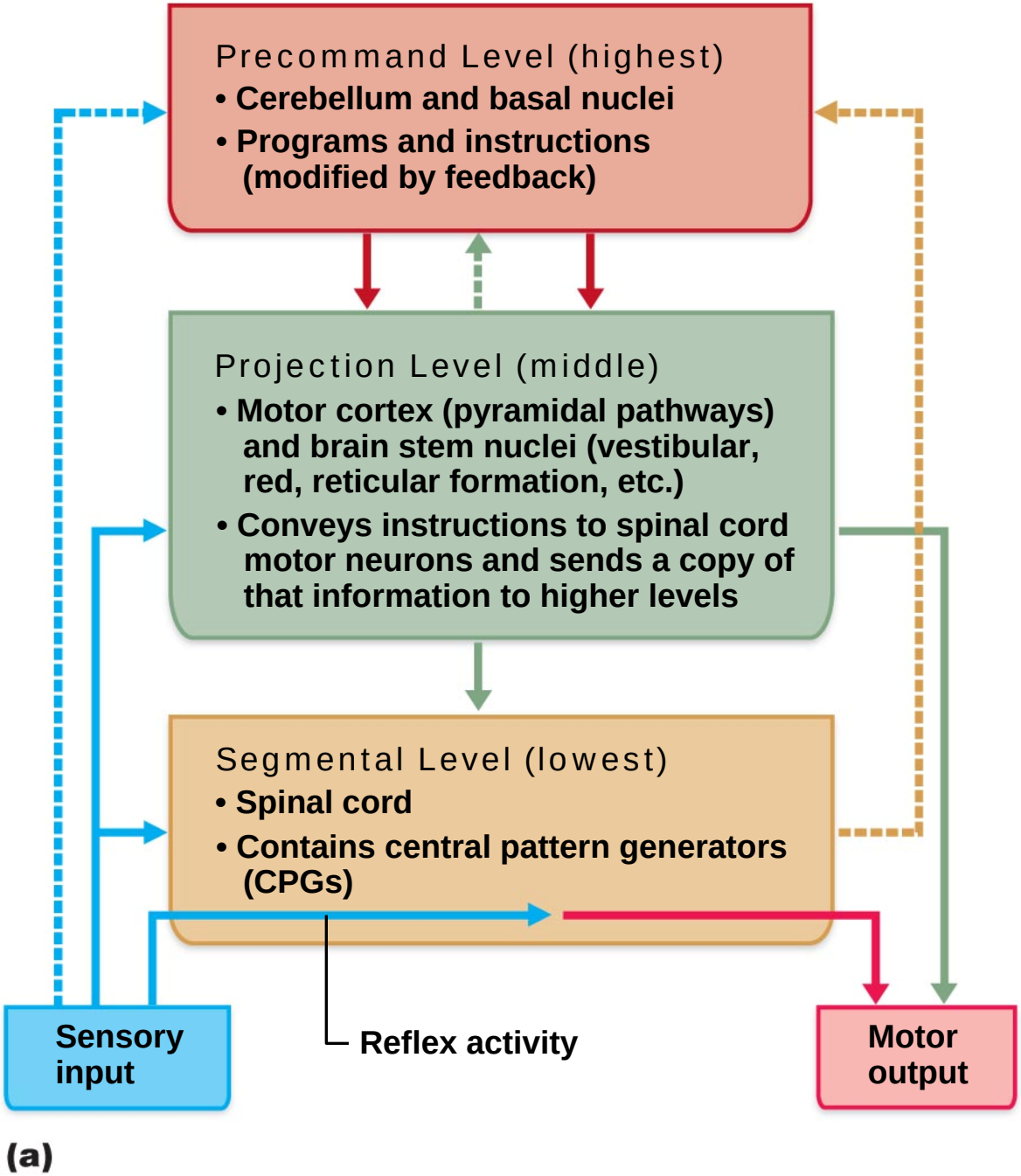
- Complex motor behavior depends on patterns of control from different levels of command signals

  – Precommand level (basal nuclei & cerebellum)

  – Projection level (corticospinal & corticobulbar tracts)

  – Segmental level (LMN with local circuit neurons)

Hierarchy of motor control.



Levels of motor control and their interactions

Segmental Level

- Lowest level of motor hierarchy
  - Reflexes and automatic movements
- Central pattern generators (CPGs): segmental circuits that activate networks of ventral horn neurons to stimulate specific groups of muscles
  - Controls locomotion
  - Specific, often-repeated motor activity

Projection Level

- **Consists of**
  - Upper motor neurons that initiate the direct pathway to produce voluntary skeletal muscle movements (also called the pyramidal tract // direct pathway)
  - Brain stem motor areas /// oversee the indirect pathway to modify commands of the direct pathway (also called the extrapyramidal tract // indirect pathway) // modify
    - Central Pattern Generators which controlled motor actions // also at segmental level of spinal cord
- Projection motor pathways send information to lower motor neurons, and keep higher command levels informed of what is happening

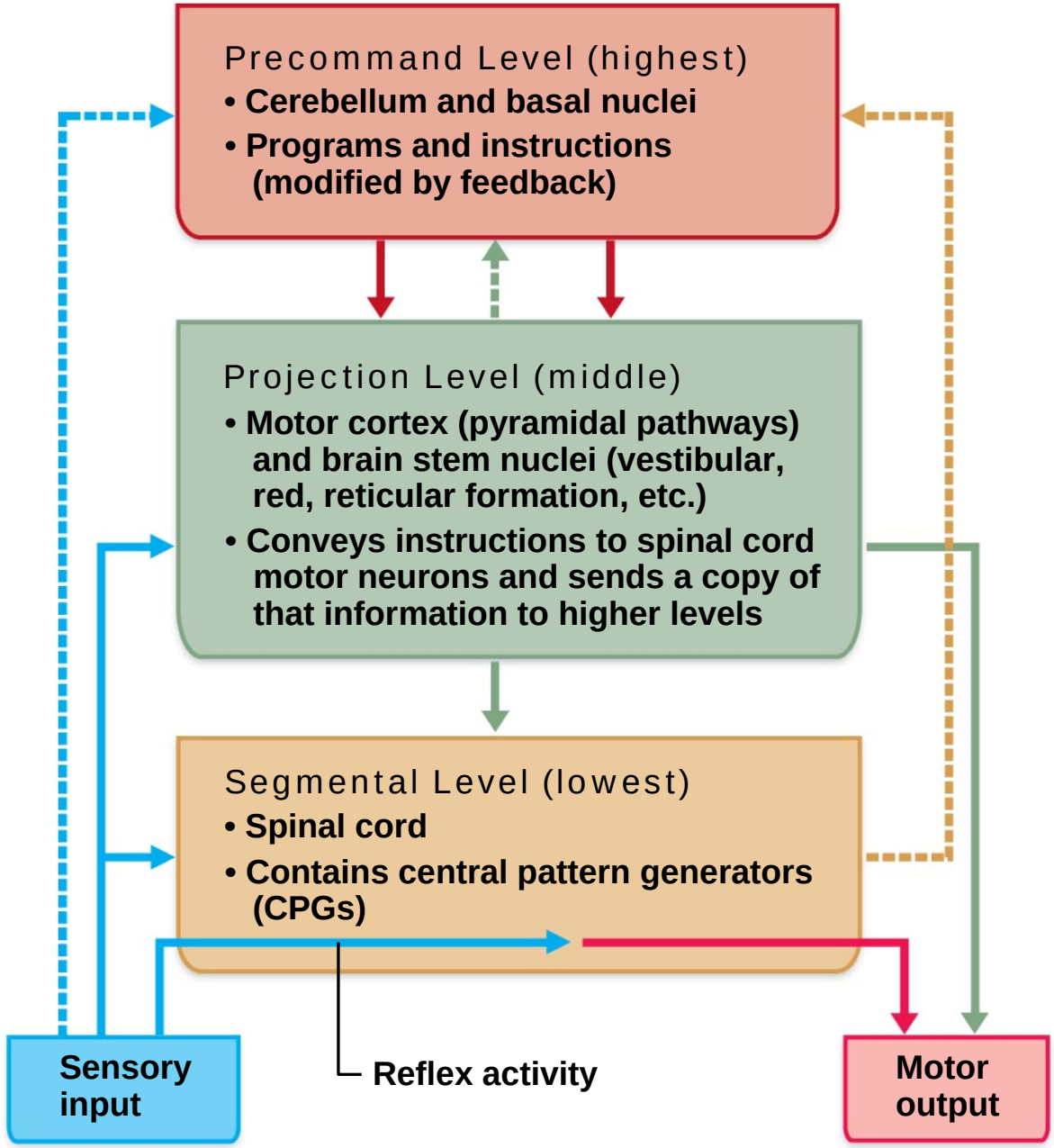
Pre-command Level

- Neurons in cerebellum and basal nuclei
- Neither cerebellum nor basal nuclei have direct synaptic contact with premotor association or primary motor cortex (thalamus lies between these loops)
  - Regulate motor activity
  - Precisely start or stop movements
  - Block unwanted movements
  - Perform unconscious planning and discharge in advance of willed movements
  - Coordinate movements with posture
  - Monitor muscle tone

Pre-command Level

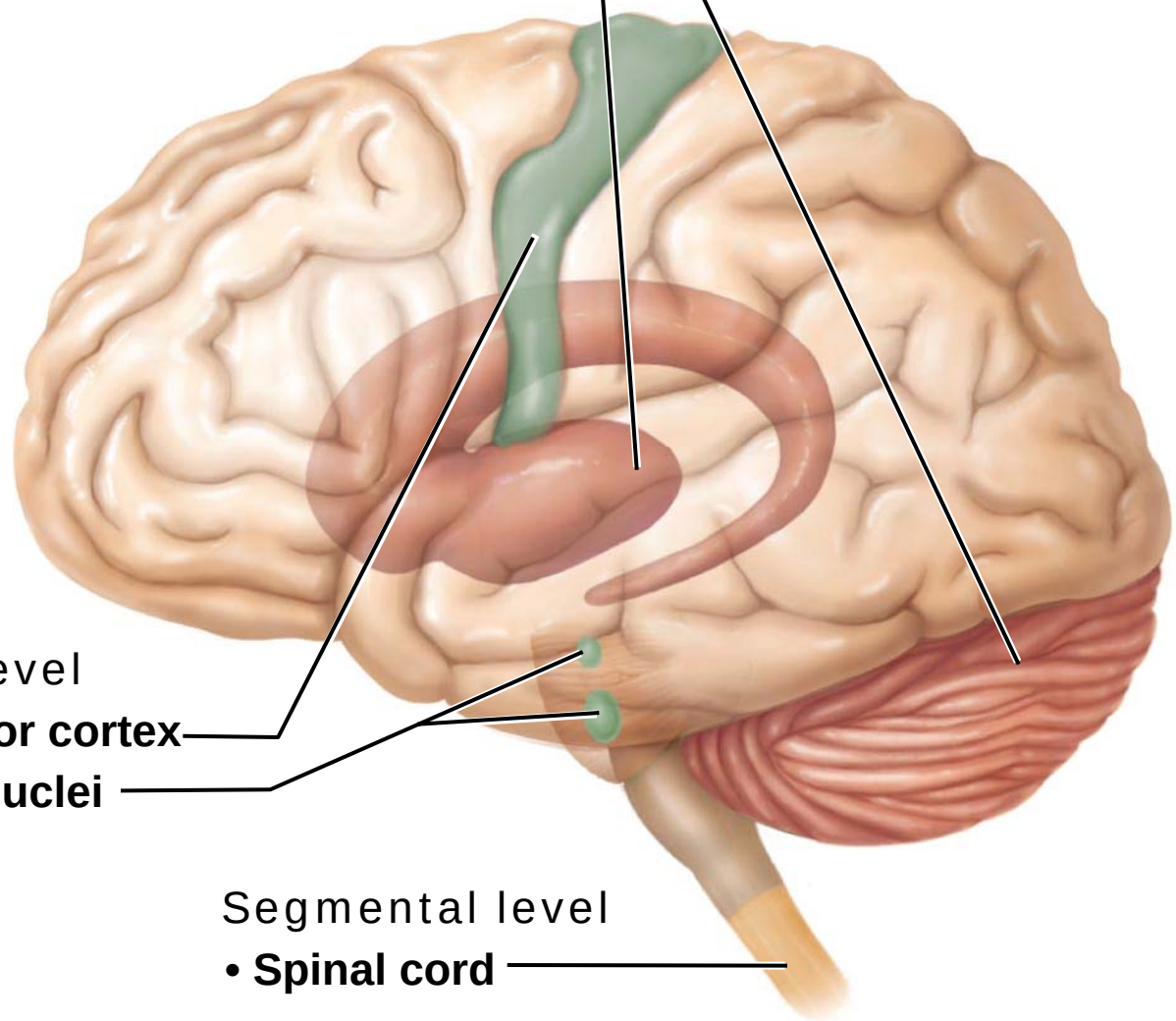
- **Cerebellum**
  - **Acts on motor pathways through projection nuclei of brain stem**
  - **Acts on motor cortex via thalamus to fine-tune motor activity**
- **Basal nuclei**
  - **Inhibit various motor centers under resting conditions**
  - **Initiates and stops repetitive motor patterns (e.g. walking / swimming)**
  - **Remember! – influence of substantia nigra on basal nuclei**

Hierarchy of Motor Control



(a)

Hierarchy of motor control.



(b) Structures involved

More on Motor Control

- pyramidal cells of the precentral gyrus are called the upper motor neurons
  - their fibers project caudally
  - about 19 million fibers ending in nuclei of the brainstem
  - about 1 million fibers form the corticospinal tracts
  - most fibers decussate in lower medulla oblongata
  - form lateral corticospinal tracts on each side of the spinal cord
- in the brainstem or spinal cord, the fibers from upper motor neurons synapse with lower motor neurons whose axons innervate the skeletal muscles

Motor Control

- basal nuclei and cerebellum // areas of brain that play important role in muscle control
- together known as the Pre-command Level of motor control
  - form feedback loops which share information
    - between cerebrum – thalamus - basal nuclei
    - between cerebrum – thalamus – cerebellum
    - contain motor programs and instructions

Motor Control

- these <u>"loops" are independent of the corticospinal track</u>
  - *allows for constant adjustment between the intent and actual performance of muscle contraction.*
- <u>While descending signals within these "loops" are being processed</u>
  - ascending (proprioception) tracks pass signals into the cerebellum where so it can "compare" the performance with intent
- <u>Note: See Video on Web Site / Upper Motor Neuron</u>

Basal Nuclei & Cerebellum Play Important Roll in Motor Control

- **Basal nuclei**
  - determines the <u>onset and cessation of intentional movements</u>
  - E.g. the repetitive hip and shoulder movements in walking
  - Note: basal nuclei is Influenced by substantia nigra
    - SN makes and transports dopamine to basal nuclei
    - dopamine reduces the degree of contractions to skeletal muscles
    - deficiency of dopamine to basal nuclei results in condition known as Parkinson

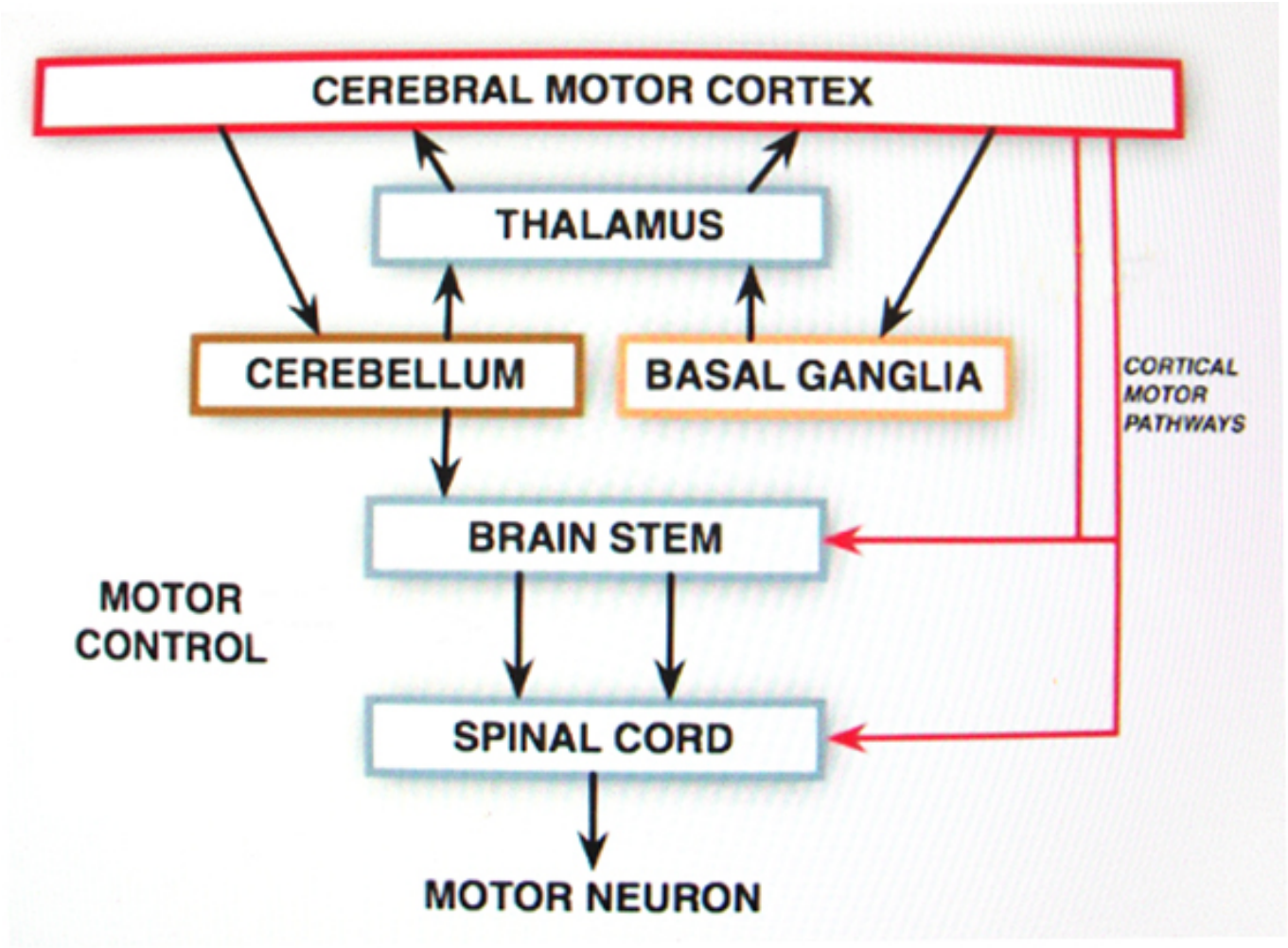
Basal Nuclei & Cerebellum Play Important Roll in Motor Control

- **Basal nuclei**
  - Another area in brain where motor programs are stored for highly practiced, learned behaviors
  - muscle contractions that one carries out with little thought // writing, typing, driving a car
  - lies in a feedback circuit from the cerebrum to the basal nuclei to the thalamus and back to the cerebrum
  - **dyskinesias** – movement disorders caused by lesions in the basal nuclei
  - Procedural memory (knowing how // implicit memory) is hippocampus independent memory which is encoded through the amygdala into basal nuclei and cerebellum.

Basal Nuclei & Cerebellum Play Important Roll in Motor Control

- Cerebellum // important role in motor coordination known for long time
  - aids in learning motor skills
  - maintains muscle tone and posture
  - smoothes muscle contraction
  - coordinates eye and body movements
  - coordinates the motions of different joints with each other
  - Lesion in cerebellum track results in ataxia – clumsy, awkward gait

Understanding Motor Control Function



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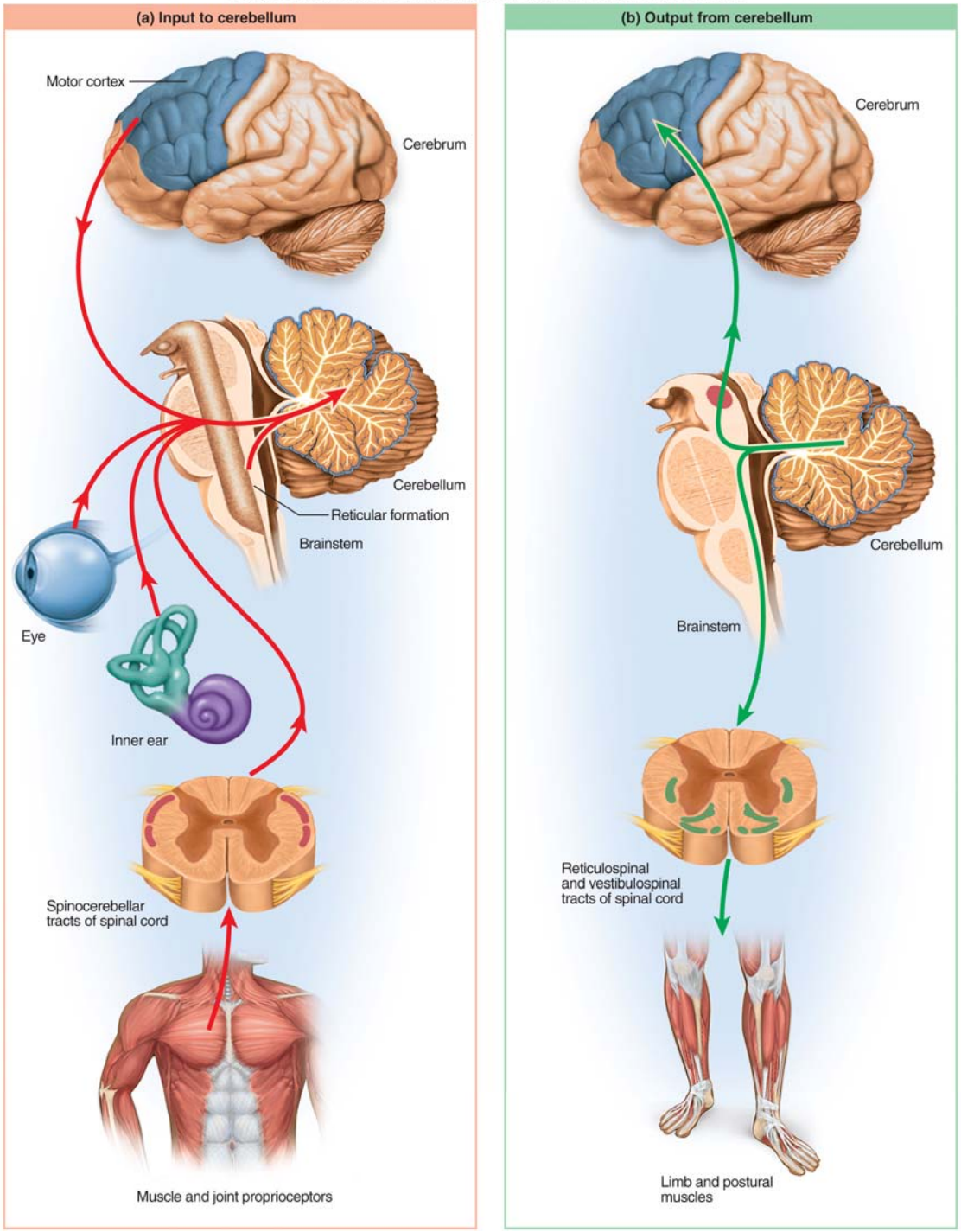
Intent vs Actural Performance

How the Cerebellum Regulates Motor Control

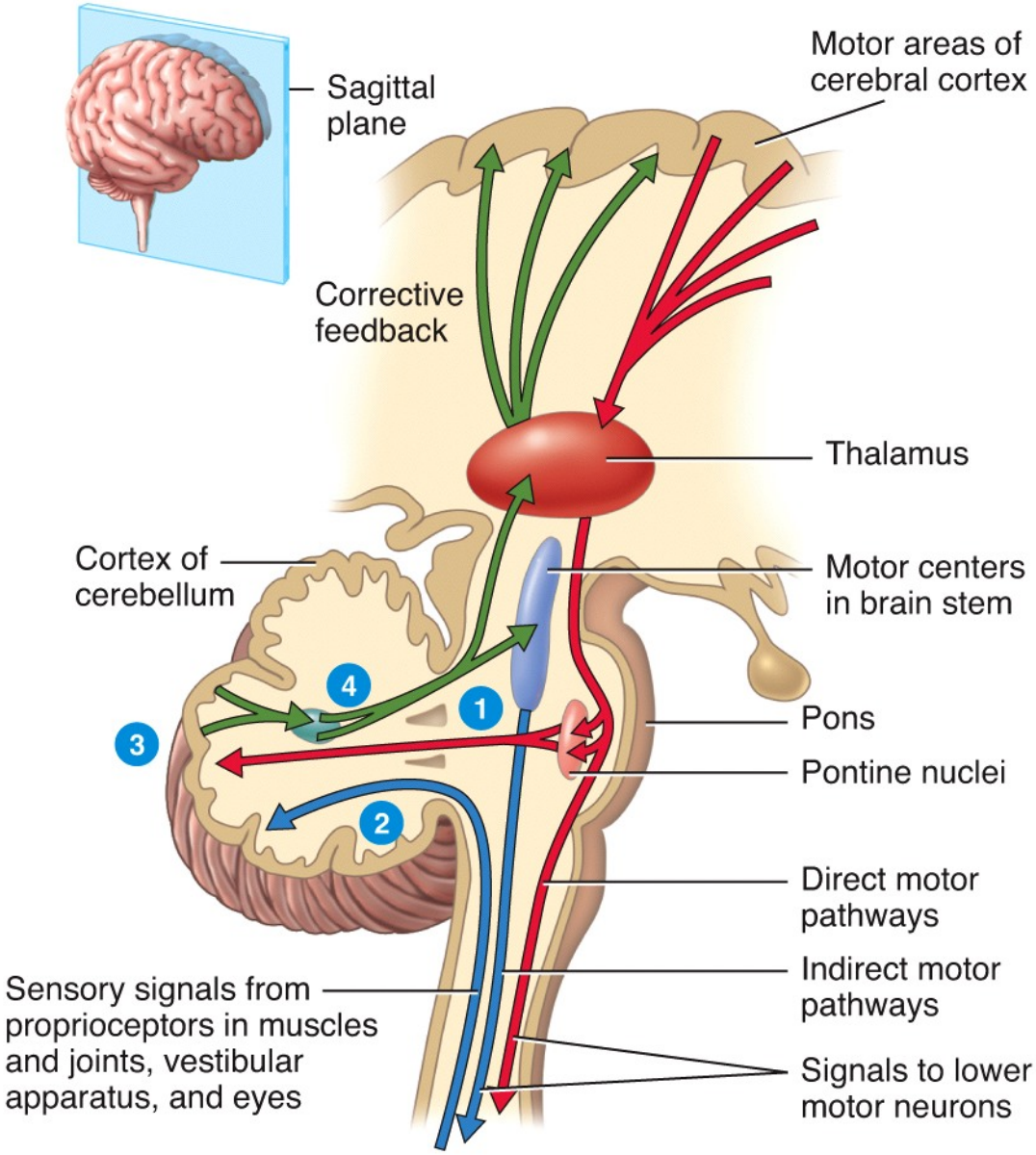
The cerebellum compares the intent (corticospinal tract) to the performance (proprioception from muscle spindles and golgi tendon organs as well as sensory info from vestibulocochlear and optic nerves).

- Middle peduncle: sends info into cerebellum from eyes, ears, and cerebrum (i.e. intent + performance).
- Inferior peduncle: sends info into cerebellum from proprioceptors in muscles and joints (i.e. performance).
- Purkinje cells of cerebellum compare info from middle and inferior peduncles….. /// If there is a discrepancy between intent and performance….
  - signal relayed to cerebellum's deep nuclei
  - signal relayed out of cerebellum by way of superior peduncle /// To motor association area (through thalamus).
  - Corrective adjustments to muscles via reticulospinal and vestibulospinal tracts



Input and Output to Cerebellum

Note: differentiate between direct and indirect motor pathways as related to function of the cerebellum



Sagittal section through brain and spinal cord

Cerebral Lateralization

- The difference in the structure and function of the cerebral hemispheres

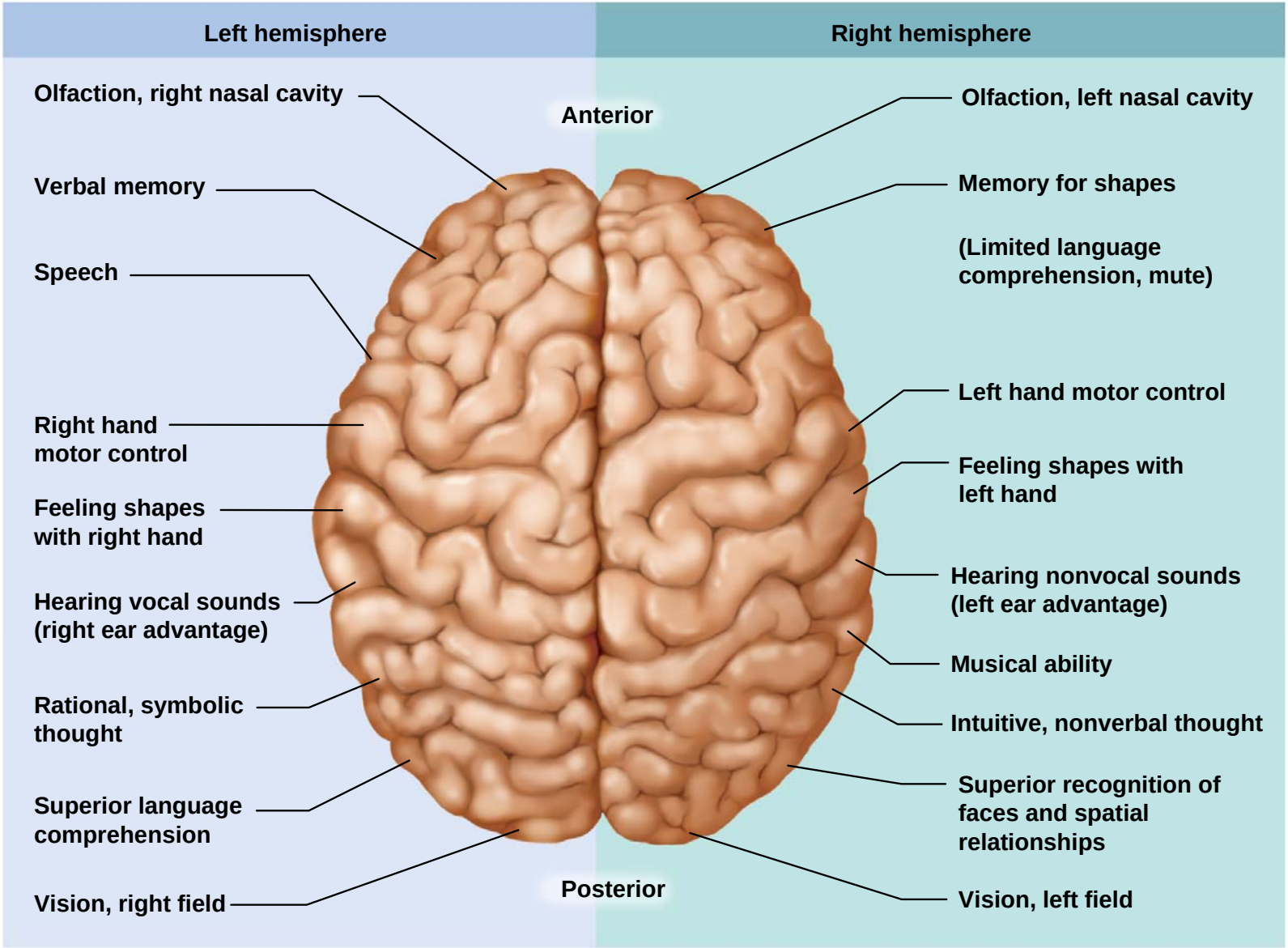
- left hemisphere – language - *categorical hemisphere*
  - specialized for spoken and written language
  - sequential and analytical reasoning (math and science)
  - breaks information into fragments and analyzes it in a linear way

- right hemisphere - *representational hemisphere*
  - perceives information in a more integrated holistic way
  - seat of imagination and insight
  - musical and artistic skill
  - perception of patterns and spatial relationships
  - comparison of sights, sounds, smells, and taste
  - Intonation of language

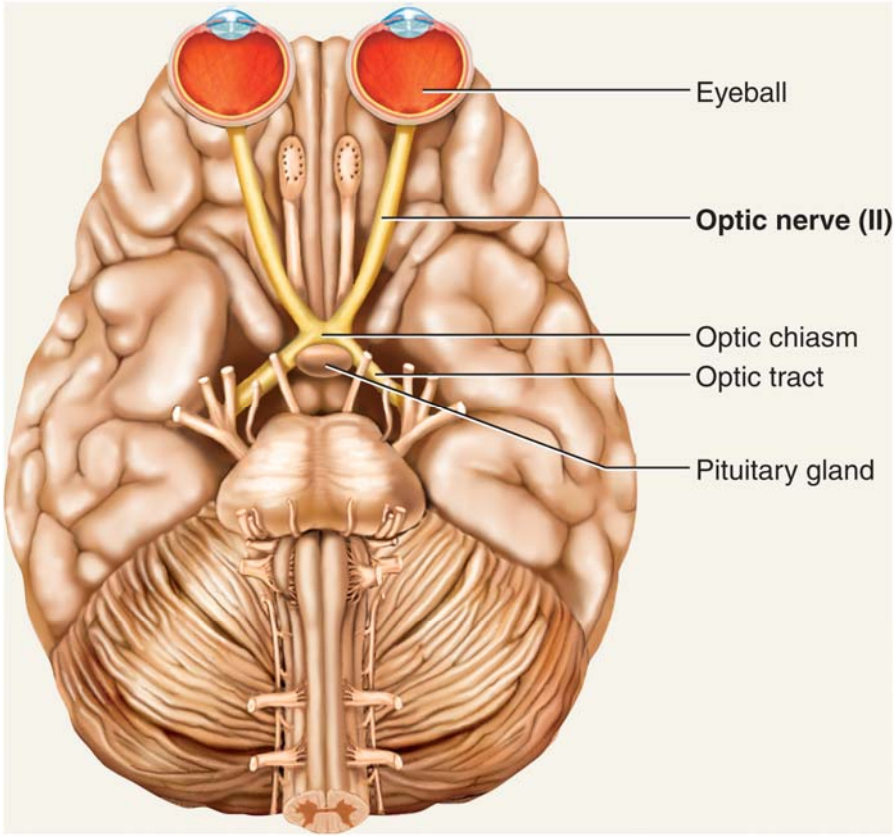
Cerebral Lateralization

- highly correlated with **handedness**
  - left hemisphere is the categorical one in 96% of right-handed people // right hemisphere is categorical in only 4%
  - left handed people – right hemisphere is categorical in 15% and left in 70%
- lateralization develops with age
  - males exhibit more lateralization than females
  - males suffer more functional loss when one hemisphere is damaged // note difference in posterior commissure

Cerebral Lateralization



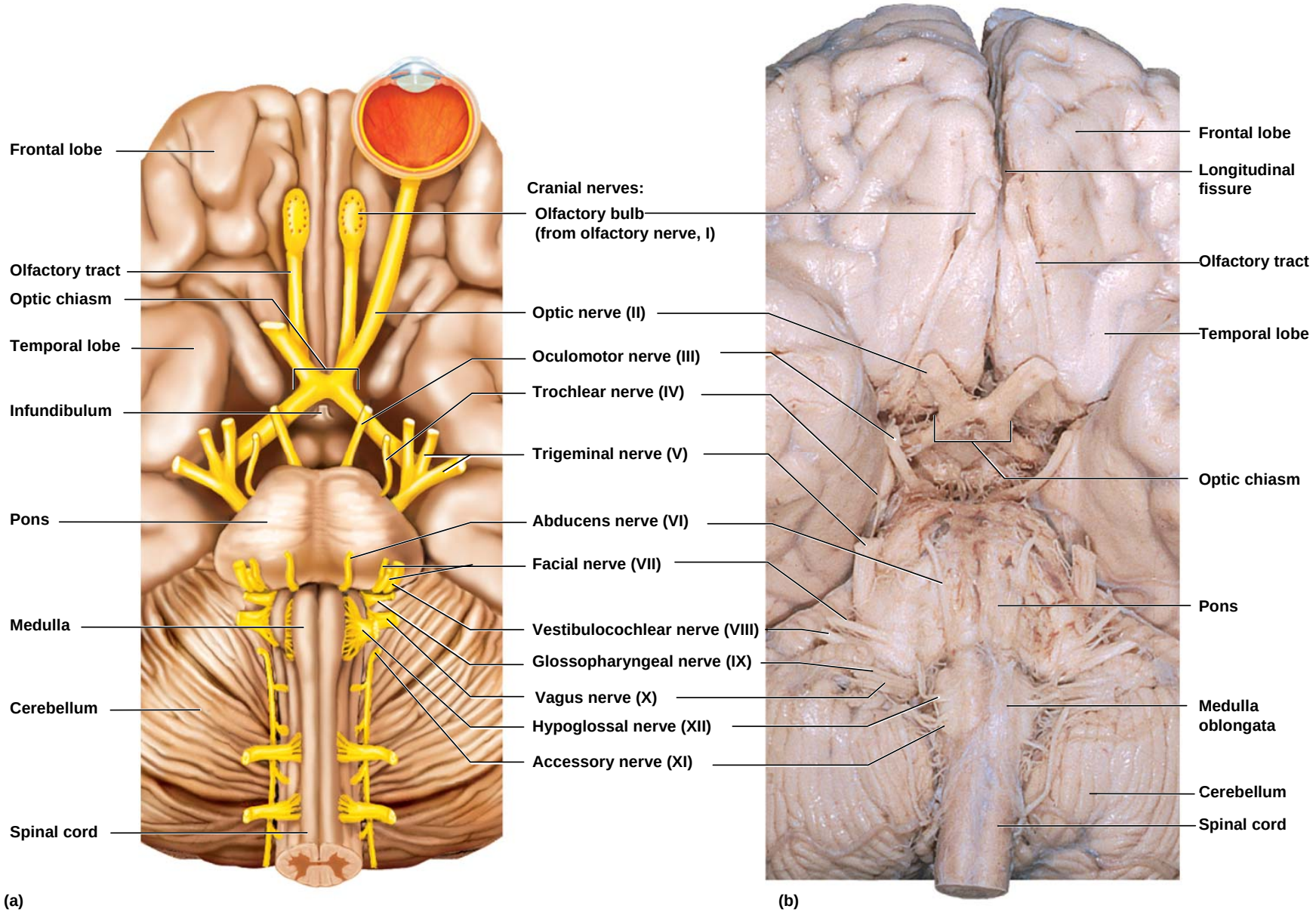
Cranial Nerves



Cranial Nerves

- the brain must communicate with the rest of the body via nerves
- most of the input and output travels by way of the spinal cord
- Cranial nerves = 12 pairs of cranial nerves /// originate from the base of the brain
  - exit the cranium through foramina
  - lead to muscles and sense organs located mainly in the head and neck
  - You need to know the functions of these four cranial nerves I, II, VIII, and X

“Oh, once one takes the anatomy final, very good vacation ahead.”



Cranial Nerve Pathways

- The origin of a cranial nerve is a nuclei in the brainstem

- The axon of cranial nerve soma exit CNS through facial bone foramen to innervate glands and skeletal muscles in head and neck (note cranial nerve ten = vagus is the exception because it innervates thoracic and abdominopelvic viscera)

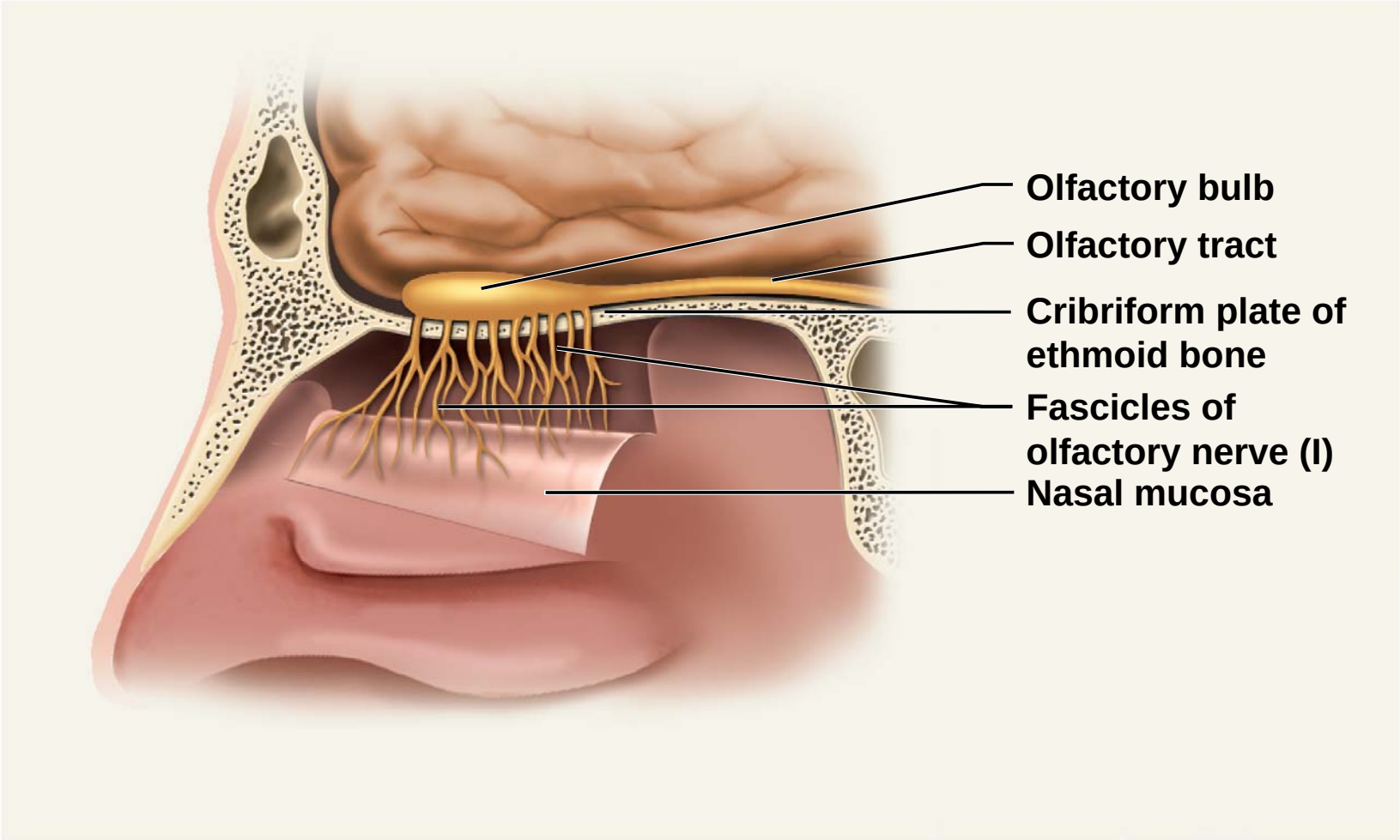
Cranial Nerve Pathways

- most cranial nerves carry fibers between brainstem and ipsilateral receptors and effectors
  - lesion in left brainstem causes sensory or motor deficit on same side
  - exceptions are
    - optic nerve where half the fibers decussate
    - and trochlear nerve where all efferent fibers lead to a muscle of the contralateral eye

Cranial Nerve Classification

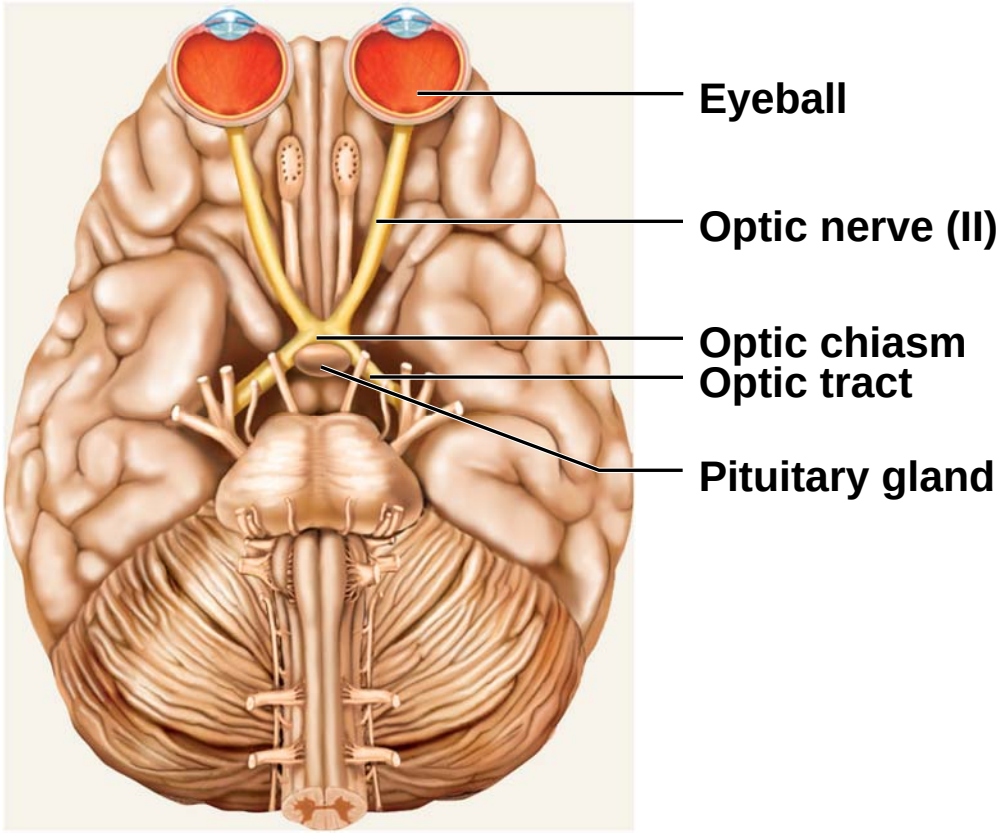
- cranial nerves can be classified as **motor**, **sensory**, and **mixed**
  - sensory (**I**, **II**, and **VIII**)
  - motor (**III**, **IV**, **VI**, **XI**, and **XII**) // stimulate muscle but also contain fibers of proprioception
  - mixed (**V**, **VII**, **IX**, **X**) // sensory functions may be quite unrelated to their motor function
  - facial nerve (VII) has sensory role in taste but motor role in facial expression

I Olfactory Nerve



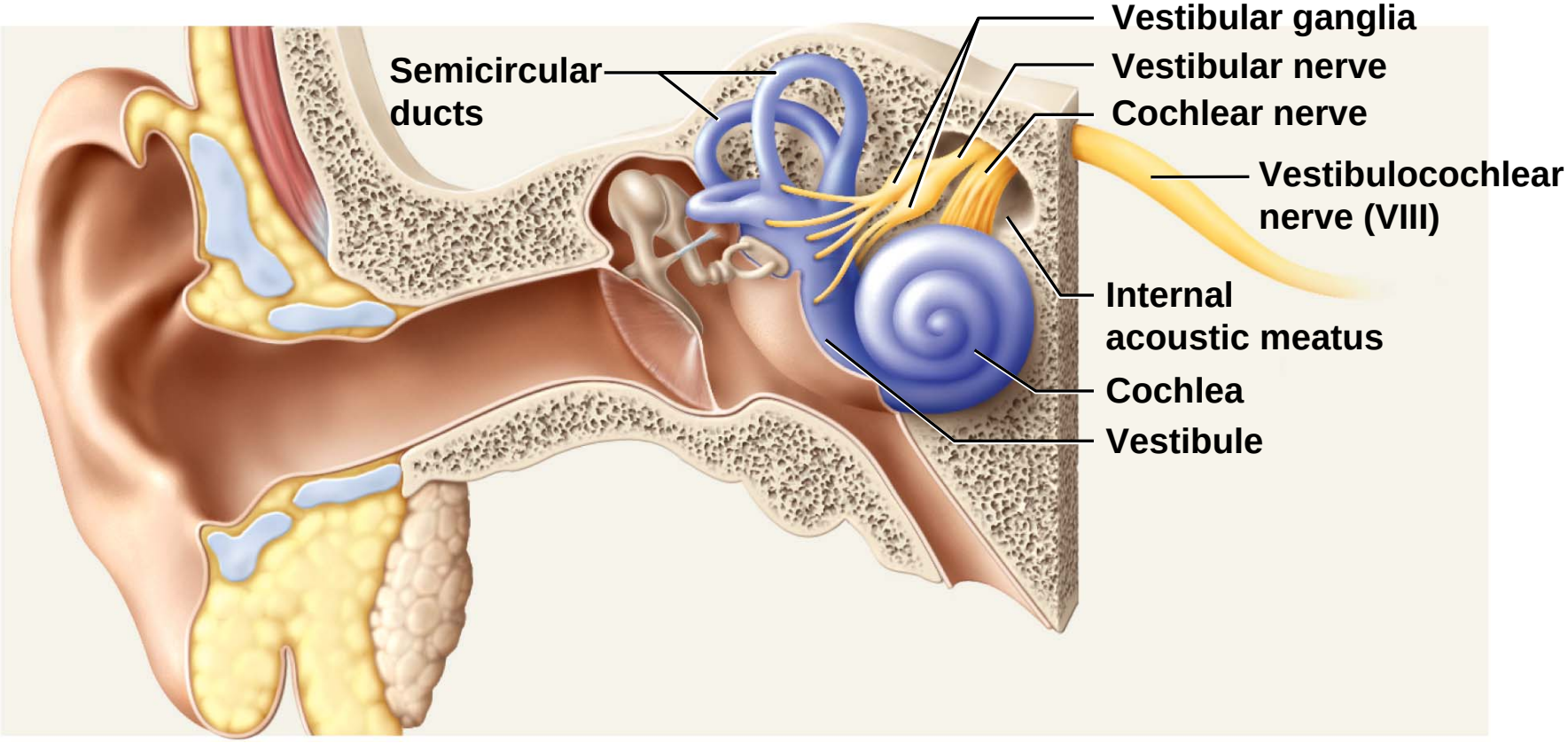
- sense of smell
- damage causes impaired sense of smell

II Optic Nerve



- provides vision
- damage causes blindness in part or all of the visual field

VIII Vestibulocochlear Nerve



- nerve of hearing and equilibrium
- damage produces deafness, dizziness, nausea, loss of balance and nystagmus (involuntary rhythms oscillation of the eyes from side to side

X Vagus Nerve

- most extensive distribution of any cranial nerve
- major role in the control of cardiac, pulmonary, digestive, and urinary function
- swallowing, speech, regulation of viscera
- damage causes hoarseness or loss of voice, impaired swallowing and fatal if both are cut