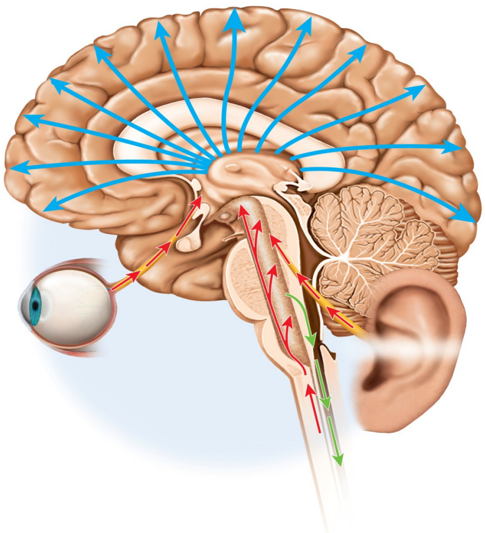
Chapter 14.3

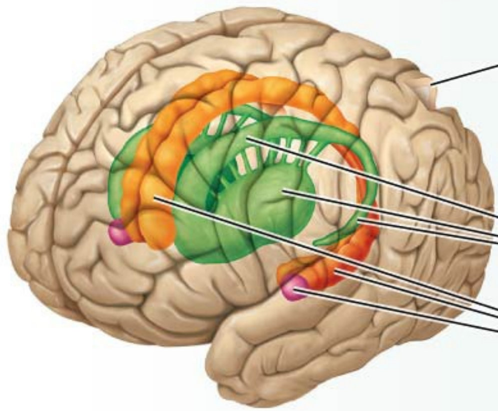
Brain Functions



What are the functions of these brain structures?

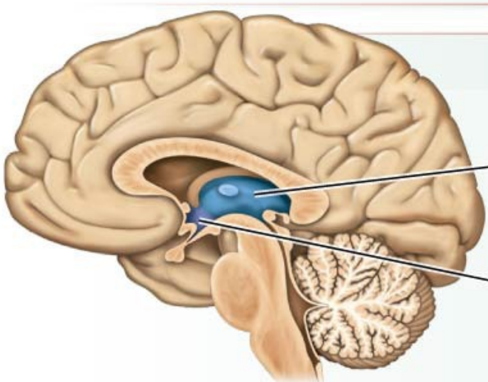
Medulla Oblongata, Pons, Mid-Brain, Reticular Formation, Diencephalon, Thalamus, Epithalamus, Hypothalamus, Cerebellum, and Cerebrum

A Summary for Major Brain Structure Functions.



Anterolateral view

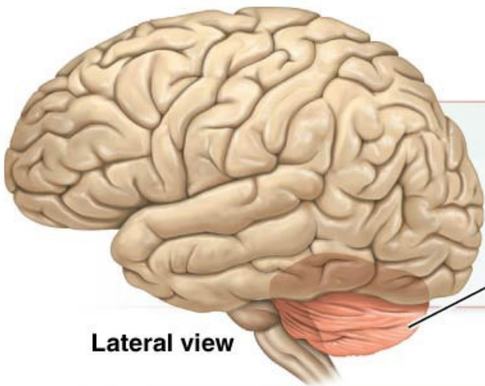
DIVISION	STRUCTURES	SUBSTRUCTURES	MAIN FUNCTIONS
Cerebrum	Cerebral cortex	Primary motor cortex	• Plans and executes movement
		Primary somatosensory cortices	• Receive and process different types of sensory input
		Multimodal association areas	• Integrate sensory and motor information from a variety of different primary cortices
	Basal nuclei	Caudate nuclei Putamen Globus pallidus	• Regulate movement
	Limbic system	Hippocampus	• Plays a role in memory and learning
		Amygdala	• Plays a role in behavioral expression and emotion



Midsagittal section

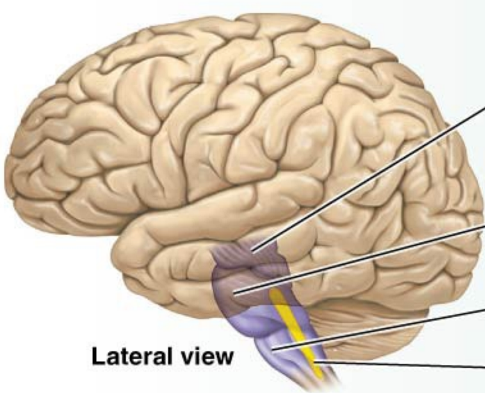
DIVISION	STRUCTURES	MAIN FUNCTIONS
Diencephalon	Thalamus	• Controls information entry into the cerebral cortex • Edits, sorts, and routes stimuli
	Hypothalamus	• Regulates the autonomic nervous system • Regulates the sleep/wake cycle • Regulates thirst and hunger • Regulates body temperature • Produces hormones • Controls secretion from the pituitary gland

A Summary for Major Brain Structures and Their Functions.



Lateral view

DIVISION	MAIN FUNCTION
Cerebellum	• Coordinates voluntary movement



Lateral view

DIVISION	STRUCTURES	MAIN FUNCTIONS
Brainstem	Midbrain	• Processes and routes visual and auditory stimuli to the thalamus • Carries motor fibers from the cerebral cortex • Monitors movement with the basal nuclei
	Pons	• Regulates breathing • Regulates reflexes • Regulates the sleep/wake cycle
	Medulla oblongata	• Contains tracts of white matter involved in movement and sensation • Regulates many homeostatic functions
	Reticular formation	• Involved in sleep and arousal • Involved in pain transmission • Plays a role in mood regulation • Involved in many homeostatic functions

The total number of neurons are not increasing, however. During the first two years of life, the human brain produces 20 million new synaptic connection between neurons per second. This creates a “confused network”. But as we learn, the brain “prunes the synaptic connections” (reduce the total number of synapses) to strengthen and improve the efficiency of the neuronal pathways. The cortical mass becomes more dense as this occurs.

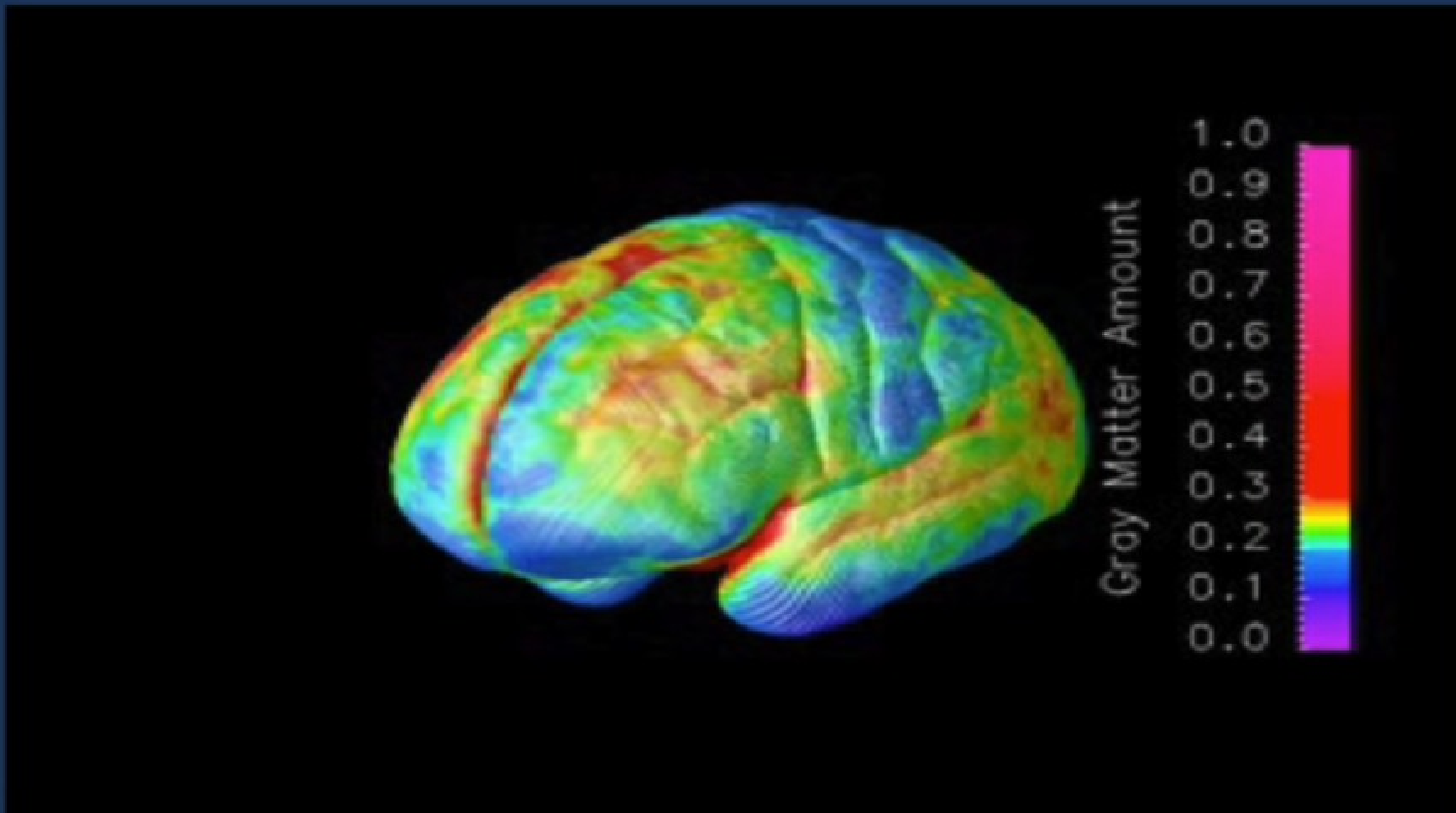
Development / learning = Synaptic growth + synaptic pruning

- Synaptic growth → novelty, new associations, increasing knowledge and skills

Synaptic pruning

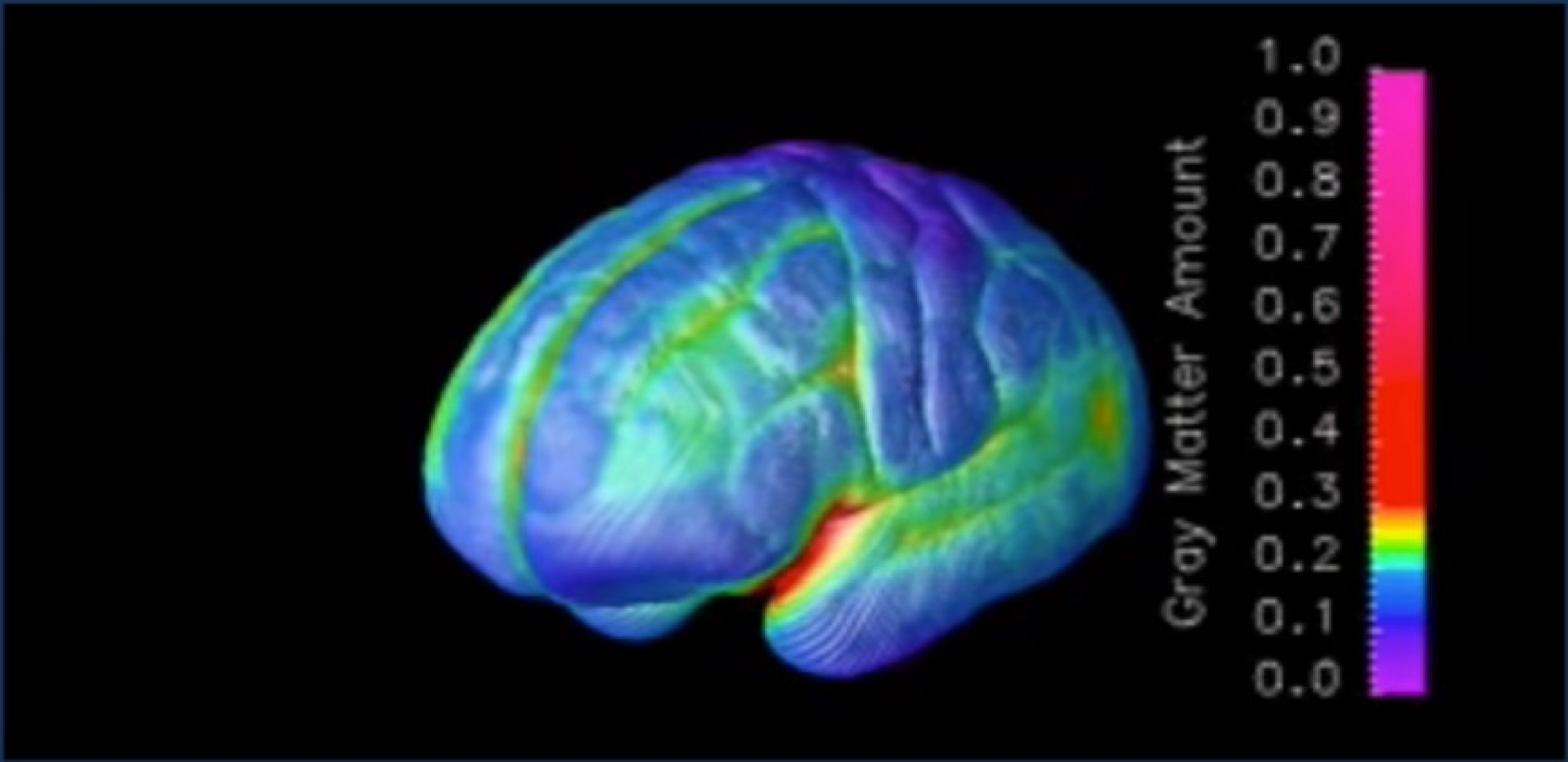
Consolidation, efficiency, habit formation

Changes in cortical density from age 4 through age 20 (from averaged MRI data)

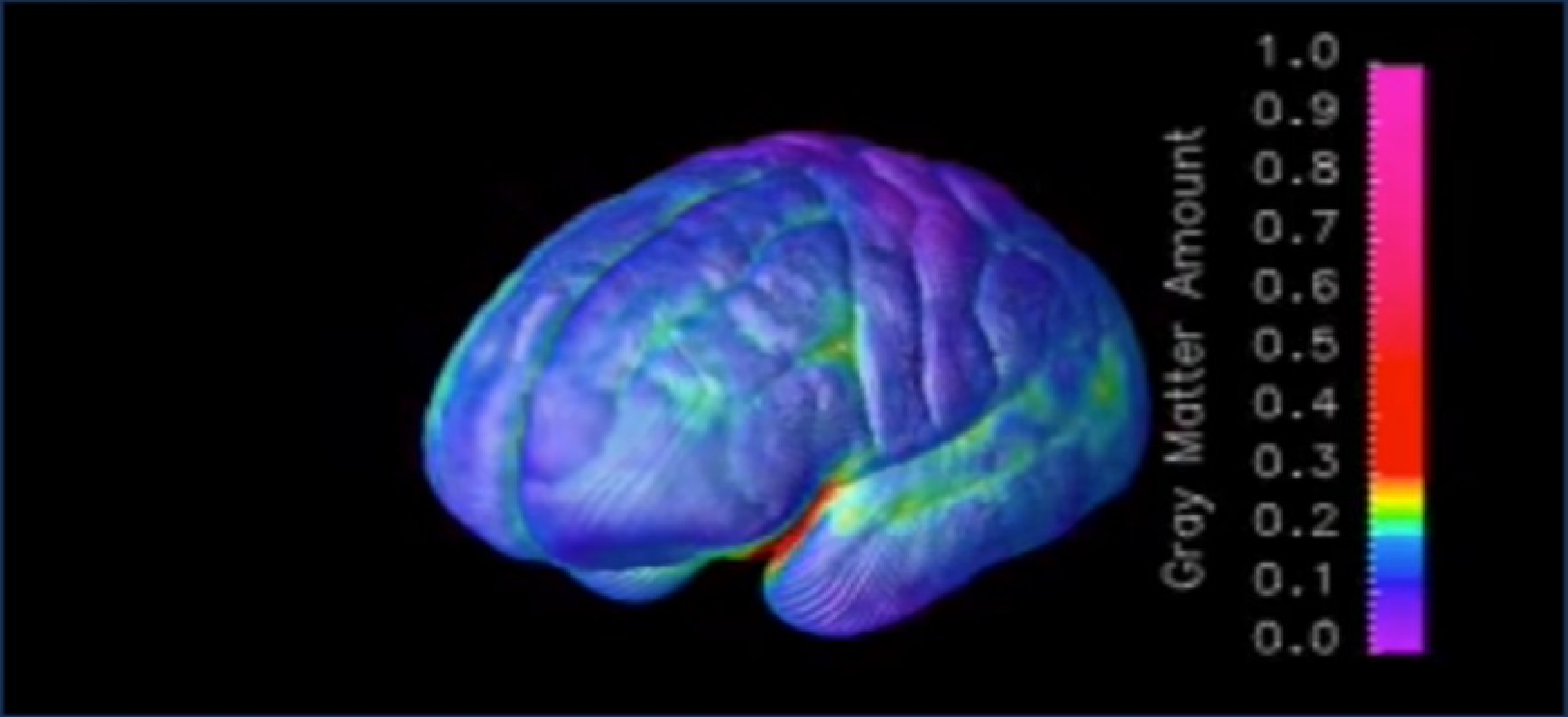


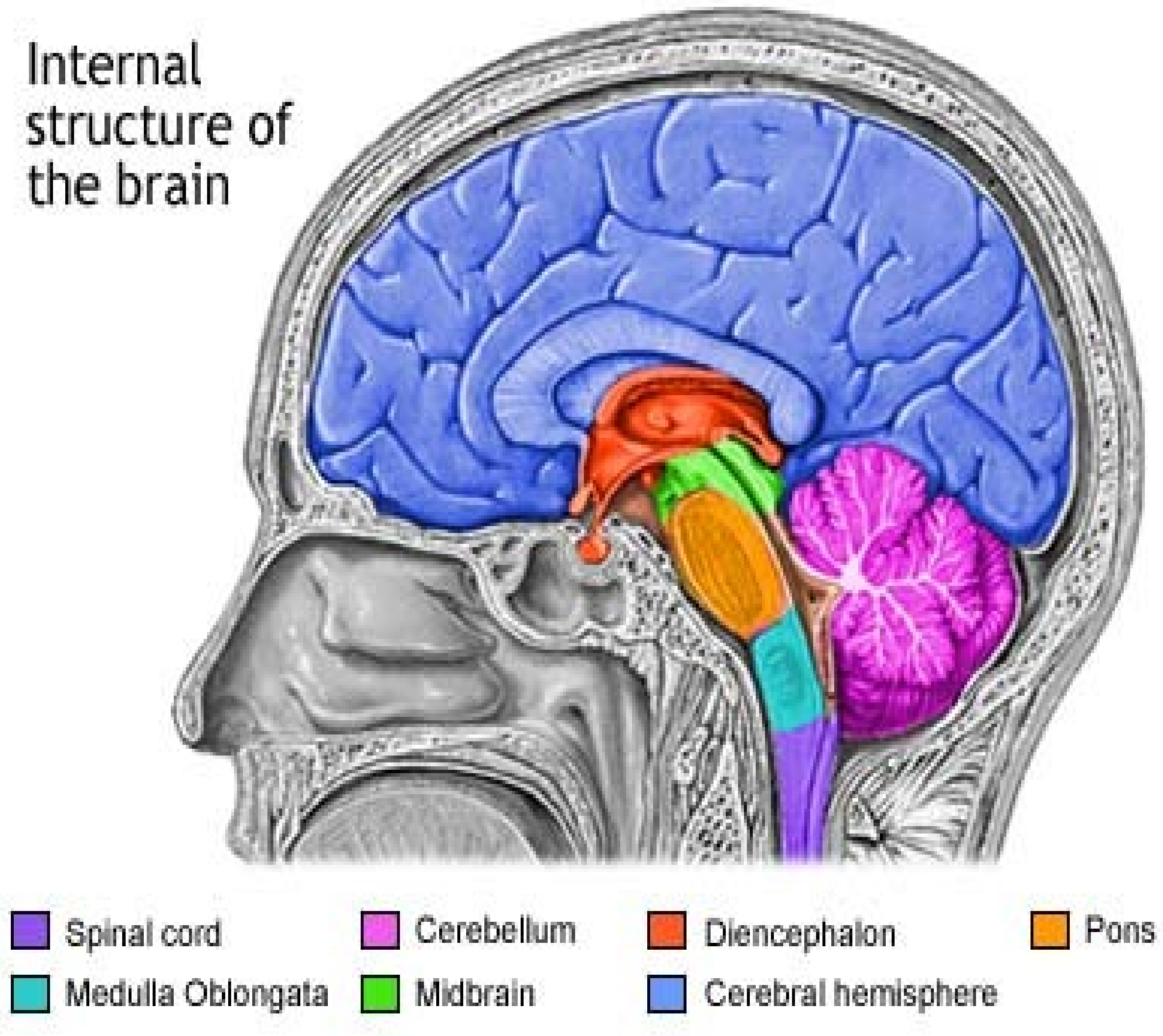
The next three slides show the how the cortical density changes as a result of “pruning”. The dark blue areas show where pruning has already occurred. The somatosensory areas are the first to be pruned.

Changes in cortical density from age 4 through age 20 (from averaged MRI data)



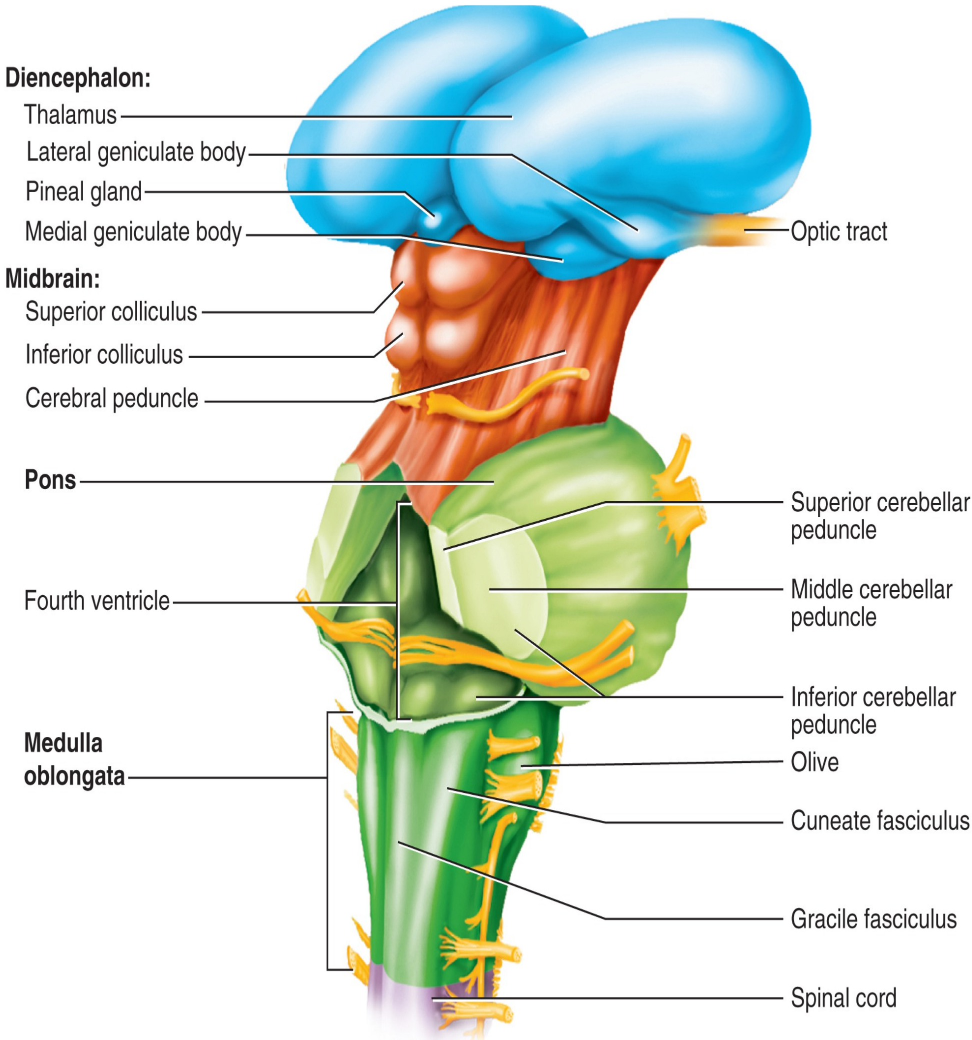
Changes in cortical density from age 4 through age 20 (from averaged MRI data)




Internal structure of the brain
Spinal cord
Cerebellum
Diencephalon
Pons
Medulla Oblongata
Midbrain
Cerebral hemisphere

Medulla Oblongata

- Part of the brain stem (medulla oblongata, pons, midbrain, and diencephalon)
- The medulla oblongata begins at the foramen magnum of the occipital bone and is approximately 3 cm long
- ends at a groove between the medulla and pons
- slightly wider than deep
- **the pyramids** – pair of external ridges on anterior surface // resembles side-by-side baseball bats



(b) Dorsolateral view

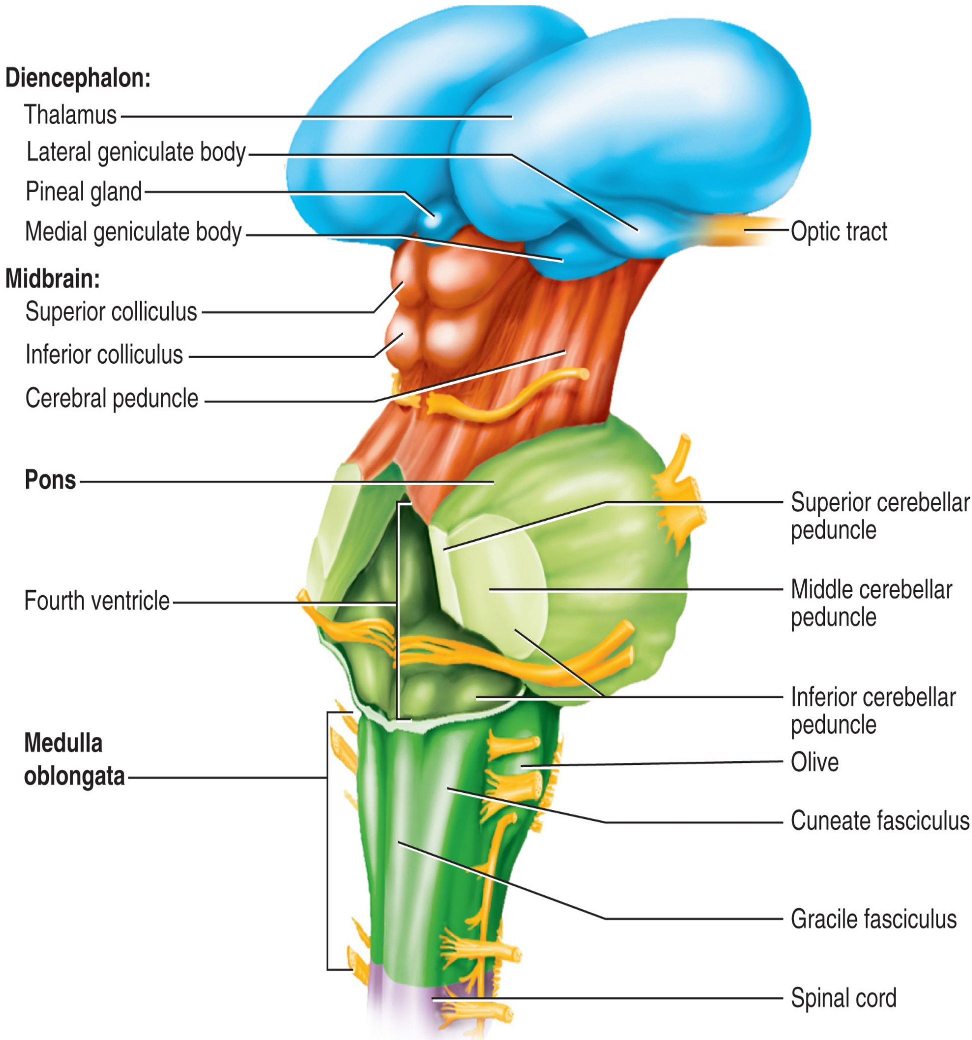
Medulla Oblongata

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

contain all the nerve fibers that connects the brain to the spinal cord // tracts must pass through the medulla oblongata

four pairs of cranial nerves begin or end in medulla -
IX, X, XI, XII



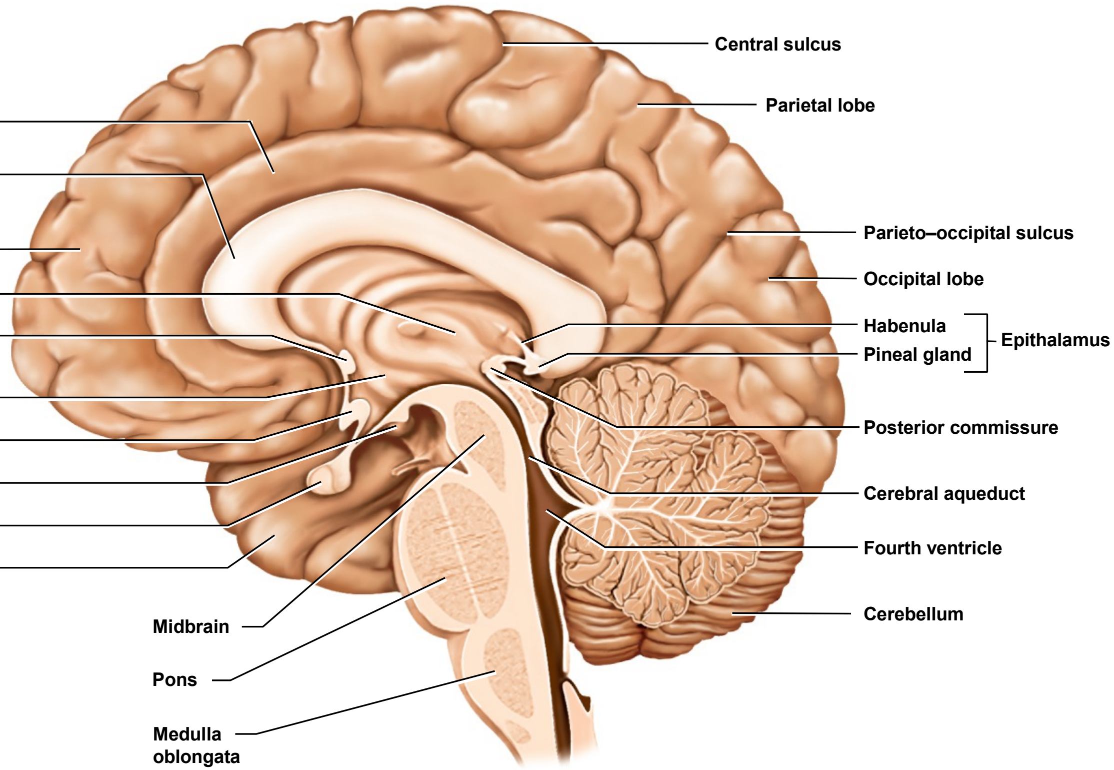
(b) Dorsolateral view

Medulla Oblongata Location for Many "Nuclei"

(Each Nuclei Regulates a Different Function)

- 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

The Pons

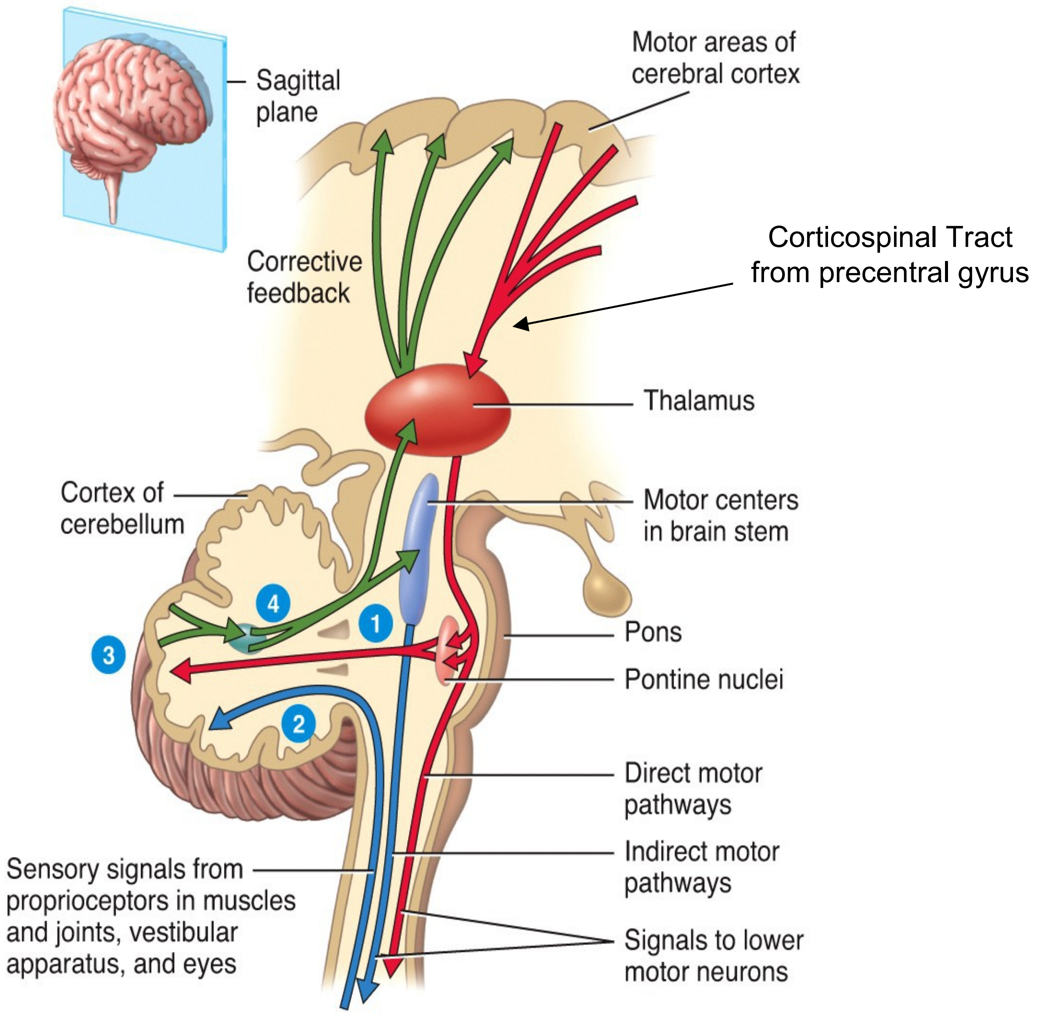


Pons – anterior bulge in brainstem, rostral to medulla

Cerebellar peduncles – <u>tracts that connect cerebellum to brainstem at the pons</u>

- inferior peduncles
- middle peduncles
- superior peduncles

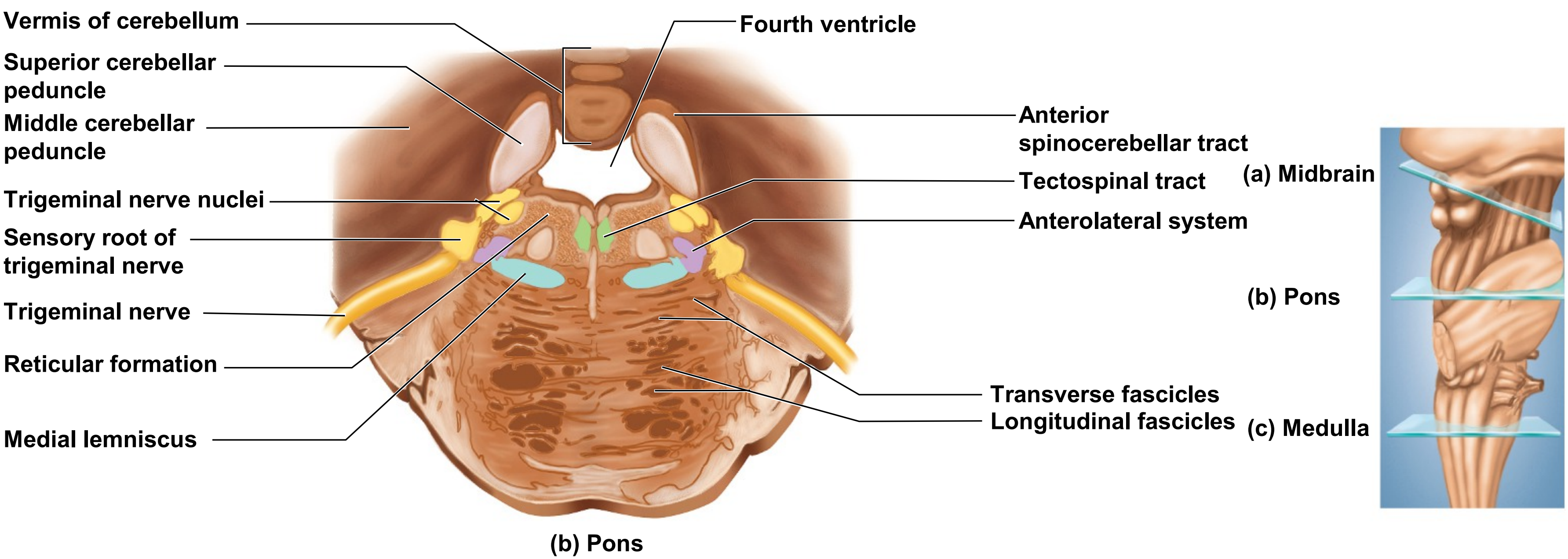
The Cerebral Peduncles and Motor Control



Sagittal section through brain and spinal cord

What is the difference between intent and performance?

Cross-section of Pons



Pons

- ascending sensory tracts /// descending motor tracts /// pathways in and out of cerebellum

- **cranial nerves V, VI, VII, and VIII originate within Pons**

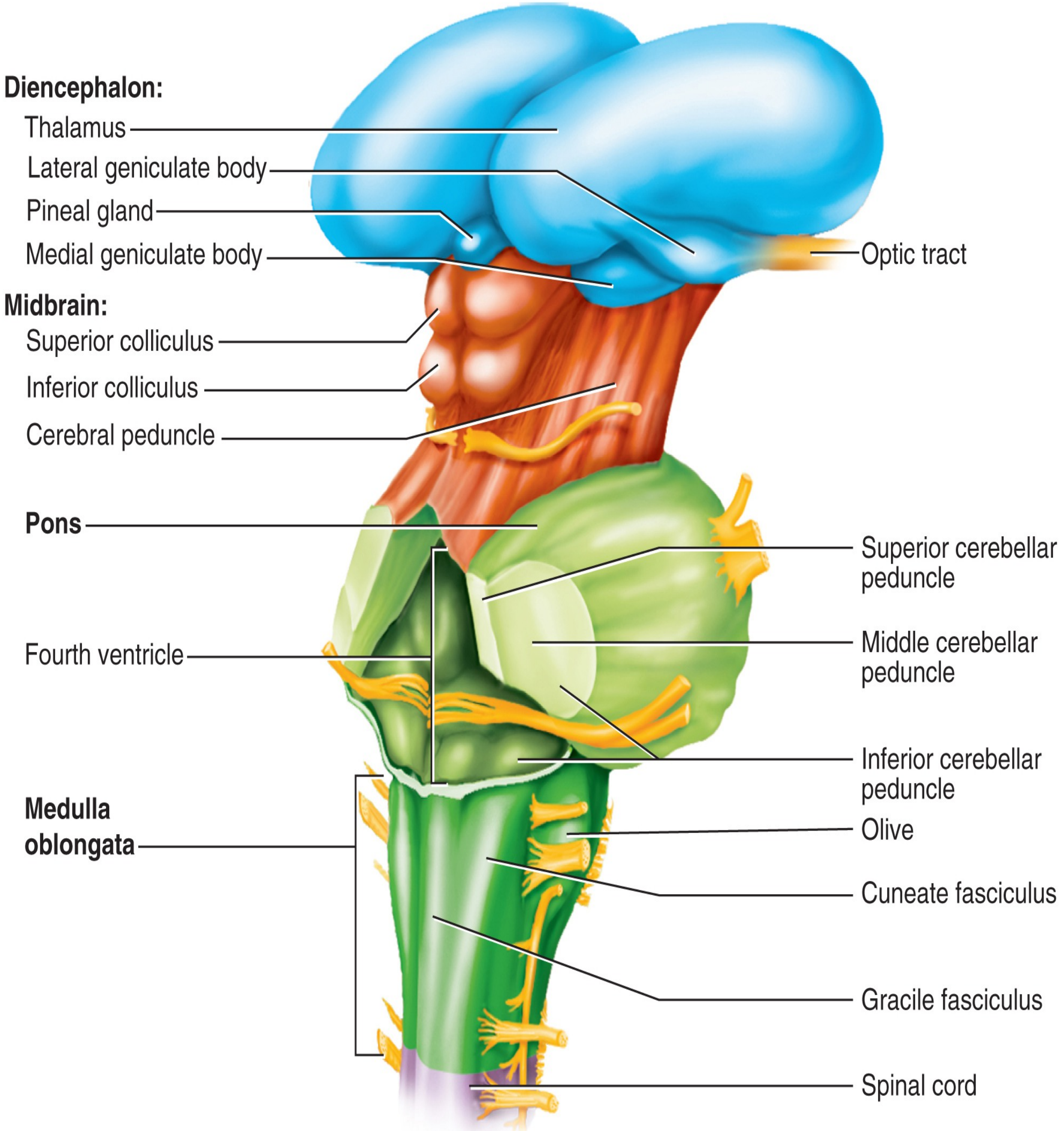
  - **sensory roles** – hearing, equilibrium, taste, facial sensations

  - **motor roles** – eye movement, facial expressions, chewing, swallowing, urination, and secretion of saliva and tears

- Pons also contain part of the reticular formation *///* additional nuclei concerned with // *sleep, respiration, analgesic descending tract, and posture*

Midbrain

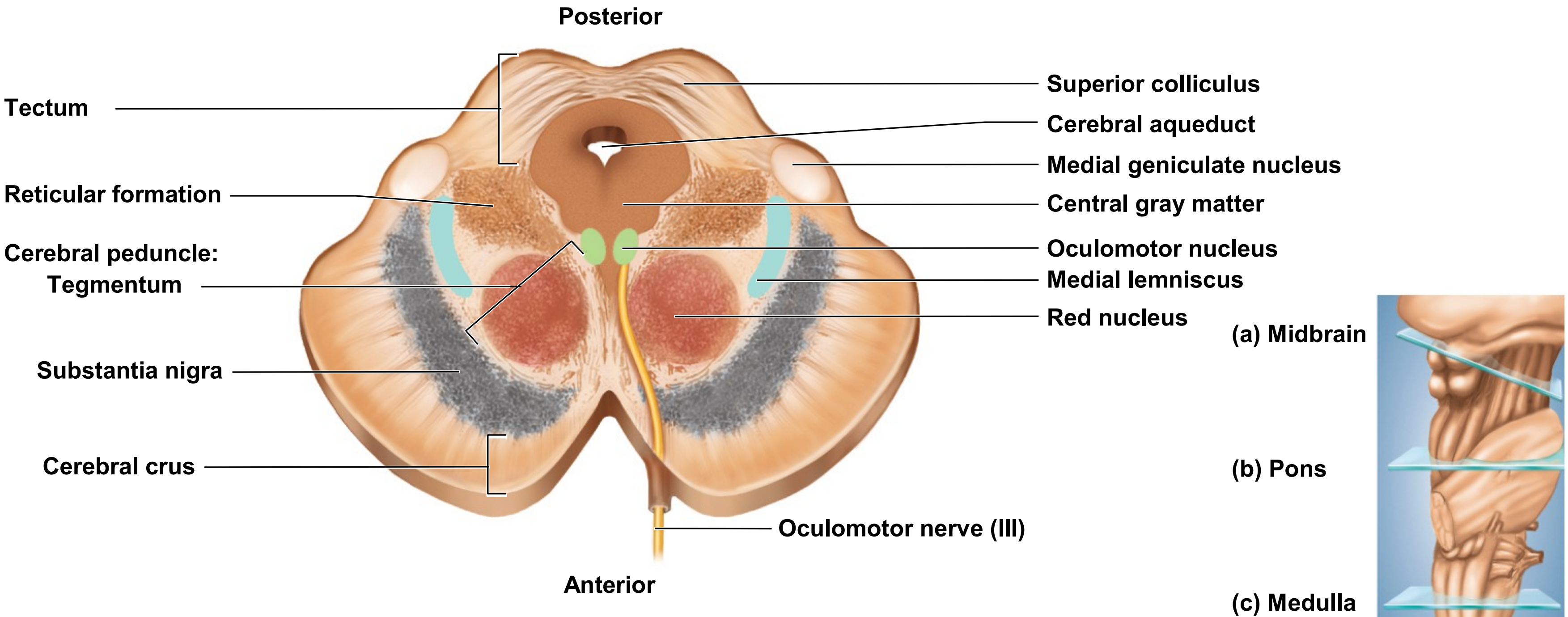
- Short segment of brainstem that connects the thalamus to the pons
  - the cerebral aqueduct runs through the length of the midbrain
  - contains continuations of the medial lemniscus and reticular formation
  - contains the motor nuclei for two cranial nerves that control eye movements – CN III (oculomotor) and CN IV (trochlear)



(b) Dorsolateral view

Note: Diencephalon consist of three main parts – thalamus, hypothalamus and epithalamus (includes other structures like the pineal gland & habenula)

Midbrain / Cross Section



(a) Midbrain

What is the function of tegmentum? It is a motor center that relays inhibitory signals to the thalamus and basal nuclei preventing unwanted body movement

What is tectum? A bodily structure serving as a roof of the midbrain.

The dorsal part of the midbrain includes the corpora quadrigemina.

Midbrain

- Tectum – roof-like structure at top of the midbrain /// posterior to cerebral aqueduct
- Corpora quadrigemina (superior and inferior colliculi)
  - four bulges, positioned under the occipital lobe
  - upper pair = superior colliculi /// visual reflexes /// function in visual attention, tracking moving objects
  - lower pair = inferior colliculi /// auditory reflexes /// receives signals from the inner ear /// relays them to other parts of the brain, especially the thalamus //
  - together, with input from eyes and ears, generate output to skeletal muscles in head/neck and is responsible for the startle reflex
- cerebral peduncles – fiber tracts passing through midbrain // two stalks that anchor the cerebrum to the brainstem anterior to the cerebral aqueduct

Midbrain

Important midbrain structures: tegmentum, substantia nigra, and cerebral crus

Tegmentum: dominate structure is red nucleus // pink because of high denisty of blood vessels // works with cerebellum in fine motor control

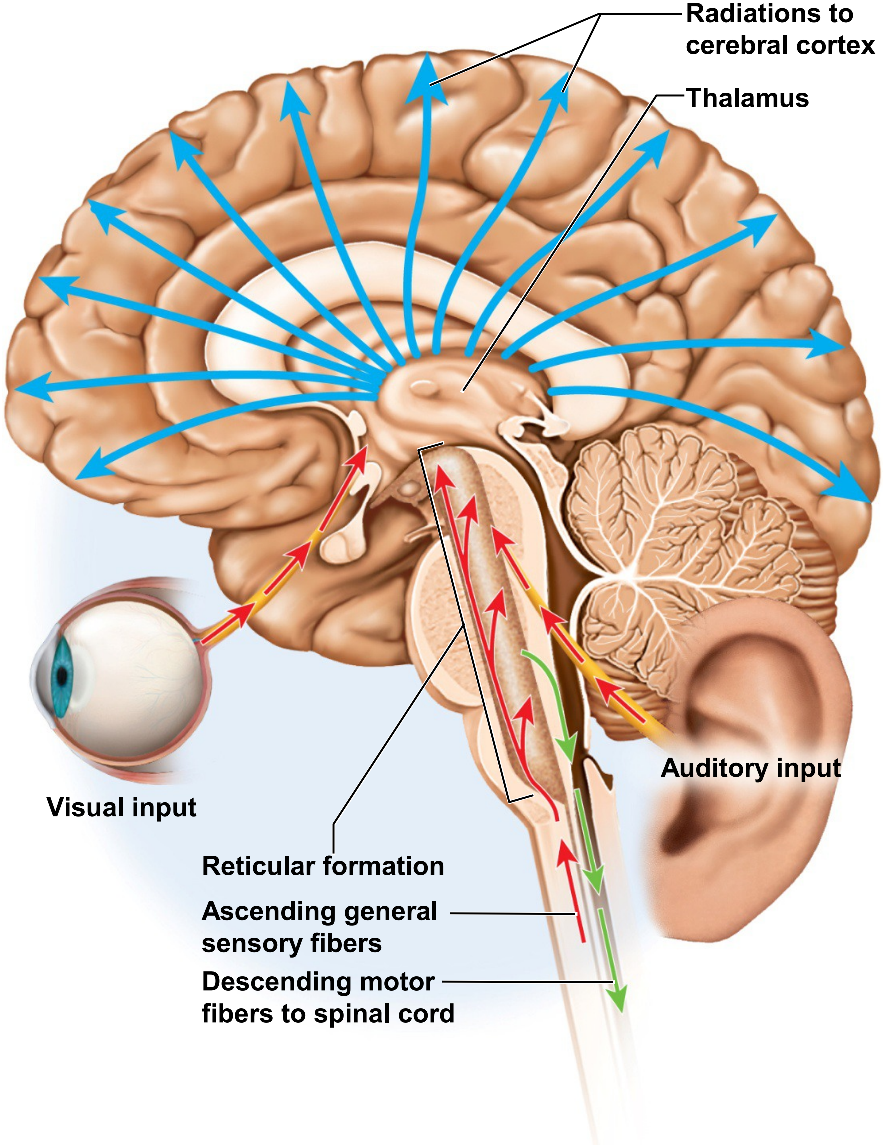
Substantia nigra: dark grey to black nucleus pigmented with melanin // motor center that relays inhibitory signals to thalamus and basal nucleus – inhibits muscle contractions

> Note: Parkinson disease – degeneration of substantia nigra neurons reduces dopamine secretion to basal nuclei // less inhibitory signals to anterior horns LMN and therefore more unwanted contractions which results in an increase in muscle tremors

Cerebral crus // bundle of nerve fibers that connects cerebrum to the pons // corticospinal tracts pass through the cerebral crus


May cause stiffness and tremors
Normal midbrain
Parkinson’s midbrain

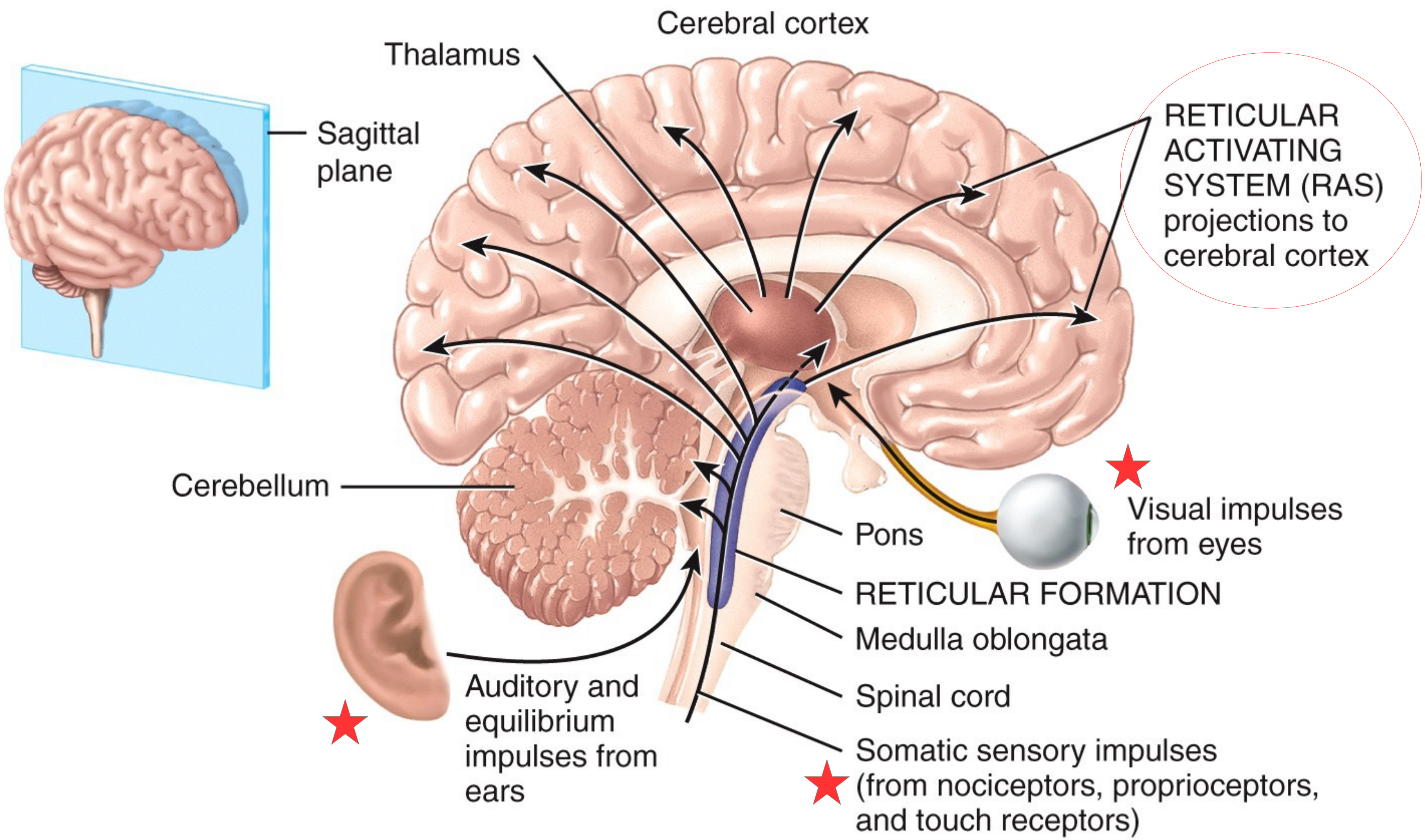
Reticular Formation



- <u>loosely organized web of nuclei (i.e. gray matter)</u>
- runs vertically through all levels of the brainstem
- RF - 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

(What type of stimulus activates the reticular formation?)



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

Functions of Reticular Formation Networks

- Sleep and consciousness

  plays central role in states of consciousness, such as alertness and sleep

  sleep or an unconscious state occurs when the reticular formation is disconnected from the cerebrum

  injury to reticular formation that breaks nerve tracks between RF and cerebrum can result in irreversible coma

The Process of Falling Asleep

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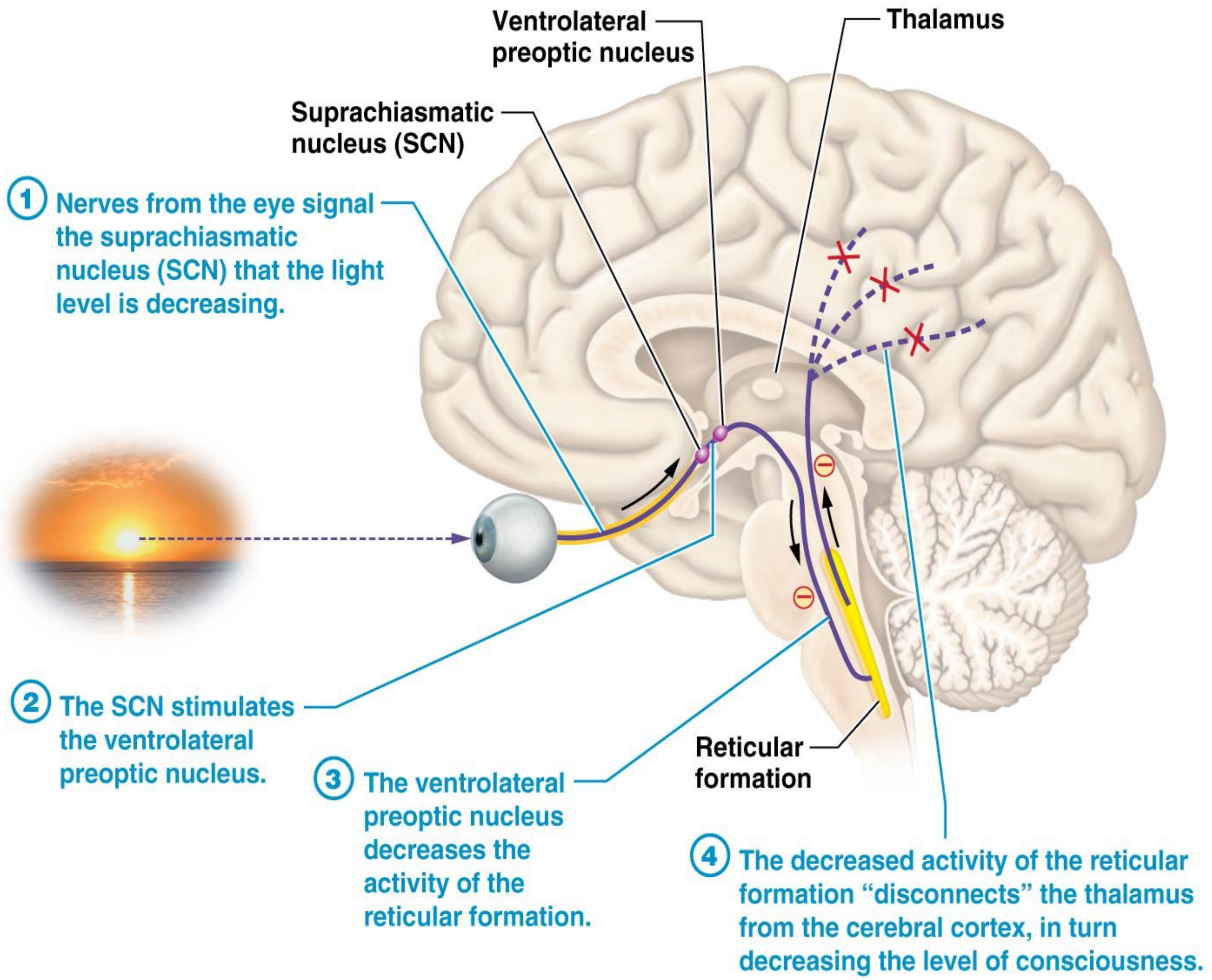


Other brain structures also influence our sleep cycle (see next slide)

Other Mechanisms That Influence Falling Asleep

The pineal gland (endocrine gland) produces melatonin which also plays a role in our mood and the process of falling asleep. Melatonin's production is directly related to darkness: the longer the night (less sunlight), the more melatonin produced. Melatonin receptors are located in the reticular formation. When melatonin binds to these receptors then the reticular formation disconnects the thalamus from the cerebral cortex.

Adenosine in the brain is created by the breakdown of ATP. There are adenosine receptors in the RF. When adenosine binds to their receptors then this too disconnects the thalamus from the cerebrum and induces sleep. The molecule structure of "caffeine" is similar adenosine. Therefore, they both complete for the same receptor. Caffeine blocks adenosine binding to the receptor but caffeine does not block action potentials from entering the cerebrum. This is why drinking coffee can keep you awake!

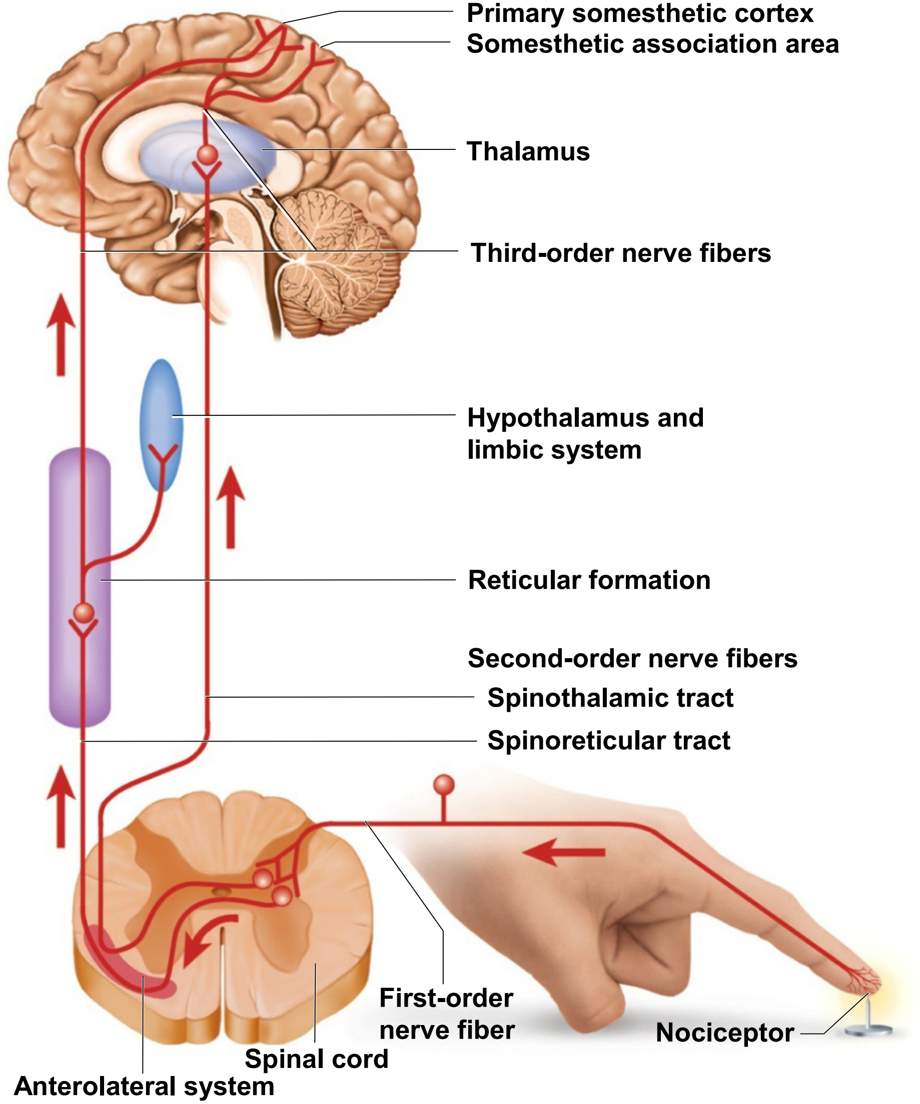
Functions of Reticular Formation Networks

- Habituation
  - process that allows brain to learn how to ignore repetitive stimuli
  - inconsequential stimuli ignored while remaining sensitive to other "important stimuli"
  - your brain is "sensitive" to what is most important to you
  - *How can this explain why some students like to study in a "busy cafeteria"?*

Functions of Reticular Formation Networks

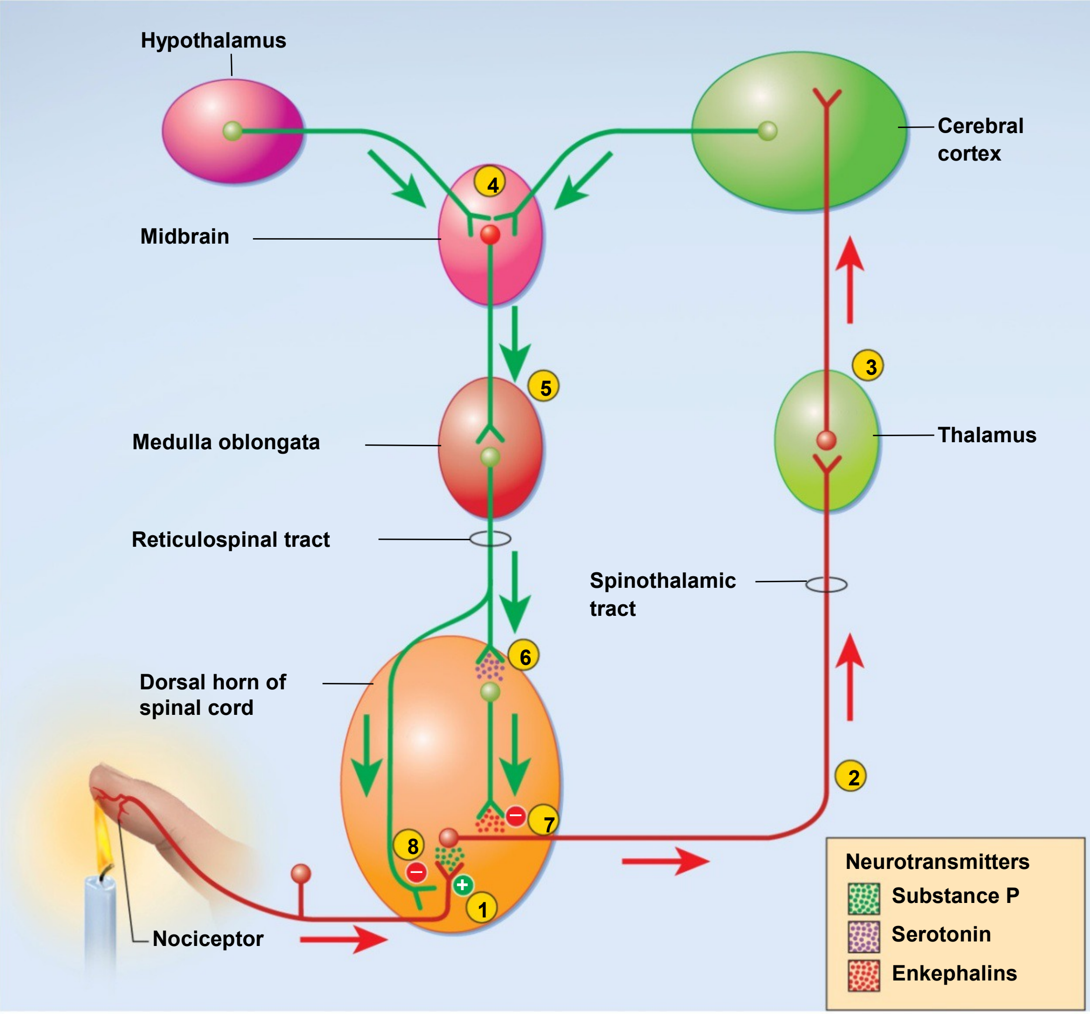
- About pain modulation
  - spinalreticular tract is one route by which pain signals from the lower body reach the cerebral cortex // on way synapse with reticular formation
  - also origin for descending analgesic pathways (reticularspinal tract) // fibers act in the spinal cord to block transmission of pain signals to the brain
  - This is pain associated with tissue damage, severe pain

Ascending Pain Signal Destinations



Spinal Gating of Pain Signals

(How the Brain Blocks Pain)



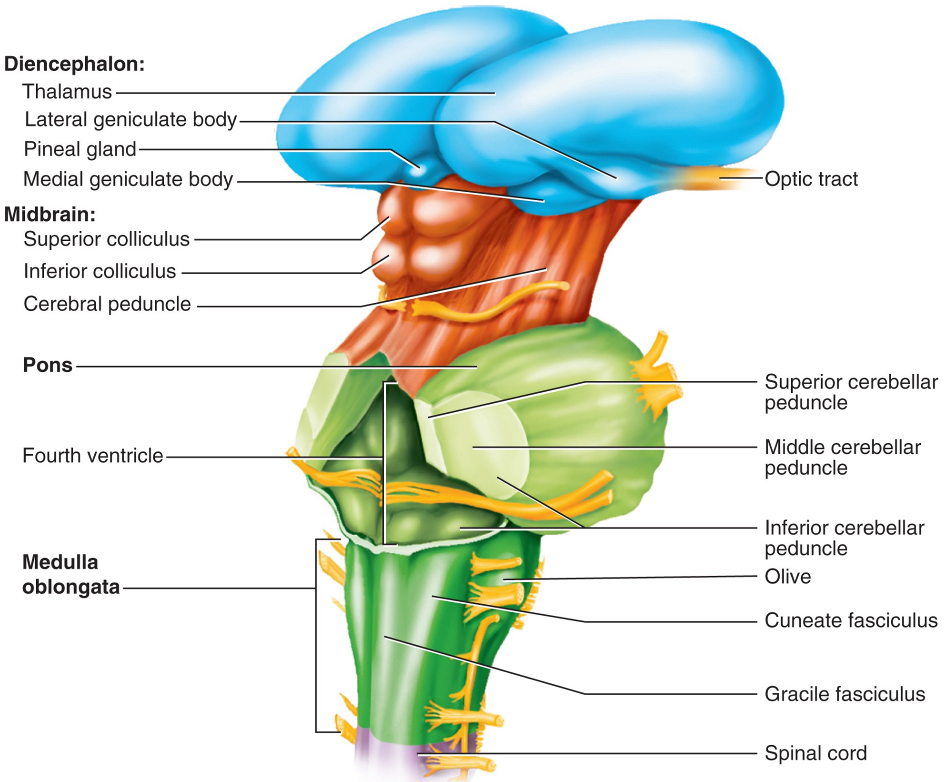
1. Nociceptor releases substance P onto spinal interneuron.
2. Second-order neuron transmits signal up spinothalamic tract to thalamus.
3. Third-order neuron relays signal to somesthetic cortex.
4. Input from hypothalamus and cerebral cortex converges on central gray matter of midbrain.
5. Midbrain relays signal to reticular formation of medulla oblongata.
6. Some descending analgesic fibers from medulla secrete serotonin onto inhibitory spinal interneurons.
7. Spinal interneurons secrete enkephalins, blocking pain transmission by means of postsynaptic inhibition of second-order pain neuron.
8. Other descending analgesic fibers synapse on first-order pain fiber, blocking pain transmission by means of presynaptic inhibition.

Functions of Reticular Formation Networks

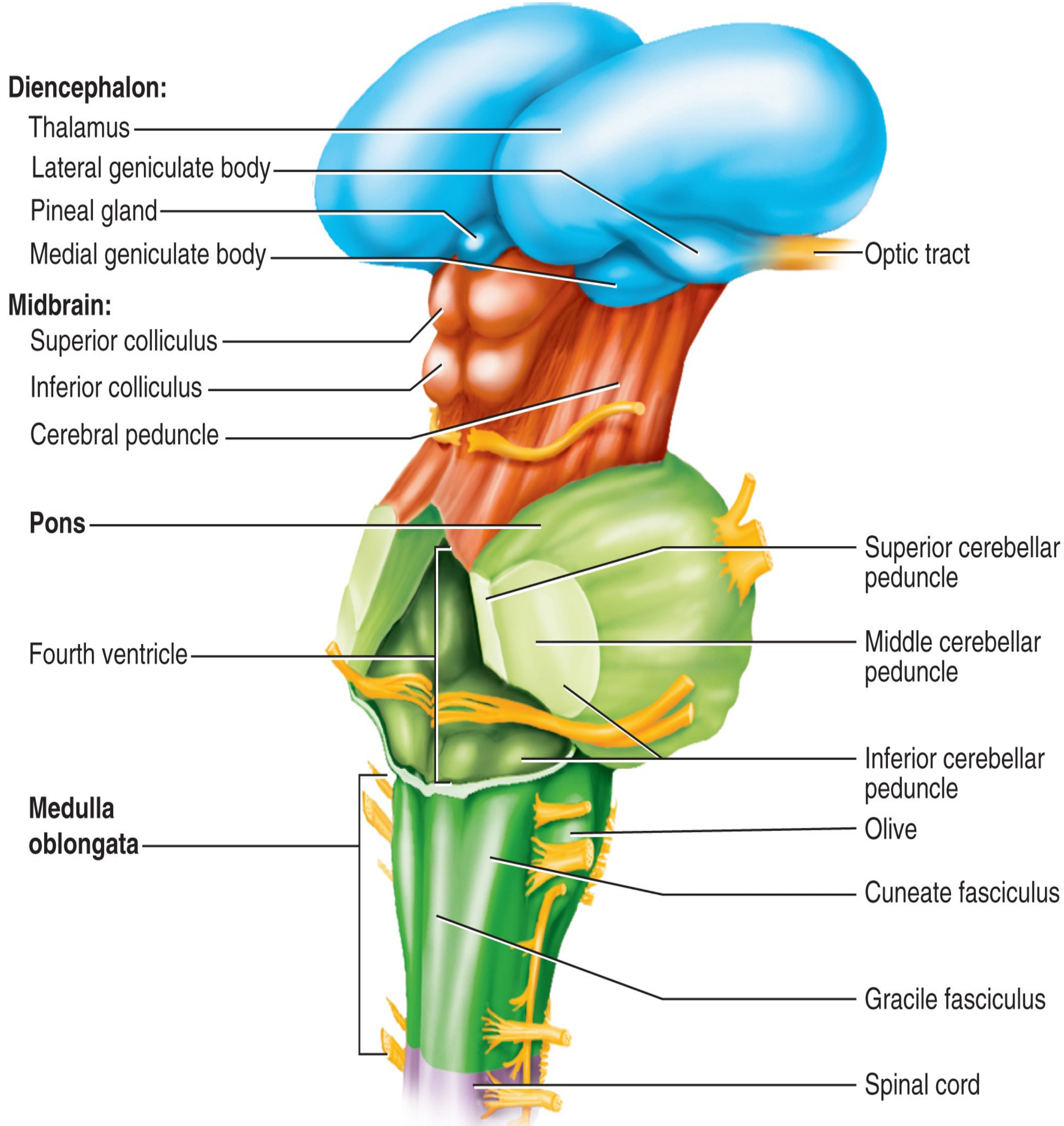
- somatic motor control
  - adjust muscle tension to maintain tone, balance, and posture // especially during body movements
  - relays signals from eyes and ears to the cerebellum // integrates visual, auditory, and balance and motion stimuli into motor coordination
- gaze center – allow eyes to track 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

The Diencephalon

- Perched at the superior end of the brainstem beneath the cerebral hemispheres
- Three main parts: thalamus, epithalamus, and hypothalamus
- Thalamus (constitutes about four-fifths of the diencephalon) // consists of two lobes joined medially by a narrow intermediate mass
- Thalamus composed of at least 23 nuclei
- All sensory stimulus (except olfaction) must pass through thalamus to enter cerebrum



(b) Dorsolateral view

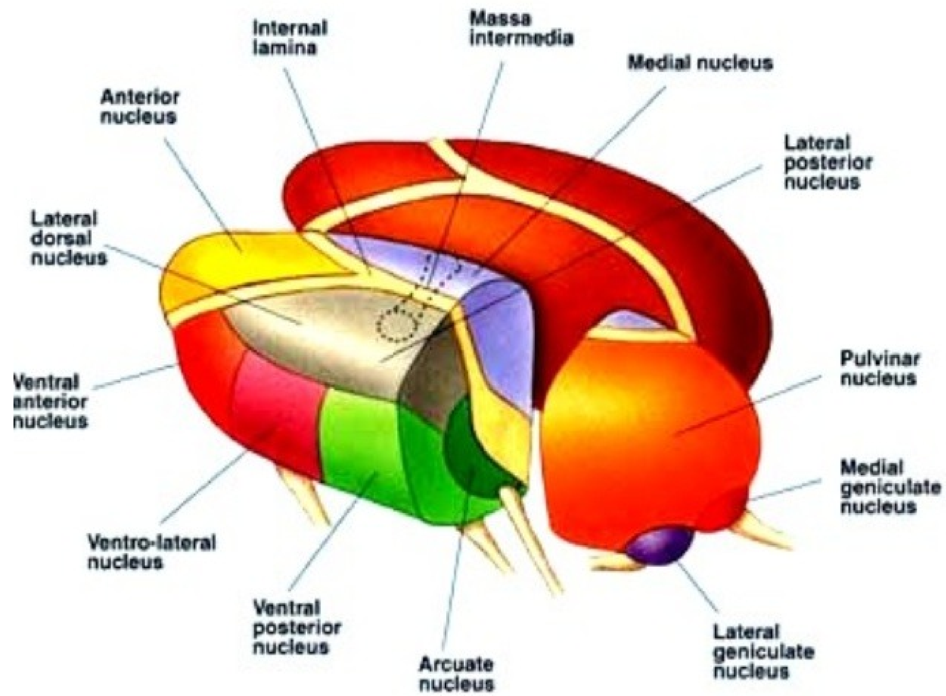


(b) Dorsolateral view

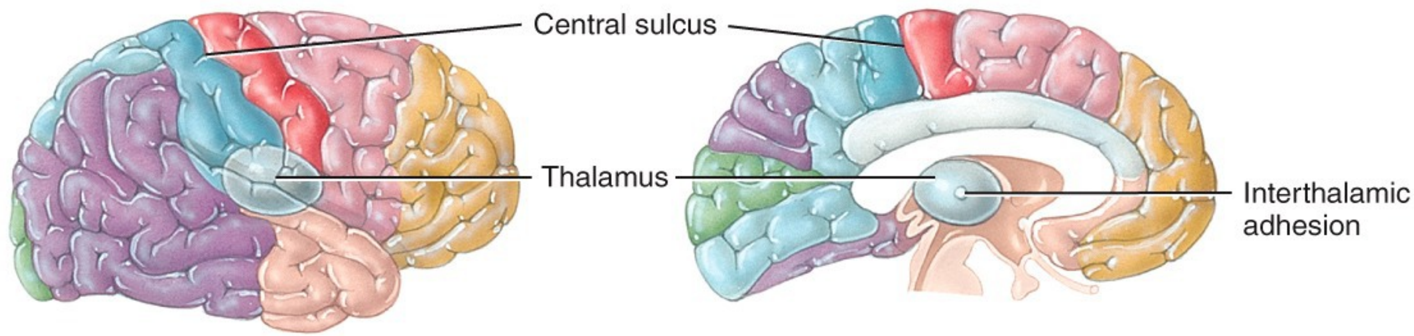
Note: Diencephalon consist of three main parts – thalamus, hypothalamus and epithalamus (includes other structures like the pineal gland & habenula)

The Thalamus

- The diencephalon has three major sub-divisions
    - thalamus
    - hypothalamus
    - epithalamus
  - The two lobes of the thalamus form the lateral walls of the third ventricle
  - Thalamus is the most rostral part of the brainstem
  - Nickname = gateway to the cerebrum or Grand Central Station

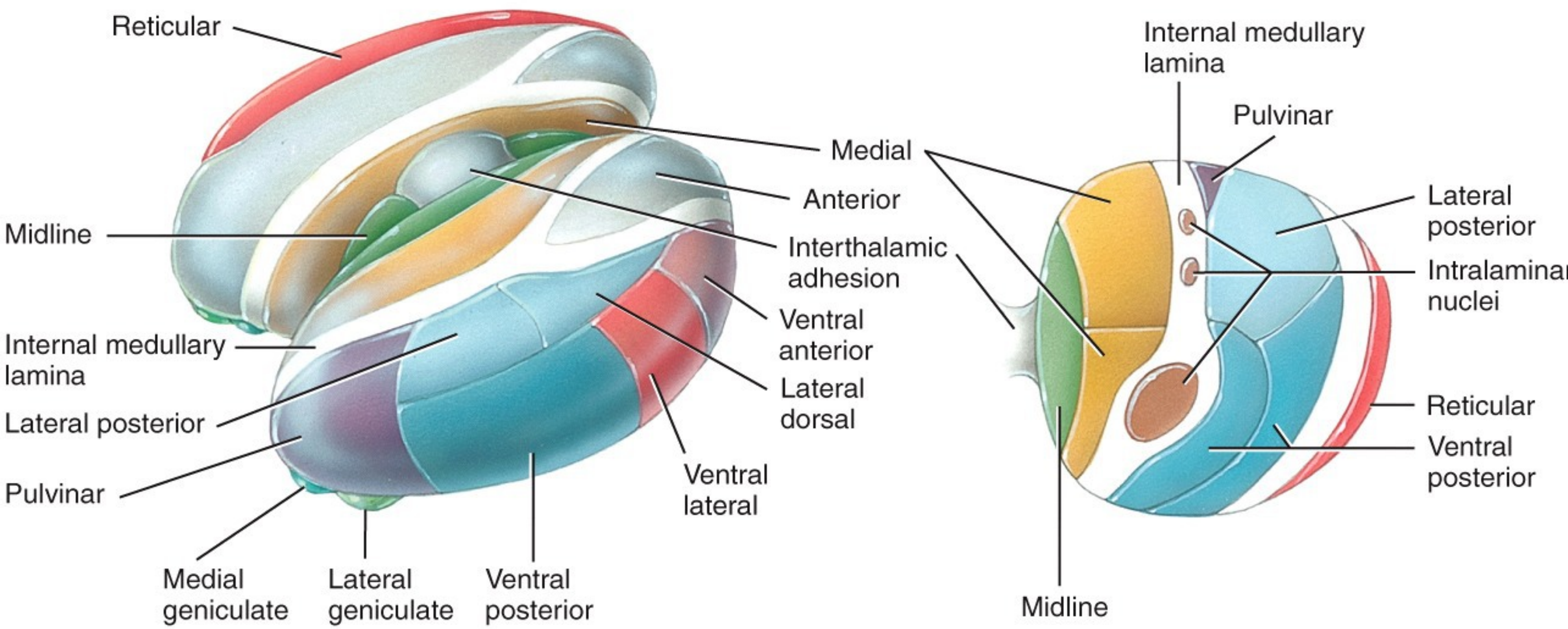


All somatosensory tracts pass through the thalamus except one. What sense does not pass through the talamus?



(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

The Thalamus

Somatosensory ascending signal synapse in thalamus.

The action potential is splits as it ascends through thalamus and sends two tracks into the cerebrum and one tract into the limbic system

One pathway into cerebrum goes to primary somatosensory area and onto the somatosensory association area

A second and separate pathway through the thalamus goes directly to the somatosensory association area!

The Thalamus Role in Motor Control

- Thalamus also plays key role in motor control.
- Motor control is how we regulate skeletal muscle contractions.

motor control requires complex pathways between the cerebrum's motor association area, basal ganglia, (and other subthalamic nuclei), thalamus, and cerebrum's motor strip

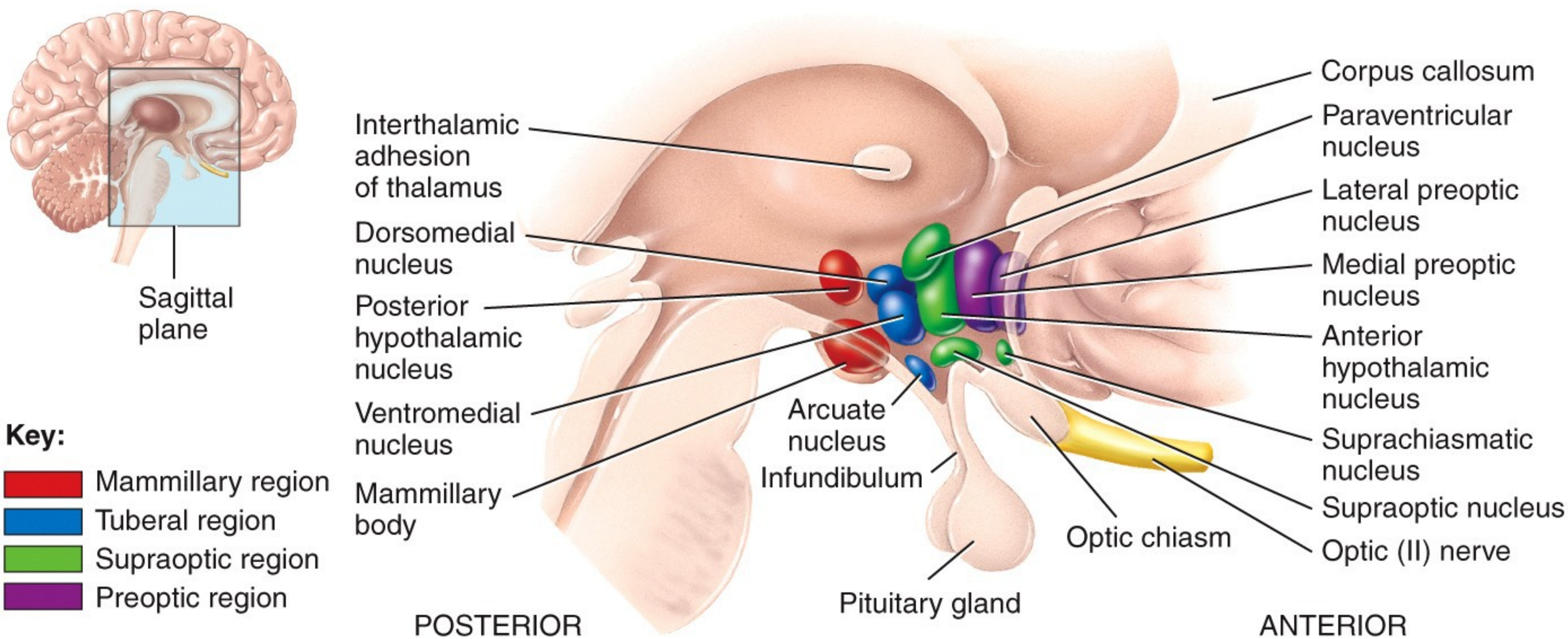
thalamus provides pathways for feedback loops between the cerebral cortex, basal nuclei, and thalamus (note: called the cortico-basal nuclei-thalamo-cortico-loop)

thalamus blocks motor action potentials from reaching the motor strip /// this prevents unwanted skeletal muscle contractions

basal ganglia must inhibit the thalamus in order to allow action potential to reach primary motor cortex (precentral gyrus) // this is origin of upper motor neurons // track that sends action potentials to lower motor neurons and then onto skeletal muscles.

We will study motor control as a function of the cerebrum.

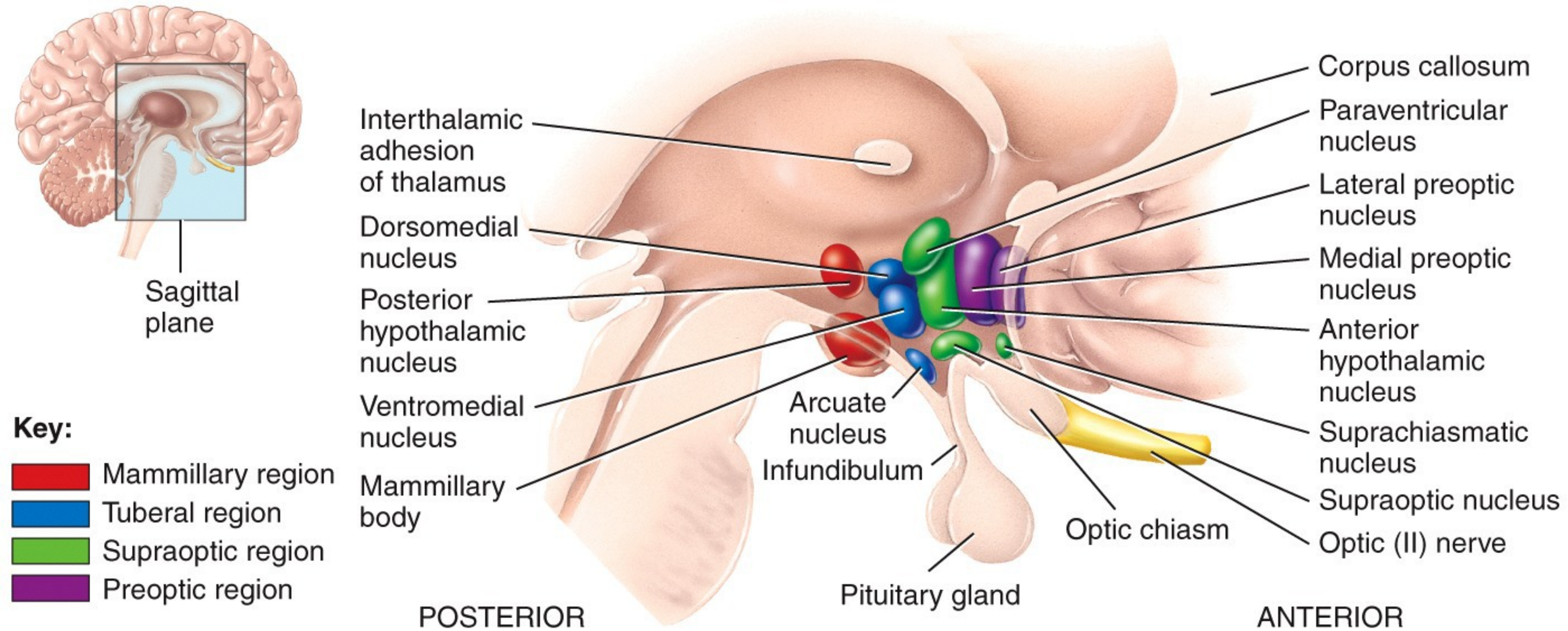
Hypothalamus



Sagittal section of brain showing hypothalamic nuclei

Funnel shaped / below thalamus / between mamillary body and optic chiasma

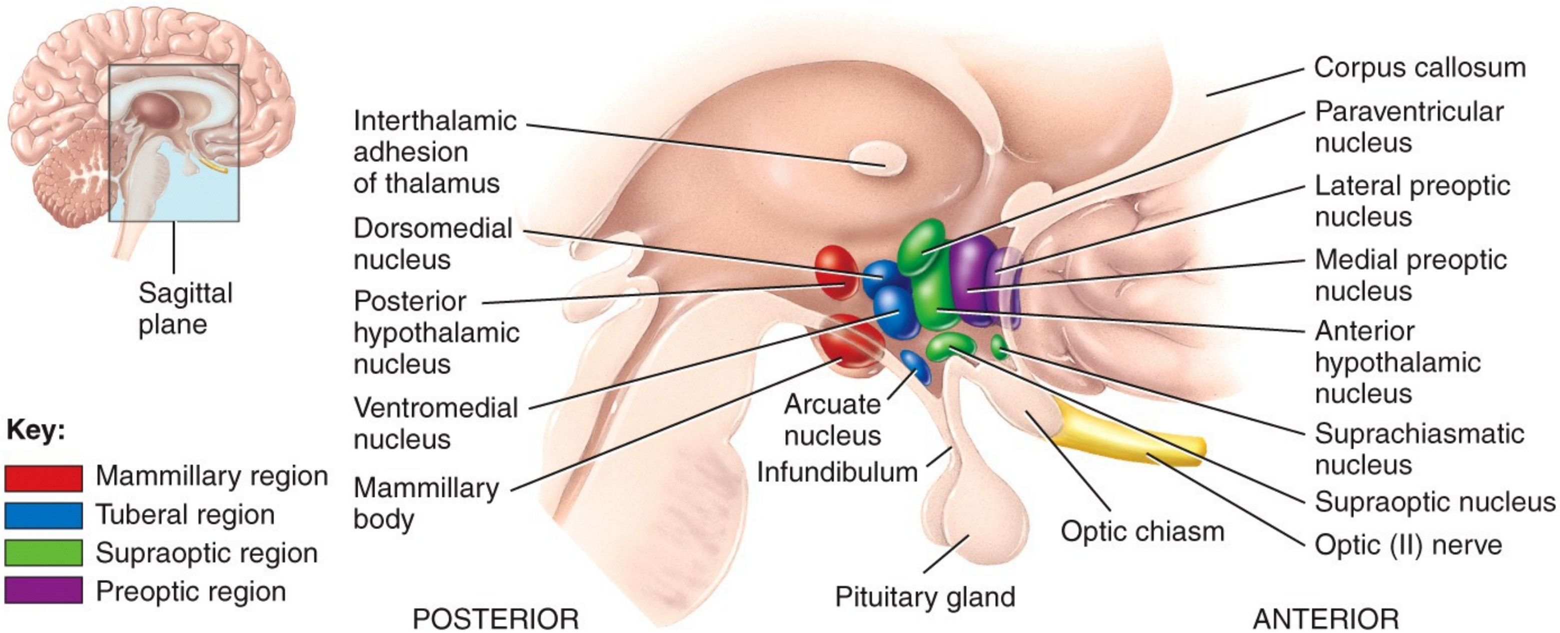
Hypothalamus



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
- Each nuclei is a control center
- Hypothalamus is the boss of the autonomic nervous system & endocrine system // *plays essential roll in homeostasis /// regulates all body systems*

Functions of Hypothalamic Nuclei

– **Regulates hormone secretions**

  - controls anterior pituitary // secrete molecules which release hormones from anterior pituitary
  - anterior pituitary hormones regulates growth, metabolism, reproduction,and stress responses

– **Regulates autonomic nervous system**

  - 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

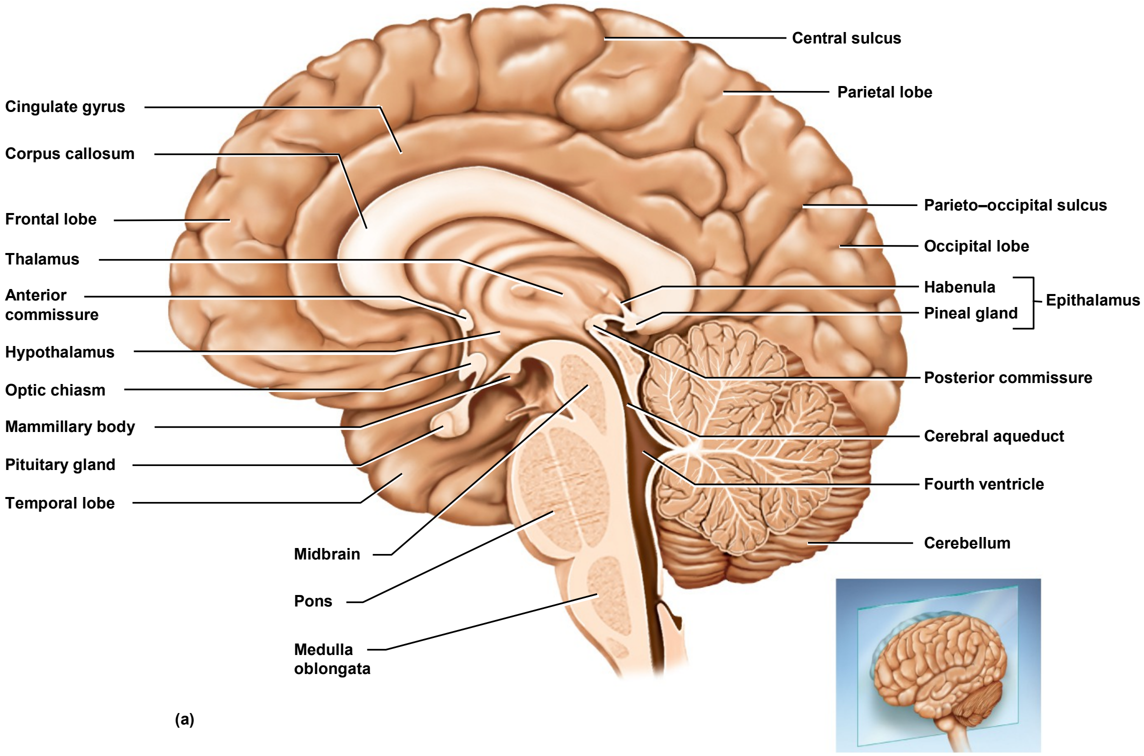
– **Thermoregulation**

  - 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

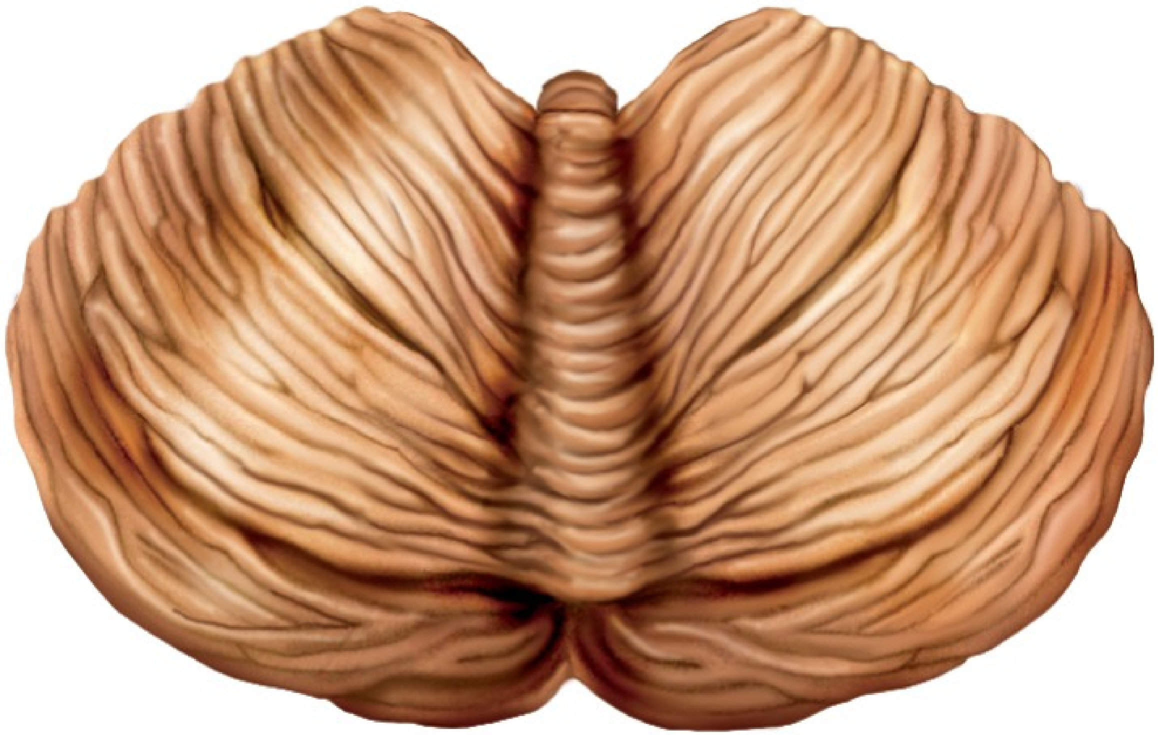
- **Food and water intake**
  - hunger and satiety centers // produce sensations of hunger and satiety
  - monitor blood glucose and amino acid levels
  - thirst center monitors osmolarity of the blood
- **Rhythm of sleep and waking** // controls 24 hour circadian rhythm of activity
- **Memory** // mammillary nuclei receive signals from hippocampus (Declaritive Memory = knowing what) /// amygdala (Procedural memory = knowing how)
- **Emotional behavior** // anger, aggression, fear, pleasure, and contentment // many tracts beween hypothalamus and limbic system

Epithalamus

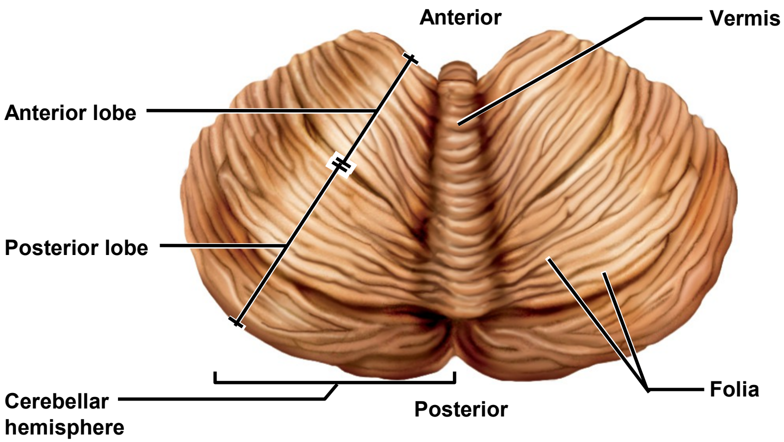


- epithalamus – thin roof over the third ventricle // very small mass of tissue composed of
  - pineal gland – endocrine gland // produces melatonin
  - habenula – relay tract from the limbic system to the midbrain

The Cerebellum



Cerebellum



(b) Superior view

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

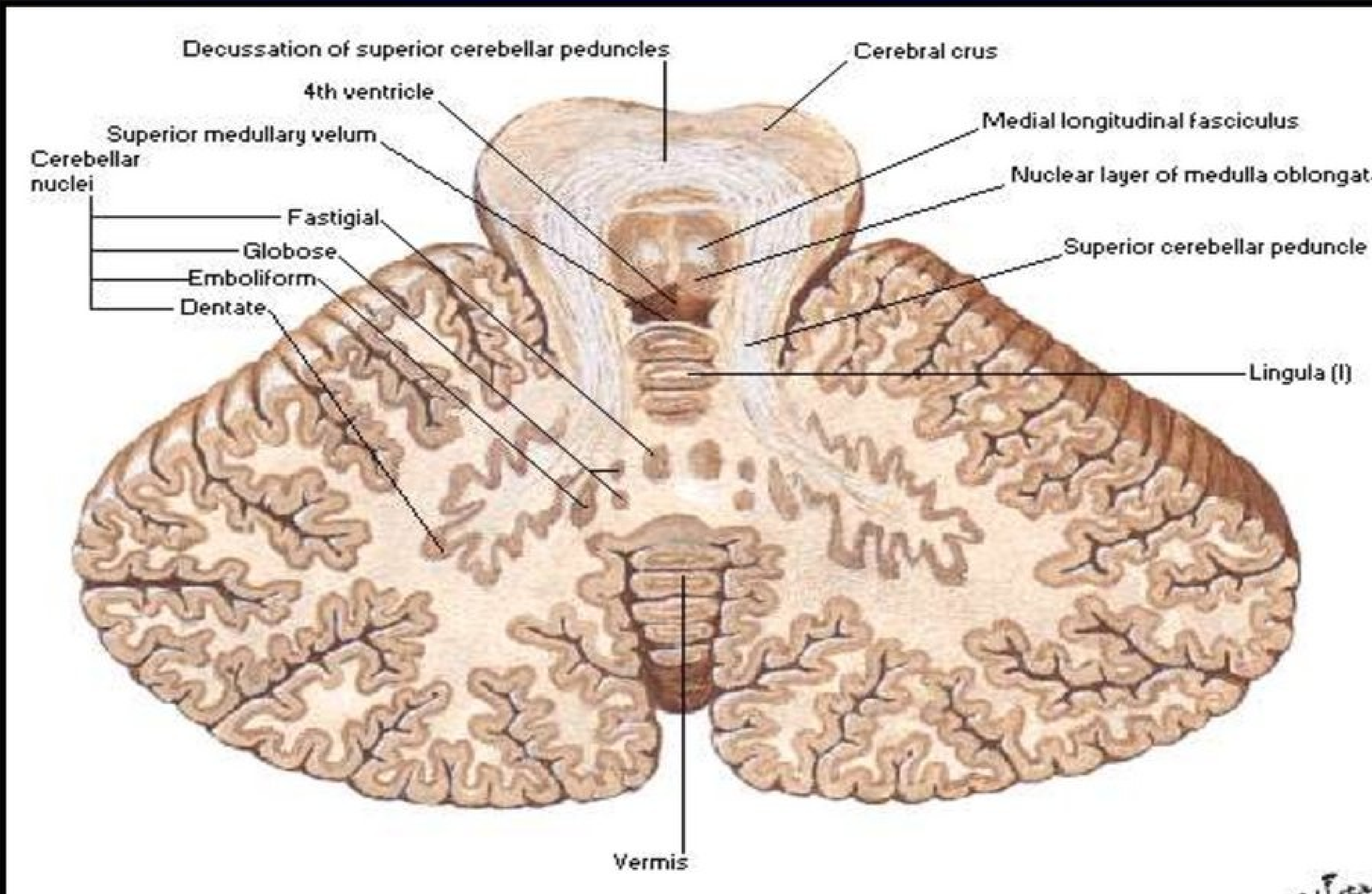
cortex of gray matter with folds (**folia**) and four deep nuclei in each hemisphere

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 second largest part of the brain as a whole
- 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

Internal structure of cerebellum (grey and white matter)



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:
- Generally speaking, the cerebellum "compares all sorts of stimuli"
- 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

Skeletal muscle “motor control” // monitor skeletal muscle's contraction the “intent” VS actual skeletal muscle contraction the “performance” // intent VS performance // Compare the two and make necessary adjustments

Cognition (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
- Lesions in cerebellum may result in emotional overreactions and trouble with impulse control

The Cerebral Peduncles and Motor Control

The cerebral peduncles are nerve tracts that pass through the midbrain. These tracks carry action potentials between the brain, skeletal muscles, and the cerebellum.

These nerve tracks are used to coordinate skeletal muscle contractions and allow the cerebellum to compare the "intent" of a skeletal muscle contraction to the actual "performance" of the skeletal muscle contraction.

There are three peduncles that enter and exit the cerebellum at the level of the pons.

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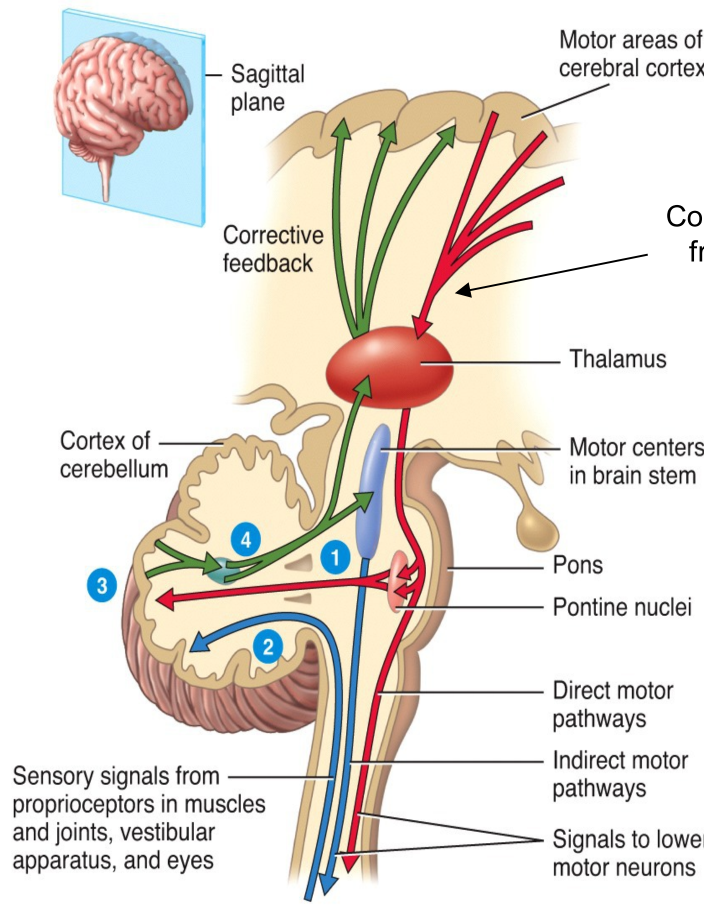
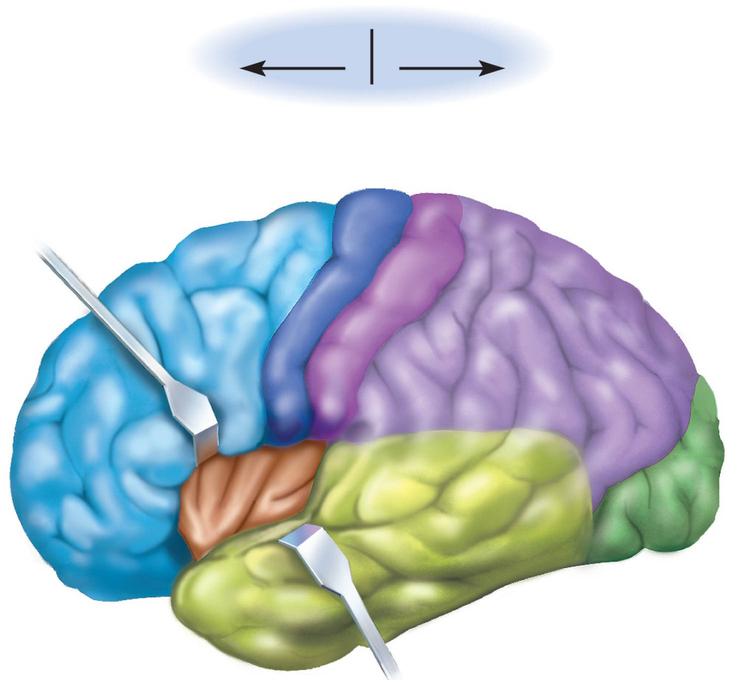
- More content about motor control to be covered later in discussion about cerebrum function.



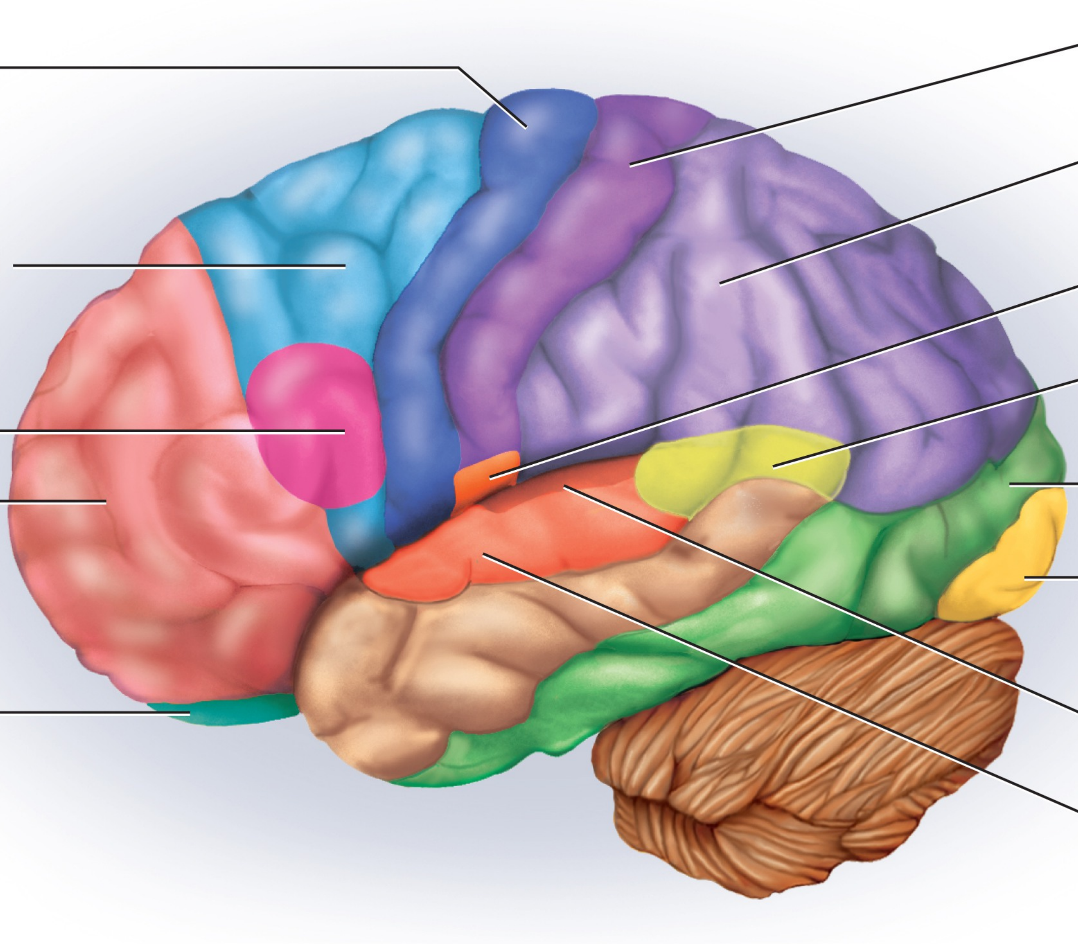
Sagittal section through brain and spinal cord

What is the difference between intent and performance?

The Cerebrum's Functions



Functional Map of the Cerebrum's Lobes

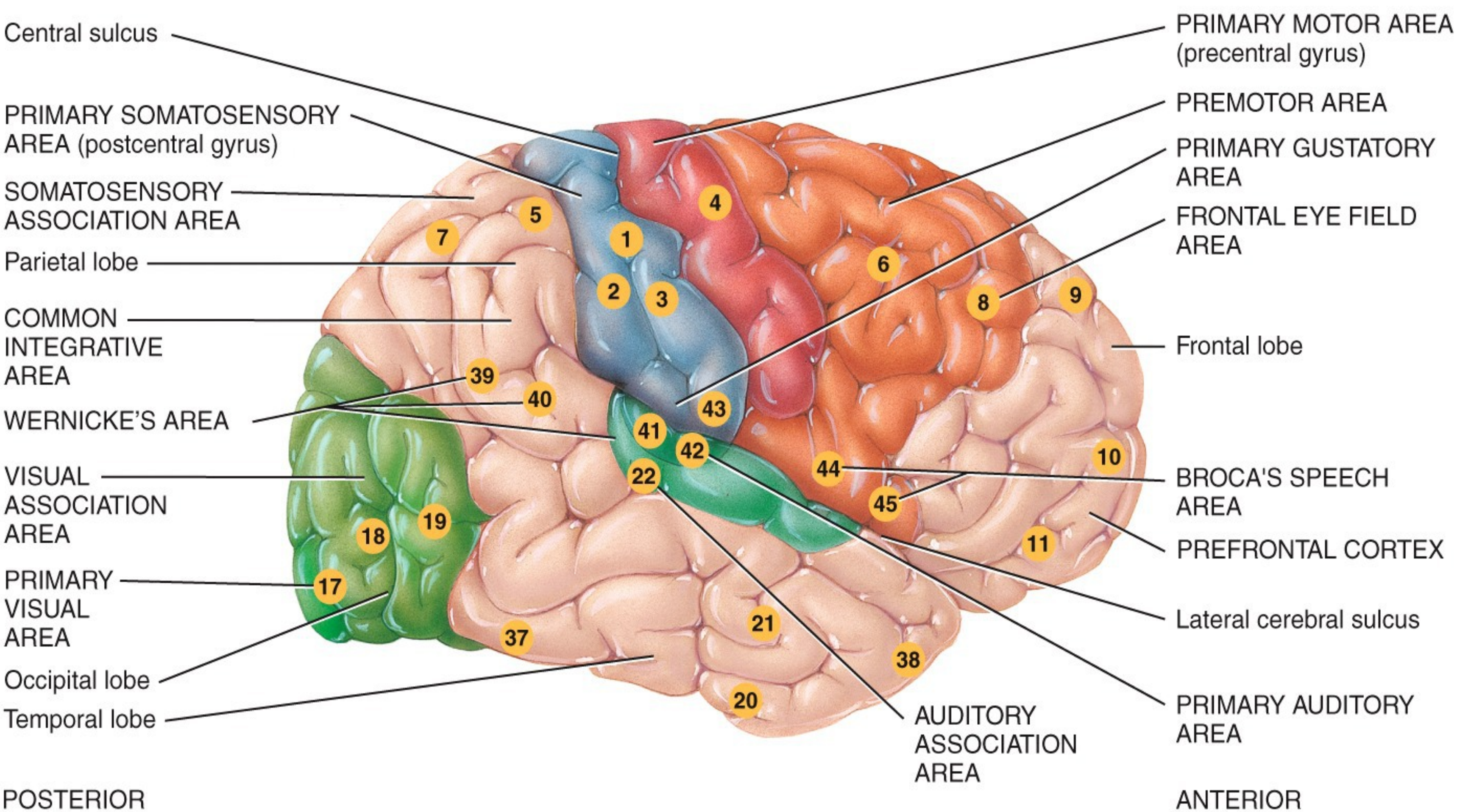


> Key surface margins (longitudinal fissure / central sulci / lateral sulcus)

> What is the significance between the primary area and their association areas?

Brain Function

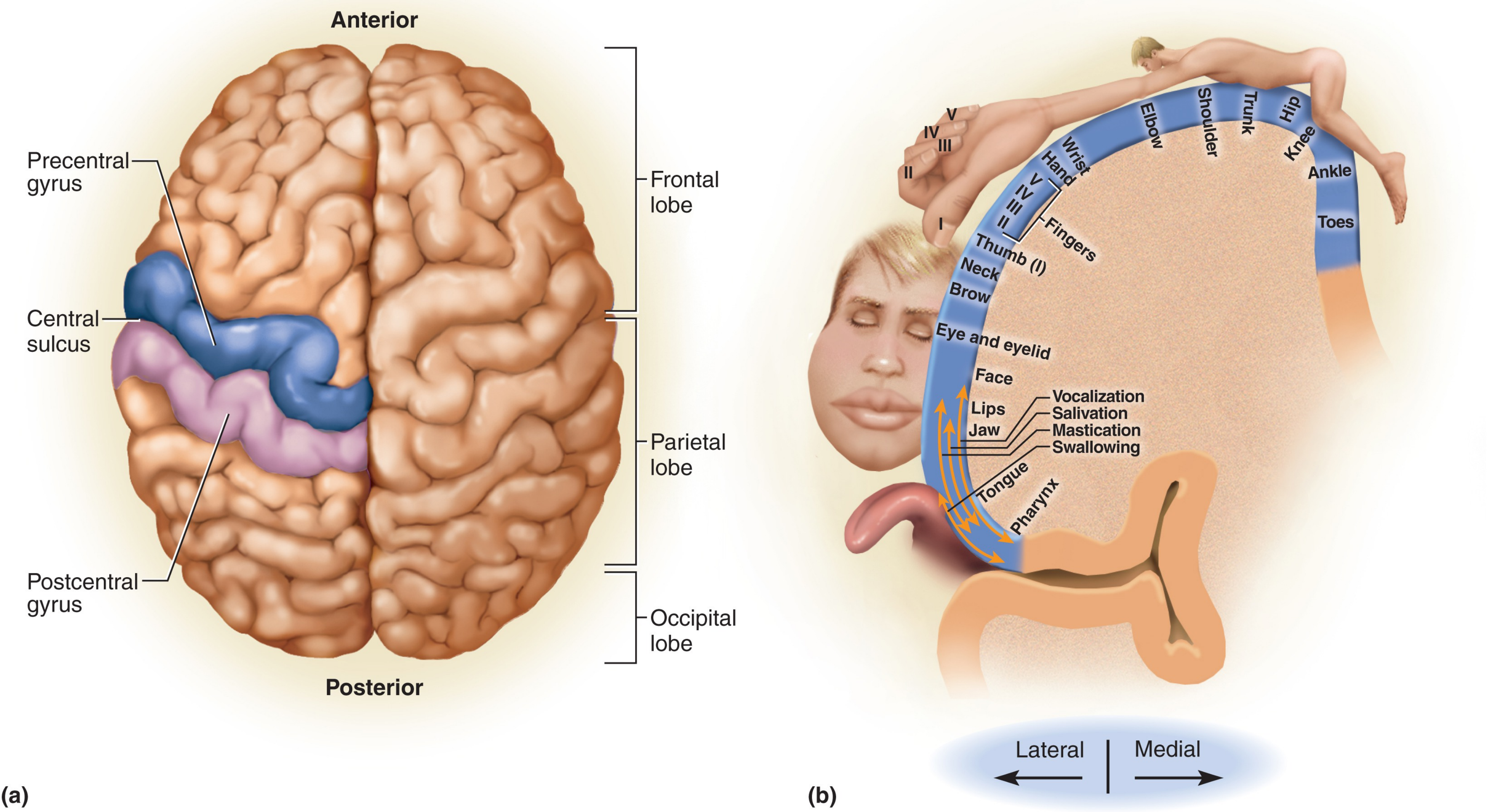
(Structure VS Function)



Lateral view of right cerebral hemisphere

Note: Functions organized as primary and association areas.

The Homunculus



Somatotopy on 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

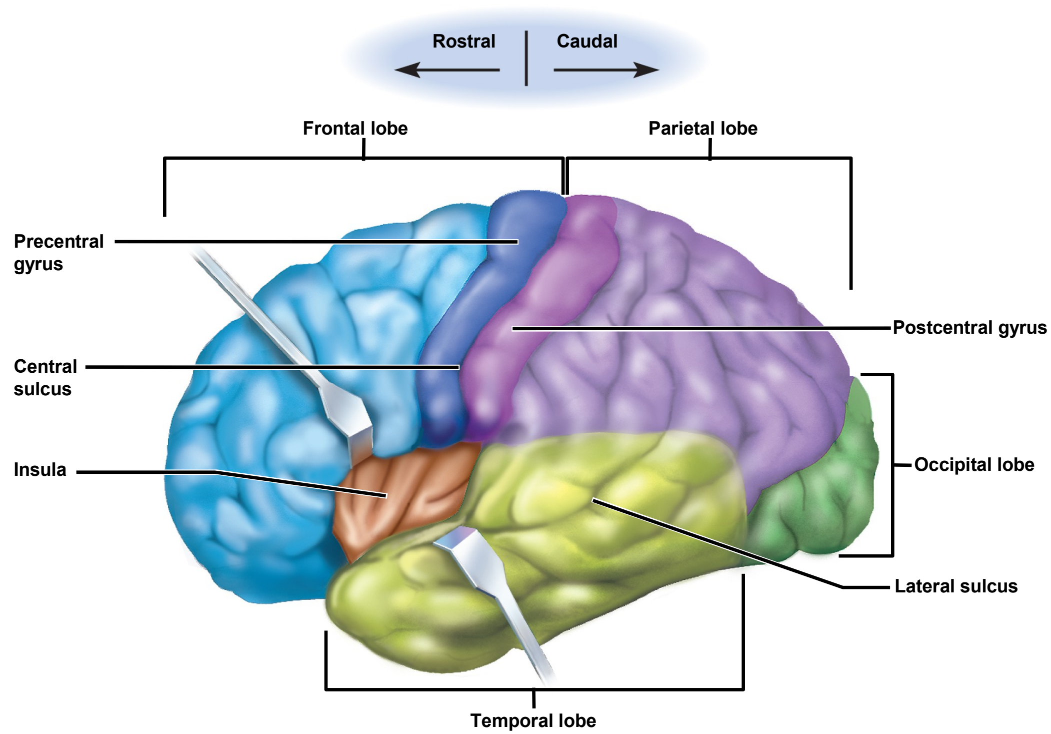
motor and sensory neurons for toe are deep in the longitudinal fissure of the medial side of the gyrus

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

Cerebrum's Functions Are Isolated in Lobes of the Cerebrum

- **Frontal lobe (precentral gyrus, motor association area, prefrontal cortex, medial orbital frontal cortex, anterior cingulate gyrus)**
  - Precentral gyrus = motor control
  - Motor association area = compile motor "applications" which maybe executed by prefrontal cortex
  - Prefrontal cortex = Executive functions, cognition, impulse control, planning, foresight, social judgment, decision making, delay gratification, it is the Captain that steers the ship", it makes you do the harder thing when it is the right thing to do!
  - Medial Orbital frontal cortex = prefrontal cortex region in the frontal lobes of the brain which is involved in the cognitive process of <u>decision-making</u>. Involved in risk reward analysis.



Note: each hemisphere's surface area is about the size of a 14 inch pizza!

- Anterior cingulate gyrus = site of empathy / bidirectional connections with prefrontal cortex – check to see if you caused the pain in other person.

What is the function of the medial orbital frontal lobe?

Medial orbital frontal lobe is the "great decider". It is an area in the frontal lobe directly above the eyes orbits.

This tissue functions to make decisions. In our conscious state, we need to make a never ending stream of decision as we move through time.

If the frontal lobe is the site of our working memory then the medial orbital frontal lobe provides the raw data for our working memory.

The medial orbital frontal lobe does two things: first, it makes the decision based on a reward-punishment analysis then sends decision to the frontal lobe to execute /// secondly, the medial orbital frontal lobe also remembers the decision process and after the execution revisits the decision to see if the reward-punishment analysis was correct

This is a key process in how we learn to make better decisions!

Cerebrum's Functions Are Isolated in Cerebrum's Lobes

parietal lobe

receives and integrates general sensory information // e.g. taste and some visual processing

occipital lobe

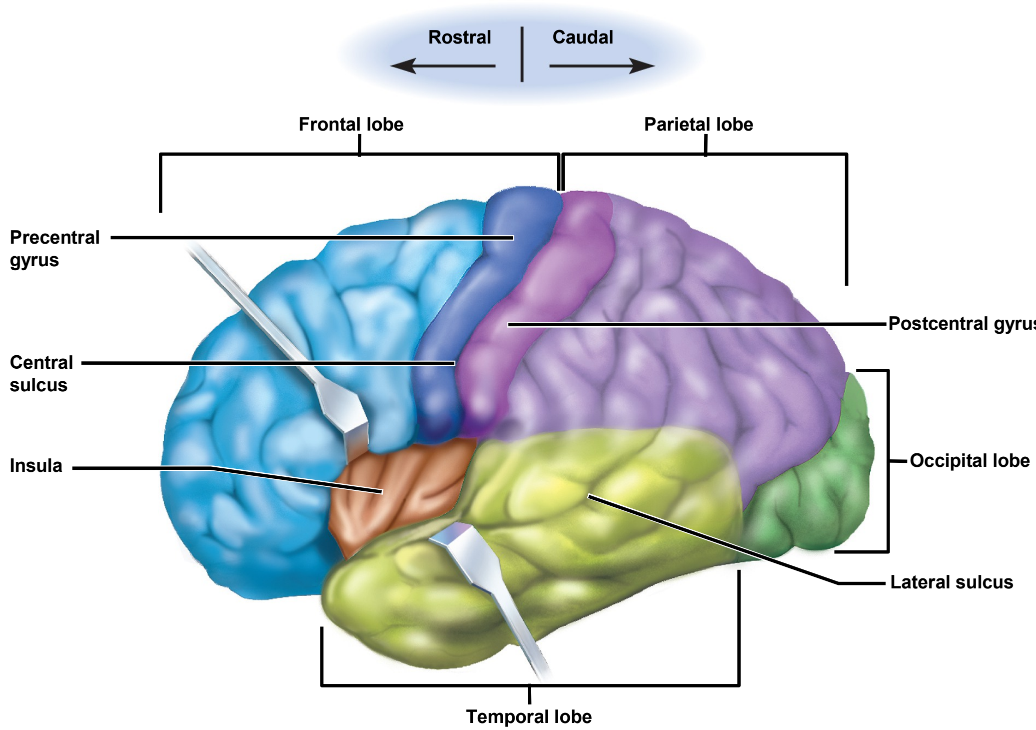
primary visual center of brain

temporal lobe

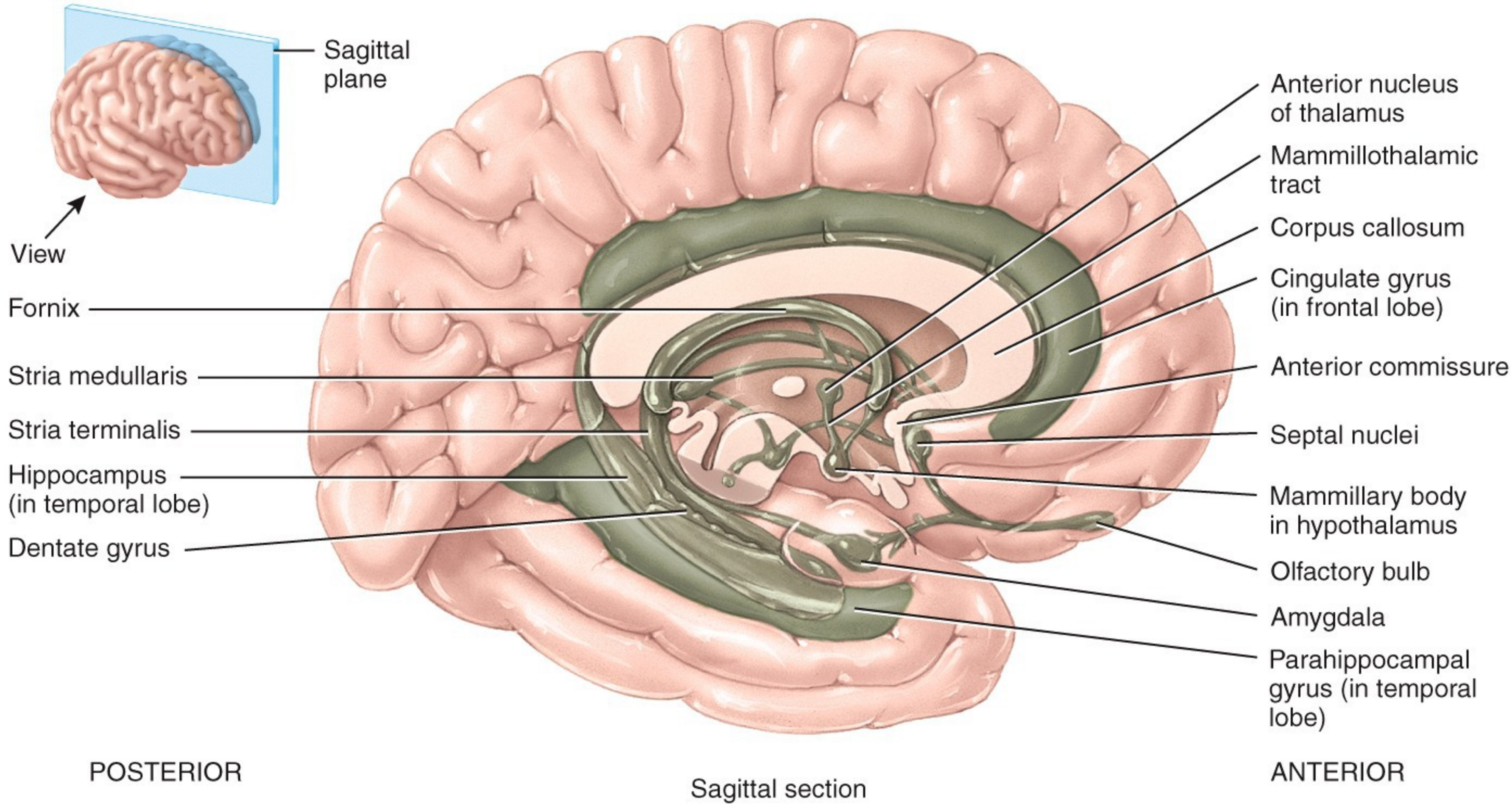
areas for hearing, smell, learning, memory, and some aspects of vision and emotion // hippocampus dependent memory

insula (hidden by other regions)

understanding spoken language, taste and sensory information from visceral receptors // gustatory disgust // in humans also moral disgust as in I am sick to my stomach



Limbic System's Location in Cerebrum



What is the relationship between the frontal lobe and the limbic system?

The frontal lobe is our conscious brain. Cognition, our "working thoughts" occur here.

The limbic system is where our subconscious judgment values and remembrances of emotional events that are stored as pleasant or unpleasant events.

These two areas are richly interconnected with nerve tracts. Therefore, the limbic system may influence frontal lobe function.

Motivational system (e.g. reward pathway that shapes our behavior // responsible for Addictions) ///   nucleus accubens = pleasure center

More importantly, if under stress then the frontal lobe stops working (i.e. panic state) and now the limbic system takes over (i.e. anxiety leads to fear leads to aggression /// the fright, flight or fight reaction)

What is the relationship between the frontal lobe and the limbic system?

The frontal lobe is our slow brain and the limbic system system is our fast brain.

These two areas are richly interconnected with nerve tracts. Therefore, the limbic system can influence frontal lobe function and frontal lobe may influence limbic system. All three brain formations are bidirectionally connected.

If under stress the frontal lobe stops working (i.e. as in a panic state) . Now the limbic system takes over (i.e. anxiety leads to fear which then leads to aggression /// it is the cause of the fright, flight or fight reaction)

The limbic system matures faster than the prefrontal cortex. The frontal cortex does not mature until the age of 25 yrs. Juvenile behavior is dictated by the limbic system.

The Limbic System

Somatosensory information is “split” at the top of the brainstem: one path goes through the thalamus and into different cerebral lobes and the other path goes into the limbic system.

Conscious = cerebrum vs subconscious = limbic

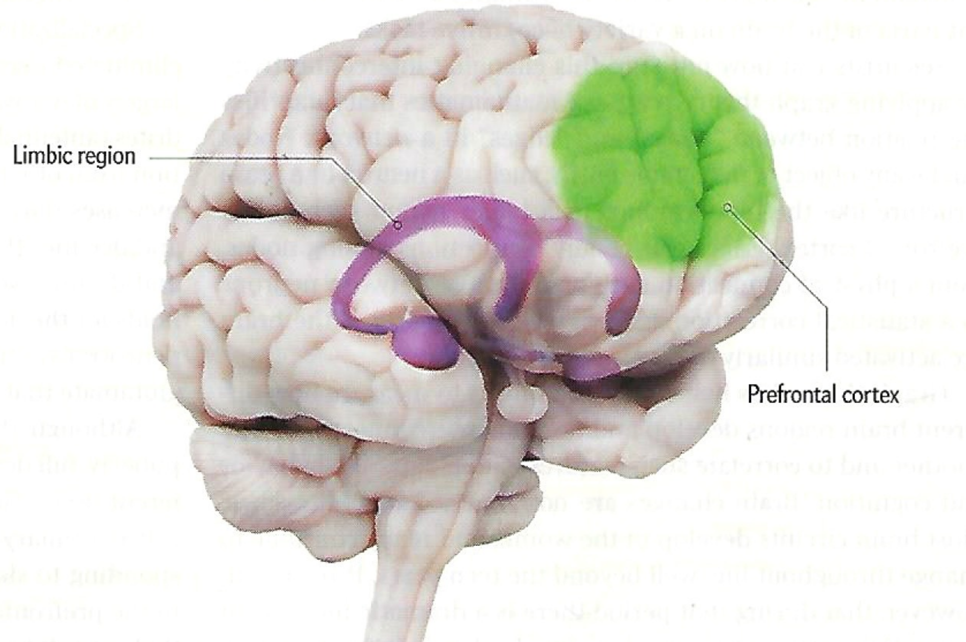
New declarative memories are formed and are dependent upon the hippocamus. (procedural memories are formed via amygdala, globus pallidus, cerebellum)

Each nuclei of the limbic system becomes associated with a different “type of emotional memory”.

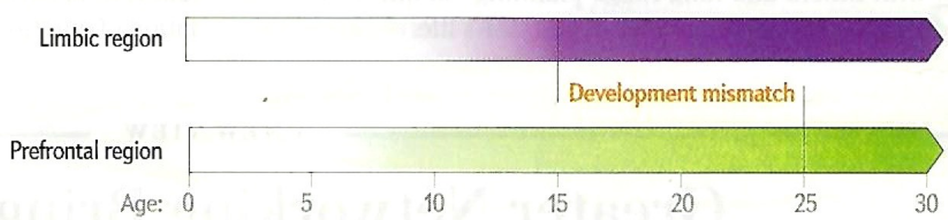
These memories of subconscious information then helps us to shape our judgments and behavior. The subconscious brain helps us guide our conscious brain.

Emotion vs. Control

Teenagers are more likely than children or adults to engage in risky behavior, in part because of a mismatch between two major brain regions. Development of the hormone-fueled limbic system (*purple*), which drives emotions, intensifies as puberty begins (typically between ages 10 to 12), and the system matures over the next several years. But the prefrontal cortex (*green*), which keeps a lid on impulsive actions, does not approach full development until a decade later, leaving an imbalance during the interim years. Puberty is starting earlier, too, boosting hormones when the prefrontal cortex is even less mature.



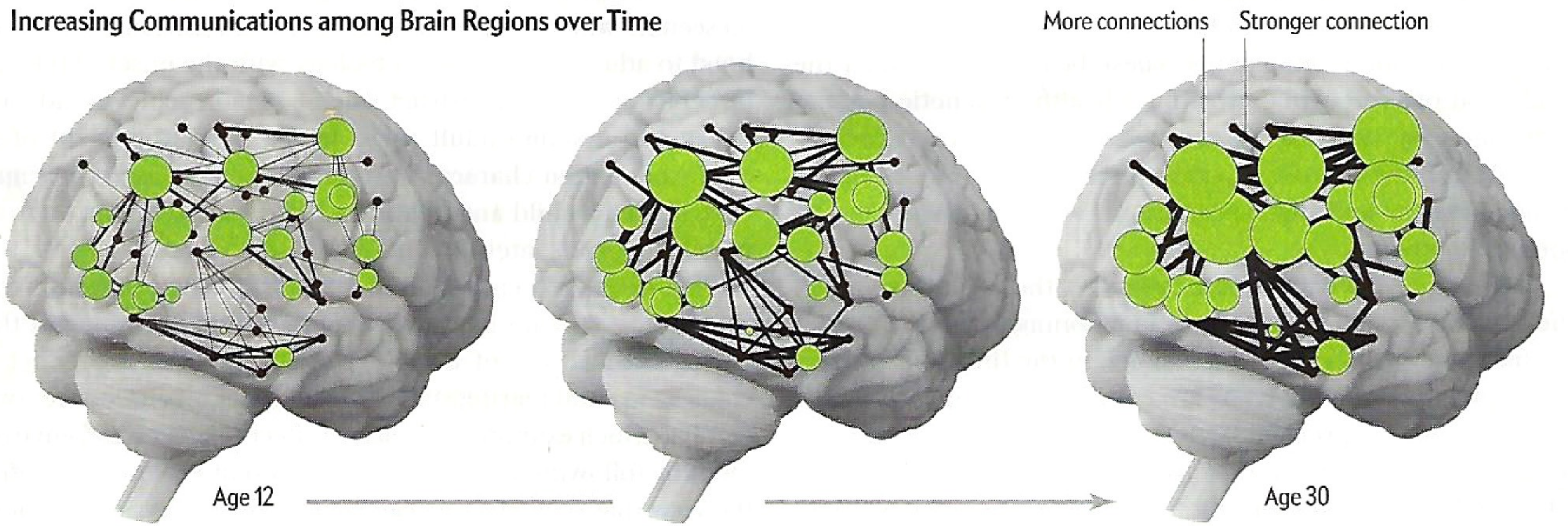
Degree of Maturation



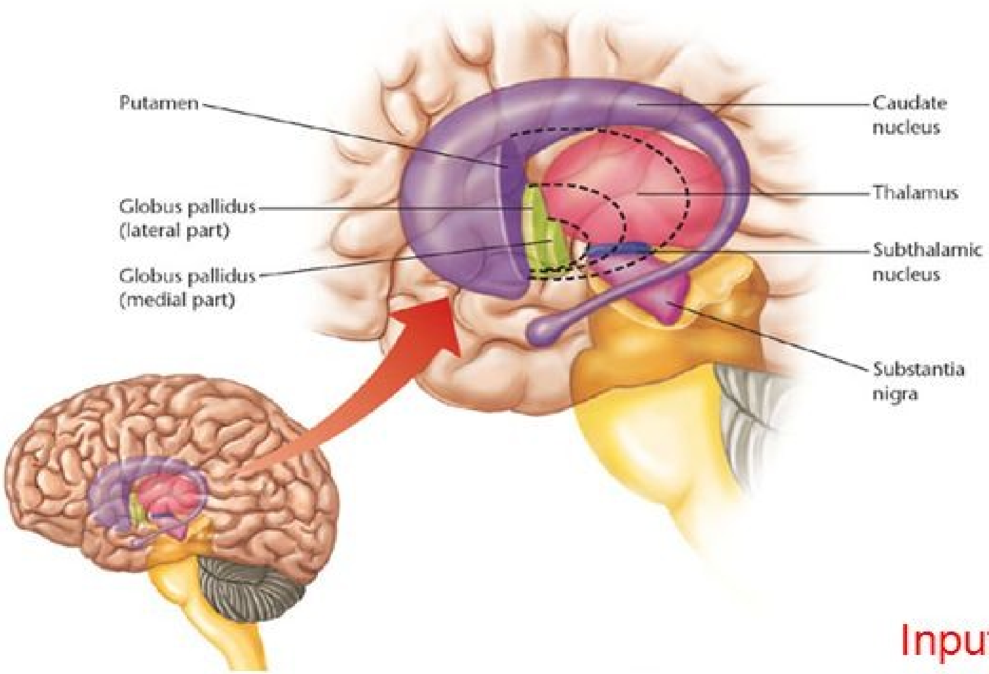
Greater Networking Brings Maturity

The most significant change taking place in an adolescent brain is not the growth of brain regions but the increase in communications among groups of neurons. When an analytical technique called graph theory is applied to data from MRI scans, it shows that from ages 12 to 30, connections between certain brain regions or neuron groups become stronger (*black lines that get thicker*). The analysis also shows that certain regions and groups become more widely connected (*green circles that get larger*). These changes ultimately help the brain to specialize in everything from complex thinking to being socially adept.

Increasing Communications among Brain Regions over Time



Basal Ganglia



Part of the motor system:
control of voluntary movement

- Caudate Nucleus
- Putamen
- Globus Pallidus

} Striatum

Input to caudate and putamen from

- Cerebral cortex
- Substantia Nigra (Dopamine)

Output through the globus pallidus to

- Thalamus to the motor cortex
- Brain stem

Basal ganglia is also able to remember and execute routine implicit memory that is independent from the prefrontal cortex.

This allows the cerebrum to work on one task while the basal ganglia executes another action.

Example: Have you ever experienced yourself "subconsciously" driving your car as your thoughts focus on another task? This is the basal ganglia taking control.

Basal Ganglia

- The basal ganglia are a group of subcortical nuclei positioned around the thalamus

- Before the motor strip can send an action potential down the upper motor neuron (UMN), the motor association cortex must first direct its commands through the basal ganglia. Think of the basal ganglia as a “skeletal muscle consultant” that prevents unwanted muscle contractions while coordinating and smoothing out wanted skeletal muscle contractions.

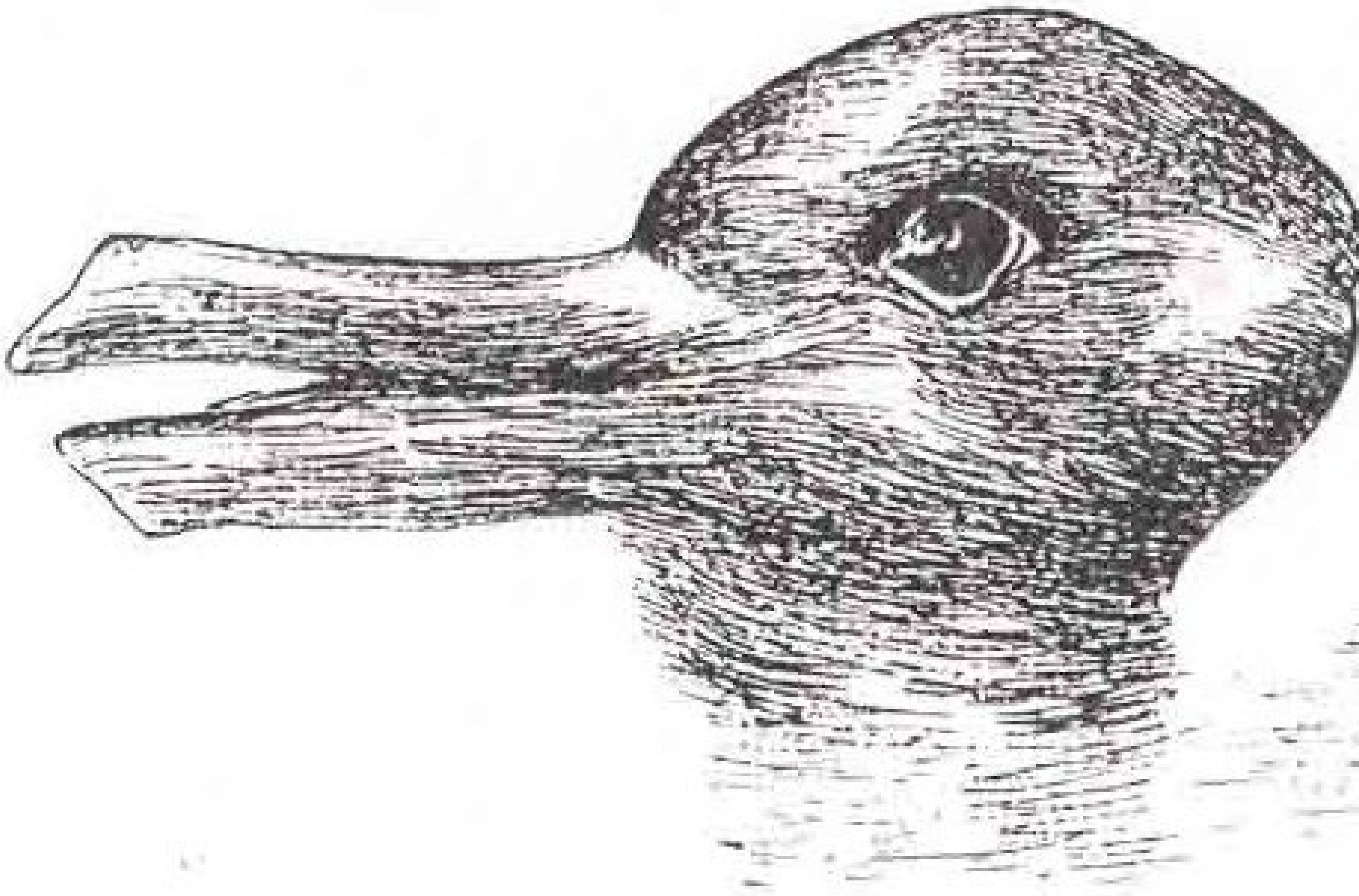
- BG is responsible for coordinating a voluntary skeletal muscle contraction (BG excitatory) while also preventing unwanted contraction (BG inhibitory). The BG also plays a role in visual perception and other functions. These are the direct (Go) and indirect (No Go) pathways.

- Think about the rhythmic muscle contraction and relaxation that occurs when you walk. You must initiate and stop contractions but you must also inhibit other skeletal muscle unwanted contractions

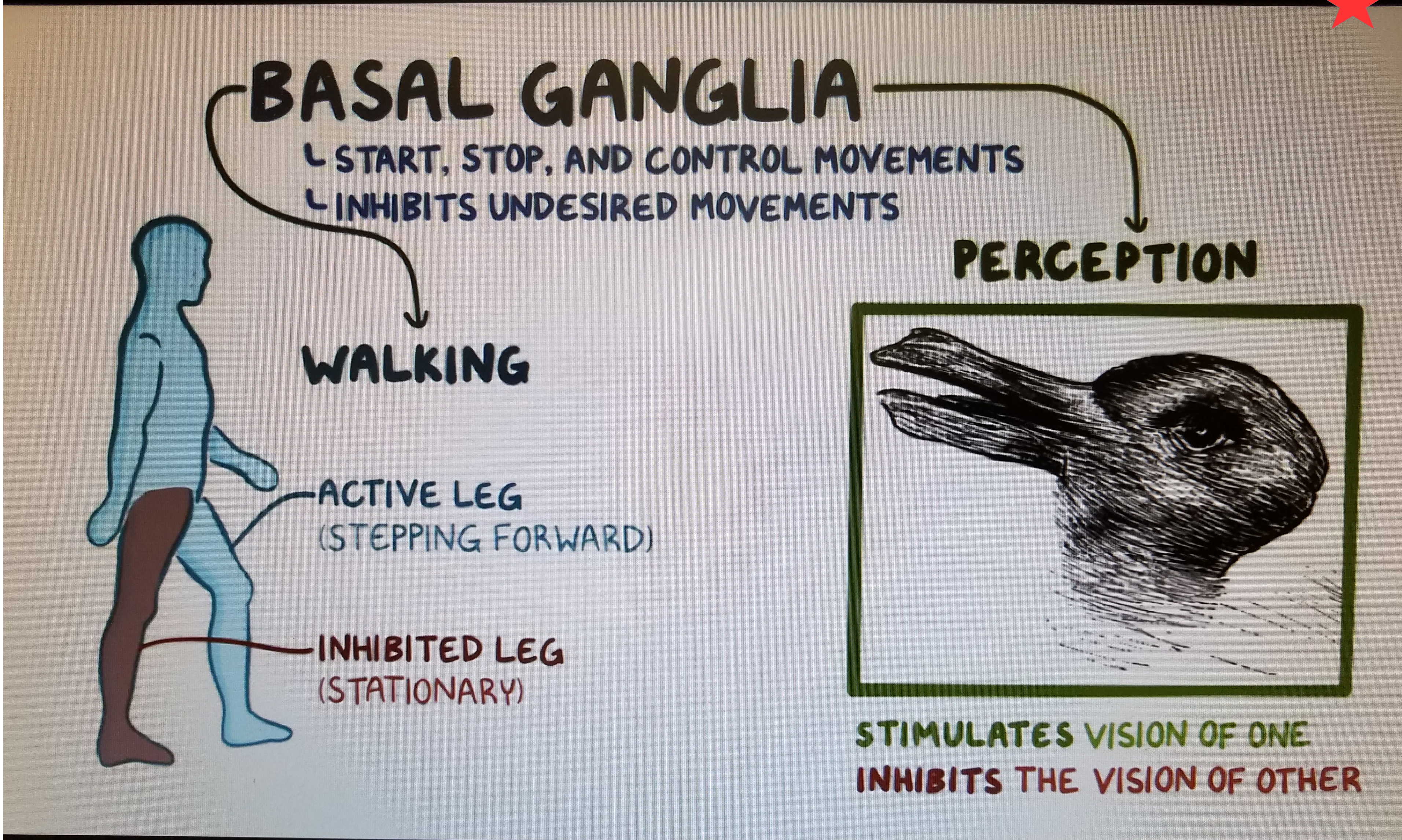
- *Motor association area sends AP into two nuclei of the basal ganglia called the striatum (cadate and putamen nuclei) // efferent AP either stimulatory or inhibitory sent to globus pallidus and eventually makes its way to the thalamus then onto the motor strip //   AP at motor strip may now move down UMN to the LMN and cause the skeletal muscle to contract.*

- Basal ganglia also play a roll in vision. Perception is limited by BG so we can only see one image at a time (see next slide)

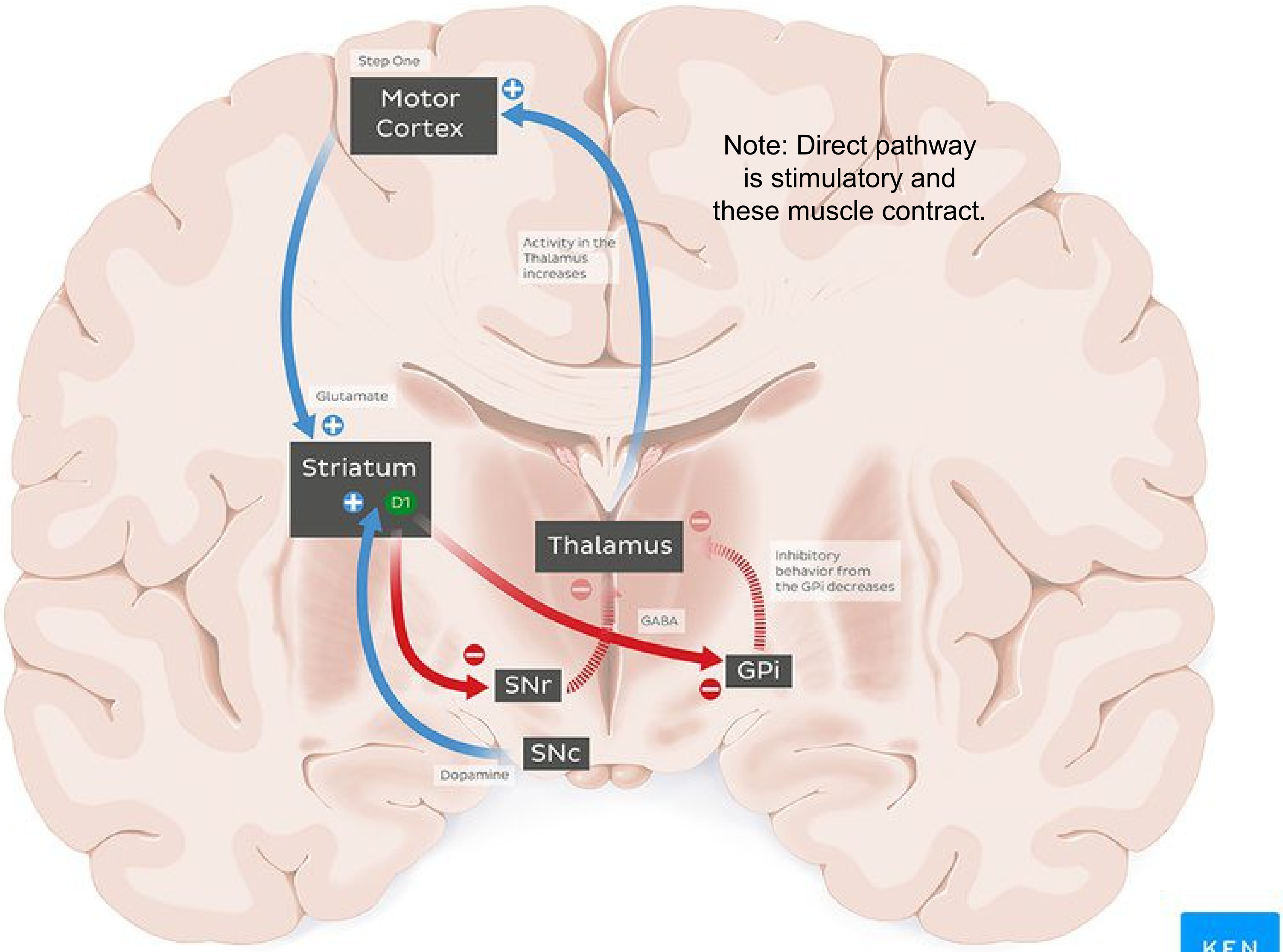
What do you see?



You can only see one image at a time. Why?

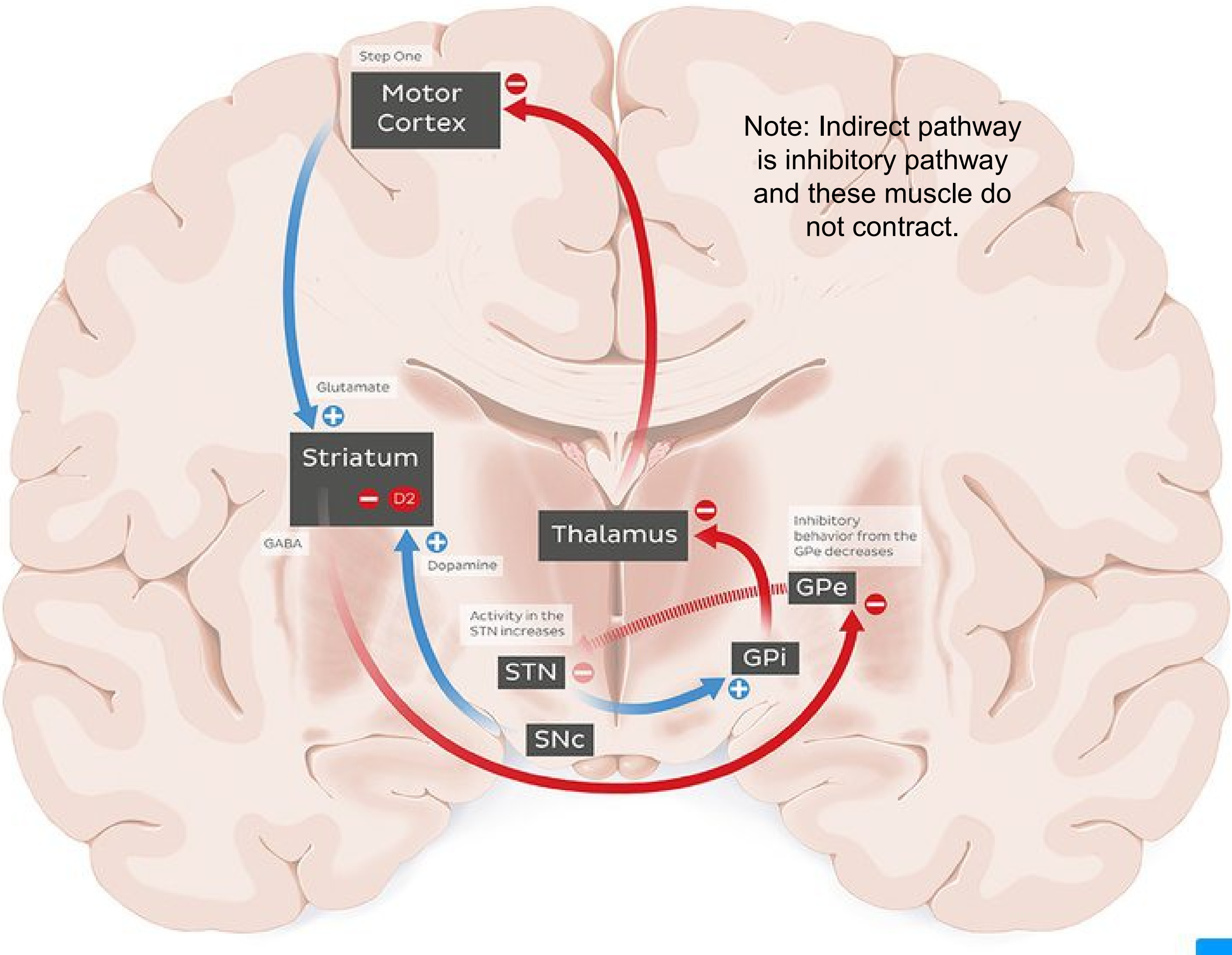

BASAL GANGLIA
START, STOP, AND CONTROL MOVEMENTS
INHIBITS UNDESIRED MOVEMENTS
WALKING
ACTIVE LEG
(STEPPING FORWARD)
INHIBITED LEG
(STATIONARY)
PERCEPTION
STIMULATES VISION OF ONE
INHIBITS THE VISION OF OTHER

Direct Pathway of the Basal Ganglia



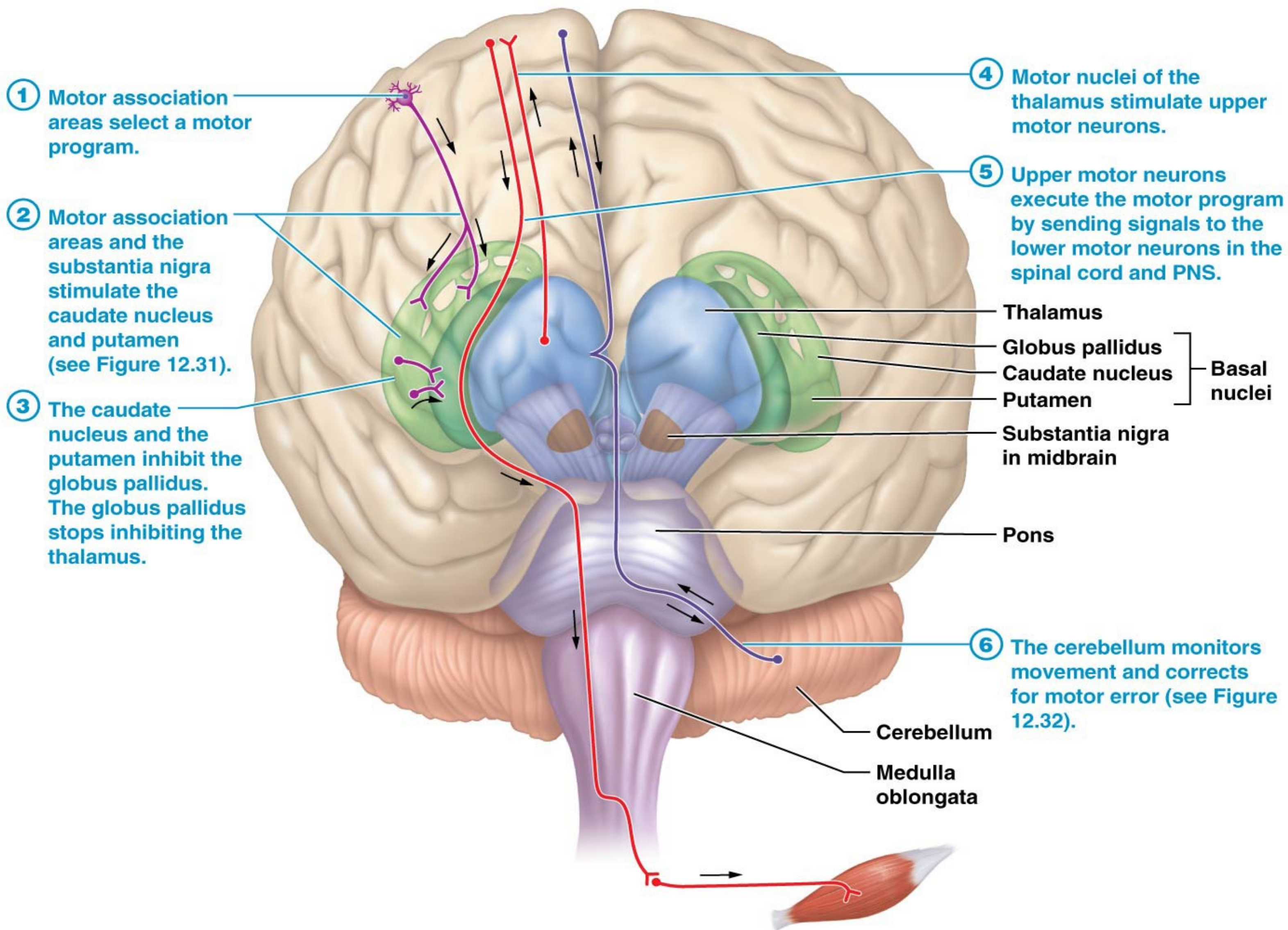
Note: Direct pathway is stimulatory and these muscle contract.

Indirect Pathway of the Basal Ganglia



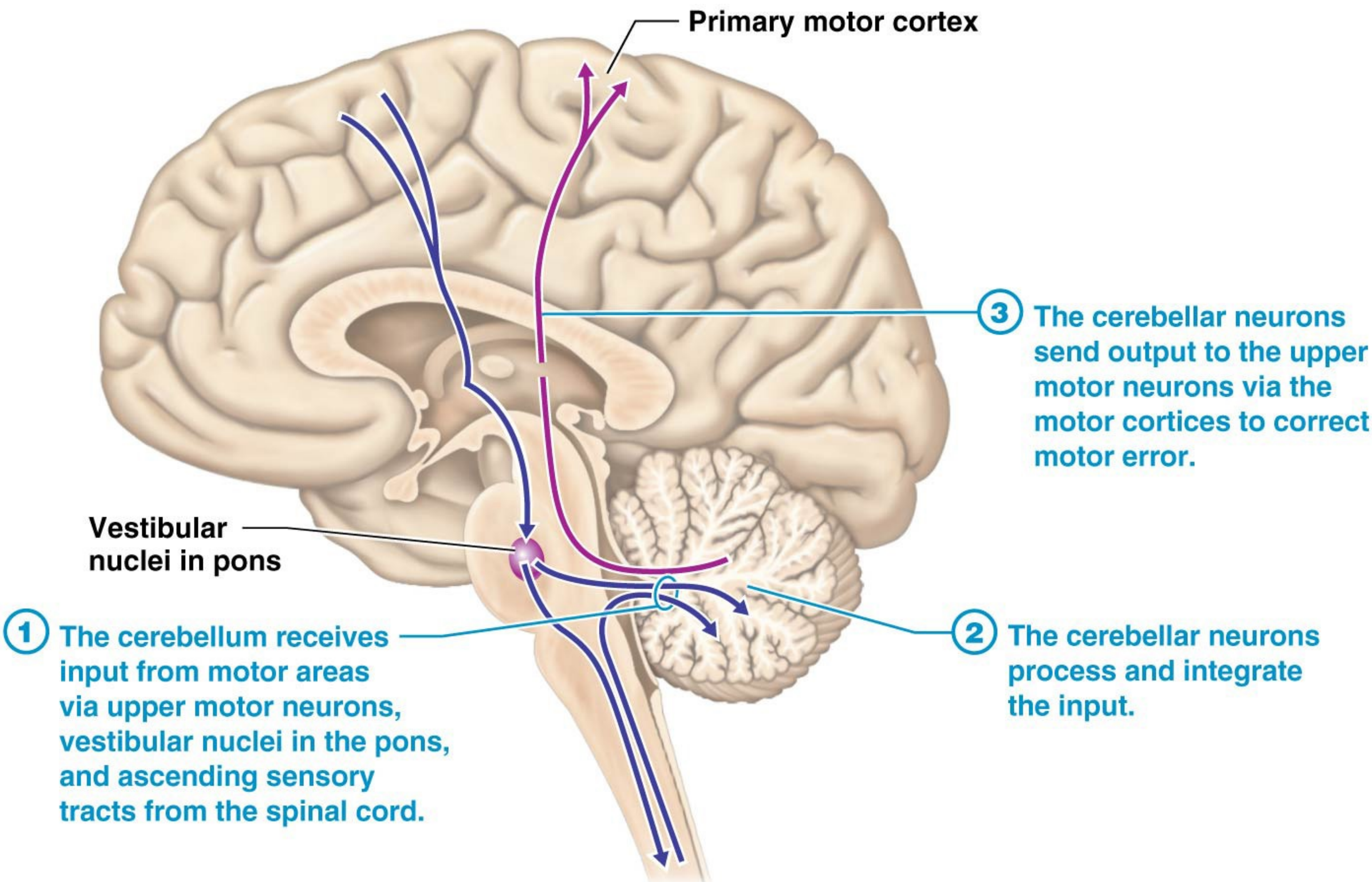
Note: Indirect pathway is inhibitory pathway and these muscle do not contract.

The Big Picture of CNS Control of Voluntary Movement.



Cerebellum function in voluntary movement.

The cerebellum compares the intent with performance.



The Cerebral Peduncles and Motor Control

The cerebral peduncles are nerve tracts that pass through the midbrain. These tracks carry action potentials between the brain, skeletal muscles, and the cerebellum.

These nerve tracks are used to coordinate skeletal muscle contractions and allow the cerebellum to compare the “intent” of a skeletal muscle contraction to the actual “performance” of the skeletal muscle contraction.

There are three peduncles that enter and exit the cerebellum at the level of the pons.

- Superior peduncle is branch of cortiocspinal tract that enters the cerebellum // tells cerebellum about the intent to contract skeletal muscle (#1)
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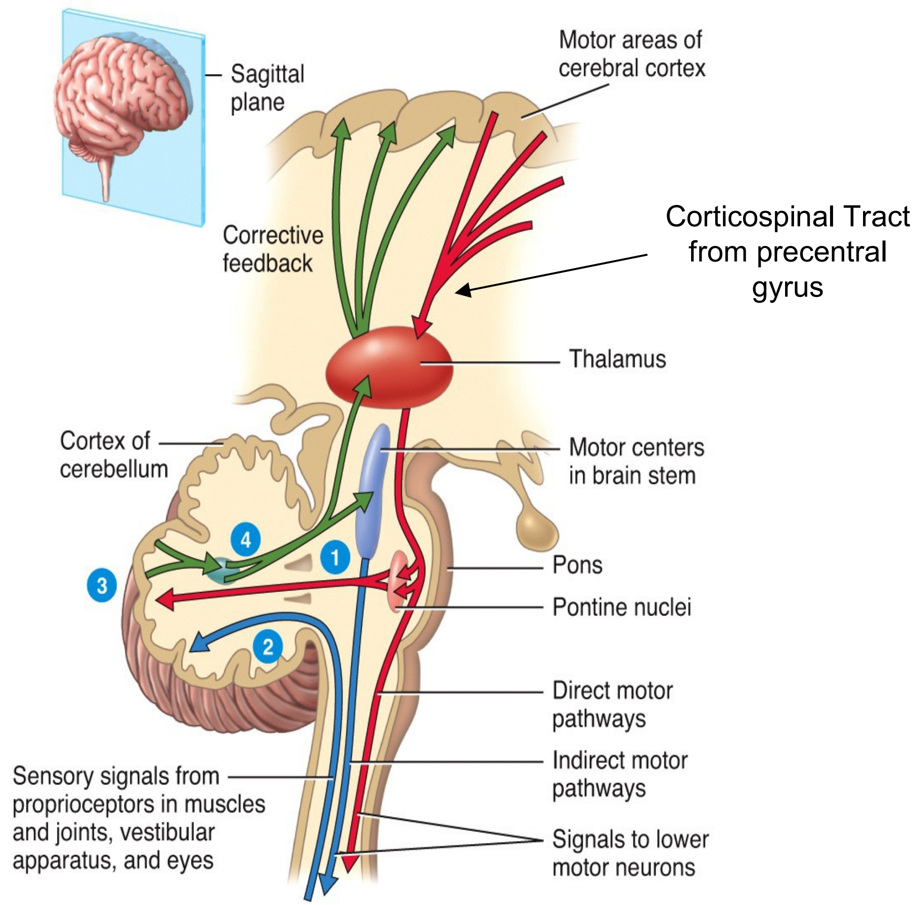
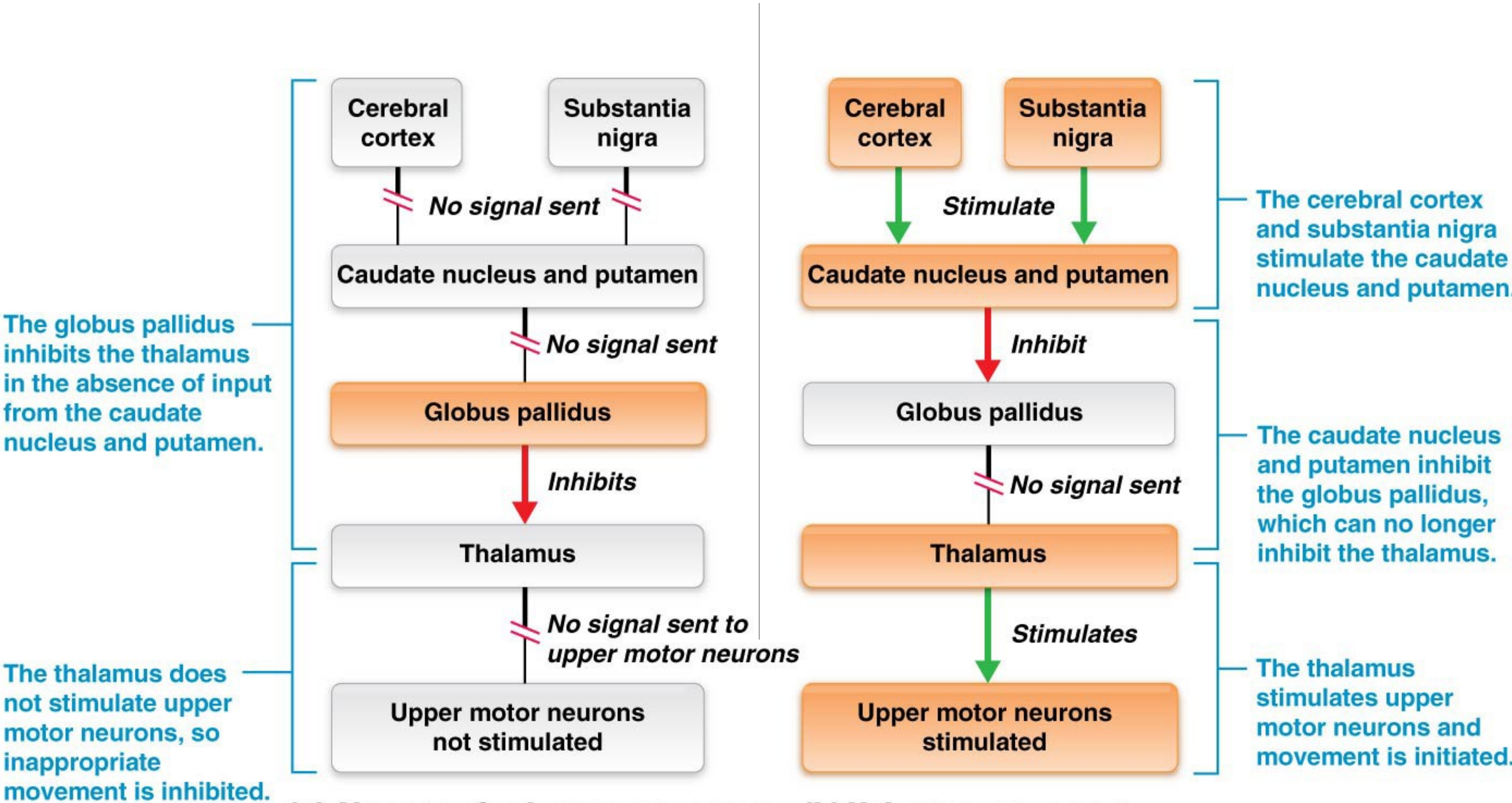


Sagittal section through brain and spinal cord

What is the difference between intent and performance?

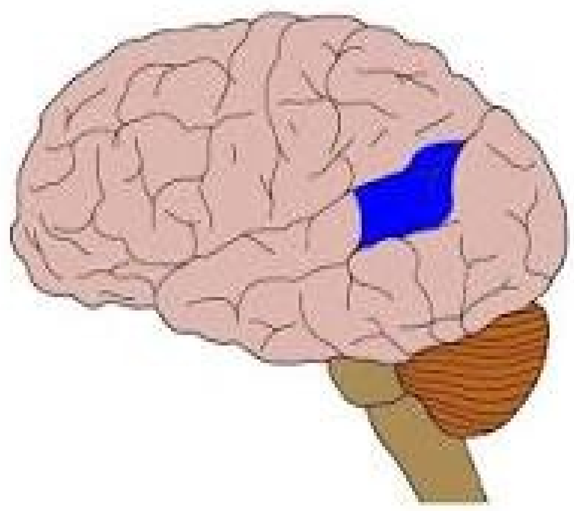
Role of the basal nuclei in voluntary movement.



(a) Absence of voluntary movement **(b) Voluntary movement**

Language

Language in early primates started as “hand gestures”.



The fox-pro-2 gene allowed the hyoid bone to be re-positioned lower in the pharynx which allowed homo sapiens (i.e. humans) to make consonants and vowels (i.e. monkeys can hoot and make sound but can not form consonants and vowels because their hyoid bone is placed higher in the pharynx)

Wernicke Areas is located in the posterior section of the superior temporal gyrus (STG) in the left cerebral hemisphere. This area encircles the auditory cortex on the lateral sulcus (the part of the brain where the temporal lobe and parietal lobe meet).

This is the receptive language center. /// other areas receive sound or symbolic stimulus and must decide if it is language. If it is language then the stimulus is passed to Wernicke Areas for interpretation

Note – language maybe written or spoken.

Language

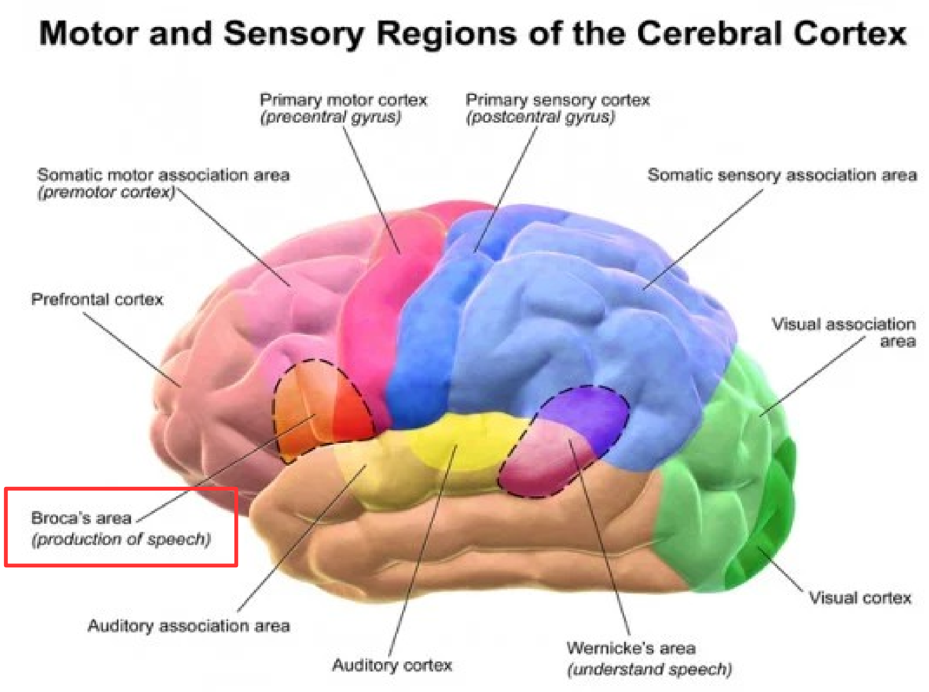
Brocca's Area is the expressive language center. It is where the grammar of our language is located

It is a region in the frontal lobe of the dominant hemisphere, on the left side of the brain with functional link to motor strip skeletal muscles used in speech production and respiratory centers.

Note the location of the primary motor cortex to Broca's Area.

What is the spacial relationship between Broca's Area and Wernicke's Area?

How do do the two areas communicate? (arcuate fasciculus)



Language

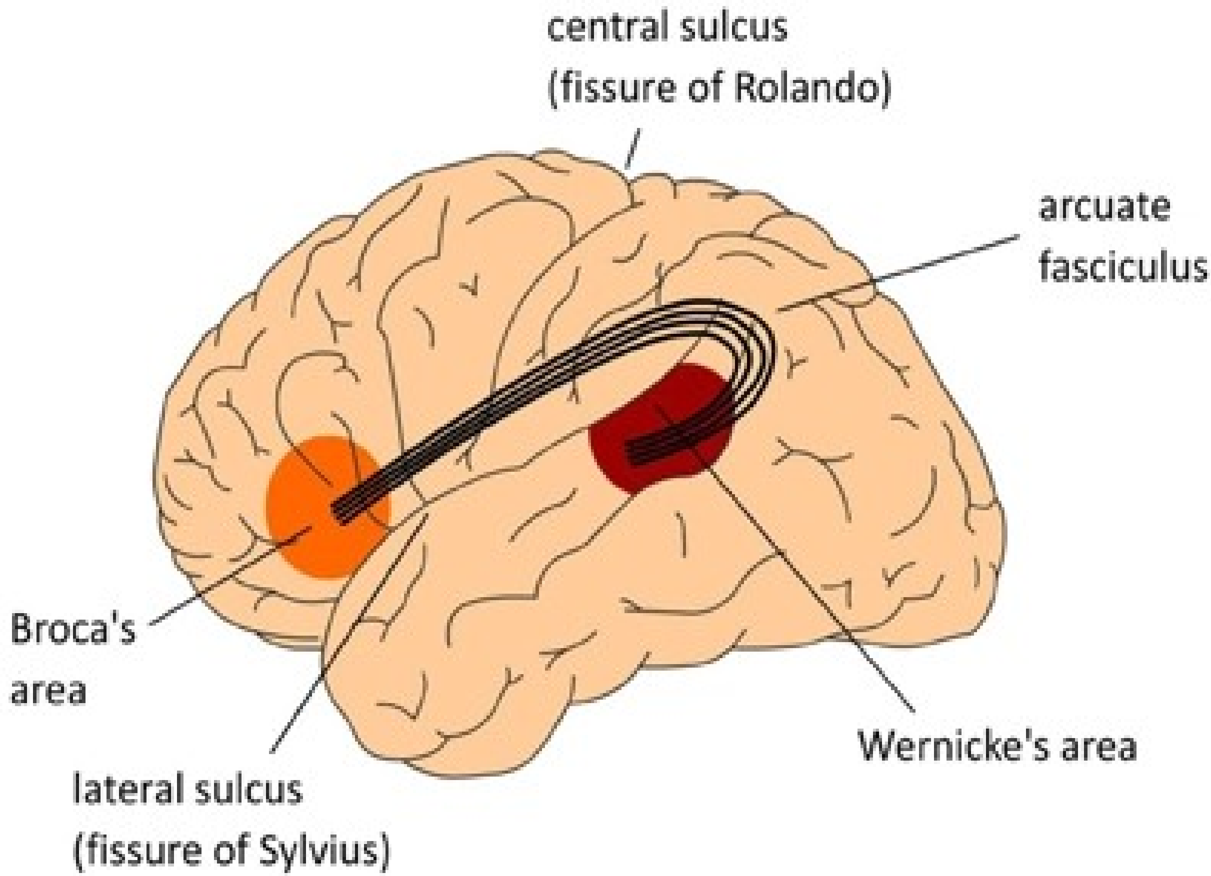
Eight-five million years ago, early primates first started to develop language as "hand gestures".

The fox-pro-2 gene allowed the hyoid bone to be positioned lower in the pharynx which allowed hominids and later homo sapiens (i.e. humans) to now make consonants and vowels (i.e. monkeys can hoot and make sound but can not form consonants and vowels because their hyoid bone is positioned higher in the pharynx)

Wernicke Areas – located in the caudal parietal lobe /// center for receptive language /// other areas of the brain receive sound stimulus and must decide if it is language (i.e. written or spoken) /// if it is language then action potentials are relaid to Wernicke Areas for interpretation

Brocca Areas – located in the lower temporal lobe near the motor strip /// this is the center for expressive language /// this is where word syntax and grammar is constructed // Brocca regulates contraction of skeletal muscles of "voice" and respiratory muscles. // note relative location of Brocca area to motor strip controlling skeletal muscles for respiration and vocalization.

Wernicke and Brocca Areas are connected by a nerve tract.


central sulcus
(fissure of Rolando)
arcuate
fasciculus
Broca's
area
lateral sulcus
(fissure of Sylvius)
Wernicke's area

What Are the Types of Aphasia?

Aphasia results from damage to the parts of the brain responsible for language and communication.

Expressive Aphasia

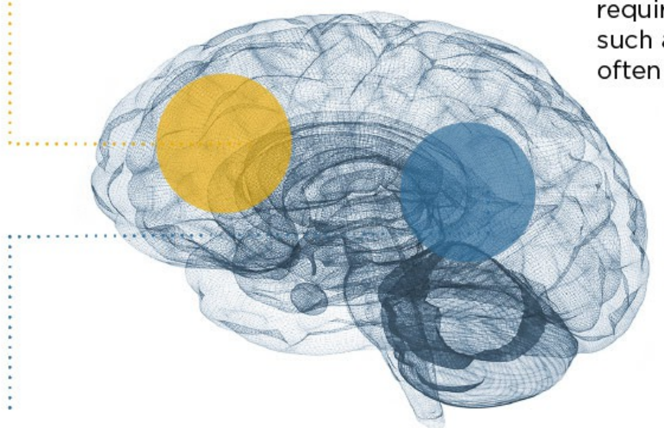
Sometimes called

Broca's or non-fluent aphasia

Region affected:

frontal lobe, which also controls motor movement

People with expressive aphasia might know what they want to say but even using single words requires great effort. Small words such as "the," "is," or "and" are often omitted.



Receptive Aphasia

Sometimes called

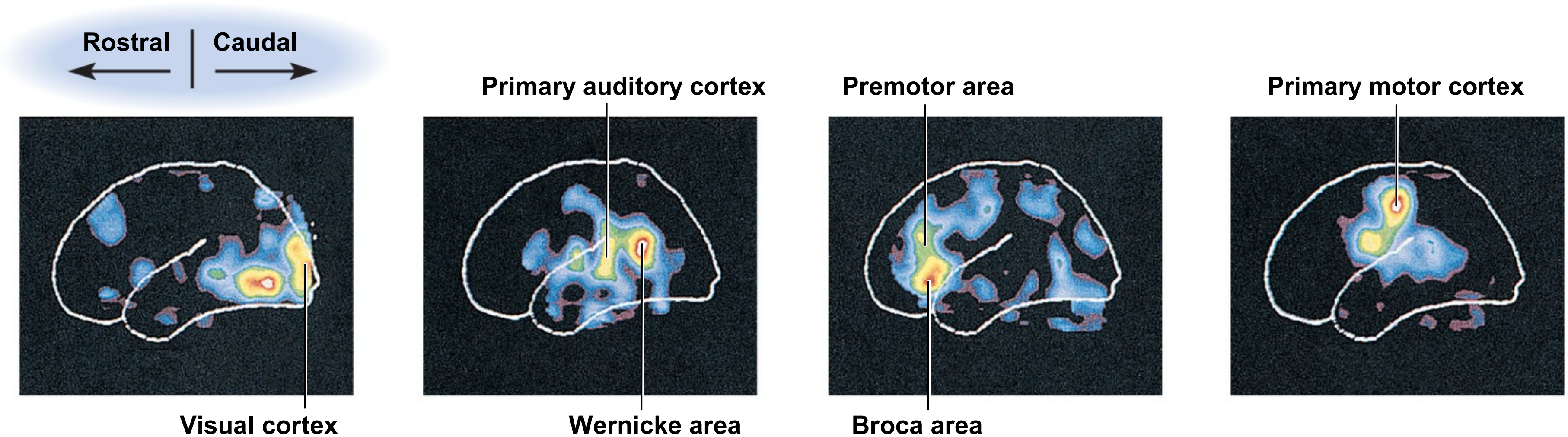
Wernicke's or fluent aphasia

Region affected:

temporal lobes, which also store memories and help with hearing, visual recognition and language

People with receptive aphasia might struggle to speak in coherent sentences. It may be a challenge to understand what they are trying to say and they are often unaware of their spoken mistakes.

PET Scans and Language Task



1. The word car is seen in the visual cortex.
2. Wernicke area conceives of the verb drive to go with it.
3. Broca area compiles a motor program to speak the word drive.
4. The primary motor cortex executes the program and the word is spoken.

This shows how brain processes information from one area onto another area.

Is the claustrum the site of consciousness?

The claustrum is located between the insula and caudate/putamen. This area has the highest density of bidirectional fiber tracts in the brain.

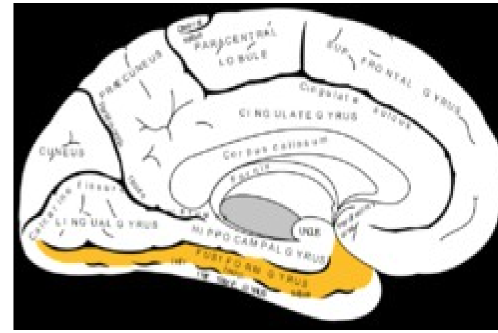
The claustrum receives major inputs from limbic, cortical, and subcortical structures and sends outputs to the entire cortical mantle, most notably regions of the frontal cortex that drive executive functions.

This network connectivity profile positions the claustrum as a limbic–sensory-motor interface, which suggests that a primary function of the claustrum is to *integrate limbic and sensory information to direct and sustain attention towards behaviorally relevant, salient stimuli during the awake state.*

What is the function of the salience network of the brain? The salience network is a collection of regions of the brain that select which stimuli are deserving of our attention. The network has key nodes in the insular cortex and is critical for detecting behaviorally relevant stimuli and for coordinating the brain's neural resources in response to these stimuli.

Fusiform Face Area

The fusiform face area (FFA, meaning spindle-shaped face area) is a part of the human visual system (while also activated in people blind from birth) that is specialized for facial recognition.



The fusiform gyrus, also known as the lateral occipitotemporal gyrus,[1][2] is part of the temporal lobe and occipital lobe in Brodmann area 37.[3] The fusiform gyrus is located between the lingual gyrus and parahippocampal gyrus above, and the inferior temporal gyrus below.[4] Though the functionality of the fusiform gyrus is not fully understood, it has been linked with various neural pathways related to recognition. Additionally, it has been linked to various neurological phenomena such as synesthesia, dyslexia, and prosopagnosia.

What can result from damage to the fusiform face area? Some evidence suggests that fusiform gyrus damage tends to bring about difficulties in face perception and recognition, whereas damage to other areas of the temporal lobes is associated with difficulties accessing memories of faces.