Fundamentals of the Nervous System

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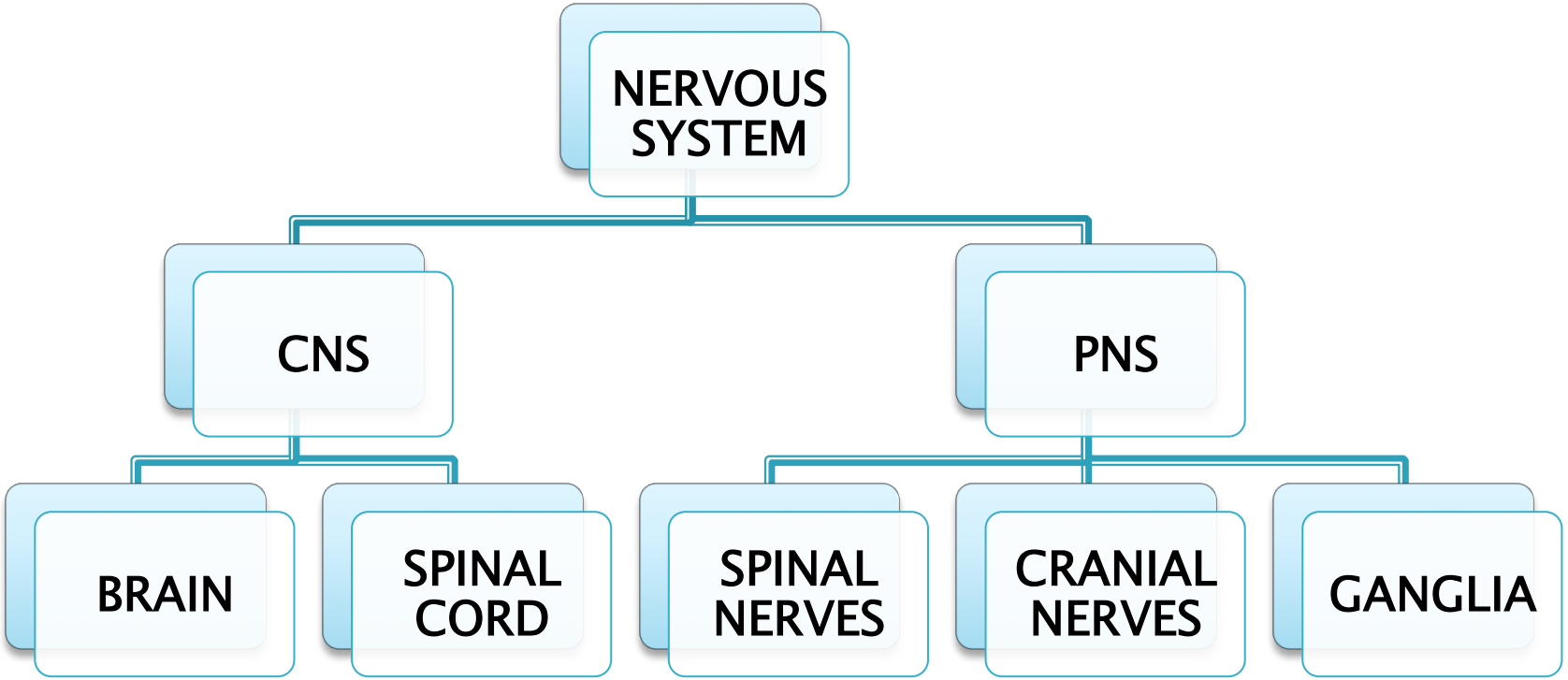
NETS AIIMS
JULY 2012

DIVISIONS OF THE NERVOUS SYSTEM



TERMINOLOGY –

Input: sensory = ***sensory input***
- Receptors monitor changes
- Changes called “stimuli”
- Information sent by “**afferent**” nerves

Integration
- Info processed
- Decision made about what should be done

Output: motor = ***motor output***
- Effector organs (muscles or glands) activated
- Effected by “**efferent**” nerves

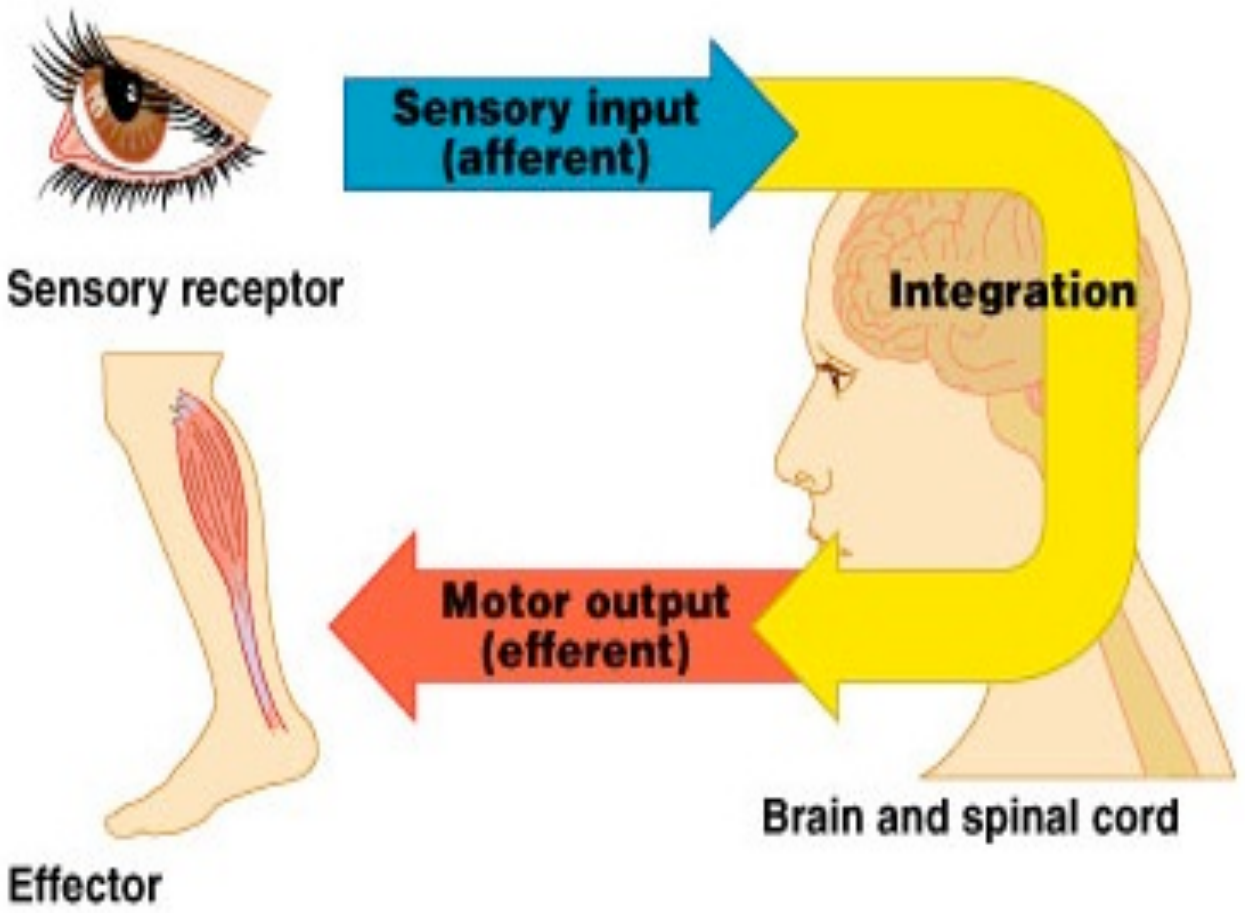
Terminology (contd..)

Neuron = nerve cell
Neuroglia = supporting cell
Nerve fiber = long axon
Nerve = collection of nerve fibers (axons) in ***PNS***
Tract = collections of nerve fibers (axons) in ***CNS***
Nucleus = cluster of cell bodies in CNS
Ganglia = cluster of cell bodies in PNS

Unilateral: on ***one*** side *Bilateral: both sides*
Ipsilateral: on the ***same*** side
Contralateral: on the ***opposite*** side

CNS vs PNS
Input: sensory: afferent: to brain
Output: motor : efferent: from brain

Anterior: towards the front ***Medial: towards midline***
Posterior: towards the back ***Lateral: away from midline***


Sensory input
(afferent)
Sensory receptor
Integration
Motor output
(efferent)
Brain and spinal cord
Effector

Nervous tissue: 2 types of cells

1. ***Neurons***
   - Excitable nerve cells
   - Transmit electrical signals

2. Supporting cells: ***neuroglia*** or just ***glia***
   - Means “nerve glue”

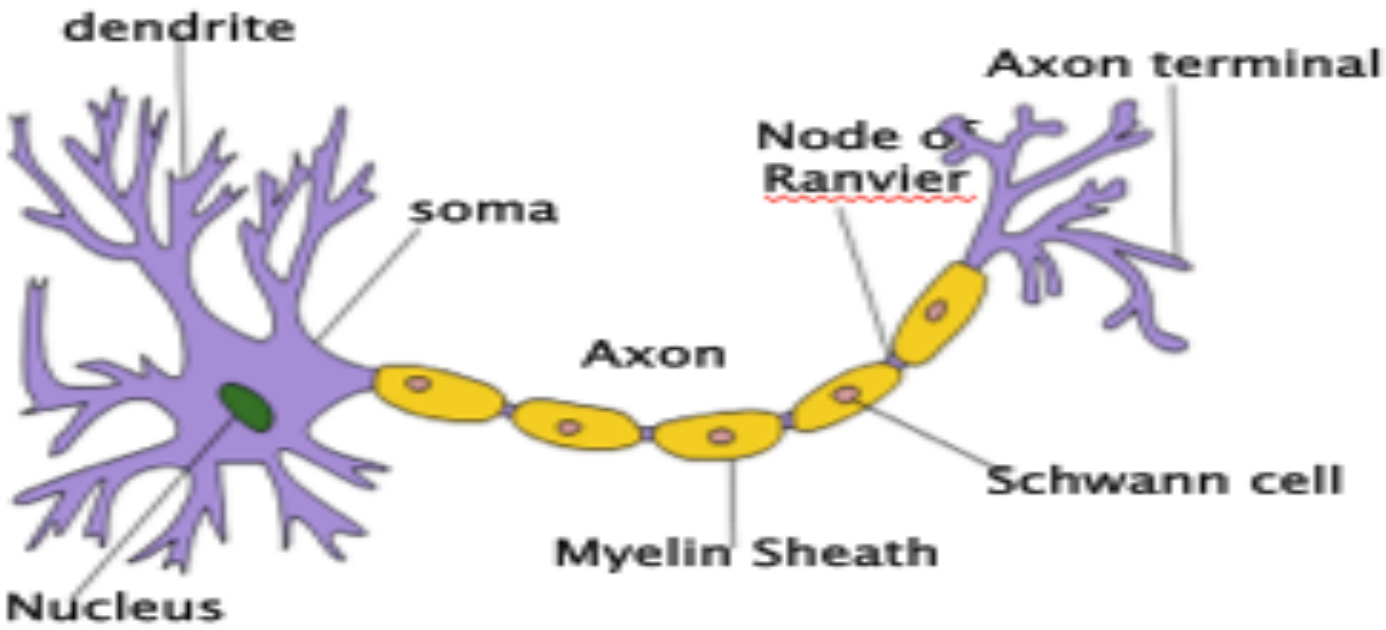
Neurons

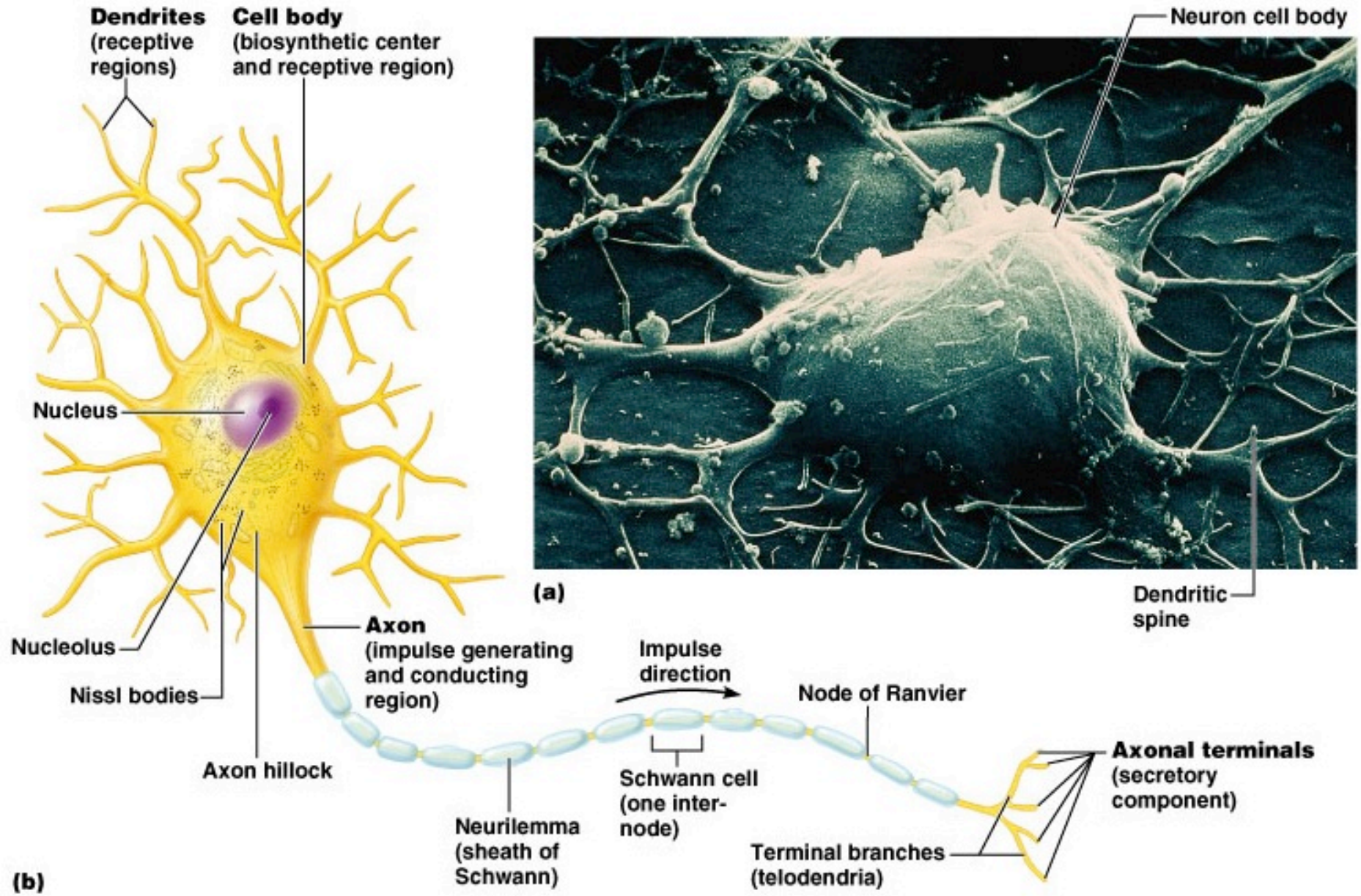
- Functional unit of nervous system
- Can live for a lifetime
- Do not divide
  - (exception: neural stem cells)
  - Cannot replace themselves
- High metabolic rate
  - Require continuous oxygen and glucose
  - Die within a few minutes without oxygen
- Processes and transmits information by electrical(ion channels & ion pumps) and chemical signaling (Synapse)

Parts of Neuron:

- Cell Body(soma)- usually compact
- Dendrites
- Axons

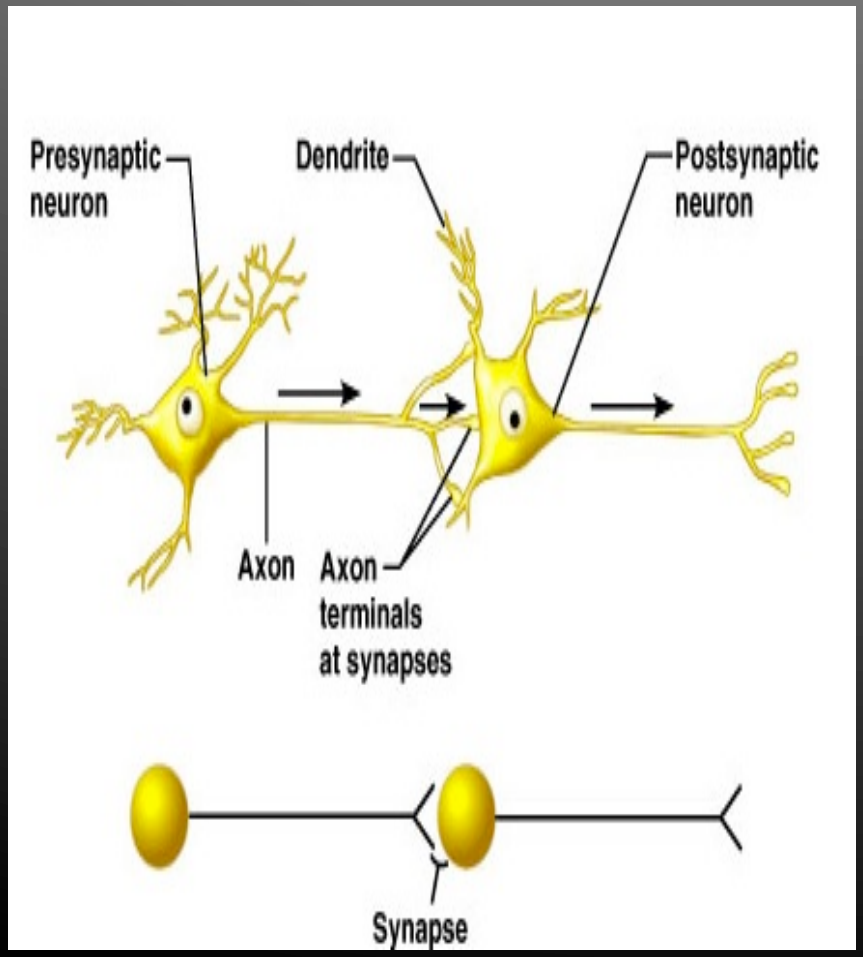
Extrude from soma



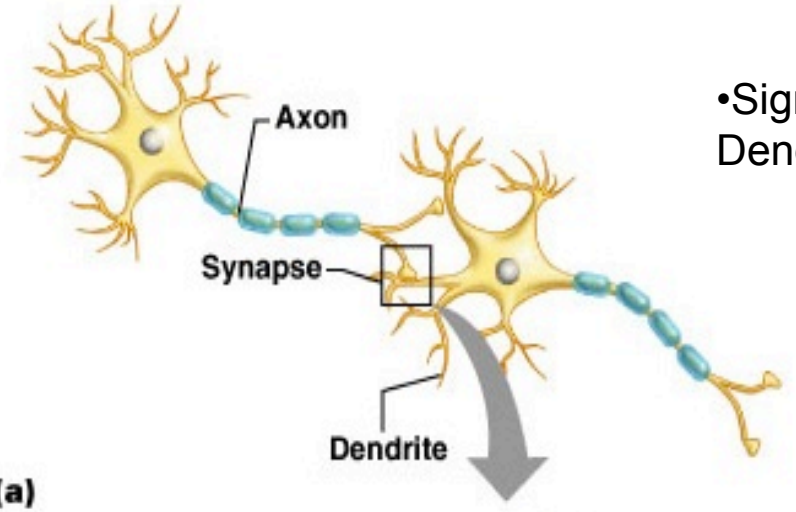

Dendrites
(receptive
regions)
Cell body
(biosynthetic center
and receptive region)
Nucleus
Nucleolus
Nissl bodies
Axon hillock
Axon
(impulse generating
and conducting
region)
Impulse
direction
Node of Ranvier
Schwann cell
(one inter-
node)
Neurilemma
(sheath of
Schwann)
Terminal branches
(telodendria)
Axonal terminals
(secretory
component)
(b)
Neuron cell body
Dendritic
spine
(a)

Neuron "processes"

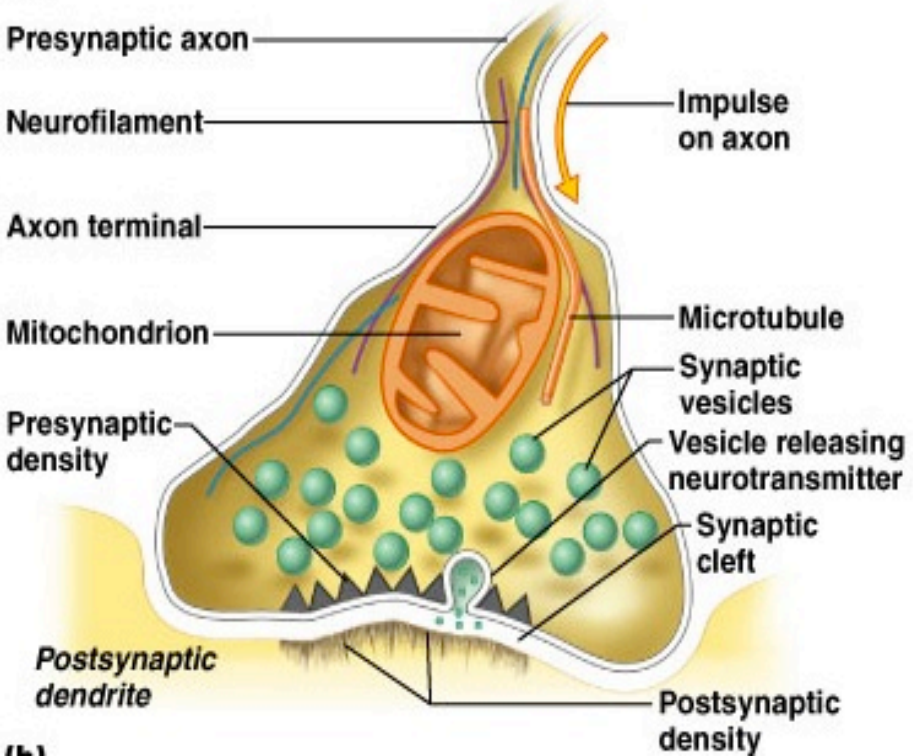
- Nerve fibers = ***Axons***
  - Arise from cell body at a site called "Axon Hillock"
  - Nerve impulse generators & transmitters
  - One per neuron, although can branch into "collaterals"
  - May branch hundreds of times before it terminates
  - At terminal end branch *a lot*
  - *can extend upto 1m in humans*
- Receptive regions =***dendrites***
  - Have receptors for neurotransmitters (chemicals released by other neurons)
  - Neurons may have many
  - Can extend for hundreds of micrometers
  - Branch multiple times (get thinner at each branching)

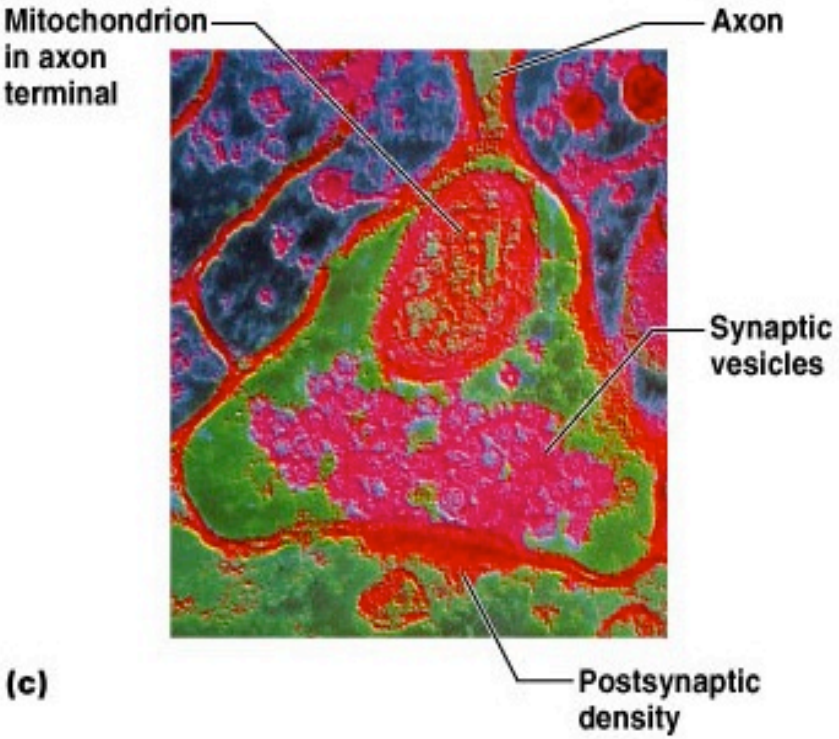


Synapse-*specialized connections with other cells*



•Signals are sent from the Axon of one neuron to a Dendrite of another(generally)



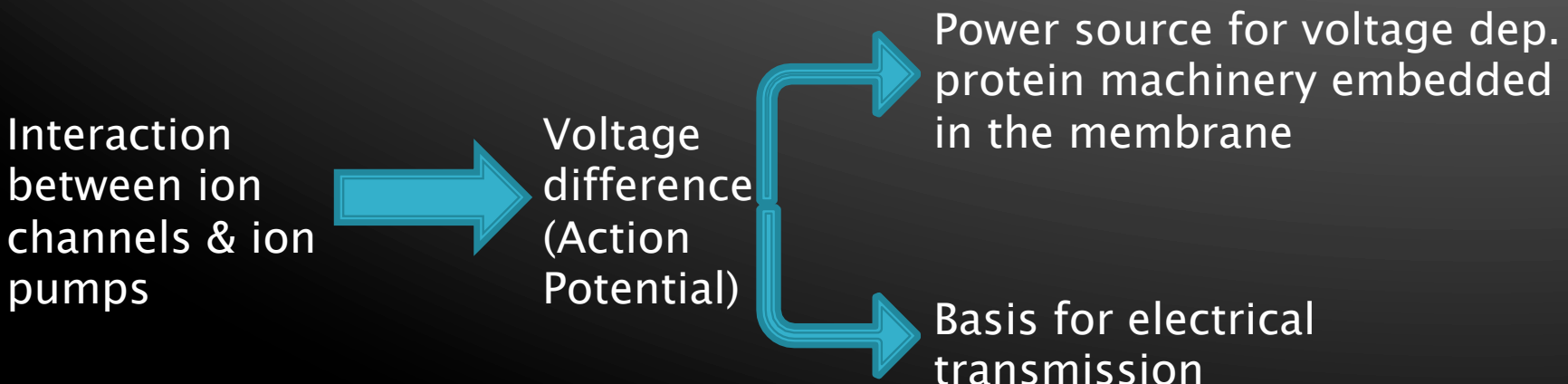


SYNAPTIC SIGNALING

ELECTRICAL ASPECT

- Depends on properties of the neuron's membrane
- Includes

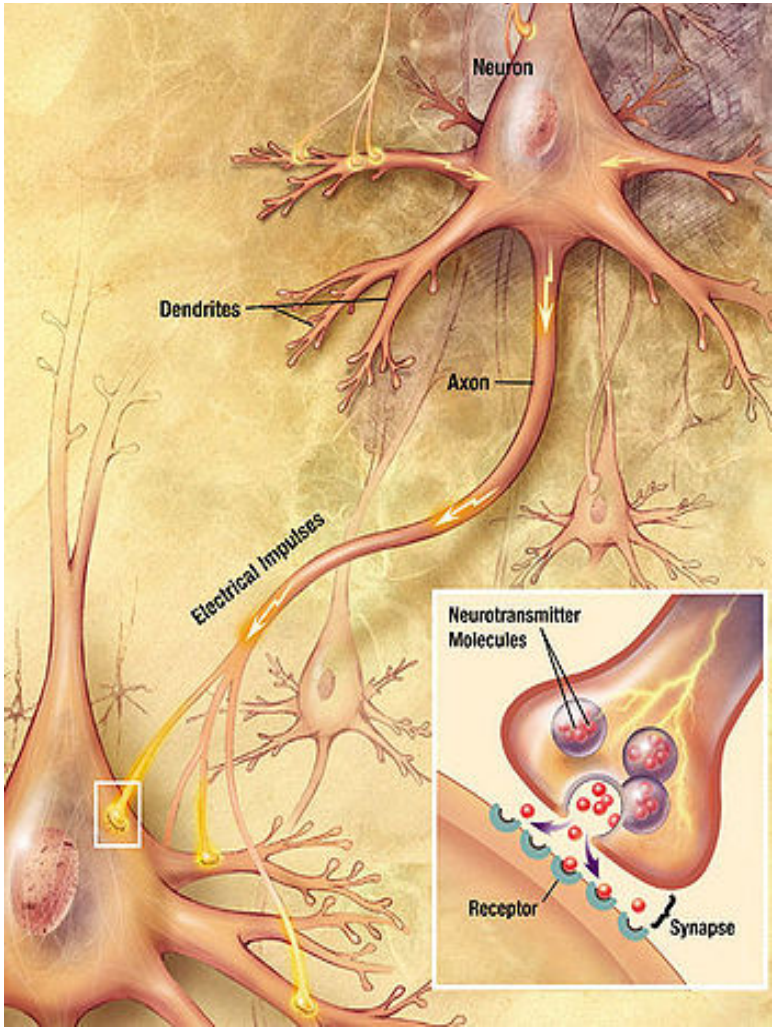
1. ion channels- permit electrical charge ions to flow across the membrane
   - Can be voltage gated or chemically gated
2. ion pumps-actively transport ions from one side of membrane to the other



Contd.

CHEMICAL ASPECT

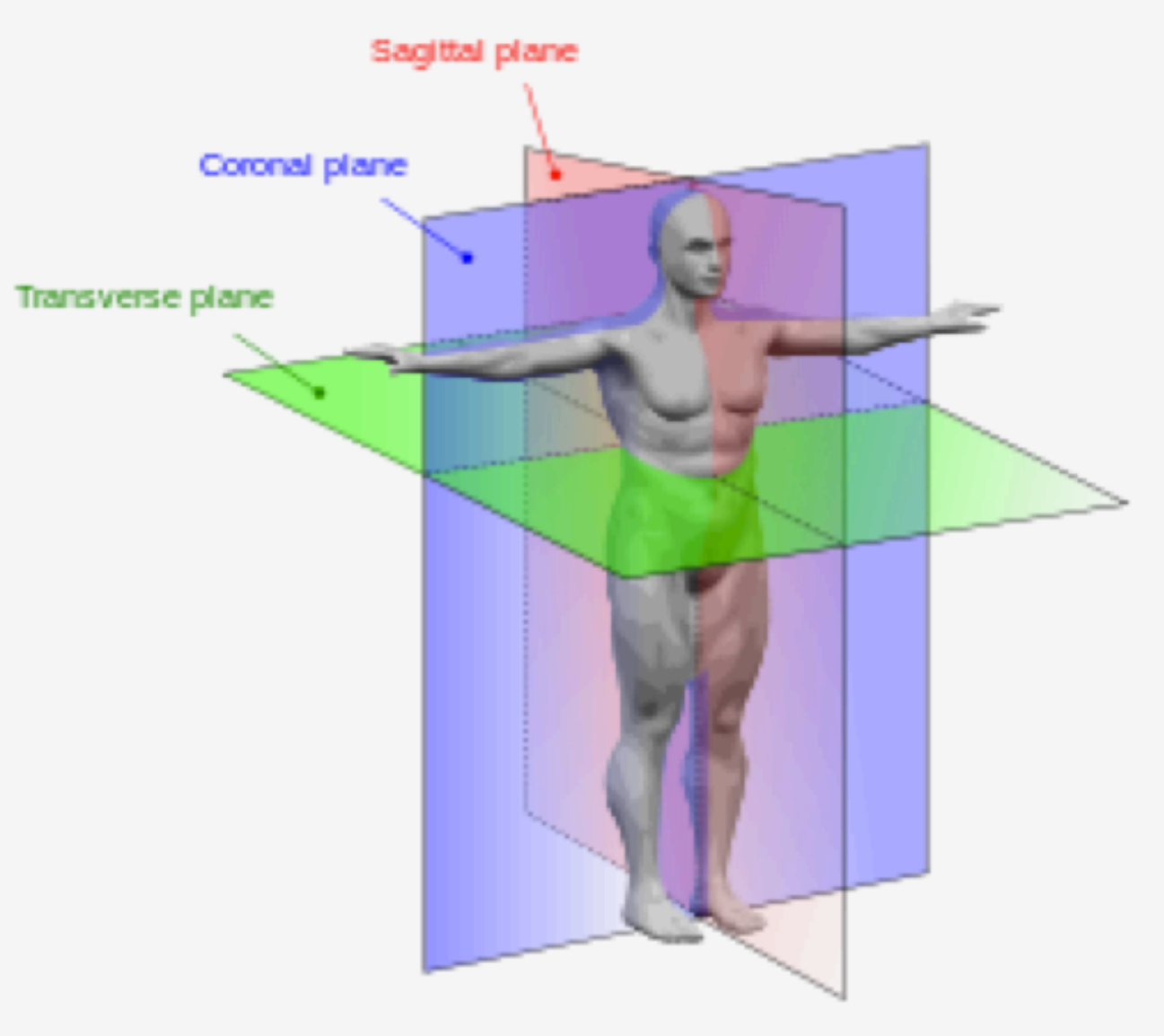
A propagating electrical signal traverse down the Axon to the Axon Terminals where neurotransmitter chemicals are released to communicate with target neurons



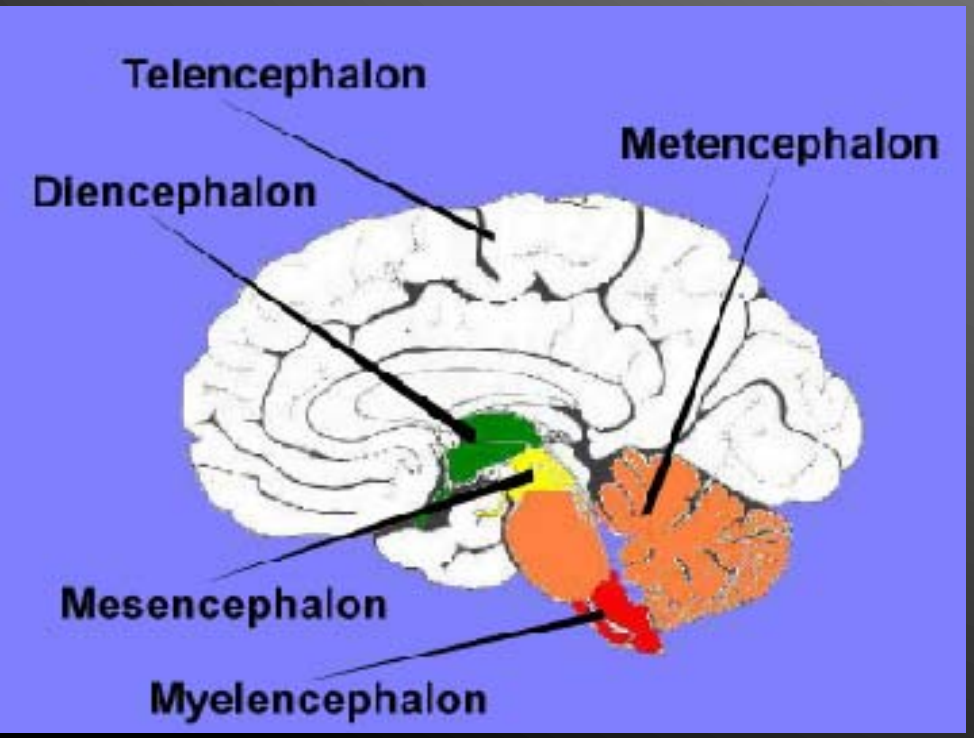
Supporting cells = neuroglia (“nerve glue”) or glial cells

- CNS
  - **Astrocytes**- Biochemical support of endothelial cells that form the blood brain barrier
    - Nutrients to nervous tissue
    - Maintenance of Extracellular ion balance
    - Repair & scarring process of brain & spinal cord following traumatic injuries
  - **Oligodendrocytes-** support and insulate Axons by creating a Myelin Sheath
  - **Microglia**- Macrophages
    - Acts as main form of Active Immune Defense in the CNS
  - **Ependymal cells-** thin epithelial membrane lining the ventricular system of brain & spinal cord
    - Involved in the production of CSF
- PNS
  - **Schwann cells**
  - **Satellite cells**

Different Planes



FIVE MAIN DIVISIONS OF THE BRAIN



Telencephalon – Cerebrum – Largest division – divided into two Hemispheres – Includes Four lobes viz Frontal, Parietal, Temporal & Occipital Lobes

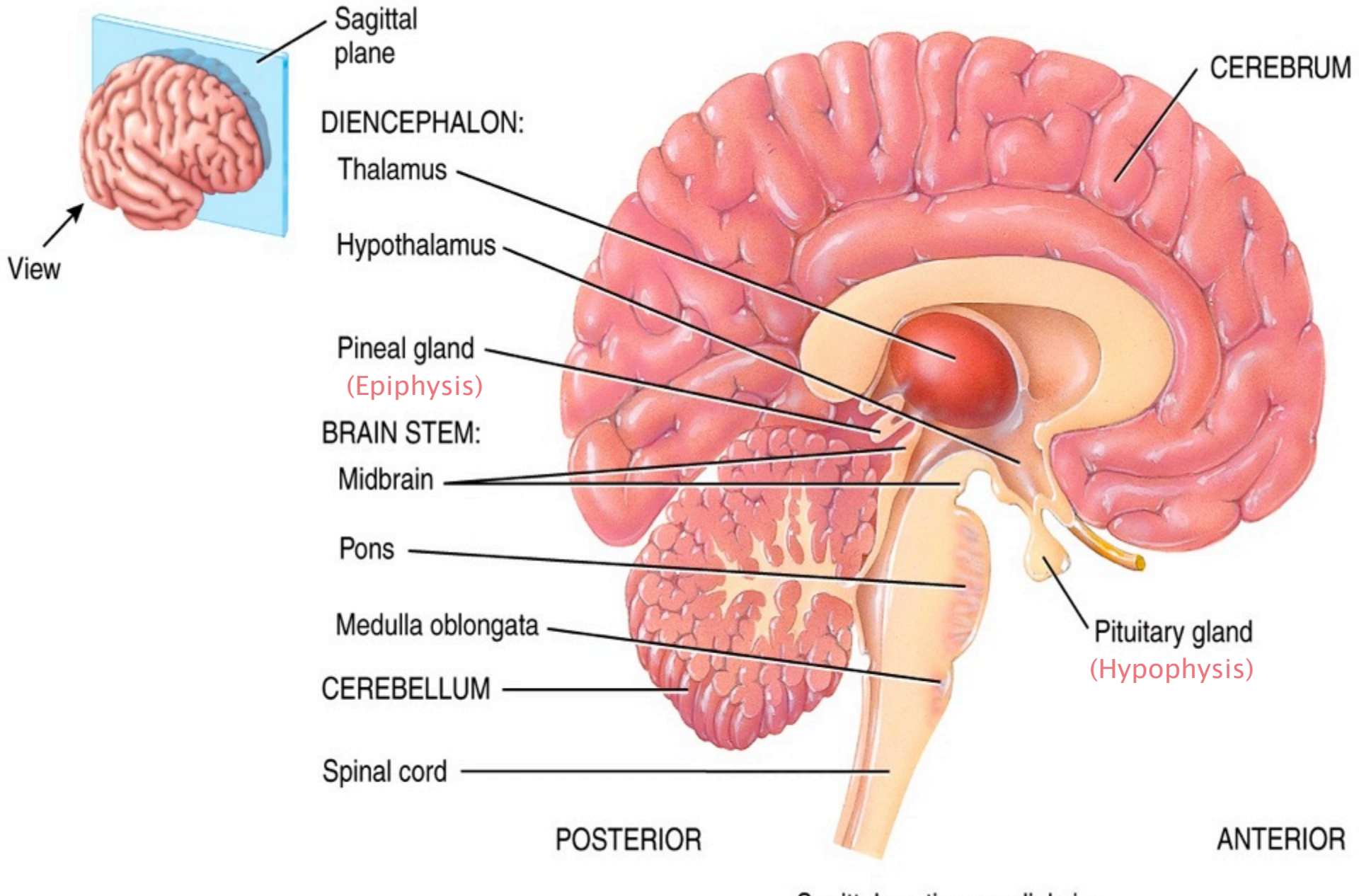
Diencephalon – Part of Forebrain – Includes Thalamus, Hypothalamus & Pineal Gland

Mesencephalon– Midbrain

Metencephalon – Part of Hind brain – Includes Pons & Cerebellum

Myelencephalon – Part of Hindbrain– Includes Medulla Oblongata

The Main Parts of the CNS



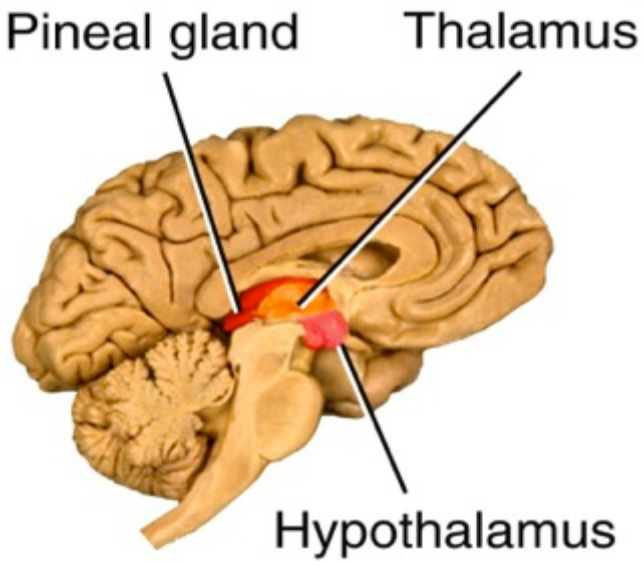
Sagittal section, medial view

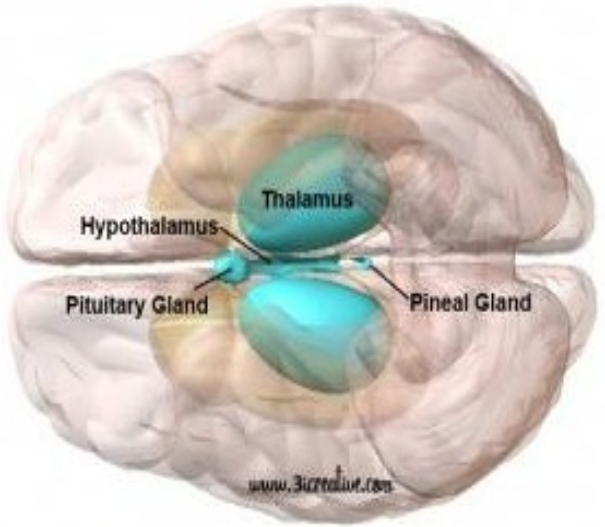
DIENCEPHELON

THALAMUS–Midline paired symmetrical structure
•Largest part of Diencephalon & surrounds the Third Ventricle
•Situated between the cerebral cortex & midbrain
•Relays sensory & motor signals to the cerebral cortex
•Regulates consciousness, sleep & alertness

HYPOTHALAMUS– Links the Nervous System to the Endocrine System via the Pituatory Gland
• synthesizes & secretes certain neuro hormones which stimulate or inhibit the secretion of Pituatory Hormones
•Controls body temperature, hunger, thirst, fatigue, sleep & cicadian cycles

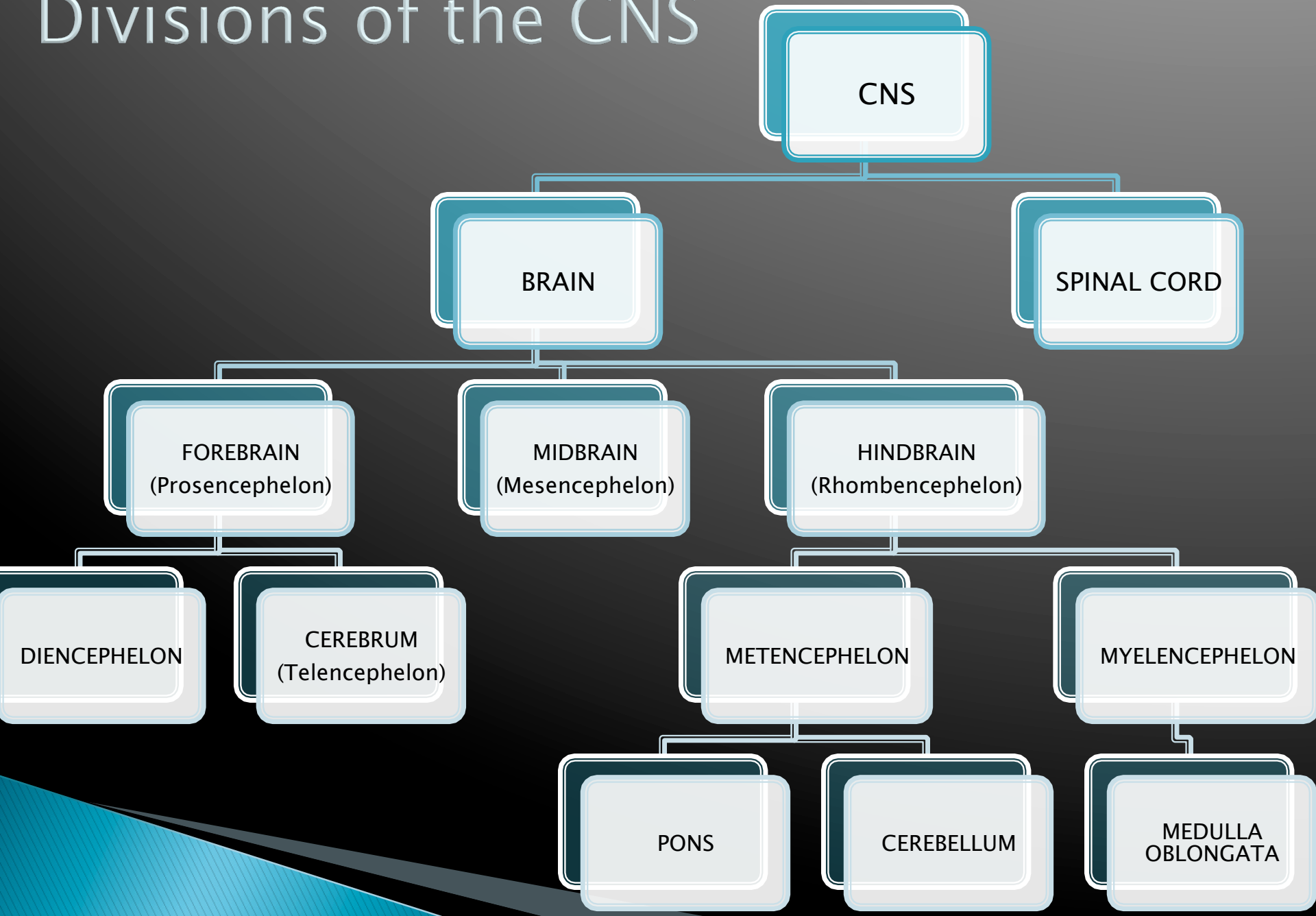
PINEAL GLAND–Produces Melatonin which affects the modulation of sleep/wake patterns, reproduction & circadian rhythm
•Activated by light, also called as THIRD EYE





Corpus Callosum

Divisions of the CNS



The Telencephalon->Cerebrum

largest &most highly developed part of the brain, encompasses about two-third of the brain mass

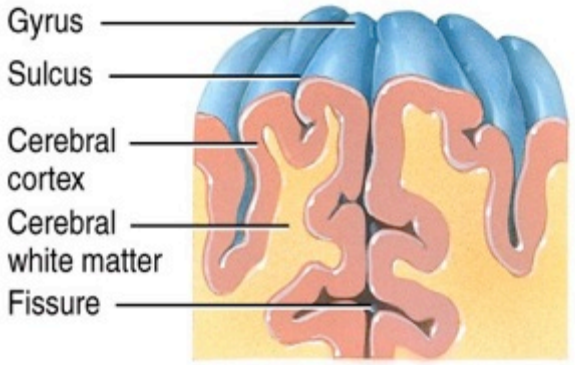
Telencephelon refers to the embryonic structure from which the mature Cerebrum develops

- Dorsal telencephelon (Pallium)-develops into cerebral cortex
- Ventral telencephelon (sub pallium)-becomes basal ganglia

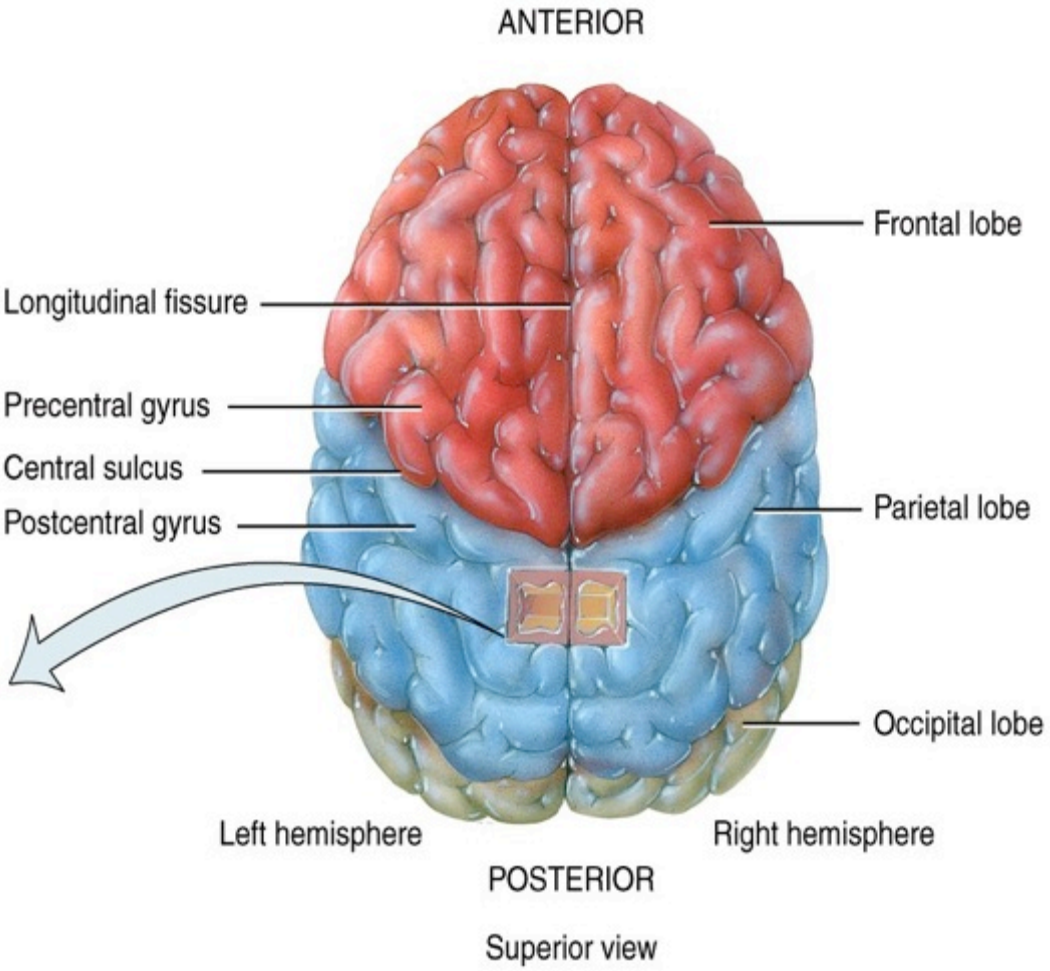
KEY STRUCTURAL TERMS:

- **Gyr**i- series of folds
- **Sulci**- grooves between gyri
- **Fissure**- deep grooves
- **Cerebral cortex-** outer covering of Cerebrum. Also called Gray Matter. Gray because nuclei lack insulation
- **White matter-** Axons of multiple Neurons. Lies deep to the cortex
- **Cerebral hemispheres**

The Cerebrum: Terminology

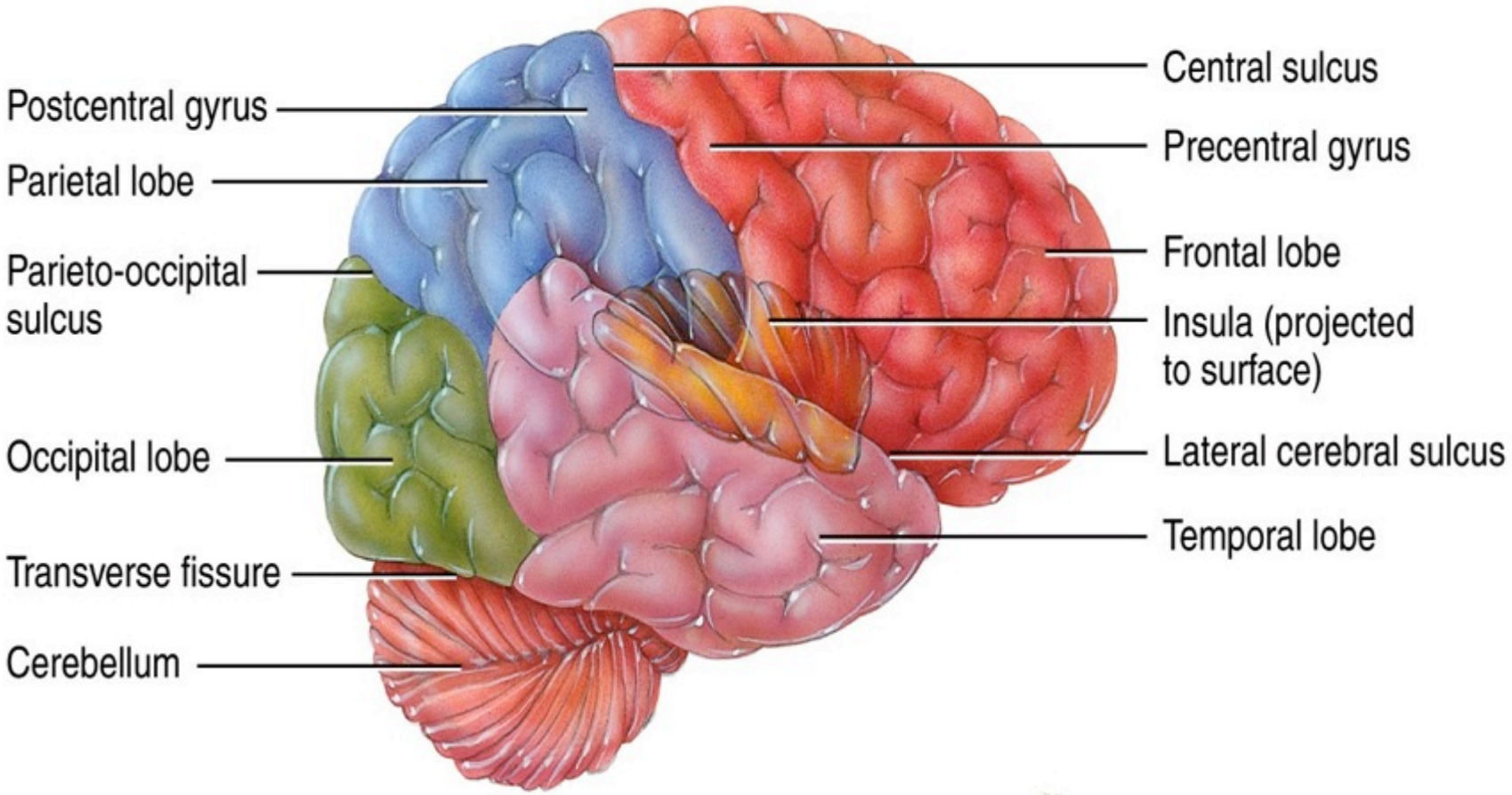


Details of a gyrus, sulcus, and fissure



Superior view

LOBES OF THE CEREBRUM

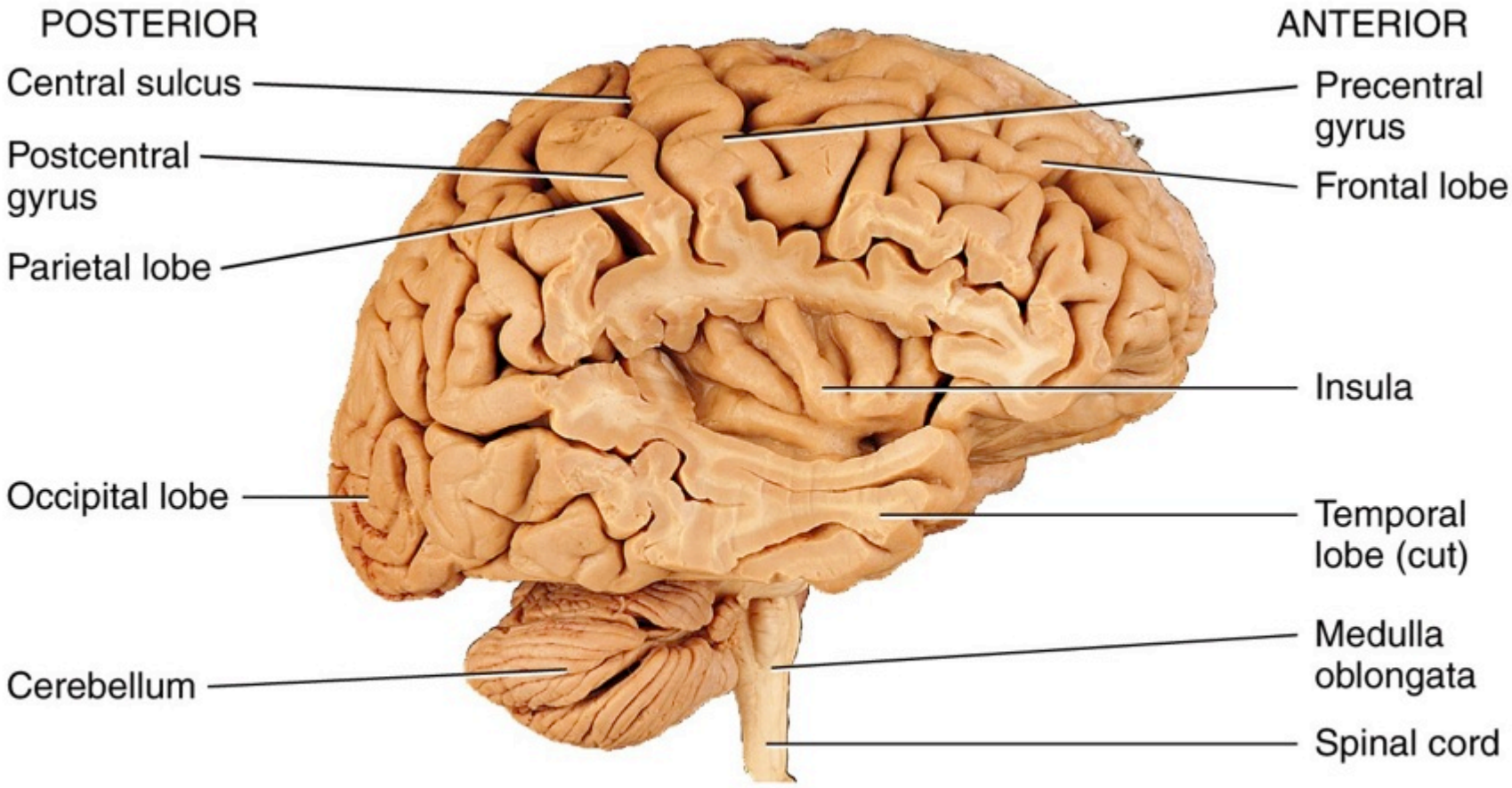


Right lateral view

LOBES OF THE CEREBRUM

- Each cerebral hemisphere has several regions known as lobes:
  - Frontal lobe-Motor Lobe-produces body movements, contributes to personality, temperament, memory & intelligence
  - Parietal lobe-Sensory Lobe-seeing, hearing, touching & smelling
  - Occipital lobe-contains visual cortex, Responsible for Vision
  - Temporal lobe-contains auditory cortex which affects hearing & interpretation of sound
  - The insula (deep to temporal lobe)- may be involved in programming for speech sounds

LOBES OF THE CEREBRUM

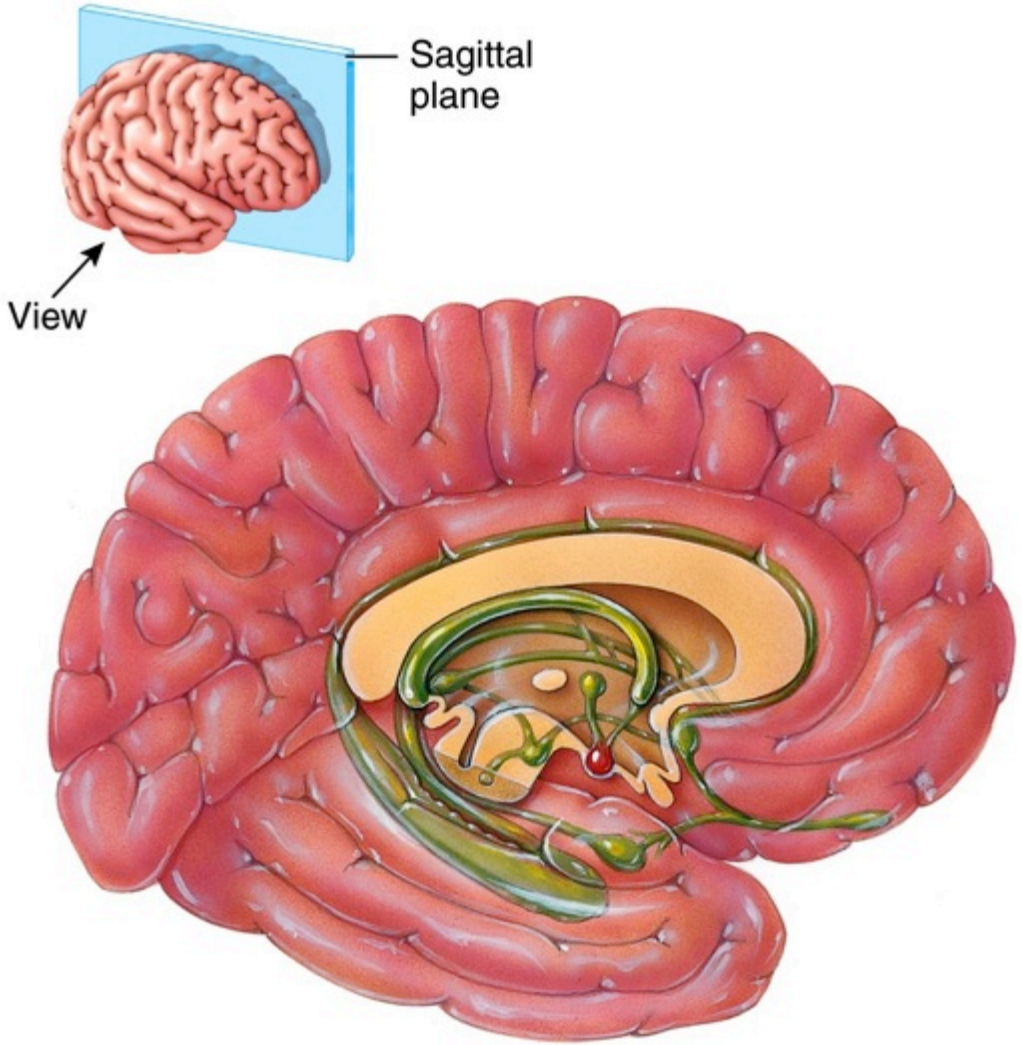


Right lateral view with temporal lobe cut away

CEREBRAL WHITE MATTER

- Most of the cerebral white matter consists of fiber tracts - major groups of axons connecting distant regions of cerebral neurons
  - **Association tracts** connect gyri in the same hemisphere
  - **Commissural tracts** connect areas in opposite hemispheres
    - ***Corpus callosum***
  - **Projection tracts connect the cerebrum to other brain regions**
    - ***Internal capsule***

The Cerebrum: The Limbic System



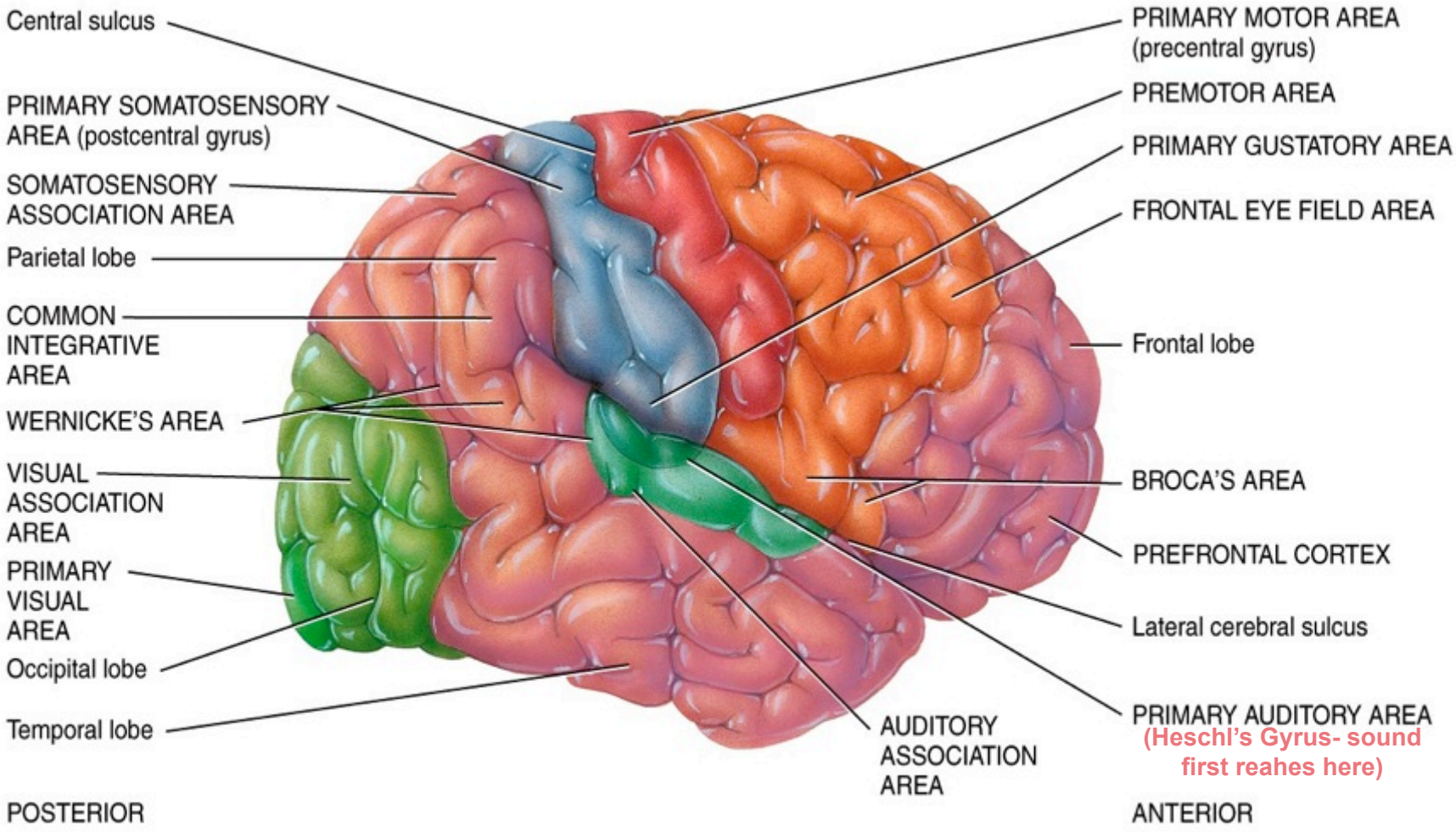
The Cerebrum: The Limbic System

- This ring-like set of structures (aka the “emotional brain”) lies along the border of the cerebrum and diencephelon

- The limbic system mediates behaviors and emotions
  - Pleasure and pain
  - Fear/rage
  - Affection

- The limbic system also has a major role in memory &in controlling emotions, decisions, motivation & learning

Functional Areas of the Cerebral Cortex WRONG

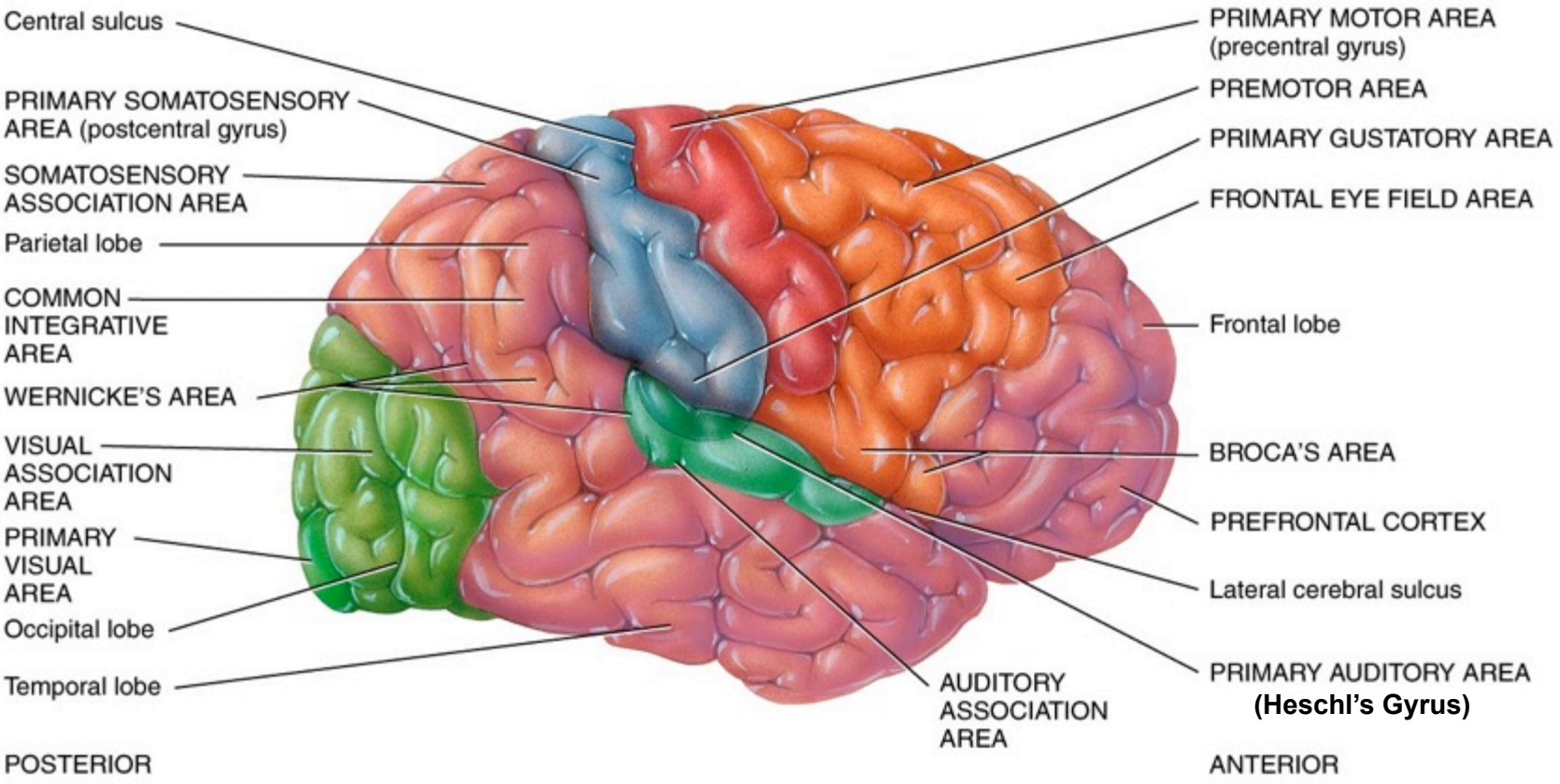


Lateral view of right cerebral hemisphere

Functional Areas of the Cerebral Cortex

- Regions of the cerebral cortex specialize in different types of information processing
  - **Sensory areas** receive and process sensory impulses
  - **Motor areas** initiate voluntary movements
  - **Association areas** perform integrative functions

Sensory Areas of the Cerebral Cortex



Lateral view of right cerebral hemisphere

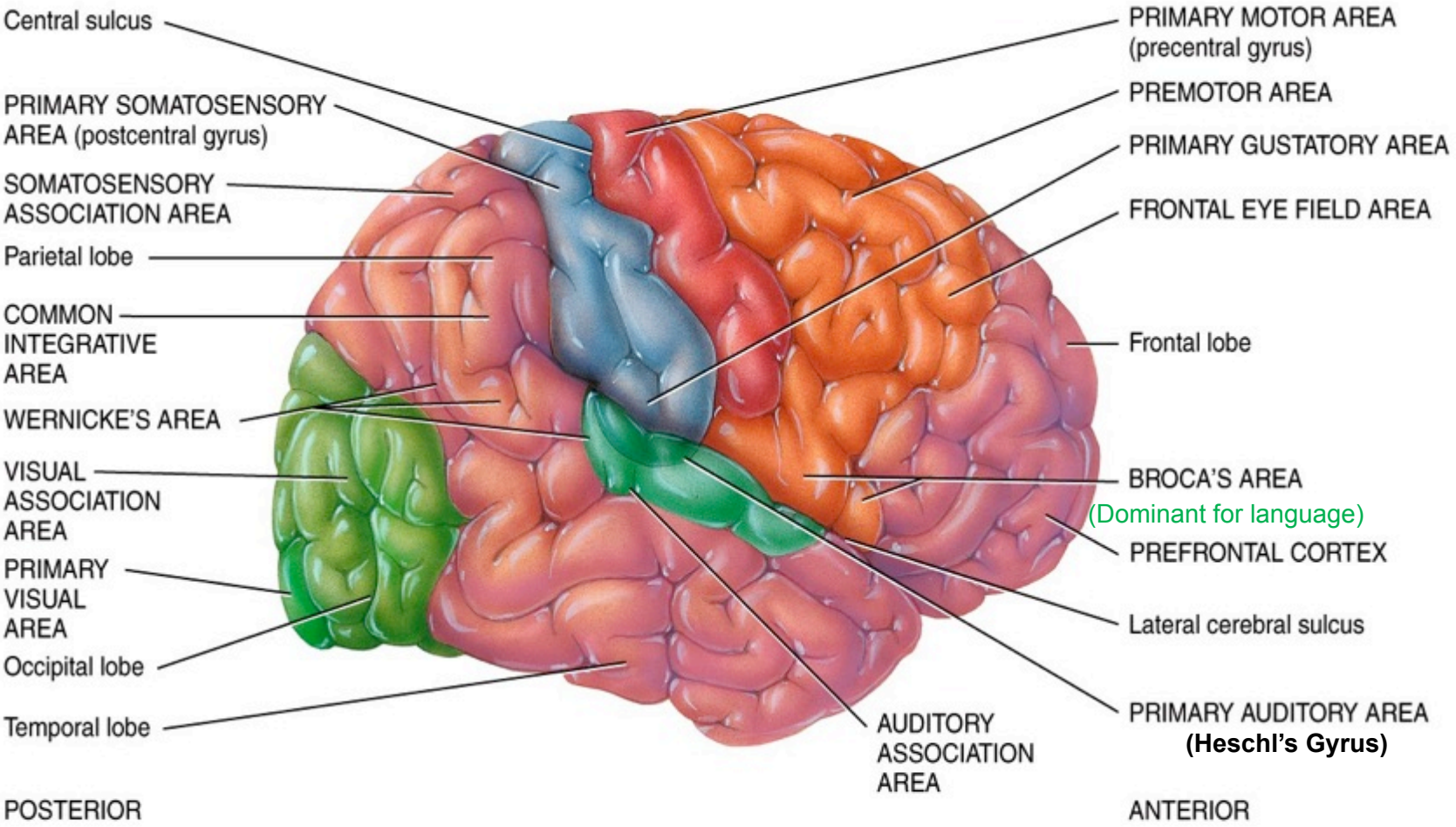
Sensory Areas of the Cerebrum

•Primary Sensory Area (postcentral gyrus)- receives sensory feedback from joints & tendons
•Presensory
•Secondary sensory
•Sensory Association Area

Located behind the postcentral gyrus. Capable of more detailed discrimination &analysis

Information is first processed in the primary sensory area & is then sent to the secondary sensory areas

Motor Areas of the Cerebral Cortex



Lateral view of right cerebral hemisphere

Motor Areas of the Cerebral Cortex

- Major motor regions of the cerebral cortex include
  - **Primary motor area** (precentral gyrus)- immediately anterior to the central sulcus. Controls the voluntary movements of Skeletal Muscles
  - **Premotor Area-** immediately anterior to the Primary Motor Area. Responsible for the programming of motor movements (other than speech)
  - **Broca's area-** dominant for language. Found on inferior third frontal gyrus

Hemispheric Lateralization of the Cerebral Cortex

TABLE 13.1

Functional Differences between the Two Cerebral Hemispheres

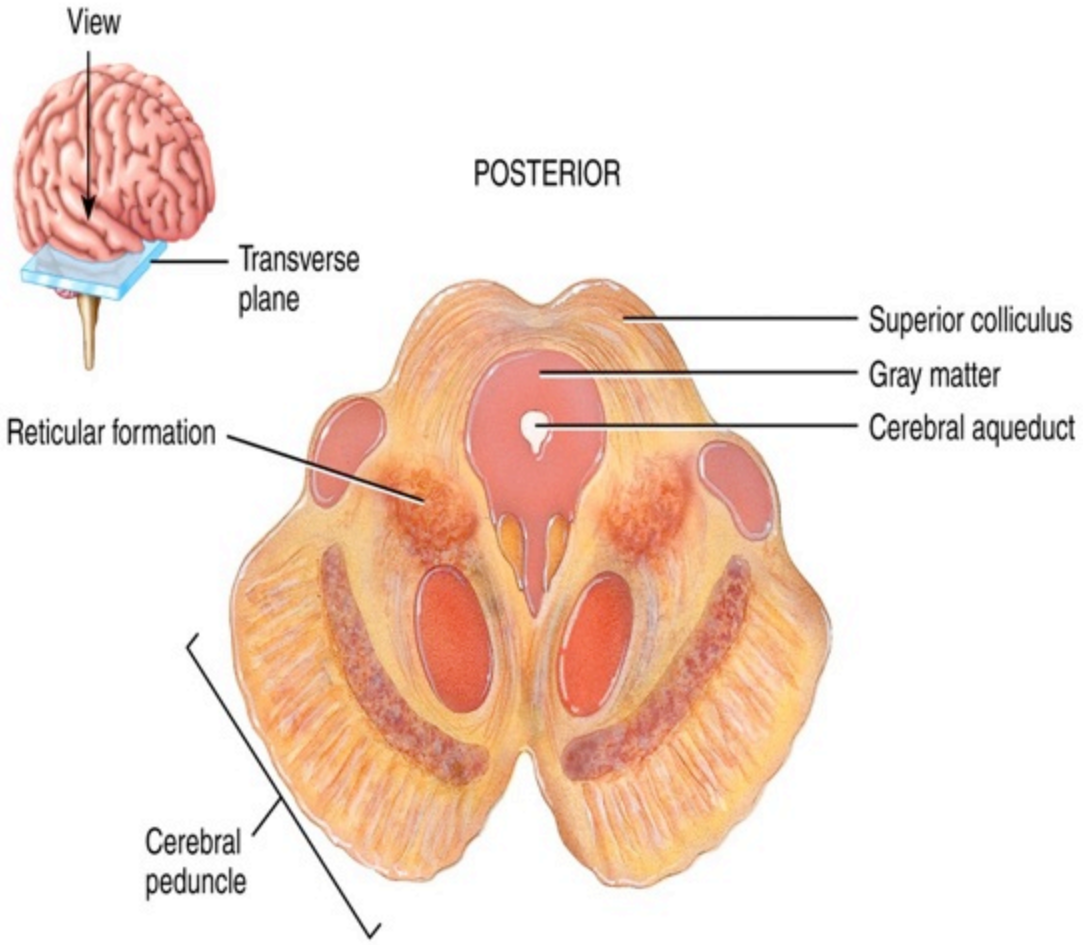
LEFT HEMISPHERE FUNCTIONS	RIGHT HEMISPHERE FUNCTIONS
Receives somatic sensory signals from and controls muscles on right side of body.	Receives somatic sensory signals from and controls muscles on left side of body.
Reasoning.	Musical and artistic awareness.
Numerical and scientific skills.	Space and pattern perception.
Ability to use and understand sign language.	Recognition of faces and emotional content of facial expressions.
Spoken and written language.	Generating emotional content of language.
	Generating mental images to compare spatial relationships.
	Identifying and discriminating among odors.

BRAINSTEM: MIDBRAIN

•Relays motor impulses from the cerebral cortex to the pons and sensory impulses from the spinal cord to the thalamus

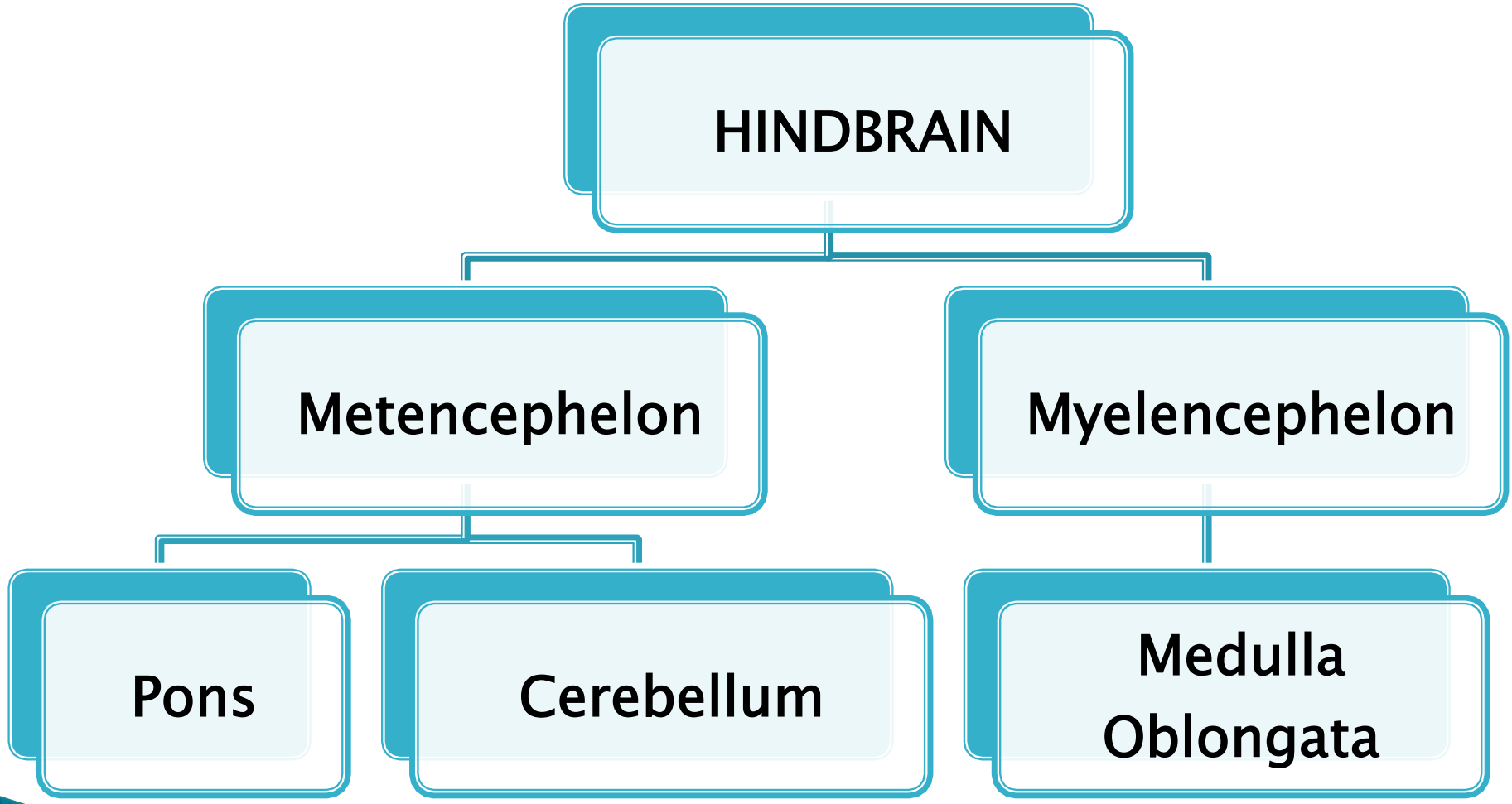
•Responsible for both Auditory & Visual responses as well as motor function

- •**Superior colliculi** coordinate movements of the head, eyes, and trunk in response to visual stimuli,
- •**inferior colliculi** coordinate movements of the head, eyes, and trunk in response to auditory stimuli. Contributes to control of movements



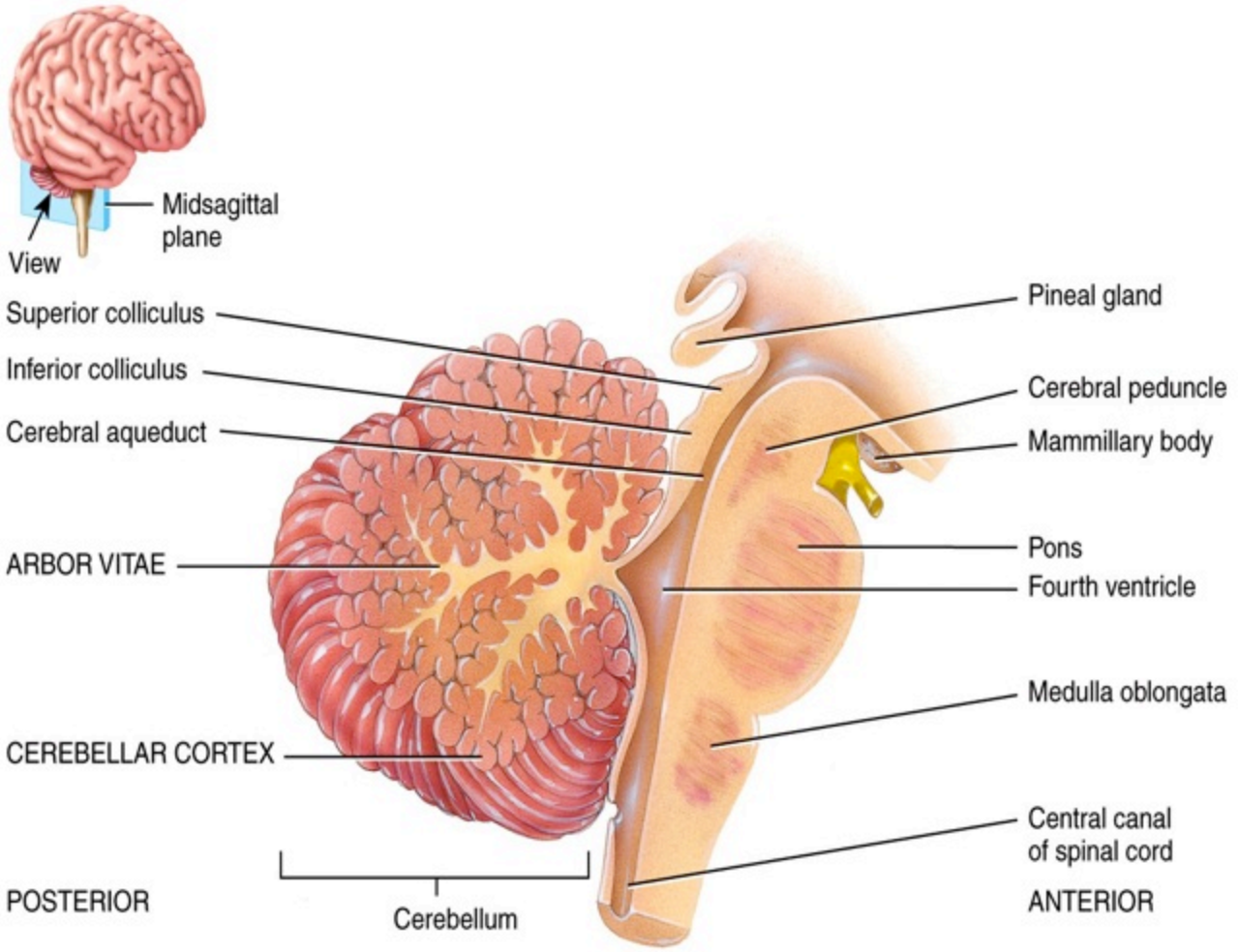
Transverse section of midbrain

DIVISIONS OF THE HINDBRAIN



BRAINSTEM: PONS

- Connects cerebral cortex with Medulla Oblongata
- Serves as a communications & coordination center between the two Hemispheres
- Relays impulses between cerebral cortex and cerebellum and between the medulla and midbrain

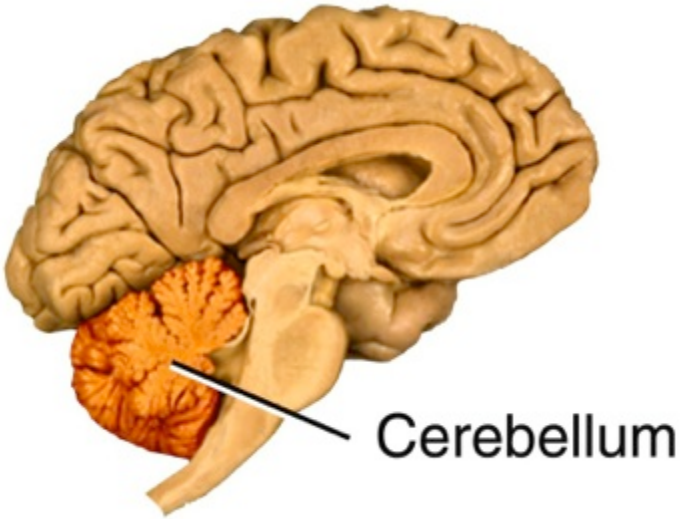


Midsagittal section of cerebellum and brain stem

THE CEREBELLUM

10% of brain mass but contains almost 50% of all brain neurons

- The cerebellum is critical to coordinated movements, and provides constant feedback to motor areas



•controls motor movement coordination, balance, equilibrium & muscle tone

•Relays information between body muscles & areas of cerebral cortex that are involved in motor control

•Compares intended movements with what is actually happening to smooth and coordinate complex, skilled movements

•Regulates posture and balance

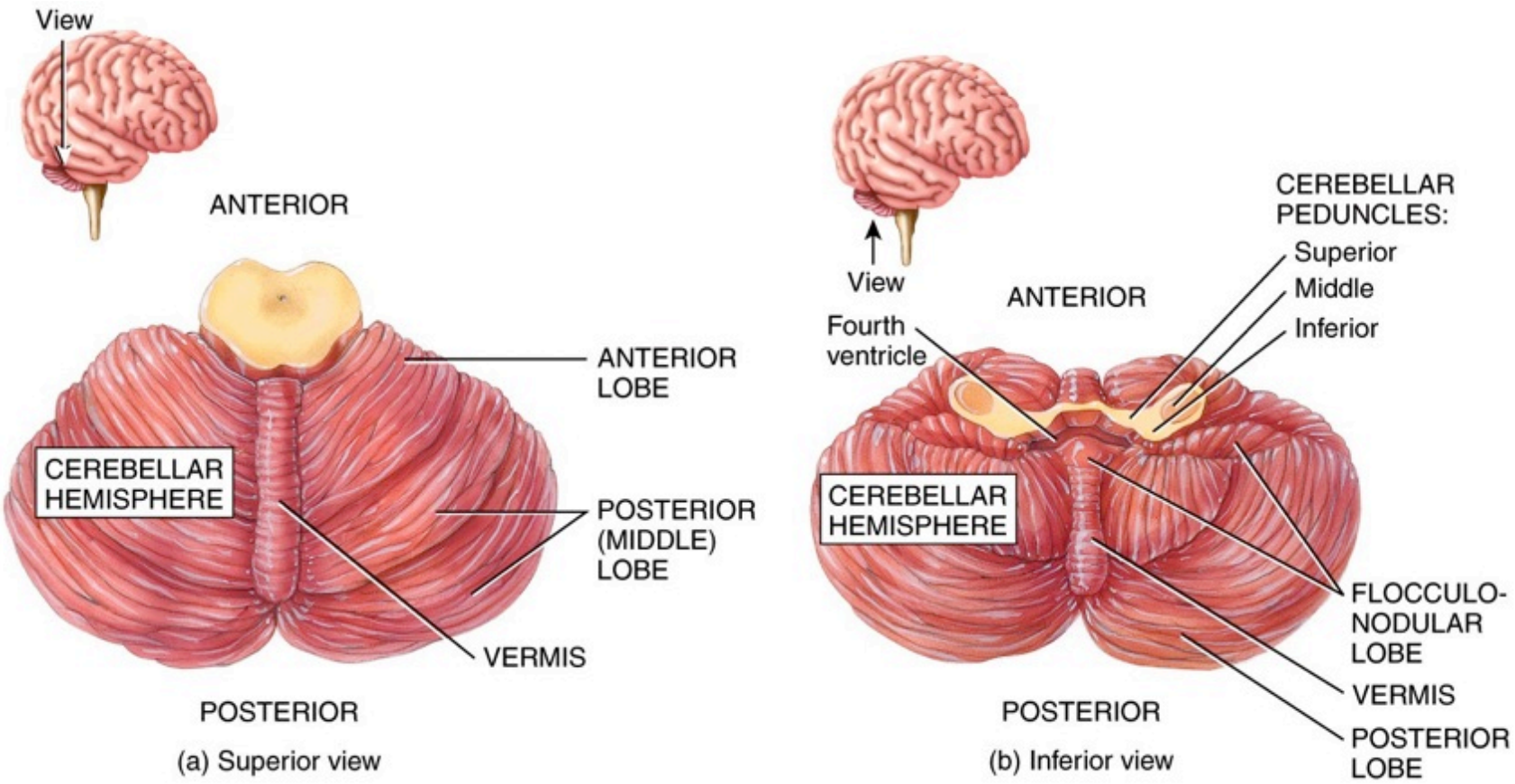
• May have a role in cognition and language processing.

The **cerebellum -** second largest area of the brain.

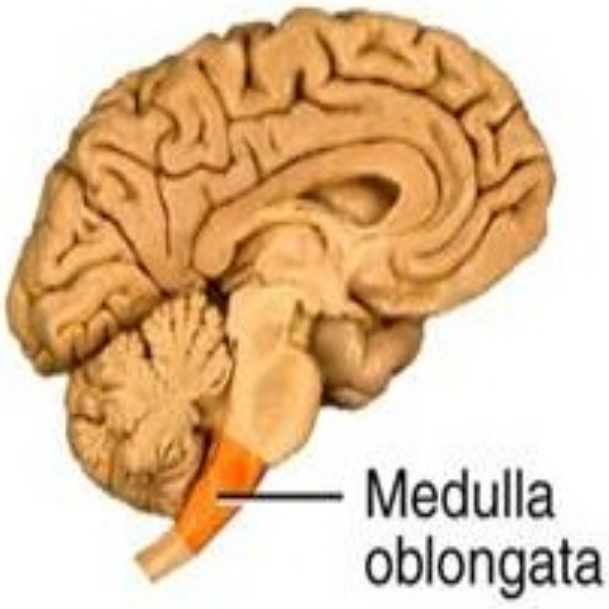
- muscle coordination, walking,and speech.
- Symptoms of lesion in the cerebellum include

swaying, difficulty with coordination and walking, and difficulty with speech.

The Cerebellum: Internal Structures

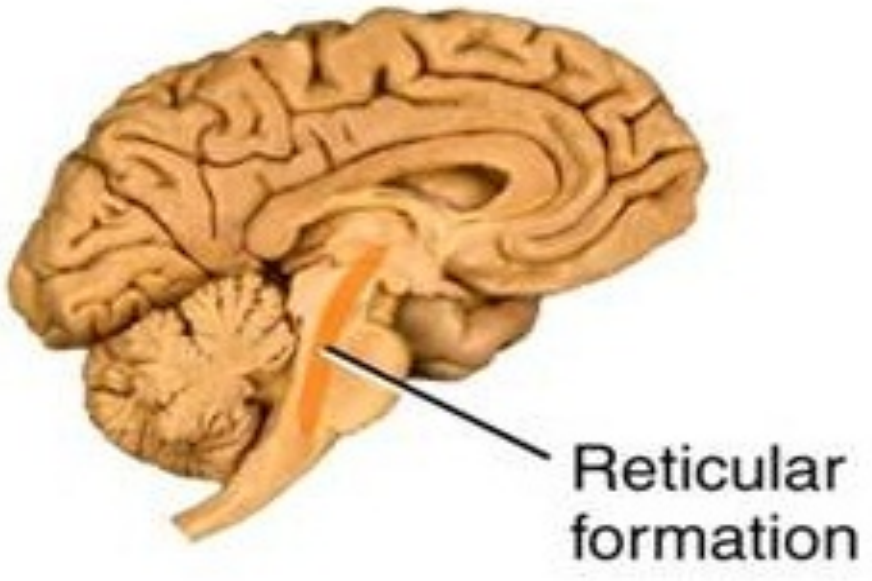


MEDULLA OBLONGATA

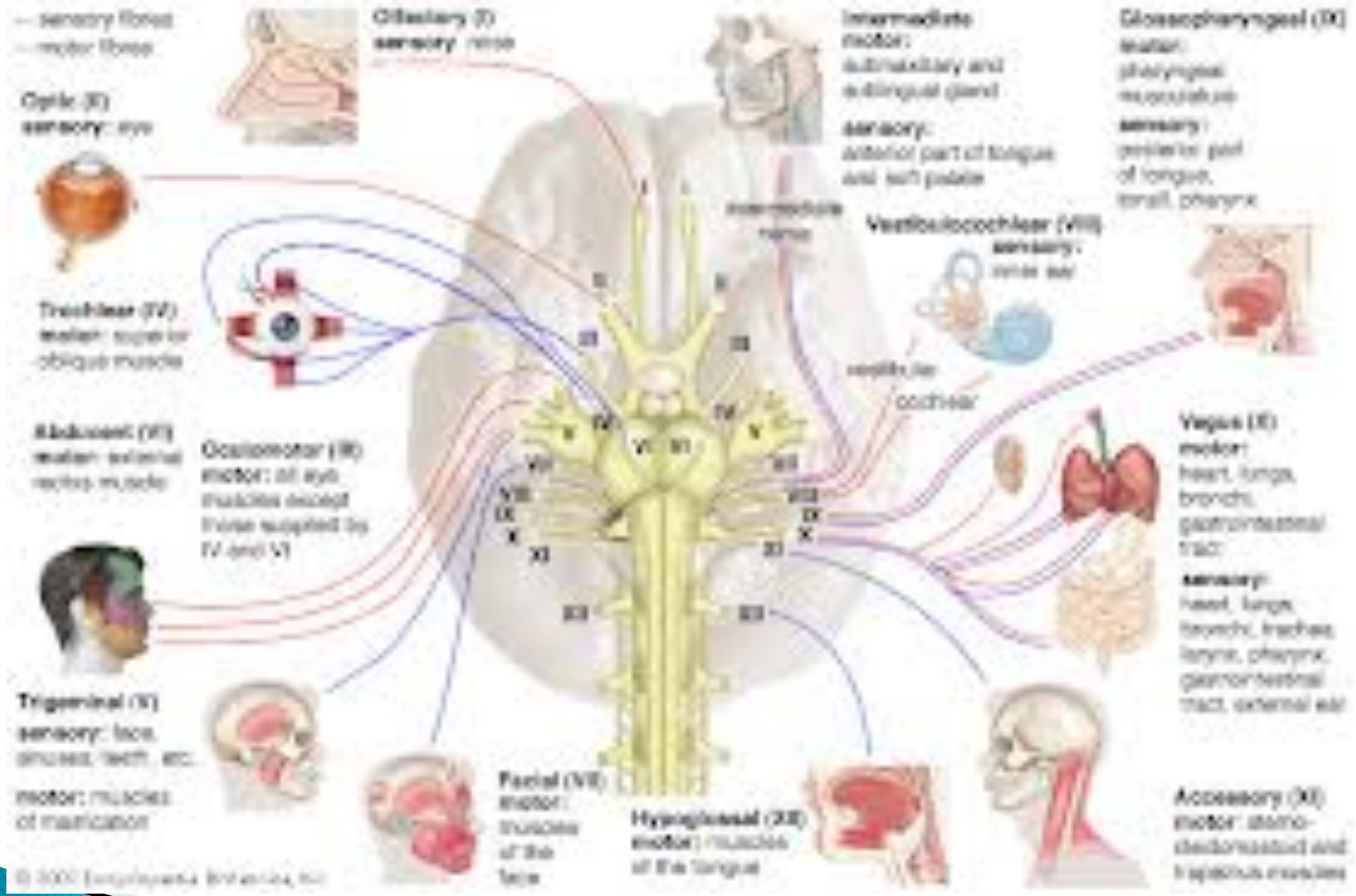


- Large fiber tracts in the medulla connect the spinal cord to the brain
- Relays motor and sensory impulses between other parts of the brain and the spinal cord
- The medulla includes control centers for respiration, heart rate, blood pressure, and other functions (e.g., coughing, vomiting, swallowing, sneezing etc.)
  - Vital centers regulate heartbeat, breathing (together with pneumotaxic and apneustic area of pons), and blood vessel diameter
  - Other centers coordinate swallowing, vomiting, coughing, sneezing, and hiccuping.

RETICULAR FORMATION



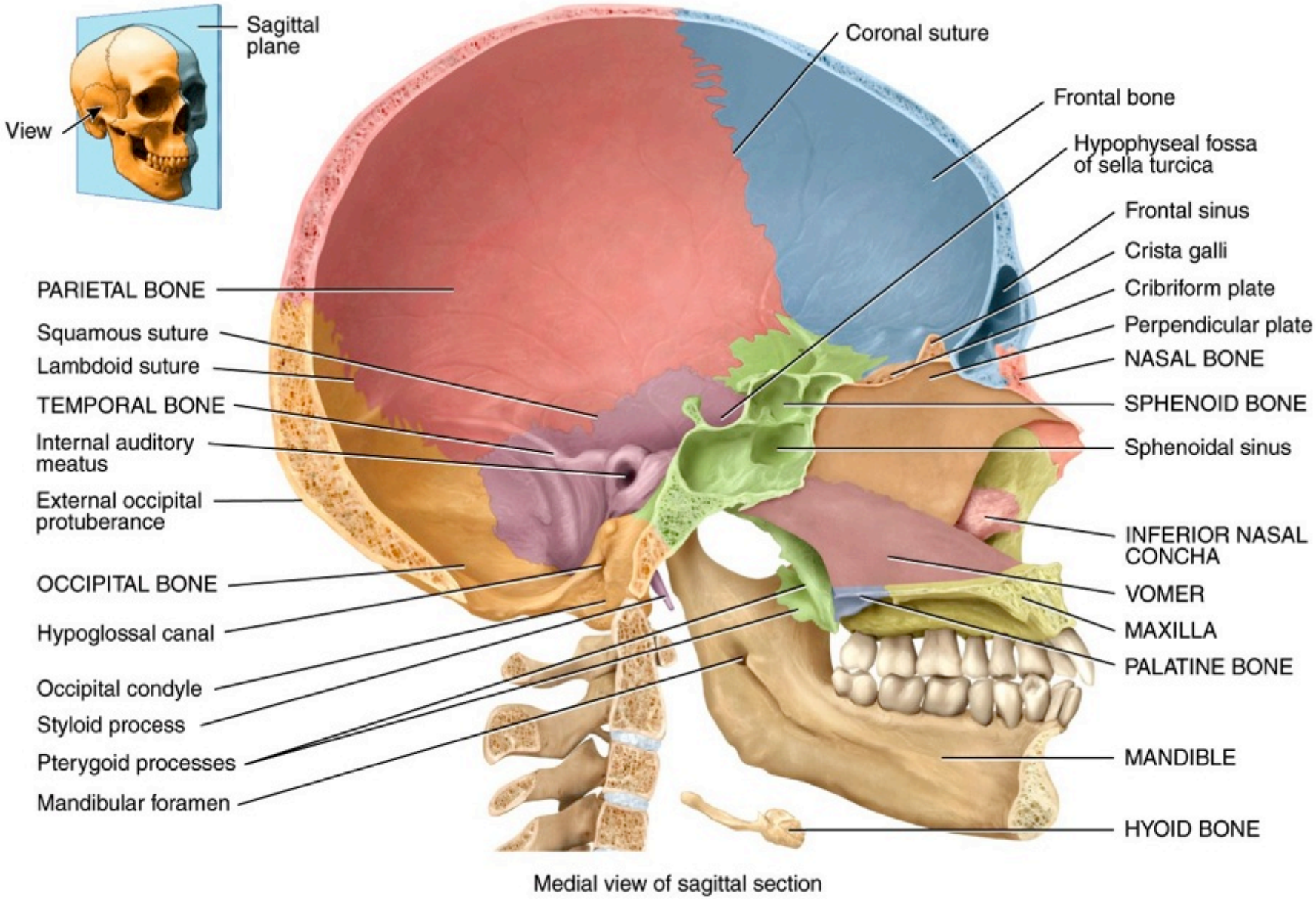
Helps maintain consciousness, causes awakening from sleep, filters repetitive sensory input, and contributes to regulation of muscle tone


— sensory fibres
— motor fibres
Optic (II)
sensory: eye
Trochlear (IV)
motor: superior oblique muscle
Abducent (VI)
motor: external rectus muscle
Trigeminal (V)
sensory: face, sinuses, teeth, etc.
motor: muscles of mastication
Olfactory (I)
sensory: nose
Oculomotor (III)
motor: all eye muscles except those supplied by IV and VI
Facial (VII)
motor: muscles of the face
Intermediate
motor:
sensory:
anterior part of tongue and soft palate
Vestibulocochlear (VIII)
sensory:
vestibular
cochlear
Hypoglossal (XII)
motor: muscles of the tongue
Glossopharyngeal (IX)
motor:
sensory:
posterior part of tongue, tonsil, pharynx
Vagus (X)
motor:
heart, lungs, bronchi, gastrointestinal tract
sensory:
heart, lungs, bronchi, trachea, larynx, pharynx, gastrointestinal tract, external ear
Accessory (XI)
motor:
sternocleidomastoid and trapezius muscles

Protection of the CNS

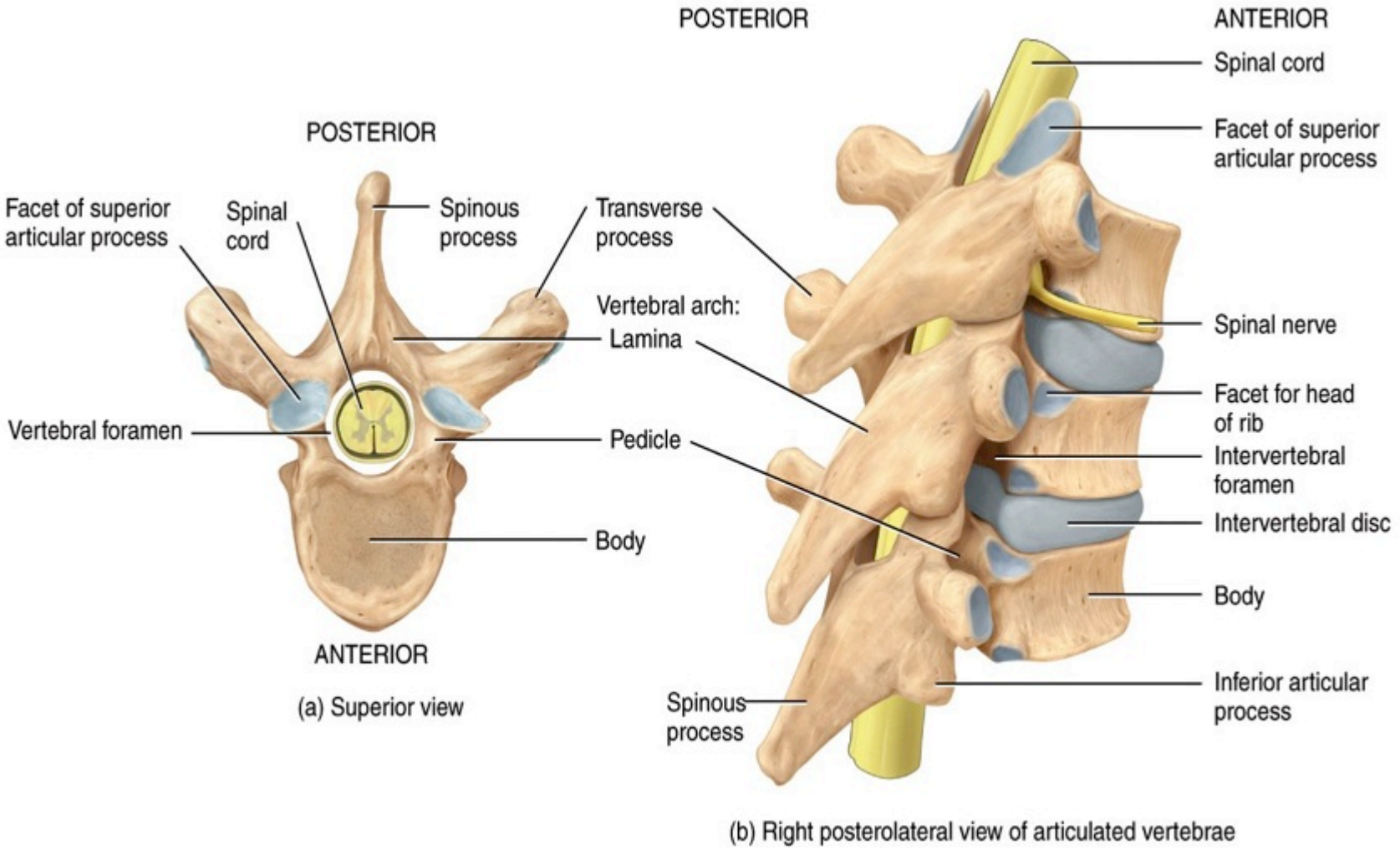
- The CNS is protected by
  - Bone
    - Cranial bones protect the brain & support the face
    - Vertebrae protect the spinal cord
  - Three meninges (layers of connective tissue surrounding the CNS)
  - Cerebrospinal fluid (CSF) - the CNS is cushioned by a thin layer of fluid

Protection of the CNS- cranial bones



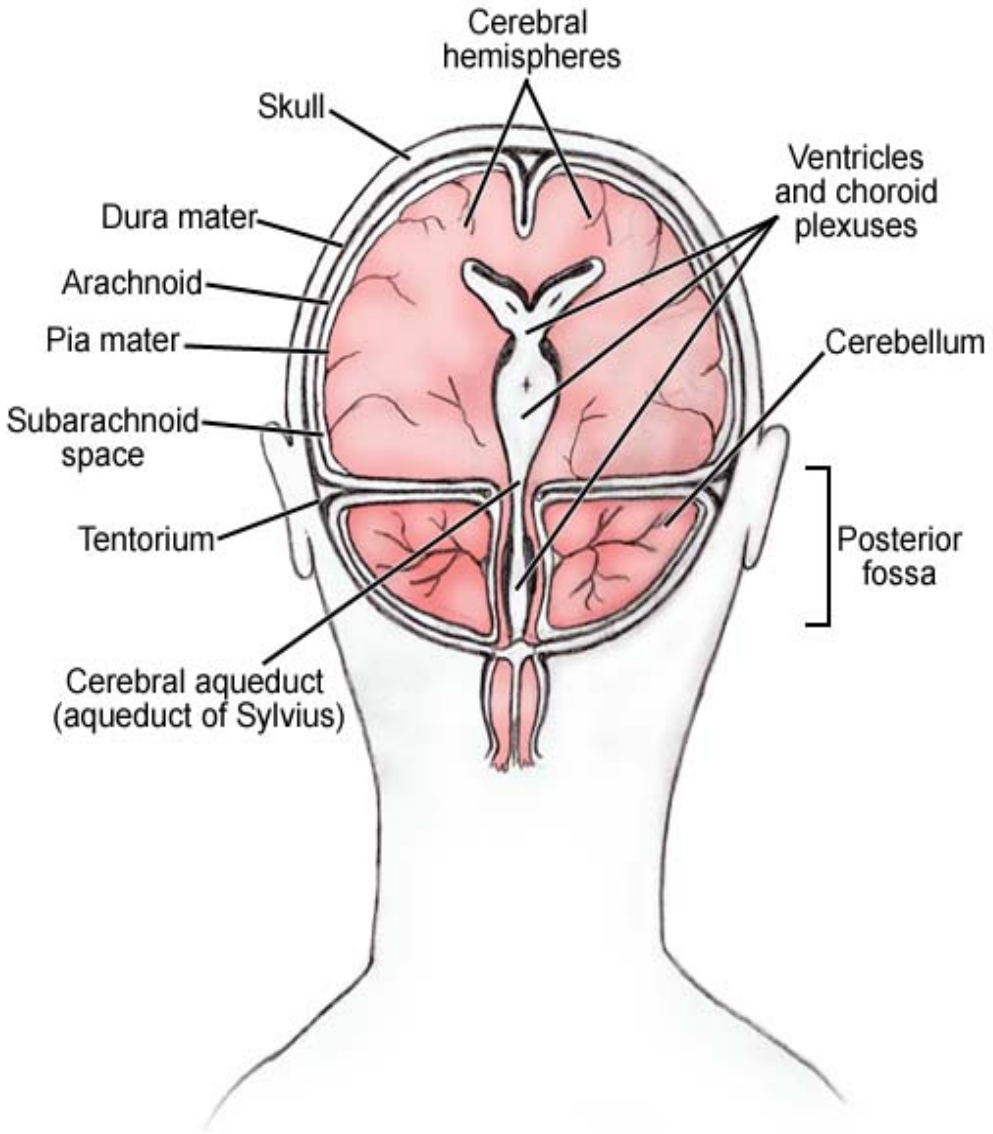
Medial view of sagittal section

Protection of the CNS- Vertebrae

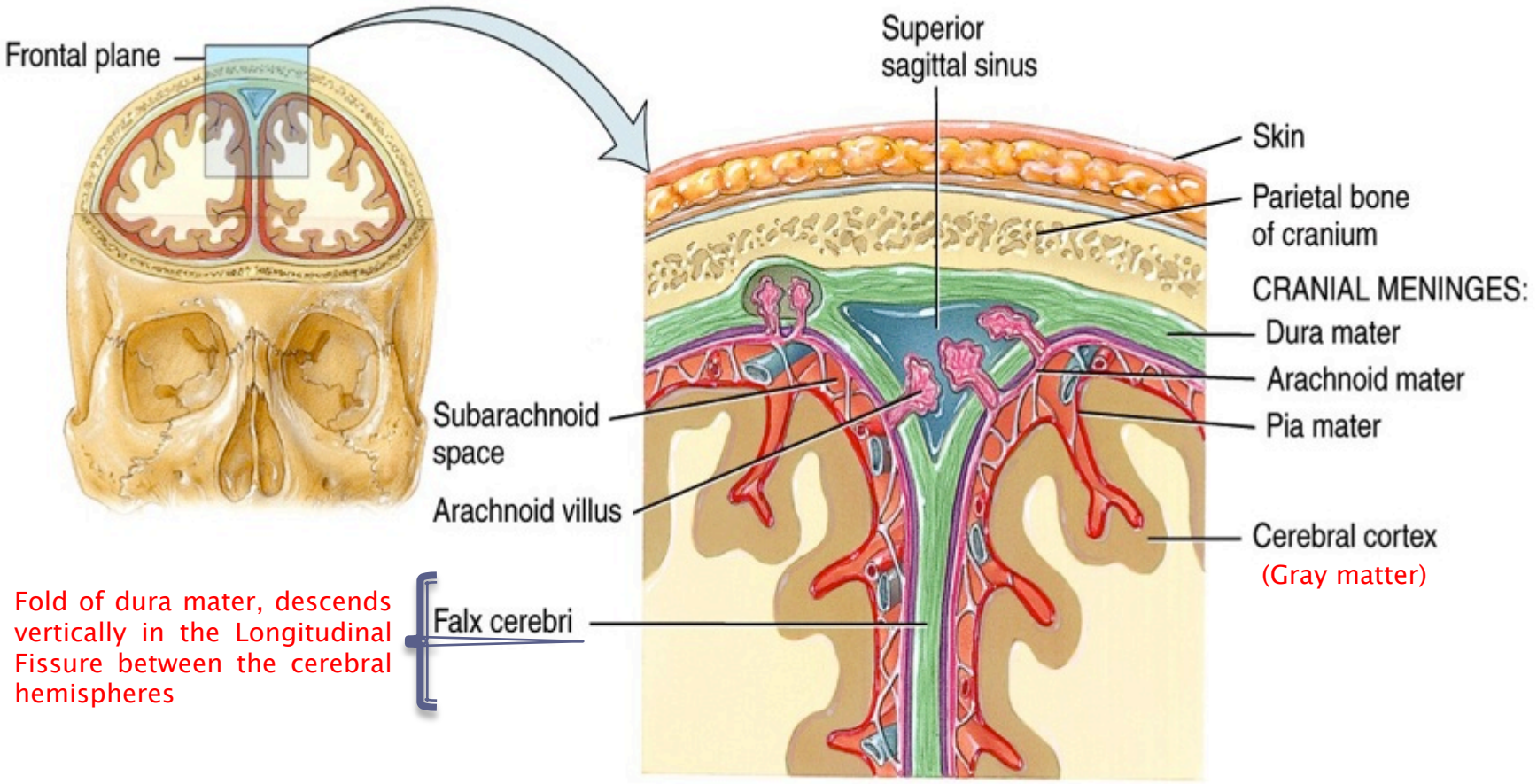


The Meninges and the Brain

- Dura mater
  - Epidural space- space between dura mater & surrounding bone of the vertebrae
  - Dural sinuses
  - Subdural Space- space between Duramater & Arachnoid Mater
- Arachnoid mater
  - Subarachnoid space- space between arachnoid mater & piamater
- Pia mater



The Meninges and the Brain



Fold of dura mater, descends vertically in the Longitudinal Fissure between the cerebral hemispheres

Anterior view of frontal section through skull showing the cranial meninges

Meninges and the Spinal Cord

- The meninges also surround the spinal cord, and the cranial and spinal meninges form a single unified protective covering for the CNS.

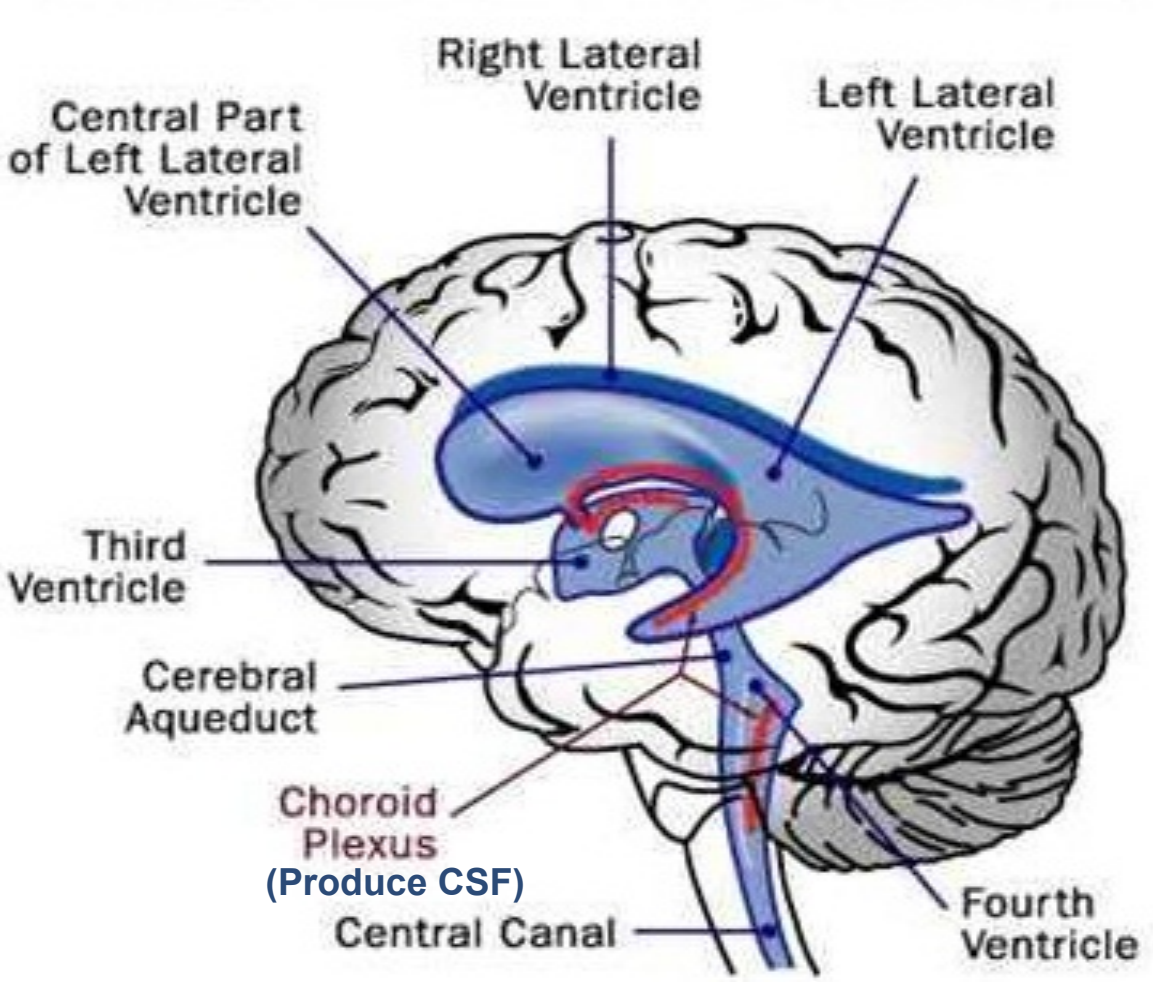
Blood Flow to the Brain

- Blood supply to the brain is a crucial source of O_2 and nutrients
- The brain receives much greater blood supply than expected based on its size and mass
- Blood flow to active areas of the brain increases during higher levels of metabolic activity
- Interruptions in blood flow have very serious consequences (unconsciousness, stroke, death)

Cerebrospinal Fluid

- Cerebrospinal fluid (CSF) is a nutrient-rich fluid that circulates within and around the CNS
- CSF serves three key homeostatic functions in the CNS
  - Mechanical protection
  - Chemical protection
  - Circulation

VENTRICLES OF THE BRAIN



Ventricles are the communicating cavities (containing CSF) within the brain that are continuous with the central canal of the spinal cord

LATERAL VENTRICLES-

•curved shaped cavities
•Largest of the ventricles
•Protects the brain from Trauma & provides pathway for the circulation of CSF

THIRD VENTRICLE

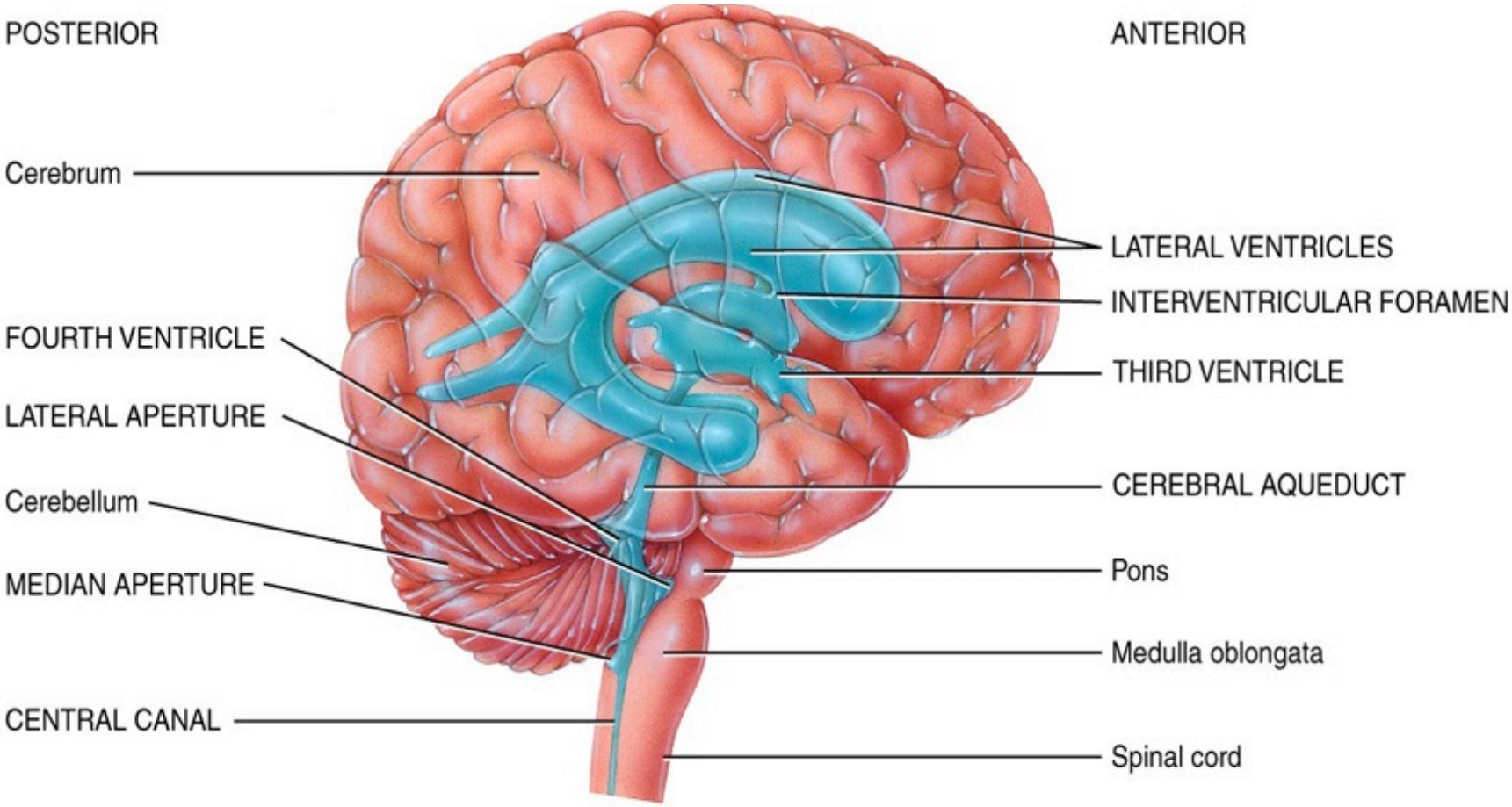
•Narrow cavity located in the middle of the Cerebral Hemispheres between the right and left thalamus
•Connected to the Fourth Ventricle via the Cerebral Aqueduct

FOURTH VENTRICLE

•Runs between the Pons, the Medulla Oblongata and the Cerebellum
•Extends from the Cerebral Aqueduct to the Obex (Point at which fourth Ventricle narrows to become the central canal of the Spinal Cord) & is filled with CSF

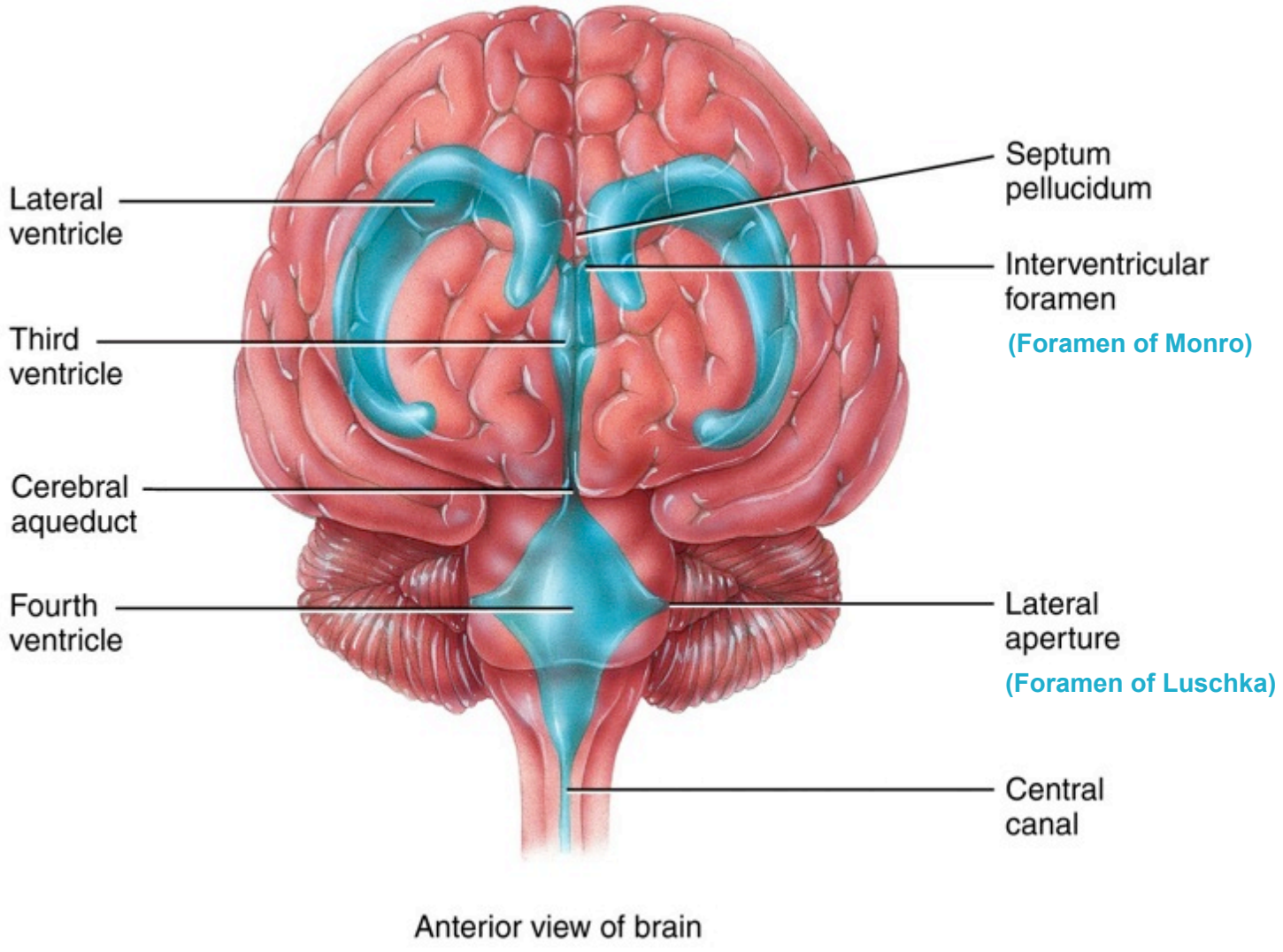
•CSF entering the Fourth Ventricle through Cerebral Aqueduct can exit to subarachnoid space through Foramen of Luschka & a single midline Foramen of Magendie

Cerebrospinal Fluid



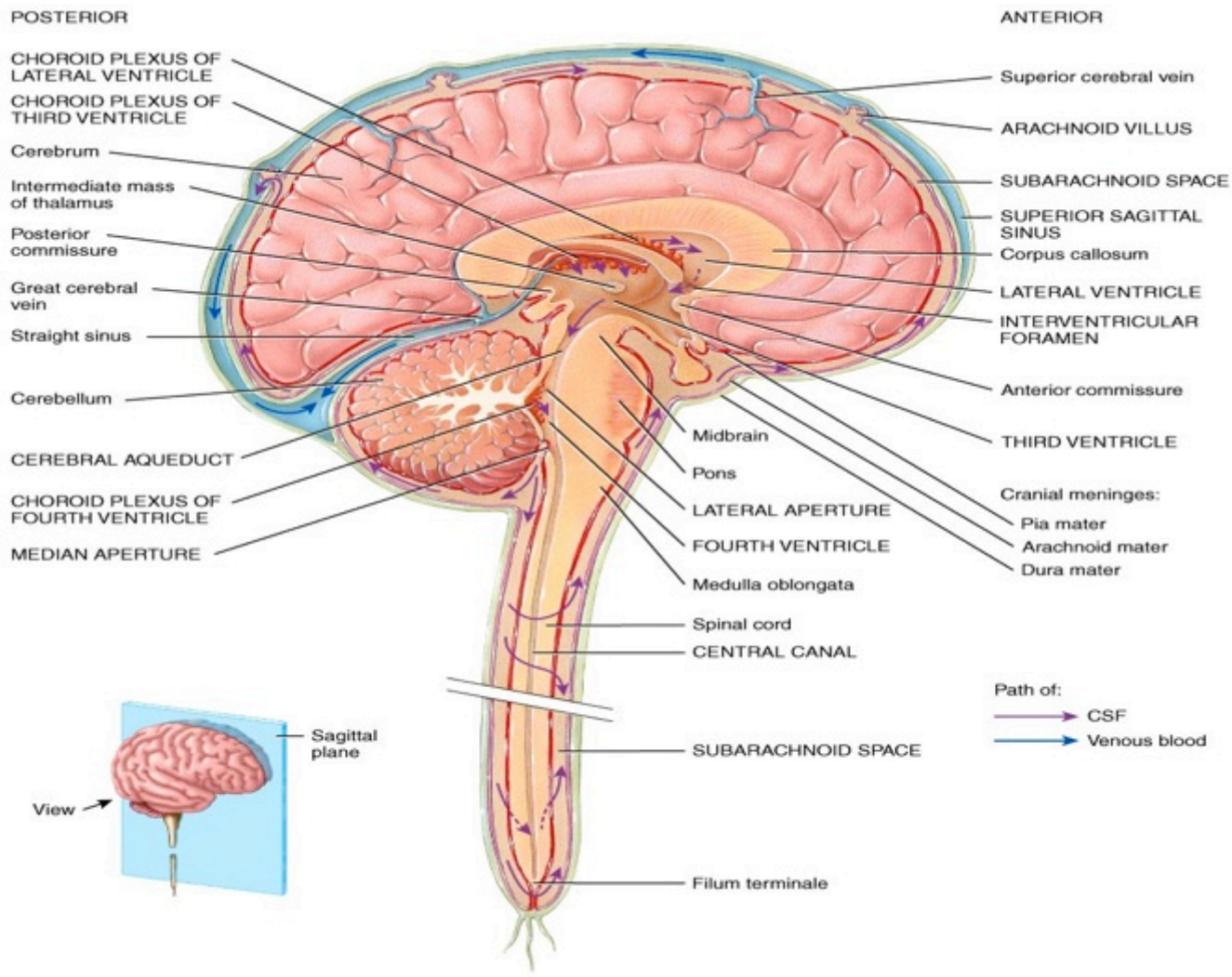
Right lateral view of brain

Cerebrospinal Fluid



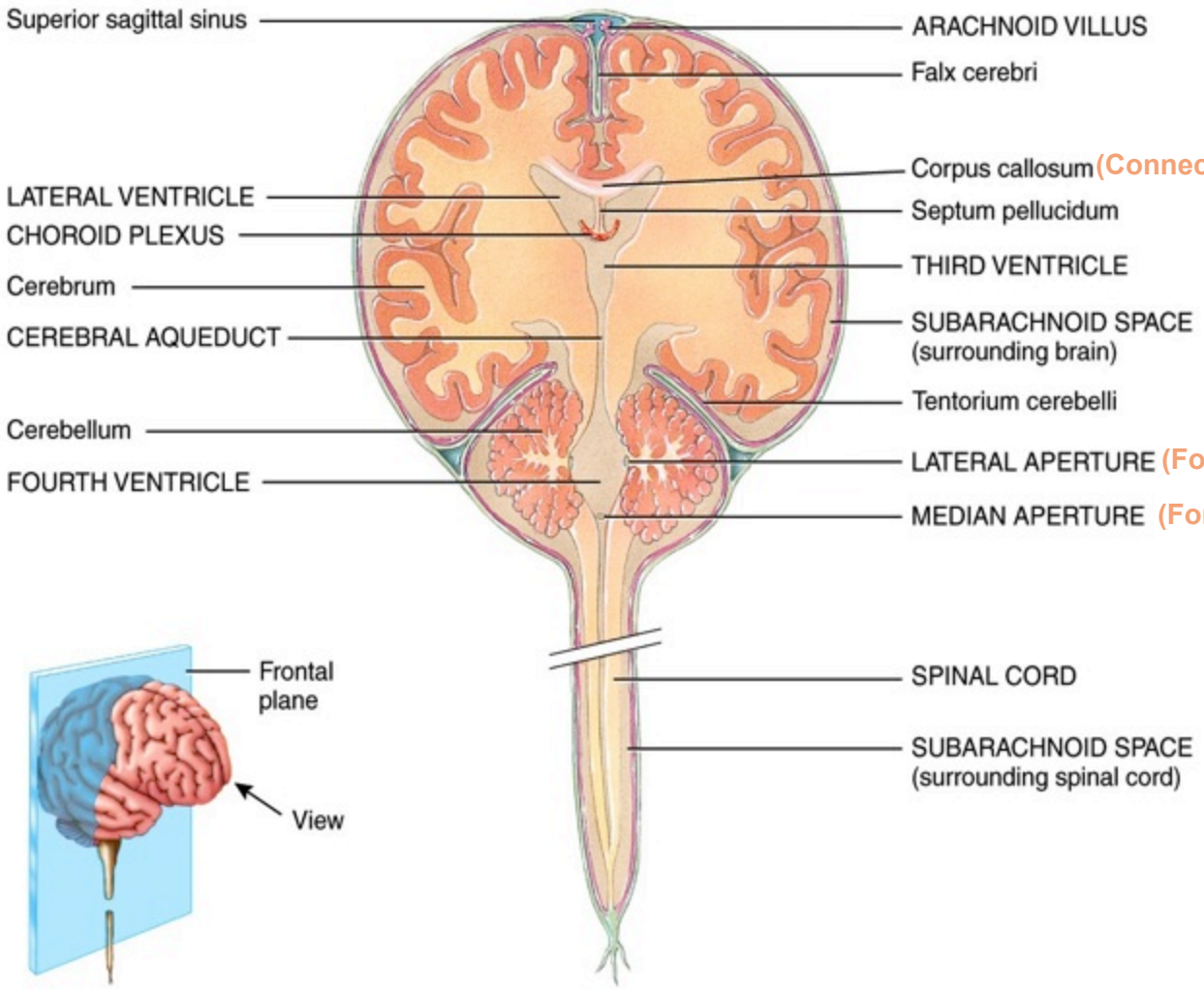
Anterior view of brain

Circulation Pattern of CSF



Sagittal section of brain and spinal cord

Circulation Pattern of CSF



Frontal section of brain and spinal cord

THANK YOU