Functional anatomy of the central nervous system. Reticular and limbic systems.

1. **Structure and functions of the nervous system**
2. **External structure of the spinal cord**
3. **Internal structure of the spinal cord**
4. **Development of the spinal cord**
5. **Anomalies of the spinal cord**
6. **General structure of the brain**
7. **Structure and functions of the brain component parts**
8. **Functional systems of the brain:**

- reticular formation

- limbic system

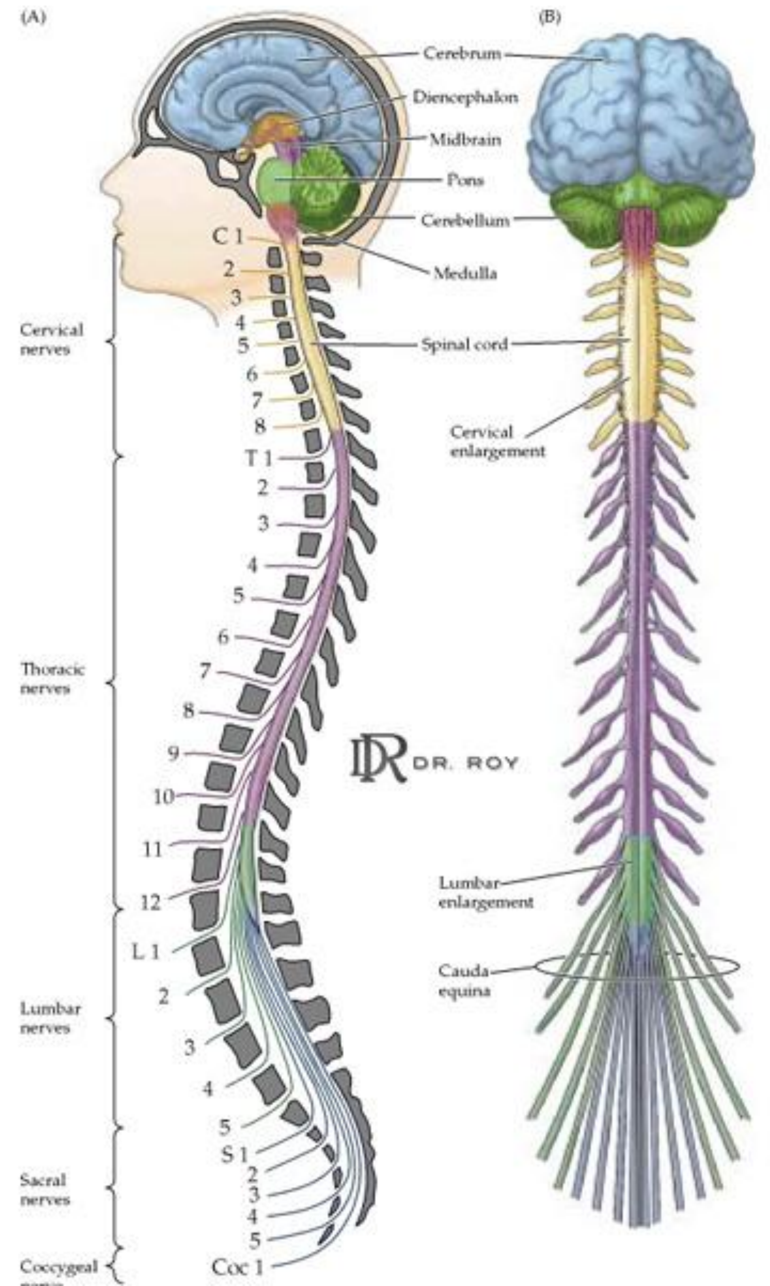
Lecturer: PhD, professor Tamara Hacina

Generalities about the Nervous System

- It is the most complex system of the body
- It determines responses of the body to changes in internal and external environments
- It also acts as a messenger and coordination system for the body

- ***Functions:***

- The perception of stimuli
- Generation of nerve impulses
- Conduction of excitation
- Signal analysis
- Formation of the response



The main elements of nervous tissue

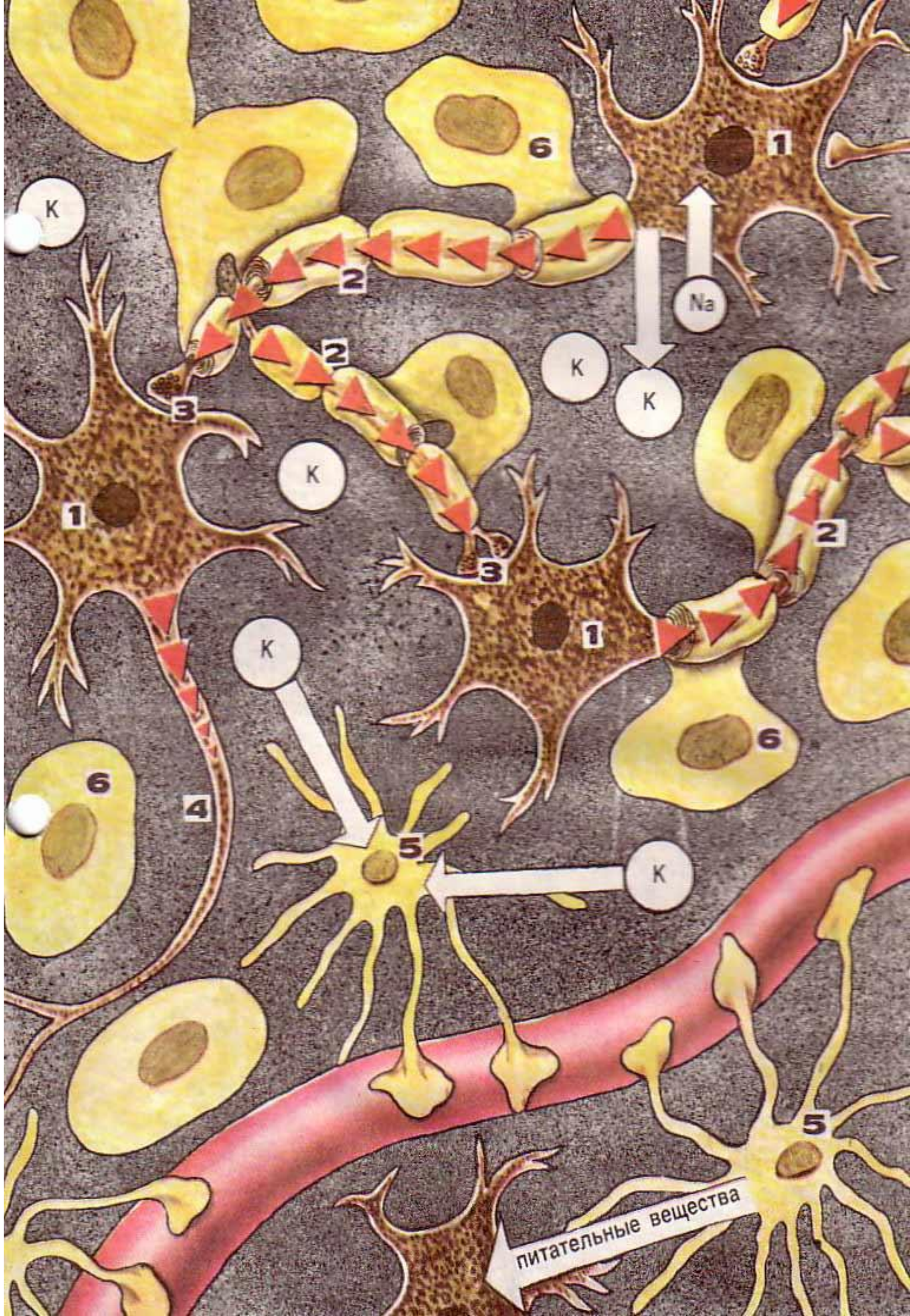
* The nervous tissue consists of two cell types: ***neurocytes (neurons***) and ***glial cells (collectively neuroglya)***.

*** Neurocytes** provide the basic functions:

- generate excitement in response to stimulation,
- spread of excitation,
- transfer of excitation to the next link

*** Gliocytes** are cells that support and protect neurons, their functions:

- mechanical
- insulation
- trophic
- protection



Contents of the nervous tissue :

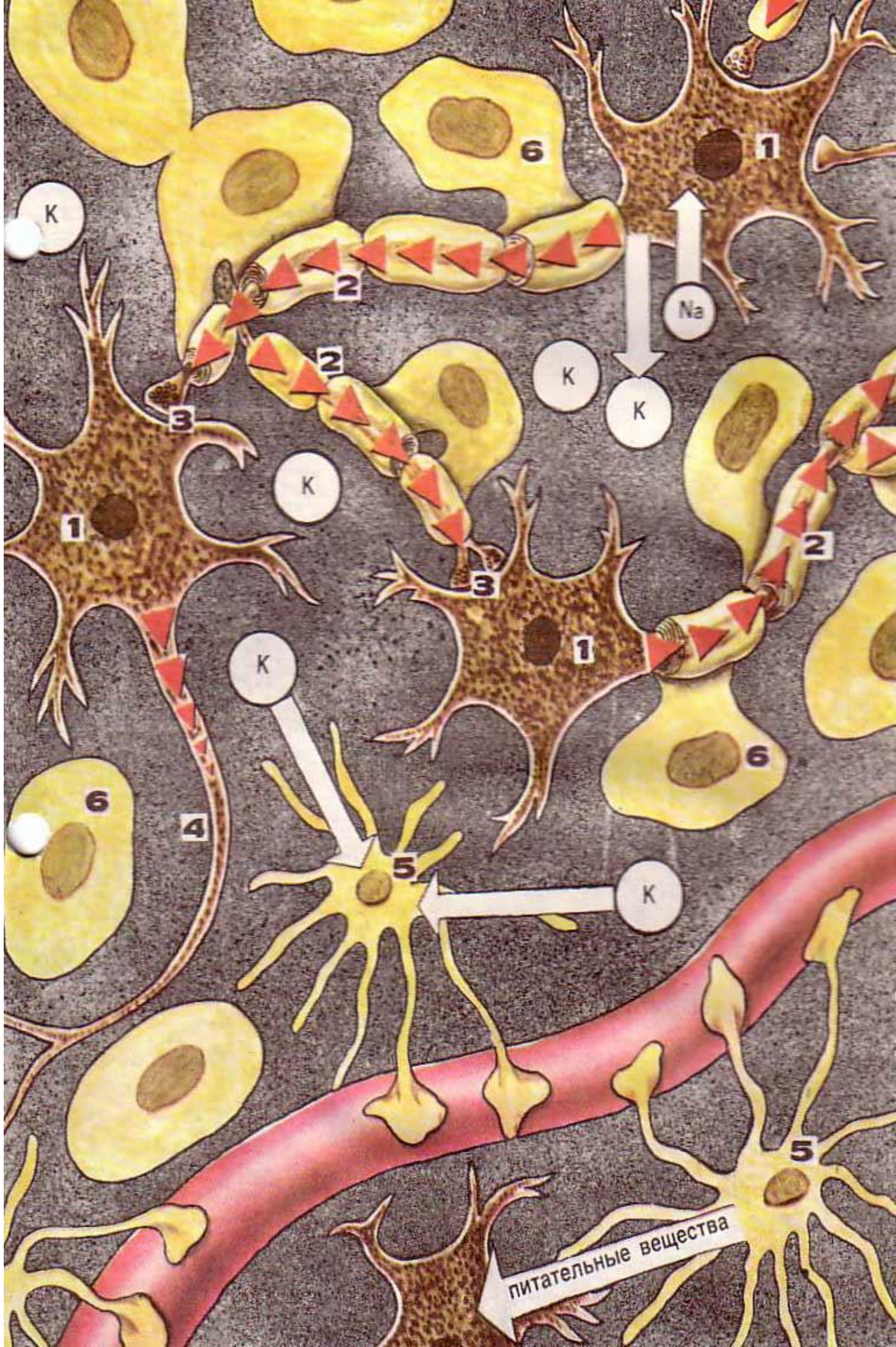
I. **The nervous cells = neurons - generate & transmit nerve impulses;**

II. **Cells of the neuroglia :**

***_Oligodendrocytes_ - neuroglial cells of ectodermal origin that myelinate axons in the central nervous system and form the white matter of the central nervous system (unmyelinated axons are grey matter)**

***_Astrocytes_ - star-shaped nutritive and supportive glia cells of the central nervous** system

***_Microglia_ - small neuroglial cells of mesodermal origin, some of which are phagocytic**



Morphological classification of the neurons
in many ways

In this regard, the <u>classification of neurons use several principles</u>:
• take into account the ***size and shape*** of the cell body;
• the ***number and nature of branching processes***;
• the ***length of the neuron*** and the availability of specialized membranes.

The shape of cells, neurons can be ***spherical, granular, stellate, pyramidal, pyriform, fusiform (spindle-shaped), irregular, etc.***

The size of the cell body varies from ***5 microns*** to small granule cells up to ***120-150 microns*** from the giant pyramidal neurons. The ***length of the neuron*** in humans ranges ***from 150 mm to 120 cm***.

By the number of processes produce the following morphological types of neurons
• ***unipolar*** (single process) neurocytes present, for example, in the sensory trigeminal nucleus in the midbrain;
• ***pseudo-cells*** are grouped near the spinal cord in the spinal ganglia;
• ***bipolar neurons*** (have one axon and one dendrite), located in specialized sensory organs - retina, olfactory epithelium and bulb, auditory and vestibular ganglia;
• ***multipolar neurons*** (have one axon and multiple dendrites), prevailing in the CNS.

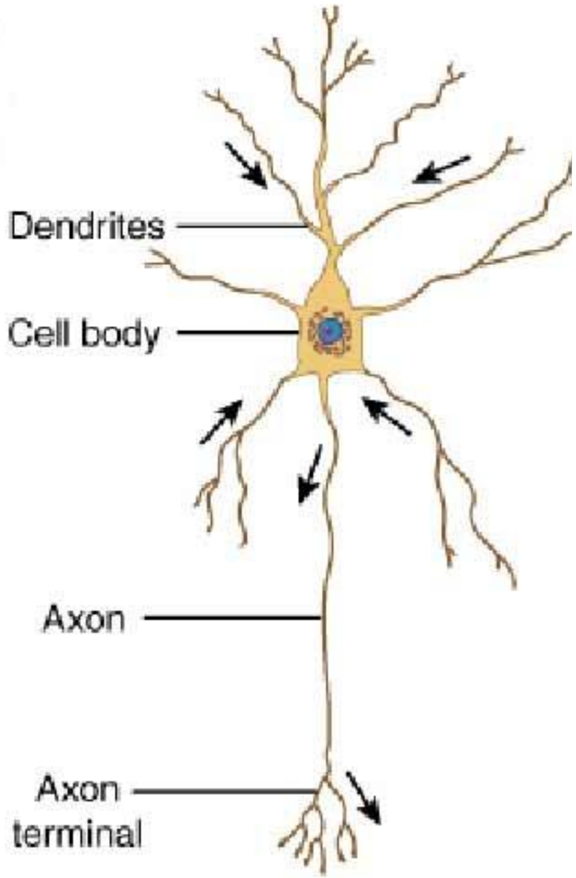
Structure of the neuron

I. **Cell body**

II. **Processes:**

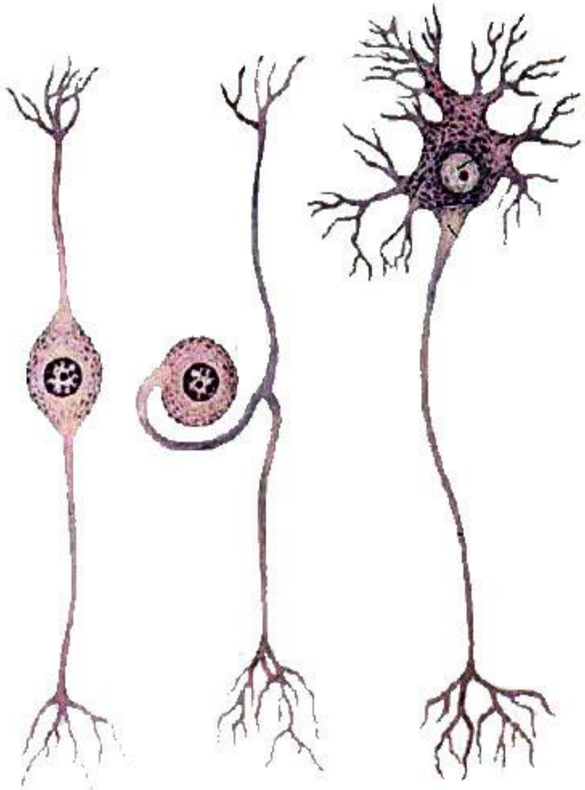
Only one axon

One & more dendrites



Structural classification

- **Bipolar neuron** has an axon and a dendrite
- **Pseudounipolar neuron** has a central branch and a peripheral branch
- **Multipolar neuron** has an axon and two or more dendrites



Functional classification

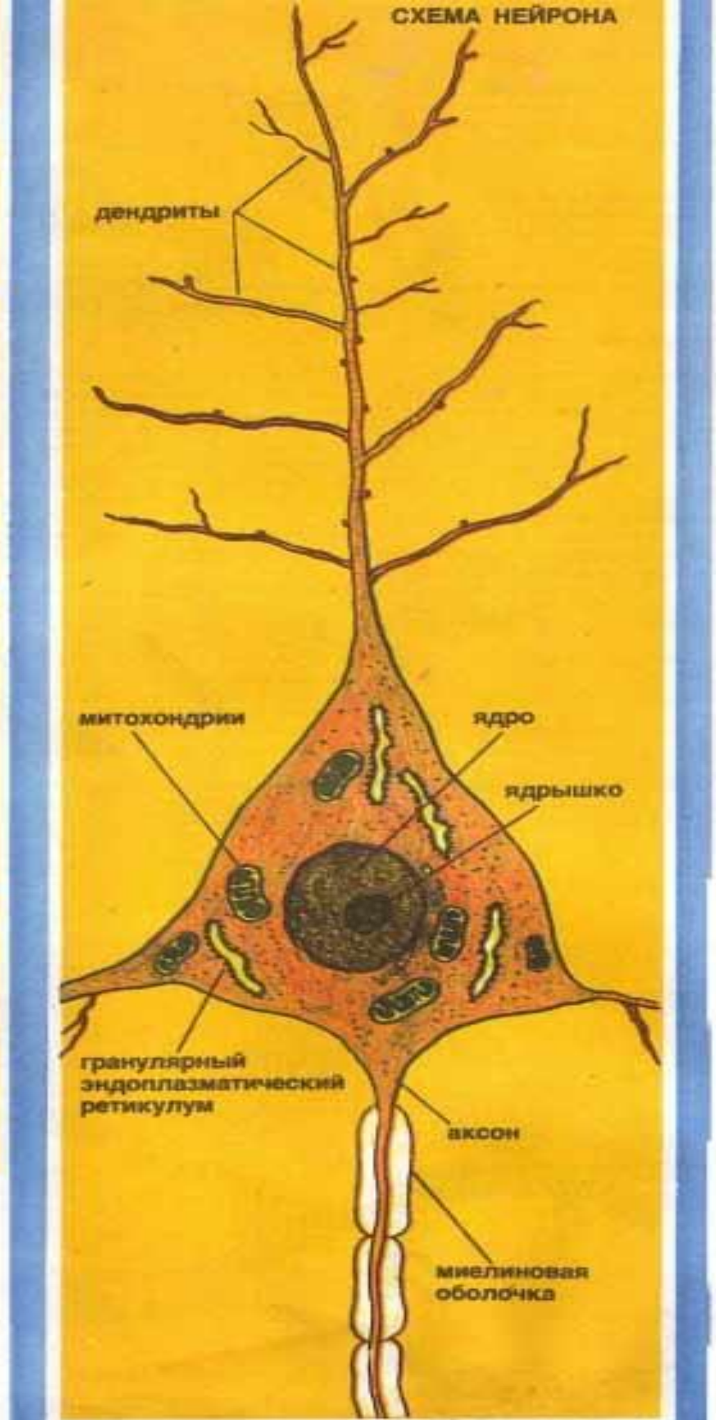
- Sensory (efferent) neuron
- Motor (afferent) neuron
- Association neuron

Cell *bodies* form the *gray matter*

Processes* form the *white matter

In the nervous system, a **synapse** is a structure that permits a neuron (or nerve cell) to pass an electrical or chemical signal to another cell (neural or otherwise).

I.granular cells
II.Pyramidal cells
III.Stelate cells
IV.Spindle-shaped cells



Shapes of the nervous tissue cells

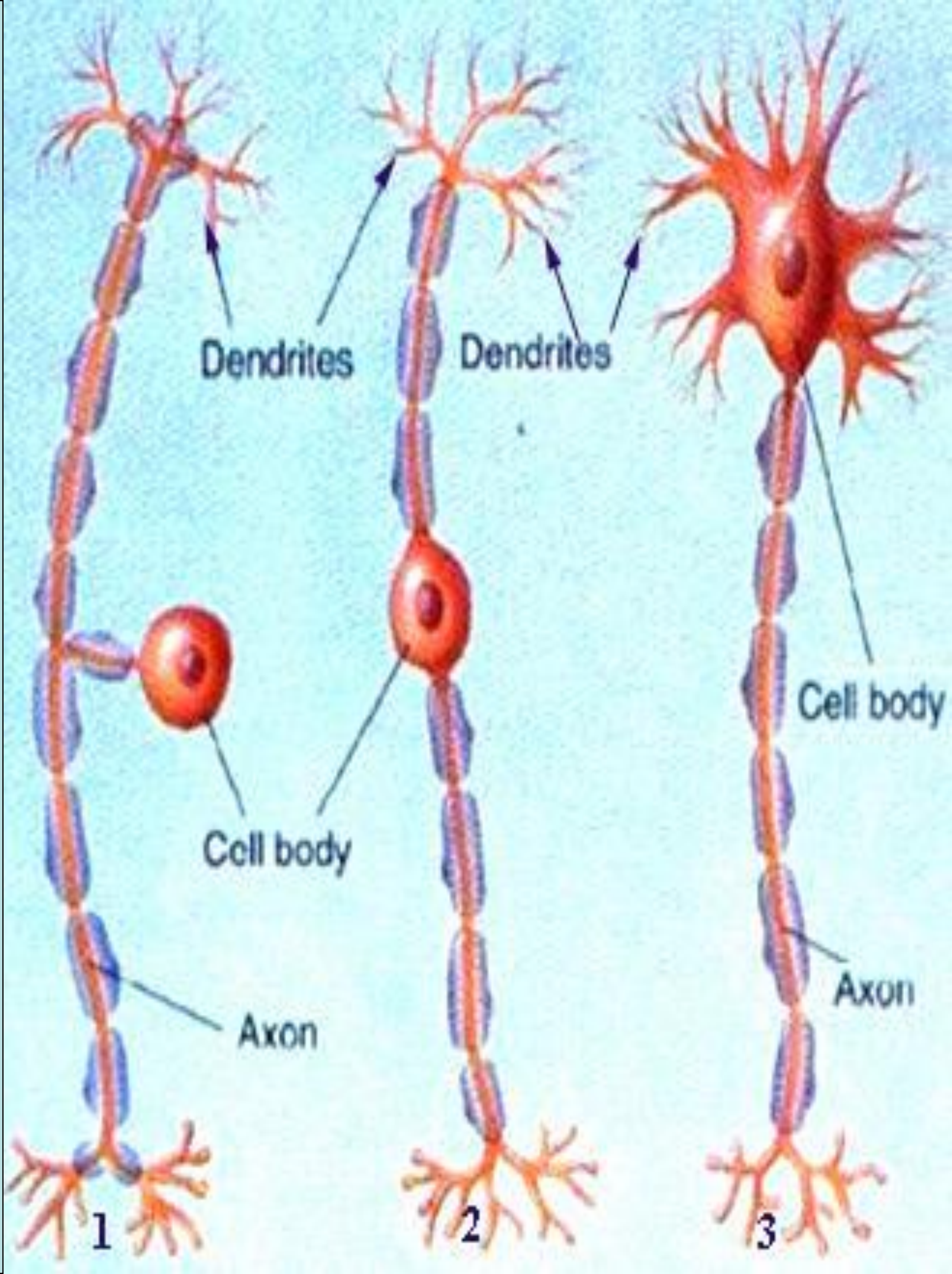
Location of the neurons

1- *Pseudounipolar*, found in the dorsal root ganglia in the PNS, have a single short process that functions as an axon and branches as a T-shape, of which one process leads to the spinal cord and the other extends to a peripheral tissue.

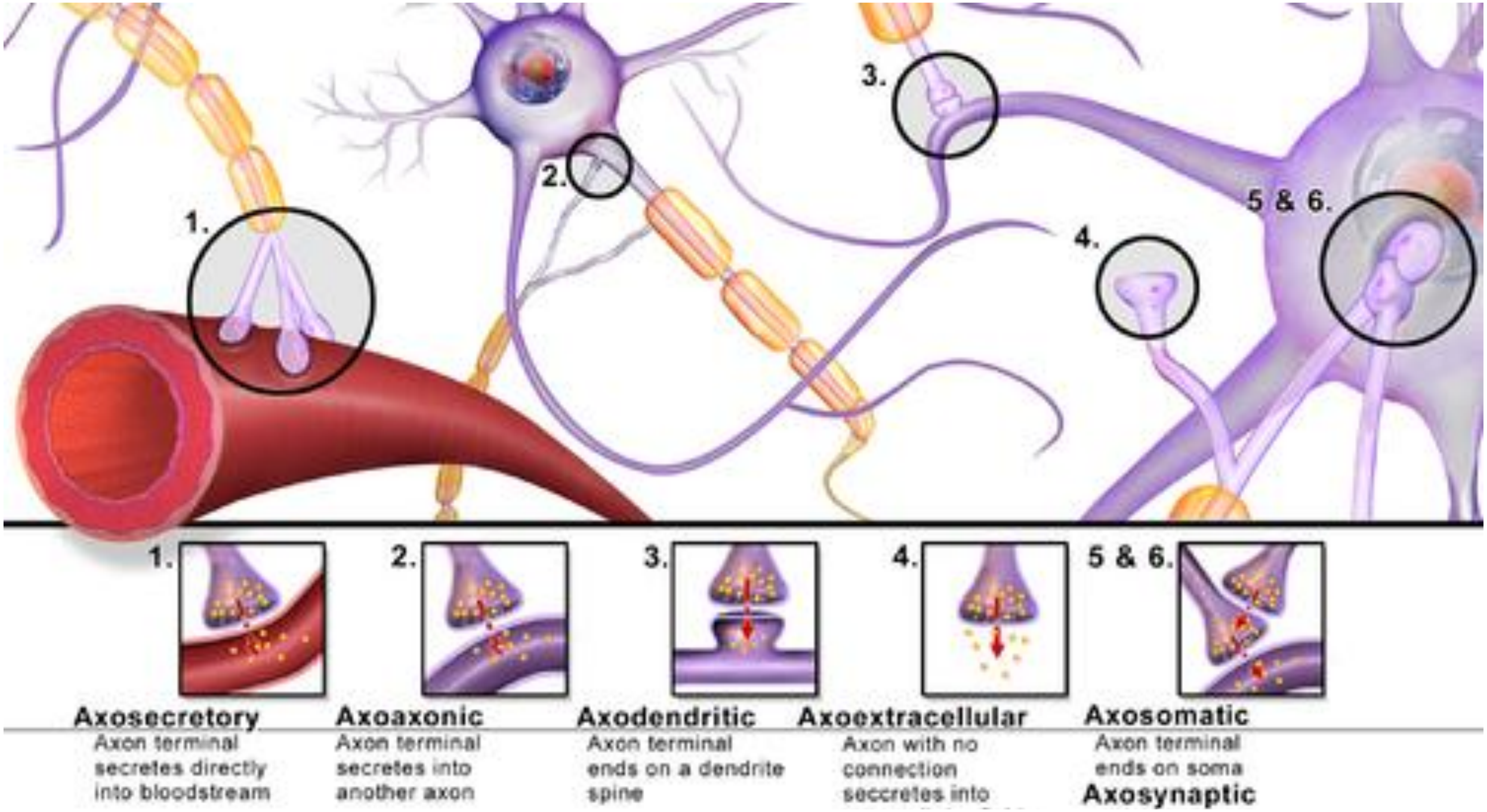
2- Unipolar- found in the dorsal horn of the spinal cord.

3- *Bipolar* neurons, found in the olfactory epithelium and retina, have only two processes – one axon and one dendrite.

4- *Multipolar* neurons, common in the CNS and ANS, have one axon and dozens of dentrites.



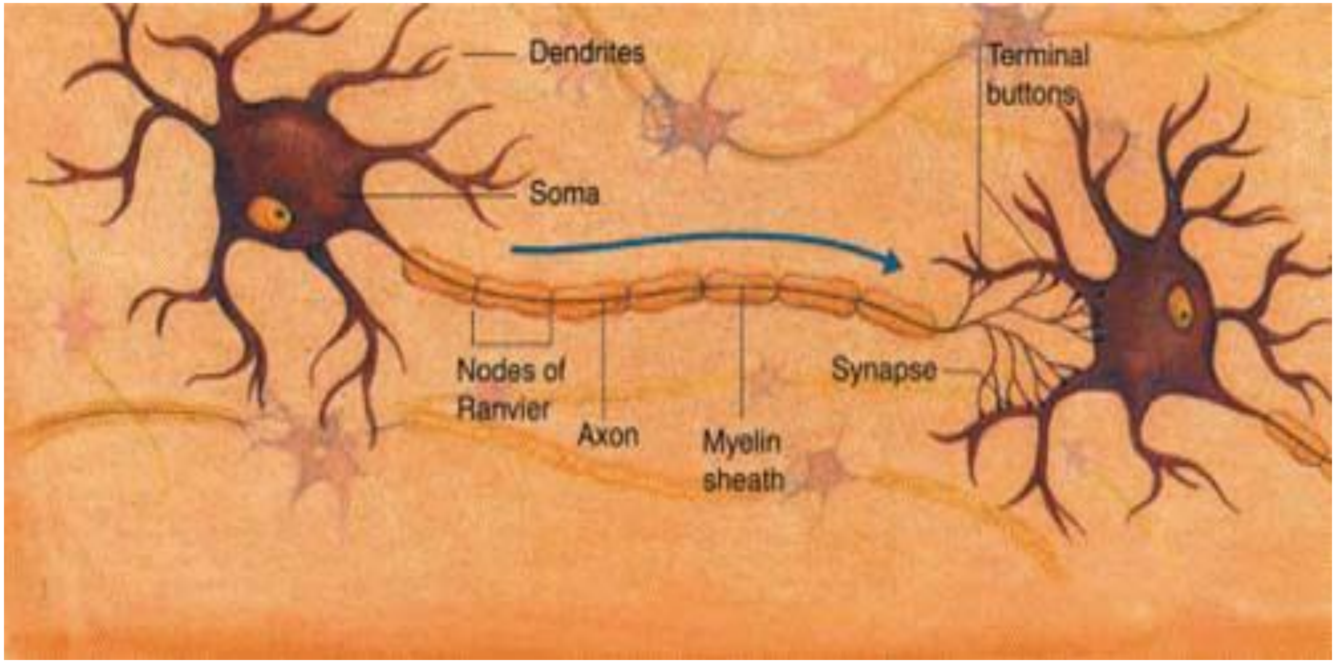
Types of the synapses



Several other types of connections between cells have been discovered. These junctions, thought to be substrates for chemical transmission, occur between:

- two dendrites (**dendrodendritic synapses**),
- a dendrite and an axon (**dendroaxonic synapses**),
- a dendrite and a soma (**dendrosomatic synapses**), and
- any part of a neuron and a node of Ranvier (**nodal synapses**).

Types of the synapses



Axosomatic;

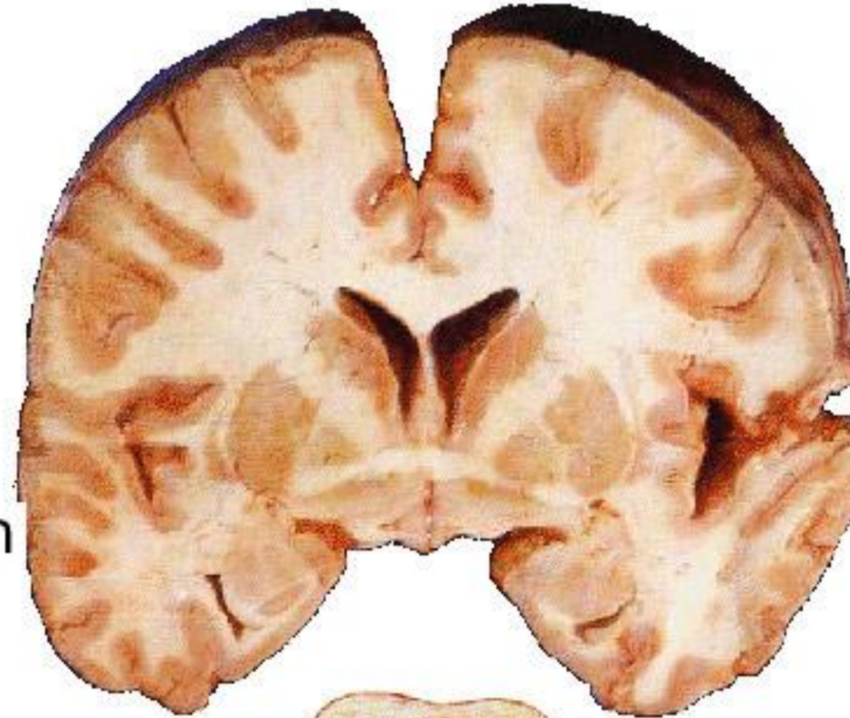
Axodendritic.

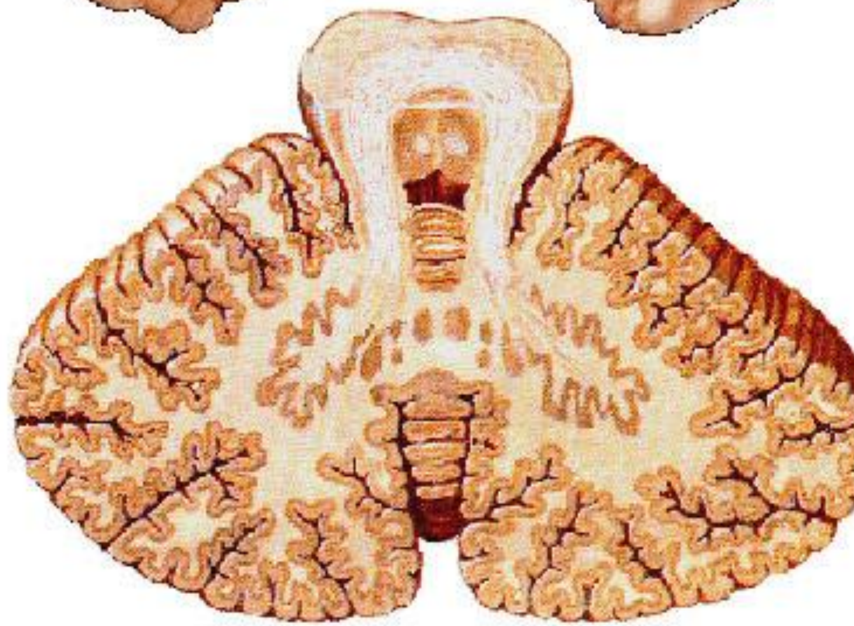
Functions of the neurons

- **sensory neurons** - afferent (receive stimuli from the internal & external environment). Conduct nerve impulses to the CNS.
- **motor neurons** - efferent (conduct impulses from CNS to other neurons, muscles or glands)
- **interneurons** - act as connectors of neurons in chain. They most commonly connect sensory & motor neurons.
- **secretory neurons** - neurons of hypothalamus: supraoptic & paraventricular nuclei – neurons produce hormones: vasopressin & oxytocin);

In the CNS

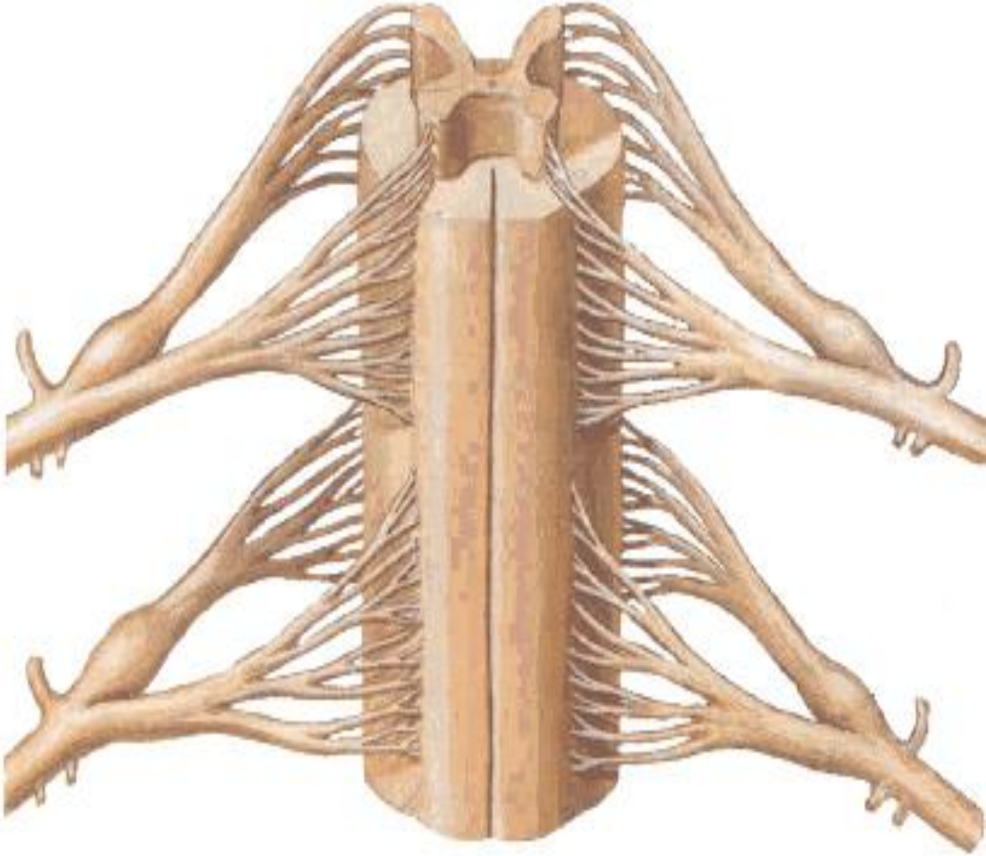
- **Gray matter** : collection of nerve cell bodies and their dendrites, gray color during fresh condition
- **Cortex** : the outermost layer of gray matter in cerebrum and cerebellum
- **White matter** : collection of nerve fibers, white color during fresh condition
- **Medulla**: a central core of white matter beneath cortex of cerebrum and cerebellum
- **Nucleus**: a collection of cell bodies which have the same shape and function





In the PNS

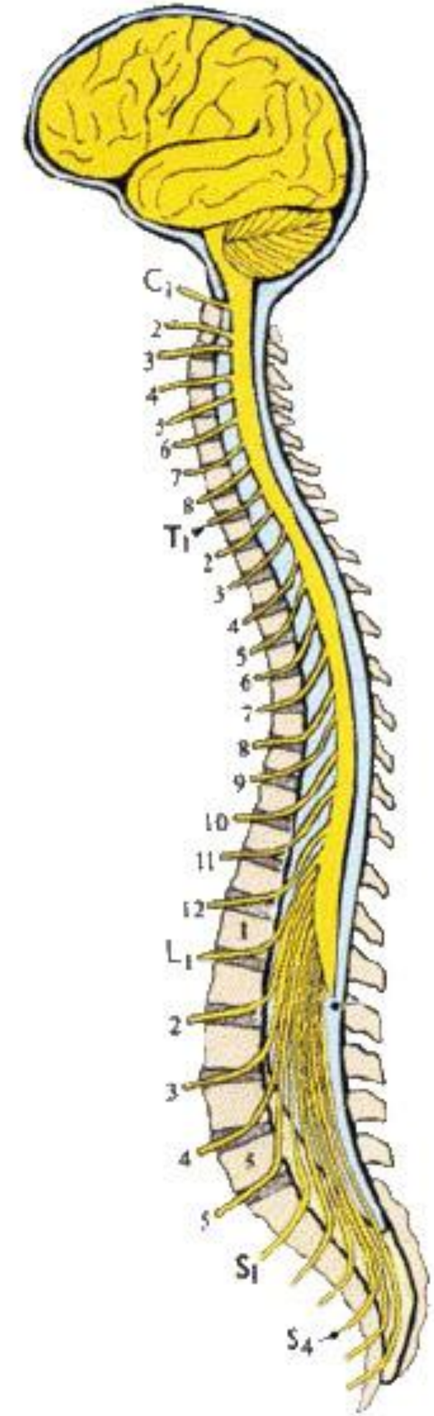
- **Ganglion**
  a collection of neuronal cell bodies outside the CNS
- **Nerve**
  a bundle of nerve fibers held together by connective tissue sheath



The Spinal Cord

Position

- Lies in vertebral canal
- Continuous above with medulla oblongata at level of foramen magnum
- Ends below at lower border of L1 in adult; at birth at level of L3



EXTERNAL ANATOMY OF THE SPINAL CORD

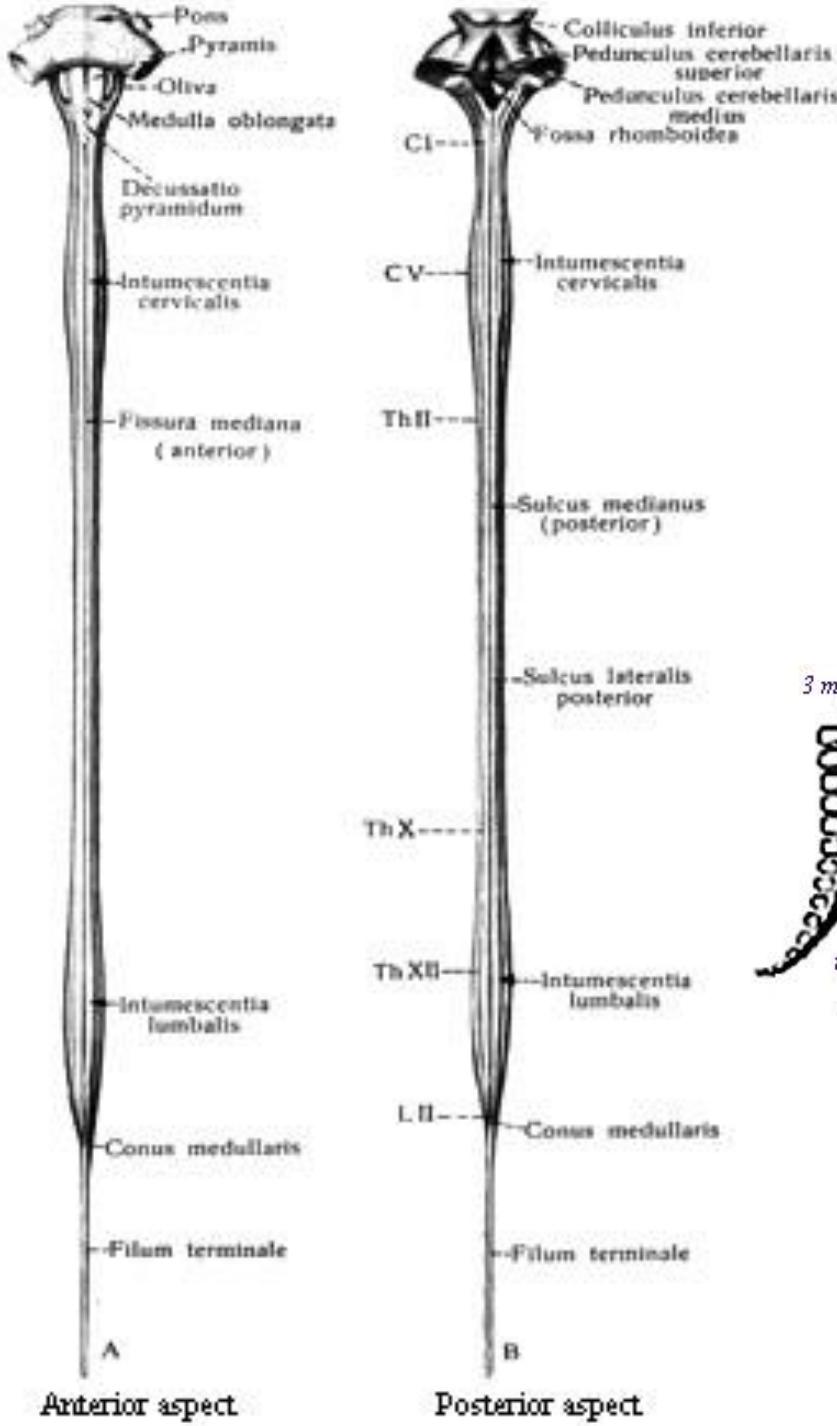
The spinal cord is roughly cylindrical and flattened in anterior-posterior dimension.

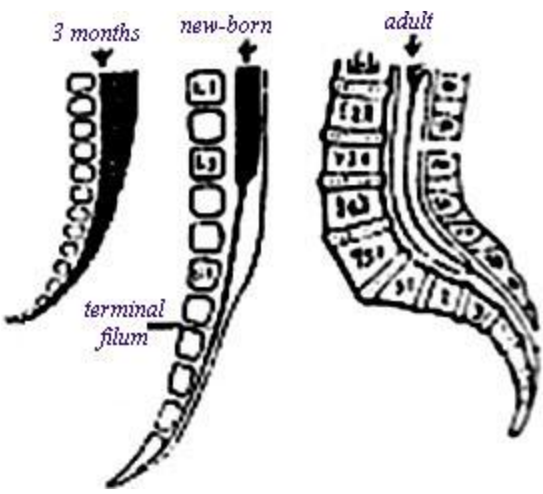
<u>Differential growth</u> – early in development the spinal cord fills the entire vertebral canal. By the time of birth, the tip of the cord reaches only to level L3-4.

At age 4-5 it had reached its adult length and ceases to grow.

Differential growth, continuing until adult statute is reached, is responsible for the disparity in length between the vertebral canal and the spinal cord of the adult.

<u>Adult length</u> –in the adult, the spinal cord extends from the foramen magnum where it is continuous with the medulla of the brain, to vertebral level L2.



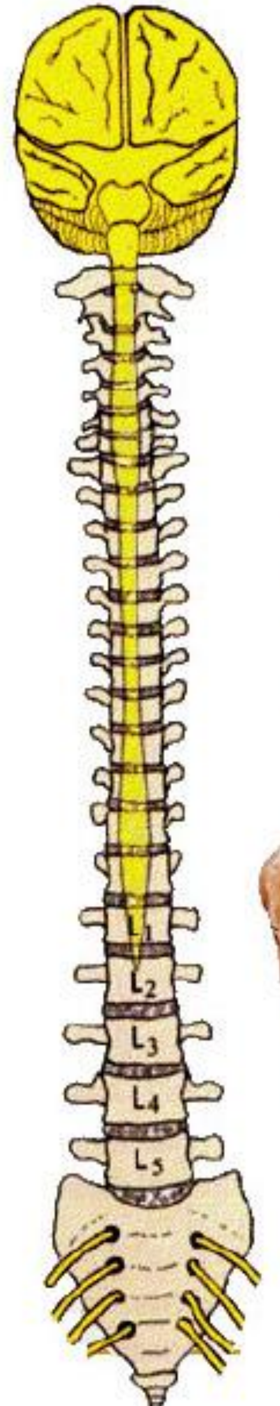


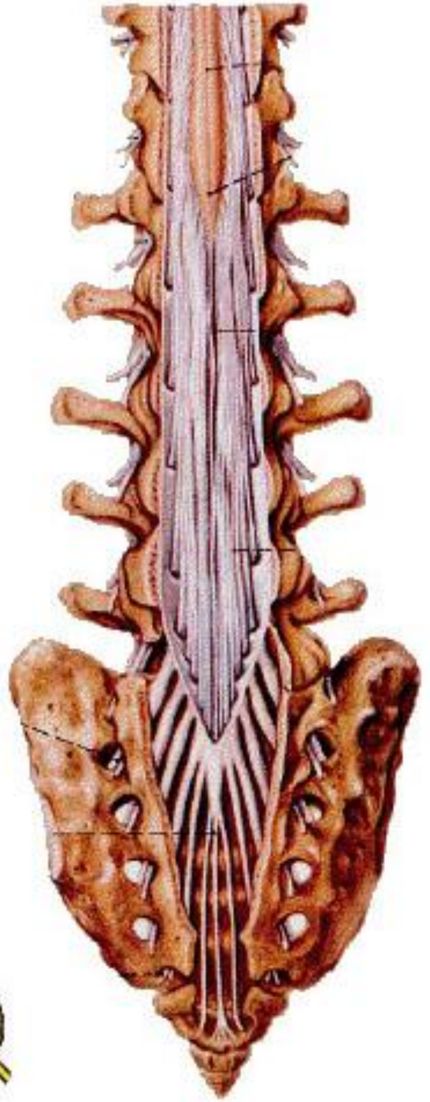
External features

- A long cylindrical structure and slightly flattened anteroposteriorly,
- **Conus medullaris**
- **Filum terminale**
- **Cauda equina**
- Two enlargements

Cervical enlargement corresponds to the C4 to the T1 segments

Lumbosacral enlargement corresponds to **the L2 to the S3** segments





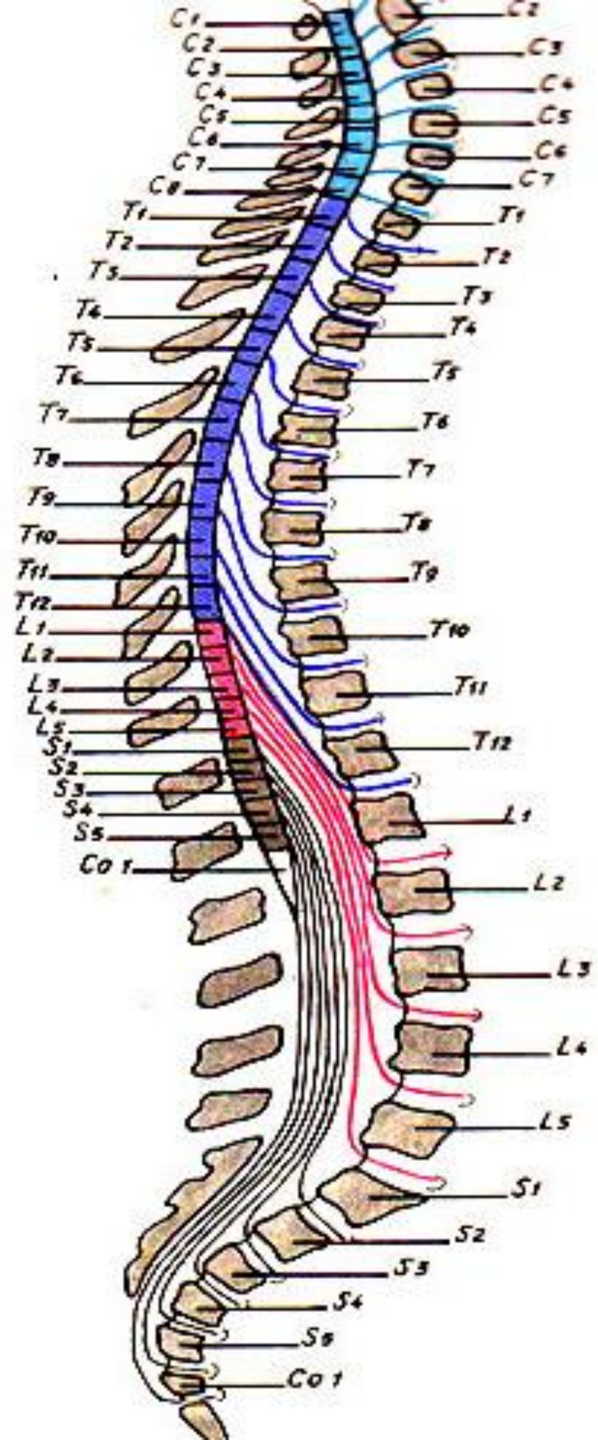
Fissure and grooves

- **Anterior median fissure**
- **Posterior median sulcus**
- **Anterolateral sulcus** – anterior (motor) roots emerge serially
- **Posterolateral sulcus**– posterior (sensory) roots enter spinal cord, each bear a spinal ganglion which constitutes the first cell-station of the sensory nerves

Relationship of segments of spinal cord to vertebrae

- A portion of the cord that gives rise to a pair of spinal nerve constitutes a segment.

- There are 31 segments
  - 8 cervical
  - 12 thoracic
  - 5 lumbar
  - 5 sacral
  - 1 coccygeal



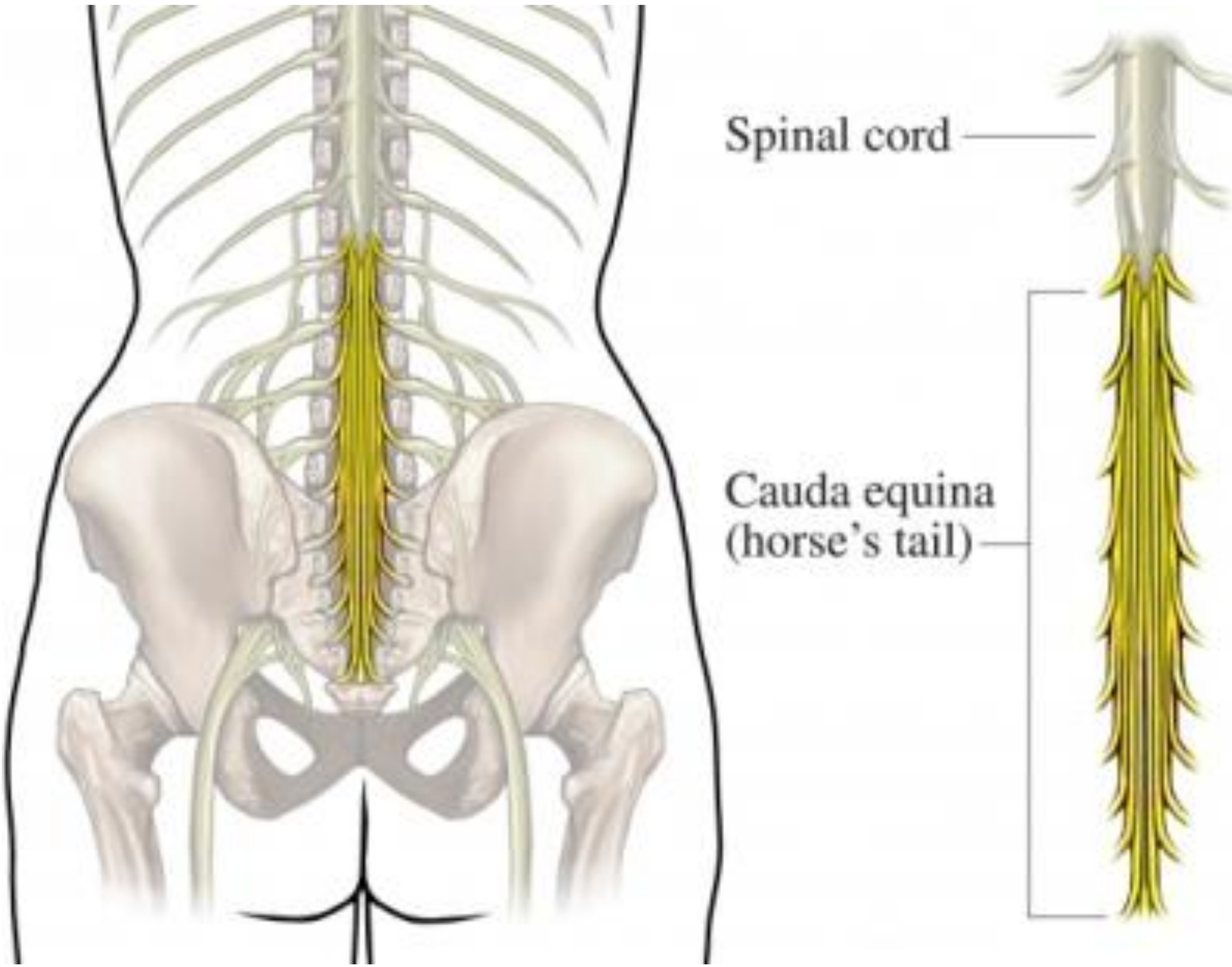
SPINAL NERVES & CAUDA EQUINA

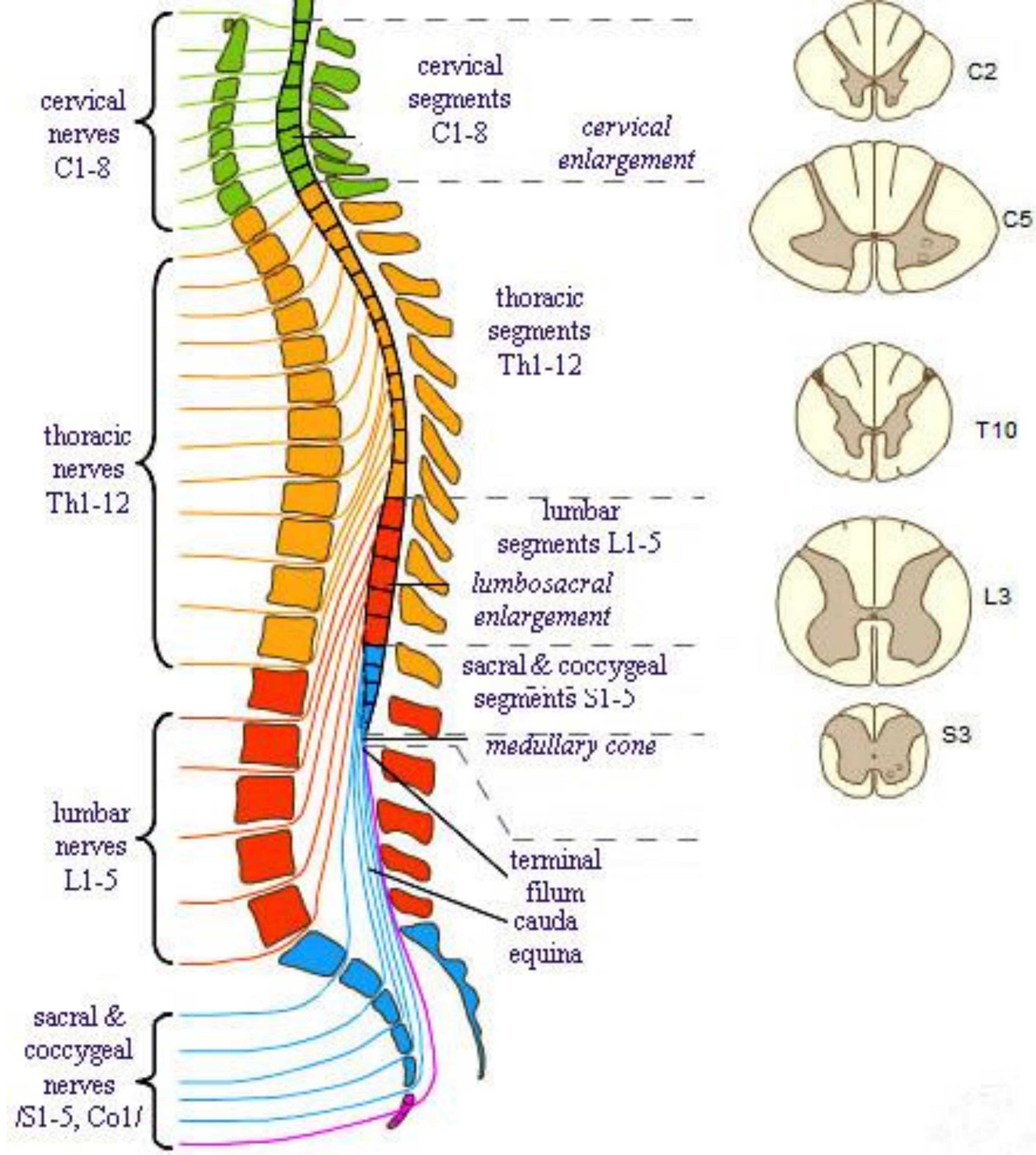
Spinal nerves

- 20 pairs between brain stem and T12
- voluntary movement
- involuntary movement

Cauda Equina

- starts at T12-L1 to coccyx
- 11 pairs of spinal nerves

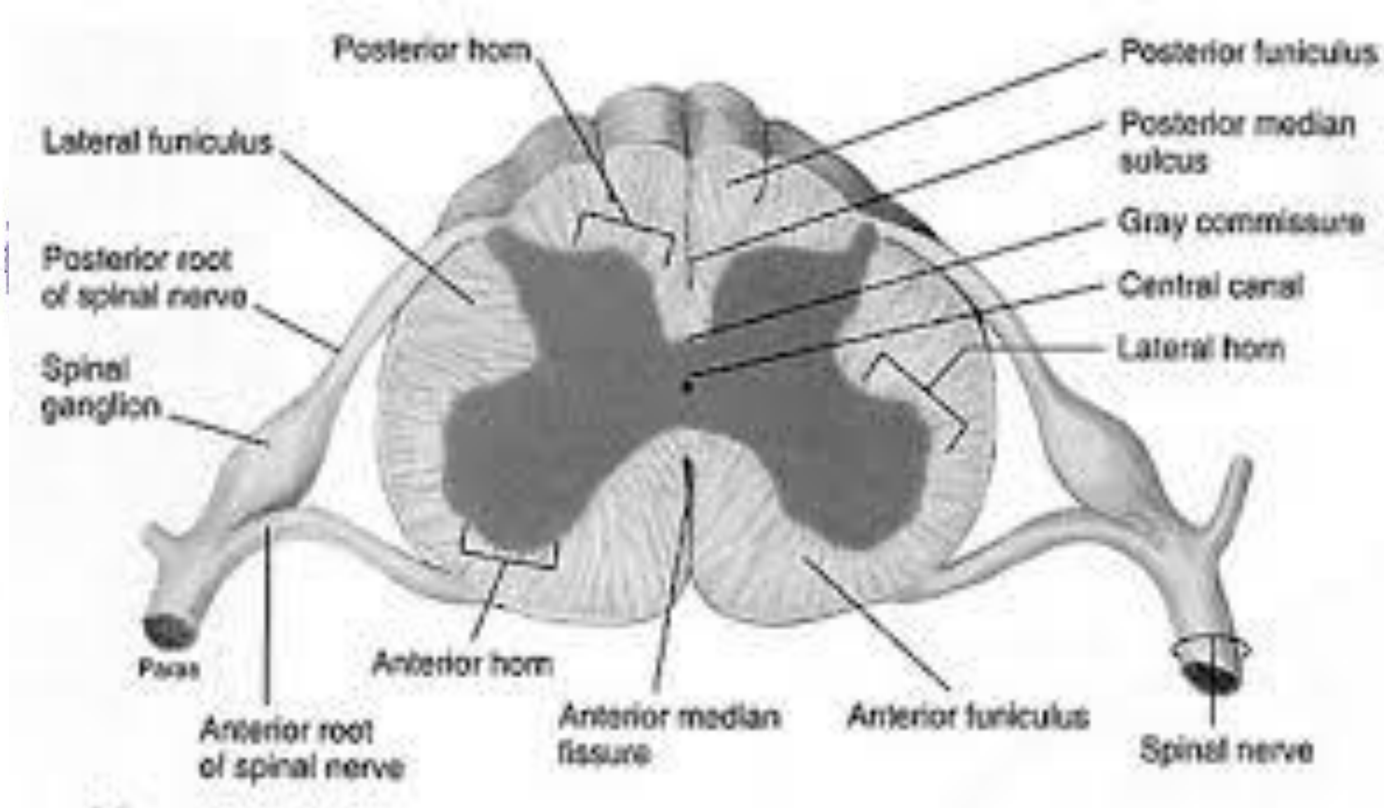




cervical nerves C1-8
thoracic nerves Th1-12
lumbar nerves L1-5
sacral & coccygeal nerves /S1-5, Co1/
cervical segments C1-8
cervical enlargement
thoracic segments Th1-12
lumbar segments L1-5
lumbosacral enlargement
sacral & coccygeal segments S1-5
medullary cone
terminal filum
cauda equina
C2
C5
T10
L3
S3

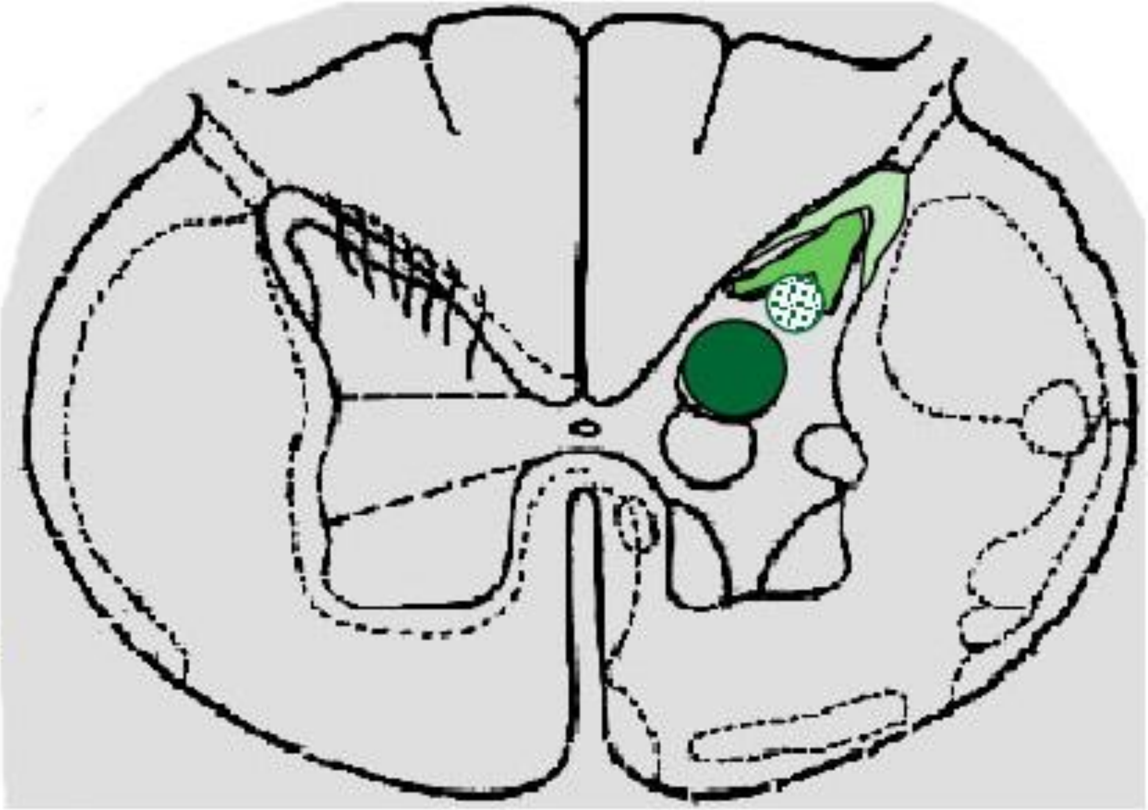
Internal structures

- Central canal
- Gray matter
  - Anterior horn (column)
  - Posterior horn (column)
  - Intermediate zone
    - Lateral horn (column)
  - Anterior gray commissure
  - Posterior gray commissure
- White matter
  - Anterior funiculus
  - lateral funiculus
  - Posterior funiculus
  - Anterior white commisure



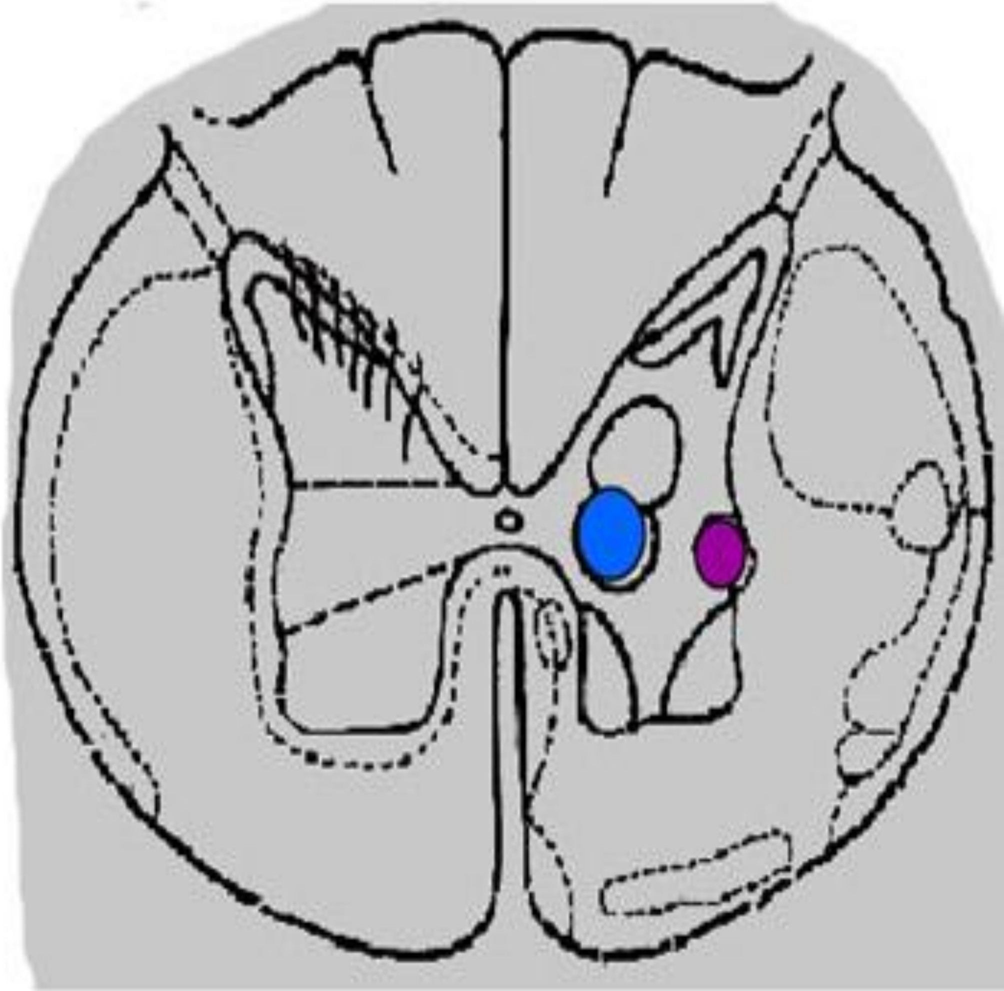
Posterior horn

- **Marginal layer**
- **Substantia gelatinosa**
- **Nucleus proprius**
- **Nucleus thoracicus** in segments C8~L3



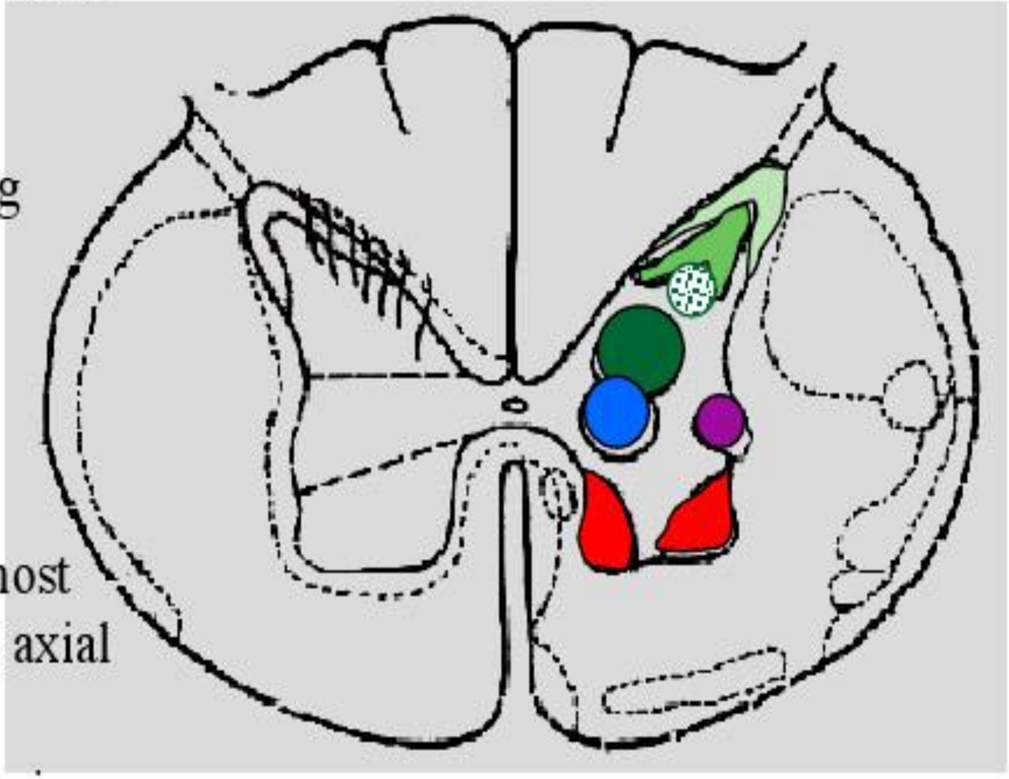
Intermediate zone

- **Intermediolateral nucleus**
  lateral horn or column
  lies in segments T1~L3.
  containing sympathetic
  preganglionic neurons
- **Sacral parasympathetic nucleus**
  lies in segments S2~S4,
  containing parasympathetic
  preganglionic neurons
- **Intermediomedial nucleus**
  for sensation of viscera



Anterior horn contains motor neurons

- Three kinds of neuron
  - **α-motor neuron**: larger multipolar neuron, innervates extrafusal fibers of skeletal m., producing contraction of m.
  - **γ-motor neuron**: smaller neuron, innervates intrafusal fibers regulating muscular tonus
  - **Renshaw's cell**: negative feedback mechanism



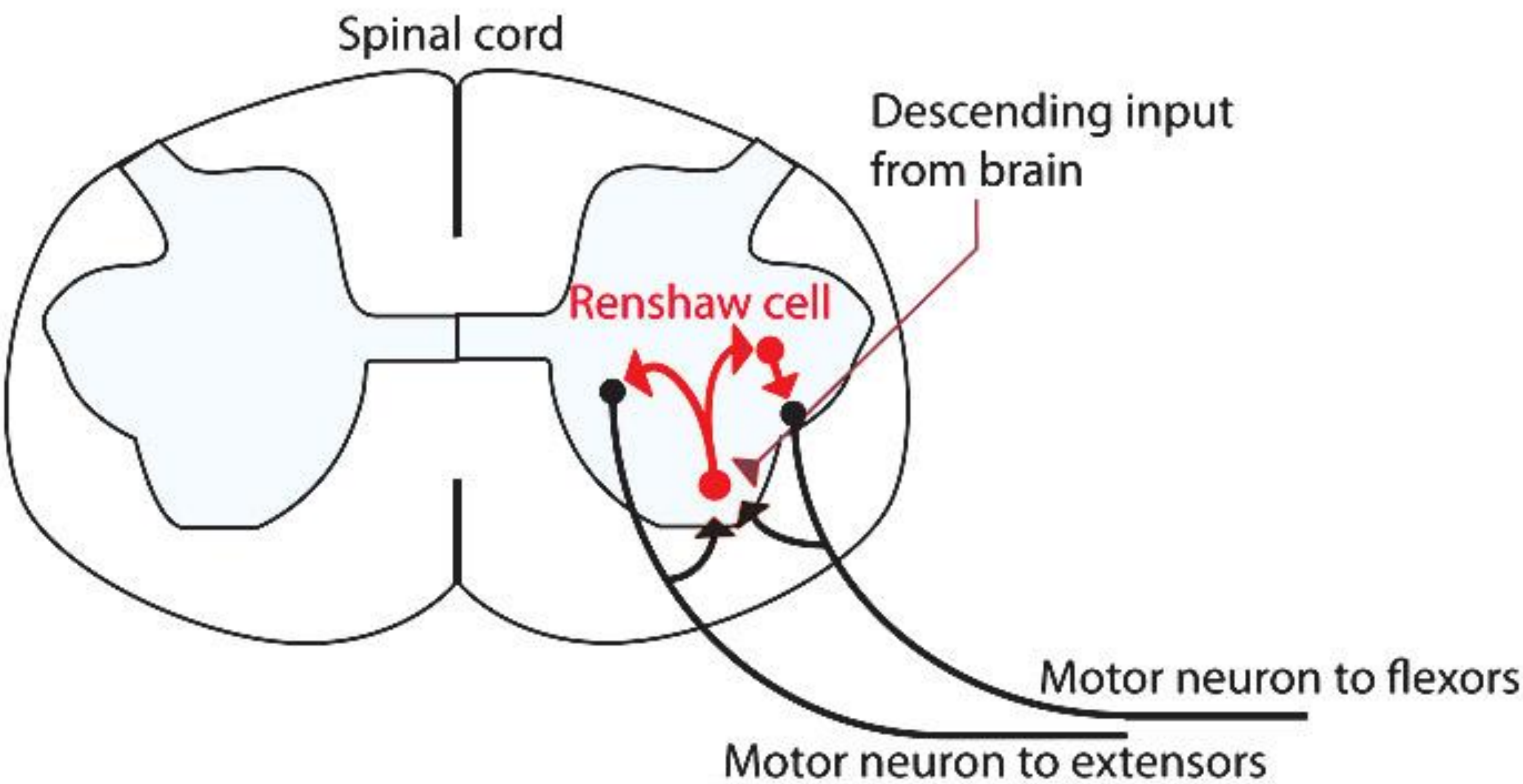
- Two groups of nuclei
  - **Medial nuclear group**: present in most segments of spinal cord, innervating axial muscles
  - **Lateral nuclear group**: present only in cervical and lumbosacral enlargements, innervating limb muscles

Important Subdivision of Spinal Cord

Gray Matter

Region	Nucleus
Posterior horn	Marginal layer
	Substantia gelatinosa
	Nucleus proprius
Intermediate zone	Nucleus thoracicus (C8~L3)
	Intermediolateral nucleus (T1~L3)
	Sacral parasympathetic nucleus (S2~S4)
	Intermediomedial nucleus
Anterior horn	Motor nuclei

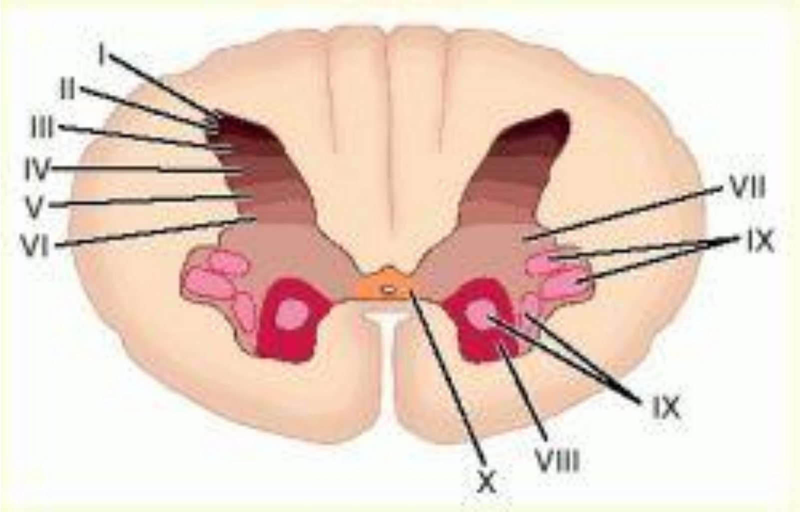
- **Renshaw cells** are inhibitory interneurons found in the gray matter of the spinal cord, and are associated in two ways with an alpha motor neuron.
- They receive an excitatory collateral from the alpha neuron's axon as they emerge from the motor root, and are thus "kept informed" of how vigorously that neuron is firing.
- They send an inhibitory axon to synapse with the cell body of the initial alpha neuron and/or an alpha motor neuron of the same motor pool.
- In this way, Renshaw cell inhibition represents a negative feedback mechanism. A Renshaw cell may be supplied by more than one alpha motor neuron collateral and it may synapse on multiple motor neurons.



Rexed laminae

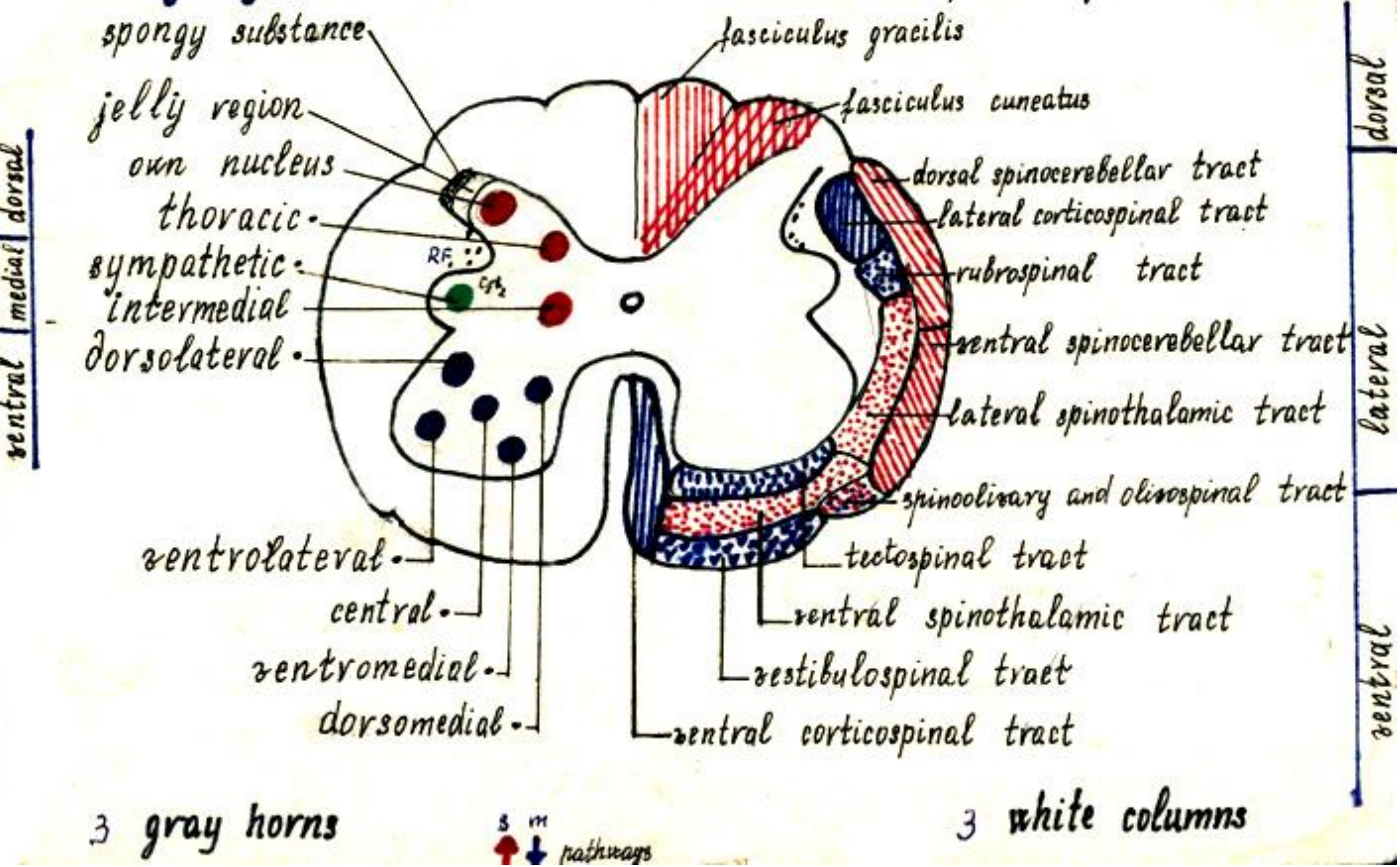
- They comprise a system of ten layers of grey matter (I-X), identified in the early 1950s by Bror Rexed to label portions of the spinal cord.
- They are defined by their ***cellular structure*** rather than by their location, but the location still remains reasonably consistent.

Laminae:



- Posterior/dorsal horn: I-VI
  - Lamina I: marginal nucleus of spinal cord or posteromarginal nucleus
  - Lamina II: substantia gelatinosa of Rolando
  - Laminae III/IV: nucleus proprius
  - Lamina V: neck of the dorsal horn
  - Lamina VI: base of the dorsal horn,
- Intermediate zone: VII and X
  - Lamina VII: intermediomedial nucleus, intermediolateral nucleus, nucleus dorsalis in the thoracic and upper lumbar region
  - Lamina X: central gray matter i.e. neurons bordering Central canal
- Anterior/ventral horn: VIII-IX
  - Lamina VIII: motor interneurons
  - Lamina IX: lateral (in limb regions) and medial motor neurons, also phrenic and spinal accessory nuclei at cervical levels, and Onuf's nucleus in the sacral region

A cross-sectinal view of the gray matter and white matter of the spinal cord

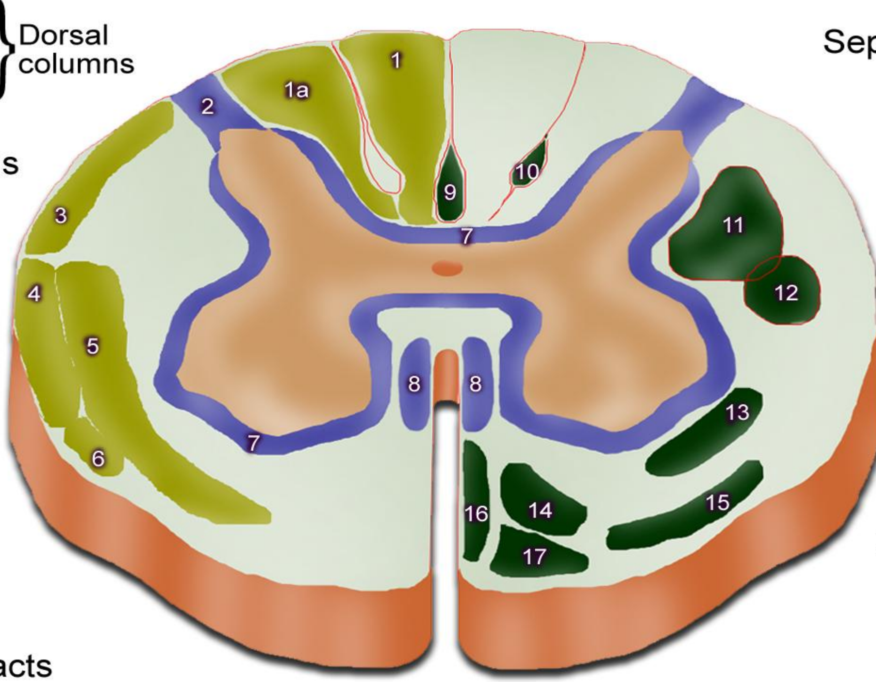


Spinal Cord Crossection: Detailed Anantomy

1. Fasciculus gracilis
1a. Fasciculus cuneatus

(1 and 1a: Dorsal columns)

2. Dorsolateral fasciculus or tract of Lissauer
3. Posterior or dorsal spinocerebellar tract
4. Anterior or ventral spinocerebellar tract
5. Spinothalamic, spinoreticular, spinomesencephalic (spinotectal), and spinohypothalamic tracts
6. Spinoolivary tract
7. Fasciculi proprii
8. Medial longtudinal or sulcomarginal fasciculi



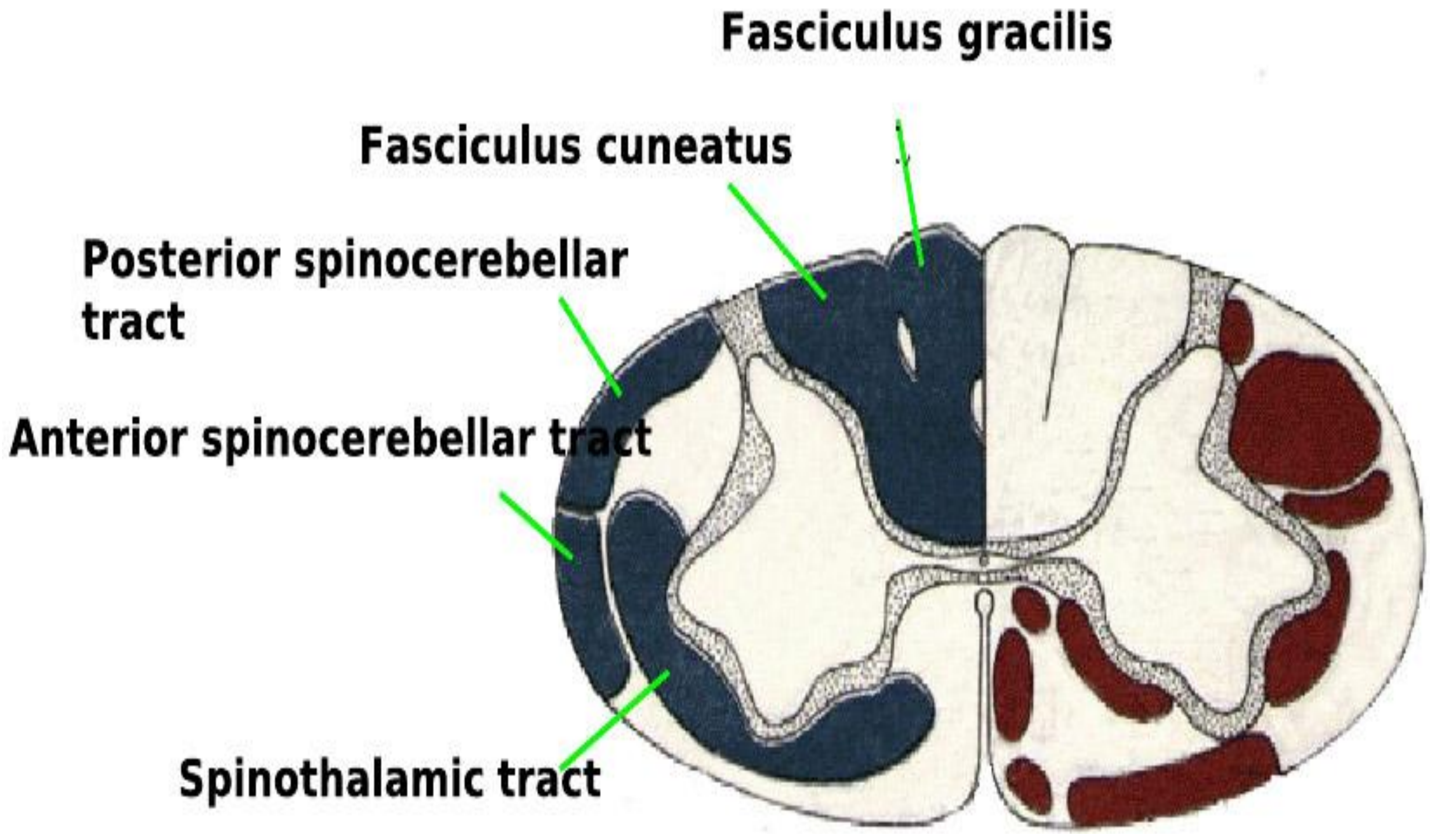
9. Septomarginal fasciculus
10. Interfascicular or semilunar fasciculus
11. Lateral corticospinal or pyramidal
12. Rubrospinal tract
13. Medullary or lateral reticulospinal tract
14. Pontoreticulospinal or medial reticulospinal tract
15. Vestibulospinal tract
16. Anterior or ventral corticospinal tract
17. Tectospinal tract

Ascending tracts

Decending tracts

Bidirectional tracts

Ascending tracts



- *sensory informations from periphery to the brain centers*

1. Spino-bulbar (posterior funiculi) – *epicritic sens.*
    a. *fasciculus cuneatus*
    b. *fasciculus gracilis*
2. Spino-thalamic (ant., lat.) – *prothopatic sens.*
3. Spino-cerebellar (ant., post.) - *proprioception*
4. Spino-tectal tr.
5. Spino-reticular tr.
6. Spino-olivary tr.

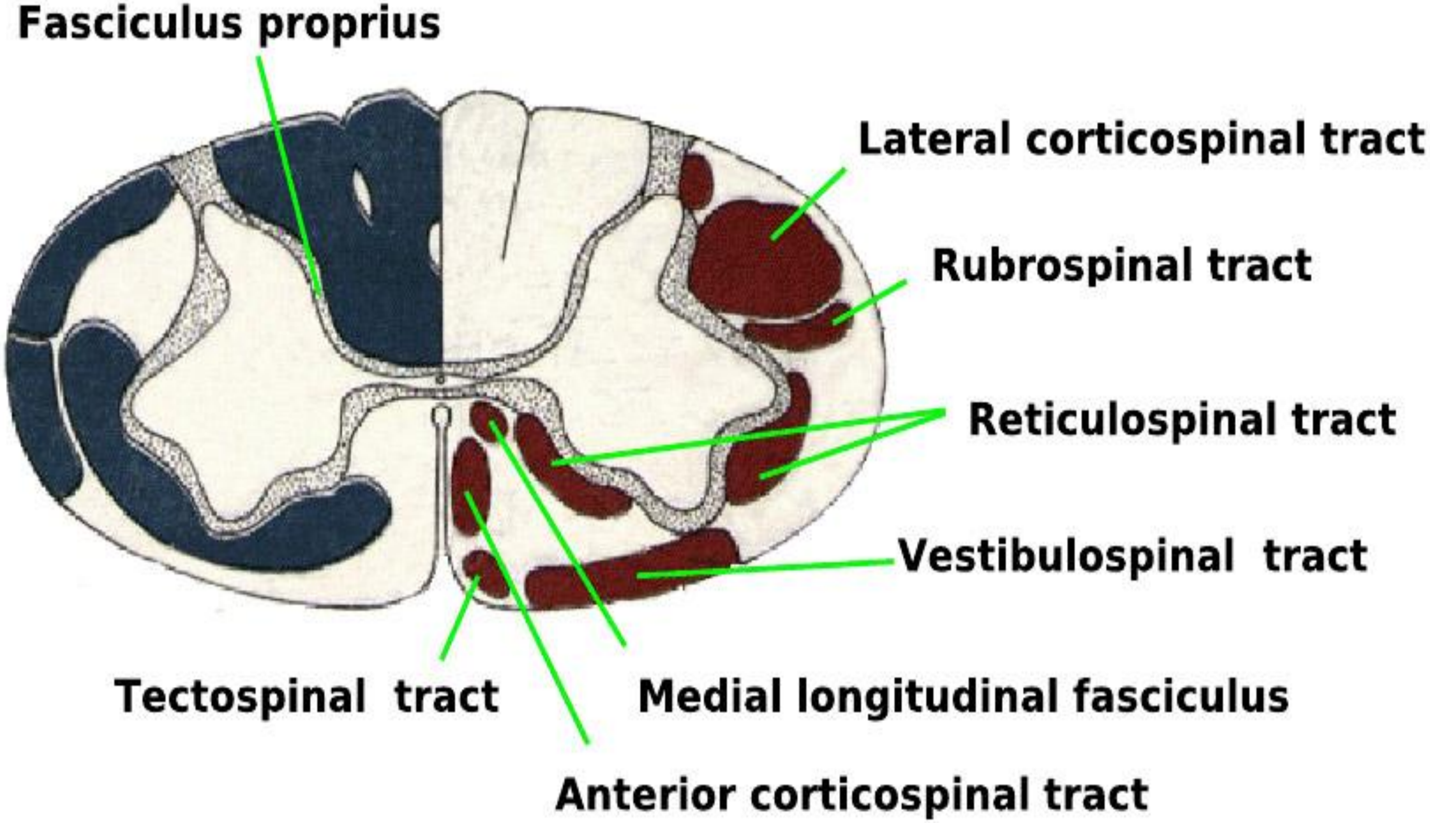
<u>Propriospinal tracts – proper fasciculi</u>

Intersegmental motor and sensory tracts

ASCENDING TRACTS

Tract	Site of origin	Funiculus	Termination	Function
Fasciculus gracilis	Spinal ganglia below segment T5	Posterior	Gracile nucleus	Convey proprioceptive and fine touch sensation of trunk and limbs
Fasciculus cuneatus	Spinal ganglia above segment T4		Cuneate nucleus	
Posterior spinocerebellar	Homolateral nucleus thoracicus	Lateral	Cerebellum	Unconscious proprioception from lower limb and lower portion of trunk
Anterior spinocerebellar	Contralateral Laminae V~VII			
Spinothalamic	Laminae I, IV~VII	Lateral and anterior	Dorsal thalamus	Pain, temperature and simple touch sensation of trunk and limbs

Descending tracts



- *motor impulses from brain to the anterior horns (motoneurons)*

1. Cortico-spinal tract (ant., lat.) *(pyramidal pathway)*

2. Rubro-spinal tr.
3. Reticulo-spinal tr.
4. Vestibulo-spinal tr.
5. Tecto-spinal tr.

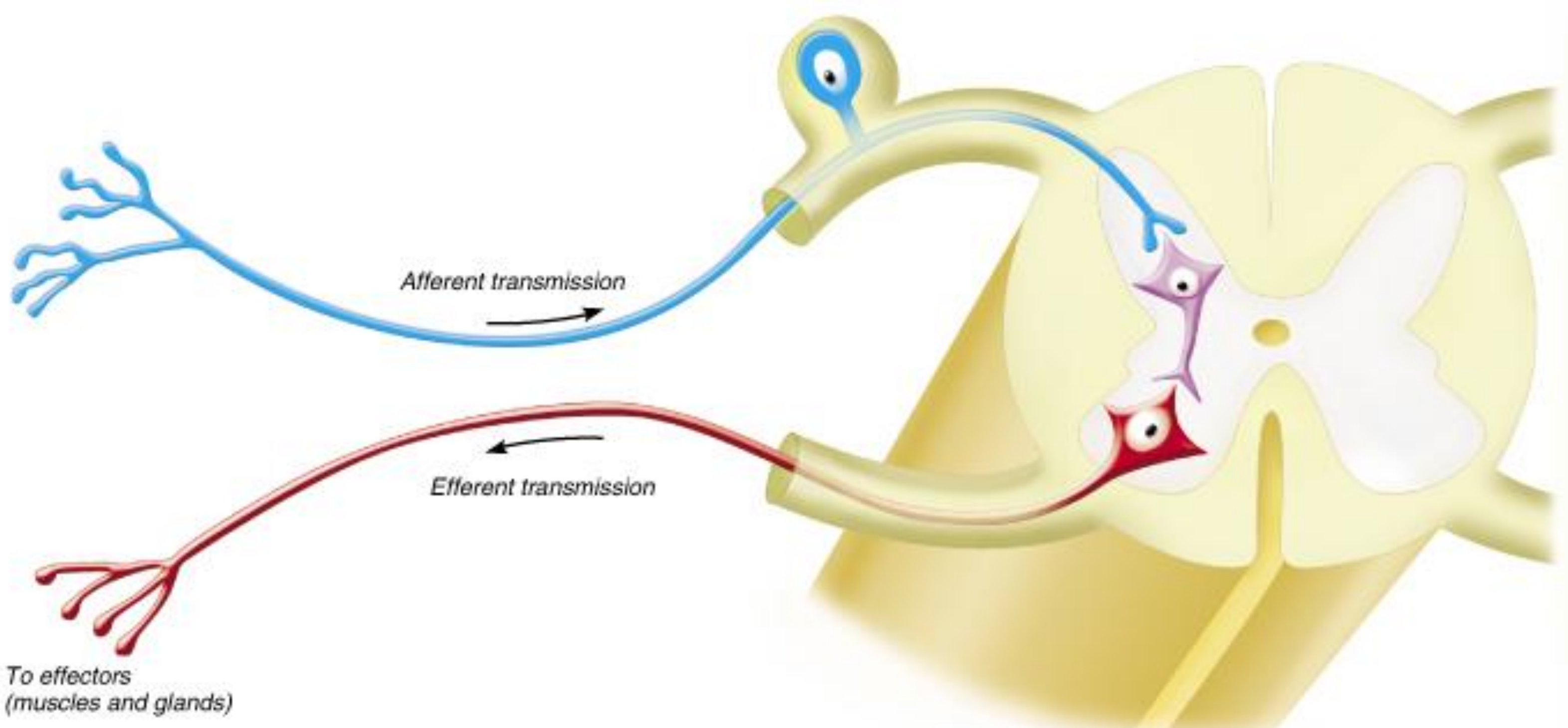
→ *extrapyramidal pathways*

Descending tracts

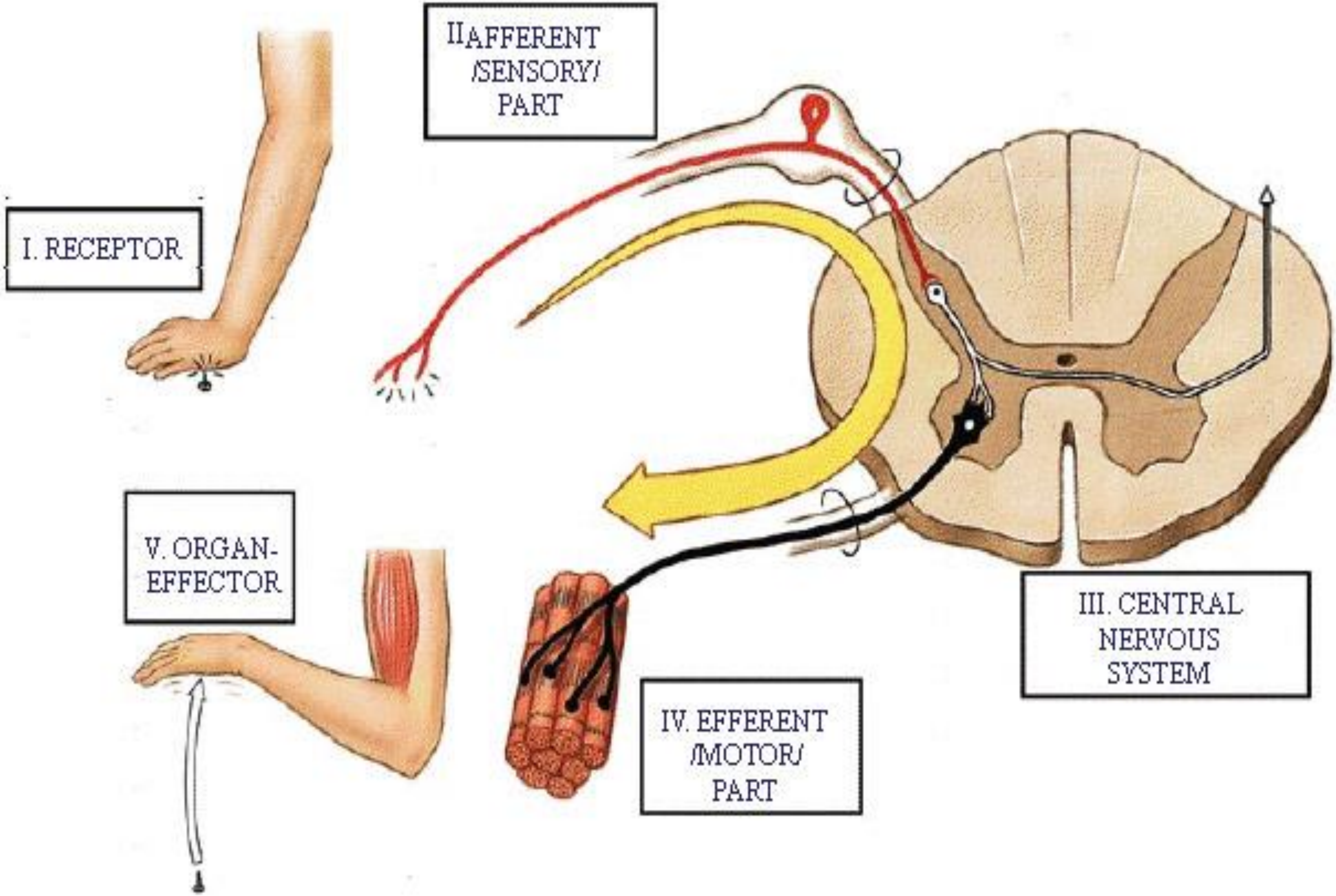
Tract	Site of origin	Funiculus	Termination	Function
Lateral corticospinal	Cerebral cortex	Lateral	Laminae IV~IX anterior horn	Voluntary movement
Anterior corticospinal	Cerebral cortex	Anterior		
Rubrospinal	Red nucleus	Lateral	Laminae VII~VII	Excitatory of flexors
Vestibulospinal	Homolateral vestibular nuclei	Anterior	Laminae VII~VIII	Excitatory of extensors
Reticulospinal	Reticular formation	Anterior and lateral	Laminae VII~VIII	Involuntary movement
Medial longitudinal fasciculus	Vestibular nuclei	Anterior	Laminae VII~VIII	Coordinate neck with eye movement
Tectospinal	Superior colliculus	Anterior	Laminae VI~VIII	
Fasciculus proprius	Spinal cord	Anterior, lateral and posterior	Spinal cord	Intrinsic reflex mechanism of spinal cord

Reflex and reflex arch

Reflex is a motor response that occurs following a sensory stimulus.
The anatomical basis of a reflex is the ***reflex arc*** formed by a ***receptor***, ***afferent path***, ***nerve center,*** ***efferent path*** and ***effector.***

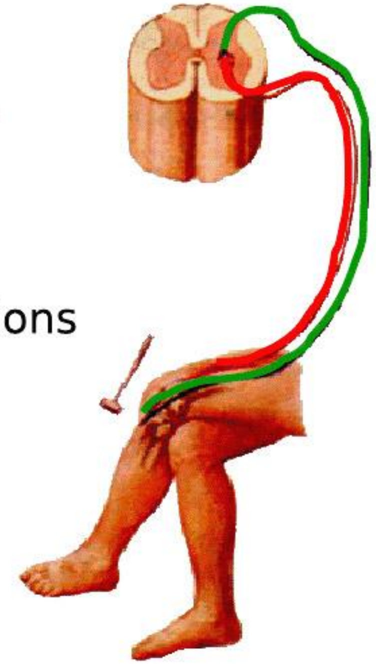


COMPONENTS OF A REFLEX ARCH



Main functions of spinal cord

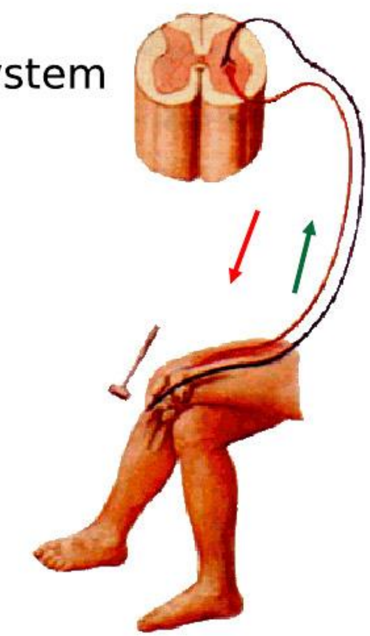
- Conduction of excitations
- Reflex activity



Reflex and reflex arch

- **Reflex**: a reaction of the organism by the nervous system in response to a stimulus
- **Reflex arch:** has 5 basic components

Receptor
↓
Sensory neurons
↓
CNS
↓
Moter neurons
↓
Effector



Reflex

- the response of the organism to external or internal irritation, which is caused by the action of the nervous system.

The reflex arch

- chain of neurons, which ensures the implementation of the reflex:

Bineuronal (tendinous)

sensory neuron
+ motor neuron

Threeneuronal

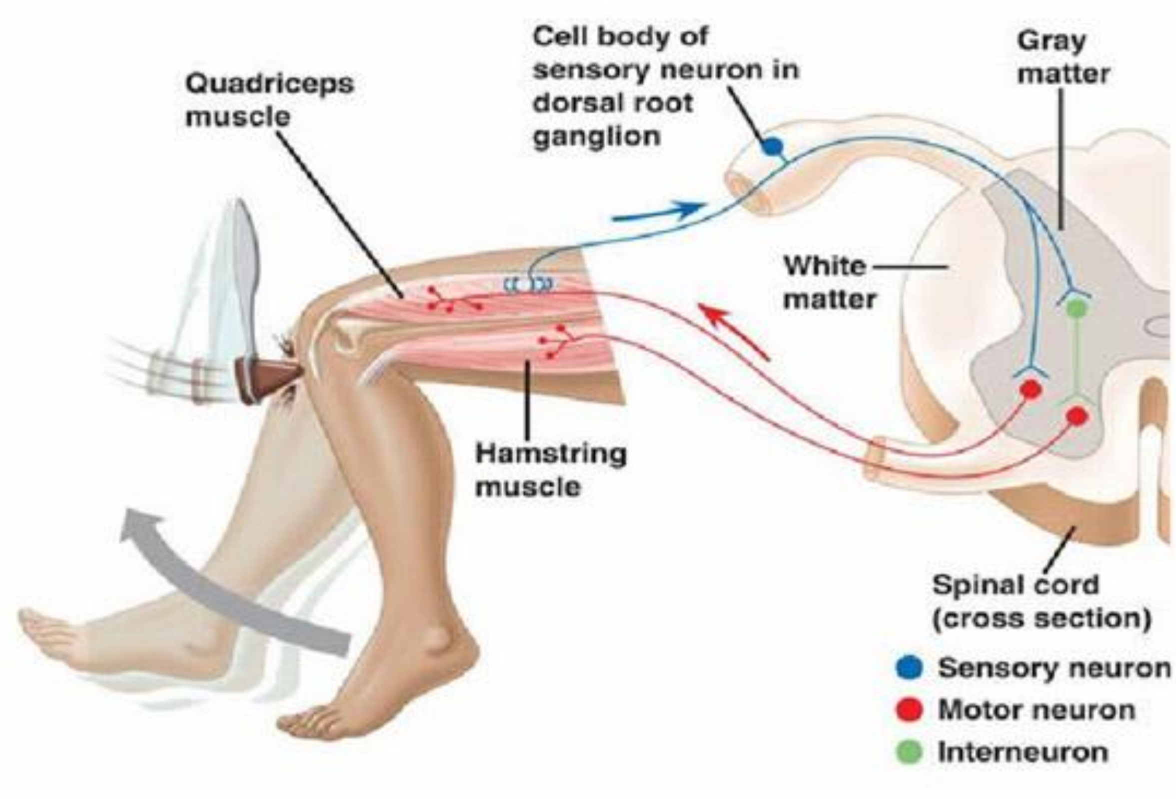
sensory neuron
+ interneuron
+ motor neuron

SPINAL REFLEX

- The **knee jerk reflex** is a well known example of stretch reflex

- Tapping the knee cap (patella) pulls on the tendon of the quadriceps femoris, which is an extensor muscle that extends the lower leg.

- When the muscle stretches in response to the pull of the tendon, information regarding this change in the muscle is conveyed by the afferent sensory neurons to the spinal cord and the central nervous system.

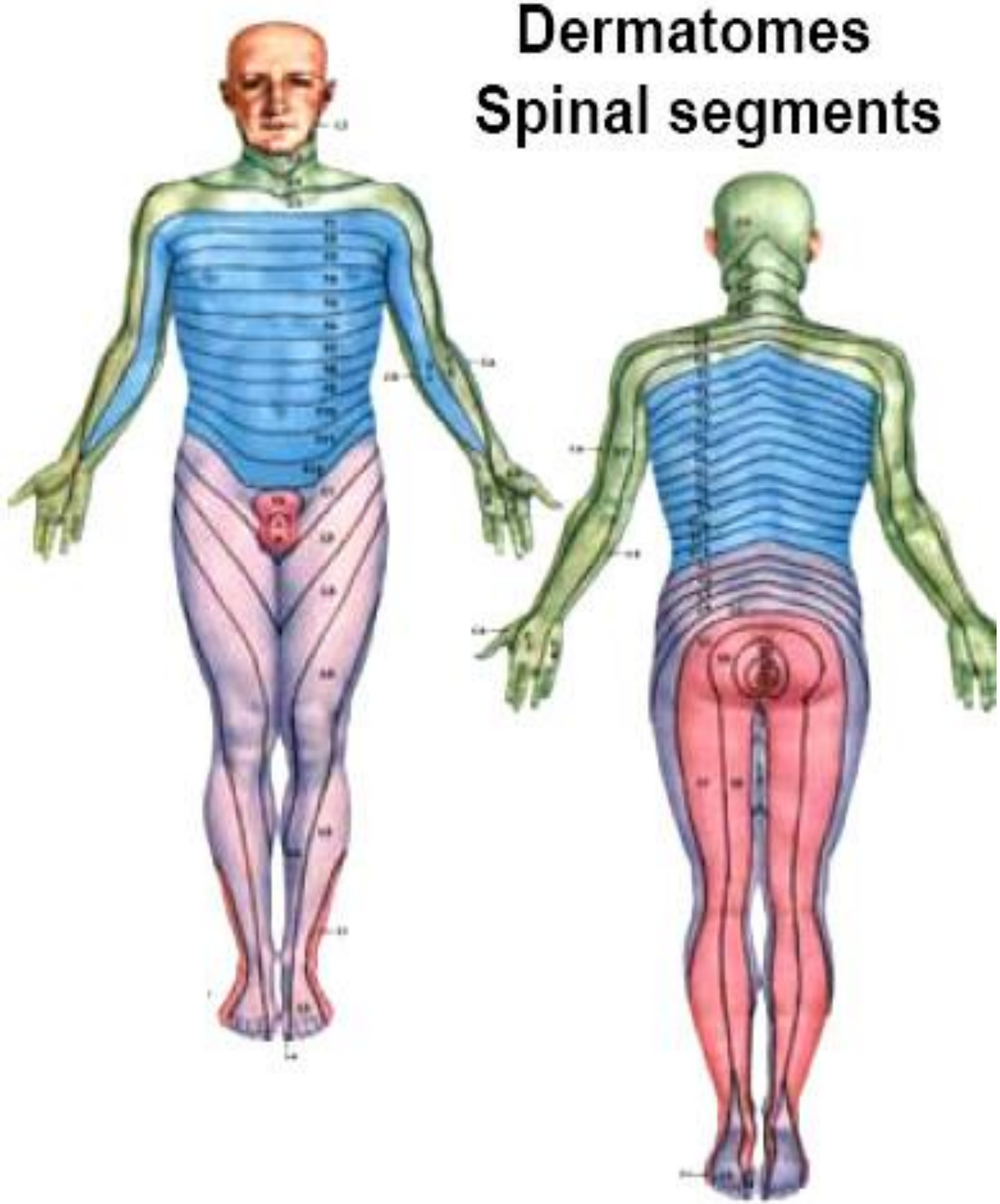


TYPES OF REFLEX ACTION

2 types of reflex action:

- a) CRANIAL REFLEX- brought about by nerve impulses travelling through the medulla oblongata.

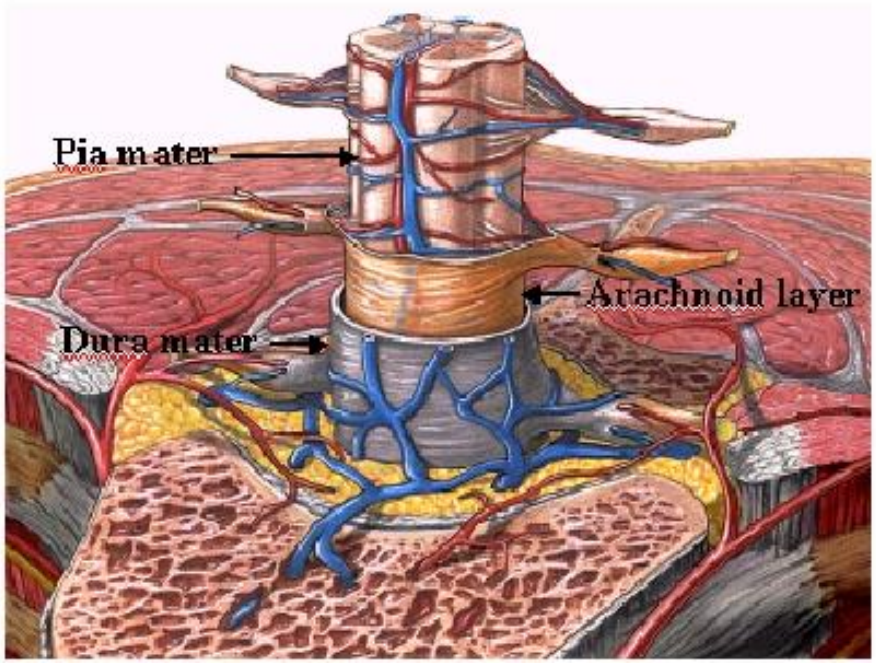
- b) SPINAL REFLEX- brought impulses travelling through the spinal cord.

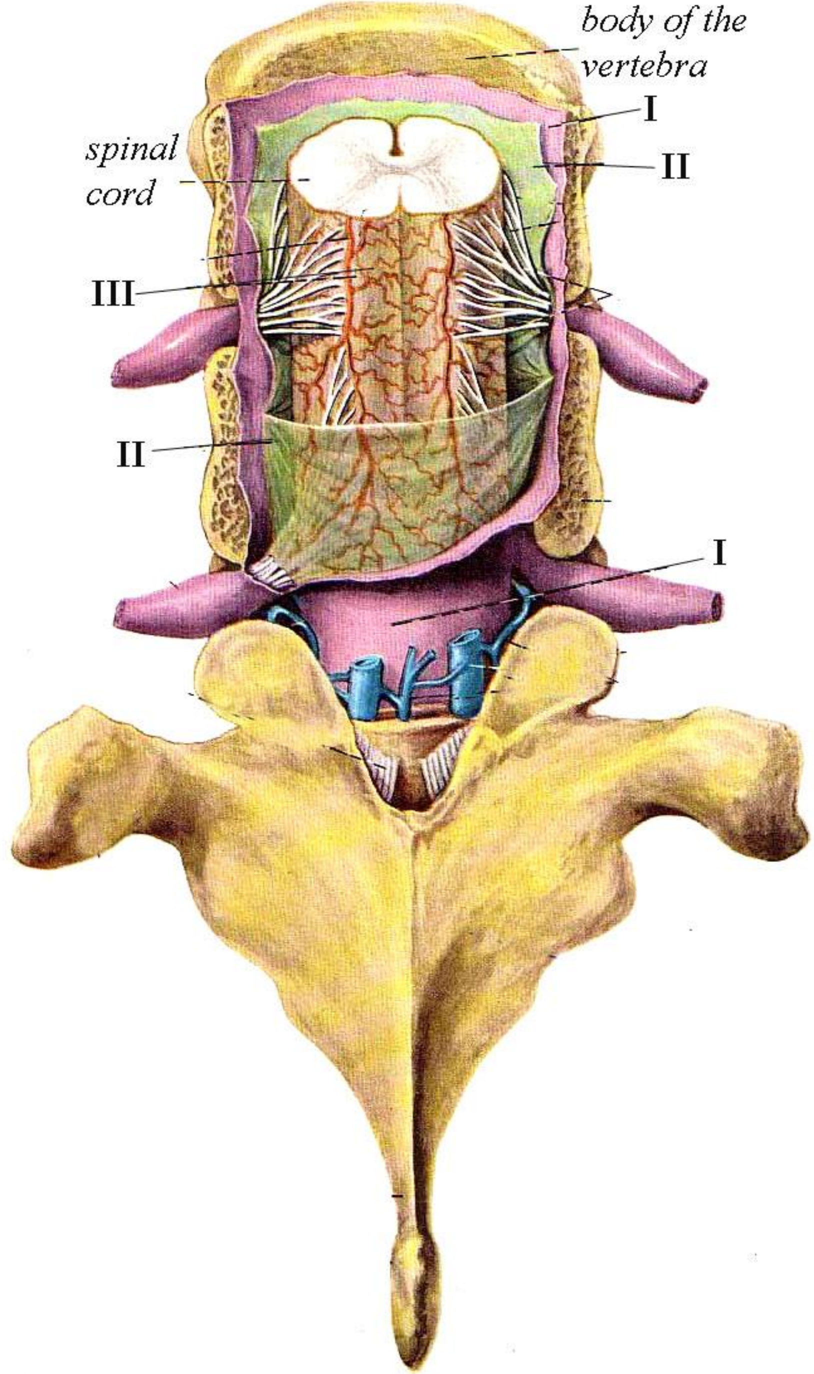


A dermatome is an area of skin that is mainly supplied by a single spinal nerve.
There are eight cervical nerves, twelve thoracic nerves, five lumbar nerves and five sacral nerves.
Each of these nerves relays sensation (including pain) from a particular region of skin to the brain.
Along the thorax and abdomen the dermatomes are like a stack of discs forming a human, each supplied by a different spinal nerve.
Along the arms and the legs, the pattern is different: the dermatomes run longitudinally along the limbs. Although the general pattern is similar in all people, the precise areas of innervation are as unique to an individual as fingerprints.

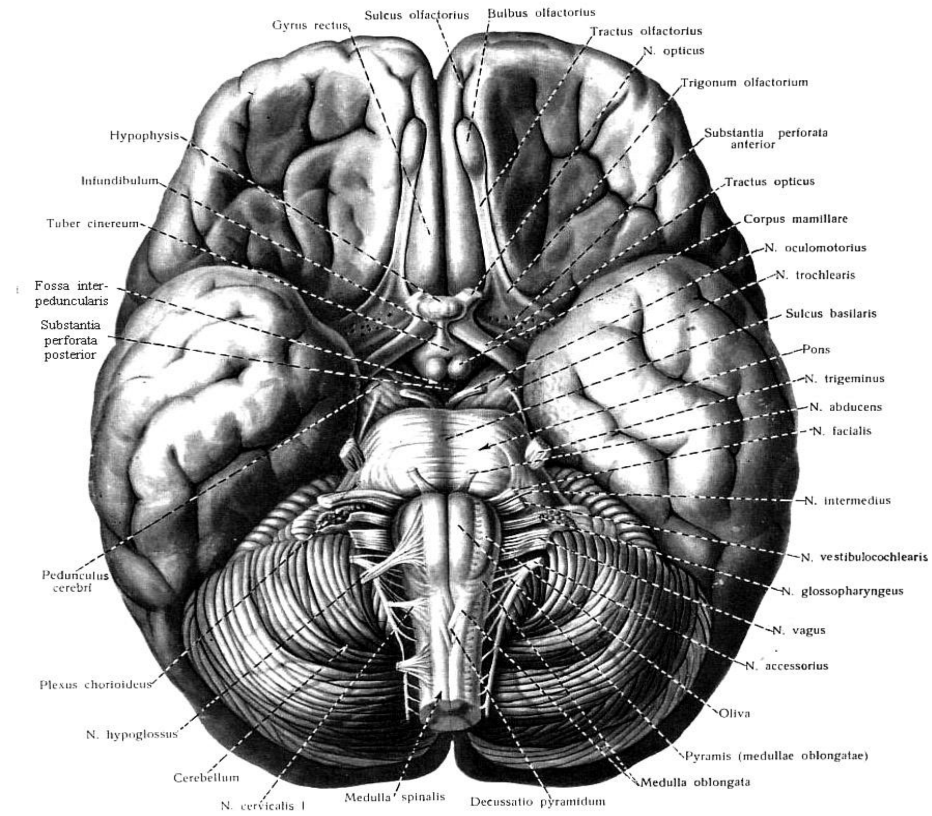
Spinal cord lesions

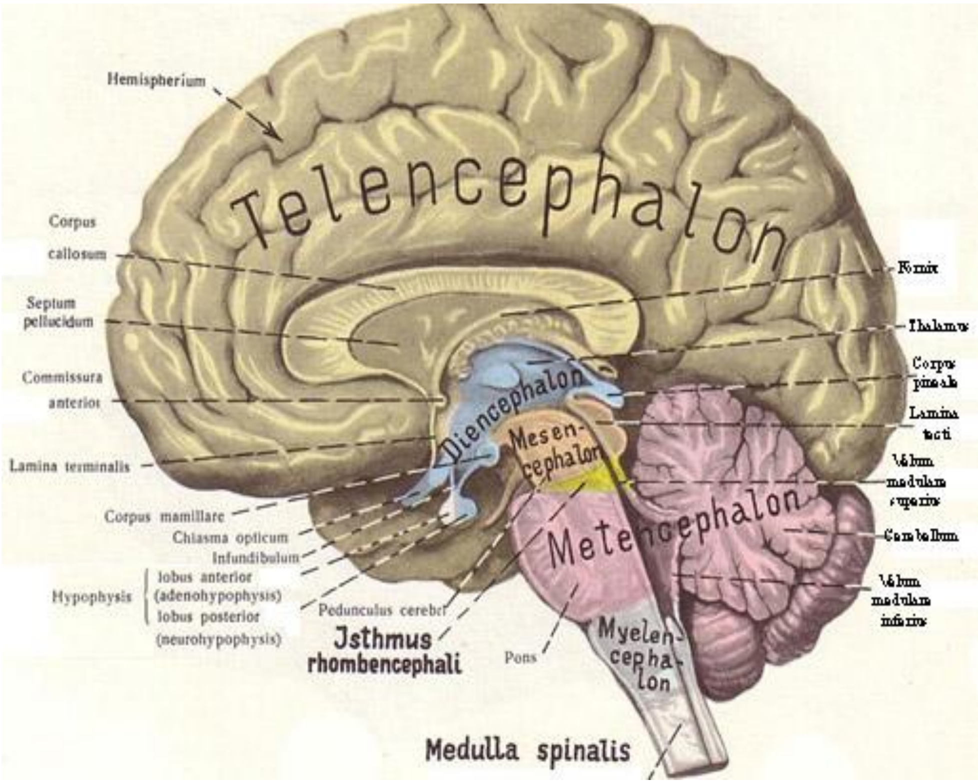
SPINAL CORD MENINGES





Meninges of the spinal cord



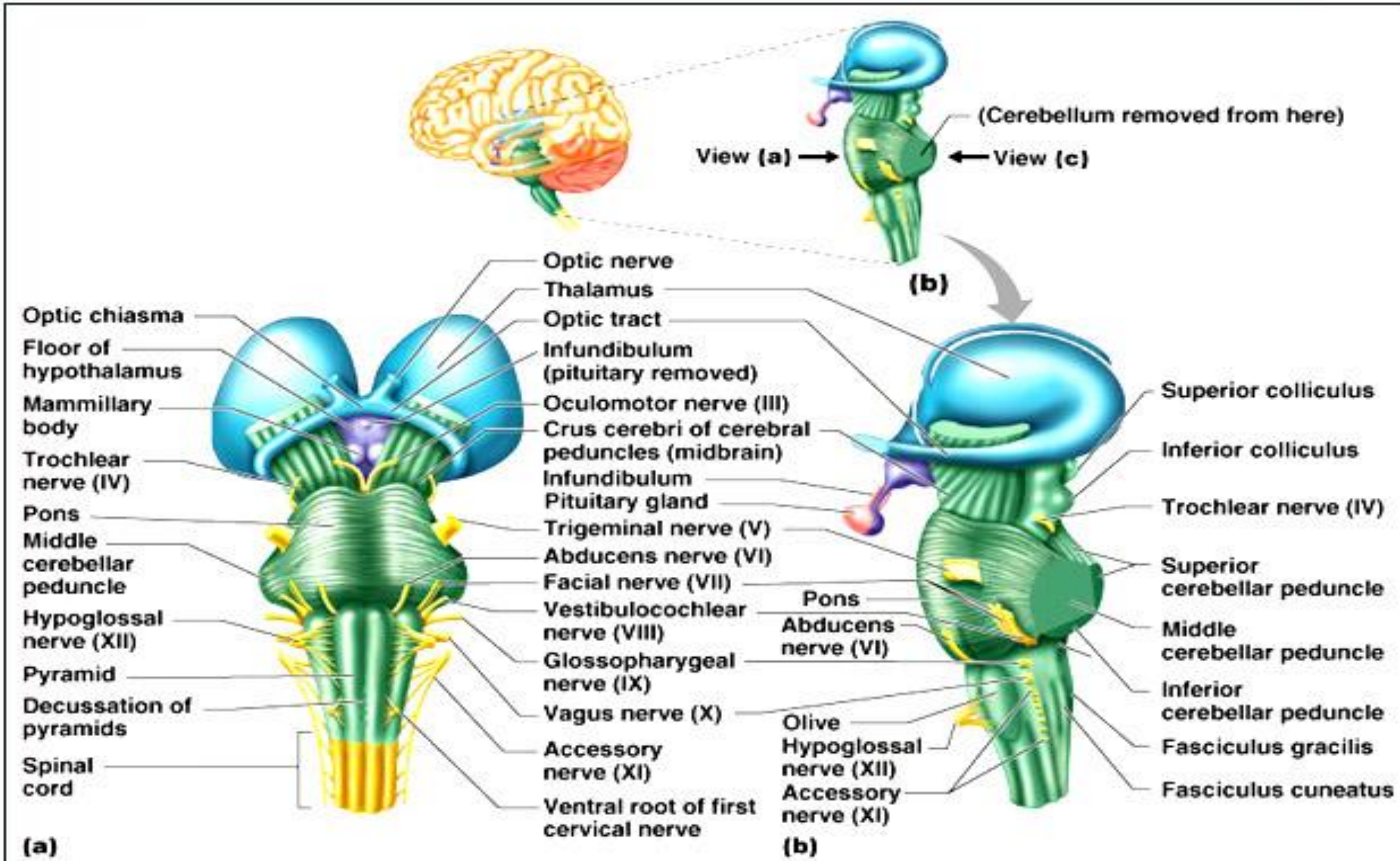


Structural divisions of the brain

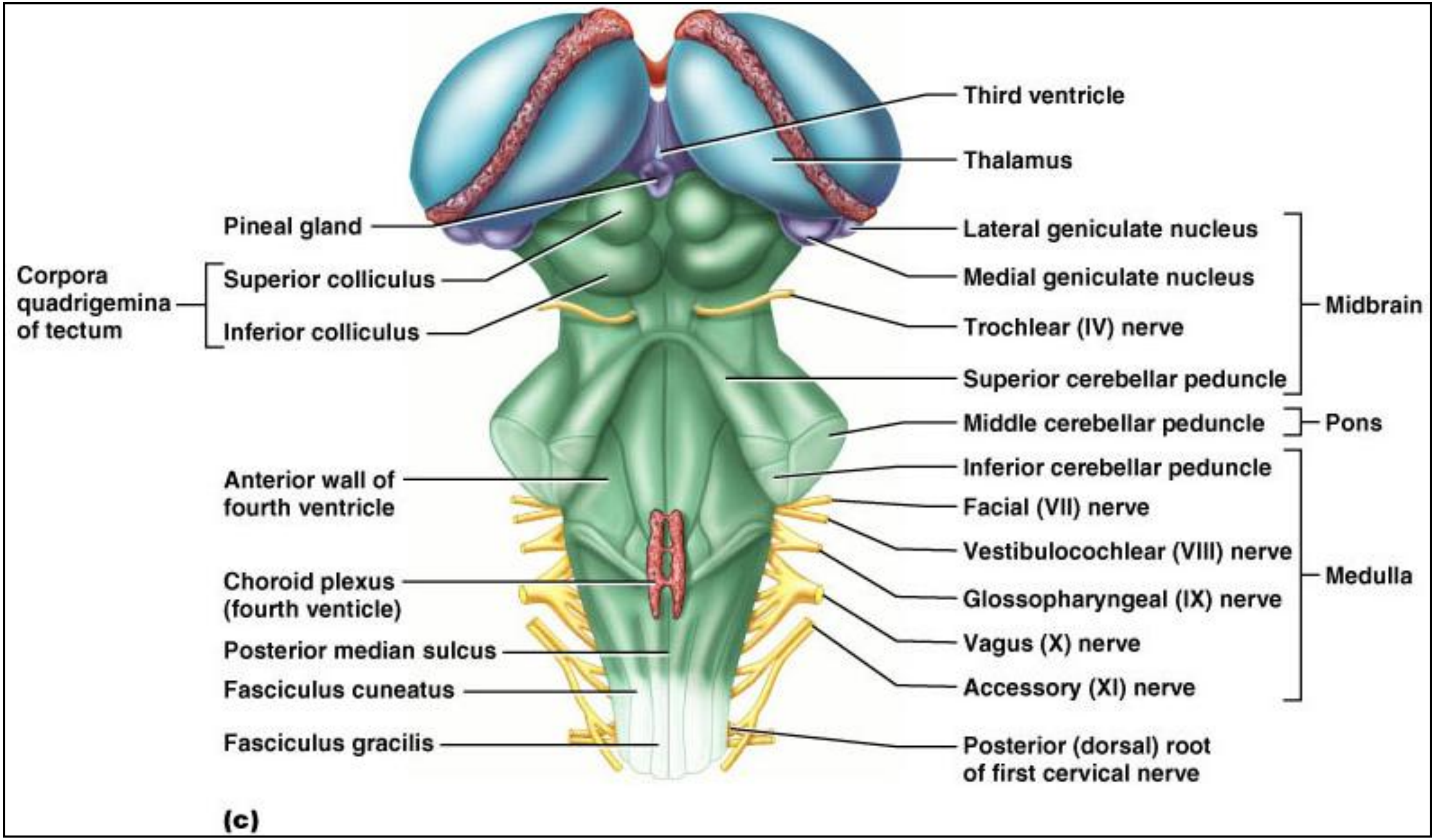
1. Myelencephalon = Madulla oblongata
2. Metencephalon = Cerebellum + Pons (Varoli's bridje)
3. Mesencephalon = Midbrain
4. Diancephalon = Between brain
5. Telencephalon = Endbrain

- **brain stem**

Brain Stem – ventral and lateral view.

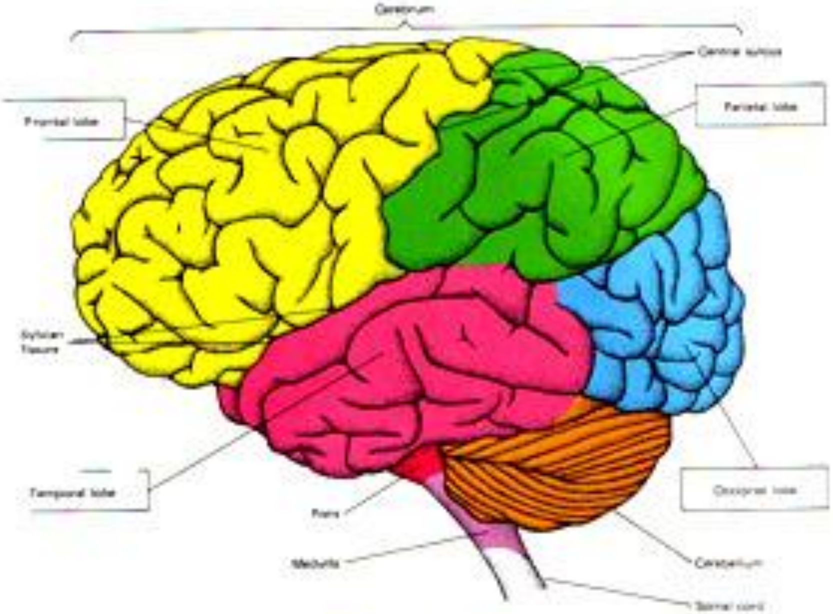


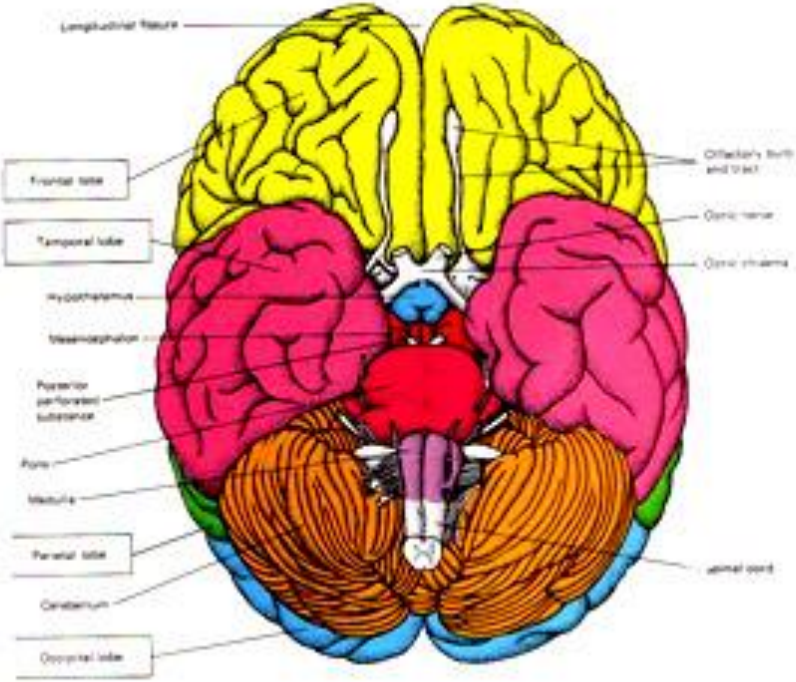
Brain stem

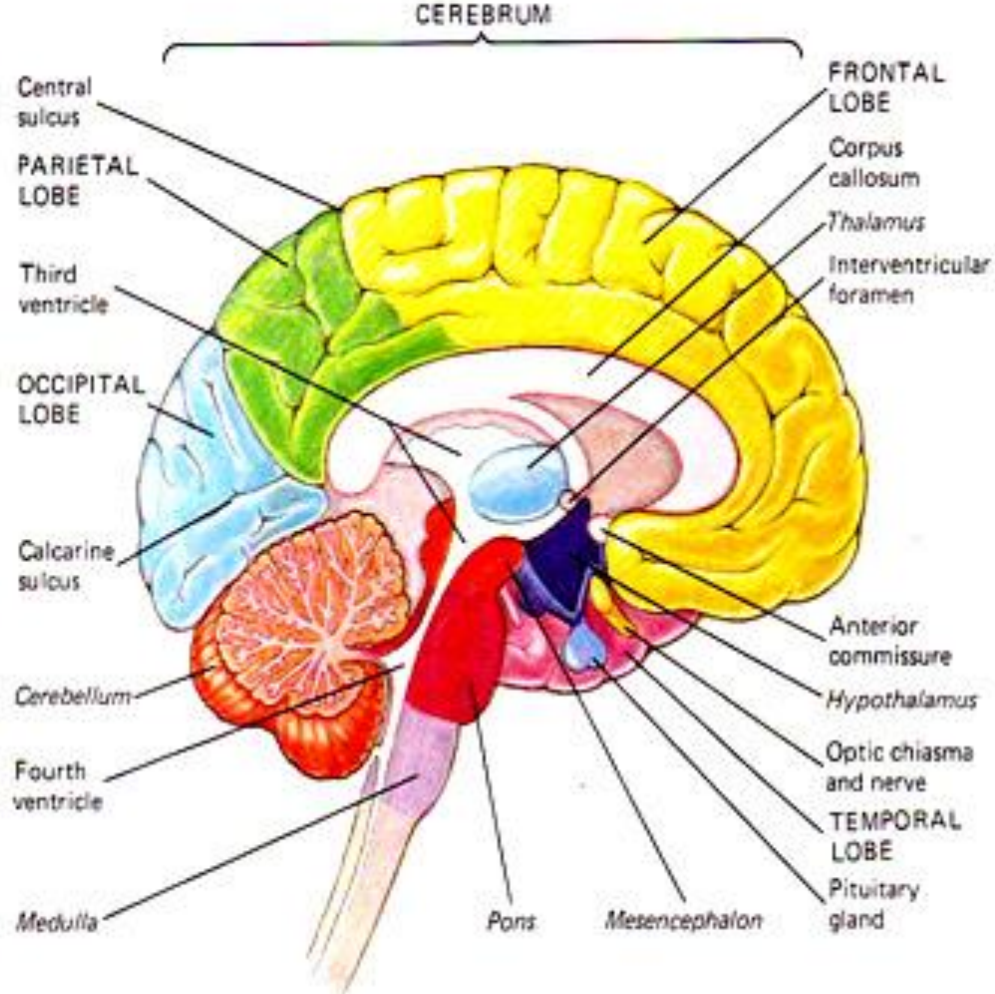


Third ventricle
Thalamus
Pineal gland
Lateral geniculate nucleus
Medial geniculate nucleus
Corpora quadrigemina of tectum
Superior colliculus
Inferior colliculus
Trochlear (IV) nerve
Midbrain
Superior cerebellar peduncle
Middle cerebellar peduncle
Pons
Inferior cerebellar peduncle
Anterior wall of fourth ventricle
Facial (VII) nerve
Vestibulocochlear (VIII) nerve
Medulla
Choroid plexus (fourth venticle)
Glossopharyngeal (IX) nerve
Vagus (X) nerve
Posterior median sulcus
Accessory (XI) nerve
Fasciculus cuneatus
Fasciculus gracilis
Posterior (dorsal) root of first cervical nerve
(c)

Lobes of the cerebral hemisphere







Medial view of the left half of the brain, showing especially the relationship of the cerebrum to the brain stem and cerebellum.

Cerebral lobes & their functions:

Frontal Lobe:

***is the largest lobe of the cerebrum**

***is responsible for controlling speech, thought, consciousness, and voluntary body movements.**

Parietal Lobe:

***is involved in controlling sensations such as touch, pressure, and pain, as well as texture and position.**

Occipital Lobe:

***is located at the back of the head and is involved in vision and reading.**

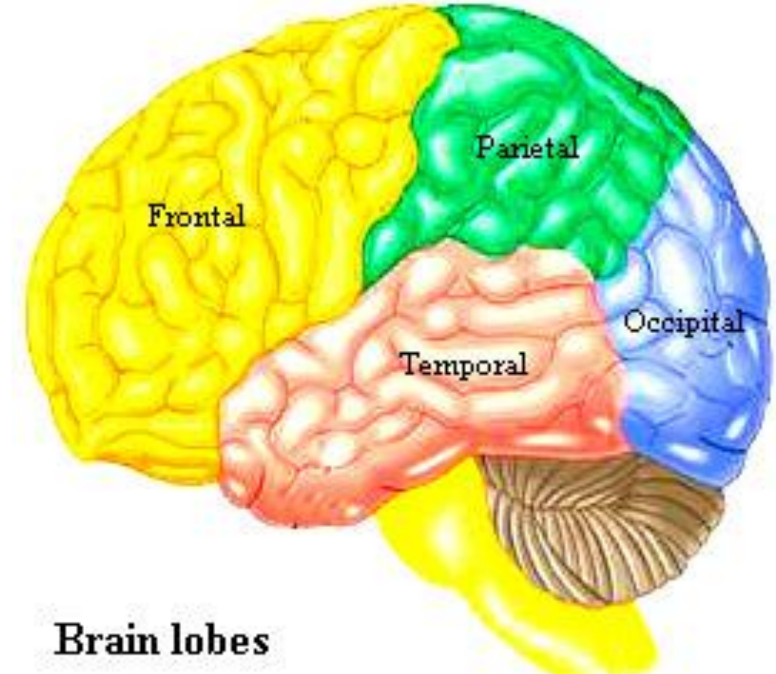
Temporal Lobe:

- ***is involved in hearing, speech memory, sight memory, and music memory.***
- ***Each ear is connected to both sides of the temporal lobes.***

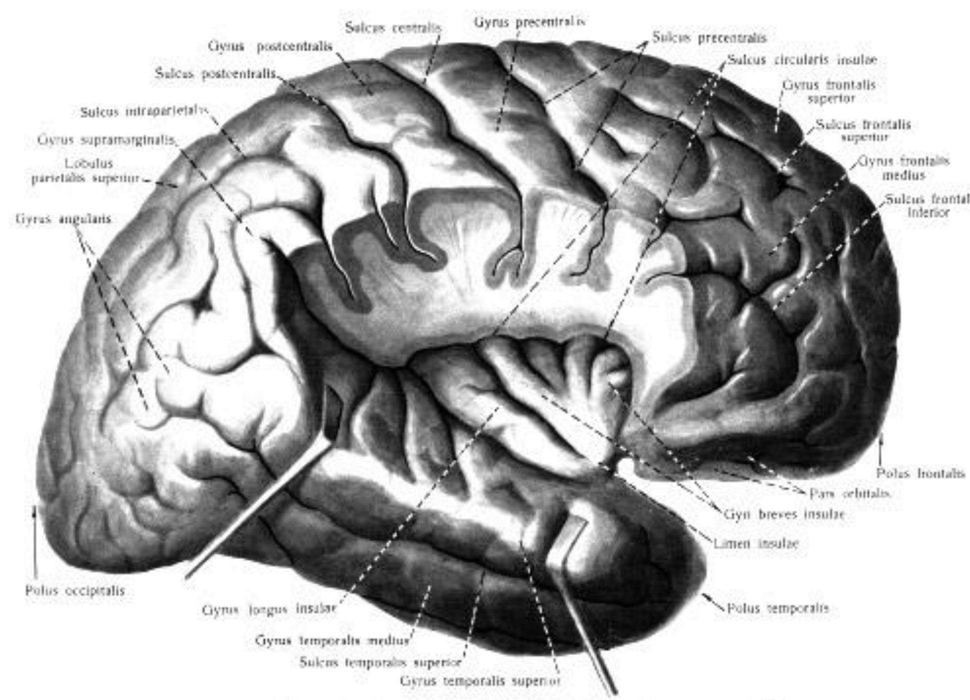
Insula:

***is located deep within the Sylvian fissure, beneath the temporal and frontal lobes.**

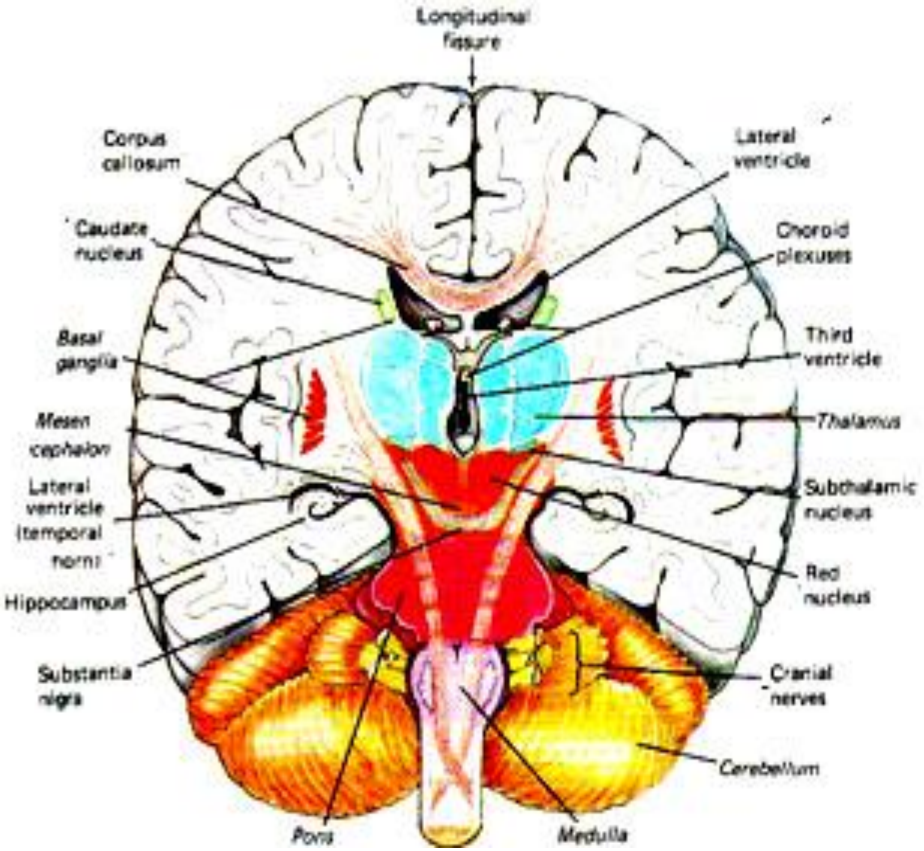
***it controls smell.**

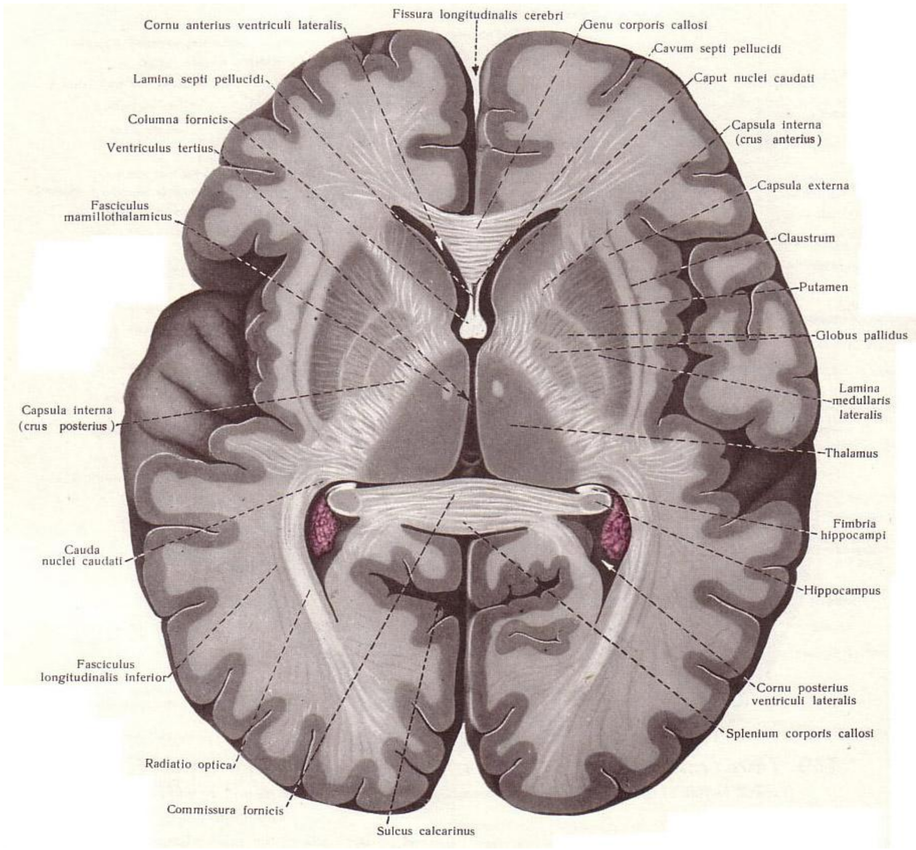


Brain lobes



Right insula; lateral and partly inferior aspect (4/5).





White matter includes 3 types of fibers:

Associative – connect gyri of the same hemisphere;

Commissural **-** connect gyri of both hemispherae /right and left/

Projectional – connect the cerebral cortex with underlying structures of the brain and spinal cord

Gray matter forms the cortex and basal nuclei:

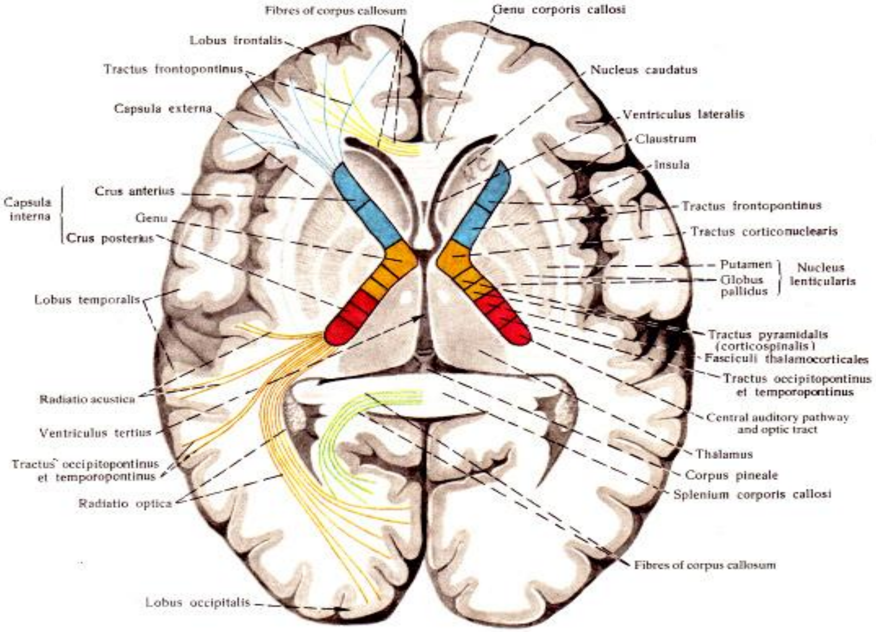
1)the striated body:

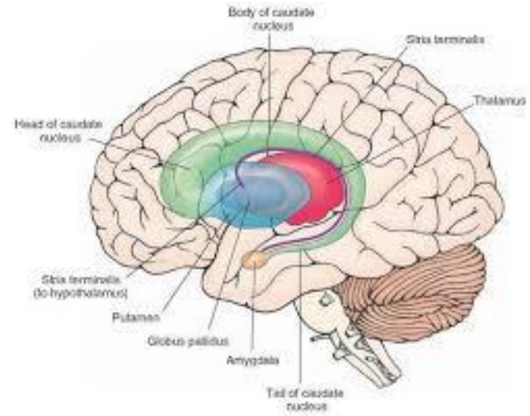
caudate nucleus + lentiform nucleus

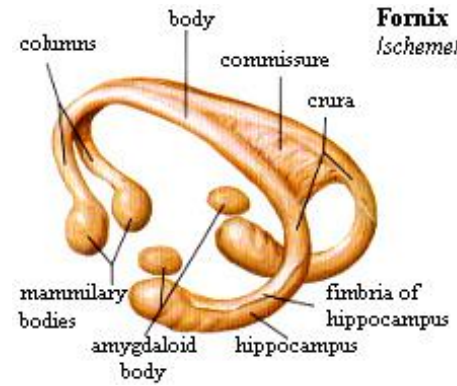
head,	medial pallid nucleus
body	lateral pallid nucleus,
tail	putamen

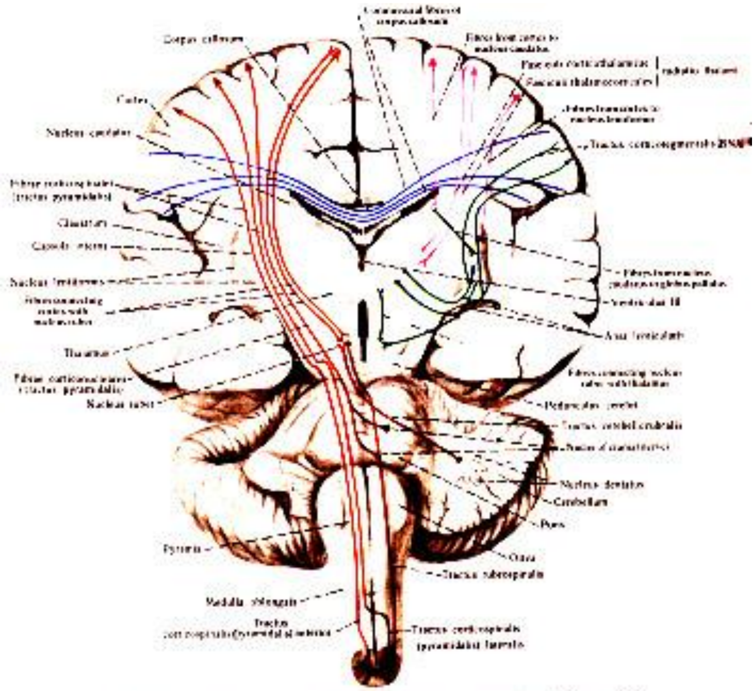
2)the claustrum

3)the amygdaloid body



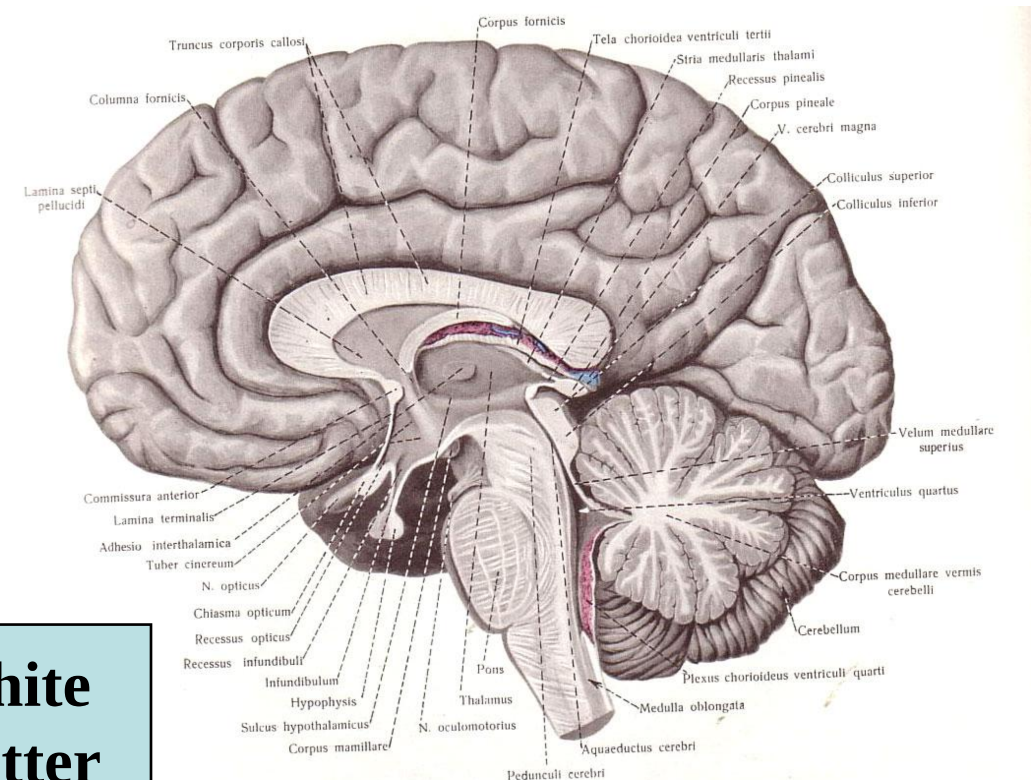




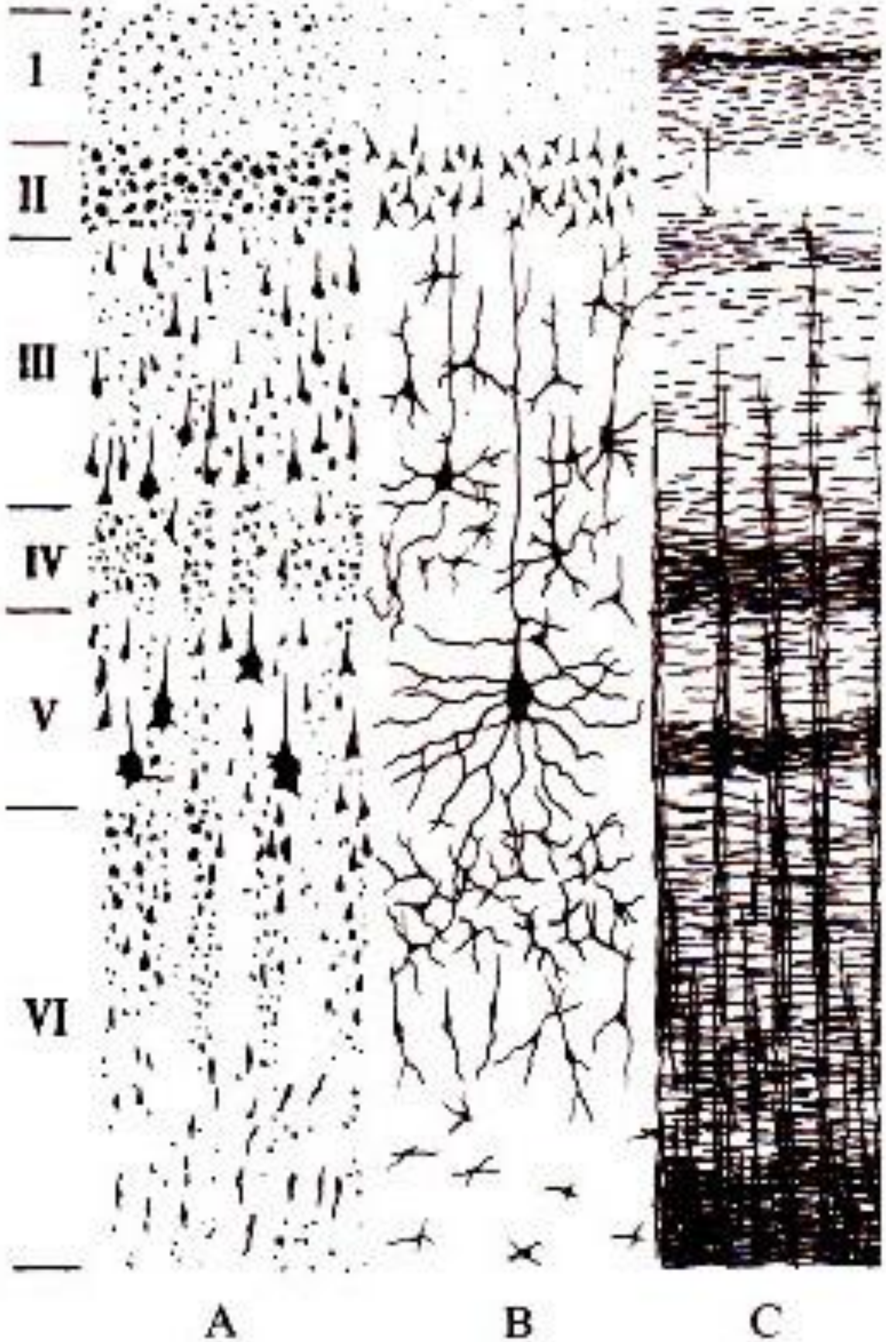


Descending tracts of spinal cord and brain; frontal section (semischematical representation).

White matter



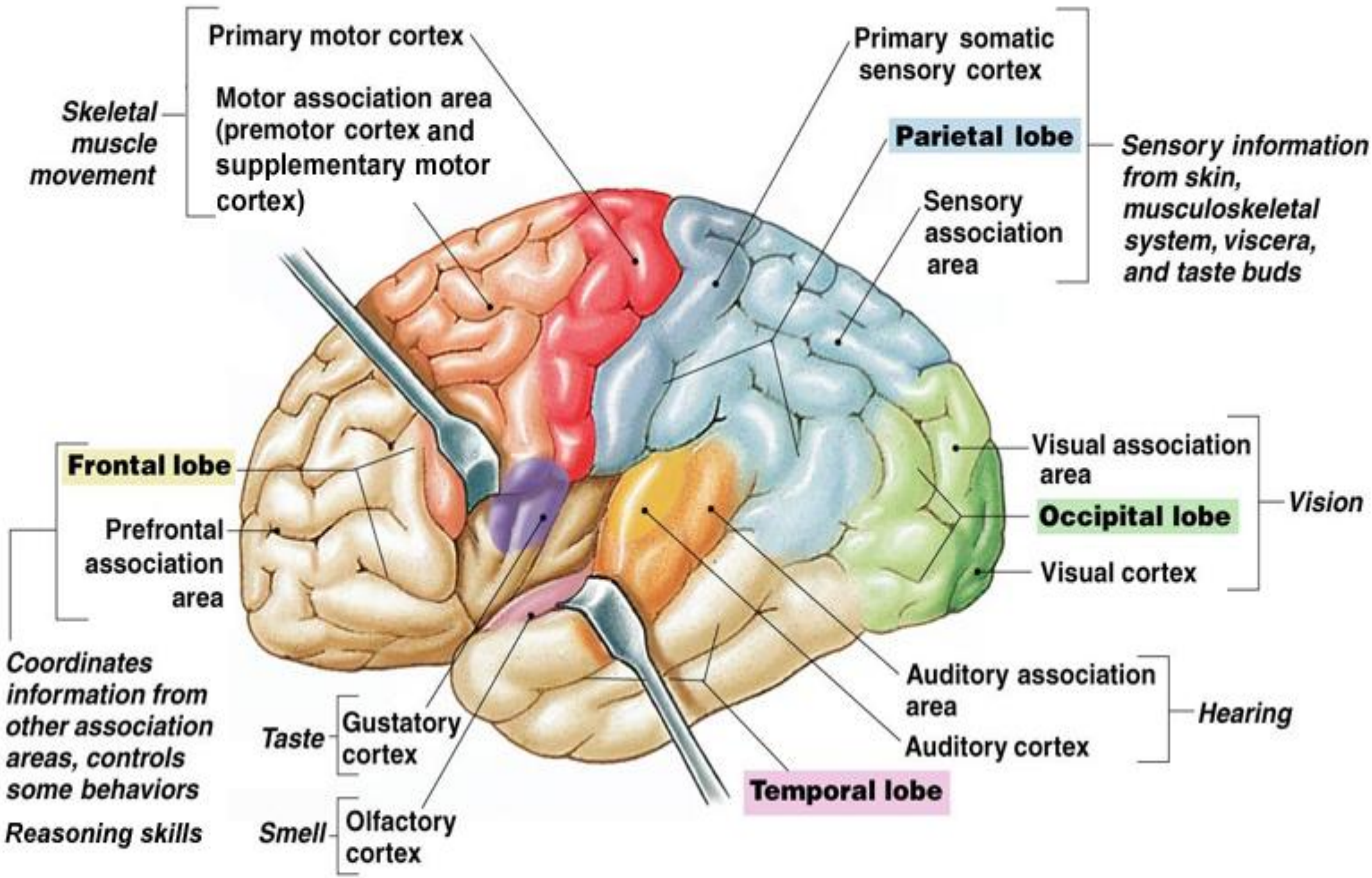
Sagittal section of the brain



A—cell layers;
B—cell types;
C—layers of fibres

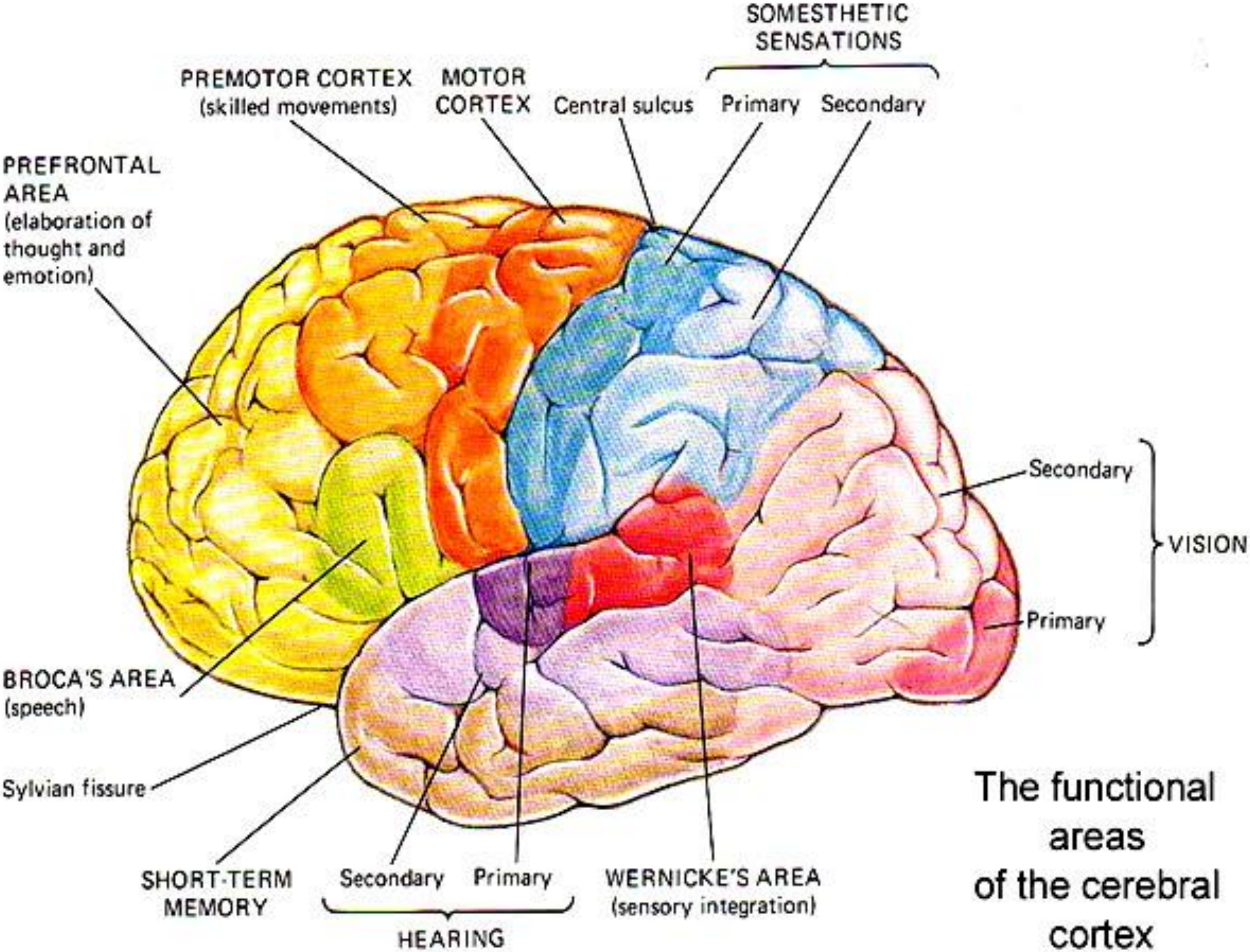
I - mollecular layer
II - external granular layer
III - external pyramidal layer
IV - internal granular layer
V - ganglionar layer
VI - multiform layer

Structure of the cortex of the cerebrum



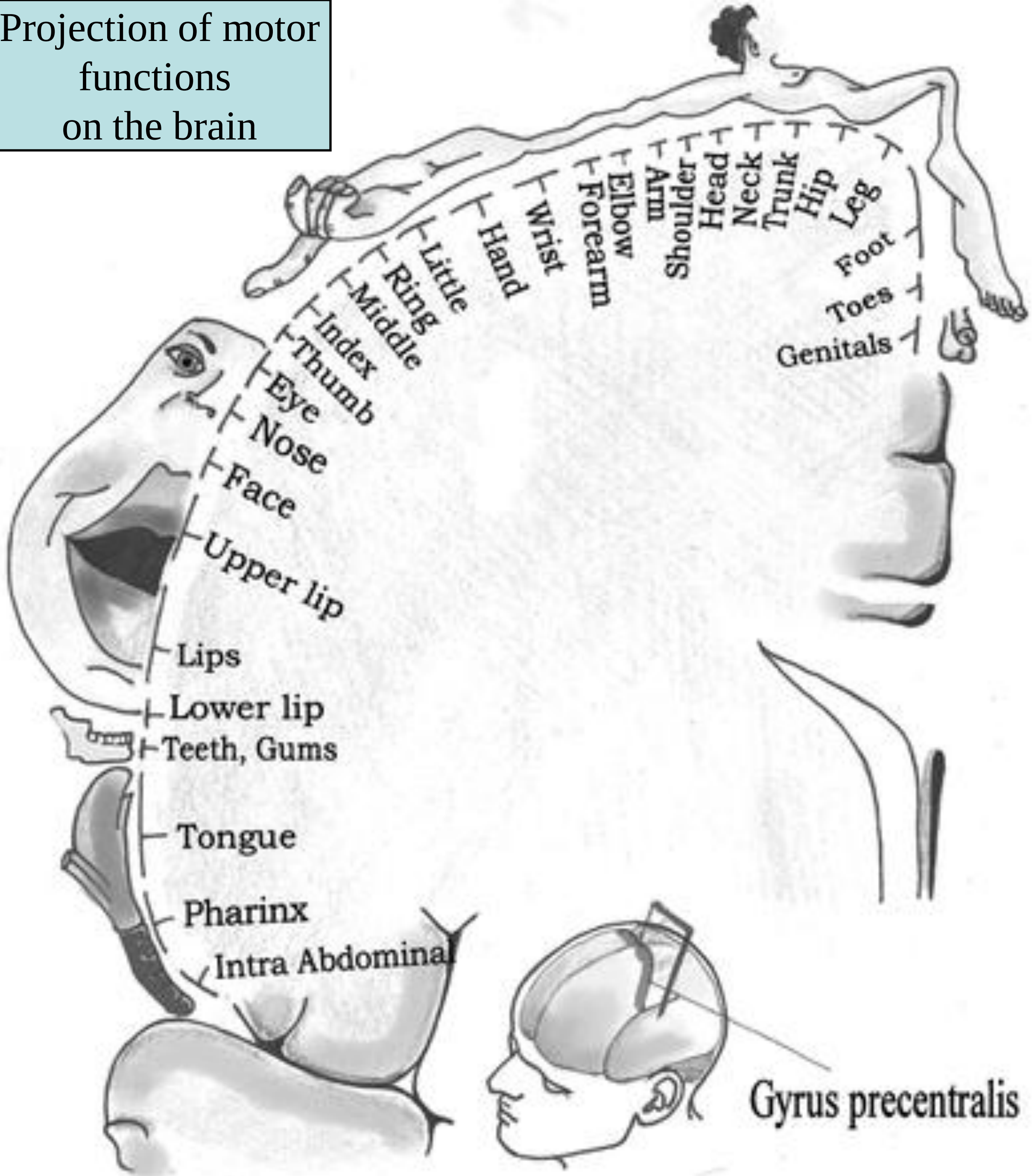
Primary motor cortex
Motor association area (premotor cortex and supplementary motor cortex)
Skeletal muscle movement
Primary somatic sensory cortex
Parietal lobe
Sensory association area
Sensory information from skin, musculoskeletal system, viscera, and taste buds
Frontal lobe
Prefrontal association area
Coordinates information from other association areas, controls some behaviors
Reasoning skills
Visual association area
Occipital lobe
Visual cortex
Vision
Taste
Gustatory cortex
Smell
Olfactory cortex
Auditory association area
Auditory cortex
Hearing
Temporal lobe

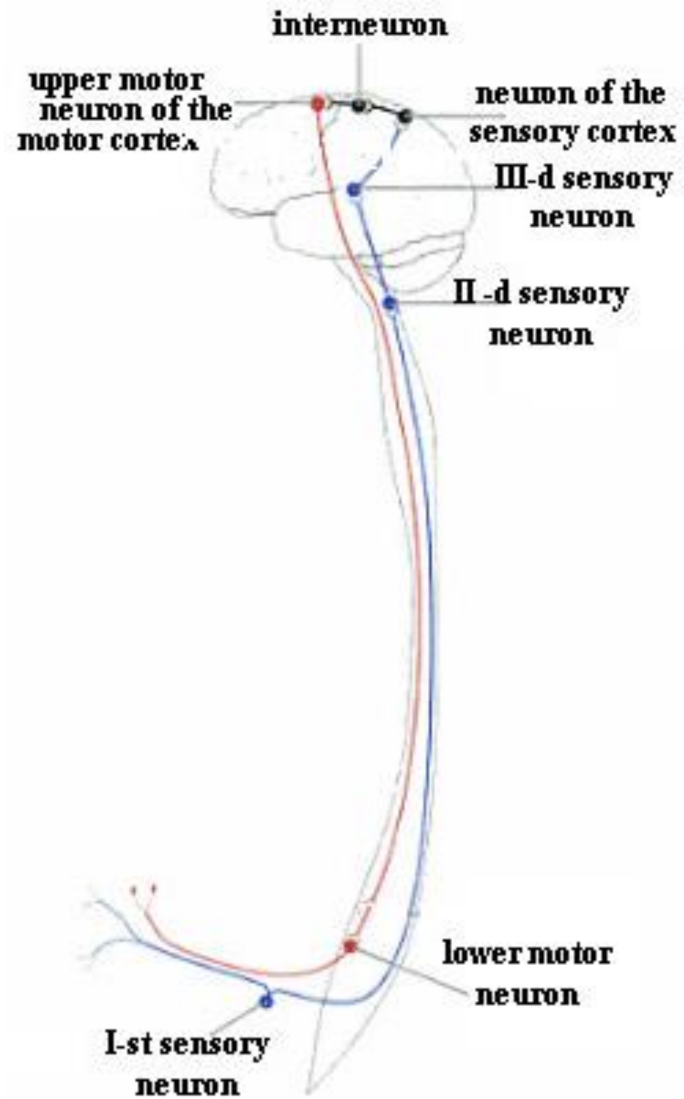
Fig. 9-15

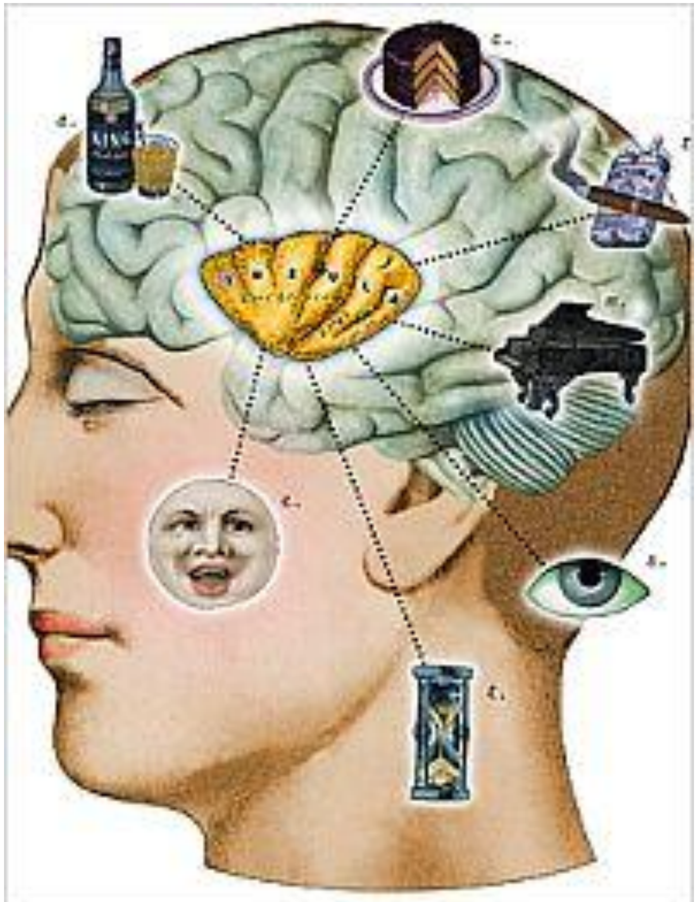


The functional areas of the cerebral cortex

Projection of motor functions on the brain







The study was carried out on the people who had damage Insula and found that they were able to give up smoking.

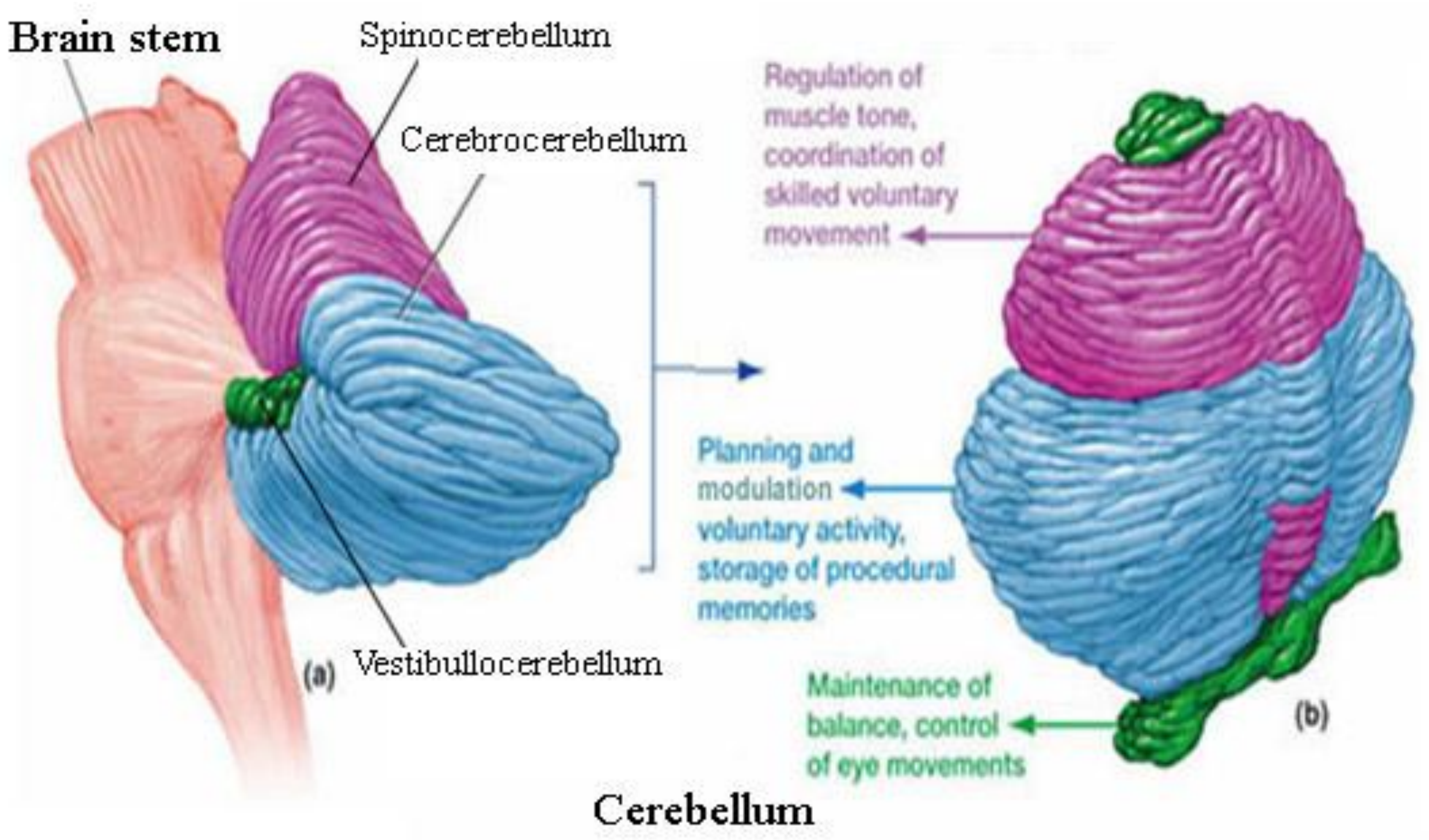
Scientists anticipate that research on Insula could possible open the new doors for treatment to drug addiction, anxiety, and eating disorders.

Scientists say that Insula is the 'wellspring of social emotions, things like lust and disgust, pride and humiliation, guilt and atonement.'

What does the Insula do?

For example, the Insula "lights up" in brain scans when people crave drugs, feel pain, anticipate pain, empathize with others, listen to jokes, see disgust on someone's face, are shunned in a social settings, listen to music, decide not to buy an item, see someone cheat and decide to punish them, and determine degrees of preference while eating chocolate. Damage to the insula can lead to apathy, loss of libido and an inability to distinguish fresh food from rotten. Scientists will have to be very cautious since people could possible not only loose desire for food and drink but they could also loose interest in sex and work.

Functions of the cerebellum



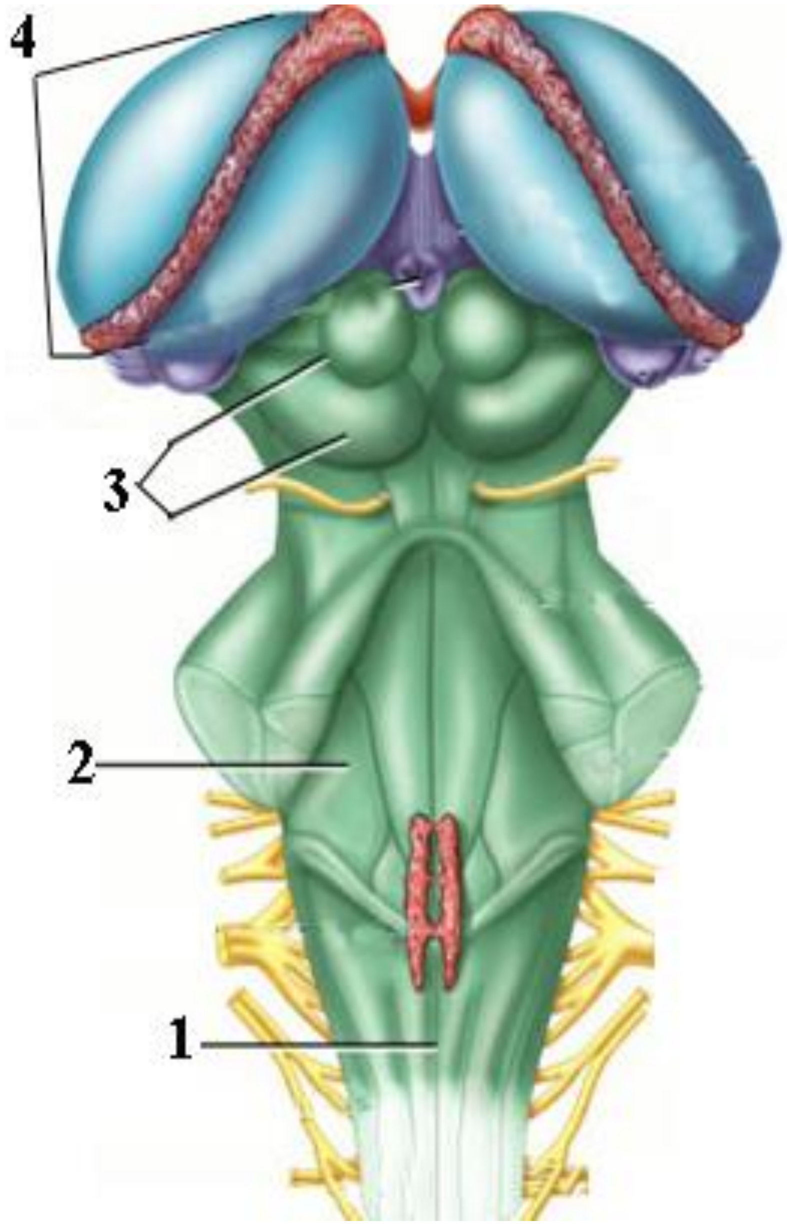
Brain Stem – diencephalon, midbrain, pons, medulla

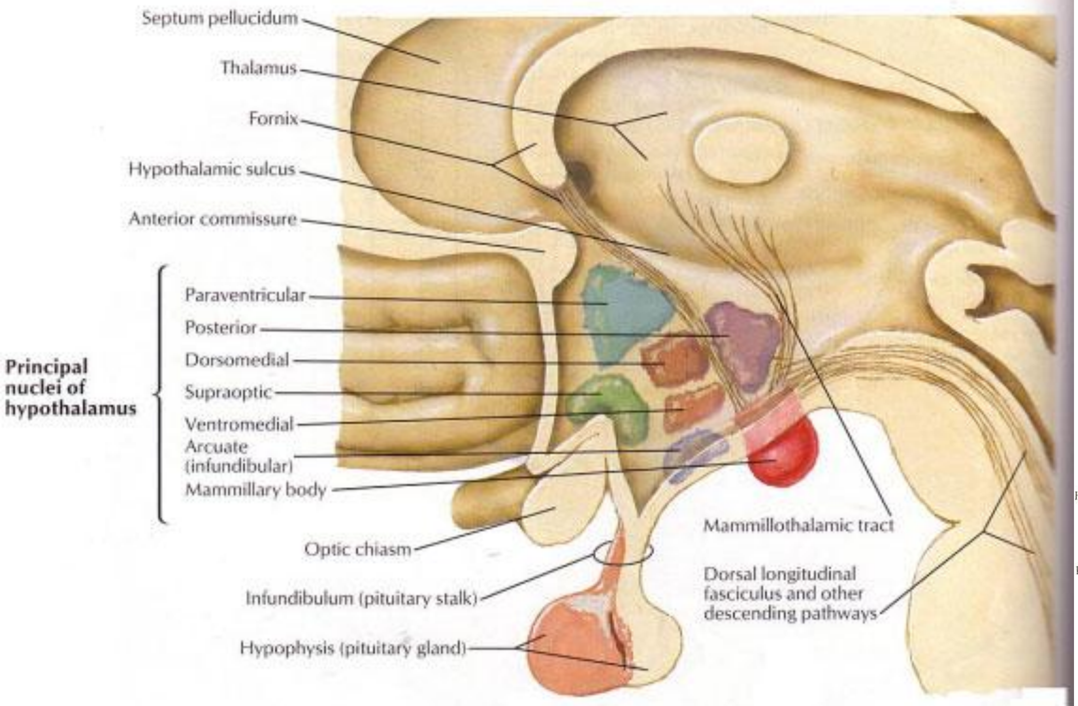
*Organization is similar to spinal cord (gray matter surrounded by white fiber tracts) but contains nuclei embedded in the white matter

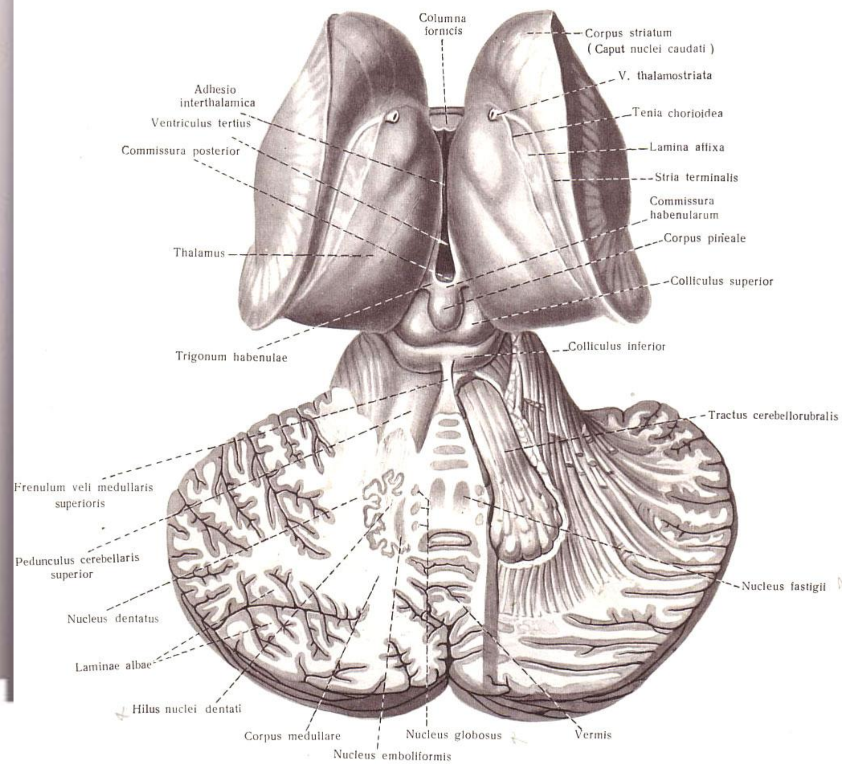
*Controls automatic behaviors necessary for survival

*Provides the pathway for tracts between higher and lower brain centers

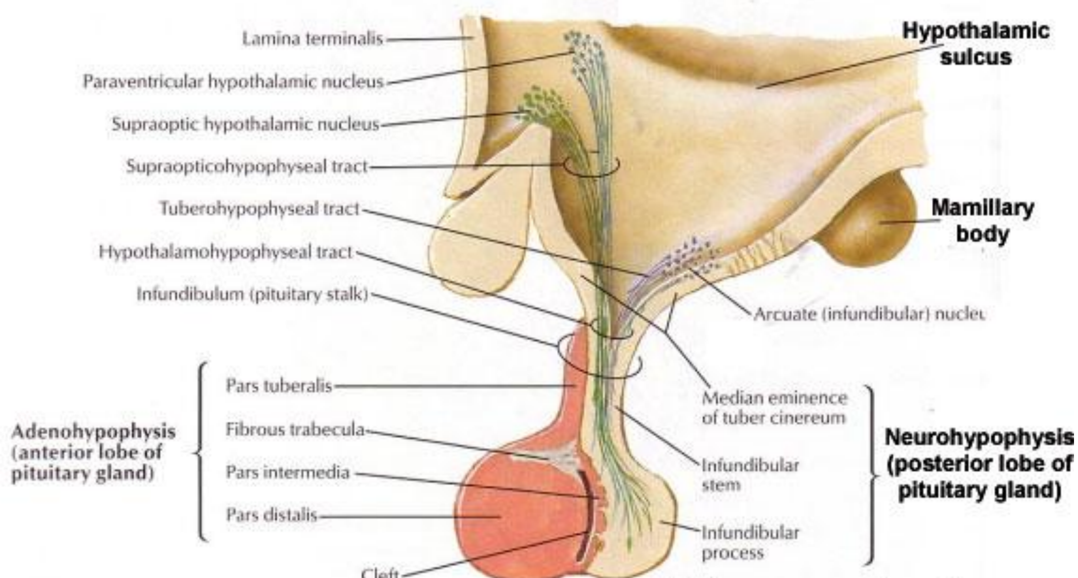
*Brain stem nuclei are associated with 10 of the 12 pairs of cranial nerves







Diencephalon, midbrain and cerebellum



Diencephalon

The diencephalon consists of the: thalamic region, hypothalamus, subthalamus, and the third ventricle.

Thalamic region in turn includes:

1) ***optic thalamus,***
2) ***epithalamus,***
3) ***metathalamus***

Functions of diencephalon

Functions of the thalamus

•it **process all sensory input (*except olfactory*) to the cortex**:
-visual, auditory, somatosensory;

•**has profound influence on motor (*via input from basal ganglia and cerebellum*);**

•**influences cognitive function**

Functions of the hypothalamus

•**it exerts control over the pituitary gland and thus over endocrine function in general;**

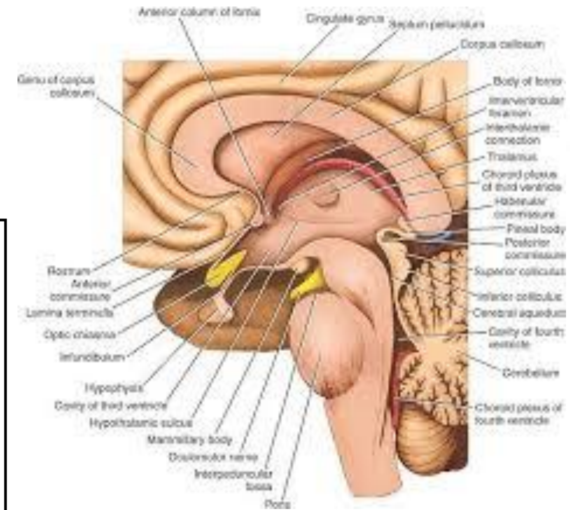
•**it has extensive connections with brain stem autonomic nuclei.**
-Lesions of the hypothalamus affect appetite, emotional behavior, temperature control, and numerous other autonomic and endocrine-influenced behaviors.

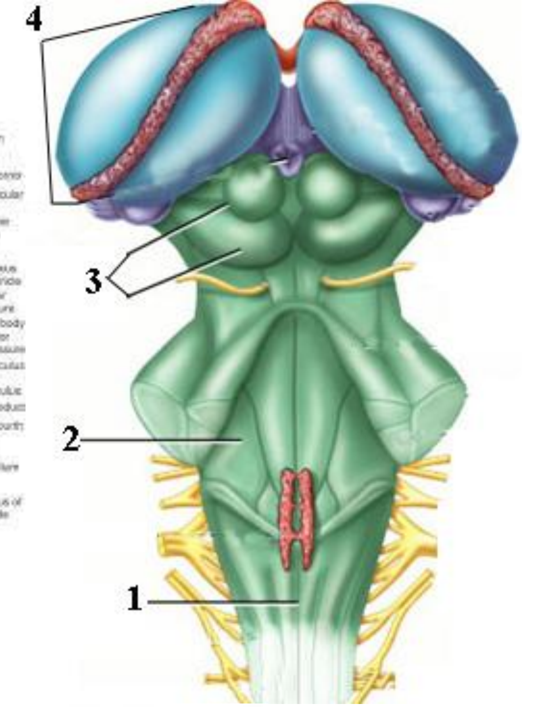
Midbrain

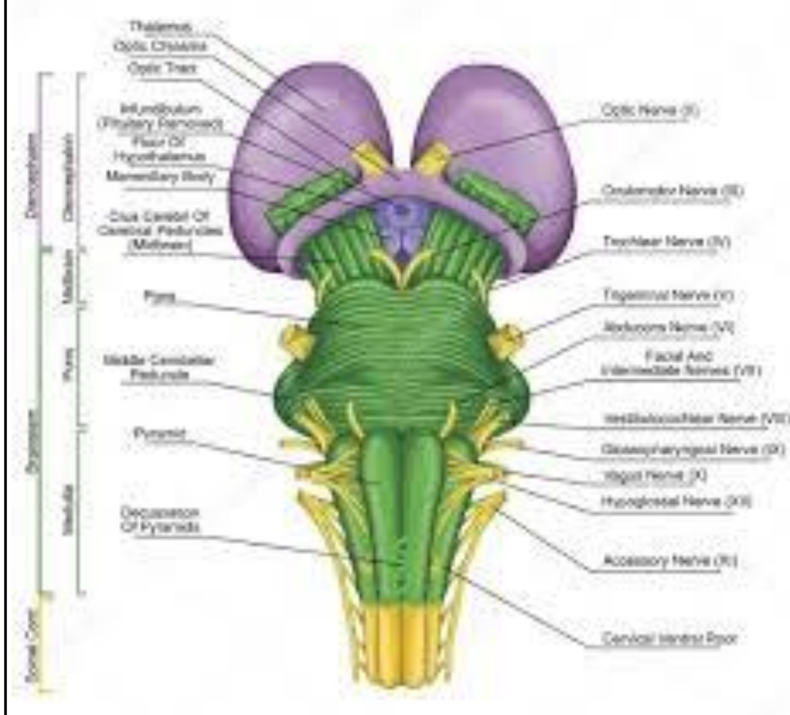
– between
diencephalon and pons

Midbrain structures include:

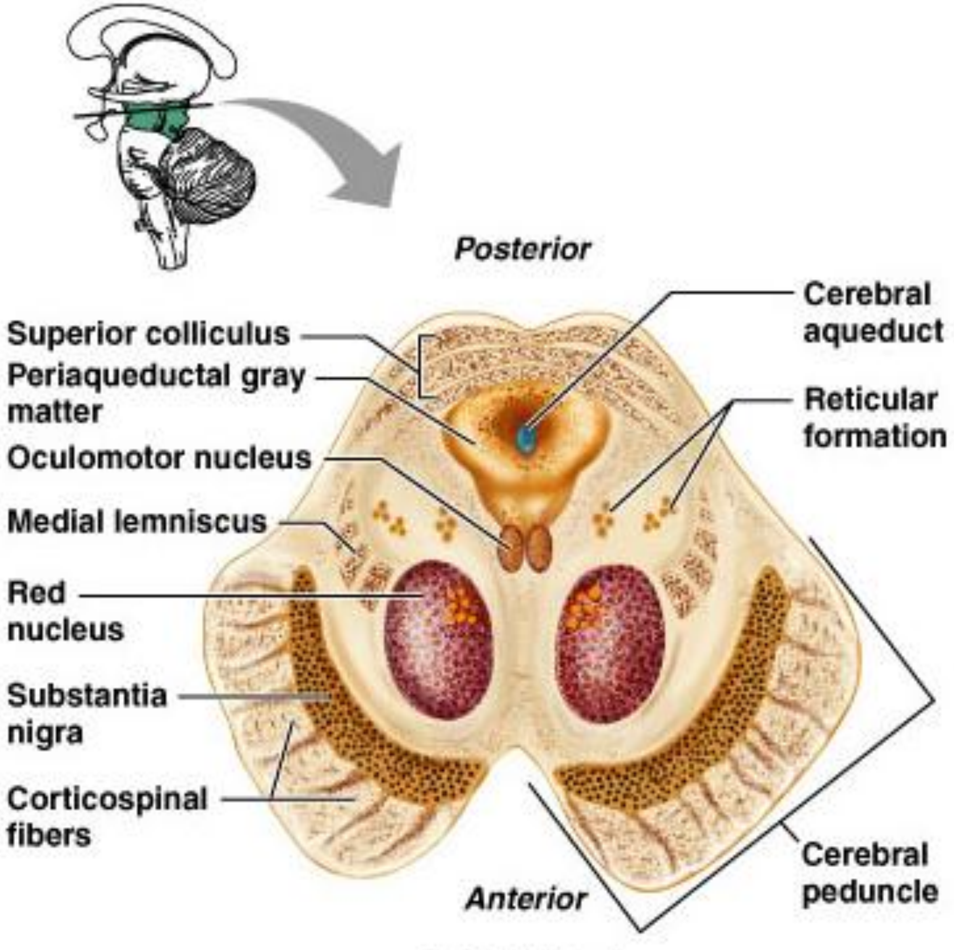
- ***Cerebral peduncles** – two bulging structures on the ventral aspect that contain descending pyramidal motor tracts*
- ***Cerebral aqueduct** – hollow tube that connects the third and fourth ventricles*
- ***Subcortical visual** and **hearing centers***
- ***Various nuclei***







Midbrain Nuclei



(a) Midbrain

Nuclei that control cranial nerves III (oculomotor) and IV (trochlear)

*Corpora quadrigemina – four domelike protrusions of the dorsal midbrain
-Superior colliculi – visual reflex centers
-Inferior colliculi – auditory relay centers

*Substantia nigra – functionally linked to basal nuclei, contains melanin pigment (precursor of dopamine)

*Red nucleus – largest nucleus (rich blood supply) of the reticular formation; relay nuclei for some descending motor pathways

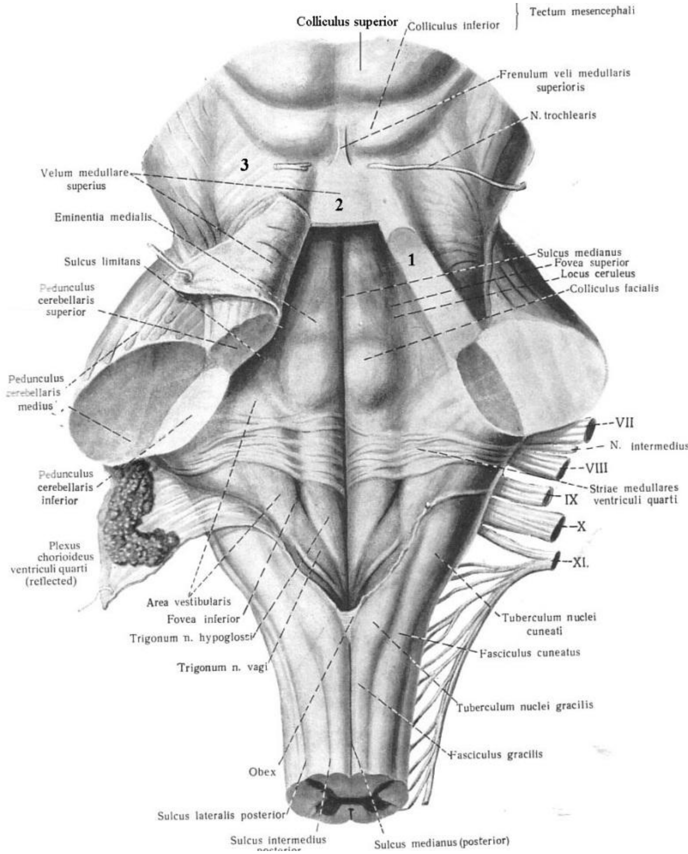
Pons – between midbrain and medulla oblongata

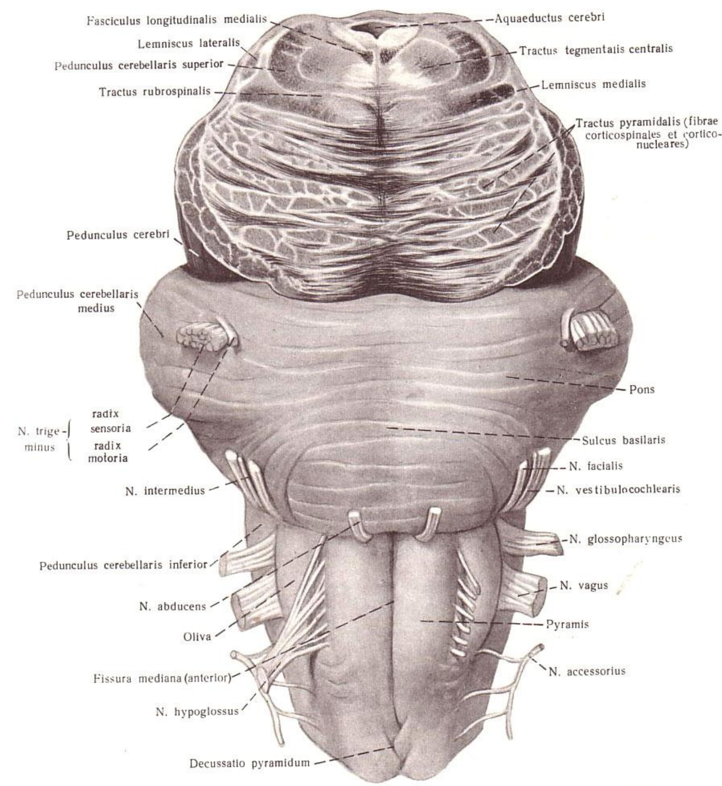
***Dorsally, it forms part of the anterior wall of the fourth ventricle**

***Deep projection fibers connect higher brain centers and the spinal cord**

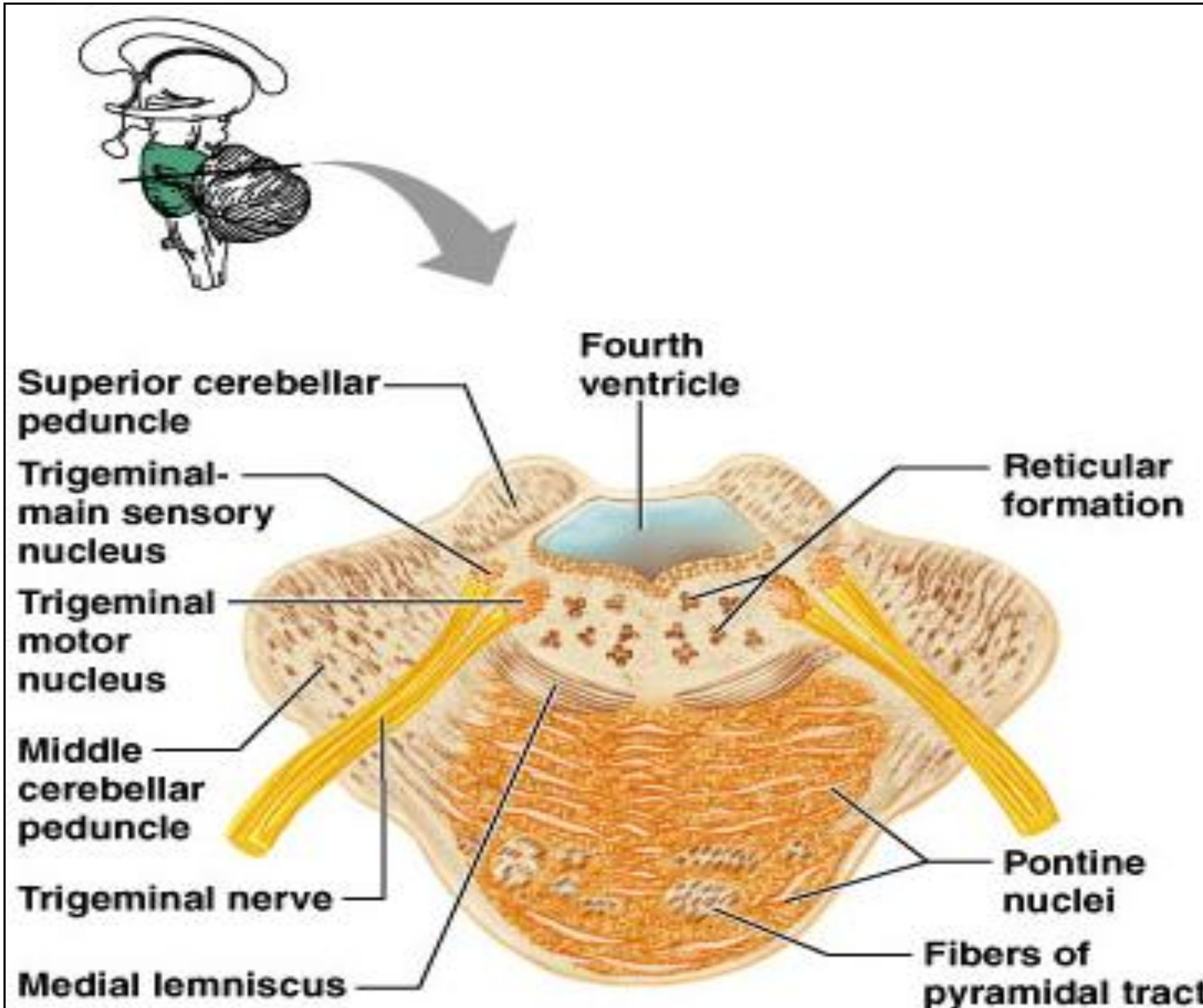
***The more superficial or ventral fibers act as relay between the motor cortex and the cerebellum**

***Origin of cranial nerves V (trigeminal), VI (abducens), VII (facial) and VIII (vestibulocochlear)**





Pons



Superior cerebellar peduncle
Trigeminal- main sensory nucleus
Trigeminal motor nucleus
Middle cerebellar peduncle
Trigeminal nerve
Medial lemniscus
Fourth ventricle
Reticular formation
Pontine nuclei
Fibers of pyramidal tract

(b) Pons

Nuclei of medulla oblongata

*Inferior olivary nuclei - gray matter that relays sensory information from muscles and joints

*Nucleus cuneatus and nucleus gracilis / Ascending sensory tract nuclei/

*Cranial nerves

VIII (vestibulocochlear),

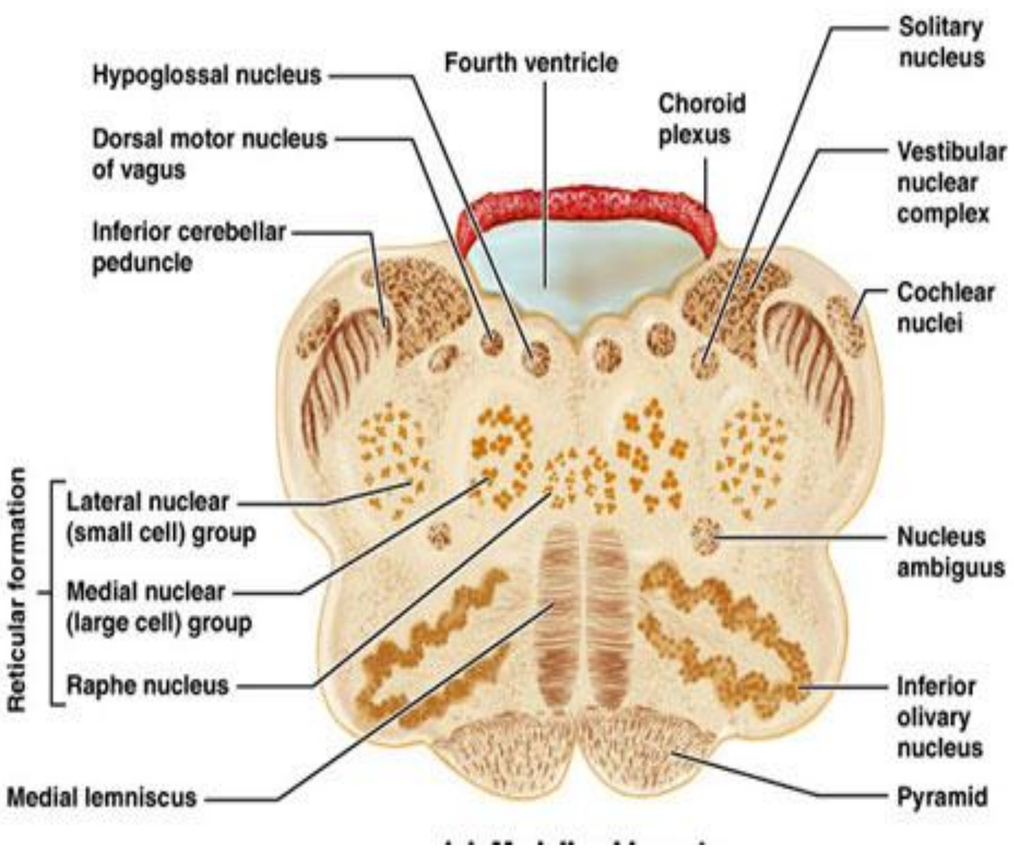
IX (glossopharyngeal),

X (vagus), XI (accessory), and XII (hypoglossal) are associated with the medulla

*Vital important centers: cardiovascular and respiratory

*Centers of reflexes of protection: coughing, sneeze, vomiting

*Nuclei of reticular formation



Functional systems of the brain

Reticular formation

- Sends impulses to the cerebral cortex to keep it conscious and alert
- Filters out repetitive and weak stimuli
- Helps control of coarse motor movements
- Autonomic centers regulate visceral motor functions: vasomotor, cardiac, respiratory

Limbic system

- Reception of olfactory stimuli,
- Integration of olfactory, visceral and somatosensory sensations,
- Influencing the behavour, emotions and memory

The Reticular Neurons

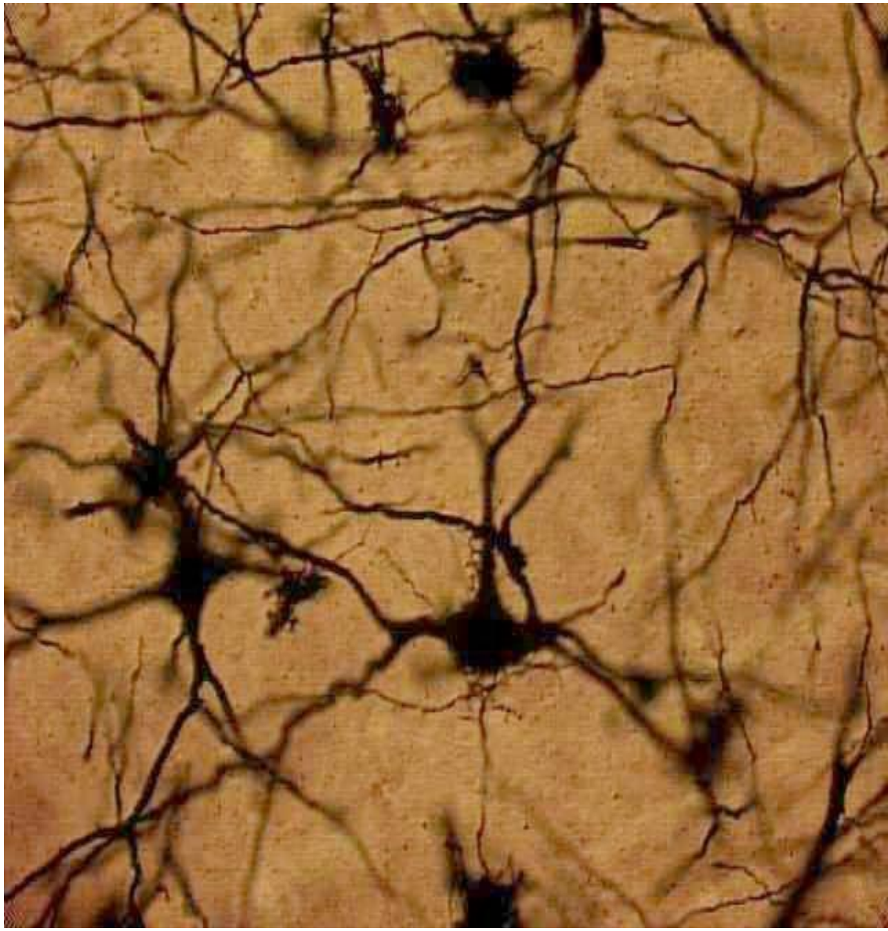
Cells in the Reticular formation characterized by their relative size:

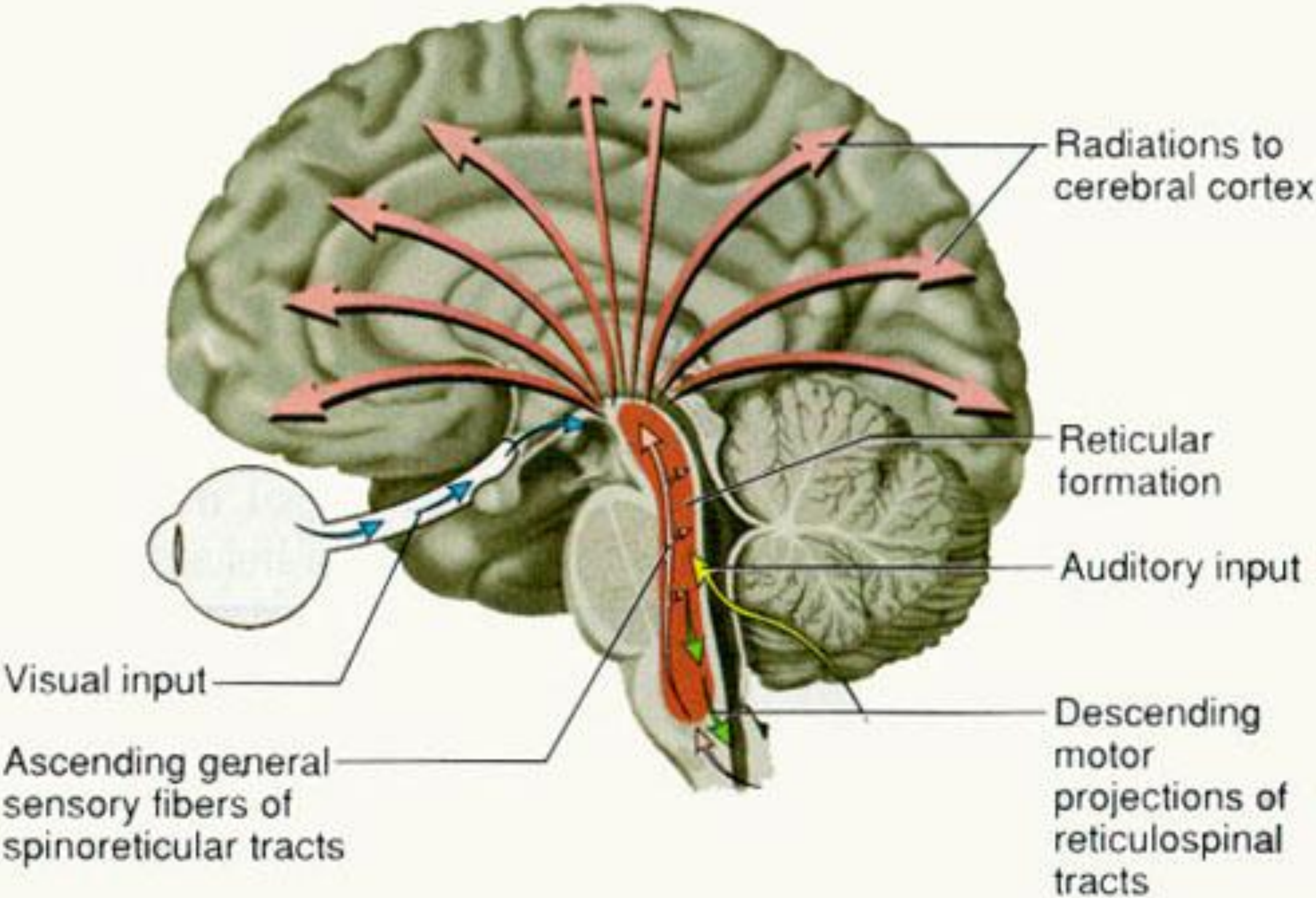
The largest cells are referred to as *giant* cells or giantocellular

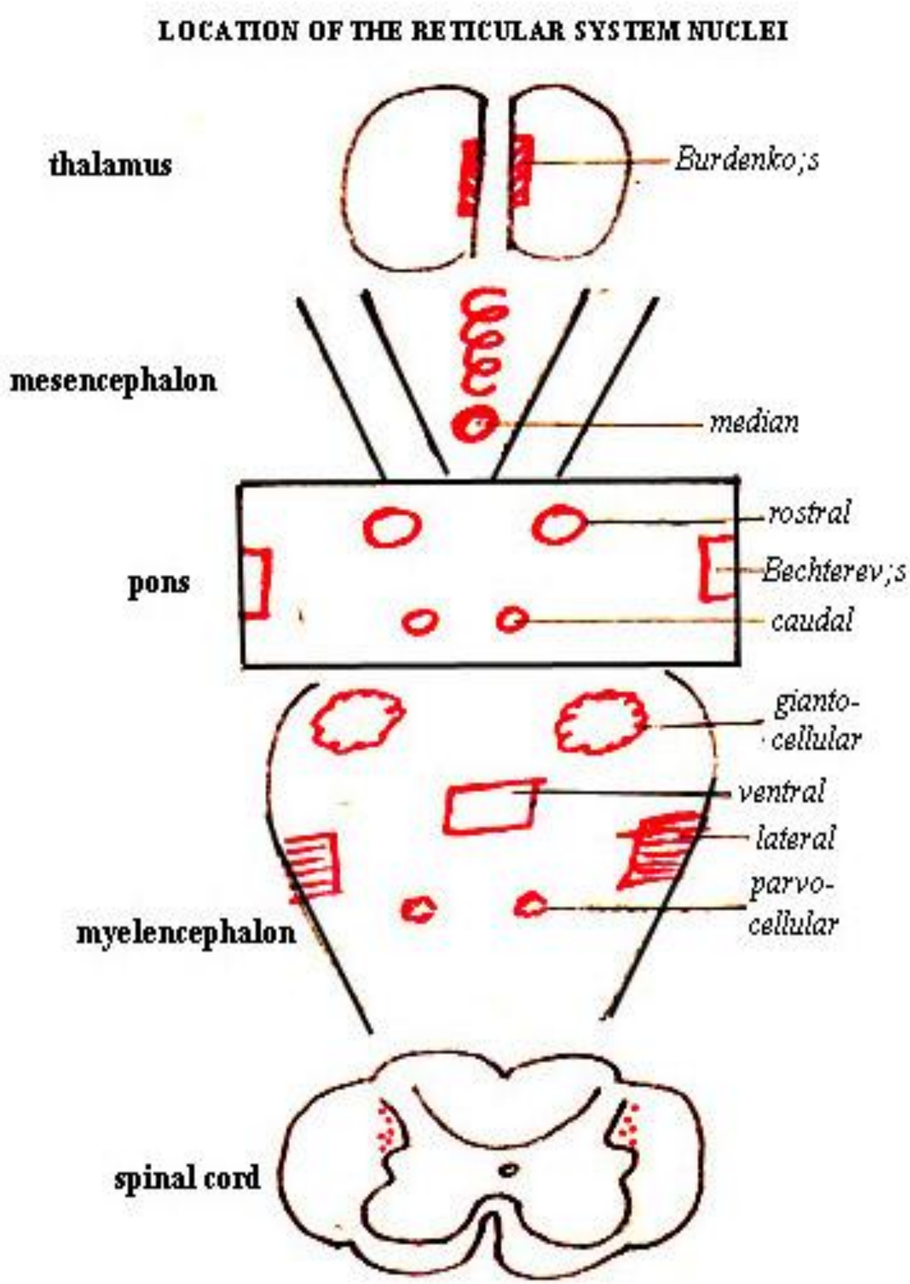
The small cells are referred to as *parvocellular*.

Medium to large size cells are referred to as *magnocellular*

- **The shape and measures of the cells are variable;**
- **Some of the cells are solitary, other – form nuclei;**
- **Processes of the RS form rich network in the brain stem;**
- **Dendrits have few branches, axons have many relations /30.000/**
- Their axons ascend and descend along the long axis of the brainstem
- Ascending axons are carried in the *central* tegmental *tract*
- Descending axons are carried in the *reticulospinal* tract




Radiations to cerebral cortex
Reticular formation
Auditory input
Visual input
Ascending general sensory fibers of spinoreticular tracts
Descending motor projections of reticulospinal tracts



Specific features of the reticular system

1) the shape and measures of the cells are variable;
2) some of the cells are solitary, other – form nuclei;
3) processes with different structure and functions;
4) processes of the reticular system form rich network in the brain stem;
5) dendrites have few branches, axons have many relations /30.000/

Relations of the reticular system

3 groups of relations:

1- reticular formation with different parts of the central nervous system,

2- different parts of the central nervous system with the reticular formation

3- among different parts of reticular formation

Functions of the reticular system

1) *regulates* to the state of sleepness and wakeupness;
2) *controls* many of the stereotyped body movements: postural motions of the limbs, turning and bending motions of the head;
3) *increases* the tone of the muscle;
4) *controls* the brain's overall level of activity
5) *selects* the most important signals and sends them to the cortex

Nuclei of RF

The reticular formation is an apparently (but not actually) diffusely organised area that forms the central core of the brain stem.

•The reason it appears to be diffusely organised is twofold:

•Its pattern of connectivity is characterised by a great deal of convergence and divergence, so that a single cell may respond to several different sensory modalities or to stimuli applied practically anywhere on the body;

•Although it is involved in several quite separate functions, the areas involved in these functions overlap considerably.

•At most levels of the brainstem, the reticular formation can be divided into 4 longitudinal zones arranged in a medial to lateral sequence, in addition a 5-th zone is defined in the medulla:

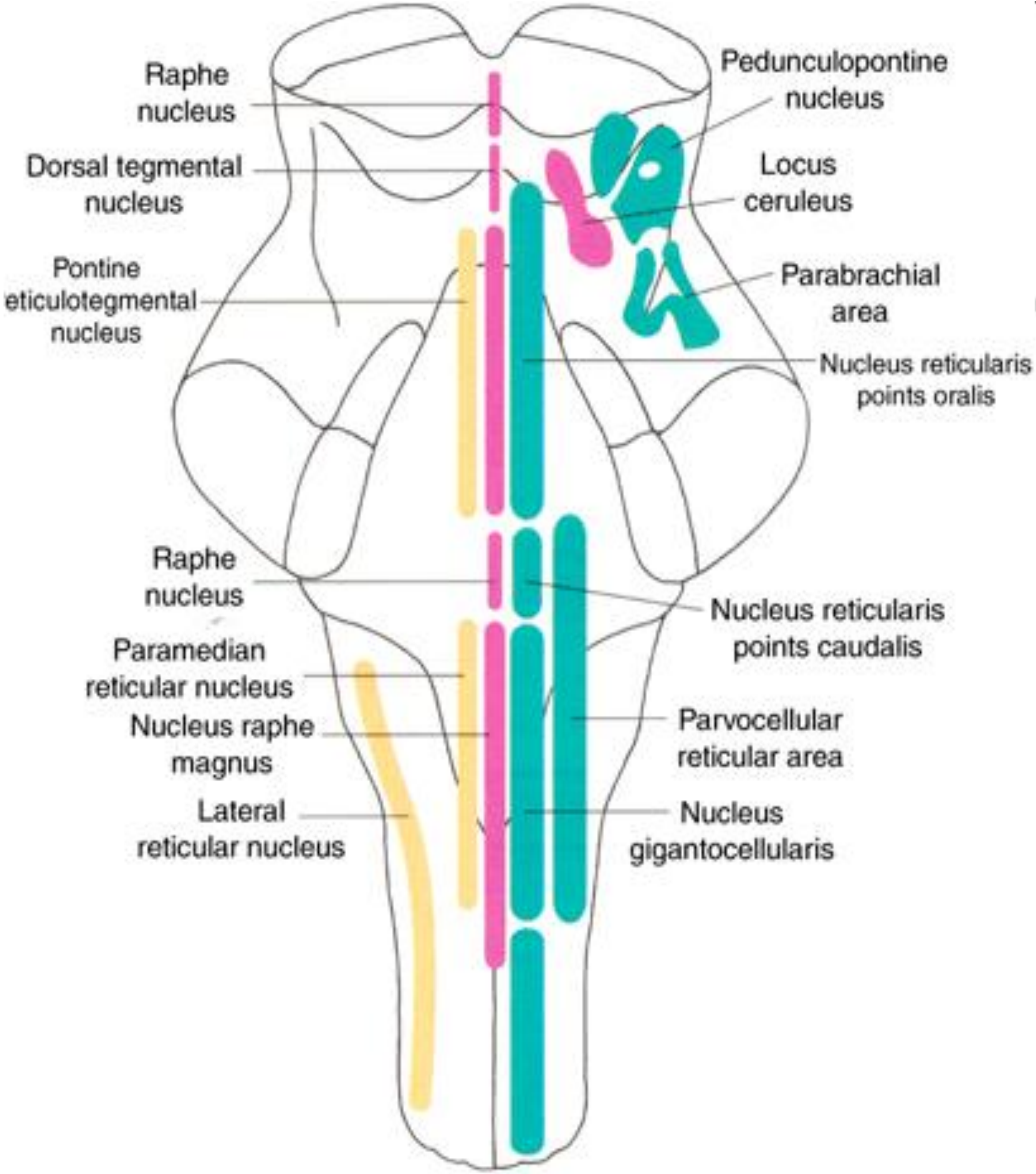
The raphe nuclei

The paramedian zone;

The medial zone;

The lateral zone

The intermediate zone.



The longitudinal arrangement of zones of the brain stem RF

The most lateral strips on both sides are the ***lateral zones***.

Along the midline is the ***median*** or ***raphe zone***.

In between is the ***paramedian*** or the ***medial zone***.

Functions of the Reticular Formation

The reticular formation is involved in **4 general types** of function:

- Motor control;
- Sensory control;
- Visceral control;
- And control of consciousness.

The reticular formation has two components

- The ***ascending reticular formation*** is also called the **reticular activating system**. It is responsible for the sleep-wake cycle, thus mediating various levels of alertness. This part of the reticular system projects to the mid-line group of the thalamus, which also plays a role in wakefulness. From there, information is sent to the cortex.

- The ***descending reticular formation*** is involved in posture and equilibrium as well as autonomic nervous system activity. It receives information from the hypothalamus. The descending reticular formation also plays a role in motor movement.

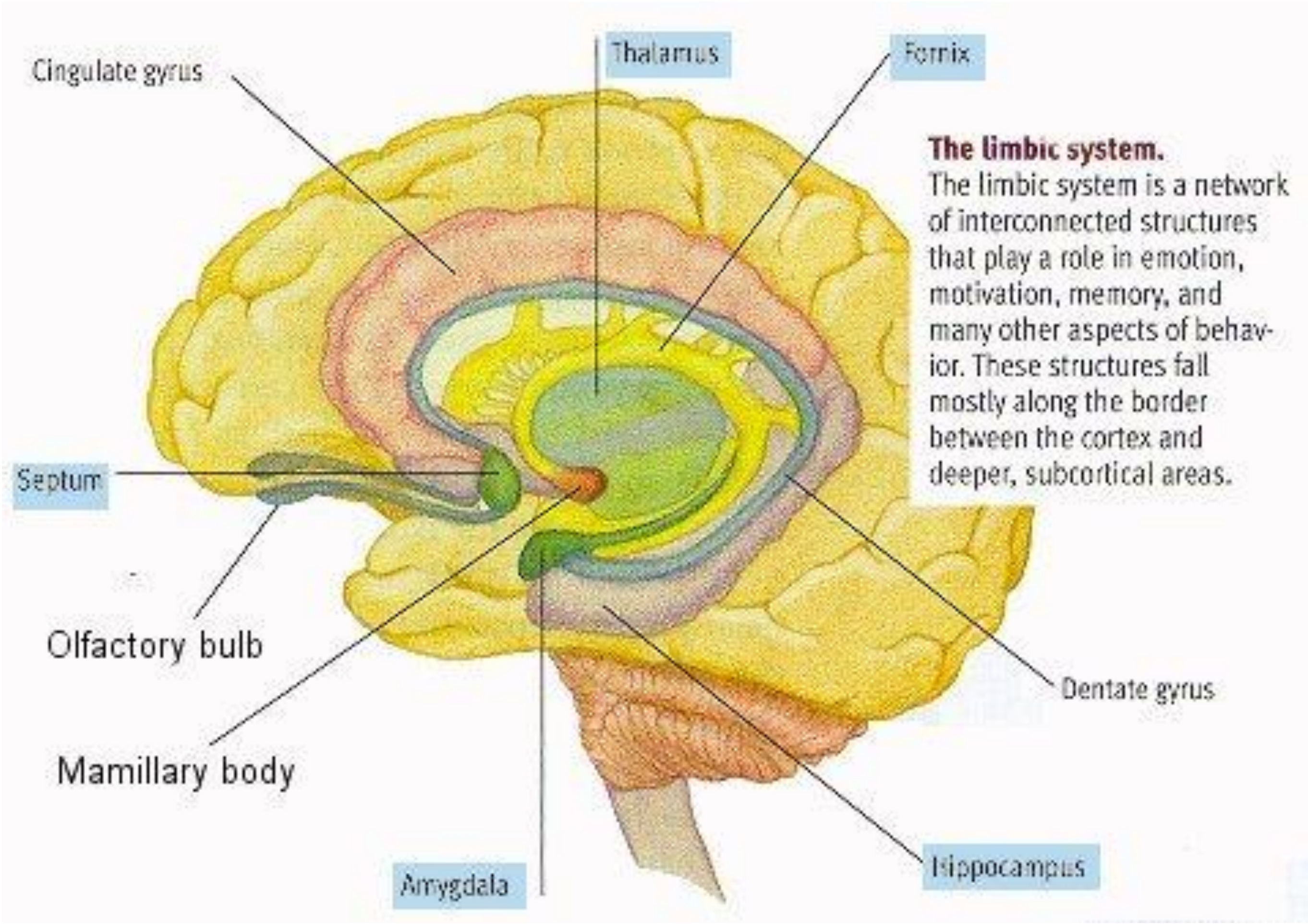
Limbic System – "emotional or affective" brain

*Structures ***located on the medial aspects of cerebral hemispheres and diencephalon*** – **encircle the upper part of the brain stem (includes the rhinencephalon, amygdala, hypothalamus, and anterior nucleus of the thalamus).**

2 parts:

-peripheral

-central



The limbic system or human rhinencephalon

- The **limbic system** . *It is a g*roup of interconnected deep brain structures, common to all mammals, and involved in olfaction, emotion, motivation, behavior, and various autonomic functions.
- The limbic system is a complex set of structures that lies on both sides and underneath the thalamus, just under the cerebrum.
- It includes the ***hypothalamus, the hippocampus, the amygdala, cingulated gyrus, and several other nearby areas***. It appears to be primarily responsible for our emotional life, and has a lot to do with the formation of memories.
- Phylogenetically the oldest part of the forebrain; it arises in association with the olfactory organ that controls the animal's behavior
- In mammals and man a new part of the forebrain develops, the ***pallium***. But it also goes through a long developmental course and contains three parts differing in phylogenetic age.

The paleopalleum (paleocortex), a small cortical area on the ventral surface of the frontal lobe, lying close to the olfactory bulb.

The archypallium (archycortex) a component of the temporal lobe. It is hippocampus, or Ammon's horn. The hippocampus is covered by cortex, archycortex.

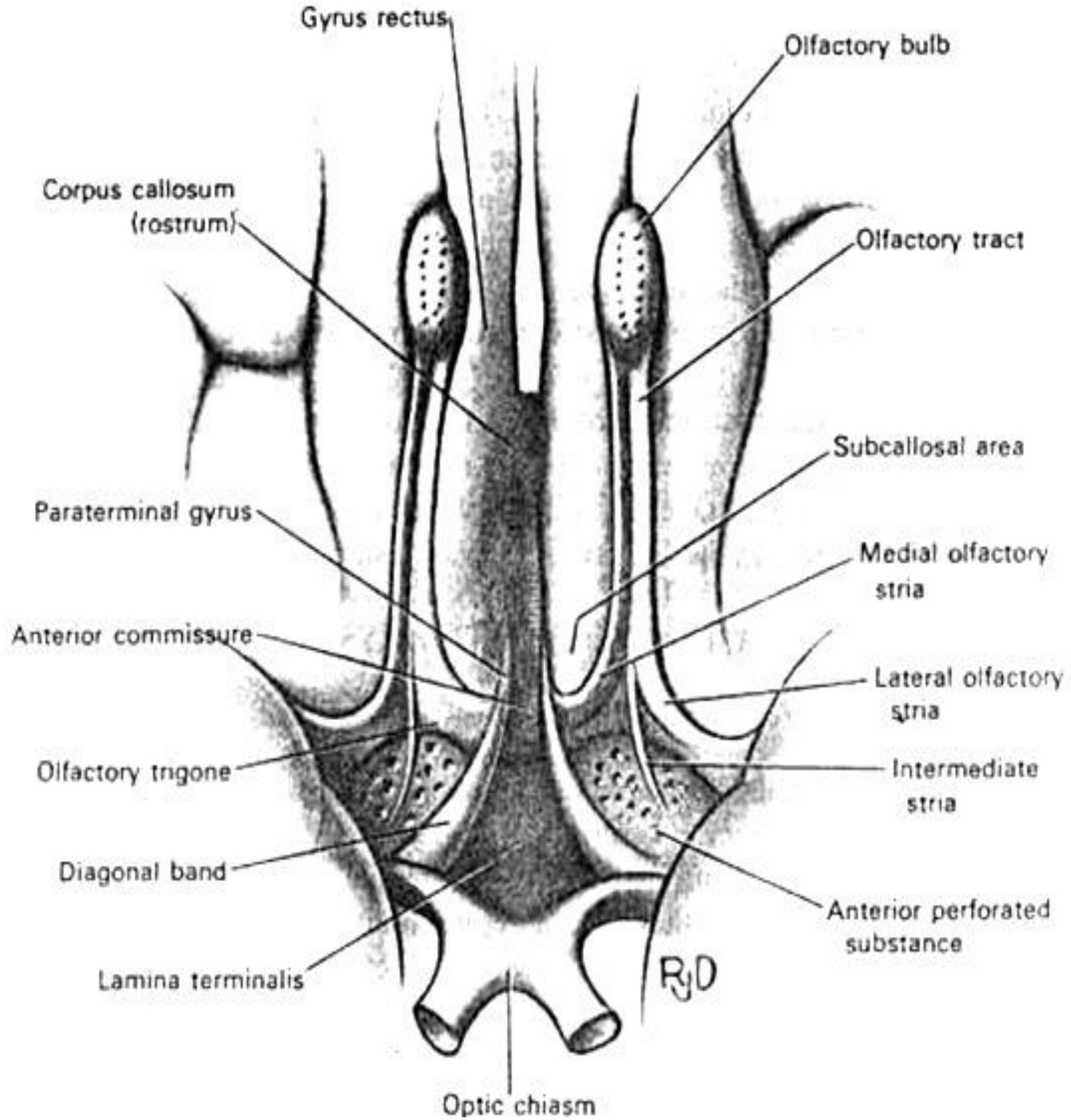
The neopallium (neocortex) in which the higher centres of olfaction have appeared

Peripheral part of the human rhinencephalon contains a number of structures: olfactory bulb, olfactory tract &pyramid (trigonum olfactorium), the anterior perforated substance.

Central part /limbic lobe/,

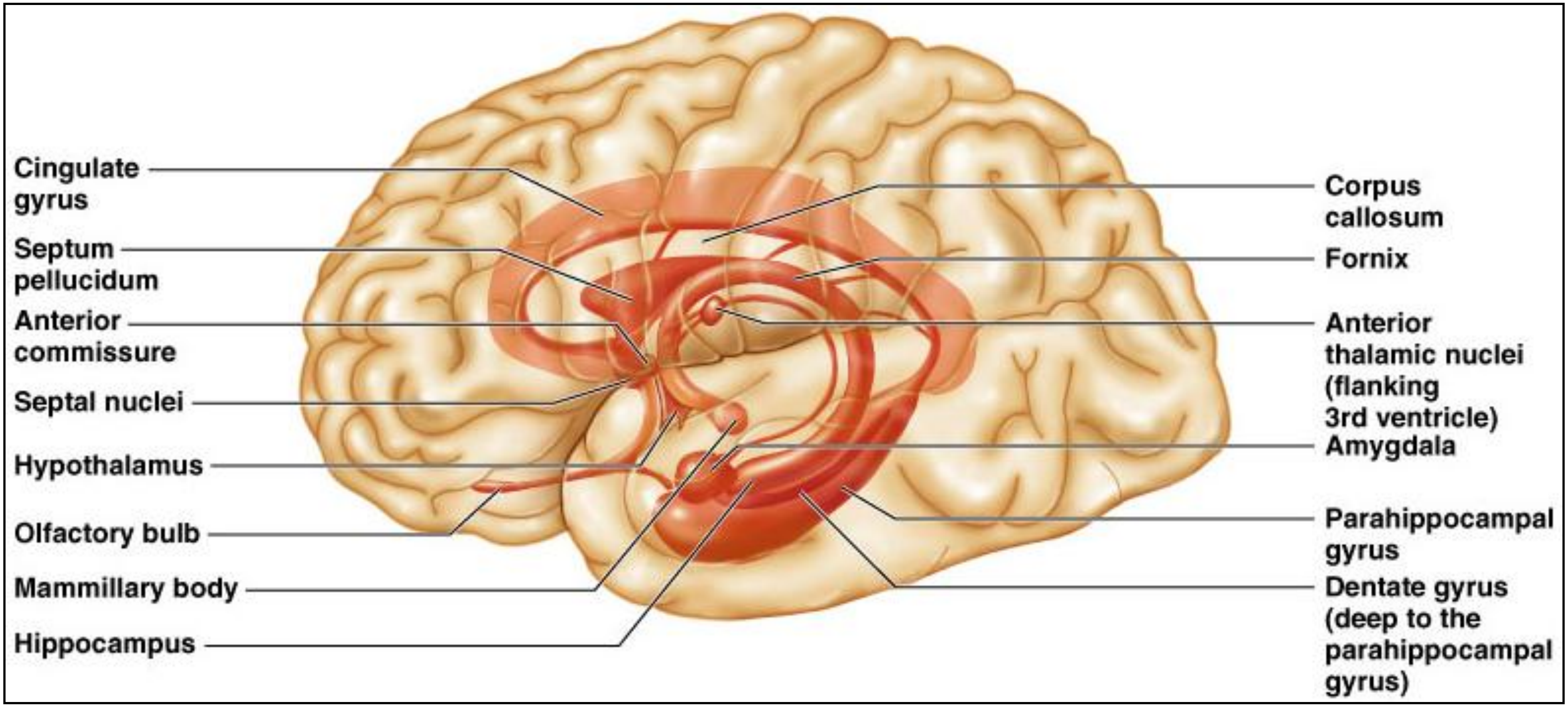
the gyri of the brain:
the hippocampus,
the dentate gyrus, the gyrus fornicatus

The word "*limbic*" means border, and ***the limbic system*** is comprised of the border structures of both the cerebrum and the diencephalon that mainly surround the hipothalamus.



Limbic System

The limbic system interacts with the prefrontal lobes, forming a connection between feelings (emotional brain) and thoughts (cognitive brain)

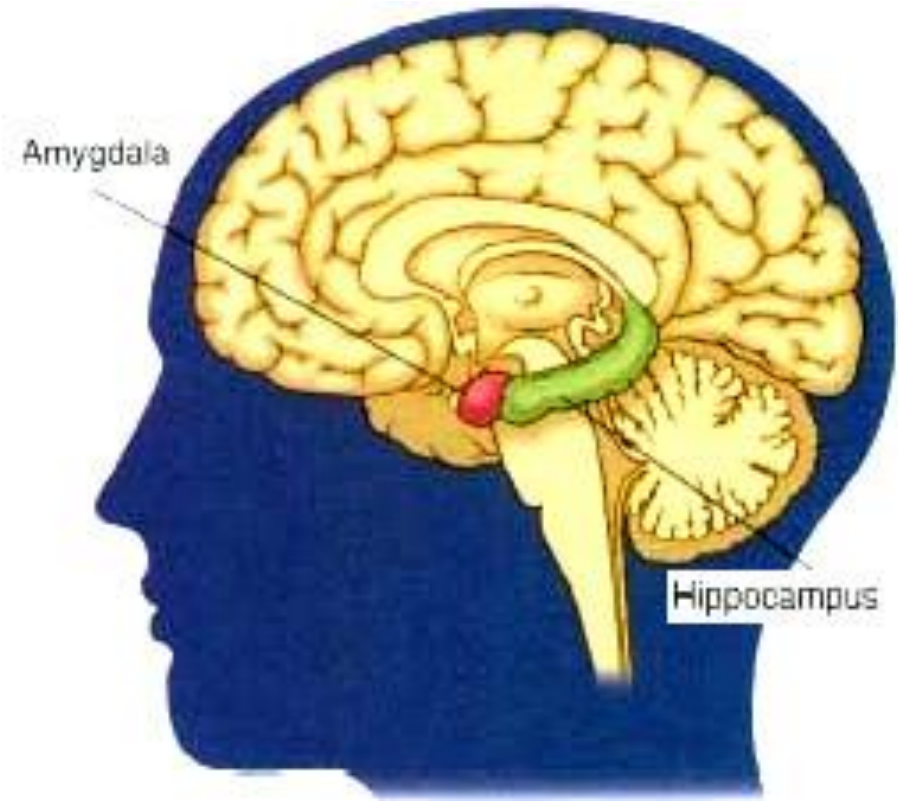


Components of the limbic system

The amygdala (also called the amygdaloid body) is a small nuclear structure located deep inside each anterior temporal lobe /immediately anterior to the hippocampus/ and considered by anatomists to one of the basal ganglia.

The amygdalas are two almond-shaped masses of neurons on either side of the thalamus at the lower end of the hippocampus.

When it is stimulated electrically, animals respond with aggression. And if the amygdala is removed, animals get very tame and no longer respond to things that would have caused rage before. But there is more to it than just anger: When removed, animals also become indifferent to stimuli that would have otherwise have caused fear and even sexual responses.



Bilateral lesions of the temporal lobes and amygdala may result in the syndrome, which is characterized by patients who develop an aberrant tendency to examine almost anything orally, visually and tactually.

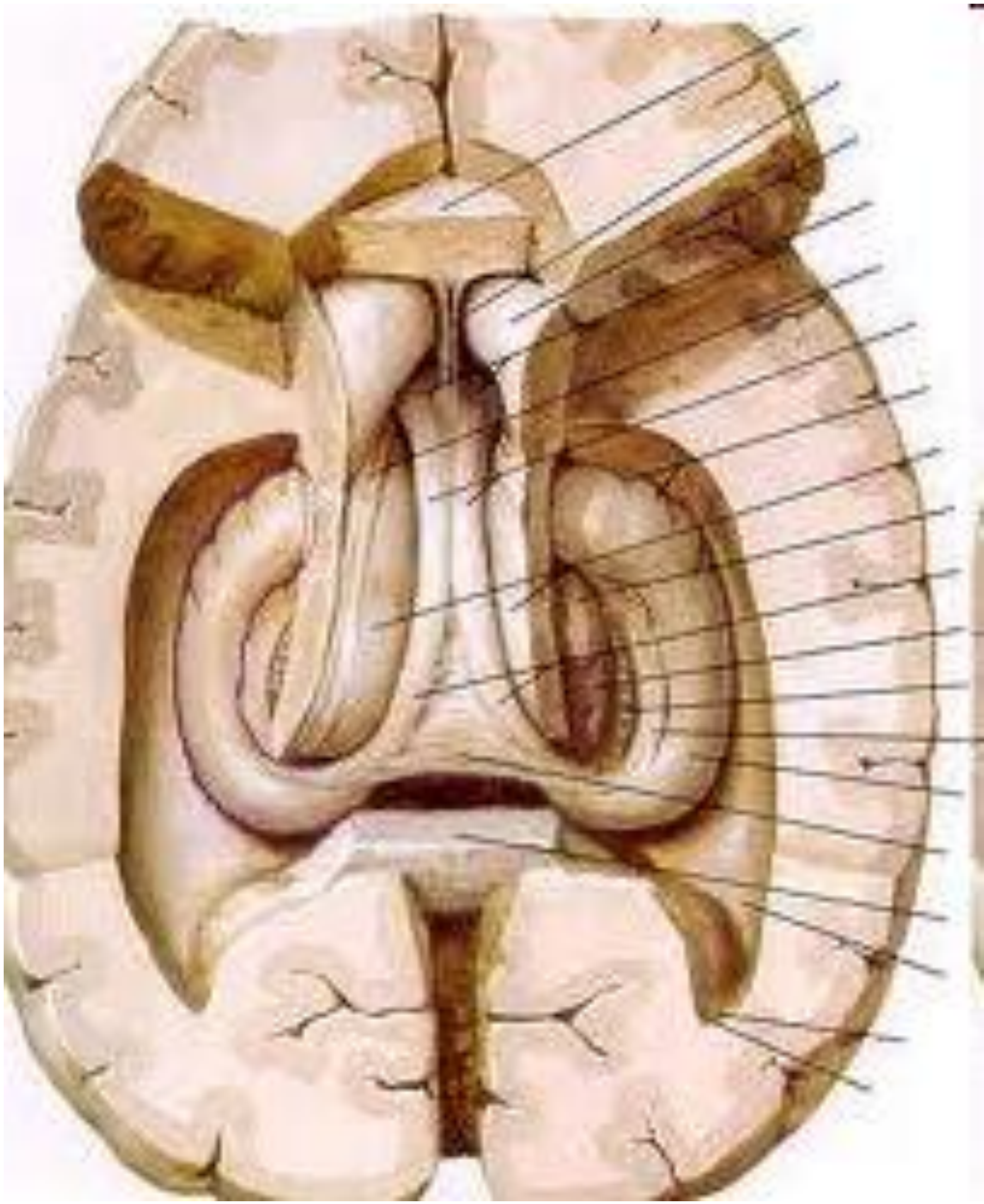
In addition, patients (males in particular) develop hypersexual tendencies toward any gender.

- ***The hippocampus*** consists of two "horns" that curve back from the amygdala. It appears to be very important in converting things that are "in your mind" at the moment (in short-term memory) into things that you will remember for the long run (long-term memory).

- If the hippocampus is damaged, a person cannot build new memories, and lives instead in a strange world where everything they experience just fades away, even while older memories from the time before the damage are untouched!

- Without the hippocampus, a person's ability to store memories becomes very deficient.

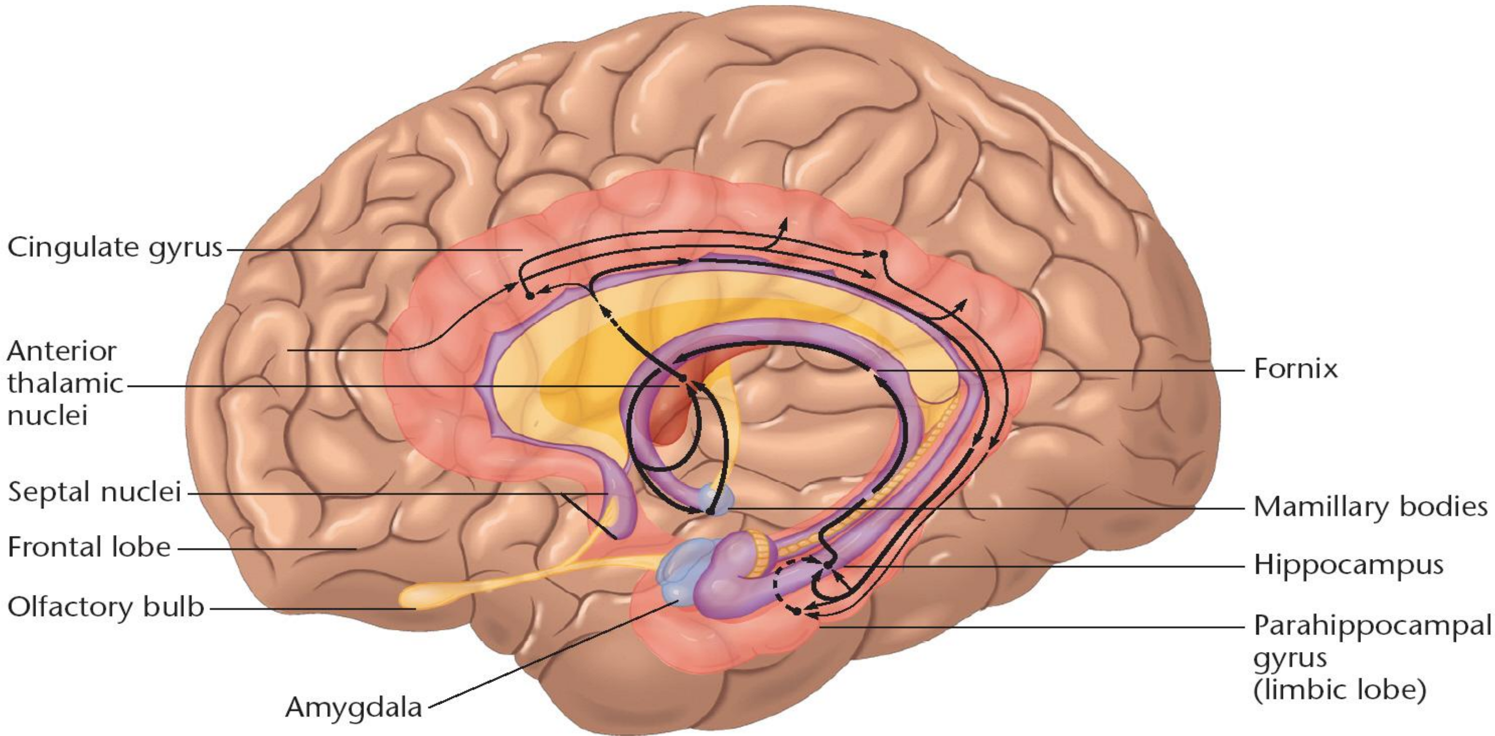
- While a unilateral ablation of the hippocampus does not result in deficits, a bilateral ablation results in a loss of short term memory and an ability to store new information.



Hippocampus

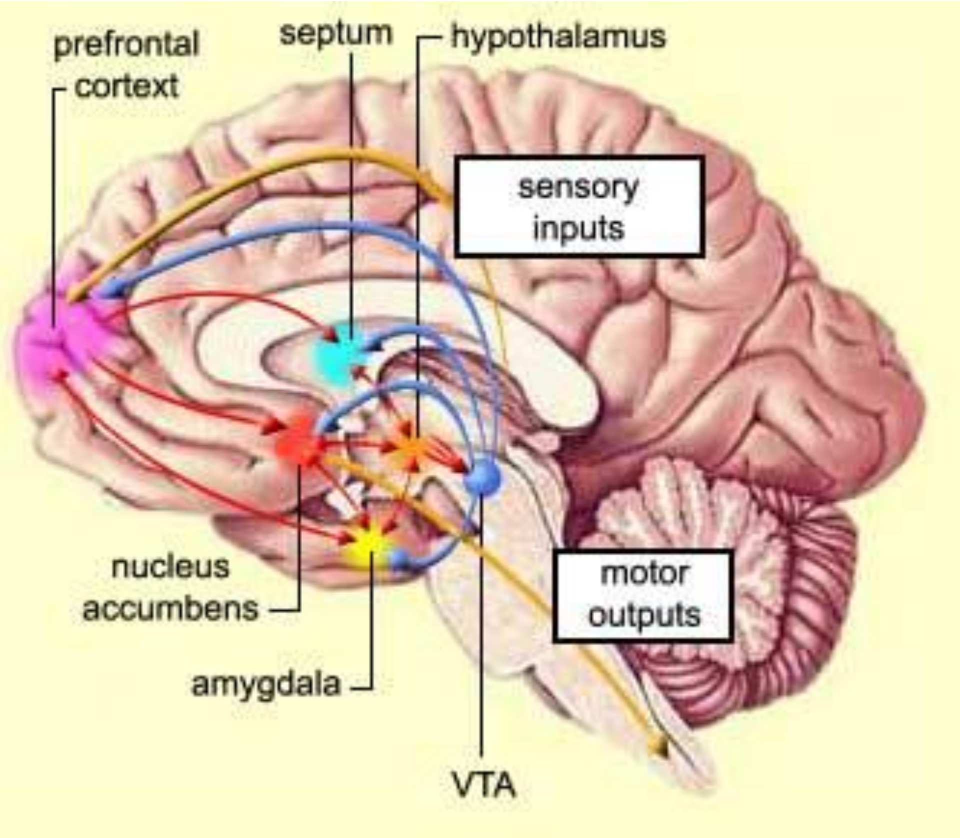
- ***The cingulate gyrus, the insula,*** *and the parahippocampal gyrus* all together form a ring of cerebral cortex in each cerebral hemisphere around the deeper structures of the limbic system.
- This ring of cortex is believed to allow association between conscious cerebral behavioral functions and subconscious behavioral functions of the deeper limbic system.

•The **cingulate gyrus** is the part of the cerebrum that lies closest to the limbic system, just above the corpus collosum. It provides a pathway from the thalamus to the hippocampus, seems to be responsible for focusing attention on emotionally significant events, and for associating memories to smells and to pain.

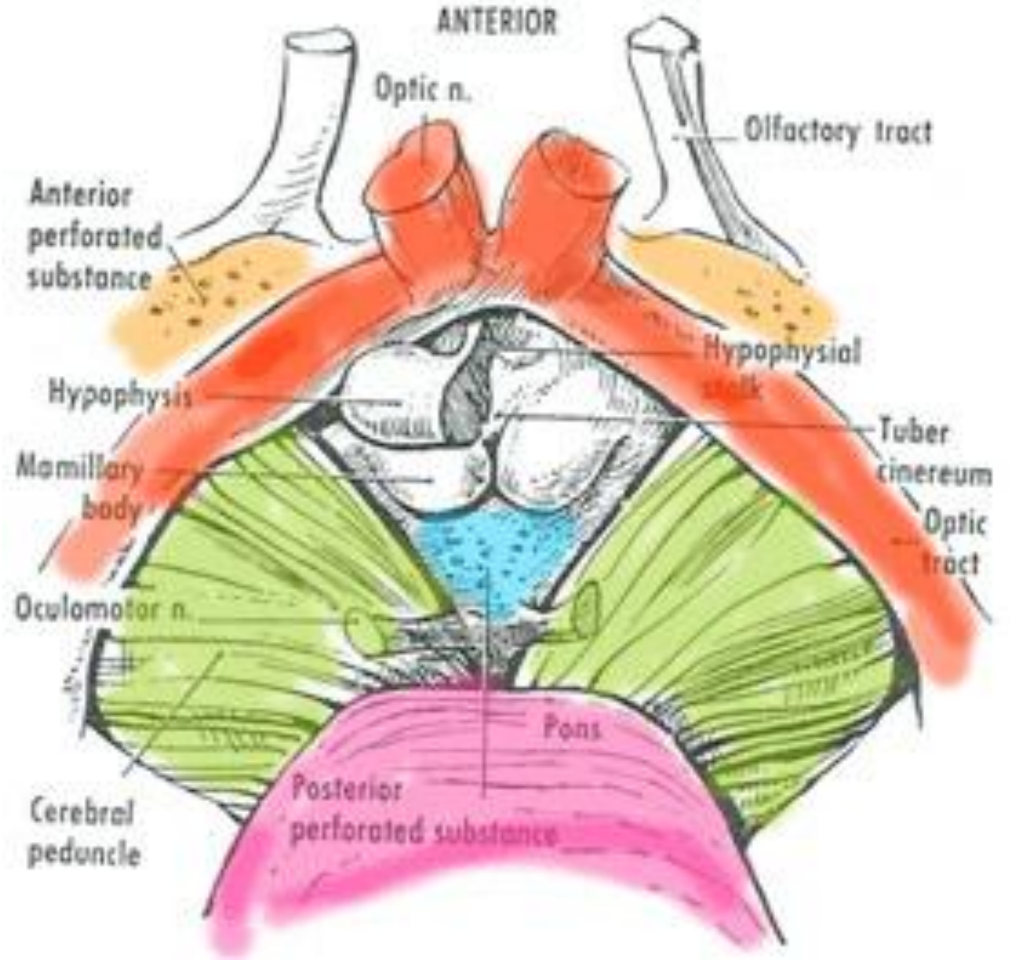


The limbic system includes many different cortical and subcortical brain structures

- ***amygdale***: involved in aggression and fear;
- ***cingulated gyrus***: autonomic functions regulating heart rate and blood pressure as well as cognitive and attentional processing;
- ***fornicate gyrus***: region encompassing the cingulated, hippocampus, and parahippocampal gyrus;
- ***hippocampus:*** required for the information of long term memories;
- ***hypothalamus***: regulates the autonomic nervous system via hormone production and release. Affects and regulates blood pressure, heart rate, hunger, thirst, sexual arousal, and the sleep/wake cycle;
- ***mammilary body***: importamt for the formation memory;
- ***nucleus accumbens***: involved in reward, pleasure, and addiction;
- ***orbitofrontal cortex***: required for decision making;
- ***parahippocampal gyrus***: plays a role in the formation of spatial memory.



The mammillary bodies lie immediately behind the hypothalamus and function in close association with the thalamus, hypothalamus, and brain stem to help control many behavioral functions such as the person's degree of wakefulness and perhaps also his feeling of well being.



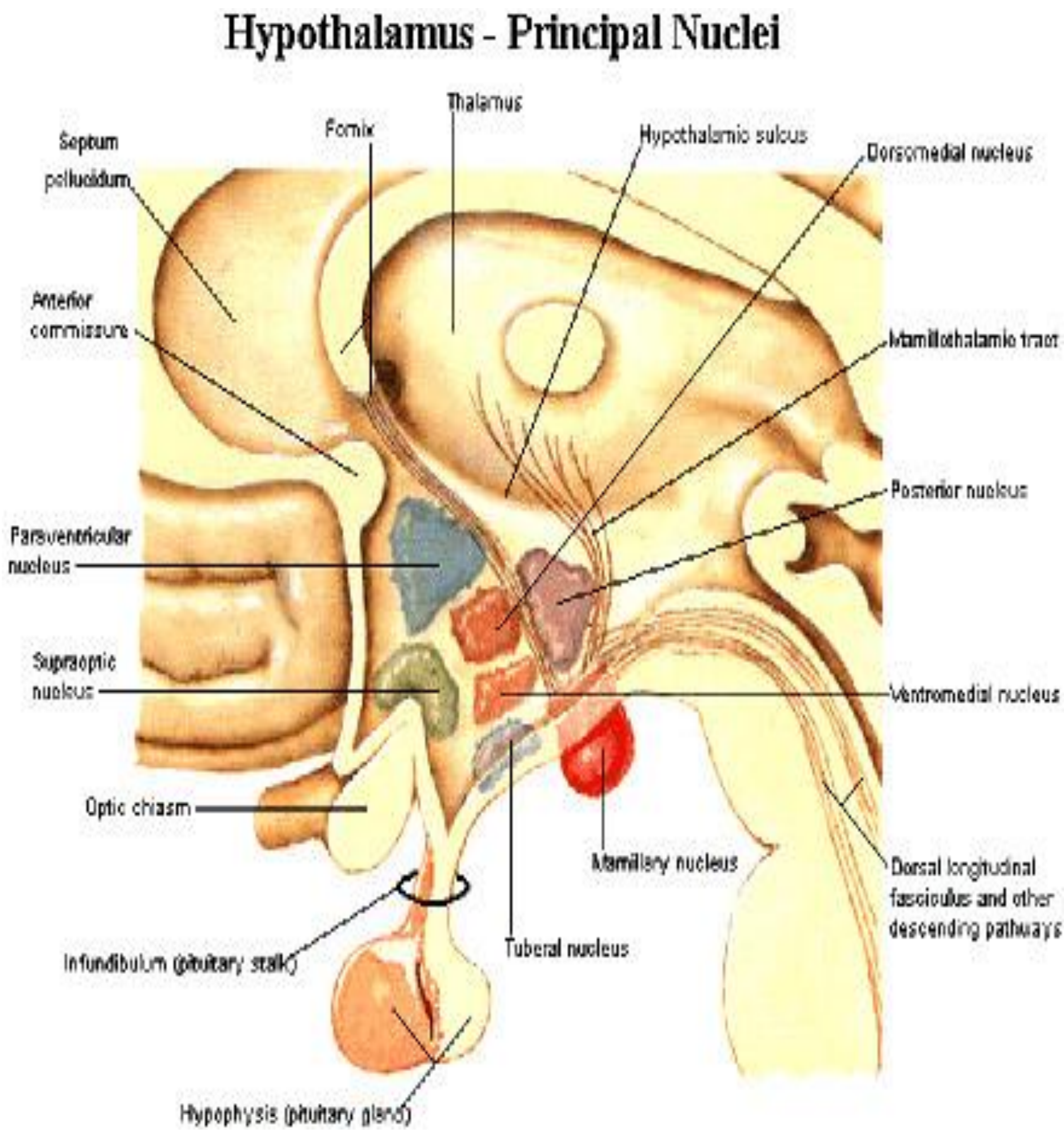
- ***The hypothalamus*** **is a small part of the brain located just below the thalamus on both sides of the third ventricle. It sits just inside the two tracts of the optic nerve, and just above (and intimately connected with) the pituitary gland.**

- **The hypothalamus is one of the busiest parts of the brain, and is mainly concerned with homeostasis. Homeostasis is the process of returning something to some "set point." It works like a thermostat: When your room gets too cold, the thermostat conveys that information to the furnace and turns it on. As your room warms up and the temperature gets beyond a certain point, it sends a signal that tells the furnace to turn off.**

- **The hypothalamus is responsible for regulating your hunger, thirst, response to pain, levels of pleasure, sexual satisfaction, anger and aggressive behavior, and more. It also regulates the functioning of the parasympathetic and sympathetic nervous systems, which in turn means it regulates things like pulse, blood pressure, breathing, and arousal in response to emotional circumstances.**

- ***The hypothalamus*** sends instructions to the rest of the body in two ways. The first is to the **autonomic nervous system**. This allows the hypothalamus to have ultimate control of things like blood pressure, heartrate, breathing, digestion, sweating, and all the sympathetic and parasympathetic functions.

- The other way the hypothalamus controls things is via the **pituitary gland**. It is neurally and chemically connected to the pituitary, which in turn pumps hormones called releasing factors into the bloodstream. As you know, the pituitary is the so-called "master gland," and these hormones are vitally important in regulating growth and metabolism.



The septum pellucidum

- It lies anterior to the thalamus, superior to the hypothalamus, and between the basal ganglia in the median plane of the cerebrum.
- The septal nuclei are located in the infero-medial portion of the frontal lobes.

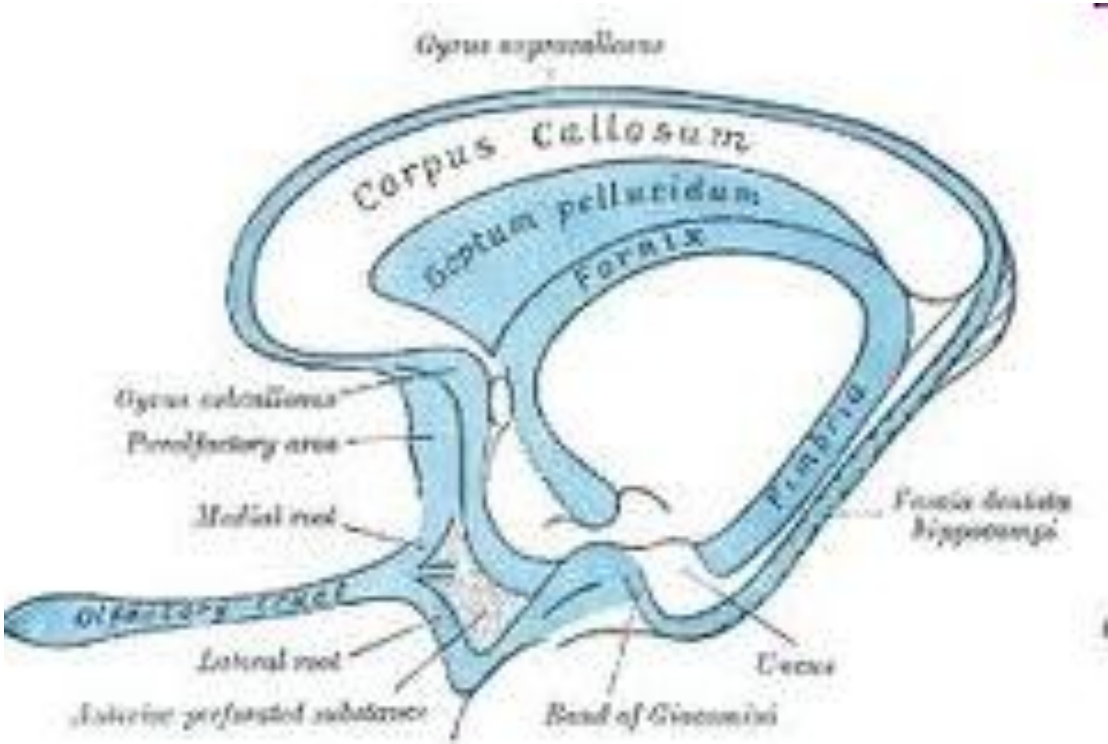
- ***They receive afferents from:***

- the hypothalamus and midbrai through the medial forebrain bundle,
- the amygdala via the diagonal band of Broca,
- the hippocampus via the fornix.

- ***Efferents from the septal nuclei*** project to the:

- hippicampus,
- hypothalamus,
- midbrain,
- habenular nuclei.

- ***The function of the septal nuclei*** is to provide a site of interaction between limbic and diencephalic structures.
- Physiological studies implicate the septal nuclei in modulating arousal, learning, emotion and sexual behavior. The **septum**, which lies in front of the thalamus, has areas that seem to be centers for orgasm.
- Stimulation of different parts of this septum can cause many different behavioral effects, including the phenomenon of rage.



Related areas

- Besides the hypothalamus, hippocampus, and amygdala, there are other areas in the structures near to the limbic system that are intimately connected to it:

- The **ventral tegmental area** of the brain stem (just below the thalamus) consists of dopamine pathways that seem to be responsible for pleasure. People with damage here tend to have difficulty getting pleasure in life, and often turn to alcohol, drugs, sweets, and gambling.

- The **basal ganglia** (including the caudate nucleus, the putamen, the globus pallidus, and the substantia nigra) lie over and to the sides of the limbic system, and are tightly connected with the cortex above them. They are responsible for repetitive behaviors, reward experiences, and focusing attention.

- The **prefrontal cortex**, which is the part of the frontal lobe which lies in front of the motor area, is also closely linked to the limbic system. Besides apparently being involved in thinking about the future, making plans, and taking action, it also appears to be involved in the same dopamine pathways as the ventral tegmental area, and plays a part in pleasure and addiction.

Functions of the limbic system

- Controls Emotions
- Emotional Responses
- Hormonal Secretions
- Mood
- Motivation
- Pain and Pleasure Sensations

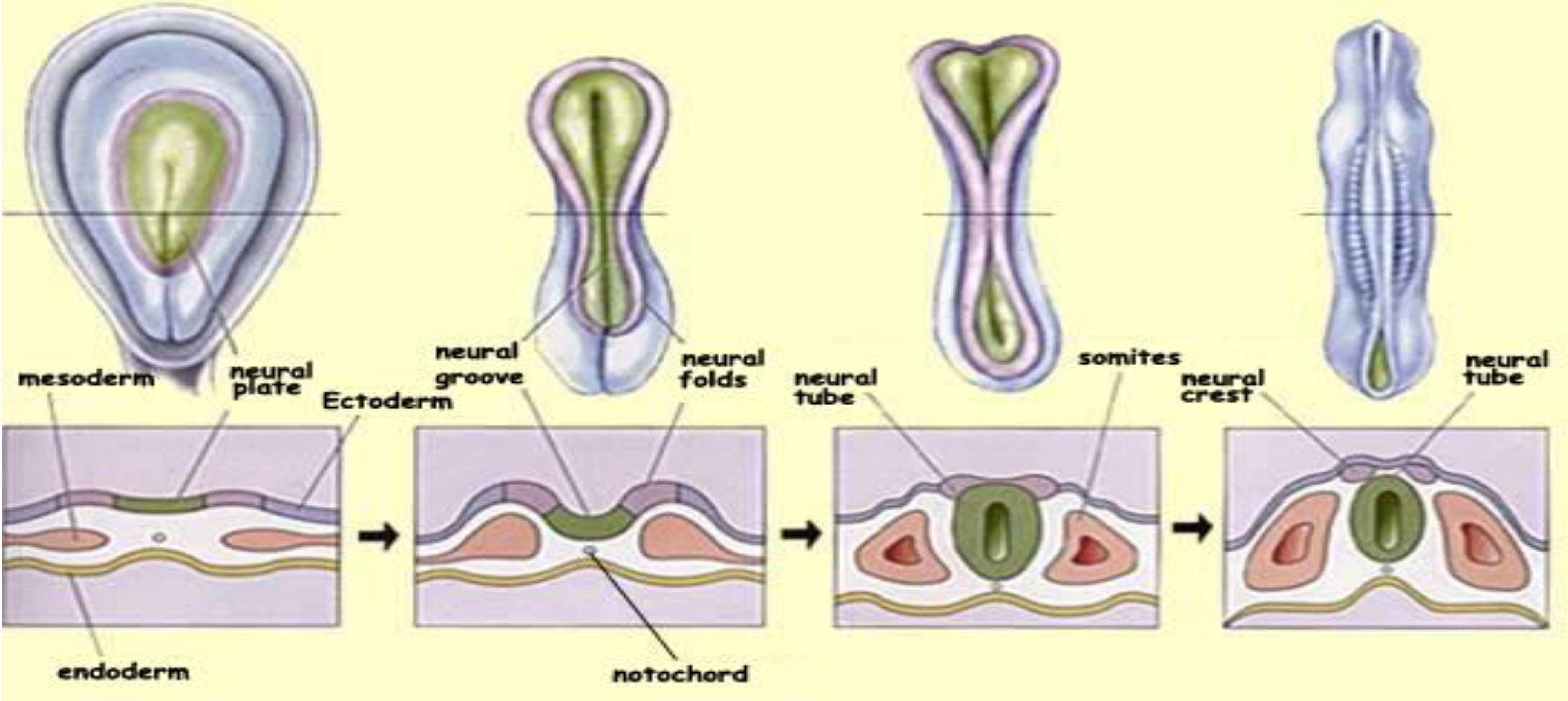
- The reticulal formation has been reffered to many times in previous units as the “arousal” center for the central nervous system and is found centrally located in the brainstem.

- The limbic system is located just superior to the corpus callosum and has primary responsibilities for olfaction and emotions.

- These two areas work closely together in what may be reffered to as *the “**reticulolimbic system**.”*

Formation of neural tube

At the beginning of the third week of development, the ectodermal germ layer has the shape of a disc that is broader in the cephalic than the caudal region .

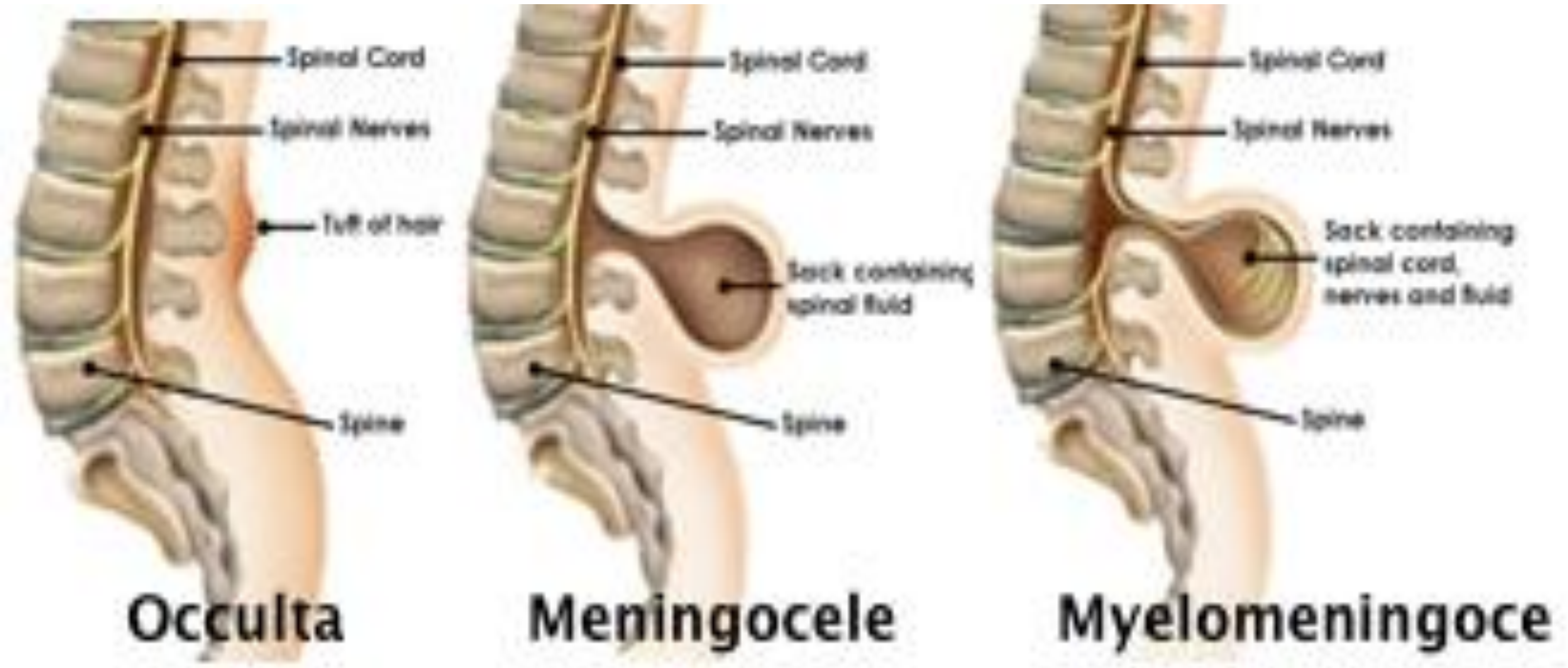


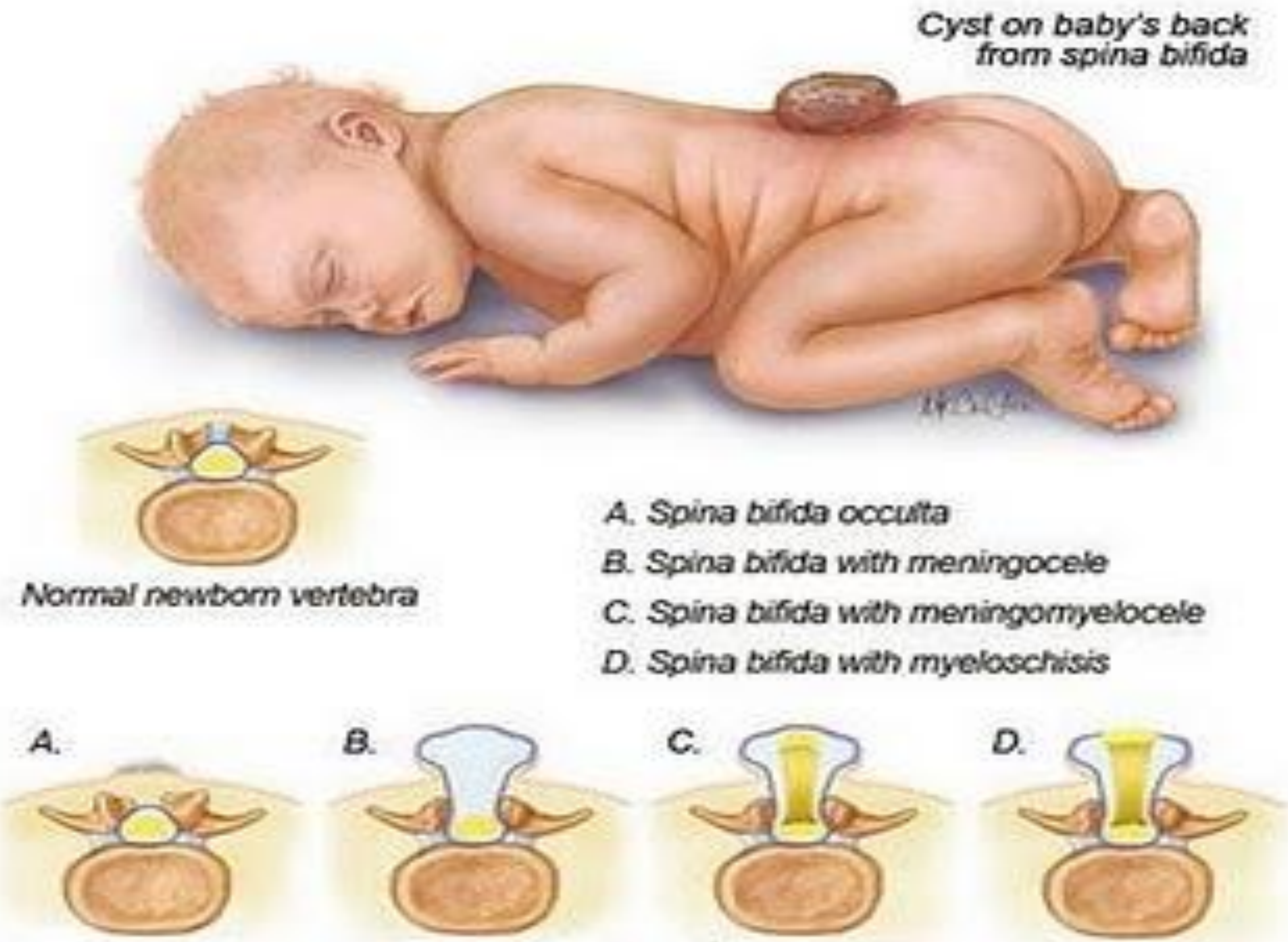
Development of the spinal meninges:

a) the ***dura mater*** develops from the ***mesoderm of the sclerotomes*** which form the vertebral column.

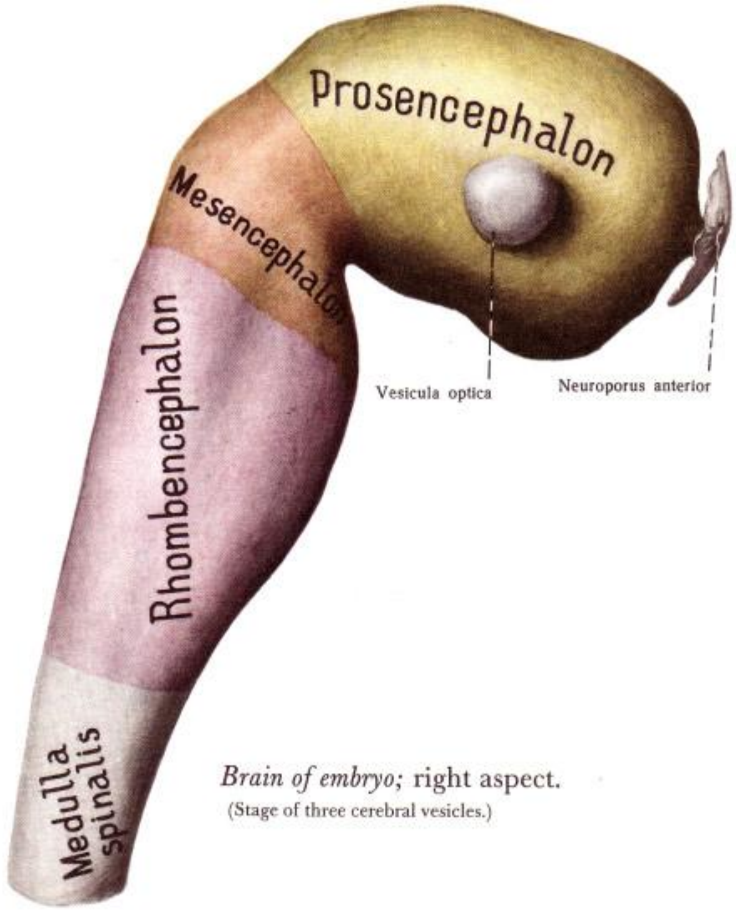
b) the ***arachnoid*** and ***pia mater*** develop from the ***neural crest***.

- **Spina bifida** is a more common and usually less severe form of failure of fusion in which there is failure of the neural arches of the vertebrae to meet, fuse, and enclose the spinal cord.
- Spinal bifida may be minimal, involving only failure of fusion of the vertebrae but the spinal cord and meninges are normal and ***without external manifestation***: this is called **spina bifida occulta**.
- When ***the meninges are also involved*** and form a fluid filled cystic structure bulging posteriorly then there is **spina bifida with meningocele**.
- When ***the spinal cord is carried outward*** with the meningocele then the condition is **spina bifida with myelomeningocele**.




Cyst on baby's back
from spina bifida
Normal newborn vertebra
A. Spina bifida occulta
B. Spina bifida with meningocele
C. Spina bifida with meningomyelocele
D. Spina bifida with myeloschisis
A.
B.
C.
D.

In the extreme example show, the spinal cord is at the surface in the form of the wide-open neural tube. This is **spina bifida with myeloschisis**.

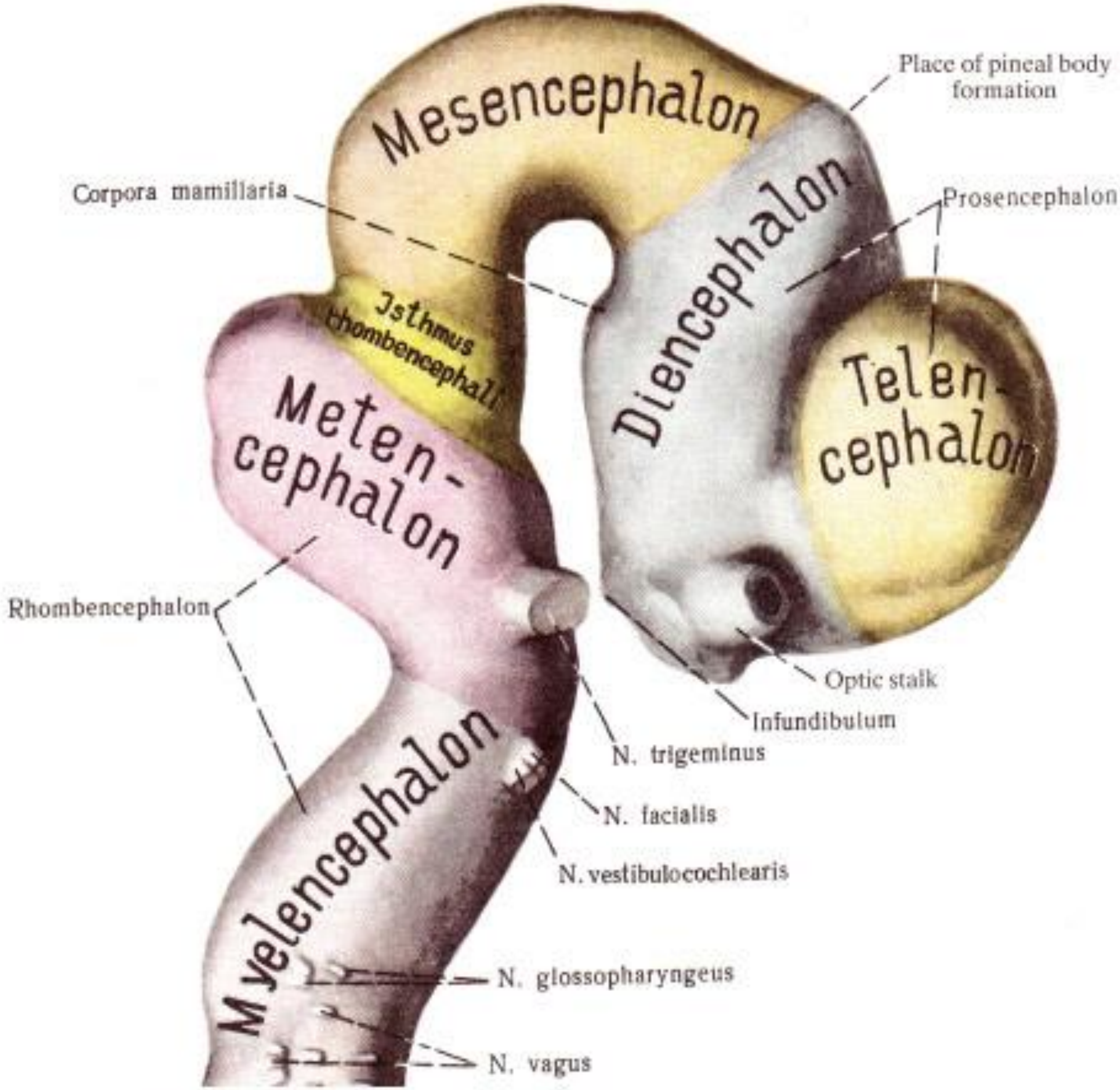


Brain of embryo; right aspect.
(Stage of three cerebral vesicles.)

Brain development

- **The brain develops from the cranial end of the neural tube as follows:**
- **1) The cranial end of the neural tube expands to form the brain swelling.**
- **2) Two constrictions appear in the brain swelling, dividing into 3 parts called *primary brain vesicles*:**
- **a) *forebrain* or *prosencephalon*,**
- **b) *midbrain* or *mesencephalon*,**
- **c) *hindbrain* or *rhombencephalon*.**

- **The human brain begins forming very early in prenatal life (just three weeks after conception), but in many ways, brain development is a lifelong project.**
- **Neural development refers to the processes that generate, shape, and reshape the nervous system, from the earliest stages of embryogenesis to the final years of life.**



Brain of 10.2-mm-long embryo;

3)The brain vesicles are differentiated in ***5 secondary brain vesicles:***

a) ***the forebrain*** gives ***2 optic vesicles*** (the future eyes) and then divides into:

- the median part called ***diencephalons***,
- two lateral diverticula called ***telencephalic vesicles*** (the future cerebral hemispheres);

b) the midbrain remains undivided;

c) ***the hindbrain*** gives rise to the following derivatives:

- the ***metencephalon*** which forms the pons and cerebellum;
- the ***myelencephalon*** which forms the medulla oblongata.

Anomalies of the brain

- ***Anencephaly*** is the most severe of neural tube defects. Babies with anencephaly have underdeveloped brains and incomplete skulls and most of them do not survive more than a few hours after birth. A baby born with this disorder is usually blind, deaf, unconscious and unable to feel pain.

- ***Encephalocele*** is where there is an opening in the skull, from which the brain protrudes. There can be a large sac like deformity which holds cerebrospianl fluid, these can be even larger than the baby's head.

- ***Microgyria:*** abnormal smallness of the convolutions of the brain.

END