MAJOR PAPER: COMPARATIVE ANATOMY OF VERTEBRATES

UNIT: 3

NERVOUS SYSTEM IN MAMMALS

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1. NERVOUS SYSTEM (CNS - BRAIN & CIRCULATION)

DIVISIONS OF NERVOUS SYSTEM

Nervous system controls all the activities of the body. It is quicker than other control system in the body, namely endocrine system. Primarily, nervous system is divided into two parts:

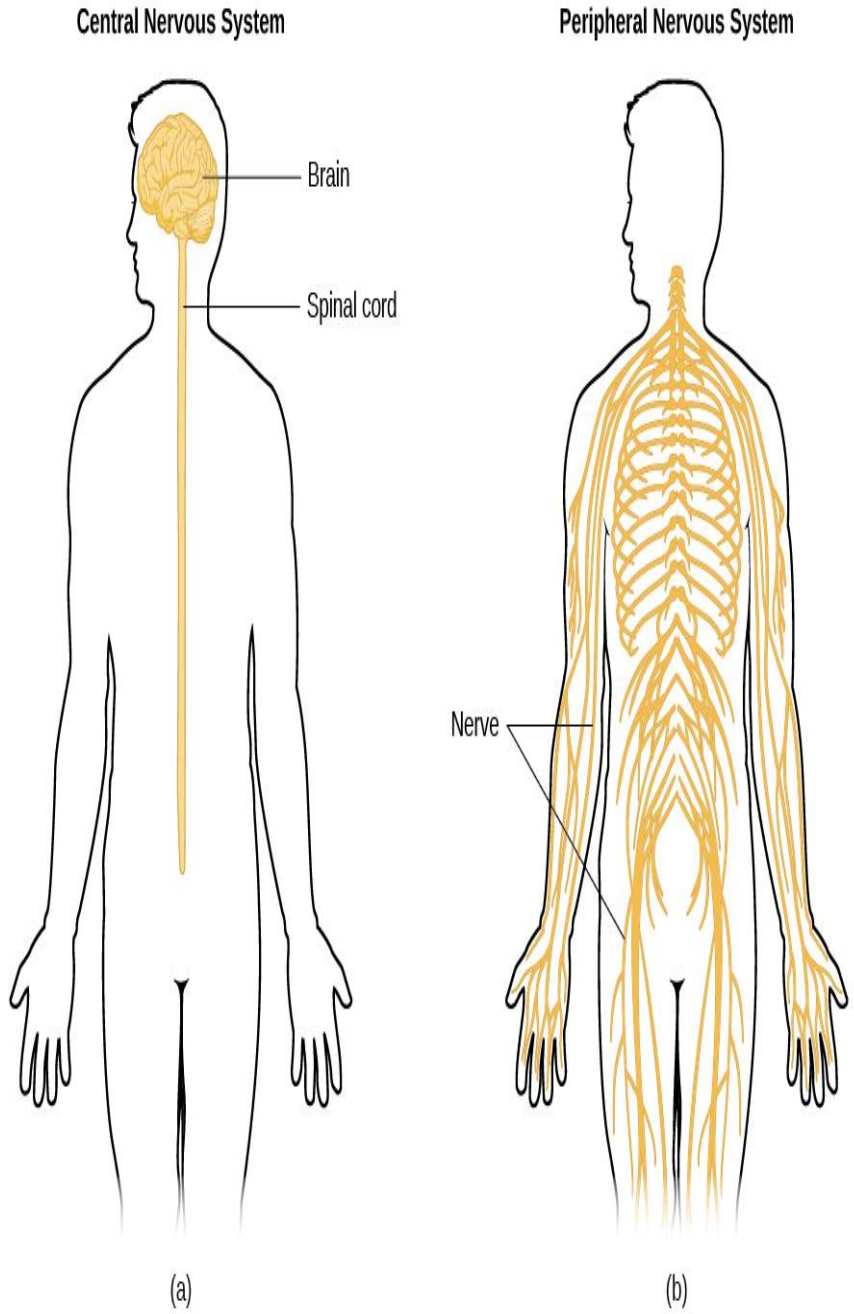
1. Central nervous system
2. Peripheral nervous system.

Nervous System

- **Central Nervous System (CNS)**
  - **Brain**: Receives and processes sensory information, initiates responses, stores, memories generates thoughts and emotions
  - **Spinal cord**: Conducts signals to and from the brain, controls reflex activities
- **Peripheral Nervous System (PNS)**
  - **Motor Neurons**: CNS to muscles and glands
    - **Somatic Nervous System**: Controls voluntary movements
    - **Autonomic Nervous System**: Controls involuntary responses
      - **Sympathetic Division**: "Fight or Flight"
      - **Parasympathetic Division**: "Rest or Digest"
  - **Sensory Neurons**: Sensory organs to CNS

Divisions of the nervous system.

http://pharmacology-notes-free.blogspot.com/

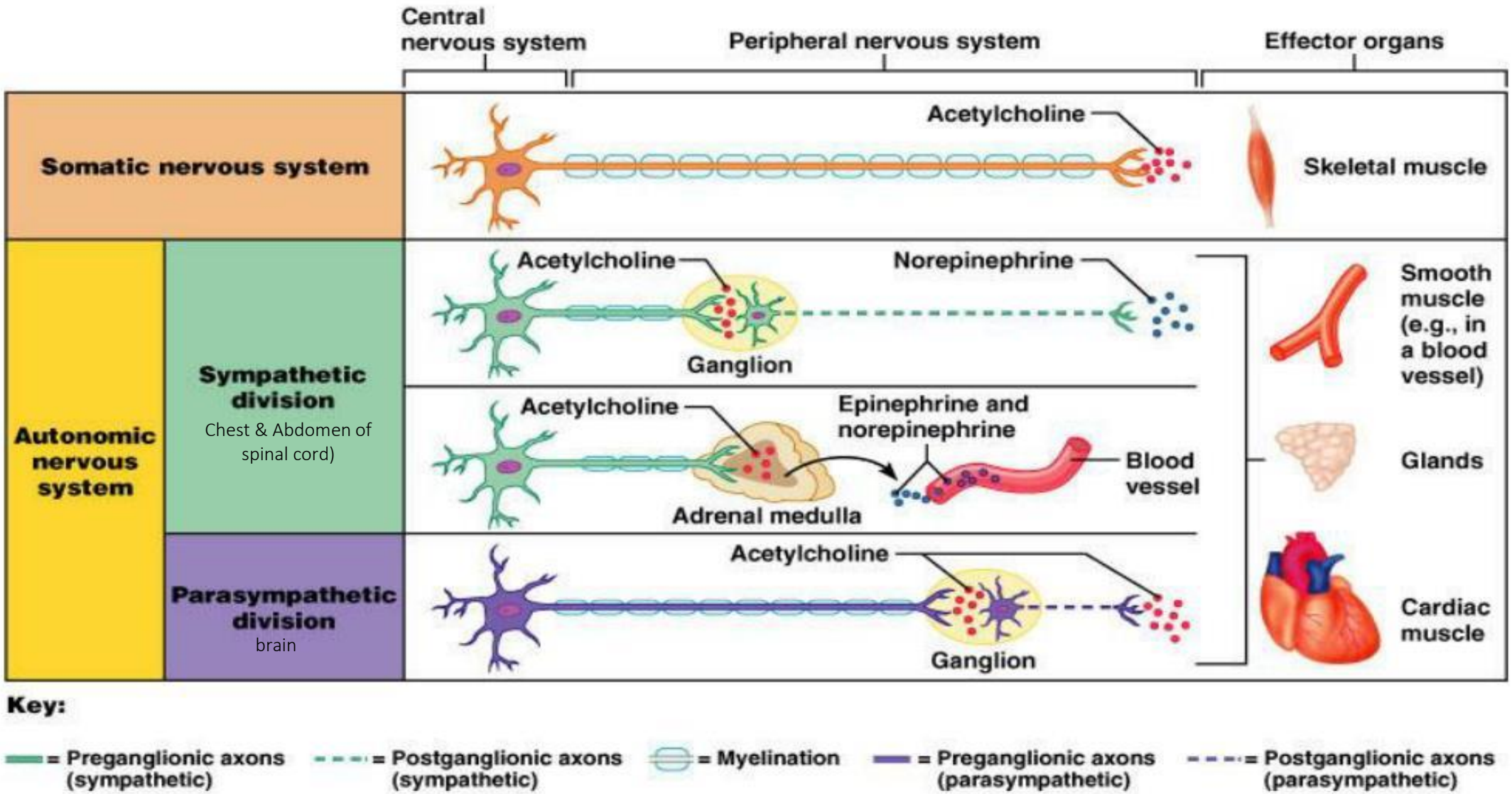


Autonomic nervous system

The PNS is subdivided into afferent and efferent divisions. The **afferent division** includes *afferent nerve fibres* that carries information from tissues and organs *to* the CNS. Instructions *from* the CNS are transmitted through *efferent nerve fibres* of the efferent division to effector organs - the muscles or glands that carry out the orders to bring about the desired effect. The efferent division is further divided into the **somatic nervous system** and **autonomic nervous system**.

Cardiac muscle, smooth muscle, most exocrine glands, some endocrine glands and adipose tissue are innervated by the *autonomic nervous system,* the *involuntary* branch of the peripheral efferent division. Skeletal muscle is innervated by the *somatic nervous system,* the branch of the efferent division subject to *voluntary* control.

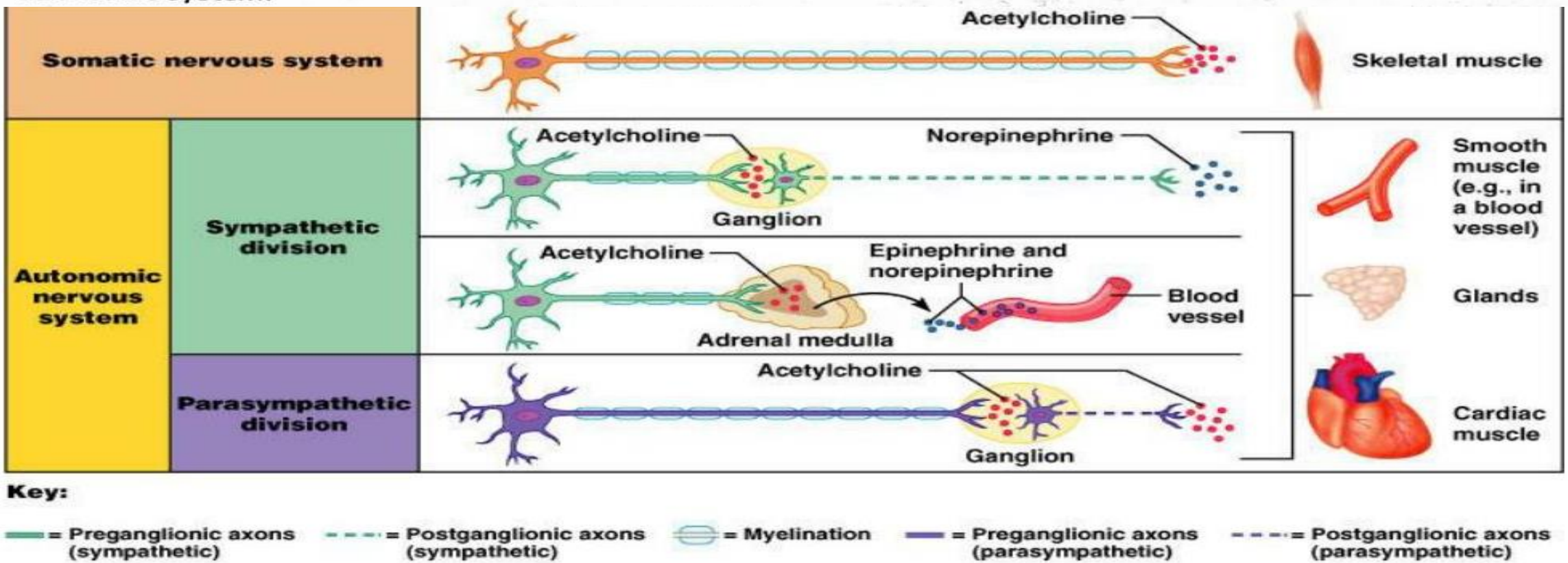
Comparison of Somatic and Autonomic Systems

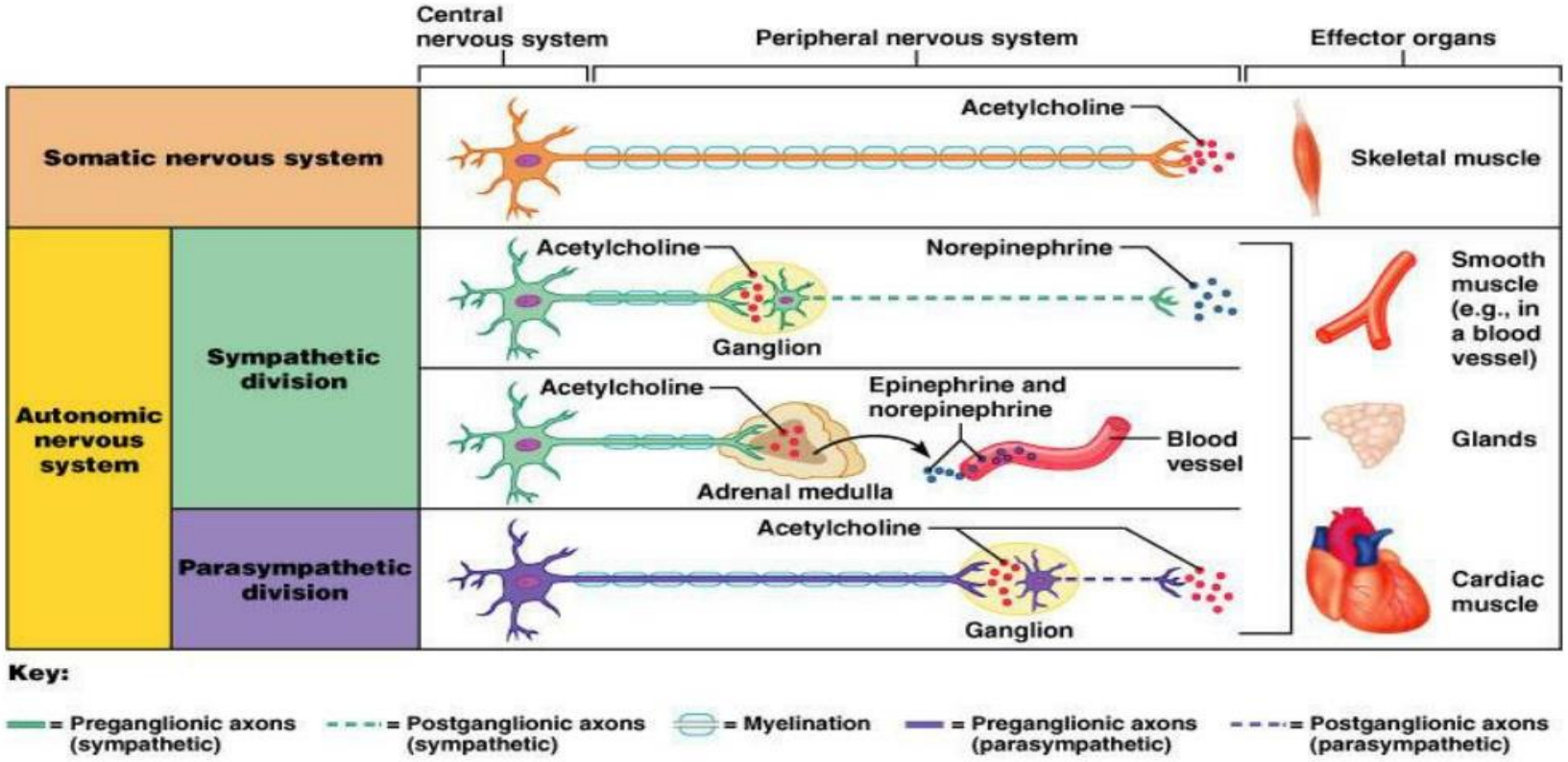


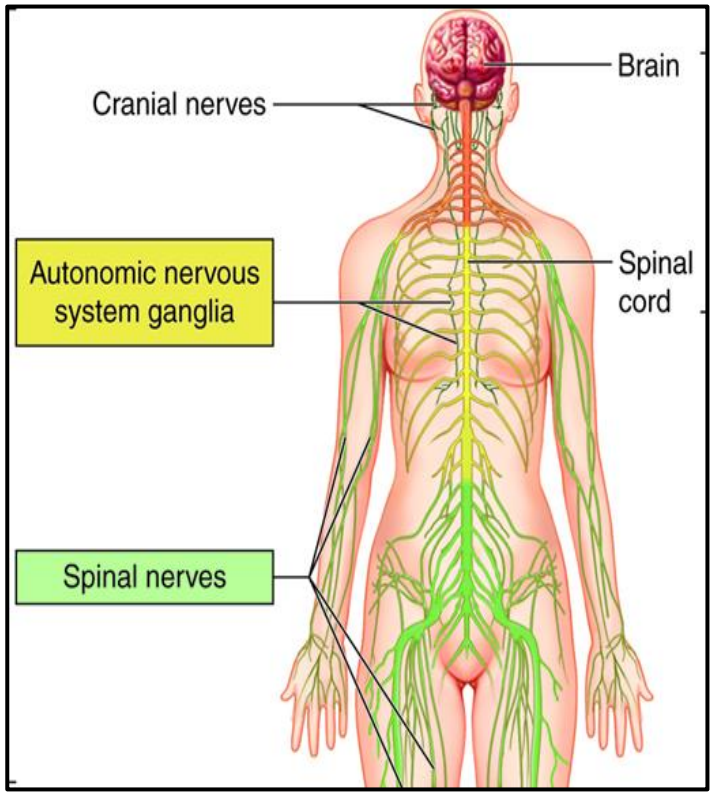
The *autonomic nervous system* consists of preganglionic neuron from CNS, ganglia and postganglionic neuron. It is also called *visceral* nervous *system* because the autonomic neurons innervates the viscera (Internal organs of the body)

Unlike somatic motor neurons of somatic nervous system, which conduct impulses along a single axon from the CNS to the neuromuscular junction, autonomic nervous system involves two autonomic motor neurons in the efferent pathway. The first of these neurons has its cell body in the gray matter of the CNS. The axon of this neuron does not directly innervate the effector organ but synapses with a second neuron within an *autonomic ganglion* (a ganglion is a collection of cell bodies outside the CNS). The first neuron is thus called a **preganglionic neuron.** The second neuron in this pathway, called a **postganglionic neuron,** has an axon that extends from the autonomic ganglion to an effector organ, where it synapses with its target tissue.

The autonomic nervous system has two subdivisions– the **sympathetic** and the **parasympathetic** nervous systems. Preganglionic autonomic neurons originate from the brain and spinal cord. The origin of the preganglionic fibers and the location of the autonomic ganglia help to distinguish the *sympathetic* and *parasympathetic divisions* of the autonomic system.







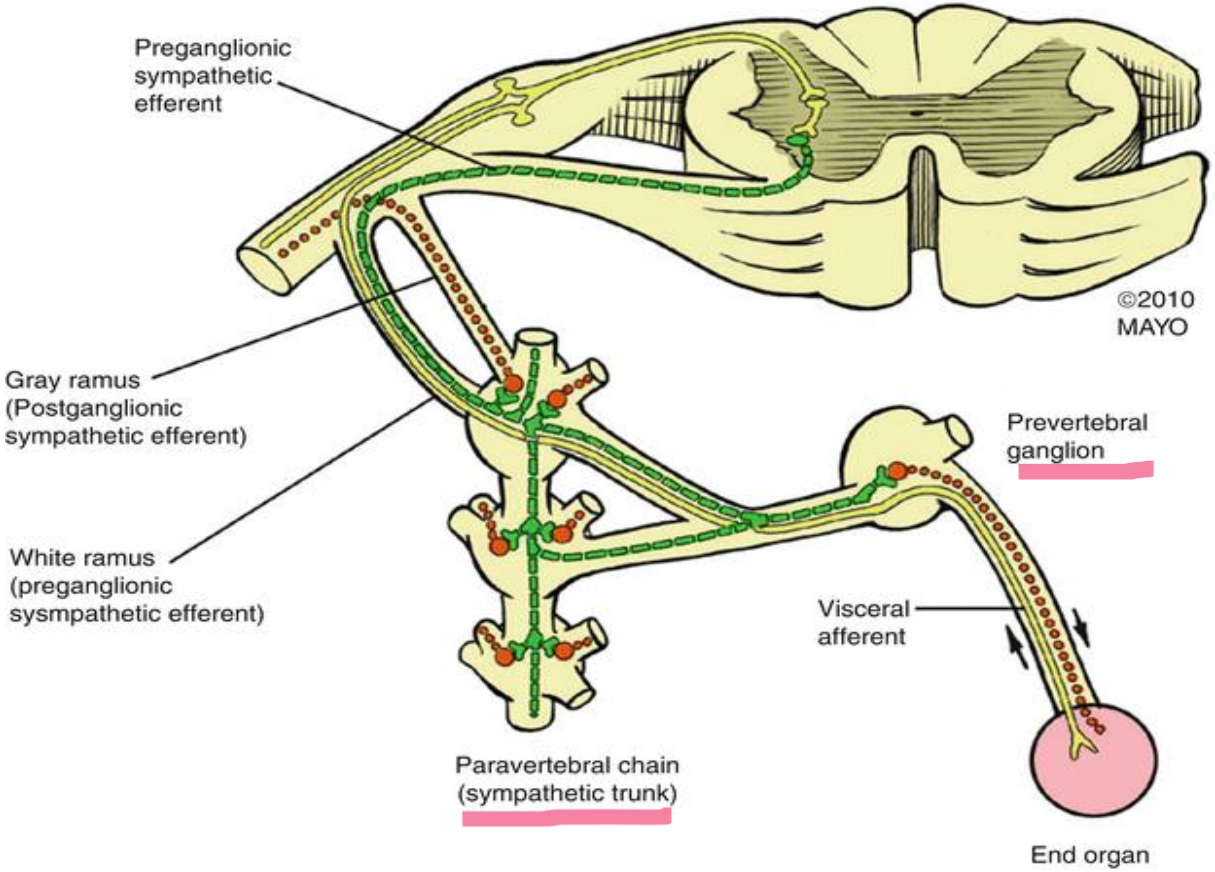
The sympathetic and parasympathetic divisions of the autonomic system have some structural features in common. Both consist of preganglionic neurons that originate in the CNS and postganglionic neurons that originate outside of the CNS in autonomic ganglia. However, the specific origin of the preganglionic fibers and the location of the ganglia differ in the two divisions of the autonomic system.

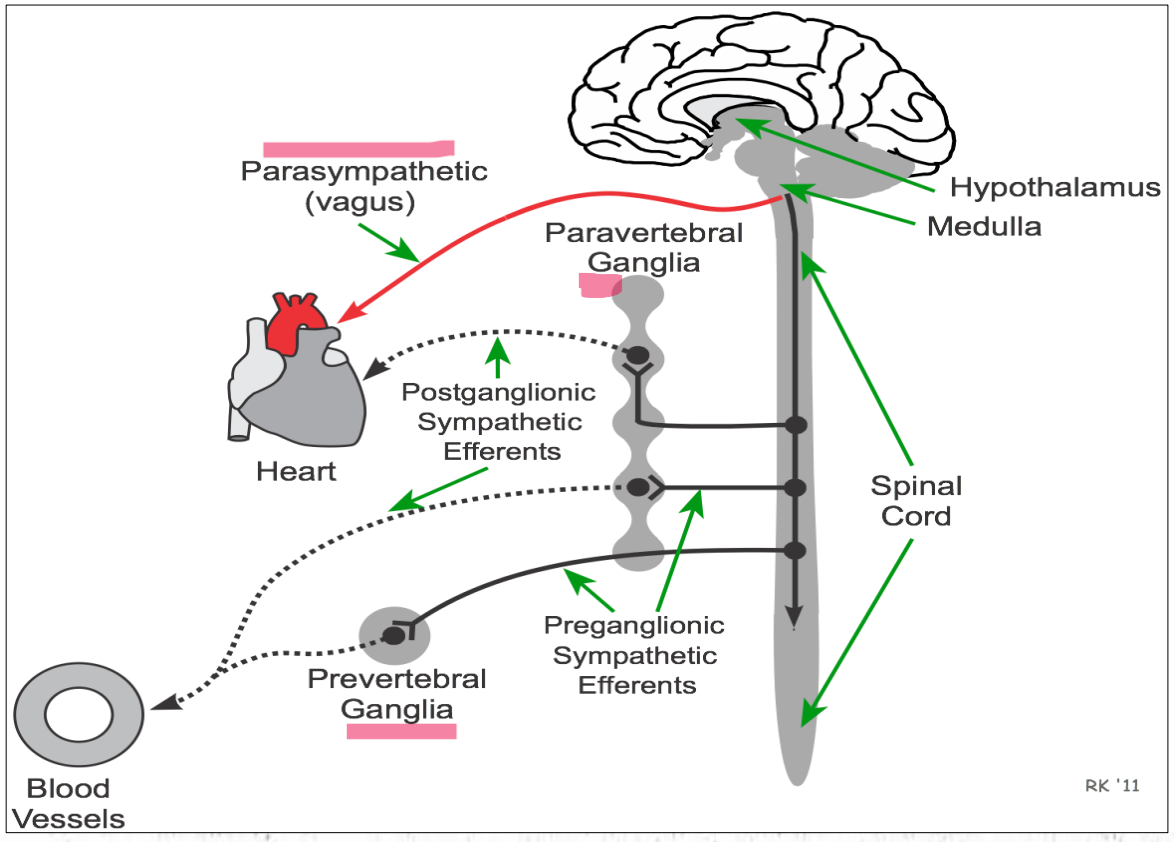
Sympathetic preganglionic nerve fibers originate in the thoracic (chest) and lumbar (abdominal) regions of the spinal cord. Hence, the sympathetic division is also called the *thoracolumbar division*. Most sympathetic preganglionic nerve fibers are very short, synapsing with cell bodies of postganglionic neurons within **sympathetic paravertebral ganglia** (or *sympathetic ganglia*), located on either side of the spinal cord. Sympathetic paravertebral ganglia within each row are interconnected via the axons of preganglionic neurons, forming a **sympathetic chain** (*sympathetic trunks*) that parallels the spinal cord on each lateral side. Long postganglionic nerve fibers originate in the ganglion chain and end on the effector organs.

AUTONOMIC NERVOUS SYSTEM

(SYMPATHETIC DIVISION)

Paravertebral and prevertebral ganglia are subdivisions of the sympathetic nervous system.
The **paravertebral ganglia** are a chain of ganglia that **run along the spinal** cord, while the prevertebral ganglia **are located in the abdominal cavity.**



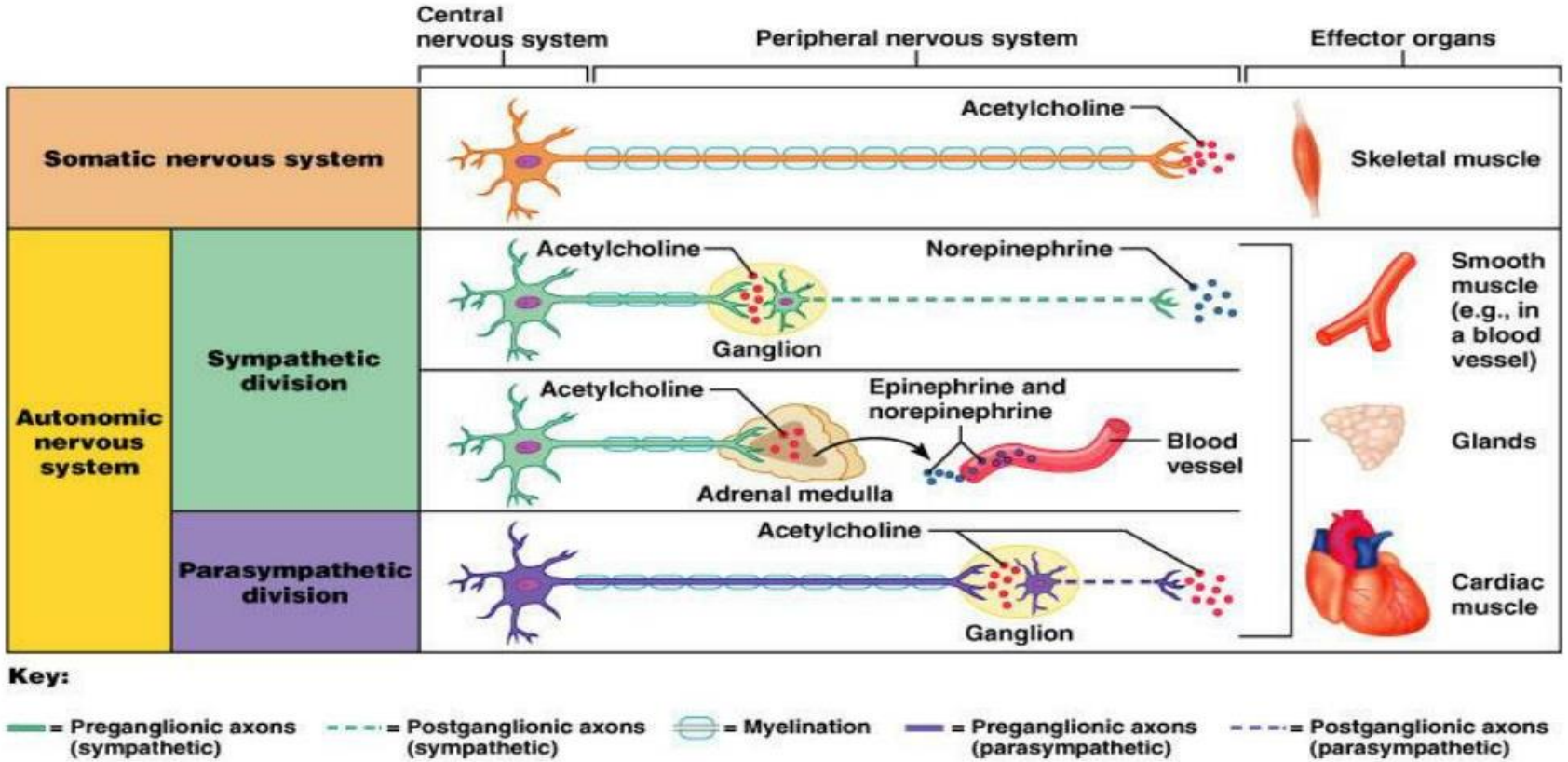


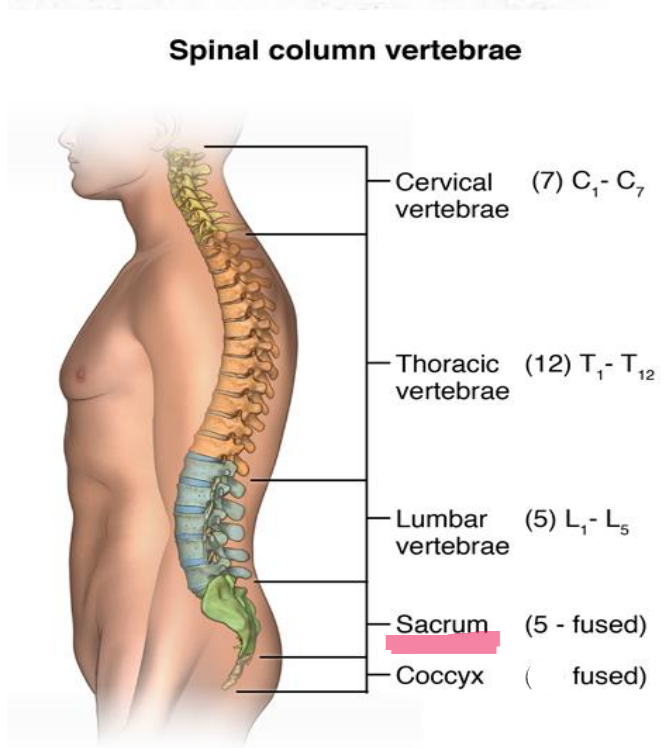
Some preganglionic neurons pass through the sympathetic chain and end on postganglionic neurons located in **prevertebral ganglia** (or *collateral ganglia*) close to viscera. Prevertebral ganglia are sympathetic ganglia which lie between the paravertebral ganglia and the target organ. There are also sympathetic preganglionic nerve fibers synapse with **chromaffin cells** of adrenal medulla.

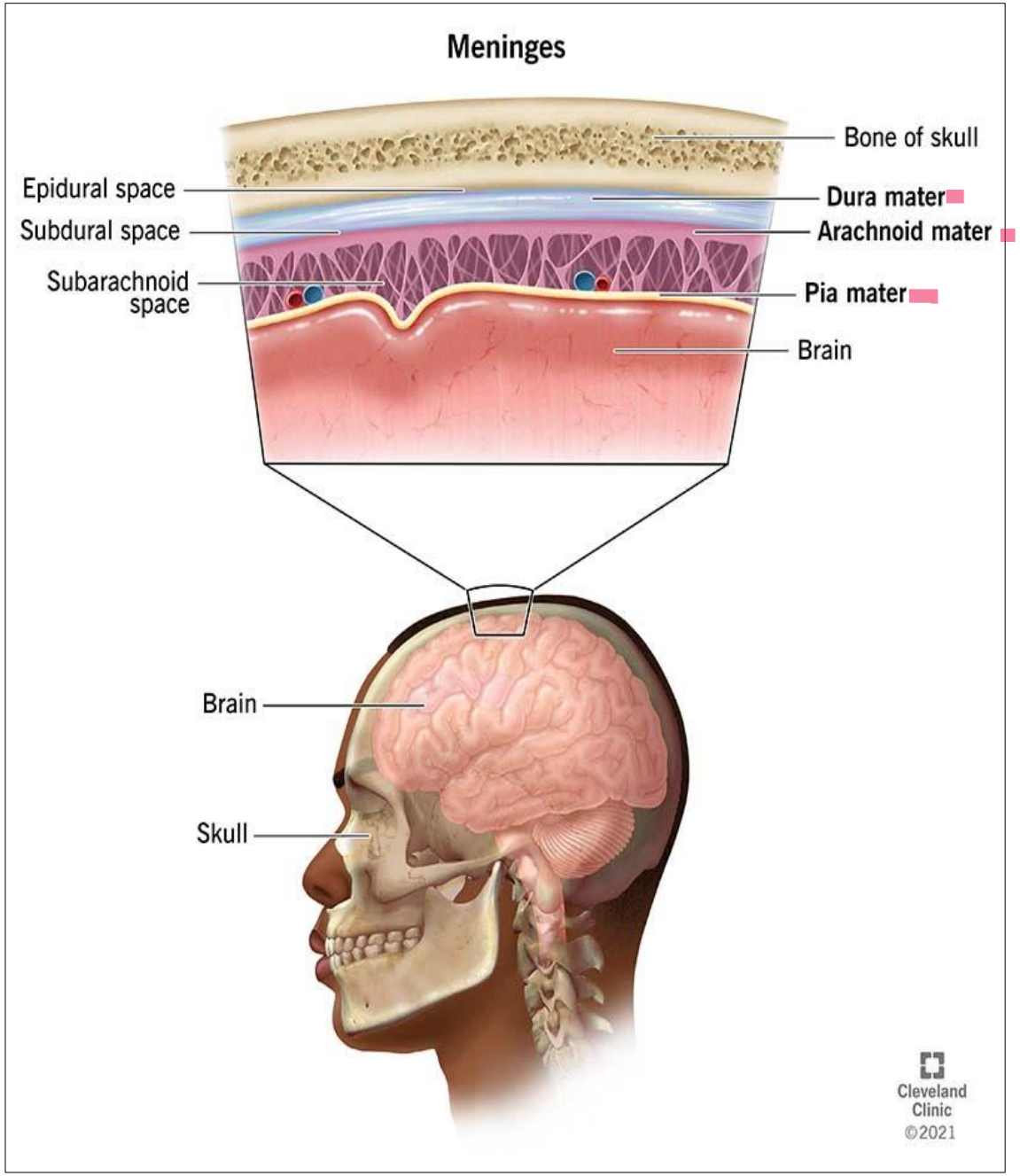
AUTONOMIC NERVOUS SYSTEM (PARASYMPATHETIC DIVISION)

Parasympathetic preganglionic nerve fibers arise from the brain (specifically, in the midbrain, medulla oblongata and pons) and sacral region of the spinal cord. These fibers are longer than sympathetic preganglionic fibers because they do not end until they reach **terminal ganglia** that lie in or near the effector organs. Very short postganglionic fibers end on the cells of an organ itself.

Sympathetic and parasympathetic preganglionic neurons release the same neurotransmitter, **acetylcholine** (ACh), but the postganglionic neurons of these two systems release different neurotransmitters. Parasympathetic postganglionic neurons release ACh. Accordingly, they, along with all autonomic preganglionic neurons, are called **cholinergic neurons**. Most sympathetic postganglionic neurons, in contrast, are called **noradrenergic neurons** because they release **noradrenaline**, commonly known as **norepinephrine** (NE). Sympathetic postganglionic neurons that innervate sweat glands are cholinergic, release Ach. *Note that all motor neurons that leave the central nervous system release neurotransmitter acetylcholine (ACh).*





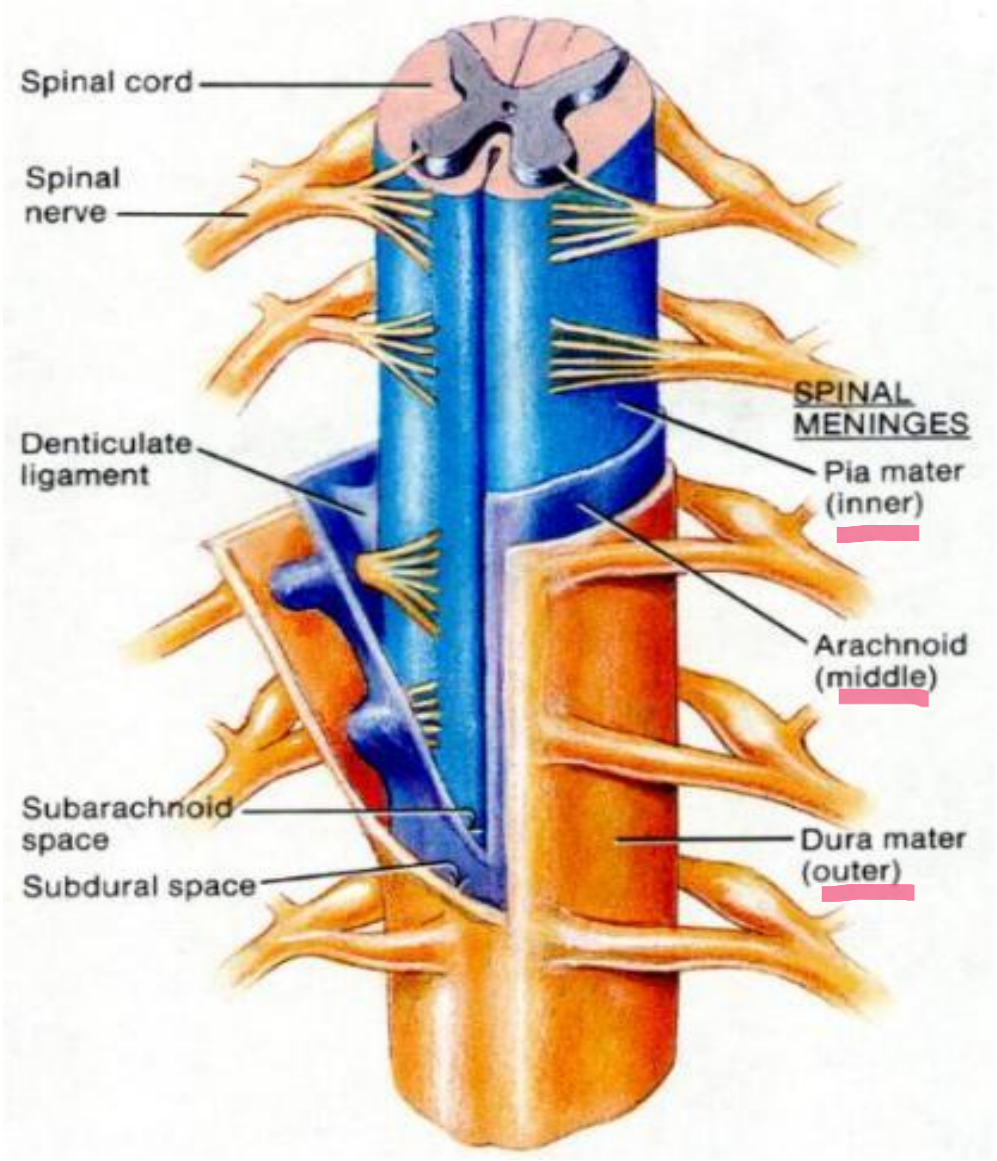


STRUCTURAL ORGANIZATION OF CNS

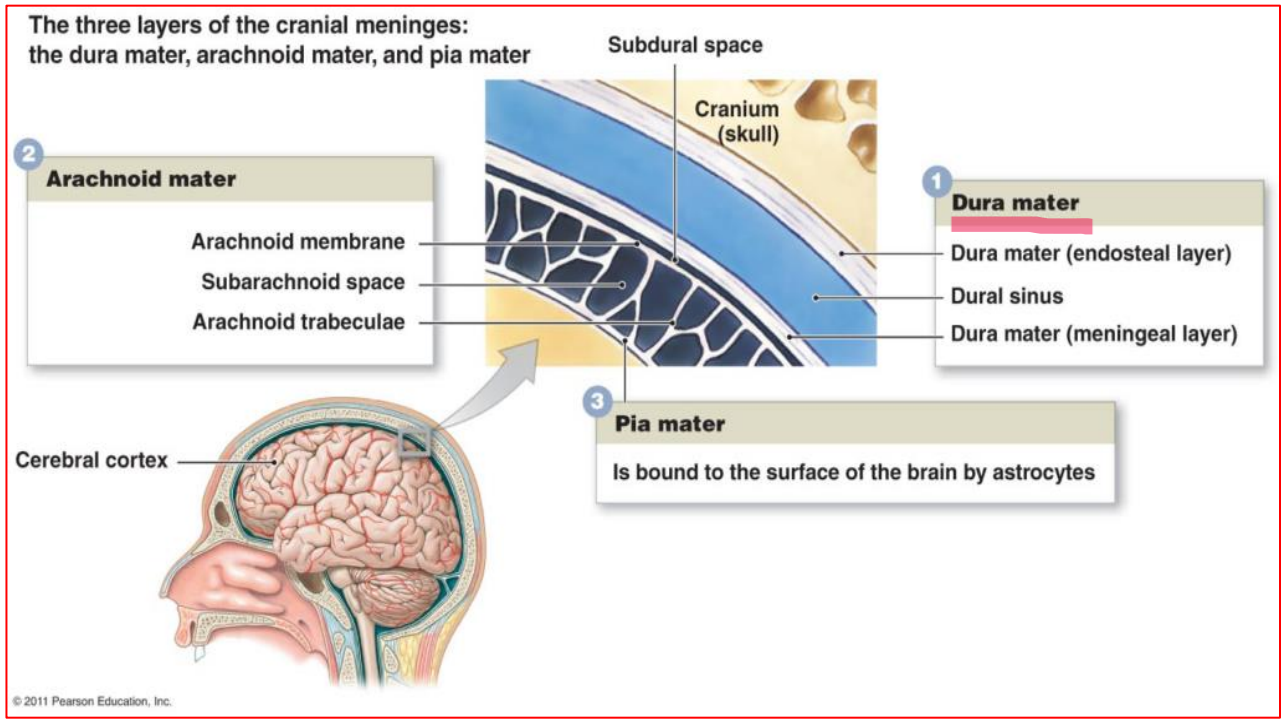
(BRAIN & SPINAL CORD)

CNS is enclosed by hard, bony structures. The **cranium** (skull) encases the brain, and the **vertebral column** surrounds the spinal cord. Inside the skull and the vertebral column, three protective connective tissue coverings, the **meninges**, lie between the bony covering and the nervous tissue.

The brain is covered by **cranial meninges**. The outermost meninx is the **dura mater** that is composed of dense, irregular connective tissue. The middle meninx is an *avascular* covering called the **arachnoid mater**. The innermost meninx is the **pia mater**, a thin transparent connective tissue layer that adheres to the surface of the brain. Between the arachnoid mater and the pia mater is the *subarachnoid space*, which contains *cerebrospinal fluid*.



The spinal cord is located within the vertebral cavity of the vertebral column. It is also wrapped in protective meninges. The **spinal meninges** surround the spinal cord and are continuous with the *cranial meninges*. The spinal meninges have the same basic structure, and bear the same names; the outer dura mater, the middle arachnoid mater and the inner pia mater. However, the cranial dura mater has two layers but the spinal dura mater has only one layer.



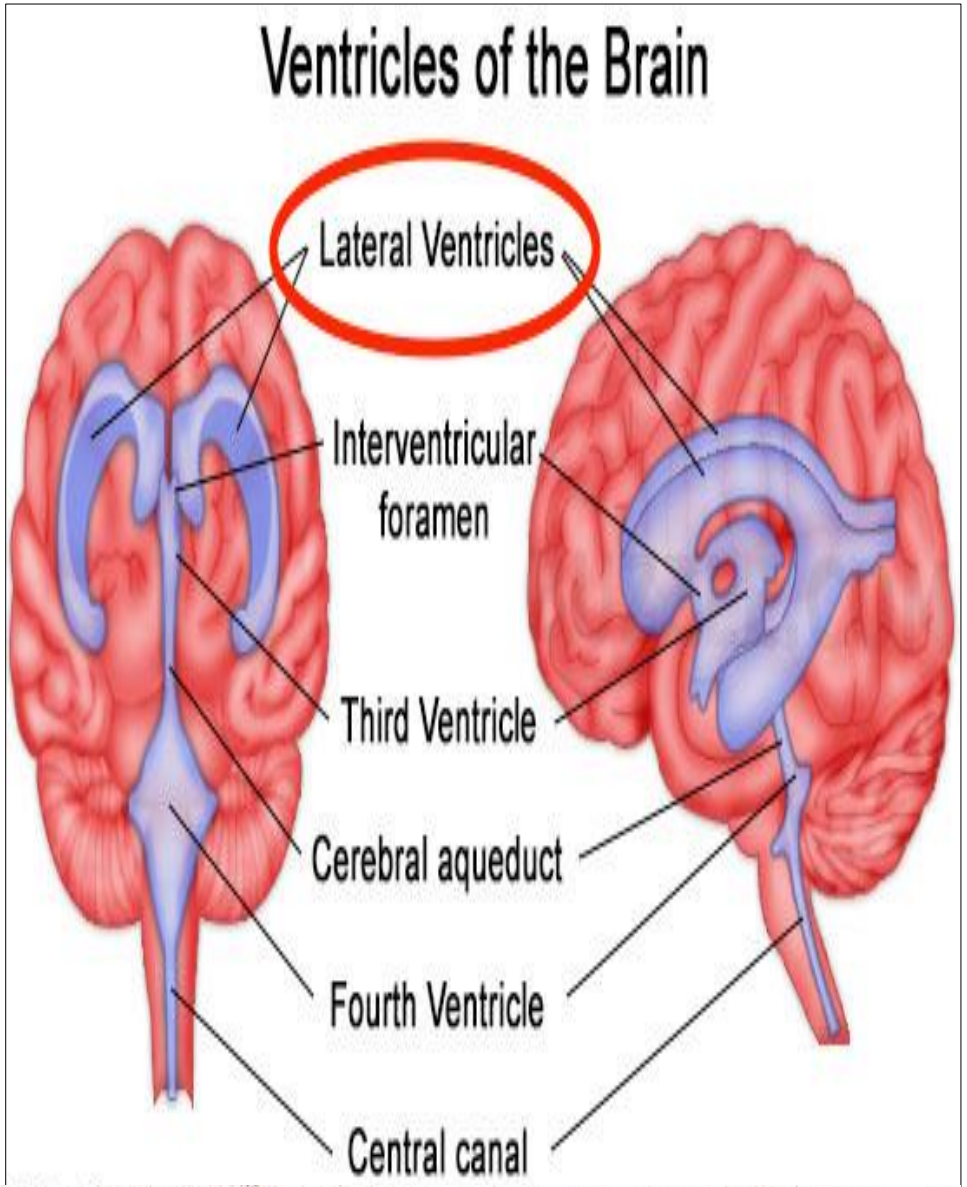


Figure 4.7 There are four CSF-filled cavities within the brain are called *ventricles*. Lateral ventricles are located deep within each cerebral hemisphere. Each lateral ventricle communicates via the interventricular foramen with the third ventricle. The third ventricle is positioned between the left and right diencephalon. The third ventricle communicates with the fourth ventricle via the cerebral aqueduct. The fourth ventricle is located superior to the pons and the medulla oblongata.

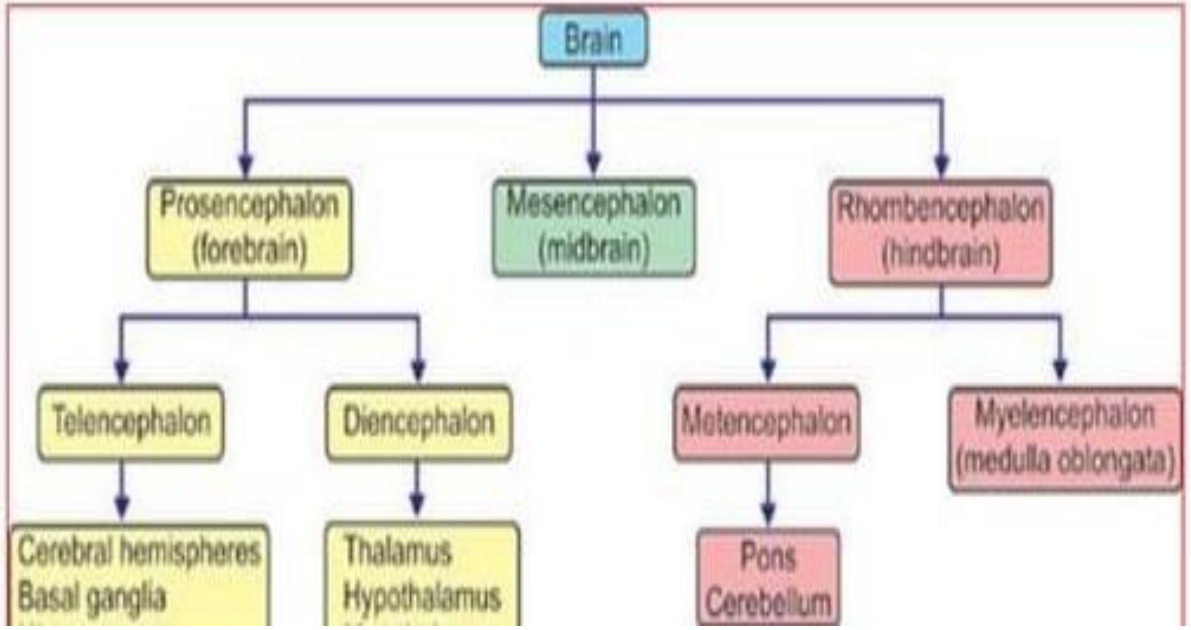
CSF-filled cavities within the brain are called **ventricles**. The *ventricular system* is composed of two *lateral ventricles*, a *third ventricle* and a *fourth ventricle*. A *lateral ventricle* is located in each hemisphere of the cerebrum. The *third ventricle* is a narrow cavity along the midline superior to the hypothalamus and between the right and left halves of the thalamus. The *fourth ventricle* lies between the brain stem and the cerebellum.

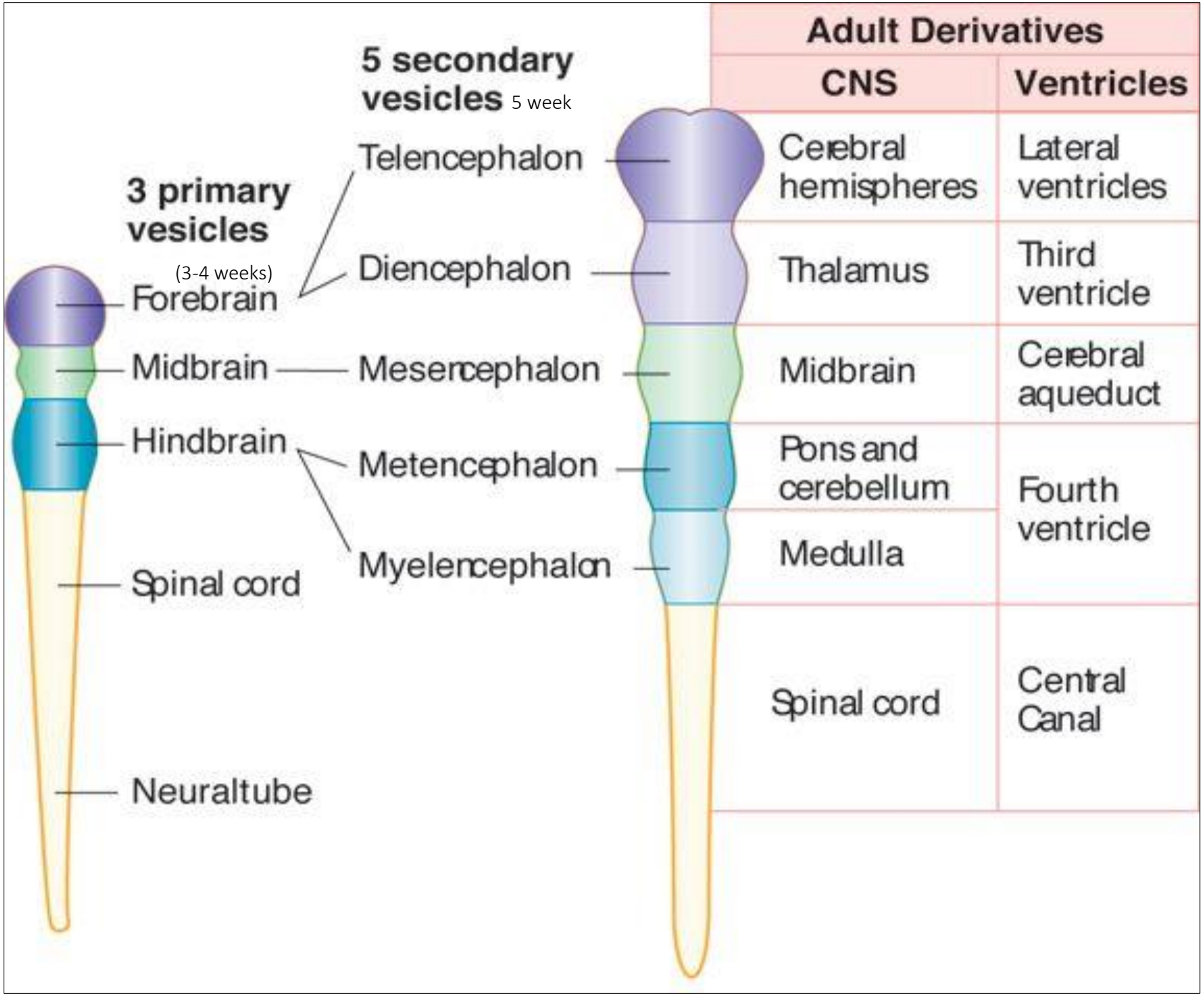
The CSF formed in the choroids plexuses of each lateral ventricle flows into the third ventricle through two narrow openings, the **interventricular foramina** (or *foramina of Monro*). More CSF is added by the choroids plexus in the roof of the third ventricle. The fluid then flows through the **cerebral aqueduct** (or *aqueduct of Sylvius*), which passes through the midbrain, into the fourth ventricle. The choroids plexus of the fourth ventricle contribute more fluid. CSF enters the subarachnoid space through three openings in the roof of the fourth ventricle: a median aperture and the paired lateral apertures, one on each side. CSF then circulates in the central canal of the spinal cord and in the subarachnoid space around the surface of the brain and spinal cord.

BRAIN CONSISTS OF 3 PARTS

Parts of Brain

Brain consists of three major divisions: 1. Prosencephalon 2. Mesencephalon 3. Rhombencephalon




3 primary vesicles
(3-4 weeks)
Forebrain
Midbrain
Hindbrain
Spinal cord
Neuraltube
5 secondary vesicles 5 week
Telencephalon
Diencephalon
Mesencephalon
Metencephalon
Myelencephalon
Adult Derivatives
CNS
Ventricles
Cerebral hemispheres
Lateral ventricles
Thalamus
Third ventricle
Midbrain
Cerebral aqueduct
Pons and cerebellum
Medulla
Fourth ventricle
Spinal cord
Central Canal

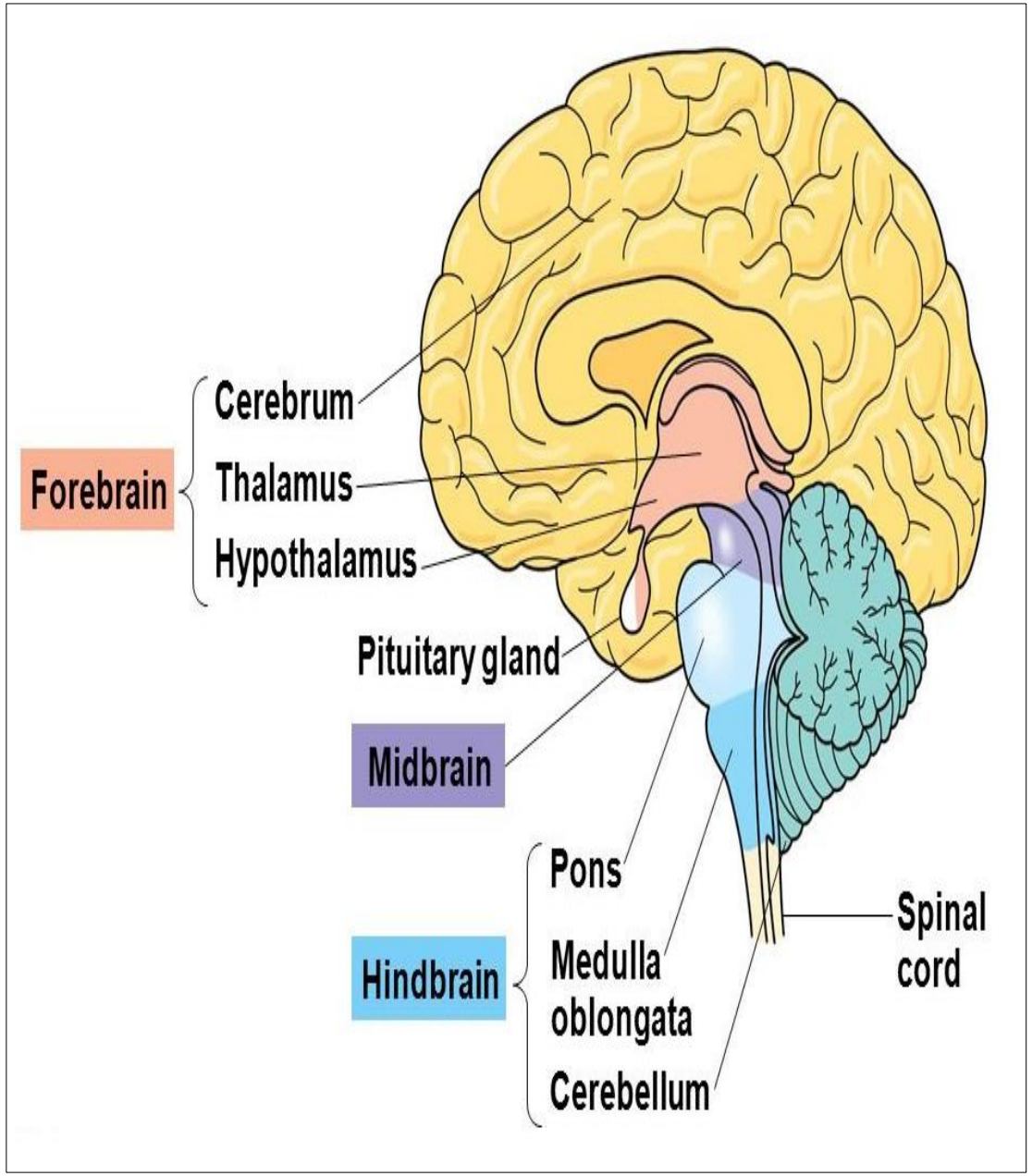
The parts of the brain can be grouped in various ways based on anatomic distinctions and functional specialization. Anatomically, the brain consists of three major parts:

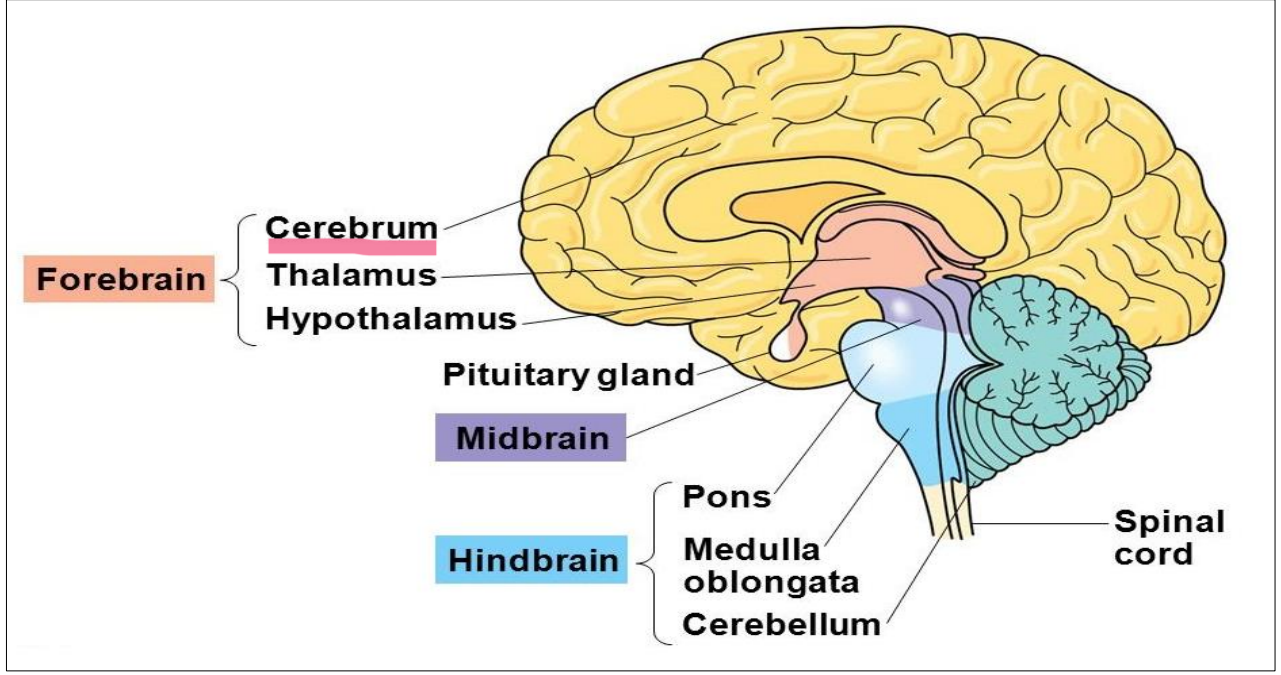
Forebrain (or prosencephalon): It is the largest part of the brain. It includes *cerebrum* and *Diencephalon*. The diencephalon consists of two main parts – the *thalamus* and the *hypothalamus*.

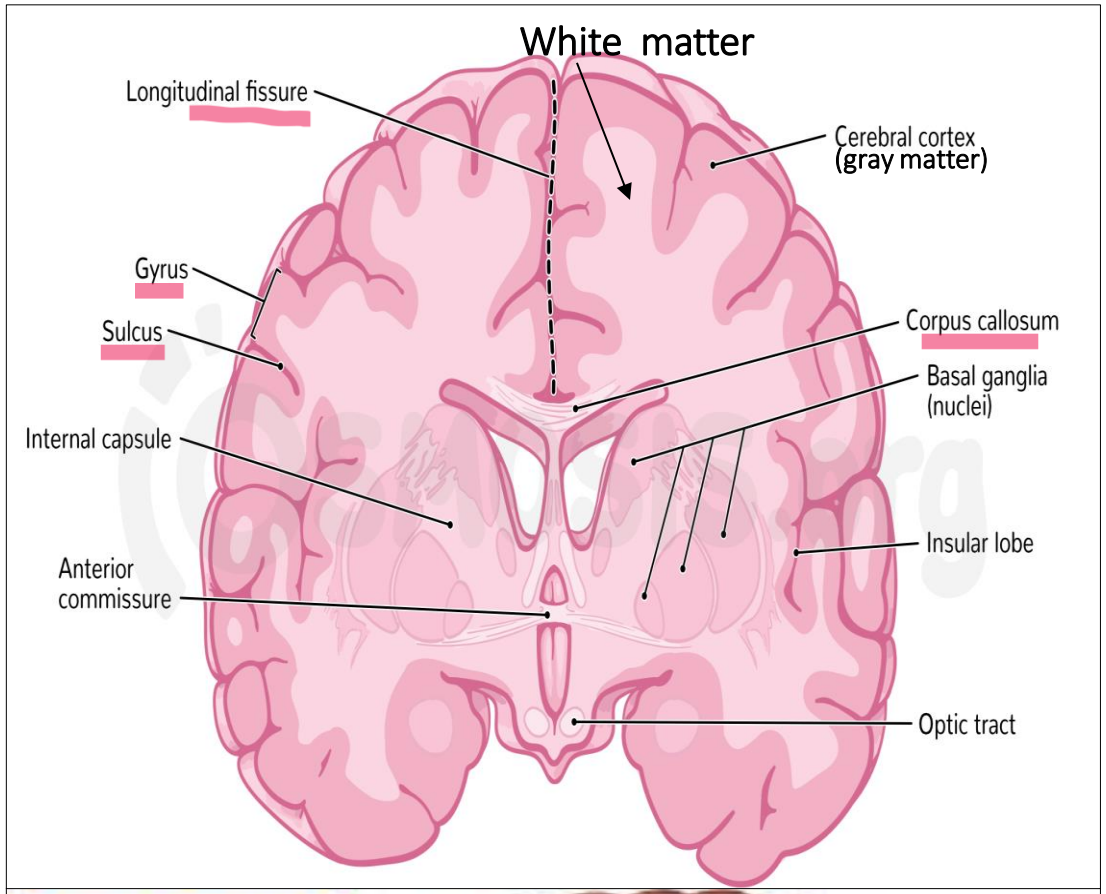
Midbrain (or mesencephalon) : It includes *tectum* (or corpora quadrigemina) and *tegmentum*.

Hindbrain (or rhombencephalon) : It includes *pons*, *cerebellum* and *medulla*.

Midbrain, pons and medulla oblongata are together called as the **brain stem**. The brain stem is continuous with the spinal cord. Posterior of the brain stem is the *cerebellum*.



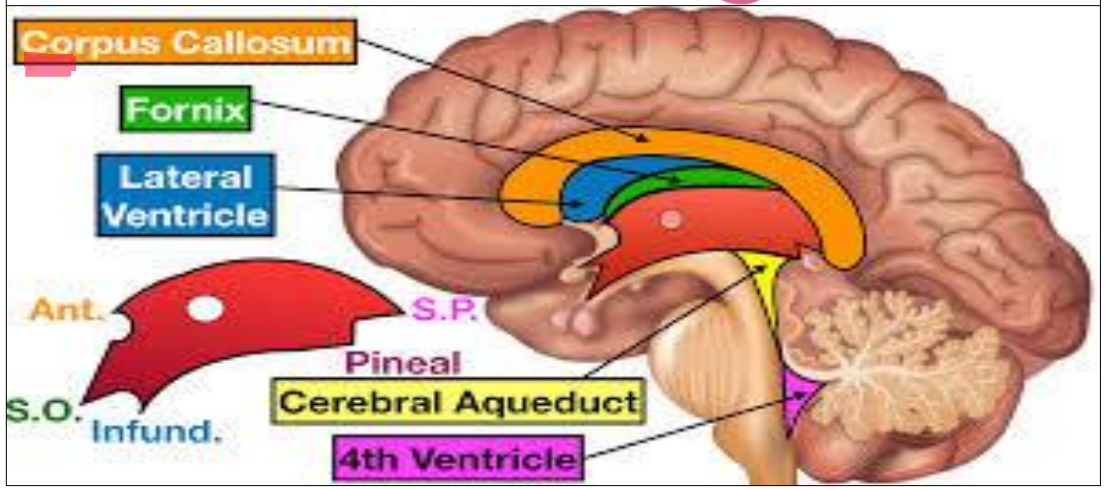




Cerebrum

The cerebrum is the *largest* part of the brain. It is divided into two halves, known as the right and left hemispheres. A mass of fibers called the **corpus callosum** links the hemispheres. The left hemisphere controls the right side of the body and the right hemisphere controls the left side of the body. The surface of each cerebral hemisphere shows many folds called **gyri** (or *convolutions*) separated by depressions, called **sulci**. The deep sulcus is called *fissure*.

Each hemisphere is composed of a thin outer layer of *gray matter* called the **cerebral cortex**. It incloses the thick central core of *white matter*. Several masses of gray matter that collectively constitute the **basal nuclei** (also known as *basal ganglia*) are also located deep within the white matter.



DIENCEPHALON

Diencephalon

It has three parts– epithalamus, thalamus and hypothalamus.

Epithalamus is non–nervous part, which is fused with pia mater to form anterior choroid plexus. It secretes cerebrospinal fluid.

Thalamus is situated between the cerebral cortex and the midbrain. It directs sensory impulses from the lower parts of the brain and spinal cord to appropriate parts of the cerebrum. Limited sensory awareness of pain, temperature, touch and pressure is provided by the thalamus.

Hypothalamus presents just beneath the thalamus. It is an integrating center for many important homeostatic functions and establish link between the autonomic nervous system and the endocrine system. The hypothalamus performs following important functions:

1. controls body temperature.
2. controls thirst and urine output.
3. controls food intake.
4. controls anterior pituitary hormone secretion.
5. produces neurohormones which control the secretions of anterior pituitary hormones. It produces the posterior pituitary hormones and control their release into the blood.
6. plays a role in emotional and behavioral patterns.
7. controls sleeping patterns and wakefulness.

Functionally, Cerebral Cortex of each hemisphere is divided into 4 lobes

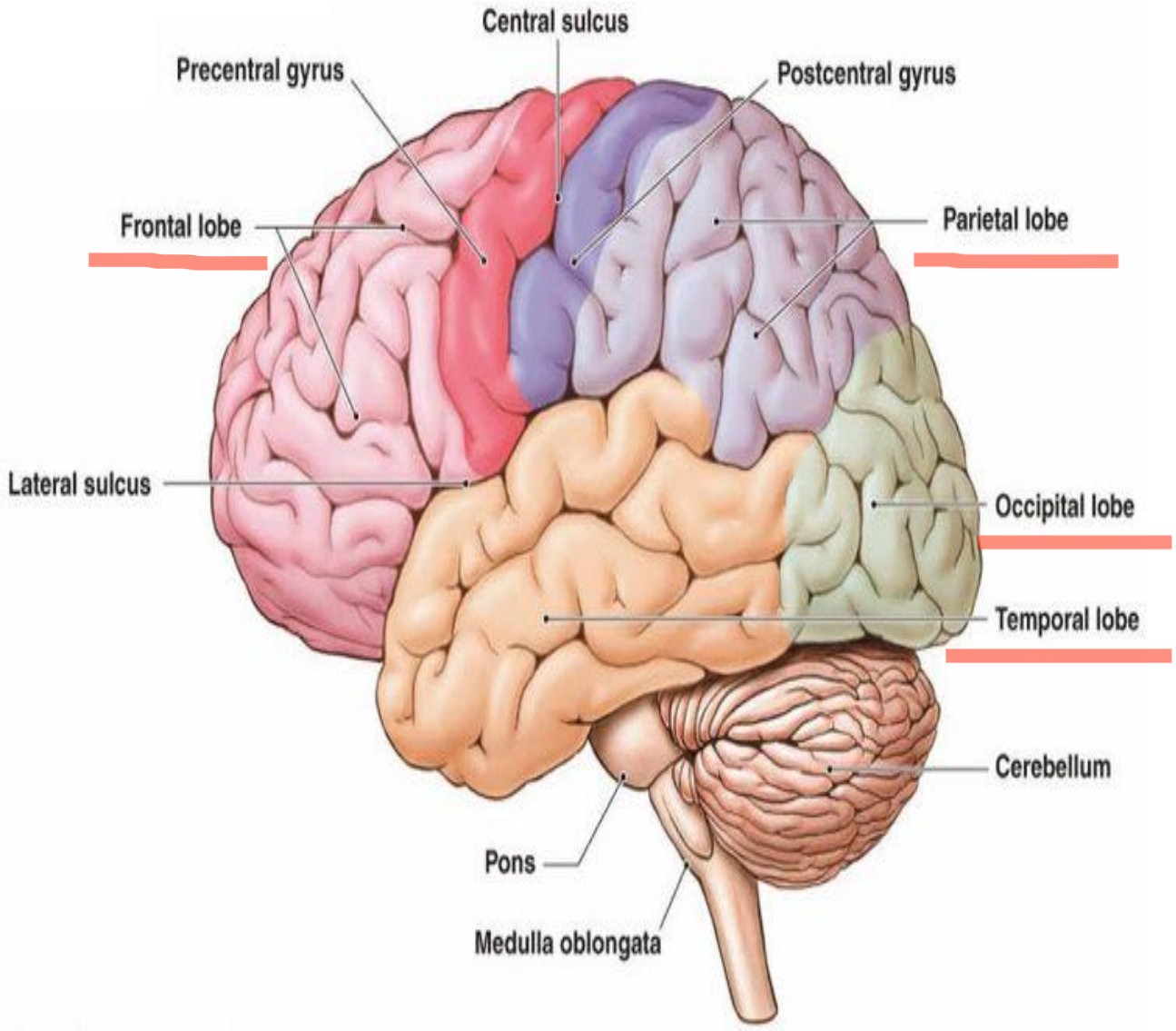
The brain's lobes are the four sections of each brain hemisphere. Each lobe controls specific functions.

Frontal lobe
- Located in the front of the head
- Controls personality, decision-making, movement, and speech
- Also involved in concentration, memory, judgment, and problem-solving

Parietal lobe
- Located in the middle of the brain
- Helps identify objects, understand spatial relationships, and interpret pain and touch
- Also involved in processing cutaneous sensations

Temporal lobe
- Located in the sides of the brain
- Involved in short-term memory, speech, musical rhythm, and some smell recognition
- Also involved in processing information from the senses of smell, taste, and sound

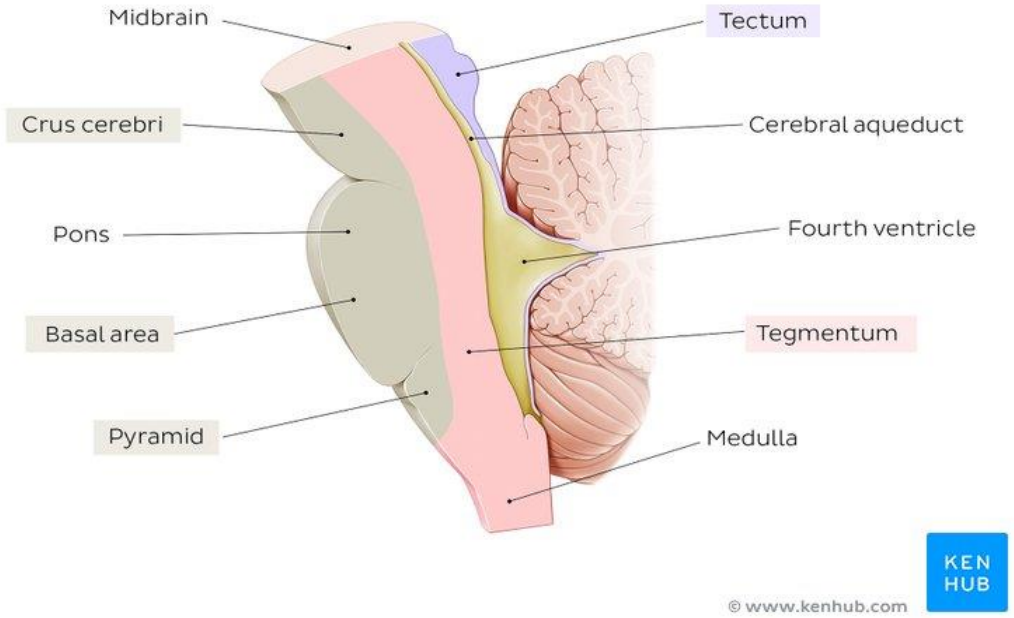
Occipital lobe
- Located in the back of the brain
- Processes images from the eyes and connects them to stored memories
- Also involved in interpreting visual stimuli and information

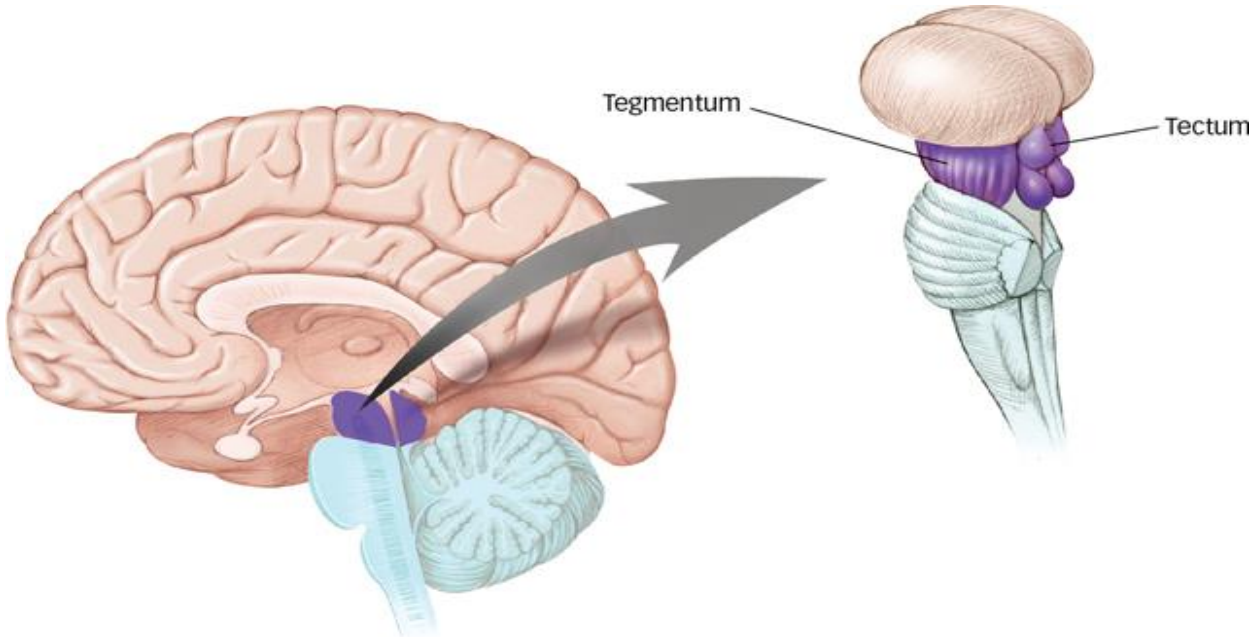


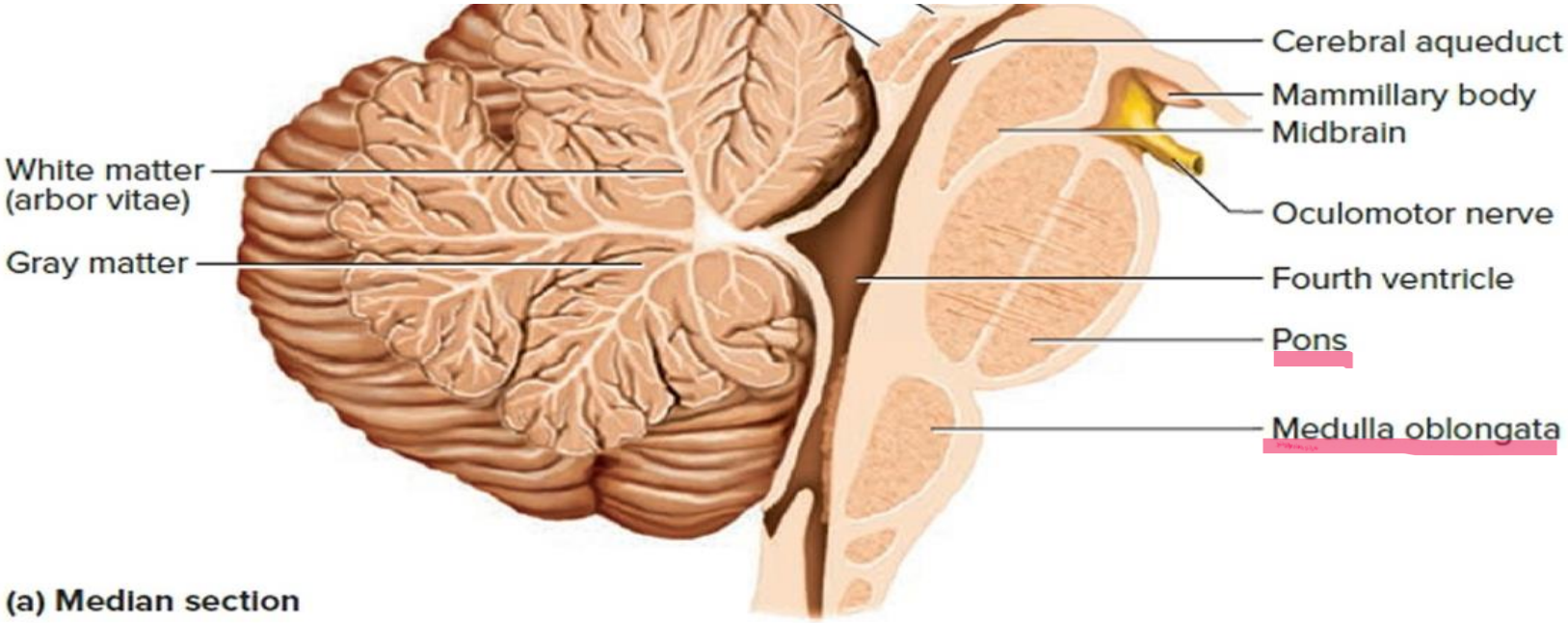
MIDBRAIN

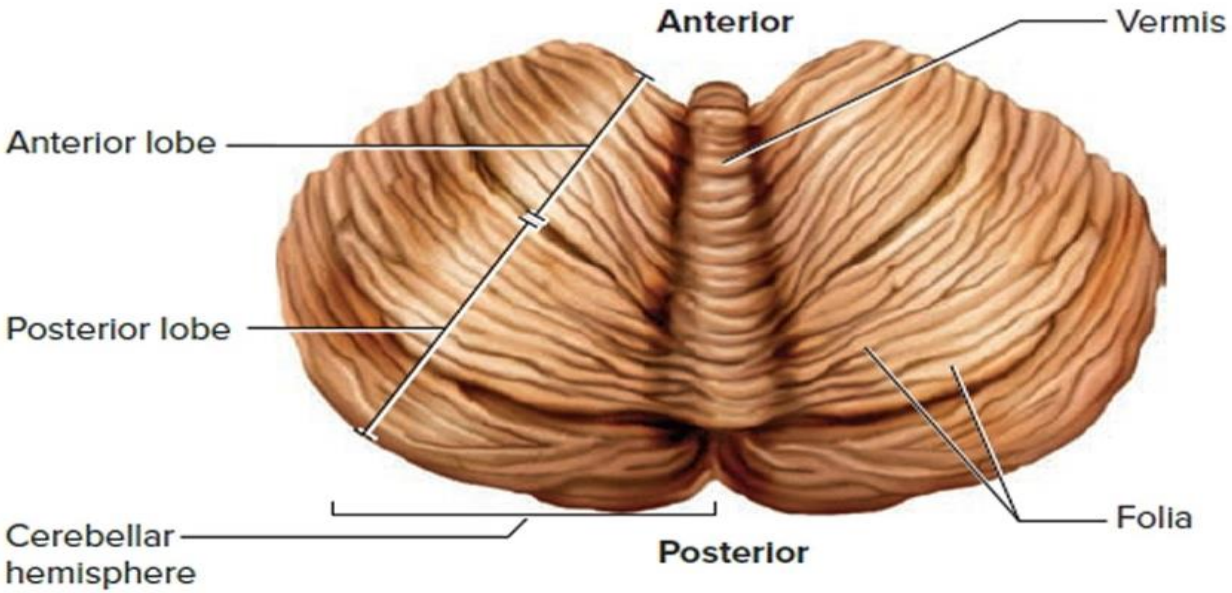
Midbrain

Midbrain is a very small constricted portion of the brain which is covered by the cerebrum. It is represented by a pair of longitudinal bands of nervous tissue, *crura cerebri* on ventral side and dorsally a pair of small swellings called *corpora bigemina* on either side. The four lobes (optic lobe) are collectively called *corpora quadrigemina*, in which superior colliculi are related to optical activity, while the two smaller posterior colliculi are related to the auditory. These two are collectively known as *tectum*.









CEREBELLUM

Second largest part of the brain
Attached to the back of the upper portion of the brain stem

- Controls body posture and balance of the body

HINDBRAIN

Cerebellum

Cerebellum, the second largest part of the brain, is attached to the back of the upper portion of the brain stem. In superior or inferior views, the shape of the cerebellum resembles a butterfly. The central constricted area is the **vermis** and the lateral "wings" or lobes are the **cerebellar hemispheres**. Each hemisphere consists of lobes. The superficial layer of the cerebellum, called the **cerebellar cortex**, consists of gray matter. Inside the gray matter are tracts of white matter called **arbor vitae** (i.e. tree of life) that resemble branches of a tree.

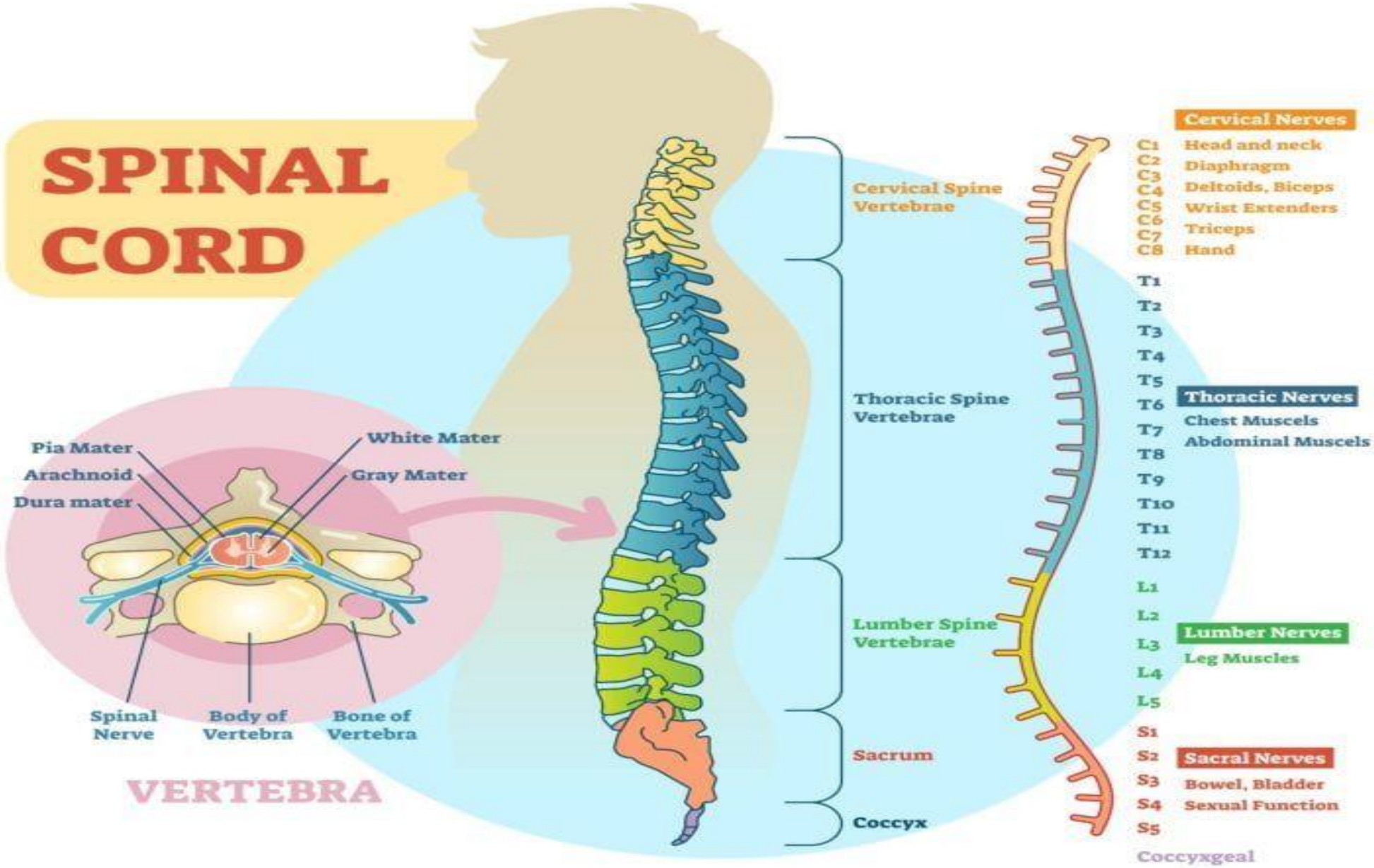
Cerebellum controls body posture, maintains muscle tone, coordinate voluntary muscular activities and balance of the body. It may have a role in cognition and language processing.

Medulla oblongata

The medulla oblongata (also called the medulla), the lowest part of the brainstem, is interconnected with the cervical spinal cord. Besides regulating heartbeat, blood vessel diameter, and the normal breathing rhythm, nuclei in the medulla also control reflexes for vomiting, swallowing, sneezing, coughing, and hiccupping.

Pons

The pons lies directly superior to the medulla and anterior to the cerebellum. Pons serves as a bridge between the midbrain and the medulla oblongata. The pons also contains the nuclei and fibers of nerves that serve eye muscle control, facial muscle strength and other functions.


SPINAL CORD
Pia Mater
Arachnoid
Dura mater
White Mater
Gray Mater
Spinal Nerve
Body of Vertebra
Bone of Vertebra
VERTEBRA
Cervical Spine Vertebrae
Thoracic Spine Vertebrae
Lumber Spine Vertebrae
Sacrum
Coccyx
Cervical Nerves
C1 Head and neck
C2 Diaphragm
C3 Deltoids, Biceps
C4 Wrist Extenders
C5 Triceps
C6 Hand
C7
C8
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
Thoracic Nerves
Chest Muscels
Abdominal Muscels
L1
L2
L3
L4
L5
Lumber Nerves
Leg Muscles
S1
S2
S3
S4
S5
Sacral Nerves
Bowel, Bladder
Sexual Function
Coccyxgeal

The spinal cord is a **Segmented** structure, has

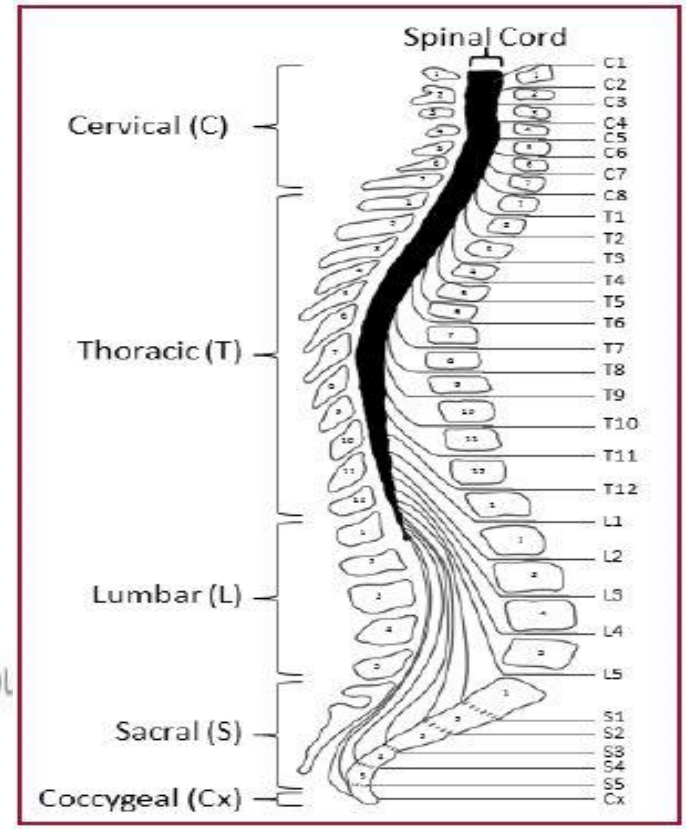
- **8 Cervical**
- **12 Thoracic**
- **5 Lumbar**
- **5 Sacral**
- **1 Coccygeal** segments

Not uniform in diameter, (not the same diameter throu

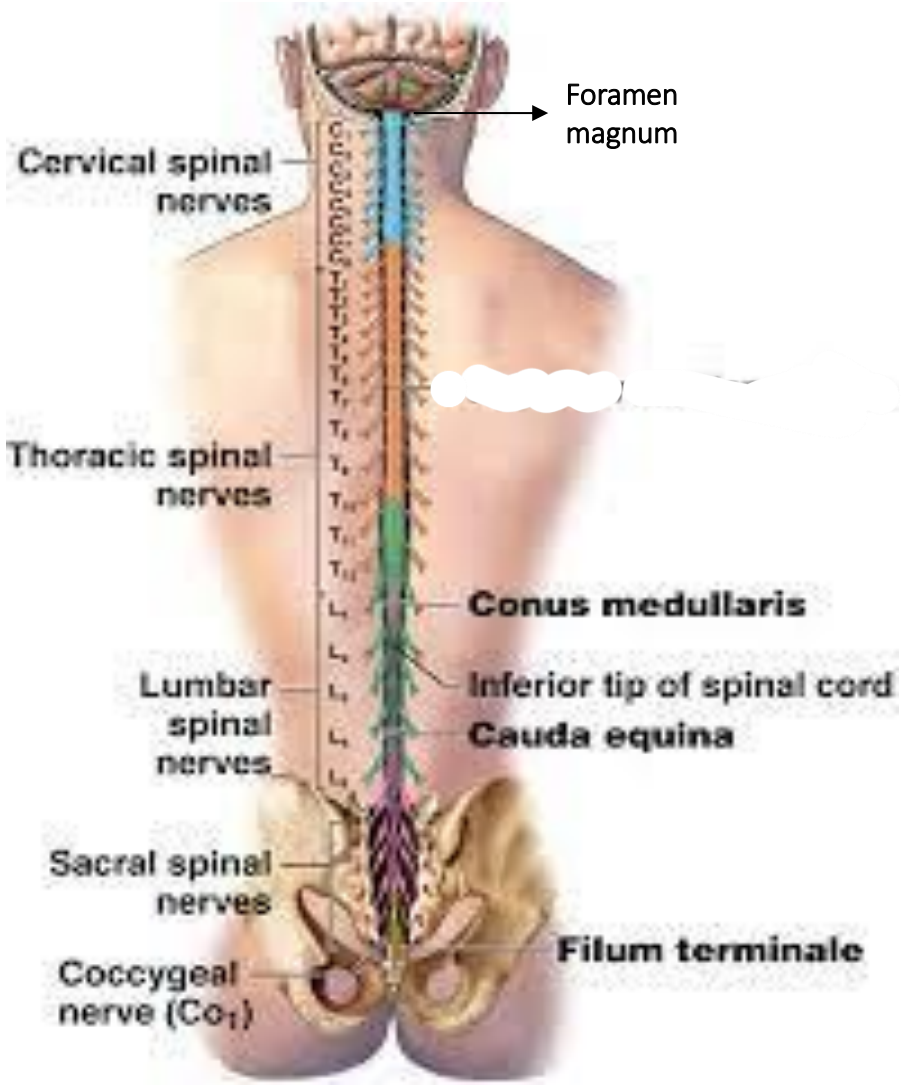
Has **two enlargements:**

- **Cervical enlargement**: supplies upper limbs
- **Lumbosacral enlargement**: supplies lower limbs

The bundle of spinal nerves extending inferiorly from lumbosacral enlargement and conus medullaris surround the filum terminale and form **cauda equina**



It extends **from base of the brain** through a large opening in the skull called **Foramen magnum** and into **the vertebral canal**



The spinal cord is made of segments (sections), which are:

- **8 Cervical** (neck area)
- **12 Thoracic** (upper back)
- **5 Lumbar** (lower back)
- **5 Sacral** (pelvic area)
- **1 Coccygeal** (tailbone area)

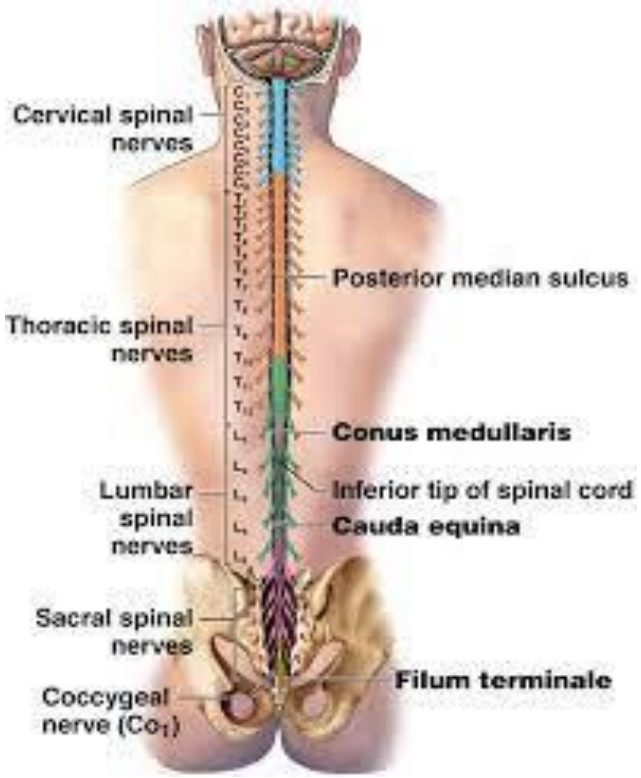
The spinal cord is not the same size throughout – its diameter changes in different areas.

It has two enlargements (wider areas):

- **Cervical enlargement**: Helps control the arms.
- **Lumbosacral enlargement**: Helps control the legs.

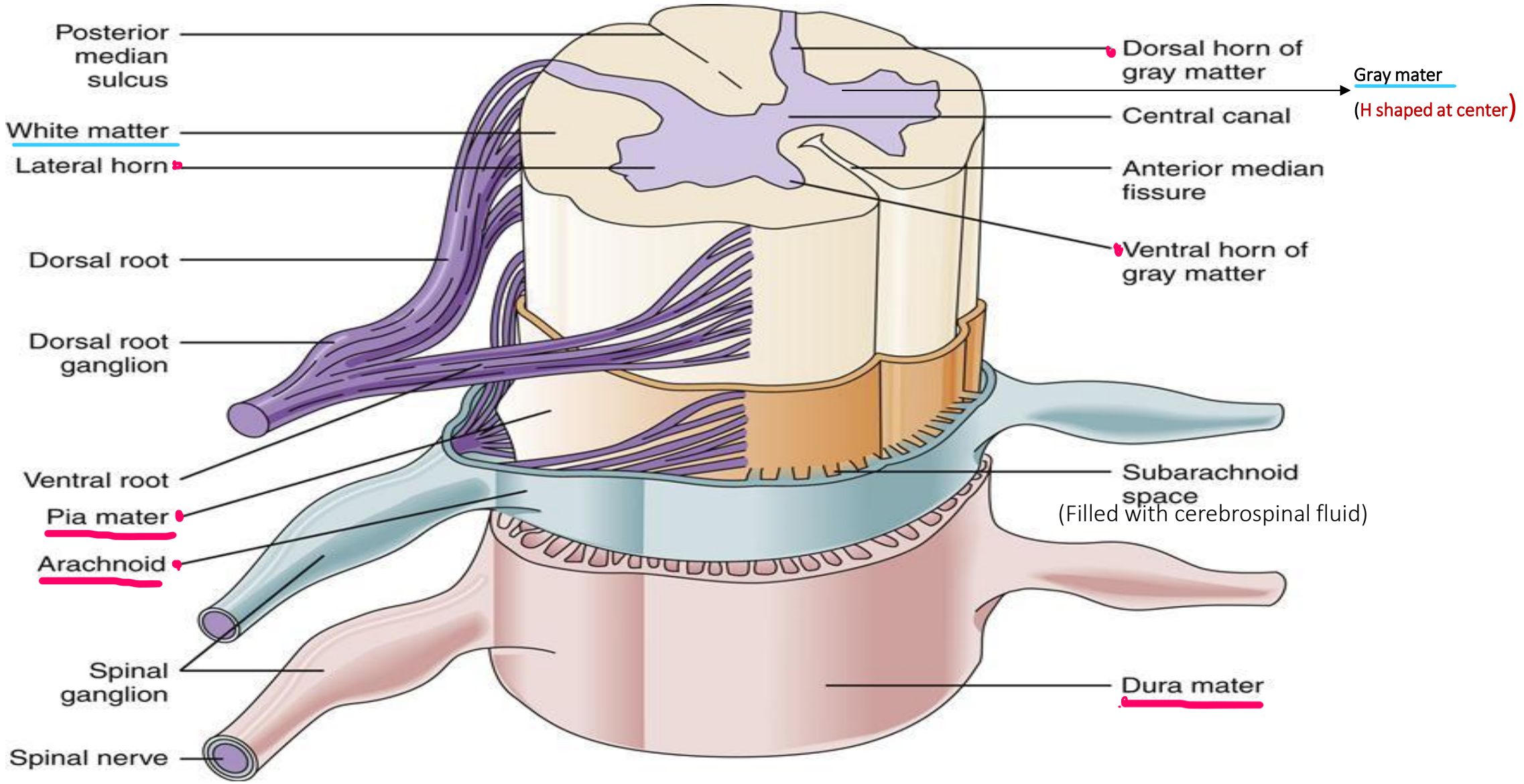
The lower end of the spinal cord has nerve fibers that extend downwards. These nerves:

- Surround the filum terminale (a thin thread-like structure).
- Form the cauda equina (which looks like a horse's tail).

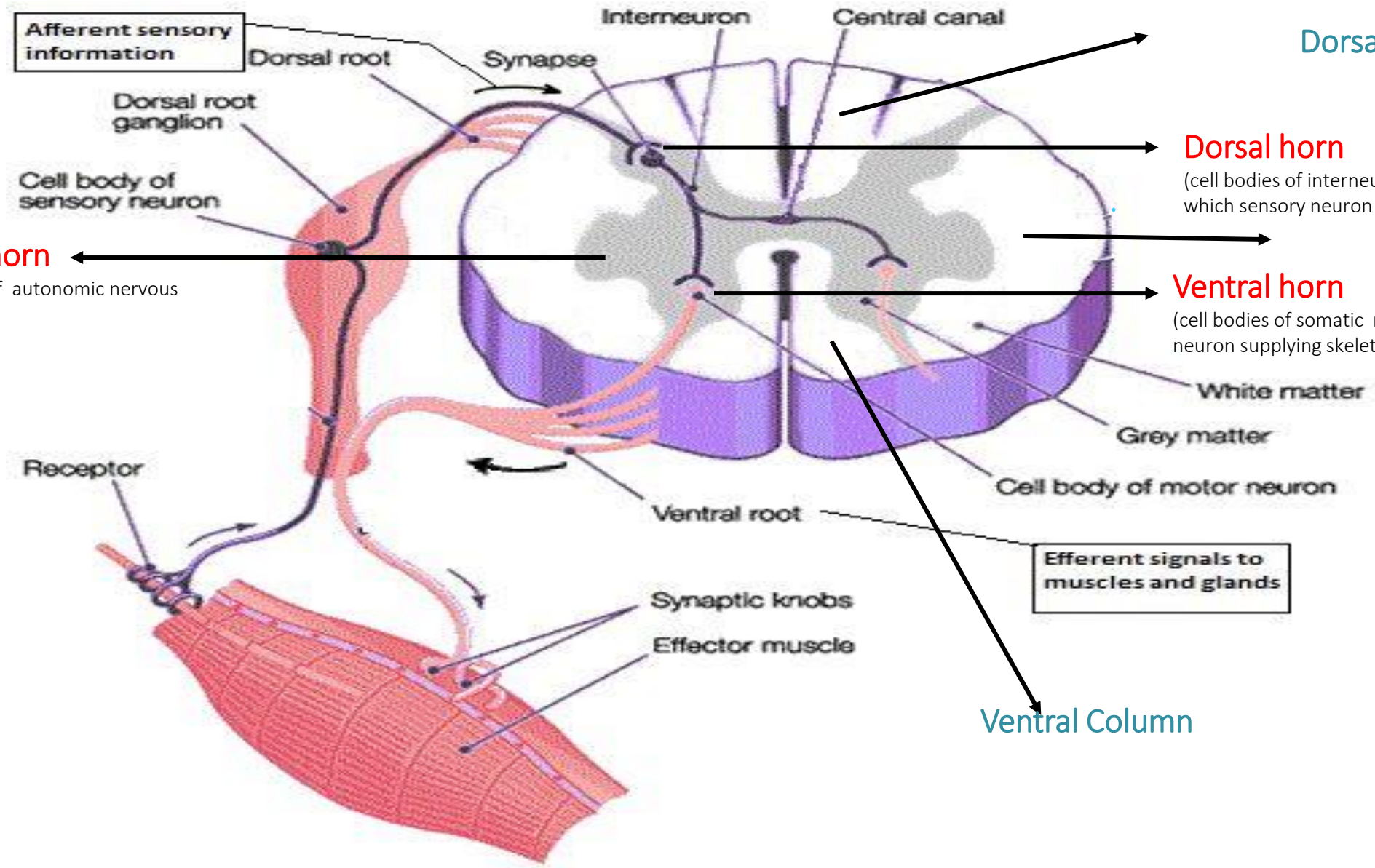


The spinal cord is located within the vertebral cavity of the vertebral column. It is also wrapped in protective meninges. The **spinal meninges** surround the spinal cord and are continuous with the *cranial meninges*. The spinal meninges have the same basic structure, and bear the same names; the outer dura mater, the middle arachnoid mater and the inner pia mater. However, the cranial dura mater has two layers but the spinal dura mater has only one layer.

CROSS SECTION SPINAL CORD



CROSS SECTION SPINAL CORD



Dorsal Column

Dorsal horn
(cell bodies of interneurons on which sensory neuron terminates)

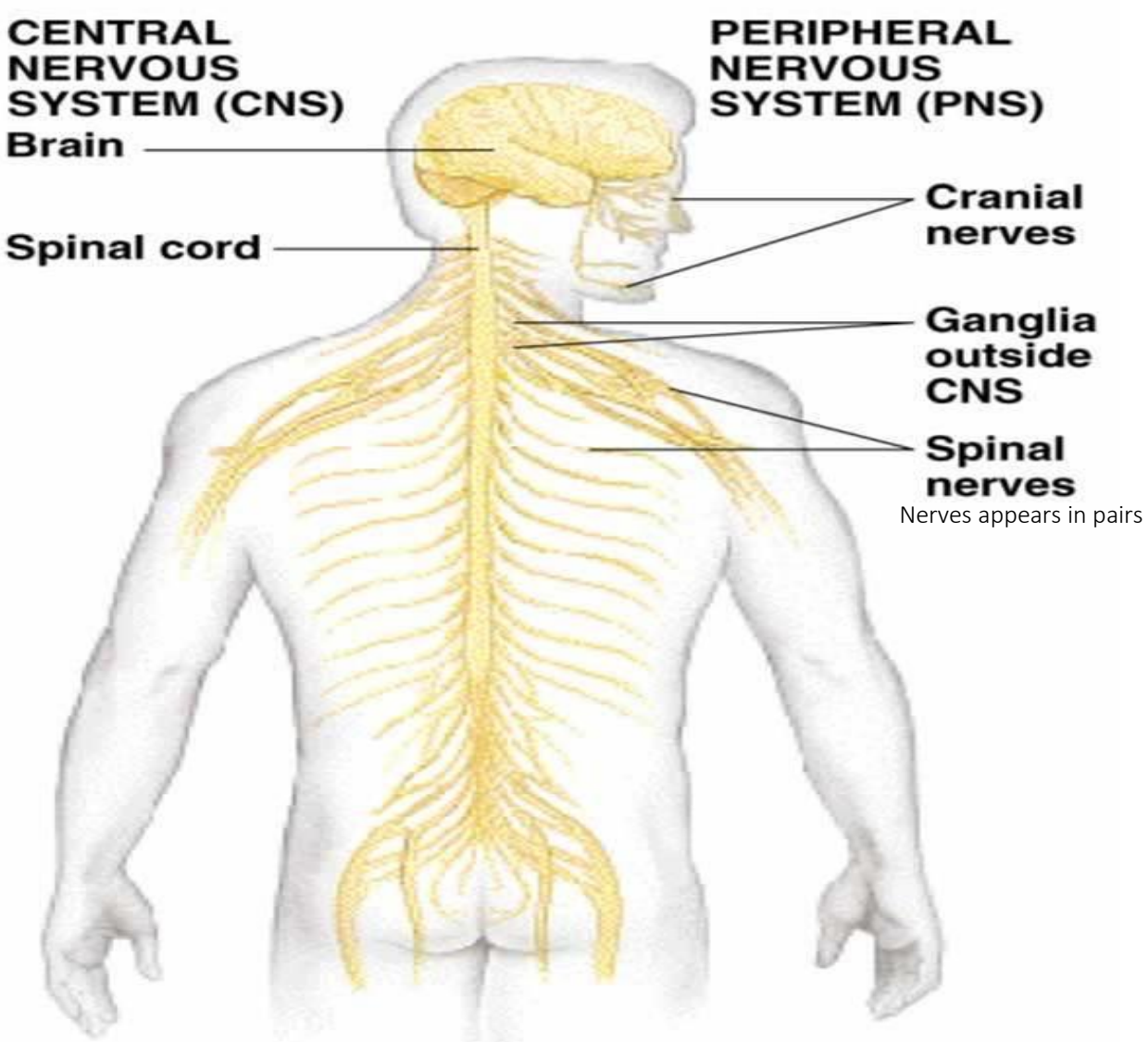
Lateral Column

Lateral horn
(cell bodies of autonomic nervous neuron)

Ventral horn
(cell bodies of somatic motor neuron supplying skeletal muscles)

Ventral Column

PERIPHERAL NERVOUS SYSTEM



The peripheral nervous system (PNS) refers to parts of the nervous system outside the brain and spinal cord. It includes the cranial nerves, spinal nerves and their roots and branches, peripheral nerves, and neuromuscular junctions

The CNS consists solely of the brain and spinal cord, while the PNS includes all the nerves that branch out from the CNS to reach the rest of the body, including the cranial and spinal nerves.

SPINAL NERVES (31 pairs-Human)

In the human body there are **31 pairs of spinal nerves**, one on each side of the vertebral column.

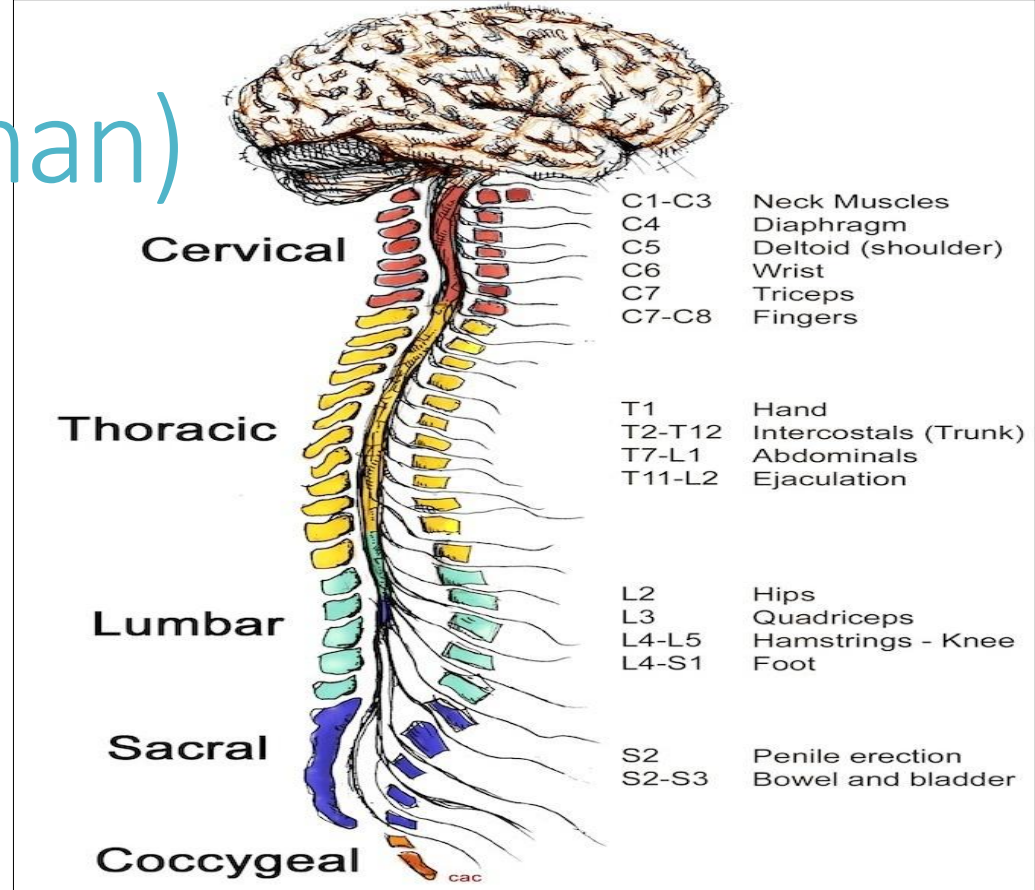
These are grouped into the corresponding cervical, thoracic, lumbar, sacral and coccygeal regions of the spine-**arise in pairs**

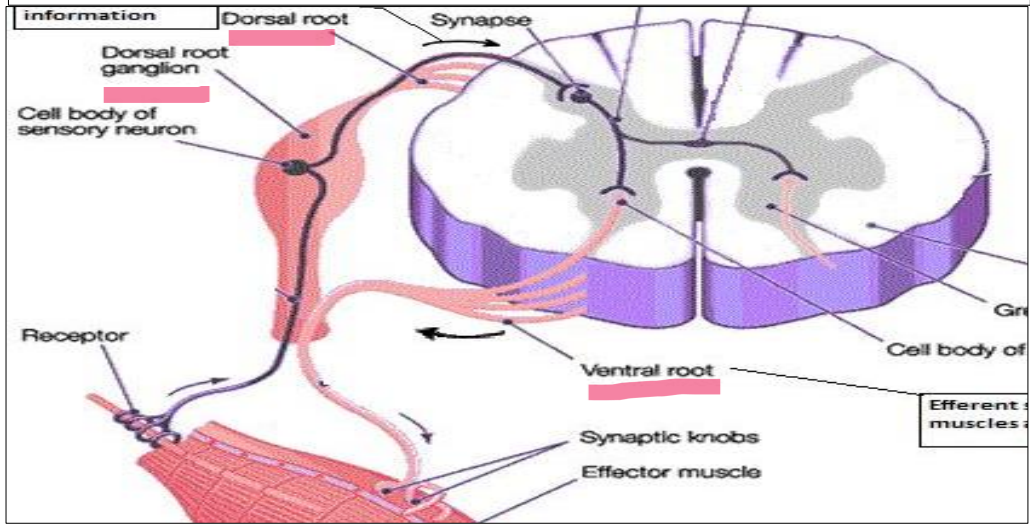
There are 8 pairs of **cervical nerves**, 12 pairs of **thoracic nerves**, 5 pairs of **lumbar nerves**, 5 pairs of **sacral nerves**, and 1 pair of **coccygeal nerves**.

The spinal nerves are part of the peripheral nervous system. A **spinal nerve** is a mixed nerve composed of both sensory and motor motor fibres. These fibres are packed together in the nerve but they separate near the attachment of the nerve to the spinal cord. These produces two roots to each nerve.

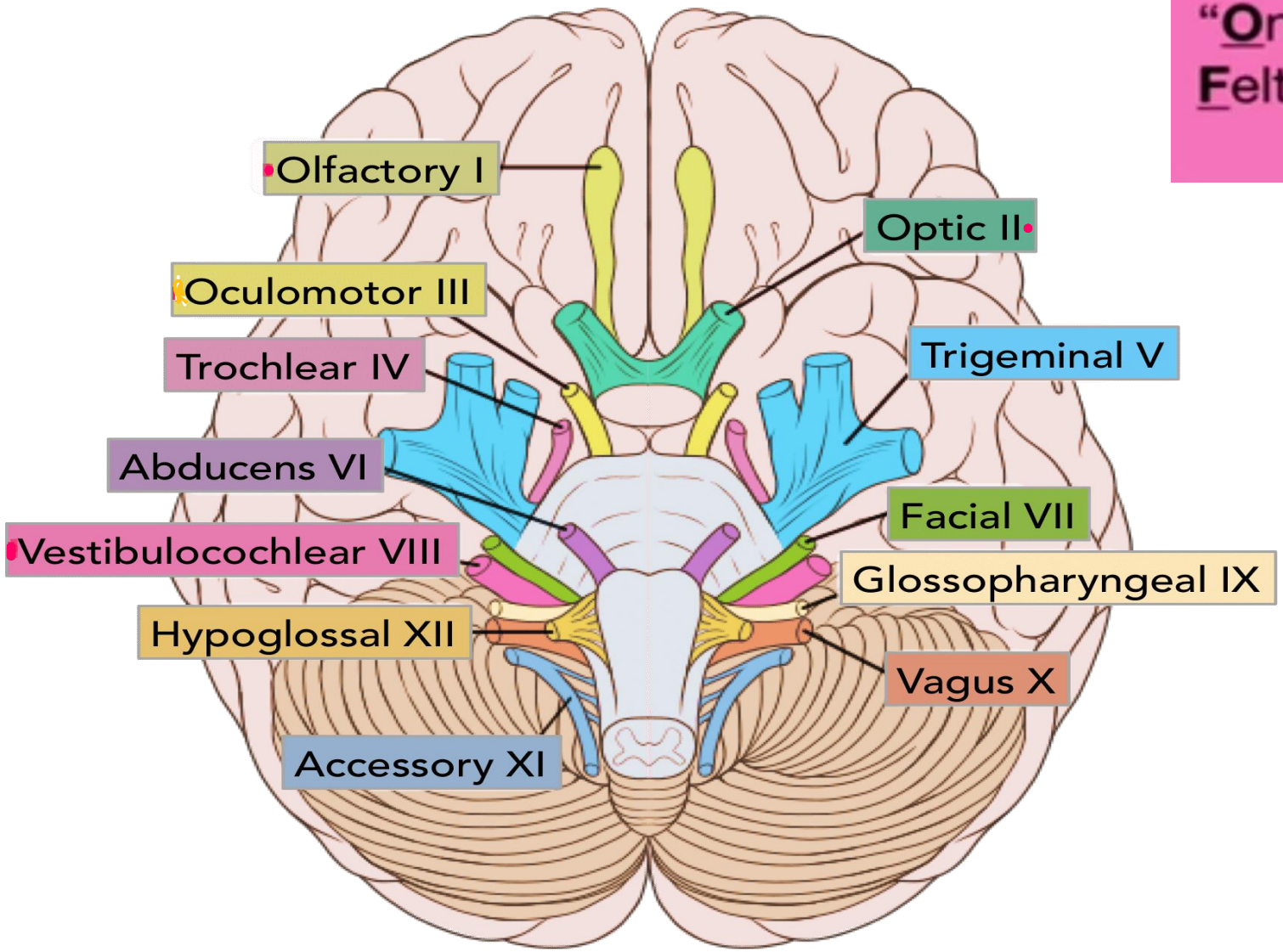
Dorsal root is composed of sensory nerve fibres and ventral root is composed of motor nerve fibres.

An enlargement of the dorsal root –the dorsal root ganglian contains all the cell bodies of the sensory neurons





CRANIAL NERVE (12pairs) -Mammals



"Only One Of The Two Athletes Felt Very Good, Victorious, And Healthy"

Only----- 1st ------OLFACTORY NERVE
One -----2nd ------- OPTIC NERVE
Of -----3rd --------OCULOMOTOR
The -----4th --------TROCHLEAR
Two ---- 5th --------TRIGEMINAL
Athletes--6th ----------ABDUCENS
Felt -----7th ------- FACIAL
Very ----8th --------VESTIBULOCOCHLEAR
Good ---9th --------GLOSSOPHARYNGEAL
Victorious-10th -------VAGUS
And -----11th -------ACCESSORY
Healthy ----12 ------- HYPOGLOSSAL

Cranial nerves

The *cranial nerves* are named because they arise from the brain inside the cranial cavity and pass through various foramina in the bones of the cranium. There are 12 pairs of cranial nerves. Each cranial nerve has both a number and a name. The numbers (designated by a roman numeral) indicate the order, from anterior to posterior, in which the nerves arise from the brain. The names indicate the structures innervated by these nerves (e.g. facial) or the principal function of the nerves (e.g. oculomotor).

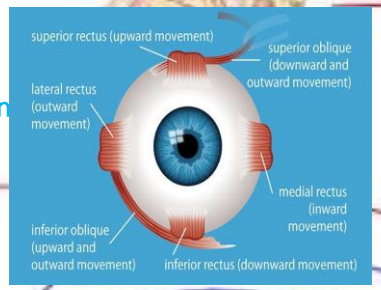
Of the twelve pairs of *cranial nerves*, two pairs arise from neuron cell bodies located in the forebrain and ten pairs arise from the midbrain and hindbrain.

Three cranial nerves (I, II and VIII) carry axons of sensory neurons and thus are called **sensory nerves**. The cell bodies of sensory neurons are located in ganglia outside the brain. Five cranial nerves (III, IV, VI, XI and XII) contain only axons of motor neurons as they leave the brain stem and are called **motor nerves**. The cell bodies of motor neurons lie in nuclei within the brain. The four cranial nerves (V, VII, IX and X) are **mixed nerves** because they contain axons of both sensory and motor neurons.

— sensory fibres
— motor fibres

Olfactory (I)
sensory: nose Smell detection

Optic (II)
sensory: eye-Vision



Eye movement
Trochlear (IV)
motor: superior oblique muscle

Eye movement
Abducent (VI)
motor: external rectus muscle

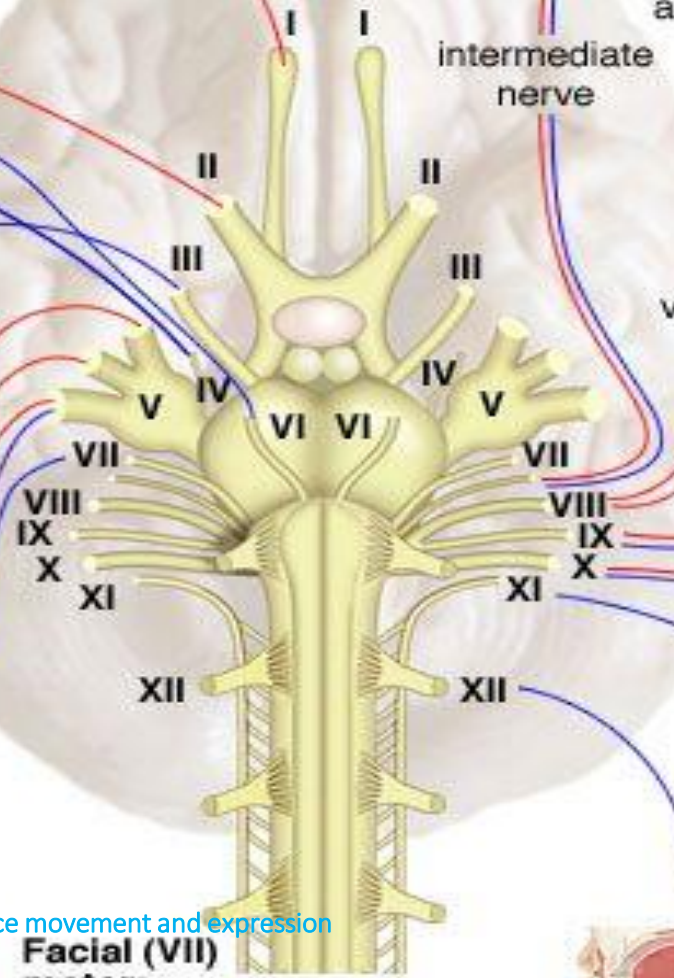
Eye movement
Oculomotor (III)
motor: all eye muscles except those supplied by IV and VI

Face sensation
Trigeminal (V)
sensory: face, sinuses, teeth, etc.
motor: muscles of mastication

Face movement and expression
Facial (VII)
motor: muscles of the face

Manticulation-taste
Intermediate
motor:
submaxillary and sublingual gland
sensory:
anterior part of tongue and soft palate

Glossopharyngeal (IX)
motor: Throat sensation
pharyngeal musculature
sensory:
posterior part of tongue, tonsil, pharynx



intermediate nerve

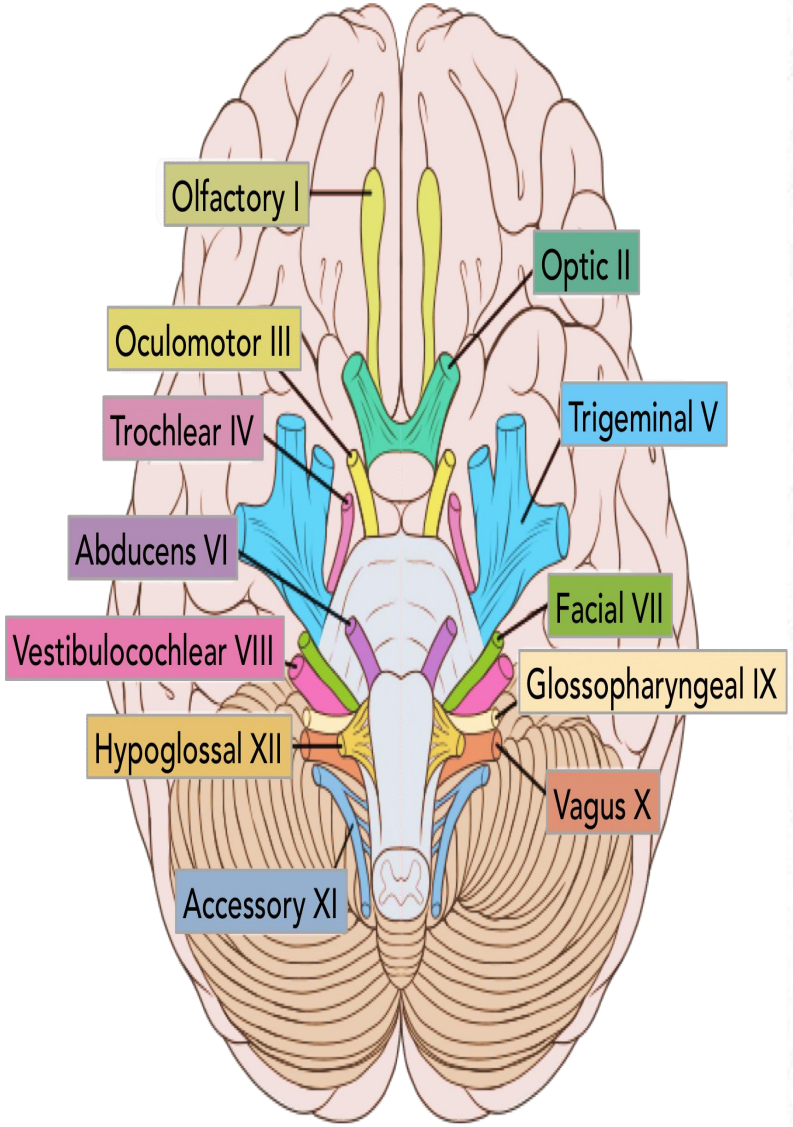
Vestibulocochlear (VIII)
sensory:
inner ear
Hearing

vestibular
cochlear

Movement, Sensation secretion, abdominal organs and glands
Vagus (X)
motor:
heart, lungs, bronchi, gastrointestinal tract
sensory:
heart, lungs, bronchi, trachea, larynx, pharynx, gastrointestinal tract, external ear

Swallowing and speech
Hypoglossal (XII)
motor: muscles of the tongue

Head, Neck, shoulder movement
Accessory (XI)
motor: sterno-cleidomastoid and trapezius muscles



Note: Vagus is the longest and Trochlear is the smallest cranial nerve.

Number Name	Origin in the brain	Peripheral termination	Nature	Func
I. Olfactory	Smell area in temporal lobe of cerebrum	Mucous membrane in roof of nose	Sensory	Sense smell
II. Optic	Sight area in occipital lobe of cerebrum	Retina of the eye	Sensory	Sight
III. Oculomotor	Floor of midbrain	Superior, inferior, medial rectus and ciliary muscles of the eye, circular fibres of the iris	Motor	Eye move focus pupil regula
IV. Trochlear	Floor of midbrain	Superior obliqne muscle of the eye	Motor	Eye Rotation
V. Trigeminal	Motor fibres pons varoli; sensory fibres trigeminal ganglion	Mastication muscles; sensory—iris, cornea, cheek, lower jaw, gums	Mixed	Chewi cial s tion
VI. Abducens	Floor, fourth ventricle	Lateral rectus muscle of the eye	Motor	Eye ment
VII. Facial	Pons varoli	Tongne, facial muscles	Mixed	Taste, expres
VIII. Auditory	Hearing area of cerebrum, cerebellum	Semicircular canals, organ of corti	Sensory	Hearin ance
IX. Glossopharyngeal	Medulla oblongata	Back of the tongne, parotid glands, pharynx	Mixed	Taste, secre phar mover
X. Vagus	Medulla oblongata	Larynx, pharynx, glands, ducts, heart, blood vessels, lung, alimentary canal	Mixed	Move of m and se in gla
XI. Accessory	Medulla oblongata	Sternocleidomastoid, trapezius, laryngeal and pharyngeal muscles	Motor	Move of shou laryn phary
XII. Hypoglossal	Medulla oblongata	Tongue	Motor	Tongu mover

Swallowing and speech

COMPARISION (Human)

Comparison of spinal and cranial nerves

	Spinal nerves	*Cranial nerves*
Designation	C1-8, T1-12, L1-5, S1-5, Co1	Roman Numerals I-XII
Number	31 pairs	12 pairs
Origin	Spinal cord	Brain
Number of roots	2 (a dorsal and a ventral root)	1
Nature	Mixed	Mixed, motor and sensory

References

- Lifesciences Fundamentals and Practices-II by P.Kumar and U. Mishra
- Images (Google)

Thank You!