

# Neuroanatomy

Introduction and Organization of the Nervous System

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# Introduction and Organization of the Nervous System

- **Neuroanatomy**

is the study of the nervous system anatomy.

- Nervous system along with endocrine system regulates the functions of all other systems of the body. Hence nervous system is also called **master system of the body**.
- **The functions of the nervous system include:**
  - **Reception** of sensory stimuli from internal and external environments.
  - **Integration** of sensory information.
  - **Coordination and control** of voluntary and involuntary activities of the body.
  - **Assimilation** and Storage of experiences,
  - **Programming** of basic instincts.

# Cellular Organization of the Nervous System

- The highly specialized and complex nervous system consists of only **two principal categories of cells, neurons, and neuroglia.**
- **Neurons form the basic structural and functional units of the nervous system.**
- They are excitable cells which are specialized for reception of stimuli and the conduction of nerve impulses.
- **Neuroglia or glial cells** are supportive cells that support the neurons both structurally and functionally. The glial cells are five times more abundant than the neurons and account for more than half of the weight of the brain.

# Introduction and Organization of the Nervous System

- **Neurons (Neuro, Nerve)**

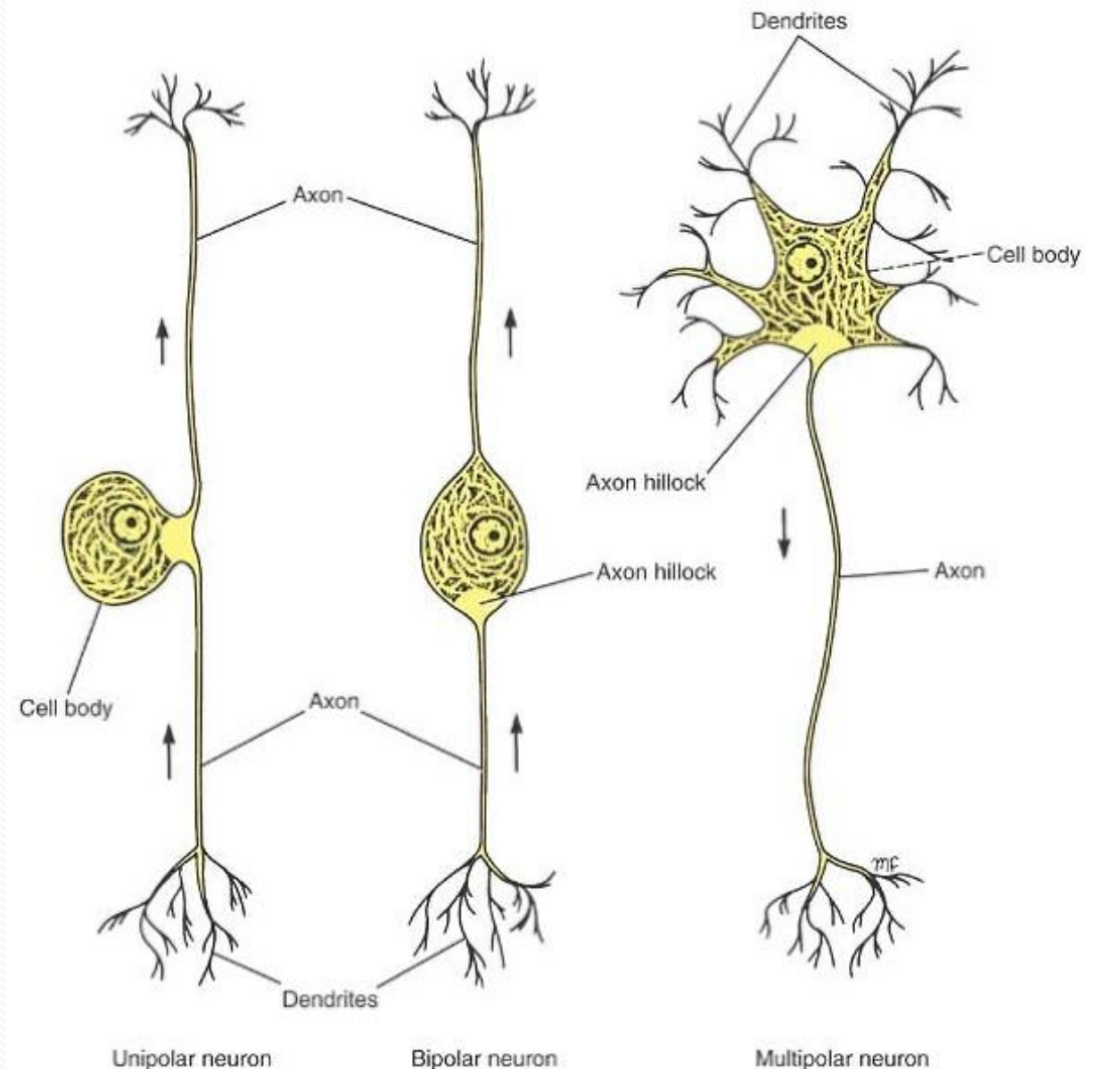
The neurons are the structural and functional units of the nervous system.

- They are specialized for reception, integration, interpretation and onward transmission of information. They conduct nerve impulses over long distances at great speeds.
- The nervous system consists of vast number (about  $10^{12}$  ) of neurons.
- Each neuron consists of a **cell body (also called soma or perikaryon or nerve cell body)**
- The typical neuron has a single long process called axon and many short processes **called dendrites**.
- A neurite refers to any projection from the cell body of a neuron. This projection can be either an axon or a dendrite

# Varieties of Neurons

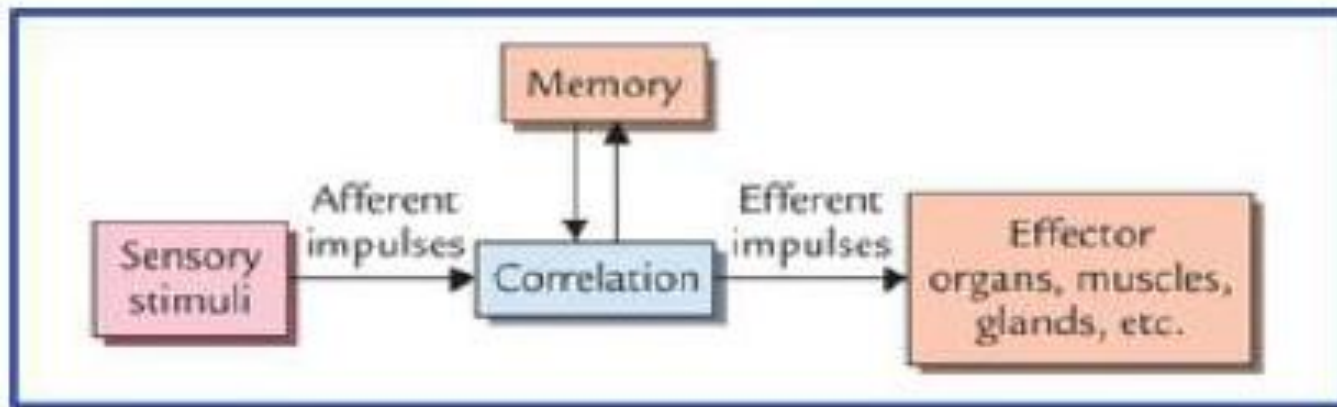
- **Unipolar neurons** are those in which the cell body has a single neurite (A neurite refers to any projection from the cell body of a neuron. This projection can be either an axon or a dendrite ) that divides a short distance from the cell body into two branches, one proceeding to some peripheral structure and the other entering the central nervous system. The branches of this single neurite have the structural and functional characteristics of an axon. In this type of neuron, the fine terminal branches found at the peripheral end of the axon at the receptor site are often referred to as the dendrites. Examples of this form of neuron are found in the **posterior root ganglion**.
- **Bipolar neurons** possess an elongated cell body, from each end of which a single neurite emerges. Examples of this type of neuron are found in the **retinal bipolar cells and the cells of the sensory cochlear and vestibular ganglia**.
- **Multipolar neurons** have a number of neurites arising from the cell body. With the exception of the long process, the axon, the remainder of the neurites are dendrites. **Most neurons of the brain and spinal cord are of this type.**

# Varieties of Neurons



# Introduction and Organization of the Nervous System

- The nervous system consists of three **basic functional types of neurons**:
- **sensory, motor and interneurons.**
- The sensory neurons detect stimuli and
- Motor neurons send commands to the effector organs.
- The interneurons confer on the nervous system its prodigious capacity to analyse, integrate and store information.



Flowchart 1 Mechanism of working of the nervous system.



# Terms commonly used for describing nervous system

Terms	Definition
Nerve fibre	Axon
Nerve	Bundle of nerve fibres outside the CNS
Tract	Bundle of nerve fibres inside the CNS
Ganglion	Collection of nerve cell bodies outside the CNS
Nucleus	Collection of nerve cell bodies inside the CNS
Sensory neuron	Neuron that transmits impulses from a sensory receptor to the CNS
Motor neuron	Neuron that transmits impulses from the CNS to the effector organ, e.g. muscle
Somatic motor nerve	Nerve that stimulates contraction of skeletal muscles
Autonomic motor nerve	Nerve that stimulates contraction/inhibition of smooth and cardiac muscles; and that stimulates secretion of glands
Nerve plexus	Network of intercalated nerves

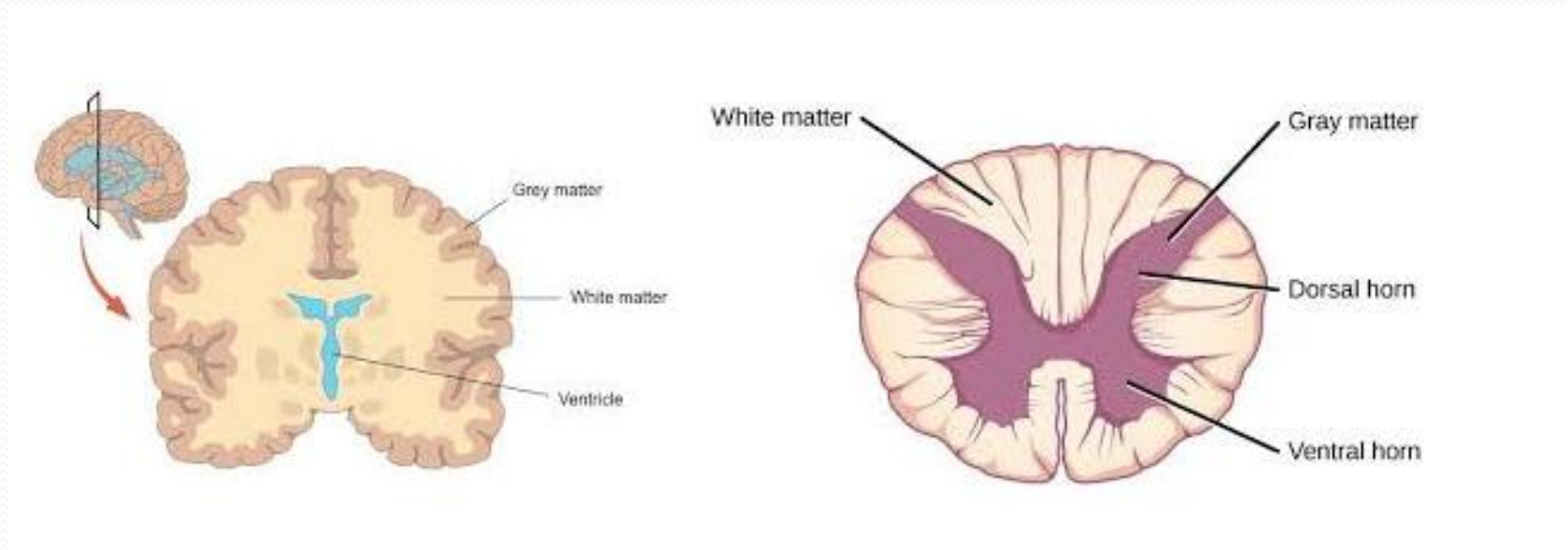
- CNS = central nervous system.
- PNS = Peripheral nervous system.



# Introduction and Organization of the Nervous System

- **Central and Peripheral Nervous Systems**
- The nervous system is divided into two main parts: the central nervous system (Fig. 1-2A), which consists of the **brain and spinal cord**, and the peripheral nervous system (Fig. 1-2B), which consists of the **cranial and spinal nerves and their associated ganglia**.
- In the central nervous system, the brain and spinal cord are the main centers where **correlation and integration of nervous information occur**. Both the brain and spinal cord are covered with a system of membranes, called **meninges**, and are suspended in the **cerebrospinal fluid**; they are further protected by the bones of the skull and the vertebral column.

- The interior of the central nervous system is organized into gray and white matter. Gray matter consists of nerve cells embedded in neuroglia; it has a gray color. White matter consists of nerve fibers embedded in neuroglia; it has a white color due to the presence of lipid material in the myelin sheaths of many of the nerve fibers.



**Brain**

**Spinal cord CS**

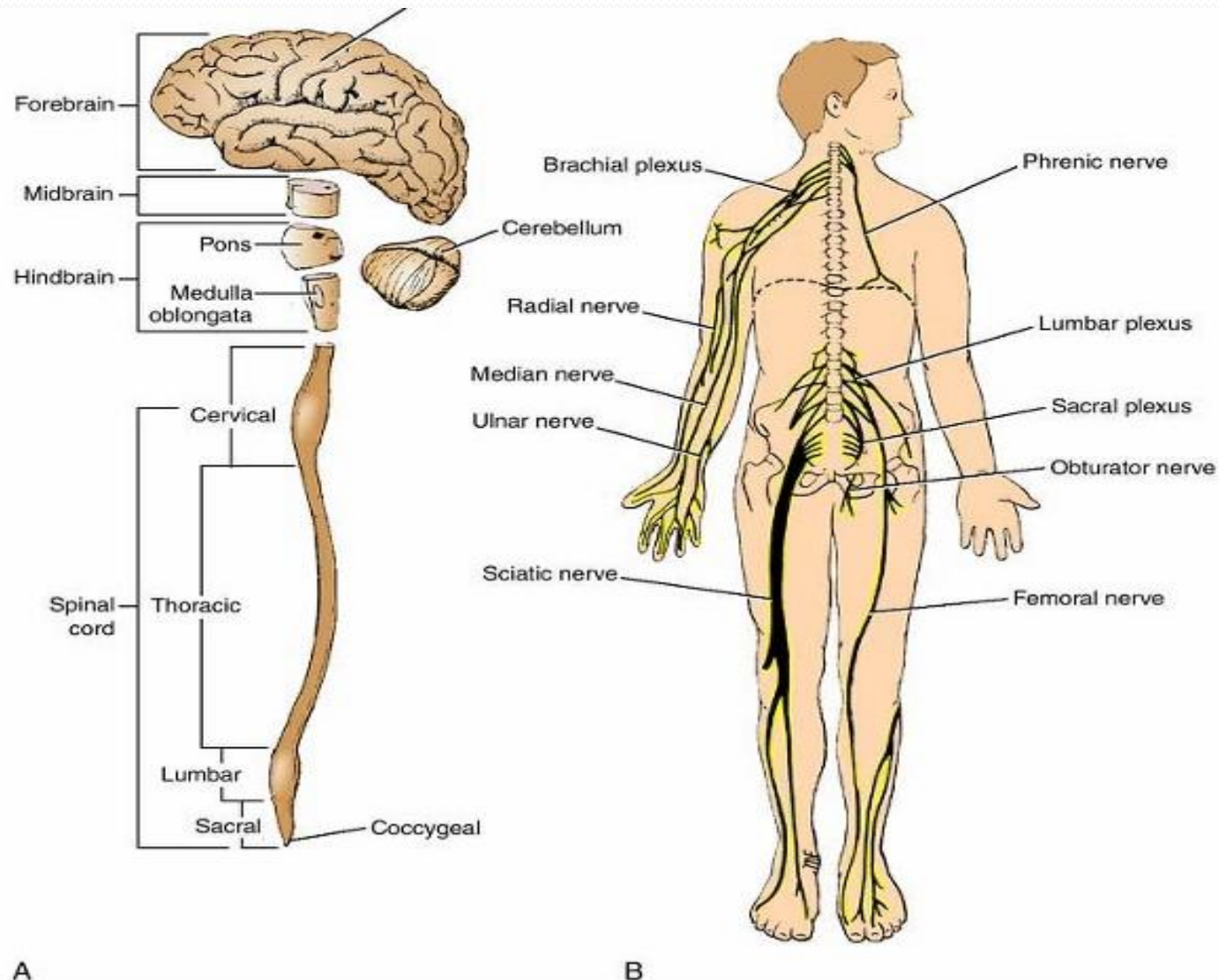
## Introduction and Organization of the Nervous System

- In the peripheral nervous system, the cranial and spinal nerves, which consist of **bundles of nerve fibers or axons, conduct information to and from the central nervous system.** Although the nerves are surrounded by fibrous sheaths as they run to different parts of the body, they are relatively unprotected and are commonly damaged by trauma.

# Autonomic Nervous System

- The autonomic nervous system is the part of the nervous system concerned with the **innervation of involuntary structures**, such as the heart, smooth muscle, and glands within the body. **It is distributed throughout the central and peripheral nervous systems.** The autonomic system may be divided into two parts, the **sympathetic** and the **parasympathetic**, and in both parts, there are afferent and efferent nerve fibers. The activities of the sympathetic part of the autonomic system prepare the body for an emergency. The activities of the parasympathetic part of the autonomic system are aimed at conserving and restoring energy.

# Major Divisions of the Central Nervous System



A

B

**Figure 1-2 A:** The main divisions of the central nervous system.

**B:** The parts of the peripheral nervous system (the cranial nerves have been omitted).

# Major Divisions of the Central Nervous System

- **Central Nervous System**

1. **Brain**

- Forebrain

- Cerebrum

- Diencephalon (the caudal (posterior) part of the forebrain)

- Midbrain

- Hindbrain

- Medulla oblongata

- Pons

- Cerebellum

2. **Spinal cord**

- Cervical segments

- Thoracic segments

- Lumbar segments

- Sacral segments

- Coccygeal segments

- **Peripheral Nervous System**

1. **Cranial nerves and their ganglia**—12 pairs that exit the skull through the foramina

2. **Spinal nerves and their ganglia**—31 pairs that exit the vertebral column through the intervertebral foramina

- 8 Cervical

- 12 Thoracic

- 5 Lumbar

- 5 Sacral

- 1 Coccygeal

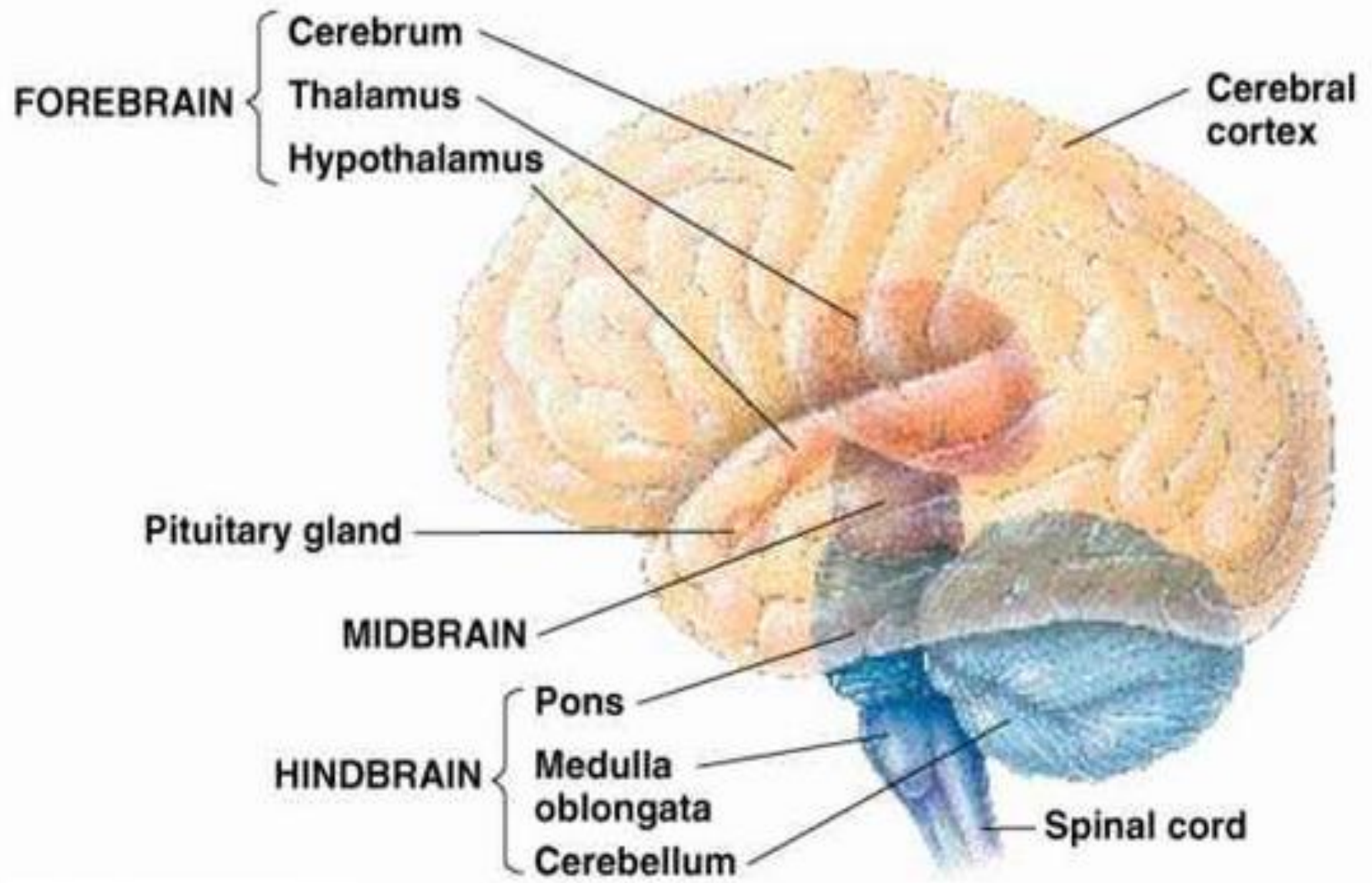
**Table 1-1 Major Divisions of the Central and Peripheral Nervous Systems**



# Brain

- The brain lies in the cranial cavity and is continuous with the spinal cord through the foramen magnum. It is surrounded by three meninges: the dura mater, the arachnoid mater, and the pia mater; these are continuous with the corresponding meninges of the spinal cord. The cerebrospinal fluid surrounds the brain in the subarachnoid space.
- The brain is conventionally divided into three major divisions. These are, in ascending order from the spinal cord, the hindbrain, the midbrain, and the forebrain. The hindbrain may be subdivided into the medulla oblongata, the pons, and the cerebellum. The forebrain may also be subdivided into the diencephalon (between brain), which is the central part of the forebrain, and the cerebrum. The brainstem (a collective term for the medulla oblongata, pons, and midbrain) is that part of the brain that remains after the cerebral hemispheres and cerebellum are removed.





# Cerebrum

The cerebrum, the largest part of the brain, consists of two cerebral hemispheres, which are connected by a mass of white matter called the **corpus callosum** (Figs. 1-11). Each hemisphere extends from the frontal to the occipital

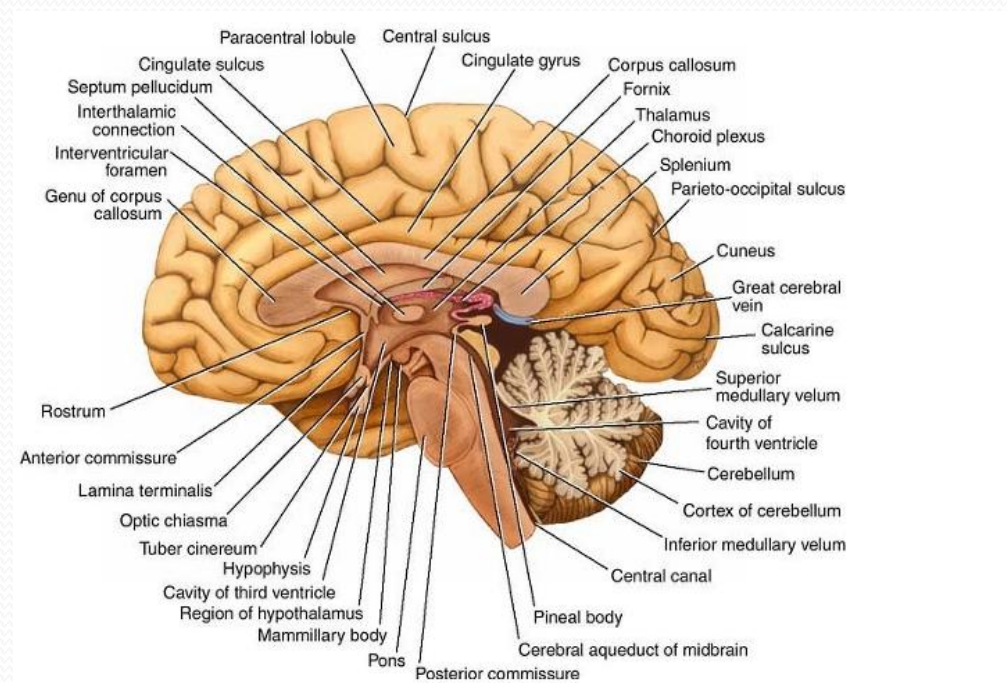
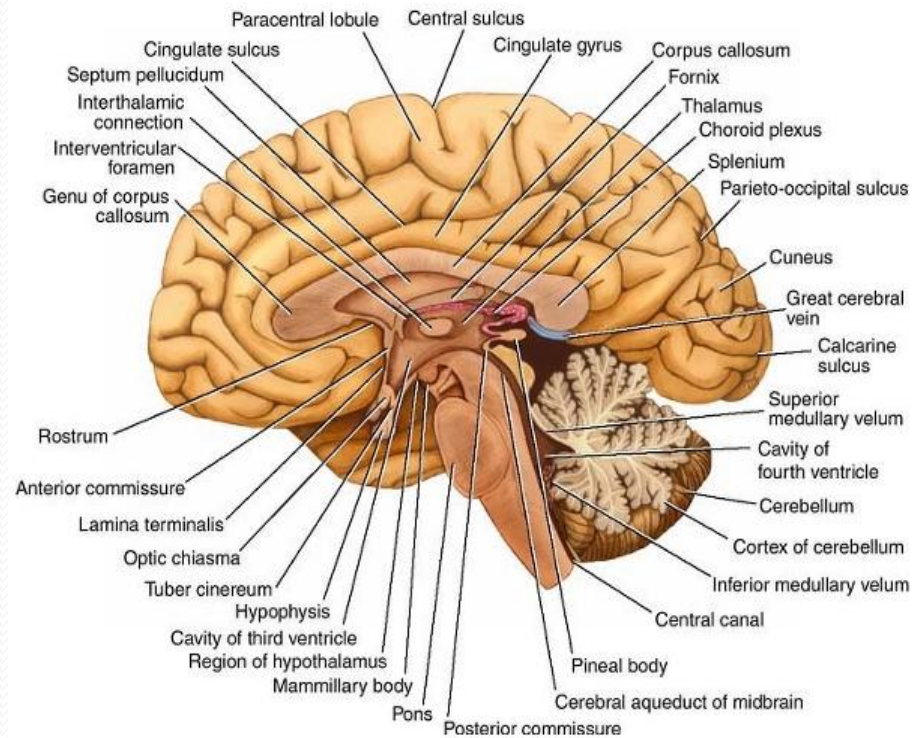
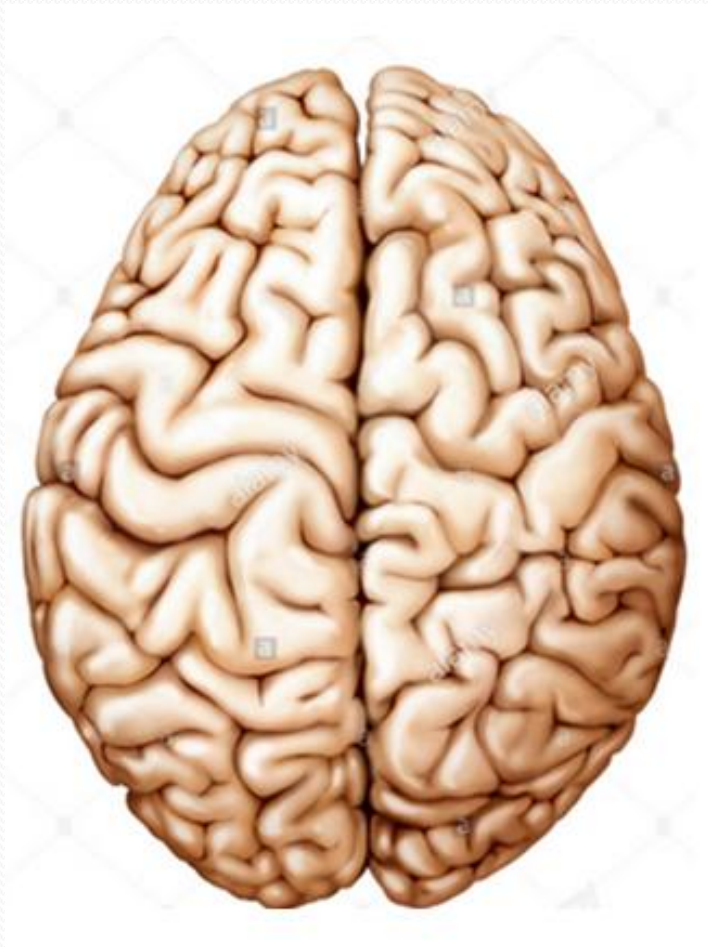


Figure 1-11 Median sagittal section of the brain to show the third ventricle, the cerebral aqueduct, and the fourth ventricle.

- The surface layer of each hemisphere, the cortex, is composed of gray matter. The cerebral cortex is thrown into **folds, or gyri**, separated by **fissures, or sulci**. The surface area of the cortex is greatly increased by this means. A number of the large sulci are conveniently used to subdivide the surface of each hemisphere into lobes. The lobes are named from the bones of the cranium under which they lie.
- Within the hemisphere is a central core of white matter, containing several large masses of gray matter, the **basal nuclei or ganglia**. A fan-shaped collection of nerve fibers, termed the **corona radiata**, passes in the white matter to and from the cerebral cortex to the brainstem. The corona radiata converges on the basal nuclei and passes between them as the internal capsule. The tailed nucleus situated on the medial side of the internal capsule is referred to as the caudate nucleus, and the lens-shaped nucleus on the lateral side of the internal capsule is called the **lentiform nucleus**.
- The cavity present within each cerebral hemisphere is called the **lateral ventricle**. **The lateral ventricles communicate with the third ventricle through the interventricular foramina.**
- During the process of development, the cerebrum becomes enormously enlarged and overhangs the diencephalon, the midbrain, and the hindbrain.

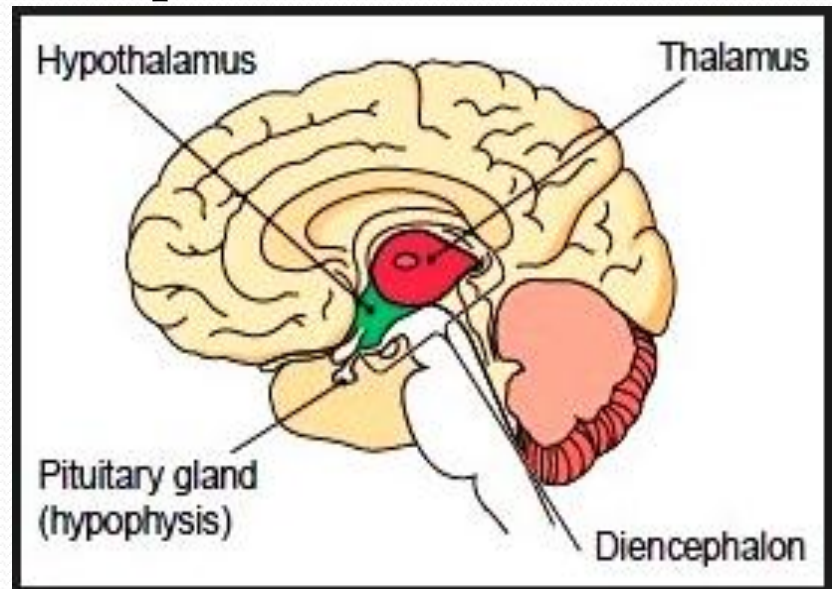




**Figure 1-11** Median sagittal section of the brain to show the third ventricle, the cerebral aqueduct, and the fourth ventricle.

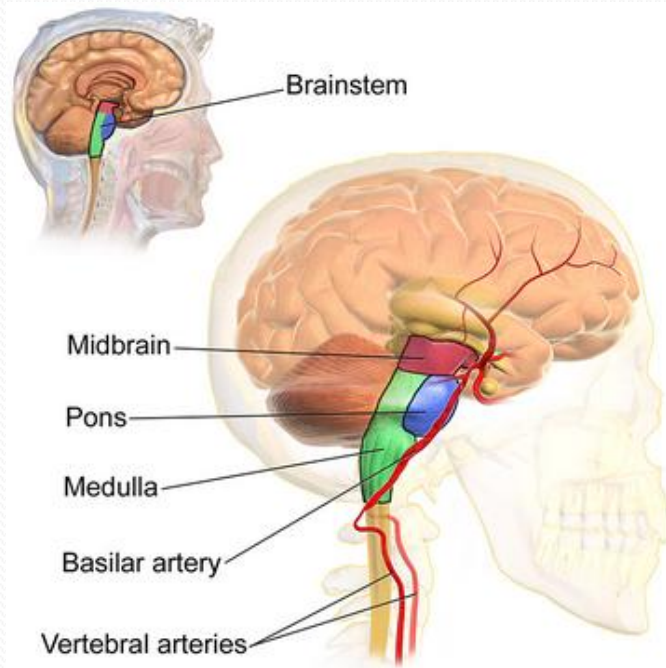
# Diencephalon

The diencephalon is almost completely hidden from the surface of the brain. It consists of a dorsal thalamus and a ventral hypothalamus. The thalamus is a large, egg-shaped mass of gray matter that lies on either side of the third ventricle. The anterior end of the thalamus forms the posterior boundary of the interventricular foramen, the opening between the third and lateral ventricles. The hypothalamus forms the lower part of the lateral wall and floor of the third ventricle

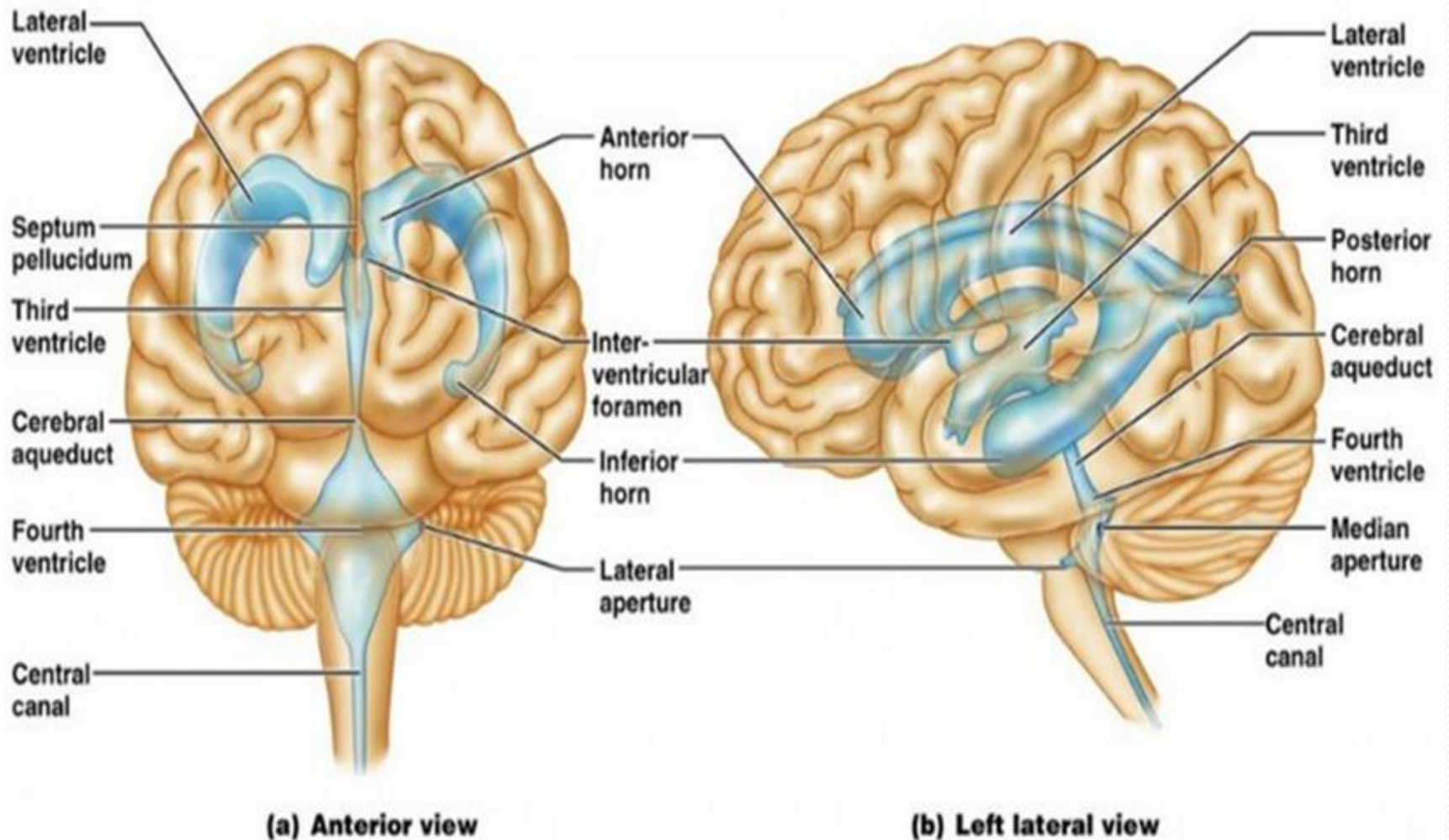


# Midbrain

- The midbrain is the narrow part of the brain that connects the forebrain to the hindbrain (Figs. 1-2A and 1-11). The narrow cavity of the midbrain is the cerebral aqueduct, which connects the third and fourth ventricles (Fig. 1-11). The midbrain contains many nuclei and bundles of ascending and descending nerve fibers.







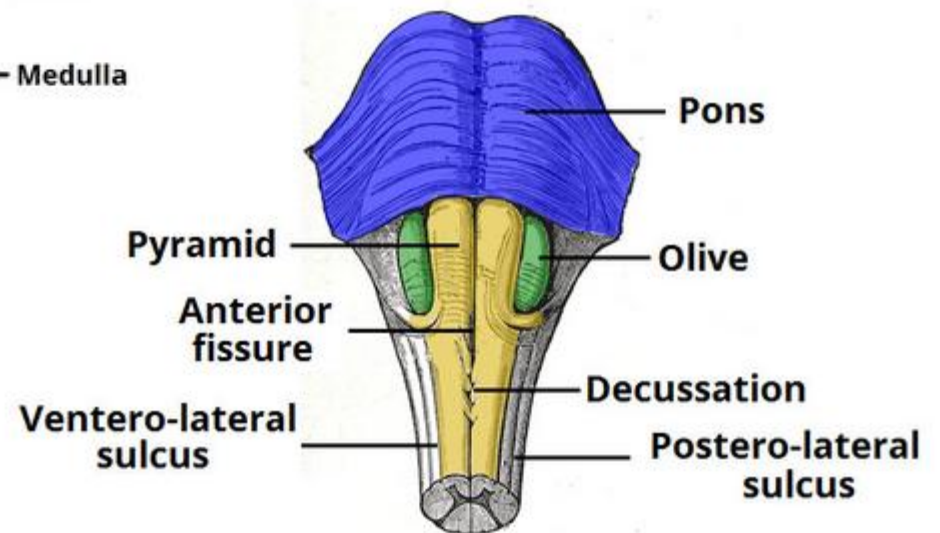
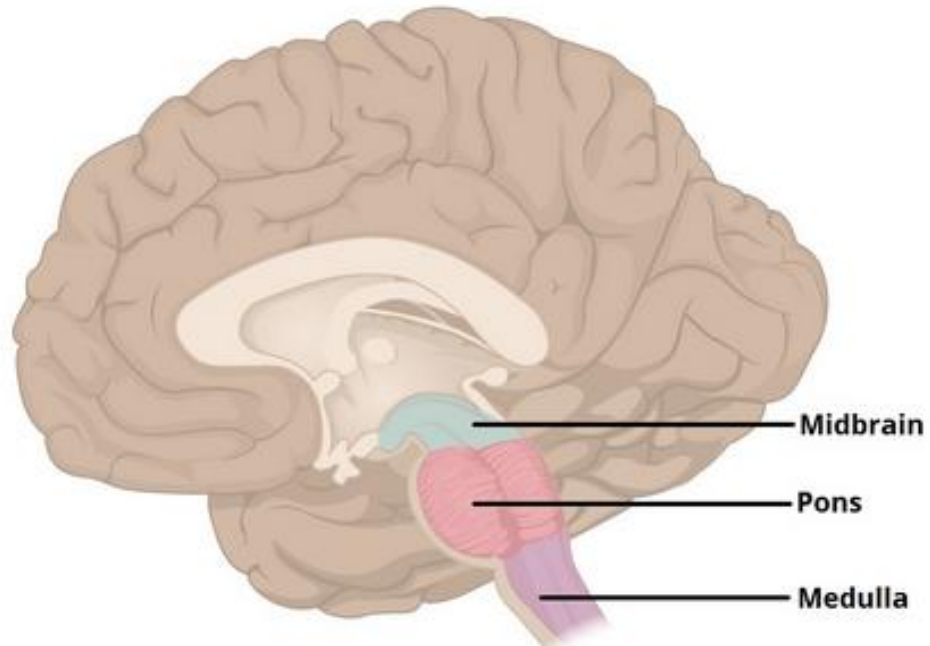
## Brain ventricular anatomy



# Hind brain

- **Medulla Oblongata**

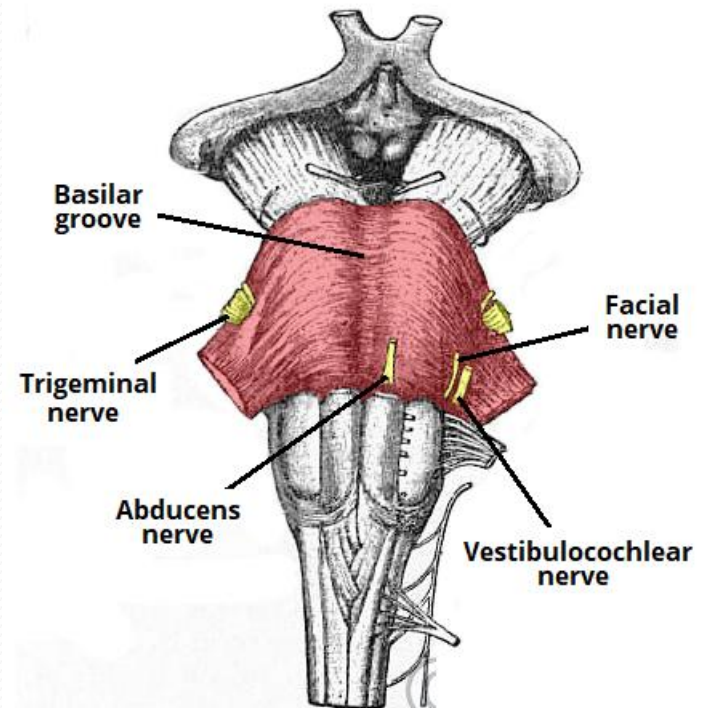
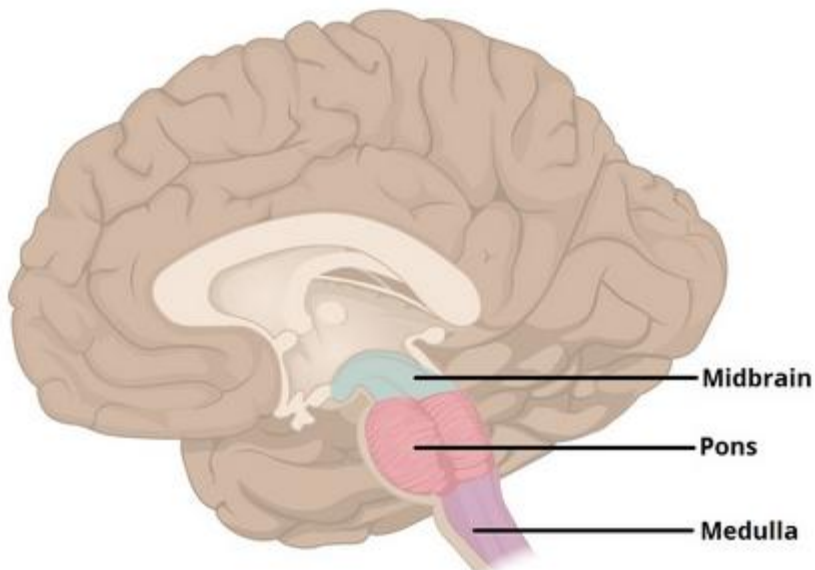
- The medulla oblongata is conical in shape and connects the pons superiorly to the spinal cord inferiorly. It contains many collections of neurons, called nuclei, and serves as a conduit for ascending and descending nerve fibers.
- The medulla oblongata, the pons, and the cerebellum surround a cavity filled with cerebrospinal fluid, called the fourth ventricle. This is connected superiorly to the third ventricle by the cerebral aqueduct; inferiorly, it is continuous with the central canal of the spinal cord. It communicates with the subarachnoid space through three openings in the inferior part of the roof. It is through these openings that the cerebrospinal fluid within the central nervous system can enter the subarachnoid space.



Anterior surface of the medulla.

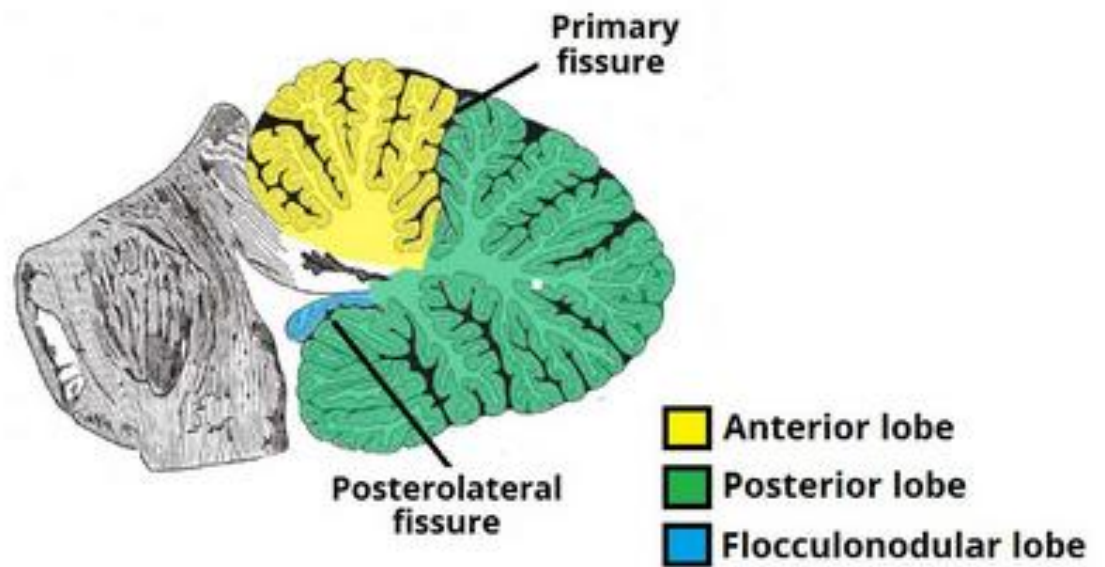
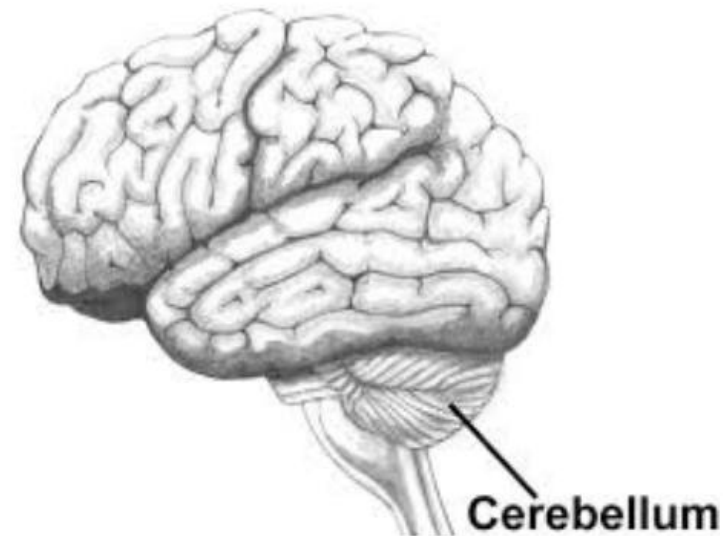
# Pons

- The pons is situated on the anterior surface of the cerebellum, inferior to the midbrain and superior to the medulla oblongata. The pons, or bridge, derives its name from the large number of transverse fibers on its anterior aspect connecting the two cerebellar hemispheres. It also contains many nuclei and ascending and descending nerve fibers.



# Cerebellum

- The cerebellum lies within the posterior cranial fossa of the skull, posterior to the pons and the medulla oblongata. It consists of two laterally placed hemispheres connected by a median portion, the vermis. The cerebellum is connected to the midbrain by the superior cerebellar peduncles, to the pons by the middle cerebellar peduncles, and to the medulla by the inferior cerebellar peduncles. The peduncles are composed of large bundles of nerve fibers connecting the cerebellum to the remainder of the nervous system.
- The surface layer of each cerebellar hemisphere is called the cortex and is composed of gray matter. The cerebellar cortex is thrown into folds, or folia, separated by closely set transverse fissures. Certain masses of gray matter are found in the interior of the cerebellum, embedded in the white matter; the largest of these is known as the dentate nucleus.

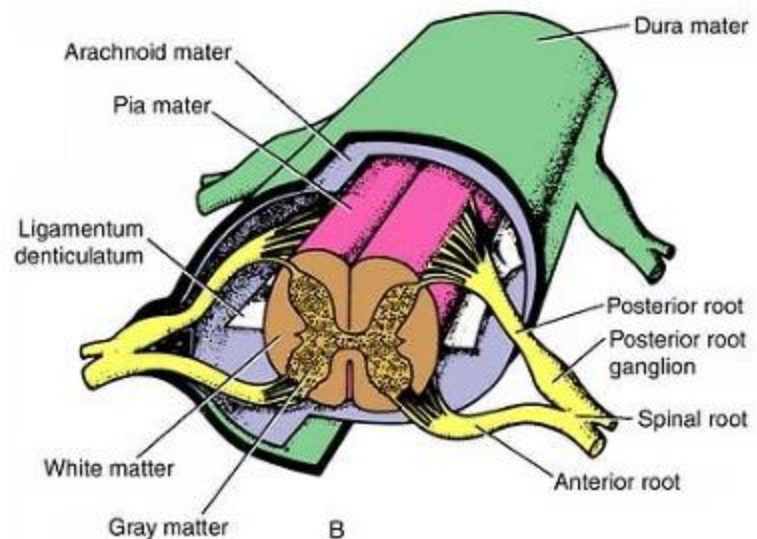
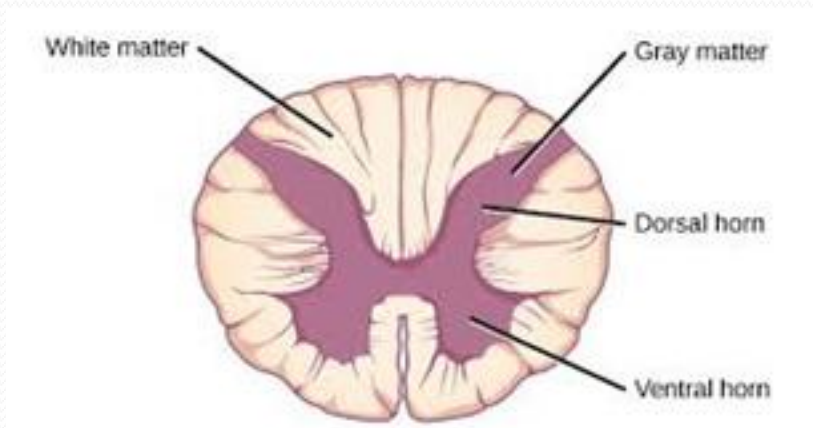


Anatomical lobes of the cerebellum.



# Spinal Cord

- The spinal cord is composed of an inner core of gray matter, which is surrounded by an outer covering of white matter. The gray matter is seen on cross section as an H-shaped pillar with anterior and posterior gray columns, or horns, united by a thin gray commissure containing the small central canal. The white matter, for purposes of description, may be divided into anterior, lateral, and posterior white columns.



# Thanks

