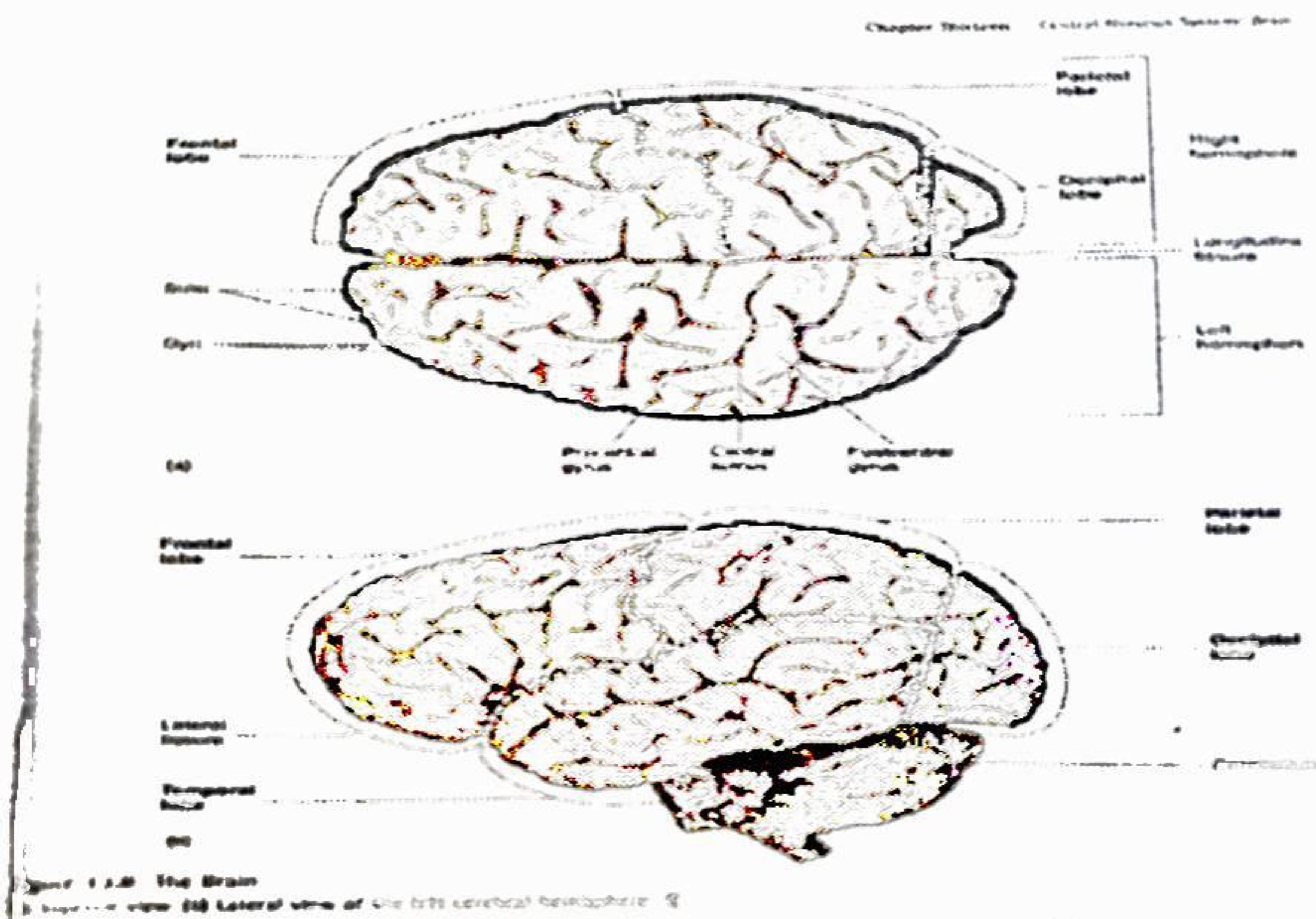


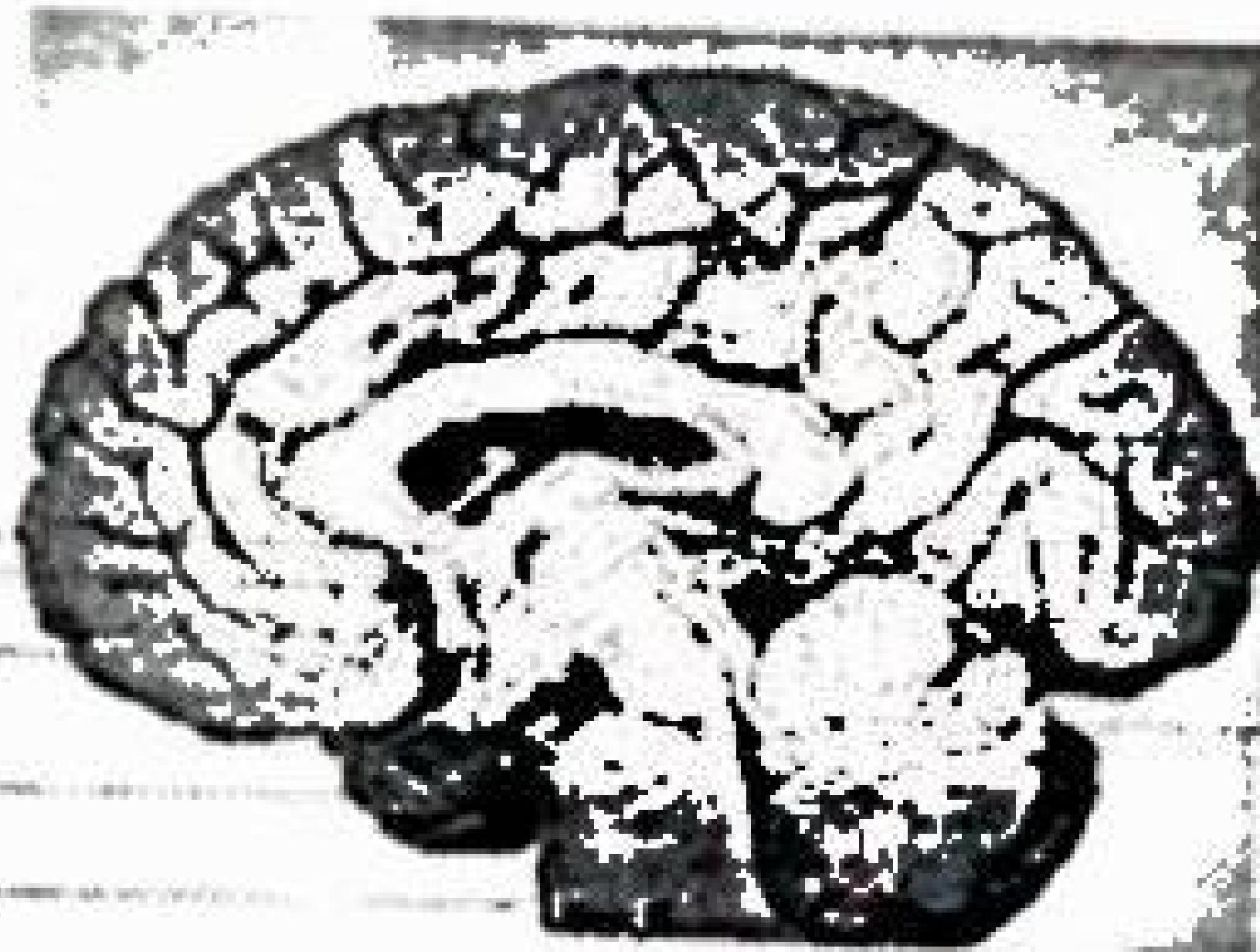
# The Central Nervous System

- The CNS develops from a flat of tissue, the neural plate located on the upper surface of the early embryo, as a result of the influence from the underlying notochord
- The lateral sides of the neural plate are elevated to form the neural folds
- The neural folds then move towards each other in the midline to form the neural tube
- The cephalic portion of the neural tube becomes the brain, while the caudal region forms the spinal cord
- The part of the neural tube that becomes the brain forms pouches; the pouch walls become the various portions of the adult brain and the cavities become fluid-filled ventricles
- The ventricles are continuous with the central canal of the spinal cord

- Three brain regions can be identified in the early embryo: forebrain or prosencephalon, midbrain or mesencephalon and hindbrain or rhombencephalon
- During development, the forebrain divides into the telencephalon (which becomes the cerebrum) and the diencephalon
- The midbrain remains undivided
- The hindbrain divides into the metencephalon (pons and cerebellum) and the myelencephalon which becomes the medulla oblongata
- The major regions of the adult brain are the cerebrum, diencephalon (thalamus and hypothalamus), midbrain , pons, cerebellum and medulla oblongata
- **Brainstem-** The medulla oblongata, pons and midbrain constitute the brainstem
- The brainstem connects the spinal cord to the remainder of the brain, damage to the brainstem often results in death because reflexes essential for survival are integrated in the brainstem
- The **medulla oblongata**, often called the medulla is the most inferior part of the brainstem and is continuous with the spinal cord

- Discrete nuclei, clusters of gray matter composed mostly of cell bodies are found in the medulla oblongata
- These nuclei have specific functions such as regulation of heart rate and blood vessel diameter, breathing, swallowing, vomiting, coughing, sneezing, balance and coordination
- On the anterior surface are two prominent enlargements called pyramids
- The pyramids consists of descending nerve tracts involved in the conscious control of skeletal muscles
- **Pons:** This is the part of the brainstem just superior to the medulla oblongata
- It contains ascending and descending nerve tracts and several nuclei
- The pontine nuclei, located in the anterior portion of the pons, relay information from the cerebrum to the cerebellum
- The nuclei of cranial nerves V (trigeminal), VI( abducens), VII (facial), VIII( vestibulocochlear) and IX(glossopharyngeal) are contained within the posterior pons





1.1.4. Superior view of the Right Half of the Brain  
Anatomical Drawing

- Other important pontine areas include the pontine sleep centre and respiratory centres
- These centres function with respiratory centres in the medulla oblongata to control respiratory movements.
- **Midbrain**
- The midbrain is the smallest region of the brainstem and contains the nuclei of cranial nerves III (oculomotor) , IV (trochlear) V (trigeminal)
- The roof (tectum) of the midbrain consists of four nuclei that form mounds on the dorsal surface , collectively called corpora quadrigemina
- Each mound is called colliculus (hill), the two superior mounds are called superior colliculi and the two inferior mounds are the inferior colliculi; they are involved in hearing and are integral part of the auditory pathways to the CNS
- The superior colliculi are involved in visual reflexes; they receive input from the eyes, inferior colliculi, the skin and the cerebrum

- Within the midbrain is the substantia nigra, containing cytoplasmic melanin granules that give it a dark gray or black colour
- The substantia nigra is interconnected with other basal nuclei of the cerebrum

## **Diencephalon**

- The diencephalon is the part of the brain between the brainstem and the cerebrum
- The components of the diencephalon are: thalamus, subthalamus, hypothalamus and epithalamus

- The thalamus is by far the largest part of the diencephalon; the two thalami are separated by the 3<sup>rd</sup> ventricle of the brain
- The thalamus influences mood and general body movements associated with emotions such as fear or rage
- **Subthalamus:** This is a small area inferior to the thalamus; it contains several nerve tracts and the subthalamic nuclei
- The subthalamic nuclei are involved in controlling motor functions

## **Epithalamus**

- This is a small area superior and posterior to the thalamus
- It consists of the habenular nuclei and the pineal body
- The habenular nuclei are influenced by the sense of smell and are involved in visceral responses to odours
- The pineal body plays a role in controlling the on-set of puberty; also involved in the sleep-wake cycle

## **Hypothalamus**

- This is the most inferior portion of the diencephalon and contains several small nuclei and nerve tracts
- A funnel-shaped stalk called the infundibulum extends from the floor of the hypothalamus and connects to the posterior pituitary (neurohypophysis)
- The hypothalamus plays an important role in controlling the endocrine system because it regulates the pituitary gland's secretion of hormones

- These hormones influence such diverse processes as metabolism, reproduction, responses to stressful stimuli and urine production
- The hypothalamus is very important in a number of functions, all of which have emotional and mood relationships: these include temperature regulation, regulation of food and water intake, autonomic functions, regulation of sleep and wake cycle etc

- **The Cerebrum**
- It is the largest portion of the brain, weighing about 1200 g in females and 1400 g in males
- The cerebrum is divided into the right and left hemispheres by a longitudinal fissure
- The most conspicuous features on the surface of each hemisphere are folds called gyri; these increase the surface area of the cortex

- The intervening grooves between the gyri are called sulci
- A central sulcus, which runs in the lateral surface of the cerebrum from superior to inferior is located midway along the length of the brain
- The central sulcus is located between the precentral sulcus and postcentral sulcus

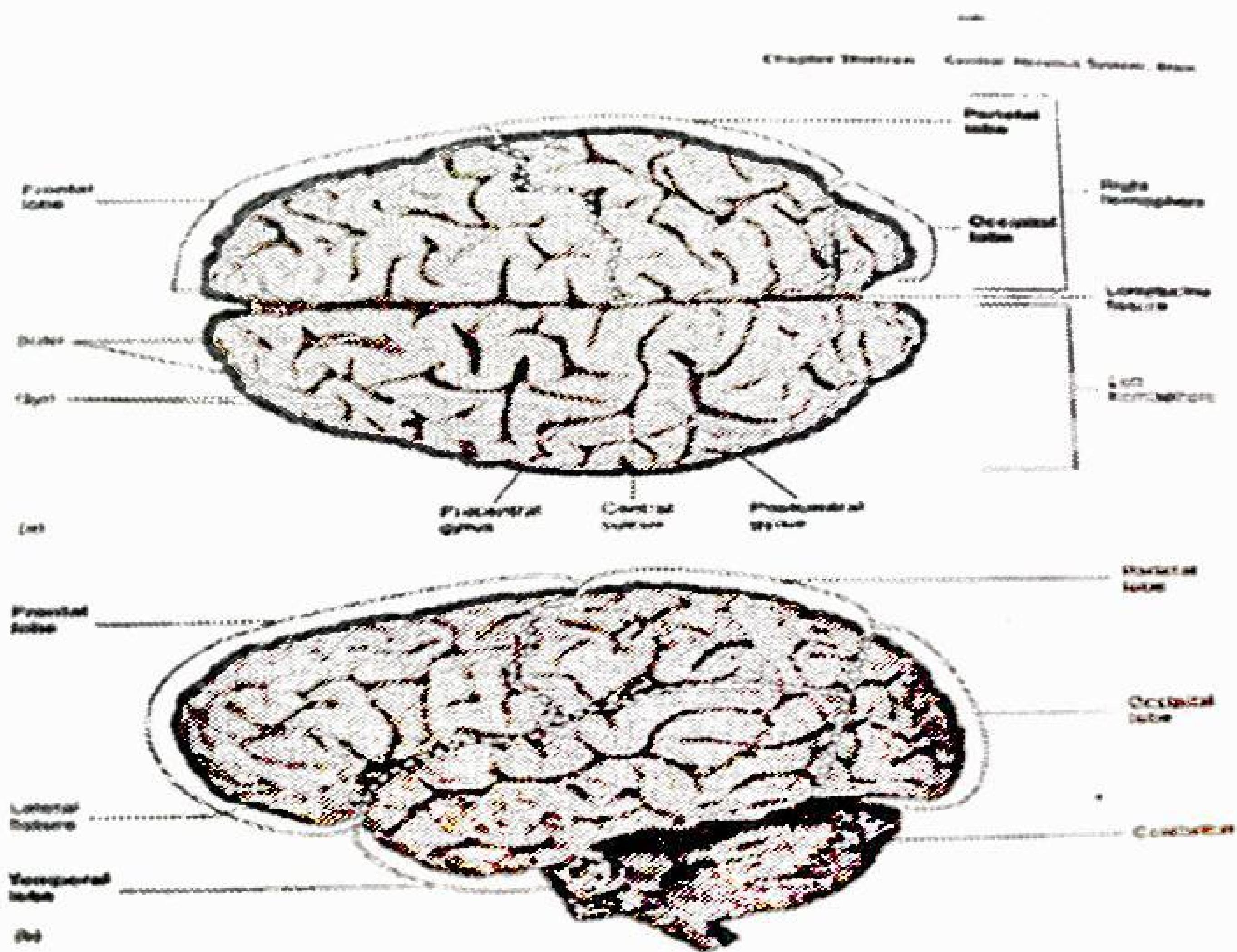


Figure 13.18 The Brain  
A Superior view and Lateral view of the left cerebral hemisphere.

- Each cerebral hemisphere is divided into lobes;
- The **frontal** lobe is responsible for voluntary motor functions, motivation , sense of smell, aggression, and mood
- The **parietal** lobe is the centre for reception and evaluation of sensory information except smell, hearing and vision

- The frontal and parietal lobes are separated by the central sulcus
- The **occipital** lobe functions in the reception and integration of visual input; not distinctly separated from the other lobes
- The **temporal** lobe receives and evaluates inputs for smell and hearing; also plays an important role in memory

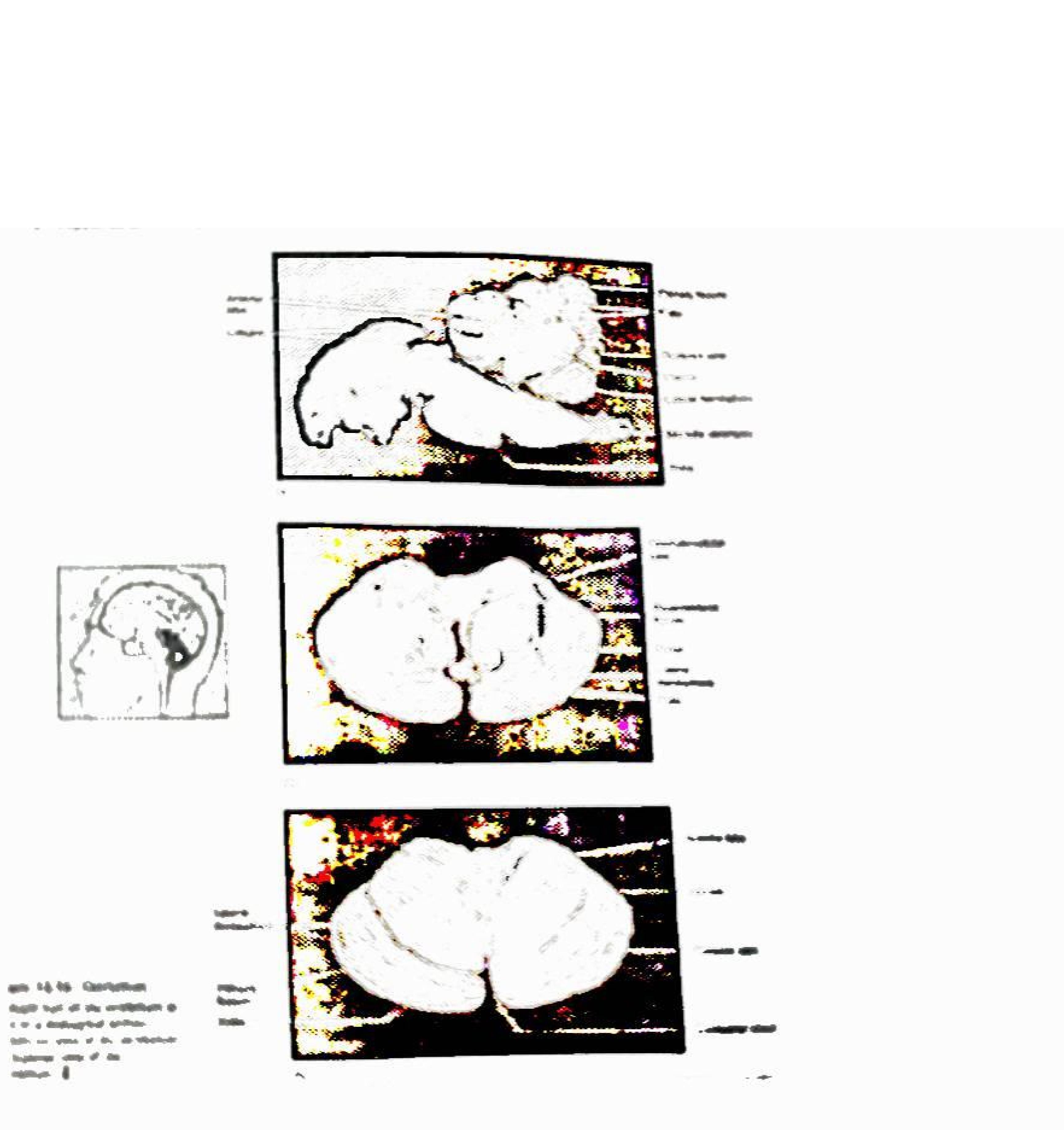
- The temporal lobe is separated from the rest of the cerebrum by a lateral fissure; deep within the fissure is the insula, often referred to as the fifth lobe
- The gray matter, located on the outer surface of the cerebrum is the cortex; clusters of gray matter deep inside the brain are called nuclei

- These tracts fall into three main categories:
- 1. Association fibres, which connect areas of the cerebral cortex within the same hemisphere
- The white matter of the brain between the cortex and nuclei is the cerebral medulla
- The cerebral medulla consists of nerve tracts that connect the cerebral cortex to other parts of the CNS

- 2. Commissural fibres, which connect one cerebral hemisphere to the other
- 3. Projection fibres, which are between the cerebrum and other parts of the brain and spinal cord

## **Cerebellum:** Known as the little brain

- It communicates with other regions of the CNS through three large nerve tracts: the superior, middle and inferior cerebellar peduncles
- The cerebellum consists of three parts: a small anterior part called flocculonodular lobe; a narrow central vermis, and two large lateral hemispheres
- Flocculonodular lobe is involved in balance and maintaining muscle tone



- The anterior part of the vermis is involved in motor coordination and muscle tone; the posterior vermis and lateral hemispheres are involved in motor coordination, producing smooth flowing movements
- **The spinal cord**
- The spinal cord is the communication link between the brain and the peripheral nervous system
- It extends from foramen magnum to the level of the second lumbar vertebra

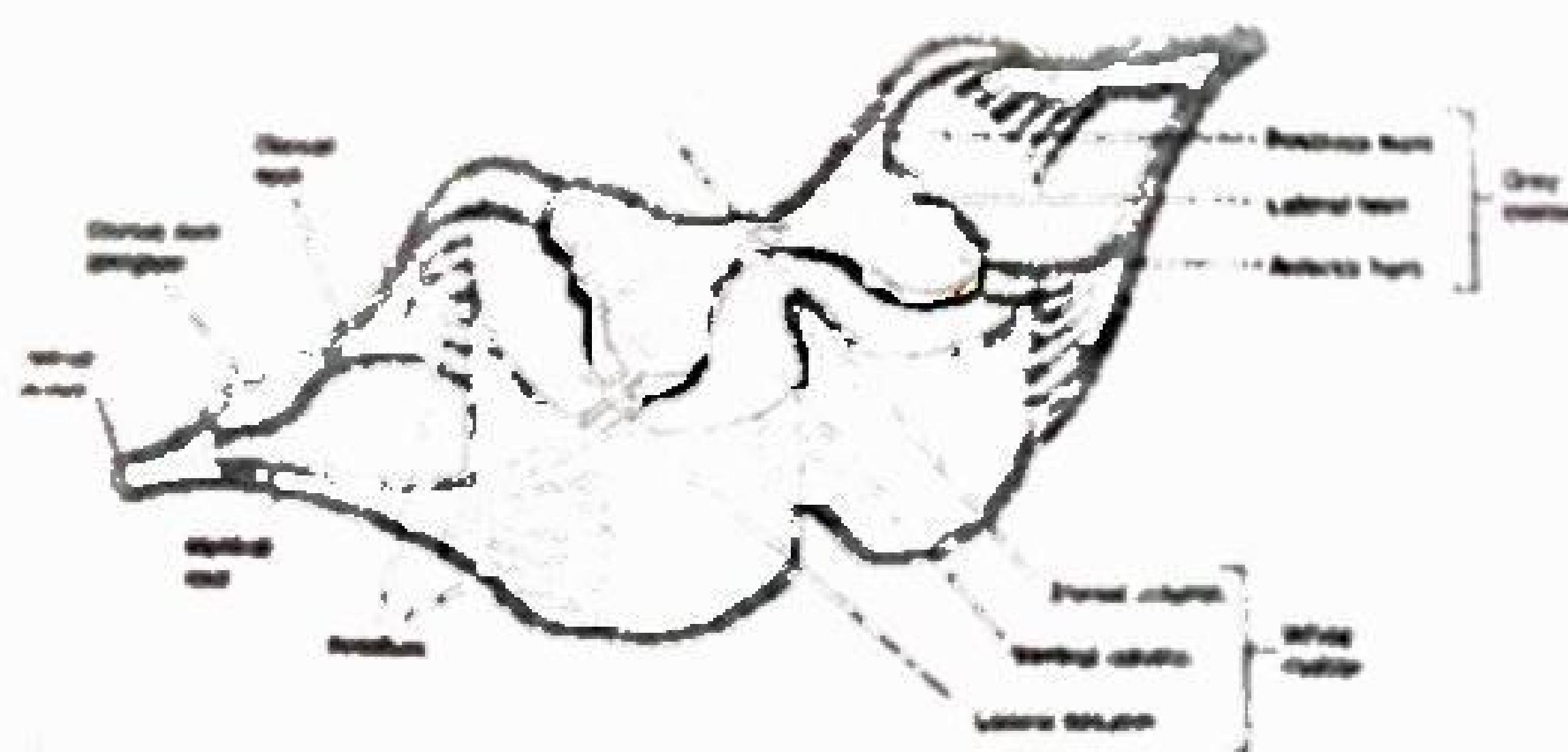
- It is composed of cervical, thoracic, lumbar and sacral segments, which are named according to the area of the vertebral column from which their nerves enter and exit
- There are thirty one pairs of spinal nerves that exit the vertebral column through intervertebral foramina
- The spinal cord is shorter than the vertebral column and so the nerves do not always exit the vertebral column at the same level as the spinal cord
- The spinal cord is not of uniform diameter throughout its length; there is a general decrease in diameter superiorly to inferiorly

- There are two enlargements where nerves supplying the extremities enter and leave the cord
- The cervical enlargement, in the lower cervical region corresponds to the location where nerves that supply the upper limbs enter or exit the cord
- The lumbar enlargement, in the inferior thoracic and superior lumbar regions is the site where the nerves supplying the lower limb enter and exit the cord

- **Cross section**
- A cross section of the spinal cord shows that it consists of a central gray matter and a peripheral white matter
- The white matter consists of nerve tracts, while the gray matter consists of cell bodies and dendrites
- The anterior (ventral) median fissure and posterior (dorsal) median sulcus are deep clefts which partially separate the cord into two halves

- The gray matter is organized into horns; each half of the gray matter consists of posterior (dorsal) horn and larger anterior (ventral) horn
- The two halves of the spinal cord are connected by the gray and white commissures; the central canal is in the centre of the gray commissure
- Dorsal (posterior) and ventral (anterior) roots exit the spinal cord near the dorsal and ventral horns respectively

- The dorsal root carries afferent action potentials to the spinal cord and the ventral root carries efferent action potentials away from the cord
- The dorsal root ganglia contains the cell bodies of sensory neurons
- The ventral root is formed by the axons of neurons in the anterior and lateral horns
- The dorsal and ventral roots unite to form the spinal nerves



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- **Meninges**
- The brain and spinal cord are surrounded by three connective tissue layers that protect them. These connective tissue layers are called meninges
- The most superficial and thickest is the **dura mater**
- Folds of dura mater extend into the longitudinal fissure between the two cerebral hemispheres and between the cerebrum and cerebellum

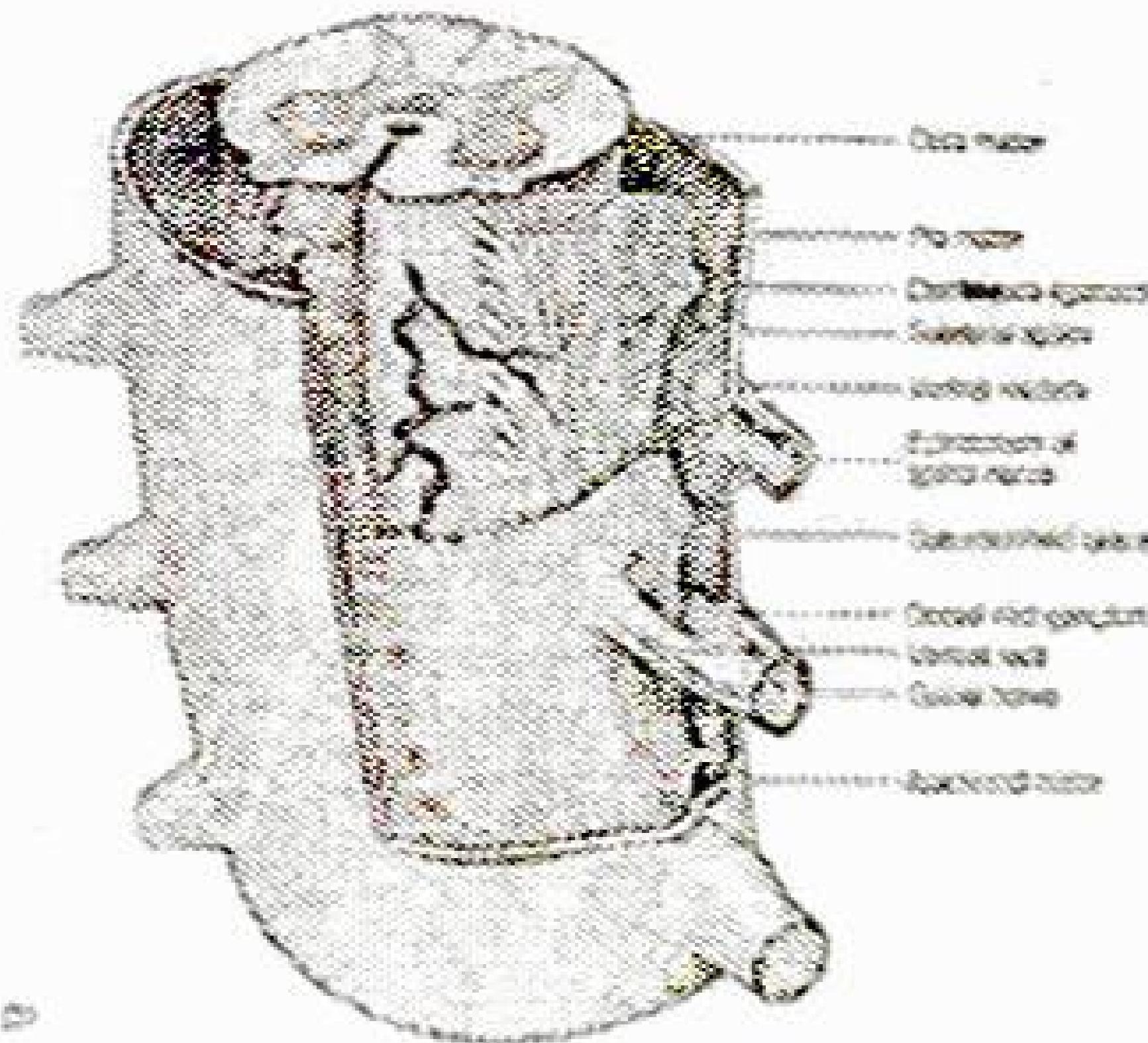
- Within these, dura mater contains spaces called dural sinuses; these collect blood from small veins of the brain
- The dura mater and dural folds hold the brain in place within the skull
- The dural sinuses empty into the internal jugular veins which exit the skull
- The middle meningeal layer is a very thin **arachnoid mater**
- The space between the dura mater and arachnoid mater is the subdural space

- The third meningeal layer is the **pia mater**; this is tightly bound to the surface of the brain and spinal cord
- Between the arachnoid and pia mater is the subarachnoid space, filled with cerebrospinal fluid
- **Ventricles**
- The central nervous system is a hollow tube, lined with a single layer of epithelial cells called ependymal cells
- The cavities of the brain are called the ventricles; there are four ventricles in the brain
- The first two ventricles form the lateral ventricles

**Interior and External surfaces**



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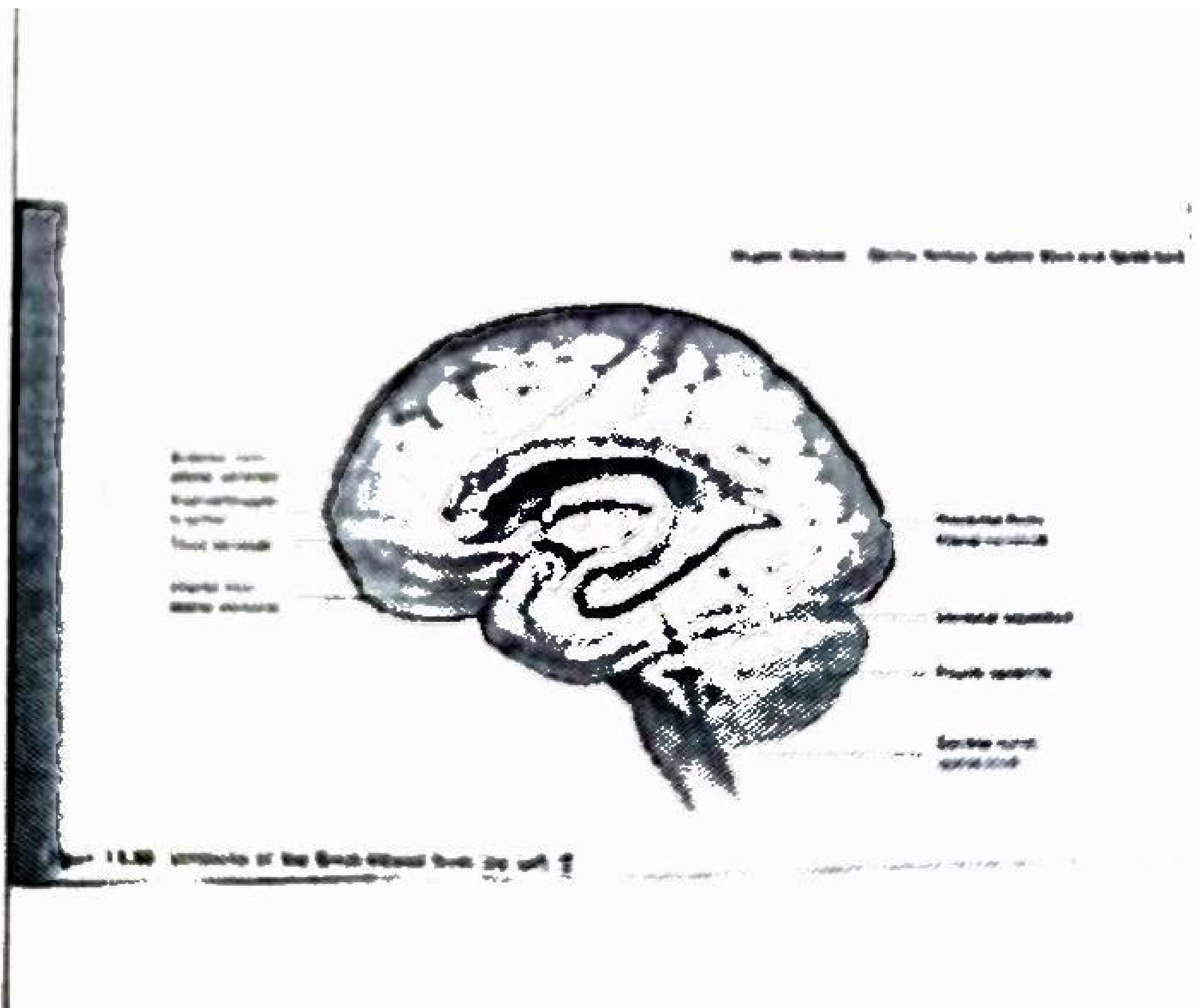


**13.29 Meninges**

General description of the body (3D biological anatomy of the skull)

- Each cerebral hemisphere contains a relatively large cavity called the lateral ventricle; the lateral ventricles are separated from each other by a thin septa pellucida
- The third ventricle is located in the centre of the diencephalon, between the two halves of the thalamus
- The two lateral ventricles communicate with the third ventricle through two interventricular foramina
- The fourth ventricle is in the superior region of the medulla oblongata at the base of the cerebellum

- The third ventricle communicates with the fourth ventricle through a narrow canal called the cerebral aqueduct (aqueduct of Sylvius) which passes through the midbrain
- The fourth ventricle is continuous with the central canal of the spinal cord



- **Peripheral Nervous System**
- The peripheral nervous system (PNS) collects information from both inside and outside the body and relay it by way of afferent fibres to the CNS
- Efferent fibres in the PNS relay information from the CNS to various parts of the body, primarily to muscles and glands
- Without the PNS the CNS would receive no sensory information and could produce no observable responses

- The PNS can be divided into two parts: a cranial part consisting of 12 pairs and spinal part made up of 31 pairs of nerves
- By convention the cranial nerves are indicated by Roman numerals (I-XII) from anterior to posterior; has three general categories of functions

- 1. sensory 2. somatic motor 3. parasympathetic
- **Sensory** functions include the special senses such as vision and the more general senses such as pain and touch
- **Somatic** motor functions refer to the control of skeletal muscles through motor neurons
- **Parasympathetic** function involves the regulation of glands, smooth muscles and cardiac muscles; these functions are part of the autonomic nervous system
- A particular cranial nerve may have one or more of the three functions
- The olfactory (I) and optic (II) nerves are exclusively sensory and are involved in smell and vision respectively
- The trochlear nerve (IV) is a somatic nerve that innervates one of the six eye muscles that move the eyeball

- The trigeminal (V) nerve has somatic, proprioceptive and cutaneous sensory functions; it supplies motor nerve to muscles for mastication, one middle ear muscle, one palatine muscle and two throat muscle