

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

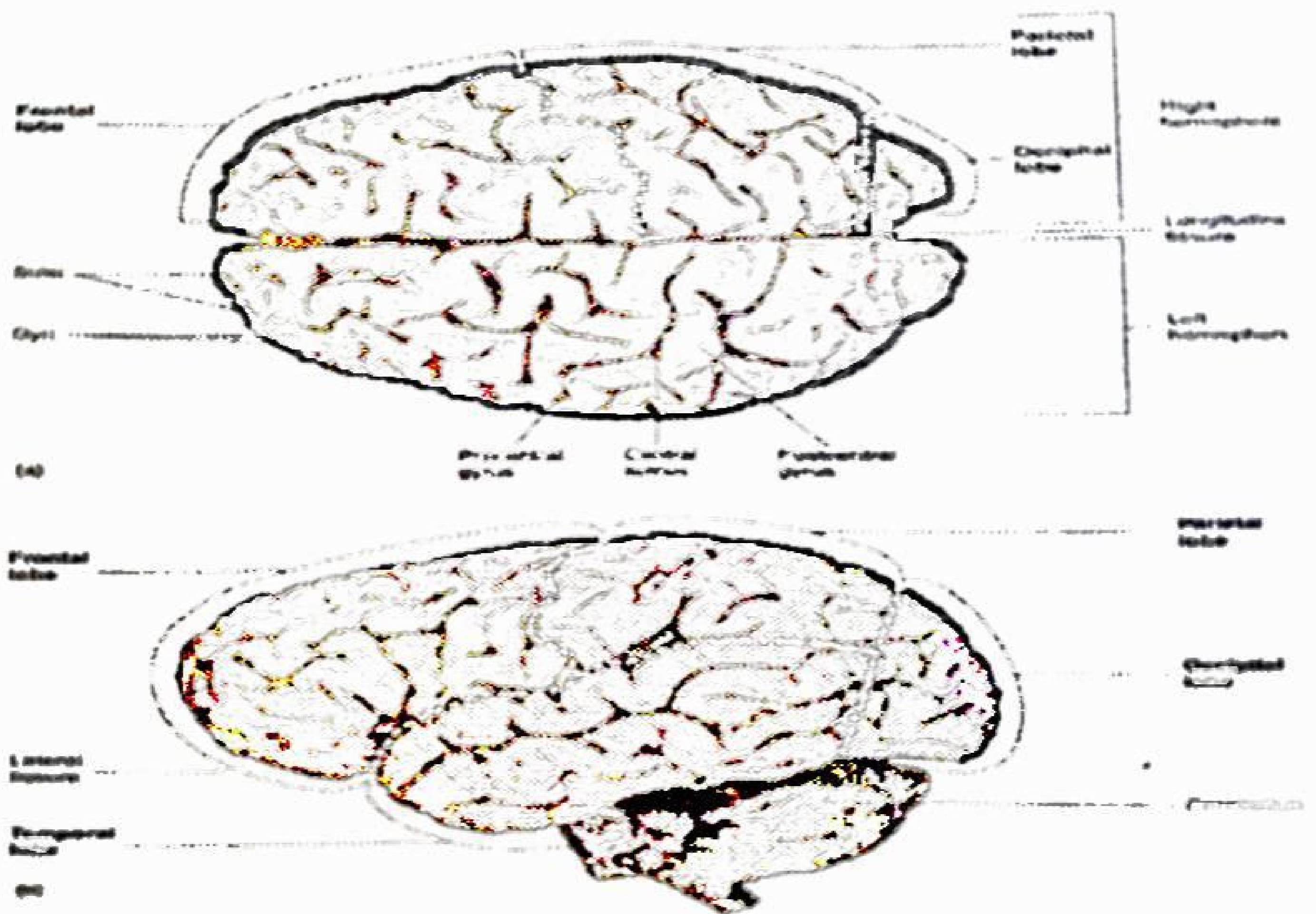


Figure 1.1.10 The Brain
 (a) Superior view (b) Lateral view of the left cerebral hemisphere

Figure 1.1.4: Medial view of the right hemisphere of the brain (superior view)

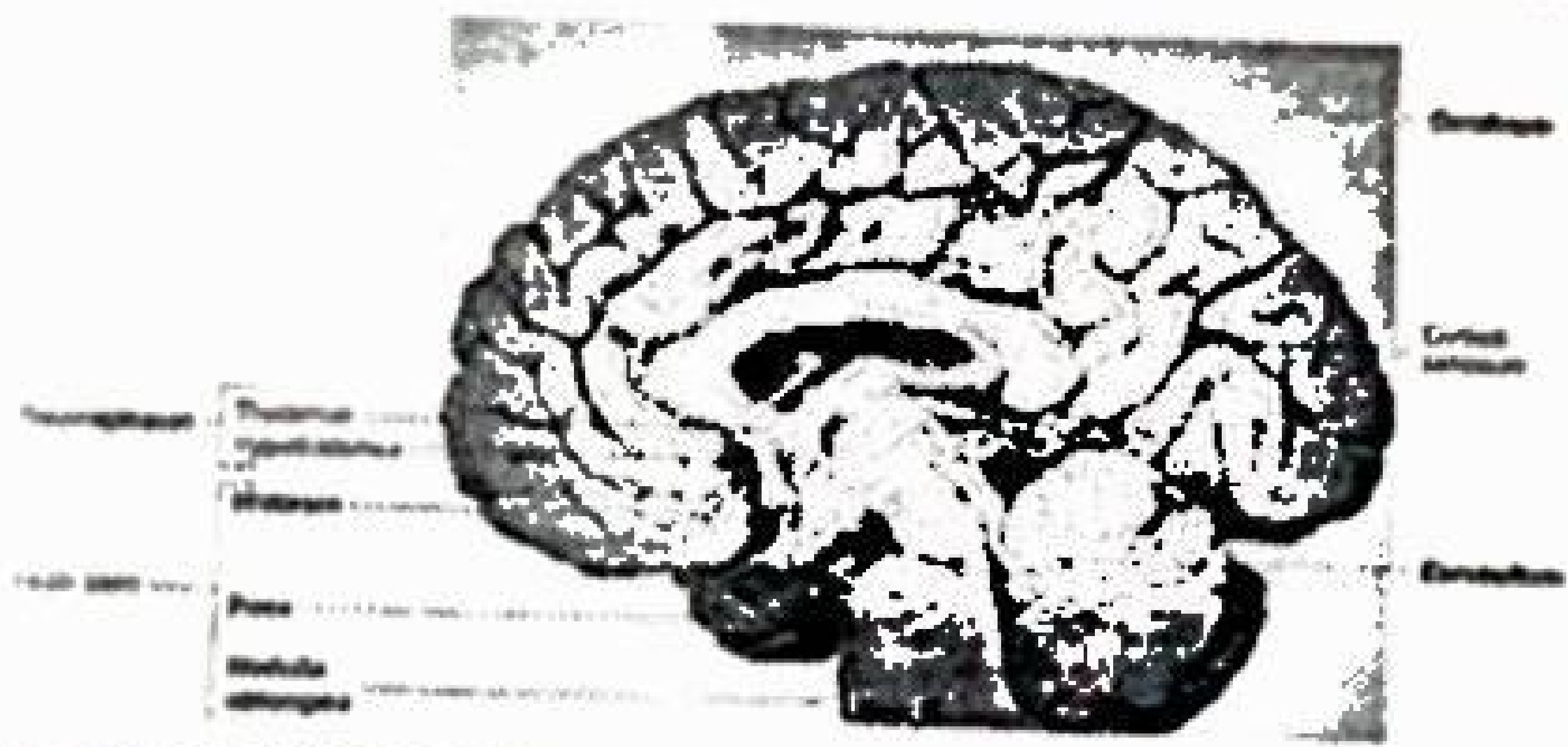


Figure 1.1.4: Medial view of the right hemisphere of the brain (superior view)

- 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 3rd 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 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

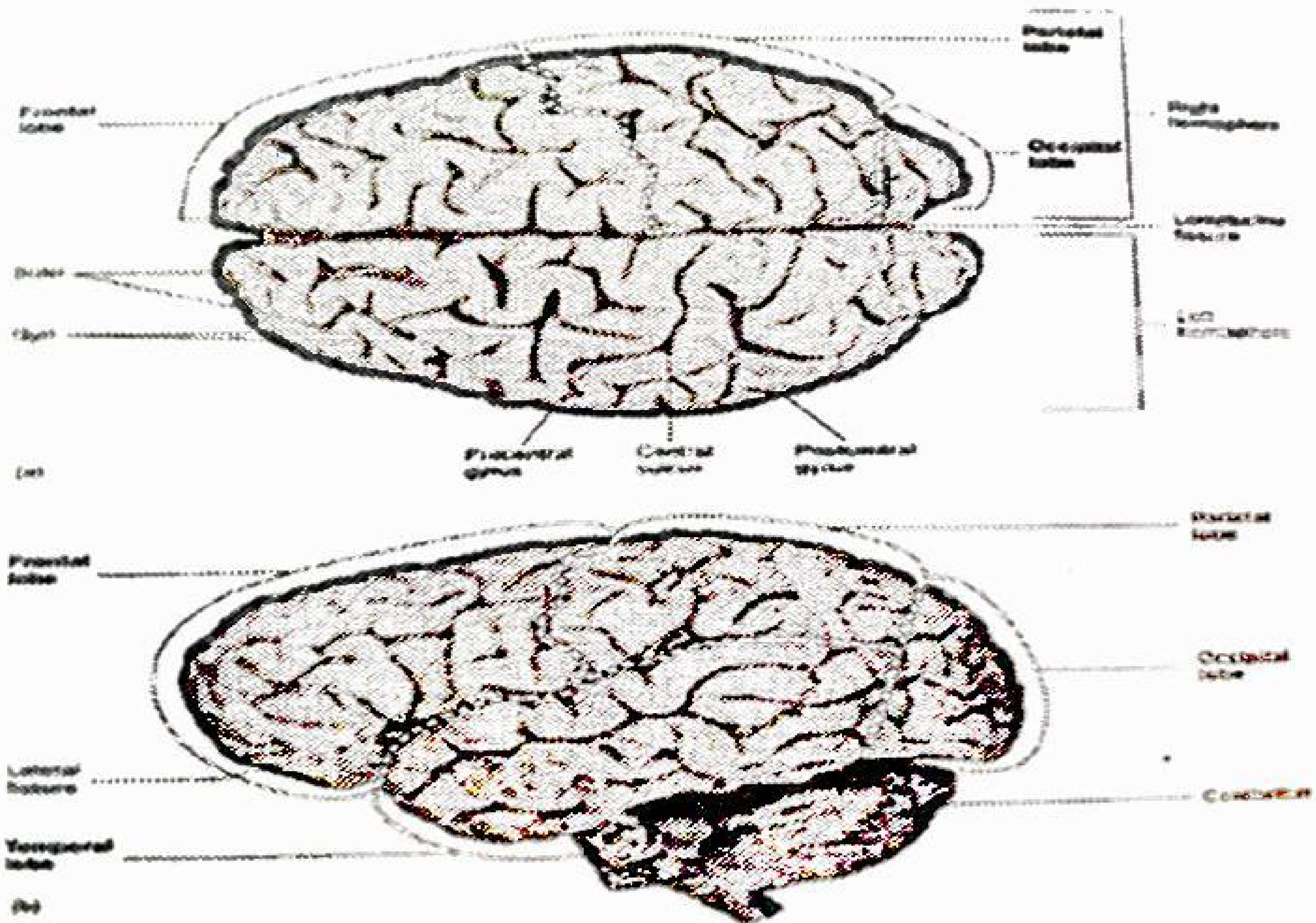


Figure 11.8 The Brain
 (a) Superior view (b) Lateral view of the left cerebral hemisphere. 3

- 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

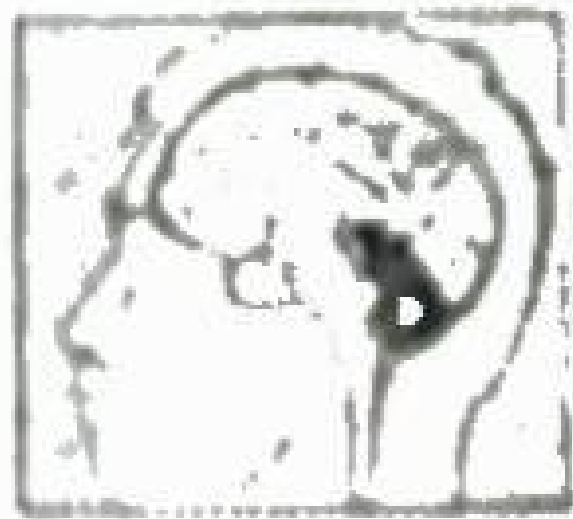
- The temporal lobe is separated from the rest of the cerebrum by a lateral fissure; deep within the fissure is the insula, often referred to as the fifth lobe
- The gray matter, located on the outer surface of the cerebrum is the cortex; clusters of gray matter deep inside the brain are called nuclei

- 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



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 Right half of the section is
 1 to a histological section.
 Left is view of the section.
 Superior view of the
 section.

- 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

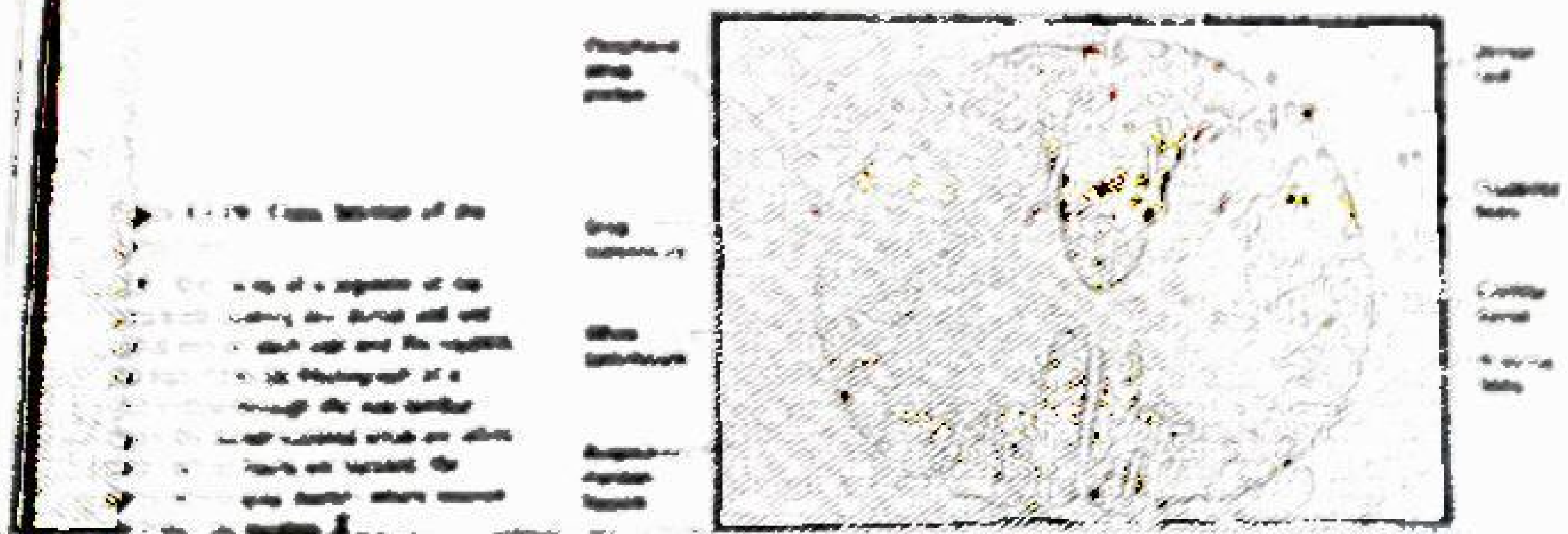
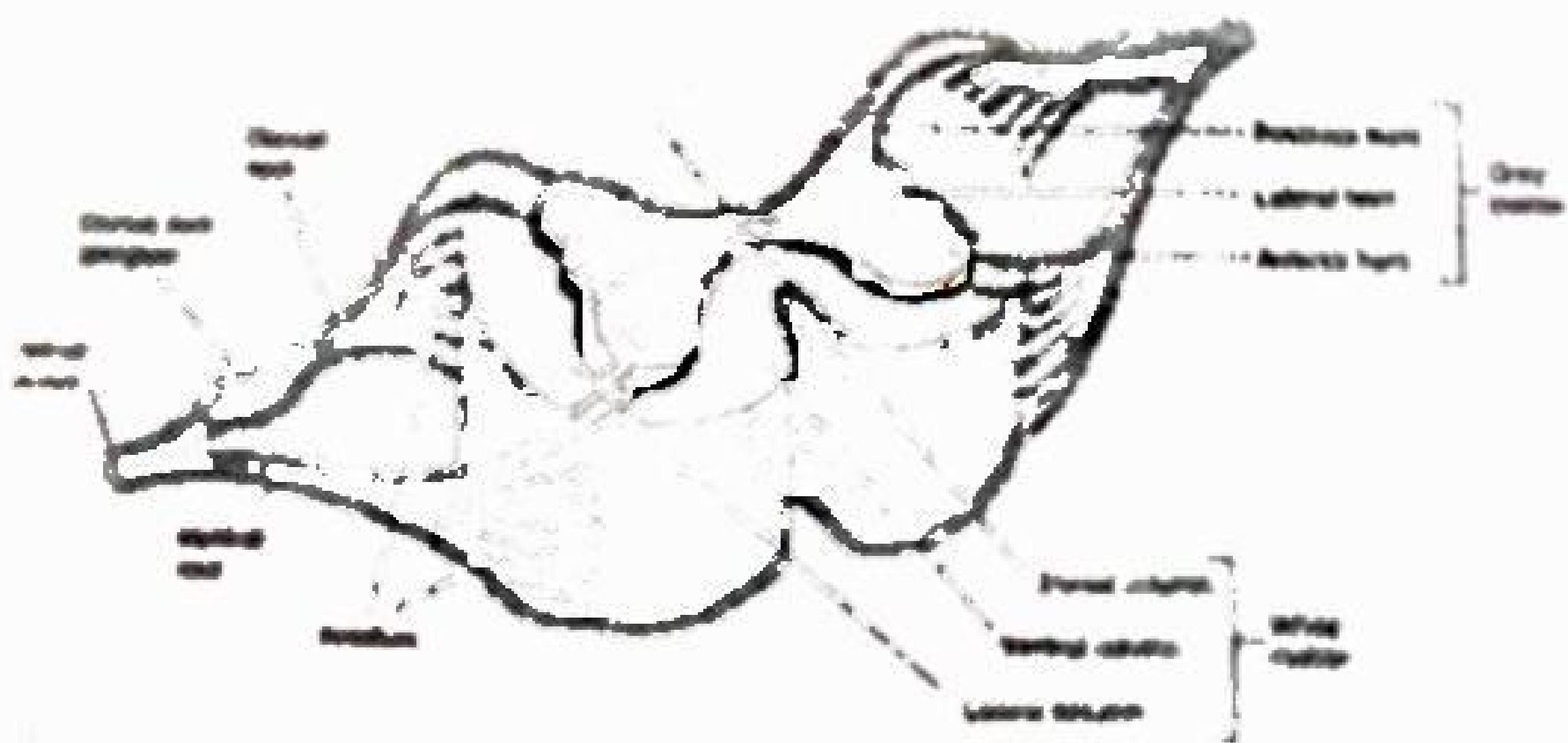
- There are two enlargements where nerves supplying the extremities enter and leave the cord
- The cervical enlargement, in the lower cervical region corresponds to the location where nerves that supply the upper limbs enter or exit the cord
- The lumbar enlargement, in the inferior thoracic and superior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

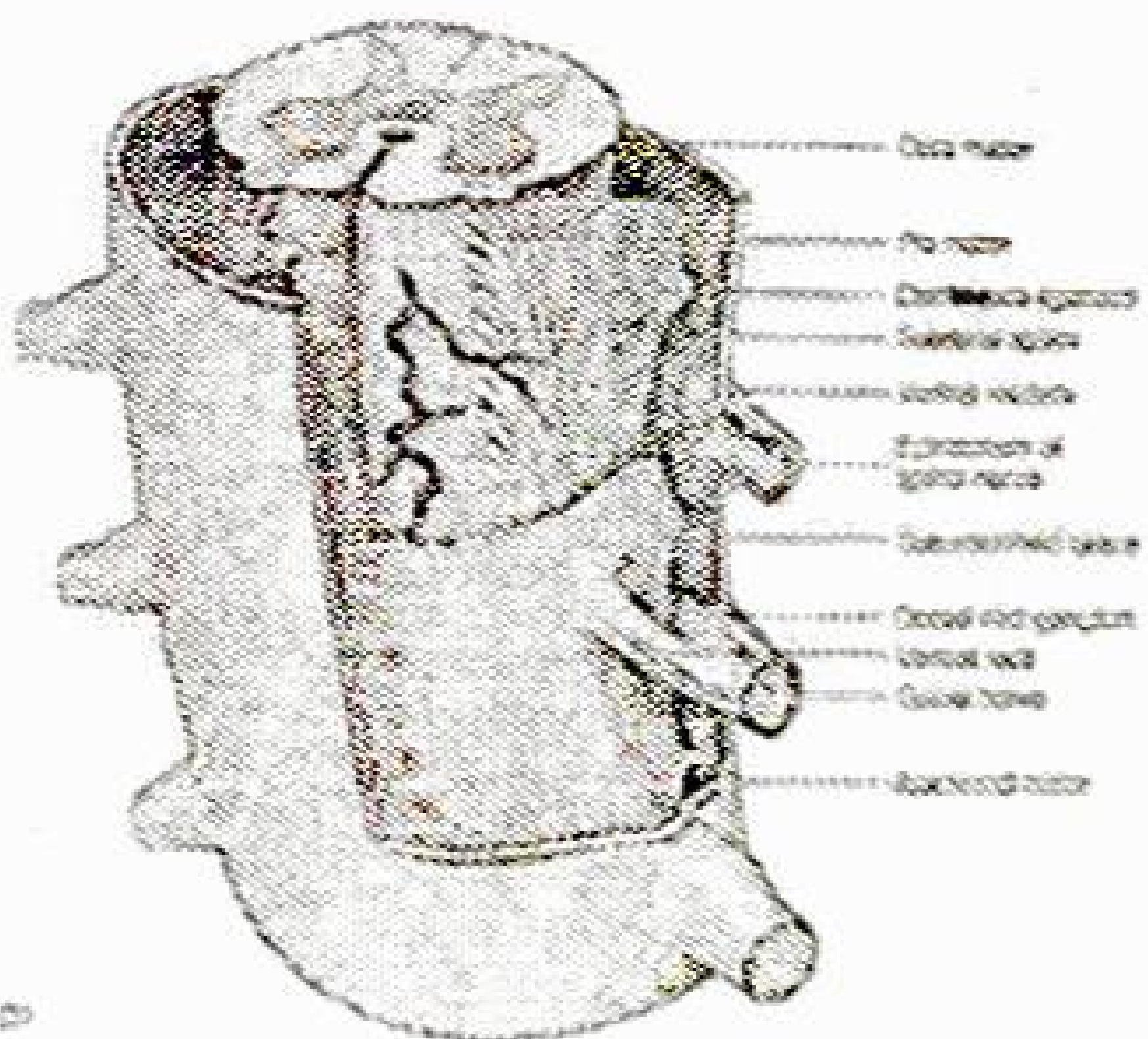
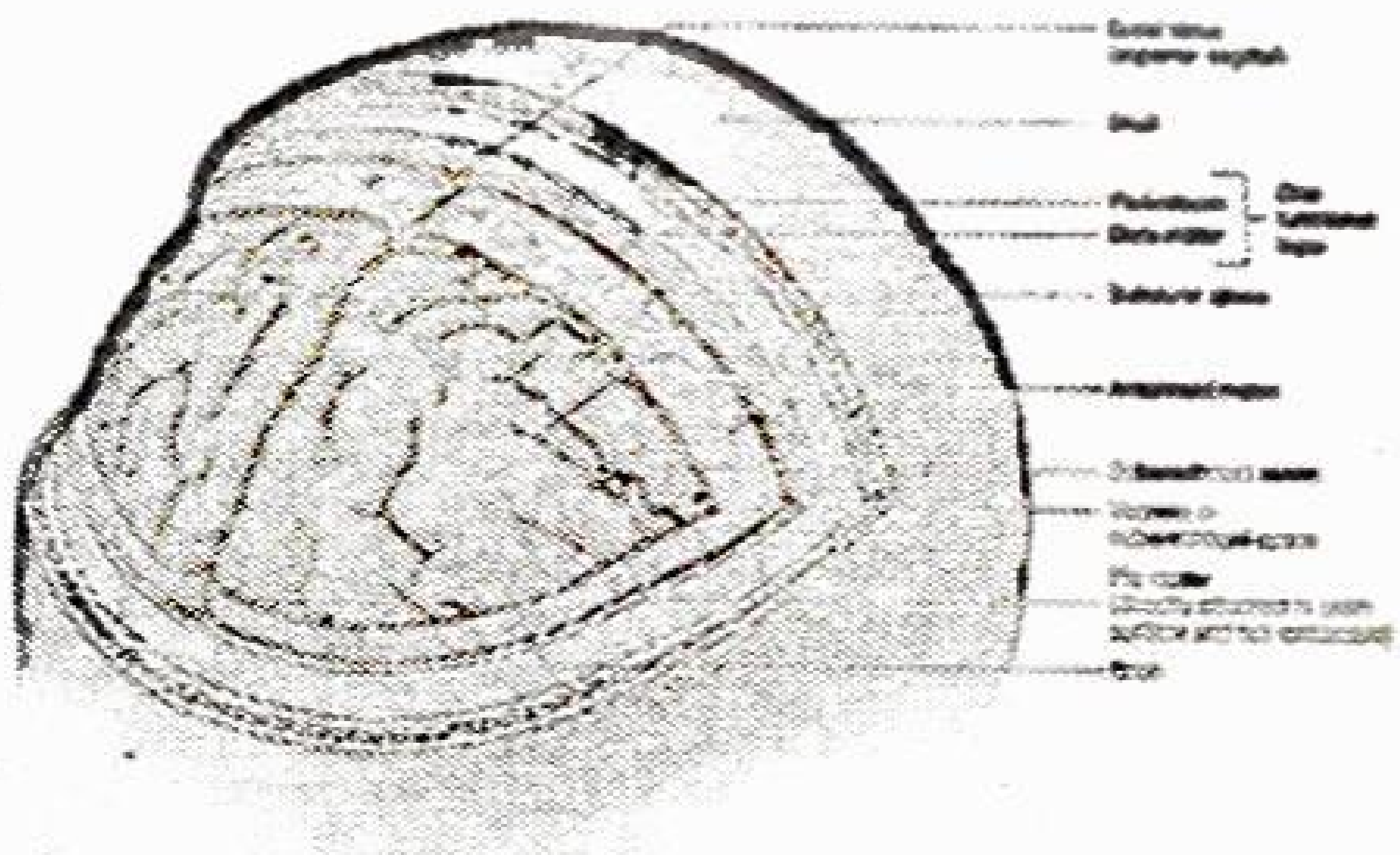
- The dorsal root carries afferent action potentials to the spinal cord and the ventral root carries efferent action potentials away from the cord
- The dorsal root ganglia contains the cell bodies of sensory neurons
- The ventral root is formed by the axons of neurons in the anterior and lateral horns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



- **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

**ILR** *Insights*

Signal strength of the tests: (a) Moderate strength of the construct.

- 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

Diagram of the Brain (Sagittal Section) showing the internal structures of the brain.

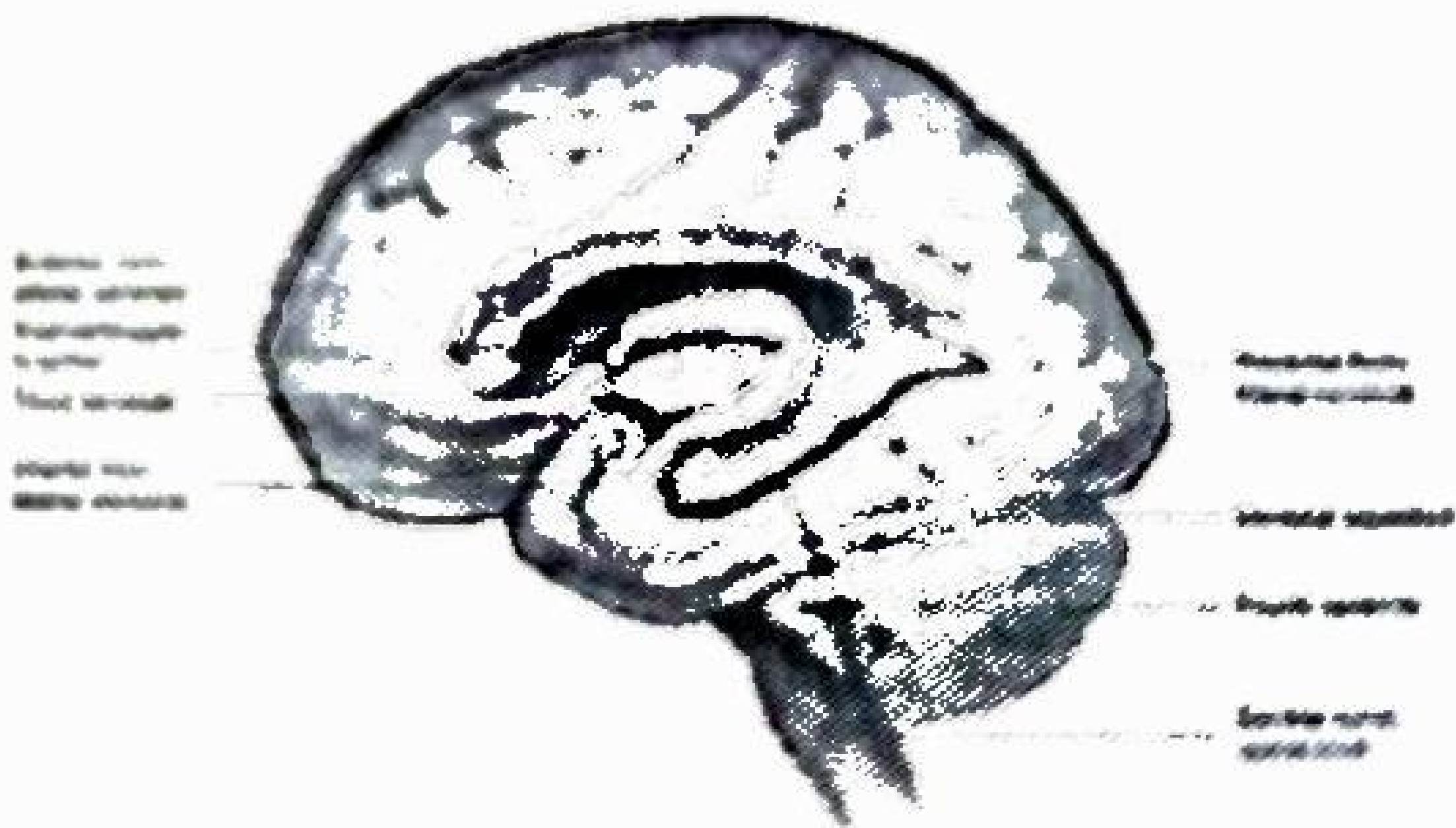


FIG. 1.1. Sagittal section of the brain showing the internal structures of the brain.

- **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 not 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