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The University of Texas
Graduate School *of* Biomedical Sciences
at Houston

Graduate Neuroanatomy

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Laboratory Guide

**Offered and Coordinated by the Department of Neurobiology and Anatomy
The University of Texas Health Science Center at Houston. This course guide was
adapted from the Medical Neuroscience Laboratory Guide. Nachum Dafny, Ph.D.,
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Overview of the Nervous System

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The human nervous system is divided into the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS, in turn, is divided into the brain and the spinal cord, which lie in the cranial cavity of the skull and the vertebral canal, respectively. The CNS and the PNS, acting in concert, integrate sensory information and control motor and cognitive functions.

The Central Nervous System (CNS)

The adult human brain weighs between 1200 to 1500g and contains about one trillion cells. It occupies a volume of about 1400cc - approximately 2% of the total body weight, and receives 20% of the blood, oxygen, and calories supplied to the body. The adult spinal cord is approximately 40 to 50cm long and occupies about 150cc. The brain and the spinal cord arise in early development from the neural tube, which expands in the front of the embryo to form the main three primary brain divisions: the prosencephalon (forebrain), mesencephalon (midbrain), and rhombencephalon (hindbrain) (Figure 1A). These three vesicles further differentiate into five subdivisions: telencephalon, diencephalon, mesencephalon, metencephalon, and the myelencephalon (Figure 1B). The mesencephalon, metencephalon, and the myelencephalon comprise the brain stem.

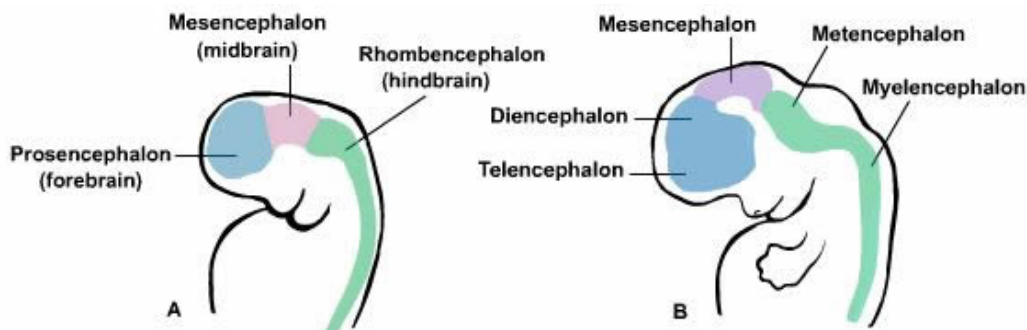


Figure 1. (Click to enlarge) Schematic lateral view drawing of human embryo at the beginning of the 3rd (A) and 5th (B) week of gestation.

Telencephalon

The telencephalon includes the cerebral cortex (cortex is the outer layer of the brain) which represents the highest level of neuronal organization and function (Figures 2A and 2B). The cerebral cortex consists of various types of cortices (such as the olfactory bulbs, Figure 1.2B) as well as closely related subcortical structures such as the caudate nucleus, putamen, globus, amygdala and the hippocampal formation (Figure 2C).

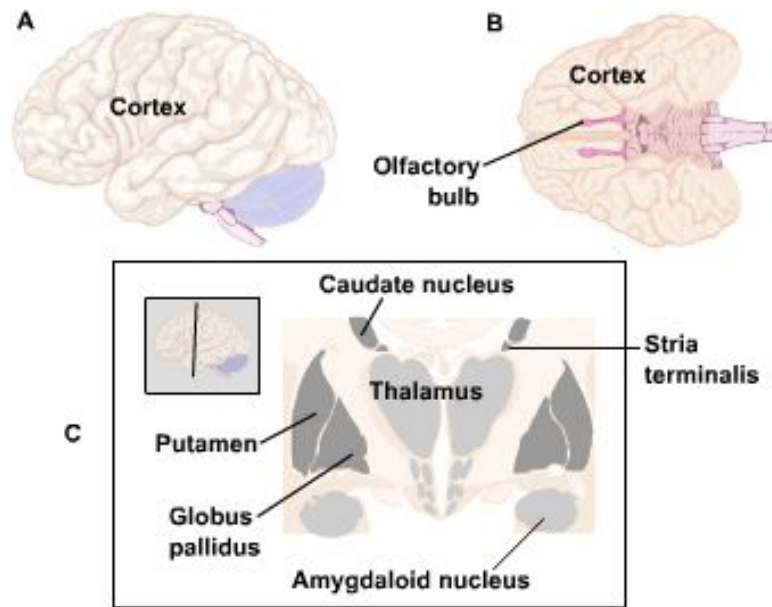


Figure 2. (Click to enlarge) Lateral (A) and ventral (B) schematic drawing of the cerebral cortex. In C, drawing of subcortical structures.

Diencephalon

The diencephalon consists of a complex collection of nuclei lying symmetrically on either side of the midline. The diencephalon includes the thalamus, hypothalamus, epithalamus and subthalamus (Figure 3).

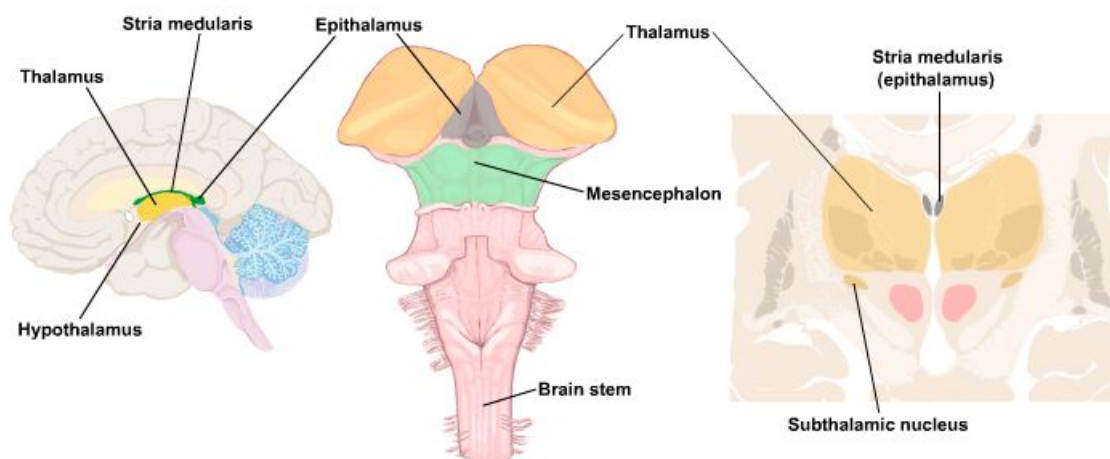


Figure 3. (Click to enlarge) Shows the main diencephalon nuclei.

Mesencephalon

The mesencephalon (or midbrain) consists of several structures around the cerebral aqueduct such as the periaqueductal gray (or central gray), the mesencephalic reticular formation, the substantia nigra, the red nucleus (Figure 4), the superior and inferior colliculi, the cerebral peduncles, some cranial nerve nuclei, and the projection of sensory and motor pathways.

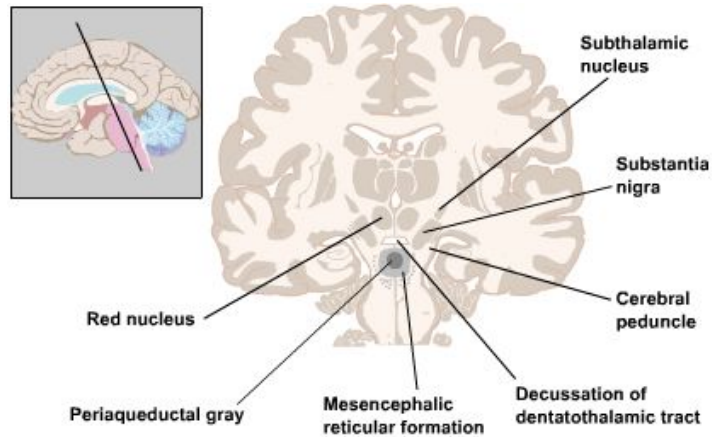


Figure 4. (Click to enlarge) Schematic drawing of subcortical diencephalic and mesencephalic structures.

Metencephalon

The metencephalon includes the pons and the cerebellum. The myelencephalon (spinal cord-like) includes the open and closed medulla, sensory and motor nuclei, projection of sensory and motor pathways, and some cranial nerve nuclei.

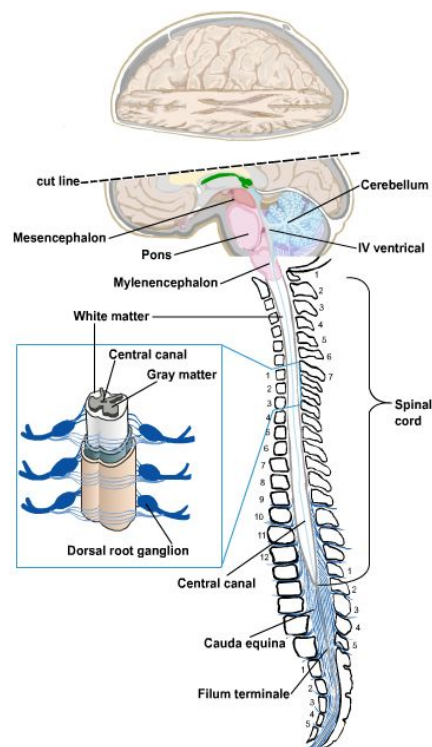


Figure 5. (Click to enlarge) Schematic lateral view of the metencephalon and a spinal cord section with ventral and dorsal root fibers, and dorsal root ganglions.

The caudal end of the myelencephalon develops into the spinal cord. The spinal cord is an elongated cylindrical structure lying within the vertebral canal, which includes the central canal and the surrounding gray matter. The gray matter is composed of neurons and their supporting cells and is enclosed by the white matter that is composed of a dense layer of ascending and descending nerve fibers. The spinal cord is an essential link between the peripheral nervous system and the brain; it

conveys sensory information originating from different external and internal sites via 31 pairs of spinal nerves (Figure 5). These nerves make synaptic connections in the spinal cord or in the medulla oblongata and ascend to subcortical nuclei.

The central nervous system, which includes the spinal cord and the brain, is the most protected organ in the human body. It is protected from the external environment by three barriers: skull, meninges, and CSF.

The meninges are composed by three fibrous connective tissues (Figure.6). The most external is a dense collagenous connective tissue envelope known as the dura mater (Latin for “hard mother”). The second, or the intermediated membrane, is a delicate non-vascular membrane of fine collagenous layer of reticular fibers forming a web-like membrane, known as the arachnoid (Greek for “spider”). It is separated from the inner pia layer by subarachnoid space, which is filled with cerebrospinal fluid. The inner most delicate connective tissue membrane of collagenous is the pia mater, a thin translucent elastic membrane adherent to the surface of the brain and the spinal cord. Blood vessels located on the surface of the brain and the spinal cord are found on top of the pia matter. The meninges are subject to viral and bacterial infection known as meningitis, a life-threatening condition that requires immediate medical treatment.

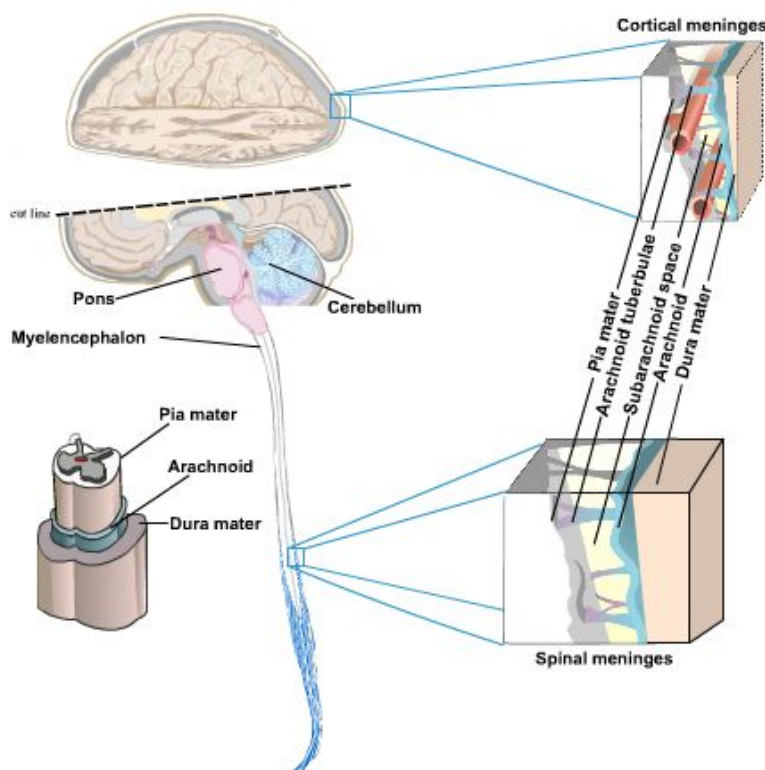


Figure 6. (Click to enlarge) Schematic drawing of the brain and spinal cord meninges.

The space between the skull and the dura is known as the epidural space. The space between the dura and the arachnoid is known as the subdural space. The space between the arachnoid and the pia is known as the subarachnoid space. In this space, there is a clear liquid known as the cerebrospinal fluid (CSF). The CSF serves to support the CNS, and to cushion as well as protect it from physical shocks and trauma. The CSF is produced by the choroid plexus which is composed of a specialized secretory ependymal layer located in the ventricular system.

The **ventricular system** is a derivative of the primitive embryonic neural canal. This system is an interconnected series of spaces within the brain containing the CSF (Figure 7).

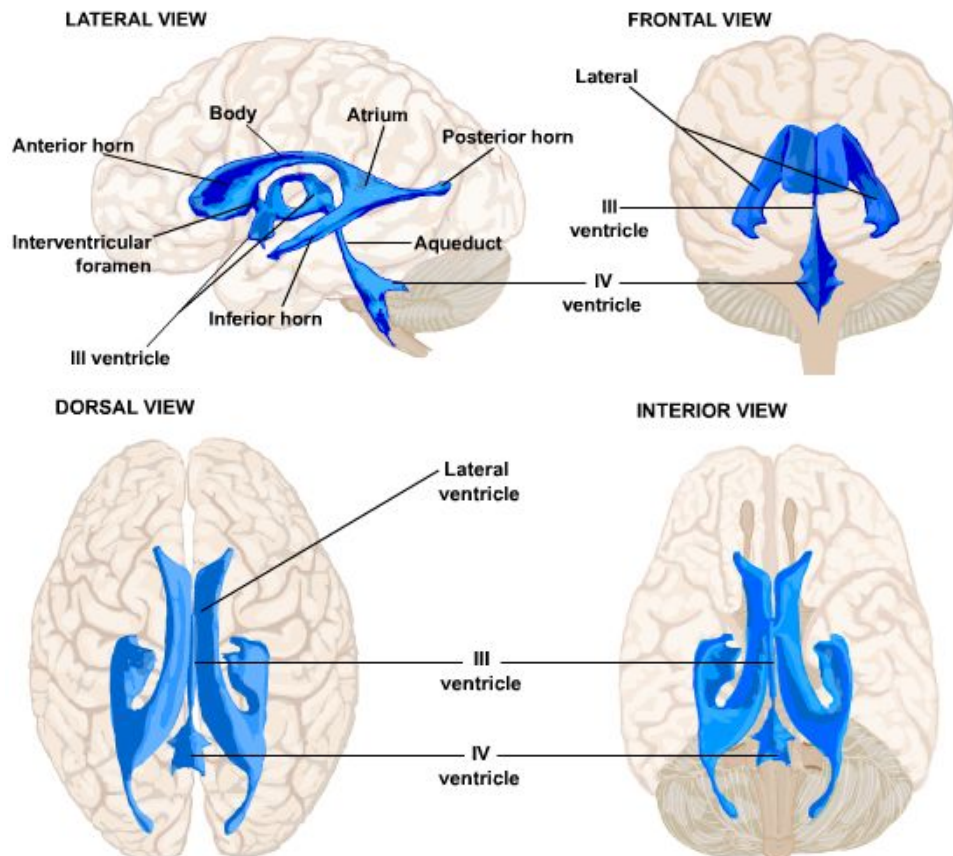


Figure 7. (Click to enlarge) Schematic drawing of ventricular system in four different angles.

In general, the CNS can be divided into three main functional components: the sensory system, the motor system, and homeostasis and higher brain functions. The sensory system consists of the somatosensory, viscerosensory, auditory, vestibular, olfactory, gustatory, and visual systems. The motor system consists of motor units, and the somatic (skeletal muscle) system, the spinal reflexes, the visceral (autonomic) system, the cerebellum, several subcortical and cortical sites, as well as the brain stem ocular motor control system. The homeostasis and higher functional system includes the hypothalamus, cortical areas involved in motivation, insight, personality, language, imagination, creativity, thinking, judgment, mental processing, and subcortical areas involved in learning, thought, consciousness, memory, attention, emotional state, sleep and arousal cycles.

The Cerebral Hemispheres

The telencephalon is the largest and most obvious parts of the human brain are the cerebral hemispheres. The cerebrum has an outer layer - the cortex, which is composed of neurons and their supporting cells, and in fresh brain, has a gray color thus called the gray matter. Under the gray matter there is the white matter, which is composed of myelinated ascending and descending nerve fibers, and in fresh brain have a white color. Embedded deep within the white matter are aggregation of neurons exhibiting gray color and known as subcortical nuclei. The cerebral hemispheres are partially separate from each other along the midline by the interhemispheric fissure (deep groove) the falx cerebri (Figure 8A); posteriorly, there is a transverse fissure that separates the cerebral hemisphere from the cerebellum, and contains the tentorium cerebellum. The hemispheres are connected by a large C-shaped fiber bundle, the corpus callosum, which carries information between the two hemispheres.

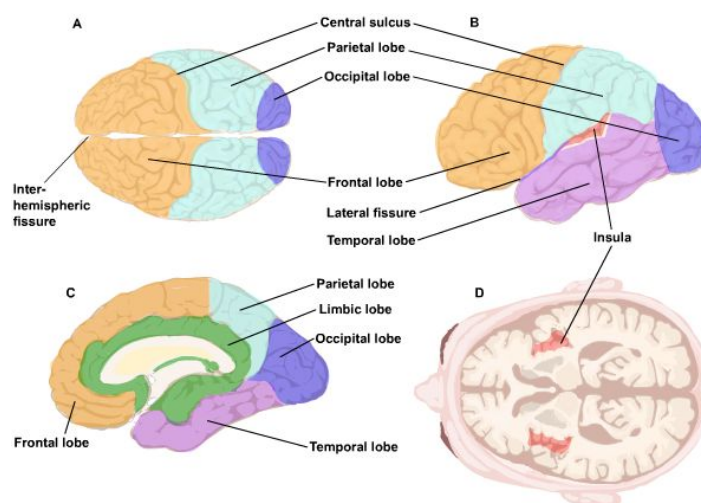
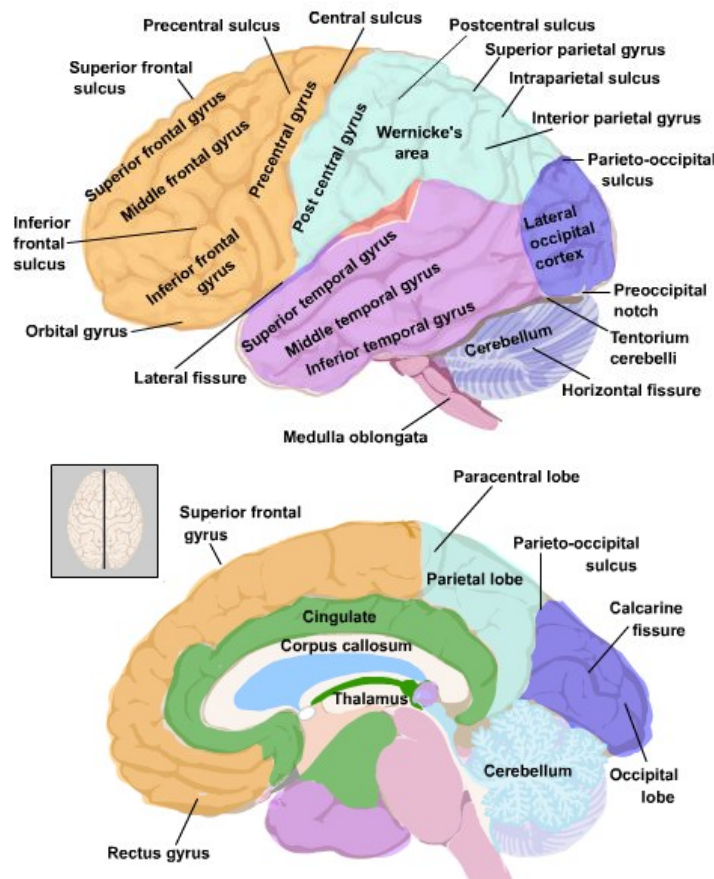


Figure 8. (Click to enlarge) Schematic drawing of six cortical lobes: Dorsal view (A), Lateral view (B), Mid-sagittal section showing the limbic lobe (in green) (C), and Horizontal section showing the insular cortex (D).

For descriptive purposes each cerebral hemisphere can be divided into six lobes. Four of these lobes are named according to the overlying bones of the skull as follows: frontal, parietal, occipital and temporal (Figures 8A and 8B), the fifth one is located internally to the lateral sulcus – the insular lobes (Figure 8B and 8D), and the sixth lobe is the limbic lobe (Figure 8C) which contains the limbic system nuclei. Neither the insular lobe nor the limbic lobe is a true lobe. Although the boundaries of the various lobes are somewhat arbitrary, the cortical areas in each lobe are histologically distinctive.

The surface of the cerebral cortex is highly convoluted with folds (gyri), separate from each other by elongate grooves (sulci). These convolutions allow for the expansion of the cortical surface area without increasing the size of the brain. On the lateral surface of the cerebral hemisphere there are two major deep grooves-sulci (or fissure), the lateral fissure (of Sylvian) and the central sulci (of Rolando), these sulci provide landmarks for topographical orientation (Figure 9A). The central sulcus separates the frontal lobe from the parietal lobe and runs from the superior margin of the hemisphere near its midpoint obliquely downward and forward until it nearly meets the lateral fissure (Figures 8A and 8B). The lateral fissure, separating the frontal and parietal lobes from the temporal lobe, begins inferiorly in the basal surface of the brain and extends laterally posteriorly and upward, separating the frontal and parietal lobes from the temporal lobe (Figure 9A). The frontal lobe is the portion which is rostral to the

central sulcus and above the lateral fissure, and it occupies the anterior one third of the hemispheres (Figures 8 and 9). The boundaries of the parietal lobe are not precise, except for its rostral border – the central sulcus. The occipital lobe is the portion which is caudal to the parietal lobe (Figures 8 and 9). Along the lateral surface of the hemisphere, an imaginary line connecting the tip of the parietal-occipital sulcus and the preoccipital notch (Figure 9A); separate the parietal lobe from the occipital lobe. On the medial surface of the hemisphere (Figure 9B), parieto-occipital sulcus forms the rostral boundary of the parietal lobe. The temporal lobe lies ventral to the lateral sulcus, and on its lateral surface, it displays three diagonal oriented convolutions-the superior, middle, and inferior temporal gyri (Figure 9A). The insula lies in the depths of the lateral sulcus. It has a triangular cortical area with gyri and sulci (Figures 8B & 2D, and Figure 9A). The limbic lobe consists of several cortical and subcortical areas (Figure 9B).



Figures 9A and 9B. (Click to enlarge) Lateral schematic drawing of the different cortices, sulci and gyri (A) and mid-sagittal drawing emphasizes the limbic lobe (in green) (B).

The cerebral cortex is a functionally organized organ. A functional organized system is a set of neurons linked together to convey a specific type(s) of information to accomplish a particular task(s). It is possible to identify on the cerebral cortex primary sensory areas, secondary sensory areas, primary motor area, premotor area, supplementary motor area and association areas, which are devoted to the integration of motor and sensory information, intellectual activity, thinking and comprehension, execution of language, memory storage and recall.

The frontal lobe is the largest of all the brain lobes and is comprised of four gyri, precentral gyrus that parallels to the central sulcus, and three horizontal gyri: the superior, middle, and inferior frontal gyri. The inferior frontal gyrus is comprised of three parts: the orbital, the triangular and opercular. The term opercular refers to the “lips of the lateral fissure. Finally, the straight gyrus (gyrus rectus) and the orbital gyri form the base of the frontal lobe (Figure 9B). Four general functional areas are in the frontal lobe. They are the primary motor cortex, where all parts of the body are represented, the premotor and supplementary motor areas. A region concerned with the motor mechanisms of speech formulation comprised of the opercular and triangular parts of the inferior frontal gyrus are known as Broca’s speech area, and the remainder of the prefrontal cortex is involved in mental activity, personality insight, foresight, and reward. The orbital portion of the prefrontal cortex is important in the appropriate switching between mental sets and the regulations of emotion.

The parietal lobe is comprised of three gyri: postcentral gyrus, superior and inferior parietal gyri (Figure 9A). The postcentral gyrus is immediately behind the central sulcus which forms its anterior boundary. The postcentral gyrus comprises the primary somatosensory cortex which is concerned with somatosensory reception, integration and processing sensory information from the surface of the body and from the viscera, and is important for the formulation of perception. Caudal to the postcentral gyrus is the inferior parietal gyrus. The intraparietal sulcus separates the posterior parietal gyrus from the inferior parietal gyrus. The inferior parietal gyrus represents the cortical association area which integrates and processes sensory information from multiple modalities such as auditory and visual information. The inferior parietal gyrus, which is known as Wernicke’s area, is also important for language and reading skills, whereas the superior parietal gyrus is concerned with body image and spatial orientations.

The temporal lobe is formed by three obliquely oriented gyri: the superior, middle, and inferior temporal gyri (Figure 9A). Inferomedial to the inferior temporal gyrus are the occipitotemporal and the parahippocampal gyri, which are separated by the collateral sulcus. The upper surface of the superior temporal gyrus, which extends into the lateral fissure, is called the transverse temporal gyrus (of Heschl) and is the primary auditory cortex. The caudal part of the superior temporal gyrus, which extends up to the parietal cortex, forms part of Wernicke’s area. Wernicke’s area is concerned, in part, with processing the auditory information and is important in the comprehension of language. The inferior part of the temporal lobe (i.e., the occipitotemporal gyri) is involved in visual and cognitive processing.

More medially is the parahippocampal gyrus, which is involved in learning and memory. Portions of the frontal, parietal, and temporal lobes, which are adjacent to the lateral sulcus and overlie the insular cortex, are known as the operculum. The inferomedial surface of the temporal lobe is made up of the uncus and the parahippocampal gyrus medially. The inferior surface of the temporal lobe rests on the tentorium cerebelli.

The occipital lobe is the most caudal part of the brain, lies on the tentorium cerebelli (Figure 9A) and is comprised of several irregular lateral gyri. On its medial surface, there is a prominent fissure – the calcarine fissure and parieto-occipital sulcus. The calcarine fissure (sulcus) and the parieto-occipital sulcus also define a cortical region known as the cuneus. The cuneus sulcus divides the occipital lobe into the cuneus dorsally and ventrally into the lingual gyrus. The occipital lobe contains the primary and higher-order visual cortex.

The insula lobe is located deep inside the lateral fissure and can be seen only when the temporal and the frontal lobes are separated. The insula is characterized by several long gyri and sulci, the gyri breves and gyri longi. There is some evidence that the insular cortical areas are involved in nociception and regulation of autonomic function (Figures 8B and 8D).

The limbic lobe is not a true lobe and is comprised of several cortical regions such as the cingulate and parahippocampal gyri, some subcortical areas like the hippocampus, amygdala, septum, and other areas with their respective ascending and descending connections (Figures 8C and 9B). The limbic lobe is involved in memory and learning, drive related behavior, and emotional function.

There are subcortical areas in the telencephalon like the basal ganglia and the amygdaloid nucleus complex. The corpus callosum is a collection of nerve fibers which connect the two hemispheres. The corpus callosum is divided into rostrum (head), body, the most rostrally part is the genu (knee) with connecting the rostrum and the body, and the splenium at the caudal extremity (Figure 10). Behavioral studies have shown that the corpus callosum play an important role in transferring information from one hemisphere to the other.

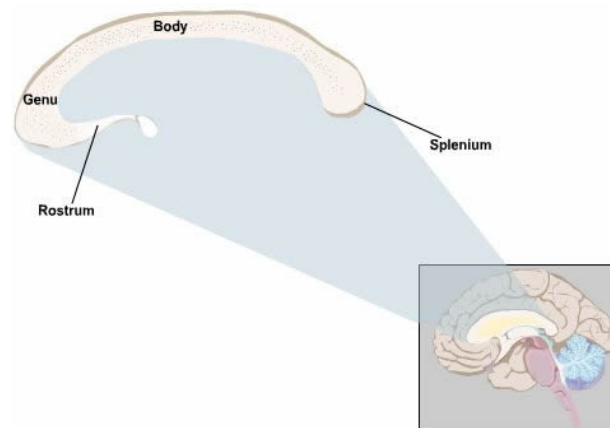


Figure 10. (Click to enlarge) The corpus callosum and its different parts.

The Diencephalon

The second major derivative of the prosencephalon is the diencephalon. The diencephalon is the most rostral structure of the brain stem; it is embedded in the inferior aspect of the cerebrum. The posterior commissure is the junctional landmark between the diencephalon and the mesencephalon. Caudally, the diencephalon is continuous with the tegmentum of the midbrain. During development the diencephalon differentiates into four regions: thalamus, hypothalamus, subthalamus and epithalamus (Figure 11). The epithalamus comprises the stria medullaris habenular trigone, pineal gland and the posterior commissure (Figure 11).

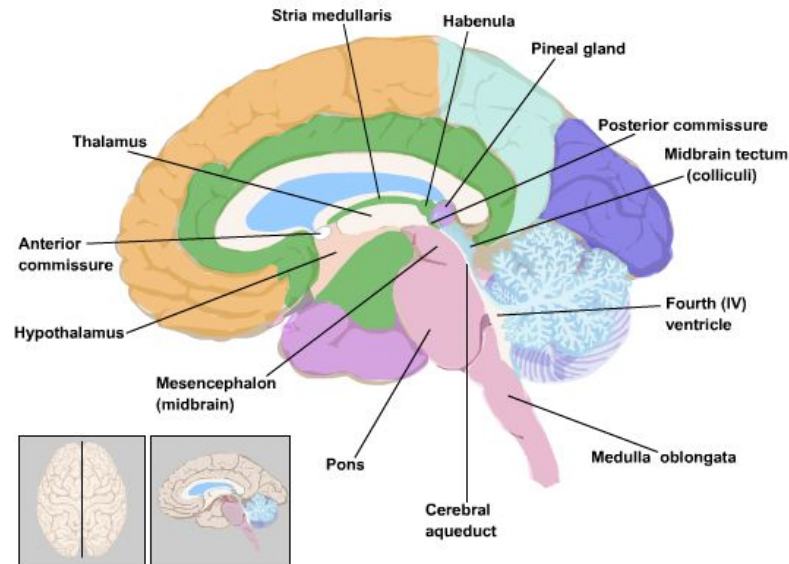


Figure 11. (Click to enlarge) Midsagittal drawing showing the main structures of the diencephalon.

The Brain Stem

The brain stem consists of mesencephalon (midbrain), metencephalon, and myelencephalon. The metencephalon and myelencephalon together compose the rhombencephalon (hindbrain), which divides into pons, and medulla oblongata (Figure 12).

Mesencephalon

Mesencephalon (midbrain) is continuous with the diencephalons rostrally and with the pons caudally. The midbrain is the smallest part of the brain stem, being about 2 cm in length. It consists of a tectum posteriorly, a tegmentum inferiorly, and a base anteriorly. The tectum forms the roof of the cerebral aqueduct, which connects the third ventricle with the fourth ventricle and the tegmentum its floor. The base of the midbrain consists of the cerebral peduncle, which contain nerve fibers descending from the cerebral cortex. The nuclei of the 3rd (oculomotor), the 4th (trochlear) and part of the 5th (trigeminal) are located in the midbrain tegmentum. The red nucleus and the substantia nigra, two prominent nuclei, are also found in the midbrain tegmentum. The midbrain tectum is formed by two pairs of rounded structures: the superior and inferior colliculi. The superior and inferior colliculi (Figure 12) are involved in visual and auditory functions respectively.

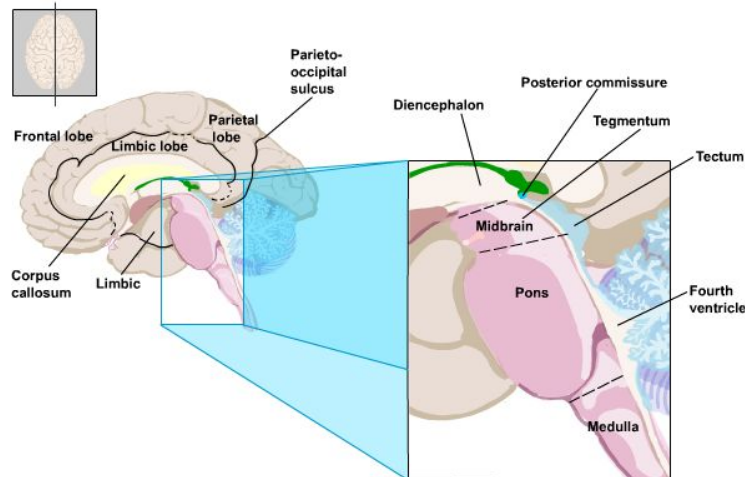


Figure 12. (Click to enlarge) Midsagittal drawing of the brain stem.

Pons

The pons is continuous with the midbrain and is composed of two parts, the pontine tegmentum (located internally) and the basilar pons. At the level of the pons, the cerebral aqueduct has expanded to form the fourth ventricle (Figure 12). The cerebellum is situated posterior to the pons and forms part of the roof (tectum) of the fourth ventricle. The pons contains nuclei that receive axons from various cortical areas. Projections from the axons of these pontine neurons form large transverse fiber bundles which traverse the pons and ascend to the contralateral cerebellum via the middle cerebellar peduncles. Also, within the pons base and tegmentum are longitudinally ascending and descending fibers. The nuclei of the 5th (trigeminal), 6th (abducens), 7th (facial) and the 8th (vestibulocochlear) nerves are located in the pons tegmentum.

Medulla Oblongata

Medulla Oblongata (myelencephalon is also known as the medulla). The medulla lies between the pons rostrally and the spinal cord caudally. It is continuous with the spinal cord just above to foramen magnum and the first spinal nerve. The posterior surface of the medulla forms the caudal half of the fourth ventricle floor and the cerebellum, its roof (Figure 12). The base of the medulla is formed by the pyramidal-descending fibers from the cerebral cortex. The medulla tegmentum contains ascending and descending fibers and nuclei from the 9th (glossopharyngeal), 10th (vagus), 11th (accessory) and the 12th (hypoglossal) nerves. The corticospinal fibers (pyramid) are alongside the anterior median fissure, and decussate (cross the midline) to the contralateral side on their way to the spinal cord. Other prominent structures in the medulla are the inferior olive, and the inferior cerebellar peduncle. The medulla contains nuclei which regulate respiration, swallowing, sweating, gastric secretion, cardiac, and vasomotor activity.

Arterial Blood Supply

The arterial blood supply to the brain is derived from two arterial systems: the carotid system and the vertebrobasilar system. A series of anastomotic channels lying at the base of the brain, known as the circle of Willis, permits communication between these two systems (Figure 13).

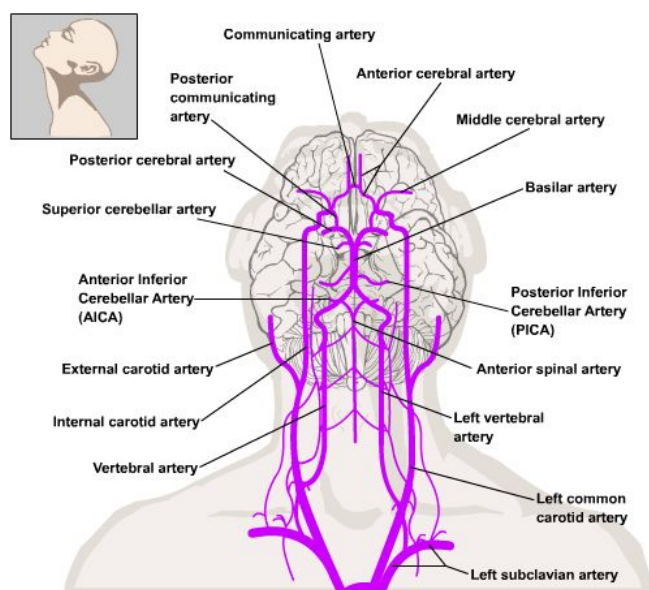


Figure 13. (Click to enlarge) Schematic drawing showing the main arterial blood supplies to the brain.

The arterial blood supply to the spinal cord is derived from two branches of vertebral artery, the anterior and two posterior spinal arteries which run the length of the spinal cord and form an irregular plexus around it (Figure 14).

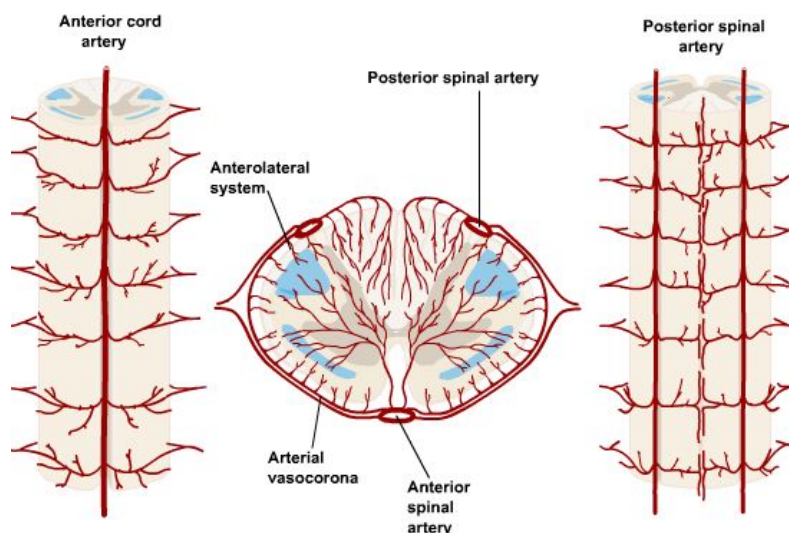


Figure 14. (Click to enlarge) Schematic drawing of the spinal cord arterial blood supply.

The Peripheral Nervous System (PNS)

The PNS includes 31 pairs of spinal nerves, 12 pairs of cranial nerves, the autonomic nervous system and the ganglia (groups of nerve cells outside the CNS) associated with them. Also included in the PNS are the sensory receptor organs. The receptor organs are scattered in all parts of the body, sense and perceive changes from external and internal organs, then transform this information to electrical signals, which are carried via an extensive nervous network to the CNS (Figure 15). The cranial and spinal nerves contain nerve fibers that conduct information to-afferent-(Latin for carry toward) and from-efferent (Latin for carry away) the CNS. Afferent fibers convey sensory information from sensory

receptors in the skin, mucous membranes, and internal organs and from the eye, ear, nose and mouth to the CNS; the efferent fibers convey signals from cortical and subcortical centers to the spinal cord and from there to the muscle or autonomic ganglia that innervate the visceral organs. The afferent (sensory) fibers enter the spinal cord via the dorsal (posterior) root, and the efferent (motor) fibers exit the spinal cord via the ventral (anterior) root. The spinal nerve is formed by the joining of the dorsal and the ventral roots. The cranial nerves leave the skull and the spinal cord nerves leave the vertebrae through openings in the bone called foramina (Latin for opening).

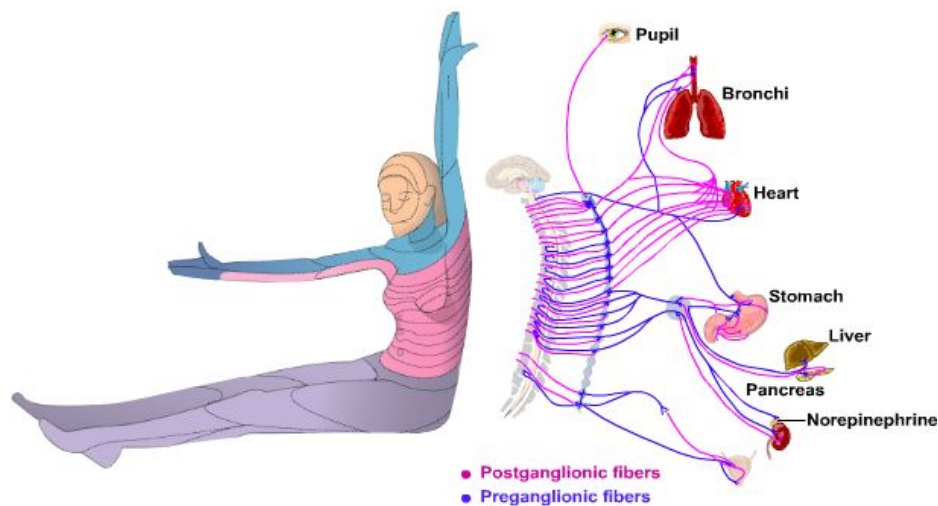


Figure 15. (Click to enlarge) Schematic drawing of the peripheral nervous system.

The PNS is divided into two systems: the visceral system and the somatic system. The visceral system is also known as the autonomic system. The autonomic nervous system (ANS) is often considered a separate entity; although composed partially in the PNS and partially in the CNS, it interfaces between the PNS and the CNS. The primary function of the ANS is to regulate and control unconsciousness functions including visceral, smooth muscle, cardiac muscle, vessels, and glandular function (Figure 16). The ANS can be divided into three subdivisions:

1. The sympathetic (or the thoracolumbar) subdivision associated with neurons located in the spinal gray between the thoracic and the upper lumbar levels;
2. The parasympathetic (or craniosacral) subdivision is associated with the 3rd, 7th, 9th and the 10th cranial nerves as well as with the 2nd, 3rd, and 4th sacral nerves;
3. The enteric subdivision is a complex neuronal network within the walls of the gastrointestinal system and contains more neurons than the spinal cord. The visceral (autonomic) system regulates the internal organs outside the realm of conscious control. The PNS component of the somatic system includes the sensory receptors and the neurons innervating them and their nerve fibers entering the spinal cord. The visceral and the somatic nervous system are primarily concerned with their own functions, but also work in harmony with other aspects of the nervous system.

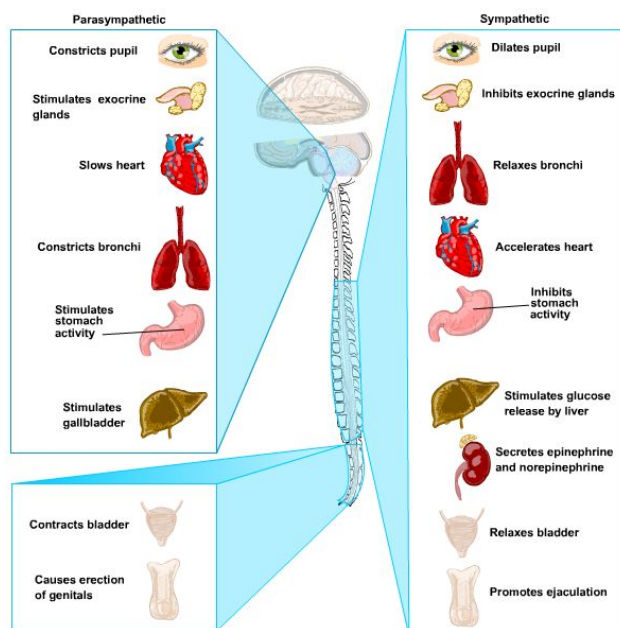


Figure 16. (Click to enlarge) Schematic drawing showing the autonomic nervous system. C, T, L and S indicate the cervical, thoracic, lumbar and sacral levels of the spinal cord, respectively. III, VII, IX, X indicate the 3rd, 7th, 9th and 10th cranial nerves respectively.

Orientation to the Central Nervous System

In this section you will be introduced to representative sections through the human CNS. They will acquaint you with prominent structures that will help you to recognize the level and orientation of the section and provide landmarks for locating nuclei and tracts involved in sensory and motor functions. Directional terms are used in describing the locations of structures in the CNS.

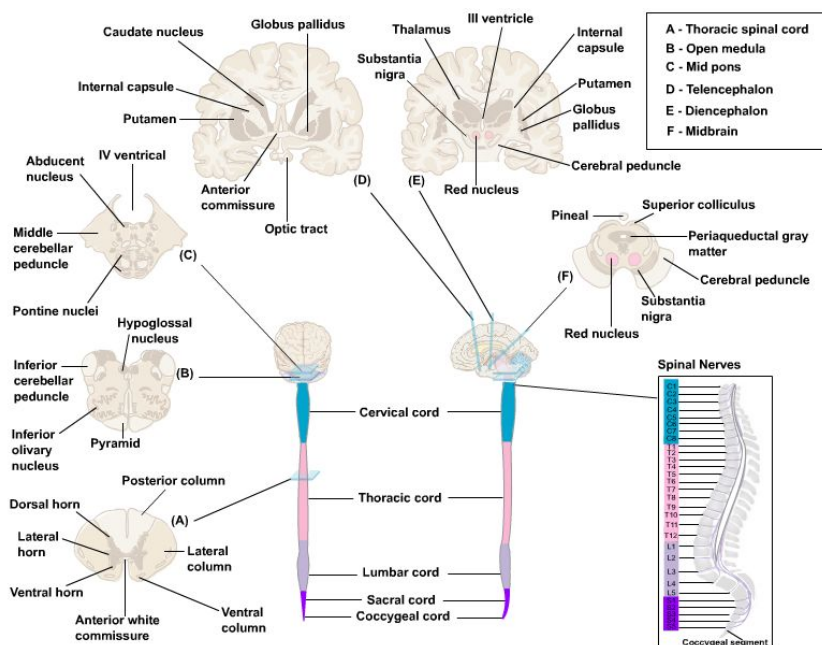


Figure 17. (Click to enlarge) Orientation of the central nervous system of the spinal cord and different brain sections.

Keep in mind that certain terms were developed to describe the nervous system of quadrupeds and may have a slightly different meaning when applied to bipeds. For example, the ventral surface of the quadruped spinal cord is comparable to the anterior surface of the biped (Figure 18). In the following descriptions, the terms are applied to a standing human. The terms rostral and anterior refer to a direction towards the face/nose. The terms caudal and posterior refer to a direction towards the buttocks/tail. The terms inferior and superior generally refer to spatial relationships in a vertical direction (Figure 18). A coronal section is parallel to the vertical plane and a midcoronal section would divide the head into anterior and posterior halves (Figure 19). The sagittal section is also parallel to the vertical plane, but a midsagittal section would divide the head into right and left halves. The horizontal (axial) section is parallel to the horizontal plane and a mid horizontal section would divide the head into superior and inferior halves. Transverse or cross sections of the spinal cord of humans are taken in a plane perpendicular to the vertical, i.e., in the horizontal plane of the head. Most electromagnetic imaging techniques produce images of the brain in the coronal, horizontal (axial) and sagittal planes. The representative sections are transverse sections through the spinal cord and brain stem and coronal sections through the telencephalon and diencephalon (Figure 17).

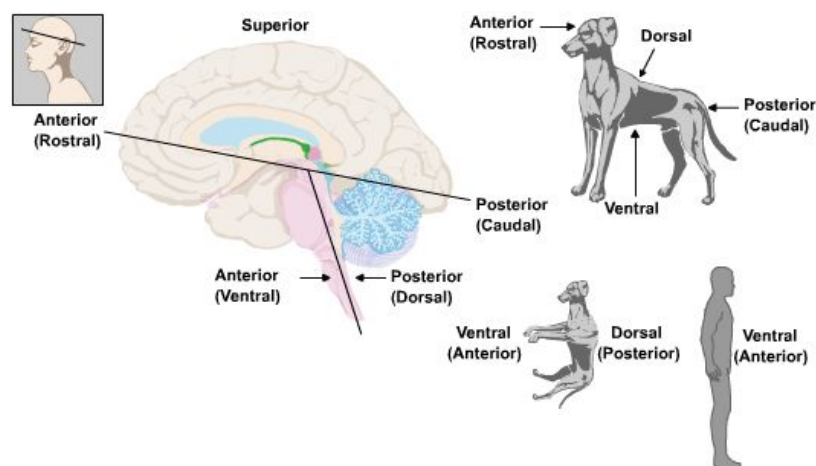


Figure 18. (Click to enlarge) A schematic illustration showing the brain direction.

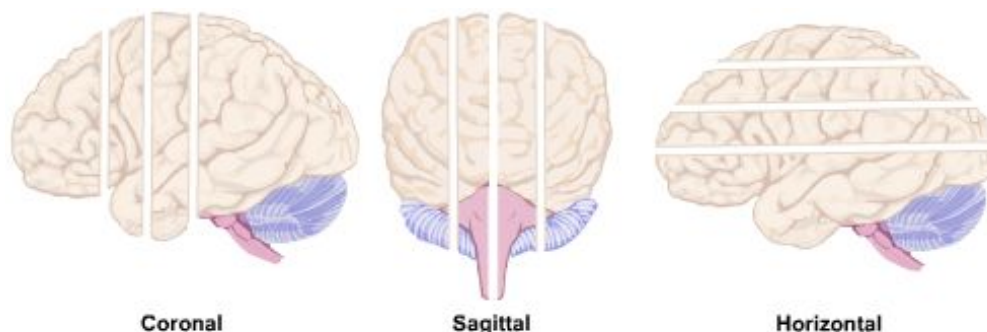


Figure 19. (Click to enlarge) A schematic illustration showing the three planes of brain section.

Transverse Section through the Spinal Cord

This section was taken at the level of the thoracic spinal cord (Figure 17A). The spinal cord neuron (gray matter) form a central core taking a butterfly configuration that is surrounded by nerve fibers (white matter). In the left and right halves of the spinal cord, the gray matter is organized into a dorsal horn and ventral horn with the intermediate gray located between them. In the thoracic spinal cord, which is illustrated in this figure, a lateral horn extends laterally from the intermediate gray (Figure 17A). The spinal cord white matter is subdivided into the posterior white column, the anterior white column and the lateral white column. The anterior white commissure joins the two halves of the spinal cord and is located ventral to the intermediate gray. The dorsal root fibers enter the spinal cord at the dorsolateral sulcus and the fibers of the ventral root fibers exit the spinal cord in numerous fine bundles through the ventral funiculus (see Figures 1-5).

Transverse Section through the Medulla

(Figure 17B) This is a section taken at the level of the upper medulla. Landmark structures include the fourth ventricle, hypoglossal nucleus, inferior cerebellar peduncle, inferior olivary complex and the pyramids. As in the spinal cord section, the fiber tracts, the inferior cerebellar peduncle and pyramids, appear dark in this section while the nuclei in the inferior olivary complex appear light.

Transverse Section through the Pons

(Figure 17C) This is a section taken at the level of the mid pons. Landmark structures include the fourth ventricle, the pons tegmentum, which includes the abducens nuclei; the pons base, which includes the corticofugal fibers and pontine nuclei; and the middle cerebellar peduncles.

Coronal Section through the Rostral Telencephalon

(Figure 17D) This is a section taken at the level of the decussation of the anterior commissure. Landmark structures include the head of the caudate nucleus, the anterior limb of the internal capsule, the globus pallidus and putamen (all-important in controlling motor functions). The anterior commissure, a fiber bundle connecting the right and left frontal lobes, can be seen decussating (crossing the midline). The corpus callosum forms a thick band of decussating nerve fibers located above the lateral ventricles. Below the telencephalon afferent nerve fibers from each eye decussate in the optic chiasm and join uncrossed fibers to form the optic tract.

Coronal Section through the Midbrain-Diencephalon Junction

(Figure 17E) This is a section taken at the level junction of the midbrain with the diencephalon. Notice that the plane of section differs from those of previously viewed sections. At this level, a landmark structure of the diencephalon is the thalamus, which surrounds the third ventricle. The posterior limb of the internal capsule separates the thalamus from the surrounding telencephalic structures, i.e., the globus pallidus and putamen. Lateral to the putamen is the insula while more dorsomedially the corpus callosum overlies the cavities of the lateral ventricles. Below the third ventricle are the red nucleus, substantia nigra and crus cerebri of the midbrain, which are the continuation of the internal capsule.

Section through the Midbrain

(Figure 17F) This section aims to show the main midbrain nuclei which include the tectum (superior colliculi) the periaqueductal gray, the red nuclei, substantia nigra and the cerebral peduncles.

Laboratory Exercise #1:

External Anatomy of the Brain

Lecturers: Michael Beierlein, Ph.D.; Michael S. Beauchamp, Ph.D.

December 3, 2013 2:00 PM - 5:00 PM, UT MSB 2.129

Introduction

The purpose of this laboratory is to introduce the terminology, gross external anatomy and 3) major functional properties associated with the human nervous system. The laboratory is composed of the following five components:

- **Part A**

- Examination of wet human brain material**

1. Features of the brain, i.e., all the gyri and sulci, use the DeArmond Atlas as a guide. In addition, take the brain from the bucket and observe the meninges and study the surface.
2. A hands-on examination by each student group of the gross morphological features described in the NeuroLab Online #01 "Overview Of The Nervous System." Each group will investigate the gross external structures of human brain and half brain using material provided to each laboratory group. Directions for this are located on Page 22 of this hand out.
3. Preparations from human brain will be used to highlight the important aspects of the anatomy of the CNS.

External Topology of the Brain

Examination of Wet Human Brain Material

The purpose of this exercise is to introduce you to: 1) the overall structure of the nervous system; 2) general principles underlying the organization of the brain, and 3) basic nomenclature. You should pay particular attention to the spatial relationship between different brain parts to help you gain a three dimensional picture of the brain. By the end of this exercise, you should know:

1. The meningeal coverings of the brain.
2. Major gyri and sulci of the cerebral cortex.
3. Major subdivisions of the cerebral hemispheres,

Note that no two brains, nor two halves of the same brain, are exactly alike in their surface pattern. Many of the major sulci and gyri, however, are generally consistent in shape and position. Do not let the inconsistent use of the terms fissures and sulci disturb you. The term fissure is supposed to indicate a groove that is deeper than a sulcus, but many times the words are used interchangeably.

Materials

Reference materials for the investigation of the human brain in this laboratory are:

1. NeuroLab Online #01 "Introduction to the Nervous System"
2. Figures on page 59-64 of Nolte
3. DeArmond Figures 1 – 6

- Brain specimen bucket containing
 - Whole brain specimen
 - Hemisected brain specimen
- Aluminum pan
- Squeeze bottles with water or bleach
- Cleanup towels for any dripping or spillage

You need to bring:

- Gloves
- Dissection kit
- Bring a plastic apron to protect your clothes.

Examination Of Whole And Hemisected Human Brains

Your group is being provided a brain specimen bucket containing a whole brain and a hemisected human brain for the study of the lateral, basal and medial surfaces of the cerebrum. Use your review of the NeuroLab Online #1 "Overview Of The Nervous System" and DeArmond Atlas as guides to learn the structures and their relationships to one another as well as the major functions related to each structure.

1. If instructed to do so, dissect away the meningeal coverings over the cerebrum with BLUNT FORCEPS and scissors, if needed (bring your own). WHENEVER POSSIBLE, PRESERVE THE BLOOD VESSELS AND CRANIAL NERVES which will be studied in later labs.
2. Identify all the sulci and the gyri using the Atlas Fig 1-4 as a reference.

In this and all other laboratory exercises, learn to identify the locations of the structures in bold type. Also learn the names, connections (if provided), and functions of the structures that appear in bold type or in italics. You will also be responsible for knowledge of the clinical consequences of damage to the identified structures when such information is provided in the exercise. Often new terminology will be underlined or italicized: Learn the definitions and the specific meaning of these terms in the context in which they are used.

Use the whole brain to orient yourself to the various orientations of the brain.

Orient yourself to these positions of the brain:

- Dorsal surface (superior) (Top of head in human upright position)
- Ventral surface (inferior) (base of brain or toward neck.)
- Rostral / anterior: Direction (toward the front of the brain i.e., direction of forehead or nose)
- Caudal / posterior direction- toward the buttock or the tail.

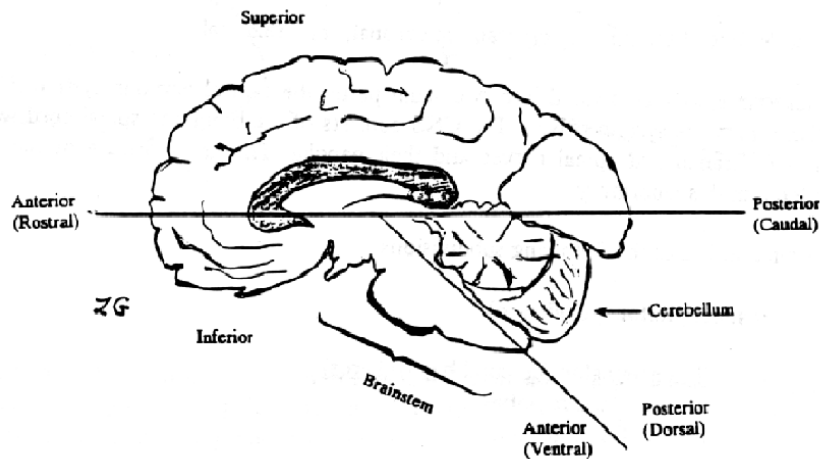


Fig. 1-1 A schematic diagram of brain directions

A coronal section is parallel to the vertical plane and a midcoronal section would divide the head into anterior and posterior halves. The sagittal section is also parallel to the vertical plane, but a midsagittal section would divide the head into right and left halves. The horizontal section is parallel to the horizontal plane and a midhorizontal section would divide the head into superior and inferior halves. Transverse or cross sections of the spinal cord of humans are taken in a plane perpendicular to the vertical, i.e., in the horizontal plane of the head

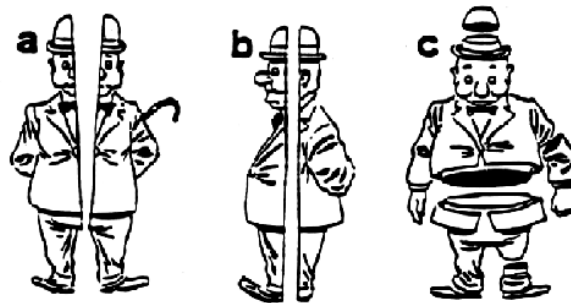


Fig. 1-2 Planes of section: (a) sagittal; (b) coronal; (c) horizontal

(Nolte pp. 80-90)

Within the cranium and spinal column, the brain is suspended in a clear liquid called cerebrospinal fluid (CSF) and is covered with three layers of non-neural connective tissue termed meninges (membranes). . Identify the meninges in your WHOLE BRAIN specimen.

1. Dura Mater

- a. dura mater, periosteum of the cranium, The cerebral dura folds into septa (partitions) to divide the cranial cavity into various components including
- b. falx cerebri between the two hemispheres, in the longitudinal fissure between the two hemispheres.
- c. tentorium cerebelli between the occipital lobe (in the back of the brain), and the cerebellum.

If the dura is still present on your specimen, gently raise it from the underlying arachnoid, and near the longitudinal fissure (midline) note the arachnoid villi (arachnoid granulations) that are extensions of the cerebral arachnoid protruding in the sinuses. In specimens with no dura attached, you may see the arachnoid villi forming small white clusters near the midline. The villi, which often become heavily calcified in older adults, serve as one-way valves in passing cerebrospinal fluid into the venous system.

2. Pia-Arachnoid

- a. arachnoid- Internal to the dura and separated from it by the subdural space is a more delicate membrane called the arachnoid ("spider's web"). The arachnoid covers the brain but does not follow the contour of its surface.
- b. The pia mater adheres intimately to the nervous tissue beneath it and follows the contours of the brain closely.
- c. arachnoid trabeculae, which resemble a lattice-work of connective tissue, normally extend from the arachnoid to the pia, traversing the subarachnoid space normally filled with cerebrospinal fluid (CSF)

3. The Subarachnoid Cisterns

- a. Identify the cerebellomedullary cistern (also known as cisterna magna) between the base of the cerebellum and medulla.

The cerebral hemispheres are paired structures separated from one another by the longitudinal fissure along the midline. A midsagittal cut through the longitudinal fissure is used to produce two hemisected brain halves.

Lateral Aspect Of The Cerebral Hemisphere

Using NeuroLab Online #1 "Overview of the Nervous System" as a guide, identify the following regions and structures on the gross brain. Be sure to learn their major functional roles. The photograph of the lateral aspect of the cerebrum (DeArmond, Fig. 2) will also be helpful.

Below is a list of material you need to identify and study. (Use DeArmond Atlas, Figs 1 and 2). Use the hemisected brain for the study of the lateral, basal and medial surfaces of the cerebrum

I. The Telencephalon (Cerebral Hemispheres)

A. The Cerebral lobes

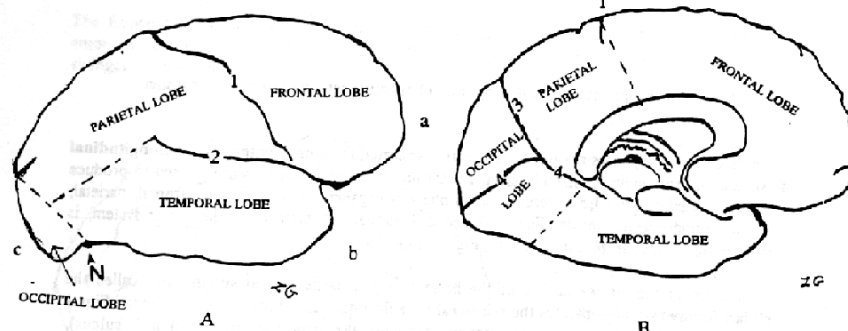


Fig. 1-3 Lateral (A) and medial (B) views of the poles, cerebral lobes and main sulci of the cerebral hemispheres; (a) frontal pole; (b) temporal pole; (c) occipital pole. (1) central sulcus; (2) lateral sulcus; (3) parieto-occipital sulcus; (4) calcarine fissure; N, preoccipital notch.

Each cerebral hemisphere is organized into five lobes: frontal, parietal, occipital, temporal and insula (Figs. 1-3 and 1-4). A sixth area, the limbic system, is sometimes called the limbic lobe.

Examination of the lateral sulcus also called the Sylvian fissure that separates the temporal lobe from the rest of the lobes (DeArmond Fig. 2, pg. 4).

The central sulcus, also called Rolandic sulcus, demarcates the frontal lobe anteriorly from the parietal lobe posteriorly.

If this sulcus is difficult to find on your specimen, look for two parallel gyri extending from the superior margin of the cerebrum down to the lateral fissure. The sulcus separating these two parallel gyri is the central sulcus. On the medial surface of the specimen (in the longitudinal fissure) look for the parieto-occipital sulcus and the preoccipital notch (DeArmond, Fig. 4, pg. 8; Fig. 1-3). A line connecting the parieto-occipital sulcus with the preoccipital notch divides the parietal lobe from the occipital lobe posteriorly.

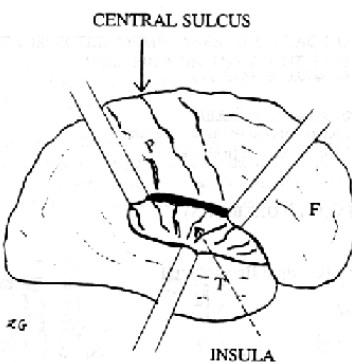


Fig. 1-4 Frontal (F), parietal (P) and temporal (T) opercula retracted to show the insula buried underneath.

Buried within the lateral sulcus is a fifth major lobe called the insula (also called the Island of Reil). The insula can be seen by gently retracting the frontal, parietal, and temporal opercula, as shown in Fig. 1-4.

Finally, examine the inferior surface of the brain to observe how the cortex of the frontal and temporal lobes spreads around to form a major part of the brain's inferior surface (DeArmond, Fig. 3, pg. 6).

Frontal Lobe

The precentral gyrus is also called the somato-motor cortex because it controls volitional movements of the contralateral side of the body.

Just rostral to the precentral gyrus are three gyri oriented in the horizontal plane: the superior frontal gyrus (on top), the middle frontal gyrus and the inferior frontal gyrus (below).

Identify the three components of the inferior frontal gyrus

1. pars opercularis,
2. pars triangularis, and
3. pars orbitalis (DeArmond, Fig. 2, pg. 4, and Fig. 1-5).

In the dominant brain hemisphere (i.e. the left side in a right-handed person), the pars opercularis and pars triangularis (collectively known as Broca's area). are involved in the production of speech and in the use of language. Damage to Broca's area in the dominant hemisphere can lead to a productive (expressive) aphasia.

The frontal lobe subserves several diverse functions, including voluntary control of eye movements, emotions, and intellectual functions. Damage to this part of the brain can lead to profound changes in personality.

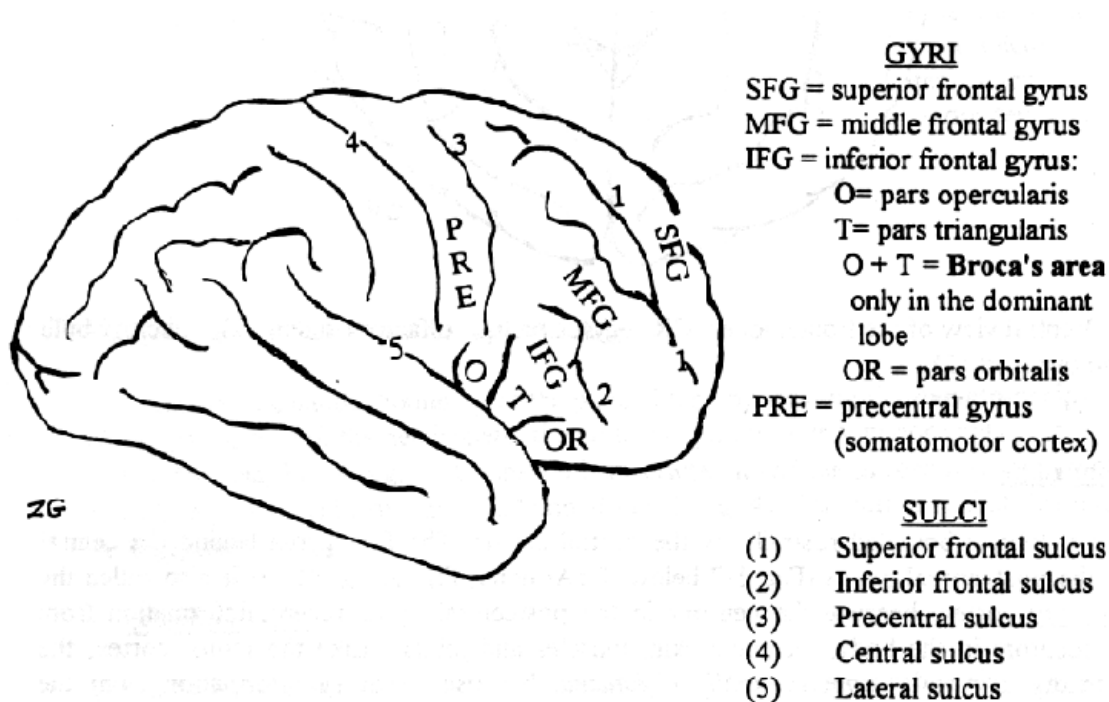


Fig. 1-5 Lateral view of the frontal lobe (right side)

Frontal Lobe

1. **Frontal pole**
2. **Central sulcus**
3. **Precentral gyrus**
4. **Precentral sulcus**
5. **Superior, middle, inferior frontal gyri**
6. **Pars opercularis of frontal lobe**
7. **Pars triangularis of frontal lobe**
8. **Pars orbitalis of frontal lobe**
9. **Broca's area**
10. **Somatomotor area**

Parietal Lobe

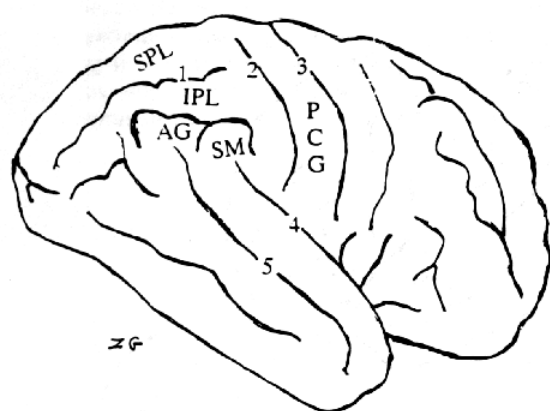
The parietal lobe is bounded rostrally by the central sulcus. The first gyrus behind the central sulcus is the postcentral gyrus (Fig. 1-7 below; DeArmond, Fig. 2, pg. 4). It is also called the somatosensory cortex, because the neurons in the postcentral gyrus receive information from sensory receptors located in the body of the skin, muscles and joints. Like the motor cortex, the somatosensory cortex is topographically organized; that is, sensory information from the contralateral side of the body, head and face is represented in specific areas of the somatosensory cortex. Damage to the postcentral gyrus produces a loss of somatosensory sensation in the half of the body contralateral to the damaged cortex.

Posterior to the postcentral gyrus is the parietal lobe, which is divided by the intraparietal sulcus into the inferior parietal lobule and the superior parietal lobule.

1. supramarginal gyrus forms a cap over the caudal end of the lateral fissure,
2. angular gyrus forms a cap over the caudal end of the superior temporal sulcus.
3. caudal parts of the superior temporal gyrus comprise Wernicke's area.

Wernicke's area is associated with the comprehension of language, both spoken and written. Damage to Wernicke's area in the dominant hemisphere reduces comprehension (receptive) aphasia.

The inferior parietal lobule includes two adjacent gyri (see Fig. 1-7) The (1)



GYRI

PCG = postcentral gyrus
(somatosensory cortex)

IPL = inferior parietal lobule
contains:

AG = Angular gyrus

SM = Supramarginal
gyrus

AG + SM =

Wernicke's area

SPL = superior parietal lobe

SULCI

- (1) Intraparietal sulcus
- (2) Postcentral sulcus
- (3) Central sulcus
- (4) Lateral sulcus
- (5) Superior temporal sulcus

Fig. 1-7 Lateral view of the right parietal lobe.

You can find the caudal boundary of the parietal lobe by locating the parieto-occipital sulcus on the medial surface of the hemisphere, and following it up to its superior limits [Fig. 1-8(B) and DeArmond, Fig. 4, pg. 8]. Then on the lateral surface, connect a line between the remote - occipital sulcus and the preoccipital notch [Fig. 1-8(A) below, and DeArmond Fig. 2, pg. 4]. The area of cortex behind this line is to the occipital lobe.

Parietal Lobe

1. Parietal lobe
2. Postcentral gyrus
3. Postcentral sulcus
4. Intraparietal sulcus
5. Superior parietal lobule
6. Inferior parietal lobule
7. Supramarginal gyrus
8. Angular gyrus
9. Parieto occipital sulcus
10. Wernicke's area
11. Somatosensory receiving area

Temporal Lobe

Find the lateral (Sylvian) fissure [Fig. 1-9(A); DeArmond, Fig. 2, pg. 4]. The cortex inferior to the lateral fissure is the temporal lobe.

1. Find the superior,
2. Middle and
3. Inferior temporal gyri.

The temporal cortex continues into the lateral fissure where its dorsal surface contains the superior bank of the superior temporal gyrus, also known as the transverse temporal gyri of Heschl. This gyrus serves as the primary auditory cortex.

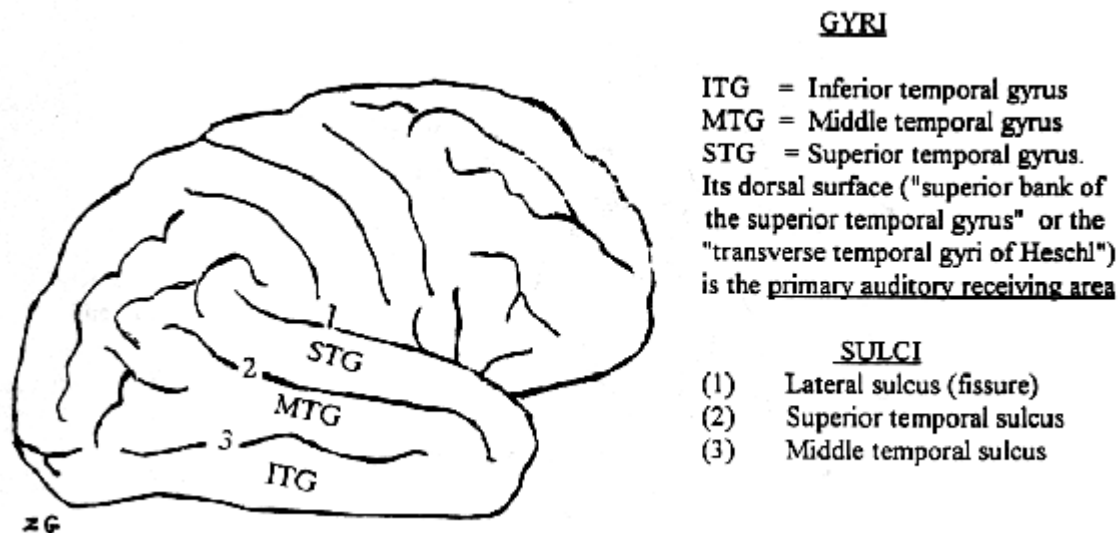


Fig. 1-9 (A) Lateral view of the temporal lobe.

Temporal lobe

1. Temporal pole
2. Lateral sulcus
3. Superior and middle temporal sulcus
4. Superior, middle, inferior temporal gyrus
5. Auditory receiving area

Occipital Lobe

The most important function of the occipital lobe in humans is processing visual information.

On the lateral surface of the hemisphere find the lateral occipital gyri [Fig. 1-8(A) and DeArmond, Fig. 2, pg. 4].

On the medial surface, note the prominent and deep calcarine fissure [Fig. 1-8(B) and DeArmond, Fig. 4, pg. 8].

The calcarine fissure separates the occipital lobe into two parts:

1. lingual gyrus (inferior part), and
2. cuneus (superior part).

The primary visual cortex (also known as calcarine cortex) consists of the gyri that lie on both sides of the calcarine fissure. A representation of the contralateral half of the visual world is contained in the visual cortex of each hemisphere. This representation is like that of the motor and somatosensory cortices: it is topographic and provides a spatial map of the visual field. Blindness results in the half of the visual field contralateral to the damaged calcarine cortex.

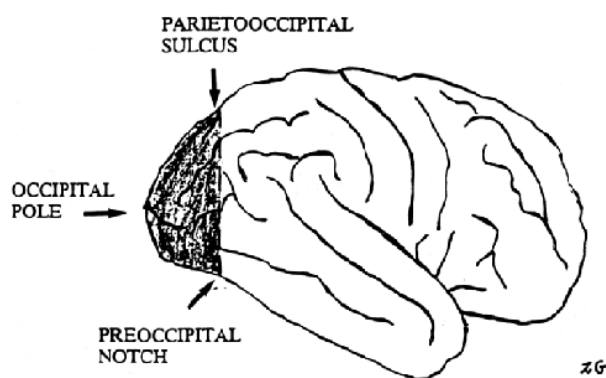
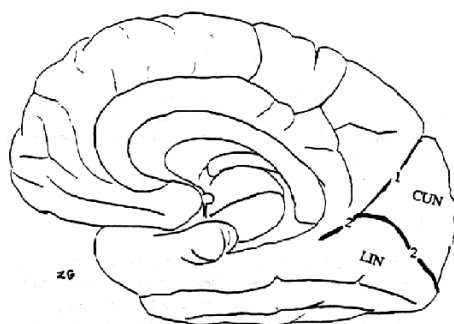


Fig. 1-8 (A) Lateral view of the occipital lobe which is formed by the lateral occipital gyri.



SULCI

1. Parietooccipital sulcus
2. Calcarine sulcus (fissure)

GYRI

CUN = cuneus

LIN = lingual (lingula)

Fig. 1-8 (B) Medial view of the occipital lobe.

Occipital Lobe

1. Occipital pole
2. Occipital lobe
3. Preoccipital notch

Insular Lobe

In the depths of the lateral fissure lies the fifth cortical lobe, the insula (island; see Fig. 1B). The insular cortex is associated with gustatory and visceral sensations.

The Limbic Lobe

The limbic lobe (also known as limbic system) is a functional grouping of telencephalic structures located on the medial and inferior aspects of the brain (Nolte, Fig. 3-2, pg. 56). These limbic structures include the: 1) subcallosal gyrus (located immediately inferior to the rostrum of the corpus callosum), 2) cingulate gyrus; 3) parahippocampal gyrus (connects to the cingulate gyrus via the isthmus, i.e. "bridge"); and 4) general location of the hippocampus (found deep in the parahippocampal gyrus) and its medial extension the uncus.

Medial Aspect Of The Cerebral Hemisphere

Using NeuroLab Online #1 “Overview of the Nervous System” as a guide, identify the following regions and structures on the gross brain. Be sure to learn their major functional roles. The photograph of the lateral aspect of the cerebrum (DeArmond, Fig. 4) will also be helpful.

On the medial aspect of the hemisected brain, identify the massive band of fibers called the corpus callosum. This fiber bundle contains commissural fibers which interconnect the two halves of the cerebrum. These fibers are observed in the half brain as is illustrated in DeArmond, Fig. 4, pg. 8, and in Fig. 1-10. The corpus callosum consists of (starting rostrally): (1) rostrum, (2) genu, (3) body and (4) splenium (most caudally). Below the rostrum is a small fiber bundle known as the anterior commissure. Attempt to locate the septum pellucidum that forms a midline partition between the two lateral ventricles in the intact brain (it may be preserved in only a few hemisected brains) (DeArmond, Fig. 4, pg. 8).

The cingulate gyrus follows the contour of the corpus callosum below, and is separated from it by the sulcus of the corpus callosum (DeArmond, Fig. 4, pg. 8). Superior to the cingulate gyrus, the cingulate sulcus separates the cingulate gyrus from the frontal, parietal, and occipital cortices (Fig. 1-10). Anteriorly, the medial surface of the frontal lobes includes extensions of the gyrus rectus (Fig. 1-6), the superior frontal gyrus, and the precentral gyrus. The paracentral lobule consists of the medial extensions of the precentral and postcentral gyri onto the medial surface of the hemisphere. The rostral border of the paracentral lobule is formed by the medial extension of the precentral sulcus and the caudal border by the marginal sulcus (pars marginalis of the cingulate sulcus). The precuneus of the parietal lobe is located between the marginal sulcus and the parieto-occipital sulcus. The cuneus of the occipital lobe is delimited by the parieto-occipital sulcus and the calcarine fissure. Below the calcarine fissure, the lingual gyrus extends inferiorly toward the inferior surface of the cerebrum.

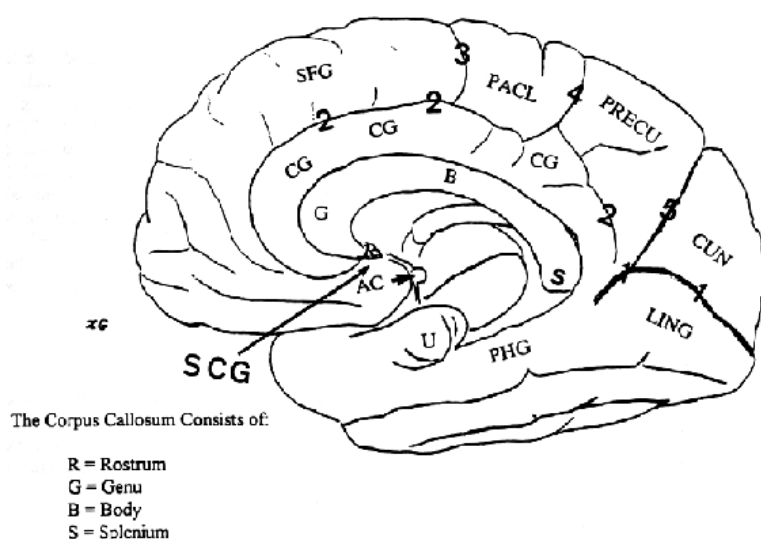


Fig. 1-10 Medial surface of the cerebrum (midsagittal section)

The Corpus Callosum Consists of:

R = Rostrum

G = Genu

B = Body

S = Splenium

AC = Anterior commissure (1) Calcarine sulcus (fissure)

CG = Cingulate gyrus (2) Cingulate sulcus

CUN = Cuneus (3) Precentral sulcus (medial extension)

LING = Lingual (lingula) (4) Marginal sulcus (an extension of the

PACL = Paracentral lobule the cingulate sulcus

PHG = Parahippocampal gyrus (5) Parietooccipital sulcus

PRECU = Precuneus

SCG = Subcallosal gyrus

SFG = Superior frontal gyrus

U = Uncus

- 1. Corpus callosum: rostrum, genu, body & splenium**
- 2. Sulcus of corpus callosum**
- 3. Cingulate gyrus**
- 4. Cingulate sulcus**
- 5. Gyrus rectus (frontal lobe)**
- 6. Superior frontal gyrus**
- 7. Precentral sulcus**
- 8. Paracentral lobule**
- 9. Precuneus (parietal lobe)**
- 10. Parieto occipital sulcus**
- 11. Cuneus**
- 12. Calcarine sulcus**
- 13. Lingual gyrus (occipital lobe)**
- 14. Septum pellucidum**
- 15. Anterior commissure**
- 16. Marginal sulcus**
- 17. Parahippocampal gyrus**
- 18. Caudate nucleus**
- 19. Thalamus**
- 20. Hypothalamic sulcus**
- 21. Hypothalamus**

Ventral Aspect Of The Brain

Using NeuroLab “Introduction to the Nervous System” as a guide, identify the following regions and structures on the gross brain. Be sure to learn the major functional roles. The photograph of the lateral aspect of the cerebrum (DeArmond, Fig. 3) will also be helpful.

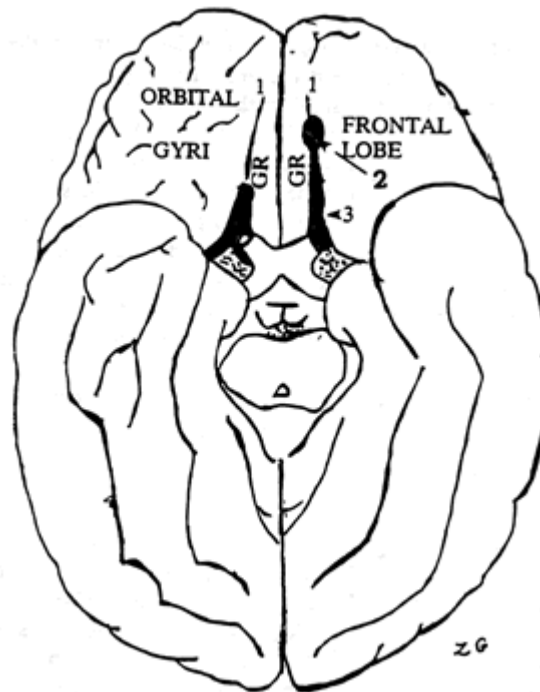


Fig. 1-6 Ventral view of the frontal lobes: GR = gyrus rectus; olfactory sulcus (1); olfactory bulb (2); olfactory tract (3) Primary olfactory cortex.

Frontal Lobe

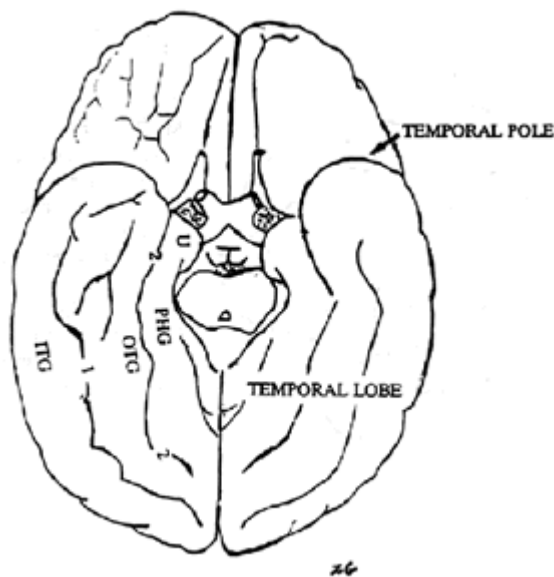
1. **Orbital gyrus**
2. **Gyrus rectus**
3. **Olfactory bulb & tract**

Temporal Lobe

1. **Temporal pole**
2. **Uncus**
3. **Parahippocampal gyrus**
4. **Collateral sulcus & rhinal sulcus**
5. **Occipitotemporal gyrus**
6. **Inferior temporal sulcus**
7. **Inferior temporal gyrus**

Insula

1. **Gustatory and visceral receiving areas**



GYRI

ITG = Inferior temporal gyrus

OTG = Occipitotemporal ("fusiform") gyrus

PHG = parahippocampal gyrus

U = Uncus

SULCI

1. Inferior temporal sulcus

2. Collateral sulcus

Fig. 1-9 (B) Ventral view of the temporal lobe.

On the inferior surface of the temporal lobe [Fig. 1-9(B); DeArmond, Fig. 3, pg. 6], locate the inferior temporal sulcus which separates the inferior temporal gyrus from the occipito-temporal gyrus (also known as "fusiform" because it is formed by the fusion of two gyri). Caudally the collateral sulcus, and rostrally, the rhinal sulcus, separate the occipitotemporal gyrus from the parahippocampal gyrus and the uncus. The anterior part of the parahippocampal gyrus and the uncus are part of the

FUNCTIONAL AREAS OF THE CEREBRAL CORTEX

Functionally, the cerebral cortex can be divided into three areas: (1) Primary sensory receiving areas: neurons in these areas process visual, auditory, vestibular, gustatory, olfactory, or somatosensory information. (2) Motor control areas: neurons in these areas are involved in the initiation of movements; and (3) Associative or integrative areas: neurons of most cortical areas outside the primary sensory and motor control areas are involved in the so-called higher functional processes such as language, learning, memory, and sensorimotor integration.

Review Questions

- 1-1. What lobe is anterior to the central (Rolandic) sulcus?
- 1 - 2. What lobe is posterior to the parieto occipital sulcus?
- 1-3. From what embryonic brain vesicle(s) is the cerebral cortex derived?
- 1-4. What part of the frontal lobe is concerned with control of speech/language production?
- 1-5. Which part of the frontal lobe is concerned with intellectual function and personality?
- 1-6. a) What divides the occipital lobe from the parietal lobe on the lateral surface of the cortex?
b) On the medial surface?
- 1-7. What gyrus caps the caudal end of the lateral fissure?
- 1-8. What separates the temporal lobe from the frontal lobe?
- 1-9. What is the spatial relationship between the uncus and the parahippocampal gyrus?
- 1-10. What part of the cortex is associated with visual sensations?
- 1-11. What part of the cortex is associated with auditory sensations?
- 1-12. Where are the gustatory and visceral cortices located?
- 1-13. Name the four nuclear groups that comprise the diencephalon.
- 1-14. Which meningeal membrane follows closely the contour of the brain surface?
- 1-15. Where is the somato-motor cortex located?
- 1-16. Where is the somato-sensory cortex located?
- 1-17. What is the difference between Broca's area and Wernicke's area?

Answers

- 1 1. Frontal lobe
- 1 2. Occipital lobe
- 1 3. Prosencephalon, telencephalon
- 1 4. Broca's area, the pars triangularis and pars opercularis of the inferior frontal gyrus
- 1 5. Most frontal areas outside the motor control areas
- 1 6. a) A line drawn between the top of the parieto occipital sulcus and the preoccipital notch; b) The parieto occipital sulcus
- 1 7. The supramarginal gyrus
- 1 8. The lateral fissure
- 1 9. The uncus is located at the medial margin of the rostral parahippocampal gyrus
- 1 10. Calcarine cortex of occipital lobe
- 1 11. Transverse temporal gyrus of Heschl, a.k.a., superior bank of the superior temporal gyrus
- 1 12. Insula
- 1 13. Thalamus, hypothalamus, epithalamus & subthalamus
- 1 14. Pia mater
- 1-15. Precentral gyrus
- 1-16. Postcentral gyrus
- 1-17. Broca's area is implicated in the production of speech whereas Wernicke's area is implicated in the comprehension of speech.

Laboratory Exercise #2:

Internal Organization of the Brain

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Introduction

The main objectives of this exercise are to familiarize you with the internal organization of the fore-brain. You will be introduced to important structures at representative levels of the brain to provide an appreciation of the three dimensional organization of the brain by relating these internal structures to the external landmarks you learned in Exercise 1. To meet these objectives, you will be required to work with the NeuroLab Online #2 along with the whole brain, hemisected brain and brainstem demonstrations. The surface morphology of the brain should be carefully reviewed and the internal structures should be correlated with the external morphology and with the DeArmond Atlas. Please keep in mind that there may be one or more terms for a particular structure. In general, the present day terminology is one with a functional basis, i.e., a tract or pathway or nuclear group is usually named for the modality mediated or for origin and/or termination of the particular pathway. At the end of this exercise you should be able to:

1. Describe the external topography of the brain stem.
2. Recognize the level of a section through the brain.
3. Identify key structures in sections through the brain.
4. Relate the positions of these internal structures with external landmarks.

- **Part A**

Examination Of Wet Human Brain Material

1. Your human specimens.
2. Demonstration material presented by teaching assistants

- **Part B**

Complete Exercise Mode of Neurolab Online #2

1. Each student should go through the NeuroLab Online computer program review mode prior to the laboratory.

- **Part C**

An Exercise At The End Of The Laboratory (~3:30 P.M.) To Assess Your Learning Progress

- **Part D**

Post-Laboratory Review Using Clinical Cases

Materials

- Brain specimen bucket containing
 - Brain stem
- Aluminum pan
- Squeeze bottles with water or bleach
- Cleanup towels for any dripping or spillage

You need to bring:

- Gloves
- Dissection kit
- Bring an plastic apron to protect your clothes.
- DeArmond Atlas

External Topology Of The Brain (Continued).

On the whole brain, REVIEW the major subdivisions of the central nervous system. The medulla (myelencephalon) is the most caudal division of the brain and is normally continuous with the spinal cord (DeArmond, Fig. 2, pg. 4). The metencephalon consists of the pons and the cerebellum. Rostral to the pons is the midbrain (mesencephalon), which is distinguished by two anteriorly located columns of fibers, the crura cerebri or cerebral peduncles (DeArmond, Fig. 3, pg. 6).

That portion of the diencephalon, which you can see on the inferior surface of the brain, is the hypothalamus. In this view, two small round elevations, the mammillary bodies (part of the hypothalamus), mark the caudal extent of the diencephalon and the optic chiasm marks its rostral border. The remainder of the brain, i.e., the cerebrum, constitutes the telencephalon. These five divisions (i.e., the medulla, metencephalon, midbrain, diencephalon, and telencephalon) together with the spinal cord constitute the bulk of the central nervous system.

The Midbrain Or Mesencephalon

(Use The Hemisected Brain And The Brain Stem)

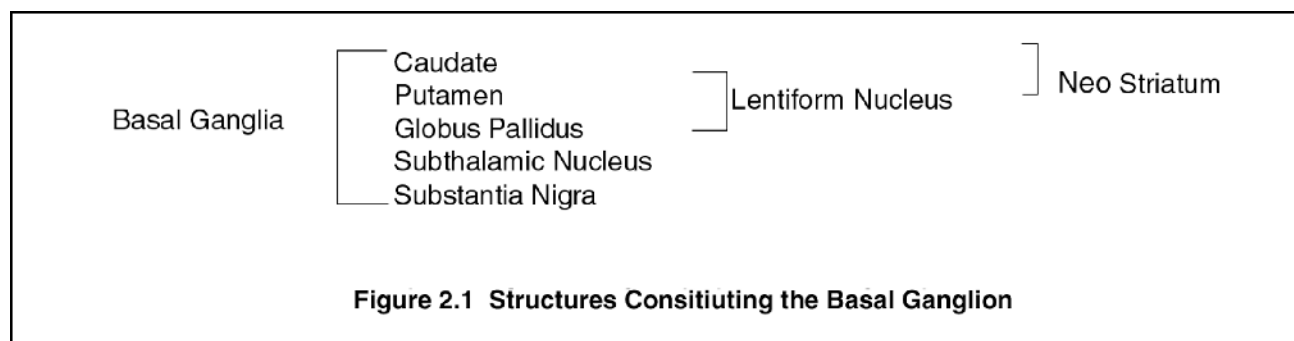
On the brain stem specimen, examine the cut edge of the midbrain and look for two black bands posterior to the two crura cerebri that are formed by the substantia nigra (DeArmond, Fig. 54, pg. 108). Locate the two large reddish gray structures, the red nuclei, located along the midline just posterior to the substantia nigra. The colors of these two midbrain nuclei in the unstained gross specimens result from pigment in their neurons. Observe also the small channel formed by the cerebral aqueduct at the midline, just anterior to the midbrain tectum. As you learned in Exercise 1, four small, round elevations, the inferior colliculi and the superior colliculi form the tectum or roof of the midbrain (DeArmond, Fig. 5, pg. 10). What is the primary function of the superior colliculi? ____ (2-1). The inferior colliculi? ____ (2-2). On the anterior surface of the midbrain two large longitudinal fiber bundles, the crura cerebri (also known as crus cerebri or cerebral peduncles) are separated by a deep groove called the interpeduncular fossa (DeArmond, Fig. 6, pg. 12).

The Basal Ganglia

Note the DeArmond figure is of a myelin stained section and therefore fiber tracts appear dark and most nuclear groups appear light in the photomicrograph.

You should recall from Exercise 1 that an important structural group in the telencephalon is the so called basal ganglia. It is not really a group of ganglia, but a collection of nuclei. The basal ganglia include the caudate, putamen, globus pallidus, subthalamic nucleus and substantia nigra (Figure 2.1). The putamen and globus pallidus are often grouped together and referred to by the descriptive name lentiform nucleus (they appear as bean shaped structures in coronal section). At their most rostral point, the caudate appears to merge with the anterior putamen to form a structure called the nucleus accumbens. The nucleus accumbens and adjacent parts of the caudate and putamen form the ventral striatum. The putamen and the caudate are referred to together as the neostriatum or striatum. Some texts also refer to the caudate, putamen and globus pallidus as the corpus striatum. The basal ganglia are a major subunit of the motor control system that works with the cerebral cortex and other brainstem structures to program movements. Name five lobes of the cerebral cortex _____, _____, _____, _____, and _____ lobes (2-3). Which cortical lobe is involved with motor control? _____ (2-4).

NOTE: The answers to questions 1-4 are at the end of this section.



Fibers within the internal capsule contain reciprocal connection between the thalamus with the cerebral cortex by thalamocortical and corticothalamic fibers. In addition to these fibers, the internal capsule contains axons, which descend from the cortex to lower levels of the neuraxis such as the brain stem and spinal cord. These cortical efferent fiber systems, which are referred to as corticofugal fibers, include the corticoreticular, corticopontine, corticobulbar, corticorubral and corticospinal tracts. Smaller projections also exist to the basal ganglia, other areas of the diencephalon and the midbrain. Below the level of the thalamus, corticofugal fiber systems make up the crus cerebri of the midbrain. When viewing the photomicrographs in this laboratory, observe how, together, the internal capsule, crus cerebri, and medullary pyramids form a continuous fiber system from the cerebral cortex down to the spinal cord.

The Diencephalon

The diencephalon consists of four parts: the epithalamus, hypothalamus, thalamus, and subthalamus. The two major structures of the diencephalon, which you have seen in the hemisected brain, are the thalamus and hypothalamus.

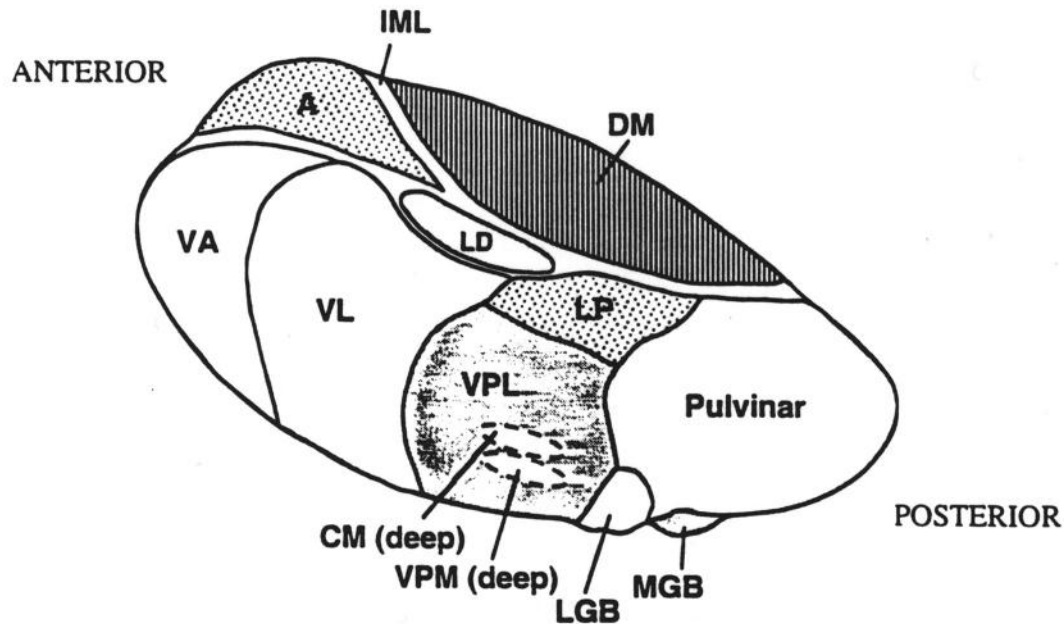
A. Thalamus

The thalamus is a collection of nuclei that have sensory, motor or association function. In the review section at the end of this laboratory is a diagram showing the gross organization of the nuclei in the thalamus. You are not responsible for knowing the organization or names of the nuclei for the first exam. This figure is simply to introduce you to the names of these nuclei for the upcoming somatosensory and motor system labs and lectures. All sensory information traveling to the cerebral cortex reaches it by way of a sensory thalamic nucleus, except the olfactory pathway.

B. Hypothalamus

The second major structure of the diencephalon is the hypothalamus. This area exerts important controls over visceral and endocrine activities. The hypothalamus is the major subcortical center for the regulation of both sympathetic and parasympathetic autonomic activities. It is connected extensively with the limbic system. These connections will be covered in detail in the laboratory on hypothalamic and limbic structures. The activity of the pituitary gland is also controlled by the hypothalamus. The gland is joined to the inferior aspect of the diencephalon, at the infundibulum. You saw on the hemisected brain that the lamina terminalis and anterior commissure marked the rostral border of the hypothalamus, the mammillary bodies its caudal border and the hypothalamic sulcus its superior border (DeArmond, Fig. 4, pg. 8).

Organization And Names Of Thalamic Nuclei



Anterior group	{	A	Anterior nucleus
Medial group	{	DM	Dorsomedial nucleus
Lateral group	[	VA	Ventral Anterior nucleus
		VL	Ventral Lateral nucleus
		LD	Lateral Dorsal nucleus
		LP	Lateral Posterior nucleus
		VPL	Ventral Posterolateral nucleus
		VPM	Ventral Posteromedial nucleus
		LGB	Lateral Geniculate Body
		MGB	Medial Geniculate Body
Intralaminar nuclei	{	CM	Centromedian nucleus
		IML	Internal Medullary Lamina

Figure 2-2. A cartoon of the general organization of the left thalamus and the major groupings of thalamic nuclei.

At the conclusion of this laboratory you should be able to identify the following internal structures of the brain. Many of these structures can be found in several slides. Some are landmarks demarcating different structures, some are nuclei, some are myelinated fiber tracts, and others are fluid filled spaces.

Internal Capsule

- Corona Radiata
- Anterior Limb
- Genu
- Posterior Limb
- Sublenticular Limb

Basal Ganglia and Related Structures

- Insula
- Claustrum
- Putamen
- Caudate
 - Head
 - Body
 - Tail
- Globus Pallidus
- Neostriatum (caudate & putamen)
- Lentiform or lenticular nucleus (putamen & globus pallidus)
- Substantia nigra
- Subthalamic
- Nucleus accumbens
- Amygdala

Diencephalon and Related Structures

- Thalamus and related structures
- Stria Terminalis
- Red Nucleus
- Terminal Vein
- Stria Medullaris Thalami
- Hypothalamus and Hypothalamic Sulcus
- Optic Tracts, Optic Chiasm, Optic Nerve
- Parahippocampal Gyrus
- Hippocampal Formation
- Temporal Lobe
- Corpus Callosum
- Fornix
- Mammillary Bodies
- Cerebral Peduncle
- Cerebral Aqueduct
- Tectum
- Inferior Colliculi
- Superior Colliculi

Answers

- 2-1. Visual
- 2-2. Auditory
- 2 3. The frontal, parietal, occipital, temporal & insula lobes
- 2 4. Frontal lobe, precentral gyrus is especially important

