Topography of the Brain (continued)

- In describing structures of the nervous system and their interconnecting pathways, we must have available a set of words that define geographical relations.
- Direction in the nervous system are described relative to the neuraxis, an imaginary line drawn through the spinal cord up to the front of the brain.
- The front end is anterior and the tail is posterior.
- The terms rostral (toward the head) and caudal (toward the tail) are also employed.
- The top of the head and the back are part of the dorsal surface, and the ventral is the front.
- The term superior and inferior are often used.
- The superior structure is above (dorsal to) the inferior one.
- The frontal view of the human illustrate the term lateral and medial.
- Toward the side and toward the midline respectively.

Topography of the Brain

- Two other useful terms are ipsilateral and contralateral.
  - Ipsilateral refers to structures on the same side of the body.
  - Thus, if I say that the olfactory bulb sends axons to the ipsilateral hemisphere.
  - I mean that the olfactory bulb sends axons to the left hemisphere and the right olfactory bulb sends axons to the right hemisphere.
  - Contralateral refers to structure on opposite side of the body.
  - If I say that a particular region of the left cerebral cortex controls movements of the contralateral hand.
  - I mean that the region controls movement of the right hand.
**Topography of the Brain**
- To see what is in the nervous system, we have to cut it open.
- To be able to convey information about what we find.
- We can slice the nervous system in three ways:
- Transversely, like a salami, giving us cross sections.
- Also known as a coronal or frontal section.

**Coronal Section**

**Horizontal Section**
- Parallel to the ground, giving us horizontal section.

**Sagittal Section**
- Perpendicular to the ground and parallel to the neuraxis.
- Gives us sagittal section.
- When the brain is half in half we have a midsagittal section.

**Blood Supply**
- Two major sets of arteries serve the brain:
  - The vertebral arteries, which serve the caudal portion of the brain.
  - The internal carotid arteries, which serve the rostral portion.
- There is a set of veins that drain blood away from the brain.

**Meninges**
- The entire nervous system - brain, spinal cord, cranial and spinal nerves, and the autonomic ganglia - is covered by connective tissue.
- The protective sheaths around the brain and spinal cord are referred to as the meninges.
- The meninges consist of three layers:
  - The outer layer is thick, tough, and flexible but unstretchable; its name, dura mater means "hard mother."
  - The middle layer of the meninges, the arachnoid membrane, get its name from its weblike appearance.
  - The arachnoid membrane is soft and spongy and lies beneath the dura mater.
- Closely attached to the brain and spinal cord, and following every surface convolution, is the pia mater "pious mother."
Meninges (continued)

- Between the pia mater and arachnoid membrane is a gap called the subarachnoid space.
- This space is filled with a liquid called cerebrospinal fluid (CSF).

The Ventricular System

- The brain is very soft and jellylike.
- The considerable weight of a human brain (approximately 1400 g), along with its delicate construction,
- necessitates that it be protected from shock.
- A human brain cannot even support its own weight well;
- it is difficult to remove and handle a fresh brain from a recently deceased human without damaging it.
- Fortunately, the intact brain within a living human is well-protected.
- It floats in a bath of CSF contained within the subarachnoid space.

The Ventricular System (continued)

- The CSF surrounding the brain and spinal cord also reduces the shock of the central nervous systems that would be caused by sudden head movement.
- concussion
- shaken baby syndrome
- The brain contains a series of hollow, interconnected chambers called ventricles, which are filled with CSF.
- The largest chambers are the lateral ventricles, which are connected to the third ventricle.
- The third ventricle is located at the midline of the brain; its walls divide the surrounding part of the brain into symmetrical halves.

The Ventricular System (continued)

- The cerebral aqueduct, a long tube, connects the third ventricle to the fourth ventricle.
- The lateral ventricles constitute the first and second ventricles, but they are never referred to as such.

The lateral ventricles
- The third ventricle
The Central Nervous System (continued)

- The third ventricle
- The cerebral aqueduct
- The fourth ventricle

The Central Nervous System (continued)

- Although the brain is exceedingly complicated, an understanding of the basic features of brain development makes it easier to learn and remember the location of the most important structures.
- The central nervous system begins its existence early in embryonic life as a hollow tube (neural tube).
- It maintains this basic shape even after it is fully developed.
- Early in development, the central nervous system contains three interconnected chambers.

The Central Nervous System (continued)

- Later, the rostral chamber divides into three separate chambers,
  - which becomes the two lateral ventricles and the third ventricle.
  - The region around the lateral ventricles becomes the telencephalon (end brain).
  - And the region around the third ventricle becomes the diencephalon (interbrain).

The Central Nervous System (continued)

- The chambers become ventricles, and the tissue surrounding them becomes the three major parts of the brain.
  - The forebrain, the midbrain, and the hindbrain.

The Central Nervous System (continued)

- In its final form, the chamber inside the mesencephalon (midbrain) becomes narrow,
  - forming the cerebral aqueduct,
  - and two structures develop in the hindbrain:
    - the metencephalon (hindbrain)
    - and the myelencephalon (marrowbrain).
The Central Nervous System (continued)

The Forebrain

- The forebrain surrounds the rostral end of the neural tube. It has two major components:
  - the telencephalon
  - and the diencephalon
- The telencephalon includes most of the two symmetrical cerebral hemispheres that comprise the cerebrum.
  - The cerebral hemispheres are covered by the cerebral cortex
  - and contain the basal ganglia and limbic system.
- The latter two sets of structures are primarily in the subcortical regions of the brain - those located deep within it, beneath the cerebral cortex.

The Forebrain (continued)

Cerebral Cortex

- Cortex means “bark,” and the cerebral cortex surrounds the cerebral hemispheres like the bark of a tree.
- In humans the cerebral cortex is greatly convoluted;
  - these convolutions, consisting of sulci (small grooves; sulcus, singular),
  - fissures (large grooves),
  - and gyri (bulges; gyrus, singular).
- The surface of the cerebral hemisphere is divided into four lobes,
  - named after the bones of the skull that overlie them.
  - The frontal lobe, parietal lobe, temporal lobe, and occipital lobe are visible on the lateral surface.

The Forebrain (continued)

- The central sulcus (fissure of Rolando) divides the frontal lobe from the parietal lobe,
- and the lateral fissure (fissure of Sylvia) divides temporal lobe from the overlying frontal and parietal lobes.
- The cerebral cortex that covers most of the surface of the cerebral hemisphere is called the neocortex.
- The frontal lobes are specialized for planning, execution, and control of movements.
- The primary motor cortex, immediately anterior to the central sulcus (precentral gyrus),
  - contains neurons that participate in the control of movement.

The Forebrain (continued)

- The posterior lobes of the brain (the parietal, temporal, and occipital lobes) are specialized for perception.
- The primary somatosensory cortex lies immediately posterior to the central sulcus on the postcentral gyrus.
- This region of the cerebral cortex receives information about the somatosensory
  - (body senses; touch, pressure, temperature, and pain).
- The primary visual cortex lies at the back of the occipital lobes long the calcarine fissure.
  - As its name implies, it receives visual information.
- The primary auditory cortex lies in the temporal lobes,
  - mostly hidden in the lateral fissure.
- The rest of the neocortex is referred to as association cortex.
The Forebrain (continued)

- The **corpus callosum**, which is the largest commissure (cross hemisphere connection) in the brain.
- The corpus callosum consists of axons that connect the cortex of the two cerebral hemispheres.
- The **limbic system** consists of a set of interconnected structures.
  - The two most important of these structures are the **hippocampus** (sea horse) and the **amygdala** (almond), located next to the lateral ventricle in the temporal lobe.
- The **basal ganglia** are a collection of subcortical nuclei in the forebrain, which lie beneath the anterior portion of the lateral ventricles.
- The basal ganglia are involved in the control of movement.

The Forebrain (continued)

**Limbic System**

- **cingulate gyrus**
- **mammillary body**
- ** fornix**
- **olfactory bulb**
- **septal nucleus**
- **amygdala**
- **temporal lobe**
- **hippocampus**

The Forebrain (continued)

**Basal Ganglia**

The Forebrain (continued)

**Diencephalon**

- The second major division of the forebrain, the **diencephalon**, is situated between the telencephalon and mesencephalon; and it surrounds the third ventricle.
- Its two most important structures are the **thalamus** and the **hypothalamus**.
The Forebrain (continued)

The Thalamus
- The thalamus is located in the dorsal part of the diencephalon.
- It is the structure with two lobes connected by a bridge called the massa intermedia.
- Most neural input to the cerebral cortex is received from the thalamus.
  - much of the cortical surface can be divided into regions that receive projections from specific parts of the thalamus.
- Projection fibers are sets of axons that arise from the cell bodies located in one region of the brain and synapse on neurons located within another region (that is, they project to those regions).

The Forebrain (continued)

Nuclei of the Thalamus
- The thalamus is divided into several nuclei, which are groups of neurons of similar shape.
  - The lateral geniculate nucleus (LGN) receives information from the eyes and sends axons to the primary visual cortex.
  - The medial geniculate nucleus (MGN) receives information from the inner ear and sends axons to the primary auditory cortex.
  - The ventrolateral nucleus receives information from the cerebellum and projects to the primary motor cortex.

The Forebrain (continued)

The Hypothalamus
- The hypothalamus lies at the base of the brain, under the thalamus.
- Although it is a relatively small structure, it is an important one.
  - It controls the autonomic nervous system and the endocrine system
    - and organizes behaviors related to survival of the species;
    - aggression (fighting),
    - food intake (feeding),
    - escape behavior (fleeing),
    - and reproduction (mating).

The Forebrain (continued)

Much of the endocrine system is controlled by hormones produced by cells in the hypothalamus.
- A small but very crucial vascular system interconnects the hypothalamus and the anterior pituitary.
- The hypothalamus also produces the hormones of the posterior pituitary gland and controls their secretion.
The Midbrain

The Mesencephalon
- The mesencephalon surrounds the cerebral aqueduct and consists of two major parts:
  - The **tectum** (roof) is located in the dorsal portion of the mesencephalon.
  - Its principal structures are the **superior colliculi** and **inferior colliculi**.
  - Which appear as four bumps on the surface of the brain stem.
    - The inferior colliculi are a part of the auditory system.
    - The superior colliculi are part of the visual system.

The Midbrain (continued)
- **Tegmentum** (covering) consists of the portion of the mesencephalon beneath the tectum.
  - It includes the rostral end of the reticular formation,
  - The reticular formation is a large structure consisting of many nuclei (over ninety in all).
  - It plays a role in sleep and arousal, attention, muscle tonus, movement, and various vital reflexes.
  - Several nuclei controlling eye movements,
  - The periaqueductal gray matter,
    - The periaqueductal gray matter is so called because it consists mostly of cell bodies of neurons that surround the cerebral aqueduct as it travels from the third to the fourth ventricle.
    - The periaqueductal gray matter contains neural circuits that control species-typical behavior, such as fighting and mating.

The Midbrain (continued)
- **red nucleus,**
- **substantia nigra,**
  - The red nucleus and substantia nigra (black substance) are important components of the motor system.
  - A bundle of axons that arise from the red nucleus constitutes one of the two major fiber systems that bring motor information from the brain to the spinal cord.
  - The substantia nigra contains dopamine-secreting neurons that project to the caudate nucleus.
  - Degeneration of these neurons causes Parkinson's disease.
  - and the ventral tegmental area.

The Midbrain (continued)
- The hindbrain, which surrounds the fourth ventricle, consists of two major divisions:
  - the **metencephalon**
    - which consists of the **pons**
    - and the **cerebellum**
  - and the **myelencephalon**
    - which consists of one major structure, the **medulla oblongata**
  - The cerebellum (little brain) resembles a miniature version of the cerebrum.
  - Damage to the cerebellum impairs standing, walking, or performance of coordinated movements.
  - Cerebellum receives visual, auditory, vestibular, somatosensory information.
The Hindbrain (continued)

- and it also receives information about individual muscular movements being directed by the brain.
- The **pons**, a large bulge in the brain stem, lies between the mesencephalon and medulla oblongata.
- The pons appears to be important in sleep and arousal.
- The medulla oblongata, called the medulla, is the most caudal portion of the brain stem.
- The medulla controls vital functions such as regulation of the cardiovascular system, respiration, and skeletal muscle tonus.  

The Hindbrain (continued)

![Diagram of brain structures](image)