Gross Anatomy and General Organization of the Central Nervous System

Chapter Outline

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A useful way to start studying the brain is to learn some of the vocabulary that refers to its major parts, and to understand in a vague way what they do. These major parts can then serve as reference points to build on in later chapters.

**The Long Axis of the CNS Bends at the Cephalic Flexure**

Most creatures move through the world with their spinal cords oriented horizontally. In humans, the cephalic flexure of the embryonic neural tube persists in the adult brain as a bend of about 80° between the midbrain and the diencephalon, allowing us to walk around upright. Terms like *dorsal* and *ventral*, however, are used as though the flexure does not exist, the CNS is still a straight tube, and we walk around on all fours. The result is that in the spinal cord and brainstem dorsal has the same meaning as posterior, whereas in the forebrain dorsal has the same meaning as superior (Fig. 3-1).

**Hemisecting a Brain Reveals Parts of the Diencephalon, Brainstem, and Ventricular System**

The cerebral hemispheres of humans are so big that they cover over much of the rest of the CNS. The medial surface of a hemisected brain, however, reveals all the major divisions (Fig. 3-2), still arranged in the same sequence as in the embryonic neural tube: cerebral hemisphere-diencephalon-brainstem/cerebellum-spinal cord.

Two fiber bundles interconnect the cerebral hemispheres. The *corpus callosum* interconnects most cortical areas, extending from an enlarged *genu* in the...
frontal lobe through a **body** to an enlarged **splenium** in the parietal lobe. The much smaller **anterior commissure** performs a similar function for parts of the temporal lobes. Beneath the corpus callosum in an accurately hemisected brain is a membrane called the **septum pellucidum**. This is a paired membrane (one per hemisphere) that separates those parts of the lateral ventricles adjacent to the midline (THB6 Figures 3-19 to 3-21, pp. 69 and 70). At the bottom of the septum pellucidum is the **fornix**, a long curved fiber bundle carrying the output of the **hippocampus** (see Fig. 3-6 later in this chapter) from the temporal lobe to structures like the hypothalamus at the base of the brain.

Hemisection passes through the middle of the third ventricle, exposing the thalamus and hypothalamus in its walls (Fig. 3-3). Each **interventricular foramen** connects the third ventricle to the lateral ventricle of that side. The **optic chiasm**, in which about half the fibers in each optic nerve cross the midline, is attached to the bottom of the hypothalamus. The **pineal gland** (part of the diencephalon) is attached to the roof of the third ventricle, near the diencephalon-brainstem junction.

The ventricular system continues through the midbrain as the cerebral aqueduct, then widens into the fourth ventricle of the pons and rostral medulla. The pons is characterized by a large basal portion (**basal pons**) that protrudes anteriorly.

The cerebellum is divided, in one gross anatomical sense, into a midline portion called the **vermis** (Latin for “worm”) and a much larger **hemisphere** on each side. In another gross anatomical sense, the deep **primary fissure** divides the bulk of the cerebellum into an **anterior lobe** and a substantially larger **posterior lobe**. Hence the anterior and posterior lobes have both vermal and hemispheral portions. Finally, there is a small **flocculonodular lobe**. The vermal part (the **nodulus**) can be seen in Fig. 3-3; the **flocculus** can be seen in THB6 Figures 3-16 and 3-17, pp. 65 and 66.

### Named Sulci and Gyri Cover the Cerebral Surface

The surface of each cerebral hemisphere is wrinkled up into a series of **gyri and sulci**, constant from one brain to another in their general configuration but not in their details (THB6 Figure 3-6, p. 58). Four sulci are particularly important for defining the boundaries of cerebral lobes (Fig. 3-4)—the **lateral sulcus** (= **Sylvian fissure**), **circumvolutional sulci** and **central sulcus** (of Rolando) on the lateral surface of the hemisphere, and the **parietooccipital and cingulate sulci** on the medial surface.

Each Cerebral Hemisphere Includes a Frontal, Parietal, Occipital, Temporal, and Limbic Lobe

### Key Concepts

- The **frontal lobe** contains motor areas.
- The **parietal lobe** contains somatosensory areas.
- The **temporal lobe** contains auditory areas.
- The **occipital lobe** contains visual areas.
- The **limbic lobe** is interconnected with other limbic structures buried in the temporal lobe.

The **frontal lobe** is above the lateral sulcus and in front of the central sulcus. The **parietal lobe** is right behind the frontal lobe, extending back to the **occipital lobe** (which is defined by landmarks more easily visible on the medial surface of the hemisphere). The **temporal lobe** is below the lateral sulcus. All four of these lobes continue onto the medial surface of the hemisphere, extending as far as the **limbic lobe**. The limbic lobe is a ring of cortex that encircles the junction between the cerebral hemisphere and the diencephalon. In addition, the **insula**, not part of any of the preceding lobes, is buried in the lateral sulcus, covered over by parts of the frontal, parietal, and temporal lobes (see Fig. 2-6; and see THB6 Figure 3-8, p. 60).
The lateral surface of the frontal lobe is made up of the precentral gyrus and the superior, middle, and inferior frontal gyri (Fig. 3-5). The precentral gyrus is located immediately in front of the central sulcus and most of it is primary motor cortex (i.e., much of the corticospinal tract originates here). The other three are broad, parallel gyri that extend anteriorly from the precentral gyrus. The precentral and superior frontal gyri extend over onto the medial surface of the frontal lobe, where they end at the cingulate sulcus. The inferior (or orbital) surface of the frontal lobe is made up of a series of unnamed orbital gyri together with gyrus rectus, which is located adjacent to the midline.

The major named gyrus of the parietal lobe is the postcentral gyrus. The postcentral gyrus corresponds to primary somatosensory cortex (i.e., ascending somatosensory pathways terminate most heavily here) and, like the precentral gyrus, extends over onto the medial surface of the parietal lobe. The rest of the lateral surface is occupied by the superior and inferior parietal lobules, separated by the deep intraparietal sulcus.

The temporal lobe is covered by four long, parallel gyri. The superior, middle, and inferior temporal gyri are exposed on the lateral surface. The inferior temporal gyrus extends around onto the inferior surface and is followed by the occipitotemporal gyrus. Most primary auditory cortex is located in transverse temporal gyri in the wall of the lateral sulcus; it extends laterally to occupy a small portion of the superior temporal gyrus.

The occipital lobe has no gyri with commonly used names. However, its medial surface is bisected by the calcarine sulcus. Primary visual cortex occupies the walls of this sulcus and extends out onto the medial surface.

The major components of the limbic lobe are the cingulate and parahippocampal gyri. The cingulate gyrus curves around adjacent to the corpus callosum, interposed between it and the frontal and parietal
lobes. Near the splenium of the corpus callosum the cingulate gyrus is continuous with the parahippocampal gyrus, which proceeds parallel to the occipitotemporal gyrus. At its anterior end the parahippocampal gyrus folds back on itself to form a bump called the uncus. The parahippocampal gyrus received its name because it is continuous with a cortical region called the hippocampus, which is rolled into the interior of the hemisphere and visible only in sections (see Fig. 3-6).

Each region of the diencephalon contains the term “thalamus” in its name. The epithalamus includes the pineal gland and a few other small structures. The subthalamus, completely surrounded by other parts of the CNS, includes an important component of the basal ganglia (see Chapter 19). The thalamus and hypothalamus form the walls of the third ventricle. Most pathways headed for the cerebral cortex involve a synapse in the thalamus (see Chapter 16), which controls access to the cortex. The hypothalamus (see Chapter 23) controls the autonomic nervous system and gets involved in various aspects of drive-related behavior.

The Diencephalon Includes the Thalamus and Hypothalamus

Key Concepts

The thalamus conveys information to the cerebral cortex.
The hypothalamus controls the autonomic nervous system.

Most Cranial Nerves Are Attached to the Brainstem

The brainstem has three longitudinal subdivisions: the midbrain (continuous with the diencephalon), pons, and medulla (continuous with the spinal cord). Most of the brainstem’s general functions you could probably guess. Cranial nerves III-XII attach here (THB6 Figure 3-17, p. 66), and the brainstem is concerned with processing their incoming information (and sending it on to the thalamus), with cranial nerve reflexes (e.g., you blink when something touches your cornea), and with getting motor commands out through cranial nerves. A second general kind of function has to do with the fact that the brainstem is interposed between the cerebral and the spinal cord. That means that a spinothalamic tract or a corticospinal tract would need to traverse the brainstem. These are usually referred to as the long tract functions of the brainstem. Finally, and one which you wouldn’t necessarily have guessed, the brainstem has some more global functions of its own. For example, it’s got some built-in circuitry (the Ascending Reticular Activating System) that regulates our state of consciousness and is central to the sleep-wake cycle.

The Cerebellum Includes a Vermis and Two Hemispheres

There are several different ways to divide up the cerebellum (see Chapter 20), but subdividing it into longitudinal strips (i.e., perpendicular to the mostly transverse sulci and fissures) corresponds best to the way the cerebellum is wired up functionally. On a gross level, the whole cerebellum can be divided into a longitudinal midline strip called the vermis (mostly concerned with coordinating trunk movements), flanked on each side by a cerebellar hemisphere (mostly concerned with coordinating limb movements).

Sections of the Cerebrum Reveal the Basal Ganglia and Limbic Structures

Key Concepts

Many parts of each cerebral hemisphere are arranged in a C shape.
The caudate nucleus, putamen, and globus pallidus are major components of the basal ganglia.
The amygdala and hippocampus are major limbic structures.

A number of forebrain structures are completely enveloped by the cerebral hemispheres and cannot be seen without sectioning the brain (Fig. 3-6). Coronal sections reveal the general arrangement of these structures; horizontal sections help to reveal their extent.

Two major components of the basal ganglia, the putamen and the globus pallidus (referred to together as the lenticular nucleus), lie beneath the insula. Another major forebrain component of the basal ganglia, the caudate (“having a tail”) nucleus, follows the wall of the lateral ventricle. Like the lateral ventricle, the caudate nucleus is C-shaped. It extends from an enlarged head in the frontal lobe, through a body in the frontal and parietal lobes, to a thin tail in the temporal lobe.

A thick bundle of fibers called the internal capsule runs between the lenticular nucleus and the thalamus; it continues anteriorly between the lenticular nucleus...