Medical Neuroscience | Tutorial Notes

Medial Surface of the Brain

MAP TO NEUROSCIENCE CORE CONCEPTS[1]

NCC1. The brain is the body's most complex organ.

LEARNING OBJECTIVES

After study of the assigned learning materials, the student will:

1. Demonstrate the four paired lobes of the cerebral cortex and describe the boundaries of each.
2. Sketch the major features of each cerebral lobe, as seen from the medial view, identifying major gyri and sulci that characterize each lobe.

NARRATIVE

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Overview

When you view the lateral aspect of a human brain specimen (see **Figures A3A** and **A10**[2]), three structures are usually visible: the **cerebral hemispheres**, the **cerebellum**, and part of the **brainstem** (although the brainstem is not visible in the specimen photographed in lateral view for **Fig. 1** below). The spinal cord has usually been severed (but we'll consider the spinal cord later), and the rest of the subdivisions are hidden from lateral view by the hemispheres. The diencephalon and the rest of the brainstem are visible on the medial surface of a brain that has been cut in the midsagittal plane. Parts of all of the subdivisions are also visible from the ventral surface of the whole brain. In this set of tutorials, you will find video demonstrations (from the brain anatomy lab) and photographs (in the tutorial notes) of these brain surfaces, and sufficient detail in the narrative to appreciate the overall organization of the parts of the brain that are visible from each perspective. As you work through this text and if you have access to an interactive digital atlas of the human brain, such as ***Sylvius4 Online***, find the structures and regions that are described here[3].

The **cerebral hemispheres** are especially large in humans. They are entirely covered by a 2–3-mm thick layer of cells and cellular processes called the **cerebral cortex**. The surface of each hemisphere is highly

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1 Visit **BrainFacts.org** for *Neuroscience Core Concepts* (©2012 Society for Neuroscience) that offer fundamental principles about the brain and nervous system, the most complex living structure known in the universe.

2 Figure references to Purves et al., *Neuroscience, 5th Ed.*, Sinauer Assoc., Inc., 2012. [click here]

3 To do so, launch ***Sylvius4 Online*** and go to **Photographic Atlas**, then select one of the atlas filters, such as **Gyri**, **Lobes**, or **Sulci and Fissures**.

infolded; the ridges thus formed are known as **gyri** (singular: gyrus) and the valleys are called **sulci** (singular: sulcus) or **fissures** (if they are especially deep). The appearance of the sulci and gyri varies somewhat from brain to brain. (As you might guess, each one has its own name, but it is necessary to become familiar with only a few of them.) The hemispheres are conventionally divided into lobes named for the bones of the skull that overlie them, namely the **frontal**, **parietal**, **occipital** and **temporal lobes** (see **Figure A3**).

Medial aspect of the brain

When the brain is cut in the midsagittal plane, all of its subdivisions are visible on the cut surface (see **Fig. 1** below). Just as in the embryo, the subdivisions are arranged as though they were stacked on top of one another, with the hemispheres bulging out laterally at the top and the cerebellum bulging out dorsally and laterally about half-way up the stack. The cerebral hemisphere is still the most prominent part of the brain in this view.

Beginning from the superior margin of the hemisphere, the most anterior and dorsal gyral formation is simply the medial continuation of the superior frontal gyrus. A long, almost horizontal sulcus, the **cingulate sulcus**, extends across the medial surface of the frontal and parietal lobes just below the superior frontal gyrus. The prominent gyrus below it, the **cingulate gyrus**, along with the cortex adjacent to it, wraps around the **corpus callosum** and lateral ventricle into the temporal lobe; this extended rim (Latin, *limbus*) of cortex is sometimes called the 'limbic lobe'. These cortical areas—and the subcortical areas connected to them, together with additional telencephalic structures in the temporal lobe and ventral frontal lobe—are often referred to as the 'limbic system'. However, this so-called system (so-called primarily for historical reasons) is not unimodal, as the term 'system' implies. Rather, the limbic 'system' is involved in the regulation of visceral motor activity, emotional experience and expression, olfaction, and memory, to name some of its better understood functions (see tutorial on ***The Amygdala and Hippocampus*** for more information on the anatomy of the limbic forebrain).

> Many authors now advocate dismissal of the term "limbic system" as an outmoded and misleading concept, and rather emphasize the diverse functions associated with the various components of expansive networks in the ventral-medial forebrain.

The caudal portion of the superior frontal gyrus forms the **paracentral lobule**, as it joins the medial continuation of the pre- and post-central gyri. Just as on the lateral surface of the hemisphere, on the medial face of the hemisphere the frontal lobe extends from the central sulcus forward. At the inferior margin of the frontal lobe is the medial aspect of an inferior gyrus called the **gyrus rectus** (see 'ventral view' below), and a small cortical division, called the **subcallosal area**, just below the genu ("knee") of the corpus callosum. This subcallosal area has become an important target for deep brain stimulation in the treatment of various psychiatric diagnoses, including major depressive disorder.

Locate again the medial terminus of the central sulcus in the paracentral lobule. That sulcus marks the anterior boundary of the parietal lobe, at least its dorsal portion; the rest of the anterior boundary follows the posterior limit of the cingulate gyrus. Now, about half-way between the central sulcus and the posterior pole of the hemisphere, note the presence of a prominent sulcus running in nearly the coronal plane (actually, it is usually angled posteriorly from its inferior to superior ends) (see **Figure A3B** and **A12**). This sulcus is the **parieto-occipital sulcus** and it divides the parietal and occipital lobes. The entire gyral formation visible in this view of the parietal lobe is called the **precuneus gyrus** (its name will make sense as you read on).

Now, consider the brain from its dorsal surface. Can you now appreciate where the parieto-occipital sulcus intersects the longitudinal fissure? In the dorsal view, there is often a rather prominent furrow where this sulcus widens at the dorsal midline. Keep the location of that intersection in mind; cortex posterior to this location is part of the occipital lobe (as our exploration of the medial parietal surface should make clear) and the gyral formation between this intersection and the central sulcus is, of course, the parietal lobe. By convention, much of the parietal lobe visible in the dorsal view, excluding the postcentral gyrus, is called the superior parietal lobule, which is a continuation of the precuneus gyrus onto the dorsal-lateral surface of the hemisphere.

So much for a brief consideration of the dorsal view of the brain; let's return to the medial (midsagittal) surface and consider the posterior aspect of the hemisphere.

To appreciate the medial parietal and occipital lobes, reorient yourself to the parieto-occipital sulcus (see **Figure A12**). Next, recognize the **calcarine sulcus**, which intersects the parieto-occipital sulcus at nearly a right angle and extends typically to the occipital pole of the hemisphere. We'll come back to this part of the brain when we study the visual system. For now, notice the "tongue"-like gyral structure that forms the inferior bank of the calcarine sulcus, and the "wedge"-shaped gyrus that forms its superior bank. Thankfully, the formal terms for these gyri mean just that:

- **Lingual gyrus**; "lingual" (Latin, *lingua*) means "tongue"
- **Cuneus gyrus**; "cuneus" (Latin, *cuneus*) means "wedge"

The precuneus gyrus, of course, lies just in front of (anterior to) the cuneus gyrus. Note that the precuneus gyrus is really a medial extension of the superior parietal lobule. But on the medial face of the hemisphere, we call this the precuneus gyrus (which you can now remember as the gyrus in front of the "wedge").

The occipital lobe serves vision. The cortex in the banks of the calcarine sulcus is the first division of the occipital lobe to receive information derived from the retinas (relayed via the thalamus); hence it is called the **primary visual cortex** (also called the "striate cortex" because of a conspicuous stripe or striation that runs through the middle of the cortex in the banks of the calcarine sulcus). Damage to this part of the occipital lobe can result in blindness for some portion of the visual field. Surrounding occipital regions—and posterior parts of the parietal and temporal lobe—process increasingly more complex aspects of vision (e.g., the location, color, form and motion of objects, and recognition of their identity). Localized injury or disease affecting one of these "higher-order" or associational visual areas can result in remarkably specific impairments of visual function, such as the inability to appreciate motion or recognize a familiar face (more on such visual functions in later class sessions).

Three prominent fiber bundles (i.e., bundles of axons extending from one part of the brain to another) associated with the cerebral hemispheres can be seen from the medial view (see **Figure A12** and **Fig. 1** below). These are:

1. the **corpus callosum**, a huge structure that contains 100s of millions of axons and connects the cortices of the two hemispheres, except for cortex in the anterior temporal and ventral (orbital) frontal lobes;
2. the **anterior commissure**, a much smaller bundle of axons that connects cortex in the anterior temporal and ventral frontal lobes, in addition to other ventral telencephalic structures; and
3. the **fornix**, a large fiber bundle that connects the hippocampus (a part of the temporal lobe that you haven't seen yet) with the hypothalamus and related ventral, midline structures.

In the view shown in **Fig. 1**, the axons in the corpus callosum and anterior commissure are running perpendicular to the plane of the page, and the visible fibers of the fornix are running within the plane of the page.

The other subdivisions of the brain, all of which can be seen in **Fig. 1** (labeled in **Figure A12**), are as follows:

1. The **diencephalon** consists of four parts arrayed from dorsal to ventral. A. The epithalamus is a small strip of tissue to which is attached the **pineal gland**. B. The **thalamus**, the largest part, relays most of the information going into the cortex from other parts of the brain and spinal cord. The thalamus consists of many further subdivisions, some of which you will learn about in later tutorials. C. The **subthalamus**, a small area concerned with control of motor and cognitive functions, cannot be seen from this view since it does not extend all the way to the midline (this small diencephalic region is a frequent target of deep brain stimulation for control of movement disorders). D. The **hypothalamus**, a small but crucial part of the brain, is devoted to the control of homeostasis and a rich variety of physiological activities that are essential for survival and reproduction. It is bounded rostrally by the optic chiasm, and its caudal extremity is made up of swellings known as the mammillary bodies. On some brain specimens, the pituitary gland or part of its stalk (the infundibulum) may still be attached to the ventral surface of the hypothalamus.
2. The **mesencephalon** or **midbrain** lies just caudal to the thalamus. Prominent landmarks that can be seen on the dorsal surface of the midbrain are the **superior** and **inferior colliculi**. They are concerned with oculomotor function and postural adjustments (superior colliculi) and audition (inferior colliculi). The other prominent external feature of the midbrain, the cerebral peduncles, cannot be seen very well from this view as they do not quite reach the midline (we will return to them in another tutorial).
3. The **pons** is next as we proceed caudally. It would be difficult to miss the pons because of the massive enlargement on its ventral surface. (Pons means 'bridge'; the enlargement is made up of cells with transversely oriented axons that cross the midline and could be said to form a bridge across the base of the brainstem.) A further feature that identifies the pons is its attachment to the cerebellum which lies dorsal to it. The cerebellum plays a crucial role in the coordination of movement.
4. Finally, the most caudal subdivision of the brainstem is the **medulla oblongata** (or "medulla" for short). From the medial view shown in **Fig. 1**, it looks relatively featureless. We will explore its external landmarks further on the ventral view of the brain in another tutorial.

Fig 1. Medial surface of the hemisected human brain. This figure is not labeled so that you may refer to it for review; see Figure A12 for illustrated and labeled views of the same hemisphere. (Image from ***Sylvius4 Online***)

All components of the ventricular system, except perhaps for the lateral ventricles, can be seen on a typical medial surface of the brain cut in the midsagittal plane. In **Fig. 1**, the **lateral ventricle** is visible in this hemisphere because the septum pellucidum has been dissected away; this is a very thin layer of tissue that forms the medial wall separating the two lateral ventricles. The **third ventricle** forms a narrow space in the midline region of the diencephalon, between the one that you see and the one that has been cut away. The communication of the third ventricle with the lateral ventricle is through a small hole, the **interventricular foramen** (or foramen of Monroe), at the anterior-dorsal end of the third ventricle. The third ventricle is continuous caudally with the **cerebral aqueduct** which runs through the midbrain. At its caudal end, it joins the **fourth ventricle**, a large space in the dorsal pons and medulla. The fourth ventricle narrows caudally to join the **central canal**. We will take a closer look at the ventricles when we inspect cross-sections through the forebrain in a later tutorial.

STUDY QUESTIONS

Q1. Which of the following **external spaces** provides a major landmark dividing one cerebral lobe from another?

A. superior frontal sulcus
B. parieto-occipital sulcus
C. calcarine sulcus
D. cingulate sulcus
E. lateral (Sylvian) fissure

Q2. Which of the following pairs of terms identify **spaces** that are roughly PERPENDICULAR (orthogonal) in the human brain (give or take 30 degrees or so)?

A. calcarine sulcus and central sulcus
B. precentral sulcus and postcentral sulcus
C. superior temporal sulcus and inferior temporal sulcus
D. superior frontal sulcus and intraparietal sulcus
E. central sulcus and the parieto-occipital sulcus