5. The Brain and the Cranial Nerves

Full dissection of the brain is beyond the scope of this manual. We will, however, note the major structures that are important to students of speech as well as the larger structures and landmarks of the brain. The brain is dissected before dissecting the larynx because the orientation of the larynx dissection requires a capless skull.

Working from the outside in, there are three layers of protective tissue, known as **meninges**, which cover the brain, seen in figure 5.1. They are: (1) the **dura mater**, (2) the **arachnoid mater,** and (3) the **pia mater**. The dura mater is a very tough and thick membrane that adheres to the inner surface of the skull. Normally, the dura and arachnoid mater are in very close contact, but after death, the brain may shrink, causing the arachnoid mater to separate away from the dura mater. The arachnoid mater covers the sub-arachnoid space, through which run many of the vessels supplying blood to the surface of the brain. The pia mater is deep to the sub-arachnoid space and separates the sub-arachnoid space from the surface of the brain. The pia mater adheres closely to the entire surface of the brain, running into all its fissures.

(a)

(b)

skull   skin

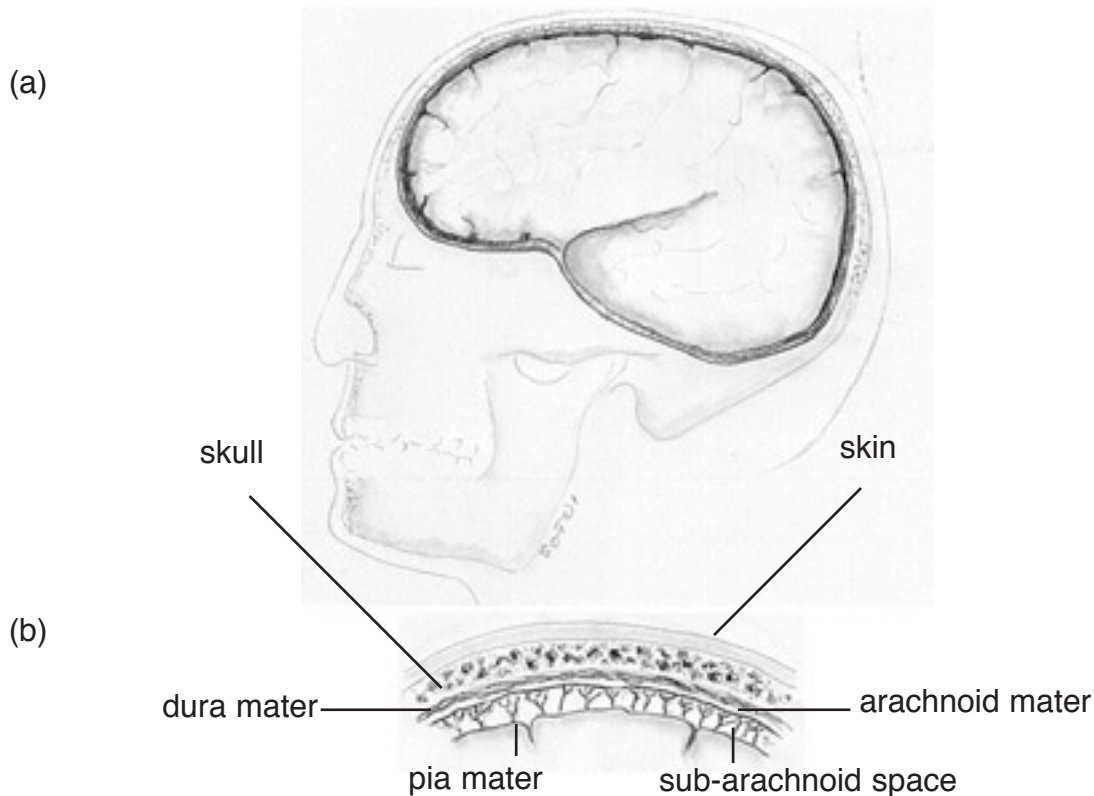dura mater   arachnoid mater

pia mater   sub-arachnoid space

Figure 5.1. (a) The location of the brain; (b) detail of the superior part of the skull, showing the protective layers of the brain, the meninges

The dura mater also delineates the major substructures of the brain with its folds known as **falces** (falx, singular, Latin for 'scythe'). These infoldings of the dura mater cause the brain within the skull to look like half a walnut in its shell. Three of the major falces of the dura mater are: the **falx cerebri**, the **falx cerebell**i and the t**entorium cerebelli**. The falx cerebri and

1

the falx cerebelli divide the brain sagitally (separating left and right); the tentorium cerebelli divides the brain transversely (separating top and bottom).
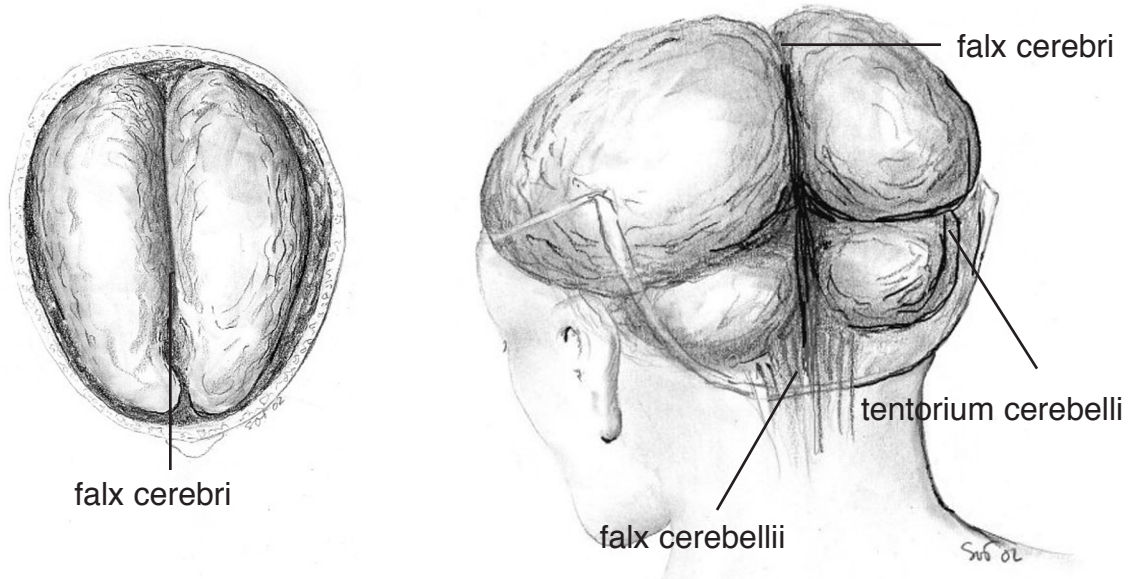

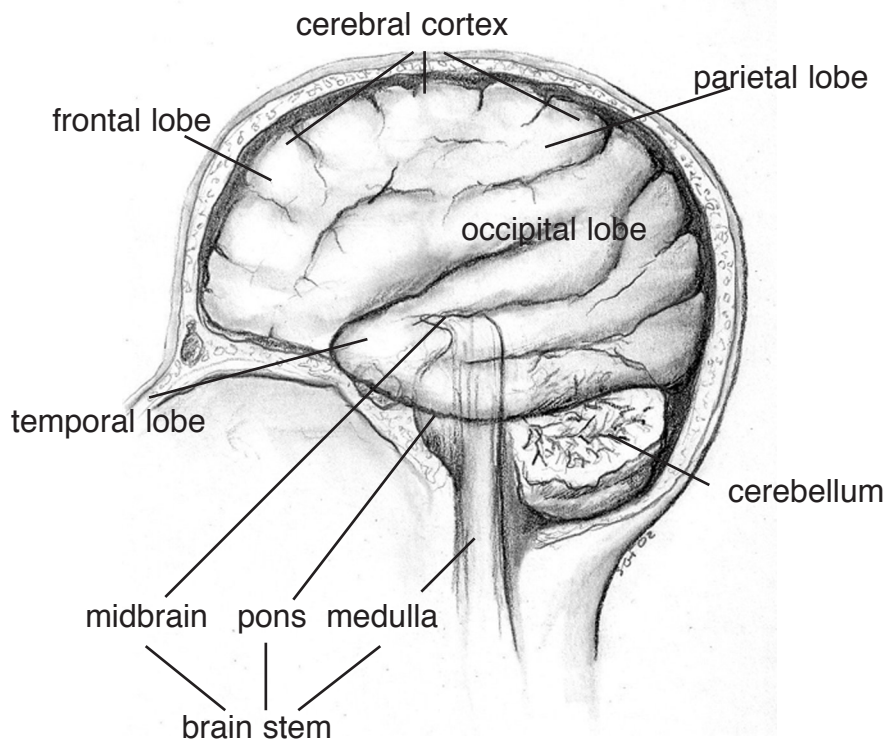Figure 5.2. The three principal falces of the brain.

Figure 5.3. Major substructures of the brain.

The brain has several major substructures, some of which are shown in figure 5.3. The **brainstem** is the lowest part of the brain where it connects to the spinal cord. The brainstem

2

may be divided into the **midbrain**, **pons** and **medulla**. The **cerebellum** is the lower back portion of the brain. The **cerebrum** is the main portion of the brain, and what we commonly think of as "the brain". The outer layer of gray matter on the cerebrum is known as the **cerebral cortex**. The brain is divided into two hemispheres, one of which (usually the left) is dominant in the processing of speech. The two hemispheres are connected by a bundle of fibers called the **corpus callosum**. The brain is further divided into six lobes. The four major lobes, named for the bones of the skull with which they are associated, are: the **frontal**, **parietal**, **occipital** and **temporal** lobes. The brain can also be described in terms of its "hills" and "valleys". The hills are called gyri (singular, gyrus) and the valleys that separate the hills are called **sulci** (singular, sulcus). A very deep valley can be called a fissure, although sulcus and fissure are often used interchangeably.

Most of what we know about the function of individual portions of the brain comes from correlating brain damage with dysfunctions in the patient, however the evidence is not always very clear. The skull provides strong protection to the brain, so any blow to the skull strong enough to damage the brain is likely to affect a wide portion of the brain, rather than a single, small area. Similarly, strokes and gunshot wounds generally affect wide areas of the brain. Finally, every brain, like every body, is different from all others. For these reasons, sources disagree about the exact location of the major language centers of the left hemisphere.

Figure 5.4 shows some of the landmarks and structures of interest that we will be pointing out in the dissection guide.
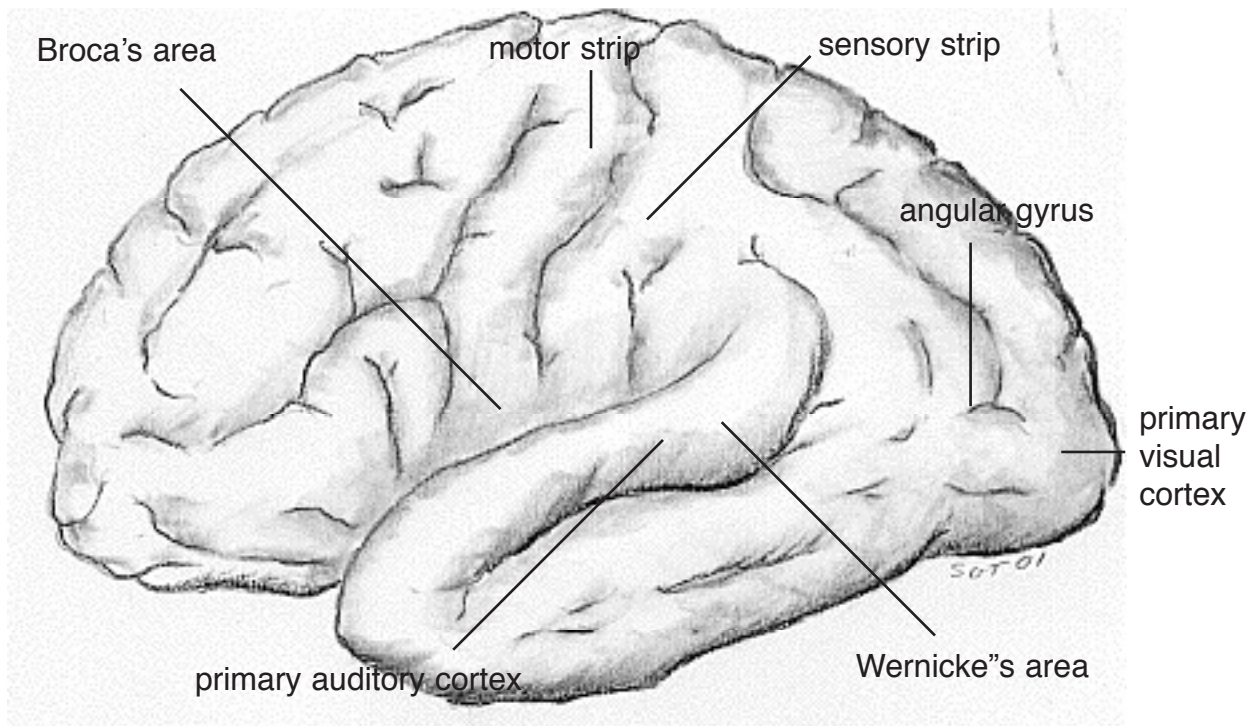

Figure 5.4. Some landmarks and structures of linguistic interest in the brain.

Brocas's area, on the inferior portion of the frontal lobe, is associated with speech production.

Wernicke's area, just below the lateral fissure on the temporal lobe, is associated with

speech comprehension.

The **sensory strip**, posterior to the central sulcus, controls the five senses, including hearing.

The **motor strip**, anterior to the central sulcus, controls all muscle movement, including those necessary for speech.

The **angular gyrus**, located in the left temporal lobe, controls speech comprehension and letter recognition.

The **primary auditory cortex,** located in the temporal lobe, processes sounds.

The **primary visual cortex,** located in the occipital lobe, processes visual information. It is important for sign language and visual processing of speech by listeners.

Dissection

Caution: Wear a double set of gloves when handling brain and nervous system tissue. There are viruses which live in the central nervous system that are not killed by formaldehyde or other fixatives. These can be transmitted through cuts or microscopic cracks in your skin. If you cut or puncture your gloves, change them immediately.

1. Removing the scalp

   Prop the head of the cadaver up on a board.

   Make a preliminary incision with a scalpel approximately 1 cm superior to the ears and eyebrows, completely encircling the skull.

   Reflect and remove the area of the skin thus delineated, and remove as much as possible of the osseous membrane below the skin. Removing the membrane will help to keep the saw from slipping when cutting through the skull.

Figure 5.5. Removing the scalp. The head is resting on a block.

2. Removing the skull cap

Mark the skull with a pen along a line just above the incision line that was used to remove the scalp.

Cut along this line with an autopsy saw or a bone saw. Begin by cutting through the frontal bone (the bone at the forehead) laterally to the temporal bone (just above the ear), as illustrated in figure 5.6. Then, turn the cadaver over, and cut from the temporal bone medially through the occipital bone (the bone above the neck).
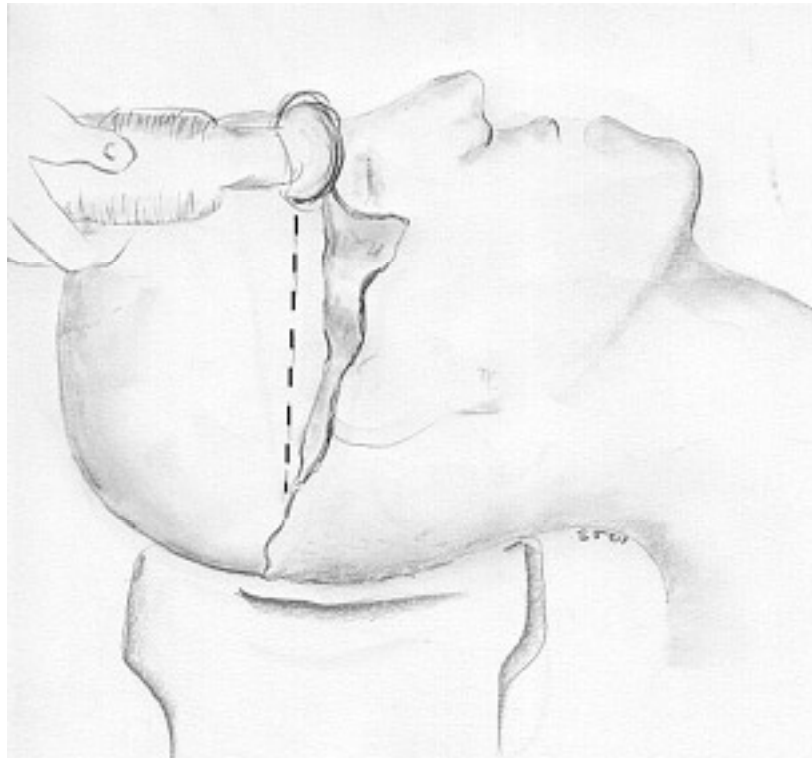

Figure 5.6. Removing the skull cap.

Take a mallet and chisel and remove any last bits of bone tissue that are holding the skullcap on, as shown in figure 5.7

Pry the skullcap free. When you lift the skullcap free, if you have not cut through the dura mater while making the incision, you will probably feel quite a bit of resistance. The dura mater may come off with the skullcap or remain on the brain.
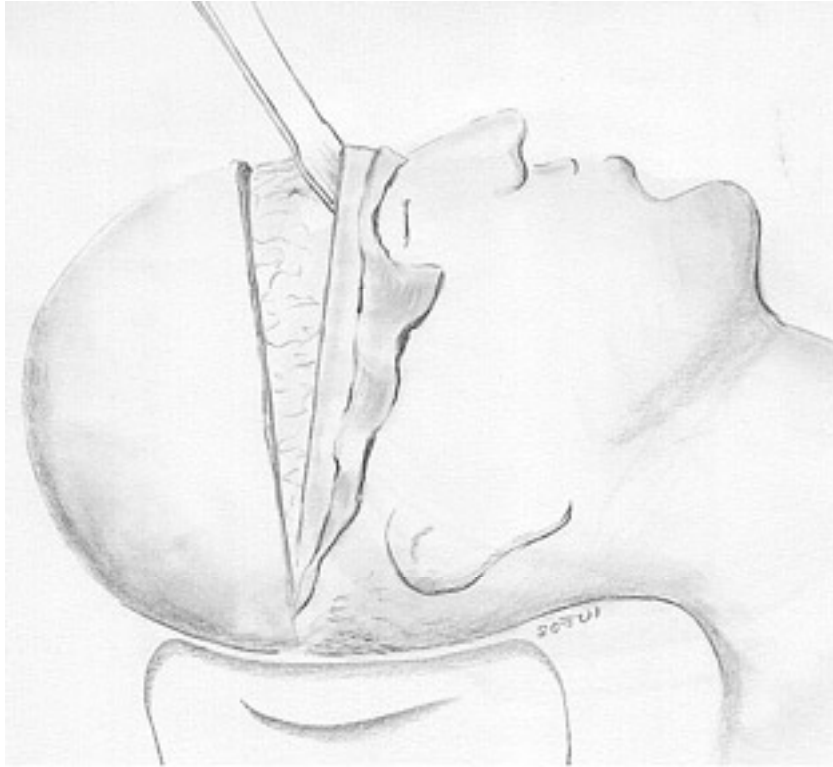
Figure 5.7. Using a chisel to remove the skull cap

3. Removing the meninges

    First remove any remaining dura mater.

    Puncture the dura mater with a scalpel. Then cut through the dura mater with a pair of scissors, following the sectioned edge of the skull cap. Make a complete circle around the opening of the skull (Figure 5.8). Gently lift up one side of the layer of the dura mater and observe the brain inside. At this time, you can observe the arachnoid covering the brain and may be able to see the fissured surface of the brain.

    Determine how well the brain has been fixed. When formalin is pumped into the cadaver, it does not necessarily penetrate all of the extremities. The brain is often insufficiently fixed. If this is the case, it will be soft and pink. To fix an unfixed brain keep it in a container of formalin after it has been removed from the skull.

    If the brain is well-fixed, you may have to remove the arachnoid membrane and some of the blood vessels which run through the sub-arachnoid space in order to better observe the fissures and the sulci of the brain. If the brain is not fixed, the arachnoid and pia mater will be nearly transparent, and it is best to leave them intact.
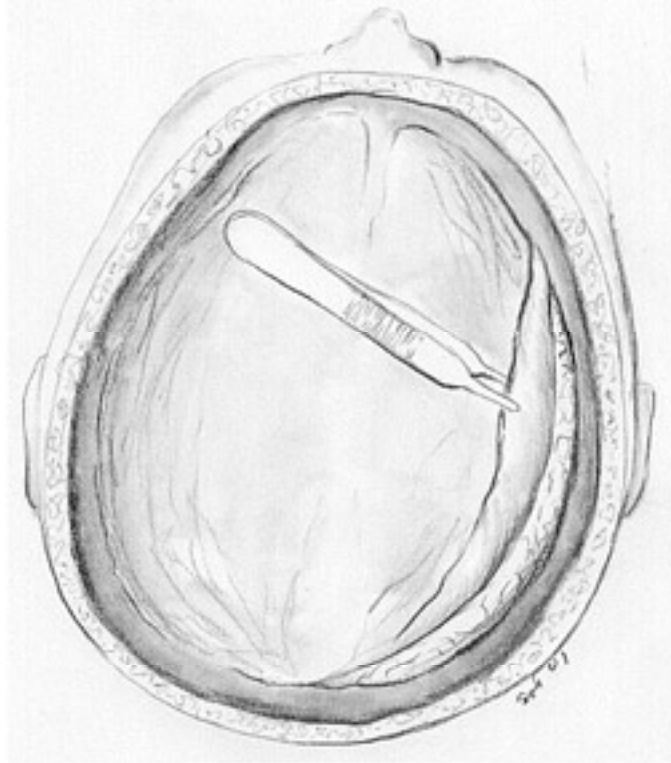
Figure 5.8. Incision and reflection of the dura mater.

4. Observing the general structure of the brain

Locate the interhemispheric fissure, or longitudinal fissure, which separates the right and left hemispheres. Within the interhemispheric fissure is an extension of the dura mater called the falx cerebri.

Reflect back the falx cerebri at its anteroinferior border (near the forehead) with a a scalpel. This is only necessary to do if the dura mater has remained attached to the brain.

5. Removing the occipital bone

Remove a trapezoidal wedge of skin from the occiput (the back of the skull), starting four or five centimeters posterior to the ear and extending downward one or two centimeters past the base of the neck to a point about three centimeters lateral to the mid-line on both sides. The object is to allow you to remove part of the bone as shown in figure 5.9

Remove as much of the fatty and muscular tissue from this area as possible. This will make it easier to cut the bone

Cut from the edge of the open skull to the foramen magnum (the large hole containing the spinal cord) with an autopsy saw. Pry off the wedge of occipital bonewith a chisel, detaching it from the dura mater underneath.

Locate the tentorium cerebelli, the fold of dura mater that projects horizontally between the occipital lobes of the cerebrum and the cerebellum. Cut and remove the tentorium cerebelli. Observe the finely fissured lobes of the cerebellum underneath it. Note the different texture of the tissue of the cerebellum, compared to the cerebrum.
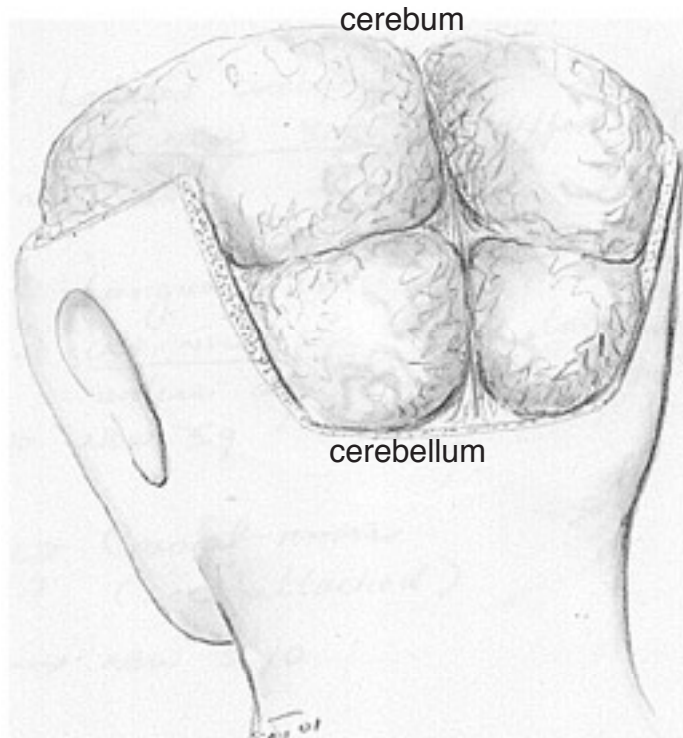
cerebum

cerebellum

Figure 5.9. Trapezoidal excision to expose the posterior brain..

Locate the falx cerebelli between the two lobes of the cerebellum and remove them.

At this point you should have removed all the dural reflections of the brain, so that it looks somewhat like a half walnut in its shell. Look carefully at the brain as it sits in the cranial cavity. Observe the lobes of the brain and how the cranial cavity envelopes it in a bony protective case.

6. Cutting the spinal cord and removing the brain

Locate the top of the spinal cord in the foramen magnum. Use a sharp scalpel blade to cut through the spinal cord at the lowest possible level down the neck, making sure that you cut the arteries that surround the spinal column, as well.

Locate the frontal lobes of the brain.

Lift the frontal lobes up from the front out of the skull, carefully and slowly. Take your time and gently pull the brain backwards, while cutting all the cranial nerves and arteries that are resisting your pull. If you do not cut them, the brain will tear as you reflect it backwards. Attempt to identify each of the cranial nerves as you cut it. Once you have severed all the arteries and nerves, the entire brain should pull free.

Remove the brain and observe the empty cranial cavity. The cranial cavity is composed of three major fossae (shallow depressions; Latin 'ditch'):

the anterior fossa supports the frontal lobe;

the middle fossa supports the temporal lobe

the posterior fossa supports the cerebellum,

Observe how the three fronal lobes sit in the their respective cranial fossae.

7. Locating structures of linguistic interest in the brain

Hold the brain with gloved hands and spend a moment gently exploring the various lobes, gyri and fissures with your fingers. Compare what you see with figures 5,2. 5.3 and 5.4.

Locate the lateral fissure and central sulcus. These may be more or less difficult to identify depending on the brain. The lateral fissure is the most prominent horizontal fissure on either hemisphere. The central sulcus is the most prominent vertical fissure extending superiorly from the lateral fissure.

Identify the frontal, parietal, temporal, and occipital lobes. Use the lateral fissure and the central sulcus to help pick out these particular lobes. The lateral fissure is the fissure that separates the temporal from the parietal and frontal lobes.

Gently separate the two hemispheres and look into the longitudinal fissure. Within the fissure is the corpus callosum, a large bundle of fibers which connects the two sides of the brain.

Locate the following structures and landmarks in the brain:

The motor strip on the frontal lobe just anterior to the central sulcus.

The sensory strip, just posterior to the central sulcus on the parietal lobe. Most of the motor control and sensory input for one side of the body is mediated by activity in the associated gyrus on the opposite side of the brain.

Broca's area on the inferior frontal gyrus just in front of the motor strip.

The primary auditory cortex on both hemispheres of the brain. The primary auditory cortex consists of the gyri on the superior portion of the temporal lobe, just below the lateral fissure.

Wernicke's area on the left hemisphere. Wernicke's area is part of the auditory cortex in the posterior region of the temporal lobe.

The occipital lobe on the posterior aspect of the brain. The occipital lobe and related structures are not as clearly delineated by anatomical landmarks as the other lobes and areas of the brain, so location is likely to be approximate.

The primary visual cortex on the posterior portion of the occipital lobe, at the very back of the brain.

The angular gyrus located on the anterior portion of the occipital lobe.

Locating the nerves

There are twelve cranial nerves which exit from the brainstem (figure 5.10). The cranial nerves relevant to speech are the fifth (trigeminal), seventh (facial), eighth (vestibulocochlear), ninth (glossopharyngeal), tenth (vagus), and twelfth (hypoglossal). Depending on the cadaver, it
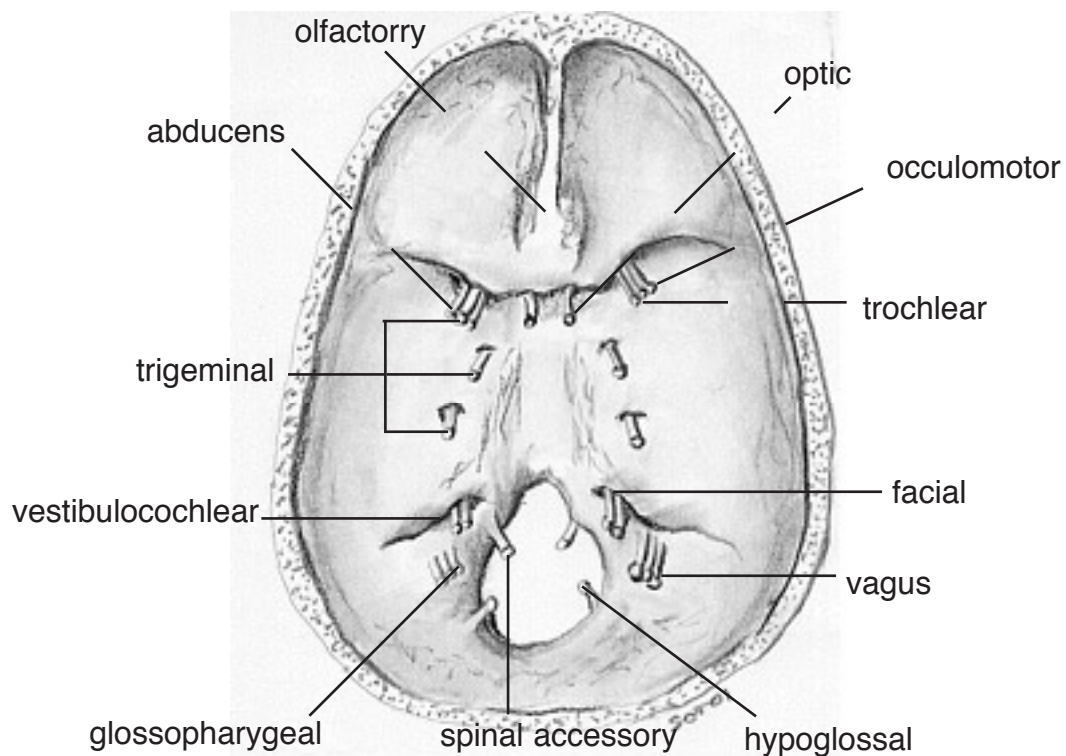
Figure 5.10. The cranial nerves and associated foramina, as seen within the skull cavity (brain removed and cranial nerves severed, superior view). Nerves not relevant to speech are indicated with dotted lines.

may be easier to locate some of the nerves on the brain and some of them on the interior surface of the skull. The two easiest nerves to locate are not speech related, the first (olfactory) and the second (optic). Use them as reference points for locating the other nerves.

Table of Cranial Nerves and Their Functions

(nerves relevant to speech in bold)

Number	Name	Function
I	Olfactory	Smell.
II	Optic	Vision.
III	Oculomotor	Motor control to extraocular muscles (controls eye movements).
IV	Trochlear	Motor control to extraocular muscles (controls eye movements).
V	**Trigeminal**	Sensory connections to face, soft and hard palate, nasopharynx, and anterior 2/3 of tongue. Motor connections to lateral and medial pterygoid, temporalis, masseter, anterior belly of digastric, mylohyoid and tensor palatini.
VI	Abducens	Motor control to extraocular muscles (controls eye movements).
VII	**Facial**	Sensory connections to taste from anterior 2/3 of tongue. Motor control to muscles of facial expression, posterior belly of digastric and stylohyoid.
VIII	**Vestibulocochlear**	Hearing and balance.
IX	**Glossopharyngeal**	General sensory and taste sensation from posterior 1/3 of tongue. Motor control to stylopharyngeus.
X	**Vagus**	General sensory from pharynx and larynx. Motor control to cricothyroid, levator palatini, palatoglossus, palatopharyngeus, salpingopharyngeus and all intrinsic muscles of the larynx.
XI	Spinal accessory	Motor control to sternocleidomastoid and trapezius.
XII	**Hypoglossal**	Motor control to genioglossus, styloglossus, hyoglossus and intrinsic muscles of the tongue.