A Laboratory Manual for the Dissection of the Sheep Brain

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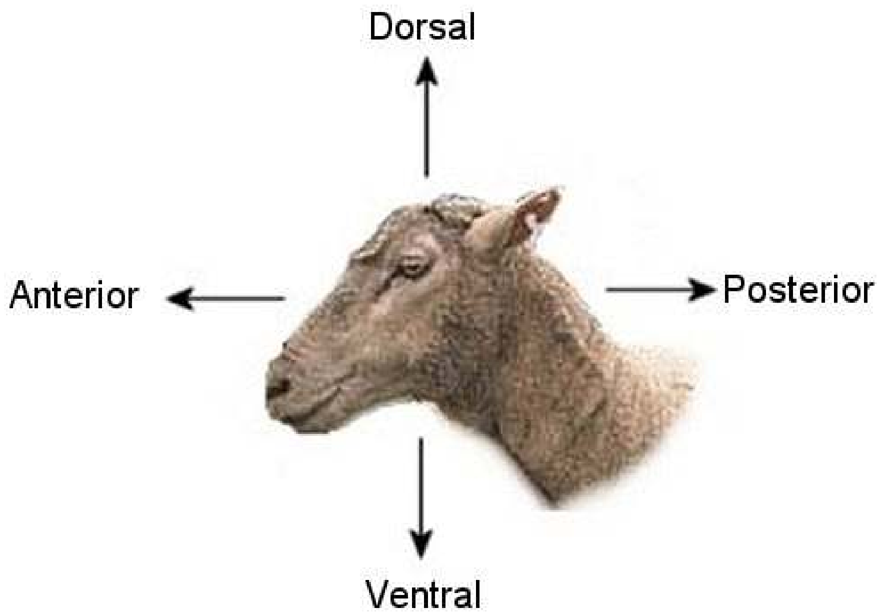
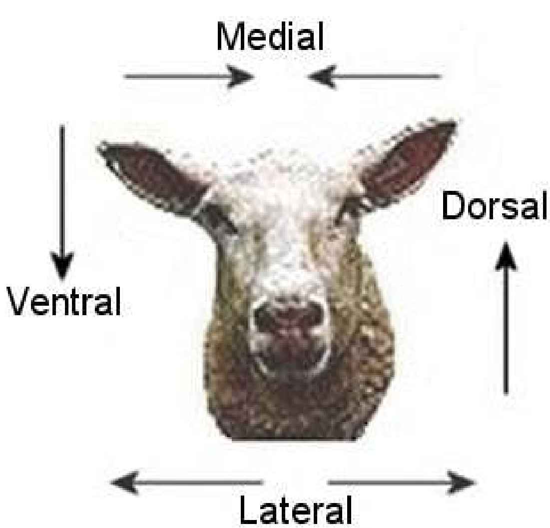
Introduction

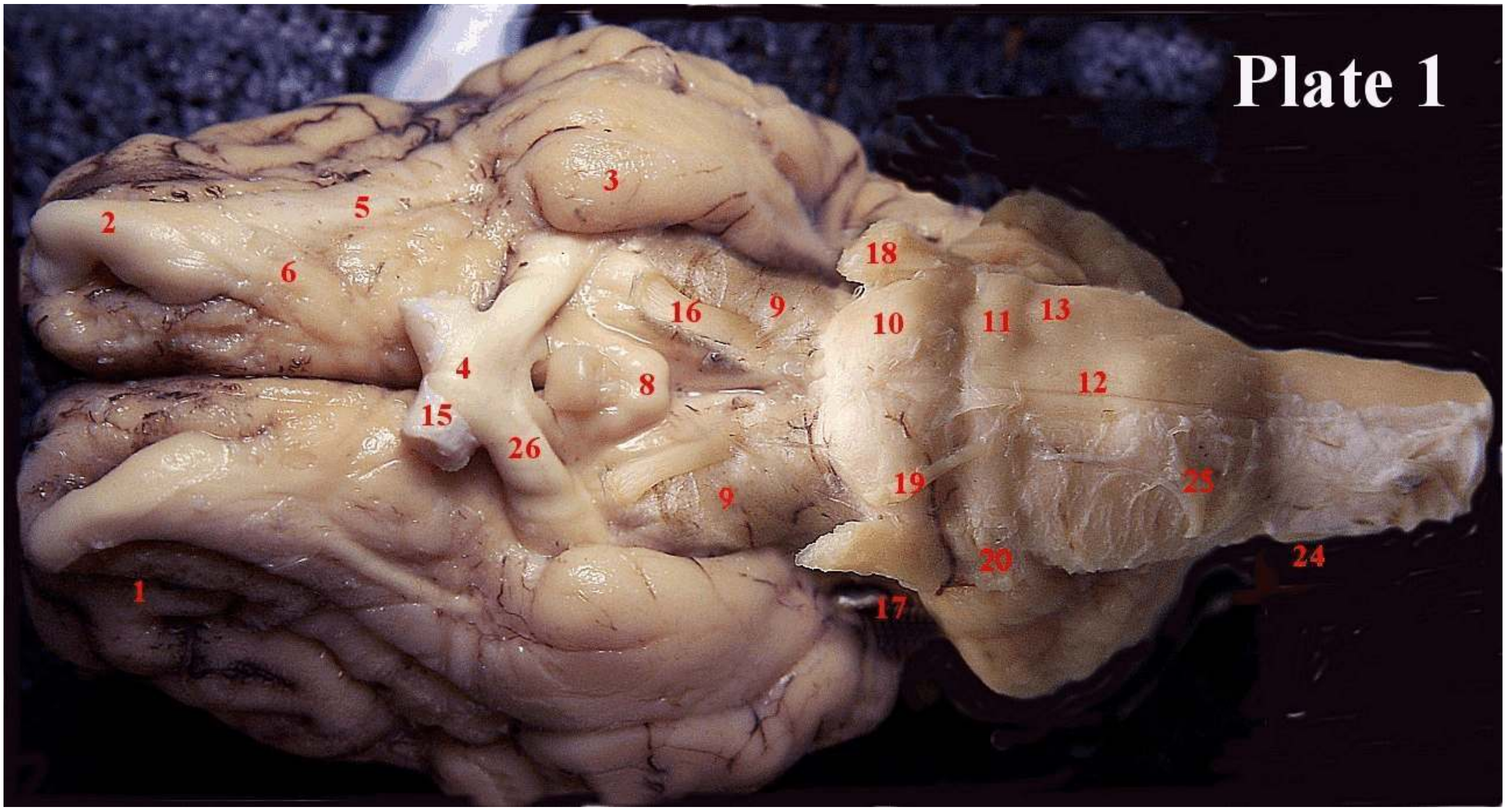


Welcome to the laboratory component of PSYC*2410. The purpose of this lab is to introduce you to the gross anatomy of the brain. Sheep brains are used in this lab because they are easy to extract, reasonably inexpensive (they are procured from the food industry), large, and mammalian.

Before we begin our dissections, you should acquaint yourself with the directional terms used in anatomy. A structure is **anterior** to another structure when it is closer to the nose of an animal (see the above diagram). Some texts use the terms anterior and rostral interchangeably, but we will stick to anterior. A structure that is **posterior** to another is closer to the back of the head. Another word for posterior is caudal. Down is **ventral**. To look at the ventral surface is to look at the bottom of the brain. **Dorsal** is up in the brain (and up in the spinal cord of animals, but not in humans– why is this?). When a structure is **lateral** to another structure, it is considered to be closer to the outside (see diagram to the left). When a structure is closer to the middle (or the midline) it is considered to be **medial** to another structure. You should memorize these terms, they are used throughout this manual.



The Ventral Surface

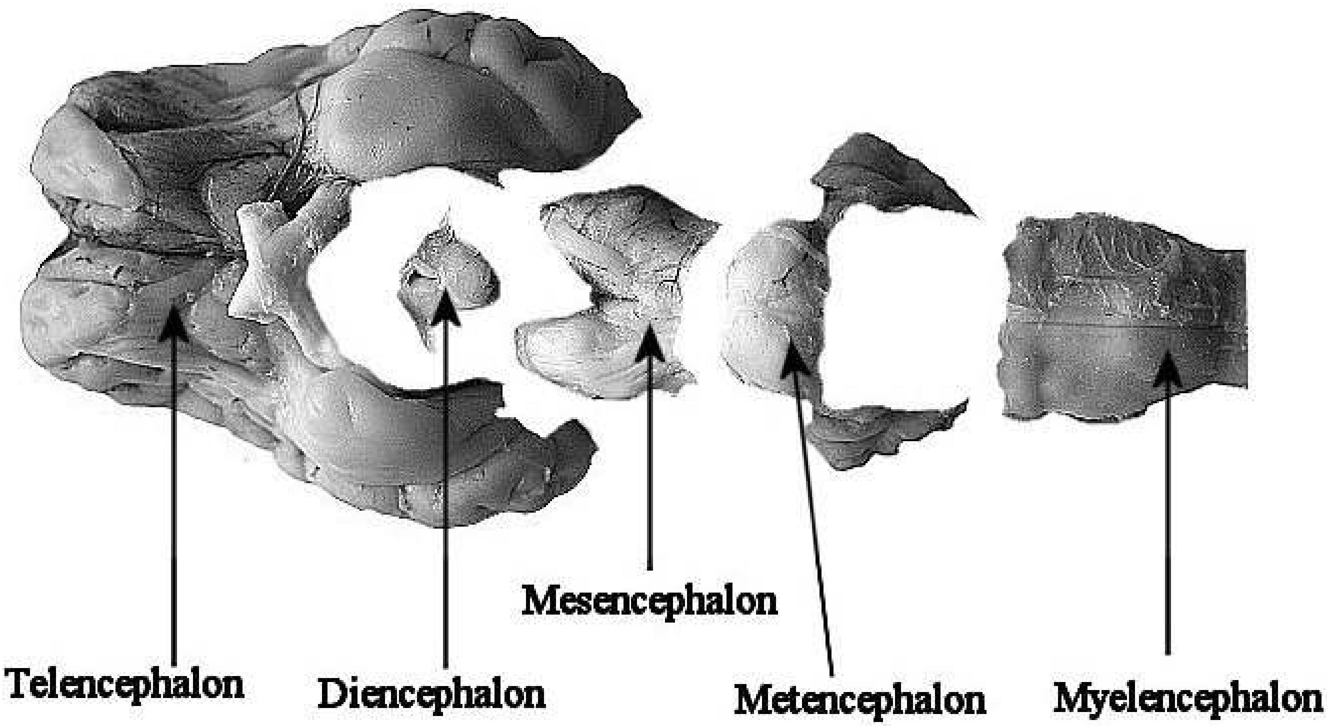


We begin our exploration of the sheep brain with the ventral surface. First, we will orient ourselves by examining some of the larger structures. Then we will proceed by relating these structures to the major subdivisions of the brain. Finally, we will examine the cranial nerves.

Some of the structures we wish to study are obscured by the **pituitary gland (7)**. Plate 1 shows the ventral surface of the brain without the pituitary gland. To remove the pituitary gland cut through the **trigeminal nerves (18)**, the **abducens nerves (19)** and the infundibulum, a stalk at the anterior end of the pituitary that attaches it to the forebrain.

Major Structures of the Ventral Surface: The anterior ventral surface is taken-up by the ventral portion of the **frontal cortex (1)** and the **olfactory bulbs (2)**. Our laboratory specimens often only have a mangled portion of the olfactory bulbs, but we can see the **lateral olfactory tract (5)** and the **medial olfactory tract (6)** quite well. These tracts travel from the olfactory bulbs to the **periamygdaloid cortex (3)**, and can be distinguished from the surrounding tissue by virtue of their myelin coated fibres. Myelination gives fibres a whitish appearance. Posterior to the olfactory tracts you can see the **optic chiasm (4)**. Just behind the optic chiasm, there is a little round bulge, often with a small visible opening. This is where the **pituitary gland (7)** was attached to the brain. Posterior to this you will also see a round protuberance, the **mammillary bodies (8)**. The term "bodies" is used because in some animals one can distinguish both a left and a right portion. In the sheep, as you can see, the two are fused into one round midline structure. Posterior and lateral to the mammillary bodies are the **cerebral peduncles (9)**. These two massive ridges route much of the information that travels to and from the brain. The **pons (10)**, a prominent bulge (What does pons mean? Hint: it's Latin), delineates the point where the cerebral peduncles disappear from view. The pons is largely made up of fibres that travel from the forebrain to the cerebellum. Eventually, these fibres ascend as **mossy fibres** into the cerebellar cortex. From the sheer size of the pons, you can imagine that it is an important fibre connection. Behind the pons is a small transverse (by this we mean that it runs from left to right, rather than from front to back) ridge that is known as the **trapezoid body (11)** (note that the VIth nerve emerges from here). Behind the trapezoid body you will find two massive fibre bundles that run just down the midline on either side. These are formed by the fibres of the **pyramidal tract (12)**. When the fibres crossover a bulge in the tract is created (is this a decussation or a commissure?). Note that the edge of the bulge is where nerve XII emerges. Behind this, the spinal cord begins. The **olive (13)** is located lateral to the pyramidal tract. Now, let us relate these substructures to the major divisions of the brain.

(Fine Print: A **commissure** is formed when fibres extend from a structure on one half of the brain to a twin structure on the other half of the brain, forming a bridge between the hemispheres. A **decussation**, on the other hand, is formed when fibres go from one structure to another completely different structure on the other half of the brain).



<u>The Major Subdivisions of the Brain</u>: The **TELENCEPHALON**, or the forebrain, extends from the front of the brain to the posterior margin of the optic chiasm. All of the cortex, on either side of the brainstem, is also considered part of the telencephalon. The **DIENCEPHALON** extends from the posterior margin of the optic chiasm to just behind the mammillary bodies. The ventral region of the diencephalon - which is what you are looking at, contains the hypothalamus (this is right above and around the point where the pituitary gland was attached to the brain). The **MESENCEPHALON** extends from just behind the mammillary bodies to the anterior margin of the pons. This structure contains the superior colliculi which we will encounter when we look at the dorsal surface of the brain stem in the hippocampal dissection. The **METENCEPHALON** is delineated more or less by the pons on the ventral surface of the brain and on the dorsal surface, it extends from just behind the inferior colliculus to, roughly, the posterior part of the fourth ventricle. The **MYELENCEPHALON** extends from just behind the pons to the beginning of the spinal cord, roughly where the pyramidal tract fibres begin to cross.

<u>The Cranial Nerves</u>: The cranial nerves provide sensory input to the brain from the visual, acoustic, gustatory and olfactory sensory organs. They also transmit sensory information from

skin and muscles. One distinguishes between **general sensory** input (example; touch and pain), **visceral sensory** input (example: information that leads to nausea), and **special sensory** input (example: hearing, taste, vision, balance, smell).

Output is directed at various muscles (such as the muscles that move the eyes and the muscles used in chewing and speaking), and to the glands of the head region. Anatomists distinguish between **somatic motor** (example: output to muscles that move the eyes) **branchial motor** (example: output to muscles used in facial expression and chewing) and **visceral motor** (example: output to muscles that constrict the pupils of the eye, output to glands and output to visceral organs).

A given cranial nerve may be involved with a whole collection of these systems. As an example, the **glossopharyngeal nerve (IX)** provides **branchial motor** output to the **pharynx** and **larynx**, **visceral motor** output to the parotid gland, carries **visceral afferent** information from the **carotid sinus**, **general sensory** information from the posterior third of the tongue (touch and pain) and **special sensory** information, also from the posterior third of the tongue (taste). You can imagine that the points of origins of the fibres that travel so nicely in this nerve are an anatomical nightmare. You don't have to memorize any of this but for those who are interested, any good text in human neuroanatomy will bring further clarification. We are mostly concerned with the location and general functions of the cranial nerves as we can see them, without paying any further heed to the specifics. The nerves are numbered, for convenience, from I to XII. The numbering goes from anterior to posterior. Thus, the first nerve encountered is I and the last is XII. You can see the point of emergence of most of the nerves in Plate I above. Below, the names and places of emergence are given.

I. The **olfactory nerve (14)**. The olfactory nerves come from the olfactory receptors and travel in small bundles through the so-called cribiform plate (a very thin bone at the base of the frontal lobes) to enter the **olfactory bulbs (2)**. When our specimens were removed from the skulls that housed them, the cribiform plate sheared the olfactory nerves. Consequently, you won’t be able to see Nerve I. The bulbs, however, should be discernable.

II. This is the **optic nerve (15)** - not really a nerve in the conventional sense, but part of the brain. As you can see, the optic nerve is quite large. It comes from the eye and reaches the optic chiasm (Greek: denotes a crossing), where some of the fibres cross over to the contralateral (opposite) side, while some stay on the ipsilateral (same) side. Please note that fibres from the eye are called **optic nerve (15)** fibres before they reach the **optic chiasm (4)** and are called **optic tract (26)** fibres after the chiasm. We will later see how most of the optic tract fibres end in a structure known as the thalamus.

III. The first of the nerves that are involved in the movements of the eye, and the largest one of these, the **occulomotor nerve (16)**. This nerve supplies the majority of extraocular (what does that mean?) muscles: the inferior oblique, the inferior, medial and superior rectus. You will see this nerve emerging roughly half-way between the pons and the optic chiasm. Compare the size of this nerve to the other two nerves that run external eye muscles! (IV & VI).

IV. The **trochlear nerve (17)**. This is the only cranial nerve that does not actual emerge from the ventral surface of the brain - it emerges from the dorsal surface and comes curving down in front of the pons (yes, what is the pons?). You may have to probe down between the membranes a bit - the nerve is very slender. The fact that it emerges from the dorsal brainstem means that you won't usually see it emerging from the brain when you view the brain ventrally (although you can see it in Plate 1). This nerve supplies the superior oblique muscle of the eye - helps your roll your eyes. The name “trochlear” means "pulley" (referring to a rope passing over a wheel).

V. The **trigeminal nerve (18)**. This is an absolutely massive nerve that carries sensory information from a region of the face that can best be outlined by imagining somebody wearing a full face mask. It also brings in sensory information from the meninges (the coverings of the brain) and is thus the nerve that brings us toothaches and headaches. It is also involved in chewing movements (operation of the jaws). This nerve can be seen coming out from the lateral aspects of the pons. You can hardly miss it because it is so large.

Depending on the quality of your specimen, you may see Nerve V separating into three major branches (ophthalmic, maxillary and mandibular branches - What do these names refer to?). Plate I only shows a solid trunk but if you poke very gently with your probe, you will see that the trunk of the nerve consists of two parts, a smaller (minor) portion that is the motor portion and a larger (major) one that is the sensory portion.

VI. The **abducens nerve (19)**, runs the lateral rectus muscle of the eye. Thus, if you move your eyes to the side, this requires the finely integrated action of two cranial nerves, the IIIrd and the VIth nerve. This nerve emerges just behind the pons from a little ridge known as the trapezoid body. In size it is intermediate between III and IV.

VII. The **facial nerve (20)** innervates much of the facial musculature that is used in forming expressions. To the extent that lip movements are used in speech, it is also involved in speech. This nerve is also mixed, since it conveys sensory information from the anterior 2/3rds of the tongue. This nerve also innervates the glands of the head with exception of the parotid glands. You don't only smile with this nerve, but you also cry with it! This nerve is found if you proceed laterally downwards from the abducens. In many of our preparations, this nerve cannot be seen very well.

VIII. This nerve is often called the **acoustic nerve (21)**, but it is actually composed of a portion that brings information from the inner ear (stato-acoustic, cochlear) and a portion that brings information from the labyrinths (vestibular). The former portion is obviously involved in hearing and the latter with the sense of balance and related functions. The vestibulocochlear nerve (the two portions of VIII) lies just posterior to VII, with the vestibular portion being more anterior and the cochlear portion being more posterior. In many of our preparations, this nerve cannot be seen very well.

IX. This is the **glossopharyngeal nerve (22)**, it conveys sensory information from the posterior 1/3 of the tongue and the pharynx. Some say it also has some motor function in the pharyngeal region. Nerves IX, X and XII emerge very closely together, in a messy little bundle. It is unlikely that our specimens will allow you to distinguish between IX and X, although you may be able to recognize XI. They emerge in anterior to posterior order as numbered. The spinal accessory (X) actually comes up alongside the uppermost portion of the spinal cord and runs along until it reaches the area where IX and X come out and then it curves outward, away from the brain with them.

X. This is the **vagus (23)**, that gives you heart pain and tummy aches. This nerve is the major outflow from the parasympathetic division of the autonomic nervous system to the viscera.

XI. The **spinal accessory (24)** nerve innervates the muscles that you use to bend your head and shrug your shoulders: it runs the sternocleidomastoid and trapezius muscles. Both of these muscles also receive a bit of input from cervical motor nerves. This nerve continues to receive little rootlets from the brainstem as it runs along and you may be able to tell it from X and XI as you trace it along.

XII. The **hypoglossal nerve (25)**. For tongue wagging. Nerve XII is involved in the control of movements of the tongue during speaking and eating. This nerve is quite massive (the tongue is very finely innervated since it has to be capable of very precise movement) and emerges from the posterior end of the medulla as a bunch of laterally spread fibres bundles that merge into one solid nerve trunk as the nerves extends from the brain. As mentioned before, you may be able to see a fringe along the pyramidal tract decussation.

For those of you with a weak memory, there is a little mnemonic device that allows you to memorize the cranial nerves alphabetically: it goes like this: On Old Olympus' Towering Tops A Fin And German Vaults And Hops. (No, it is not by Byron). Plate 1 will give you a rough orientation as to where the cranial nerves are located. Unfortunately, most of the sheep brains we get are damaged in the lower portion of the brain stem and it is not often that you can see all of the nerves. Often you will only be able to see nerves II-VII and XI. For the rest you will have to consult the demonstration brains and plates that are made available.

By the end of this lab you should be able to identify the following structures without difficulty:

<u>Structures</u>:

1 frontal cortex

2 olfactory bulbs

3 periamygdaloid cortex

4 optic chiasm

5 lateral olfactory tract

6 medial olfactory tract

7 pituitary gland *(not seen in Plate 1)*

8 mammillary bodies

9 cerebral peduncles

10 pons

11 trapezoid body

12 pyramidal tract

13 olive

14 olfactory nerve *(not seen in picture)*

15 optic nerve

16 occulomotor nerve

17 trochlear nerve

18 trigeminal nerve

19 abducens nerve

20 facial nerve

21 vestibulo-acoustic nerve *(not seen in Plate 1)*

22 glossopharyngeal nerve *(not seen in Plate 1)*

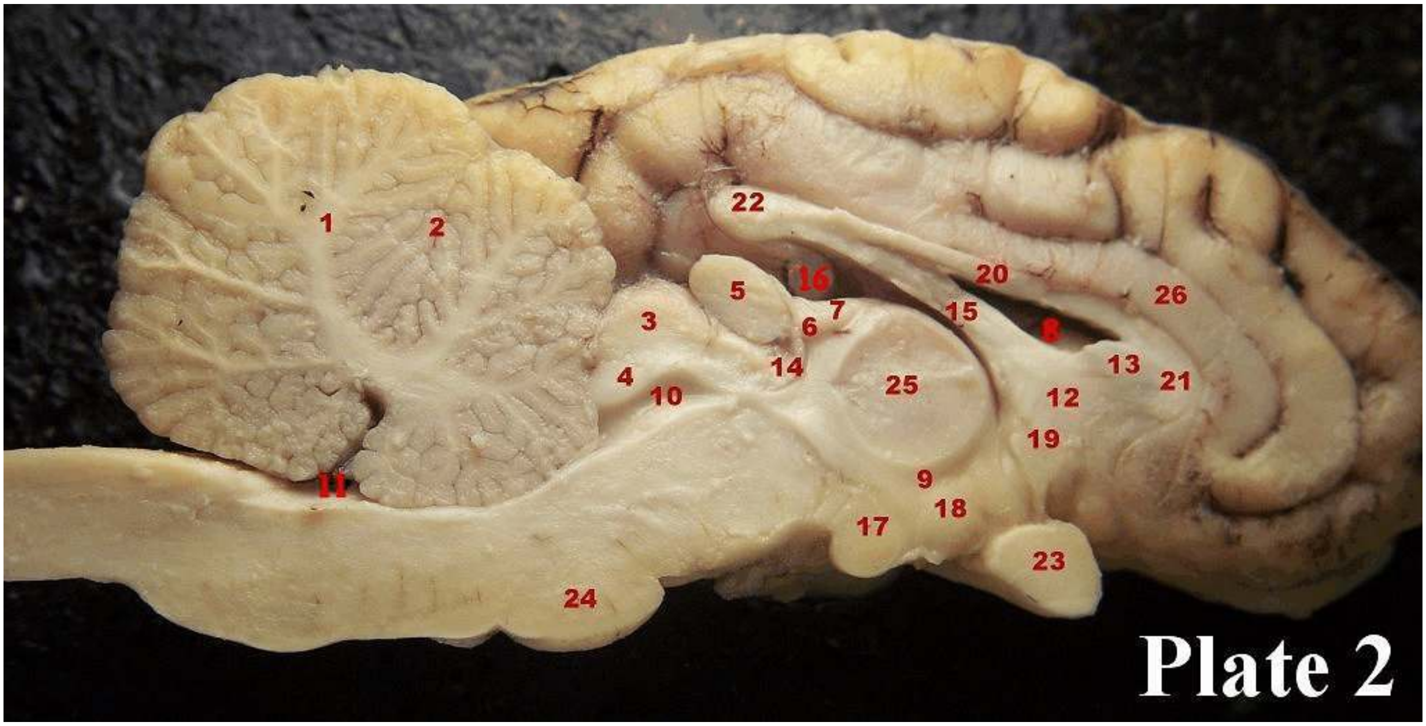
23 vagus nerve *(not seen in Plate 1)*

24 spinal accessory nerve

25 hypoglossal nerve

26 optic tract

The Mid-Sagittal Cut



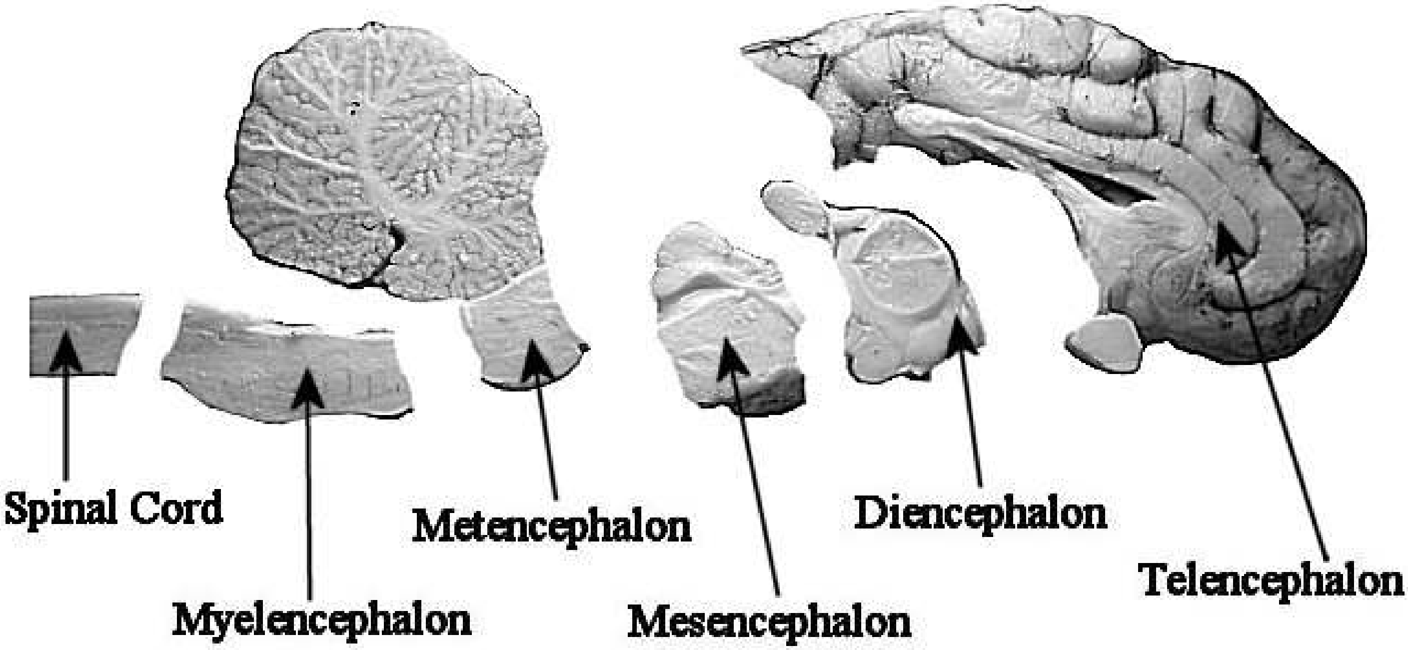
The mid-sagittal cut is a straight forward dissection. Remove the pituitary gland. Turn the brain over. Align your knife or razor by placing it in the longitudinal fissure (between the two hemispheres) . Using smooth sawing motions, cut your brain in half.

We begin our study of the mid-sagittal cut with the **massa intermedia (25)**, the point at which the two halves of the thalamus join across the midline. This joining is not seen in all mammals, or even within all individuals of a species. In humans for instance, only one third of the population has this joining. Dorsal to the massa intermedia is the **fornix (15)**. Above the fornix, in our picture, is one of the lateral **ventricles (8)**. It happens to be the left lateral ventricle. There are a total of four ventricles in the brain. The first ventricle is the left lateral ventricle. The second ventricle is the right lateral ventricle. The **third ventricle (9)** surrounds the massa intermedia. The **cerebral aqueduct (10)** which begins just behind the most ventral and posterior part of the **anterior commissure (14)**, connects the third ventricle and the **fourth ventricle (11)**. The fourth ventricle is situated underneath the **cerebellum (1)**. Mercifully we won't bother with naming all of the lobes of the cerebellum, but in a later lab we will distinguish between the anterior and posterior lobe. Therefore, it is important for you to note the **primary fissure (2)** which differentiates these structures. We also see, below the cerebellum, the **pons (24)**, which is formed by massive fibre bundles on their way to the cerebellum from the brain.

The numbers **(20), (21) and (22)** denote the **corpus callosum**, the massive fibre bundle that connects upper two halves of the brain in both sheep and humans. The area in (**21)** is known as the **genu** while the area denoted by the number **(22)** is known as the **splenium**. Genu refers to "knee" and you can remember that the knee points forward and the genu is the front part of the corpus callosum. We can't help you with the splenium - the name refers to a patch or bandage- and who knows why the anatomists of the 19^{th} century gave it this name. (**20)** just denotes the main body of the corpus callosum. The **cingulate gyrus (26)** lies right above the corpus callosum. The number **(13)** refers to a bit of tissue called the **septum pellucidum** that normally closes off the lateral ventricle, and which has mostly been removed in our picture (what does septum mean?). Your dissection may have an intact septum pellucidum. (**12)** is the **septum**, not to be confused with the septum pellucidum. The septum is a solid aggregation of neurons that is considered part of the limbic system. Posterior and ventral to the septum you see a round white circle. This is a tract and is denoted by number **(19)**, the **anterior commissure**, a much smaller version of the corpus callosum, which connects the lower portion of the two brain halves. Below, going straight down (ventrally) you will see the **optic chiasm (23)** sliced right through. Posterior to that you see **(18)**, which denotes part of the **hypothalamus** and a bit behind that, the **mammillary body (17)**. These can be considered part of the limbic system and you will hear about them in class (it is highly recommended that you read about them in your text as well). Raising our sights again, past the massa intermedia, we see dorsally **(7), the stria medullaris**, a flat fibre tract that runs into **(6), the habenula**. Slightly more dorsal to this, hidden in the depth is a glimpse of the **hippocampus (16)**. All of this is part of the limbic system as well. A slightly different bit of tissue, the **pineal gland (5)** is near the habenula, and, as the name implies, it is tissue that has some functions of a gland. We have already mentioned the **superior colliculus (3)**, concerned with vision, and right below it is the **inferior colliculus (4)**, concerned with hearing which lies right above the cerebral aqueduct.

(Fine print: Septum usually refers to a structure that divides something, else. For instance you have a septum in the heart that divides the ventricles, and one in the nose that divides the two nostrils).

Finally, this is a good opportunity to recap the major divisions of the brain.



<u>Structures</u>:

1 cerebellum

2 primary fissure, cerebellum

3 superior colliculus

4 inferior colliculus

5 pineal gland

6 habenula

7 stria medullaris

8 lateral ventricle

9 third ventricle

10 cerebral aqueduct

11 fourth ventricle

12 septum

13 septum pellucidum (a bit of it)

14 posterior commissure

15 fornix

16 hippocampus

17 mammillary body

18 hypothalamus

19 anterior commissure

20 body of corpus callosum

21 genu of corpus callosum

22 splenium of corpus callosum

23 optic chiasm

24 pons

25 massa intermedia - thalamus

26 cingulate gyrus

The Hippocampal Dissection

Plate 3

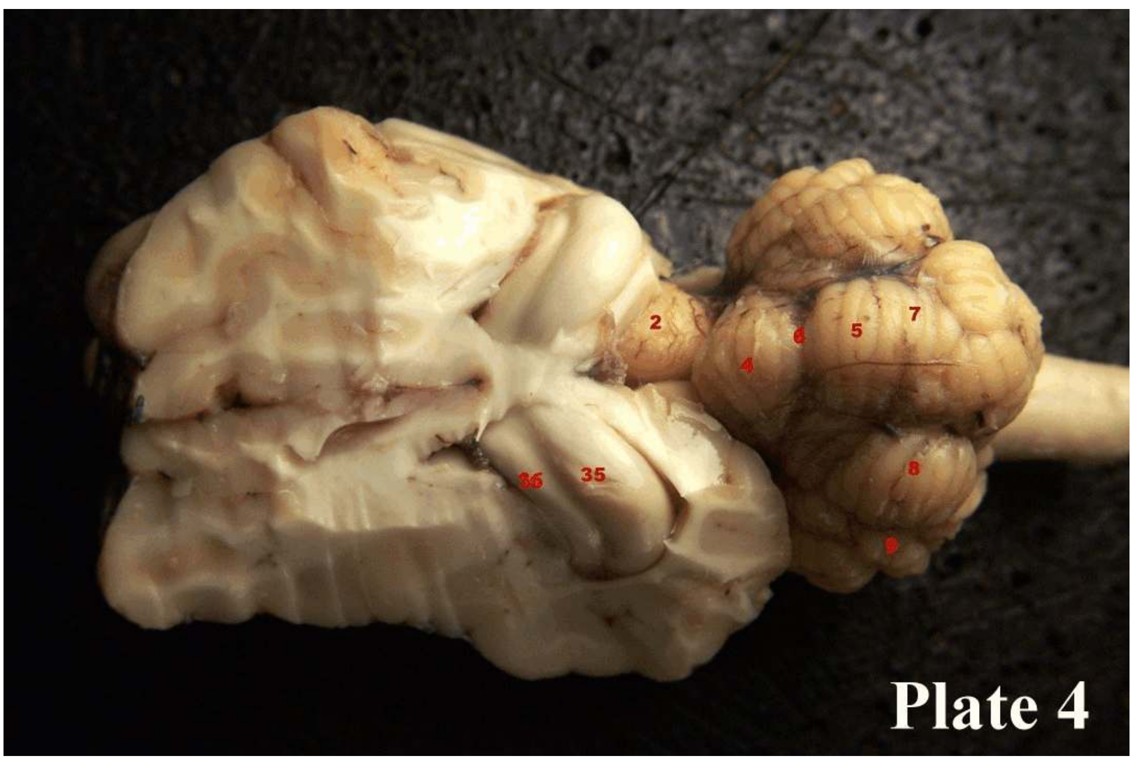


Plate 4

Plate 5

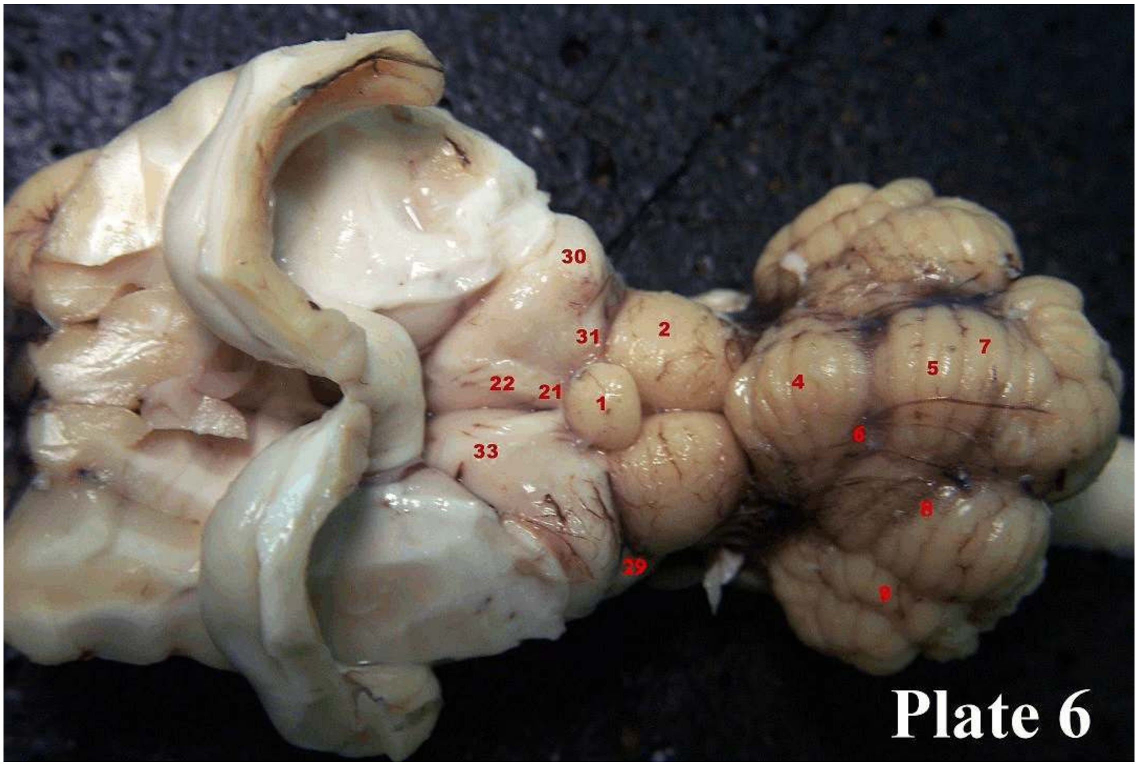


Plate 6

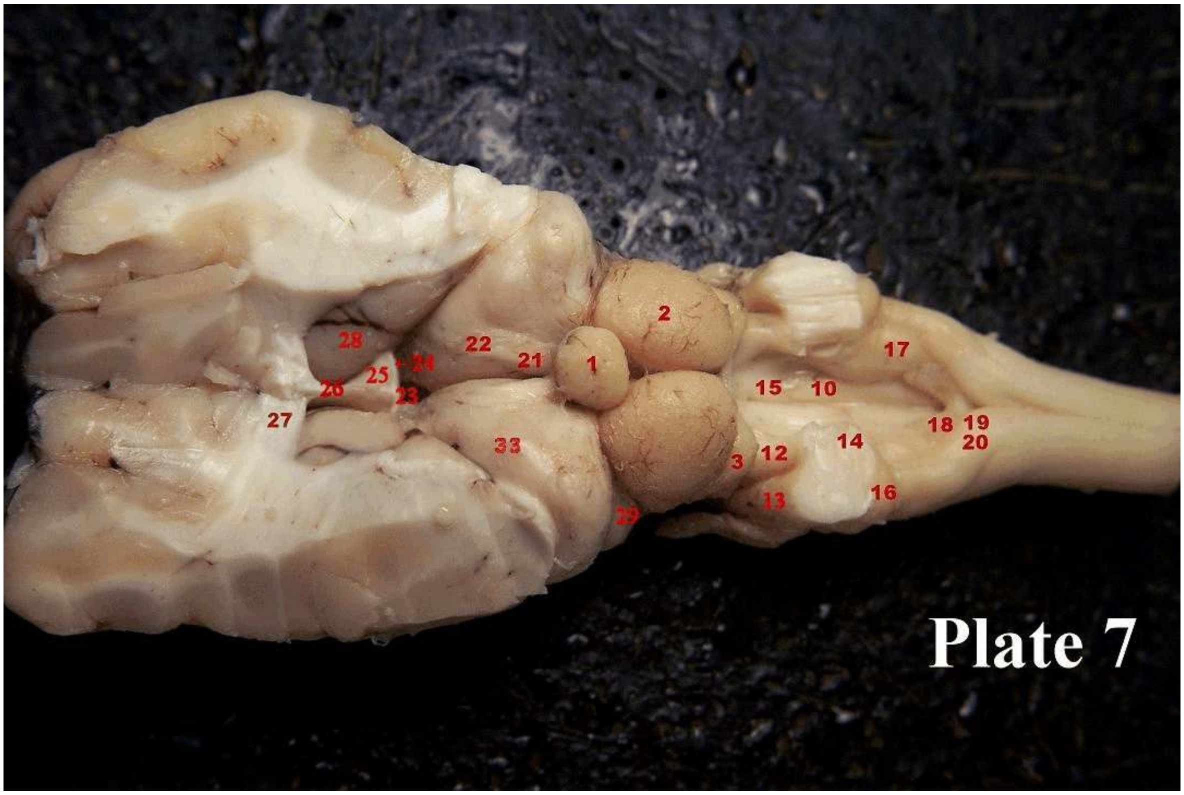


Plate 7


Plate 8

We progress through the hippocampal dissection in stages. Each image depicts a new step in the dissection. Again, make even cuts with your razor by using smooth sawing motions. Take your time, and be mindful of your fingers.

Plate 3: The first plate suggests that we begin our dissection by removing a portion of the dorsal cortex. We can take a good centimetre off of the top before becoming more careful. We then proceed by cautiously shaving thin slices off until we reach the posterior horns of the lateral ventricles. We know we are getting close when the white matter in the posterior part of the cortex spreads out into a large sheet. In Image A, on the right side you see a cut that exposes the ventricle. On the left side we have gone lower and you can just make out the **hippocampus (35)** peeking through. Behind the cortex, you see the cerebellum, with the **anterior lobe (4)** and **posterior lobe (5)** marked.

Plate 4: Now we show what the dorsal brain stem looks like when we have carefully removed the cortex around the hippocampus, peeling downward from the point exposed **(35)** in Image A. Note that the hippocampus is continuous with the cortex on its posterior edge, where is receives cortical input. We now see the main body of the **hippocampus (35)** and the **fimbria (36)**, which is formed by the fibres that stream out of the hippocampus. Right behind the hippocampus, we have exposed the **superior colliculus (2)**. Behind this lie the cerebellar structures seen in Image A, but we have added a label to the **primary fissure (6**) that divides the **anterior lobe (4)** and **posterior lobe (5).** The midline region of the cerebellum, front to back, is also known as the **vermis (7) -** literally, “worm” because of its appearance. Laterally to the vermis lies the **intermediate zone (8)**, and the **lateral zone (9)**. This way of dividing up the cerebellum makes as much sense as the anterior/posterior way because the projections of the cerebellar cortex to the **cerebellar nuclei** follow this longitudinal pattern.

(fine print for those who are interested: All output from the cerebellum travels through three nuclei - the medial **fastigial nuclei**, the intermediate **interpositus nuclei** and the lateral **dentate nuclei**. These sit right inside the body of the cerebellum, close to the fourth ventricle).

Plate 5: We can use a small-pea sized structure as a central landmark in the midline. This is the **pineal gland (1)** which secretes the hormone **melatonin**. Behind lies the **superior colliculi (2)**. Because we have now exposed the cortex and corpus callosum overlying the anterior aspect of the hippocampus, we can see the **fornix (37)**, which is the output tract of the hippocampus, and the **septum (25)** that lies at the anterior edge of the fornix. Note that the output from the hippocampi from the left and right brain half seems to flow together in the middle. This is deceiving because the output actually stays separate in a clearly defined left and right fornix, as we will see later. There are two other new structures that appear in this image. First, we see a part of the **caudate nucleus (28)** peeking out. This is a part of the basal ganglia. Second, we see part of the **corpus callosum (27)**, close to the point where it curves down to form the genu of the corpus callosum. Numbers **(4)**, **(5)**, **(6)**, **(7)**, **(8)**, **(9)**, **(35)**, and **(36)** are still labelled (can you identify these structures?)

Plate 6: In this image, we have peeled back the hippocampus on both sides, exposing the underlying **thalamus (33)**. There are quite a few structures of interest in this region. We can see a broad fibre band, the **stria medullaris (22)** curving across the surface of the thalamus. The stria medullaris originates in the anterior region of the thalamus and ends close to the middle, very near the **pineal gland (1)**, in the **habenula (21)**. This image also shows the **pulvinar nucleus (31)** which lies lateral to the pineal gland. This nucleus receives input from, among other places, part of the visual cortex, and sends fibres to the **superior colliculus (2)**. Also included are the **lateral geniculate nucleus (30)**, which receives fibres from the optic tract and the **medial geniculate nucleus (29)**, which receives input from the ear. Again, numbers **(4)**, **(5)**, **(6)**, **(7)**, **(8)**, and **(9)** are labelled.

Plate 7: We have now removed the hippocampus and the cerebellum. Anterior to the thalamus, we see the **septum (25)** and again and the **fornix (24)** is formed by a band of white fibres that run at the posterior edge of the septum. A bit of the thin dividing membrane that separates the lateral ventricles can be seen anterior to the septum, we encountered it in the mid-sagittal section as the **septum pellucidum (26).** Again, we see a massive part of the anterior **corpus callosum (27)**. The number **(23)** denotes the region of the **third ventricle**. Now we can pay attention the hindbrain. The cerebellum has been removed, and the massive stalks (peduncles) that connect the

cerebellum to the rest of the brain have become visible. We can clearly see one of the output paths of the cerebellum, the **superior cerebellar peduncle (12)** and the **middle cerebellar peduncle (13)**, the most massive one, which carries input to the cerebellum from all over the brain, can also be seen as distinct entity, at least where we have marked it. The peduncle that carries input to the cerebellum from the spinal cord, the **inferior cerebellar peduncle (14)** is a bit less clear in its definition in this preparation. We have to imagine it as the posterior and more medial part of the combined complex of outputs and inputs into the cerebellum. The superior cerebellar peduncle disappears on its way to the anterior parts of the brain just under the **inferior colliculus (3)**, which seems to be squished under the superior colliculus.

The removal of the cerebellum has also exposed the **fourth ventricle (10)** into which the bottom part of the cerebellum fits quite snugly. We can now see the **facial colliculus (15)**, which is caused by a bulge from the nucleus of the abducens nerve (VI) and fibres running from the nucleus of the facial nerve (VII). The **dorsal cochlear nucleus (16)**, a major input nucleus from the ear, can be seen posterior to the inferior cerebellar peduncle, as a tidy little bulge. The **vestibular nucleus (17),** crucial for balance and the maintenance of body posture can also be seen as a bulge medial and slightly behind the inferior cerebellar peduncle.

Toward the very posterior part of the fourth ventricle, we see a small bulging mass, that tends to look slightly gelatinous, lining the end of the ventricle, and forming a triangle, the **motor nucleus of the vagus nerve (18)**. Incidentally, a very tiny opening just at the apex of this triangle leads the spinal fluid down the middle of the spinal cord, and a narrow canal. Dorsal to this we see the switching stations for the incoming information from the very massive spinal tracts that carry information about fine touch discrimination from the lower and upper parts of the body. The fibres from the former tract travel in the fasciculus gracilis and end in the region of the **nucleus gracilis (19)** while fibres from the latter travel in the fasciculus cuneatus and end in the **nucleus cuneatus (20)**. Numbers **(1)**, **(2)**, **(21)**, **(22)**, **(28)**, **(29)**, **(30)**, **(31)** and **(33)** are still labelled (do you remember their names?)

Plate 8: This lateral view of the brain stem is meant to give another look at the medial and lateral thalamic nuclei. You can see the **optic tract (32)** coming up from the optic chiasm (recall that

before the chiasm, we refer to the fibres from the eye as the optic nerve and after the chiasm the fibres from the eye are referred to as optic tract). The fibres stream upward into the **lateral geniculate nucleus (30)**. And now, from this perspective, we can also see the **medial geniculate nucleus (29)** quite nicely. **(2)** and **(3)** show the superior and inferior colliculi in relation to the geniculate bodies, and the **pons (34)** has also been numbered as a landmark.

Plate 3:

4 anterior lobe of the cerebellum

5 posterior lobe of the cerebellum

35 hippocampus

Plate 4:

2 superior colliculus

4 anterior lobe of the cerebellum

5 posterior lobe of the cerebellum

6 primary fissure

7 vermis

8 intermediate zone of the cerebellum

9 lateral zone of the cerebellum

35 hippocampus

36 fimbria

Plate 5:

1 pineal gland

2 superior colliculus

4 anterior lobe of the cerebellum

5 posterior lobe of the cerebellum

6 primary fissure

7 vermis

8 intermediate zone of the cerebellum

9 lateral zone of the cerebellum

Plate 5 (continued):

25 septum

27 genu of the corpus callosum

28 caudate nucleus

35 hippocampus

36 fimbria

37 fornix

Plate 6:

1 pineal gland

2 superior colliculus

4 anterior lobe of cerebellum

5 posterior lobe of cerebellum

6 primary fissure

7 vermis

8 intermediate zone of cerebellum

9 lateral zone of cerebellum

29 medial geniculate nucleus

30 lateral geniculate nucleus

31 pulvinar nucleus of the thalamus

32 optic tract

33 thalamus

Plate 7:

1 pineal gland

2 superior colliculus

3 inferior colliculus

10 fourth ventricle

12 superior cerebellar peduncle

13 middle cerebellar peduncle

14 inferior cerebellar peduncle

15 facial colliculus

16 cochlear nucleus

17 vestibular nucleus

18 motor nucleus of the vagus nerve

19 area of the nucleus gracilis

20 area of the nucleus cuneatus

21 habenula

22 stria medullaris

23 third ventricle

24 columns of the fornix (not in picture)

25 septum

26 septum pellucidum (dividing membrane)

27 corpus callosum

28 caudate nucleus

29 medial geniculate nucleus

30 lateral geniculate nucleus

31 pulvinar nucleus of the thalamus

33 thalamus

Plate 8:

2 superior colliculus

3 inferior colliculus

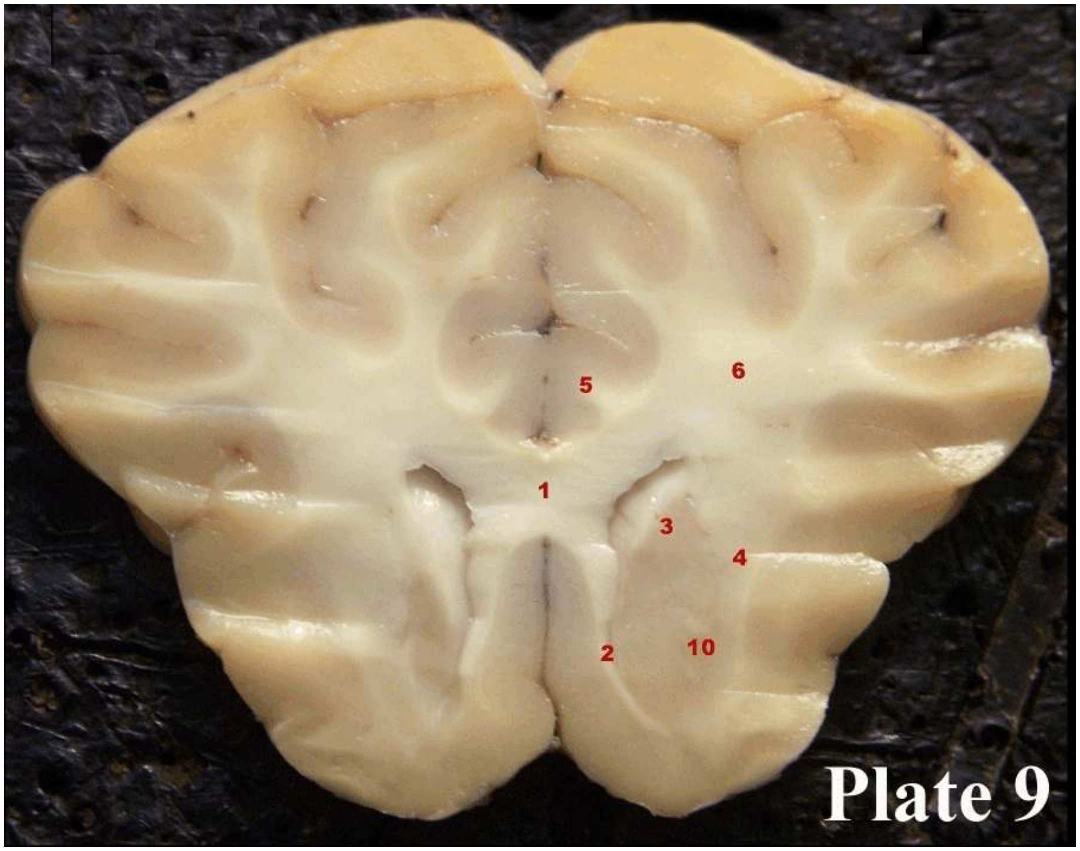
29 medial geniculate nucleus

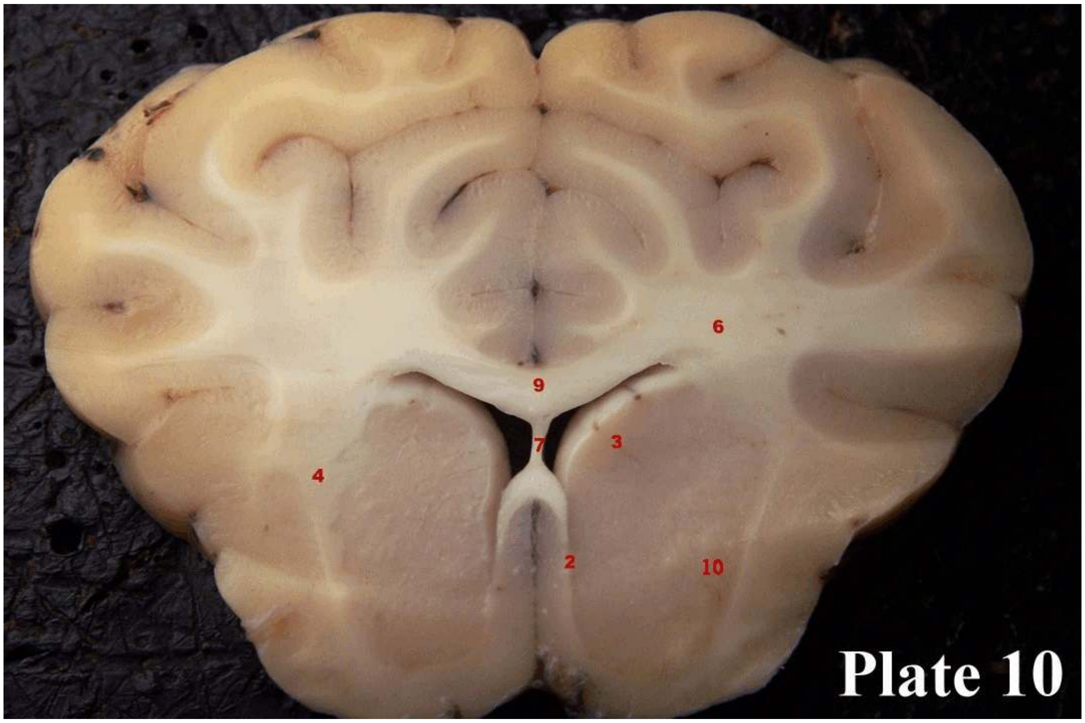
30 lateral geniculate nucleus

32 optic tract

34 pons

Coronal Cuts





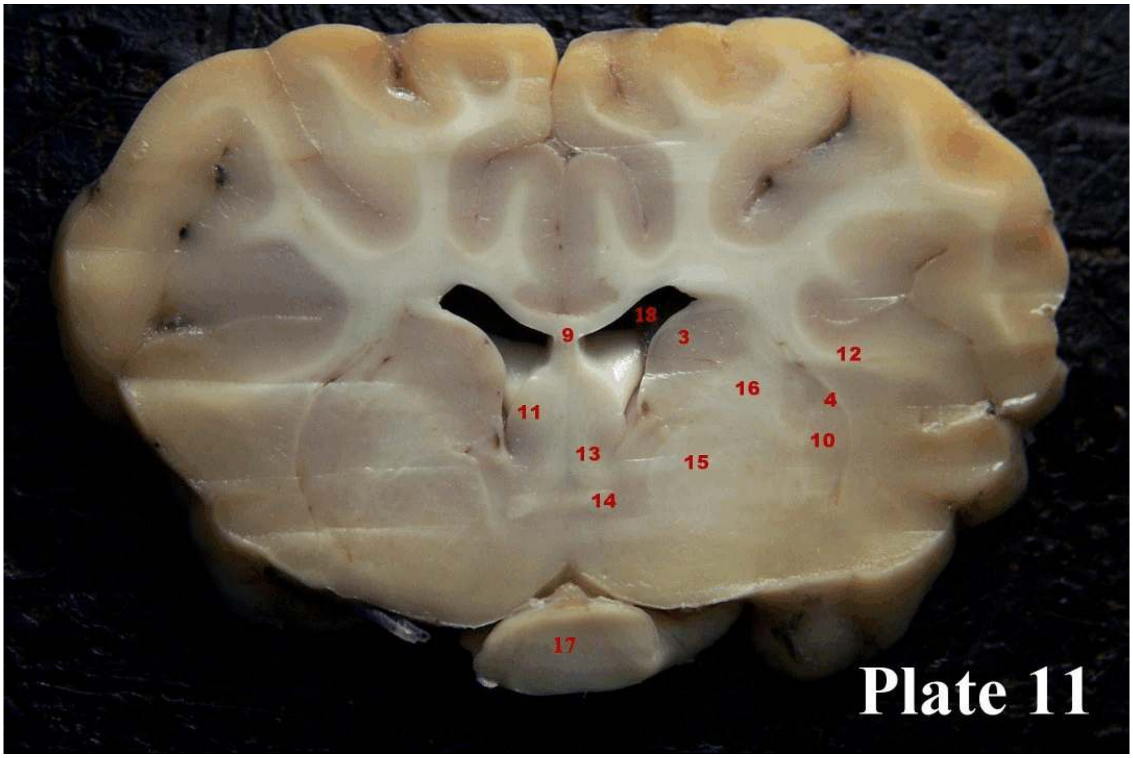

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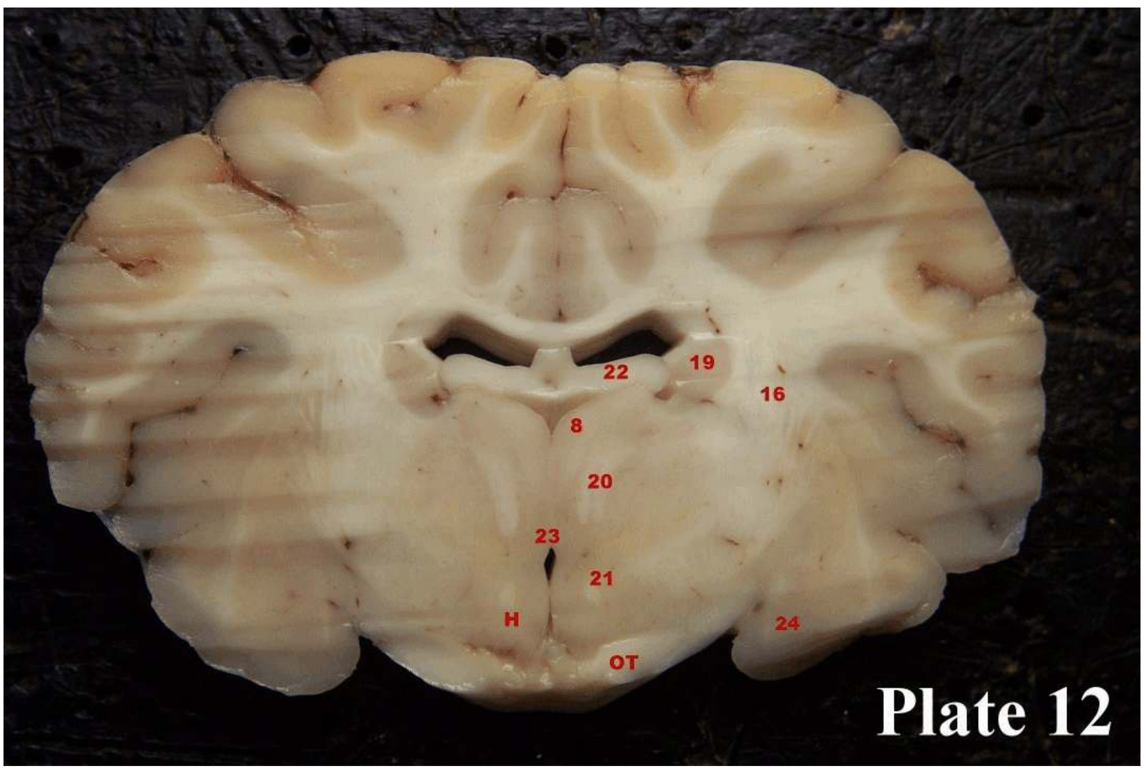
Plate 11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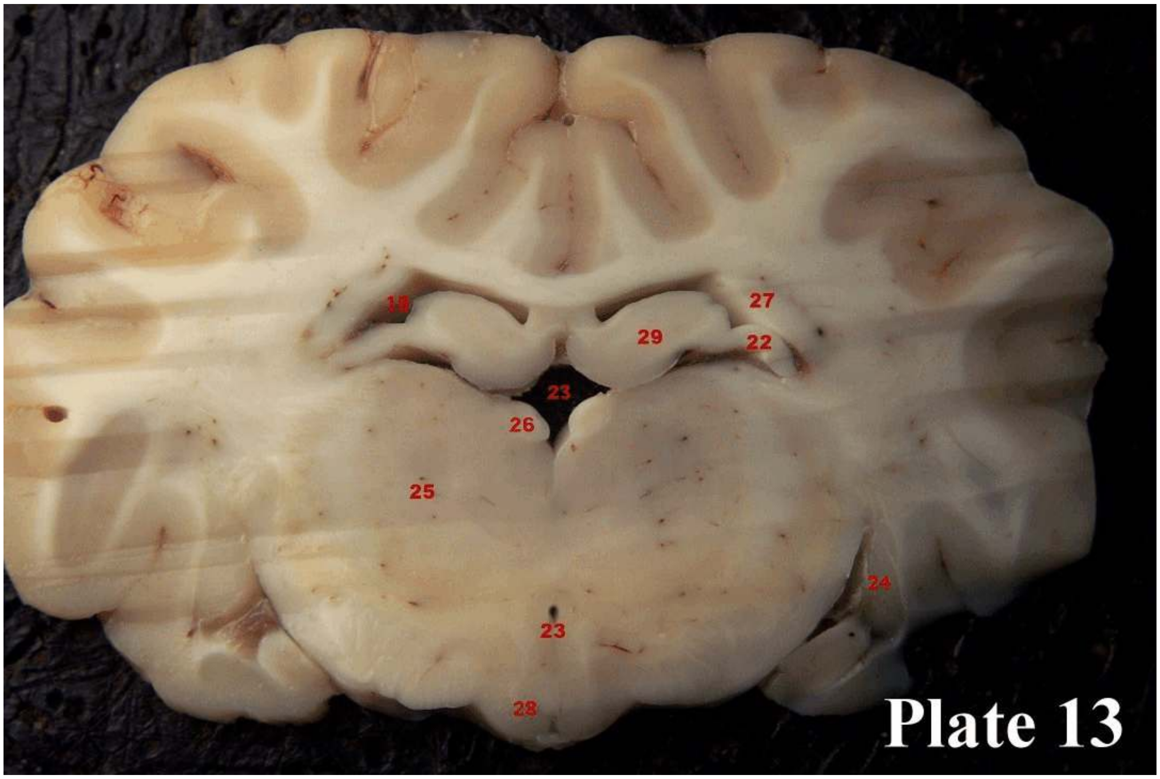
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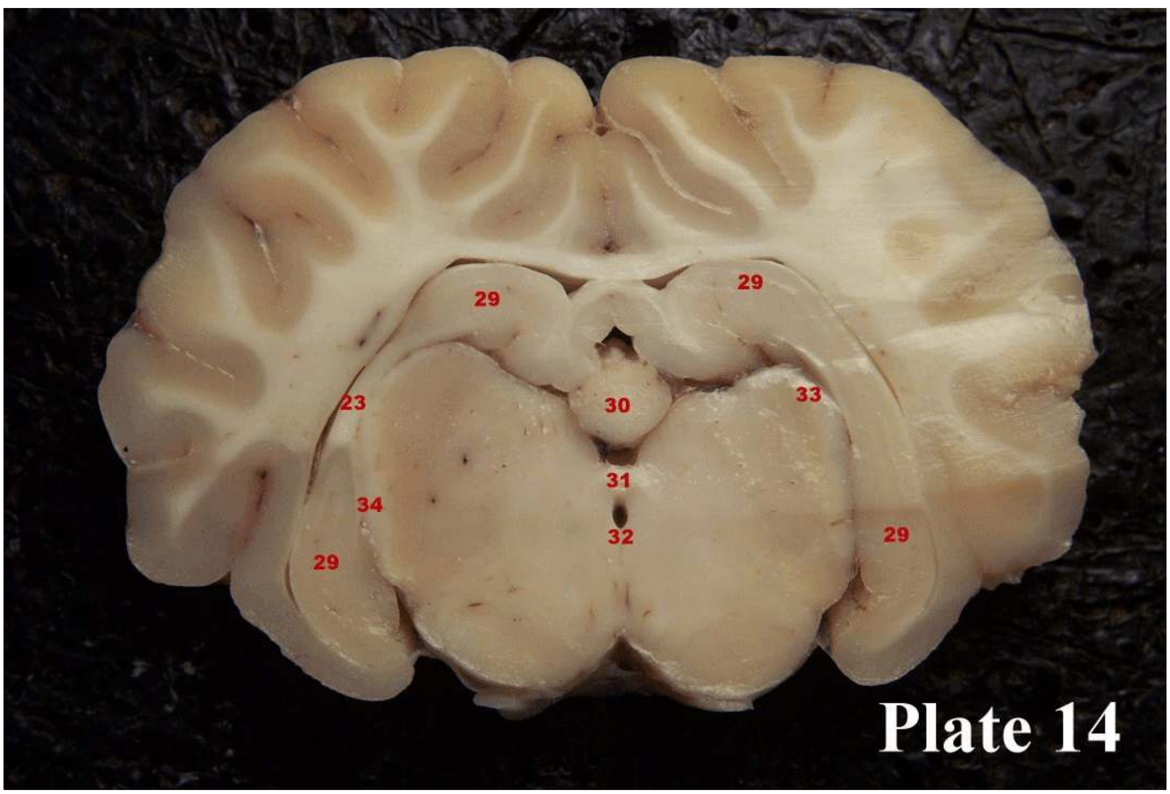
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Plate 14


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Plate 15

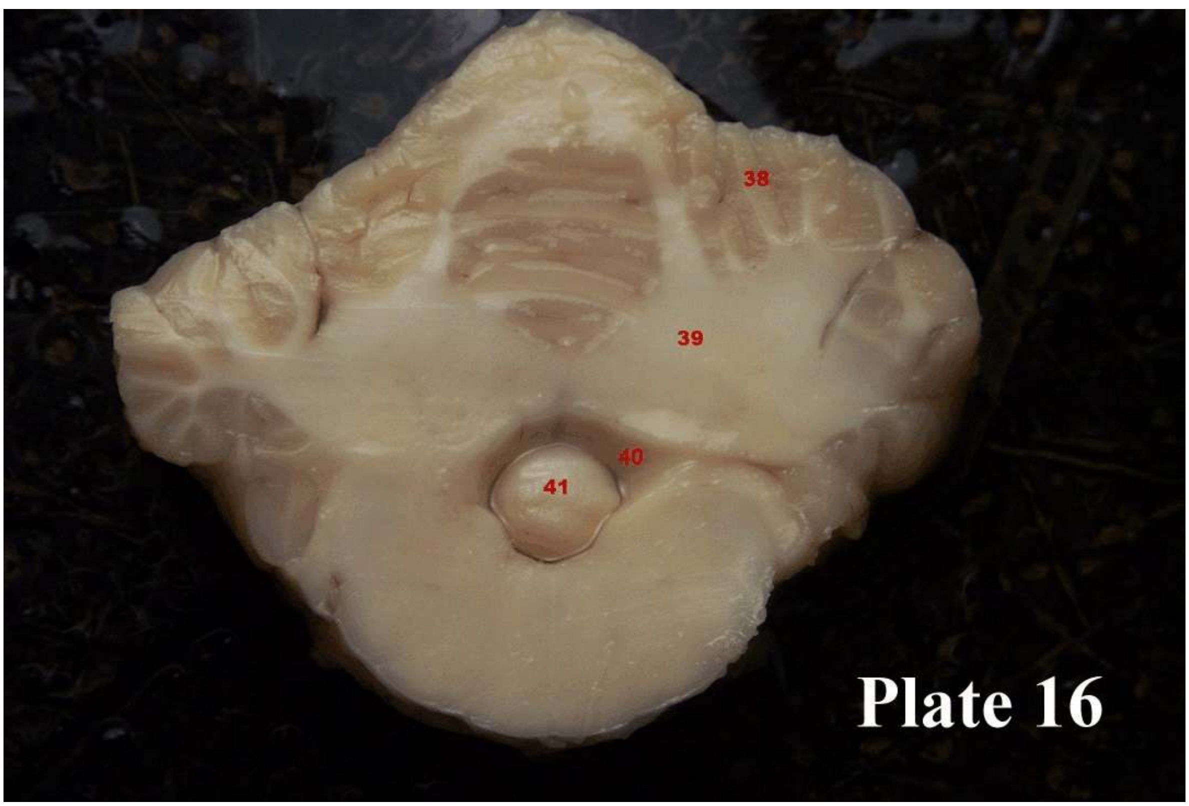
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Plate 16

The coronal cuts in this manual were created by shaving the anterior tip of the brain until the **genu (1)** appeared. When the genu became visible slices where created by making half centimetre cuts, towards the posterior end of the brain. Many of the slices that you make will not match the slices depicted in this manual. This is because you are not necessarily cutting at exactly the same level.

<u>Plate 9</u>: In the centre we see the **genu of the corpus callosum (1)**. The corpus callosum flows laterally into a mass of myelinated fibres which are collectively known as the **corona radiata (6)**. The corona radiata provide all the fibres that eventually stream down between the basal ganglia to form the **internal capsule (16**) (see Cut 3). Put differently, when the fibres from the internal capsule fan out to reach the cortical areas of the brain, they are given a new name: corona radiata. We can also see, at the ventral and medial aspect of the cut, the beginnings of the **caudate nucleus (3)** and the beginnings of the **putamen** in the region indicated by **(10)**. These, you remember, are two prominent parts of the basal ganglia (literally: collections of neurons at the base of the brain). We further see a tract that comes from the septum and goes to the hypothalamic region and the regions of the olfactory cortex of the forebrain, the **septohypothalamic tract (2)** which also houses fibres that go to the olfactory regions of the brain. In the septohypothalamic tract, there are quite a few fibres that travel to the hypothalamus from the fornix. **(4)** denotes fibres of the **external capsule** which contains fibres that connect the putamen to the cortex. The **cingulum bundle (5)** is made-up of longitudinal fibres that run along the cingulate cortex.

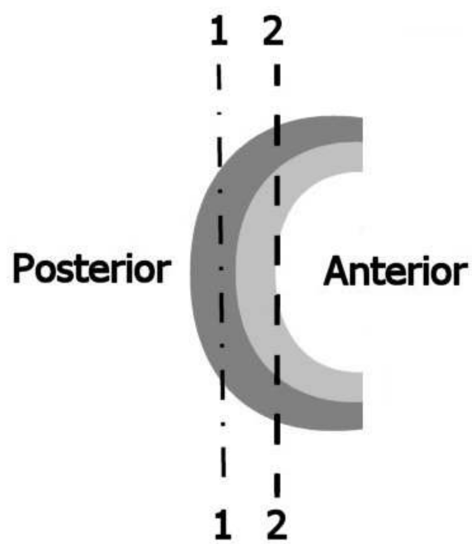
<u>Plate10</u>: Here, the genu of the corpus callosum gives way to the body of the **corpus callosum (9)**. Right underneath, we see the **septum pellucidum (7)**, which divides the left and right ventricles. The **septohypothalamic tract (2)** is still visible, and the **caudate nucleus(3)** and **putamen (10)** begin to really make their appearance. The bits of white fibre striations in that region give that part of the basal ganglia the name “corpus striatum”. The **external capsule (4)** is still faintly visible. Number **(6)** is still labelled (What is it?).

Plate 11: At this level, roughly in the region of the crossing of the **optic chiasm (17)** we see the **anterior commissure (14)** in the midline, which connects the subcortical regions of the left and right brain halves. The columns of the **fornix (13)** curving downwards and posterior towards the hypothalamus, have passed through the **septum (11)** where many of the fibres of the fornix terminate. The white mass of fibres that appears lateral and ventral to the now much smaller **caudate nucleus (3)** is the **internal capsule (16)**, the very massive fibre system through which most of the output from the cortex runs on its way to subcortical, brainstem and spinal targets. We still see a bit of the **external capsule (4)** that borders the **putamen (10)** laterally and we can also see fibres of the **extreme capsule (12)**. These fibres connect the frontal cortex to the temporal cortex and are also known as uncinate fasciculus. We can see the last of the three major basal ganglia in this section, the **globus pallidus (15)**, so named because it appears lighter than the putamen or caudate nucleus. The ventral region of this structure, incidentally, is the target for procedures meant to lessen the effects of Parkinson's disease. Finally, we see the **lateral ventricles (18)** larger than in the more anterior sections and the **corpus callosum (9)** appears thinner.

Plate 12: The lateral ventricles now appear smaller, largely because they are filled by the **fimbria (22)**, the outflow of information from the hippocampus. The **internal capsule (16)** is visible still. The caudate nucleus has petered out into the **tail of the caudate nucleus (19)**. This slice has cut across a fibre bundle that extends from the mammillary bodies to the medial and dorsal region of the **thalamus (8)** called the **mammillo-thalamic tract (20)**. The **third ventricle (23)** makes its appearance and we see two dots on either side, the **fornix (21)** as it curves posteriorly to reach the mammillary bodies. If you look closely, you will see the third ventricle as a thin slit extending to the bottom of the brain. The thick white fibre bundles at the very bottom are actually fibres of the **optic tract (OT)**. The **hypothalamus (H)** lies to either side of the **third ventricle(23)**. At the tip of the temporal lobe we have caught the anterior portion of the **amygdala (24)**.

Plate 13: The body of the **hippocampus (29)** is just starting, and we can also see how the fibres from it form the **fimbria (22)**. The **subcallosal fasciculus (27)**, which consists of fibres that connect the occipital and temporal lobe of the cortex with the frontal lobes and also the insula can be seen squeezed in the corner of the **lateral ventricles (18)**. The main body of the **thalamus (25)** is in massive evidence and at the dorsal and very medial aspect of it we see the **habenula (26)**. The **mammillary bodies (28)** are also visible. The **third ventricle (23)**, looms above the thalamus and beneath the hippocampus and also appears at the ventral aspect of the section. Finally, the **amygdala (24)** is more distinctly visible than in Cut 4.

Plate 14: Now the **hippocampus (29)** is becoming very prominent. Our cut is slightly slanted so that the left half of the brain lies slightly posterior to the right half of the brain. Review Plate 5. The fimbria (light grey in the diagram to the right) is anterior to the hippocampus (dark grey in the diagram to the right). Imagine both structures flowing together, forming a "C". On the right side of the brain pictured in Plate 16 we can see only the hippocampus as it curves from the top to the bottom. This is because we have cut through the posterior portion of the "C" (Line 1 in the diagram) . On the left side of the brain we can see both the **fimbria (F)** and the hippocampus because the cut is closer to the anterior end of the brain (Line 2 in the diagram).



Looking again at Plate 16, the **pineal gland (30)** lies in the midline, and below it you can see the **posterior commissure (31)**. You can see the third ventricle on its way to becoming the **cerebral aqueduct (32)**. Finally, **(34)** denotes the fibres of the **optic tract** as they curve up and into the **lateral geniculate nucleus (33)** of the thalamus. **(32)** denotes the **beginning of the cerebral aqueduct**.

Plate 15: Here the **cerebral aqueduct (35)** is fully visible underneath the **superior colliculi (36)**. A region around the cerebral aqueduct, the **periaqueductal gray (37)** is marked because we will hear about it when talking about pain.

Plate 16: This cut was made through the cerebellar peduncles and shows the bottom of the **cerebellum (41)** fit snugly into the **fourth ventricle (40)**. We also see the region of the cerebellum within which the **cerebellar output nuclei (39)** are found, and the **cortical region of the cerebellum (38)** (previously mentioned in fine print).

By the end of this lab you should be able to identify the following structures without difficulty:

Plate 9:

1 genu of corpus callosum
2 septohypothalamic tract
3 head of caudate nucleus
4 external capsule
5 cingulum bundle
6 corona radiata
10 putamen

Plate 10:

2 septohypothalamic tract
3 head of caudate nucleus
4 external capsule
6 corona radiata
7 septum pellucidum
9 body of the corpus callosum
10 putamen

Plate 11:

3-caudate nucleus
4 external capsule
9 corpus callosum
10 putamen
11 septum
12 extreme capsule
13 columns of the fornix
14 anterior commissure
15 globus pallidus
16 internal capsule
17 optic chiasm
18 lateral ventricle

Plate 12:

8 dorsal medial region of the thalamus

16 internal capsule

19 tail of the caudate nucleus

20 mammillo-thalamic tract

21 fornix

22 fimbria

23 ventricle

24 amygdala

OT optic tract

H hypothalamus

Plate 13:

18 lateral ventricle

22 fimbria

23 third ventricle

24 amygdala

25 body of thalamus

26 habenula

27 subcallosal fasciculus

28 hypothalamus

29 hippocampus

Plate14 :

29 hippocampus

30 pineal gland

31 posterior commissure

32 beginning of cerebral aqueduct

33 lateral geniculate nucleus

34 optic tract fibres on way into lateral geniculate nucleus

F fimbria

Plate 15:

35 cerebral aqueduct

36 superior colliculus

37 periaqueductal gray

Plate 16:

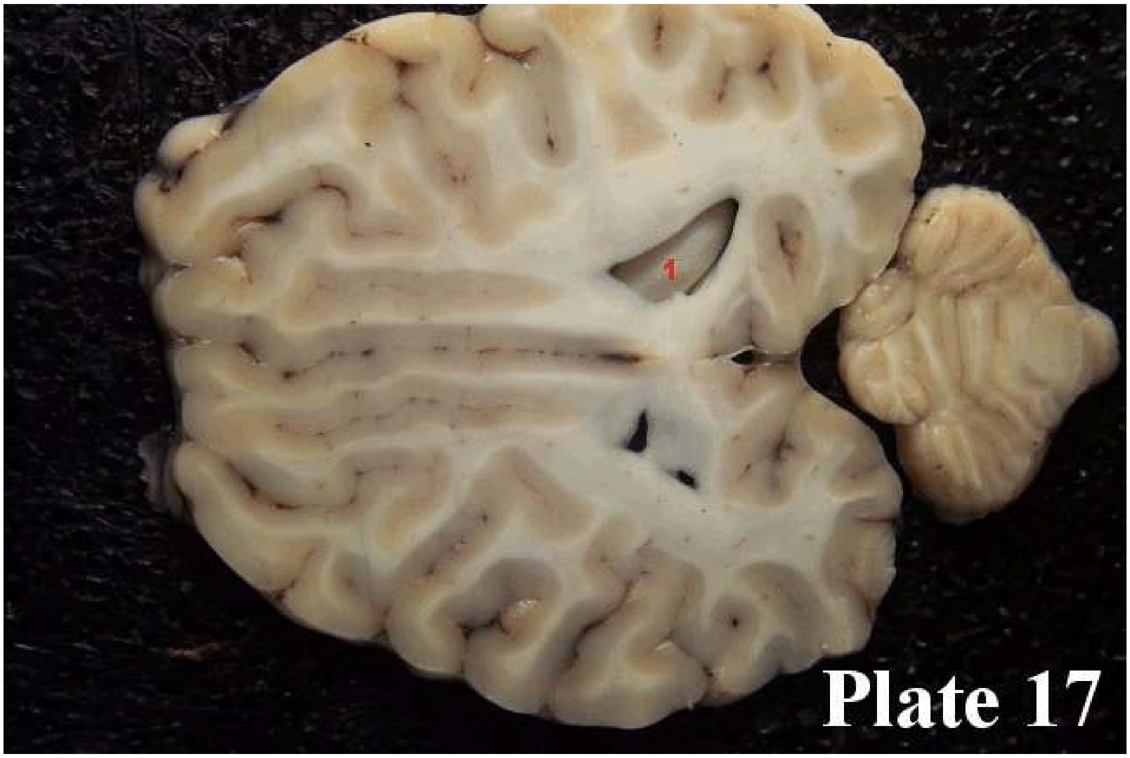
38 cerebellar cortex

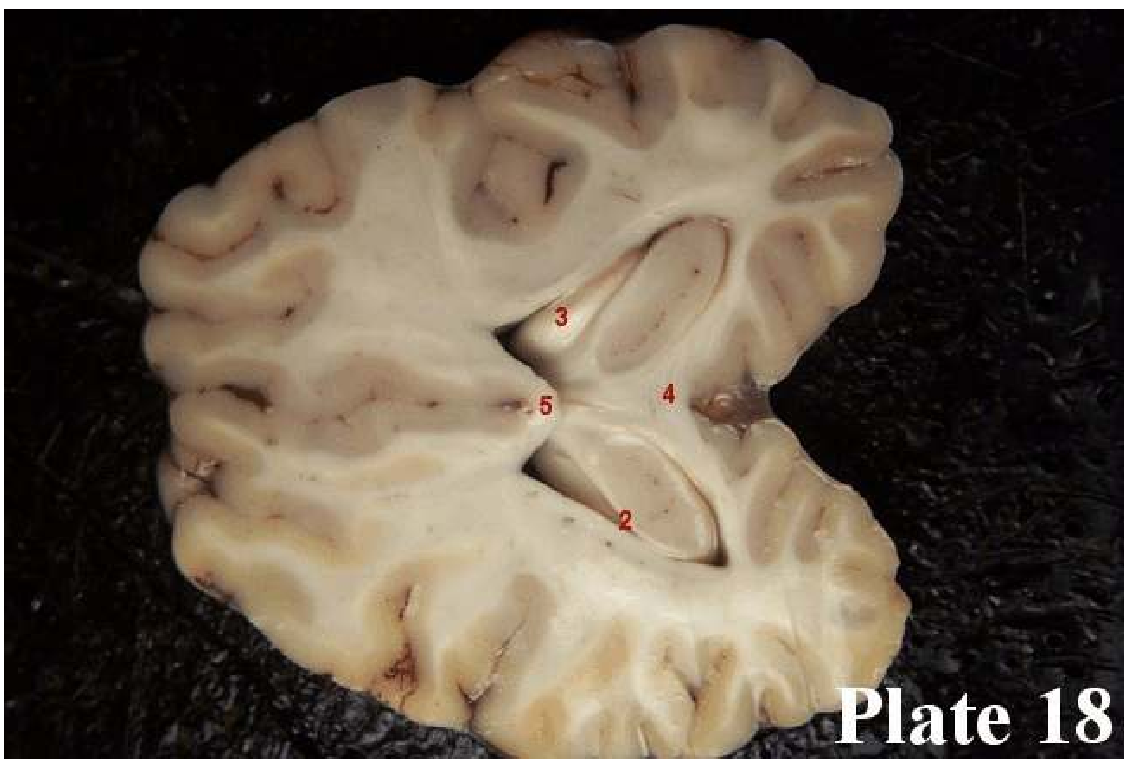
39 nuclei of the cerebellum and fibres

40 fourth ventricle

41 part of the bottom portion of the cerebellum, cortex

Horizontal Cuts





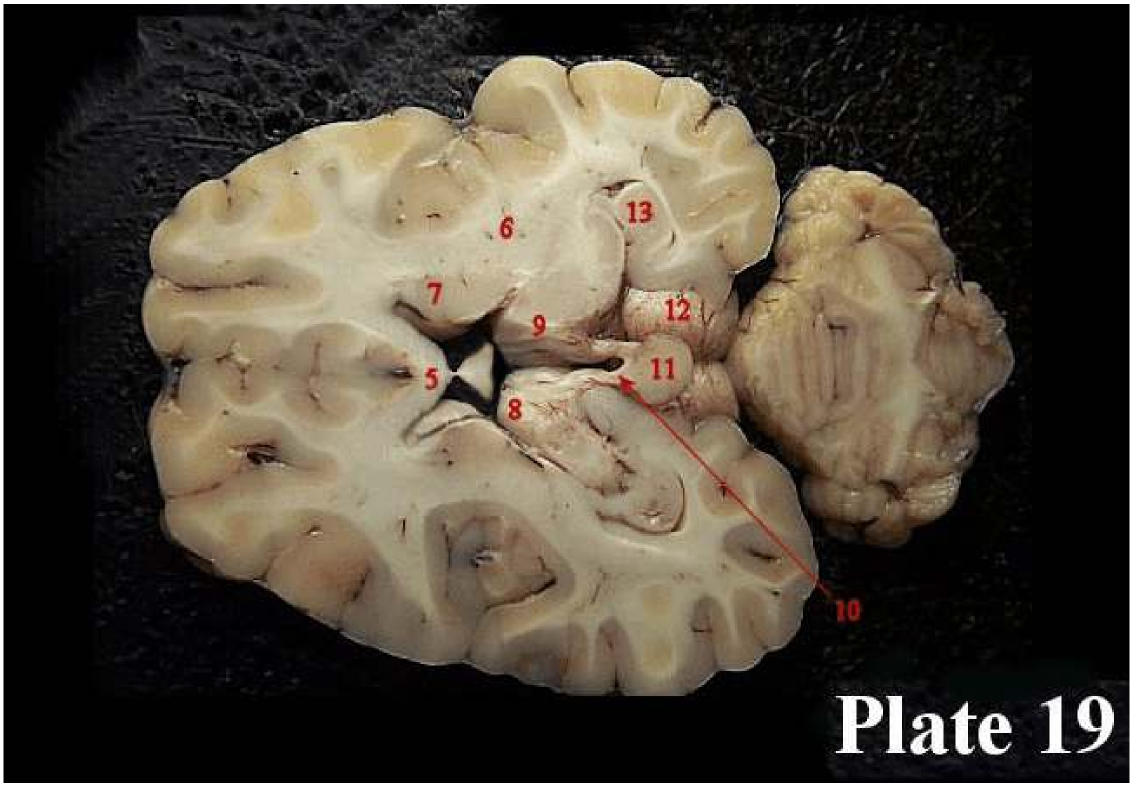

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Plate 19

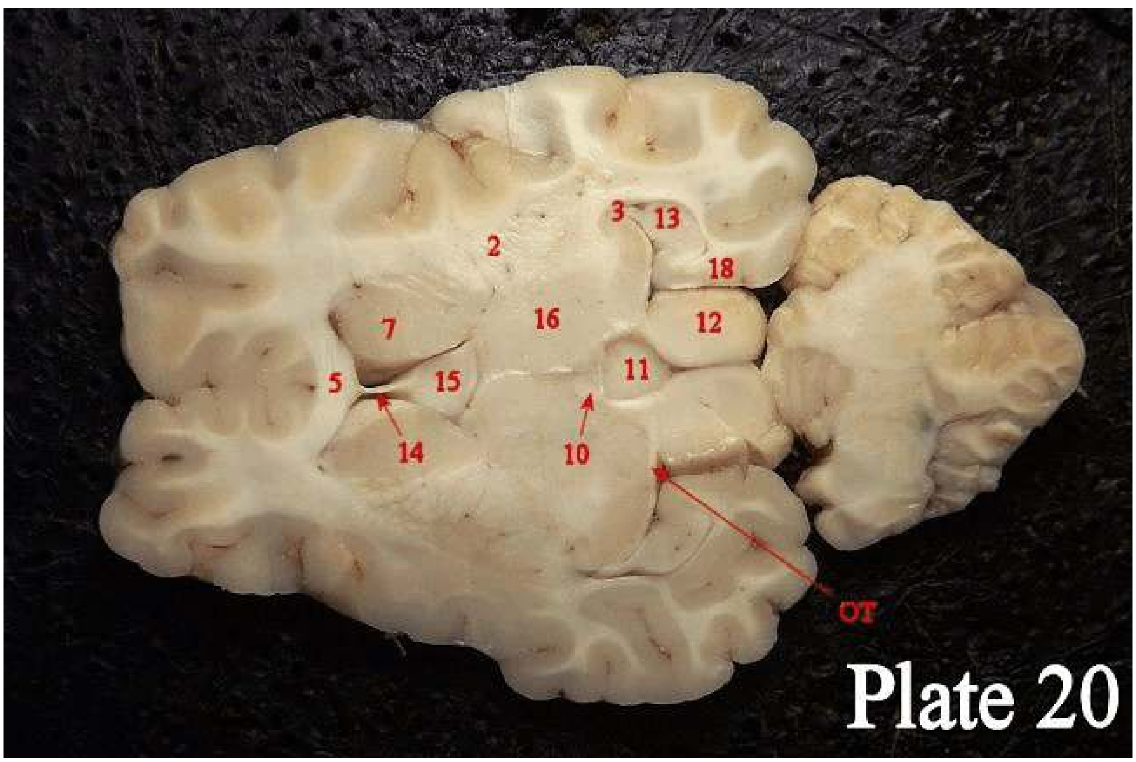
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Plate 20

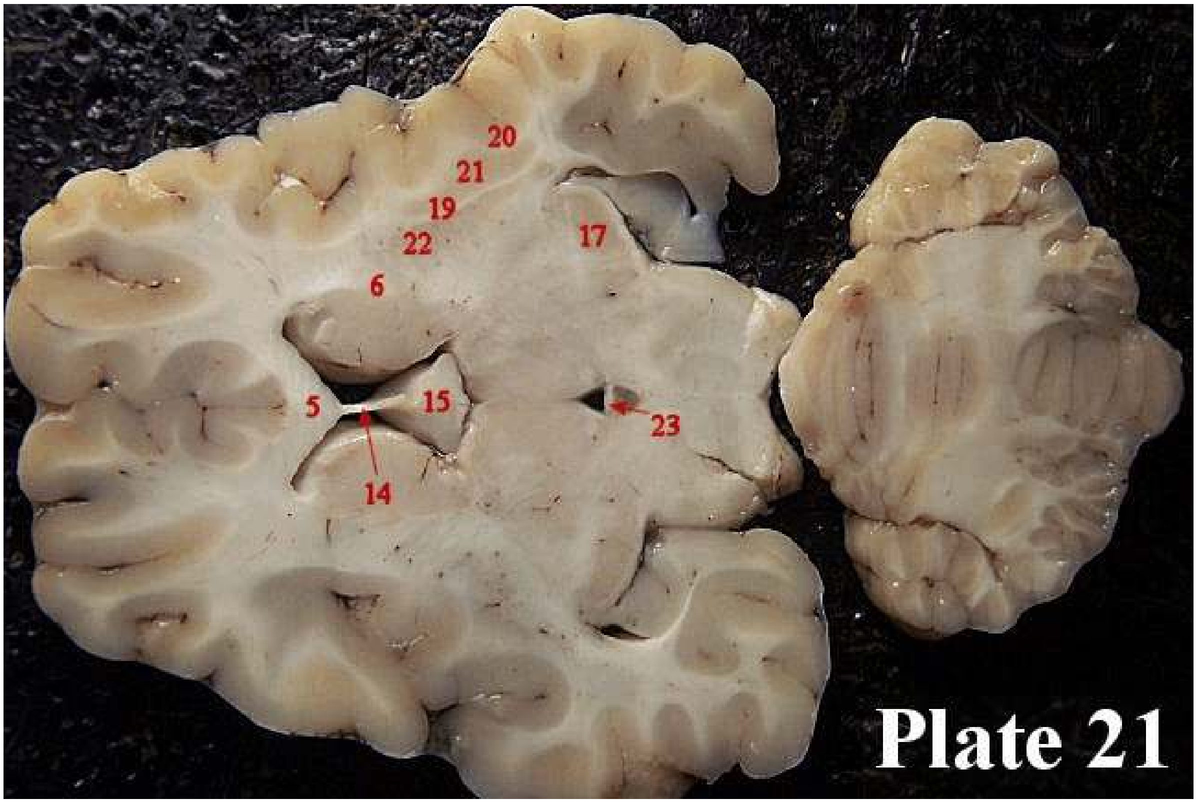

Plate 21

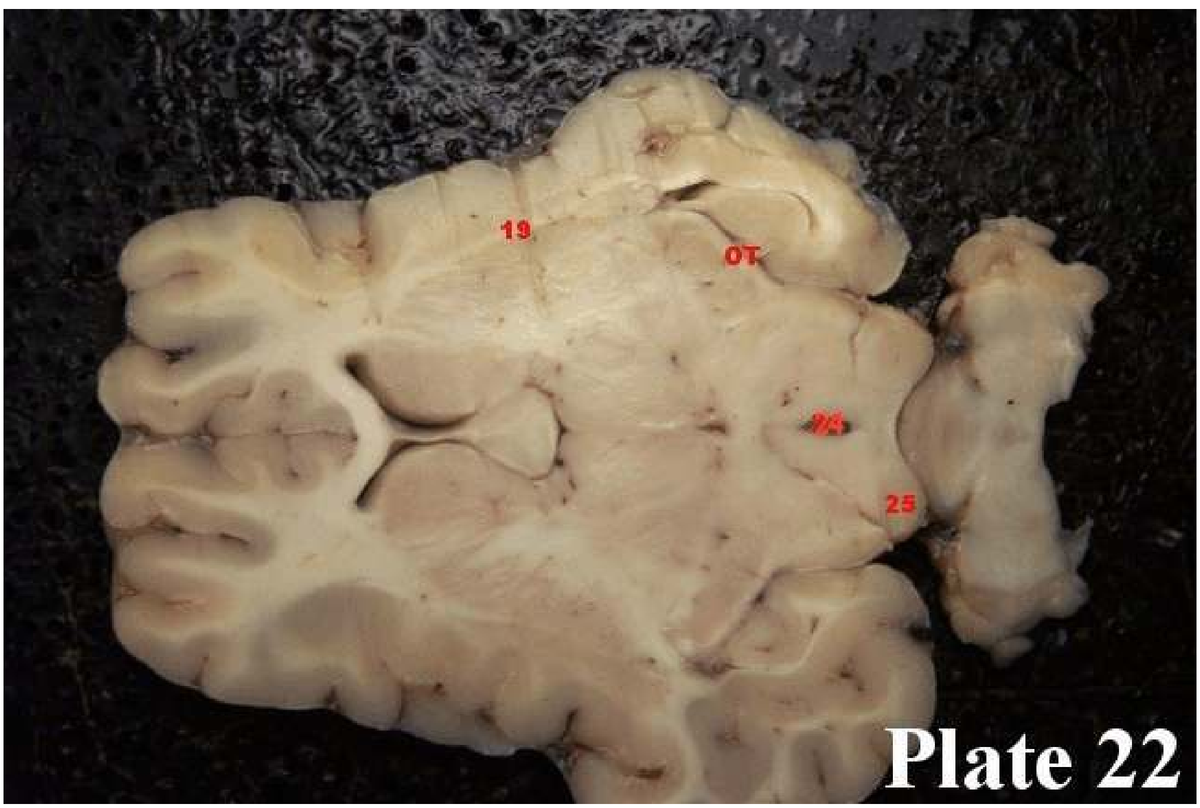

Plate 22

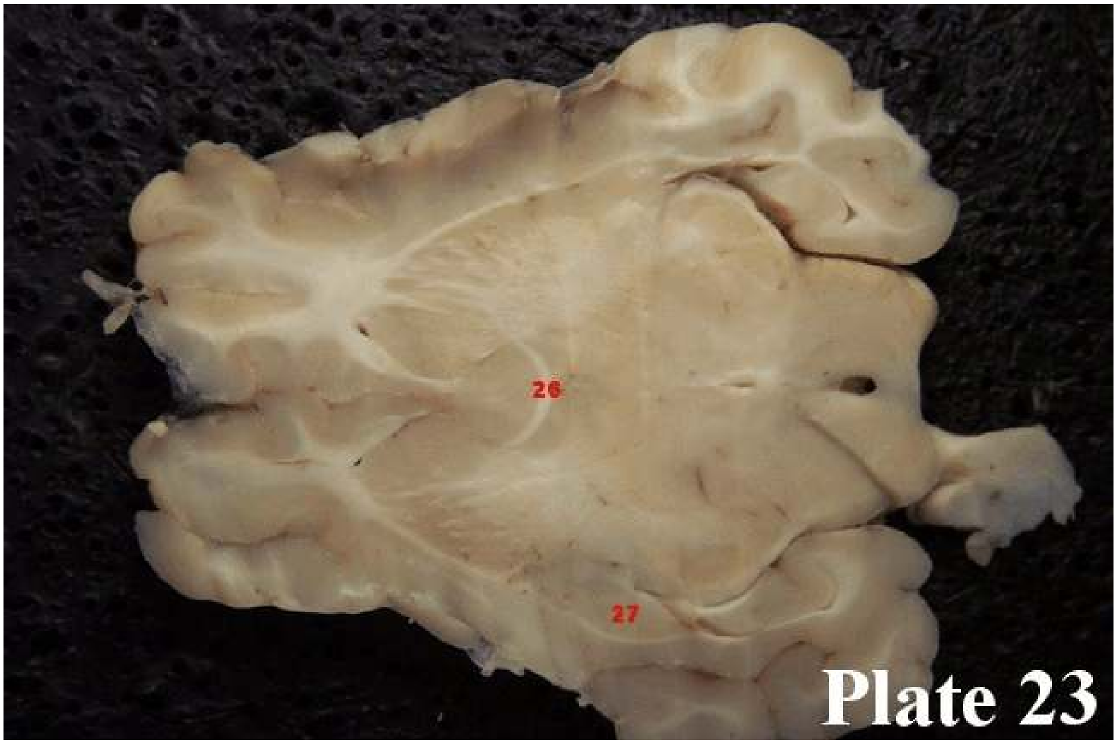

Plate 23

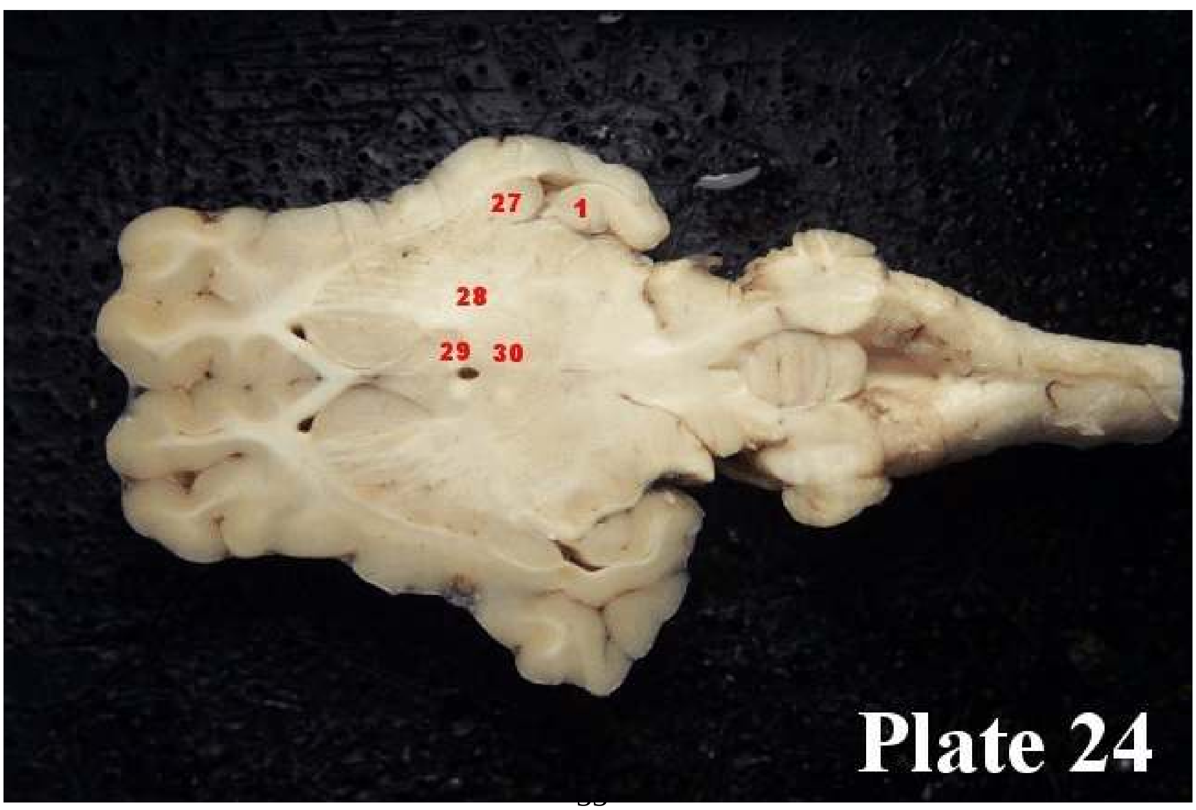

Plate 24

Horizontal cuts are produced by placing your knife or razor at the anterior end of the brain and slicing back to the posterior end. Cuts should be made approximately every half centimetre. Starting at the top and working your way down.

Plate 17: We have courageously cut off a large chunk of cortex with a horizontal cut. The cut is slightly slanted so that it is a bit deeper on the right than on the left brain half. You can see the **hippocampus (1)** peeking out as it lies inside the posterior horn of the lateral ventricles. On the left side of the brain the cut has just barely nicked the roof of the ventricles.

Plate 18: Going a bit deeper, we have now cut across body of the hippocampus. The oval shapes you see represent the gray matter of the hippocampus and the thin while fringe around the hippocampus, especially clear on the right side, is the **alveus (2)**, which is made up of myelinated axons on the way to the **fimbria (3)**. We can also see the **splenium (4)** of the corpus callosum, and the **body of the corpus callosum (5)**. The white fibre masses you see in the body of the cortex represent fibres that stream into and out of the cortical (gray) matter.

Plate 19: At this point we have gone considerably below the level in Cut B. The cut is, again, slanted so that it goes deeper on the right side, and we are can now see the **internal capsule (6)**. Also best seen on the right is the **caudate nucleus (7)** that lies nestled in the anterior horns of the lateral ventricles. The cut has also exposed the **anterior part of the thalamus (8)** and we can see rather nicely how the **stria medullaris (9)**, the fibre tract that runs along the surface of the thalamus and which comes from, among other things, the amygdala, enters the **habenula (10)** on each side of the midline. In this view, the habenulae (this is the plural of habenula) are partially obscured by the **pineal gland (11)**. There is a bit of crossover from fibres of each habenula to the other, across the habenular commissure which can be seen as the thin layer of fibres anterior to the pineal gland. The pineal gland is actually an endocrine gland, and as noted before is involved in the production of melatonin.

To either side of the pineal gland we can see the **superior colliculus (12)**. The **hippocampus (13)** is now seen as a curled structure right behind the posterior part of the thalamus. Behind all this lies the cerebellum. **(5)** denotes the **body of the corpus callosum** again.

<u>Plate 20</u>: This cut was taken only millimetres below the last cut. We see a nice view of the **septum pellucidum (14)**, the thin membrane that separates the lateral ventricles in the midline, and right behind it the **septum (15)**. On either side of these lies the head of the **caudate nucleus (7)**, now noticeably thicker than in the higher sections. “Caudate” means “with a tail” and the head is the thick portion that peters out into the tail (which you have seen in the coronal section). The massive central structure behind the septum is the **thalamus (16)**, and at the posterior margin of the thalamus we can see the **lateral geniculate nucleus (17)**. If you look carefully at the posterior margin of this structure (also in Cut E), you can see the thin white fibre band which is made up of optic fibres that stream into the lateral geniculate nucleus from the **optic tract (OT)**. The central small round structure is the **pineal gland (11)**, and just anterior to the pineal gland, on either side of the midline, lie the **habenulae (10)**. Posterior to these we have cut straight through the **superior colliculi (12)**. We also have a nice look at the **internal capsule (6)** on the right side of the cut. Finally, we can see where the input to the **hippocampus (13)** flows from the so-called **entorhinal cortex (18)**. The outflow is provided by the **fimbria (3)**, which becomes the fornix that reaches the septum, leaves quite a few fibres there and then curves down and in a posterior direction to provide input to the mammillary bodies. We now see the most anterior part of the corpus callosum, the **genu of the corpus callosum (5).**

<u>Plate 21:</u> Here we see the **genu of the corpus callosum (5)**, as well as the **septum pellucidum (14)** and the **septum (15)**. The caudate nucleus is still visible, although no longer marked. As in the coronal cut, lateral to the caudate nucleus is the **internal capsule (6)**. Lateral to the internal capsule is the **putamen (22)**. Lateral to the putamen is the **external capsule (19)**. Lateral to the external capsule is the **claustrum (21)**, and finally, lateral to the claustrum is the **extreme capsule (20)**. The **Lateral geniculate nucleus (17)** is still visible. In the middle, we see a fine thin band stretching across the midline. This is the **posterior commissure (23)**. Behind it lie the superior colliculi.

Plate 22: This section shows us the **cerebral aqueduct (24)** as it conducts cerebrospinal fluid from the third ventricle to the fourth ventricle. Because we are now quite low in the brain, and because we have cut into the cerebral aquaeduct, we deduce that we have now cut through the **inferior colliculi (25)**. Going to a more anterior portion of this section, we have a very nice view of the **external capsule (19)** and the putamen is more clearly defined. We can now also see the striations (really, stripes) that run across the anterior part of the putamen, and it is from these that anatomists have derived the name "corpus striatum" - striped body - that is often applied to that part of the basal ganglia. The fibres of the **optic tract (OT)** are still visible.

Plate 23: This we have selected for several features. First, we can see the **anterior commissure (26)**, which connects the subcortical regions of the brain halves. Second, we have a very nice look at the striations across the putamen, plus a nicely defined external capsule. The **amygdala (27)** makes its appearance on the left side of the cut.

Plate 24: Now we are very close to the bottom of the brain. We can now see all three of the basal ganglia together: the head of the caudate nucleus, the putamen, and the pale region posterior to the putamen and caudate, and lateral to the septum, the **globus pallidus (28)**. You can see why it is called the "pale globe" - it looks very light, more like a fibre mass than a nucleus. Anterior to the **hippocampus (1)** at the bottom of the temporal lobe, we can see the **amygdala (27)** on both sides and its oval form gives it the name "almond" because of its almond shape. In the middle of the section, just where the little black hole formed by the third ventricle can be seen, we see four white dots. These are formed by fibre bundles that travel from above this section to below the section - and you have encountered both of them. The anterior pair of dots, just behind the septum, are the two columns of the **fornix (29)**. The posterior dots are the **mammillo-thalamic tracts (30)** which, as the name suggests, are on the way from the mammillary bodies to the thalamus.

By the end of this lab you should be able to identify the following structures without difficulty:

Plate 17:

1 hippocampus

Plate 18:

2 alveus

3 fimbria

4 splenium of corpus callosum

5 body of the corpus callosum

Plate 19:

5 body of the corpus callosum

6 internal capsule

7 caudate nucleus

8 anterior thalamus

9 stria medullaris

10 habenula

11 pineal gland

12 superior colliculus

13 hippocampus

Plate 20:

3 fimbria

5 genu of corpus callosum

6 internal capsule

7 caudate nucleus

10 habenula

11 pineal gland

12 superior colliculi

14 septum pellucidum

15 septum

16 thalamus

17 lateral geniculate nucleus

18 entorhinal cortex

OT optic tract

Plate 21:

5 corpus callosum

6 internal capsule

14 septum pellucidum

15 septum

17 lateral geniculate nucleus

19 external capsule

20 extreme capsule

21 claustrum

22 putamen

23 posterior commissure

Plate 22:

19 external capsule

24 cerebral aquaeduct

25 inferior colliculi

OT optic tract

Plate 23:

26 anterior commissure

27 amygdala

Palte 24:

27 amygdala

28 globus pallidus

29 fornix

30 mammillo-thalamic tracts