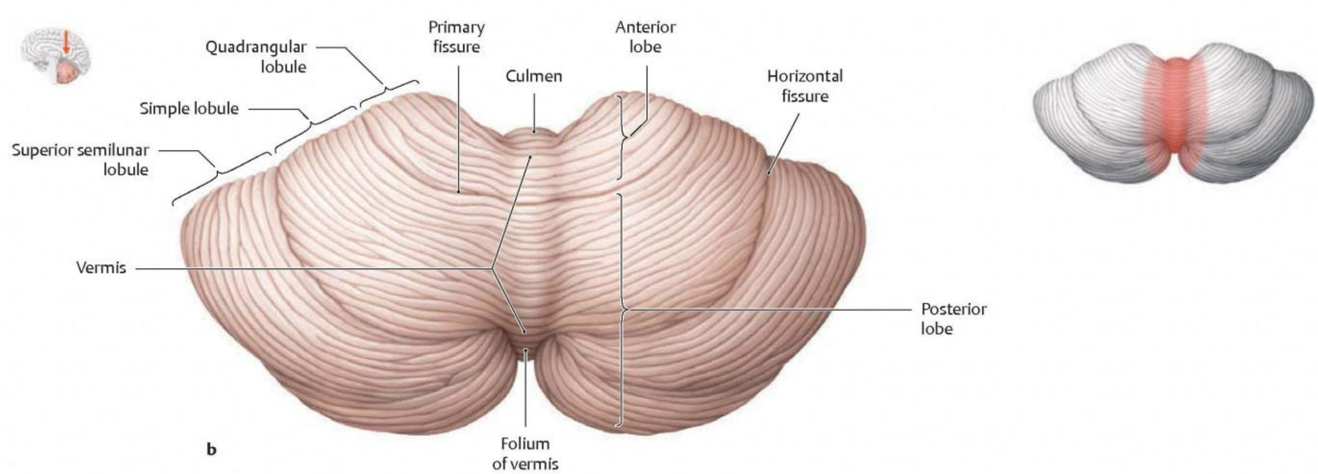
Look in the clear dissection bucket and remove the cerebellum

The cerebellar cortex

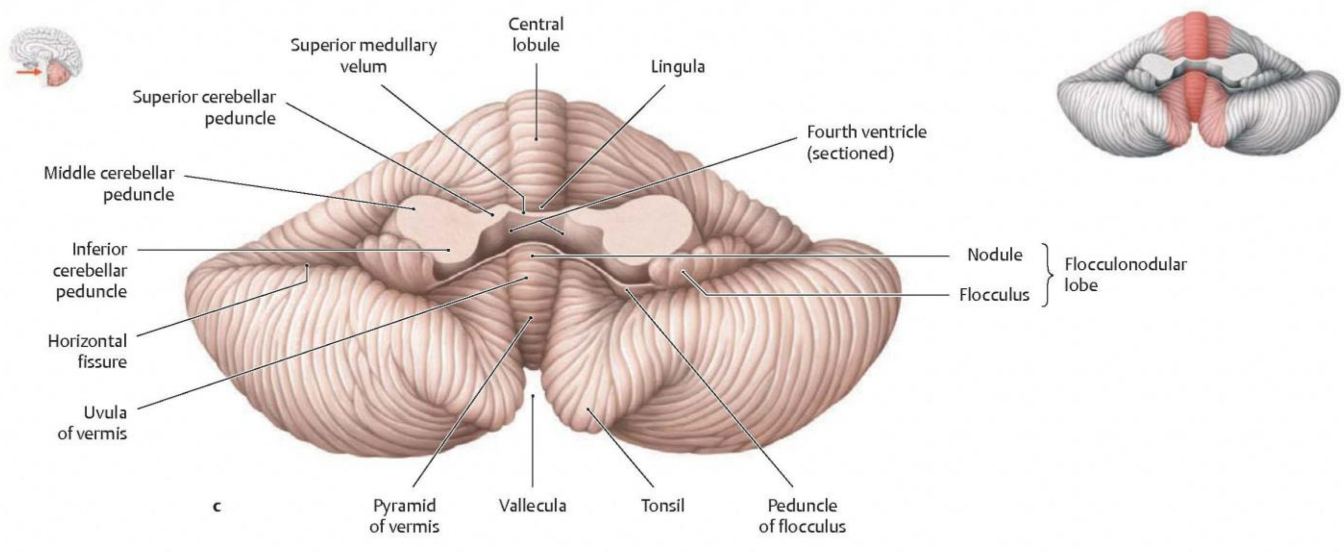
Examine the superior surface of the whole cerebellum. First identify the vermis — a blunted ridge along the midline — and the cerebellar hemispheres. Notice the many transversely oriented grooves — the cerebellar version of sulcuses. The narrow 'gyruses' in between the grooves are called folia. Some of the grooves are a bit deeper and separate lobules of the cerebellar cortex. You can best appreciate this by gazing at the longitudinally cut vermis on the half cerebellum. You can also appreciate that the vermis begins rostral to the cerebellar stalk and curves sharply back over the stalk until the caudal end of it almost touches the rostral end. The whole of cerebellar cortex follows this severe recurve. Two of the deeper grooves, the primary fissure and the posterolateral fissure are worth remembering. These two fissures separate the cerebellar cortex into three lobes. The separation is important since these lobes of the cerebellum are phylogenetically and functionally distinct.



The primary fissure is on the superior surface of the cerebellum and marks the boundary between the smaller anterior lobe and the huge posterior lobe. The posterior lobe extends all the way around onto the inferior surface of the cerebellum.

➔ To view the underside of the cerebellum, rotate the cerebellum ventral side up, so you can see the cut surfaces of the cerebellar peduncles.

On the underside (the side facing into the fourth ventricle), the posterior lobe ends at the posterolateral fissure. The far smaller flocculonodular lobe sits on the other side of the posterolateral fissure (Fig. 10). The flocculonodular lobe is closely related to the vestibular system, and therefore, is often referred to as the vestibulocerebellum.



Identify the cut surfaces of the cerebellar peduncles. The largest portion is the middle cerebellar peduncle connecting the cerebellum with the pons. The most posterior part is the inferior peduncle connecting the cerebellum with the medulla and spinal cord. The most anterior part is the superior peduncle connecting the cerebellum with the midbrain and thalamus.

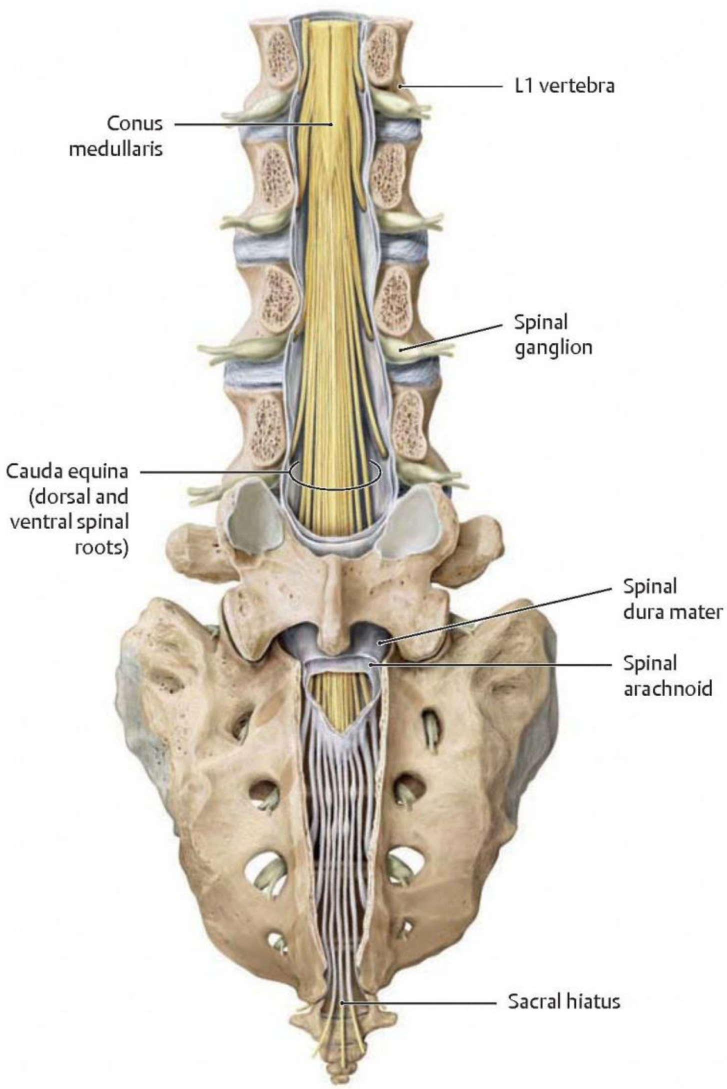
Identify the cerebellar *tonsils*. These are bulges in the inferior cerebellar surface near the midline which, in the living state, slump a little bit through the foramen magnum on either side of the medulla. They can herniate through the foramen magnum whenever there is a space occupying lesion that presses downward on the brain as might happen with an extradural bleeding. When the tonsils are squeezed through the foramen magnum, they press against the sides of the medulla and the pressure interrupts its neural activity. Since several vital functions — such as breathing and heart rhythm — are dependent on medullary cell groups, a tonsilar herniation can be fatal if not relieved.

➔ Before putting away your brain dissection, take a few minutes to look at the spinal cord specimen in your bucket.

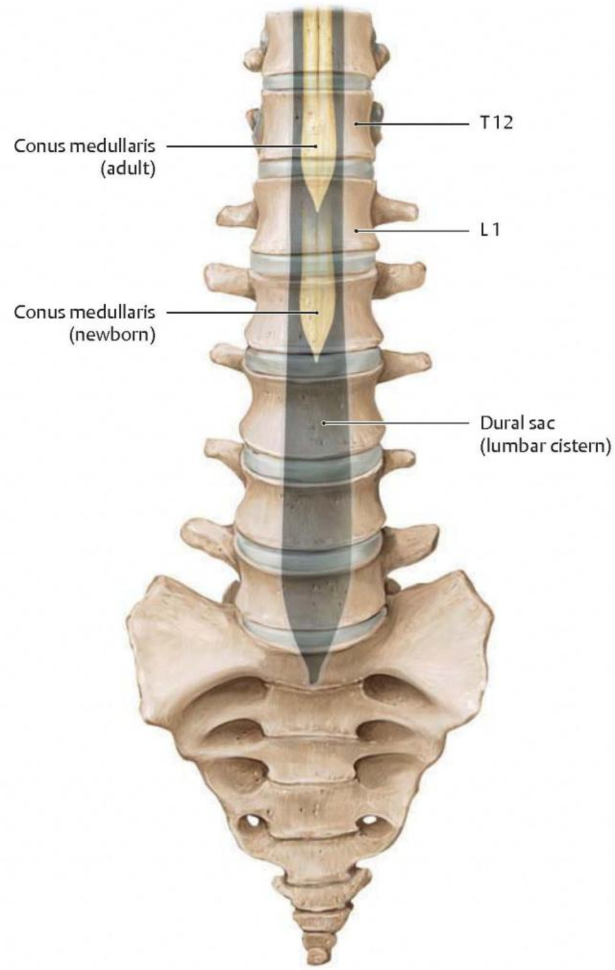
THE SPINAL CORD (Review its structure and the functions you learned this fall in the block covering peripheral nerves and spinal cord)

Observe the spinal cord specimen which you have. Is it still completely covered in dura? If so you will need to begin cutting through the dura at one end. Can you find the three meninges surrounding the cord? Look for the extensions of pia out to the dura - the **denticulate ligaments**, which anchor the cord inside the dural sac.

At its caudal end the spinal cord tapers into the **filum terminale**. Dorsal and ventral root fiber bundles continue for several more centimeters as the **cauda equina** before leaving the spinal column as the lumbar and sacral nerves. Why does the spinal cord end before the end of the spinal column? What is the CSF-filled space called which contains the cauda equina?

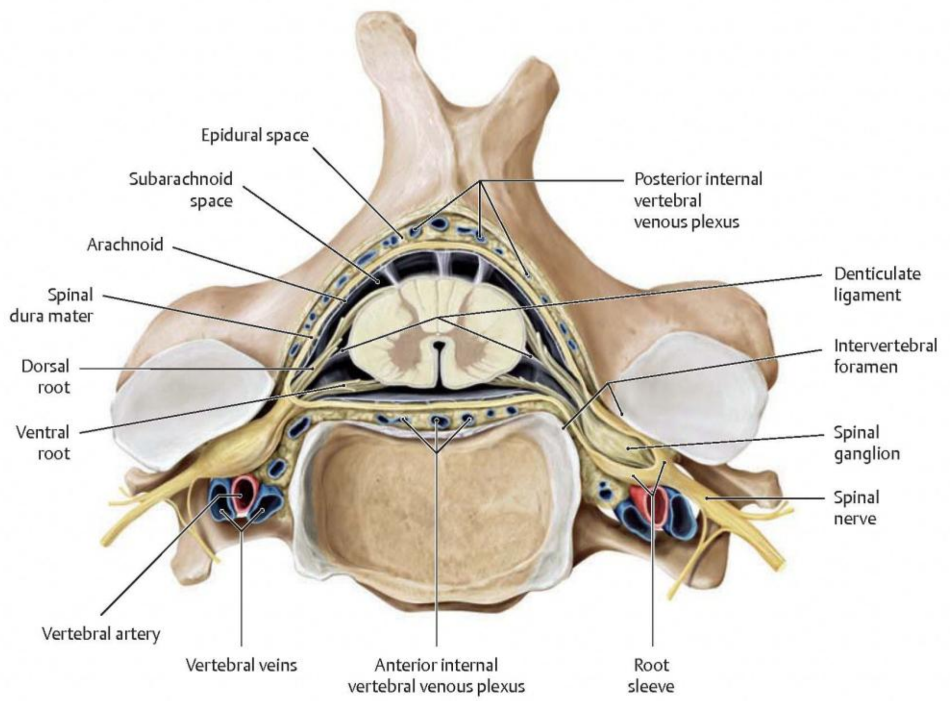


As a person grows and the spinal column lengthens, the spinal cord does not lengthen as quickly. The disparity results in a relative shortening of the spinal cord compared to the CSF-containing dural space. This means that nerve roots have further to travel within the spinal canal before they exit at their respective intervertebral level. It also means that the conus medullaris is located at a higher level in adults. What is the significance of this to a clinician performing a lumbar puncture?

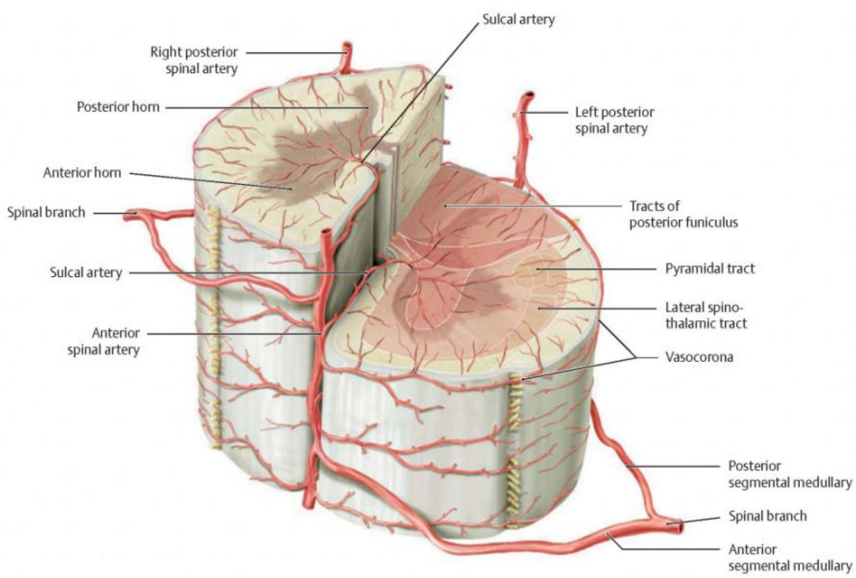


Trace the spinal cord rostrally from the filum terminale and find the **lumbar enlargement**. The diameter of the cord is larger here where the lumbar roots are attached. Look a bit more rostral and you will see the diameter decrease somewhat as you move to thoracic levels. Most of the cords in your bucket are too short to see that the diameter of the cord again increases at cervical levels - the **cervical enlargement**. Why are these enlargements present?

Look at the external surface of the cord. Locate its anterior (ventral) surface by the deep medial groove, the **anterior (ventral) median fissure**. (The **anterior spinal artery** runs along this fissure.) You should see **anterior (ventral) roots** attached to the cord on either side of the anterior median fissure. Which direction do impulses normally travel along these roots?
Turn the cord over to look at the posterior (dorsal) surface. You should find a broad ridge of white matter extending laterally from the midline - the **posterior (dorsal) columns**. Along the groove at the lateral edge of the posterior columns find the **posterior (dorsal) roots**. Which direction do impulses normally travel along these roots?



See if there are small blood vessels adhering to the spinal cord. The anterior (motor) side of the cord receives arterial blood from a midline vessel that is located in the deep anterior sulcus. The posterior (sensory) side of the cord receives blood from paired posterior spinal arteries.



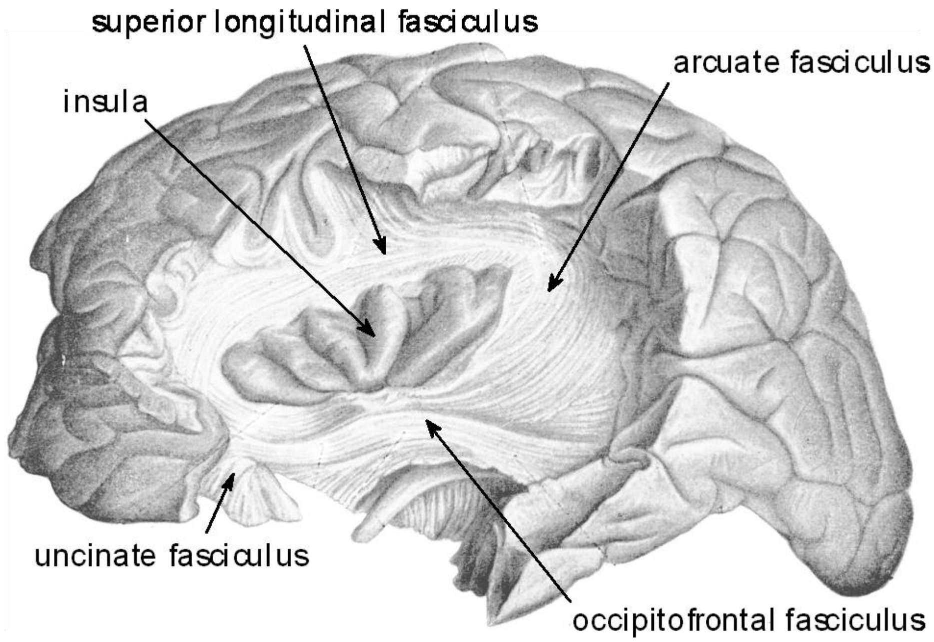
Where does the blood supply to the cord come from at different levels of the spinal cord? The THIEME Atlas of Anatomy: Head and Neuroanatomy provides answers on pages 286-287.

Brain Dissection Laboratory

THE FIBER BUNDLES

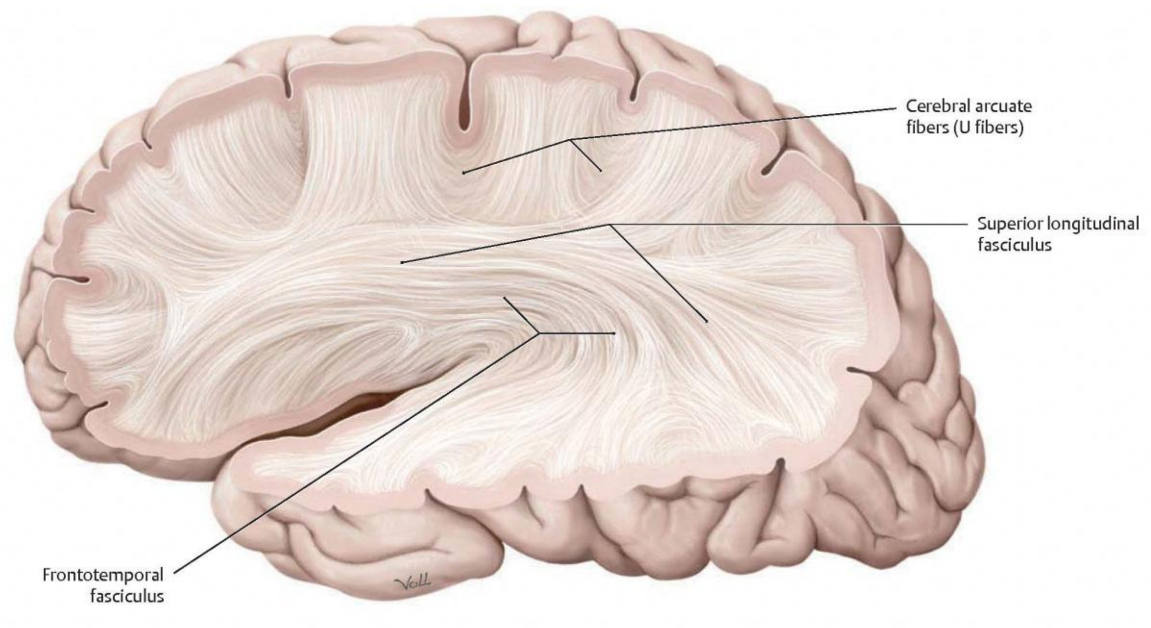
Beneath the cerebral cortex, the center of the hemisphere consists of massive bundles of myelinated fibers that can be categorized into three general groups with respect to the cerebral cortex — *association*, *commissural* and *projection*. Association fibers interconnect nearby and distant cortical regions within the same hemisphere. Commissural fibers cross between the two hemispheres. Projection fibers are those that leave the cerebral cortex to reach subcortical nuclei. You will now do a blunt dissection which will reveal several examples of each group.

⇒ Choose the half brain from the dissection bucket (clear plastic) on which you previously exposed the insula. Lay the half brain lateral side up. On the half in which you exposed the insula, use the back end of your knife handle to pry away the cortex of the frontal and parietal lobes. Begin above the insula and pry up and away to expose the deep-lying white matter.



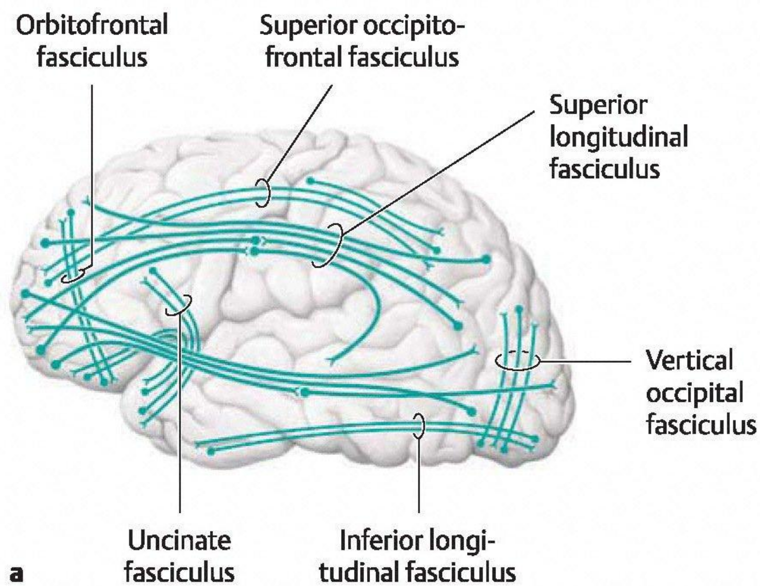
Corticocortical association bundles

The first bundle to be exposed is the superior longitudinal fasciculus which courses immediately above the rim of the (still intact) insular cortex. It runs rostrocaudally through the hemisphere and carries axons interconnecting the cortex of the frontal lobe with the parieto-occipital and temporal regions. Try to tease it out with the back of your knife and follow it around the bend into the temporal lobe. Where it curves around, it is often called the arcuate fasciculus. It merges with another association bundle — the occipitofrontal fasciculus — that courses rostrocaudally through the white matter of the temporal lobe.

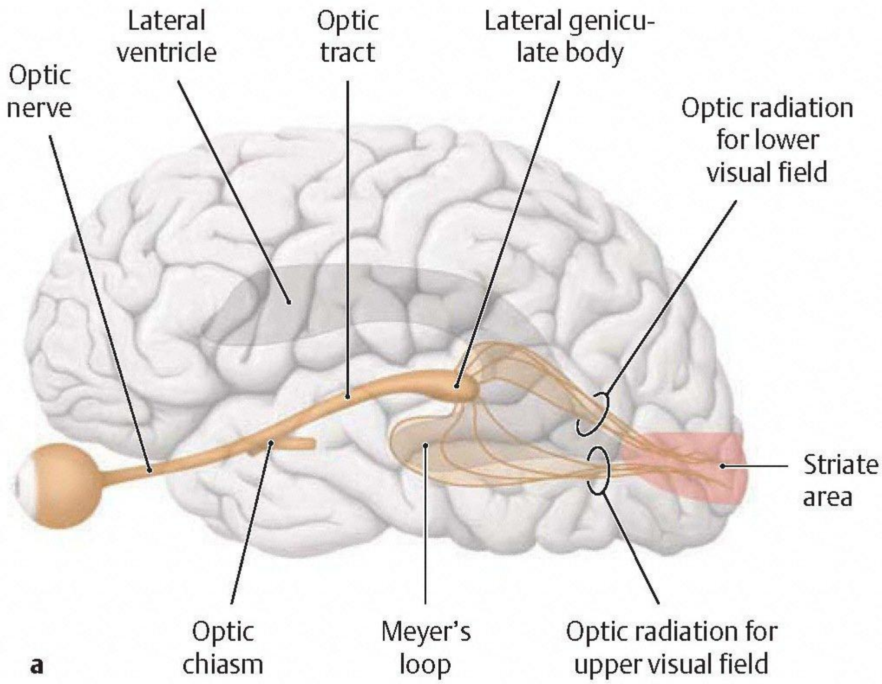


Now peel the cortex upward along some of the gyruses above the superior longitudinal fasciculus to discover a few of the many short association bundles that run from gyrus to gyrus under the sulcuses. These are called U-bundles or arcuate fibers.

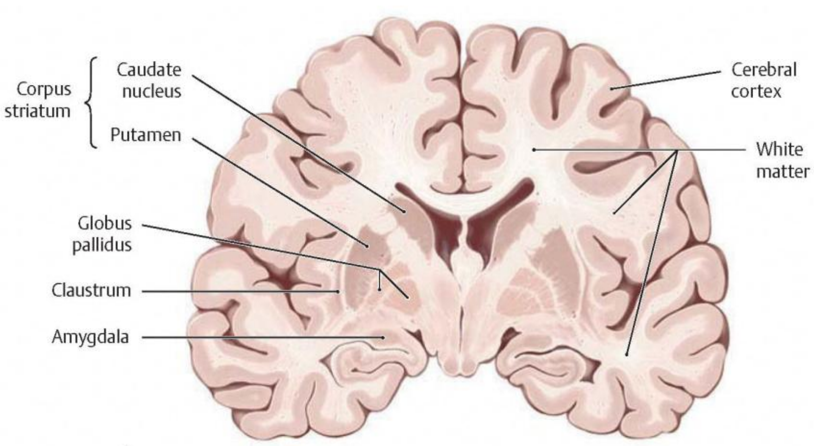
Next focus your efforts on the temporal lobe to expose first the occipitofrontal fasciculus. You should be able to detect its confluence with the superior longitudinal fasciculus. Use the same blunt dissection technique to expose the uncinate fasciculus linking the cortex of the temporal pole with that of the orbital surface of the frontal lobe. You'll find it by peeling away the cortex at the rostroventral margin of the insula, the limen insulae (Fig. 14). Notice that many fibers of the occipitofrontal fasciculus appear to join the uncinate fasciculus.

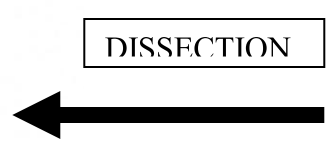


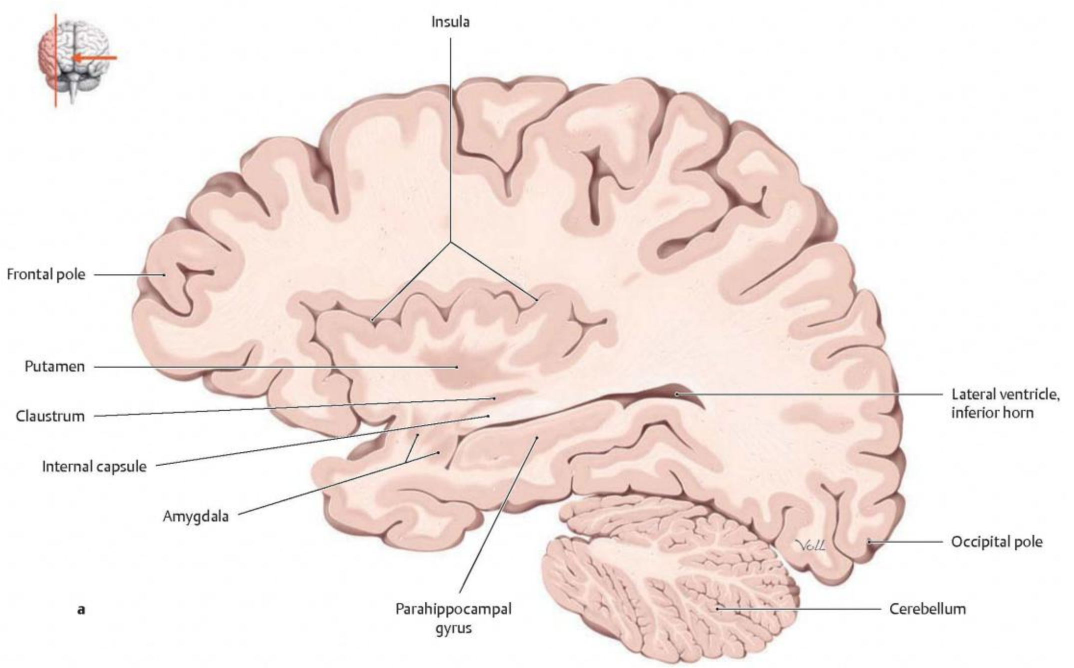
If you are particularly dexterous, and a little bit lucky, you may be able to pry away the occipitofrontal fibers to reveal the underlying optic radiations. Be careful! The optic radiations form a sheet as thin as bathroom tissue adjacent to the lateral ventricle — you can easily gouge through and miss it entirely. And you know how unpleasant it is when you accidentally break through your piece of bathroom tissue. The very best dissectors among you can even uncover Meyer's loop where some of the fibers of the optic radiation swing rostralward before heading back toward the occipital lobe. Is the optic radiation an association bundle?



⇒ As you proceed with the next phase of this dissection, you should refer frequently to the schematic frontal section of the brain shown below. It shows the relative positions of several of the structures you will encounter sequentially as you probe ever deeper in to the core of the brain. Begin by prying out the superior longitudinal fasciculus. Next, gingerly peel away the insular cortex.

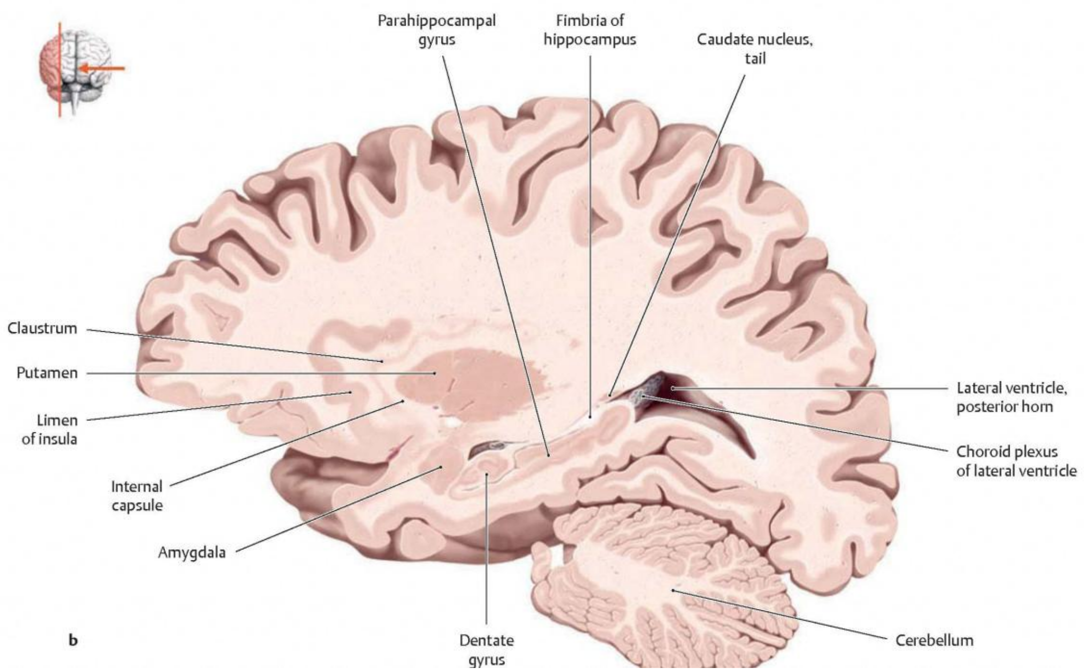




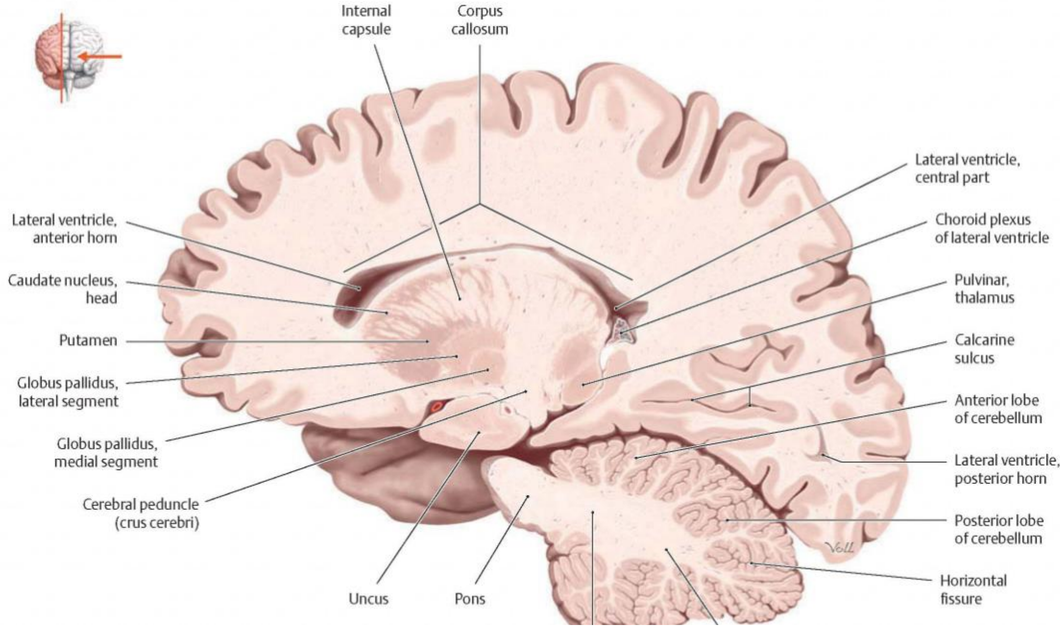


Deep structures of the cerebral hemisphere

Under the insular cortex, you'll first encounter subcortical white matter. It's called the extreme capsule and it is extreme not only in position, but in dimension as well. It is extremely thin. If you are not careful, you will scrape it away along with the insular cortex. Deep to the extreme capsule you'll reveal a layer of gray matter — the claustrum — which is also very thin. The claustrum is a sliver of subcortical gray matter of obscure function that is known to be interconnected with parts of the cerebral cortex. Cautiously continuing deeper, you next expose yet another thin layer of white matter called the external capsule. Scraping away the external capsule brings you to the lateral face of the putamen.

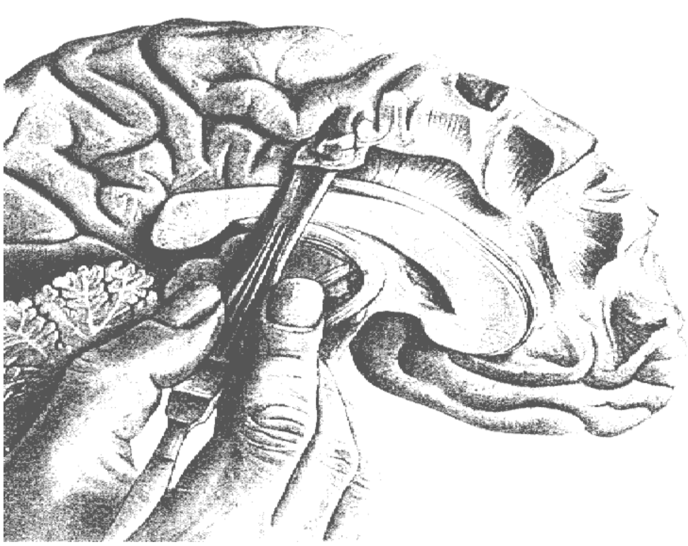


The putamen is gray matter and a large nucleus of the basal ganglia lying deep within the cerebral hemisphere. It receives many axons of cortical origin. If you scoop it out, you will find medial to it the globus pallidus, another gray matter component of the basal ganglia. The globus pallidus has a slightly lighter hue than the putamen because several bundles of myelinated fibers enter it. One major source of those axons is the putamen.

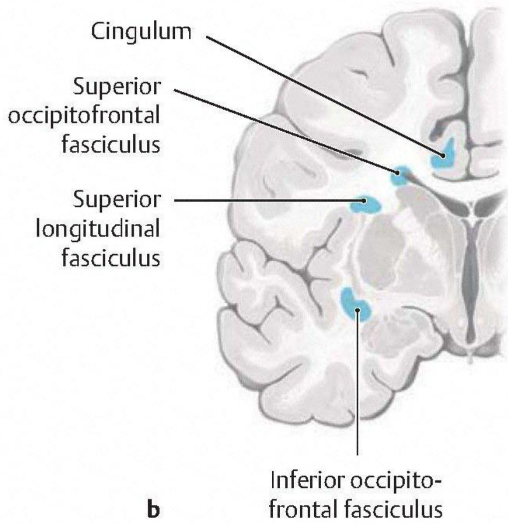


Another is the caudate nucleus which you will see better from the medial side. Once you scoop out the globus pallidus, you are looking at the lateral side of the internal capsule — a bundle composed of axons descending from and ascending to the cerebral cortex. Before you finish today, you'll see the internal capsule again from its medial side. Is the internal capsule an association bundle, a commissural bundle, or a projection bundle?

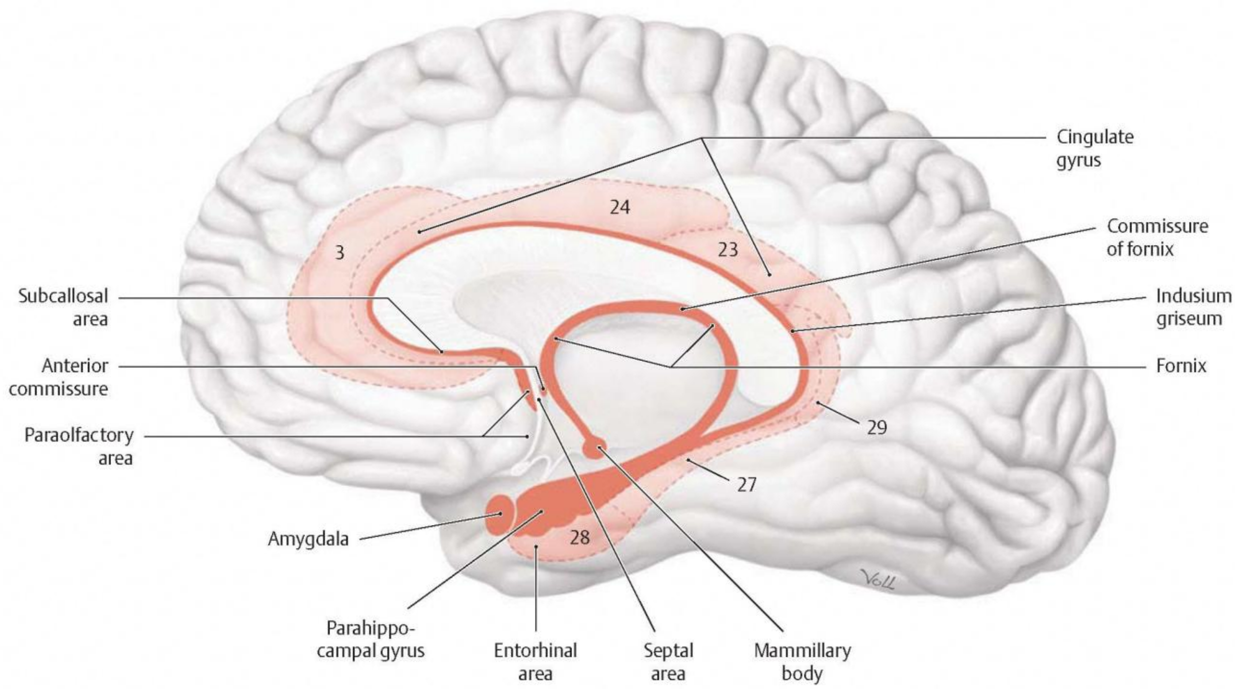
⇒ Stop scraping from the lateral side and flip the brain over to go at it from the medial side. Moisten the brain, then use the same knife handle technique.



Begin by peeling away the cingulate gyrus to expose the cingulum bundle, which travels longitudinally.

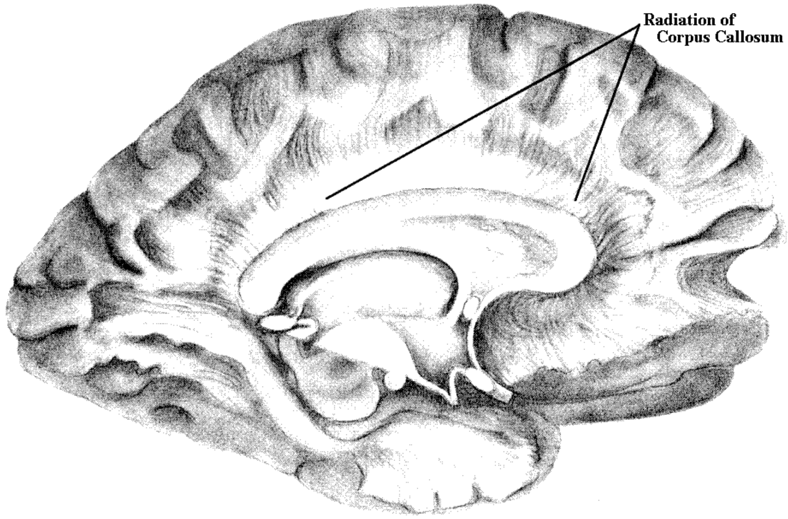


The axons in the cingulum travel the length of the cingulate gyrus and arch behind the splenium of the corpus callosum to enter the parahippocampal gyrus. Thus, the cingulum bundle is an important association system for the cortex along the medial fringe of the cerebral hemisphere (sometimes called the limbic lobe). While you remove the cingulum bundle, review mentally the major corticocortical association bundles you have seen. Appreciate that they connect cortical areas within the same hemisphere.



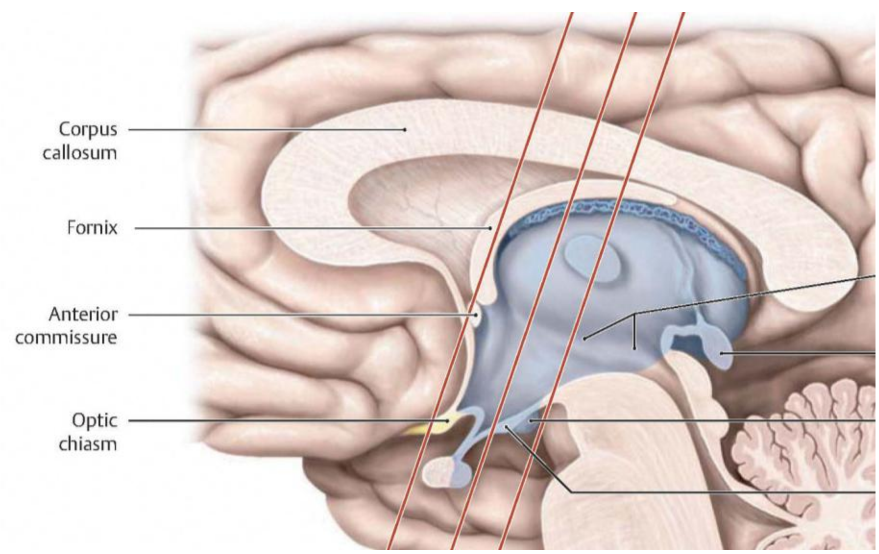
Now turn your attention to the axons that interconnect cortical areas of the two hemispheres with one another — the commissural fibers.

⇒ Lay your knife handle flat on the dorsum of the corpus callosum and press gently inward (toward the lateral side of the brain) and upward. This technique should allow your knife handle to follow the laterally upsweeping course of the corpus callosum fibers. Repeat the process along the length of the corpus callosum until you've achieved something similar in appearance below.



You can now fully appreciate that the millions of axons in the corpus callosum interconnect wide areas of the cortex in the two hemispheres. Most of the time, the interconnections link homotopic areas with one another.

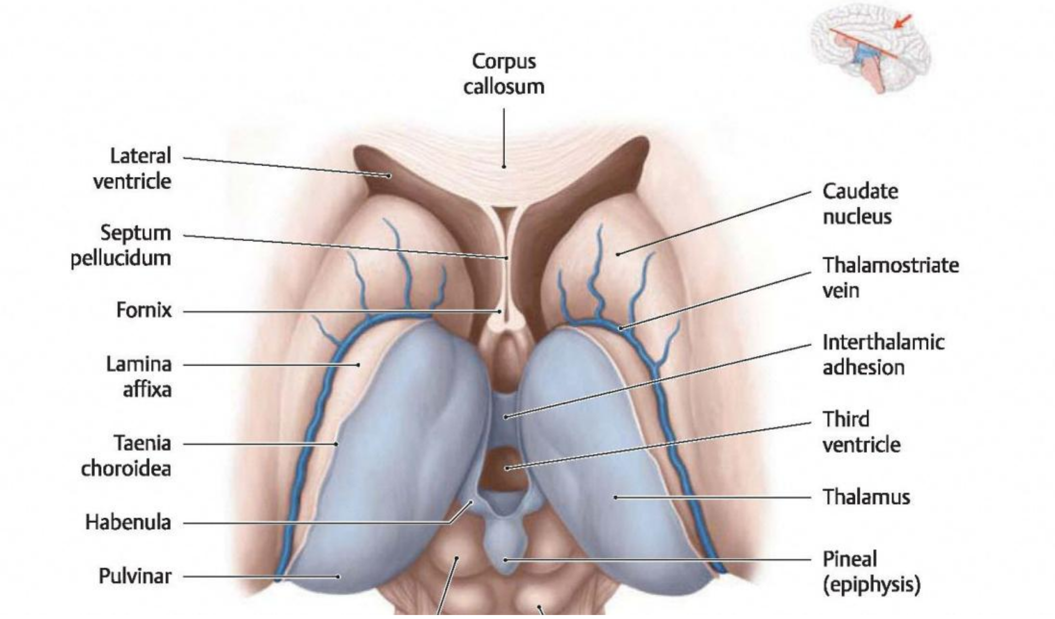
Now find the cut end of the anterior commissure and pry away the tissue surrounding it. See how far you can follow it laterally. The bundle you can distinguish easily is actually only the posterior limb of the commissure which interconnects the cortex of the temporal poles. The commissure also has a smaller anterior limb which carries fibers from the olfactory bulbs.



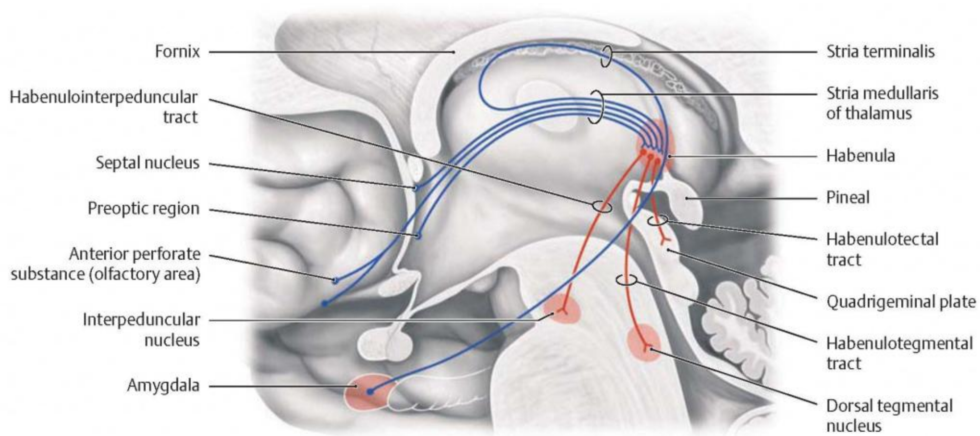
⇒ Use the sharp knife to slice along and remove the corpus callosum. This excision opens the lateral ventricle.

The interior of the lateral ventricle

Peering into the lateral ventricle you can see its far wall. This far lateral wall is made-up of ascending and descending axons traveling to and from the cerebral cortex — of course, they are covered by the ependymal layer that always lines the ventricle. Notice that the floor of the lateral ventricle consists partly of the dorsal surface of the thalamus and partly of the body of the caudate nucleus (another nucleus of the basal ganglia). Pause for a moment to examine the choroid plexus visible in the lateral ventricle. Where are its attachments? Take a look at some of the features visible on the dorsum of the thalamus. Do you see a vein in the groove between the thalamus and caudate nucleus? It's the thalamostriate vein.



Do you see a fiber bundle there? It's called the stria terminalis. There is another, similar thin fiber strap that creates a ridge along the medial edge of the thalamus at the third ventricle. This medial one is called the stria medullaris.

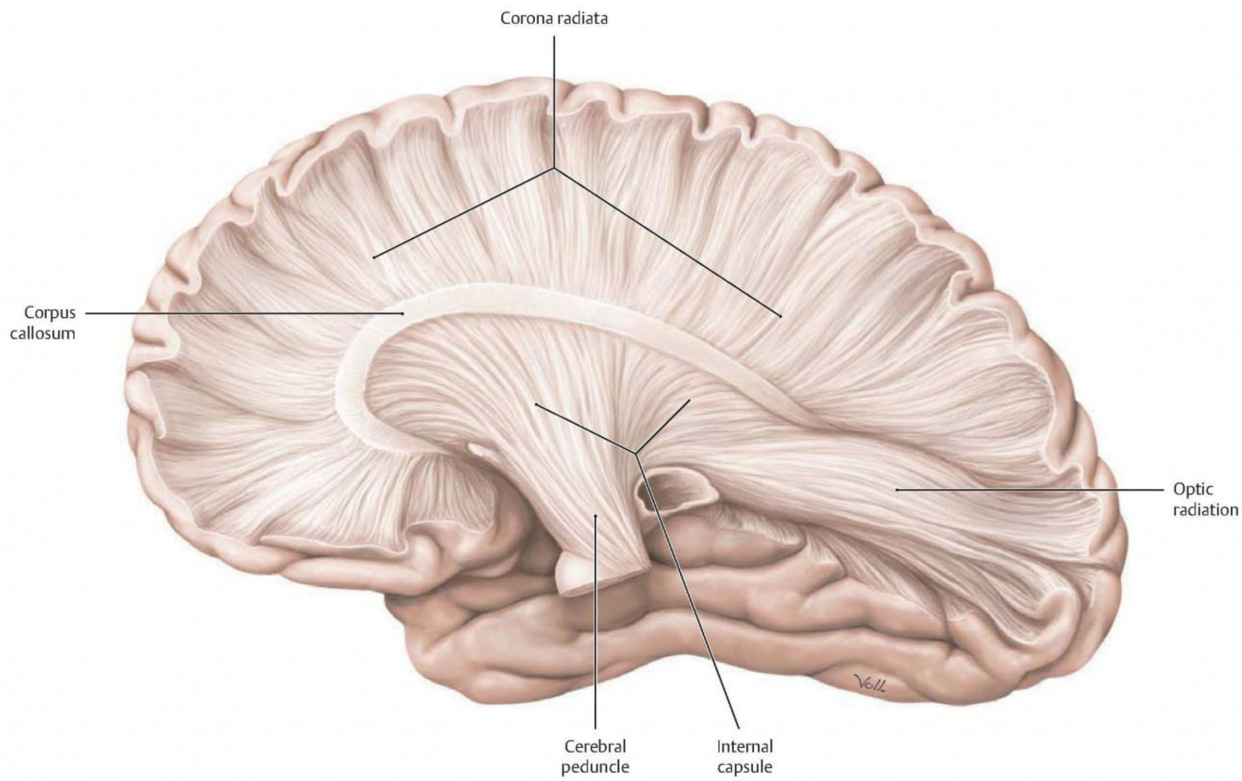


Corticifugal and corticipetal fiber bundles

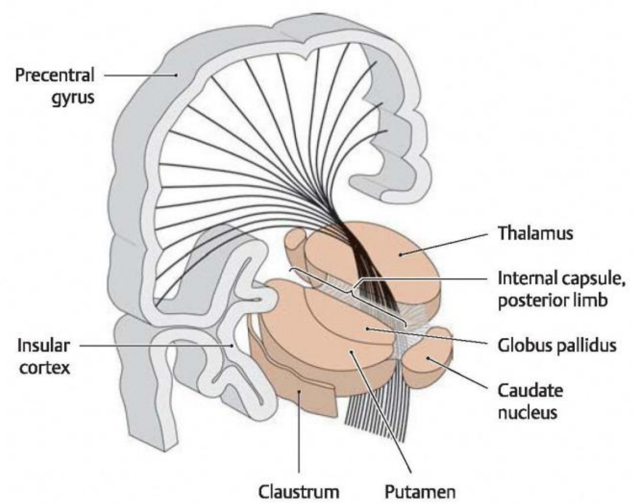
You have left to examine only the projection group of fibers. These are fibers that originate from neurons in the cerebral cortex and descend to terminate in subcortical nuclei. Some go as far as the spinal cord by way of the cerebral peduncles and pyramidal tracts that you saw in the first dissection.

By the next series of maneuvers, you will see how the axons get from the cortex to the cerebral peduncles. Many of the fibers in the bundle you reveal, however, are not coming from the cerebral cortex. Instead, they are going to it to make synaptic contacts with and carry signals to the cortical neurons. These ascending, corticipetal fibers come from subcortical nuclei, especially those in the thalamus.

⇒ Use the knife handle to scoop out the caudate nucleus to expose underlying white matter.



Now you clearly see the ascending and descending axons of the cerebral hemisphere (Fig. 22). Remember you have already reached these same fibers from the other side. You can peel upward along these fibers to appreciate how they fan out to distribute to all parts of the cerebral cortex. This fan-like array is referred to as the *corona radiata*.

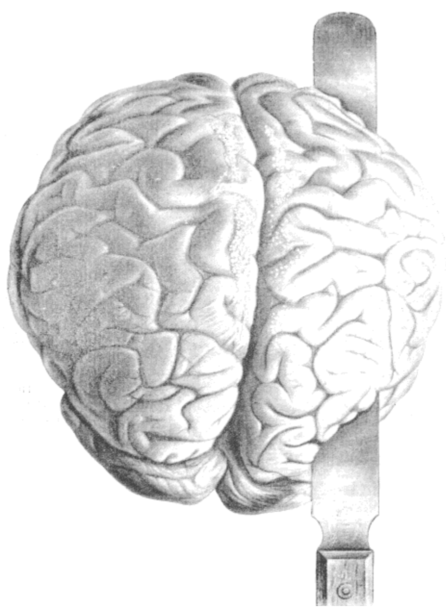


⇒ Scoop out the thalamus just as you did the caudate nucleus.

You can follow the continuity of the corona radiata fibers as they converge on the internal capsule. Remember that you have already reached the internal capsule from the lateral side. Now you know that the internal capsule passes between two pairs of nuclear masses. What are the two on the medial side? What are the two on the lateral side?

Back in the first dissection, you cut through the midbrain. Look at that cut surface and identify the fibers of the cerebral peduncle. Your next objective is to scoop out the substance of the midbrain, both the tectum and tegmentum, much as you did the thalamus, leaving behind the cerebral peduncles. Now you see with certainty that the corona radiata, internal capsule and cerebral peduncle are continuous with one another. Are the same axons present in all three?

THE VENTRICULAR SYSTEM



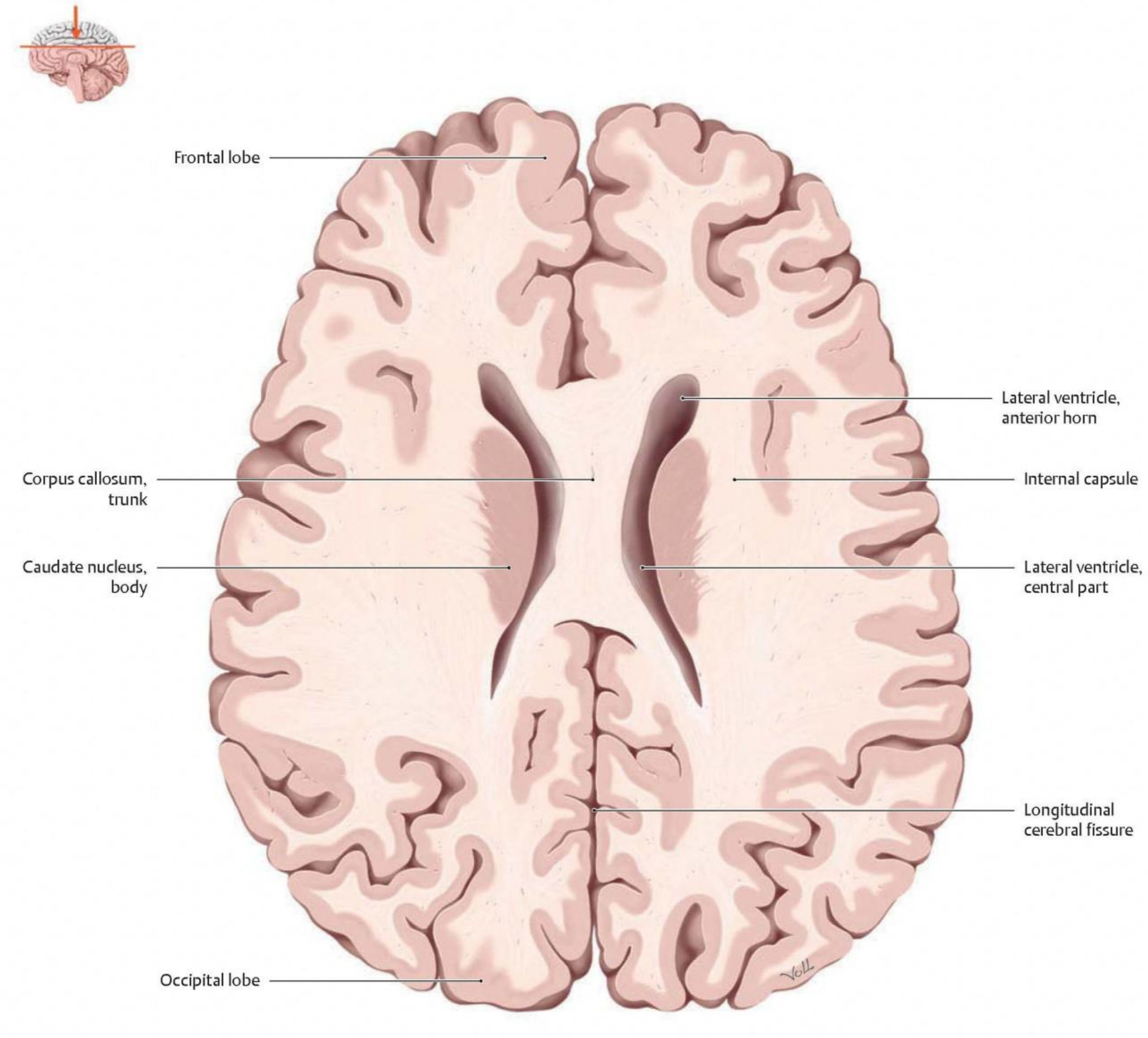
This dissection will give you a vivid three-dimensional vision of the lateral ventricular system and the interior of the cerebral hemisphere.

➔ Take out the undissected half of the brain from the clear bucket. Cut a series of horizontal slabs, each about one inch thick, down through the hemisphere only until you reach a depth just about one-half inch above the corpus callosum.

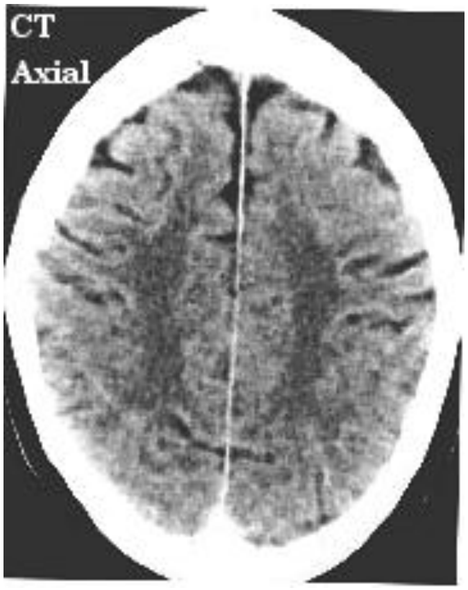
The semioval center and the corpus callosum:

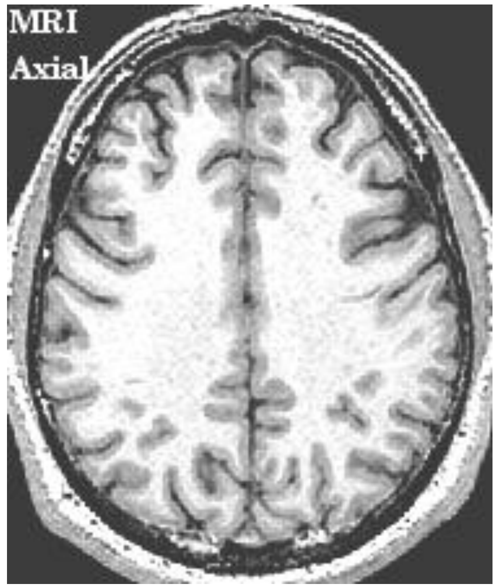
After each slice, examine the relationship of gray and white matter. You'll notice that the white matter increases in volume as you proceed into the core of the hemisphere. Keep in mind that this white matter core contains association, commissural and projection fibers.

⇒ Use a small knife to trim away remnants of the cingulate gyrus on each side and to expose the genu and splenium of the corpus callosum. With your index finger, press on the white matter about an inch lateral to the body of the corpus callosum. You should feel it yield readily under the press of your finger because the lateral ventricle is just below. Carve a small square window — about a half inch on a side — where you pressed in order to open the ventricle. You'll find it easy to follow the ventricle by enlarging the window fore and aft.



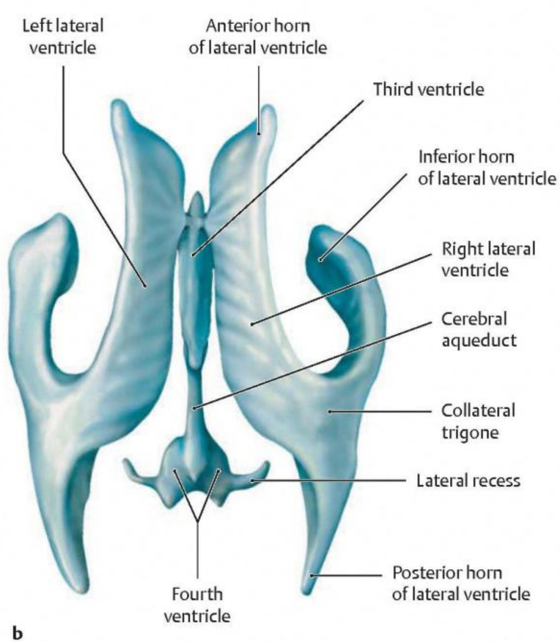
How many features can you identify in the images below? They correspond to the surface of the brain you have just exposed with your knife.



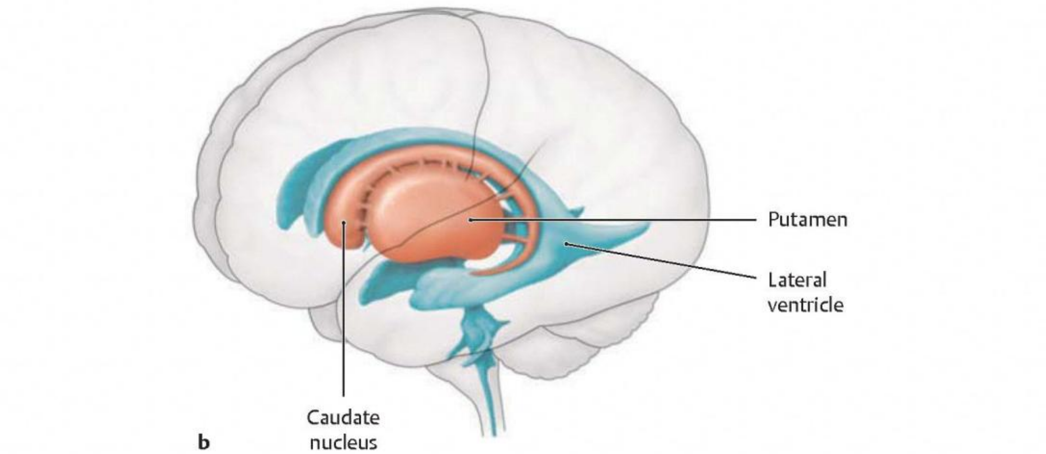


The superior limb of the lateral ventricle

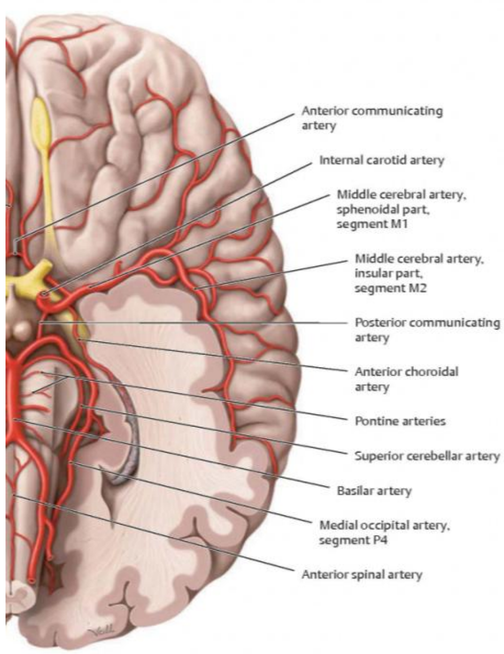
As you extend the window rostralward to open the rostral horn of the lateral ventricle, you'll soon see that it ends blindly. You can see the head of the caudate nucleus forming the floor and lower part of the lateral wall of the ventricle in the rostral horn. The medial wall up here in the rostral horn is the septum. Next, as you expand the opening caudalward, you'll notice a lateral and steeply downward digression of the ventricle towards the temporal lobe — don't try to follow it yet. Instead, continue to cut caudalward where the ventricle narrows considerably into its caudal (or occipital) horn.



Notice that the lining of the ventricle has the same appearance everywhere you look. What is the tissue layer that lines the ventricular system? Now that the entire superior limb has been laid open for view, try to identify the structures you see within it. Notice how the head of the caudate nucleus progressively narrows into the body next to the thalamus then continues to taper into a tail as it curves out of sight into the depths of the temporal lobe. Envisioning the overall structure of the caudate nucleus in isolation puts one in mind of a porpoise frozen in at the height of its cetaceous leap. In the middle of the superior limb of the ventricle, the floor is formed in part by the thalamus. You are probably wondering how can this be. If the lateral ventricle is in the telencephalon, how can a diencephalic structure form its floor?

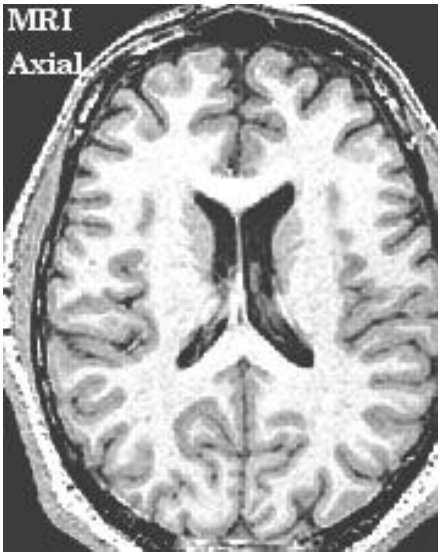


Next peer under the corpus callosum to identify the fornix. Notice that the fornix dives downward in front of the thalamus toward a small hole. The hole is the interventricular foramen (of Monro) that leads into the third ventricle allowing the CSF produced by the extensive choroid plexus to flow out of the lateral ventricle -- one leading from each lateral ventricle. The choroid plexus is most abundant in the widest part of the superior limb of the ventricle — a part we call the atrium. Can you discern the two lines of attachment of the choroid plexus, one about midway across the dorsum of the thalamus and the other along the free edge of the fornix?

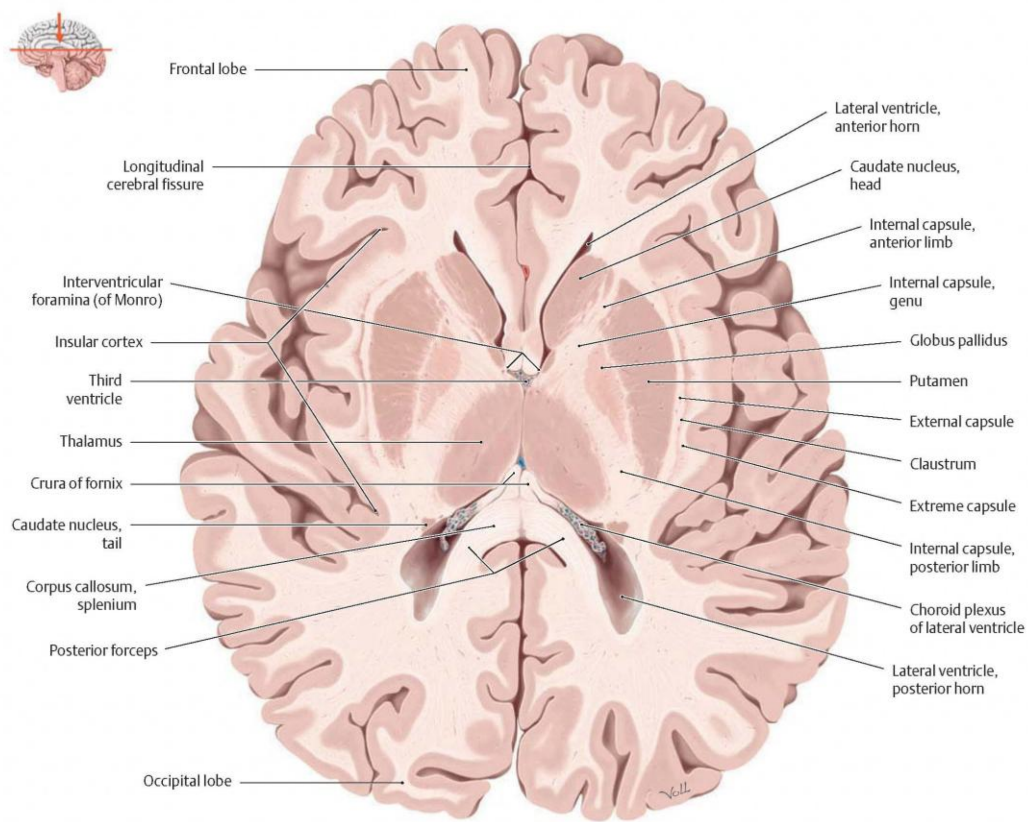


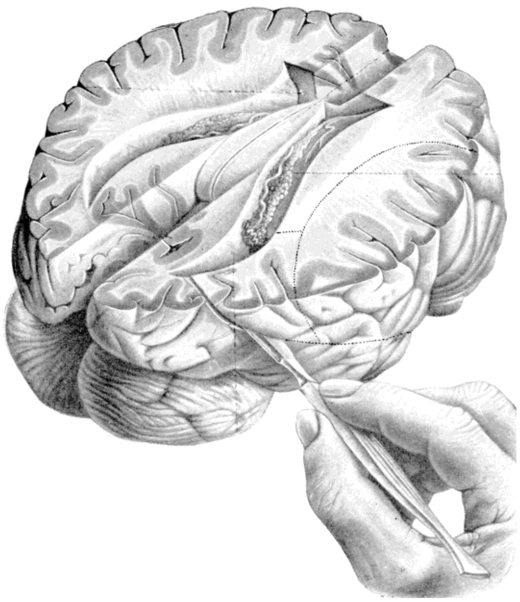
See if you can locate the anterior choroidal artery on the basal surface of the brain, and try to follow it through the choroid fissure on the medial side of the temporal lobe.

How many features from your dissection can you see in the MR images below? What parts of the corpus callosum are visible at this level? Where is the central fissure, the precentral and the postcentral gyruses? What deep gray matter structures can you identify?



Compare what you have identified with the labeled structures in the transverse (axial) drawing below.



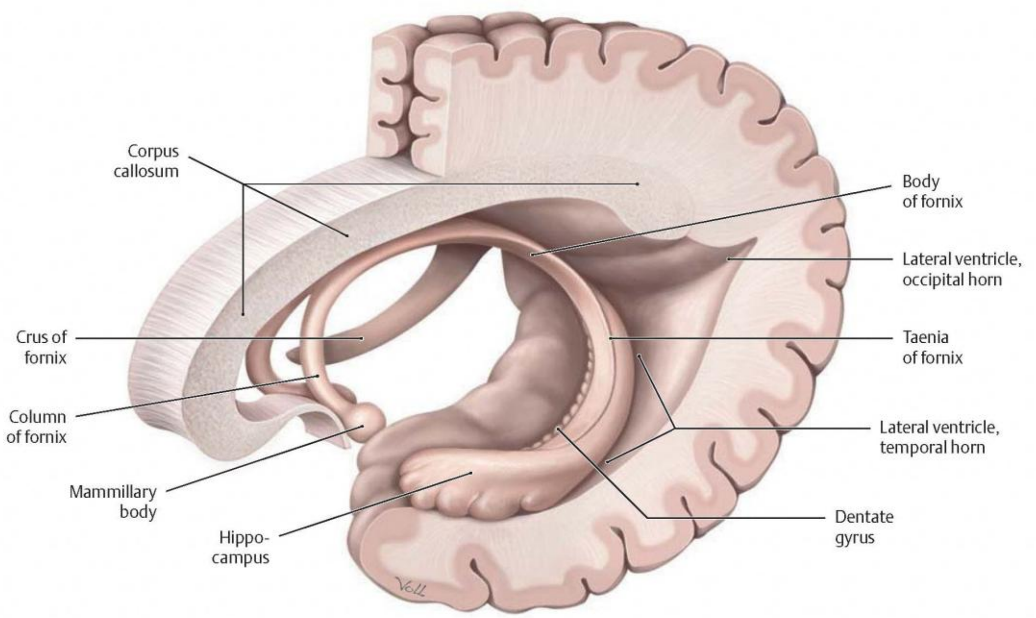


➔ Now it's time to pursue the inferior (temporal) limb of the lateral ventricle. To facilitate access, first remove the opercula from around the lateral fissure to expose the insula and temporal plane (you remember how to do this). Now remove the entire superior temporal gyrus by cutting parallel to the superior temporal sulcus as shown.

You should now be able to extend your piecemeal opening of the ventricle in to the temporal lobe with little opposition.

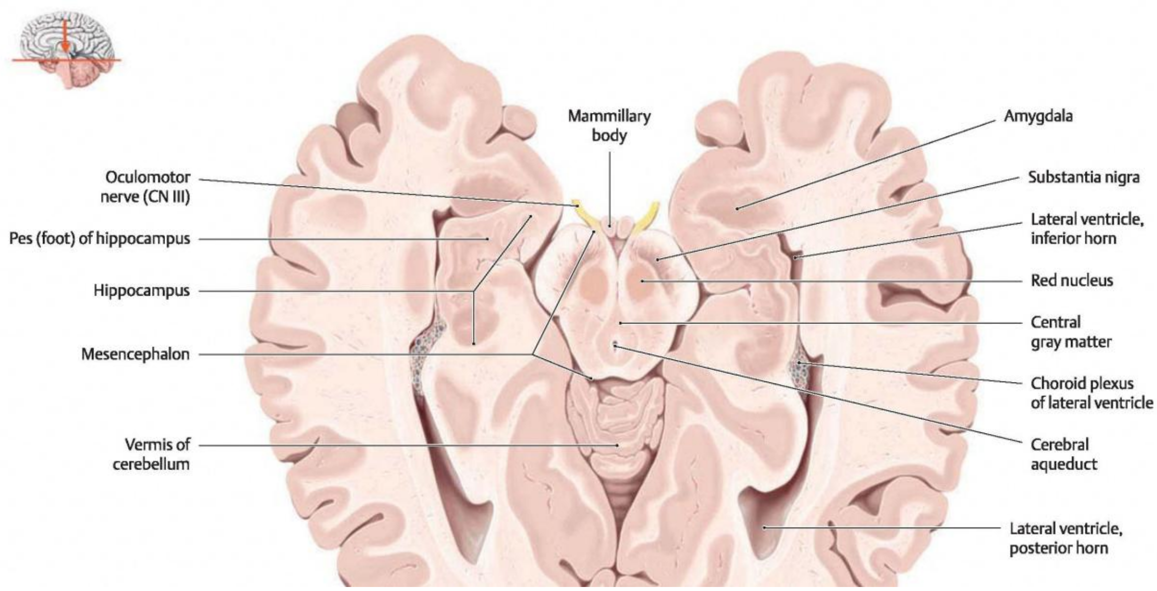
The inferior (temporal) limb of the lateral ventricle

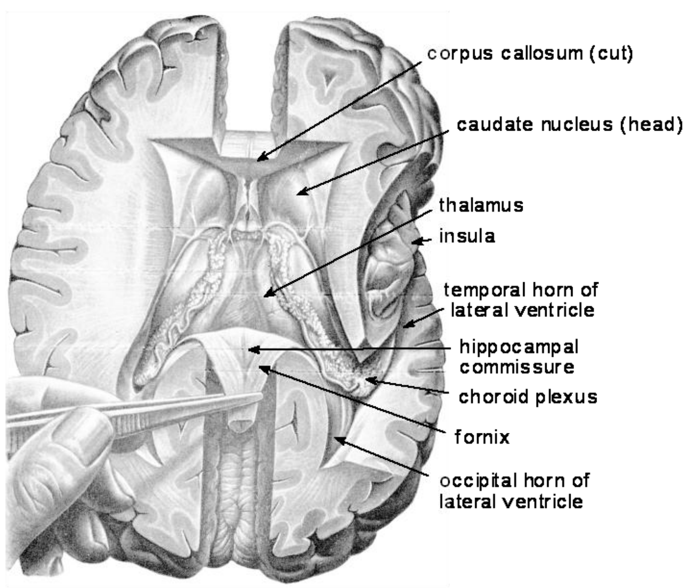
Realize that as you follow the inferior limb of the ventricle into the temporal lobe, you remove its lateral wall. To visualize the medial wall of the ventricle, you'll have to gently lift the choroid plexus whose loose coils hang like Rastafarian dreadlocks into the ventricular space. In lifting them, you gain the privilege of appraising one of the most graceful and elegant structures in the human body if not in all of nature. Behold hippocampus! Its gracefully arched body rests languidly on the ventricular floor, its silken ependymal skin aglow beneath a patina of CSF. Later, we'll examine more closely the singular configuration of the hippocampus. For now, be content to know that, as if to match function to beauty, Mother Nature has assigned to the hippocampus a profound mental task — the sculpting of new memories both sublime and melancholy.



Now that you've laid open the entire lateral ventricle, you can follow the fornix as it curves down from beneath the corpus callosum to flatten itself against the surface of the hippocampus. The flattened part near the hippocampus is often called the fimbria of the fornix. In fact, the axons that make up the fornix arise from hippocampal neurons and emerge from the temporal lobe to descend to the ventral forebrain and the hypothalamus. The fornix is thus a projection bundle.

Lying hidden just in front of the hippocampus is the amygdala. To confirm this, look at the medial side of the temporal lobe to see that the forward end of the hippocampus lies at approximately the caudal end of the uncus. Now cut a slice into the uncus with your knife to expose the gray matter of the amygdala.





➔ Make a transverse cut just caudal to the genu of the corpus callosum, and continue it downward and slightly caudalward through the septum, and the columns of the fornix near the interventricular foramens. Grasp the cut end of the corpus callosum and reflect it up and back away from the underlying structures as shown in the figure.

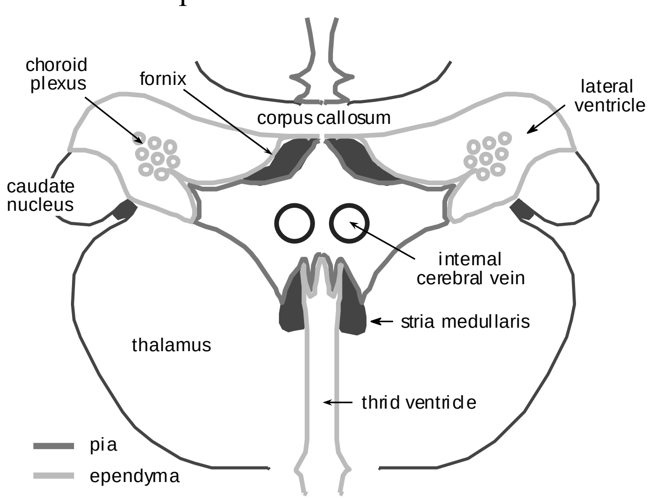
The fornix and the hippocampal commissure

This maneuver provides you with a clear view of the bodies of the fornices as they sweep up from the temporal lobes and converge to lie side by side under the corpus callosum. With the fornices bent back like this, it is easy to appreciate the many fibers running transversely between the two bodies under the splenium. These are the axons of the hippocampal commissure which arise from cells of the hippocampal cortex and travel with the fornix on one side before crossing to the fornix of the other side to run in the opposite direction.

The transverse fissure

With the fornix and corpus callosum still pulled back, you can look down upon the roof of the third ventricle. It's formed by a thin sheet of tissue stretched between the thalamic masses of either side (if you like euphonic Latin names call it the *velum interpositum*). The inner surface of the roof which faces the CSF of the third ventricle is a layer of ependymal cells. The outer surface is pia mater and it is also in contact with CSF in the living condition, but that CSF is in the subarachnoid space.

The overgrowth of the brain stem and cerebellum by the telencephalic vesicles creates a low, wide subarachnoid space in between — the *transverse fissure*. If you were miniaturized enough to walk into the transverse fissure, you would walk on the roof of the third ventricle and overhead would be the hippocampal commissure. You could only walk forward to the interventricular foramens, however, before you would have to forcibly tear through the choroid membrane. Once you've broken through, you'll have left behind the subarachnoid space and entered the ventricular space.

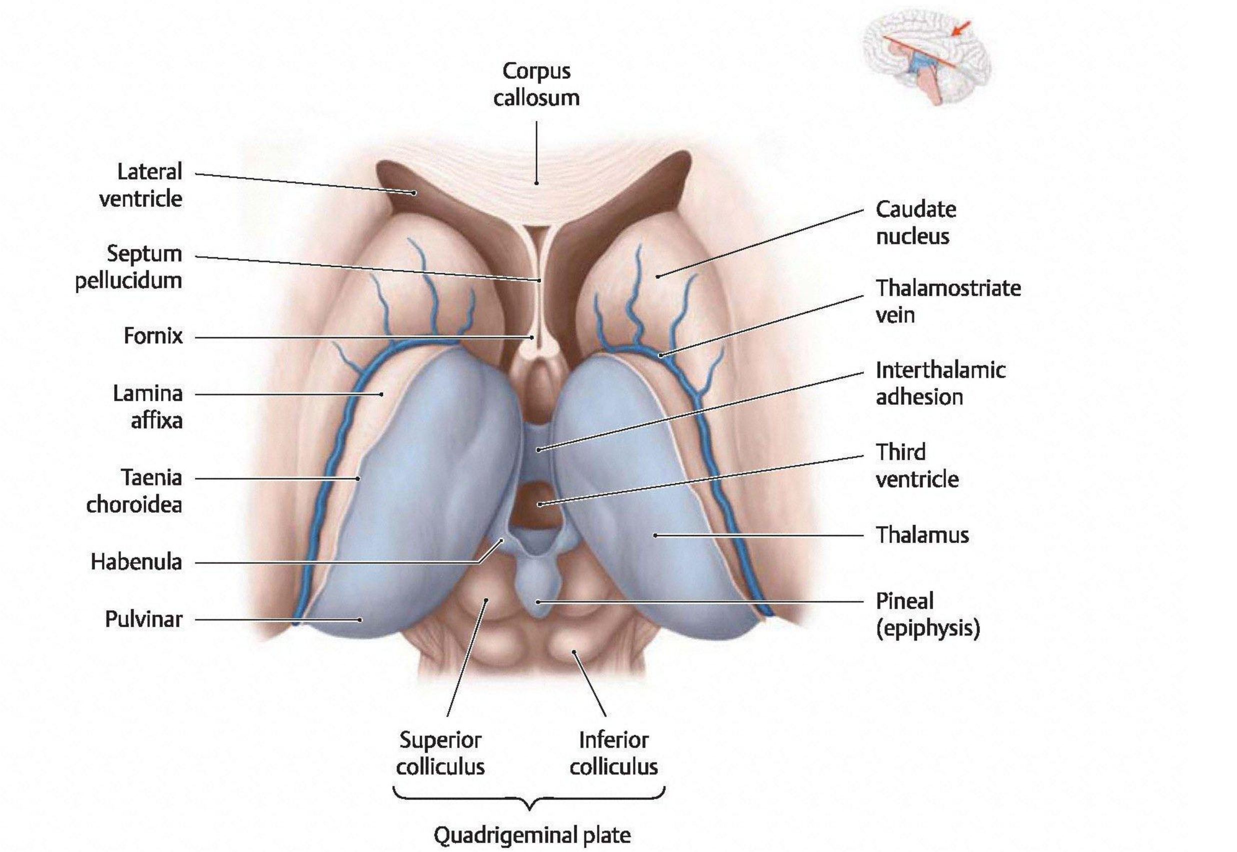


You may be able to find two large blood vessels in the transverse fissure that lie side by side above the thalamus near the midline — the internal cerebral veins. They unite at the caudal end of the transverse fissure to form the great cerebral vein (of Galen) which itself is continuous with the straight sinus. The internal cerebral veins receive blood from the septal vein, choroid vein and thalamostriate vein. Can you find them?

⇒ By snipping through the body of the fornix on either side, the entire temporal lobes should come free with a gentle tug. This exposes the dorsal and caudal surfaces of the thalamus and the dorsal surface of the midbrain for further exploration.

The thalamus, the caudate nucleus and the midbrain:

See if you can identify the following structures — the stria terminalis (a bundle of fibers that runs from the amygdala in the temporal lobe to nuclei in the ventral forebrain and hypothalamus), the thalamostriate vein, and the stria medullaris. Locate the pineal body hanging by its stalk off the back end of the thalamus. Squeeze it to see if it's calcified — it usually is with increasing age.



The habenular commissure crosses just in front of the pineal's stalk and the posterior commissure just behind it. Notice the irregularities of contour on the surface of the thalamus. At the rostral end, the prominence you see is called the anterior tubercle. It's caused by the underlying anterior group of thalamic nuclei. The large caudal expansion of the thalamus is called the pulvinar. Can you find the medial and lateral geniculate bodies on the underside of the thalamus? Follow the optic tract. It will lead you to the lateral geniculate nucleus. The rounded bump medial to the lateral geniculate is the medial geniculate. It's a part of the thalamus even though it looks like it's clinging to the side of the midbrain. Do you see anything peculiar about the relationship of the medial geniculate body and the inferior colliculus? Yes, there is a fiber bundle that runs from the inferior colliculus to the medial geniculate. It's called the brachium of the inferior colliculus and its axons carry auditory signals to the medial geniculate nucleus. Do you remember where the cortical area is located that receives signals from the medial geniculate neurons? How about the cortical area that receives input from the lateral geniculate nucleus?