CNS ANATOMY

DOCTOR NOTES

LECTURE NO. 3

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Today in this lecture, we will focus on the types of brain fibers inside the brain and also the anatomy of the basal nuclei.

3.1 Fibers/ Association Fibers:

what are the types of matters inside the brain?

Previously in the **coronal section**, we discussed that we have two types of matters inside the brain: White matter and gray matter.

1. The gray matter in the cerebral cortex and in the basal nuclei.
2. The white matter which has three different types. As you can see here in this photo:

A. Association fibers connect between different areas, but on the same cerebral hemispheres.

B. Commissural fibers. The idea of the commissural fibers is to connect similar areas in the opposite cerebral hemispheres, as represented by this arrow here.

C. Projection fibers that connect or that project to or from the cerebral cortex, like the ascending and descending tracts. So it project from the cortex downward to the spinal cord in the descending tracts, or from the spinal cord upward to the cortex in the ascending sensory tracts.

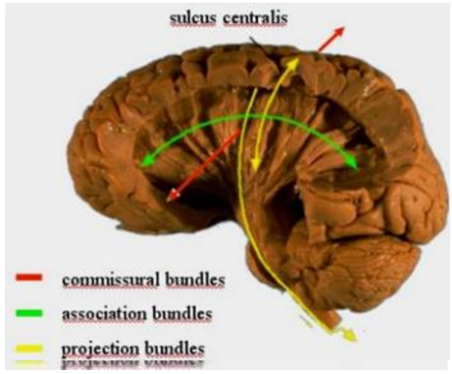


Figure (1): The white matter

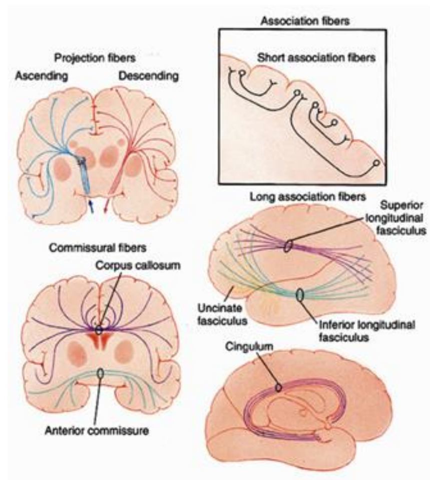
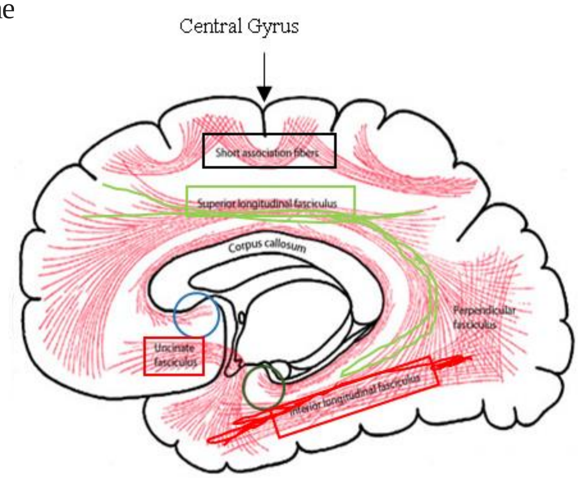


Figure (2):Extra

The association fibers are divided according to their length into: short and long association fibers:

1. Short association fibers are very short U-shaped bundles, connect adjacent gyri together, as you can see here on the medial side of the brain, the pointed structure is the ce sulcus, in front there is the precentral gyrus, and behind the the postcentral gyrus.

In front of the pre-central gyrus, the premotor area.



2. **long association fibers** are divided into 4 different types :

We have this huge bundle which is called **A.superior longitudinal bundle** (look at figure 3), it connects between the frontal and parietal and occipital and also temporal lobe of the brain, which is responsible for the association of function between them. We have another bundle, which is the **B.inferior longitudinal bundle**, it connects only between the temporal and the occipital lobes. And we have another v.imp bundle, which is called **c.cingulum** (next page)...

Remember when we talked about something called the limbic system? We said that there is something called the limbic lobe. The limbic lobe lies on the median side of the brain mainly on the cingulate gyrus that lies above the corpus callosum.
So the cingulum is related to the cingulate gyrus. And it forms incomplete circle around the corpus callosum. It begins nearly to the rostrum of the corpus callosum, in the front to it (look at the blue circle in figure 3), it then forms a circle around the whole corpus callosum, then ends in the temporal lobe in a structure called **uncus** (look at the green circle in figure 3).
The uncus lies on the anterior part of the parahippocampal gyrus-If you remember from gyri on the inferior surface, we have described three different gyri,The medial one is the parahippocampal gyrus, and medial occipitotemporal, lateral occipitotemporal gyri-.

So the cingulum is part of the limbic lobe. It connects between the frontal, parietal, and also the temporal lobe of the brain, and it ends in the uncus.

We have lastly another very important one which is called **D.the uncenate fasciculus**, it runs from the frontal pole to the temporal pole.
These association fibers are very important in connecting the functions between the different gyri inside the same cerebral hemisphere so that the frontal lobe is aware of the function of the occipital lobe and temporal lobe and the parietal lobe.

3.2 Fibers/ Commissural Fibers:

As we mentioned, the commissural fibers connect between the same areas on the opposite cerebral hemispheres.
We have different types of these commissural fibers:
A. Anterior commissure. You can find them in front of the anterior column of the fornix(explained on the next pages).
The anterior commissure connects between an area called **piriform fossa** of the right cerebral hemisphere and on the left cerebral hemisphere.
-This piriform fossa is located on the inferior surface of the brain in the most anterior part of the temporal lobe, it has a role in smell.

The anterior commissure has a great role in the smell pathway, and also it plays a role in transmission of acute pain -as you know, we have two types of pain, visceral and acute or sharp pain-.

B. Posterior commissure. If you look at the posterior part of the brain, you will find a structure called **pineal body** or pineal gland, it is the posterior in the posterior aspect of the thalamus. The pineal body plays an important role in regulation of the dark light cycle.

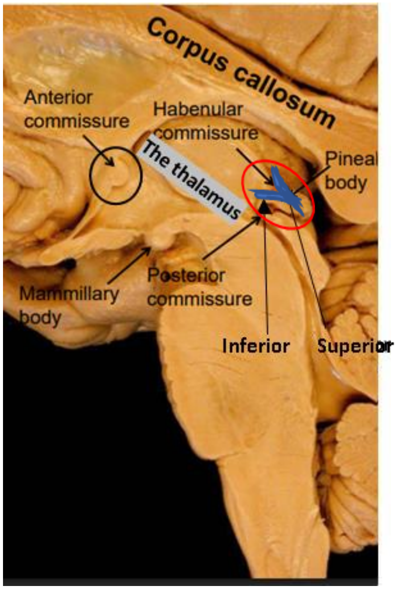


Figure (4)

-The pineal gland is hanged by two limbs, the superior limb and the inferior limb (look at the figure).
In the superior limb, you will find a commissure called **the habenular commissure**. And in the inferior limb, you will find another commissure called **the posterior commissure**.

The posterior commissure plays an important role in light reflex. We have two types of light reflex: direct and consensual light reflex. The direct light reflex is the constriction of the pupil in relation to the light, so if you move a source of light near your right eye, your right pupil will constrict in response to this source of light. However, your left pupil will constrict in response to the source of light because of this commissure, the posterior commissure, in which some fibers will cross from your right brain or your right cerebral hemisphere to the left cerebral hemisphere in this commissure.

C. Habenular commissure lies just above the pineal body in the upper limb, the habenular commissure is connected to the amygdala nucleus.

-So where is the **amygdala**? If you remember the inferior surface of the brain, we have two different parts: the orbital part and tentorial part. The tentorial part is divided into three gyri one of them is the parahippocampal gyrus. The most anterior part of the parahippocampal gyrus is called the **uncus**, if you dissect this uncus, you will find a nucleus of gray matter inside, this nucleus is what we call the amygdala. As we mentioned before, the amygdala plays an important role in smell function, and also in the limbic system in fear emotions. So It's anatomically related to the basal nuclei, but functionally it's related to the limbic system.

Because of the connection between this commissure and the amygdala, the habenular commissure plays an important role in integration of olfactory and visceral pathways of smell.

D. **The fornix** which consists of two parts, opposites to each other. The fornices are the efferents of the **hippocampus** (which is a structure lies inside the parahippocampal gyrus that locates on the inferior surface of the brain).

-The hippocampus is part of the limbic system, and it's responsible for short-term and recent memory. A lesion in this part, will make the person loses their recent memory.

-The efferent fibers of the hippocampus are forming the posterior column of the **fornix**(or what's called **crura** of the fornix). These crura arches are in the superior surface of the thalamus and then form the body, then it runs anteriorly to form the anterior column of the fornix.

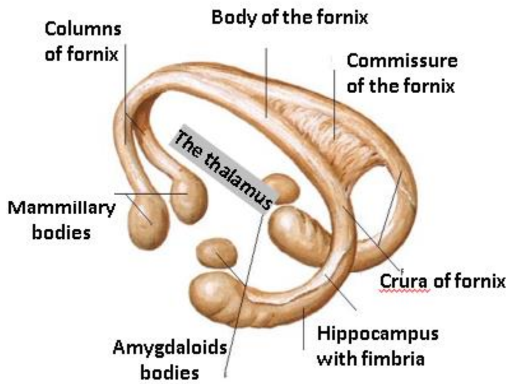


Figure (5)

The anterior column of the fornix deeply in the brain passed to form what's called **mammillary bodies**. The mammillary body is a nucleus of the hypothalamus, which is appearing here on the sagittal surface of the brain.

The efferent of the other hippocampus form the other fornix (the posterior column of the fornix), then the other fornix arches over the thalamus. Then anteriorly, it will make the anterior column of the fornix and pass deep inside the substance of the brain to reach the nucleus of the hypothalamus, which is called the mammillary body.

So we have 2 mammillary bodies, 2 fornices and 2 hippocampi.

- Look at figure 6 which represents the fornix parts: red for the posterior column of the fornix, blue for the body of the fornix and green for the anterior column of the fornix which passes deeply inside the brain by a tract till it is connected to the mammalian body.

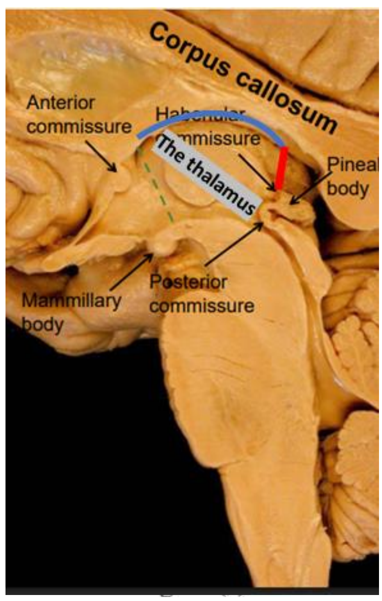
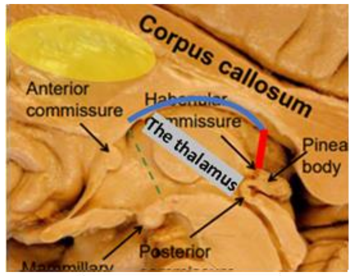


Figure (6)

-This is why the fornix is also part of limbic system, to ensure the nuclei of the hypothalamus are also participating in the function of the limbic system.



-Remember that the fornix is separated or connected to the inferior surface of the corpus callosum by a structure called **septum lucidum**. (in yellow)
Septum lucidum closes the cavity of the **lateral ventricle**, so if you remove this septum, you will find a cavity inside the cerebral hemisphere, which is called the lateral ventricle.
As you can see, the two fomices are connected together by this commissure, which is called the fornix commissure or the hippocampal commissure.

E. **Corpus callosum**, the largest commissure of fiber inside the brain. You can see the corpus callosum parts only on the sagittal section of the brain. If you look from above, the pointed structure is the corpus callosum in the center. **Around it** we can see fibers (look at figure 8), they connect different areas of the opposite cerebral hemispheres. We will mention these parts in details shortly.

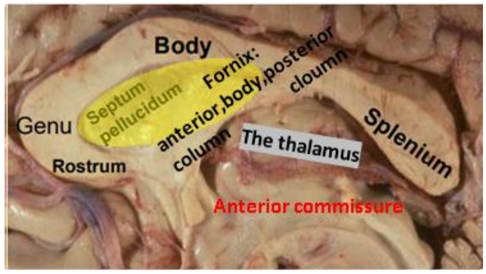


Figure (7)

The corpus callosum lies above the fornix (look at figure 7 in order to see its parts again).
-The septum lucidum (in yellow) closes the cavity of the lateral ventricle on the sagittal section.

The fibers that curve from the anterior side, or the genu of the corpus callosum to connect between both frontal lobes, are called **forceps minor**.
And the backward fibers that originates from the splenium that connects between the occipital lobes are called **forceps major**. And the other fibers that connect different parts of the cerebral hemisphere are called **tabetum of the corpus callosum**.

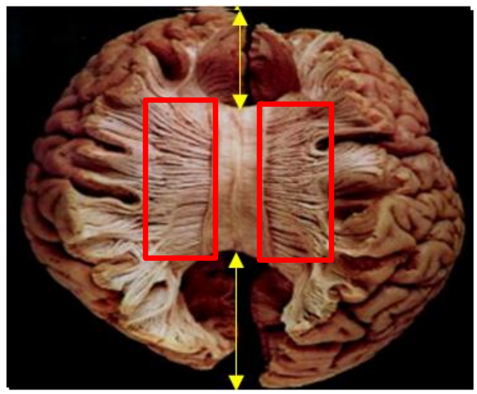


Figure (8)

-How to differentiate between the anterior and posterior sides of the corpus callosum?

It's simply by measuring the distance between either end of the corpus callosum and either end of the cerebral cortex, the shortest one is towards the anterior (look at the yellow arrows in figure 8), the shortest distance is pointing to the frontal lobe, so that the **forceps major** is posterior and the **forceps minor** is anterior (figure 9)

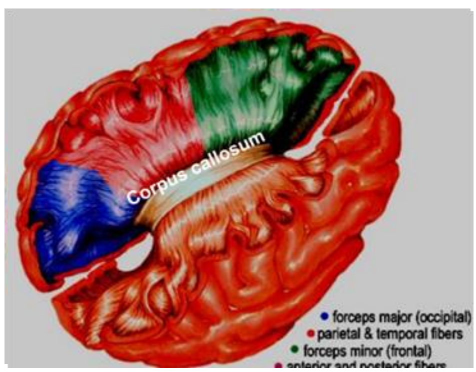


Figure (9)

The blood supply of the corpus callosum is very important. We will discuss the blood supply in details, but just to mention the corpus callosum, **all** the corpus callosum parts are originating from **anterior cerebral artery**. The anterior cerebral artery runs in the callosal sulcus, which is just above the corpus callosum, so it gives branches to all parts of the corpus callosum, except the splenium.
The blood supply of the splenium, is emerging from another artery on the **posterior aspect** of the brain, which is the **posterior cerebral artery.**

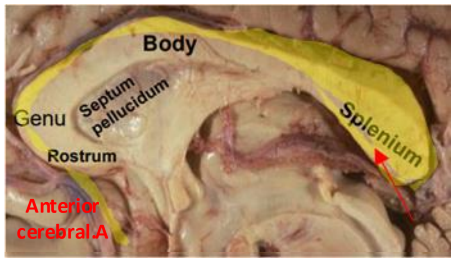


Figure (10) : The red arrow represents the posterior cerebral.A

-What if we have a lesion in this corpus callosum? Because it is the largest commissural fibers, connects between right and left cerebral hemisphere, so if you cut this connection, you will have a phenomena called **dissociation of the brain** or **split brain**. So that your right cerebral hemisphere is working separately without the left cerebral hemisphere, this is because the right cerebral hemisphere (half of the body) is controlling the left side (the other half) of the body and vice versa.
Your right half will not be aware of your left half of the body, and this phenomena sometimes leads to **apraxia**, apraxia is a motor disorder that in which you don't have any paralysis, but the coordination of the motor movement is not occurring in a proper way so that your right half is not aware of your left half. (Apraxia is also resulted from a lesion in the parietal association area or in the premotor area, as we discussed before).
Note that some doctors do that in a treatments of some neurological disorders.

3.3 Fibers/ Projection Fibers:

We have two types of fibers:
A. projecting to the cortex and **B. away from the cortex.**

As we know from the spinal cord section, the fibers projecting to the cortex are called sensory, and that projecting away from the cortex are called motor.

Just to collect the fibers that are projected toward the cortex, we have a very important fibers called **sensory radiation, anterior thalamic radiation, visual radiation** and **auditory radiation.**
We call them radiation because when they reach the cerebrum, they are shining like the sun rays.

A. The sensory radiation (ascending):

The sensory radiation are all projected from the thalamus. As you may know, the thalamus is the largest relay station inside the brain, it receives all of the body sensations , including visual sensation, hearing sensation, smell sensation.
The thalamus is divided into so many nuclei, a nucleus in the posterior part of the thalamus is called
1. posterolateral ventral nucleus, the fibers that are projected from this nucleus to the area 312 in the postcentral gyrus, transmit the general sensation of the body like pain, touch, temperature.
2. Anterior thalamic radiation, from the anterior nuclei of the thalamus to the cingulate gyrus. This connection is very important in the limbic system.
3. Visual radiation that is projected from the lateral geniculate body.
-What is the lateral geniculate body? It is a nucleus situated in the most posterior part of the thalamus. We have in the posterior part of the thalamus, a structure called **pulvinar** -as we will describe in the section of the diencephalon-. The pulvinar is divided into: **1.medial** geniculate body and **2.lateral geniculate body.**

1. The **lateral** geniculate body is related to the visual pathway that connects the lateral geniculate body and the visual area 17, which is the center of the vision here.
These fibers are also called **optic radiations,** they connect between the lateral geniculate body on the posterior aspect of the thalamus to the visual area 17 on the occipital cortex.

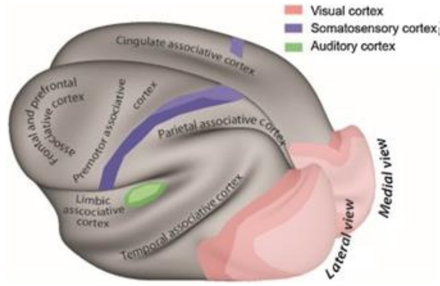


Figure (11): Extra it represents the pulvinar body parts

2. The **medial** geniculate body is related to the auditory pathway.

These fibers are also called **the auditory radiations,** they connect between the medial geniculate body which is also lies on the posterior aspect of the thalamus to the auditory area 41 and 42 in the superior temporal gyrus.

B. They motor radiation:

We studied in details in the spinal cord section the descending tracts, we divided them into **1.pyramidal fibers 2.extra pyramidal fibers 3.Corticopontine fibers 4.Corticopontocerebellar fibers.**

1. Pyramidal fibers originate from the three gyri of the brain: the motor area four, pre-motor area six, and somatosensory area 312. These projecting fibers from these different gyri downward in the internal capsule and then on the midbrain, pons, medulla. In the medulla, they cross to the opposite side to reach the anterior horn cells.

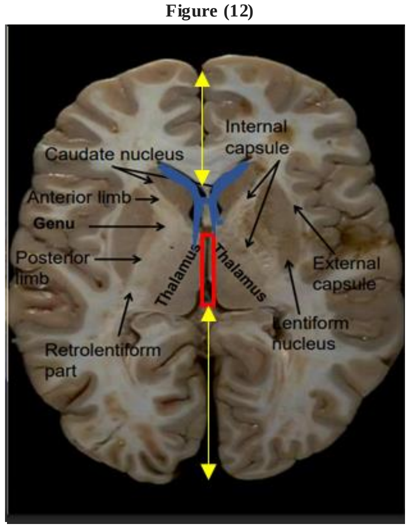
2. Extra pyramidal fibers that pass in a different pathway other than the pyramid of the medulla, like vestibulospinal, reticulospinal, rubrospinal. They are under the control of the cerebral cortex.

3. Corticopontine fibers, from the name, these fibers are projected from the cortex to the pons.

4. Corticopontocerebellar fibers. these fibers are projected from the cortex down to the pons and then crossing to the opposite side to reach the cerebellum.
These fibers are very important in planning and coordination of movement.
5. Corticothalamic fibers are projected from the cortex to the thalamus.

3.4 Main structures of the horizontal section of the brain :

Figure (12)



This is a very important picture here, which represents the **horizontal section** of the brain. The horizontal section, as you can see, has many details.
But first how do we distinguish the front side from the back?
If you measure the distance you will see that the shortest distance is pointing toward the frontal part of the brain, and the longest part is toward the posterior side (as represented in yellow arrows).

We will describe in details the horizontal section in the lab. But now focus on these structures here. **l.The internal capsule** which is a V-shaped bundle of projection fibers between the thalamus and the basal nuclei of the brain. **2**.**The thalamus** it is the most medial structure. Between the two thalami, you have **3.the third ventricle** (in red). And sure you can see **4.the lateral ventricle** (in blue**),** part of the lateral ventricle can be seen in the posterior or the occipital lobe, as we will describe the ventricles in detail in the coming lectures.

In this section too we can see **5. basal nuclei**, which is called the lentiform nucleus on the lateral side, and the codate nucleus on the medial side of the internal capsule, and the thalamus also lies on the medial side of the internal capsule.
This V-shaped bundle is divided into five parts. It is very important to know the divisions of the anatomical part of the internal capsule:

(1) **Anterior limb** of the internal capsule, which is this part here, between the caudate nucleus and the lentiform nucleus.

(2) **Genu** of the internal capsule between the caudate nucleus and thalamus medially and the lentiform nucleus laterally.

(3) **Posterior limb** of the internal capsule which lies between the lentiform nucleus laterally and the thalamus medially.

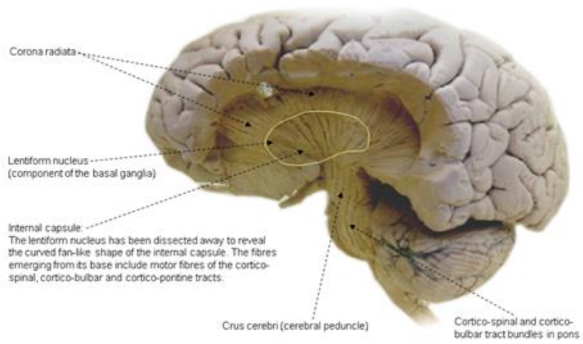


Figure (13): Extra

(4) **Retro-lentiform part** just passes behind the internal capsule, so it's called retrolantiform part. which includes very important fibers which are the optic radiation fibers, the fibers that connect between the lateral geniculate body to the area 17 of the cerebral cortex.

(5) **Sub-lentiform part,** but the sub-lentiform part does not appear on the horizontal section of the brain, because the sub-lentiform part contains the auditory radiation which passes from medial geniculate body of the thalamus down to the temporal lobe, so the level of this section lies below the level of the horizontal section.
So in conclusion, only the first four parts of the internal capsule appear on the horizontal section, without the fifth part.

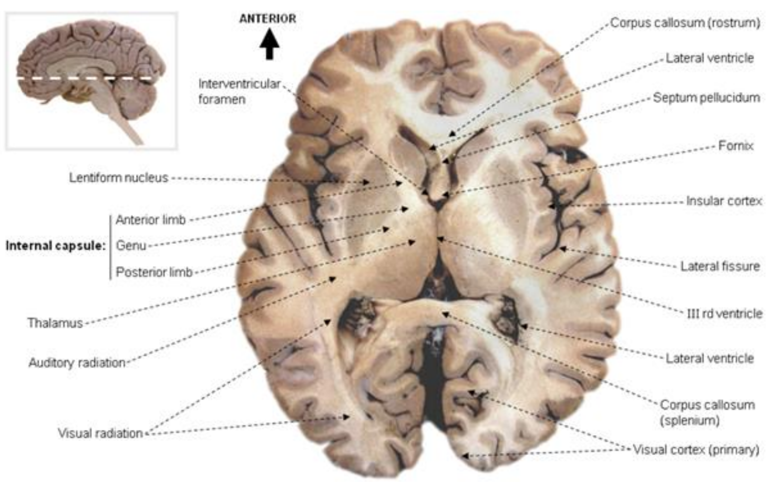


Figure (14): Extra

3.5 Fibers of the horizontal section of the brain:

The fibers that pass in the internal capsule are continuous up to the cerebral cortex, so we call it **radiation**, they are also called **coronaradiata**. They're continuous below to the midbrain, pons and medulla.

It's very important to differentiate between each anatomical part of the internal capsule and types of fibers that pass in each of them.

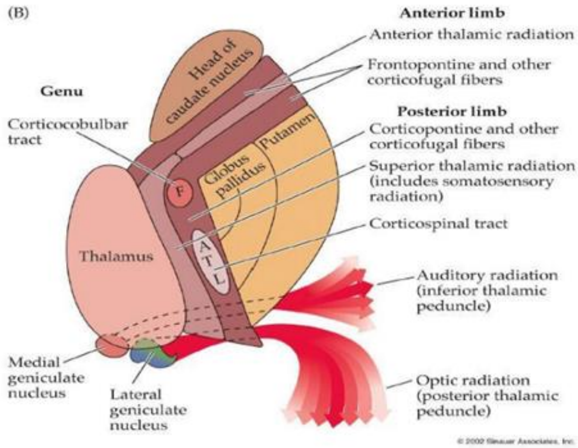


Figure showing Corticospinal & Corticobulbar Fibers in Internal capsule

A. The anterior limb of the internal capsule that locates between the caudate nucleus medially and the lentiform nucleus laterally contains:

(1) Descending fibers (motor): frontopontine fibers,frontopontocerebellar (corticopontocerebellar) that we have described in the last page (from the frontal cortex to the pons, and then wIll cross to the middle cerebellar peduncle to the other side of the cerebellum to complete the circuit.

(2) Ascending fibers in the anterior limb, which is called **the anterior thalamic radiation** (these fibers, if you remember, connect the anterior nucleus of the thalamus to the frontal lobe and cingulate gyrus, and as we mentioned, they play an important role in the limbic system).

B. The genu of the internal capsule (it lies in the horizontal section between the caudate nucleus and the thalamus medially and the lentiform nucleus laterally).

The genu contains very important fibers which are called **corticobulbar fibers** which are projected from the cortex to the cranial nerve nuclei and stops at the cranial nerve nuclei.

The corticobulbar fibers are part of the pyramidal tract, but it is separated from the whole course of the pyramidal tract because it does not project downward in the spinal cord.

C. The posterior limb of the internal capsule also contains:

(1) Descending fiber in the anterior half of the posterior limb contains **corticospinal fibers**, which forms the pyramidal tract from motor area 4 to the anterior horn cells of the spinal cord.

(2) Ascending fiber in the posterior half of the posterior limb contains sensory fibers projecting from the superior thalamic radiation to the thalamus in the postcentral gyrus. That carries the pain touch, temperature and the general sensation of the opposite side of the body (area 312).

So if you divide the posterior limb into two parts like this, so the fibers in the anterior half are descending, and the fibers in the posterior half are ascending to the thalamus. and from the thalamus to the cerebral cortex in the area 312.

D. The retro-lentiform contains fibers of the:

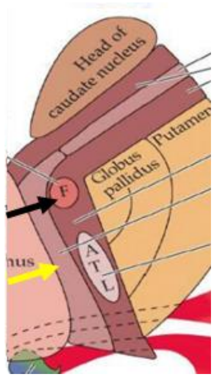
(1) Optic radiation (also called posterior thalamic radiation)

(2) Auditory radiation that are projected from the medial geniculate body of the thalamus to the auditory cortex. They are present in the **E. sublenticular part** or the **sublentiform** part as we described before.

-It's very important to know the types of fibers in each part of the internal capsule, because the internal capsule is a very tight place inside the cerebral cortex. A condition like **hypertension** will affect the blood supply so they become delicate and soft, or they may be even ruptured when the blood accumulates between the fibers of the internal capsule and exerts pressure on these fibers. At the end the function of these fibers will be lost.

For example, if someone had bleeding at the yellow pointed part here inside the internal capsule, they will lose the function of sensory, since the posterior half of the posterior limb contains sensory fibers from the superior thalamic radiation to the 312 area of the cortex.

If someone had a lesion in the pointed anterior half (represented in black here), they would lose the descending fibers or they would be just affected, the motor function of the other half of the body will be lost, because the crossing happens downward in the pyramid of the medulla oblongata.



Look at figure ,you can see the **anterior limb**, the **posterior limb** which contains both ascending and descending fibers, and the **visual radiations** from the lateral geniculate body to the occipital cortex which runs in the **retro-lentiform part**, and the **auditory radiation** in the **sub-lentiform part**.

Note that the blood supply of the internal capsule is **very important** , but now we will postpone slide number 13 until we describe in detail the blood supply of the brain and different parts of the brain.

3.6 The basal nuclei:

The anatomy of the basal nuclei is very easy. If you remember the horizontal section and the sagittal section of the brain.

What are the functions of the basal nuclei?

In physiology, the function of the basal nuclei are described as **voluntary control of movement**.

So the voluntary control is **not** for fine movements, instead **1. it controls groups of movements or sequencing of movements,** like in the football game, if you look to the players, they can flex their heads with their knees, extend their legs, running and focus on their bodies just to **anticipate the movement**.

Also, it has a very important role in **2. posture control**, in automatic movements like in posturing, walking and especially while dancing.

3. It controls axial and trunk movements.

So the idea of the basal ganglia is to control many movements that require sequencing and adjust the body in a way to **anticipate the future movement**.

The anatomy of the basal nuclei (old classification):

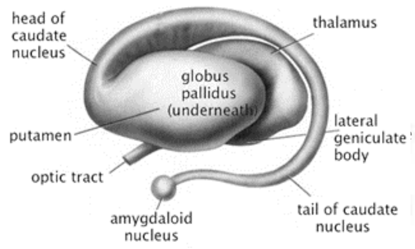
We have what's called striatum and lentiform nucleus, amygdala, substantia nigra, subthalamic nucleus, and finally the clostrum.

So what is striatum? Striatum is a part of the basal nuclei that is striated in appearance. As you may know, the caudate nucleus and the lentiform nucleus, and the thalamus which appears in the horizontal section which is located on the medial aspect of the basal nuclei.

The lentiform nucleus is divided into outer part (lateral) called **l.__putamen__** and inner part (medial) called 2.__**globus pallidus external** and **internal**__. All these parts will be described in details later.

The caudate nucleus and putamen parts are called neostriatum are **the newest parts** of the striatum, **the oldest part** is called globus pallidus.

Figure (17)



-Why does its appearance look striated ? Because the internal capsule fibers appear between the caudate nucleus and lentiform nucleus, so the **dark** of the basal nuclei, and then **white** of the anterior limb of the internal capsule, and then the **dark** color of the lentiform nucleus.

And then we have the **3.__amygdala__**, which is called in some books, archistriatum. This amygdala is connected to the **caudate nucleus** which is a comma-shaped. There is also the lentiform nucleus here.. And more medially, you will find the thalamus.
These are parts of the basal nuclei. And we will postpone this subject (slide 17) until we finish the anatomy of the basal nuclei and then we'll return to it.

Here you can see the basal nuclei in relation to what's called the ventricular system or the **4.__lateral ventricle__** of the brain. The lateral ventricle is a cavity which lies inside the cerebral hemisphere. it has an anterior horn, body and posterior horn. the posterior horn lies in the occipital lobe, the body lies in the parietal lobe, he anterior horn lies in the frontal lobe, it is in __direct contact__ with the basal nuclei.

5.__The lentiform nucleus__ inside the red circle. It represents the most lateral gray matter of the basal nuclei. The anterior end of the lentiform nucleus is connected to the caudate nucleus.

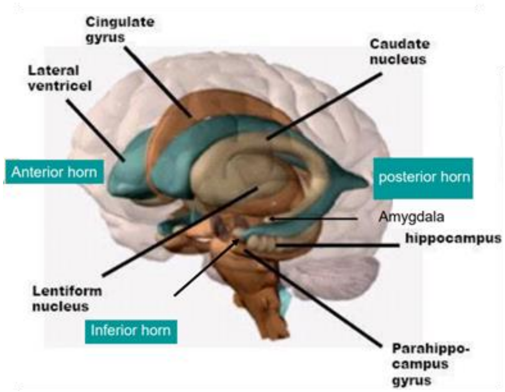


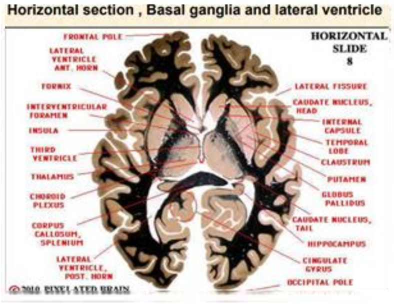
Figure (18)

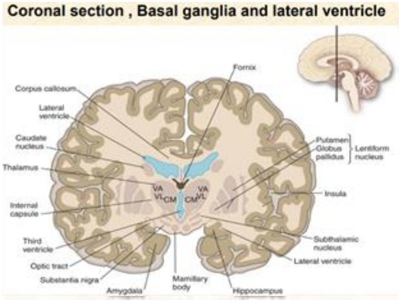
You can see the **6.__caudate nucleus__** forming a comma shape structure, this comma arches under the lateral ventricle in its floor and forms the body, then the body turns on the inferior aspect of the lateral ventricle to form the tail. Finally, the tail of caudate nucleus is continuous with the amygdala.

So as you can see here, the caudate nucleus is in __direct relation__ with the lateral ventricle, especially the anterior wall and body (this is very important in the future lecture when we describe the relation of the lateral ventricle with the caudate nucleus). And then the body of the caudate nucleus moves to the posterior and arches over the inferior or the temporal end of the lateral ventricle to be continuous with amygdala.

The temporal horn of the lateral ventricle to be continuous with the amygdala. . (so the lentiform nucleus laterally and the caudate nucleus is joined with the anterior end of the lentiform nucleus and on the floor of the lateral ventricle).

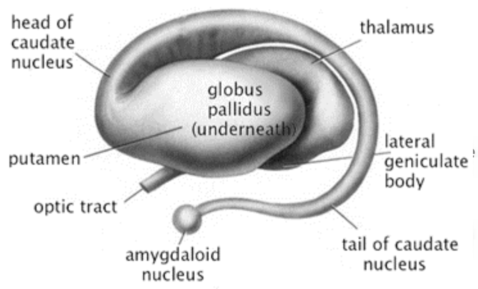
Figure (19)





3.7 The caudate nucleus:

Figure (20)



To begin with, this is the caudate nucleus, it's a comma-shaped or C-shaped nucleus.

The anterior part of the lentiform nucleus is joined with the head of caudate nucleus. The head of caudate nucleus moves posterior to form the body, and then the tail of caudate nucleus, reaching down to the amygdala body.

3.8 The lentiform nucleus:

It is a very simple lens-shaped structure of gray matter which lies on the lateral aspect of the caudate nucleus. It is divided into **A.lateral part called putamen** and a smaller, medium part called **B.globus pallidus**. which is subdivided into external and internal segments as we said before.

The anterior limb of the internal capsule locates between the caudate nucleus and lentiform nucleus (in red), and then the posterior limb which locates between the thalamus and lentiform nucleus (in orange).

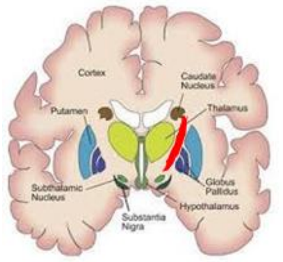
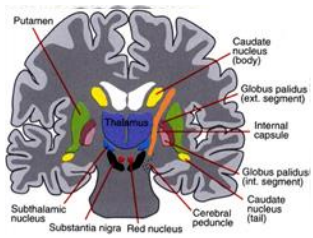


Figure (21)



3.9 The amygdala:

The amygdala is continuous with the tail of the caudate nucleus, it lies in the temporal lobe in a structure called uncus, anatomically it is part of the basal nuclei, but functionally, it's related to the limbic system.

Functions: It has several connections with the hypothalamus and other nuclei of the thalamus, it also plays an important role in smell sensation and in the fear sensation.

3.10 Subtantia nigra:

Substantia nigra in the midbrain, anterior to the cerebral aqueduct.

Function: It is very important because it produces a neurotransmitter called dopamine, this neurotransmitter is very important in the circuits of basal nuclei.

A **lesion** in the substantia nigra, will stop the effective production of dopamine, this will result in a disease called **Parkinson's**: a failure or huge difficulty initiating motor movements because of the reduction of dopamine in the substantia nigra.(The famous boxer called Mohamed Ali was diagnosed with Parkinson's)

3.11 Subthalamic nuclei:

Subthalamic nuclei are called the motor zone of the diencephalon. They produce the tetraneurotransmitter glutamine.

As we can see here, this is a subthalamic nucleus , just below the thalamus.

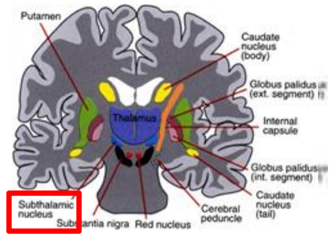


Figure (22)

3.12 The claustrum :

And lastly, we have what's called claustrum. The claustrum is a sheet of gray matter lateral to the lentiform nucleus inside what's called the external capsule.
It has no function, or unknown function till now.

3.13 Functions of the basal nuclei:

The connections of the basal nuclei are very important. It receives afferent input and produce output.
The part that receives afferent is the caudate nucleus and putamen, which is the corpus striatum.
And the part that gives efferent is called globus pallides.
So all afferents are going to the caudate nucleus and putamen,
and the efferents that leaves the basal nuclei are coming from the globus pallidus.
And all these afferent and efferent fibers are discussed in the physiology lectures, and you can find them here in these two tables.

Read only

Afferent	Efferent
•Corticostriate Mostly from same side Sensory/Motor Glutaminergic++	•Striatopallidal GABA—
•Thalamostriate	•Striatonigral GABA, Acetylcholine,Substance P
•Nigrostriate Dopaminergic—	•Pallidofugal fibres (from GB) **Ansa lenticularis** (thalamus) **Fasciculus lenticularis** (thalamus) **Subthalamic fasiculus** (subthalmus)
•Brainstem striatal fibres Serotonin –	•Pallidotegmental Tegmentum of midbrain
•Subthalamic nucleus	
•Mostly end in neostriatum except subthalamic N end in paleostriatum	

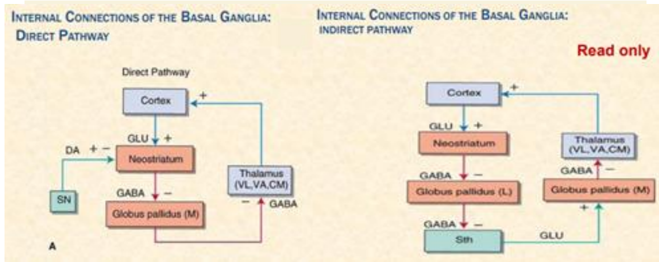
-The basal nuclei or the basal ganglia (as the old name), but you know that the ganglia is a collection of nerve fibers outside the central nervous system. But because these nuclei lie inside the nervous system, it's called a nuclei, not a ganglia.

So the idea of the basal nuclei function is in **circuits**. We have <u>two types of circuits pathways :</u> direct and indirect pathway.
In the direct pathway, the cerebral cortex gives excitatory glutamate fibers to the caudate nucleus and putamen, which is called striatum, and then the GABA inhibitory fibers are coming from the globus pallidus to the thalamus, then the thalamus gives excitatory again to the cortex.
The direct pathway ends with increase or produce the voluntary movement. So the direct is excitatory.

The indirect pathway is inhibitory to the cortex. The indirect circuit inhibits the motor movement.

When you contract the biceps, you result in inhibition of the triceps, so you have two circuits at the same time, the direct, which is excitatory to your biceps and the indirect, which is inhibitory to your triceps to produce the movement.

Okay. So what is the function of the basal ganglia? It is responsible for both direct and indirect circuits at the same time to control the net result of the motor movement. It excites the cortex in some parts and inhibits it in other parts to produce the voluntary movement.



Lesions:

1. An example of a lesion in the **direct pathway** is **Parkinsonism** , in which there is a decrease in the stimulation of the cerebral cortex.
The Parkinson's is a disease of the direct pathway in which you have **hypokinesia** and also **hypertonia** and rigidity, because you have a lesion in the dopamine neurotransmitter, which is produced by the substantia nigra inside the midbrain.

2. A lesion in the **indirect pathway**, which is inhibitory to the cerebral cortex (a disease that inhibits the inhibition so you end with excitation). This is called **hyperkinesia,** which happens in many diseases like Huntington’s Chorea disease, Sydenham's chorea, , and also Hemiballismus.

Figure23 represents Huntington’s Chorea. You can see the involuntary extra movement of the arm and leg.

Figure 24 represents Sydenham's chorea is a famous disease which affects young patients, it's called the dancing movement or the dancing disease because they cannot control the movement of their body so the involuntary movements make them appear like they are dancing.

Figure 25 represents the Hemiballismus in which half of the body produces sudden forceful movement in the upper limb and the lower limb. And you can end with a complete ballismus if it affects both sides.

Figure (23)

Figure (24)

Figure (25)

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