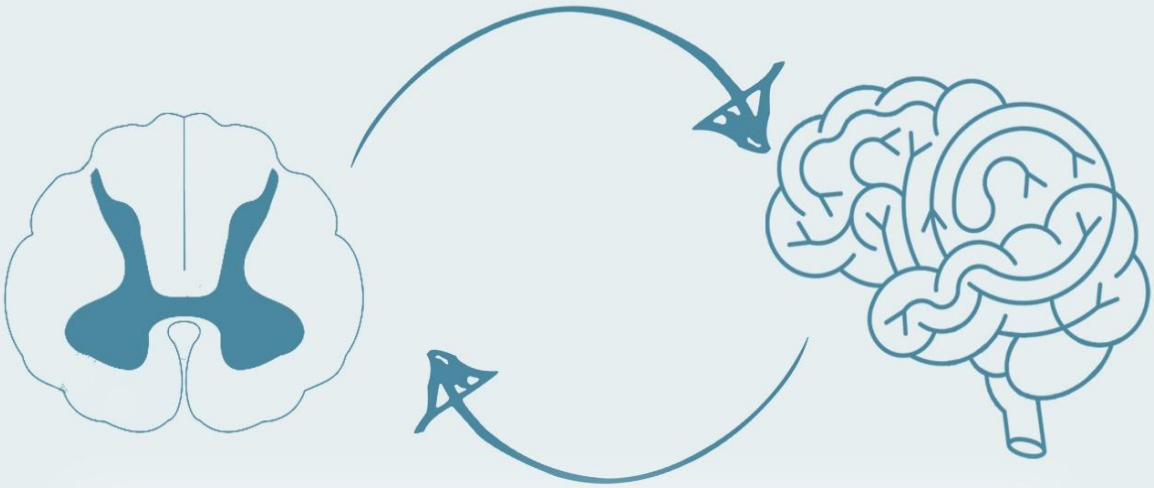


# CNS

## Anatomy

0 slides  0 sheets

number **6**

Done by **Rahaf Akroush**

Correction **Ahmad Al-Tarefe**

Doctor **Mohammad Alsalem**

Note: the doctor said that 'SNELL - NEUROANATOMY 'is the recommended text book, for those who face problems during studying Anatomy. This sheet is written according to section 2 and everything in the slide#6 is mentioned here.

To start with :

The pyramidal tracts are made of: **the corticospinal tract** (the lateral and the anterior=ventral) and **the corticonuclear**=corticobulbar ( despite it does not look pyramidal , but it is functionally , a part of the pyramidal tracts) .

while the extrapyramidal tracts apparently start from the brain stem as their name implies ( reticulospinal , tectospinal … ), but actually they are under the control of the cortex ( to be more precise , they should be named as corticoreticulospinal , corticotectospinal ,… ).

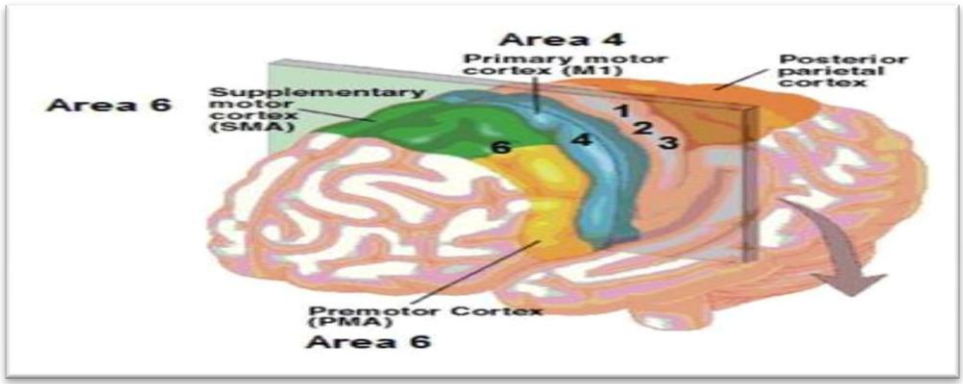
Recall: since both the pyramidal and the extrapyramidal tracts are under the control of the cortex, they are responsible for motor pathways, so mainly these cortex regions belong to the frontal lobe which is anterior to the central sulcus. The first area directly after the central sulcus is area number 4 , which is named primary motor cortex " functionally " or pre central gyrus " anatomically " . Then area number 6 - the association motor area - which is divided into: supplementary motor area (medially) and premotor area (laterally).

Area number 4 is mainly responsible for simple movement , executes skilled movement and controls the pyramidal tracts .

Area number 6 is mainly responsible for subconscious control of skeletal motor movement ( coordination ) .

Note: area 4 can do simple movements by its own, or execute the area 6-planned movements = skilled movement .

- The pyramidal pathway arises from Area 6 , part of sensory cortex area and **MAINLY** Area 4 .
- While the extra pyramidal pathway arises **MAINLY** from Area 6.
- The pyramidal tracts supply the muscles of the limbs and face, while extrapyramidal tracts supply the axial and proximal muscles.




Now, to differentiate between the supplementary motor area and the premotor area, read the following experiments :

**Experiment 1:**

Three light bulbs accompanied by their levers , a monkey is trained to click the lever when pointing to the bulb of the corresponding lever like the green bulb is 1 , so when the monkey see the green bulb will press on lever number 1 .The monkey undergoes a surgery , damaging pre-motor area in its brain. After this surgery, the monkey isn't capable to turn the lights on anymore, despite the fact that it can see and move. In fact the monkey couldn't integrate and interpret the visual data into motor output.

**Experiment 2:**

The monkey is not trained to recognize the lever of each light, rather it should click the levers in a specific sequence, for example : lever 1 then 3 then 2 , thus this way the monkey should depend on its memory , after damaging the supplementary motor area in its brain ( keep in mind there is no loss in memory ) , the monkey couldn't do the training as well, since it couldn't integrate the memory into motor output .

Conclusion: the difference between them, is that the supplementary motor area uses **internal cues** and an example on them is memory, while the premotor area uses **external cues** and an example on them is vision.

# 1-Pyramidal pathway:

## A- Corticospinal tracts:

Note: the number of motor units is the reason why the presentation of a specific area in the cortex is big or small , for e.g. : the hand has large presentation in the cortex , due to high number of motor units .

Let's start: (refer to picture below):

The corticospinal fibers originate from area number 4 in the cortex, they are scattered at first – called corona radiata – , then they collect together in the internal capsule (a common place for strokes ) , which is surrounded by nuclei; the thalamus medially and the lentiform nucleus laterally.

After that, they descend to the brainstem; the first area to face is the midbrain. In the center of the midbrain is the cerebral aqueduct, which connects the third ventricle superiorly with the fourth ventricle inferiorly . The anterior of the cerebral aqueduct is called **Tegmentum** and the most anterior part of it is called the crus cerebri or basis pedunculi of the midbrain. The corticospinal fibers occupy the middle three fifths of the basis pedunculi of the midbrain.

After that, they will descend to the pons , the anterior area of the pons is the basilar part of pons **which contains scattered pontine nuclei , so the corticospinal fibers cannot continue their way straight forward they have to pass in between the nuclei.**

Keep in mind, that there are fibers coming from the cerebrum Ponto cerebellum fibers passing **horizontally** and forming what is called **the middle cerebellar peduncle** which is connect the Pons with cerebellum, so there is an area of intersection between these fibers and the corticospinal fibers.

In the medulla oblongata, the scattered fibers reunite to form the pyramid so that we called these tracts pyramidal pathway ( the anterior aspect of medulla oblongata). At the lower part of medulla, 85-90% of the fibers will cross the midline to the opposite side; this is called **pyramidal motor decussation** (تصالب).

The fibers that undergoing the decussation are called **lateral corticospinal tracts.** While the other 10-15% are called the **anterior/ventral corticospinal tracts** ( epsilateral ).

Keep in mind that before the lower point of the medulla, the fibers were **epsilateral** .

The majority (not all of them) of the anterior corticospinal tracts cross the midline as the lateral, but at the level of spinal cord. In other words the majority of fibers decussate, but the difference is at which level they do so, this is the **first anatomical** difference between them.

The **second** difference is **functional**, the lateral corticospinal tracts' main effect is on the lateral part of the anterior horn that controls the distal muscles, that are responsible for fine/skilled movements .on the other hand, the anterior corticospinal tracts' main effect is on the medial part of the anterior horn , which is responsible for the axial and proximal muscles' movements , such as , posture , walking and running.

- **lateral corticospinal tract fibers synapse with alpha and gamma nuclei of the:**

1- **55%** of the LCSTs end at the level of the cervical segments , which are responsible for the very fine movements ( the upper limb can do fine movements and is more used than the lower limb, that's why the larger portion of the fibers end at the cervical level).

2- **20**% of the fibers end at the level of thoracic segments .

3-**22**% of the fibers end at the lumbosacral segments (which are responsible for the lower limb).

Remember : the enlargement areas are the brachial plexus (C5-T1) which is responsible of the movement of the upper limb - , and the lumber plexus (L1-L4) , so the majority of the LCST will end in cervical region which is responsible for complex movement more than the thoracic and lumbosacral movements .

The lateral cortionospinal tract has a proximal effect but mostly distal effect. It facilitates ( excites ) mostly the distal flexor muscles ( that what makes us hold things in our hands,write,draw…). While the ventral tract has axial and proximal muscle effects.

**General principle:** the upper neuron cannot control the lower neuron directly, it usually requires an interneuron, yet there are some exceptions.

In the corticospinal tracts , since there are interneurons , the neuron cannot descend directly to lamina 9 , it should end before lamina 9 a bit , then the interneuron gets into lamina 9 eventually , the corticospinal neuron can pass through lamina 4th ,5th ,6th ,7th ,8th .

The lamina 8 is sensible and is present in the anterior horn , so they are considered motor neurons.

As we mentioned at the beginning there are some fibers in Pyramidal pathway originate from sensory cortex area (3,1,2), these fibers will synapse in 4th , 5th , 6th and 7th laminae .

NOTE: laminea 4,5and 6 in the dorsal horn are sensory.

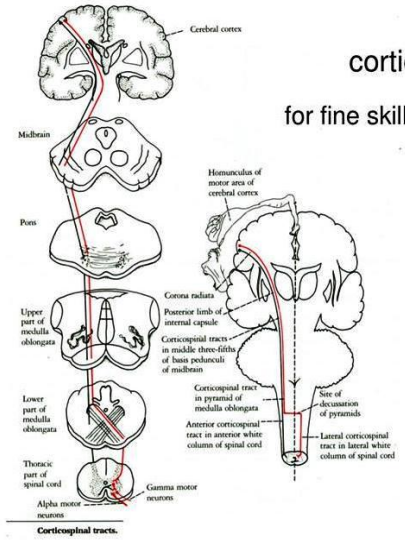
- Why does the corticospinal tract synapse into sensory neurons?

**To block certain sensations**. For example: blocking a tract that transports pain.

- Which means that the lateral corticospinal tract is a motor pathway ,but there is a part of that pathway that prevents certain types of sensations to reach into the brain ( it blocks them).

When your hand touches something hot you will move it away and in a random way (for example : moving your hand upward and downward continuously ), this movement is done by the activation of the conticospinal pathway . And by this movement there will be blocking of the sensory neurons by impulses that block the pain sensation and prevent it from going upwards.

The neocortex (a more complicated part of the cortex) is made of six layers, the upper four layers are input to the cortex and the lower two are output from the cortex. layer number five in specific , has large bulk of cells called giant cells of petz ( 3%) ,that don't require interneurons ,and they are responsible for very fine movements of the small muscles for accuracy.( For example: stimulating the first and the second lumburicals in the hand without stimulating the third and the fourth).

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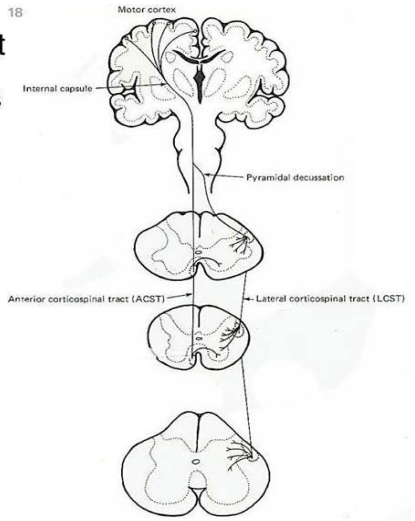
corticospinal tract

for fine skilled movements




**The anterior corticospinal tract**
acts on the proximal muscles of upper limb (shoulder muscle) of the ipsilateral and contralateral sides
*Fibers leave the tract at various levels to cross over in the anterior white commissure to synapse on interneurons in the anterior gray horn.*

## B-Corticonuclear tracts :

Originate from the cortex areas of head and neck in general, at the lateral side of the the precentral gyrus of the lower quarter of the motor cortex. .

These fibers will descend (same story as the previous tracts) until they reach the brainstem.

- keep in mind that the foot is the closest to the midline (paracentral lobule).

- we said that 10 out of the 12 cranial nerves emerge from the brainstem, while the olfactory and the optic don't emerge from the brainstem. Many of the cranial nerves that emerge from the brainstem have motor components, e.g. Oculomotor III , facial VII , trigeminal V , vagus X , accessory XI , etc . There is a motor nucleus for each nerve.

So that's why it is called corticonuclear. The nuclei has the lower motor fibers, as if you're saying that the nuclei of the cranial nerves are the anterior horn of the cranial nerves.

*Note:The origin of Cranial nerves III and IV in the midbrain / V, VI. and VII in the pons / and IX, X, XI, and XII in the medulla.

There is a pair of nerves for each cranial nerve; right and left. Each one of them, whether it is right or left, obtains motor fibers bilaterally from the cortex. so the motor nucleus on the right takes motor fibers from the left and right side of the cortex, and vice versa for the nucleus on the left ( general principle ) , yet there are some exceptions ( **IMPOTANT** ) :

1- Part of facial nerve :Lower facial muscles ( motor nucleus of the facial nerve ).

- Each nucleus has a map of presentation (specific area in the nucleus for a specific area of innervation in the body).

In this case, the lower part of the face is the exception, its fibers are from the opposite side of the cortex (resembles the spinal cord system ).

2- Part of Hypoglossal nerve ( muscles of the tongue ) : the fibers responsible for the **genioglossus** muscle is the exception only.

Conclusion: the fibers responsible for the genioglossus muscle and the lower part of the face are the exceptions.

# 2- Extrapyramidal pathway:

## A-Rubrospinal tracts:(Refer to pictures below)

Starts from the red nucleus present in the midbrain superiorly at the level of the superior colliculus , behind the substantia nigra which is posterior to the basis peduncle.

The red nucleus obtains its fibers from the **cerebral cortex** and the **cerebellar cortex**. From the red nucleus, fibers descend down to the anterior horn, these fibers **crossed** immediately, **approximately at the same level of the nucleus**, these fibers that decussate descend in the lateral white column, so they are closer to the lateral aspect of the spinal cord.

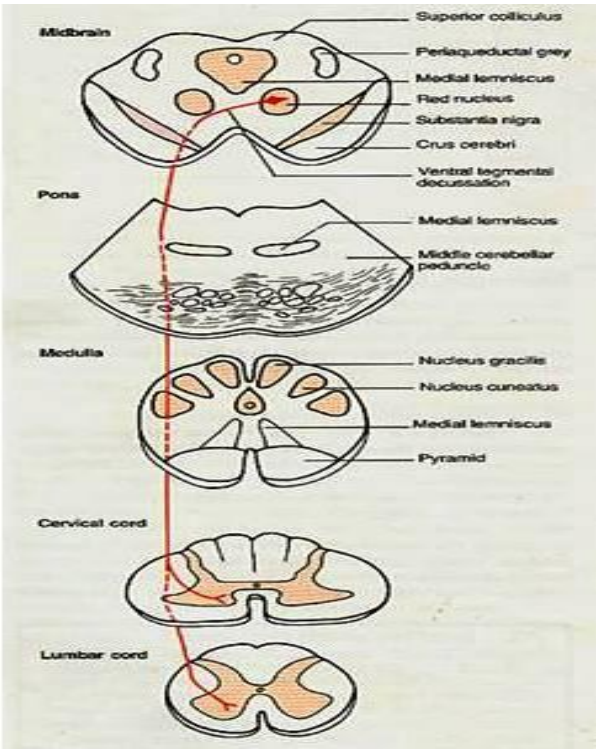
Function: they facilitate flexors movement and inhibit extensors movement of the distal flexor muscles precisely, and have a little effect on the proximal muscles.

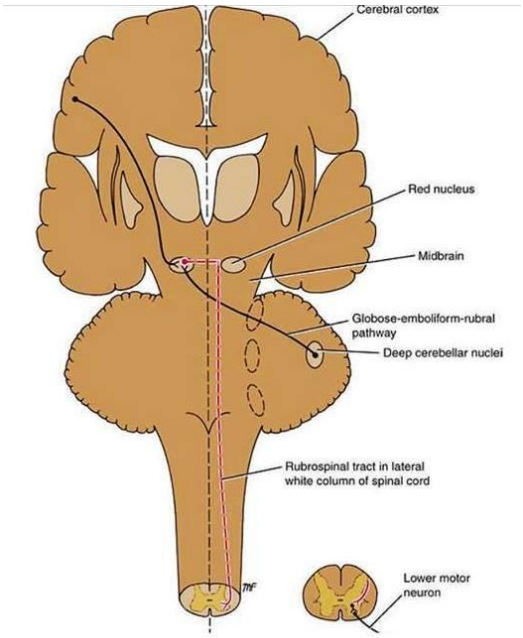
* Skilled movements are usually flexion.

**The lateral corticospinal tracts (pyramidal) and the rubrospinal tracts (extrapyramidal) together form the LATERAL MOTOR SYSTEM .**

Note: extrapyramidal tracts are responsible for tuning, while the pyramidal tracts are responsible for movements.

The role of the cortex on the rubrospinal fibers is inhibitory, because it is highly active, these tracts are considered the cortex in animals since they lack actual cortex, and they are very important in human children in crawling, since the cortex requires about 1-1 ½ years to be well-developed.




**B-Reticulospinal tract :**(Refer to picture below)

The reticular formation extends in the brainstem , but mainly in pons and medulla oblongata .In fact this tract receives inputs from the cortex so they are actually corticoreticulospinal.

So there are : 1- Pontine reticulospinal tracts.
2-Medullary ( or lateral ) reticulospinal tracts.

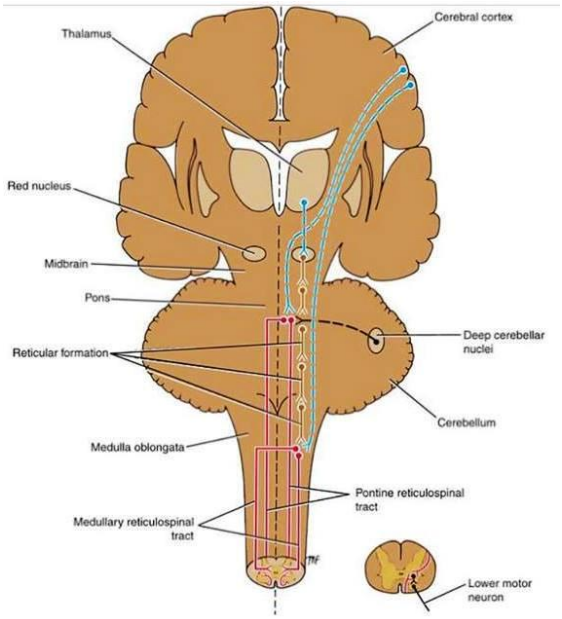
In general, the pontine reticulospinal tract is the opposite in function to the rubrospinal tract → facilitates extension mainly on the **axial and proximal muscles** , thus help extension ( posture ) specifically the lower limbs.

- There are muscles called antigravity muscles, help standing, they are called extensors in the lower limbs , but flexors in the upper limb.

Another thing to know about the pontine reticulospinal tract is that its fibers are **uncrossed**, and they are considered as part **of the medial motor system,** so they descend on the anterior white column. The pontine reticulospinal tract is over reactive, so the cortex effect on it is inhibitory.

The medullary reticulospinal tract is an antagonist to the pontine. Starts from the medullary reticular formation, could be **crossed** or **uncrossed**, and it descends in the **lateral white column** , but facilitates flexion and inhibits extension of the **axial and proximal muscles**. The medullary reticulospinal tract is under reactive, so the cortex effect on it is excitatory .

lateral reticulospinal tract has also descending autonomic regulation fibers providing a pathway by which the hypothalamus can control the sympathetic and sacral parasympathetic outflow.




## C-Vestibulospinal tract : (refer to picture below)

Similar to the pontine reticulospinal tract. Starts from the vestibular nucleus, mainly laterally. Facilitate the activity of extensor muscles and inhibit the activity of flexor muscles in association with the maintenance of balance.

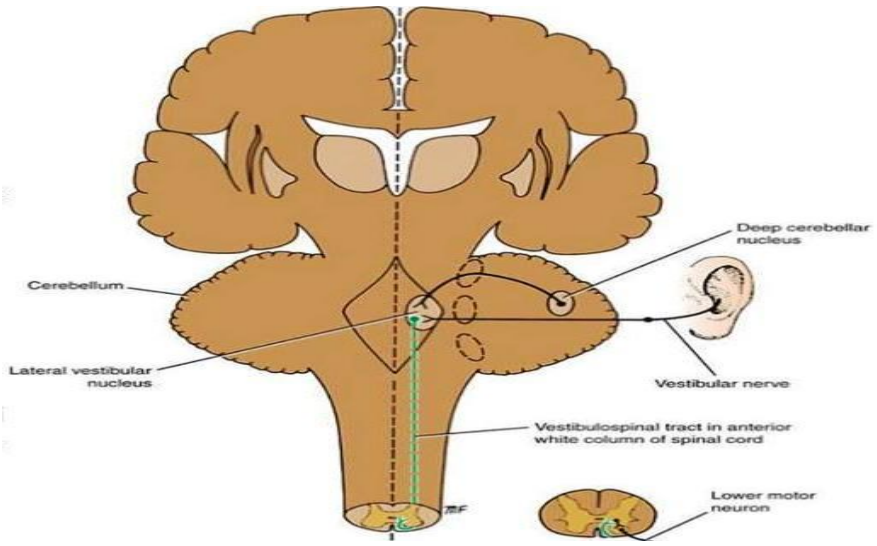
The vestibular nucleus is a part of the sensory fibers of one of the cranial nerves , which is cranial nerve number 8 , that is made of :

1-vestibular nerve ( responsible for the detection of position and relation to gravity ).

2-cochlear nerve ( responsible for hearing ).

Mainly **uncrossed**, descending in the anterior white column, so it is related to the medial motor system. It has an inhibitory input from the cerebellum.

* Cranial nerve VIII (vestibulocochlear) has 4 vestibular nuclei in pons and medulla.




**D-Tectospinal tract:** (Refer to the picture below)

Starts from the tectum which is the posterior aspect of midbrain.

Note: The Tectum made of four balls ; two superior colliculi ( responsible for visual reflexes) , and two inferior colliculi ( responsible for hearing reflexes).

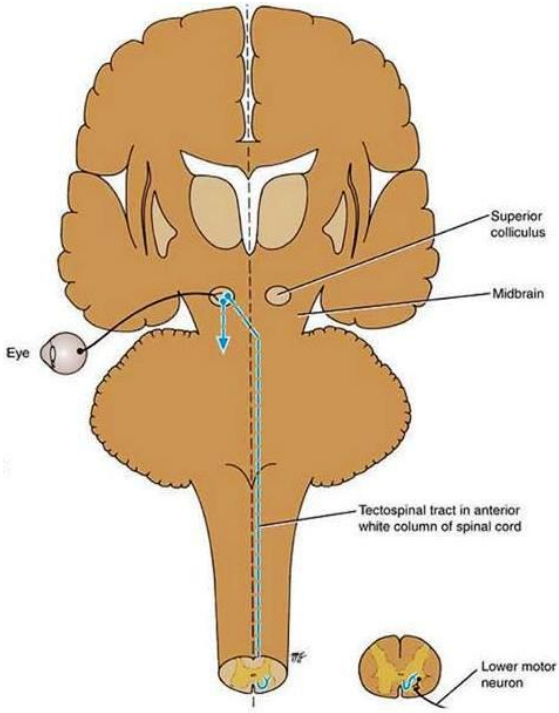
This tract Responsible for Visio-spinal reflexes ( not spinovisual , because the afferent fibers responsible for visual stimuli and the efferent fibers give spinal reflexes in our case , not the opposite).

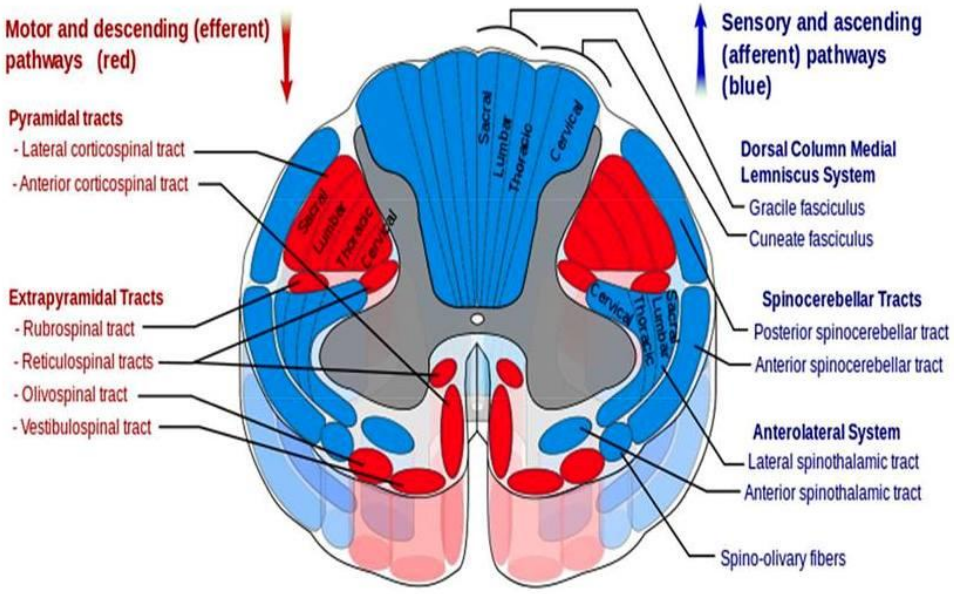
For example: when you through something on your friend and he is not careful, he will make a reflex immediately, stepping backwards for example, without taking some time to think. So these fibers are present in areas responsible for head & neck reflexes to visual stimuli and **end in the upper cervical area**.

The fibers are **crossed** in midbrain and present in the anterior white column **close** to the anterior median fissure.

**<u>To sum up:</u>**

The motor pathways are classified into:
- **Medial motor system**: axial and proximal muscles. Medial motor system includes:
  * Anterior corticospinal tract.
  * Extrapyramidal pathway in general except rubrospinal tract.
- **Lateral motor system:** distal muscles mainly, lateral motor system includes:
  * Lateral corticospinal tract.
  * Rubrospinal tract distal muscles mainly ( and the proximal muscles ).




**NO PAIN, NO GAIN**

**BEST OF LUCK!**