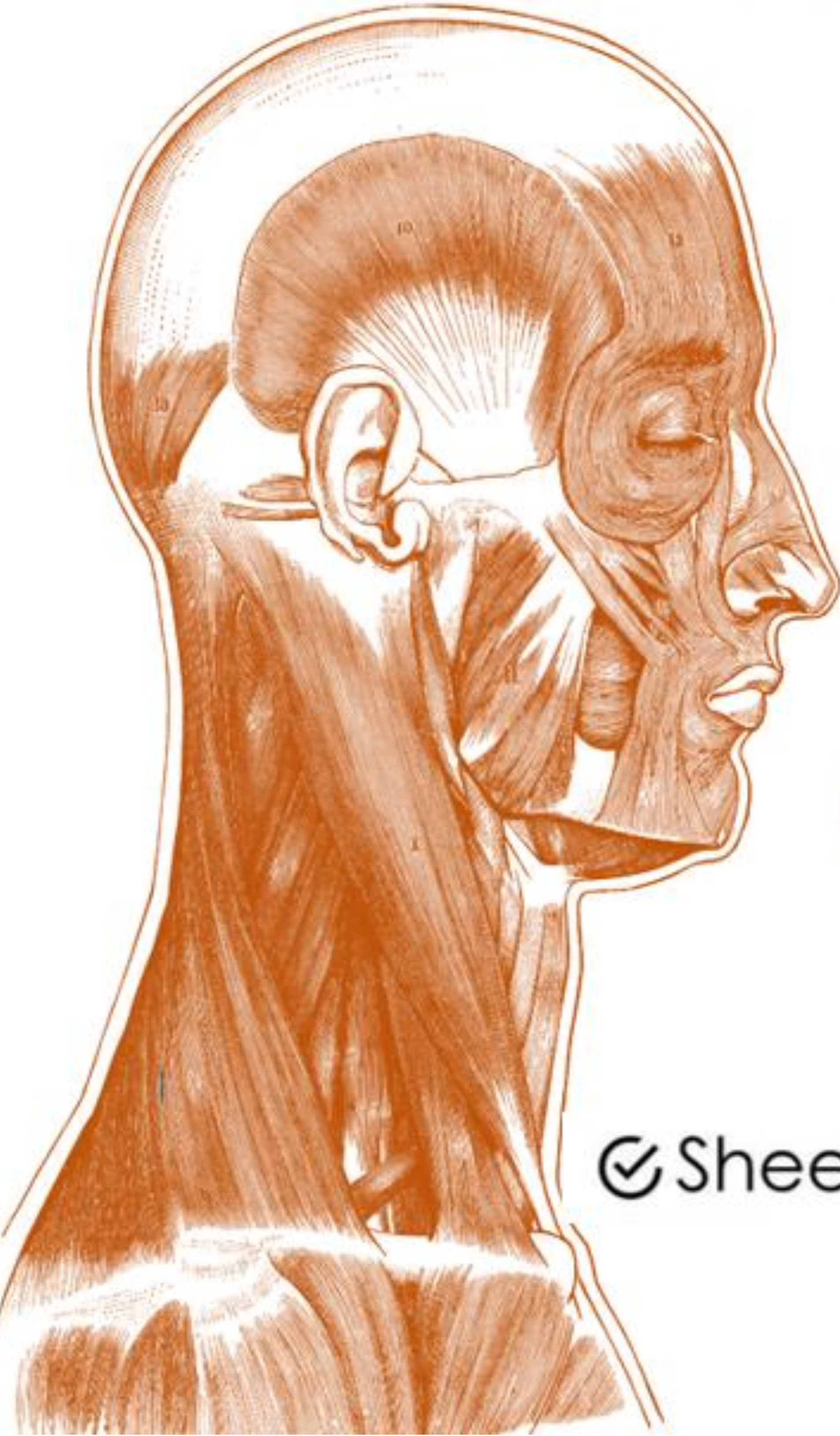
15

Anatomy

DENTISTRY 2017- UNIVERSITY OF JORDAN



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☑ Sheet ◯ Slide

Lajneh 017

Motor Tracts

-Introduction: Last lecture we talked about the stretch reflex which is very important in studying the motor system. We also said that the innervation for Extrafusal muscle fibers is by alpha motor neurons (bigger ones), while the Intrafusal muscle fibers are innervated by gamma motor neurons. We studied about Renshaw cells that inhibit alpha motor neurons because they tend to over react. Alpha fibers give collateral branches that activate inhibitory interneurons, these interneurons when activated will secrete glycine (inhibitory neurotransmitter) which in turn will inhibit alpha motor neurons.

-**Strychnine poisoning:** inhibits the Renshaw cells and prevents them from secreting glycine, so alpha motor neurons will over react and that will cause contractions and convulsions "تشنجات".

-B and C fibers are related to the autonomic nervous system:

> B fibers for preganglionic autonomic fibers "white ramus communicans" (bigger)

> C fibers for postganglionic autonomic fibers (smaller).

Now let's start with our lecture……

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-**Motor system** starts from the cortex down to the spinal cord (opposite to sensory system).

-The **frontal lobe** of the brain that is anterior to the central gyrus is called "Motor lobe".

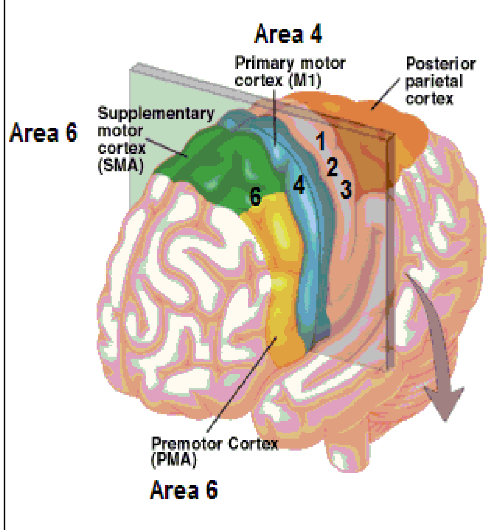
-This frontal lobe is different divided into areas such as:

*Area 4: primary motor cortex.

*Area 6: motor association area and it includes 2 areas:

a)**Premotor area:** uses external cues (Lateral)

b)**Supplementary motor area**: uses internal cues



-The tracts that descend from the cortex down to the spinal cord are divided into 2 main types of tracts:

* **Pyramidal** Tracts. * **Extrapyramidal** tracts.

Type of tract	**Pyramidal** tracts	**Extrapyramidal** tracts
Responsibility (Function)	**Conscious control** of skeletal muscles movement (Final execution of the movement)	**Subconscious control** of skeletal muscles movements.
Area of the cortex that is related to it	Related **Mainly** to **area 4** of the cortex. (they are also related to premotor area from area 6 and to the sensory cortex "area 312")	Related to **Premotor area** which is a portion from **area 6** of the cortex.

-**Conscious control of skeletal muscles**: Upper motor neuron controls lower motor neuron which will make the muscle contract.

-When we say **subconscious control**, we **DON'T** mean **smooth muscles** (they make part of the autonomic nervous system). We mean that even skeletal muscles (voluntary muscles) need some sort of subconscious control.

-What is the difference between pyramidal/extrapyramidal tracts:

*If a lesion happens in **area 4** (primary motor area) which is related to **Pyramidal** tracts, paralysis will happen and the patient will lose the ability to move.

*On the other hand, if a lesion happens in **area 6** which is related to Extrapyramidal tracts (Subconscious control/Coordination), the patient will lose the coordination effect but NOT the whole movement (No paralysis) (رح يواجه صعوبة يدخل ابرة بخيط مثلا بس بقدر يحرك ايدو واصابعو)

-So we conclude that fine movements that need coordination are controlled by the subconscious level.

-We said earlier that premotor area from area 6 uses external cues, while supplementary motor area uses internal cues, what do we mean by cues?? And what is the difference between external/internal cues??

-**External cues**: (Such as vision, voice) to understand them, the doctor talked about an experiment that we tried on a monkey. In this experiment, there were 3 lamps with 3 buttons, each lamp has a button, the monkey was trained to click on the button (a motor task) corresponding to the lamp that turns on only.

-يعني باختصار كإنو حافز من البيئة الخارجية بحفزنا انو نعمل motor activity معين.

>> If the premotor area which uses the external cues was absent, the monkey will still can move and see the light, but will lose the ability to use the vision information to integrate (turn) it to a motor activity.

-**Internal cues**: another experiment, imagine that there were 3 buttons that have numbers on them, when the monkey clicks on the buttons in a certain order (button 1 then 2 then 3)for example the monkey will receive a reward, now this order will be stored in the monkey's memory, and each time it will use the stored memory to click on the buttons in the right order to get the reward (the monkey used an internal cue (زي حافز) to do the motor task which is clicking on the buttons).

>> If the supplementary area was absent, the monkey will not be able to use the memory information to integrate it to a motor action.

Now to the tracts….

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Pyramidal Tracts

1) Lateral Corticospinal tract

-It starts from the cortex, from the primary motor cortex in the frontal lobe which contains the cell bodies of the upper motor neuron, so:

Cell bodies of the upper motor neurons of this tract are located in the primary motor cortex in the frontal lobe.

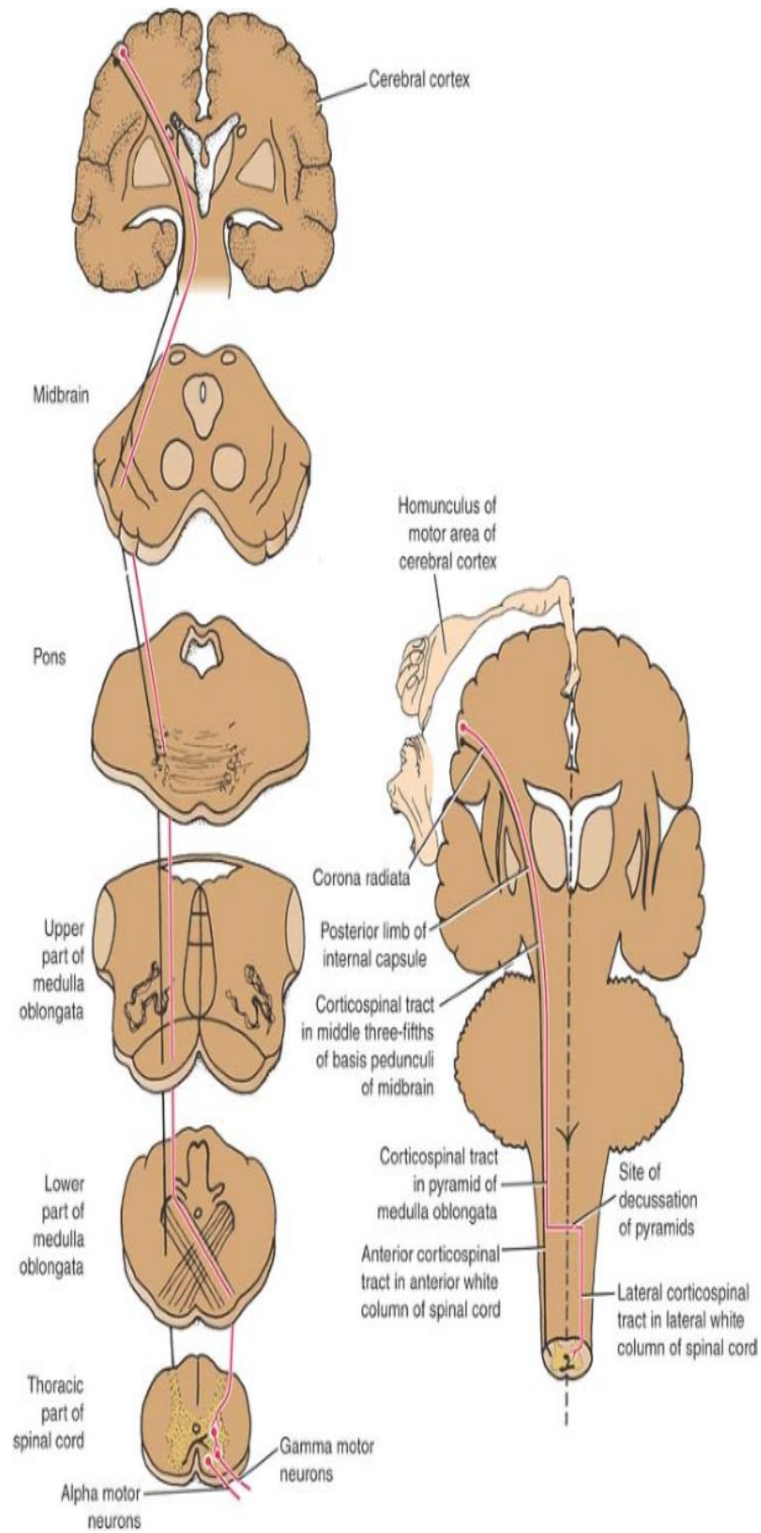
-Upper motor neuron starts from the cortex, which is divided into homunculi, each homunculus is responsible of the motor activity of a certain area in the body (each homunculus contains the cell bodies of neurons that are responsible of the movement of a certain part of the body).

-Then the fibers descend down from the cortex, passing and forming corona radiata, then they will enter the internal capsule (which is between caudate nucleus and thalamus medially and lentiform laterally).

-After that fibers reach the brain stem, exactly the midbrain.

-In the center of the midbrain there is a cavity called “Cerebral aqueduct”, a duct between the third and the fourth ventricles, it allows the passage of cerebrospinal fluid.

-Behind the cerebral aqueduct there is something called “**Tectum**”, which contains the colliculi, and anterior to the cerebral aqueduct there is something called “**Tegmentum**”, the <u>anterior part of the tegmentum</u> is called “crus cerebri” or “basis pedunculi of the midbrain”.



-While the fibers are descending down, they form a nice bundle in the **crus cerebri**, exactly in the **middle three-fifths** (one fifth medial and one fifth lateral are excluded, and fibers pass through middle three-fifths).

-So, when we take a cross section in the midbrain, we see corticospinal fibers in the middle three-fifths of crus cerebri.

-Now, after the midbrain, fibers descend down to **pons**, to its anterior part called "**basal/basilar part"** (the name is related to the basilar artery which is a union of two vertebral arteries), this basilar part is characterized by the presence of pontine nuclei (collection of cell bodies) these nuclei maintain connection "cross talk" between cerebrum and cerebellum (its pathway called "cerebro-ponto-cerebellar pathway).

-When fibers reach these nuclei, they will be scattered between them (they won't form a nice bundle as the one in the crus cerebri in the midbrain)

-So a cross section in pons will not show a nice bundle of corticospinal fibers.

-Down from pons to the lower level, the **medulla oblongata** (lowest part of the brainstem), fibers will gather together forming a bundle (**bulge**) anterior and medial to the medulla oblongata, this bulge is called "**Pyramid**", and because of that this tract is called pyramidal tract.

So, **pyramid is a bulge of corticospinal fibers (white matter) located anterior and medial to the medulla oblongata.**

-Until now, the fibers are descending in an **ipsilateral** direction (the right pyramid is descending from the right portion of cortex, and the left one from the left portion of the cortex).

-At the lower part of medulla oblongata, 85% of the fibers cross the midline (fibers in right pyramid go to the left side and vice versa), forming something called "**pyramidal decussation**" or "**Major motor decussation**".

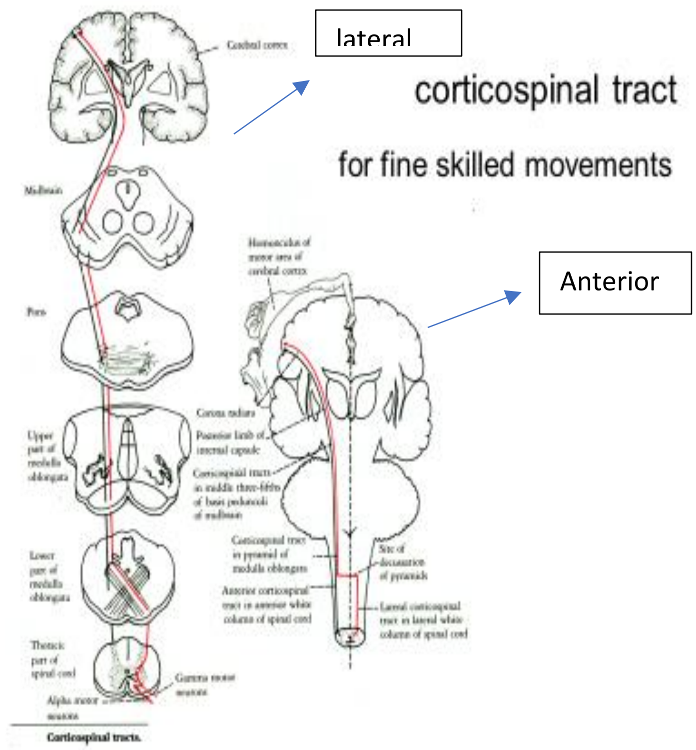
- Fibers that crossed the midline (the 85%) are called "**lateral corticospinal fibers**".

-The remaining 15% of fibers (minority) that didn't cross the midline and continued descending ipsilaterally are called "**Anterior corticospinal fibers**".

-The **lateral** corticospinal fibers continue descending down until they reach the **anterior horn in the spinal cord**, and their will synapse.

-The anterior corticospinal fibers continue descending down in ipsilateral direction.

-When these fibers reach the spinal cord and at the level of their corresponding spinal segment, they will cross the midline eventually forming the "**anterior white commissure**"



-So in conclusion, all fibers will cross the midline, in fact the right cortex controls the left side of the body and the left cortex controls the right side of the body.

-Lateral corticospinal fibers: crossed the midline happened at the lower part of medulla oblongata.

-Anterior corticospinal fibers: crossed the midline happened at the level of the spinal cord.

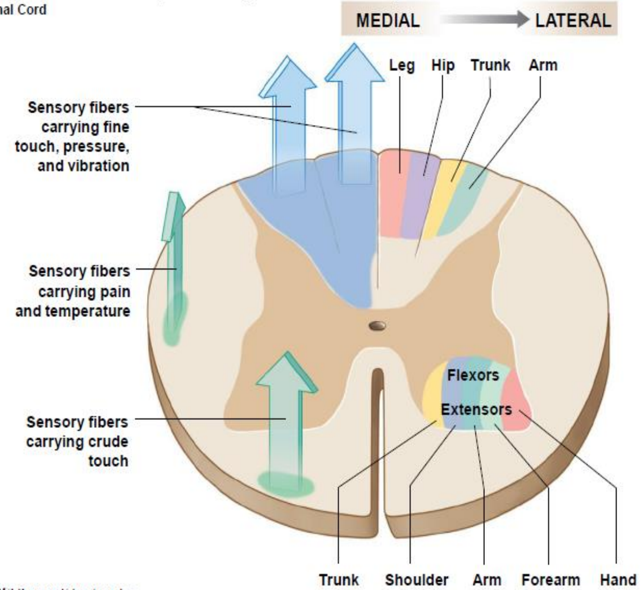
(Anatomical difference between lateral and anterior corticospinal fibers).

-As we said earlier (from Rexed divisions), the anterior horn took laminae 8 and 9.

-Inside the anterior horn there is some kind of organization like a "map", each part is responsible of the muscles of a certain area in the body.

-For example, lateral portion of the anterior horn is responsible for the innervation of muscles of our hands, and the medial one for muscles of the trunk.

Figure 15.1 Anatomical Principles for the Organization of the Sensory Tracts and Lower–Motor Neurons in the Spinal Cord



-Muscles in our body are divided into:

1) Axial (medial) muscles: related to **posture** of the body (they don't provide skilled movements).

2) Peripheral (lateral) muscles (like muscles of the foot, hand): responsible for the skilled movements.

-Now going back to our tract, **lateral corticospinal fibers,** they descend down (decussation happens in pyramids) and reach the anterior horn, they will synapse their and innervate the regions of anterior horn that are related to the **lateral muscles**.

-On the other hand, the **anterior corticospinal fibers** descend ipsilaterally and eventually at the level of spinal cord they cross the midline through the anterior white commissure which is related to the **axial muscles** (posture).

The anterior corticospinal tract acts on the proximal muscles of upper limb (shoulder muscle) of the ipsilateral and contralateral sides (this sentence is from slide 80)

-So, we have **Lateral motor system** and **Anterior motor system** in our bodies.

(This is the difference in function between anterior and lateral corticospinal fibers, one for the skilled movements and one for maintaining the body in a good posture).

-Lateral corticospinal tract descends the full length of the spinal cord.

-Lateral corticospinal fibers synapse with alpha and gamma nuclei of:

-55% at the cervical region (55**%** of the lateral corticospinal fibers end at the cervical region (cervical segments of spinal cord) (no role in the lower limb), because these fibers are responsible for the skilled movements, and most of them are done by the hands (lateral muscles), and the hand is innervated by brachial plexus (C5,C6,C7,C8,T1) so we need them mostly in the cervical segments.

-20% at the thoracic region (segments).

-25% at the lumbar and sacral regions.

-If we made a cross section at cervical region of spinal cord, we will be able to see the representation of hand in the spinal cord (in anterior horn), but moving down to thoracic, lumbar and sacral segments, we will not be able to see representation of hand.

-For example, at the thoracic region we can see the representation of intercostal muscles in the anterior horn of spinal cord, so the anterior horn is narrow here.

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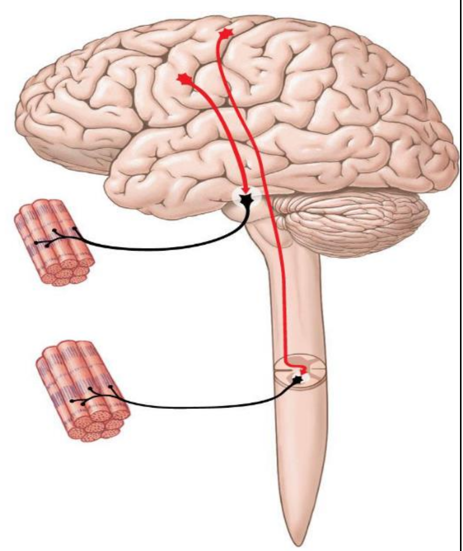
-In most cases, upper motor neuron synapses with interneuron, then the interneuron synapses with lower motor neuron (majority of cases).

-In 3% of the cases, upper motor neuron synapses with the lower motor neuron directly without interneuron (exception). (originates from the fifth layer of area 4 (giant cells of betz))

-The lateral corticospinal tract synapses **mainly with interneurons** In laminae 4,5,6,7,8.

-Laminae 8 (and 7 somehow) are in anterior horn, so it's logical to synapse there, but what about laminae 4,5,6??

-Laminae 4,5,6 are in the posterior horn (sensory horn), so what is going here??



-To answer that we need to go back to the fibers that descend from the somatosensory cortex and participate in the pyramidal tract, the fibers that originate from sensory origins go to the sensory portions (to the posterior horn).

-There are many theories about this, one of them links what happens here with learning new motor skills and movements (such as learning carving of teeth ☺), so we need sensory data to learn new motor skills.

- In the 3% of cases, upper motor neurons from "**Giant cells of betz**" in area 4 in the cortex descend down to lamina 9 and synapse there and control lower motor neurons directly **with no interneurons**, and the goal from this direct connection between upper and lower motor neurons is **to provide very <u>accurate</u> movements** (we need few motor neurons to contract).

-Most of muscles of head and neck area are supplied by **cranial nerves** (Such as muscles of facial expression, muscles of mastication, muscles of larynx, muscles of pharynx..) and when talking about cranial nerves, there is no anterior horn, we have instead **motor nuclei.**

1)The tract of the motor cranial nerves is called Corticonuclear tract.

2)This tract is composed of fibers originating from the precentral gyrus of the lower quarter of the motor cortex.

3)The descending fibers terminate in the motor nuclei 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**.

4)The corticobulbar fibers from one side of the brain project to the motor nuclei on both sides of the brainstem (bilateral input)

(last 4 sentences are from slide 81)

-For example, Trigeminal nerve has motor nuclei in pons (this nerve is mainly sensory but it has a small motor portion) so upper motor neuron descends down from the cortex to the motor nuclei, then lower motor neuron goes from the nucleus to the muscle. (للعضلة المعنية) >> وتحية لأحمد المعني >> 1 خاص لسكشن

-For cranial nerves, sometimes the upper motor neuron is called also “supranuclear neuron” (from cortex to the nuclei) and the lower motor neuron is called “infranuclear neuron” (from nuclei to the muscle).

-As a conclusion in the spinal system (very important), the anterior horn on the right side is supplied by the left cortex and vice versa because of decussation. (for spinal nerves)

-For cranial nerves, motor nuclei are supplied **bilaterally** (from both sides, contralateral+ipsilateral), that means the right motor nuclei for trigeminal nerve for example, is supplied by the left and the right cortexes, and vice versa.

-There is an exception for the bilateral direction of cranial nerves, which is the part of **facial nerve** that supplies the lower part of the face, to make it clear, when we look at the motor nucleus of facial nerve, we will find something like a “map” in the nucleus, and each part of this map is responsible for the innervation of certain muscles in the face, the part of nucleus that is responsible for the innervation of the lower aspect of the face is supplied in contralateral direction (exception for the general role).

-Another exception is the hypoglossal nerve (12^{th} cranial nerve that supplies the tongue), and like trigeminal, each part of the motor nucleus of hypoglossal nerve is responsible for the innervation of certain muscles, **the part that is responsible for the innervation of genioglossus muscle is supplied in contralateral direction also.**

-So to conclude, the corticoneuclear input is bilateral **Except** :

1- Part of 7^{th} (which supplies LOWER facial muscles)

2- Part of 12^{th} (which supplies genioglossus muscle)

Now moving to the extrapyramidal tracts…

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Extrapyramidal tracts

-Vesitibulospinal tracts.

-Tectospinal tracts.

-Reticulospinal tracts.

-Rubrospinal tracts.

*Their names suggesting that they originate/start from structures in the brain stem then descend down to the spinal cord, for example:

"**Rubro**" refers to the red nucleus in the brain stem.

"**Reticulo**" refers to the reticular formation in the brain stem.

"**Vestibulo**" refers to the vestibular nucleus in the brain stem.

-PAY ATTENTION!! these tract's names may be **misleading** because we would think from the names that they originate from brain stem without any higher control, but **in fact they are under the control of <u>cortex</u> (area 6 "premotor area+supplementary motor area**) so for more accuracy their names should start with "Cortico", for example cortico-rubro-spinal tract.

>> "cortico" refers to cortex, we remove it from the name for simplicity, but always remember that these tracts are under the control of CORTEX.

-Extrapyramidal tracts are related to (their functions) **Coordination**, **muscle tone**, **posture** and **subconscious control of skeletal muscles movement**.

Now let's start with the first tract..

Rubrospinal Tract

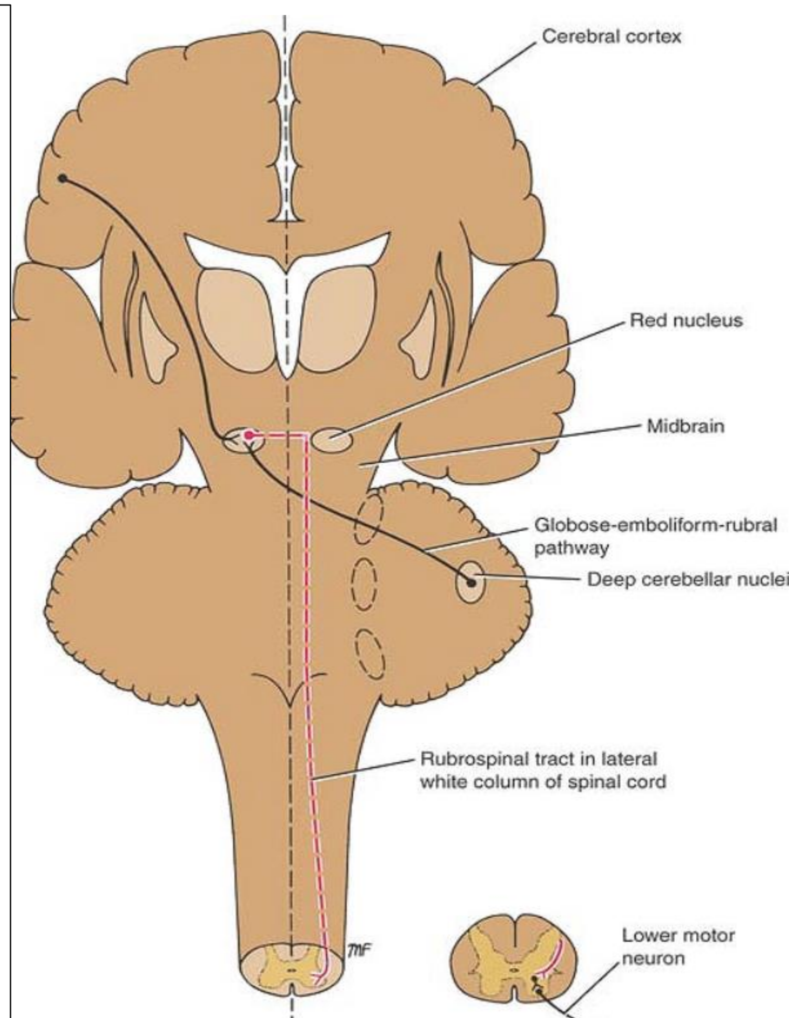
-The word "**Rubro=red**" suggesting that this tract descends down from the red nucleus (red because its highly vascular) in the midbrain (brain stem) behind something called "**Substantia nigra**",

-The red nucleus has very important role in the motor system, it receives input from the cerebellum through a pathway called "**Globose-embolifrom-rubral pathway**"

(**Globose+embolifrom** are deep cerebellur nuclei, will be discussed later)

-Cerebellum receives afferent data from spinocerebellar tracts from spinal cord that gives the muscle-joint sense.

-So cerebellum is well informed about our bodies situations in space (knows which muscles are relaxed and which are contracted)



-This tract also receives data from **cerebrum** (Big boss) which contains the higher centers (command/intention centers) (Before we do any movement, an idea about the movement is formed)

-So, intention is in the cerebrum and current position of the body is in the cerebellum, so consultation must happen (before we do any movement the cerebrum does some consultation with structures involved in the motor system like **cerebellum** and **basal ganglia** and take the feedback from them).

-The Rubrospinal tract is crossed, it does early crossing at the level of red nucleus itself (when we take a section in midbrain, we see the red nucleus and the fibers crossing the midline there).

-Then after crossing, fibers descend to the lateral white column.

-The function of **Rubrospinal** tract is to:

*__Facilitate__ **the activity of** __**flexors**__ and __**inhibit**__ **the activity of** __**extensors**__.

-So this tract (Rubrospinal) is the __**coordinator**__ for the __**lateral corticospinal tract**__ (which is responsible for skilled movements as we said earlier)

- Lateral corticospinal tract and **Rubrospinal tract** collectively form something called "**Lateral Motor System**". (Facilitate flexors and inhibit extensors).

-So we conclude that __**muscles of *skilled* movements (such as writing muscles)**__ are __***flexors***__ in general.

-Extrapyramidal tracts in general are related to the **proximal muscles**, and because it's related to the coordination of Skilled movement muscles (lateral/distal muscles), the Rubrospinal tract is an **exception**.

<u>**Pontine Reticulospinal tract**</u>

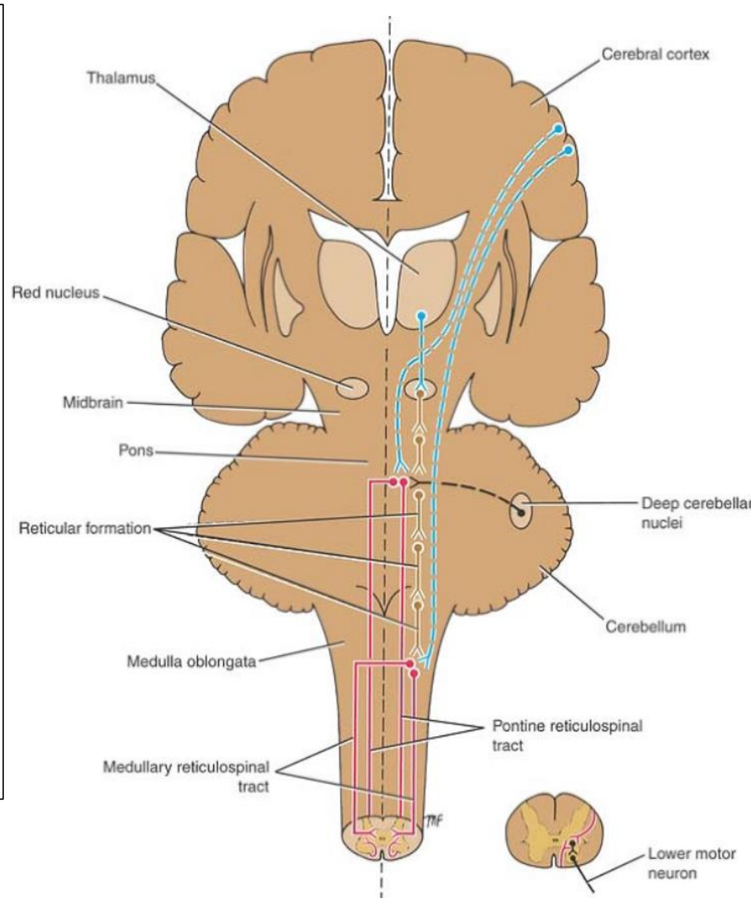
-Due to the differences between the reticular formation in the <u>pons</u> and the reticular formation in the <u>medulla oblongata,</u> we divide the tract **functionally** to:

a) Pontine reticulospinal tract.

b) Medullary reticulospinal tract

-“Reticulo” refers to reticular formation in the brain stem.

-The fibers of these tract descend from the **reticular formation in the <u>pons</u>** down to the spinal cord. (Anterior white column)



- **Pontine reticulospinal tract** is <u>**uncrossed**</u> (اليمين بنزل يمين واليسار بنزل يسار).

- The action of this tract is to: **Facilitate the activity of <u>axial</u> <u>extensors</u>**. (work in contrary to the rubrospinal tract)

- This tract is **tonically active,** that means it’s <u>always active under normal conditions</u> and the **cortex** has only inhibitory effect on it, this mechanism is called “**Disinhibition**”.

-Disinhibition means the activation is done by removing the inhibitory effect, for example if we cut the fibers that descend from the cortex to the reticular formation in the pons, the pontine reticulospinal tracts will get activated (will be hyperactive) because we removed the inhibitory effect (disinhibition)

Medullary reticulospinal tracts

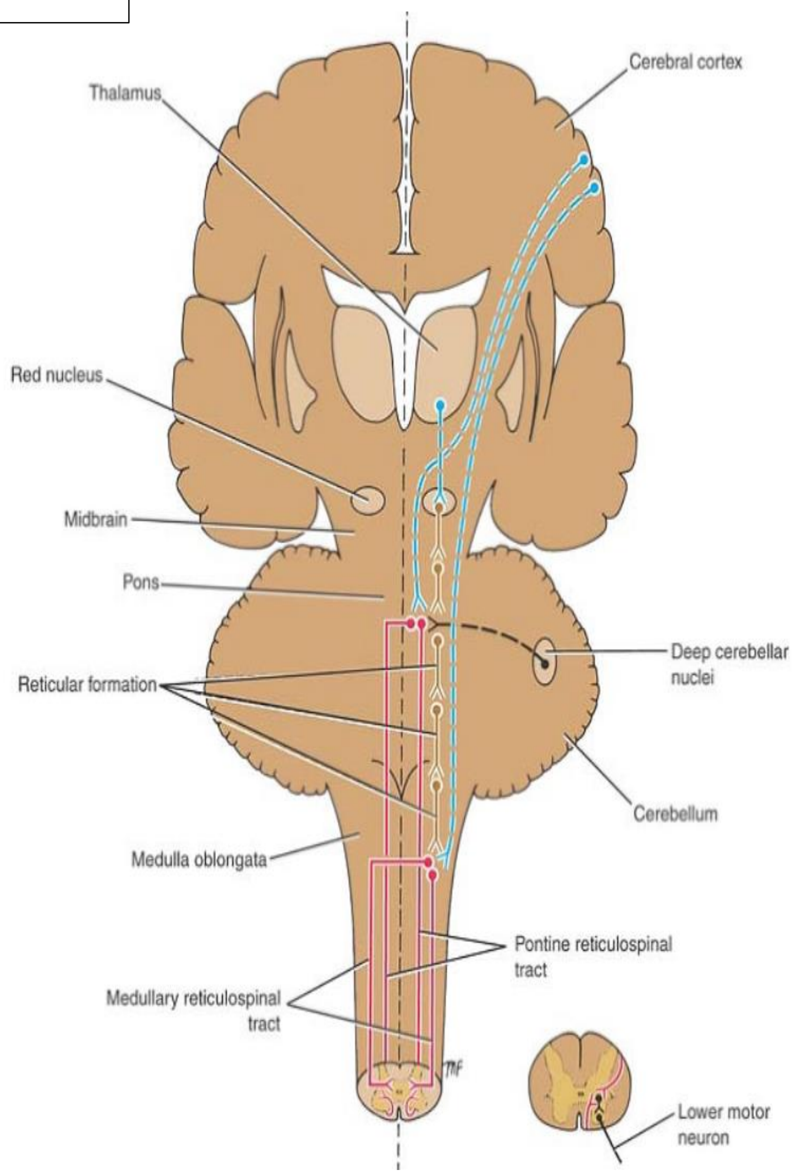
-Its nearly completely opposite to the pontine reticulospinal tracts.

-Fibers descend from the reticular formation in medulla oblongata **crossed** and **uncrossed** down to the spinal cord (Lateral white column)

-Not tonically active (at normal conditions it's not active and needs stimulation to get activated)

-Its function is to inhibit the axial and proximal limb extensors and to facilitate the flexors.

-In our bodies, there are flexors and opposite to them functionally there are extensors (it's impossible for example to activate the biceps and triceps at the same time, each time the biceps gets activated the triceps gets inhibited) the same concept is applied to the tracts, when the tract that activates the flexors is highly active, the antagonist system that inhibits them gets inhibited).



-Fibers descending from **hypothalamus** (big boss of autonomic nervous system) to the lateral horn cells pass with the medullary reticulospinal tract.

Pontine reticulospinal tract and **Vestibulospinal tract** work together.

Medullary reticulospinal tract and **Rubrospinal tract work** together**.**

Vestibulospinal tract (similar to pontine reticulospinal tract)

-Fibers descend from **vestibular nucleus** in the brain stem (in Ponto-medullary junction).

-Vestibular nucleus receives data from:

1) Vestibular nerve which is a part of vestibulocochlear nerve in inner ear (vestibule) which contains the saccule, semicircular canals (contain endolymph fluid) and hair cells.

-When your head moves, the fluid in semicircular canals moves and the movement causes firing in hair cells, so the data about the position of your body in relation to the gravity is transmitted to the nucleus (balance info).

2) Cerebellum

-Cerebellum is divided into 3 parts:

Cerebrocerebellum, **spinocerebellum** and **vestibulocerebellum >> related to vestibular system.**

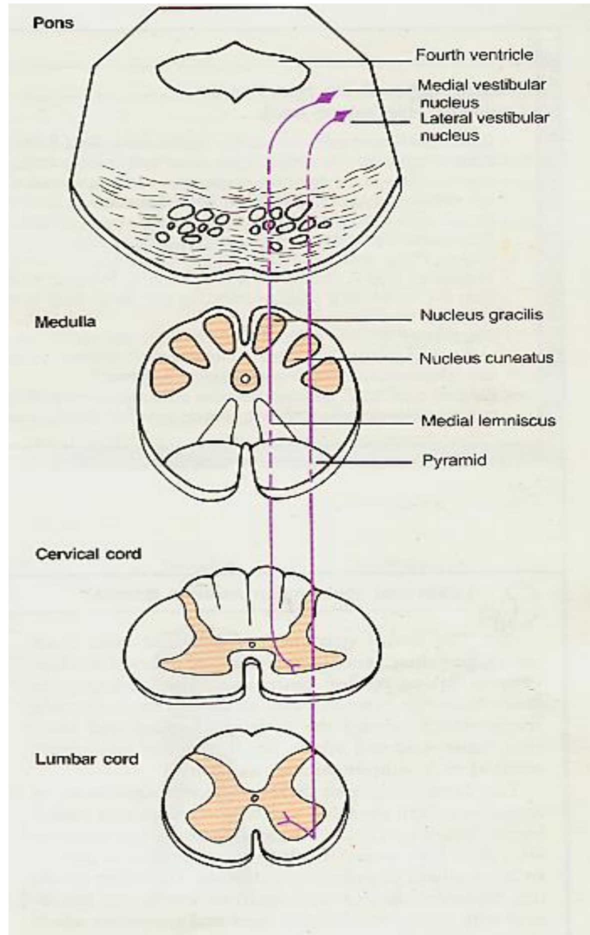


Fig. 5.19 Vestibulospinal tracts.

-The fibers descend **uncrossed** from the nucleus to the spinal cord (**Anterior white column**)

-Then they synapse with neuron in the anterior gray column of the spinal cord (from slide 88)

-The function of this tract is **to facilitate the activity of extensors** (to stand up in fully extended position) and (opposite to **rubro** and **medullary** tracts, similar to **pontine** tract)

-To stand up in a fully extended position, 2 tracts is involved:

Pontine and **vestibulospinal** tracts.

Tectospinal tract

-Tectum is composed of 4 balls "corpora quadrigemina ":

*2 superior colliculi.

*2 inferior colliculi.

-**Superior colliculi** are related to the **visual pathway** and **inferior colliculi** are related to the **auditory pathway**.

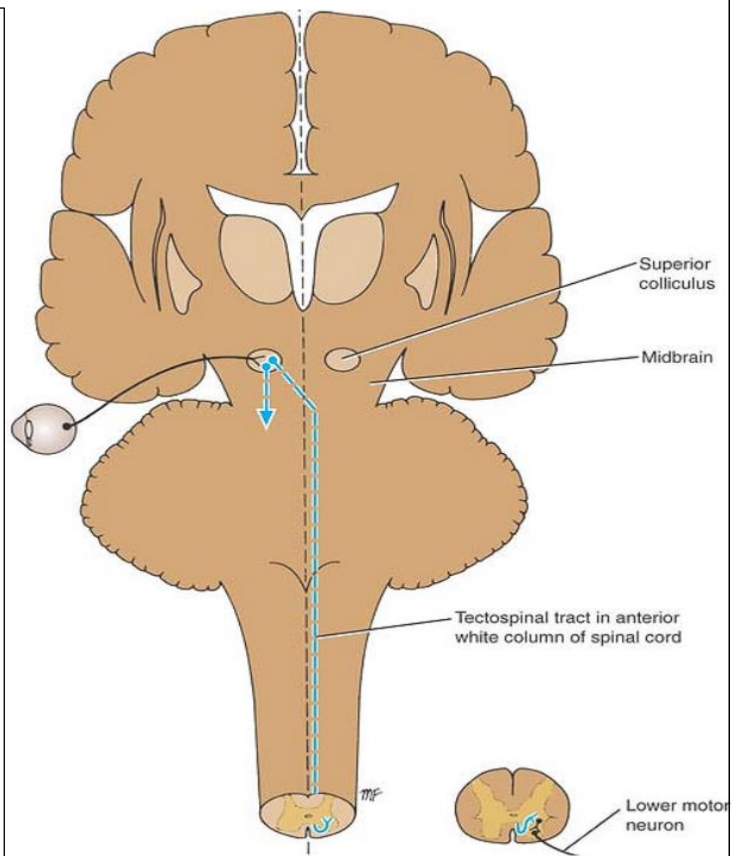
-Fibers of this tract descend from the **tectum** (posterior aspect of the midbrain) , exactly from 2 **superior colliculi** down to the spinal cord.

- The tract descends in the anterior white column close to Anterior median fissure

-Tectospinal tract is responsible for the reflex movement of the head and neck area in response to visual stimulus (**Visuospinal** reflexes).

-Each reflex has an afferent limb (sensory) which activates an efferent limb (motor).

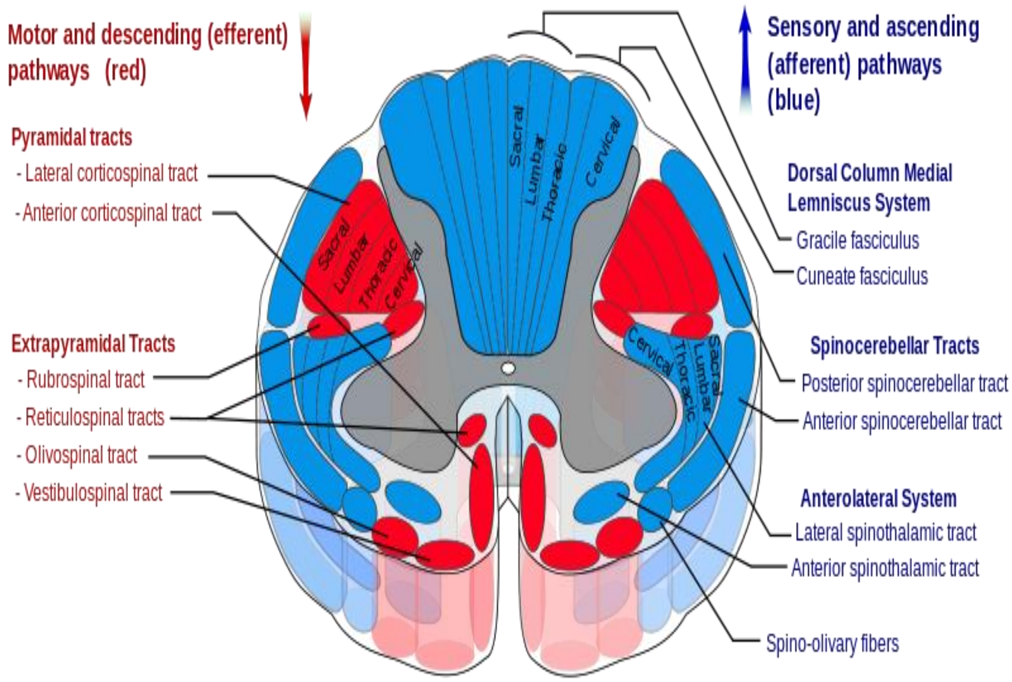
-Example on visuospinal reflex, when I act that I'm going to throw a ball on you, the **afferent** limb is **visual**, you **see** me acting like (throwing the ball), and the **efferent** limb is **moving your head away** (**motor**).



- Majority of fibers terminate in the anterior gray column of **upper cervical segments of the spinal cord (**which are related to the muscles that move the head and neck area**).**

The motor pathways are classified into

- ❑ **Medial Motor system**: axial & proximal muscles. Medial Motor system includes:
  - ➢ Anterior corticospinal tract.
  - ➢ Extrapyramidal pathway in general
- ❑ **Lateral Motor system**: distal muscles mainly(skilled movement), lateral Motor system includes:
  - ➢ lateral corticospinal tract;
  - ➢ Rubrospinal tract distal muscles mainly (and proximal).



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