



Anatomy

Sheet ✓

Lec No: 2

Subject: Spinal segments & nerves

Done By: Abdullah S. Sulaiman

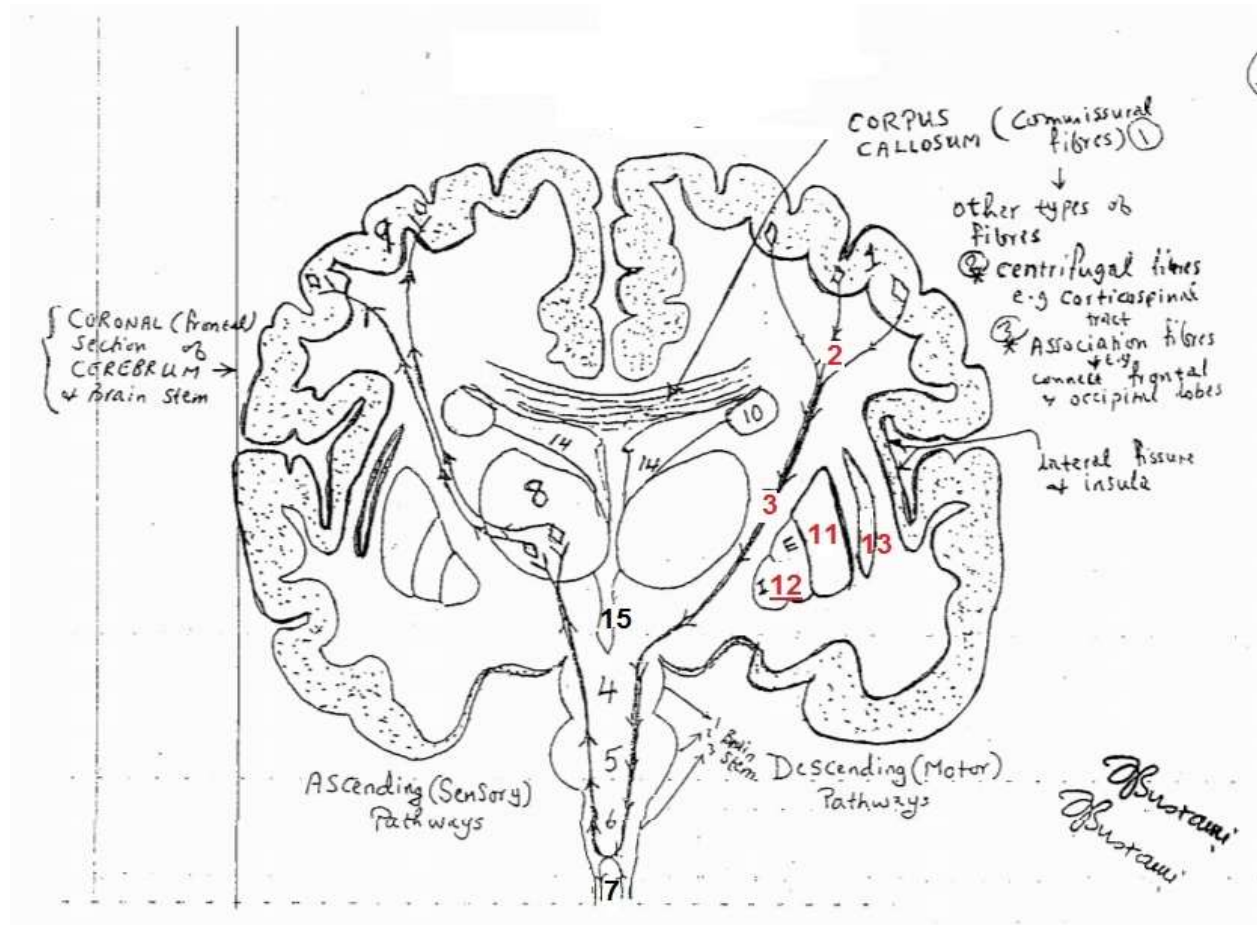
Corrected By: Omar Mahafza

Doctor: Faraj Al-bustami

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Sorry to do it late (Abdallah S.)



This is a coronal section passing the cerebral hemispheres both right and left. Each cerebral hemisphere has an outer layer called grey matter (cerebral cortex = leadership), where it is white matter from inside.

As discussed before sulci and gyri are to increase the surface area and the number of neurons.

The bundle of fibers that run between the two hemispheres is called corpus callosum which is an example of commissural fibers (running from one side to the other). Remember the other types; projection fibers (run downwards) and association fibers (that connects two areas in the same side; lobe to lobe, gyrus to gyrus, etc...)

This figure shows the following:

The cell bodies (perikaryon/soma) give rise to the axons then go down forming descending pathway (mainly motor). Where on the other hand the ascending pathway (sensory).

These nerve fibers (axons) form bundles (tracts / pathways)

We see the ascending pathway on one side while the descending on the other side.

(Remember we can't find both sensory and motor on the same side.)

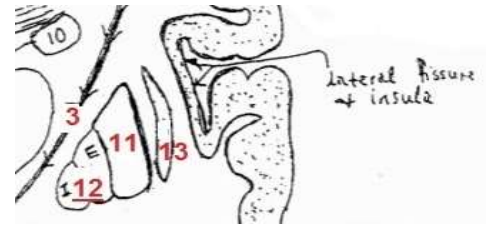
Cells of a certain tract that are in the cerebral cortex (#1) are called upper motor neurons. The lower motor neurons are in the brain stem or spinal cord. Those lower neurons give rise to **spinal nerves, reaching the muscles** or cranial **nerves from the motor part of the brain stem** that control muscles of the face, esophagus, larynx, etc.

Any sensory (ascending) pathway before reaching the cerebral cortex will enter and synapse in certain nuclei in the thalamus.

The white matter contains masses of grey matter as the following:

- Mass on either side is called diencephalon; consisting of thalamus (#8) and hypothalamus. In between there is a cavity called **third ventricle**(#15) (ventricles filled with CSF)

- Basal nuclei or basal ganglia: it consists of **claustrum (#13)**, **caudate(#10)** nucleus, **lentiform or lenticular** nucleus (which consists of putamen(11), then medially external and internal globus pallidus(12) (Important in LAB exam).



However Caudate and Putamen are separated anatomically, they have the same function. Together, they are called >> Striatum or neostriatum (منشط) >> nerve fibers appear as lines in histological section. While the internal & external globus pallidus are called a pallidum each.

Back to the diagram, we have the lateral fissure which separates frontal and parietal lobes above from temporal lobe below. In the depth of the fissure we see the “insula” (some references consider it as the 5th lobe while Prof. Faraj does not because it is of no functional significance).

If you follow motor fibers down, this part of white matter between thalamus and lentiform is called the “internal capsule”(3). This tract is extremely important as it’s composed of ascending and descending pathways (sensory and motor). {Here thousands of nerve fibers in a small area; if it is deprived of blood supply, stroke occurs resulting in paralysis and weakness (hemiplegia/hemiparesis) AND loss of sensation (hemianesthesia) as both motor and sensory neurons are damaged}.

Motor fibers as they go down they leave internal capsule then enter the brain stem passing through midbrain (#4), pons(#5) and medulla(#6). At the lower part of medulla motor fibers will cross to the opposite side.

So that right cortex will control the muscles on the left side, while left cortex will control right muscles. The same concept applies to the sensory pathways as they ascend they will cross in the medulla.

LOWER PART OF MEDULLA – CROSSING (DECUSSATION)

The motor fibers decussate as well as some of the sensory fibers.

Note: The source of embolus that affect the brain is either from left ventricle or an atherosclerotic plaque affecting the common carotid (another source discussed in pathology lecture is paradoxical or crossed embolism).

Stroke: a part of the brain is deprived of blood supply either by embolus, thrombus or due to bleeding.

Between thalamus and the other thalamus there is the third ventricle.

The function of the thalamus is mainly sensory and to some extent motor.

All types of sensations (all sensory pathways) before reaching the cortex will synapse in certain nuclei in thalamus.

Another function of the thalamus: certain nuclei there **{VA ventral anterior & VL ventral lateral}** are called specific thalamic nuclei.

→ To produce a smooth & accurate movement (not clumsy) we need the cerebral cortex, cerebellum, and basal ganglia. Origin (initiation) of the movement are carried on by the cortex, mainly in areas 4 (primary motor) & 6 (supplementary, premotor). These areas have neurons that their axons form motor tracts.

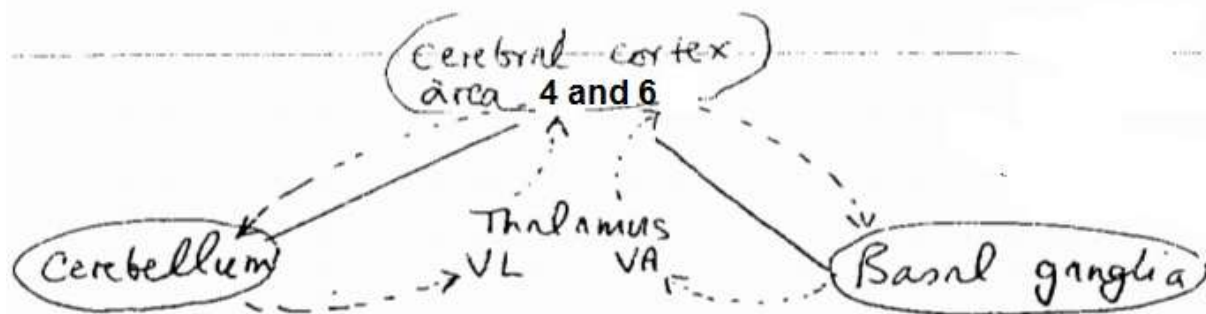


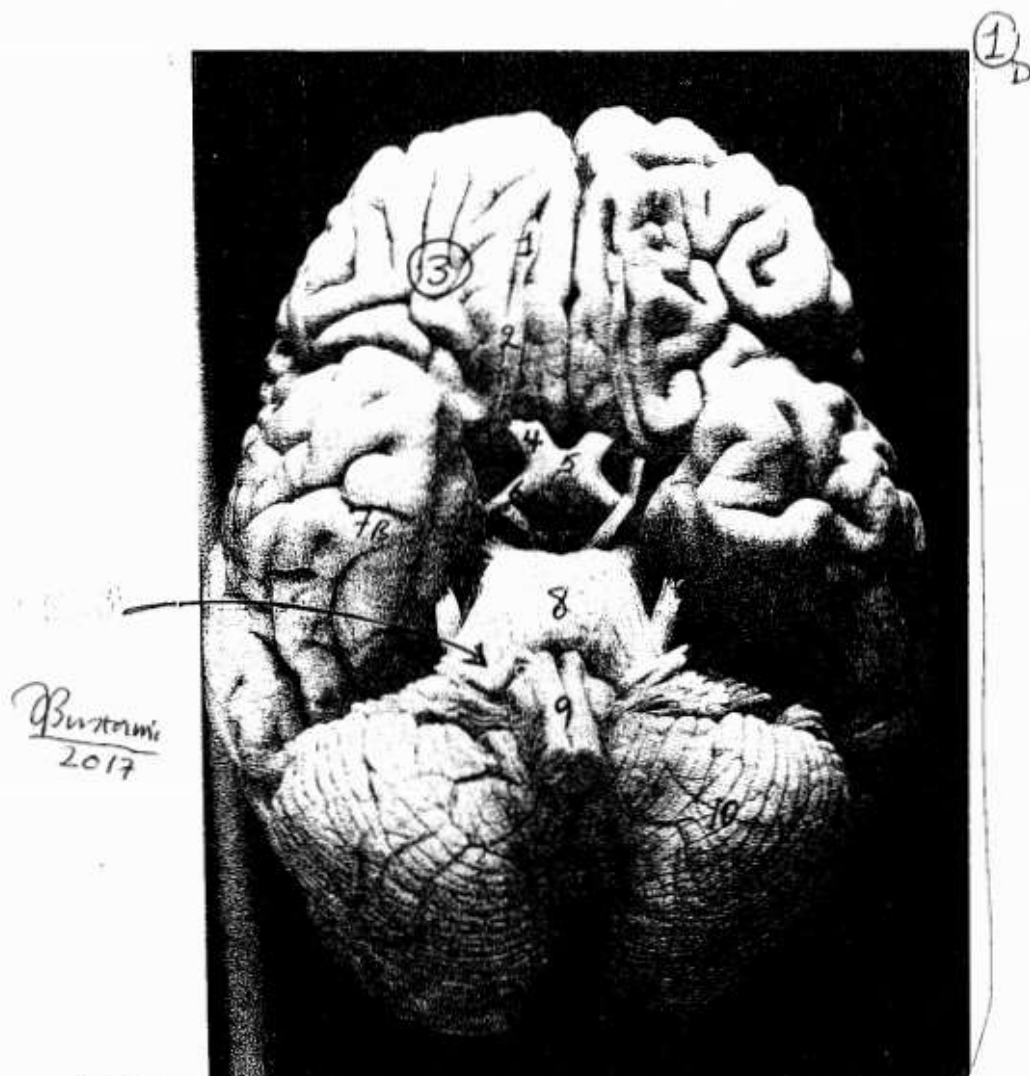
After initiation of the movement by the cortex, now we need accuracy, and this is carried on by the cerebellum and basal ganglia. So, we conclude that the motor cortex needs the cerebellum and basal ganglia in order to produce accurate movements, therefore, a connection between them called reciprocal connection.

→ Therefore, if the motor cortex or its running-down tracts (Neither cerebellum nor basal ganglia) are affected this can lead to **paralysis or paresis** (partial paralysis/weakness) BUT if the damaged part was the cerebellum or a basal ganglion (e.g. tumor), this'll cause **disturbed movements**.

Note: Parkinson's patients have defects in the basal ganglia, this manifests by walking slowly (that doesn't mean weakness or paresis), and it is caused due to a high tone of stimulation!

Motor cortex (areas 4 & 6) can send impulses to go down **directly**, while any other part of the brain needs to send impulses first to pass the thalamus to reach the motor cortex. So thalamus is considered a secretary (سكرتيرة) for the cerebral cortex (both motor and sensory impulses need to pass by it).
(Functional Circus)





Brain → inferior view

4 = optic nerve
5 = optic chiasma
6 = optic tract

7A = parahippocampal gyrus (part of limbic lobe & limbic system)
7B = temporal lobe

1 = olfactory bulb
2 = olfactory tract
3 = orbitofrontal surface (part of frontal lobe)

8 = Pons

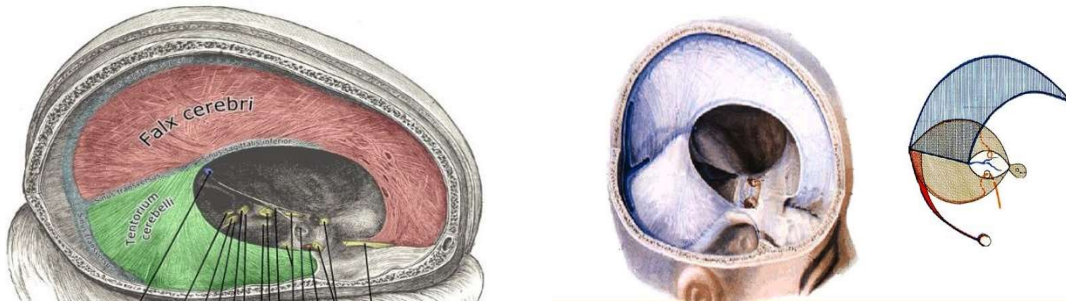
The pointed structure is the middle cerebellar peduncle (brachium Pontis) how it is formed ???

9 = medulla oblongata
10 = cerebellar hemisphere
11 = vermis

According to the figure we notice the following: (view from the inferior surface)

Orbitofrontal surface: the inferior surface of the frontal lobe. (also called fronto-orbital surface) as it's above the orbit. Remember the frontal lobe occupies anterior cranial fossa.

Temporal lobe: occupies the middle cranial fossa.



Anterior and middle cranial fossae are called supra-tentorial compartments.

The tentorial fold of dura matter covers the roof of posterior cranial fossa which contains the hindbrain.

Posterior cranial fossa is called infra-tentorial compartment.

At the middle of supra-tentorial compartment there is the falx cerebella, which separates the 2 cerebra.

Also we see part of the olfactory pathway as well as the optic pathway.

Optic chiasma is a partial intersection of neural fibers.

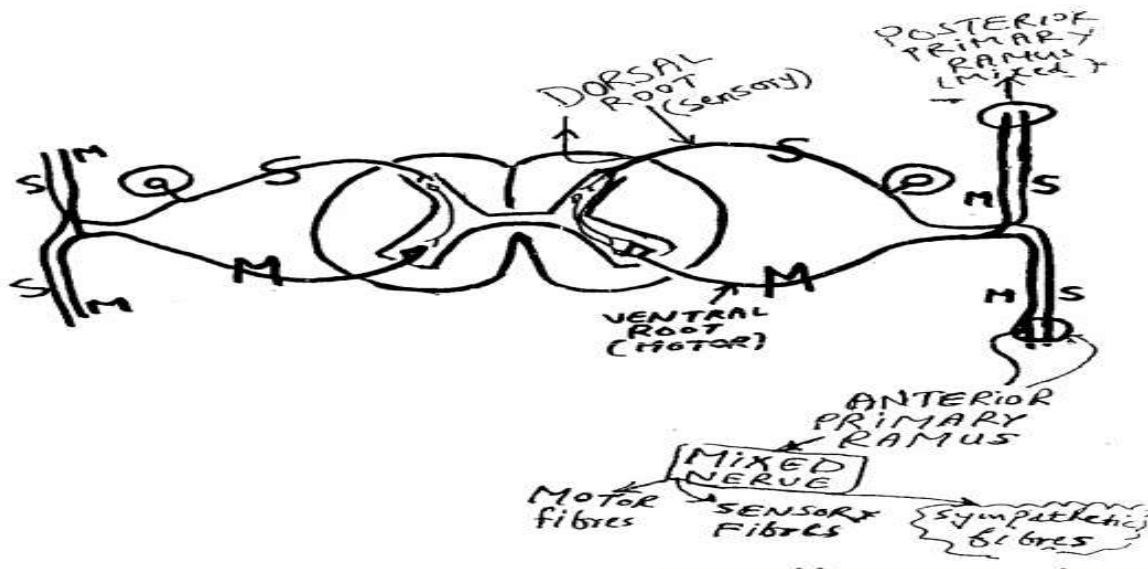
8 + 9 + 10 = hind brain

Pons has an extension to cerebellum called middle cerebellar peduncles (brachia pontis)

Cerebellum has 3 extensions:

- superior cerebellum peduncle to the midbrain
- middle cerebellum peduncle to the pons
- inferior cerebellum peduncle to the medulla

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- We have 31 spinal segments; 8 Cervical, 12 Thoracic, 5 Lumbar, 5 Sacral and 1 Coccygeal, each segment is centered between 2 spinal nerves emerging from the right and left borders of the segment.



This is the basic structure of a spinal segment of the spinal cord

The H-shape is grey matter, while outside is white matter, and that is opposite to the cerebrum.

the grey matter as usual is neurons and neuroglial cells.

**The subdivisions of this H-shaped grey matter are:

- **Dorsal horn** (mainly sensory and interneurons; a cell between sensory and motor)
- **Ventral horn** is mainly motor fibers of two types; large alpha & small gamma.
- **Ventral root:** The cell bodies are located inside the grey matter (alpha & gamma bodies). The axons of these alpha and gamma neurons will leave the spinal cord forming the ventral root of spinal nerve.
- **Dorsal root:** The cell bodies are in a ganglion outside of the spinal cord (**dorsal root ganglion / sensory ganglion**) and it is a sensory ganglion **with no synapse**. Part of the axons is going from the ganglion to the periphery & another part goes to the spinal cord.

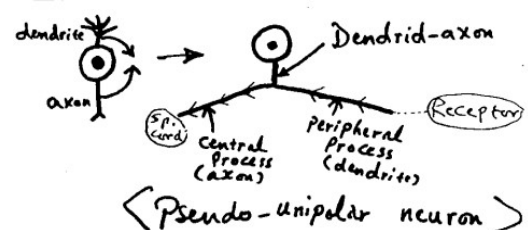
Synapse only occurs in autonomic ganglia (sympathetic and parasympathetic).

Inside the vertebral canal the two roots merge to form the trunk of spinal nerve which emerges from the vertebral canal through intervertebral foramen and immediately divides into posterior and anterior primary rami with both carrying **motor**, **sensory**, and **sympathetic** fibers (mixed - SMS). The posterior primary ramus supplies the skin and muscles of the back, while the anterior primary ramus runs along the ribs as intercostal & abdominal nerves and only **anterior** ramus forms a plexus.

☞ Dendrites are of two types according to function: receiving and sending.

☞ There are three types of synapses: axo-dendritic, axo-somatic and axo-axonic.

Dorsal root ganglion is of the **pseudo-unipolar type**; initially, dendrites of a neural cell merges with its axons to form a single process called **dendrid-axon**, which then divides into peripheral process (dendrites) that goes with the nerve to receptors of the PNS & central process (axons) goes to the spinal segment.



Notice the direction of the impulses (PNS → CNS // dendrites → axons) nerve impulse goes towards spinal cord but doesn't synapse in the ganglion, so the role of cells there is just nutritional for axons.

Note: lower motor neurons are called final common pathway as they obey upper motor neurons orders (alpha-gamma neurons are example of lower motor neurons).

Any peripheral (somatic) nerve consists of sensory, motor and sympathetic fibers.

Spinal cord

Symmetrical structure with enlargements in some regions (not fully uniform);

- Cervical enlargement at the segments of the root value of brachial plexus (C5,6,7,8 and T1)
- Lumber enlargement at the root of lumbo-sacral plexus segments (L 4,5 and S1,2,3).

It starts at foramen magnum as a continuation of medulla oblongata and ends at the lower border of L1 as conus medullaris. It doesn't fill the whole vertebral canal, it only fills the upper two thirds.

The lower third is occupied by roots of lower lumber and sacral spinal nerves running down in the shape of a horse tail, so called cauda equine.

The spinal cord has the same coverings as the brain (i.e. meninges) and they are continuous throughout all parts of the CNS:

→ Diagnose subarachnoid hemorrhage by a Lumbar puncture (LP); insert a needle between vertebrae L3 and L4 untill reaching the subarachnoid space and then draw the CSF, if it was mixed with blood then hemorrhage might have occurred around the spinal cord or in the brain as the meninges are continuous, so is CSF.

The white matter has both myelinated and non-myelinated axons forming bundles (bundle for each tract).

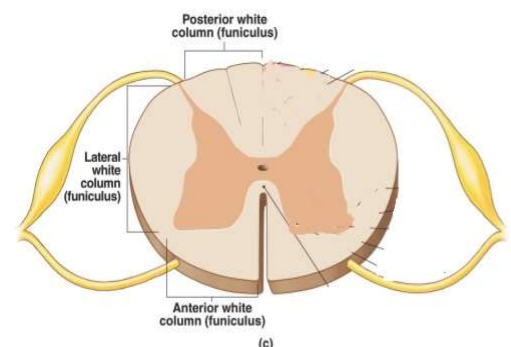
☞ The subdivisions of white matter of spinal cord are:
dorsal, ventral and lateral columns or funiculi.

Dorsal column above T6 has two tracts: cuneate and gracile, while only gracile below T6. (These two tracts are called the dorsal column system); they bring proprioception sensation (i.e. deep sensation from muscles & joints)

The ventral horn in thoracic region is small as it supplies intercostal muscles (10 muscles only). In the lumber and sacral region the ventral horn is huge due to high need for the supply of bulky muscles such as gluteus maximus and quadriceps femoris.

The central canal lies at the middle of spinal cord and in all segments.

Check the figure in the last page.



The subdivisions of grey matter of spinal cord are: dorsal horn, ventral horn and **sometimes the lateral or intermediolateral horn which is present only in:**

- 1) All thoracic segments, 2) upper two lumbar segments, 3) S2,3,4

The lateral horns in thoracic segments and L1,2 contain preganglionic sympathetic.

There is parasympathetic innervation coming from the lateral horns of S2,3 and 4

☞ *Each spinal nerve accompanies sympathetic fibers, how?*

Remember that somatic nerves reach the effector organs (skeletal muscles) directly without the need to synapse in a ganglion, while the autonomic nerves from lateral horns leave the spinal segment accompanying the ventral root and before reaching the effector organ it leaves the ventral root and enter a ganglion and synapse there. Here the post-ganglionic nerves reach the effector organs (smooth muscles, cardiac muscles and glands anywhere)

“arrector pili muscle” is a smooth muscle that is attached to hair follicles, it results in body hair to erect in cases of cold/shivering and fear. Depriving this muscle from sympathetic innervations will result in the inability for hair erection.

{not all skeletal muscles are voluntary as pharynx/diaphragm muscles}.

1) In segments with lateral horns (T1-12 and L1,2):

As the autonomic fiber leaves the ventral root it enters the sympathetic chain to synapse there, then exit it as postganglionic which goes with the spinal nerve of the same segment to the effector organ.

(**Preganglionic sympathetic fibers are called white ramus communicans (rich in myelin), while the postganglionic fibers are called grey ramus communicans.)

2) The lower lumbar and sacral spinal nerves & cervical nerves (No lateral horns)

They get preganglionic fibers from L1 and L2 or from T1 and T2, the preganglionic fibers enter the sympathetic chain then run downwards or upwards BEFORE synapses and exit the chain as postganglionic. So if I cut the sympathetic chain at the lower neck, this deprives the head and neck from sympathetic innervation (i.e. Horner syndrome; with ptosis, miosis and anhydrosis)

Anhydrosis: Inactivity of sweat glands

Ptosis: as the smooth part of Levator palpebrae muscle is supplied by sympathetic fibers and now it's deprived of stimulation

Miosis: constriction of the pupils (dilation of pupils is mainly carried on by sympathetic)

- 3) The third probability is that the preganglionic sympathetic fiber enters the sympathetic chain and as it leaves the chain it's still **preganglionic** and before reaching the target organ it'll synapse with a *collateral/terminal ganglion* (any autonomic ganglion out of the sympathetic chain). But remember, an autonomic nerve MUST synapse before reaching the target organ.

What's the difference between spinal nerves and cranial nerves?

- Spinal nerves are all a mix of sensory, motor & sympathetic fibers
- Cranial nerves are of 3 types:-
 -) Some are pure sensory (e.g. Olfactory, optic nerves)
 -) Some are pure motor (e.g. Hypoglossal nerve)
 -) Some are mixed (sensory, motor & parasympathetic) (e.g. Oculomotor, Facial, Glossopharyngeal & most importantly, Vagus nerve)

NO SYMPATHETIC FIBERS IN CRANIAL NERVES.

This figure is related to the enlargements, horns, and white matter funiculi along spinal segments.

