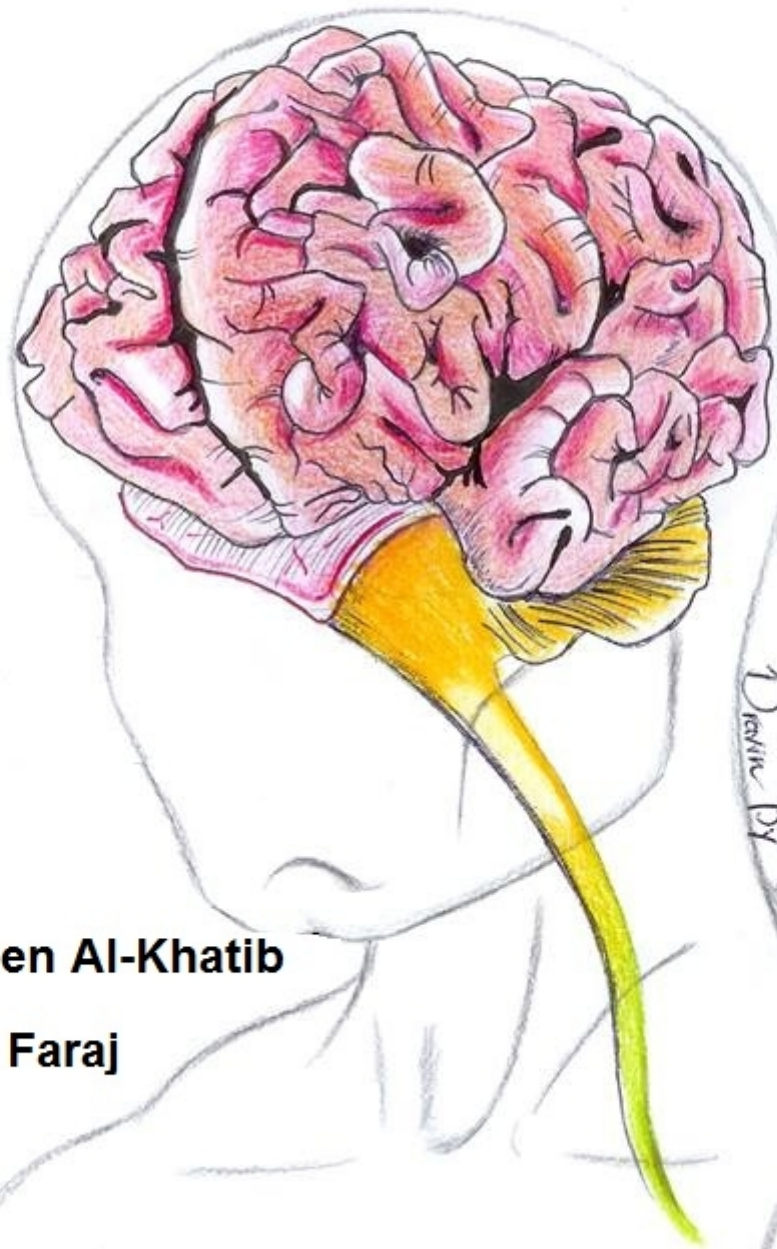


CENTRAL NERVOUS SYSTEM

- Handout
- Sheet
- Slide

- Anatomy
- Physiology
- Pathology
- Biochemistry
- Microbiology
- Pharmacology
- PBL



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Lec #: **1**

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Brain & Spinal cord

What is the central nervous system?

- It's the system that is compromised of the **brain** & the **spinal cord**. Whereas the **peripheral** nervous system include the **spinal** nerves (31 pairs) & the **cranial** nerves (12 pairs).
- **Embryologically** : Both the **brain** & the **spinal cord** were **one** tube called the **neural tube** -**ectodermal** in origin- . It has two parts; a cranial part we call it **rostral**, & a **caudal** part.
- The **Cranial (Rostral part)** forms the **brain**.
- The **Caudal** part forms the **spinal cord**.

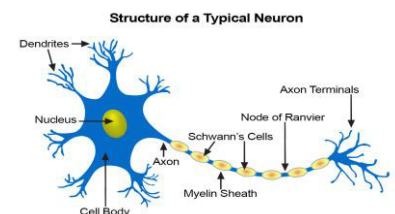
BRIAN

- Now, the **brain** is compromised of three parts :

1-**Cerebrum** :made two **cerebral hemispheres (right & left)**, & they are connected with each other by a bundle of **commissural** nerve fibers which are called **corpus callosum**, & if we want to separate the brain into two halves, we have to cut the **corpus callosum**.

Ma3loumat saneh oola :P

Nerve fiber : axon





⇒ There are three types of nerve fibers within the brain :

- 1) **Commissural** : connect the two hemispheres of the brain.
- 2) **Association** : connect different neurons of the same cerebral hemisphere.
- 3) **Projection** : connect the cortex with lower part of the brain & with the spinal cord.

2-Cerebellum : also made of two cerebellar hemispheres

3-Brain stem : it's compromised of three parts from **rostral** to **caudal** :

1) **Mid brain.**

2) **Pons.**

3) **Medulla oblongata** : **The lower most part** ,this part emerges through **foramen magnum** at the base of the skull and becomes the **spinal cord**. Actually, what passes through the **foramen magnum** is the **medulla** **not** the spinal cord, then it becomes the **spinal cord**.

*always remember that the spinal cord is NOT found within the cranial cavity .

Anatomic relations →

-The **cerebellum** is **below** the **posterior** part of the **cerebrum** & the **brain stem** is **anterior** to the **cerebellum**.

-**Developmentally**; the **brain** in the **rostral part** of the **neural tube** was formed by **three vesicles** from **superior** to **inferior** :

1-Forebrain:

-It's called **prosencephalon**, & is compromised of **two** parts from **rostral** to **caudal** :



1) **Telencephalon** : it forms the two cerebral hemispheres, grows faster than the diencephalon; that's why the cerebral hemisphere will become outside & the thalamus/diencephalon will become inside.

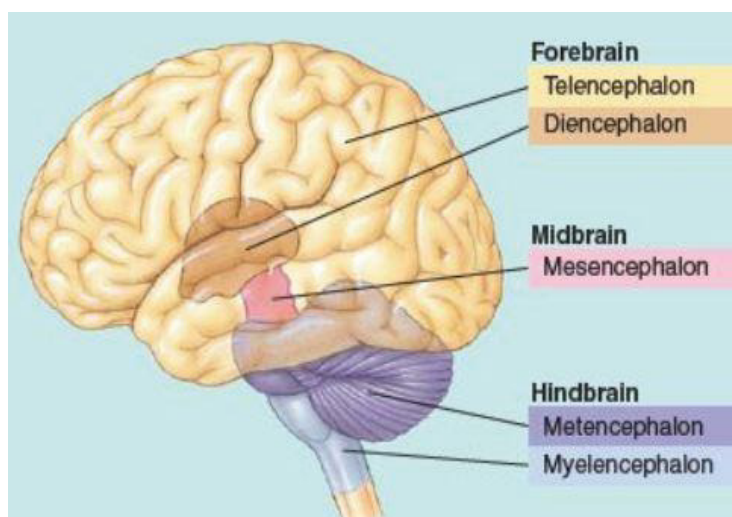
2) **Diencephalon** : forms the thalamus, hypothalamus, & subthalamus, we don't see it on the outer surface because of the previous point.

2-**Midbrain** : it's called **mesencephalon**. It forms a relatively small part of the upper part of the brain stem

3-**Hindbrain** :

-It's called **rhombencephalon** & is comprised of **three** parts (**Pons + Medulla + Cerebellum**) & **developmentally**, it's divided into **two** parts: **myelencephalon** which forms the **medulla oblongata**, & **metencephalon** which forms the **pons** & the **cerebellum**.

☺ **From the writer** : Note that part of the brain stem is a part of the hindbrain & this part includes the "pons & the medulla" –Mutual Part between both the brain stem & the hindbrain.



-These were mentioned in the last five minutes of the lecture:

* the neural tube which forms the brain the spinal cord has a cavity inside it , these cavities might enlarge at certain places forming ventricles :

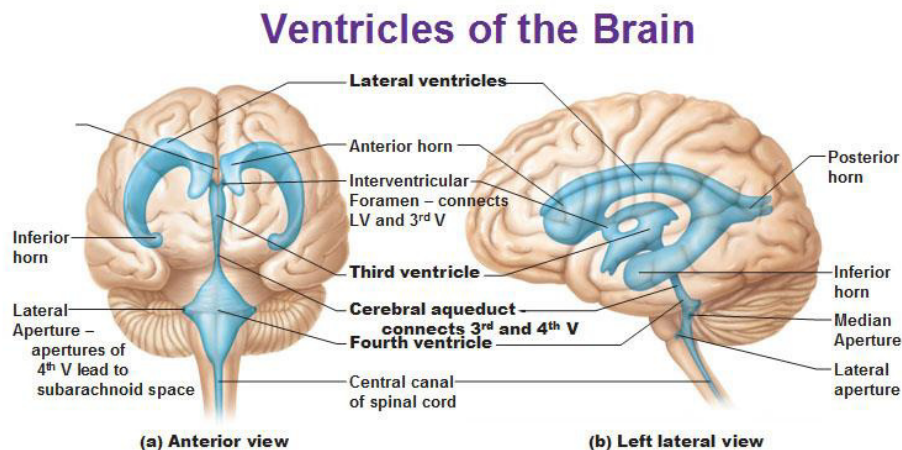
1-The cavity of the forebrain will form the lateral ventricle.

2-The cavity of the diencephalon will form the third ventricle between the two halves of the thalamus. The lateral ventricle is connected to the third ventricle by an interventricular foramen

3-The cavity of the midbrain will form the cerebral aqueduct.

4-The cavity of the hindbrain will form the fourth ventricle.

-All these ventricles contain cerebrospinal fluid .



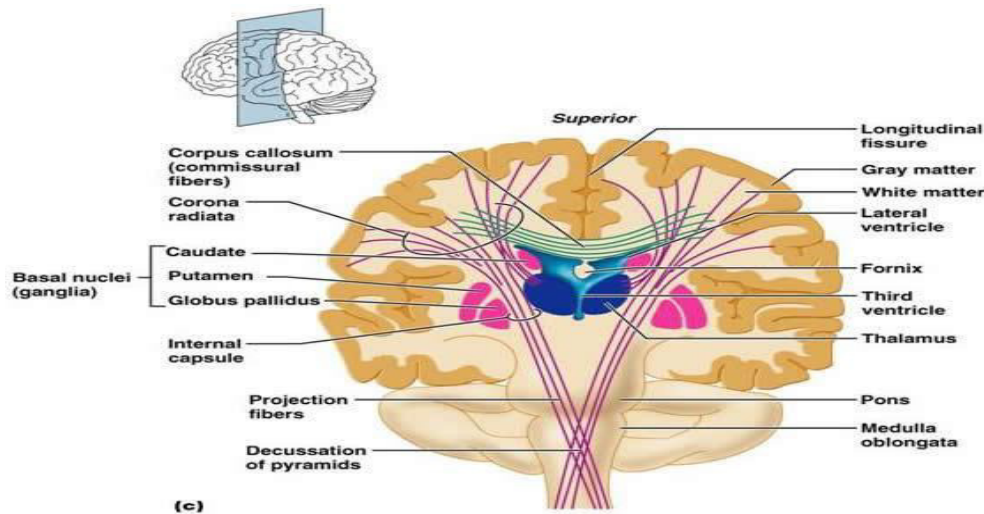
-NOW each cerebral hemisphere has three surfaces :

1-Medial (on the inside)

2-Superolateral (السطح الخارجي).

3-Inferior –the doctor didn't mention it.

⇒ This is a coronal section of the cerebrum :

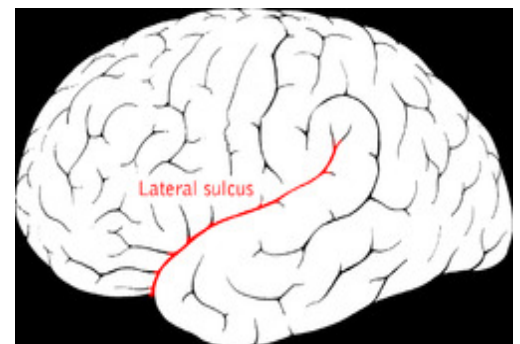


-the **outer** part of the **cerebrum** is called **cerebral cortex** ; which is formed of **gray mater**.

*Recall that **Gray matter** is formed of **neurons & neuroglial cells (supporting cells)**.

-We notice also from this section that the cortex is thrown into **sulci** or **fissures** (شقوق) & **gyri** (تلافيف), these are presented in order to increase the surface area to increase the number of neurons, because as we know; after birth, the neurons –as well as muscle tissue- don't undergo mitosis, so they don't regenerate, & that's why we need huge number of neurons.

->This is one of the sulci : **Lateral sulcus**; also called **sylvian fissure** : inside this fissure/sulcus we find a part of the cortex which is called; the **insula**.



-We said that the the cerebral cortex is formed of **gray mater**. NOW, if we look **inside** the



cerebrum we will find that it's formed of **white mater**. In the spinal cord we'll find the opposite; **white mater outside & gray mater inside**.

☺ **From the writer** : We also find masses of gray mater inside the white mater of the cerebrum which is represented by the thalamus, hypothalamus & the basal ganglia. –I think the doctor will talk about this later in this sheet-.

*Recall that the white mater is a group of axons (nerve fibers) myelinated or poorly myelinated.

-NOW, a group of these axons which carry out the same function, and have the same origin & the same termination we call them a **pathway** or a **tract** (they can be sensory

From wiki :

Grey matter is distinguished from [white matter](#), in that it contains numerous cell bodies and relatively few myelinated axons, while white matter contains relatively very few cell bodies and is composed chiefly of long-range myelinated axon tracts.

(**ascending to the cortex from sensory receptors**) or **motor** (**descending from the cortex**)).

● In the cortex, we have many cell bodies of neurons. From these cell bodies, the axons are going down forming what we call **corona radiata** (مروحة) -**You** can notice them from the picture I put above-.

-You can notice also that these axons will run between the **thalamus** & the **basal ganglia** (specifically the **lentiform nucleus of basal ganglia**) & will accumulate in a narrow area that we call it **internal capsule** (between **thalamus medially & basal ganglia laterally**).

Actually, **both** the **sensory** fibers & the **motor** ones will run through this area not only the motor. Because of that its also called **porta cerebri** (بوابة).



-However; most of stroke cases occur in this area -the **internal capsule**- Ex : because of occlusion of blood vessels which supply this area either by thrombus, embolus or rupture which will lead to death of many nerve fibers in this area because of ischemia . the blood supply of internal capsule comes from the **middle cerebral artery** .

NOTE : most of diseases of the CNS are vascular (thrombotic , embolic or hemorrhagic)

-NOW, these fibers after running through the internal capsule, they will reach the brain stem (mid brain then pons then medulla) & at the lower part of the medulla they will cross opposite to each other (the right become left & the left become right).

● **Recall : we said that** a group of axons which carry out the same function, and have the same origin & the same termination we call them a **pathway** or a **tract**. One of these tracts is a **motor** tract, we call it **corticospinal tract**.

● Let's talk now about the **thalamus** :

-We said that it's part of the **forebrain** specifically the **diencephalon**, & it has two functions sensory & motor. all types of sensation **except smell** before reaching the cortex (القيادة) must reach the **thalamus (Final relay station) & synapse with a part of the thalamus** .

Note from correction : if you are confused about this point take the eye sight sensation for example . before neural fibers which carry out eye sight reach the cerebral cortex they must synapse with a specific nuclei in the thalamus then the thalamus will direct them to the functional area of the cerebral cortex that carry out this function (which is in the occipital lobe) . same thing with hearing , pain all sensory axons which carry these signals will synapse with a specific nuclei in the thalamus to direct them to their area in cerebral cortex .



NOW, we said that the origin of movement is from the cortex, & in order for this movement to be accurate & smooth we need two parts :

1-Cerebellum (part of the hindbrain).

2-Basal ganglia or nuclei.

These two parts will coordinate with two parts of the thalamus (**بستعينوا** (فيهم) which are :

1- Ventral anterior nucleus (VA).

2- Ventral lateral nucleus. (VL).

-Motor triangle (cortex, cerebellum, basal ganglia).

-We lose movement ONLY if the pathways that comes from the cortex were damaged (the damaged neural bodies in the cortex for example will lead to the damage of the axons that come from them).

-However; damage to either the cerebellum or the basal ganglia will NOT lead to loss movement. Instead, it'll lead to disturbance of movement. VERY IMPORTANT.

-Remember

Nucleus : is a group of neurons within the CNS (brain & spinal cord).

Ganglion : a group of neurons outside the central nervous system.

● Let's talk now about the **hypothalamus** :

-found Below the thalamus functions in

homeostasis .(regulation of body temperature, heart rate, blood pressure, fluids and electrolytes, sleep mechanism...etc).

Let's talk now about the **basal ganglia (medial to the insula):**

-composed of two nuclei :



1) **Caudate nucleus (Medially; at the same level of the thalamus):** part of it is near the lateral ventricle which is a cavity inside the cerebrum & above the lateral ventricle we find the corpus callosum.

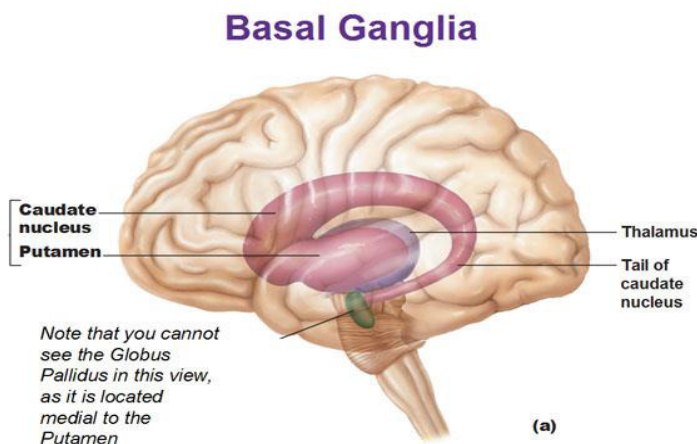
-**Note :** We also have the **third** ventricle between both halves of the thalamus. And between the lateral ventricle & the third ventricle we have **interventricular foramen**.

2) **Lentiform nucleus (Laterally; lateral to the thalamus) : three parts:**

1-**Putamen (outer).**

2-**Globus pallidus (external segment & internal segment) (Inner).**

***Remember that the internal capsule separate the thalamus from the lentiform nucleus.**



● Let's talk now about the **brain stem** (midbrain, pons, medulla) :

-Any of these parts (the components of the brain stem) will have descending pathways (motor) & ascending pathways (sensory).



-We will also have in the brain stem the mother cells (cell bodies) of some cranial nerves. Remember that the mother cells of the spinal nerves are present in the spinal cord.

^In the **Midbrain** : we have the mother cells of the **third (oculomotor)** & the **fourth (trochlear)** nerves.

^In the **Pons** : we have the mother cells of the **fifth (trigeminal), sixth (abducent), seventh (facial), & eighth (vestibulocochlear)** nerves.

^In the **Medulla** : we have the mother cells of the **ninth (glossopharyngeal), tenth (vagus), eleventh (accessory –the cranial part -), & twelfth (hypoglossal)**.

-Another component of the brain stem is the **reticular formation (RF)**. It was believed that the reticular formation was a network of nerve fibers & neurons, but it's actually organized.

-This reticular formation contains vital centers (cardiac, vasomotor, respiratory , chemotaxic, vomiting, swallowing, cough centers ...).

-Another importance of this formation that all the sensory pathways as they ascend will give collaterals (أفرع جانبية) to this reticular formation.

-Part of the reticular formation (RF) is called reticular activating system (RAS) & this system receives stimulation from the sensory pathway & that will lead to stimulation of the cortex which will lead to wakefulness and alertness .

*What will happen if this reticular formation was damaged?

-COMA ☺



-Many of drugs work on reticular activating system; ex : the anesthetics & the tranquilizers inhibit the reticular activating system which induces a state of unconsciousness .

SPINAL CORD

- The spinal cord is present **OUTSIDE** the cranial cavity & occupies the upper two thirds of the vertebral canal.

-It begins at the foramen magnum as a continuation of the medulla oblongata.

-It ends at the lower border of L1; opposite the disc between L1 & L2.

- The roots of the Lumbar & Sacral nerves occupies the lower third of the vertebral canal, & we call these roots **Cauda equina** (ذيل الحصان).

☺ **From the writer** : Note that the spinal cord ends at the lower border of L1 which means that the **first lumbar spinal nerve pair** is not a part of the **cauda equina**.

-In the spinal cord, the **gray matter** is **inside** & the **white matter** is **outside**.

--The **white matter** which contains bundle of nerve fibers/axons forming pathways) is divided into columns :

1-Posterior (dorsal) column.

2-Anterior (ventral) column.

3-Lateral column.



->Each column contains either ascending (sensory) or descending (motor) pathways.

->Each spinal nerve has two roots:

1-Dorsal (Sensory):

-The cell body (perikaryon) is present outside the spinal cord inside a ganglion called (dorsal root/sensory/spinal) ganglion.

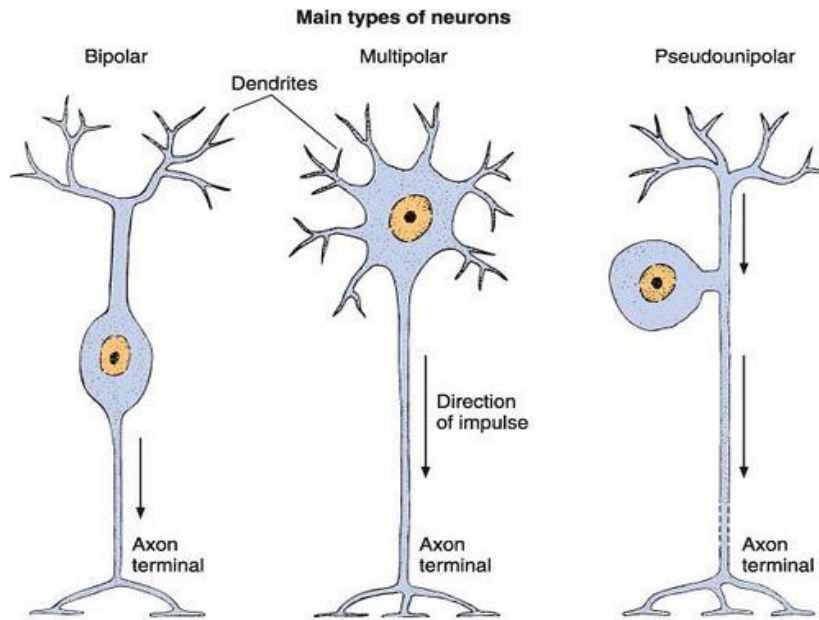
-VERY IMPORTANT : In this ganglion there is NO synapse.

-Synapse is only present in the autonomic ganglion (sympathetic & parasympathetic).

*NOW, the neurons which are present in the sensory root are of the pseudounipolar type.

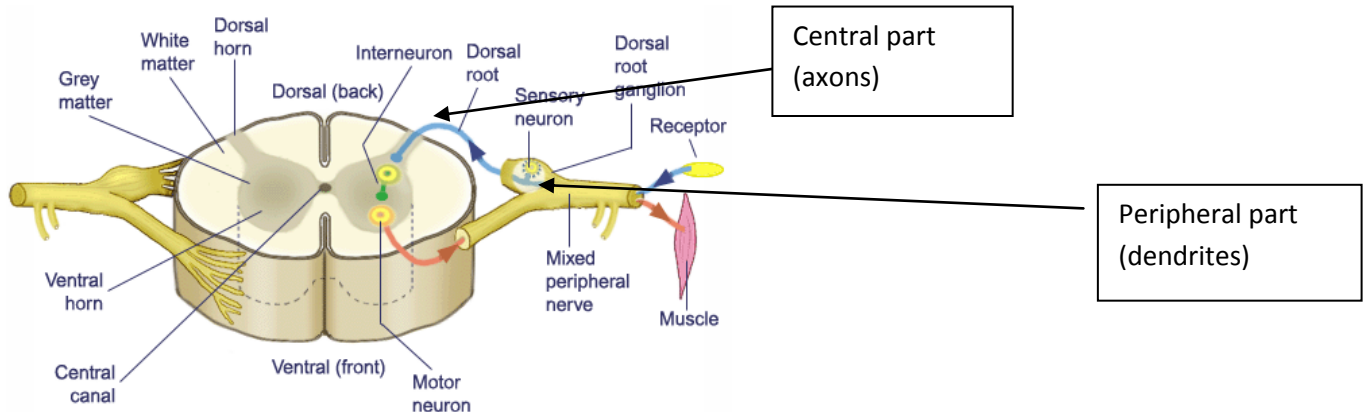
-Notice in this figure that this neuron contains an axon that has split into two branches; one to the periphery (to the sensory receptors) & the other to the spinal cord, in contrast to the typical neuron which have separate dendrites & axonal process. It's actually produced from the fusion between the dendrites & the axon of a neuron to form a single process (dendridaxon) which split into two branches (central (axonal) & peripheral (dendrital)) -IMPORTANT-.

-The central process of dendridaxon will enter the spinal cord & will either stay in the white matter or enter the gray mater & synapse directly in the ventral horn.



2-Ventral. (Motor).

-The cell body (perikaryon) is present inside the spinal cord in the gray matter of the ventral horn.



--The gray matter is divided into three parts:

1-Dorsal horn : it's neurons are either sensory or interneurons & most of them are **INTERNEURONS**. It has large number of interneurons.

Neurons -> (sensory, motor, interneurons (between sensory and motor)).



2-Ventral horn : it's neurons are either motor or interneurons & most of them are MOTOR neurons.

3-Intermediolateral horn.

-NOW, both the ventral root and the dorsal root will come close to each other to form the trunk of the spinal nerve, & the trunk of the spinal nerve will come out from the intervertebral foramen, & then immediately divides into posterior primary ramus (sensory, motor & sympathetic) and anterior primary ramus (sensory, motor & sympathetic).

****ONLY the ANTERIOR rami will form plexus. VERY IMPORTANT. (Brachial (C5-C8 + T1) & lumbosacral).**

-Each peripheral SPINAL nerve (ex: ulnar, sciatic..) is formed of (sensory, motor, sympathetic).

***sensory : brings sensation from the skin, muscles & joints.**

-Two types of sensation :

1-Exteroception : pain, temperature & pressure from the skin.

2-Proprioception : from the muscles & joints.

***motor : for movement of muscles.**

***sympathetic : for sweat glands & smooth muscles in the wall of blood vessels.**

○ What about the parasympathetic?

-It's only present in some cranial nerves (third, seventh, ninth & tenth), & the second, third and fourth sacral spinal nerves.



-Spinal nerves : (sensory, motor, sympathetic)

-Cranial nerves : Some of them are only motor, some are sensory, some are mixed (motor & sensory).

VERY IMPORTANT : We don't have sympathetic in the cranial nerves.

***First, second, eight cranial nerves : Sensory only.**

***Forth, sixth, eleventh, twelfth : Motor Only.**

*** Third : Motor + parasympathetic.**

***Fifth : mixed (motor & sensory).**

*** Seventh, ninth, tenth : mixed (motor+sensory) + parasympathetic.**

● **Three meninges surround both the brain & the spinal cord from inside to outside :**

1-Pia mater –The inner most layer-.

2-Arachnoid mater.

3-Dura mater –The outer most layer-.

-Between the pia mater & the arachnoid mater there is a space (Subarachnoid space) that contains cerebrospinal fluid (CSF) as well as major blood vessels. When these vessels rupture , the blood will mix with the CSF leading to Subarachnoid hemorrhage .

Note : Cerebrospinal fluid is present outside the brain in the subarachnoid space & inside the brain in the ventricles.

GOOD LUCK ☺