Physiology

Sheet

Lec No: 1

Subject: Neurophysiology- Organization of the Central Nervous System - Introduction

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In this semester our physiology lectures are going to be parallel to anatomy lectures in term of topics.

We will talk about the sensory and the motor parts of the nervous system.

In this system there is too much overlap between the neuroanatomy and neurophysiology so it would be better if you study them together.

In the slides you can find the syllabus of the CNS system with its 22 lectures' topics of the physiology part, so please refer to the slides.

Please refer also to the BOOK (Guyton and John E. Hall, 12th Ed. 2011 or 13th ed. 2016) since the doctor said that he could bring up questions in the exam that are written in the book and were not mentioned during the lectures.

This lecture is going to be an introduction lecture. So kindly relax, I guarantee that it's easy. "saffar:I don't 😀"

Objectives:

- **State the parts of the central nervous system:**
  In terms of anatomy: Brain and Spinal cord.
  In terms of function:
  a) Motor system.
  b) Sensory system.
  c) Integration area; it integrates the sensation of the sensory part with the motor part.

- **Describe the level of organization of the CNS:**
  The lowest level of organization that is found in lower animals and in human beings at the level of the spinal cord, the integration starts here at the level of the synapse(later on this course we will take a lecture that is going to discuss this point in details. So, if it looks like Chinese to you, "jump over it!").

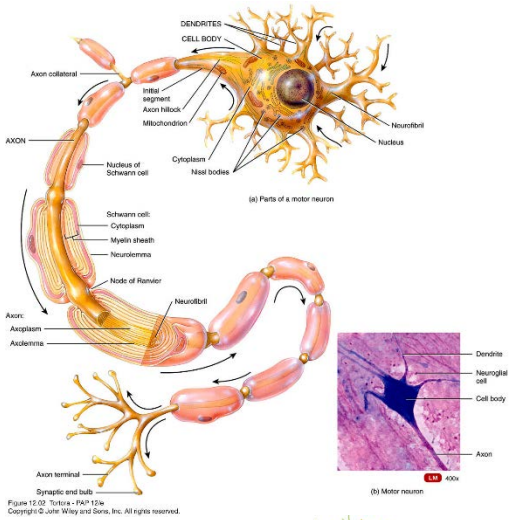
- **List the major functions of the CNS:**
  We will talk about the functions related to the sensory part, motor part and the integration area of the CNS, and other functions such as higher intellectual functions; sleep, thoughts, ideas …

- **Compare the Endocrine system and nervous system:**
  Both systems are called <u>control system.</u>

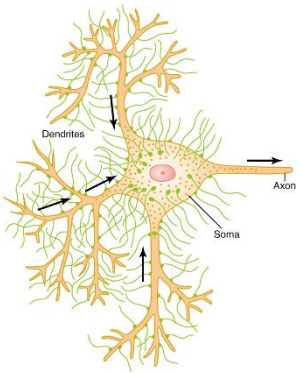
- The endocrine system uses hormones that combine with its receptors after travelling in the blood and reaching its tissue and the hormone has to combine with its receptors then we will have hormone receptor interaction, second messenger …
  This kind of action is slow (it uses chemicals "hormones"), but there is another advantage for the hormonal thing that it has a very high gain.

- The central nervous system:
  It uses nerves and neurons and the action potential passes through them.
  The action potential in some neurons runs very fast and it can reach 120m/sec and this is a very fast speed. So the CNS is very fast but compared to the endocrine system it has a low gain.
  Its action is very specific, it affects either muscles or glands but when the endocrine system induces the hormone its action goes almost everywhere and it changes the metabolism of the tissues or the growth, so it doesn't work by stimulating skeletal muscles and glands.

  - **Describe the anatomy of the functional unit of the nervous system:**
    The functional unite of the nervous system is the neuron, and it's composed of:



    a) The cell body (soma); and it has almost every organelle of the cell except those needed for cell division "the centrosomes"; because the neurons don't "divide" regenerate.
       Once the neurons die they don't regenerate and that's why they are located in a very hard tissue (brain in the skull, spinal cord in the verte bral column "the bone is the hardest tissue in our body").
       <u>Note:</u> in the brain there are some cells that can regenerate but their function is support not transmission of action potential.
       they also have specialized endoplasmic reticulum called **Nissl bodies** which forms the neuropeptides
    b) Dendrit es.
    c) Axon: Mylenated or non-Mylenated
    d) Axon terminal.

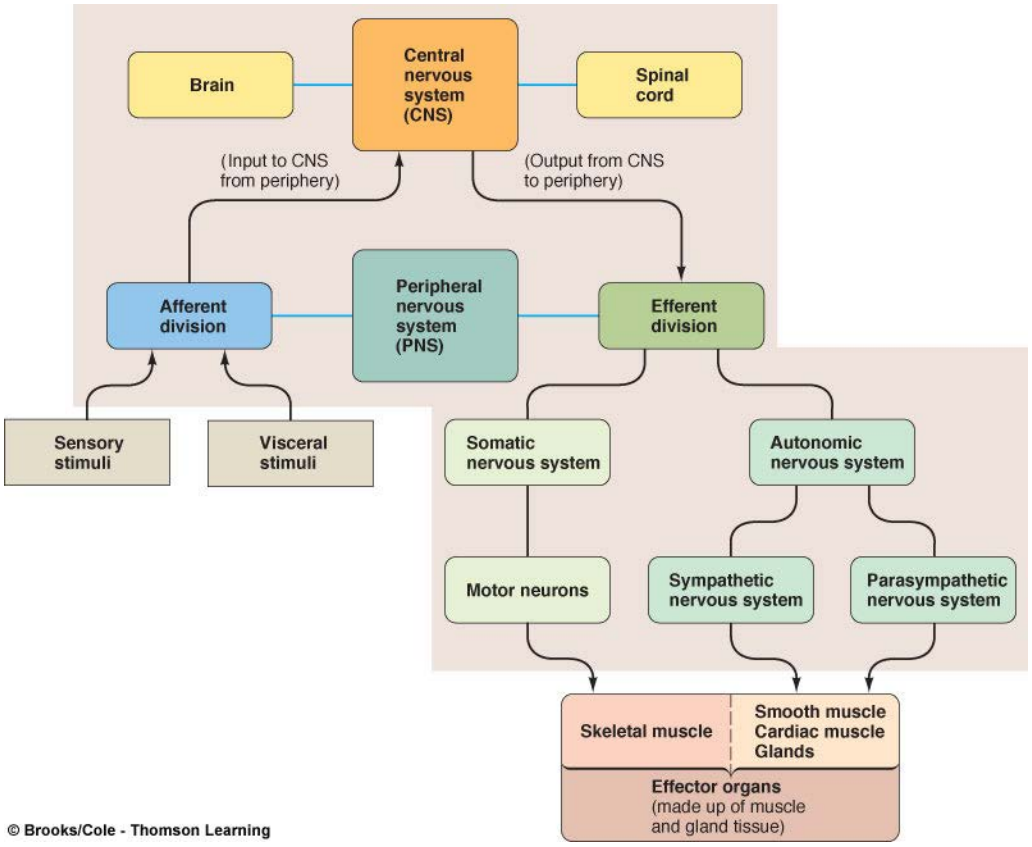


  - **Determine the area of communication in the CNS.**

Remember:

a) In the CVS we said that the short term regulators (chemoreceptors, Baroreceptors) of blood pressure have very low gain, that's why we need the long term regulators.
b) Gain = Correction / Error

❖ Organization of Nervous System:



- Tracts: collection of axons in the CNS and it can be of two:
  a) Sensory tracts; afferent tracts, Ascending tract; they collect the sensory information of our body then they ascend in the spinal cord (to the brain).

- The afferent division comes usually from:
  1) Sensory stimuli. “somatic”
  2) Visceral stimuli.
     They run through certain kinds of tracts and then they go to the CNS; either to the spinal cord or to the brain through the spinal cord.
     These are the sensory or the ascending tracts.

  b) The motor tracts that descend from the brain are called descending tracts and it could be from the motor cortex “the highest **Hierarchy** area of the CNS” or from brain stem areas “in the brain stem we have nuclei and from them we have tracts that are descending downward, to supply skeletal muscles” for example we have vestibular nuclei in which we have a tract named as vestibulospinal.

The output to the periphery is called the efferent division and it means motor that comes from up down, that can be somatic and goes to the skeletal muscles.

Remember: smooth muscles are supplied by ANS.

- The efferent division is divided into:
  1) Autonomic nervous system ANS
     a) Sympathetic nervous system.
     b) Parasympathetic nervous system.
  2) Somatic nervous system; motor neurons

- Ganglion: is the collection of cell bodies and dendrites in the PNS.
- Nucleus: is the collection of cell bodies and dendrites in the CNS and we have sensory nuclei, motor nuclei.
  One of the nucleus in the brain is called the Basal ganglia but it have to be scientifically named as Basal nuclei "located in the brain", when this part of the brain was discovered, scientist named it ganglia and the name stuck to it.
  Note: axons of the peripheral nervous system "PNS" are called nerves.

Note:

Descending tracts end with (-spinal), for example:

a) Corticospinal; from the cerebral cortex.
b) Vestibulospinal; from the vestibular nuclei in the brain stem.
c) Reticulospinal; from the reticular formation of the brain stem.
d) Rubrospinal; from the red nucleus. "rubro in latin means red"
e) Tectospinal tract; from the tectum in the midbrain.
   "The tectum is composed of two areas, superior and inferior calculi of the midbrain but they are in the dorsum (the tectum is dorsal)".

""Whereas the ascending tracts don't* start with spinal they might start from something else"", so when you say spinothalamic tract; it's obvious that we are talking about an ascending tract; so it's a sensory afferent tract. "* it actually starts with spino- but the doctor either said it doesn't mistakenly or he meant that there might be other places to start from which is less likely to be thmeaning"

So, again we have:

1) Sensory division with somatic & special sensations.
   When we say a special sensation; they have the same mechanism and their receptors are located in specialized area for example:

   a) Vision >>> receptors are located in the retina.
   b) Hearing >>> receptors are located in the inner ear.
   c) Taste >>> receptors are located in the tongue.
   d) Smell >>> the receptors are located in the nose.
      …etc. " common sense"

But when we talk about pain, pain receptors are found everywhere in your body.

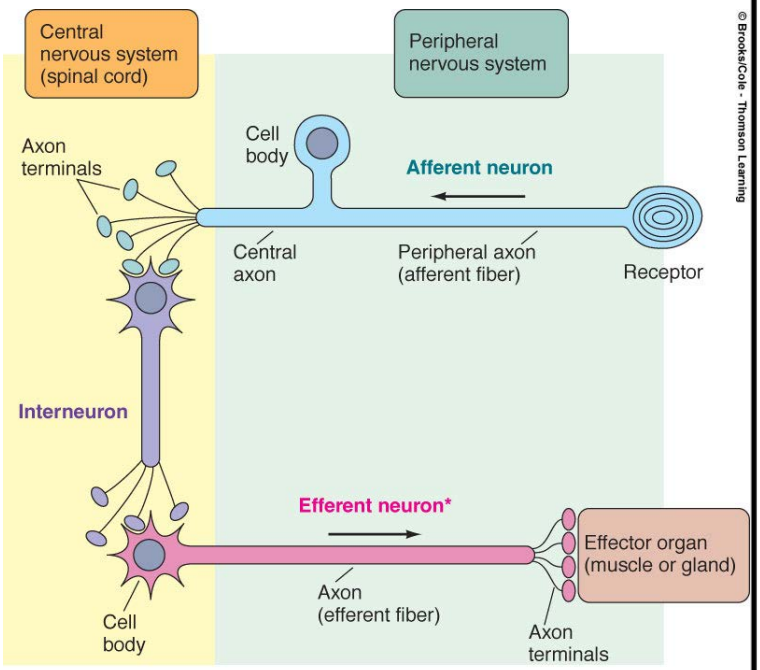
Thermal sensation is also one of the specific sensory mechanisms, and we're gonna talk about them more thoroughly later on.

2) Motor division responds to the sensations received by a motor stimuli

Functional classes (once again):

I. Afferent neurons; Inform CNS about conditions in both the external and internal environment.
II. Efferent neurons; Carry instructions from CNS to effector organs – muscles and glands.
III. Interneurons:

- They connect the sensory to the motor neuron and they occupies most of neurons of the CNS.
- Found entirely within CNS and are responsible for:
  a) Integrating afferent information and formulating an efferent response.
  b) Higher mental functions associated with the "mind".

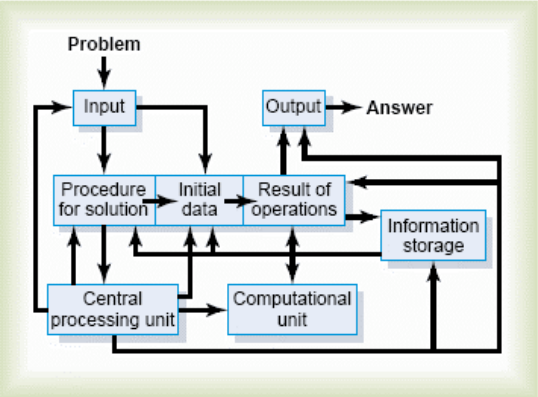


* Efferent autonomic nerve pathways consist of a two-neuron chain between the CNS and the effector organ.

Nowadays our CNS is said to be working like a computer, so we have:

1) Input ➔ sensory unit.
2) CPU "central processing unit" ➔ integration.
3) Output ➔ motor unit. (that could be anything; speaking, jumping, hitting …)

Scientists are trying to build a computer that can work like our brain, definitely not the opposite.



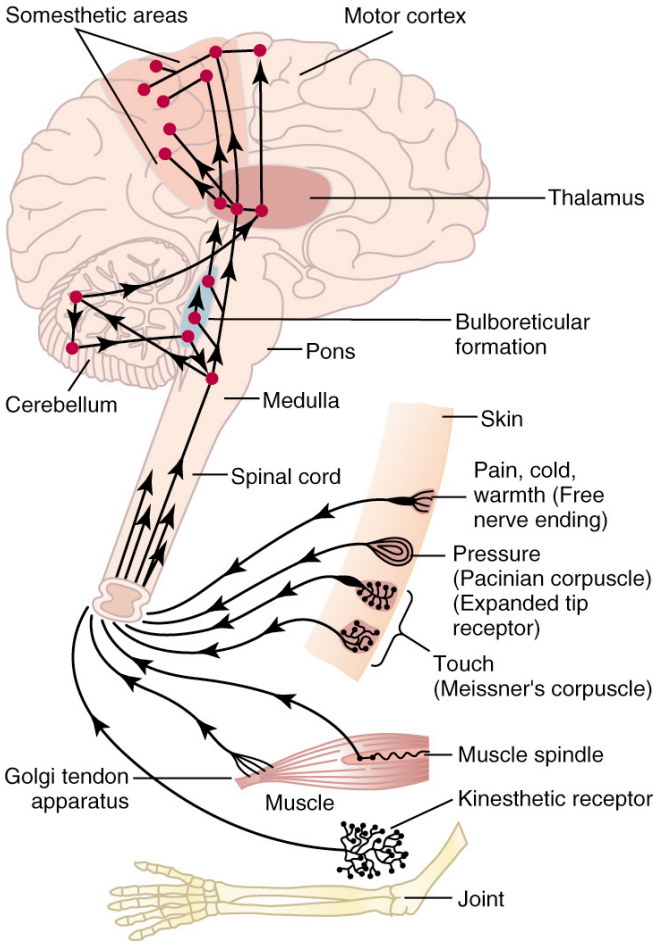
"The eye works like a camera", in fact engineers tried so much to make the camera similar to the eye to get the best resolution of images,

For example when the images were not clear and foggy; they figured that the eye had a black background on the retina "composed of melanin" that absorbs the extra light which makes the image sharp, so when they did the same with the camera by adding a black film; the images were much clearer,

Also the concept of focus was taken from the eye lens which we can change its curvature according to the distance of the object being seen!

And also the concept of colored image was figured when scientists noticed that the retina had three types of receptors "cones" for green red and blue, so they placed three colored diode group across the screen which produces colored image!

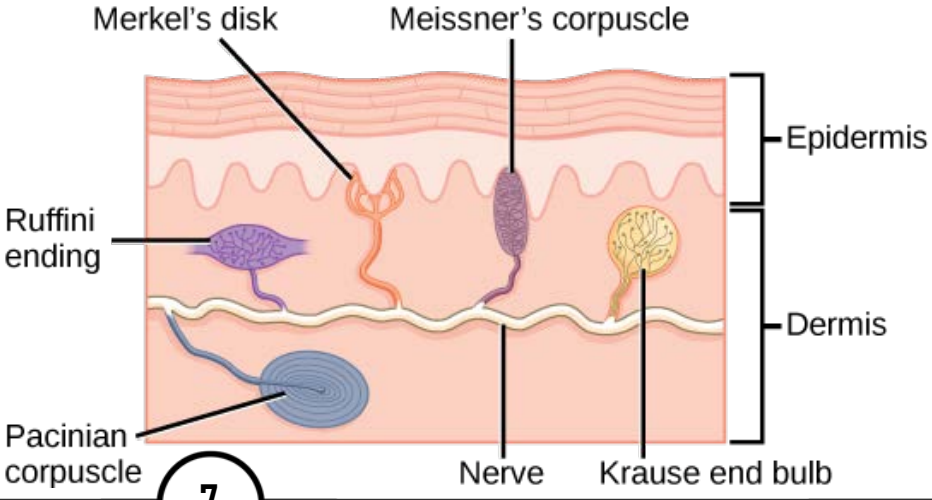
- Sensory part of CNS:
  For each sensation we should have a receptor, this receptor responds to certain stimuli by generating action potentials.
  These receptors are specific for their kind of sensation and don't generate action potential to any other type of stimuli,



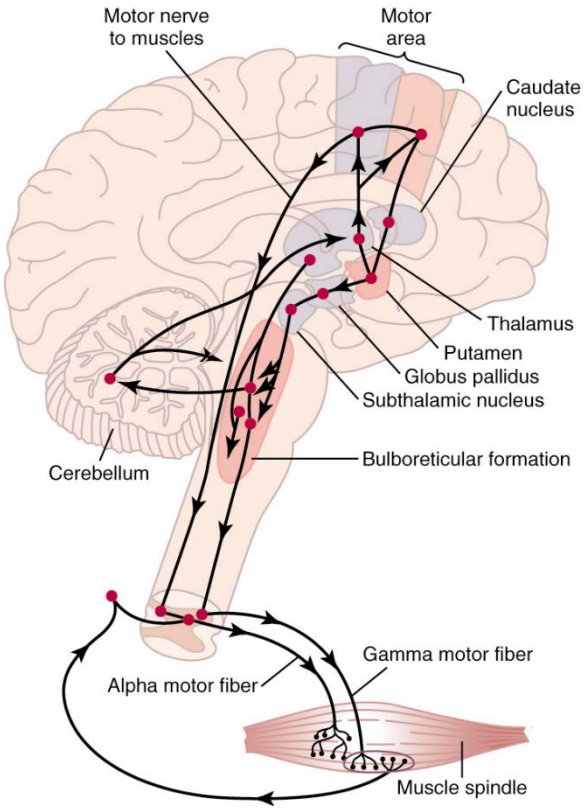
- for example:
  - For touch and light pressure, we have tactile receptor like **Meissner's** corpuscles in the skin and **Ruffini** endings in organs.
  - **Pacinian** or lamellar corpuscles for deep pressure.
  - We have also specific receptors to detect Movement of the muscles like receptors in muscle spindle, or change in tension and the change of position of the joints Temperatures and pain. All these receptors will be discussed later during this course

Now the action potential generated from each type of receptors reaches the CNS through a bundle of axons called a **tract,** wherever you stimulate this tract the kind of sensation is felt in the brain (whether stimulated from the receptor, in the spinal cord, or in the brain),

- in the end it should reach the cerebral cortex to be felt,
- if it didn't reach the cortex it cannot be felt whatsoever , which leads to a mechanism to inhibit some unwanted sensations (i.e. in the thalamus),
- actually more than 90% of our sensations are inhibited "for example you are not feeling the clothes you wear right now☺".



The Tracts:



A) Sensory = Ascending:

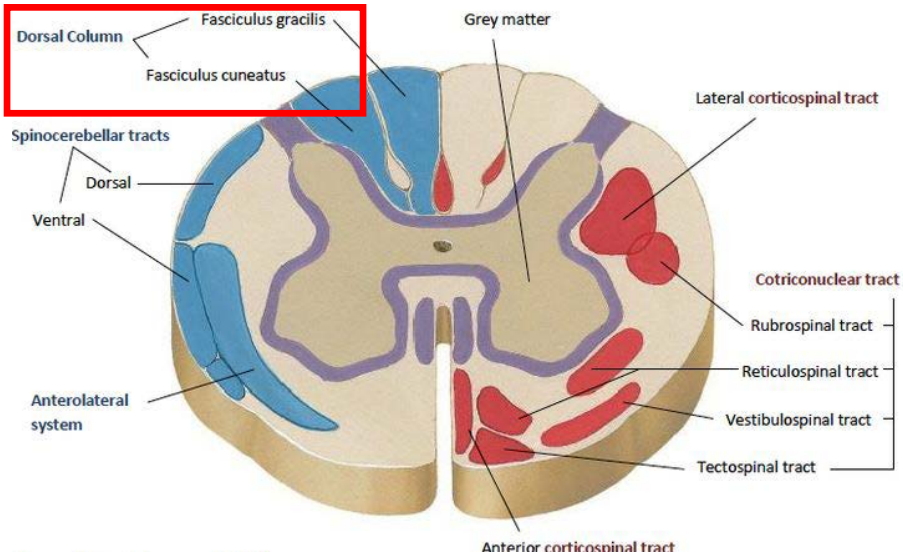
- Spinothalamic
- Spinocerebellar
- fasciculus gracilis
- fasciculus cuneatus

❖ they <u>perceive</u> the information only when reaching the conscious area of the cerebral cortex "*remember the control of the thalamus"*

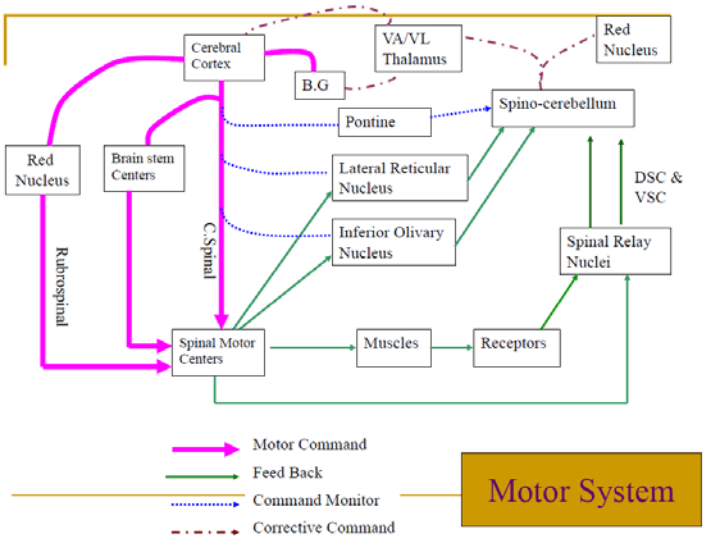
❖ Most of these tracts stop at the medulla like gracilis and cuneatus, or stop at the spinal cord, and by stopping it means that they make a <u>synapse</u> with other neurons, theses other neurons will transmit the signal and they are called the **second order neurons** and they crosses to the other side, which means that the sensation coming from the right will cross to the left side of the brain and vice versa.

❖ So if a stroke occurs in the left side of the brain the problem in sensation "also the same applies to the motor" is seen in the right side, **Contra-lateral**!! *"Opposite to ipsilateral which is on the same side*", because most of the sensation goes to the contralateral side of the brain.

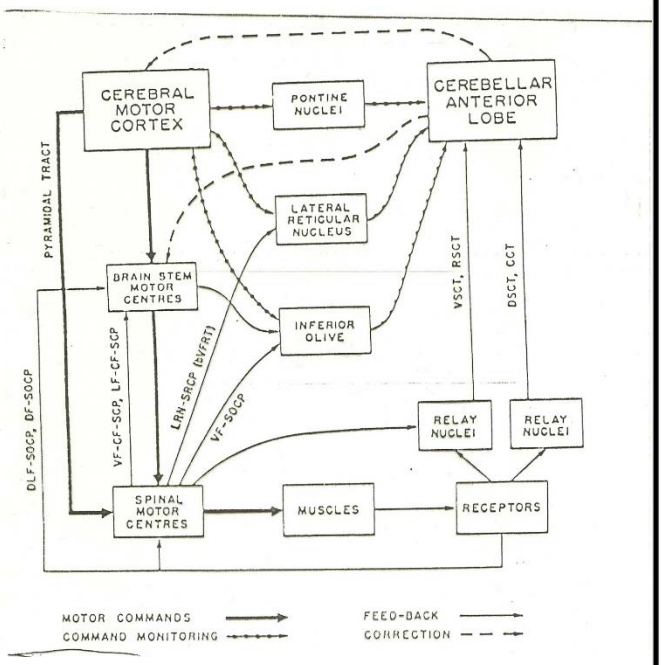
❖ Almost all the sensation stops at the thalamus, then they go to their specialized areas in the cerebral cortex.



B) Motor = descending:



- They might come from the motor areas in the cerebral cortex "cortico-spinal" or from brain stem nuclei. (Motor neurons that come from the brain stem are under control of higher neurons that originate from cortex)
- also these motor tracts cross to the other side "contralateral" in the brain stem "specifically the medulla (remember decussation)" , the area of crossing in the medulla is called the pyramids, that's why they might be called **the Pyramidal tracts**
- So again and again, if there was a problem or a lesion in the motor areas of the cortex, paralysis will occur on the contralateral side of the body.
- Yet keep in mind, in both the motor and sensory tracts, if the lesion was below the crossing are "i.e. in the spinal cord", the problem will be ipsilateral!!!



- The **Extrapyramidal** tracts are also responsible for movement and synapse with the alpha motor neurons

  They are:
  - Vestibulospinal.
  - Olivospinal.
  - Reticulospinal.
  - Rubrospinal.
  - Tectospinal.
- And as you know, there is upper and lower motor neurons; The upper descends from the brain to the spinal cord, while the lower motor neurons are from the spinal cord to the muscles.

☆ Lower brain areas are:

- Brain stem: which is the Mesencephalon "mid-brain", pons and medulla.
- Also the Thalamus, hypothalamus, cerebellum and basal ganglia.
  - they control **subconscious** body activity like the BP, respiration, equilibrium..

☆ Higher level of organization are located in the **Cerebral Cortex:**

- The Cortex never functions alone!!!
- It always associates with the lower centers.
- It has a large memory store, essential for thoughts.

❖ Motor tracts never sends the exact same intended amount of stimuli at the first time, either higher or lower than the intended, so there are areas in the brain that sends feedbacks to the motor areas to monitor the commands, as they compare the command and the feedback, and if they don't fit they try to make a correction to the command, so that the movement would be smooth and directed

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Le Fin.

"Don't wait for the perfect moment, Take the moment and make it perfect." – Uknown

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