بسم الله الرحمن الرحيم

Physiology | Lecture 1

Organisation and Function of the NS

Written & reviewed by :
Sarah Jafar

Introduction to Neurophysiology 1

Organization and functions of the nervous system

Note: this modified file includes what the doctor explained regarding these slides in both the face-to-face lecture and the online recorded lecture.

Black text is the original slides text
Blue text is what the doctor said

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Overview of the nervous system

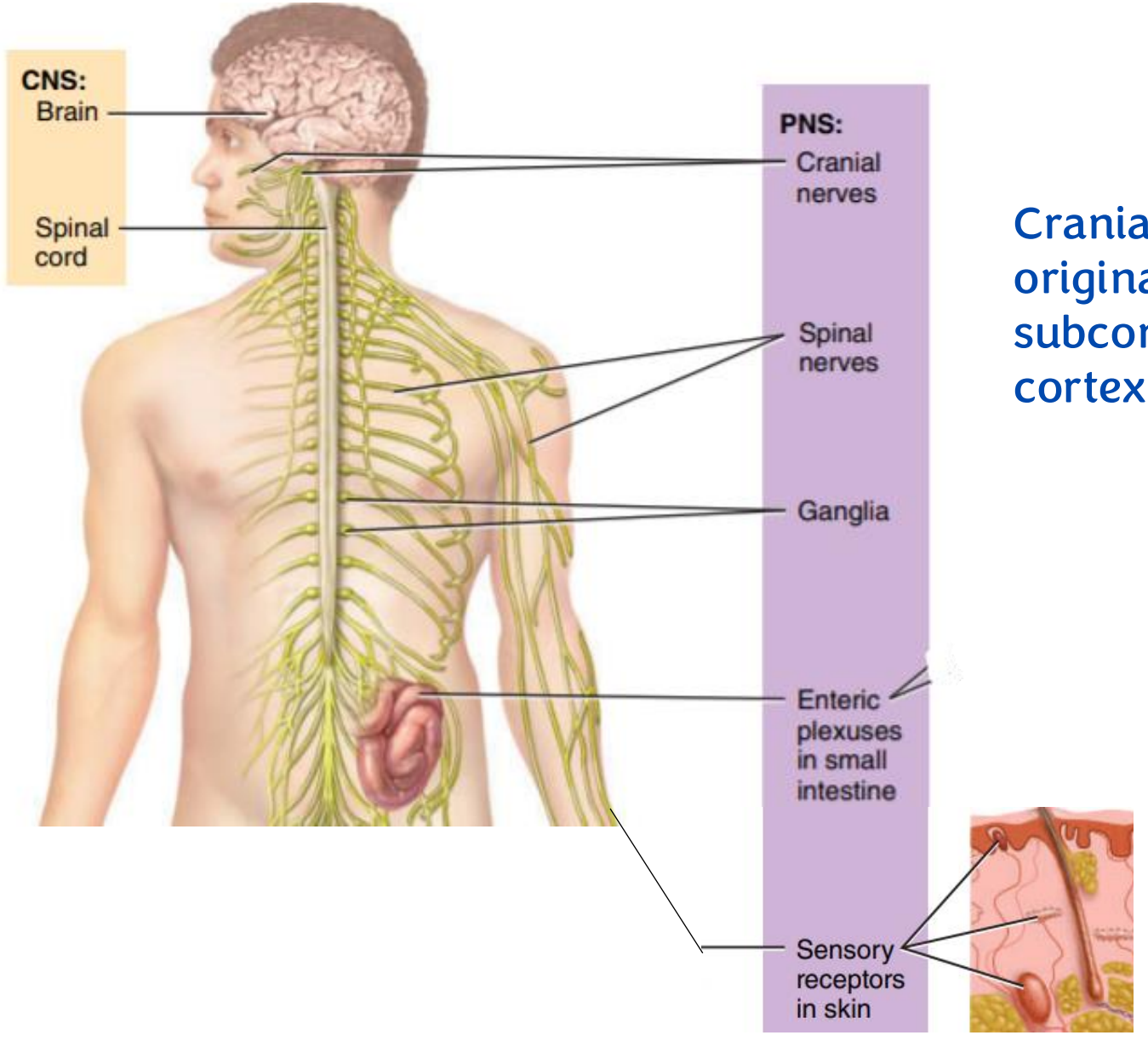
Functions in general: control

- The nervous system is composed of two divisions: (divided anatomically)

- The central nervous system (CNS), which includes the brain and the spinal cord.

- The peripheral nervous system (PNS), which includes sensory receptors, nerves, and ganglia.

Organization of the nervous system



Cranial nerves originate from subcortical area not cortex

Functions of the nervous system

There are three main functions of the nervous system.

- **Sensory function**: sensory receptors detect internal or external stimuli. The sensory information is carried to the CNS through cranial and spinal nerves.

- **Integrative function**: process sensory information by analyzing it and making decision for appropriate responses.

- **Motor function**: activation of effectors (muscles and glands) through cranial and spinal nerves.

Sensory function

- Most activities of the nervous system are initiated by sensory experiences that excite sensory receptors.
- These sensory experiences can either cause immediate reactions from the brain, or memories of the experiences can be stored in the brain for minutes, weeks, or years and determine bodily reactions at some future date.

Sensation is a process of being aware of the internal and external environments.
Changes in environment that can be detected by the body=stimuli

These stimuli have different characteristics & types so there has to be a specialized structure for each type. Receptors are selective or differentially sensitive to the type of stimulus.
For example:
1: to detect changes in temperature: Thermoreceptors, and they cannot detect changes in other types of stimuli like mechanical changes for example.
2: There are sensory receptors in the retina that detect changes in light(electromagnetic waves) that will not respond to other types of stimuli.
3:Changes in blood pressure are detected by receptors found in the vascular system like in the aortic arch.

Functions of the nervous system

- **Sensory function**: sensory receptors detect internal or external stimuli. The sensory information is carried to the CNS through cranial and spinal nerves.

- **Integrative function**: processes sensory information by analyzing it and making decision for appropriate responses.

- **Motor function**: activation of effectors (muscles and glands) through cranial and spinal nerves.

Integrative function

- More than 99 percent of the sensory information is discarded by the brain as irrelevant and unimportant.
- However, when important sensory information excites the mind, it is immediately channeled into proper integrative and motor regions of the brain to cause desired responses.
- This channeling and processing of information is called the integrative function of the nervous system.

Processing of information (integrative function) happen exclusively in the CNS.

What determines whether or not we will be consciously aware of a sensation is where integration takes place:

- If a sensation was processed in the cerebral cortex, we will be consciously aware of it and we call this perception (conscious awareness of the environment).

- Whereas if it was processed in the brain stem (subcortical below the cortex) , we will not. Like sensing changes in blood pressure.

The analysis happens by comparing the new information to previous information and experiences that we have stored ,then making decisions accordingly.

The decision will be made by the CNS will be one of three types of decisions according to how the CNS perceives the info:

- whether it is very important that we have to react immediately and cause an immediate motor response
- Or maybe the CNS will decide that it doesn't need this info for now but store it in the CNS for use in the future. The main store house for information in the cerebral cortex.
- Or maybe the CNS will decide that this info isnt important and should be discarded. (more than 90% of info is discarded) You can try to imagine the amount of inputs you get as you are watching the lecture right now for example: auditory, visual, tactile (touch, pressure, vibration and tickling) in addition to internal inputs.

Storage of information: memory

- Only a small fraction of even the most important sensory information usually causes immediate motor response.

- Much of the information is stored for future control of motor activities and for use in the thinking processes.

- Most storage occurs in the cerebral cortex, but even the basal regions of the brain and the spinal cord can store small amounts of information.

Storage of information: memory

- Once memories have been stored in the nervous system, they become part of the brain processing mechanism for future “thinking.”

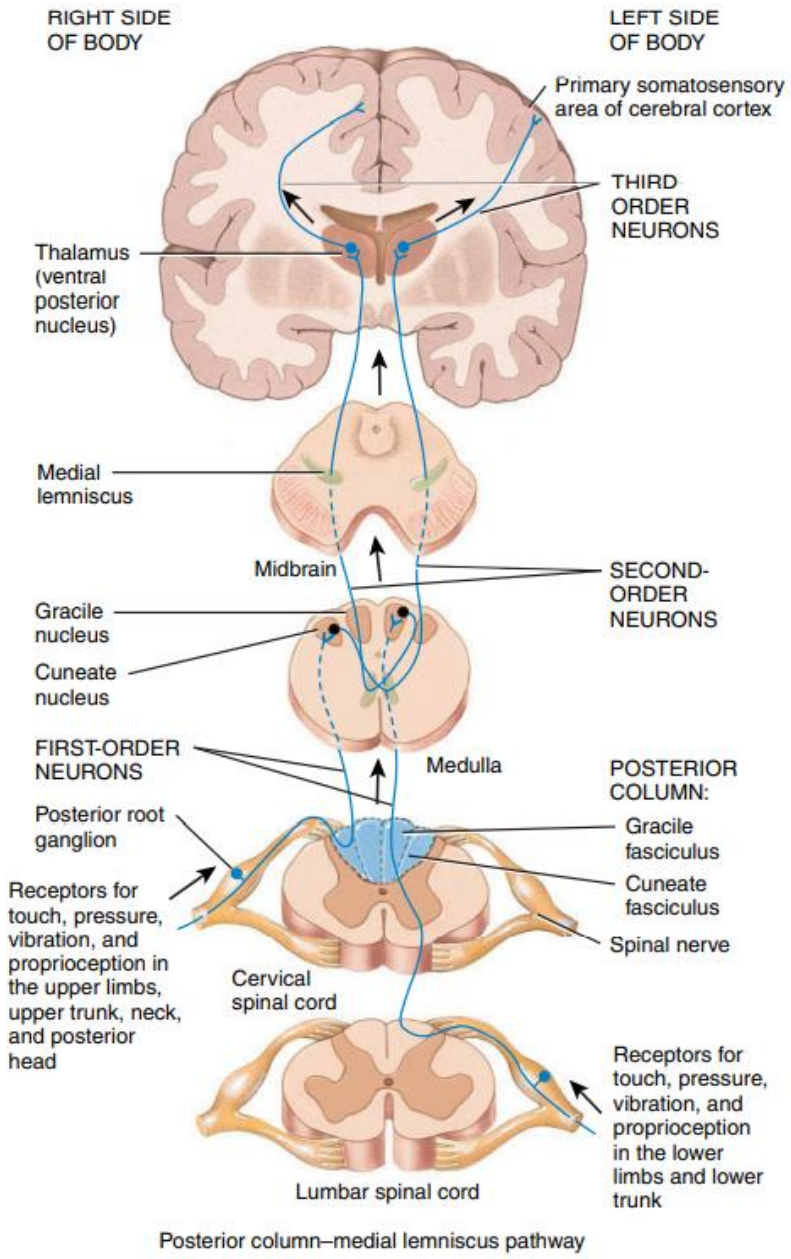
- The thinking processes of the brain compare new sensory experiences with stored memories; the memories then help to select the important new sensory information and to channel this into appropriate memory storage areas for future use or into motor areas to cause immediate bodily responses.

Spinal cord

- The spinal cord has two main functions:

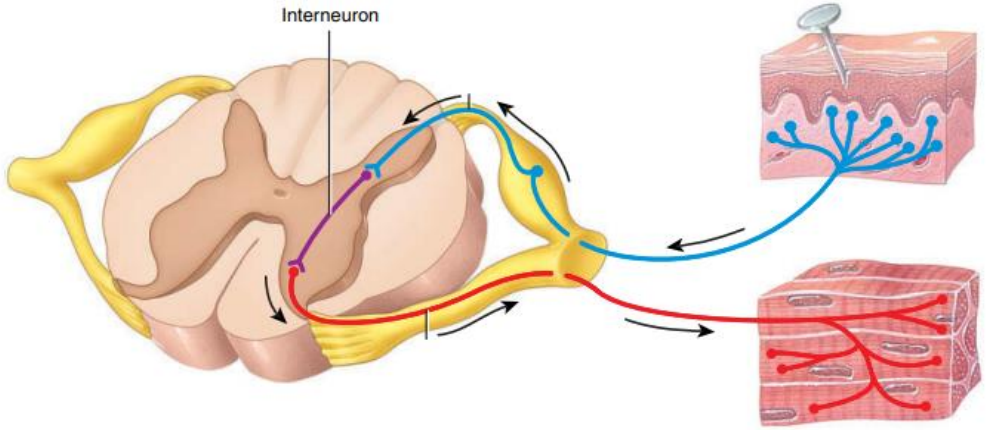
- 1- nerve impulse propagation (sensory and motor tracts): transmits signals from the periphery of the body to the brain, or in the opposite direction from the brain back to the body.

- 2- integration of information (such as in spinal reflexes).



Posterior column–medial lemniscus pathway

Any part of the CNS can make decisions. The spinal cord doesn't function only in propagation of info between the PNS and the CNS. It also has an integrative function which is called spinal reflex.



This is a reflex arch and it is composed of 5 components.

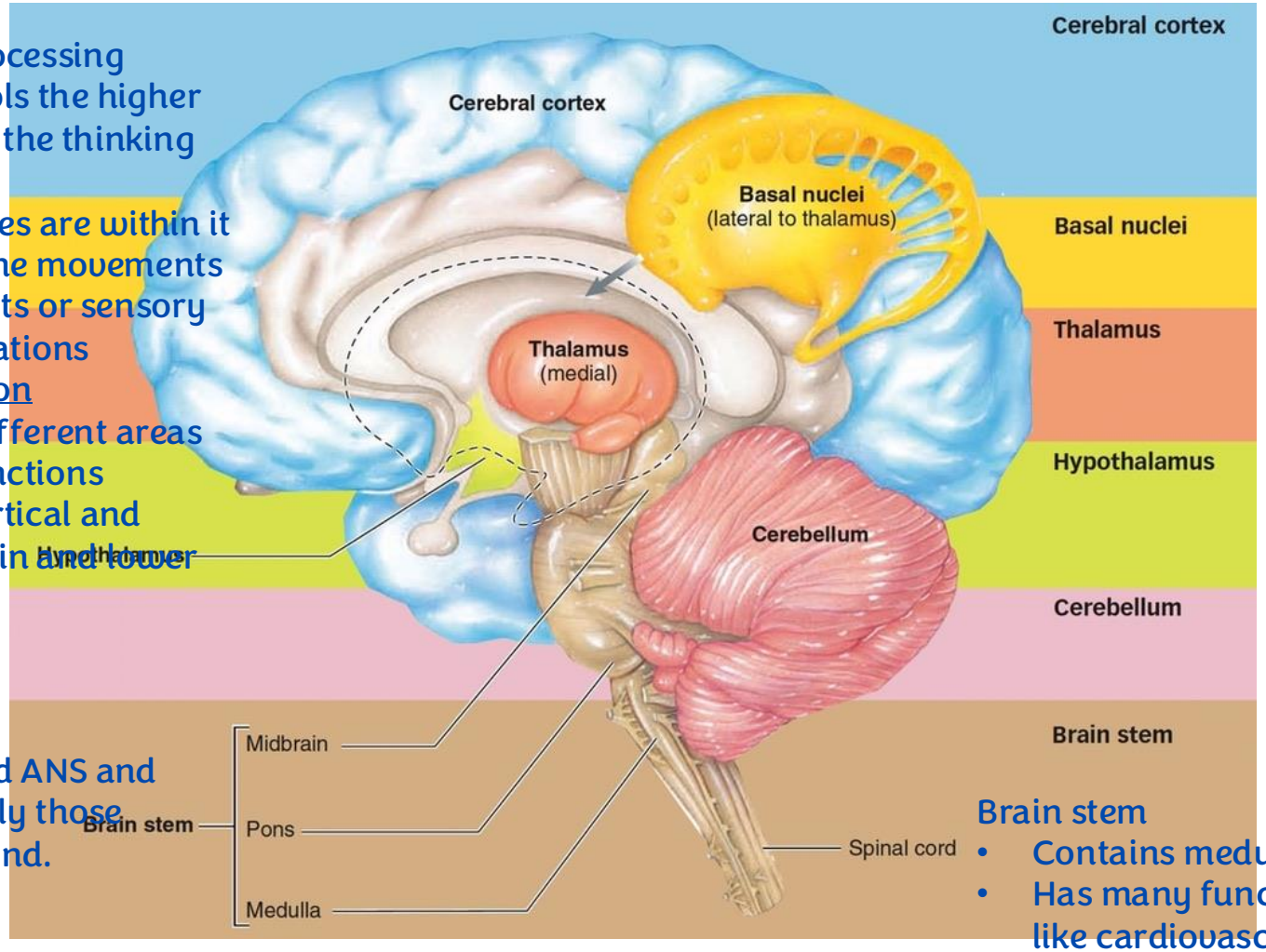
The stimulus
Sensory receptor
Sensory neuron
Integrative center (gray matter of the spinal cord)
Motor neuron will execute the function through an effector

This is flexion or withdrawal reflex (to quickly pull away (flex) a body part — usually a limb — in response to a painful or harmful

All these parts can perform integrative functions

Cerebral cortex

- highest sophisticated processing mechanisims so it controls the higher intellectual function and the thinking process
- Most of the memory stores are within it
- It controls precise and fine movements and precise sensory inputs or sensory awareness of these sensations
- Responsible for perception
- Divided into lobes and different areas that control different functions
- Divides the brain into cortical and subcortical or higher brain and lower brain



Basal nuclei

- Involved in movement. If there was a problem in this part it could lead to Parkinson disease
- Mainly involved in motor control by sending inhibitory or excitatory signals to the cerebral cortex and other parts of the brain

Cerebellum

Mainly functions to control balance by sending corrective feedbacks to the different parts involved in the motor function

Hypothalamus

Control vegetative states and ANS and different hormones especially those secreted by the pituitary gland.

Brain stem

- Contains medulla, pons and midbrain
- Has many functions but mainly control vital functions like cardiovascular center in the medulla that controls heart rate and the vascular tone and respiratory center that controls breathing

Subcortical- no conscious awareness

Vascular tone → the degree of constriction or dilation of blood vessels

Thalmus

Gateway to the cerebral cortex.
It has many nuclei, so it is integrated with sensory and motor functions

Lower brain (subcortical regions)

- Many, if not most, of the subconscious activities of the body are controlled in the lower areas of the brain.

- Examples of subcortical structures are brain stem, cerebellum, diencephalon, basal nuclei, hippocampus, and amygdala.

Higher brain (cerebral cortex)

- Cerebral cortex is an extremely large **memory storehouse**.
- Without the cerebral cortex, the functions of the lower brain centers are often imprecise. Cortical information usually converts these functions to determinative and **precise operations**.
- The cerebral cortex is essential for most of our **thought processes**.

Functions of the nervous system

- **Sensory function**: sensory receptors detect internal or external stimuli. The sensory information is carried to the CNS through cranial and spinal nerves.

- **Integrative function**: process sensory information by analyzing it and making decision for appropriate responses.

- **Motor function**: Through motor neurons activation of effectors (muscles skeletal or cardiac or smooth and glands) through cranial and spinal nerves.

Motor function

- The most important eventual role of the nervous system is to **control the various bodily activities.**

- This task is achieved by controlling:
- (1) contraction of appropriate skeletal muscles throughout the body.
- (2) contraction of smooth muscle in the internal organs.
- (3) secretion of active chemical substances by both exocrine and endocrine glands in many parts of the body.

Motor function

- These activities are collectively called motor functions of the nervous system.

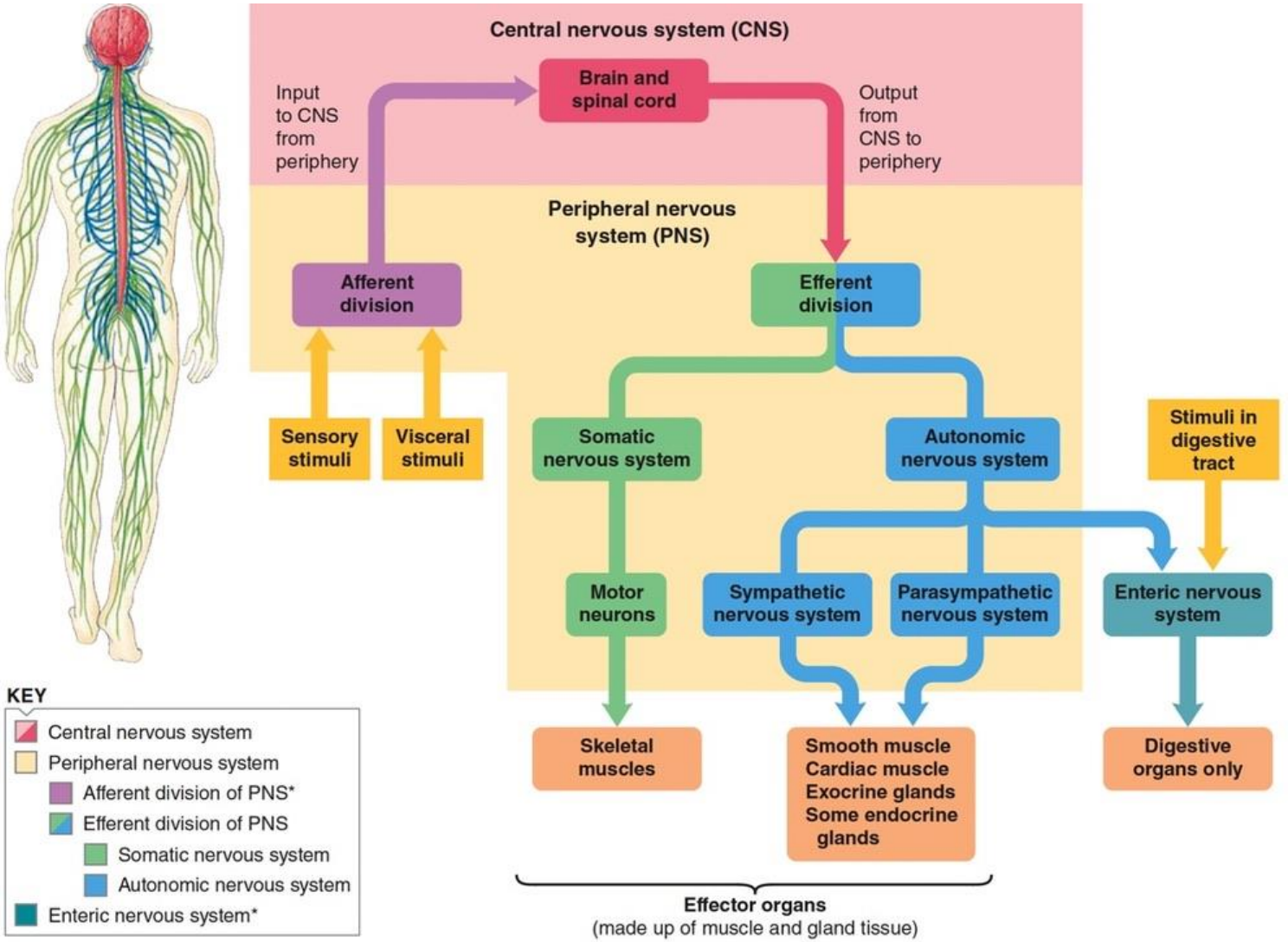
- The muscles and glands are called **effectors** because they are the actual anatomical structures that perform the functions dictated by the nerve signals.

Stimuli can be:

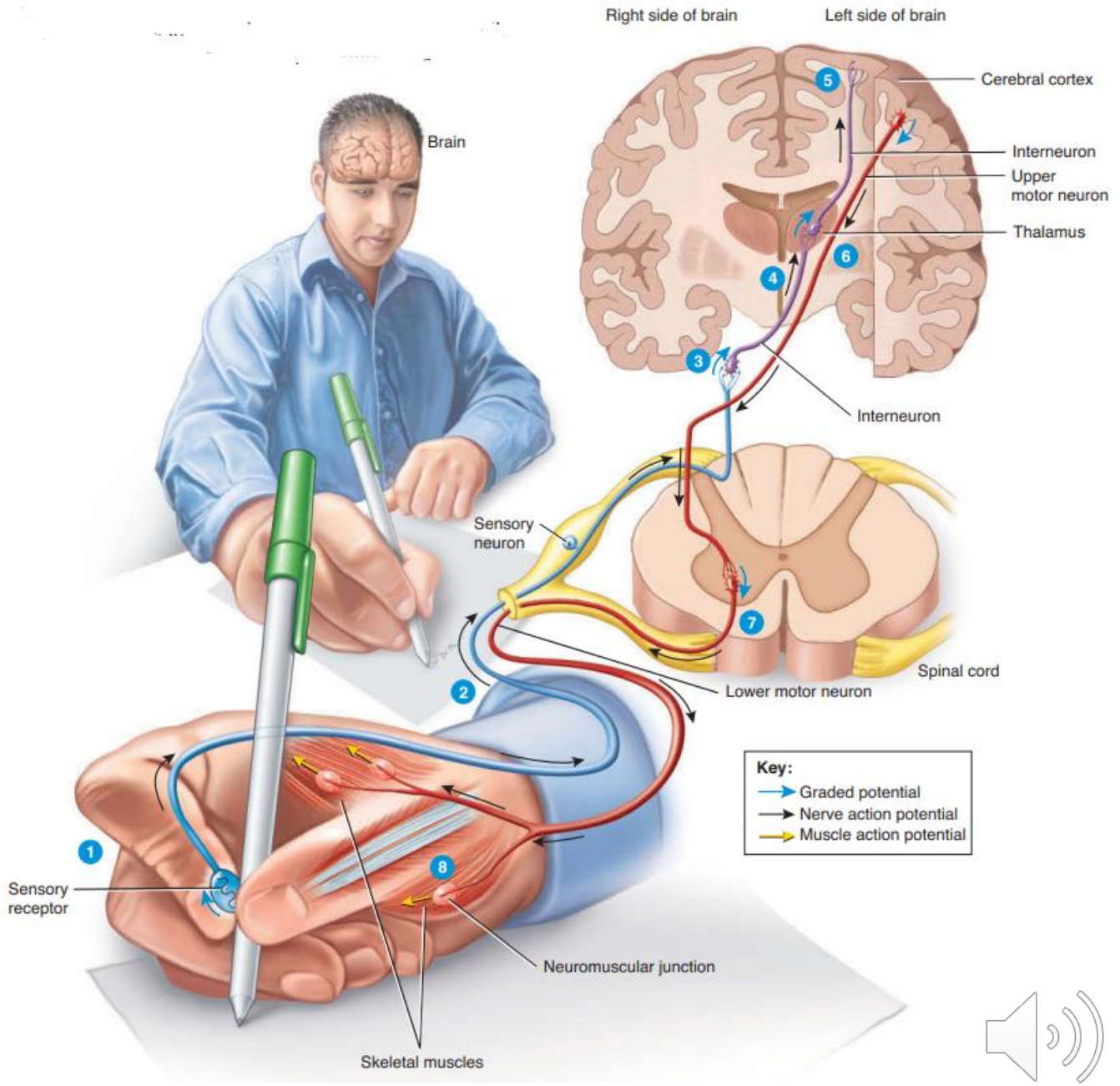
- external and called somatic. reach the eyes or ears which are considered special sensors Signals are mostly sent to the somatic NS.

- internal and called visceral.

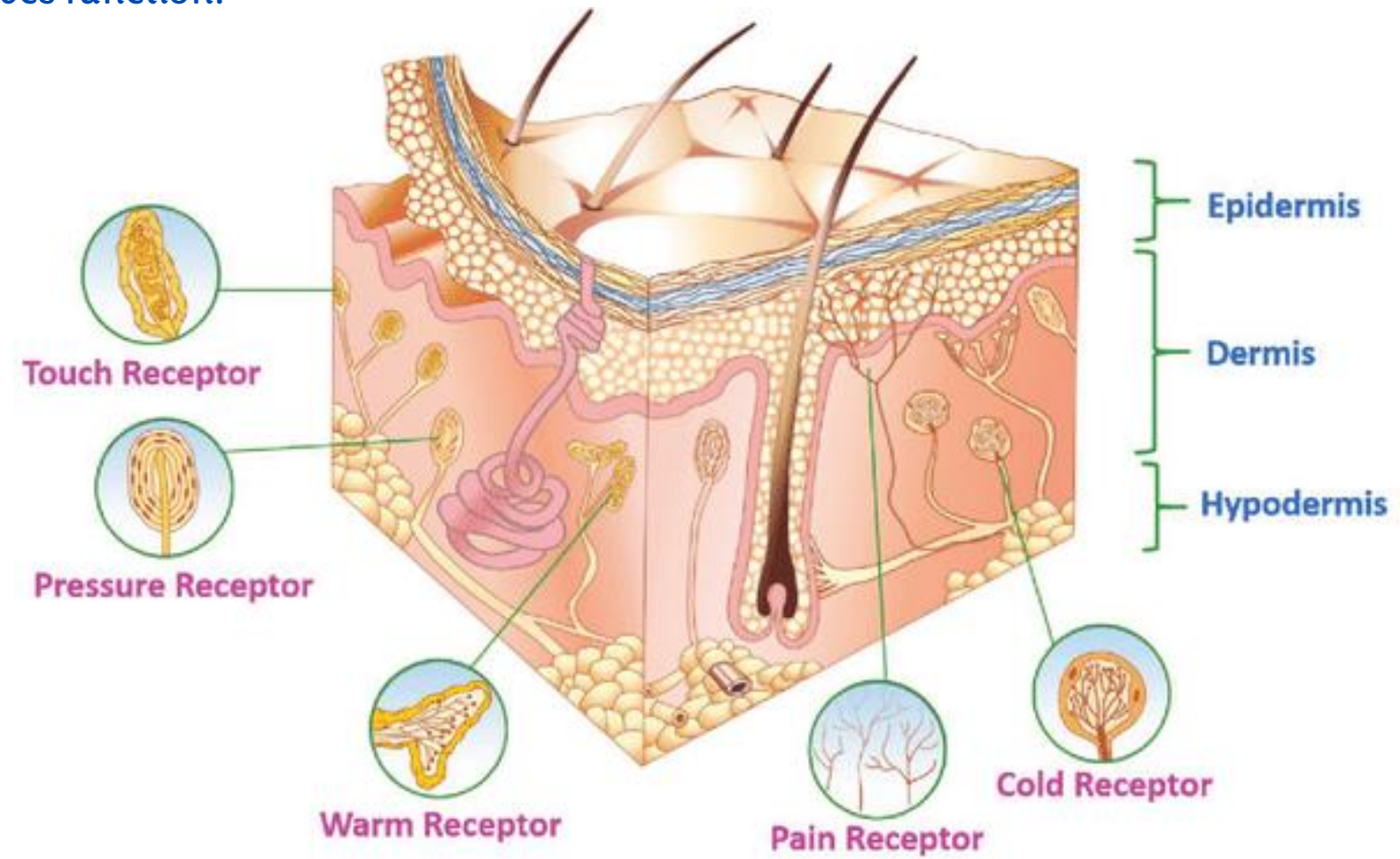
They reach the CNS through sensory neurons(afferent neurons).
The processing that happens in the CNS will come as an output to the motor neurons (efferent neurons)
These neurons will inhibit or stimulate effectors



Imagine you are holding a pen with your hand and you want to start writing, the holding of the pen means that you are pressing on the skin on your fingers which stimulates sensory receptors specific for pressure and touch sensations called tactile sensations and send signals through sensory neurons(blue) through specific tracks ascending to the cerebral cortex where integration happens because it is a voluntary type of movement that we are consciously aware of. A decision will be made to do some sort of contraction of these muscles so you can move your fingers and the pen can write on the paper. The output signal will descend through motor neurons to reach muscles and perform the decision.

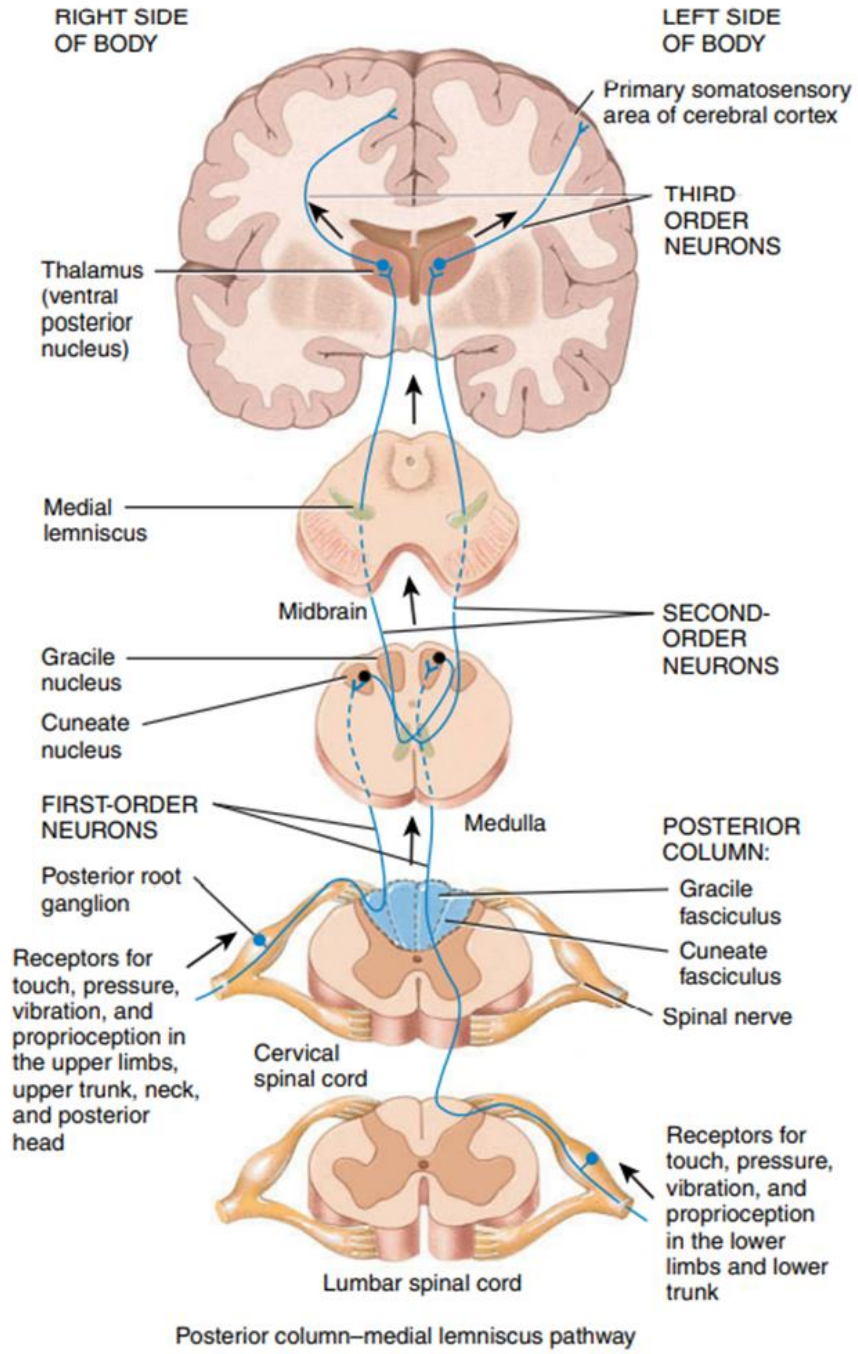


The different types of sensory receptors present in this area of the skin and subcutaneous tissue.
They are different in structure
Keep in mind that in physiology structure serves function.



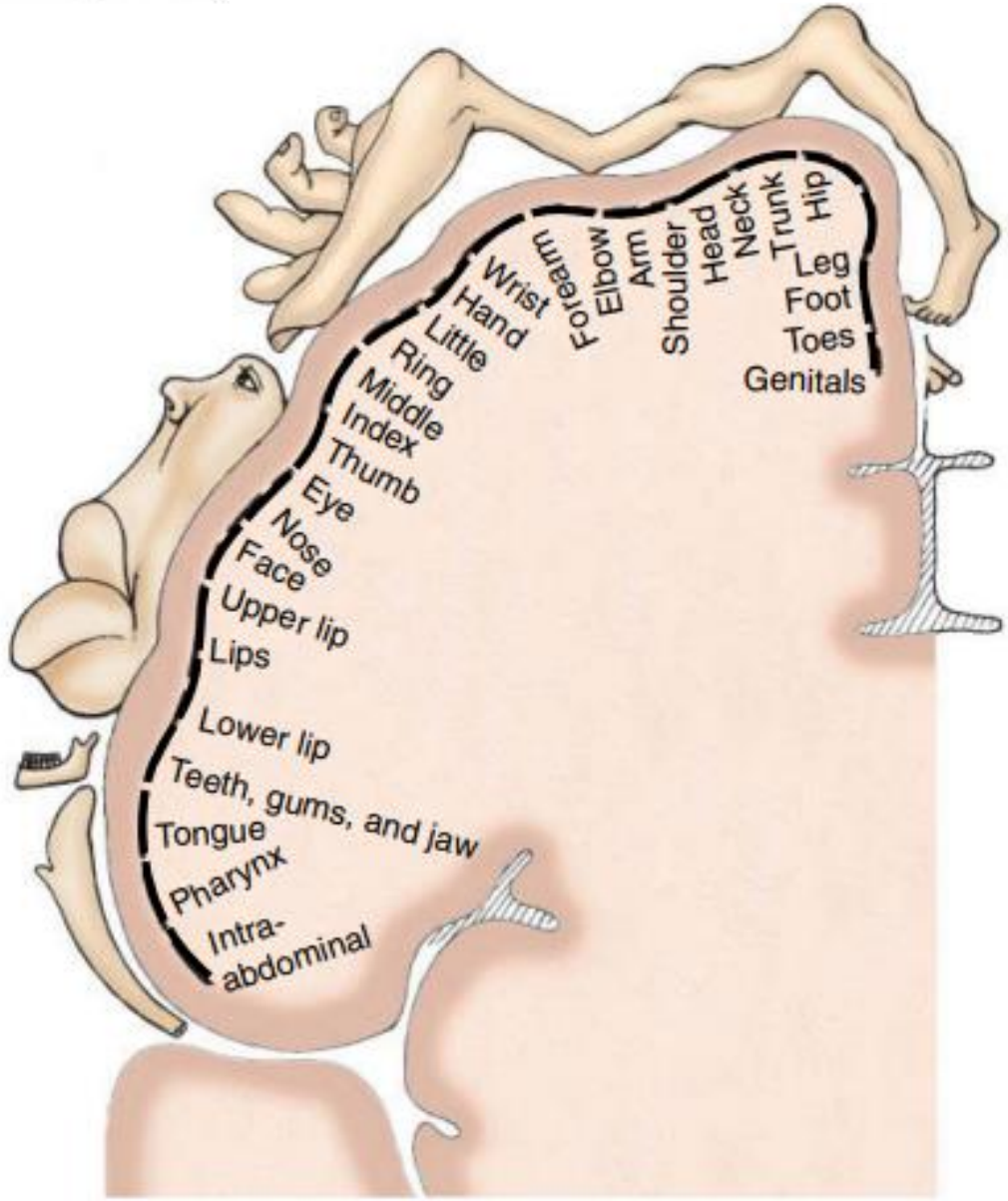
This figure shows how this specific type of sensory stimulus will pass through a series of sensory neurons in a specific pathway.
They synapse at specific sites in the CNS until they reach the ultimate processing center in the cerebral cortex in this example.
This pathway is called afferent or ascending pathway.

You don't have to remember all the details or names here.



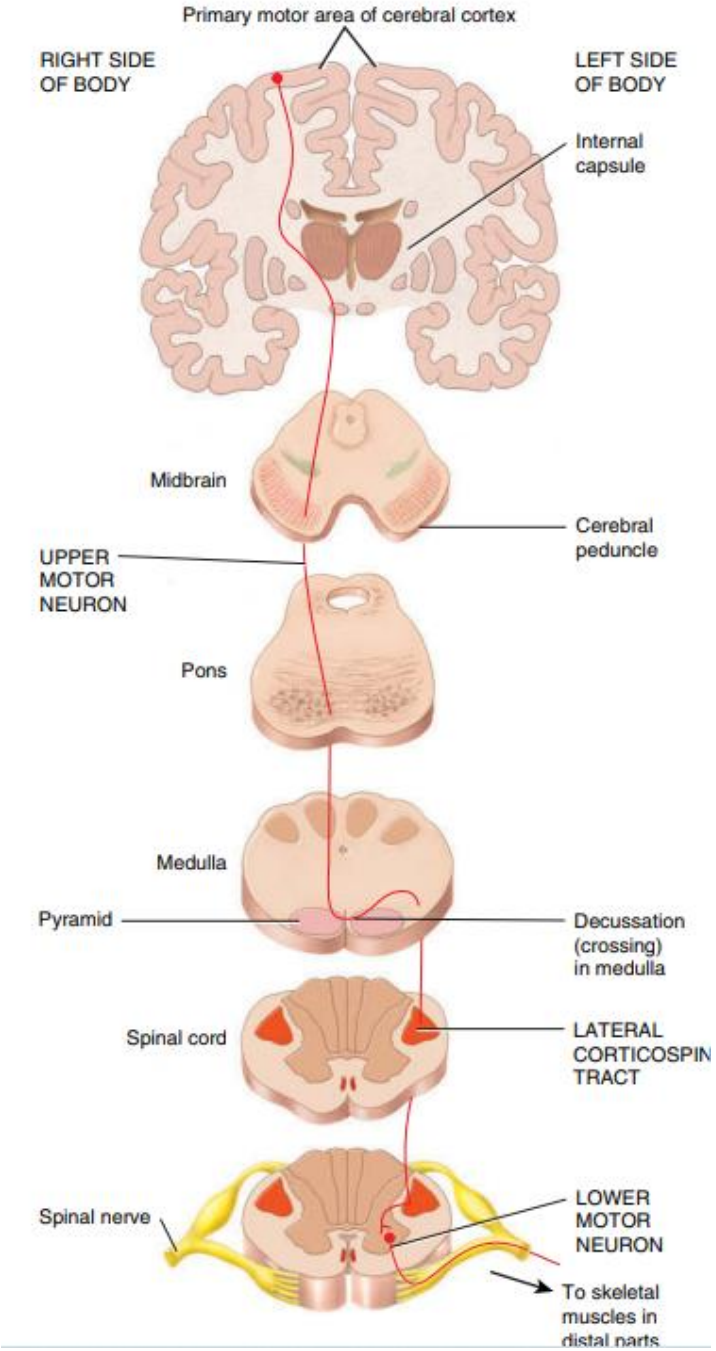
Posterior column–medial lemniscus pathway

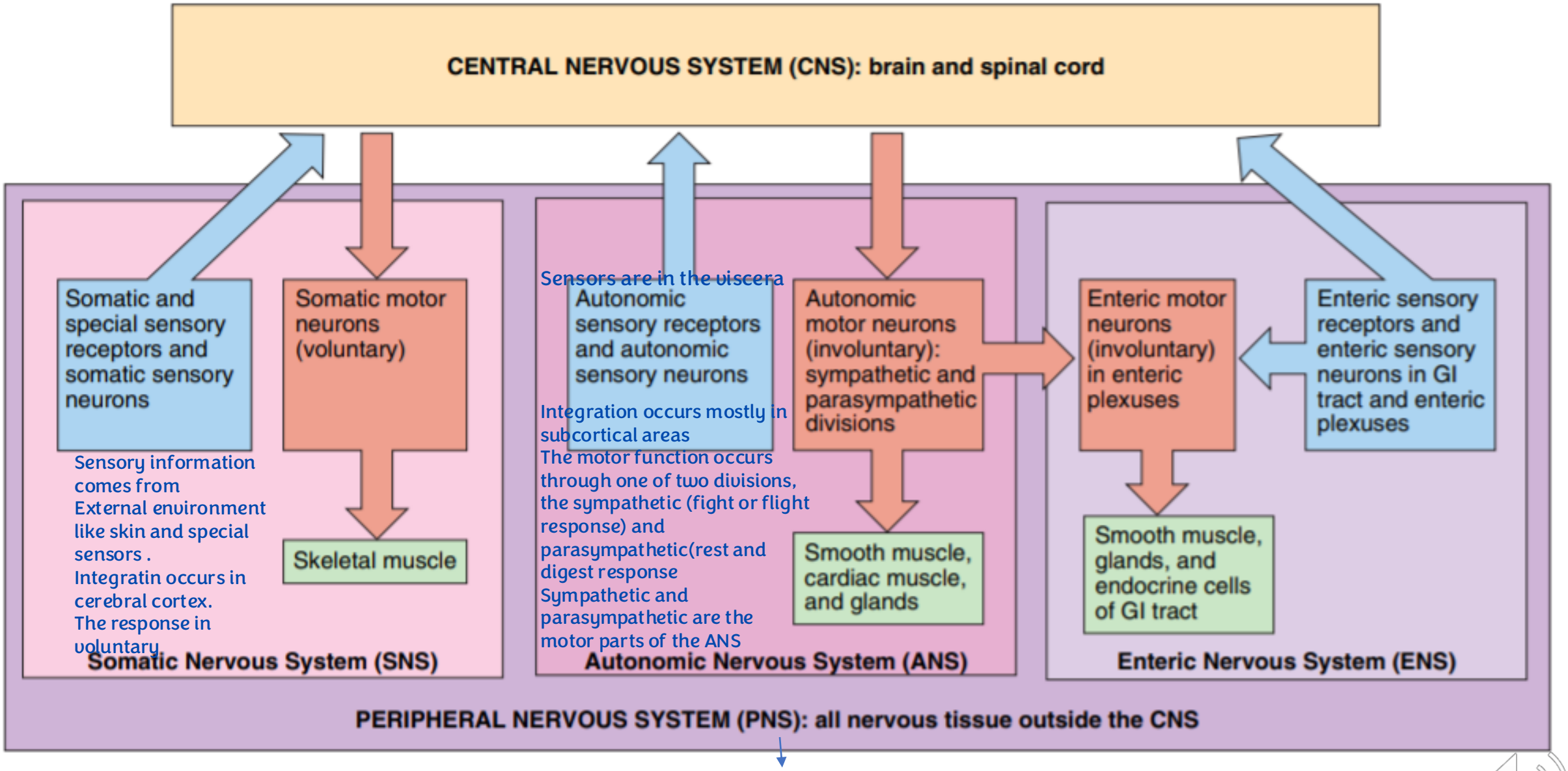
As the fibers ascend upwards to the cerebral cortex they will go specifically to an area in it that will process this type of sensory info.



(a) Frontal section of primary somatosensory area in right cerebral hemisphere

After processing the info and making the decision to contract muscles, it will go to the motor area in the cerebral cortex then to specific motor neurons that will communicate together in specific sites as they go through this descending pathway to certain skeletal muscles to cause contraction and then you can start writing.





It is divided into somatic, autonomic and enteric.
Blue : sensory part, Red: motor part, Green: effector part

Somatic nervous system

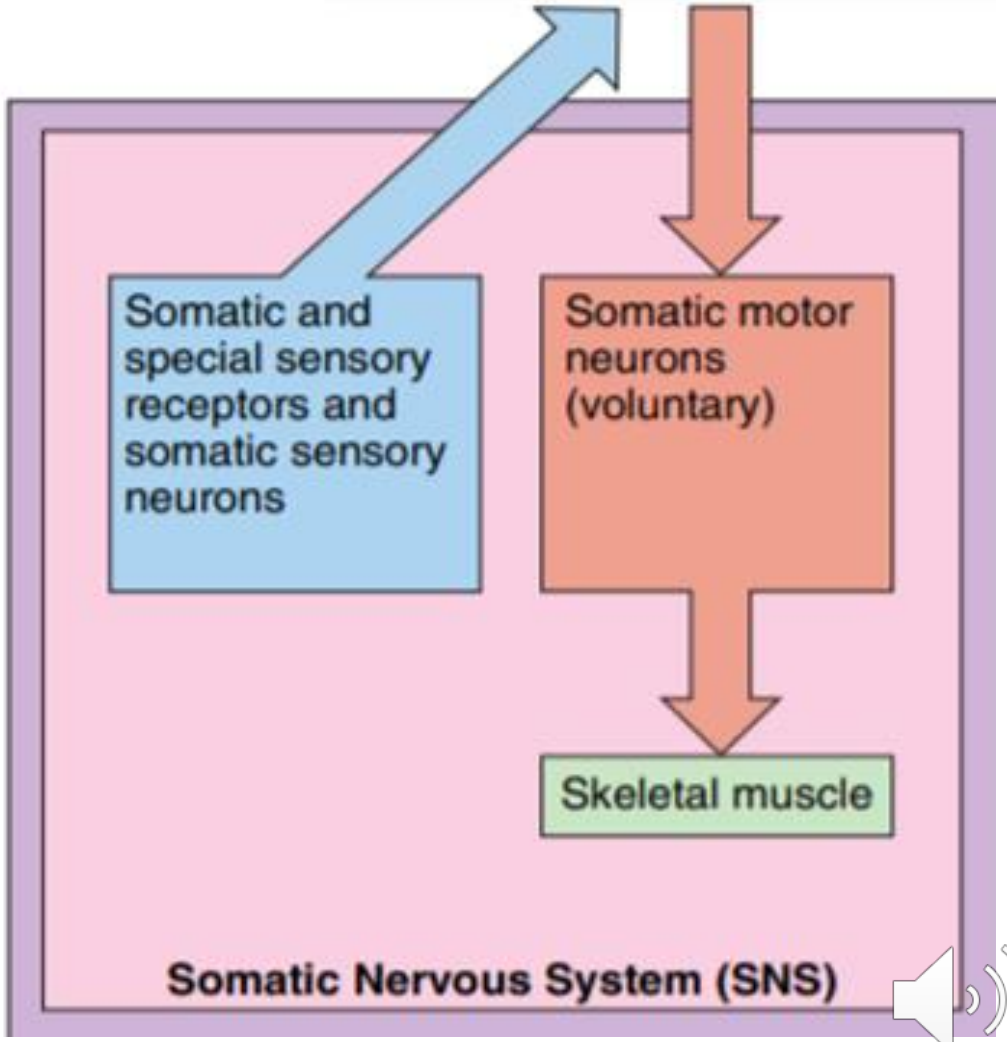
Sensory info will be transmitted through spinal or cranial nerves to the CNS where it will be processed and come back through motor neurons to effectors.

Soma means body.

- **sensory neurons**: convey information from somatic receptors (in the in the head, body wall and limbs in the skin, muscles and bones)and from receptors of special senses: vision, in the inner ear for hearing and balance and taste and for smells in the nose to the CNS.

- **motor neurons**: conduct impulses from CNS to skeletal muscles only.

- It is the **voluntary** part of PNS because the motor response can be consciously controlled.

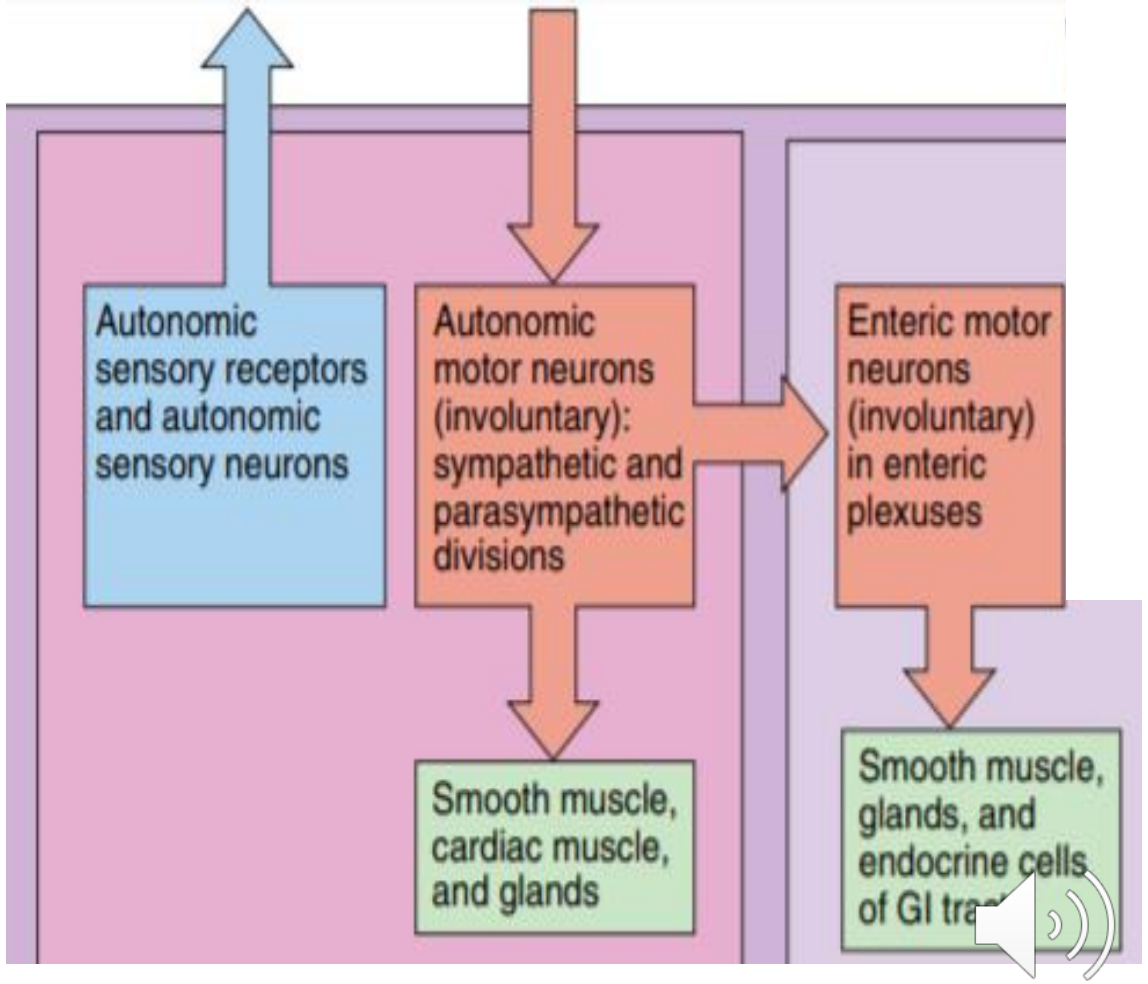


Autonomic nervous system

- **sensory neurons**: convey information from autonomic sensory receptors (located mainly in the visceral organs) to the CNS.

- **motor neurons**: conduct impulses from CNS to smooth muscles, cardiac muscles and glands. because the motor responses are not normally under conscious control, its action is <u>involuntary</u>.

- The motor part is divided into **sympathetic and parasympathetic** divisions.



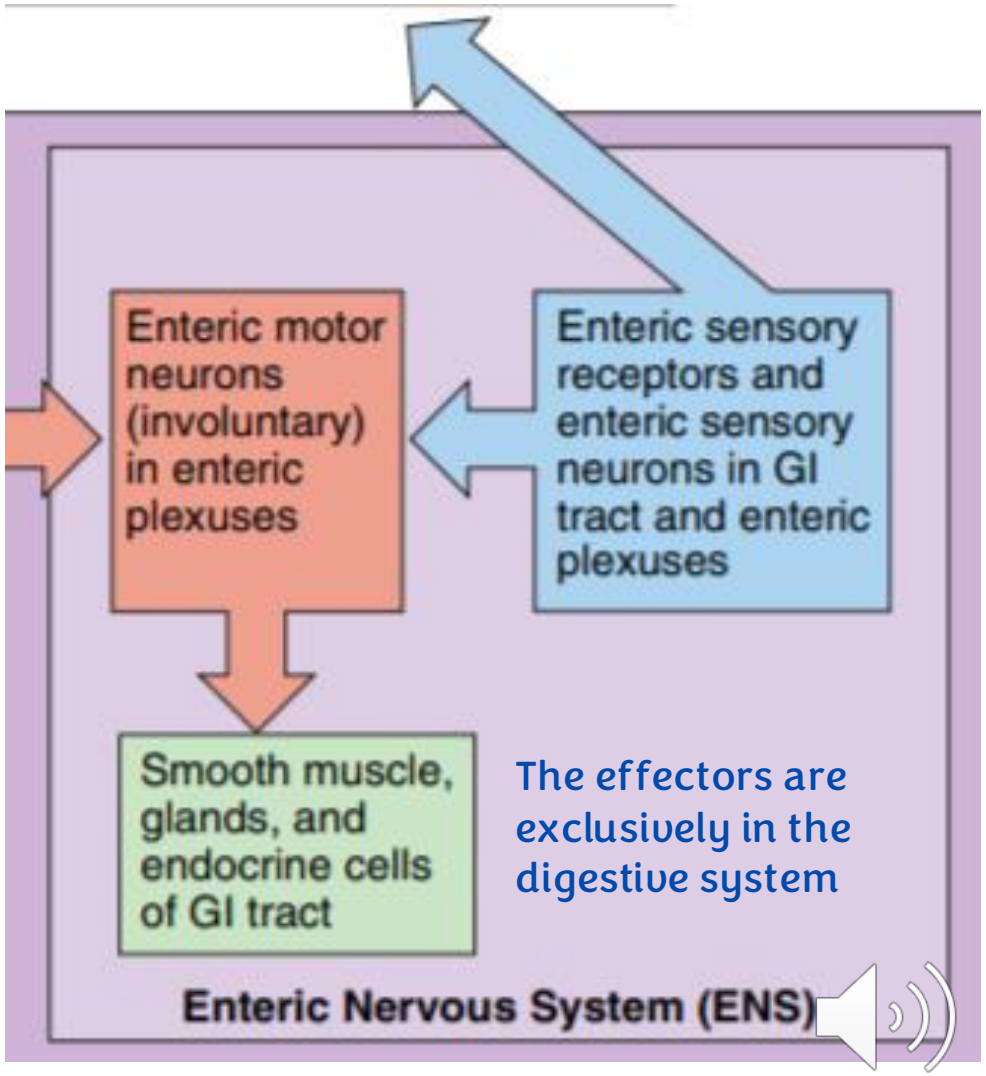
Enteric nervous system

Enteric refers to the digestive system

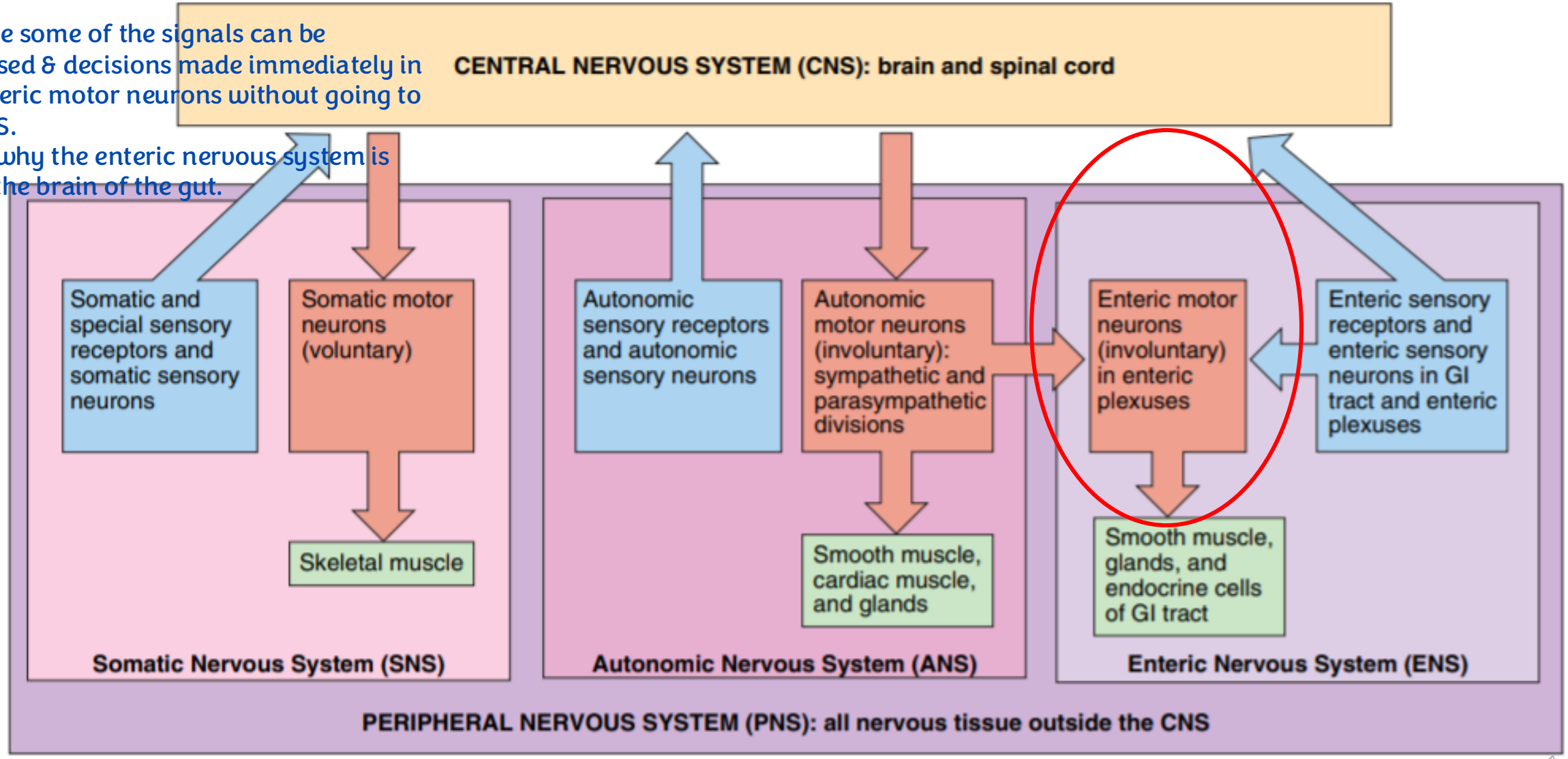
- **Sensory neurons**: monitor changes within the digestive system (gastrointestinal: GI). They could be chemical changes or mechanical stretching in the intestine for example.

- **Motor neurons**: control the contraction of GI smooth muscles , the secretions of GI organs, and the activities of GI endocrine cells. It is called the brain of the gut. Motor neurons or motor information do not come directly from the CNS, they come through the sympathetic and parasympathetic neurons or from the digestive system.

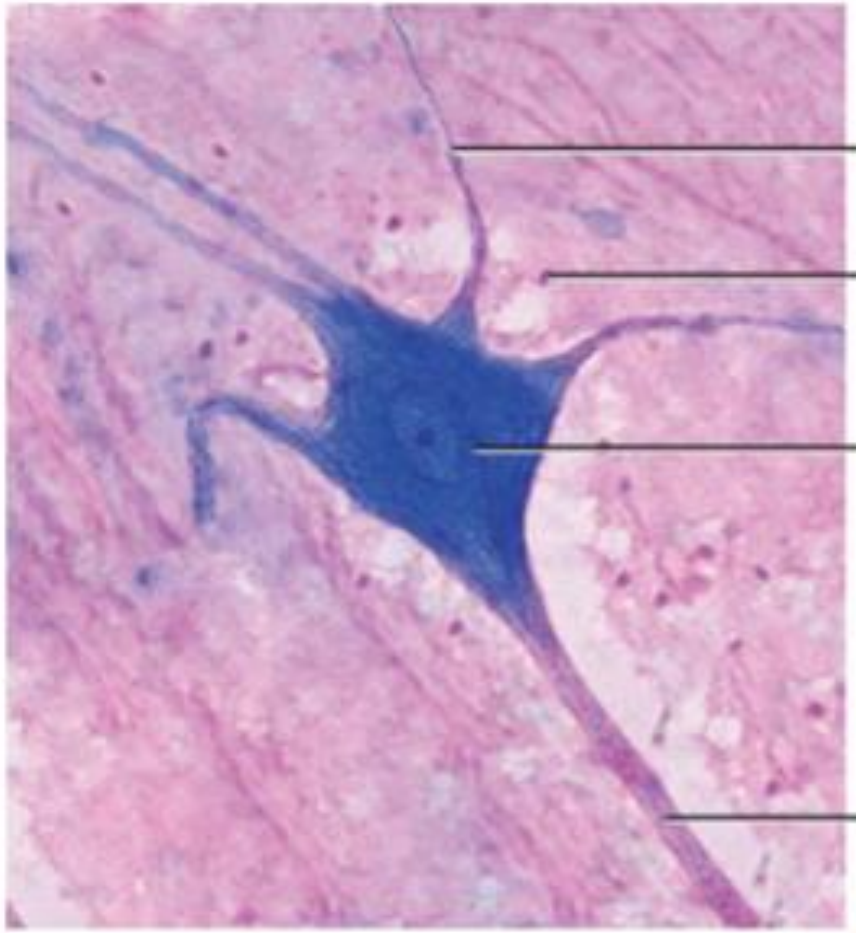
- It is involuntary. Many of ENS neurons function independent of ANS or CNS, although they also communicate with the CNS via sympathetic and parasympathetic neurons.



Why they separated the enteric NS from the ANS?
Because some of the signals can be processed & decisions made immediately in the enteric motor neurons without going to the CNS.
That's why the enteric nervous system is called the brain of the gut.



The functional unit of the nervous system is the neuron



Branches coming out of the soma to communicate with other neurons s single neuron can communicate with even thousands of other neurons

Long because neurons travel long distances like from your toe to the brain

Collections of nervous tissue

- Components of nervous tissue are grouped together in a variety of ways.

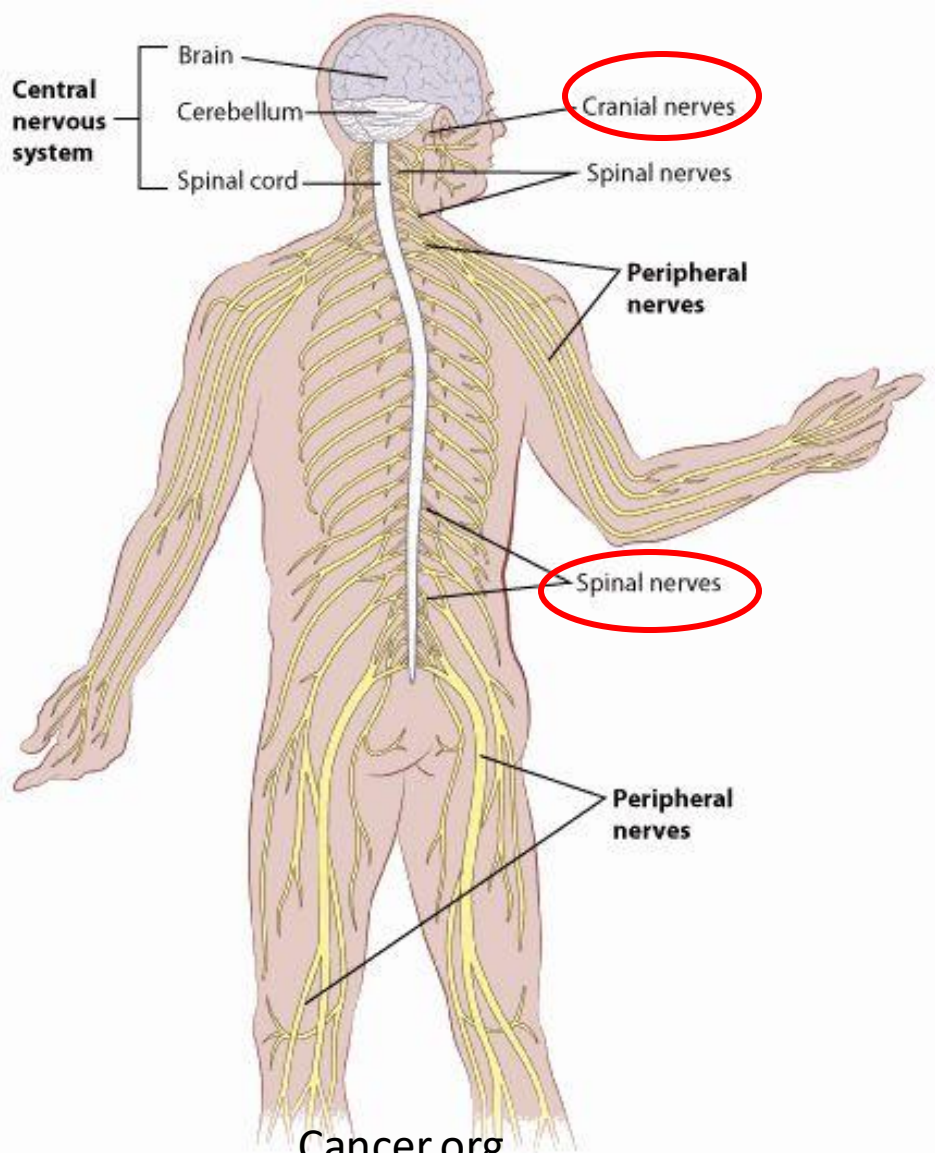
Collections of axons

- The widespread collection of axons in the CNS is called **white matter**.
- A bundle of axons in the CNS is called **tract**.
- A bundle of axons in the PNS is called **nerve**.

Nerve

Neuron= single cell
Nerve= bundle of axons in the PNS
Anatomical-wise they can be spinal or cranial depending on the site in the CNS where they originate from (motor) or come to (sensory)

motor nerves originate from CNS
Sensory nerves carry info to the CNS

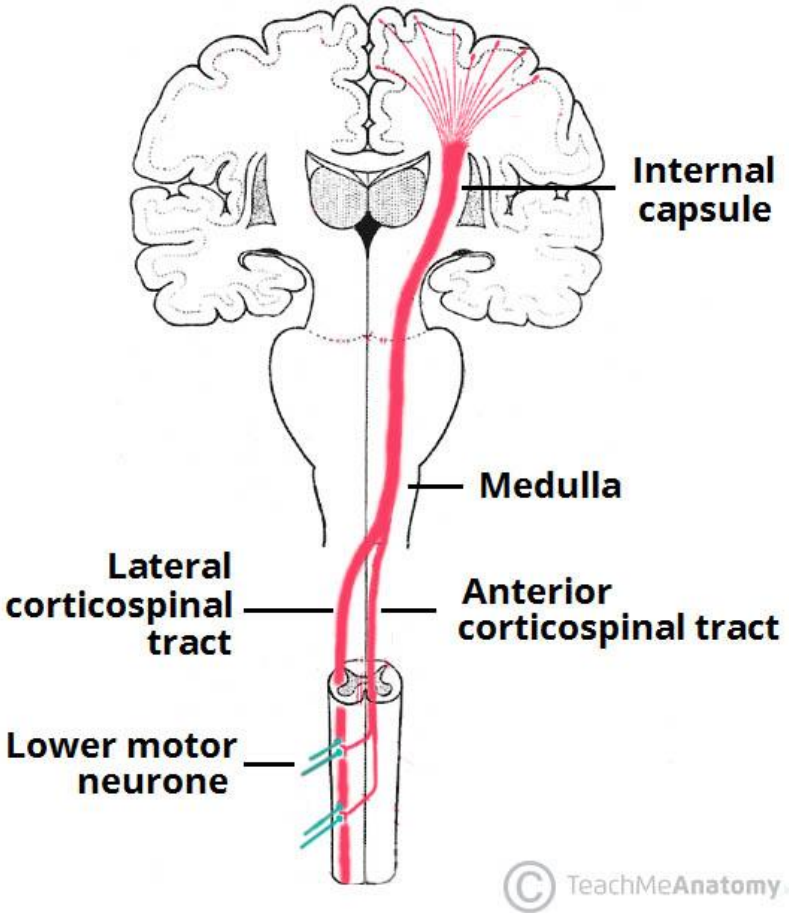


Cancer.org

Tract

- Ascending (sensory tracts)
- Descending (motor tracts)

A collections of axons in the CNS



Descending pathway

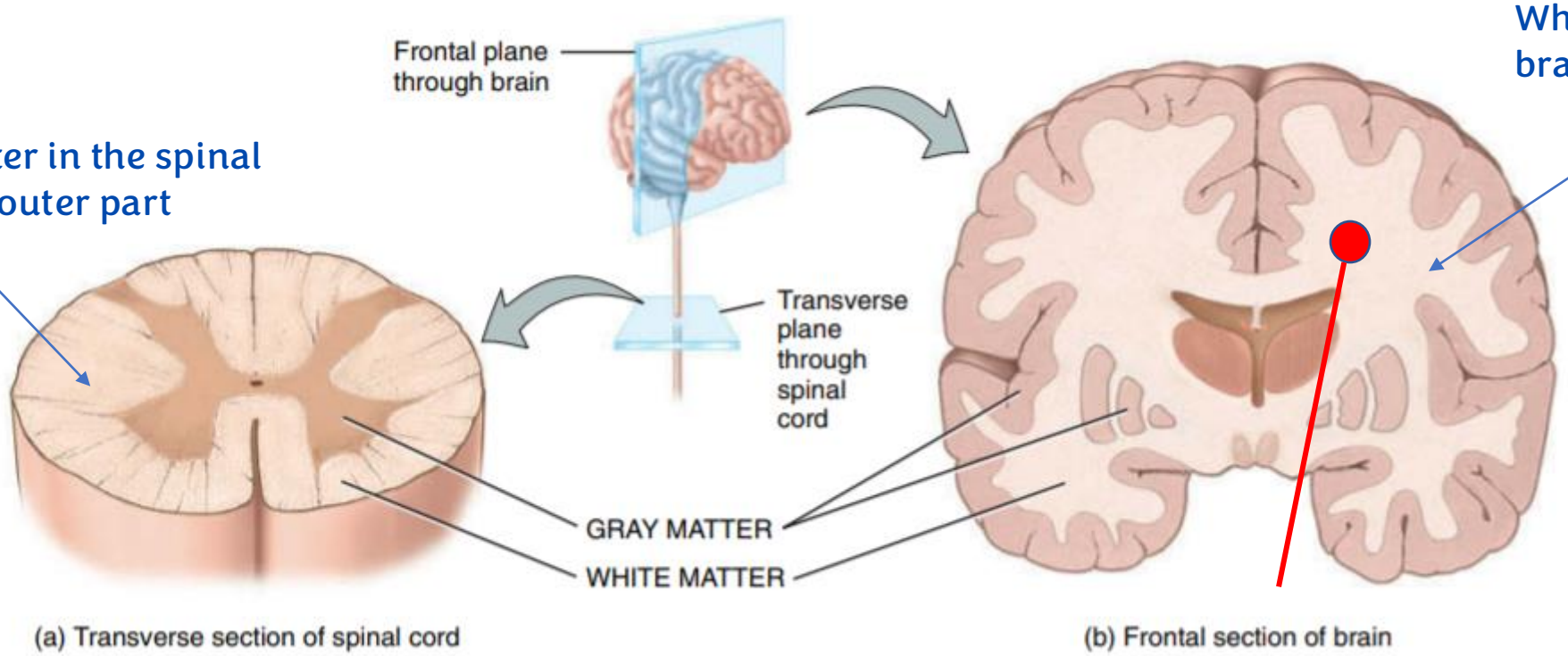
It is called white because it has a high content of myelin which is mainly fat and in autopsy fat appears white

White matter

A widespread area (not a bundle)of axons in the CNS

White matter in the brain is the inner part

White matter in the spinal cord it the outer part



Collections of neuronal cell bodies

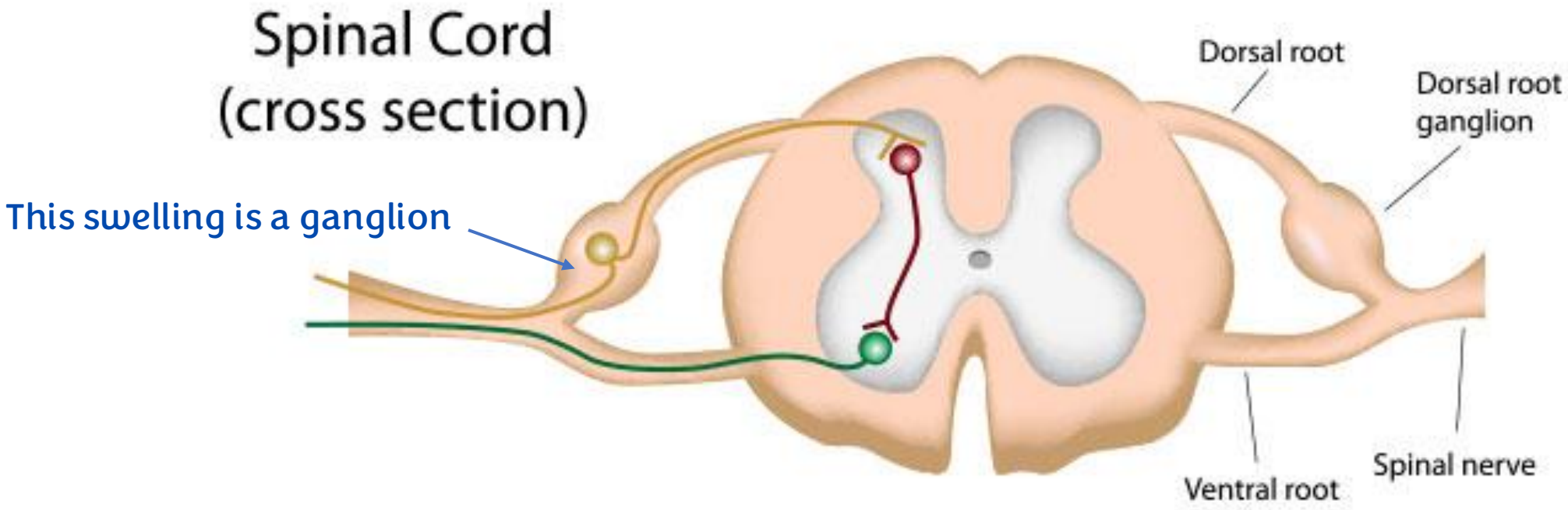
A widespread collection of neuronal cell bodies is called **gray matter**.

A cluster of neuronal cell bodies in the CNS is called **nucleus**.

A cluster of neuronal cell bodies in the PNS is called **ganglion**.

Ganglion

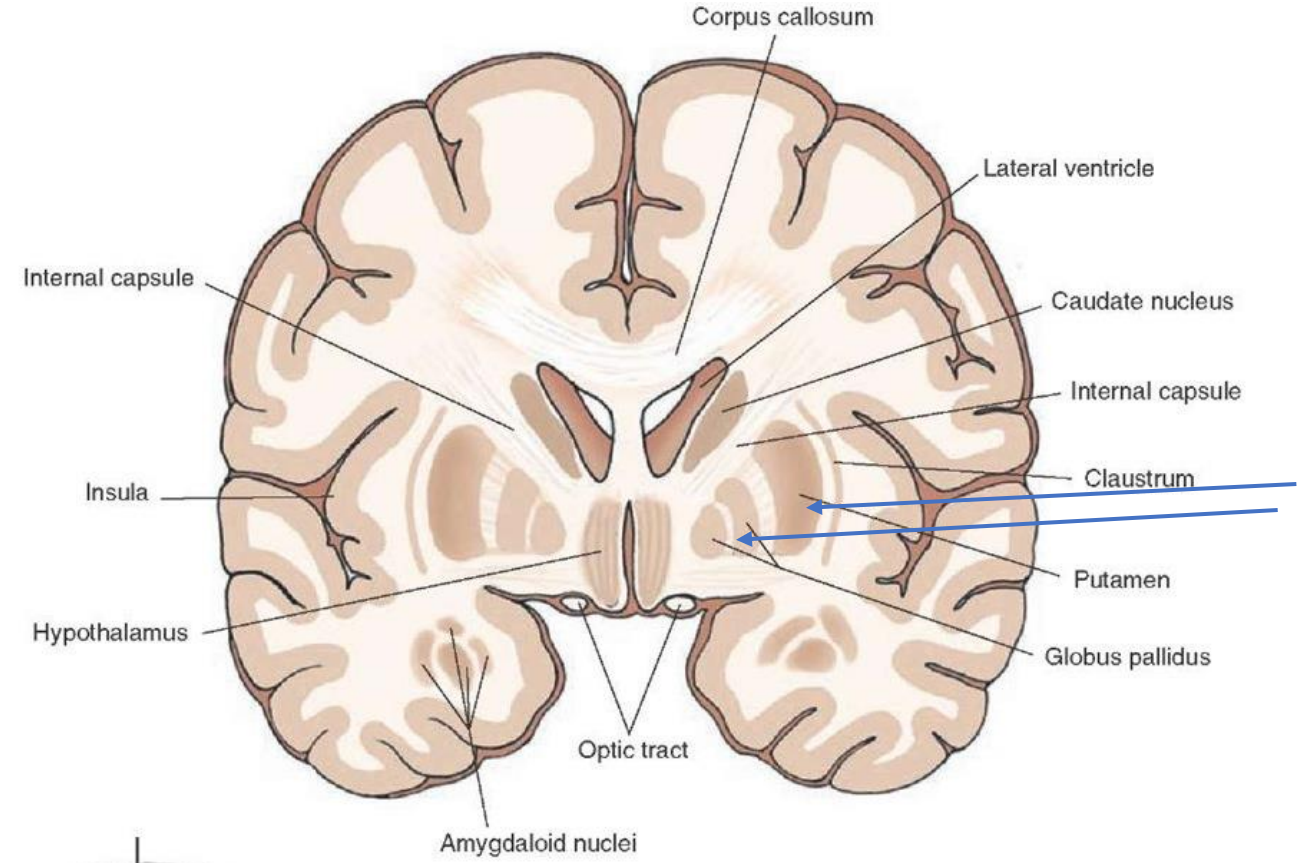
A collection of cell bodies in the PNS

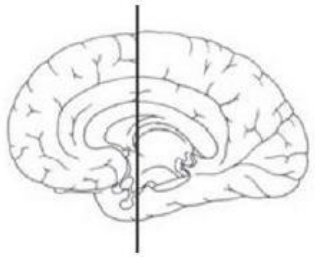


https://socratic.org

Nucleus

A collection of cell bodies in the CNS





These gray coloured areas surrounded by white matter are nuclei
These are basal nuclei

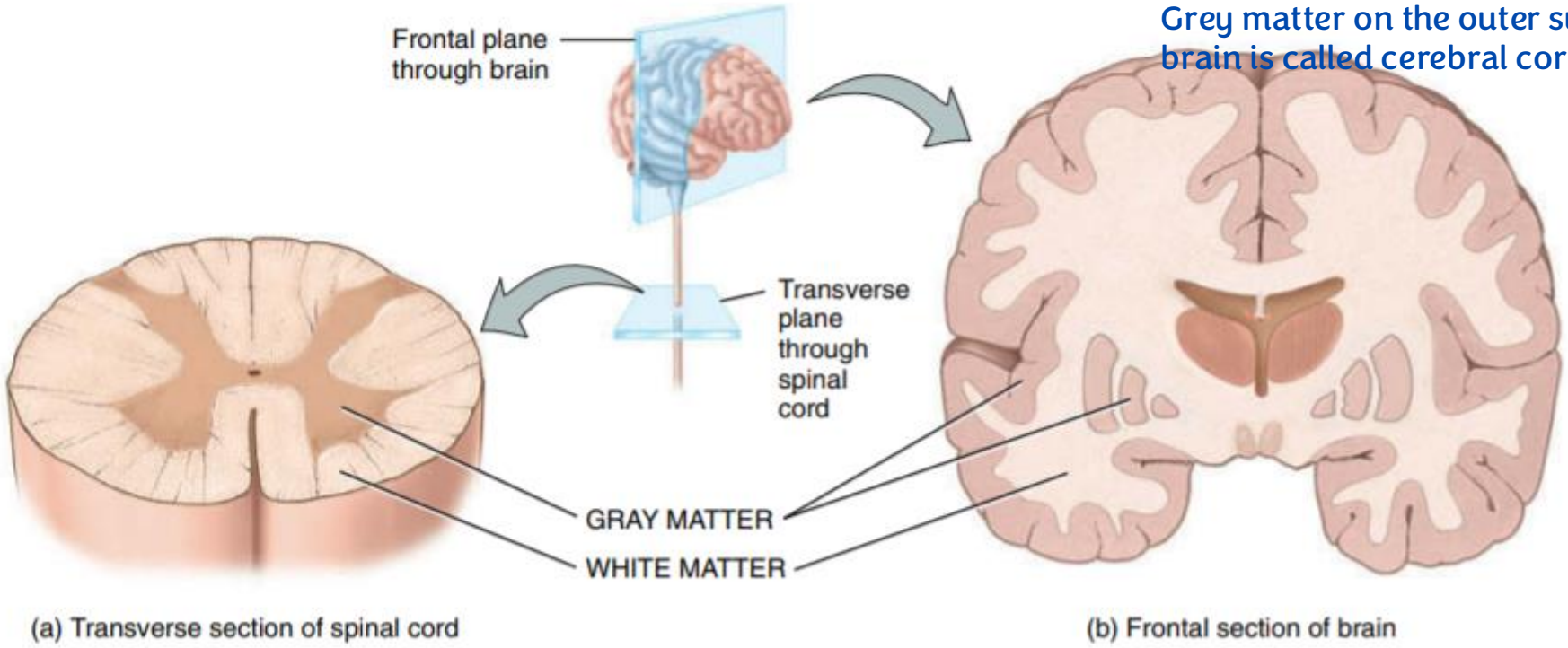
They are still called basal ganglia but that is a misnomer the correct name in basal nuclei

https://what-when-how.com/

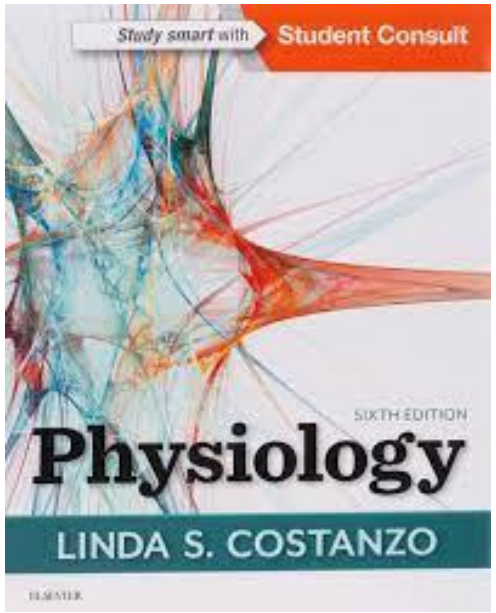
Gray matter

A widespread area of cell bodies in the CNS

Grey matter on the outer surface of the brain is called cerebral cortex



References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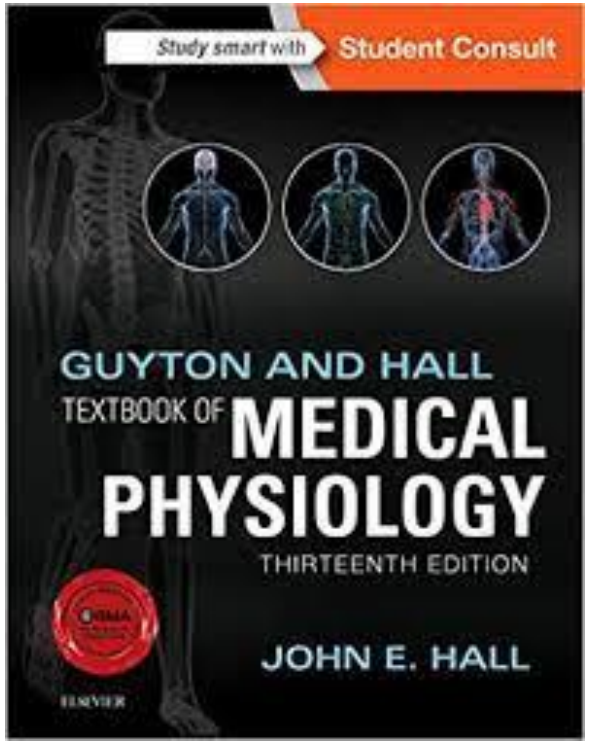
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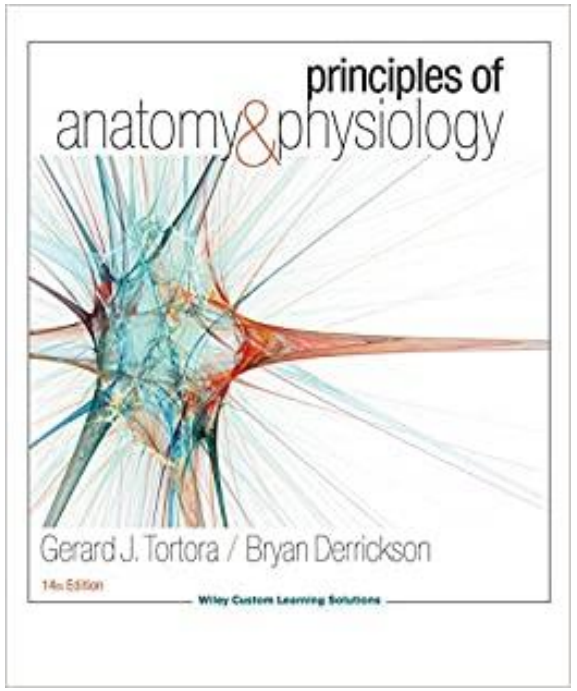
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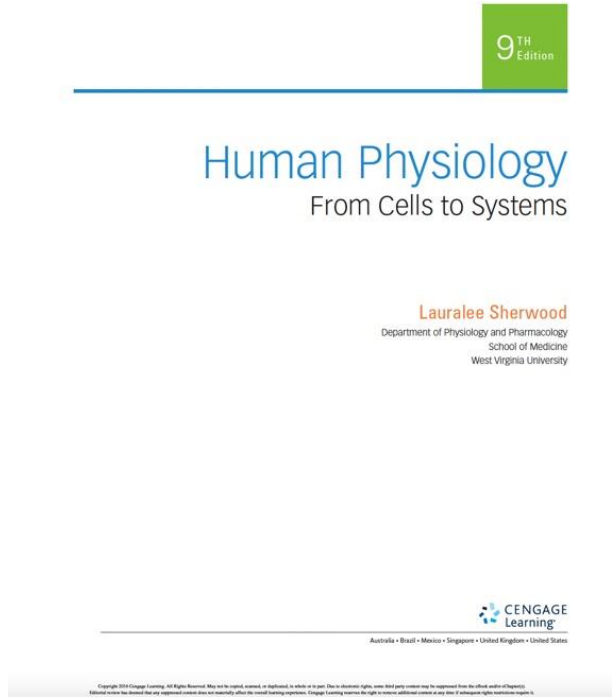
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Questions? Feedback?

Thank you

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	26	External environment like skin and special sensors (the five senses)	Removed the (the five senses) to not be misunderstood. The doctor didn't clarify clearly what the special senses are, but they actually are: Hearing,Smelling,Taste, Vision,**balance(not touch)** As mentioned in the book page 599
V1 → V2			

Additional Resources:

رسالة من الفريق العلمي: