Introduction to Neurophysiology 1

Organization and functions of the nervous system

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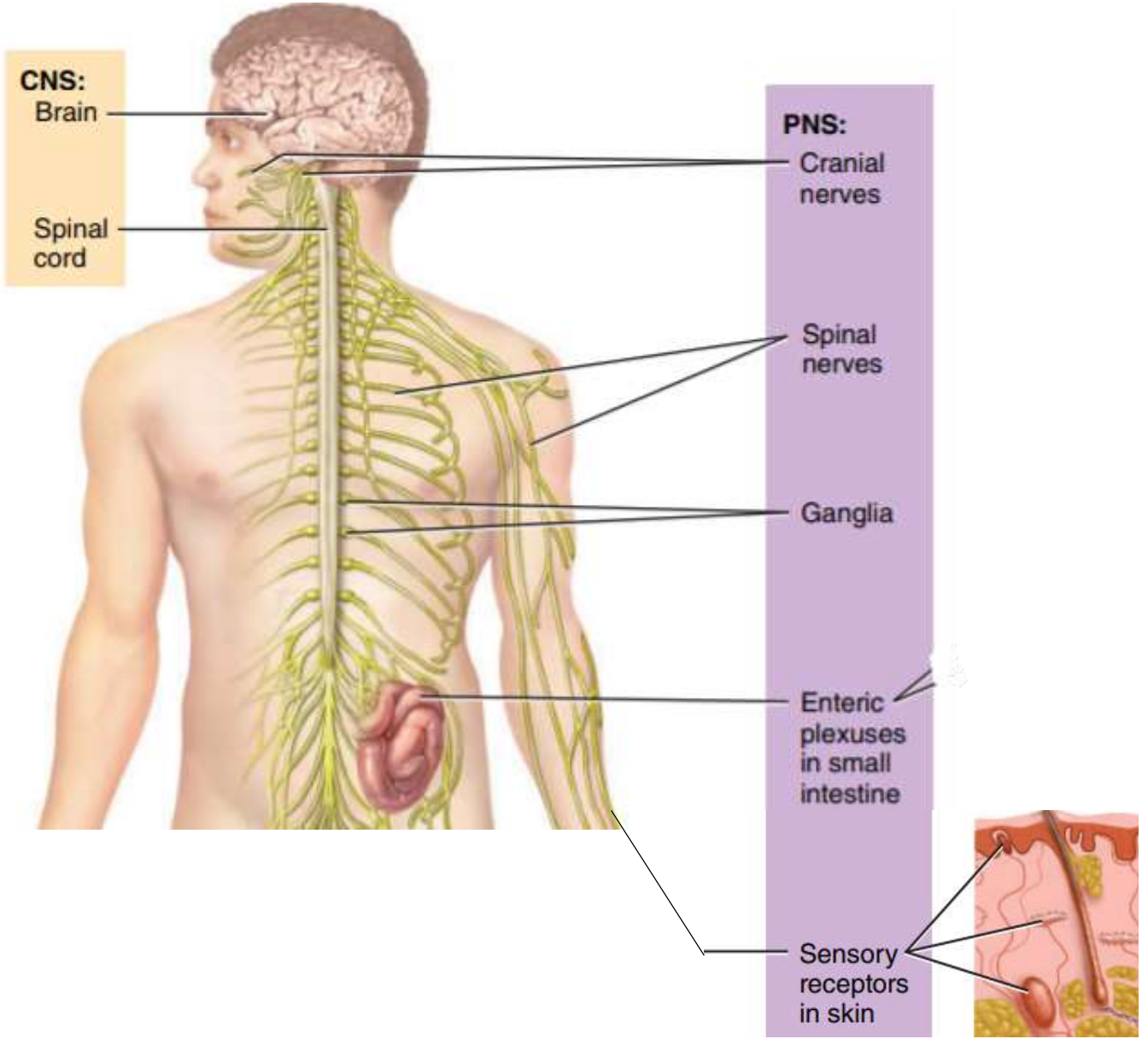
Overview of the nervous system

- The nervous system is composed of two divisions:
- 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



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.

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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.

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.”

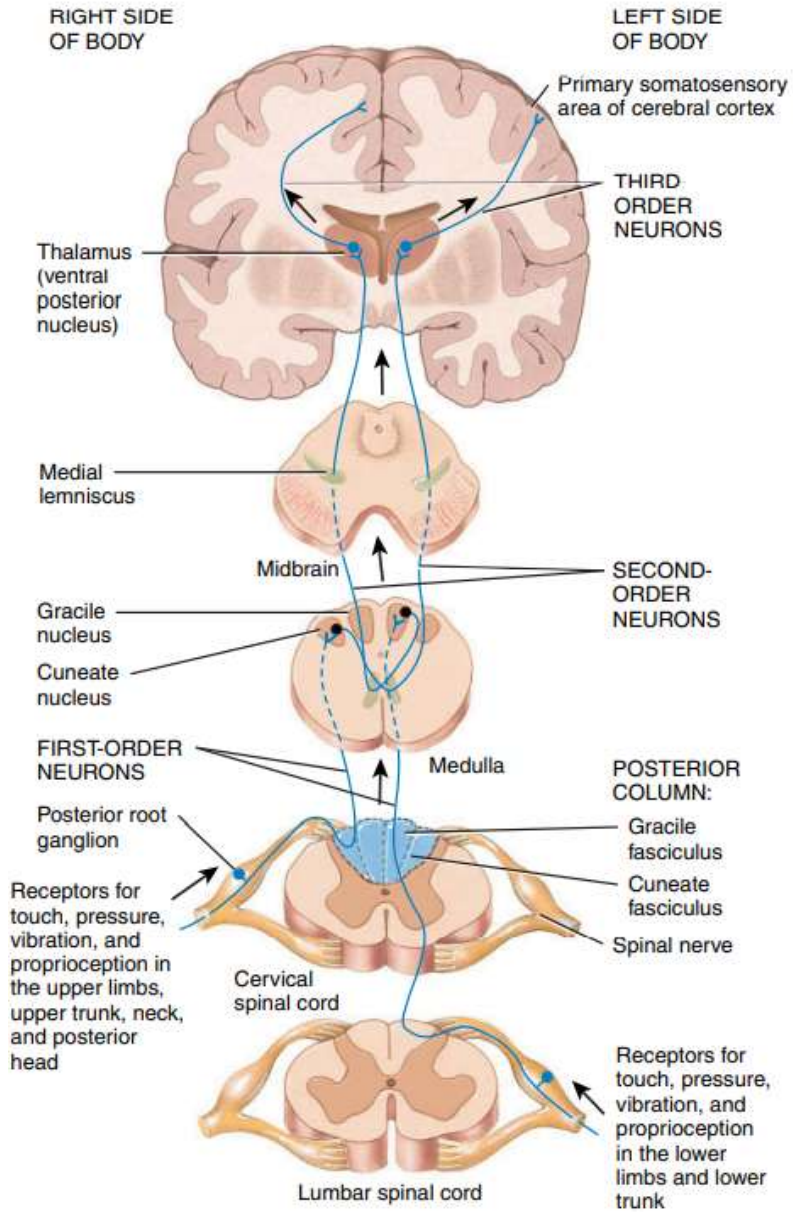
- The thinking processes of the brain compare new sensory experiences with stored memories; the memories then help to select the important new sensory information and to channel this into appropriate memory storage areas for future use or into motor areas to cause immediate bodily responses.

Spinal cord

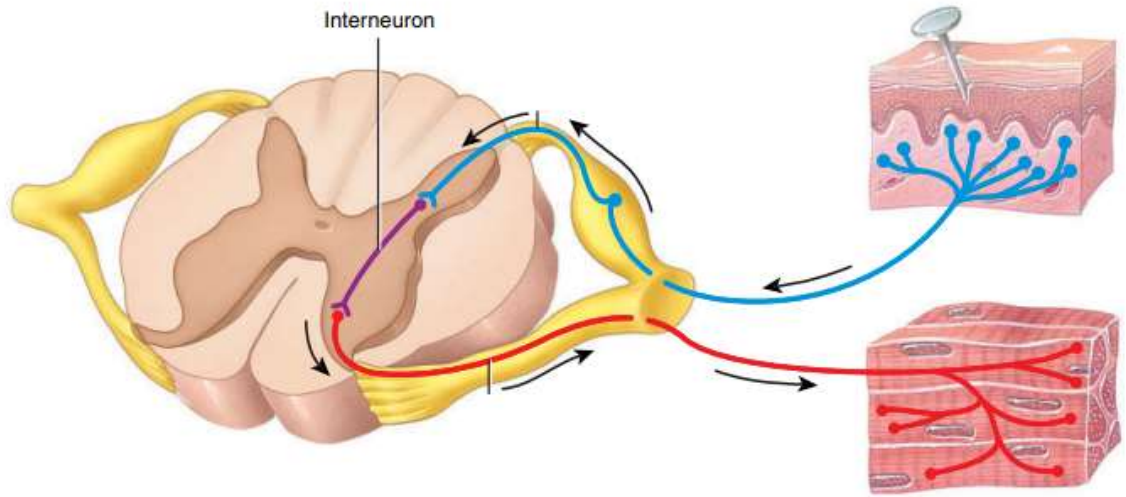
- The spinal cord has two main functions:

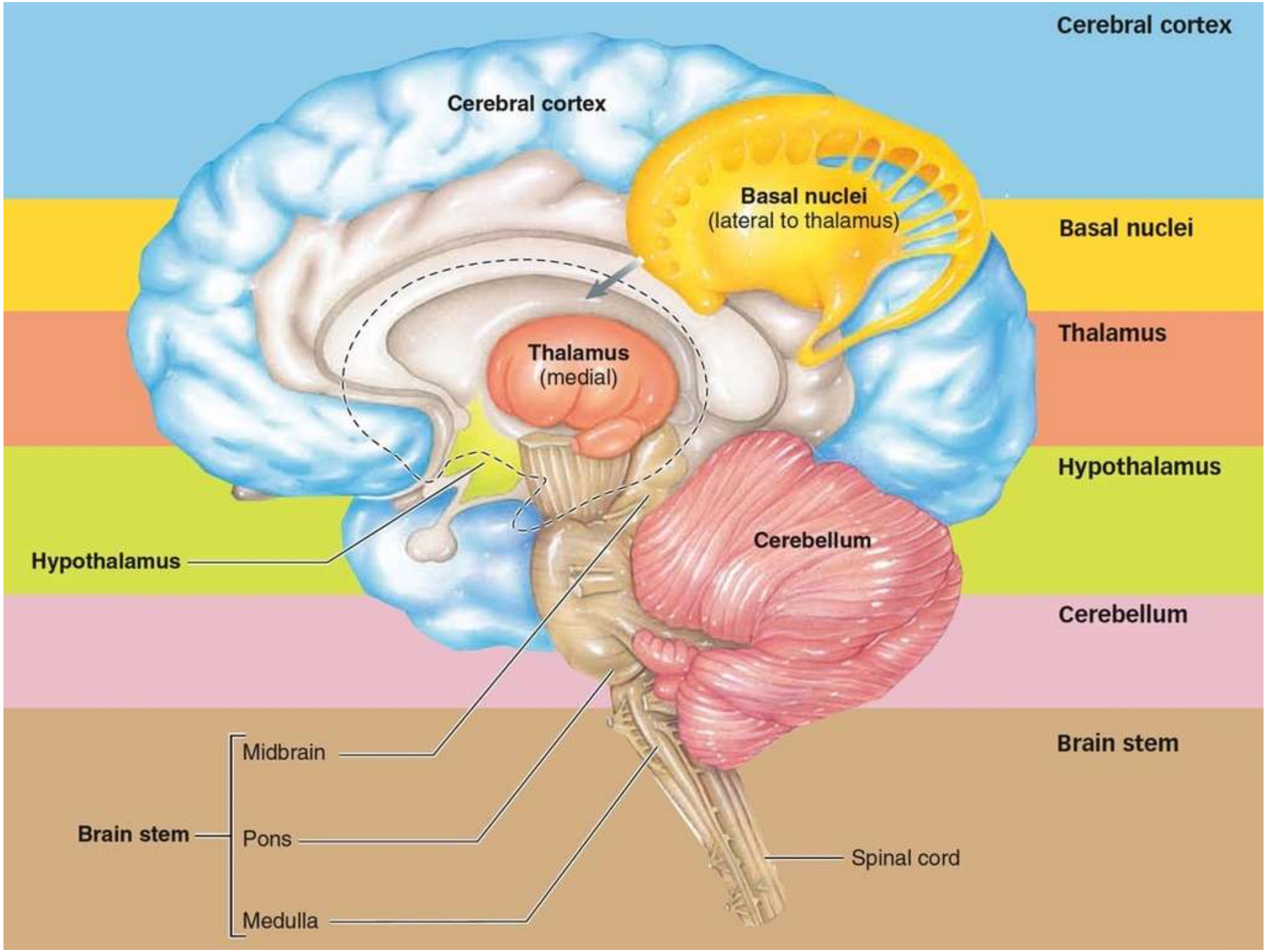
- 1- nerve impulse propagation (sensory and motor tracts): transmits signals from the periphery of the body to the brain, or in the opposite direction from the brain back to the body.

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



Posterior column–medial lemniscus pathway




Cerebral cortex
Basal nuclei
Thalamus
Hypothalamus
Cerebellum
Brain stem
Cerebral cortex
Basal nuclei
(lateral to thalamus)
Thalamus
(medial)
Hypothalamus
Cerebellum
Brain stem
Midbrain
Pons
Medulla
Spinal cord

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

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Motor function

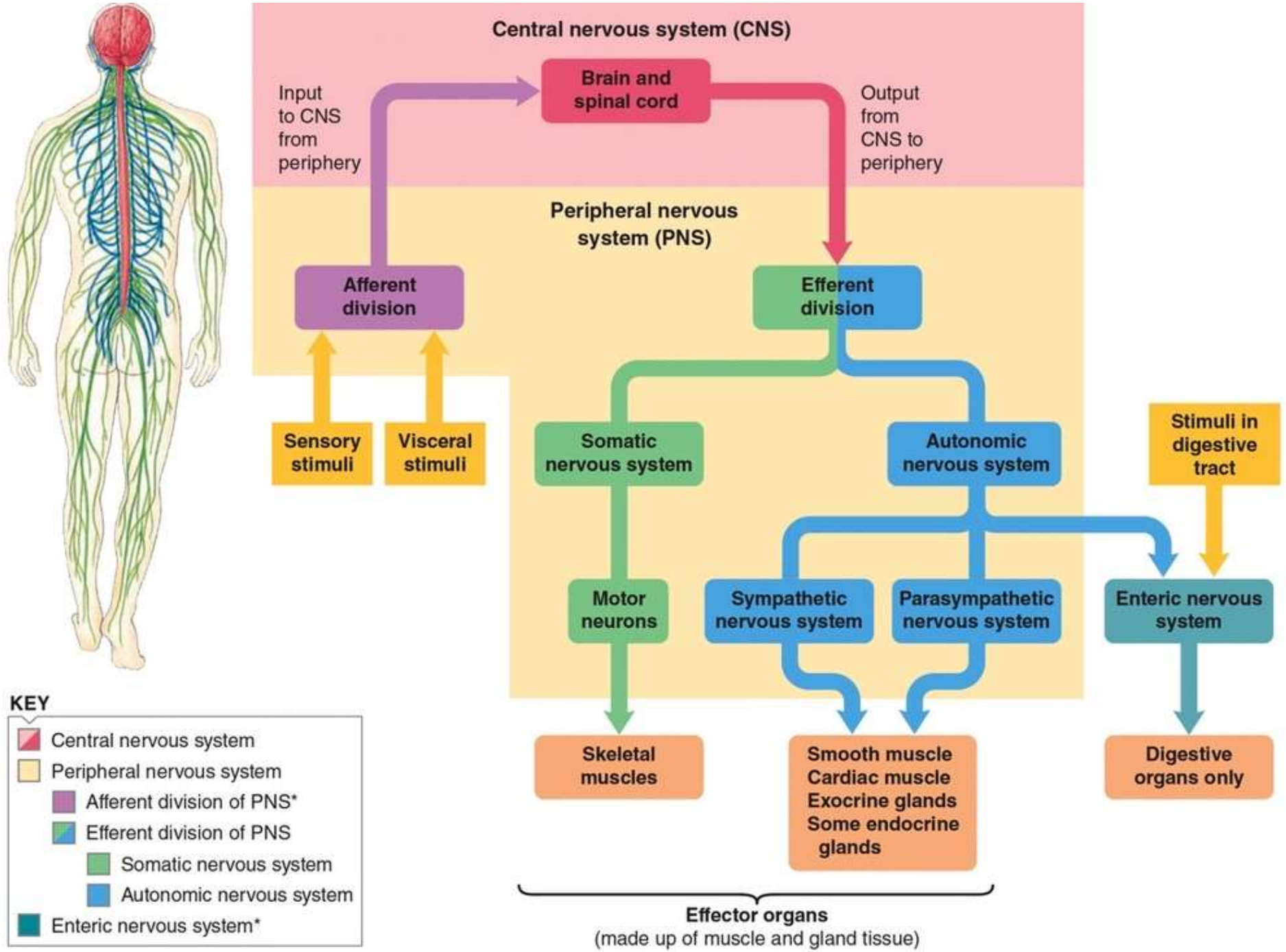
- The most important eventual role of the nervous system is to **control the various bodily activities.**

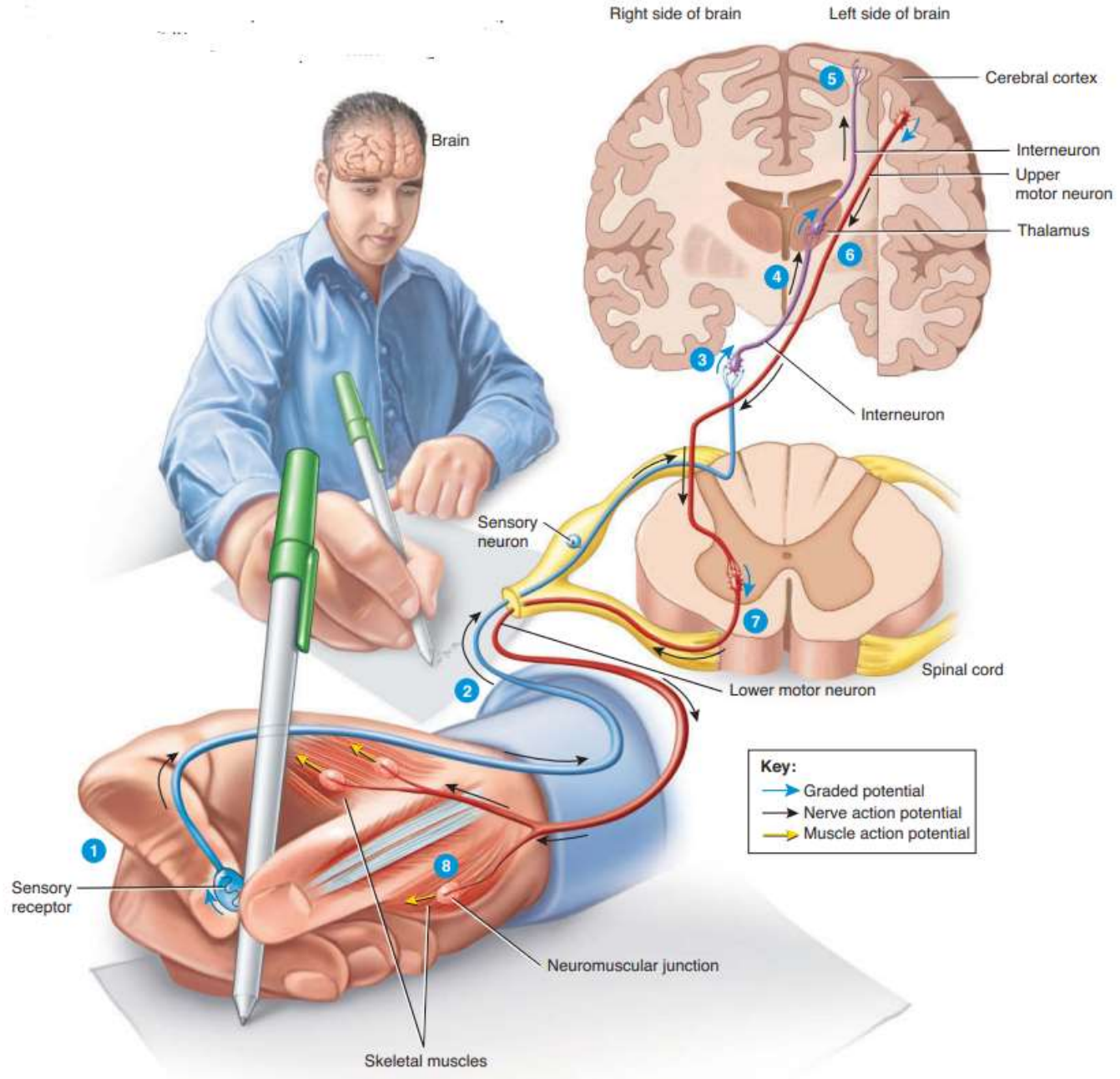
- This task is achieved by controlling:
- (1) contraction of appropriate skeletal muscles throughout the body.
- (2) contraction of smooth muscle in the internal organs.
- (3) secretion of active chemical substances by both exocrine and endocrine glands in many parts of the body.

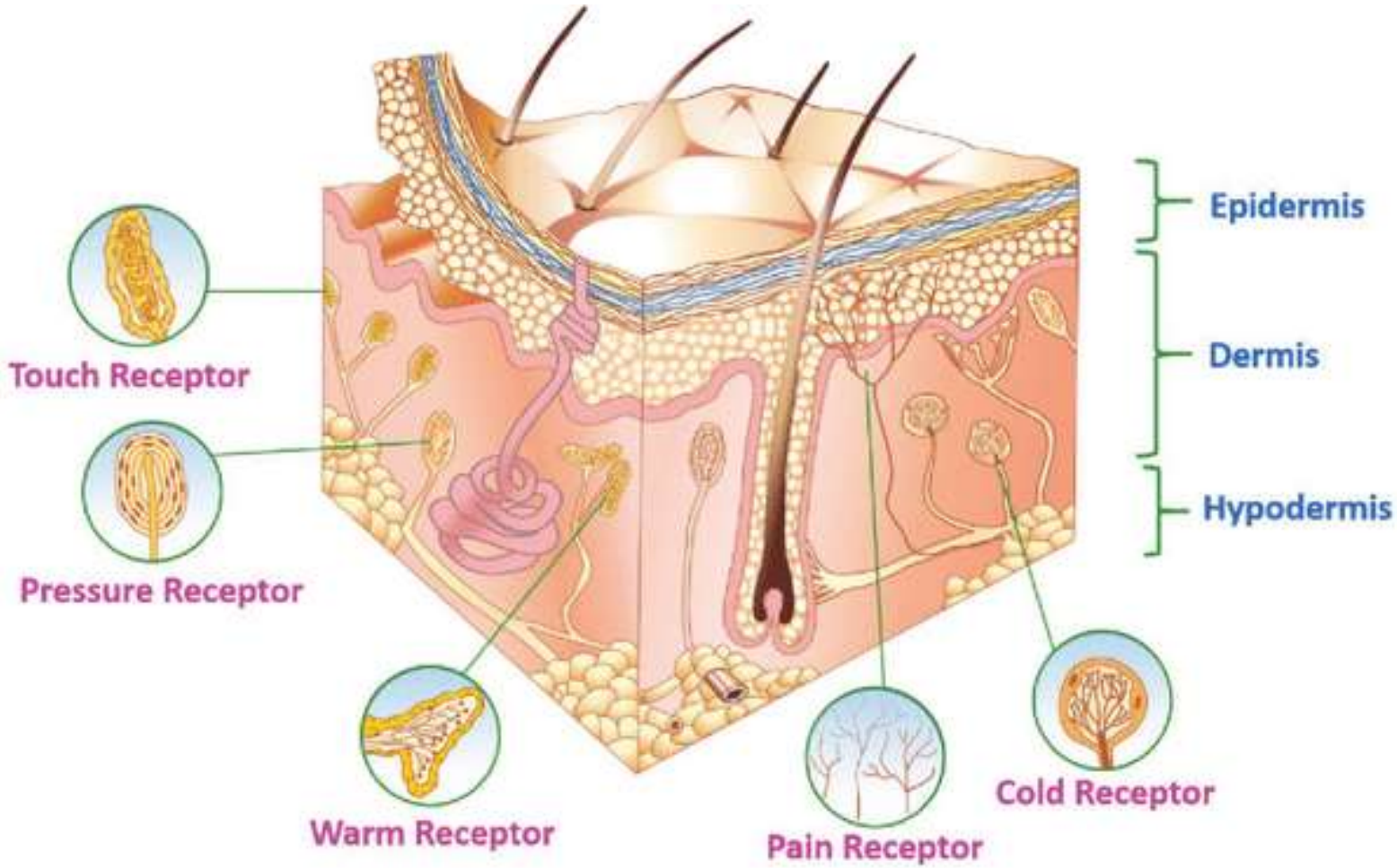
Motor function

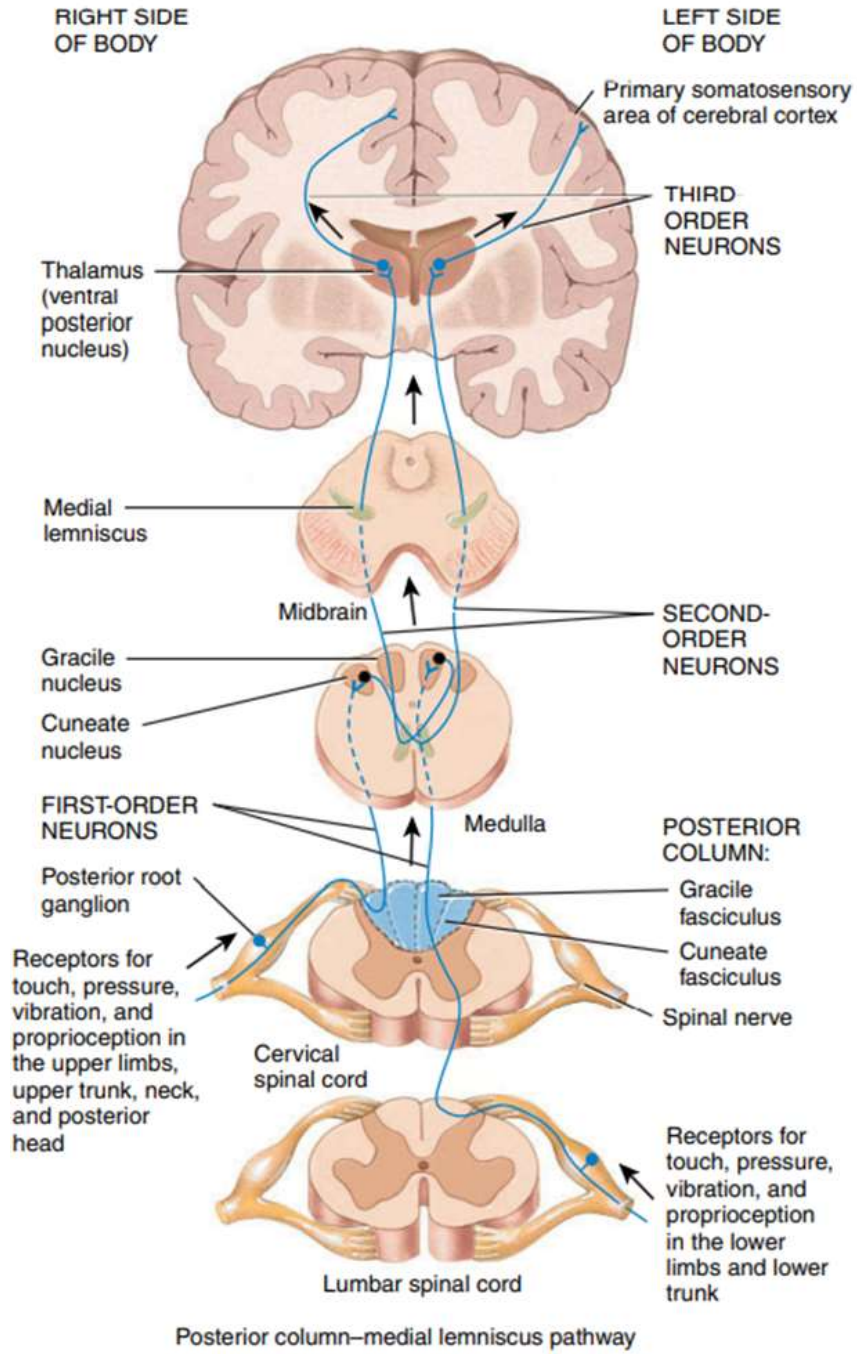
- These activities are collectively called motor functions of the nervous system.

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

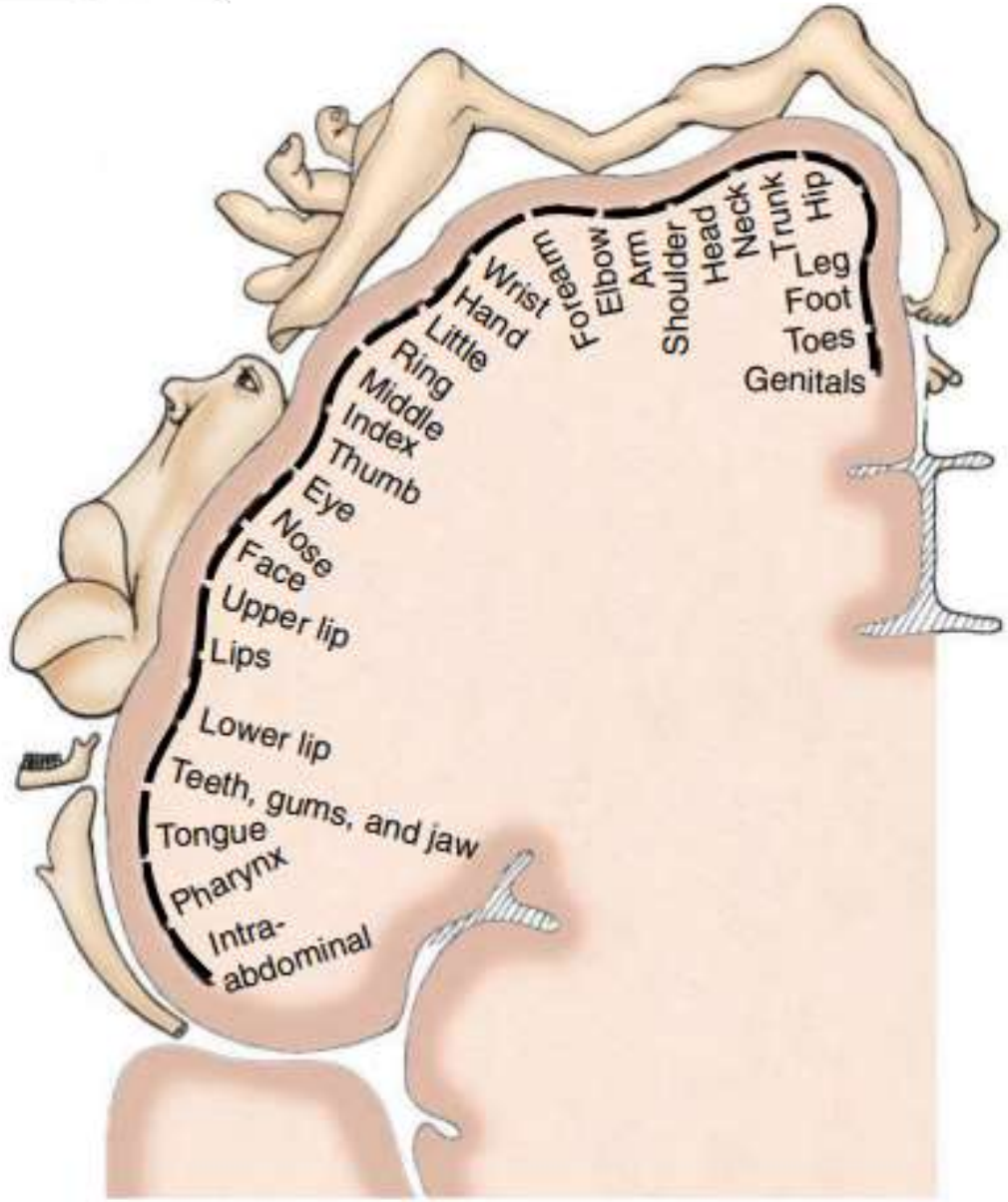

Central nervous system (CNS)
Brain and spinal cord
Input to CNS from periphery
Output from CNS to periphery
Peripheral nervous system (PNS)
Afferent division
Efferent division
Sensory stimuli
Visceral stimuli
Somatic nervous system
Autonomic nervous system
Stimuli in digestive tract
Motor neurons
Sympathetic nervous system
Parasympathetic nervous system
Enteric nervous system
Skeletal muscles
Smooth muscle
Cardiac muscle
Exocrine glands
Some endocrine glands
Digestive organs only
Effector organs
(made up of muscle and gland tissue)
KEY
Central nervous system
Peripheral nervous system
Afferent division of PNS*
Efferent division of PNS
Somatic nervous system
Autonomic nervous system
Enteric nervous system*


Right side of brain
Left side of brain
Cerebral cortex
Brain
Interneuron
Upper motor neuron
Thalamus
Interneuron
Sensory neuron
Spinal cord
Lower motor neuron
Key:
Graded potential
Nerve action potential
Muscle action potential
Sensory receptor
Neuromuscular junction
Skeletal muscles

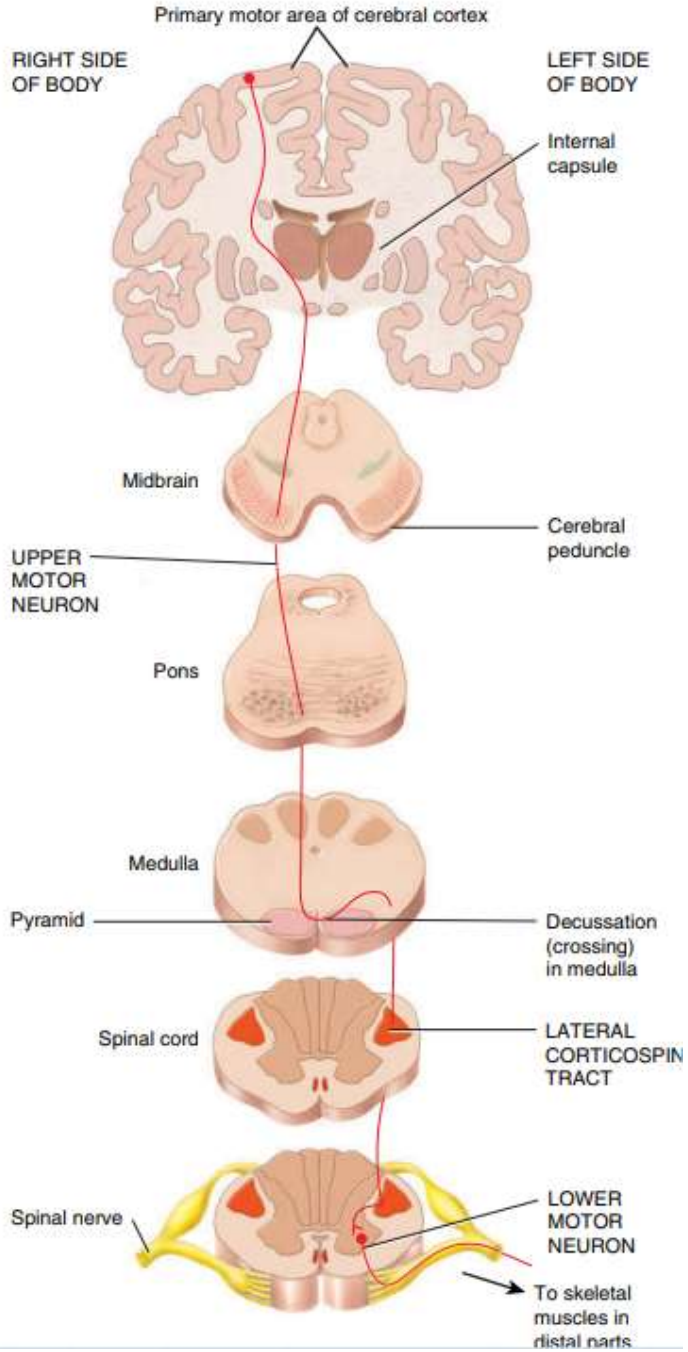

Epidermis
Dermis
Hypodermis
Touch Receptor
Pressure Receptor
Warm Receptor
Pain Receptor
Cold Receptor

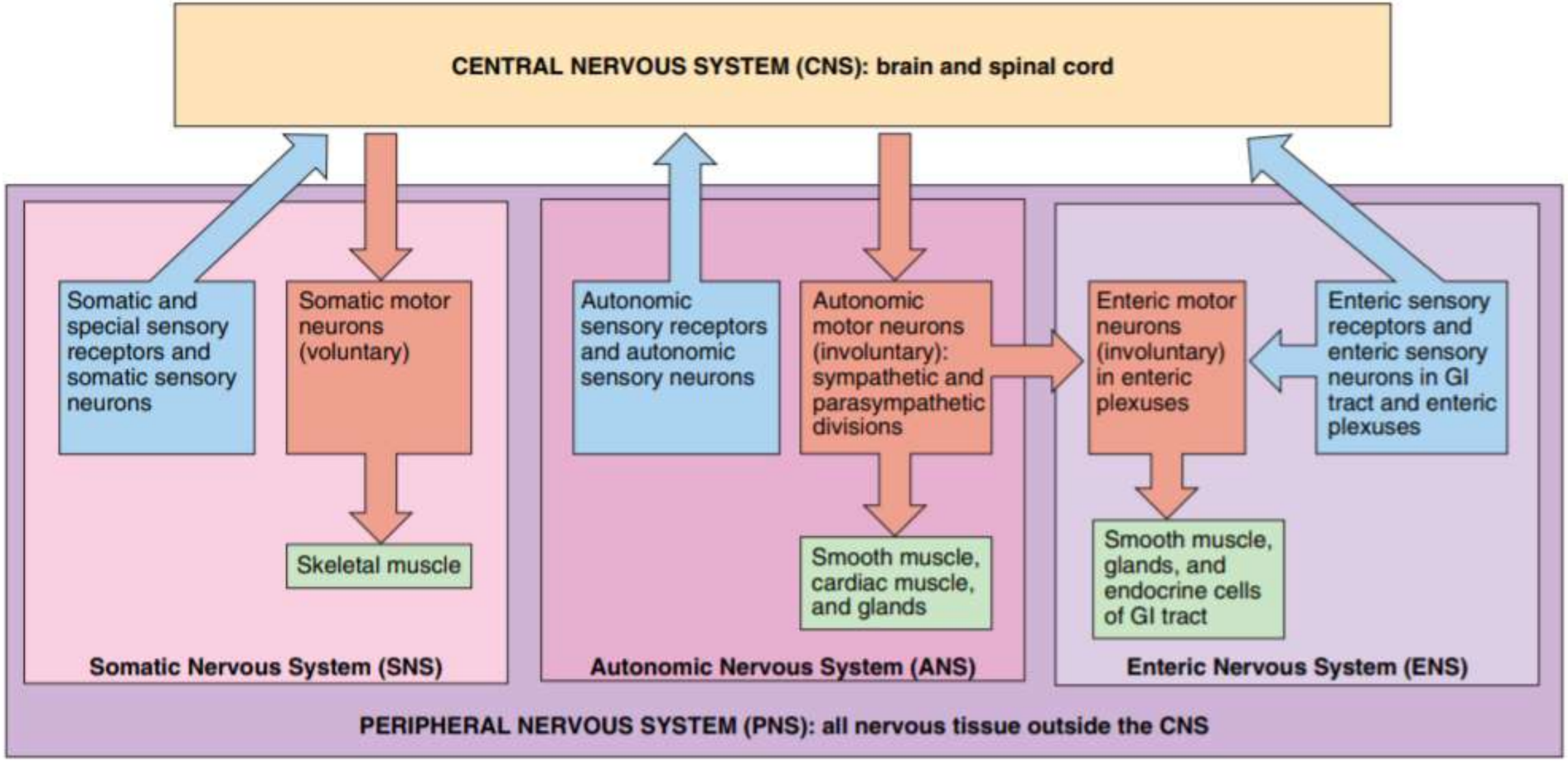


Posterior column–medial lemniscus pathway



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


Primary motor area of cerebral cortex
RIGHT SIDE OF BODY
LEFT SIDE OF BODY
Internal capsule
Midbrain
Cerebral peduncle
UPPER MOTOR NEURON
Pons
Medulla
Pyramid
Decussation (crossing) in medulla
Spinal cord
LATERAL CORTICOSPIN TRACT
Spinal nerve
LOWER MOTOR NEURON
To skeletal muscles in distal parts

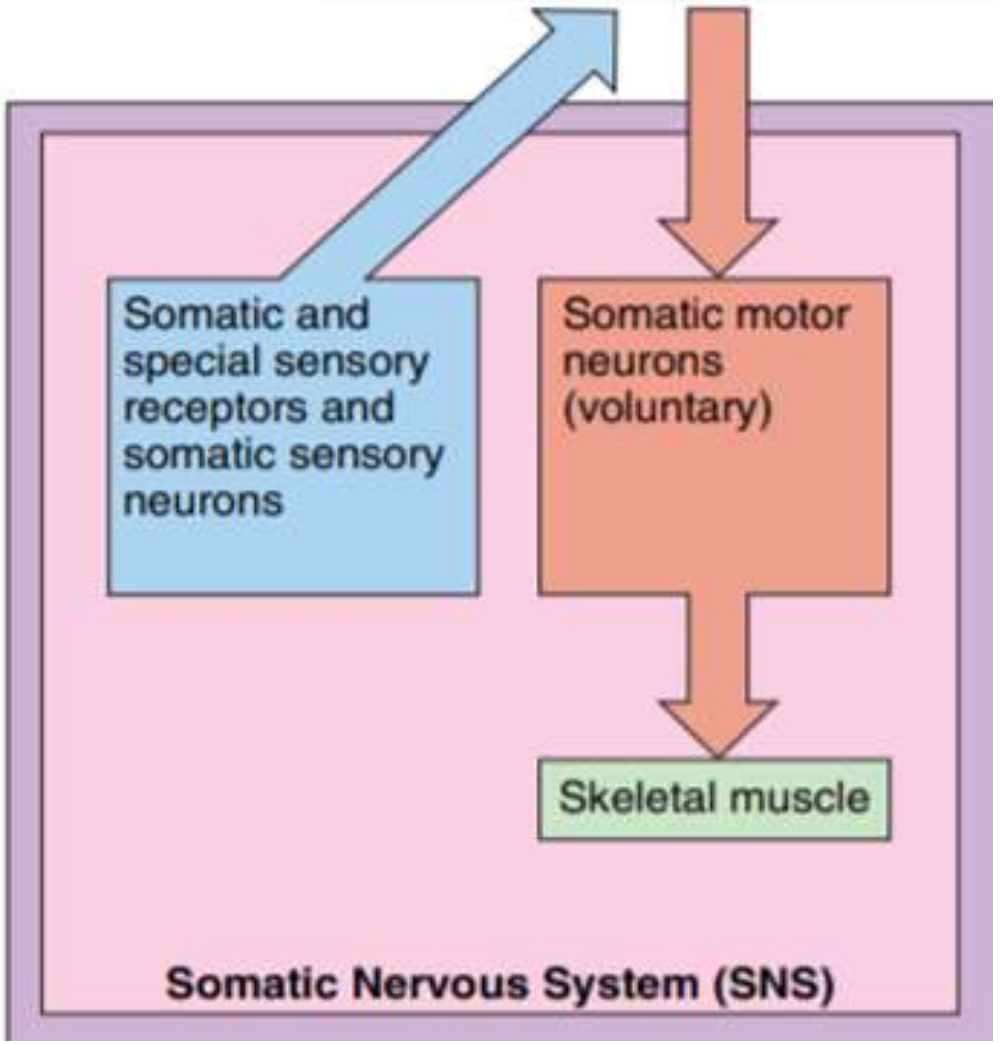

CENTRAL NERVOUS SYSTEM (CNS): brain and spinal cord
Somatic and special sensory receptors and somatic sensory neurons
Somatic motor neurons (voluntary)
Skeletal muscle
Somatic Nervous System (SNS)
Autonomic sensory receptors and autonomic sensory neurons
Autonomic motor neurons (involuntary): sympathetic and parasympathetic divisions
Smooth muscle, cardiac muscle, and glands
Autonomic Nervous System (ANS)
Enteric motor neurons (involuntary) in enteric plexuses
Enteric sensory receptors and enteric sensory neurons in GI tract and enteric plexuses
Smooth muscle, glands, and endocrine cells of GI tract
Enteric Nervous System (ENS)
PERIPHERAL NERVOUS SYSTEM (PNS): all nervous tissue outside the CNS

Somatic nervous system

- **sensory neurons**: convey information from somatic receptors (in the in the head, body wall and limbs)and from receptors of special senses: vision, hearing and taste 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.

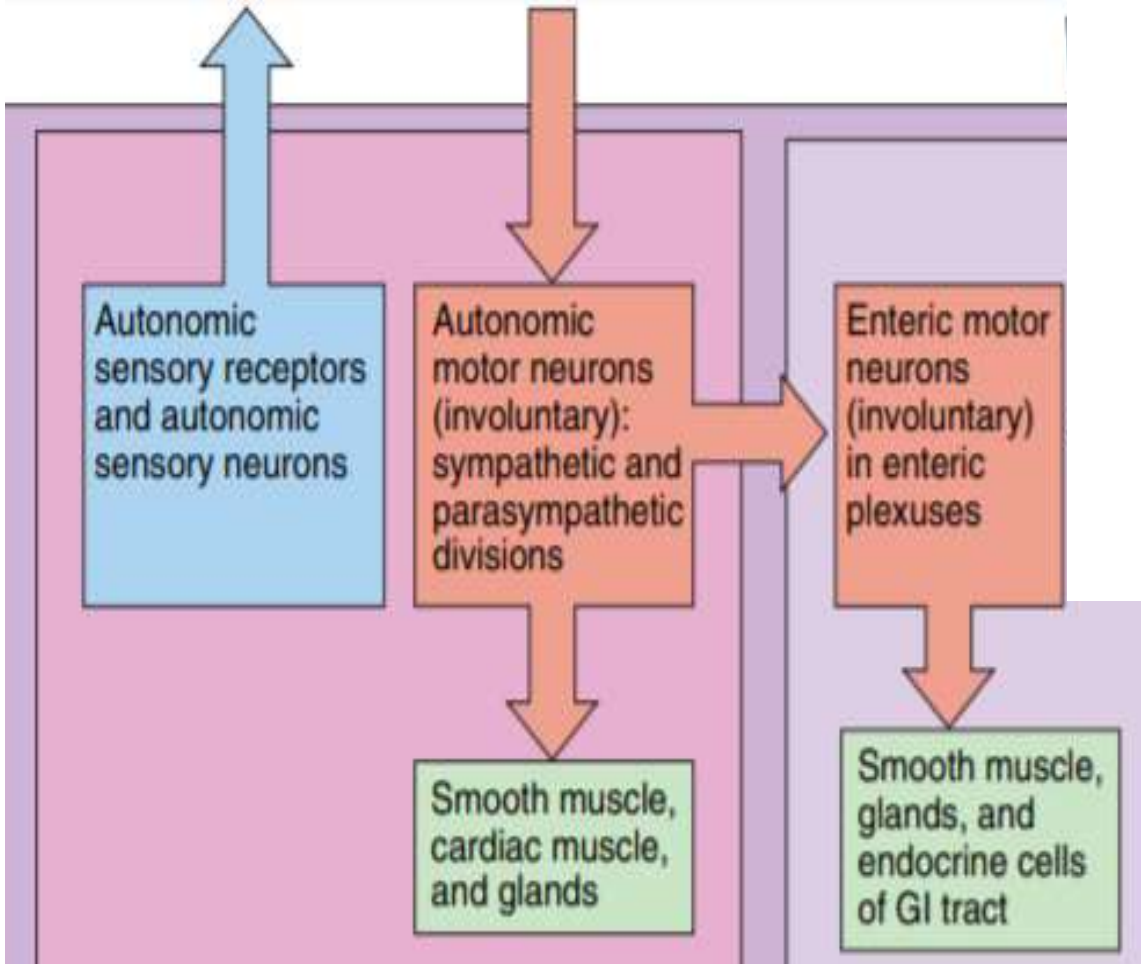


Autonomic nervous system

- **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.

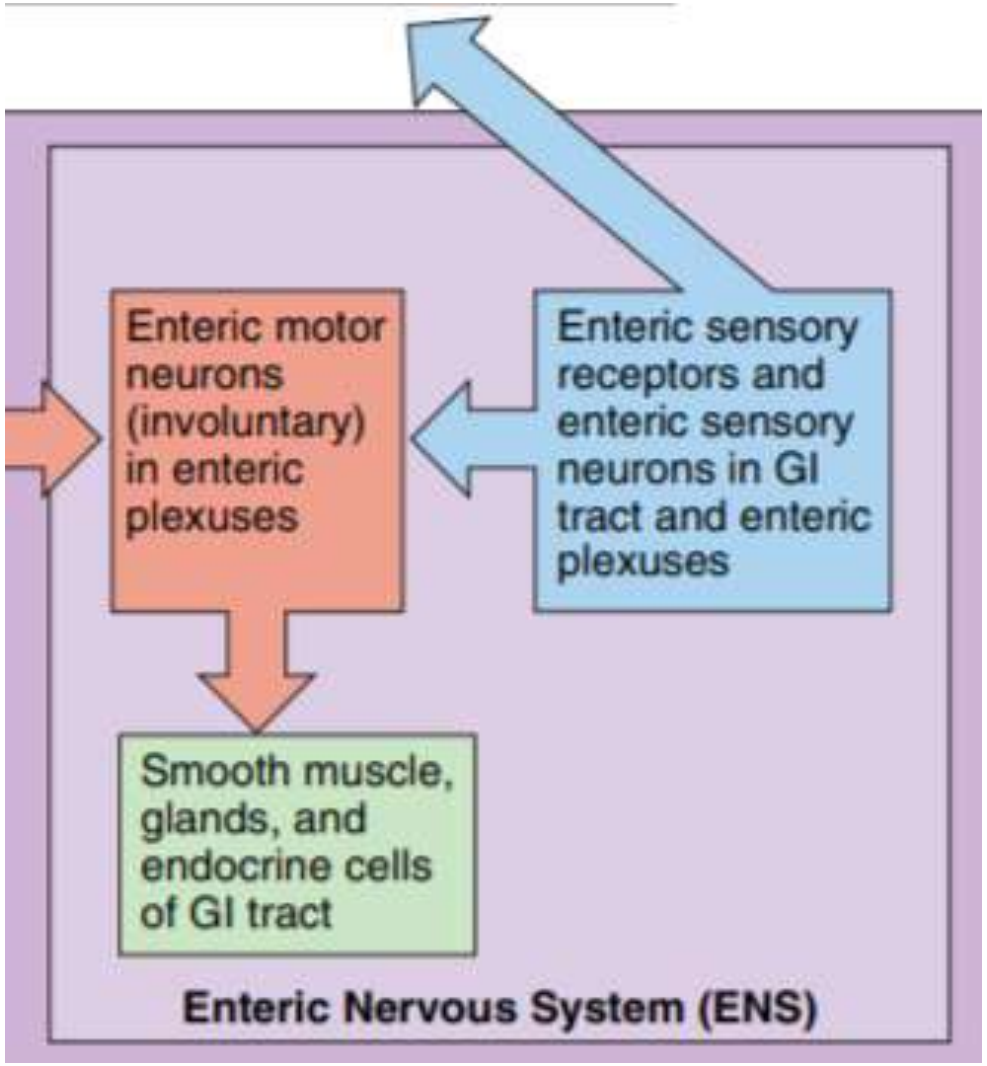


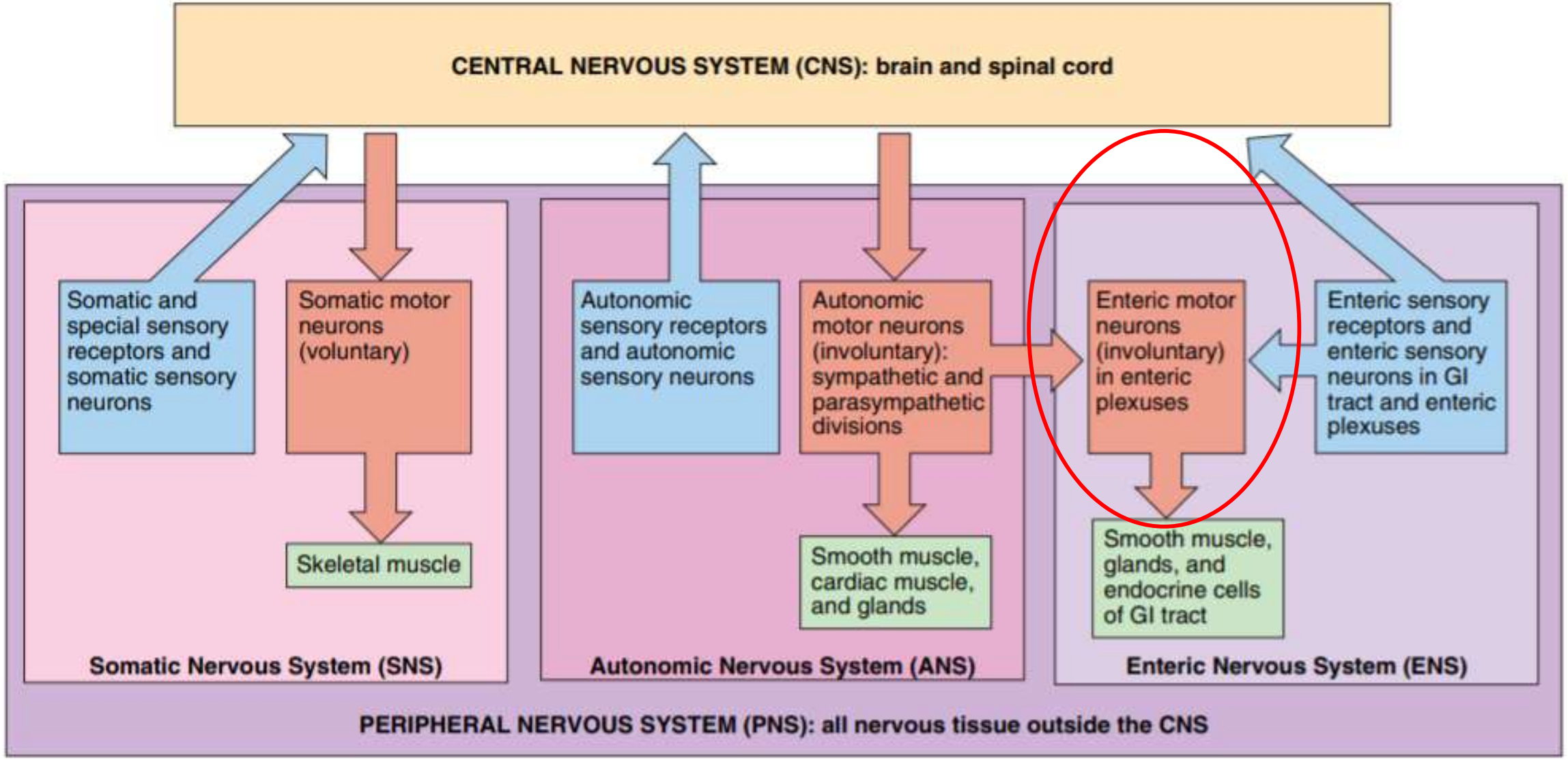
Enteric nervous system

- **Sensory neurons**: monitor changes within the digestive system (gastrointestinal: GI).

- **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.

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

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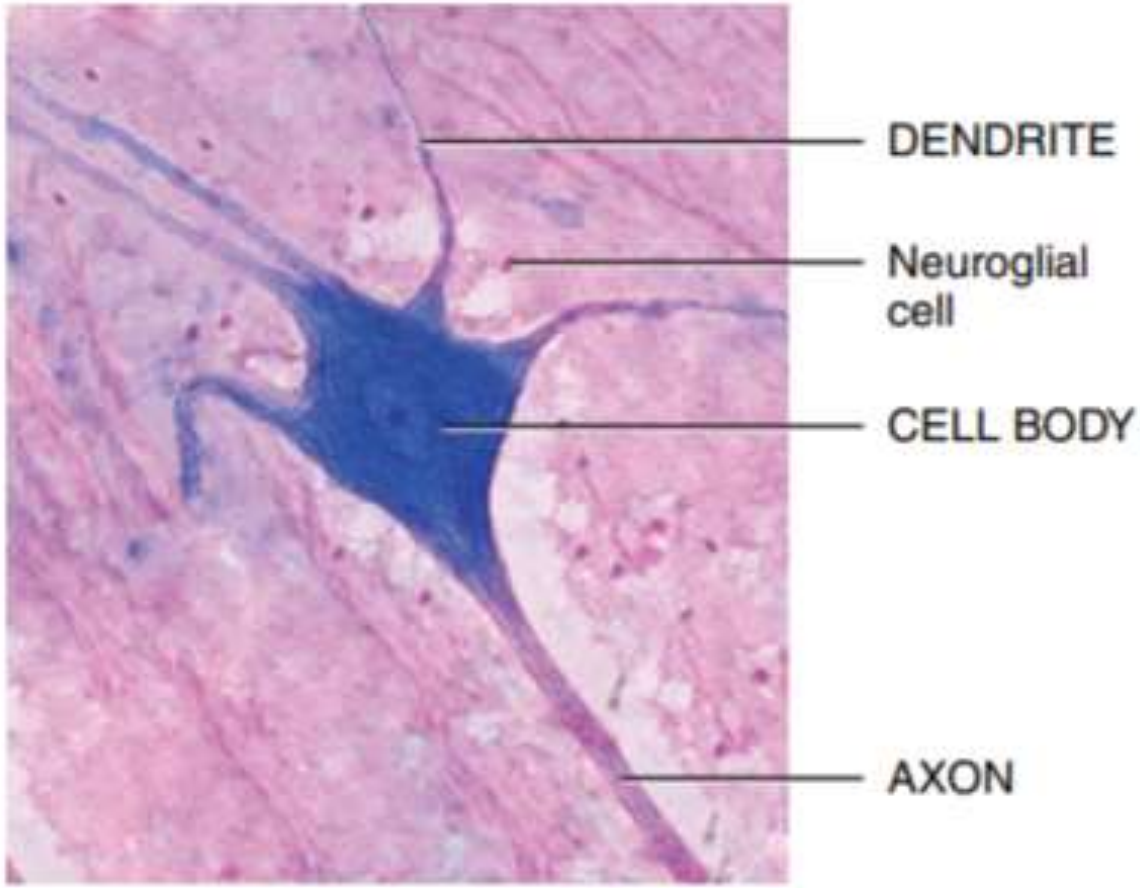
The functional unit of the nervous system is the neuron



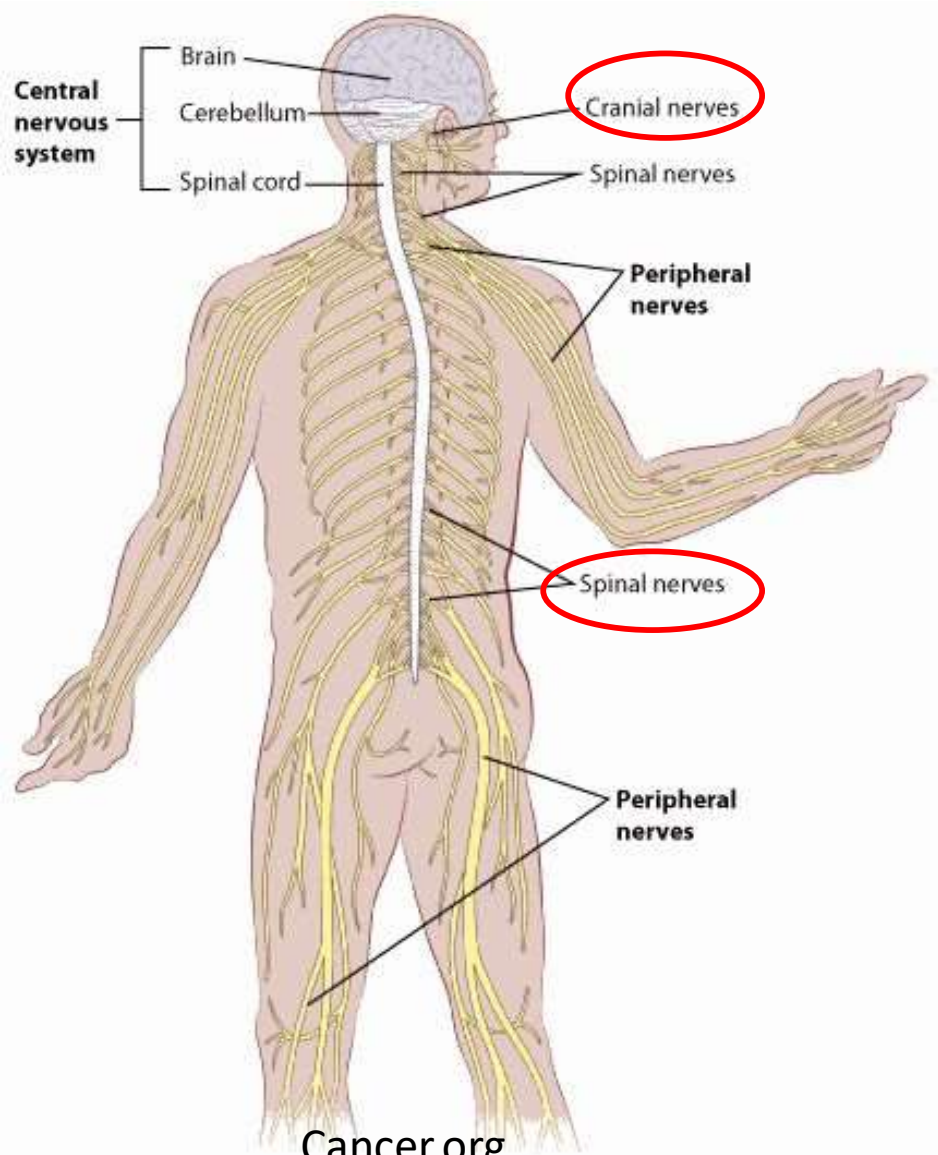
Collections of nervous tissue

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

Collections of axons

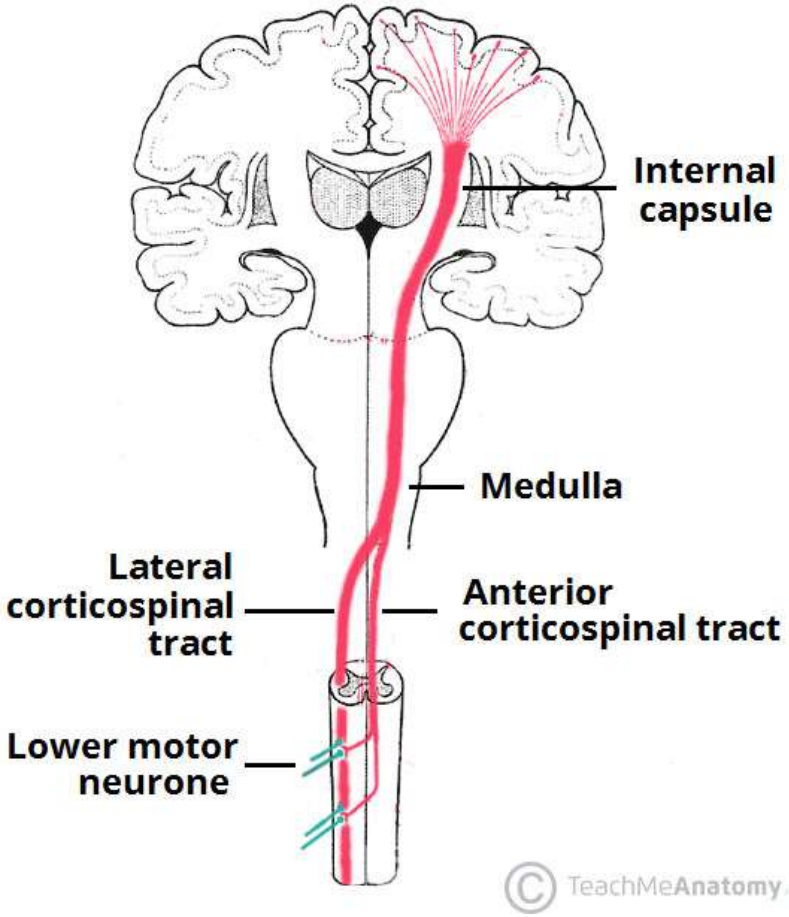
- The widespread collection of axons in the CNS is called **white matter**.
- A bundle of axons in the CNS is called **tract**.
- A bundle of axons in the PNS is called **nerve**.

Nerve



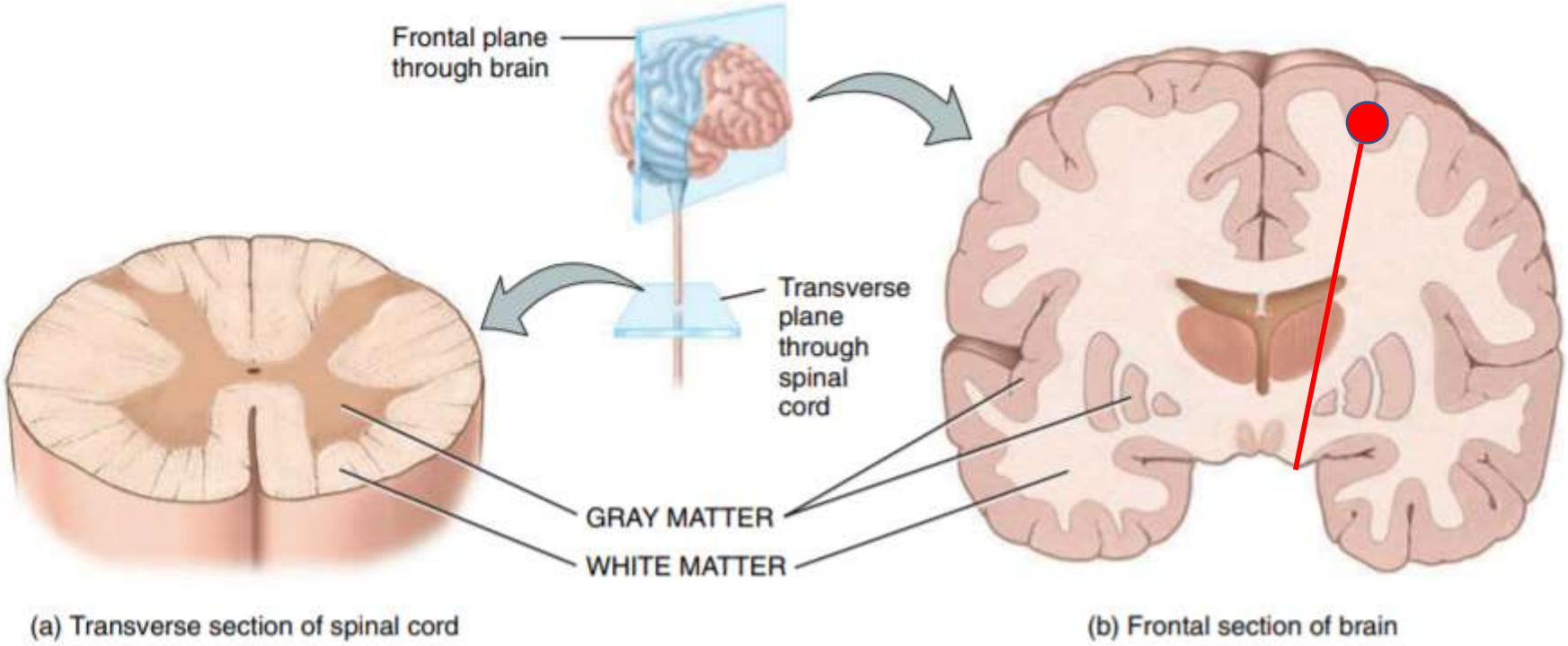
Cancer.org

Tract



Descending pathway

White matter



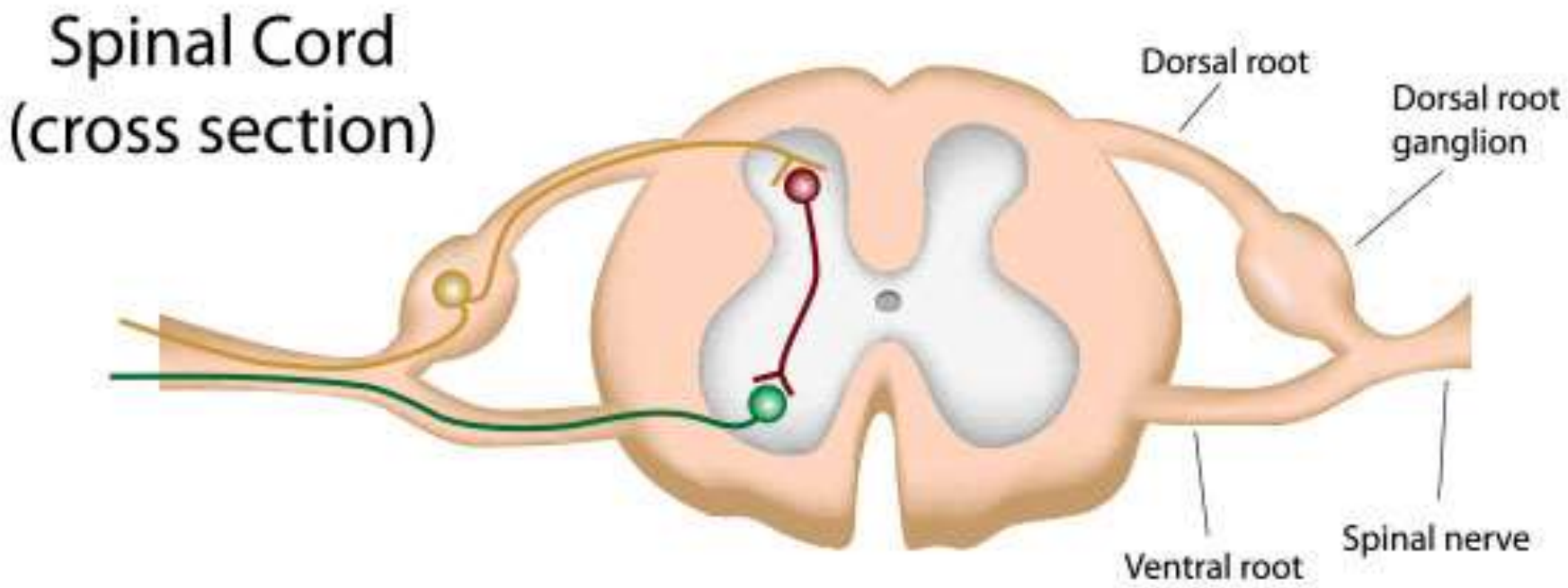
Collections of neuronal cell bodies

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

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

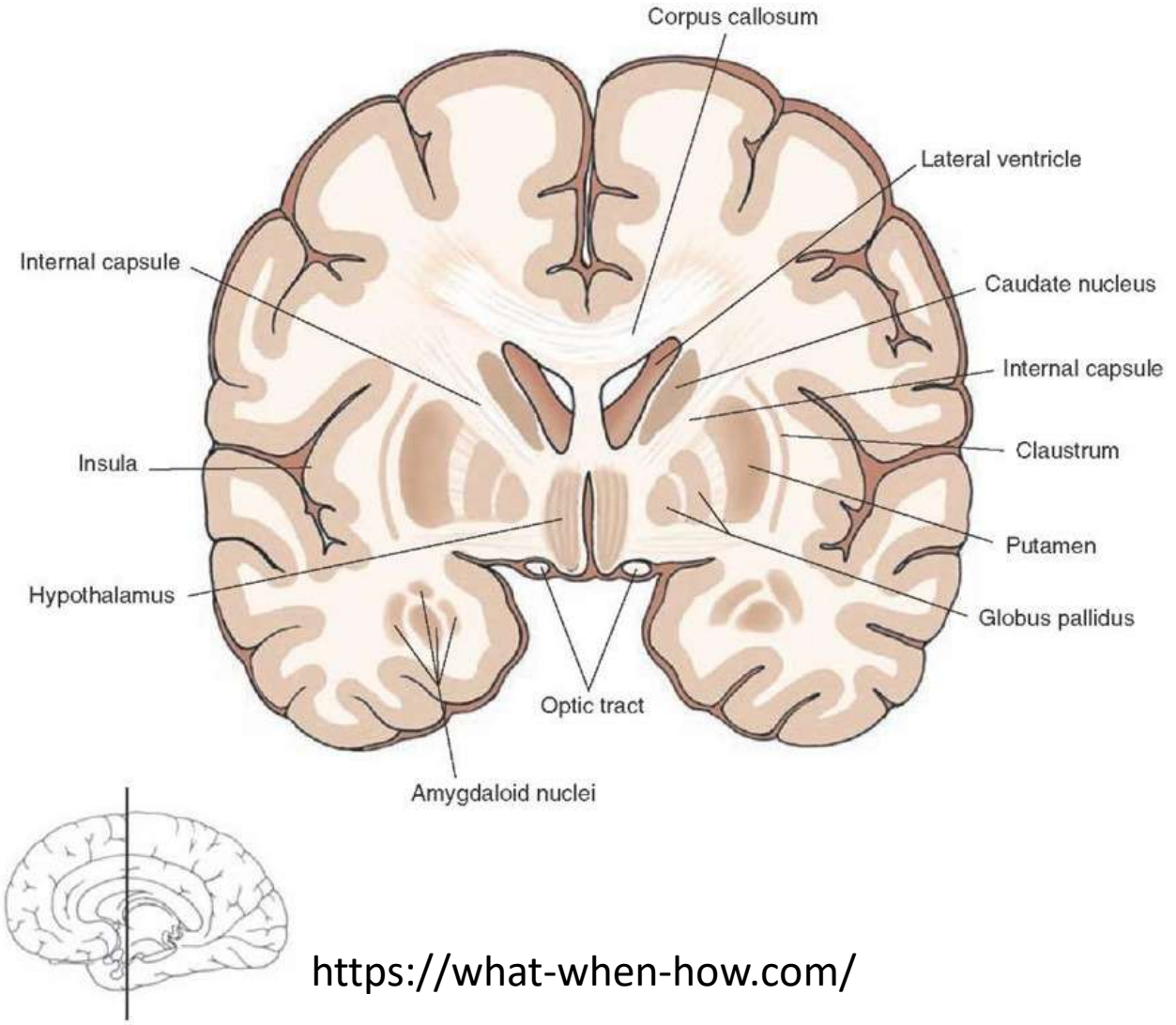
A cluster of neuronal cell bodies in the PNS is called **ganglion**.

Ganglion



https://socratic.org

Nucleus



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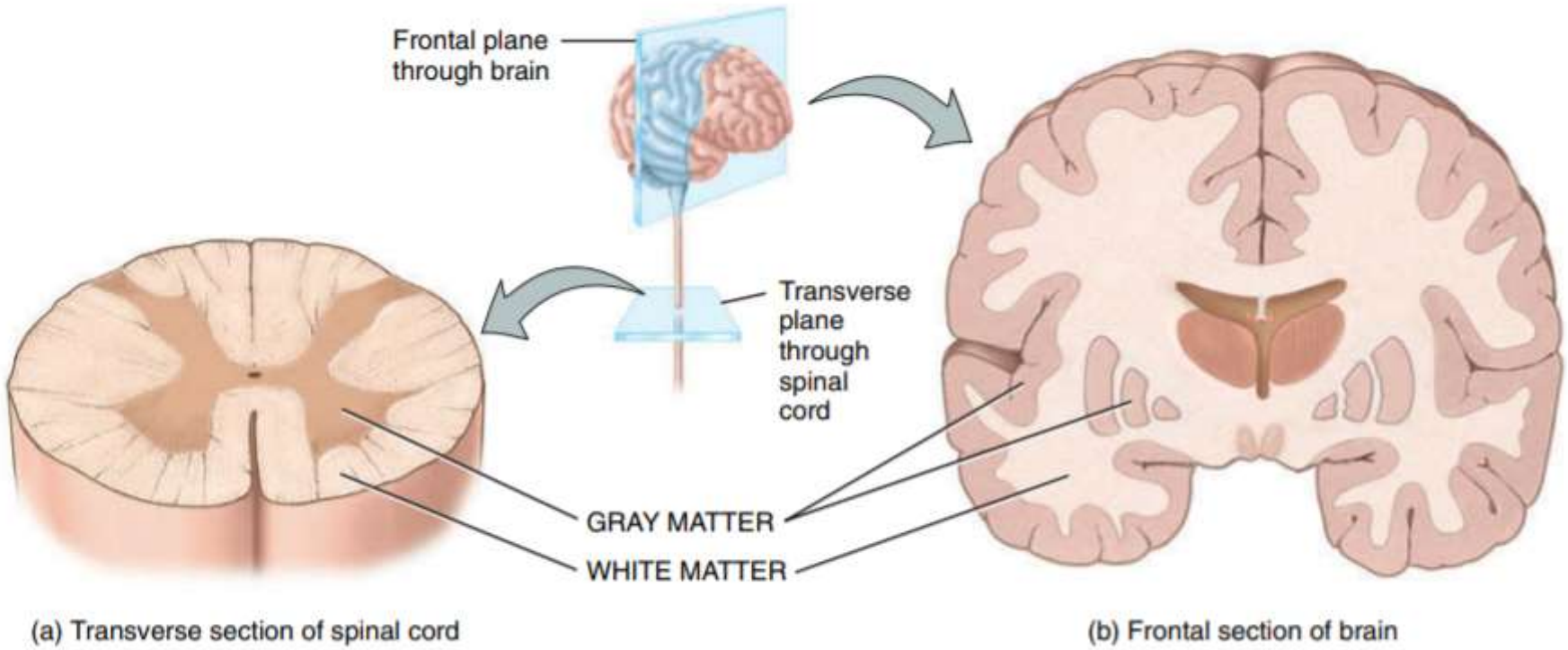
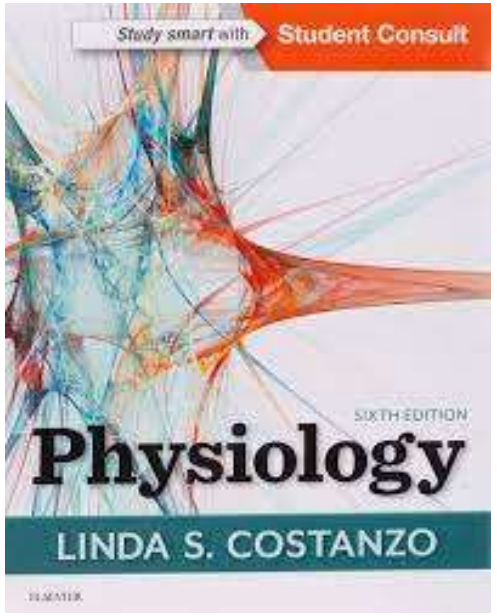
Gray matter


Frontal plane through brain
Transverse plane through spinal cord
GRAY MATTER
WHITE MATTER
(a) Transverse section of spinal cord
(b) Frontal section of brain

References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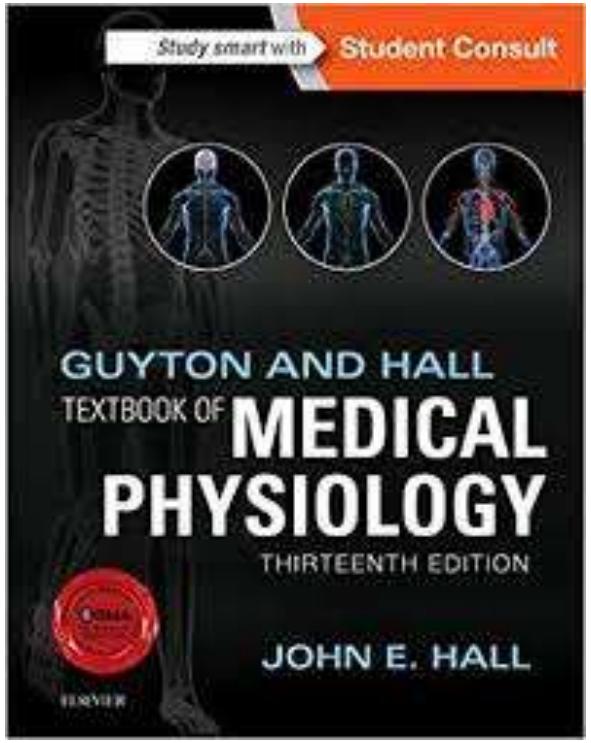
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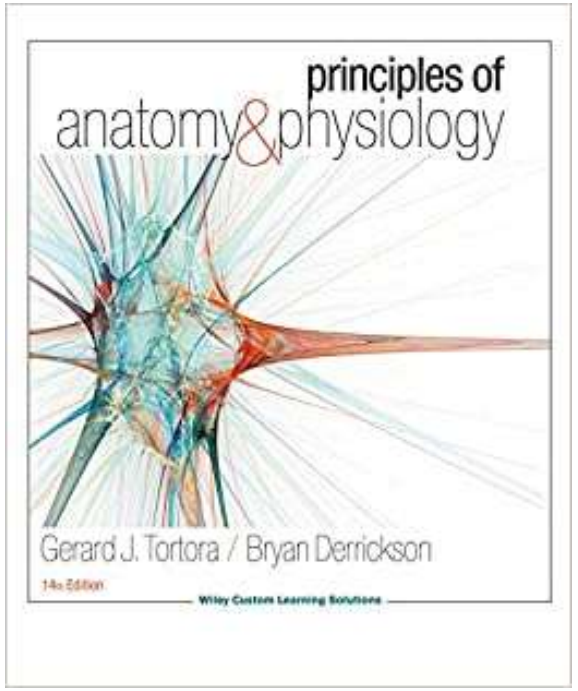
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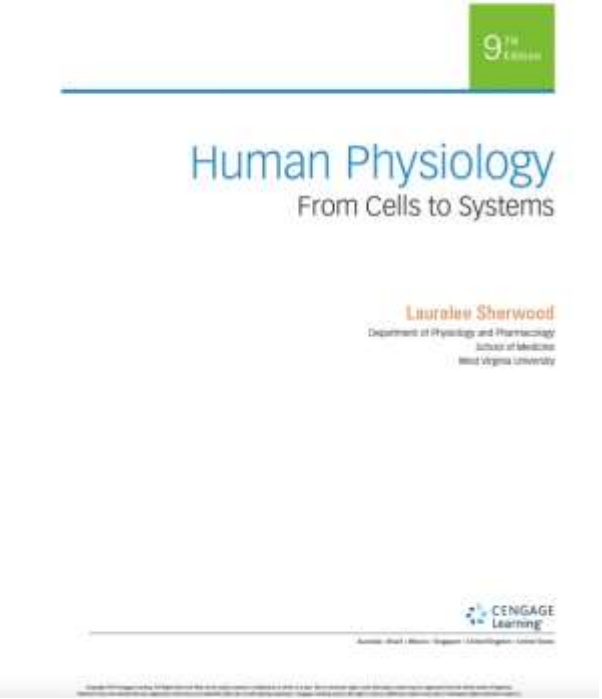
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