Central Nervous System: Brain & Spinal cord

Physiology-2nd class

Neuronal Signaling and the Structure of the Nervous System

The various structures of the nervous system are interconnected, but for convenience we divide them into two parts:

(1) the **central nervous system** (**CNS**), composed of the brain and spinal cord; and

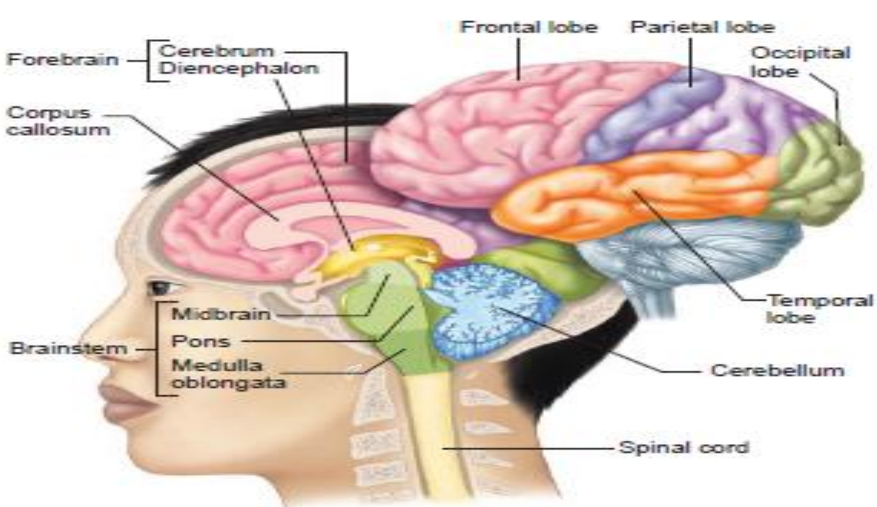
(2) the **peripheral nervous system** (**PNS**), consisting of the nerves that connect the brain and spinal cord with the body's muscles, glands, sense organs, and other tissues.

The basic unit of the nervous system is the nerve cell, or **neuron.** Neurons operate by generating electrical signals that move from one part of the cell to another part of the same cell or to neighboring cells. In most neurons, the electrical signal causes the release of chemical messengers—**neurotransmitters** —to communicate with other cells.

Central Nervous System:

Brain

The brain has four different regions: the **cerebrum, diencephalon, brainstem,** and **cerebellum**. The cerebrum and diencephalon together constitute the **forebrain.** The brainstem consists of the **midbrain, pons,** and **medulla oblongata.** The brain also contains four interconnected cavities, the **cerebral ventricles,**which are filled with fluid.



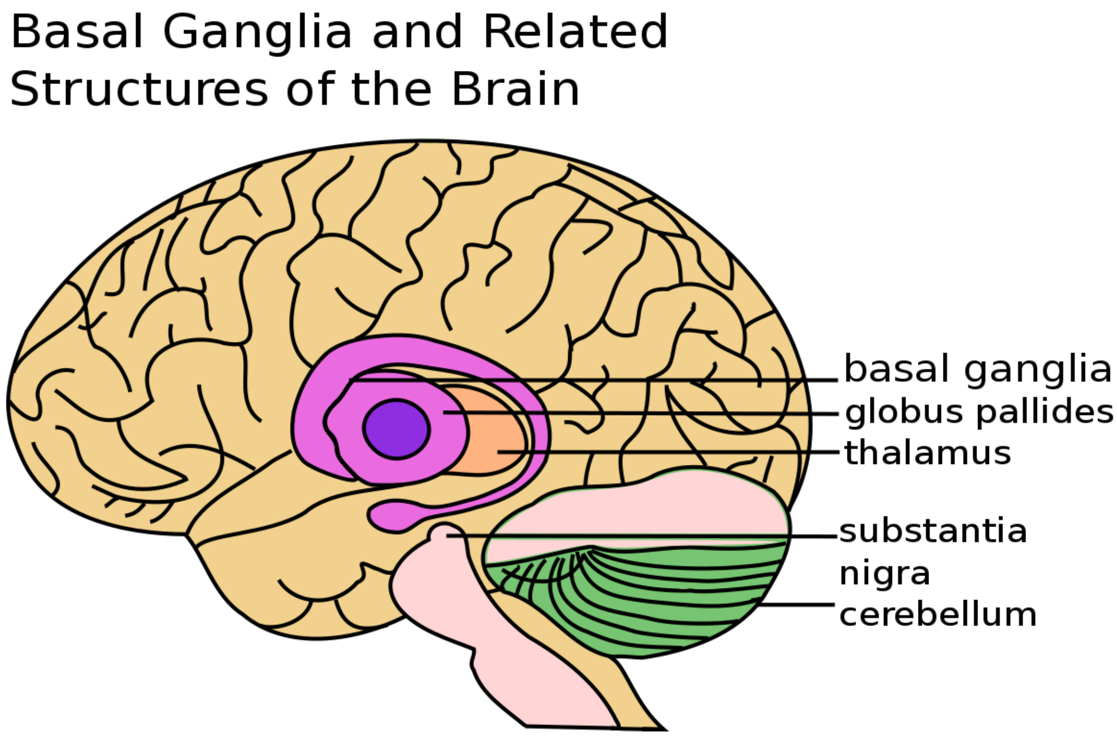
Forebrain

The larger component of the forebrain, the cerebrum, consists of the right and left **cerebral hemispheres نصف كرة** as well as some associated structures on the underside of the brain. The central core of the forebrain is formed by the diencephalon.

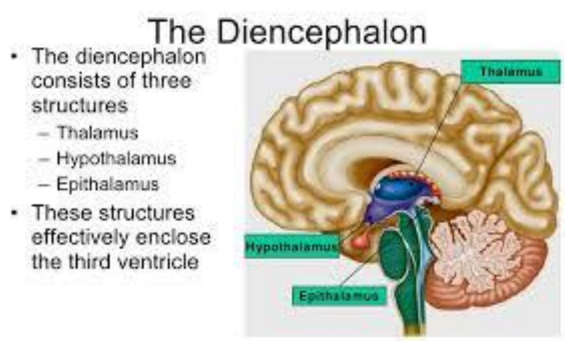
The cerebral hemispheres consist of the **cerebral cortex** —an outer shell of **gray matter** composed of cell bodies that give the area a gray appearance—and an inner layer of **white matter,** composed primarily of myelinated fiber tracts.

The cortex of each cerebral hemisphere is divided into four lobes: the **frontal, parietal, occipital,** and **temporal lobes.** Although it averages only 3 mm in thickness, the cortex is highly folded. This results in an area containing cortical neurons that is four times larger than it would be if unfolded.

The cerebral cortex is one of the most complex integrating areas of the nervous system. In the cerebral cortex, basic afferent الوارده information is collected and processed into meaningful perceptual images, and control over the systems that govern تتحكم the movement of the skeletal muscles is refined. The sub cortical nuclei are heterogeneous groups of graymatter that lie deep within the cerebral hemispheres. Predominant among them are the **basal nuclei** (often, but less correctly referred to as **basal ganglia**), which play an important role in controlling movement and posture and in more complex aspects of behavior.



The diencephalon, is the second component of the forebrain. It contains the thalamus, hypothalamus, and epithalamus.



The **thalamus** is a collection of several large nuclei that serve as synaptic متشابكrelay stations and important integrating centers for most inputs to the cortex, and it plays a key role in general arousal اثارة. The thalamus also is involved in focusing attention. The **hypothalamus** lies below the thalamus and is on the undersurface of the brain. Although it is a tiny region that accounts for less than 1% of the brain's weight, it contains different cell groups and pathways that form the master command center for neural and endocrine coordination. Indeed, the hypothalamus is the single most important control area for homeostatic regulation of the internal environment. Behaviors having to do with preservation of the individual (for example, eating and drinking) and preservation of the species (reproduction) are among the many functions of the hypothalamus.

The hypothalamus lies directly above and is connected by a stalk to the **pituitary gland,** an important endocrine structure that the hypothalamus regulates.

The **epithalamus** is a small mass of tissue that includes the **pineal gland,** which has a role in regulating circadian rhythms through release of the hormone melatonin.

Summary of Functions of the Major Parts of the Brain

I. Forebrain

A. Cerebral hemispheres

1. Contain the cerebral cortex, which participates in perception; the generation of skilled movements; reasoning, learning, and memory

2. Contain subcortical nuclei, including those that participate in coordination of skeletal muscle activity

3. Contain interconnecting fiber pathways

B. Thalamus

1. Acts as a synaptic relay شبكة متناوبة station for sensory حسي pathways on their way to the cerebral cortex

2. Participates in control of skeletal muscle coordination

3. Plays a key role in awareness

C. Hypothalamus

1. Regulates anterior pituitary gland function

2. Regulates water balance

3. Participates in regulation of autonomic nervous system

4. Regulates eating and drinking behavior

5. Regulates reproductive system

6. Reinforces certain behaviors

7. Generates and regulates circadian rhythms

8. Regulates body temperature

9. Participates in generation of emotional behavior

D. Limbic system

1. Participates in generation of emotions and emotional behavior

2. Plays essential role in most kinds of learning

II. Cerebellum

A. Coordinates movements, including those for posture and balance

III. Brainstem

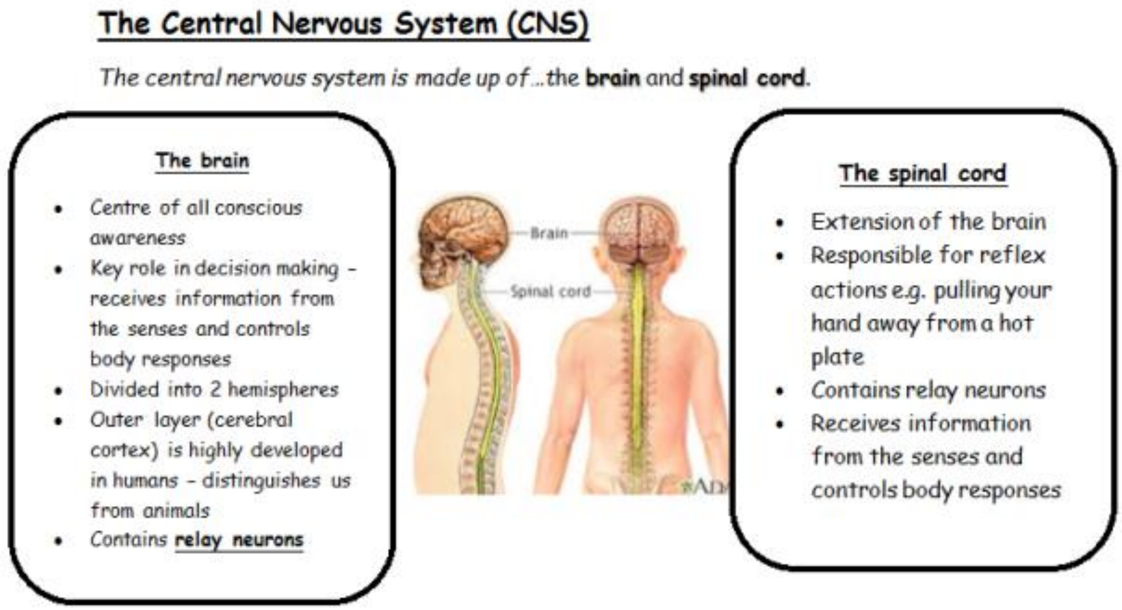
A. Contains all the fibers passing between the spinal cord, forebrain, and cerebellum

B. Contains the reticular formation and its various integrating centers, including those for cardiovascular

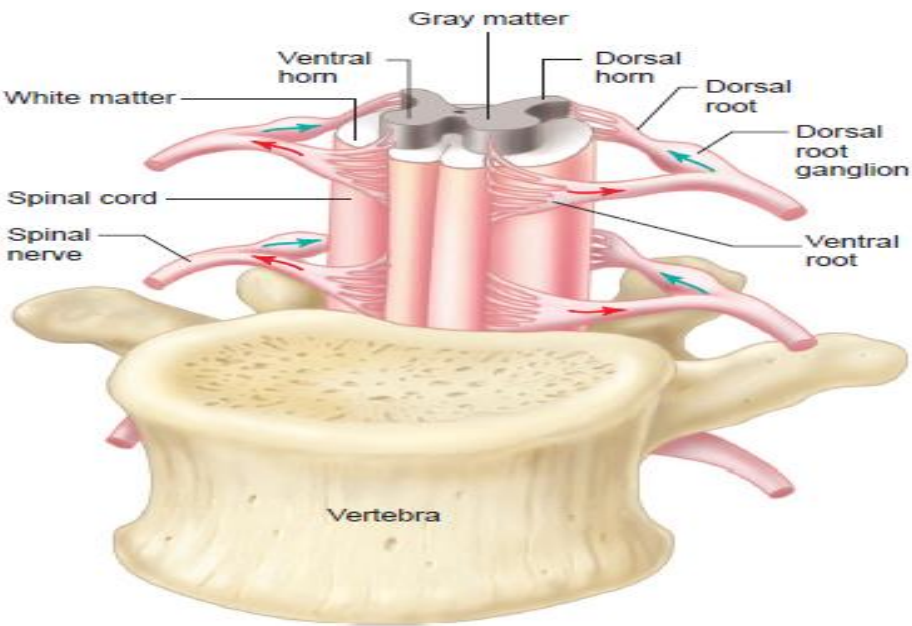
and respiratory activity

C. Contains nuclei for cranial nerves III through XII

Spinal Cord



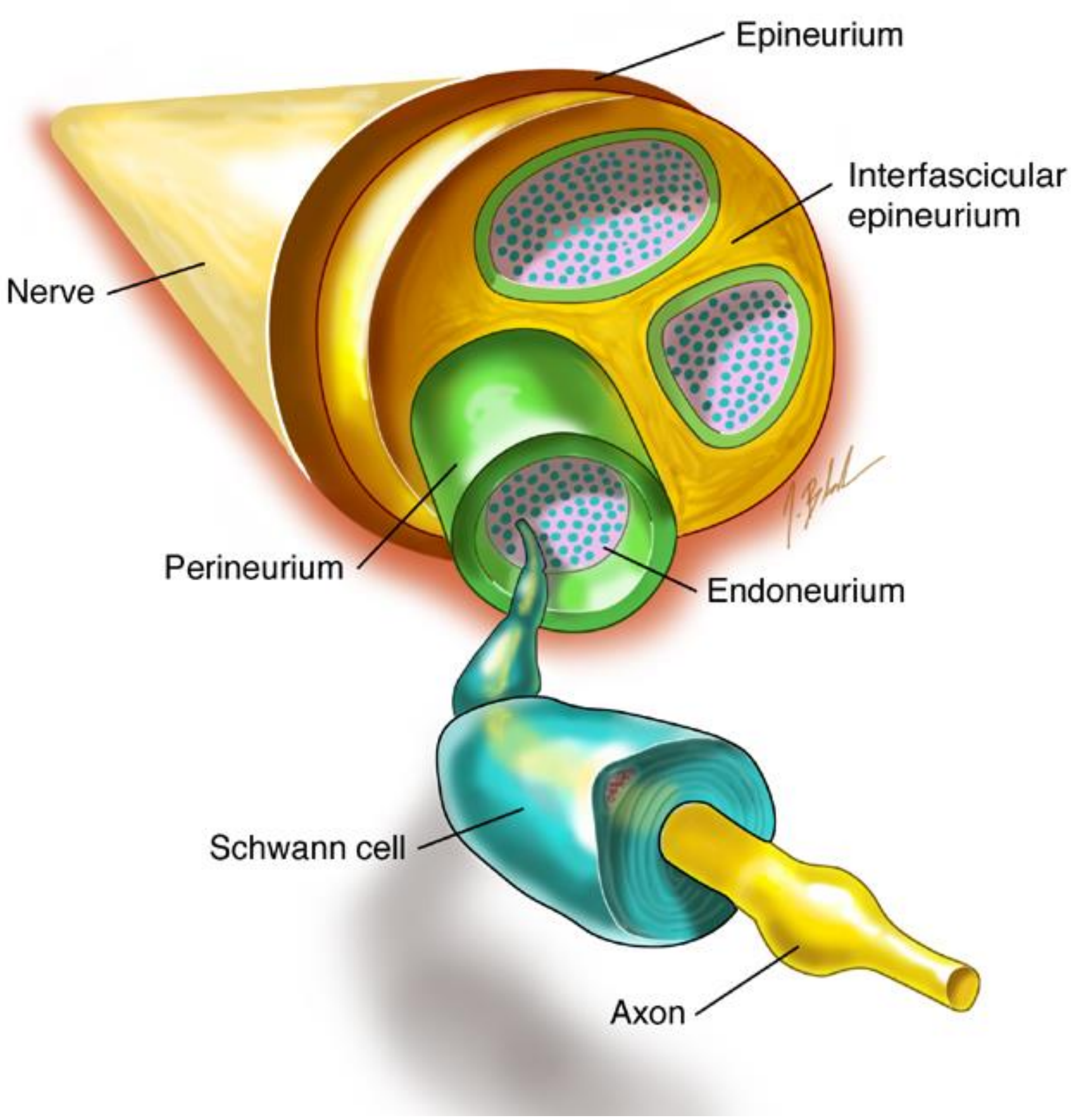
The spinal cord lies within the bony vertebral column. It is a slender cylinder of soft tissue about as big around as your little finger.



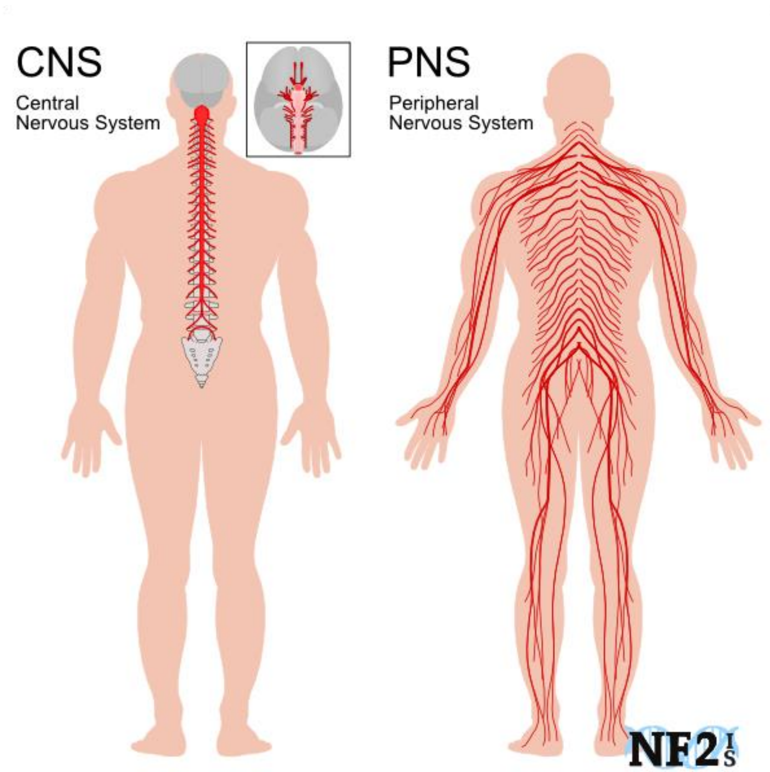
The central butterfly-shaped area (in cross section) of gray matter is composed of interneurons, the cell bodies and dendrites of efferent neurons, the entering axons of afferent neurons, and glial cells. The regions of gray matter projecting toward the back of the body are called the **dorsal horns,**whereas those oriented toward the front are the **ventral horns.**The gray matter is surrounded by white matter, which consists of groups of myelinated axons. These groups of fiber tracts run longitudinally through the cord, some descending to relay information *from* the brain to the spinal cord, others ascending to transmit information *to* the brain. Pathways also transmit information between different levels of the spinal cord. Groups of afferent fibers that enter the spinal cord from the peripheral nerves enter on the dorsal side of the cord via the **dorsal roots.**

Peripheral Nervous System

Neurons in the PNS transmit signals between the CNS and receptors and effectors in all other parts of the body. The axons are grouped into bundles called nerves.

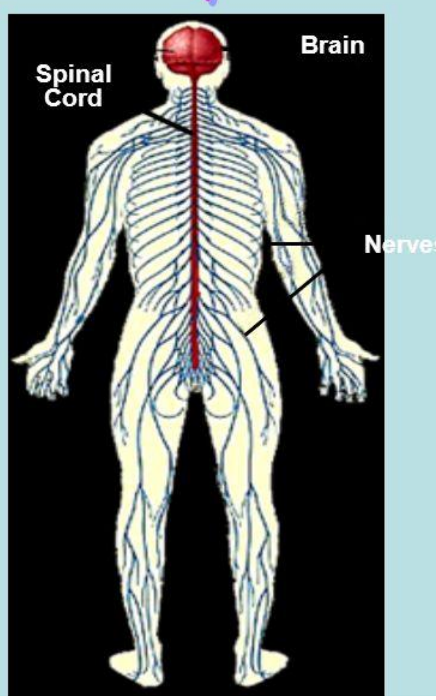


The PNS has 43 pairs of nerves: 12 pairs of cranial nerves and 31 pairs of spinal nerves that connect with the spinal cord.

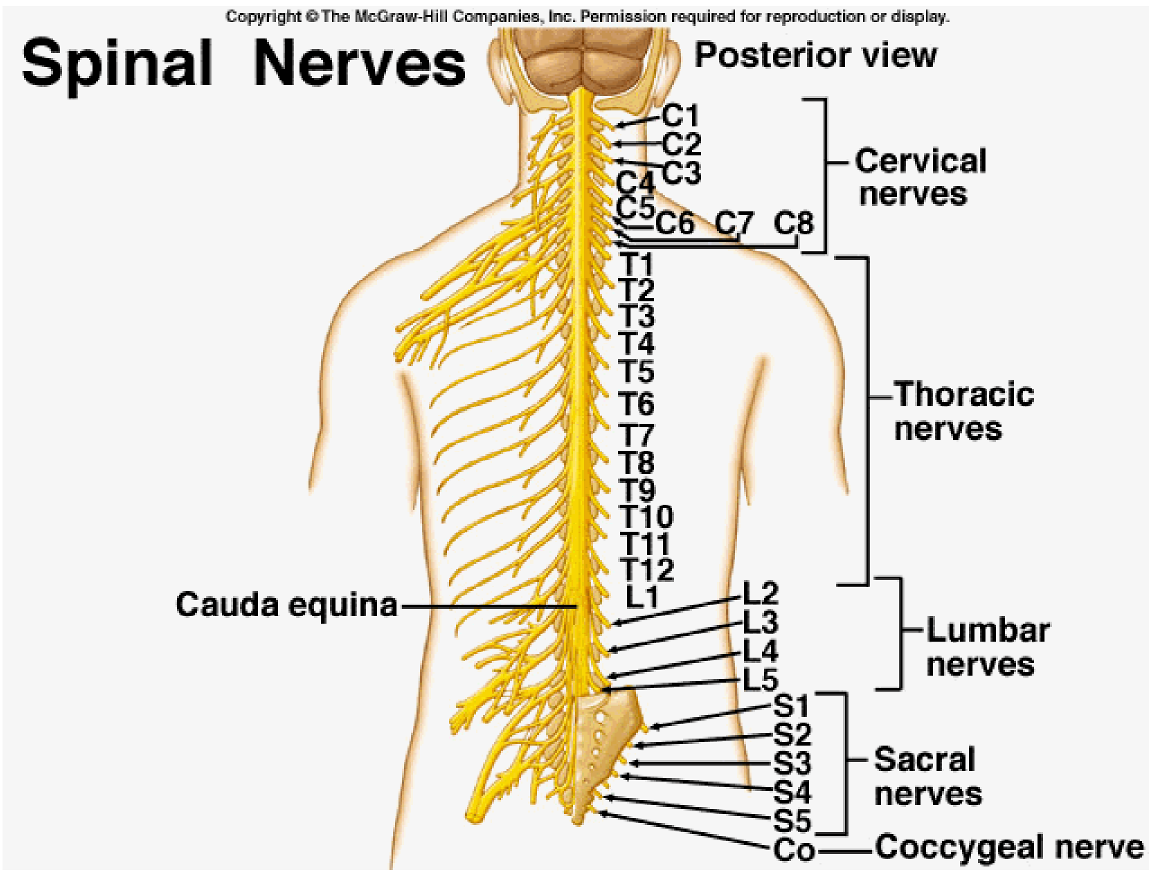


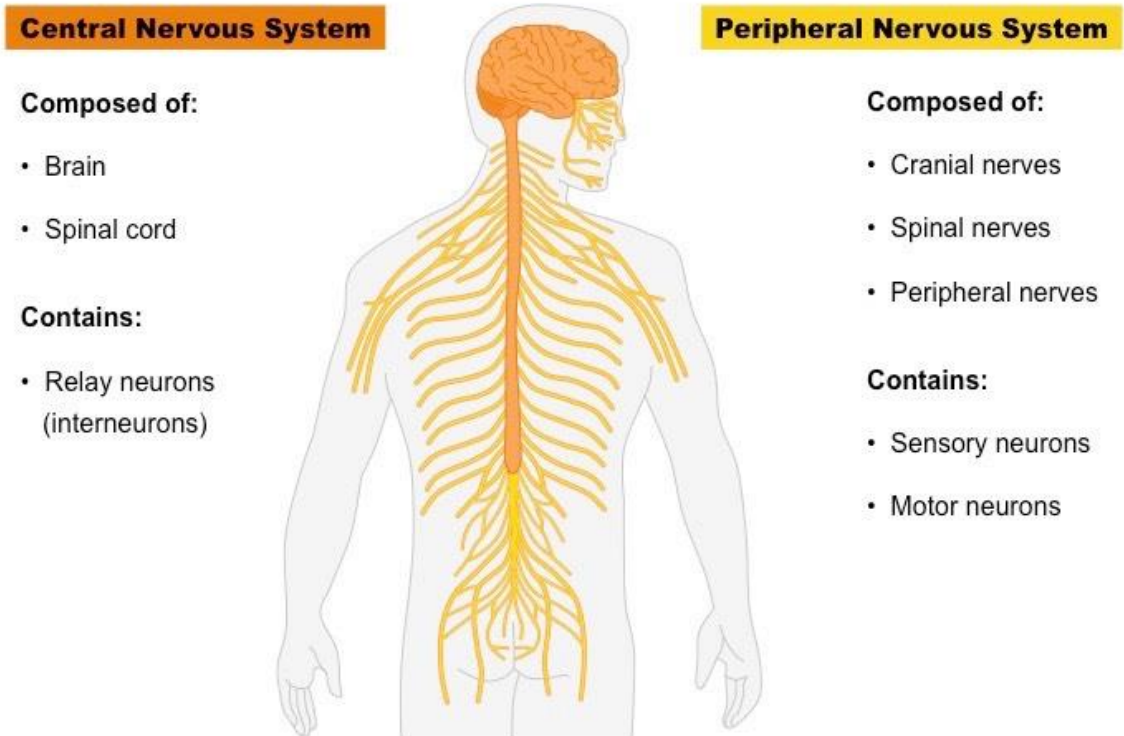
Peripheral Nervous System

- PNS consists of 43 pairs of nerves that transmit info to and from CNS
- 12 pairs of cranial nerves enter the brain directly
- 31 pairs of spinal nerves enter the spinal cord between vertebrae



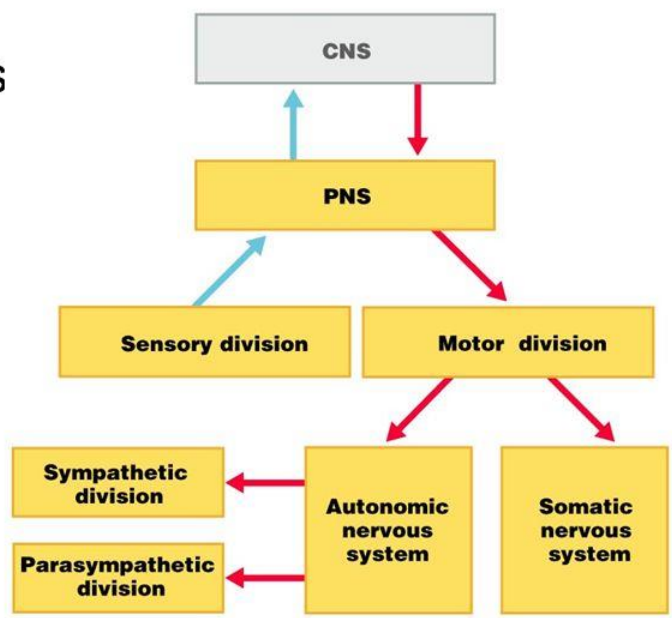
The 31 pairs of spinal nerves are designated by the vertebral levels from which they exit: **cervical, thoracic, lumbar, sacral, and coccygeal**. Neurons in the spinal nerves at each level generally communicate with nearby structures, controlling muscles and glands as well as receiving sensory input. The eight pairs of cervical nerves innervate the neck, shoulders, arms, and hands. The12 pairs of thoracic nerves are associated with the chest and upper abdomen. The five pairs of lumbar nerves are associated with the lower abdomen, hips, and legs; the five pairs ofsacral nerves are associated with the genitals and lower digestive tract. A single pair of coccygeal nerves associated with the tailbone brings the total to 31 pairs.





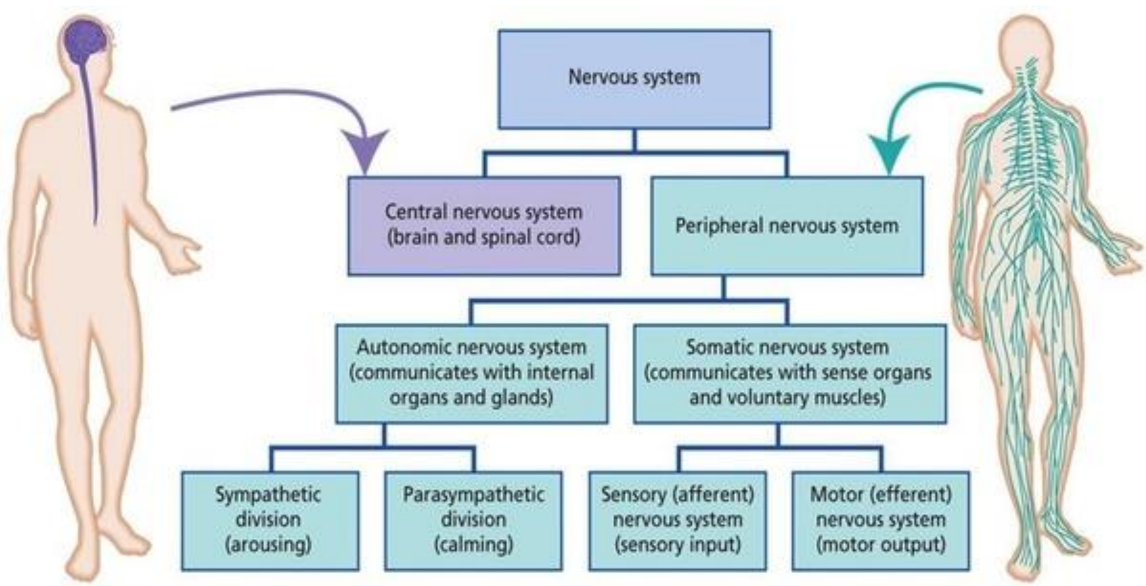
PNS

- Cranial nerves
- Spinal nerves



These peripheral nerves can contain nerve fibers that are the axons of efferent neurons, afferent neurons, or both. Therefore, fibers in a nerve may be classified as belonging to the **efferent** or the **afferent division** of the PNS. All the spinal nerves contain both afferent and efferent fibers, whereas some of the cranial nerves contain only afferent fibers (the optic nerves from the eyes, for example) or only efferent fibers (the hypoglossal nerve to muscles of the tongue, for example).

Efferent neurons carry signals out from the CNS to muscles, glands, and other tissues. The efferent division of the PNS is more complicated than the afferent, being subdivided into a **somatic nervous system** and an **autonomic nervous system.** The simplest distinction between the somatic and autonomic systems is that the neurons of the somatic division innervate skeletal muscle, whereas the autonomic neurons innervate smooth and cardiac muscle, glands, neurons in the gastrointestinal tract, and other tissues. (SoNS vs ANS. The **Somatic Nervous System** is the part of the peripheral **nervous system** that handles voluntary control of body movements. ... The ANS controls the connections between the brain, spinal cord and organs/glands, whereas the SNS connects external sensory organs through the brain to the muscles.)

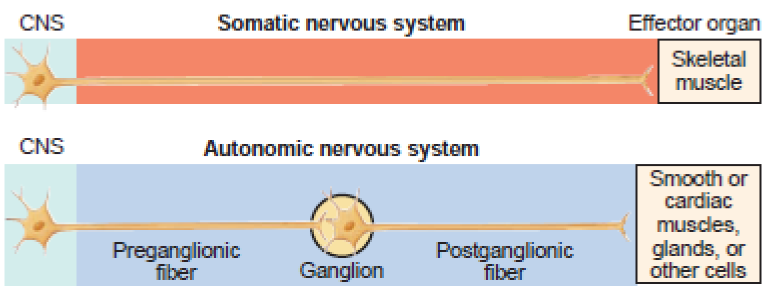


The somatic portion of the efferent division of the PNS is made up of all the nerve fibers going from the CNS to skeletal muscle cells. The cell bodies of these neurons are located in groups in the brainstem or the ventral horn of the spinal cord. Their large-diameter, myelinated axons leave the CNS and pass without any synapses to skeletal muscle cells. The neurotransmitter of these neurons release acetylcholine. Because activity in the somatic neurons leads to contraction of the innervated skeletal muscle cells, these neurons are called **motor neurons.** Excitation of motor neurons leads only to the *contraction* of skeletal muscle cells; there are no somatic neurons that inhibit skeletal muscles. Muscle relaxation involves the inhibition of the motor neurons in the spinal cord.

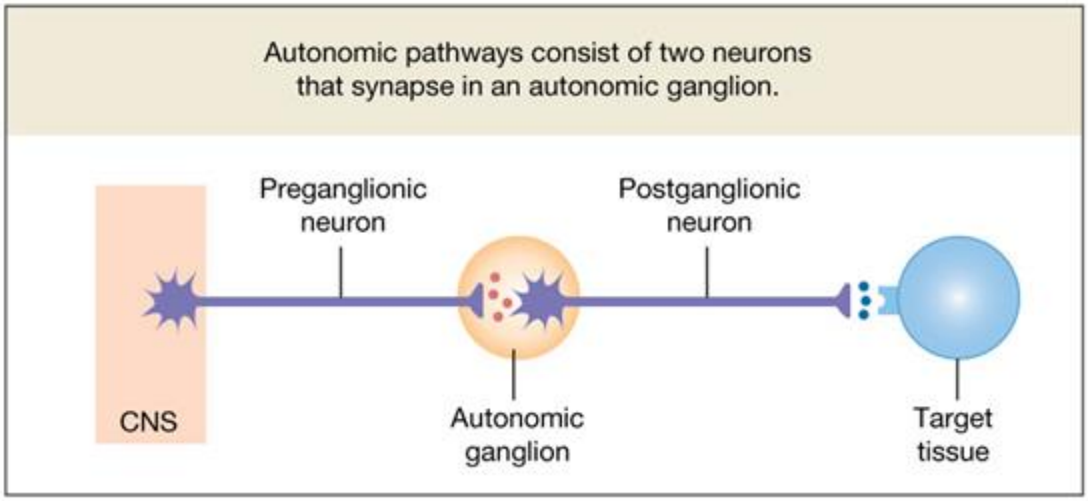
Autonomic Nervous System

The efferent innervation of tissues other than skeletal muscle is by way of the autonomic nervous system. A special case occurs in the gastrointestinal tract, where autonomic neurons innervate a nerve network in the wall of the intestinal tract. This network is called the **enteric nervous system,** and although often classified as a subdivision of the autonomic efferent nervous system, it also includes sensory neurons and interneurons.

In contrast to the somatic nervous system, the autonomic nervous system is made up of two neurons in series that connect the CNS and the effector cells.



The first neuron has its cell body in the CNS. The synapse between the two neurons is outside the CNS in a cell cluster called an **autonomic ganglion (**An **autonomic ganglion** is a cluster of nerve cell bodies (a **ganglion**) in the **autonomic** nervous system. The two types are sympathetic **ganglion** and parasympathetic **ganglion**)**.**

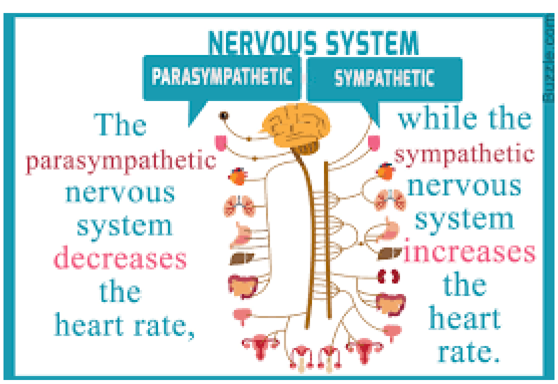


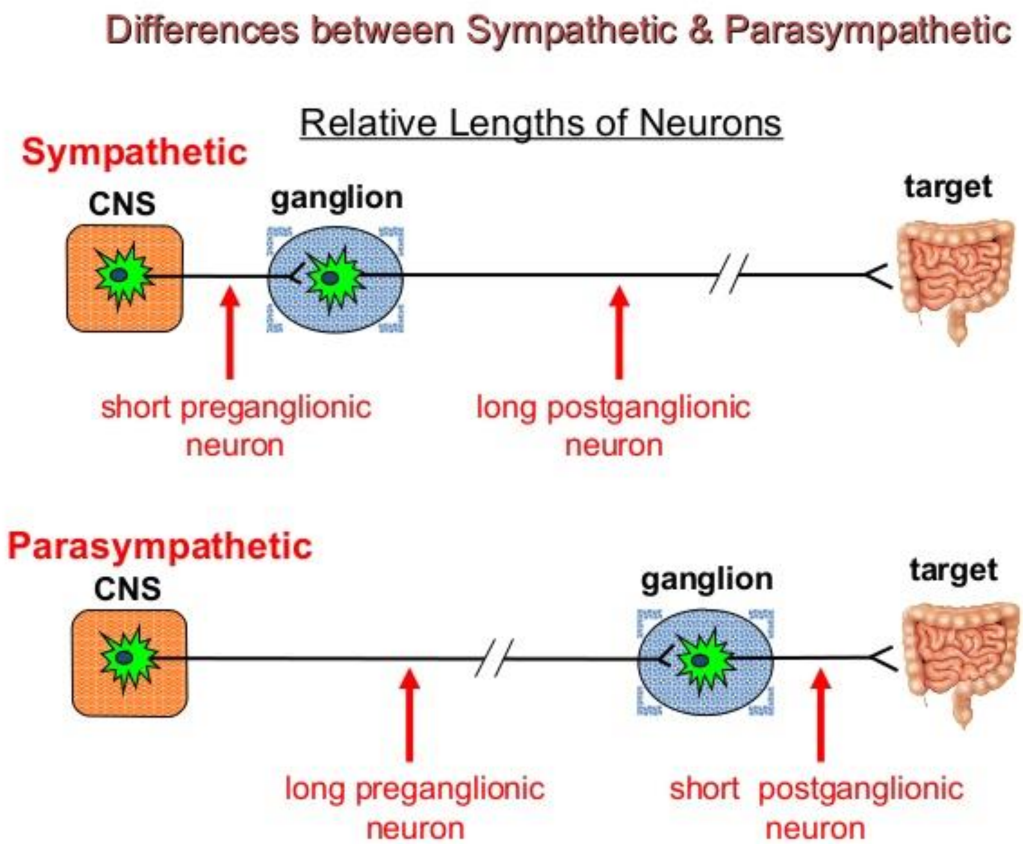
The neurons passing between the CNS and the ganglia are called **preganglionic neurons;**those passing between the ganglia and the effector cells are **postganglionic neurons.**

Anatomical and physiological differences within the autonomic nervous system are the basis for its further subdivision into **sympathetic** and **parasympathetic divisions.**

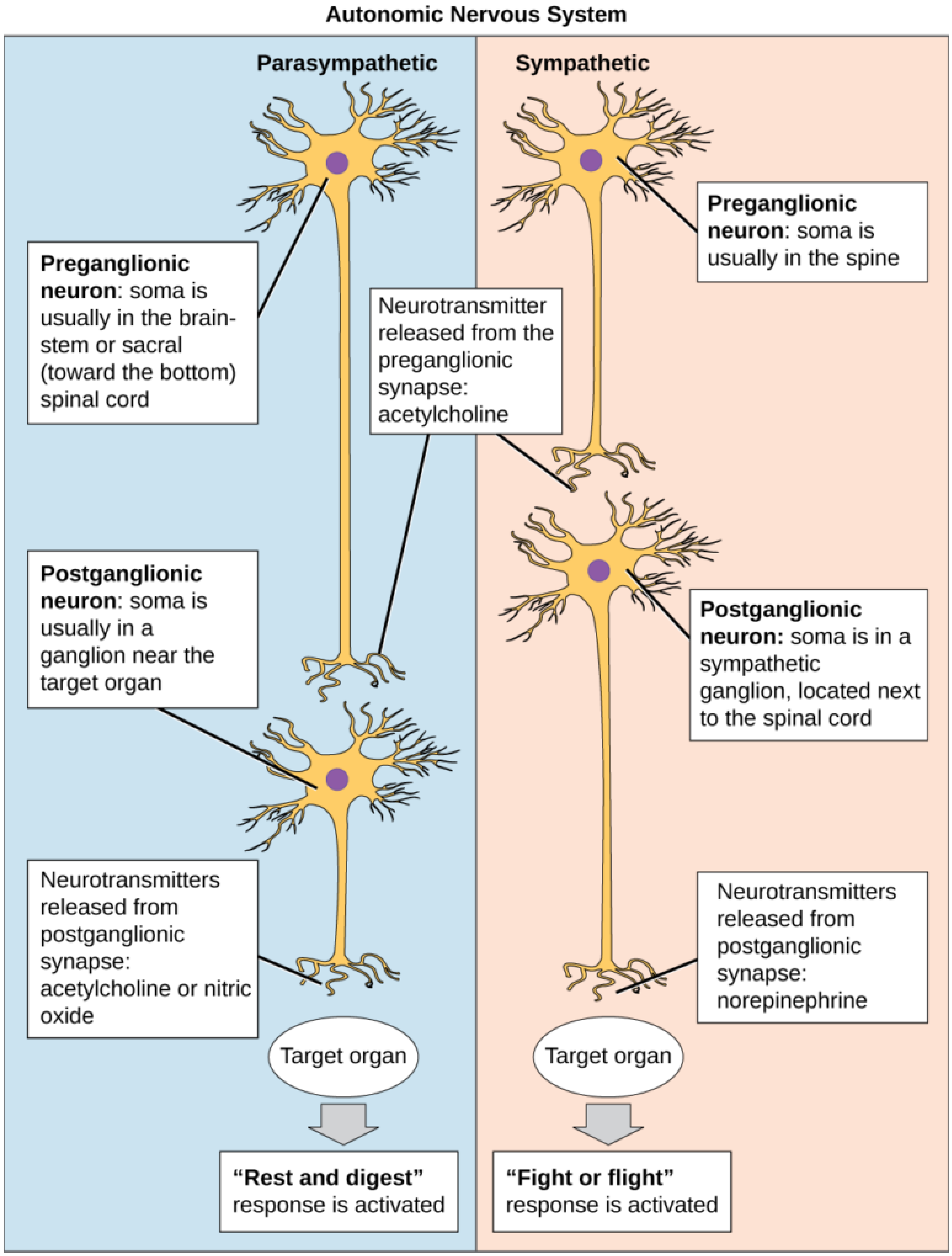
The neurons of the sympathetic and parasympathetic divisions leave the CNS at different levels—the sympathetic fibers from the thoracic (chest) and lumbar regions of the spinal cord, and the parasympathetic fibers from the brainstem and the sacral portion of the spinal cord. Therefore, the sympathetic division is also called the thoracolumbar division, and the parasympathetic division is called the craniosacral division.

(The **sympathetic** nervous system prepares the body for intense physical activity and is often referred to as the fight-or-flight response. The **parasympathetic**nervous system has almost the exact opposite effect and relaxes the body and inhibits or slows many high energy functions.)





In the parasympathetic division, acetylcholine is the neurotransmitter between the postganglionic neuron and the effector cell. In the sympathetic division, norepinephrine is usually the transmitter between the postganglionic neuron and the effector cell. We say "usually"because a few sympathetic postganglionic endings release acetylcholine (e.g., sympathetic pathways that regulate sweating).



Many of the drugs that stimulate or inhibit various components of the autonomic nervous system affect receptors for acetylcholine and norepinephrine. Recall that there areseveral types of receptors for each neurotransmitter.

A great majority of acetylcholine receptors in the autonomic ganglia are nicotinic receptors. In contrast, the acetylcholine receptors on cellular targets of postganglionic autonomic neurons are muscarinic receptors. The cholinergic receptors on skeletal muscle fibers, innervated by the *somatic* motor neurons, not autonomic neurons, are nicotinic receptors.

	Muscarinic receptors (M-receptor)	Nicotinic receptors (N-receptor)
Locations	smooth muscle, gland and cardiac muscle ●M--- smooth muscle、 gland ●M1-- ganglia、 gland ●M2--- heart	**skeletal muscle-- motor ending-plate (N2 N2), ganglia-postsynaptic membrane(N1),**
Effect	**inhibiting the cardiac muscle, exciting the smooth muscle & gland**	**N2:exciting skeletal muscle , N1 exciting the postsynaptic neuron in ganglia**
Antagonist	**Atropine**	**N1:hexamethonium** **N2:decamethonium**

Nicotinic and Muscarinic receptors are both Acetylcholine (ACh) receptors. The same neurotransmitter binds to them, yet their mechanism of action (MOA) differs quite greatly due to their uniqueness.

First off **Nicotinic Receptors** are ionotropic. Which means that when ACh binds to it, ions flow through it. It acts as a channel for positively charged ions, mainly sodium. Which depolarizes the cell.

While on the other hand **Muscarinic Receptors** have a different MOA. Instead of becoming an ion channel for sodium, they use a G-Protein. When ACh binds to the receptor, this protein changes shape, which then allows it to phosphorylate various second messengers.

The main difference between the two is their MOA, one uses Ions (**Nicotinic**) and one uses G-Proteins (**Muscarinic**). **Nicotinic receptors** are all exciatory, while **Muscarinic receptors** can be both excitatory and inhibitory depending on the subtype. Another difference being where they are found on the body. (Sympathetic vs Parasympathetic Nervous System)