

كلية المستقبل الجامعة قسم الفيزياء الطبية  
المرحلة الثالثة

**ANATOMY**

**The Nervous System 2**

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# Nervous System

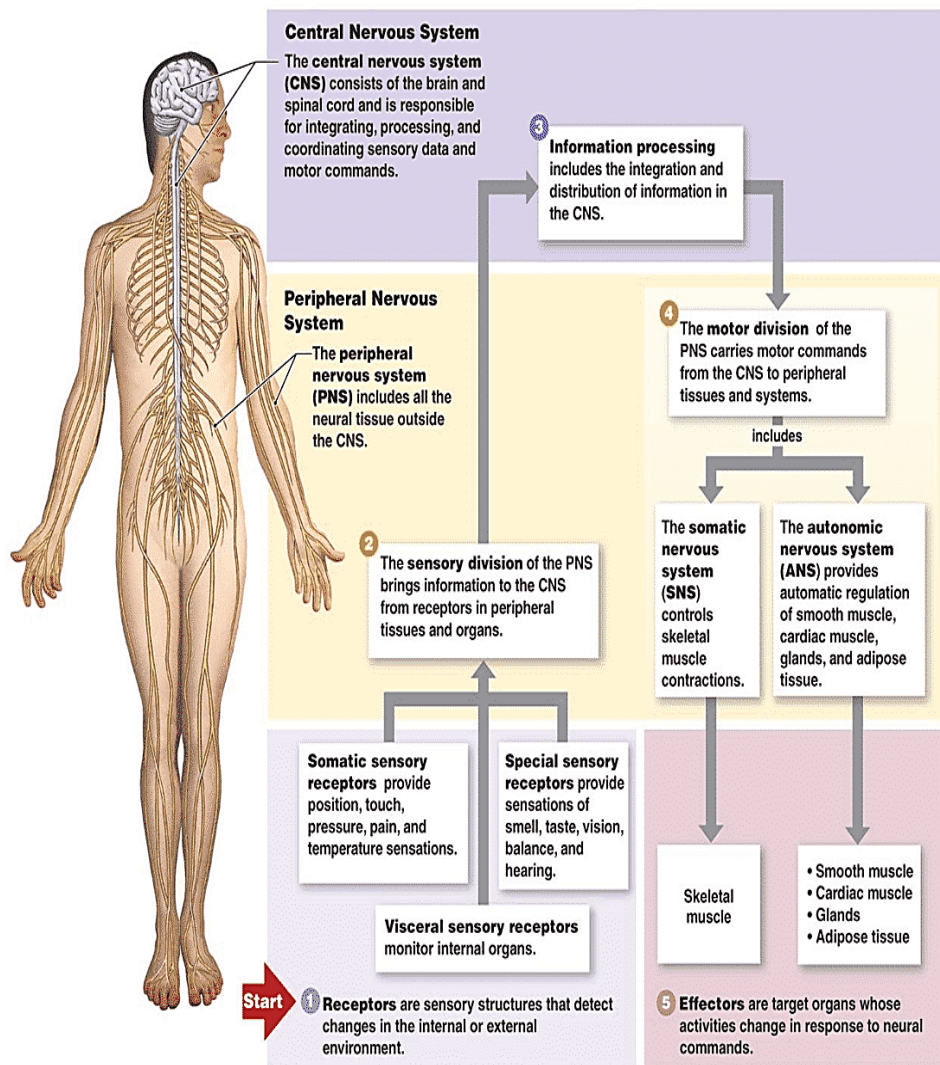
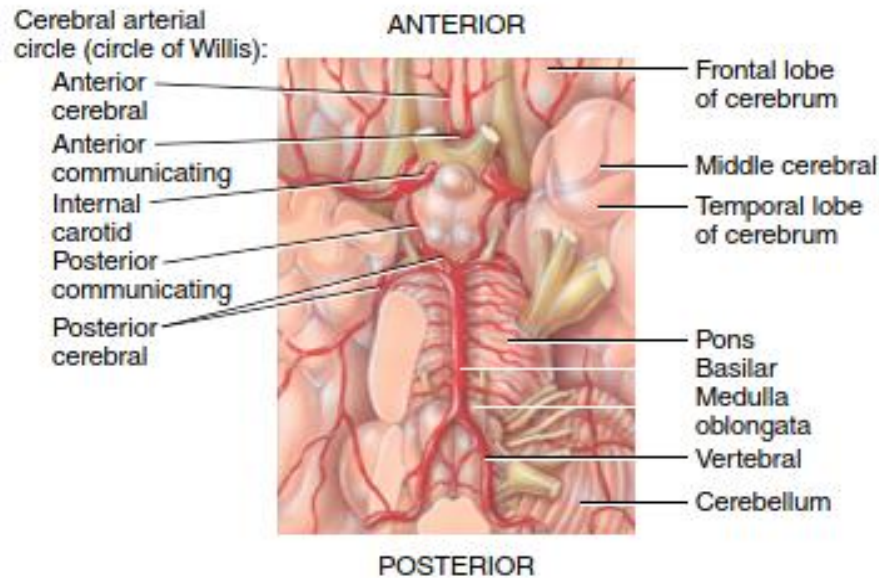


image via: highlands.edu

## The brain

The brain lies in the cranial cavity and weighs between 1450 and 1600 g. It receives 15% of the cardiac output and has a system of **autoregulation** ensuring the blood supply is constant despite positional changes. The arrangement of the arteries serving the brain is unique, and they are connected

to each other by a structure called the circle of Willis. This arrangement ensures that blood pressure remains equal in both halves of the brain. Should one of the arteries serving the brain become narrowed by arterial disease or thrombus then there will be an alternative route available, maintaining the essential supply of oxygen and glucose required by the brain.



**Circle of Willis**

The brain can be divided into four anatomical regions. Each region contains one or more structures : cerebrum (cerebral hemispheres), diencephalon, brain stem, and cerebellum.

## Cerebrum

This is the largest brain structure. It is divided into the left and right hemispheres by the **longitudinal cerebral fissure**. Each hemisphere can be divided into lobes – occipital, frontal, parietal and temporal. The outer layer of the cerebrum is called the cerebral cortex and is made of grey matter (nerve cell bodies). The layers below this are white matter (nerve fibres). The cerebral cortex is responsible for our conscious mind and consists of interneurons (the neurons that lie between sensory and motor neurons).

# Brain Anatomy

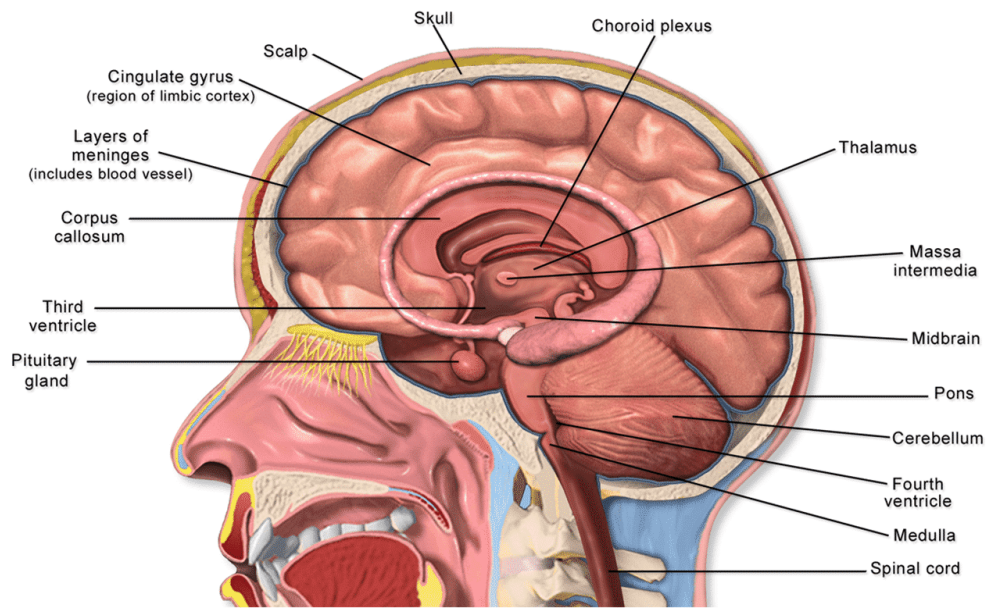
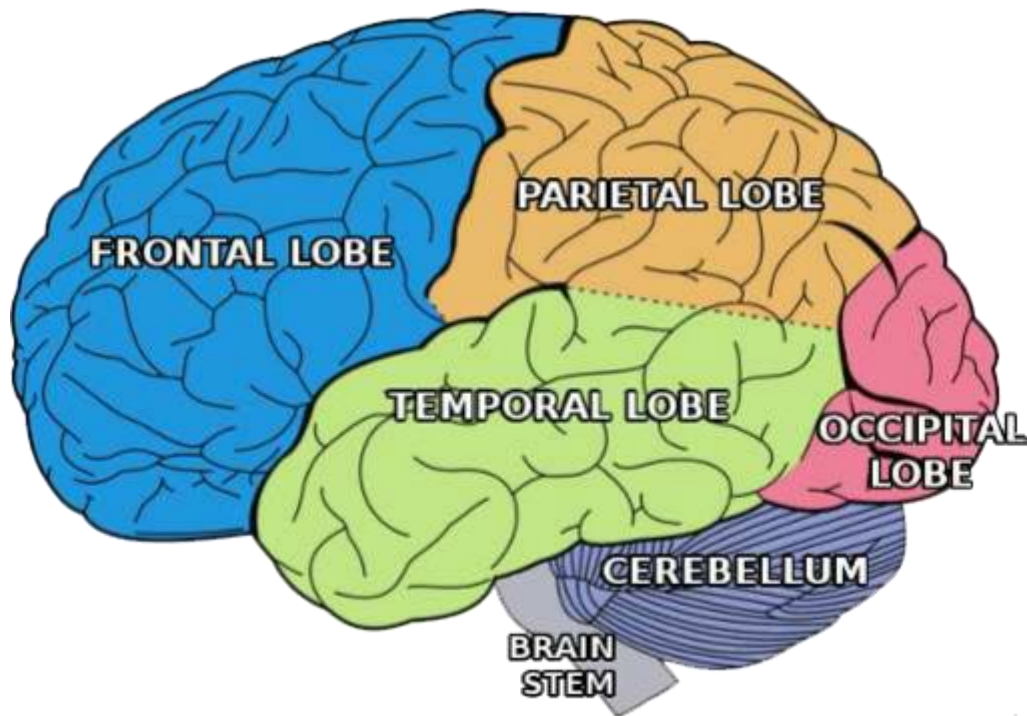


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## Diencephalon

This part of the brain is surrounded by the cerebrum and contains three paired structures:

- Thalamus – acts as a relay station for sensory impulses going to the cerebral cortex for integration and motor impulses entering and leaving the cerebral hemispheres. It also has a role in memory.
- Hypothalamus – is closely associated with the pituitary gland and produces two hormones: antidiuretic hormone (ADH) and oxytocin. The hypothalamus has many functions and these include:
  - control of body temperature
  - control of the autonomic nervous system
  - control of fluid balance and thirst
  - control of appetite
  - associated with the limbic system dealing with emotional reactions
  - control of sexual behaviours.
- Epithalamus – responsible for sleep–wake cycles.



## Brainstem

The structures that form the brainstem are involved in many activities that are essential for life. The brainstem is associated with the cranial nerves.

- **Midbrain** – conduction pathway that connects the cerebrum with the lower brain structures and spinal cord.
- **Pons** – also a conduction pathway communicating with the cerebellum. The pons works with the medulla oblongata to control depth and rate of respiration.
- **Medulla oblongata** – relay station for sensory nerves going to the cerebrum. The medulla contains autonomic centres such as the cardiac centre, the respiratory centre, the vasomotor centre and the coughing, sneezing and vomiting centre. The medulla is also the site of decussation of the pyramidal tracts – this means that the right side of the body is controlled by the left cerebral hemisphere and vice versa.

## Cerebellum

The cerebellum coordinates voluntary muscle movement, balance and posture. It ensures that muscle movements are smooth, coordinated and precise.

## The spinal cord

The average adult spinal cord is between 42 and 45 cm long and extends from the medulla oblongata (lower part of the brain) to the upper part of the second lumbar vertebra. The spinal cord is enclosed within the vertebral canal, which forms a protective ring of bone around the cord. Other protective coverings include the spinal meninges, which are three layers of connective tissue coverings that extend around the spinal cord. The spinal meninges consist of

- **the pia mater** – the innermost layer;
- **the arachnoid mater** – the middle layer;
- **the dura mater** – the outermost layer, which consists of a dense, irregular connective tissue.

The spinal cord consists of a central canal and grey and white matter. The central canal and the spinal meninges contain CSF. The grey matter consists mostly of cell bodies and their dendrites, and the whiter areas consist of the axons of neurones, which carry signals up and down the cord via ascending and descending tracts. These tracts cross as they enter and exit

the brain, and this explains why the right side of the brain controls the left side of the body and the left side of the brain controls the right side of the body.

# The Spinal Cord

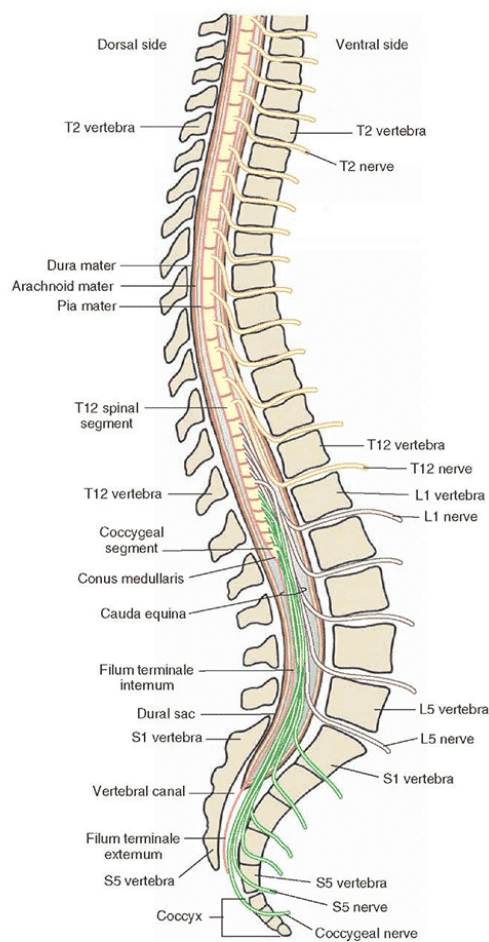


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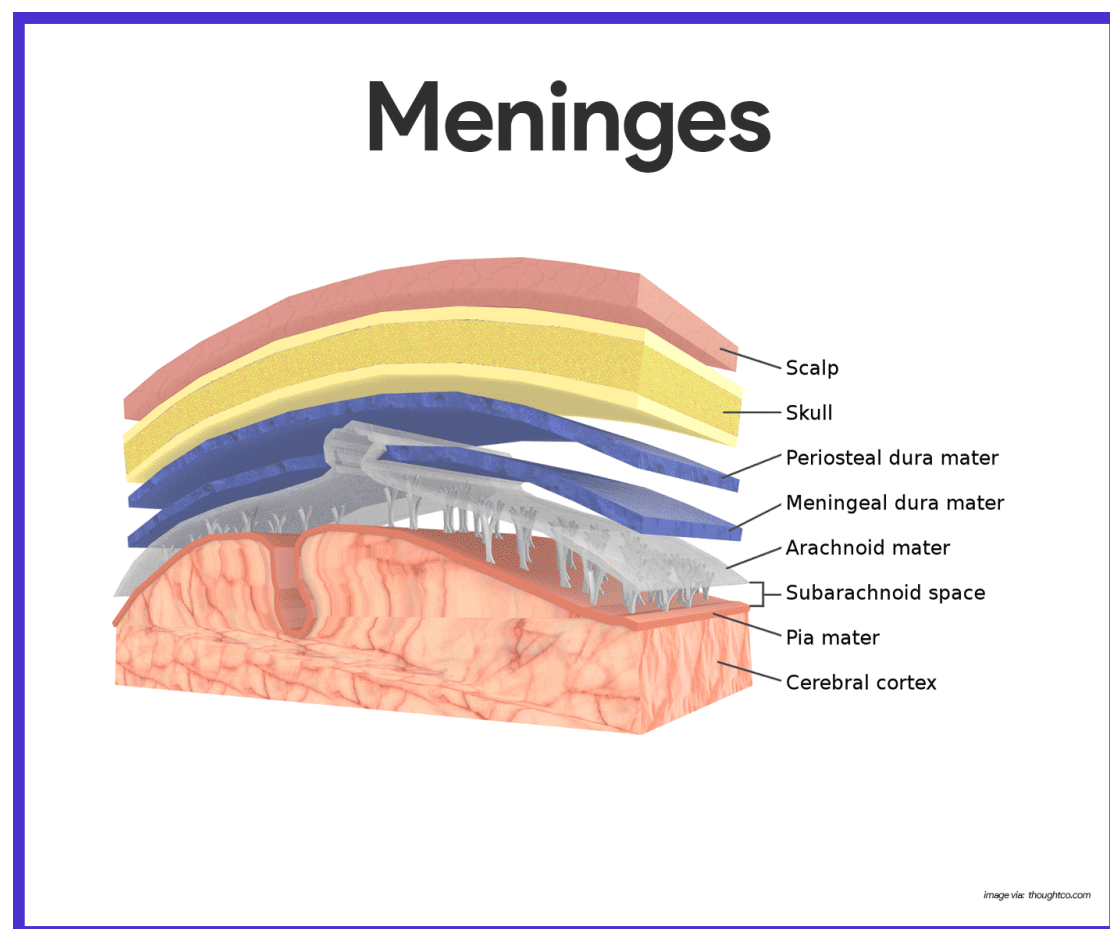
## Functions of the spinal cord

The spinal cord provides a means of communication between the brain and the peripheral nerves that leave the spinal cord and has two major functions in maintaining homeostasis :

- The tracts of the white matter of the spinal cord carry sensory impulses to the brain and motor impulses from the brain to the skeletal muscles and other effector muscles.
- The grey matter of the spinal cord is a site for integration of reflexes, which is a rapid, involuntary action in relation to a particular stimulus.

## Protection of the Central Nervous System

Nervous tissue is very soft and delicate, and the irreplaceable neurons are injured by even the slightest pressure, so nature has tried to protect the brain and the spinal cord by enclosing them within bone (the [skull](#) and vertebral column), membranes (the meninges), and a watery cushion ([cerebrospinal fluid](#)).





## The Blood-Brain Barrier

No other body organ is so absolutely dependent on a constant internal environment as is the brain, and so the blood-brain barrier is there to protect it.

- **Function.** The neurons are kept separated from bloodborne substances by the so-called blood-brain barrier, composed of the least permeable capillaries in the whole body.
- **Substances allowed.** Of water-soluble substances, only water, glucose, and essential amino acids pass easily through the walls of these capillaries.
- **Prohibited substances.** Metabolic wastes, such as toxins, urea, proteins, and most drugs are prevented from entering the brain tissue.
- **Fat-soluble substances.** The blood-brain barrier is virtually useless against fats, respiratory gases, and other fat-soluble molecules that diffuse easily through all plasma membranes.

## Peripheral Nervous System

The peripheral nervous system consists of nerves and scattered groups of neuronal cell bodies (ganglia) found outside the CNS.

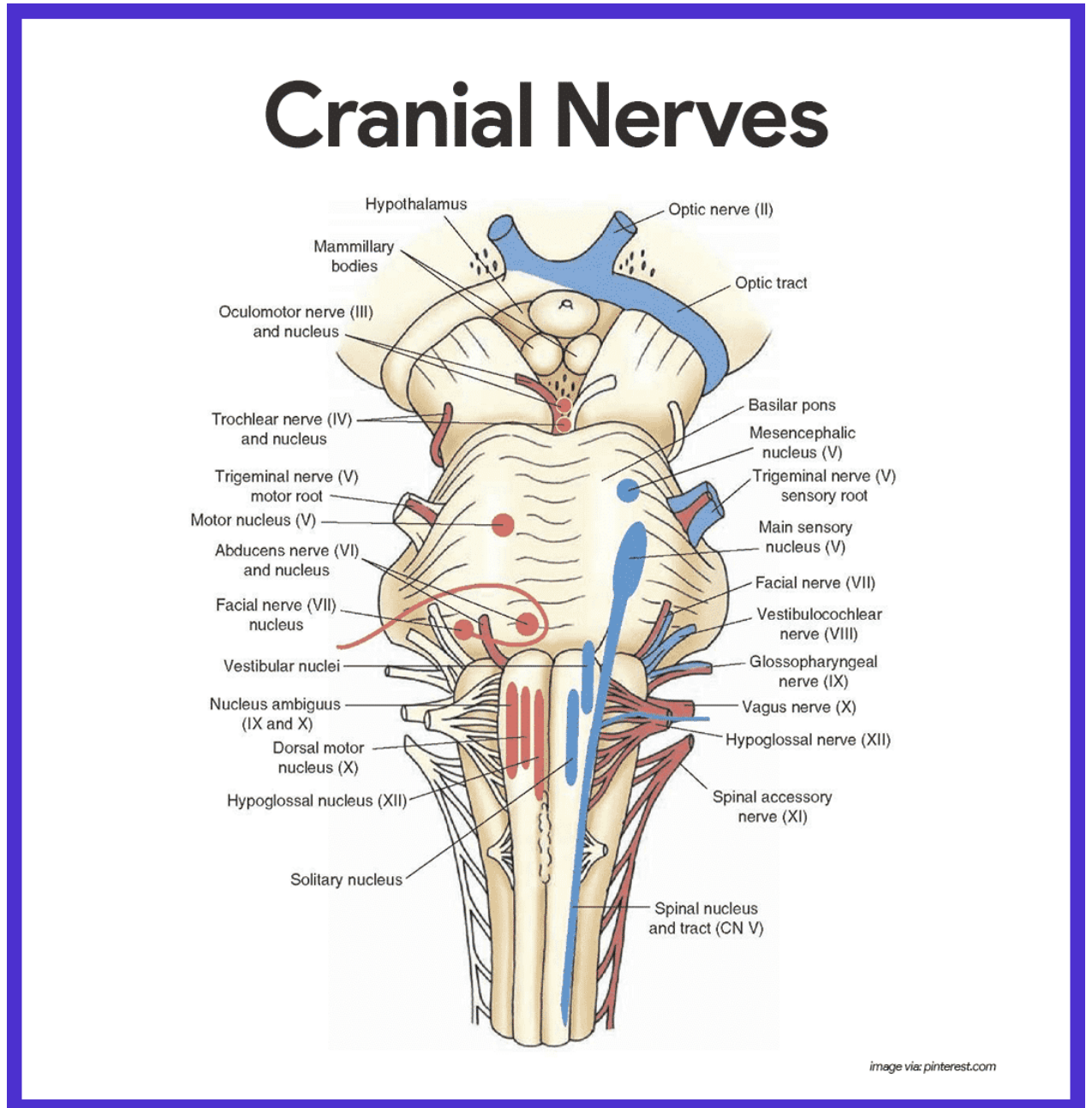
### *Structure of a Nerve*

A nerve is a bundle of neuron fibers found outside the CNS.

- **Mixed nerves.** Nerves carrying both sensory and motor fibers are called mixed nerves.
- **Sensory nerves.** Nerves that carry impulses toward the CNS only are called sensory, or afferent, nerves.
- **Motor nerves.** Those that carry only motor fibers are motor, or efferent, nerves.

## Cranial Nerves

The 12 pairs of cranial nerves primarily serve the head and the neck.



- **Olfactory.** Fibers arise from the olfactory receptors in the nasal mucosa and synapse with the olfactory bulbs; its function is purely sensory, and it carries impulses for the sense of smell.
- **Optic.** Fibers arise from the retina of the eye and form the optic nerve; its function is purely sensory, and carries impulses for vision.

- **Oculomotor.** Fibers run from the midbrain to the eye; it supplies motor fibers to four of the six muscles (superior, inferior, and medial rectus, and inferior oblique) that direct the eyeball; to the eyelid; and to the internal eye muscles controlling lens shape and pupil size.
- **Trochlear.** Fibers run from the midbrain to the eye; it supplies motor fibers for one external eye muscle ( superior oblique).
- **Trigeminal.** Fibers emerge from the pons and form three divisions that run to the face; it conducts sensory impulses from the skin of the face and mucosa of the nose and mouth; also contains motor fibers that activate the chewing muscles.
- **Abducens.** Fibers leave the pons and run to the eye; it supplies motor fibers to the lateral rectus muscle, which rolls the eye laterally.
- **Facial.** Fibers leave the pons and run to the face; it activates the muscles of facial expression and the lacrimal and salivary glands; carries sensory impulses from the taste buds of the anterior tongue.
- **Vestibulocochlear.** fibers run from the equilibrium and hearing receptors of the inner ear to the brain stem; its function is purely sensory; vestibular branch transmits impulses for the sense of balance, and cochlear branch transmits impulses for the sense of hearing.
- **Glossopharyngeal.** Fibers emerge from the medulla and run to the throat; it supplies motor fibers to the pharynx (throat) that promote swallowing and saliva production; it carries sensory impulses from the taste buds of the posterior tongue and from pressure receptors of the carotid artery.
- **Vagus.** Fibers emerge from the medulla and descend into the thorax and abdominal cavity; the fibers carry sensory impulses from and motor impulses to the pharynx, larynx, and the abdominal and thoracic viscera; most motor fibers are parasympathetic fibers that promote digestive activity and help regulate heart activity.
- **Accessory.** Fiber arise from the medulla and superior spinal cord and travel to muscles of the neck and back; mostly motor fiber that activate the sternocleidomastoid and trapezius muscles.

- **Hypoglossal.** Fibers run from the medulla to the tongue; motor fibers control tongue movements;; sensory fibers carry impulses from the tongue.

## *Spinal Nerves*

The 31 pairs of human spinal nerves are formed by the combination of the ventral and dorsal roots of the spinal cord.

## *Autonomic Nervous System*

The autonomic nervous system (ANS) is the motor subdivision of the PNS that controls body activities automatically.

- **Composition.** It is composed of a specialized group of neurons that regulate cardiac muscle, smooth muscles, and glands.
- **Function.** At every moment, signals flood from the visceral organs into the CNS, and the automatic nerves make adjustments as necessary to best support body activities.
- **Divisions.** The ANS has two arms: the sympathetic division and the parasympathetic division.

## *Parasympathetic Division*

The parasympathetic division allows us to “unwind” and conserve energy.

## *Sympathetic Division*

The sympathetic division mobilizes the body during extreme situations, and is also called the thoracolumbar division because its preganglionic neurons are in the gray matter of the spinal cord from T1 through L2.

# Central and Peripheral Nervous System

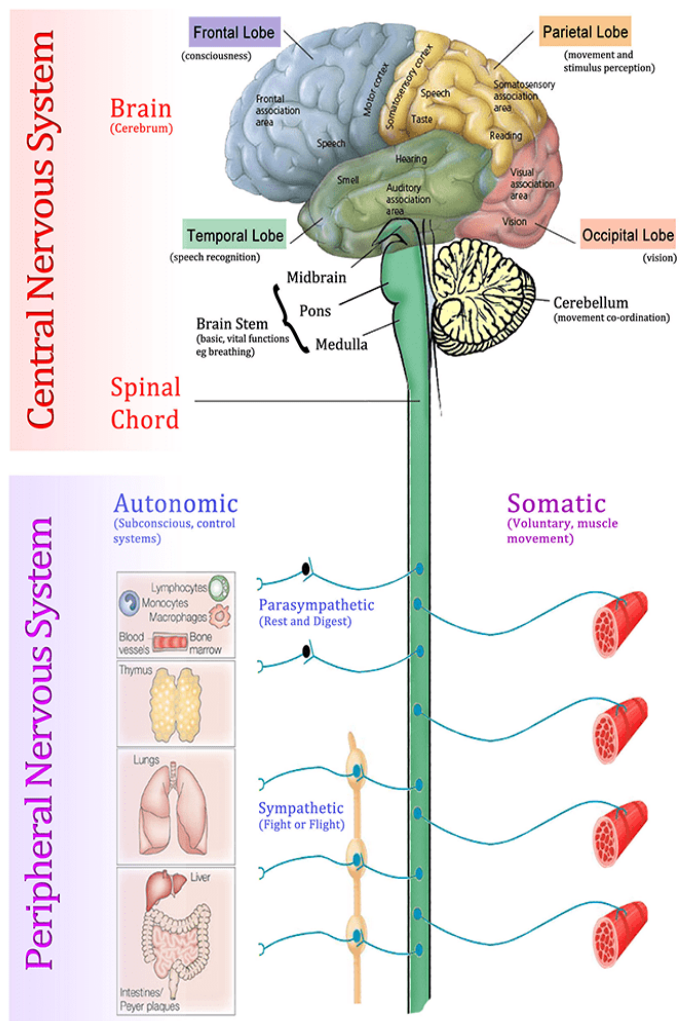


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