University of Anbar
College of science
Department of biotechnology

Lectures of human physiology

Lec. 3

The central and peripheral Nervous System

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central nervous system

The **central nervous system (CNS),** consisting of the brain and spinal cord (fig.1), receives input from *sensory neurons* and directs the activity of *motor neurons* that innervate muscles and glands

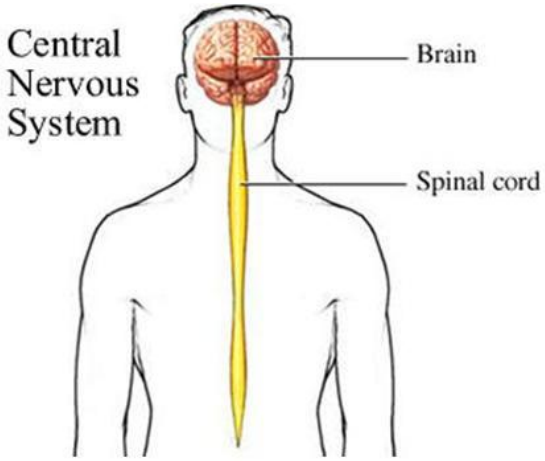

Fig.1 Central nervous system

The brain is one of the most important parts of the nervous system and it consists of soft tissue, the outer part of which contains about 85% water, making it the softest tissue in the body. Histologically composed of two region gray and white matter. The gray matter, containing neuron cell bodies and dendrites, is found in the *cortex* (surface layer) of the brain and deeper within the brain in aggregations known as *nuclei.* White matter consists of axon tracts (the myelin sheaths produce the white color) that underlie the cortex and surround the nuclei. The adult brain contains an estimated 100 billion (10^{11}) neurons, weighs approximately 1.5 kg (3 to 3.5 lb), and receives about 15% of the total blood flow to the body per minute. This high rate of blood flow is a consequence of the high metabolic requirements of the brain.

Sections of the brain

The brain consists of three sections:

1- Fore-brain.

2- Mid-brain.

3- Hind-brain.

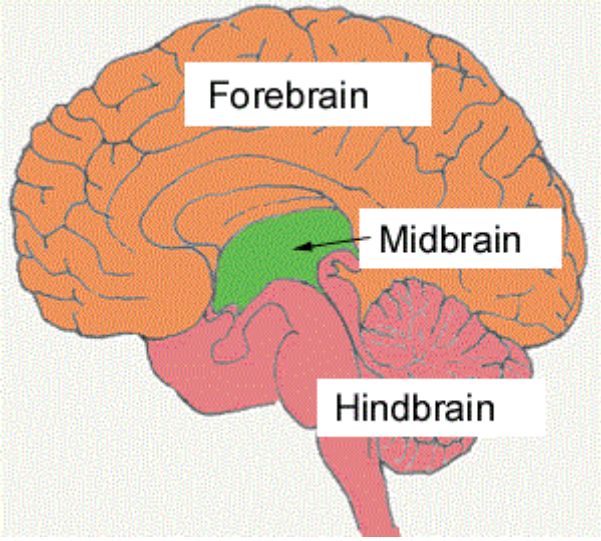

Fig.2 Section of the brain

The forebrain consists of:

1- Cerebrum.

2- Basal ganglia.

3- Thalamus.

4- Pineal body

1- Cerebrum

The cerebrum (fig.3) is the largest portion of the brain (accounting for about 80% of its mass) and is the brain region primarily responsible for higher mental functions. The cerebrum

consists of right and left hemispheres, which are connected internally by a large fiber tract called the corpus callosum.

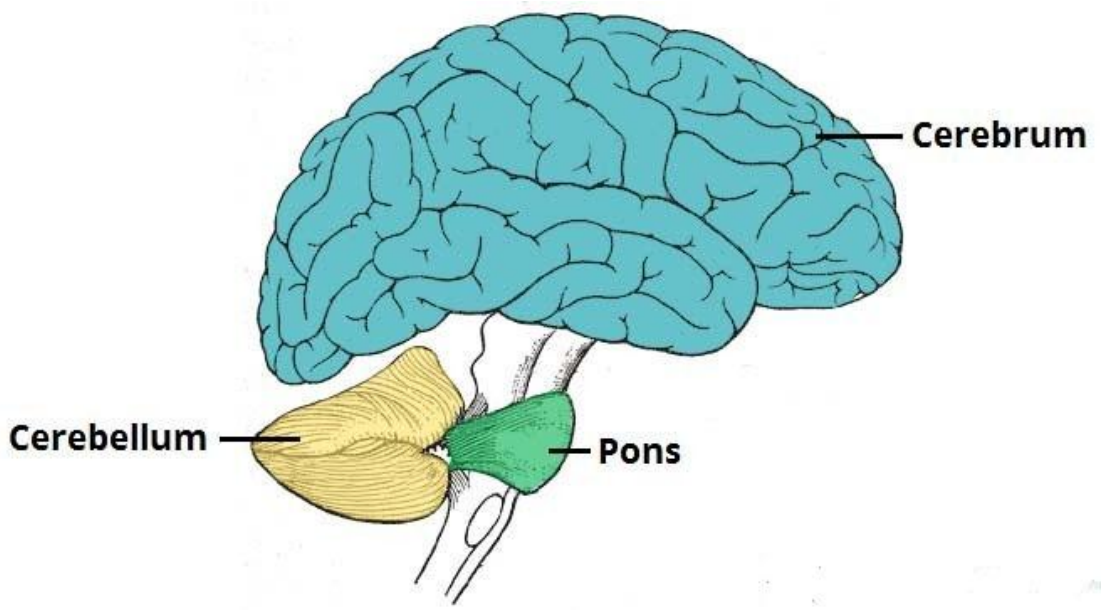

Fig. 3 Cerebrum

The corpus callosum is the major tract of axons that functionally interconnects the right and left cerebral hemispheres called convolutions. The elevated folds of the convolutions are called gyri, and the depressed grooves are the sulci. Many depressions called grooves penetrate the cerebrum, the outer part of the cerebral hemispheres consists of the cerebral cortex, which is highly convoluted and gray in color because it contains the bodies of neurons and small fibers and some of them are deep to divide the brain into lobes. These grooves are called according to their locations or shapes into:

A- Lateral sulcus: It separates the temporal and important cotyledons, and on this groove is the area of hearing and speech

B- Central sulcus: It starts from the middle of the upper surface of the brain and descends towards the lateral groove, where the area of movement and sensation is located (fig. 4).

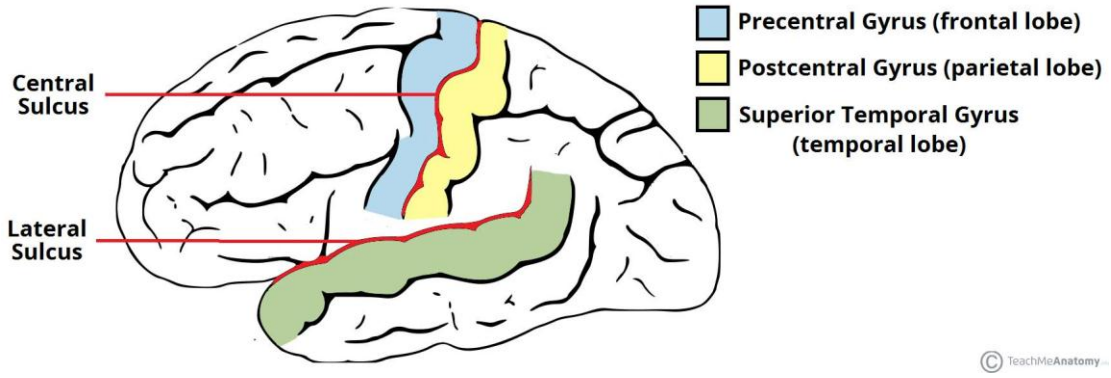

Fig.4 Cerebrum sulcus

Each cerebral hemisphere is subdivided by deep sulci, or fissures, into five lobes, four of which are visible from the surface (fig. 5).These lobes are the frontal, parietal, temporal, and occipital, which are visible from the surface, and the deep insula, which is covered by portions of the frontal, parietal, and temporal lobes

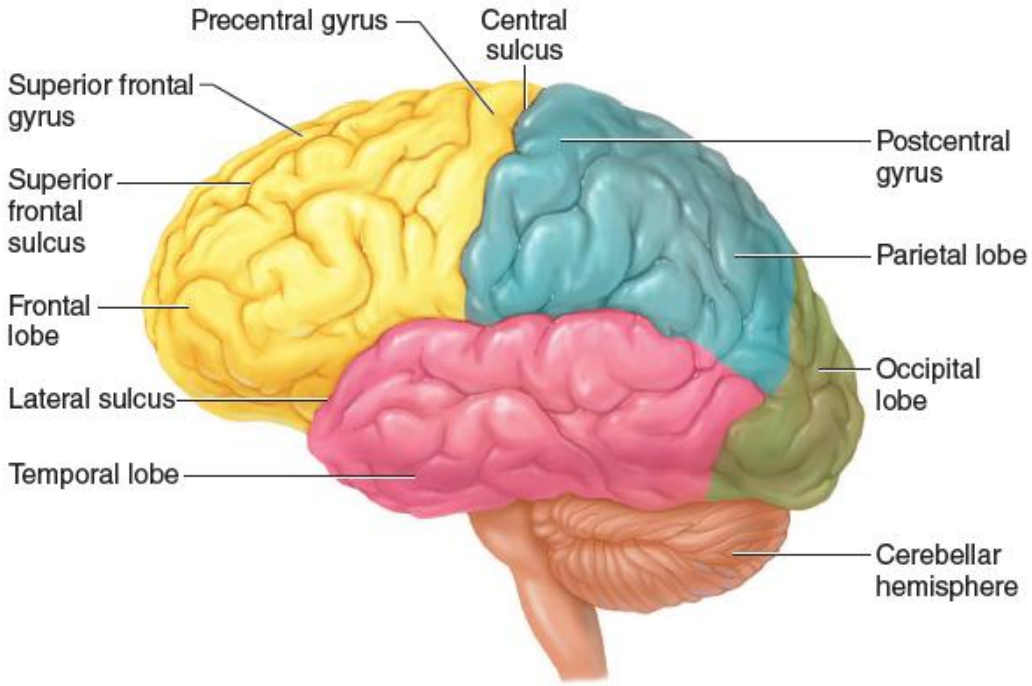

Fig.5 cerebrum lobes

The frontal lobe is the anterior portion of each cerebral hemisphere. A deep fissure, called the central sulcus, separates the frontal lobe from the parietal lobe. The precentral gyrus (fig.

5), involved in motor control, is located in the frontal lobe just in front of the central sulcus. The cell bodies of the interneurons located here are called upper motor neurons because of their role in muscle regulation. The postcentral gyrus, which is located behind the central sulcus in the parietal lobe of each hemisphere, contains the somatosensory cortex. This is the primary area responsible for the perception of somatesthetic sensations — sensations arising from cutaneous, muscle, tendon, and joint receptors.

Functions of the Cerebral Lobes

Lobe	Function
Frontal	Voluntary motor control of skeletal muscles; personality; higher intellectual processes (e.g., concentration, planning, and decision making); verbal communication
Parietal	Somatesthetic interpretation (e.g., cutaneous and muscular sensations); understanding speech and formulating words to express thoughts and emotions; interpretation of textures and shapes
Temporal	Interpretation of auditory sensations; storage (memory) of auditory and visual experiences
Occipital	Integration of movements in focusing the eye; correlation of visual images with previous visual experiences and other sensory stimuli; conscious perception of vision
Insula	Memory; sensory (principally pain) and visceral integration

2- Basal Nuclei

The basal nuclei are masses of gray matter composed of neuron cell bodies located deep within the white matter of the cerebrum (fig. 6). Although these are more commonly called basal ganglia, the term “basal nuclei” is more anatomically correct. This is because the basal ganglia are actually subcortical nuclei

(collections of neuron cell bodies in the CNS) that control voluntary actions.

The most prominent of the basal nuclei is the corpus striatum, which consists of several masses of nuclei. The upper mass, called the caudate nucleus, is separated from two lower masses, collectively called the lentiform nucleus. The lentiform nucleus consists of a lateral portion, the putamen, and a medial portion, the globus pallidus. The basal nuclei (basal ganglia) function in the control of voluntary movements.

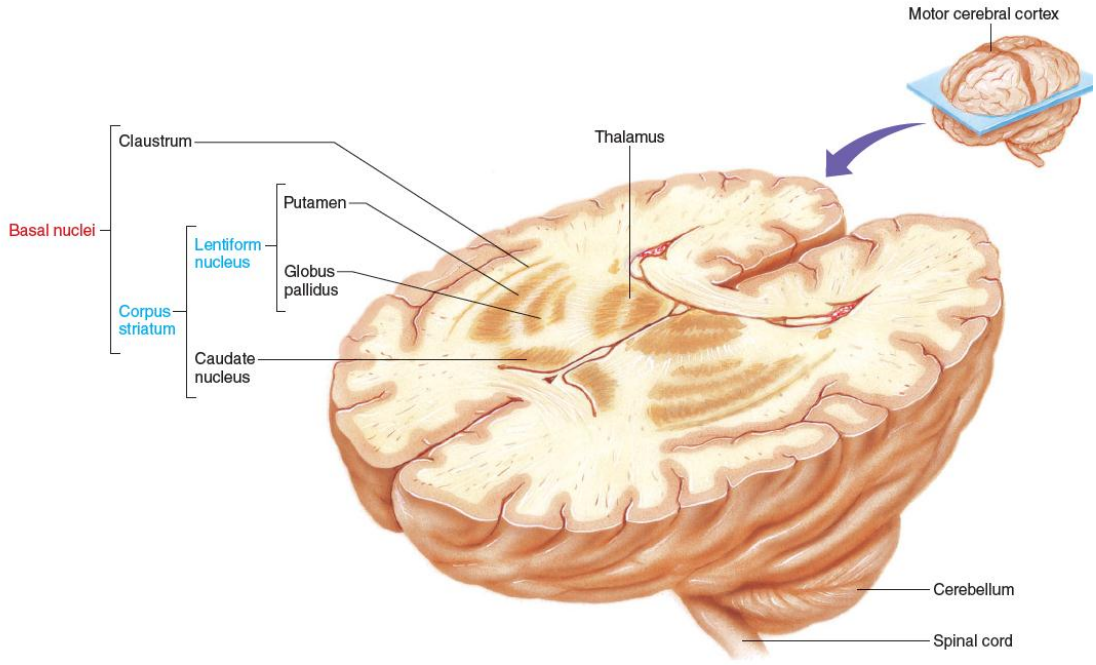

Fig.6 Basal nuclei

3- Thalamus:

The thalamus composes about four-fifths of the diencephalon and forms most of the walls of the third ventricle (fig. 6). It consists of paired masses of gray matter, each positioned immediately below the lateral ventricle of its respective cerebral hemisphere. The thalamus acts primarily as a relay center through which all

sensory information (except smell) passes on the way to the cerebrum.

4-Pineal body:

The pineal gland is a small endocrine gland in the brain of most vertebrates. The pineal gland produces melatonin, a serotonin-derived hormone which modulates sleep patterns in both circadian and seasonal cycles. The shape of the gland resembles a pine cone, which gives it its name. The pineal gland is located in the epithalamus, near the center of the brain, between the two hemispheres, tucked in a groove where the two halves of the thalamus join. It is composed of neuroglial cells, portions of neurons, and cells known as 'pinealocytes.' Pinealocytes are types of endocrine cell.

DIENCEPHALON:

It contains the thalamus region and its sub-brain between the midbrain and hemisphere of the brain. The thalamus consists of nuclei whose function is to deliver nerve messages related to sensation and emotion to the cerebral cortex. The thalamus also contains nuclear mass that transmit the impulses from the cerebellum to the hemisphere of the brain. In the thalamus there is a sensory center for feeling pain, and all senses (except for smell) end in the thalamus. It is responsible for states of awareness and alertness. (Fig. 7)

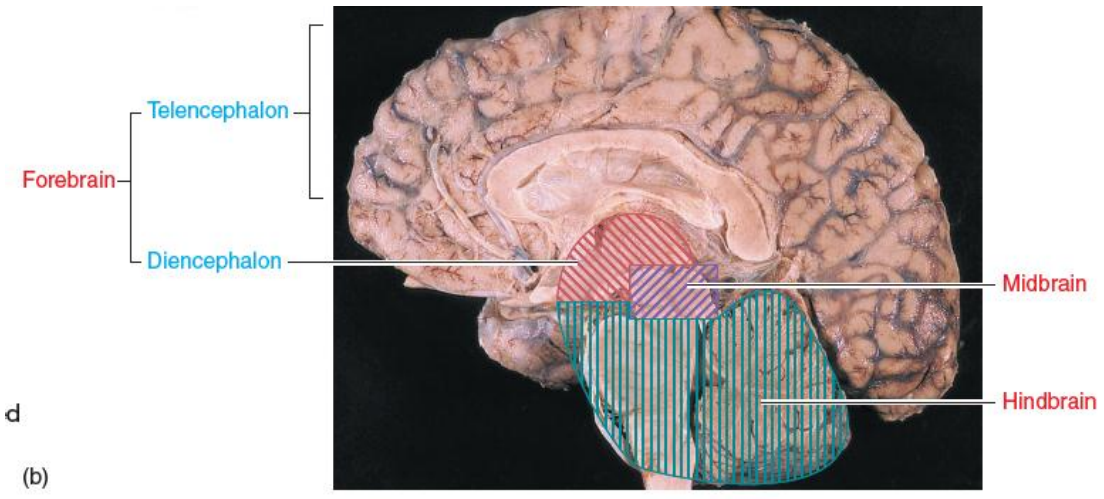

Fig.7 sections of brain

-Mid-brain:

It consists of two important parts:

1-**Cerebral peduncles**: They are strands of nerve fibers that connect the forebrain to the hind brain

2- **Cropora Quadrigemina**: They are four protuberances that - contain the centers of auditory and visual sensations.

-Hind-brain:

It consists of the cerebellum, pons, and medulla oblongata.

Cerebellum:

It is a small body located below the hemispheres of the brain and behind the medulla oblongata, and it is also called the small brain. The cerebellum, containing about 50 billion neurons, is the second largest structure of the brain. Like the cerebrum, it contains outer gray and inner white matter. Fibers from the cerebellum pass through the red nucleus to the thalamus, and then to the motor areas of the cerebral cortex. Other fiber tracts connect the cerebellum with the pons, medulla oblongata, and

spinal cord. The cerebellum receives input from proprioceptors (joint, tendon, and muscle receptors) and, working together with the basal nuclei and motor areas of the cerebral cortex, participates in the coordination of movement. The cerebellum is needed for motor learning and for coordinating the movement of different joints during a movement. It is also required for the proper timing and force required for limb movements. The cerebellum, for example, is needed to touch your nose with your finger, bring a fork of food to your mouth, or find keys by touch in your pocket or purse.

-Cerebellum hemispheres:

They are distinguished by the presence of convolutions on their surfaces that increase their surface area and consist of gray material, as is the case in the brain. The gyrus appears more closely connected than it is in the brain, and the inside of the cerebellum contains white matter as well.

-Vermis:

It was called by this name because of the transverse grooves on its surface that make it divided into worm-like rings.

Pons:

It is located above the medulla oblongata on the lower face of the brain, and is the bridge that transmits nerve impulses from the cerebral cortex to the cerebellar ball.

Medulla oblongata:

It lies below the cerebrum and the cerebellum, where the spinal cord connects to the parts of the brain, and most of the motor nerves intersect within the medulla oblongata to form what looks like pyramids inside it is the nuclei of most of the cerebral nerves. The medulla oblongata performs important functions, including

transmitting sensory nerve impulses from the spinal cord to the brain. It also works to transmit motor neuron impulses from the brain to the spinal cord. It also contains centers specializing in regulating heartbeat, chewing, swallowing and vomiting in humans.

Peripheral nervous system

It consists of all the cranial nerves that originate from the brain and spinal nerves. It is divided into the somatic nervous system, the nervous system and the autonomic nervous system.

Spinal cord:

It includes the lower part of the central nervous system, and figure 9 shows that it is composed of two layers, and the inner layer is the gray or gray matter and is grouped in the form of a letter H. The outer layer surrounds the first, which is the white matter.

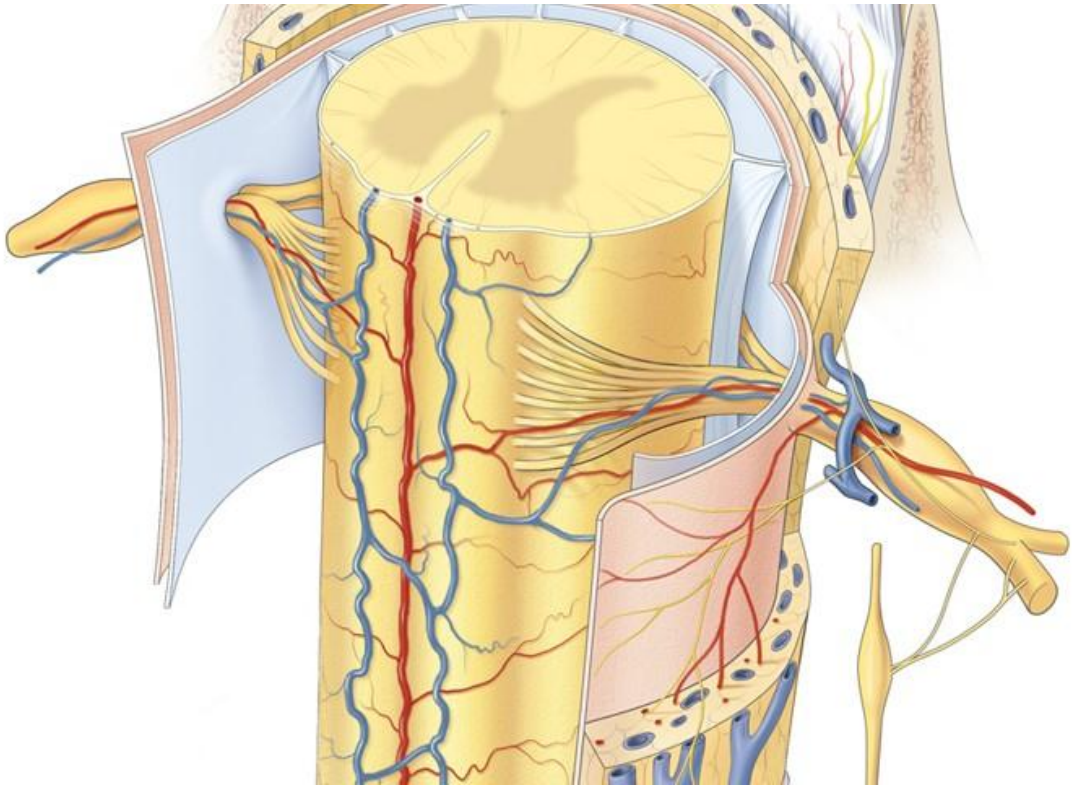

Fig.8 Spinal cord

Most of the white layer consists of ascending and descending sheathed fibers. As for the gray layer that resembles H letter, the transverse line represents a central channel that connects to the ventricles of the brain, while the edges of the upper letter represent the two front horns, and the edges of the lower letter represent the two posterior horns.

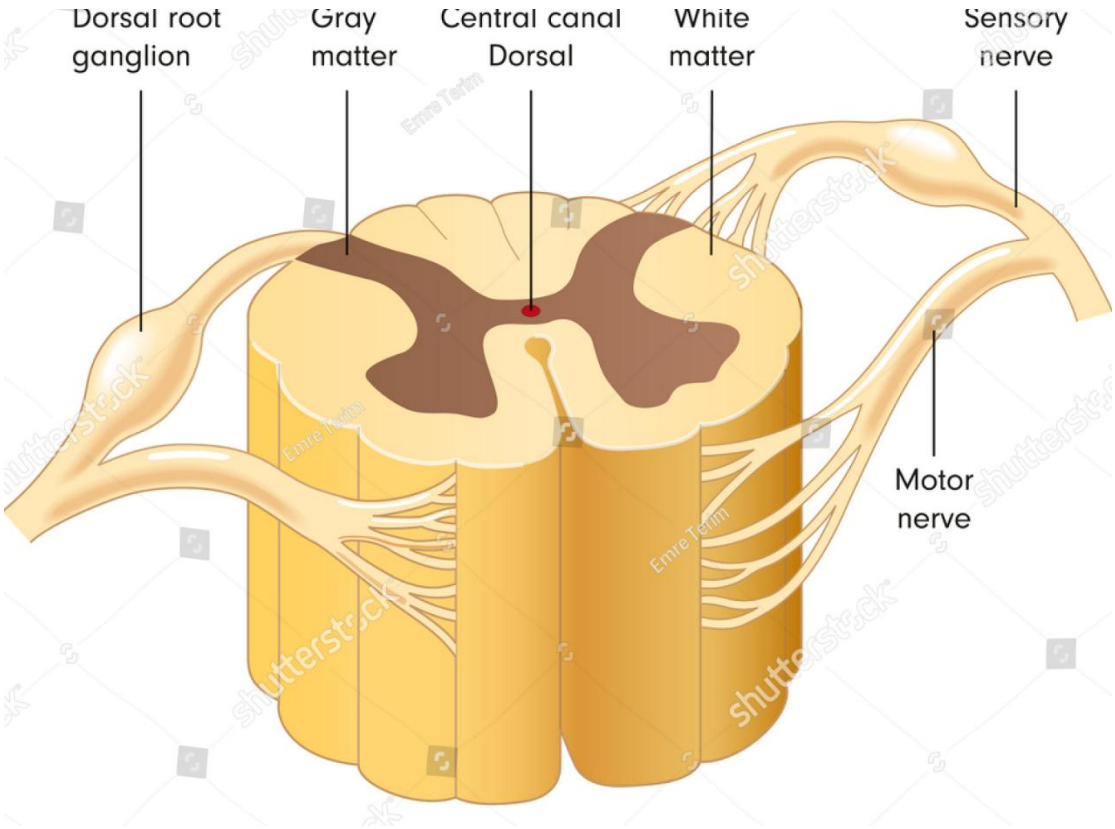

Fig.9 spinal cord

Membranes of the spinal cord and brain:

The spinal cord and brain are surrounded by three layers of membranes called the meninges:

1- Pia matter:

It forms a thin membrane that directly surrounds the spinal cord and brain

2- Dura matter:

It is the outer layer and it is fibrous that surrounds the bones of the skull and the vertebral canal.

3- Arachnoid matter:

Between the pia mater and the Dura mater, it is called arachnoid because it contains fine threads similar to cobwebs. It is a thin membrane separated from the Dura mater by a space called under the Dura mater. This space contains serous fluid. The space above the arachnoid membrane is filled with cerebrospinal fluid and contains the largest blood vessels in the brain.

Cerebrospinal fluid:

There is a space filled with cerebrospinal fluid that fills the cerebral ventricles, the central canal of the spinal cord, and the subarachnoid space.

The fluid is formed and secreted from the Choroid plexuses on both sides of the lateral ventricles, as well as the third and fourth ventricles, as well as the blood vessels of the pia mater. The quantity of cerebrospinal fluid in human 120-170 cm^3 and specific gravity is 1.005-1.007, and the pH is 7.4. It is a liquid that has no color or smell and contains a small number of cells, but it contains the same amount of salts and electrolytes in the blood and contains a percentage of sugar equivalent to 2/3 of its percentage in the blood and a small amount of proteins estimated at about 0.02%.

Spinal fluid has an important role in protecting the nervous tissues from shocks and creating regular pressure around these tissues, supporting them and providing them with nutrition, especially in areas that are not connected by blood vessels.

CRANIAL AND SPINAL NERVES

The central nervous system communicates with the body by means of nerves that exit the CNS from the brain (cranial nerves) and spinal cord (spinal nerves). These nerves, together with aggregations of cell bodies located outside the CNS, constitute the peripheral nervous system.

Cranial Nerves:

Of the 12 pairs of cranial nerves, 2 pairs arise from neuron cell bodies located in the forebrain and 10 pairs arise from the midbrain and hindbrain. The cranial nerves are designated by Roman numerals and by names. The Roman numerals refer to the order in which the nerves are positioned from the front of the brain to the back. The names indicate the structures innervated by these nerves (e.g., facial) or the principal function of the nerves (e.g., oculomotor). Most cranial nerves are classified as mixed nerves. This term indicates that the nerve contains both sensory and motor fibers. Those cranial nerves associated with the special senses (e.g., olfactory, optic), however, consist of sensory fibers only. The cell bodies of these sensory neurons are not located in the brain, but instead are found in ganglia near the sensory organ.

Spinal Nerves:

There are 31 pairs of spinal nerves. These nerves are grouped into 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal according to the region of the vertebral column from which they arise (fig.10).

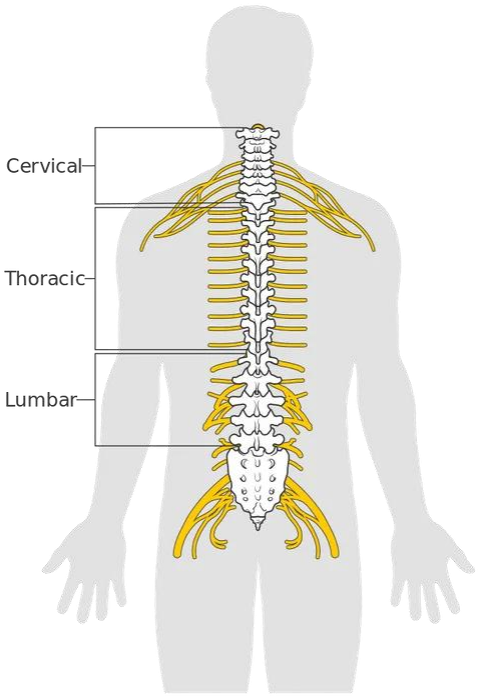

Fig.10 spinal nerves

Each spinal nerve is a mixed nerve composed of sensory and motor fibers. These fibers are packaged together in the nerve, but they separate near the attachment of the nerve to the spinal cord. This produces two "roots" of each nerve. The dorsal root is composed of sensory fibers, and the ventral root is composed of motor fibers (fig. 11). An enlargement of the dorsal root, the dorsal root ganglion, contains the cell bodies of the sensory neurons.

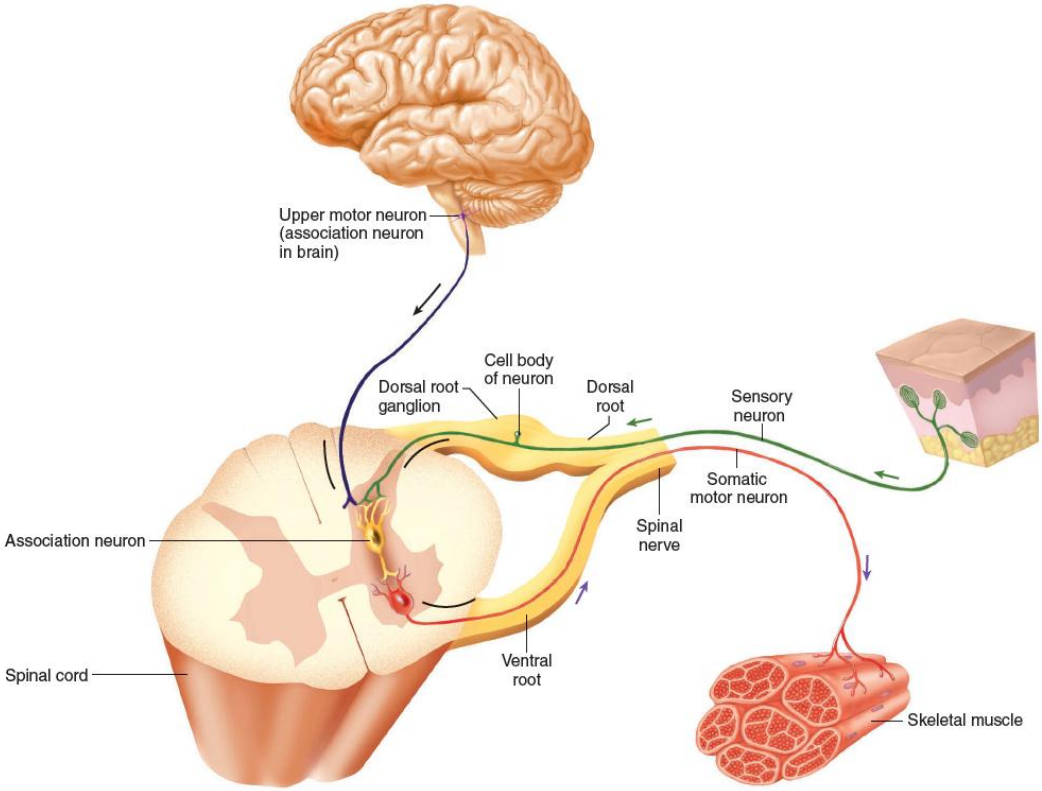

Fig.11 Activation of spinal nerve

-Reference

Fox, S. I. (2014). Fox Human Physiology.