

Unit 5:

The nervous and endocrine systems



1. The interaction function

2. The nervous system

- 2.1. The cells of the nervous system
- 2.2. Nerve impulse and synapse

3. Central nervous system (CNS)

- 3.1. The spinal cord
- 3.2. The encephalon

4. Peripheral nervous system (PNS)

- 4.1. The somatic nervous system
- 4.2. The autonomic nervous system

5. The endocrine system

Think and answer?

- a. How are the nerve cells called? How do they look like?
- b. What are the functions of the brain and the spinal cord?
- c. How do reflex actions differ from voluntary actions?
- d. What are hormones? Where are they produced?

UNIT OBJECTIVES

In this unit you will learn:

- The anatomy of the nervous and endocrine systems.
- To the processes of transmitting the nerve impulse throughout the body.
- To distinguish between the nerves centres and their functions.
- To distinguish among the different hormones and their functions.
- To appreciate the importance of healthy habits related to nervous and endocrine systems.
- The main diseases of the nervous and endocrine systems.

1. The interaction function

Interaction is the set of processes, which allows living beings to obtain information and to respond in consequence.

It is a group of processes, which allows living beings:

- Interact with their environment (other living beings and their surroundings)
- Perceive what is happening in the inside of their organisms themselves.

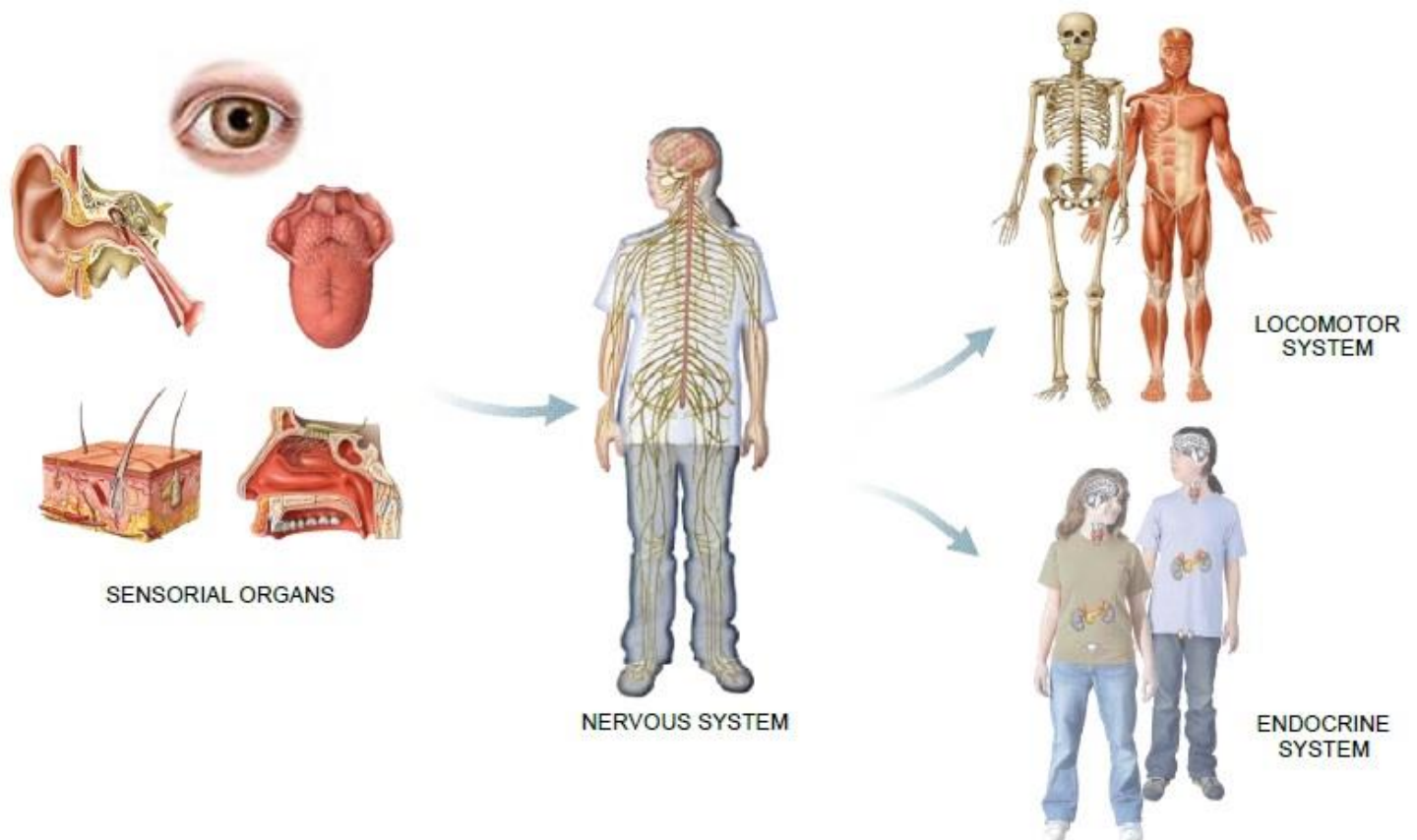
They have *sensitivity*; that is they are able to react to different circumstances:

- **Stimulus** is the change able to cause a reaction in an organism.
- **Response** is the provoked reaction itself.

On the other hand, interaction function includes all the mechanisms which assure that the different organ systems of the body act in coordination.

The organ systems involved in the interaction function are:

- **Nervous system.** It receives information from the sensory organs, processes this information and elaborates appropriate responses.
- **Endocrine system.** It produces hormones as response to the orders of nervous system. These hormones control many functions and processes of the body.
- **Skeletal system.** Its function is to allow the movement and to protect organs. It is the passive part of the locomotor system.
- **Muscular system.** Its function is the movement. It forms, with the skeleton, the locomotor system. It is the active part of it.



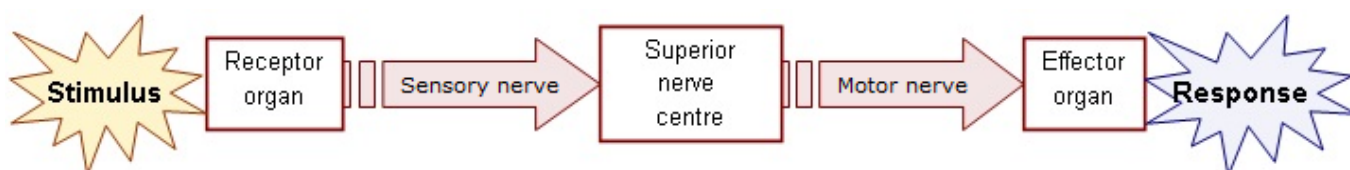
2. The nervous system

a) Functions of the nervous system:

- It receives the sensorial information from sense organs.
- It interprets this information.
- It elaborates appropriate responses.
- It transmits orders to effector organs which perform the response.
- It coordinates the operation of all organs.
- It carries out the intellectual and mental functions.
- It is responsible for the feelings and the emotions.

b) General organisation of the nervous system:

The nervous system is organised following this sketch:



The elements which participate are:

- **Receptor.** It is a cell that is able to perceive the stimulus, transforms it in nerve impulse and transmits it to other nerve cell. Sometimes these cells are grouped forming **sense organs**. Each receptor is sensitive to a specific stimulus (light, sound, pressure, pain...)
- **Nerves.** They are formed by nerve cells which transmit nerve impulses from receptors to nerve centres (**sensory nerves**) or from them to effectors (**motor nerves**).
- **Nerve centre.** It is the organ which receives the information, processes it and elaborates the response.
- **Effector.** It is the organ which performs the response. There are two types of effectors:
 - **Muscles.** They produce a **motor response** (a movement).
 - **Glands.** They produce a **secretory response** (a substance's secretion)

c) Structure of the nervous system:

Our nervous system is divided into two subsystems:

- **Central nervous system.** It is formed by the **nerve centres** (Encephalon and spinal cord)
- **Peripheral nervous system.** It is formed by the **nerves**.
 - **Somatic.** It controls the voluntary movement of skeletal muscles.
 - **Autonomic.** It controls self-regulated actions of internal organs and glands.
 - Sympathetic
 - Parasympathetic

ACTIVITIES

2.1. Imagine that you are going to cross the street. You get distracted and do not look before crossing. Suddenly you hear a claxon. Immediately you go back to the pavement.

- a. What are the stimulus and the response in this example?
- b. What are the sensorial and the effector organs implicated?
- c. What nerve centre receives the sensorial information, elaborates the response and transmits it to the effector?

2.2. Listen and identify what component of the nervous system functional sketch is described:

a. Receptor organ

b. Nerve centre

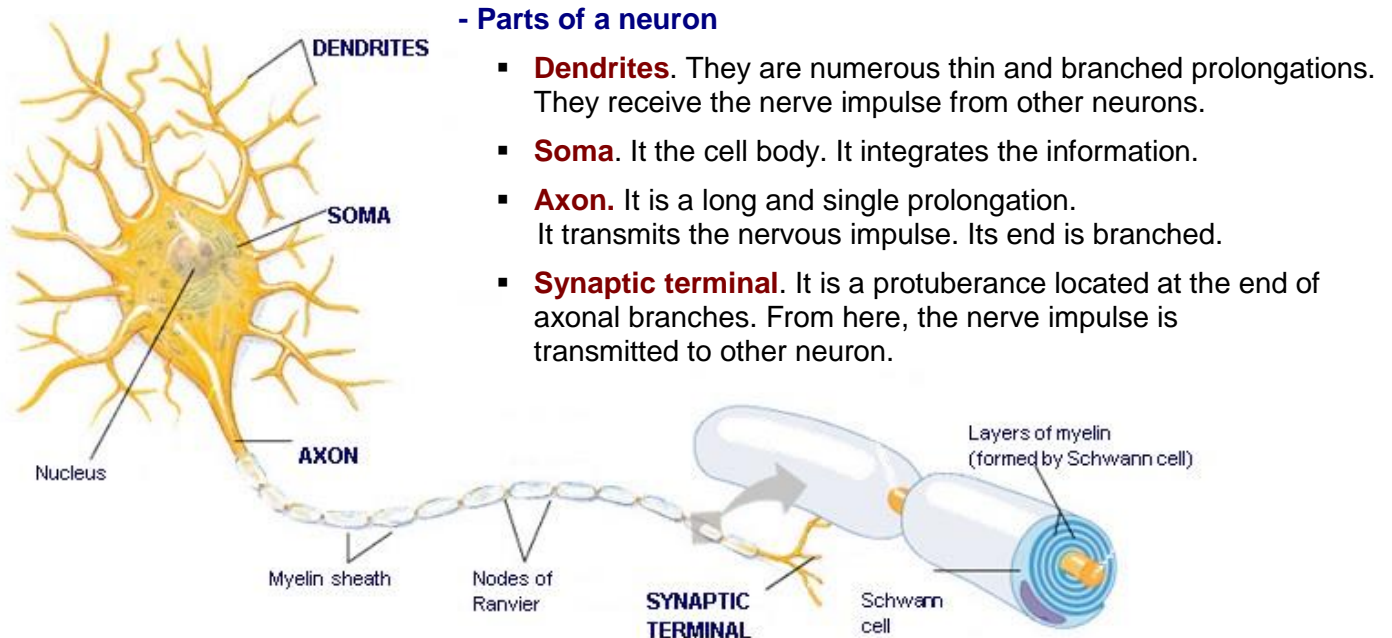
c. Effector organ

2.1. Cells of the nervous system

The nervous system is formed by two types of cells: neurons (the proper nerve cells) and glial cells.

a) Neurons:

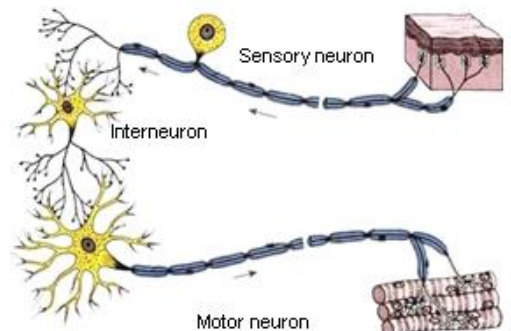
Neuron is the anatomical and physiological unit of the nervous system. They form the 90 % of it.



- Types of neurons

According to its *structure*, a neuron can be:

- **Multipolar neuron.** They are most abundant. They have numerous dendrites, and one axon. They are usually motor neurons.
- **Bipolar neuron.** They have a dendrite and an axon. They are usually interneurons.
- **Unipolar neuron.** They do not have dendrites. They are usually sensory neurons.



Other criterion to classify neurons is their *function*:

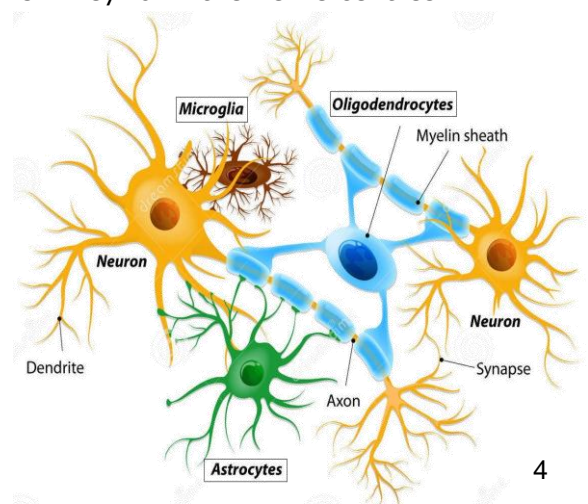
- **Sensory neuron.** They carry the nerve impulse from receptors to nerve centres. They form nerves.
- **Motor neuron.** They carry the nerve impulse from nerve centres to effectors. They form nerves.
- **Interneuron.** They are located connecting neurons. They form the nerve centres.

b) Glial cells (Neuroglia):

They represent the 10% of the nerve tissue cells.

These cells are in direct contact with neurons and surround them.

They support, nourish and protect neurons (astrocytes, oligodendrocytes, etc). Some of them form myelin sheath (Schwann cells) and others make cerebrospinal fluid.

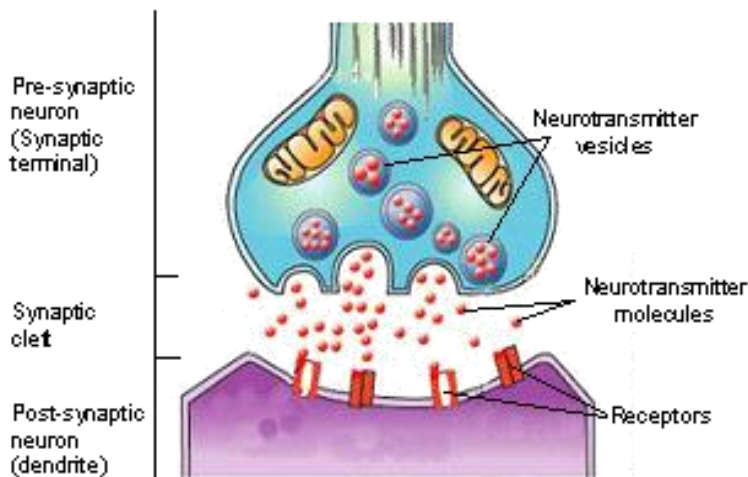


2.2. Nerve impulse and synapse

Neurons transmit and create nerve impulses. A **nerve impulse** is the electrical signal which spreads along the neuron. When neurons are stimulated they transmit impulses from their dendrites to their axons.

Neurons are not in contact. Between a neuron and other, there is a space called **synaptic cleft**. The nerve impulse has to cross this space. This occurs thanks to chemical substances called **neurotransmitters**. Synapse is the pass of nerve impulse from a neuron to another.

We can divide the process in several stages:



1st) Nerve impulse arrives to the pre-synaptic neuron.

2nd) This provokes the production of neurotransmitter vesicles in the synaptic terminal.

3rd) Vesicles fuse with the cytoplasmic membrane and release the neurotransmitter molecules to the synaptic cleft.

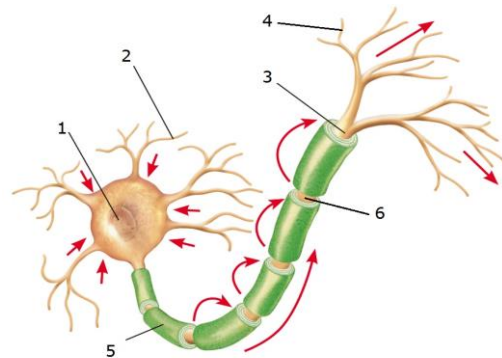
4th) Neurotransmitter molecules bind to specific receptors on the membrane of dendrites of post-synaptic neuron.

5th) This provokes the transmission of the nerve impulse to this neuron.

ACTIVITIES

2.3. Look at the picture and identify what each number represents. Now listen and indicate which part of the neuron is described.

2.4. What represent the arrows in the picture of the previous activity?



2.5. Myelin sheath forms an insulating layer that covers the axon. Then, how is nerve impulse transmission possible? Does this substance give any advantage?

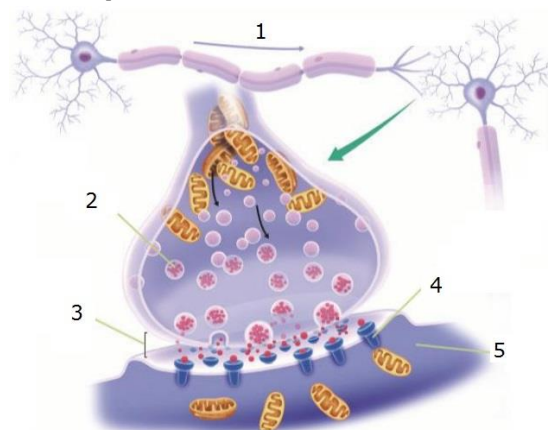
2.6. Interneurons are also called "association neurons". Explain the reason for this name.

2.7. Listen and identify the type of neuron that is described.

- Interneuron
- Motor neuron
- Sensory neuron

2.8. What is the function of glial cells? Could neurons survive without them?

2.9. Listen and related each step of the synapse with its correspondent number in the picture.



3. The central nervous system (CNS)

It is formed by the nerve centers: the **encephalon** (brain) and the **spinal cord**.

These organs are protected by bones:

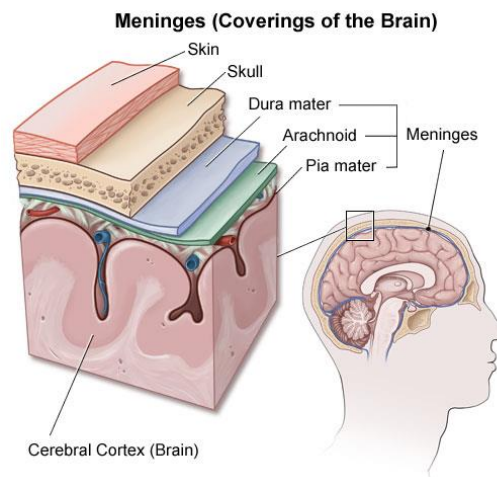
- **Cranium** (skull) that covers the encephalon
- **Vertebral column** that covers the spinal cord

In addition, there are three membranes that are located underneath the bone and that envelop these nerve centers, the **meninges**. They are from outside to inside: *dura mater*, *arachnoid mater* and *pia mater*.

Between the meninges and the central nervous system is a fluid called the **cerebrospinal fluid**. This fluid acts as mechanical and immunological protection and provides nourishment to the nerve tissue.

In the organs that forms the central nervous system is possible to differentiate two zones:

- **Grey matter**, formed by somas and dendrites.
- **White matter**, formed by axons.



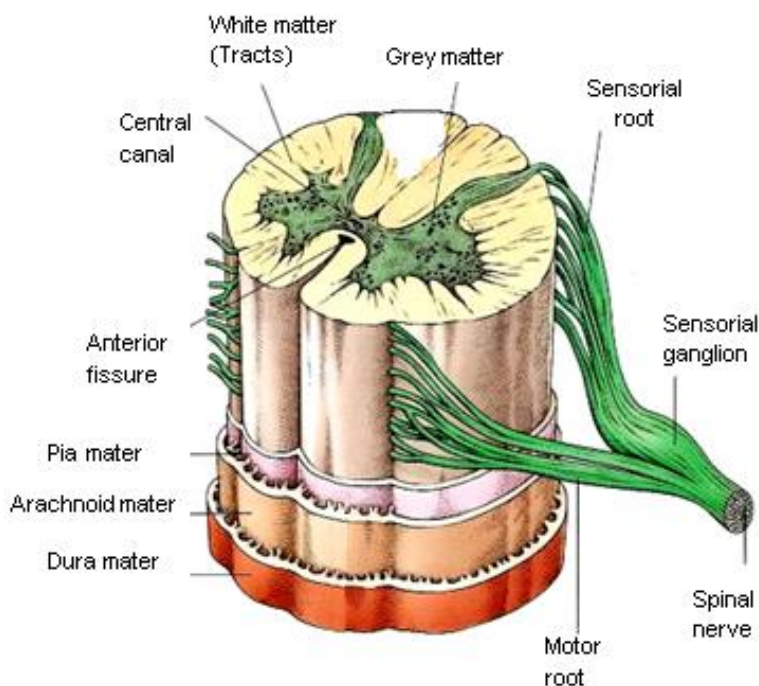
3.1. The spinal cord

This is a thin nerve tube about 45 cm long that is located inside the vertebral column.

- White matter is on the outside of the spinal cord and it is formed by ascending and descending bundles of axons, called **tracts**.
- Grey matter is on the inside and it is shaped like the wings of a butterfly.

In the centre of the spinal cord there is the **central canal** (or *ependyma*) which is an anatomic extension of the spaces in the brain known as the *ventricles* and, like the ventricles, contain cerebrospinal fluid.

Pairs of spinal nerves originate from the spinal cord to the right and to the left. Each one has a **sensory root** attached to the posterior or dorsal horn of the grey substance and a **motor root** attached to the anterior or ventral horn. These two roots join then to form the **spinal nerve**.



The functions of the spinal cord are:

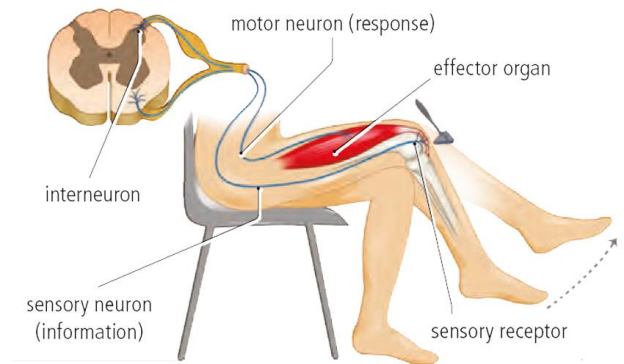
- To transmit the sensorial impulses from sensorial nerves to the encephalon and the motor impulses from the encephalon to the motor nerves.
- To carry out the reflex responses for some sensory impulses directly.

A **reflex action** is an automatic and unconscious reaction produced as response to a specific stimulus. The cerebral cortex is not involved in type of nerve actions.

Reflex acts are related with the survival. For example if you feel that something can enter in your eye, you close it without think about it. Or if you burn your hand you retire it immediately, before you will be conscious of what has happened.

Three types of neurons participate in reflex actions. They form the **reflex arc**.

- A **sensory neuron** that comes from a receptor and enters into the spinal cord through its sensory root.
- An **interneuron** that connects with the sensory neuron and transmits the impulse to the motor neuron.
- A **motor neuron** that exits from the spinal cord by its motor root and arrive to a muscle.



3.2. The encephalon

The **encephalon** or **brain** is formed by several nerve centres. The most important are the cerebrum, the cerebellum and the brain stem.

a) The cerebrum:

It is the largest part of the encephalon and the main nerve center.

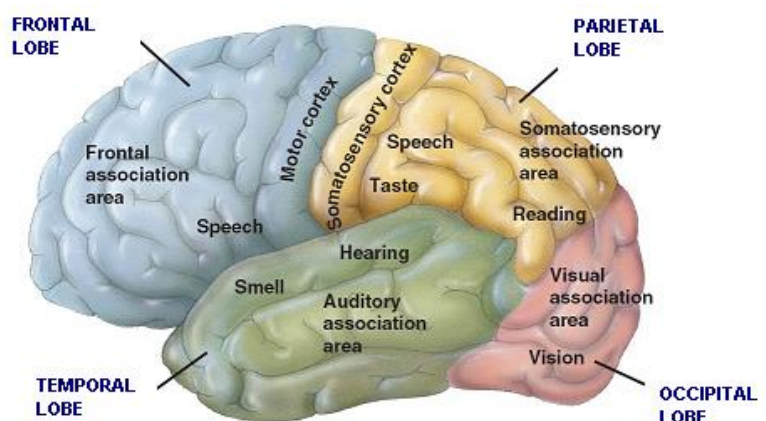
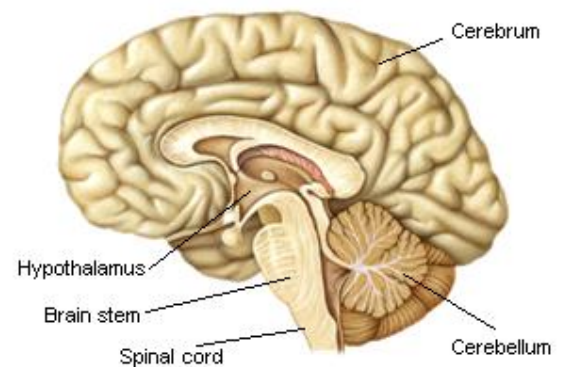
Grey matter is located on the outside and white matter on the inside. Grey matter is called the **cerebral cortex**. It is a very thin layer (only about 2 mm thick). It is divided in three functional areas: motor, sensory and association cortex.

The cerebral cortex is full of folds and furrows. These folds divide the cerebrum surface in:

- **Circumvolutions** (or *gyri*). They are more numerous and less deep lines.
- **Fissures** (or *sulci*). They are less numerous and deeper lines.

Fissures divide the cerebrum in **lobes**. Each lobe receive the name of the cranial bone under it is situated (*frontal, parietal, occipital* and *temporal lobes*). Each zone has a function. The main fissure (*great longitudinal fissure*) divides the organ in two **cerebral hemispheres**. Their functions are different:

- Intuitive and creative capacities are located in the right hemisphere.
- Logic and analytic capacities are located in the left hemisphere.

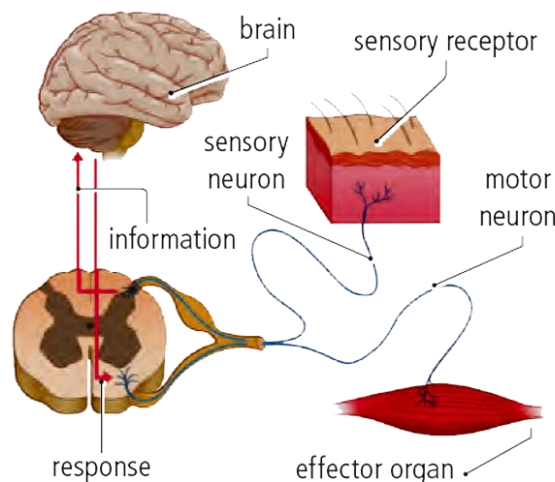


Cerebral hemispheres are joined by a structure called *corpus callosum* that allows the coordination between them and with other parts of CNS.

Cerebral cortex functions are many and very important:

- It receives and processes the sensory information, except the balance.
- It controls and coordinates all parts of the body.
- It develops the higher nerve functions (memory, reasoning, intelligence, conscience and will)
- It controls the voluntary and conscious movement (voluntary actions)

In **voluntary actions** the response is generated consciously in the cerebral cortex.



The **limbic system** is other important part of the cerebrum. It includes several structures. **Hypothalamus** is the most important. It is located between the brain stem and the cerebrum.

Their functions are:

- To regulate the function of the endocrine system through the **hypophysis**.
- To be responsible for emotions, feelings (love, hatred, sadness, happiness, fear, etc.) and basic instincts such as hunger, thirst and sexual desire.

b) The cerebellum

It is located under the cerebrum in the occipital zone.

Its external shape is similar to cerebrum. Its surface is folded and it is divided into two **cerebellar hemispheres**, although in this case appears other central protuberance, the **vermis**.

Grey matter is on the outside and white matter is on the inside and is tree-shaped.

The functions of cerebellum are:

- It receives and processes the sensory information of balance.
- It controls the balance and the posture.
- It coordinates the movements to assure that they are precise and harmonic.

c) The brain stem

It includes several parts of the encephalon between the spinal cord and the cerebrum. The most important part of the brain stem is the **medulla**.

The medulla is a bulky prolongation of the spinal cord. Its surface is smooth and uniform. White matter is on the outside and grey matter is on the inside.

Nervous bundles which come from the spinal cord cross in the medulla (decussation). As a result, the left cerebral hemisphere controls the right side of the body and the right hemisphere controls the left side.

The medulla is responsible for several automatic and vegetative functions like heartbeat, breathing rate and blood pressure and it is also involved in some reflex acts such as coughing or vomiting.

ACTIVITIES

3.1. Why is the colour of grey and white substances different?

3.2. What are the protective structures of the nerve centres?

3.3. Listen and find the six mistakes in the text:

The spinal cord

The spinal cord is a short, thin tube made up of muscle tissue protected by the skull, which links the encephalon to the rest of the body.

It serves as a conduit for nerve impulses from the effectors to the encephalon and from the encephalon to the receptors.

It also coordinates simple responses called voluntary actions.

3.4. Why do you think that the cerebral cortex is so much folded?

3.5. Indicate which part of the CNS is the responsible for these actions:

- | | |
|-----------------------------|------------------------------|
| ▪ To resolve a math problem | ▪ To talk to a friend |
| ▪ To ride on bicycle | ▪ To keep the cardiac rhythm |

3.6. Listen and say to which part of the encephalon corresponds each sentence:

- | | | |
|-------------|---------------|------------|
| a. Cerebrum | b. Cerebellum | c. Medulla |
|-------------|---------------|------------|

3.7. Listen to the sentences and decide if they refer to voluntary or involuntary actions.

- | | | | | | |
|----|----|----|----|----|----|
| a. | b. | c. | d. | e. | f. |
|----|----|----|----|----|----|
-

4. The peripheral nervous system (PNS).

It is formed by nerves which connect the CNS with the receptors and effectors.

A **nerve** is an association of myelinated axons involved in connective tissue.

Many nerves have ganglia. A **ganglion** is a relay point of the nerve impulse. It contains the dendrites and soma of a postsynaptic neuron.

The PNS can be divided into two functional subsystems:

- **The somatic nervous system.** It is the part of the peripheral nervous system that controls the voluntary movement of skeletal muscles.
- **The autonomic nervous system.** It is the part of the peripheral nervous system that controls the visceral functions. Most of its actions are involuntary and unconscious.

4.1. The somatic nervous system

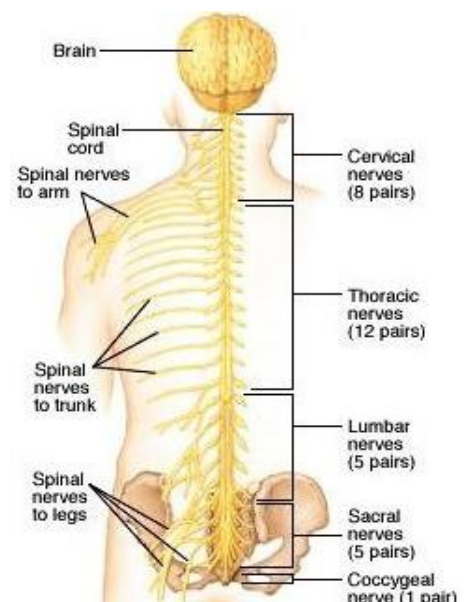
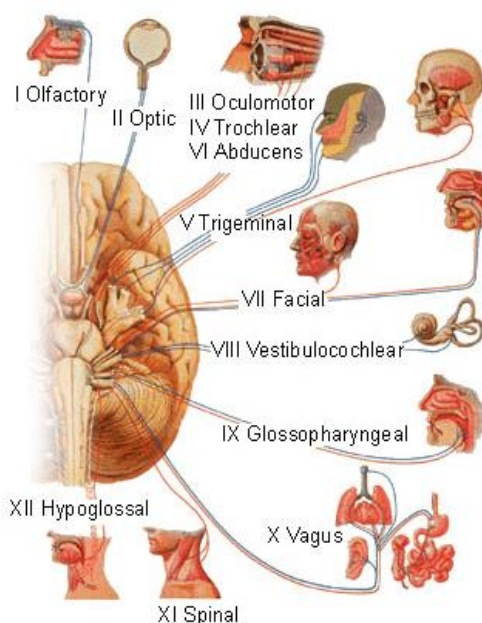
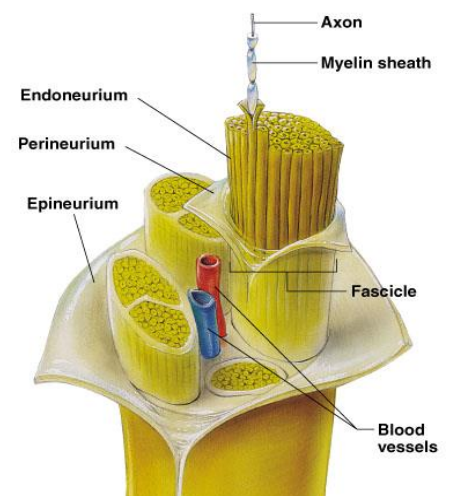
Nerves can be classified in two ways:

- By the **direction of nerve impulse** transmission:

- **Sensory nerves**
They transmit the information from the sense organs.
They are formed only by sensory neurons.
- **Motor nerves**
They transmit orders to effector organs (muscles).
They are formed only by motor neurons.
- **Mixed nerves**
They transmit sensations and orders.
They are formed by sensory and motor neurons.

- By the **nerve centre** from which they emerge:

- **Cranial nerves**
They come from the encephalon.
There are 12 pairs.
They can be sensory or motor nerves.
They innervate the head and neck.
- **Spinal nerves**
They come from the spinal cord.
There are 31 pairs.
All of them are mixed nerves.
They innervate trunk, legs and arms.



4.2. The autonomic nervous system

It innervates smooth muscle, cardiac muscle and glands. It is concerned with heart rate, breathing rate, blood pressure, body temperature, and other visceral activities that work together to maintain homeostasis.

It is formed by nerves which come from the medulla, the spinal cord and parts of the hypothalamus.

It is divided into two subsystems which functions are opposite (antagonistic) and complementary.

- Sympathetic nervous system.

Its function is to activate the organs (with the exception of digestive system)

Its nerves come from the encephalon and the cervical spinal cord.

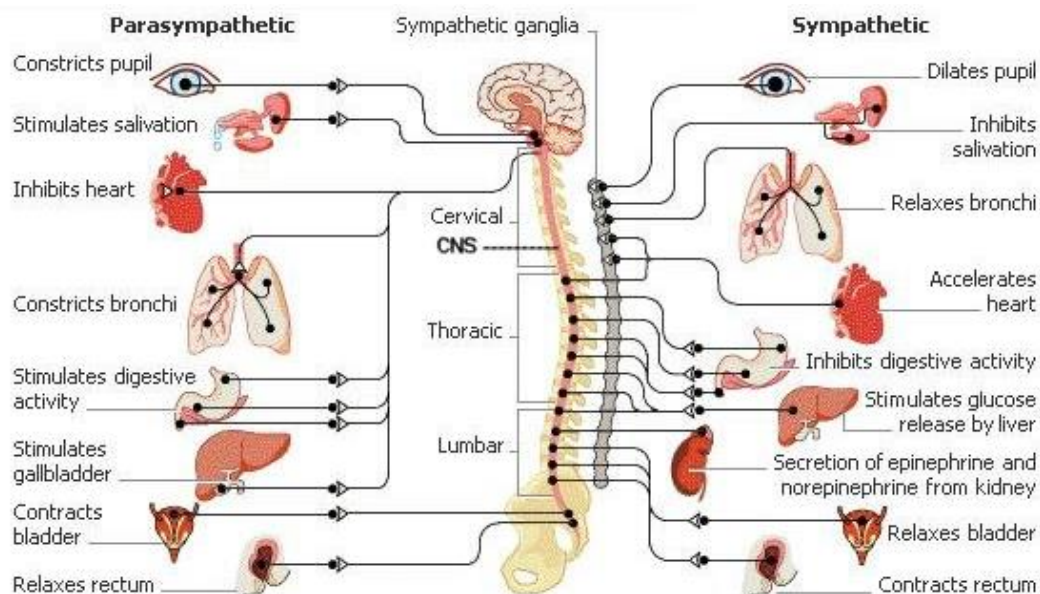
Their ganglia form a chain close to vertebral column.

- Parasympathetic nervous system

Its function is to deactivate the organs (with the exception of the digestive system)

Its nerves come from the thoracic and the lumbar spinal cord.

Their ganglia are close to the organs which it innervates.



ACTIVITIES

4.1. What criterion do we follow to divide the peripheral nervous system into somatic and autonomic nervous system?

4.2. Describe the main differences between sensory nerves and motor nerves. What is a mixed nerve?

4.3. Think about the actions of Autonomic Nervous System. Could they be conscious? Why?

4.4. Listen and indicate if the following sentences related to the peripheral nervous system are true or false.

a. T / F

b. T / F

c. T / F

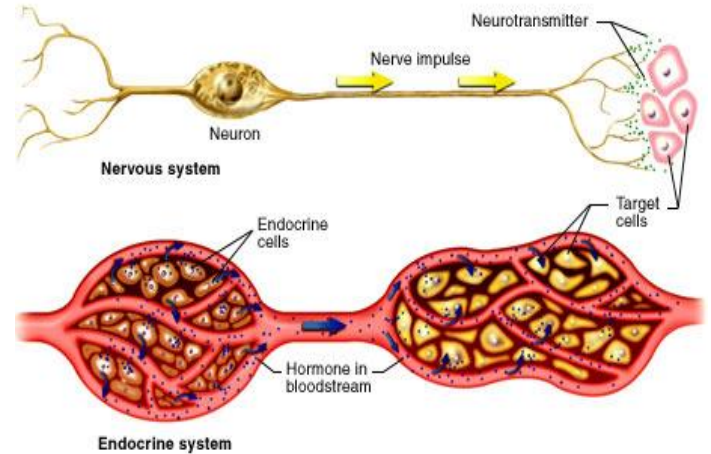
d. T / F

5. The endocrine system

The endocrine system is the other coordination system of the body. It is closely related with the nervous system and they depend on each other. Sometimes the nervous system stimulates or inhibits the secretion of a hormone, and other times hormones stimulate or inhibit the action of the nervous system.

They control different situations because their characteristics are different too:

- The nervous system transmits the information through the **nervous impulse** that is an electrical signal while endocrine system transmits the information through **hormones** that are chemical substances.
- Nervous impulse passes from **neuron to neuron**, while hormones are carried by **bloodstream**.
- The nervous system acts **quickly** (milliseconds) and its actions are **short in time**. Usually this **action ends** when stimulus disappears. In contrast, the endocrine system acts **slowly** (from seconds to days) and its actions are **lasting in time**. Usually this **action continues** although the stimulus disappears.
- The nervous impulse has **local effects** while hormones have **general effects** that many times affect to all the body.



The functions controlled by the endocrine system are:

- Reproduction
- Growth and development
- Mobilisation of body defenses
- Maintenance of homeostasis
- Regulation of metabolism

The endocrine system is formed by several glands (**endocrine glands**) distributed through all the body and that are not connected to each other. These glands produce substances (**hormones**) that are released directly into the blood.

A **hormone** is an organic chemical substance that controls the activity of an organ.

- Each hormone exerts its action only over a determine cell type (**target cell**).
- It is necessary only a very little amount of hormone to assure its effect.
- They are only produced when and during the time that it is necessary.
- They are only produce in the optimal amount.

The main endocrine glands are:

- **Hypothalamus**. It is situated in the basis of encephalon and is attached to the hypophysis.
- **Hypophysis** (or **pituitary gland**). It is a little gland situated in the encephalon.
- **Thyroid**. It is located in the neck under the larynx and behind the trachea.
- **Parathyroid**. It is formed by four small glands attached to the thyroid.
- **Adrenal capsules**. Two glands located on the kidneys.
- **Pancreas**. It is a mixed gland because it has two types of secretion, a digestive juice (pancreatic juice) and a hormonal secretion.
- **Gonads**. They are **testicles** (males) and **ovaries** (females). They are mixed glands too because they produce gametes (ovules and spermatozoids) in addition to hormones.

The main hormones produced by each one are:

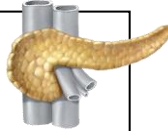
HYPOPHYSIS (PITUITARY GLAND)

- **Antidiuretic hormone (ADH).** It reduces the water amount eliminated by urine.
- **Oxytocin.** It stimulates uterus contractions during labour and milk ejection in mammary glands.
- **Stimulating hormones.** They provoke the secretion of other glands (gonads, thyroid and adrenal capsules)
- **Somatotropin.** It is the growth hormone. Provoke the enlargement of bones and general growth of body.



PANCREAS

- **Insulin.** It increases the use of glucose by tissues and muscles (reduces the glucose in blood)
- **Glucagon.** It provokes the transformation of glycogen from liver into glucose (increases the glucose in blood)



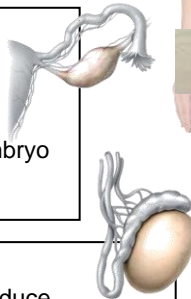
THYROID

- **Thyroxine.** It regulates the metabolism
- **Calcitonin.** It reduces the blood calcium levels and provokes its deposition in bones.



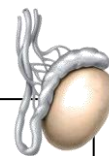
OVARIES

- **Oestrogens.** They produce and maintain the female secondary sexual characters.
- **Progesterone.** It allows the embryo implantation into uterus.



TESTICLES

- **Androgens.** They produce and maintain the male secondary sexual characters.

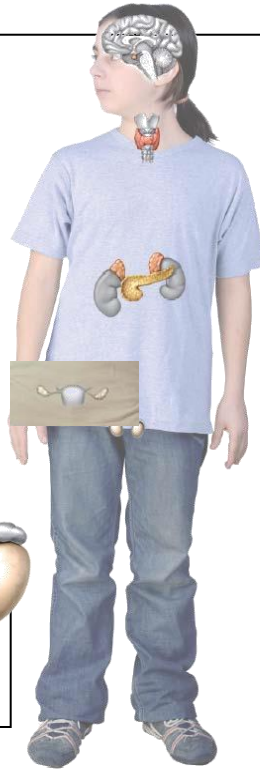


PARATHYROID

- **Parathyroid hormone.** It regulates the levels of calcium and phosphorus in blood.

ADRENAL CAPSULES

- **Adrenalin.** It prepares the organism for action.
- **Corticoids.** They control several metabolic processes and water amount in tissues.
- **Aldosterone.** It regulates the sodium and potassium concentration in blood.



ACTIVITIES

5.1. Hormones are called many times "chemical messengers". What does it mean?

5.2. What hormone will be secreted when:

- Your body is dehydrated and you cannot drink water.
- You have just eaten and the glucose levels in blood are high
- You are excited and nervous because you are in danger.

5.3. Listen and indicate what endocrine gland is described. Which are missing?

a.

b.

c.

d.

e.