Unit 5 textbook

Coordination and nerves

1 Human interaction and coordination

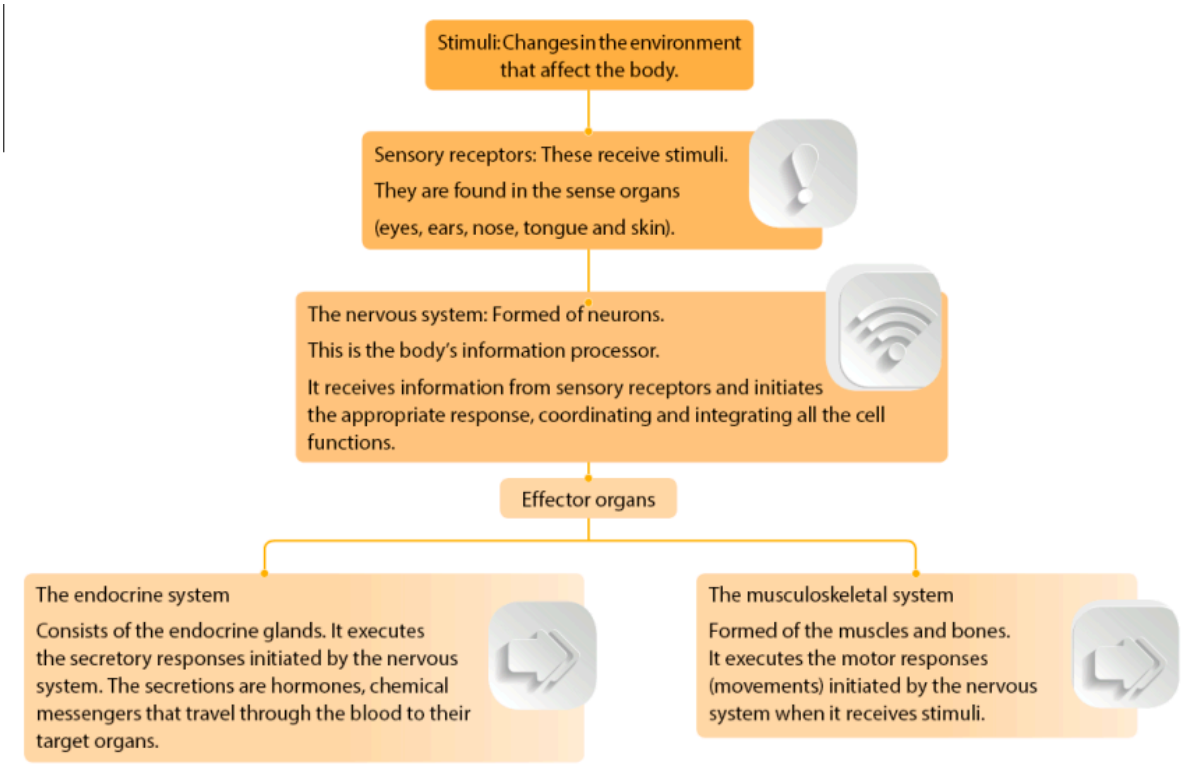
The **function of interaction** is essential for survival. It allows the body to perceive **stimuli** or changes in the environment and respond to them appropriately through the **effector organs**.

Interaction allows the body to:

- Adapt to its constantly changing external and internal environment.
- Coordinate its different organs and systems so that they work as a single unit.

Interaction involves the following organs and systems:

- Sensory receptors or sense organs
- The nervous system
- The endocrine system
- The musculoskeletal system

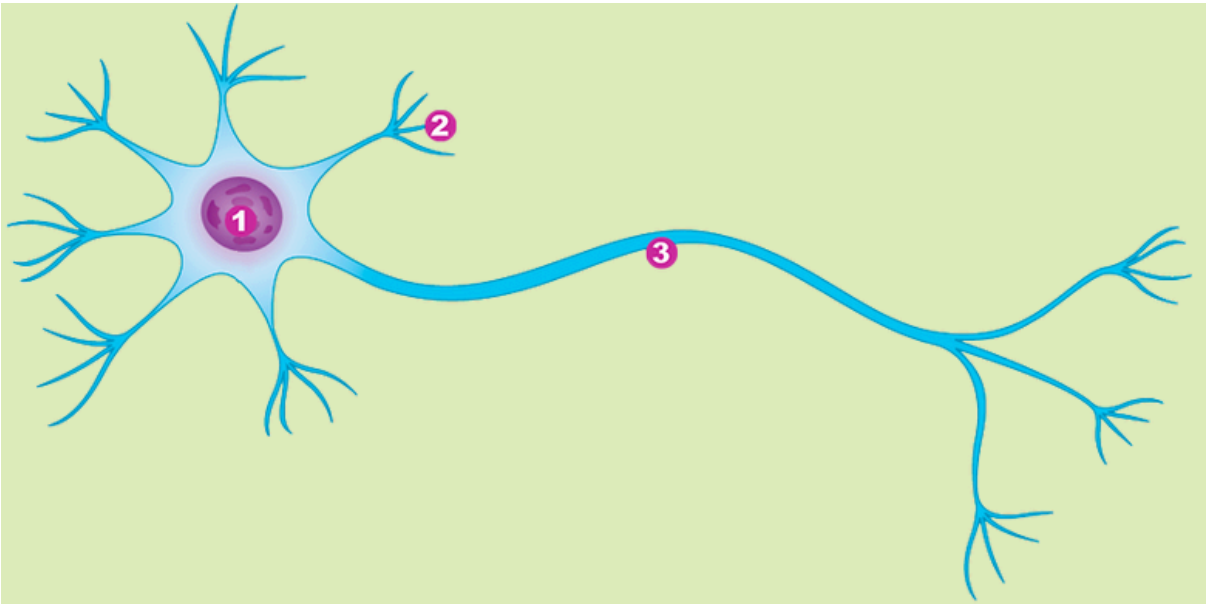


Info link 1:
http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_pre_2011/brain_mind/environmentrev1.shtml

2 Nerve cells

The nervous tissue coordinates the body's functions. It is formed of two types of cell: **neurons** and **neuroglia**.

Neurons are highly specialised, star-shaped cells that have lost their ability to divide. They initiate and transmit nerve impulses. They are formed of the following parts:

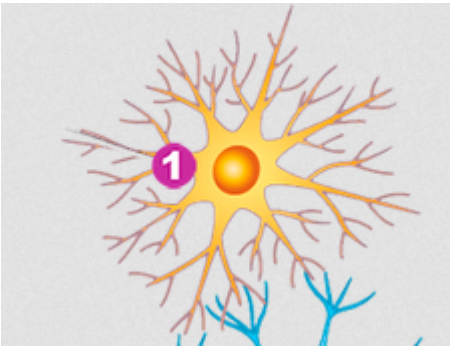


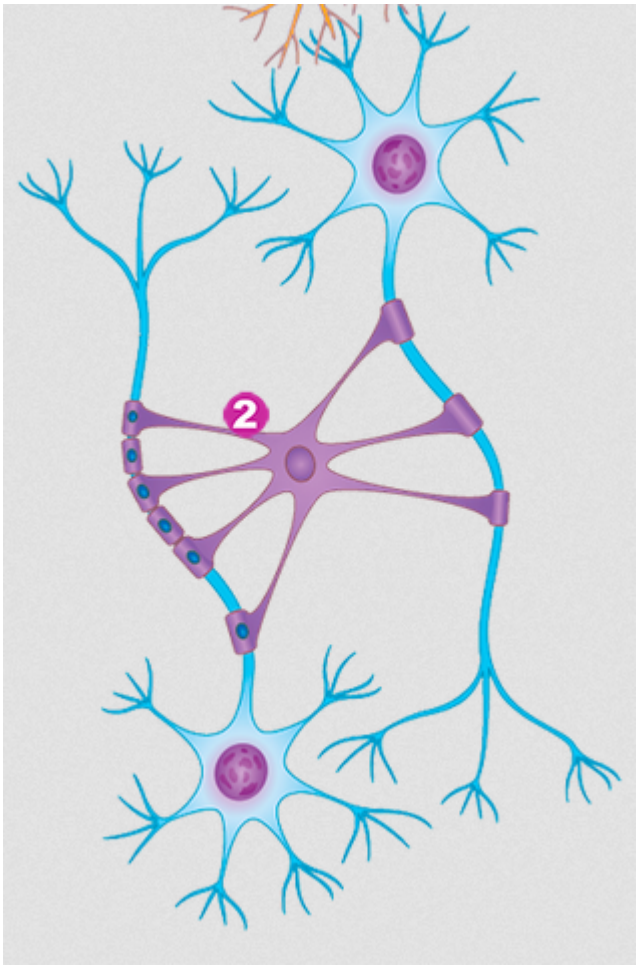
1 Most of the cytoplasm is concentrated in the soma. The **soma** contains the nucleus. The dendrites and axon branch out from here.

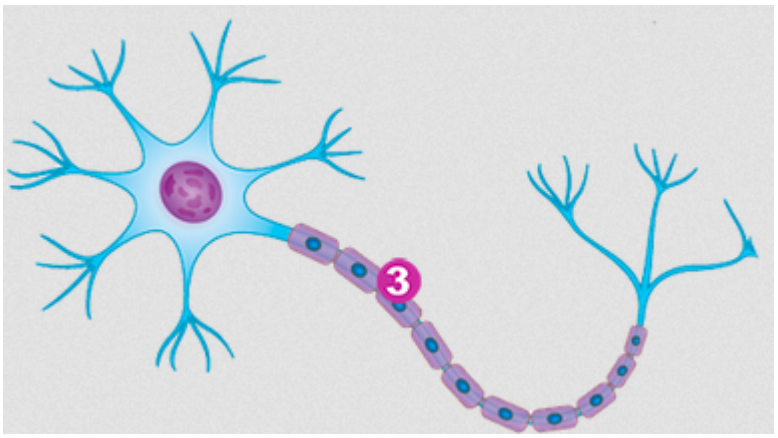
2 Dendrites are short cell projections with many branches. Most neurons have multiple dendrites.

3 The **axon** or **nerve fibre** is a long cell projection. It is only branched at one end. There is usually only one axon.

Neuroglia cells are located between the neurons. They support, nourish and protect them. There are various types, but the three main ones are oligodendrocytes, astrocytes and Schwann cells.







1 Astrocytes are involved in neuron nutrition. They remove neurotransmitters from the synaptic cleft and act as supporting cells.

2 Oligodendrocytes wrap around the axons of several neurons in the central nervous system simultaneously. They form an insulating layer called the **myelin sheath**. This is essential for the correct transmission of nerve impulses.

3 Schwann cells wrap around part of the axon of a single neuron in the peripheral nervous system. They form the myelin sheath together with oligodendrocytes.

link: Neurons and what they do: https://www.youtube.com/watch?v=vyNkAuX29OU

3 Nerve impulses and synapses

When a neuron is excited, a **nerve impulse** is generated. This impulse is transmitted along the neuron in the form of an electric current. It always travels in one direction: it enters through the dendrites, travels to the soma and leaves through the axon.

The nerve impulse passes from one neuron to the next via connections called **synapses**.

Each synapse consists of the following parts:

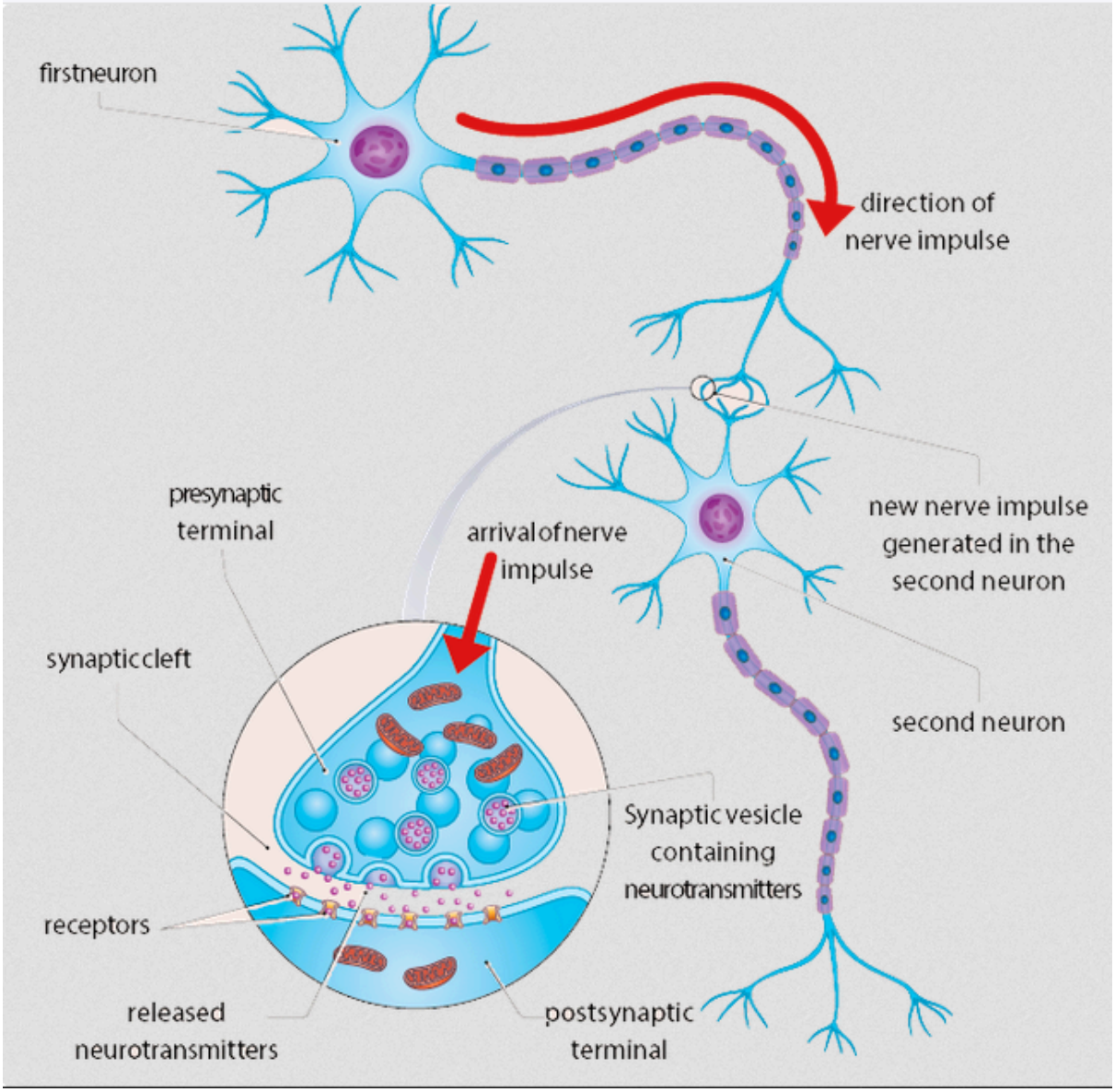
- A **presynaptic terminal**. This is the end of the axon of the presynaptic neuron (first neuron). It contains numerous synaptic vesicles that store chemical signalling molecules called neurotransmitters.

- A **synaptic cleft**. This is a small space between two neurons. Neurons never touch.

- A **postsynaptic terminal**. This consists of the dendrites or soma of the postsynaptic (second) neuron.

When the nerve impulse reaches the end of the presynaptic neuron's axon, the neuron releases the neurotransmitters in the synaptic vesicles into the synaptic cleft.

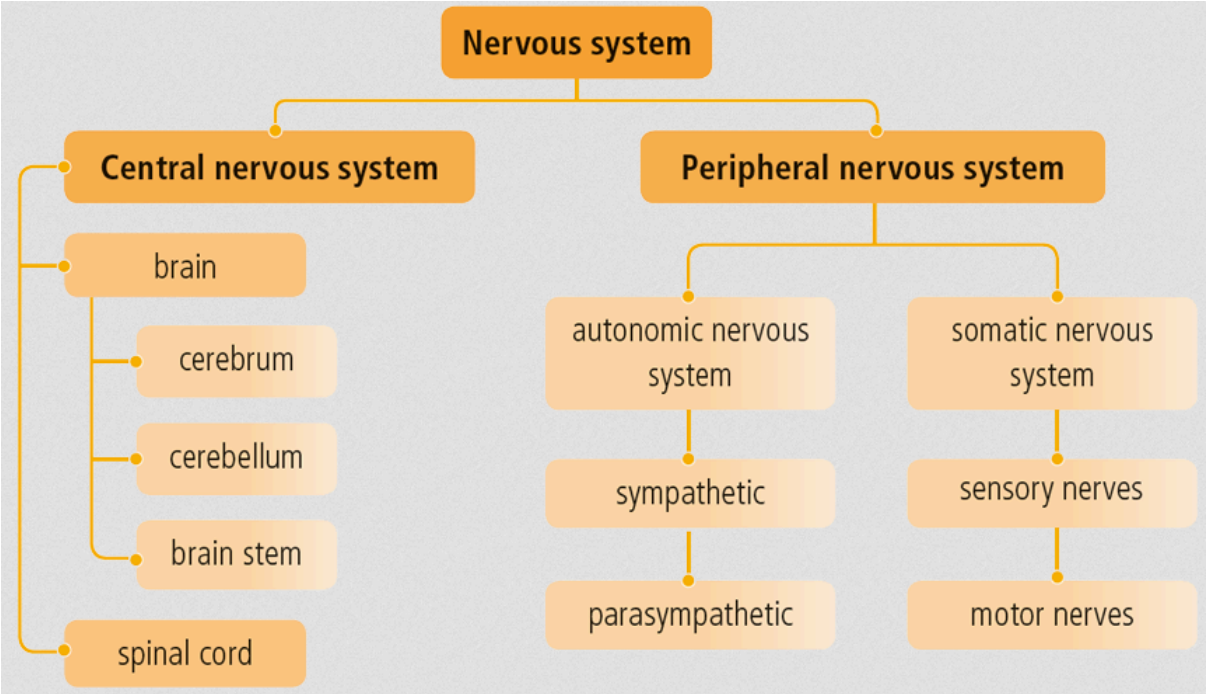
The neurotransmitters cross the synaptic cleft and bind to specific receptors in the membrane of the postsynaptic neuron. This generates a new electric current or nerve impulse in the second neuron. The new impulse passes from the soma to the end of the axon.



4 The nervous system

The nervous system coordinates all of the body's functions. It is responsible for intellectual function, emotions and feelings.

The human nervous system is divided into two parts: the **central nervous system** (**CNS**), formed of the brain and spinal cord; and the **peripheral nervous system** (**PNS**), formed of all the nerves and nerve ganglia throughout the body.



4.1 **The central nervous system**

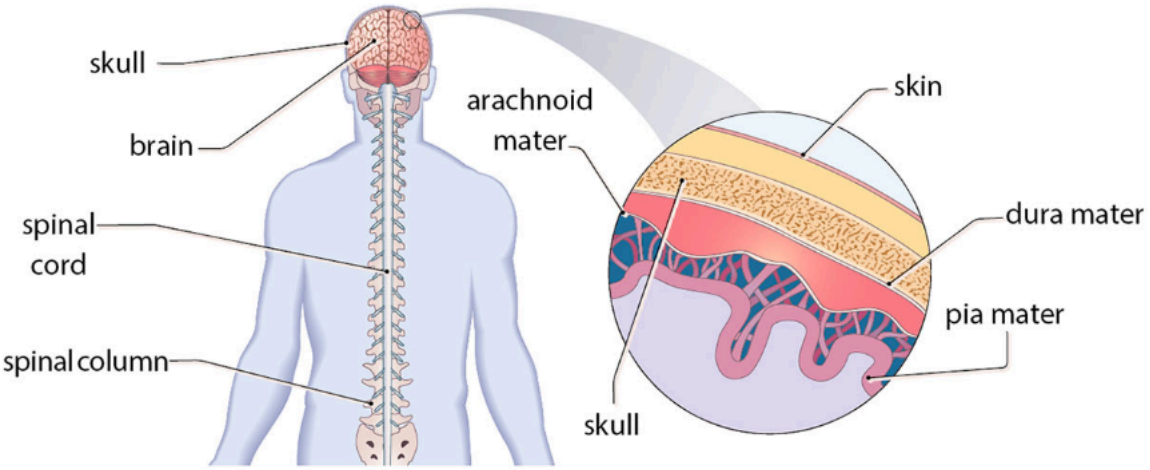
In humans, the central nervous system is responsible for higher **cognitive** functions. It is also responsible for general sensory integration and coordination.

At microscopic level, the central nervous system is formed of two parts:

- the **grey matter**, formed of neuron somas and dendrites.
- the **white matter**, formed of neuron axons covered in the myelin sheath.

The central nervous system consists of the **brain** and **spinal cord.** These are protected by:

- **The skull** and **spinal column**.
- The **meninges**. These are three protective membranes of connective tissue that surround the brain and spinal cord. The three layers are the **pia mater** (inside), **arachnoid mater** (middle) and **dura mater** (outside). The pia mater and arachnoid mater are surrounded by **cerebrospinal fluid**, which cushions the brain and spinal column, protecting them from impact.

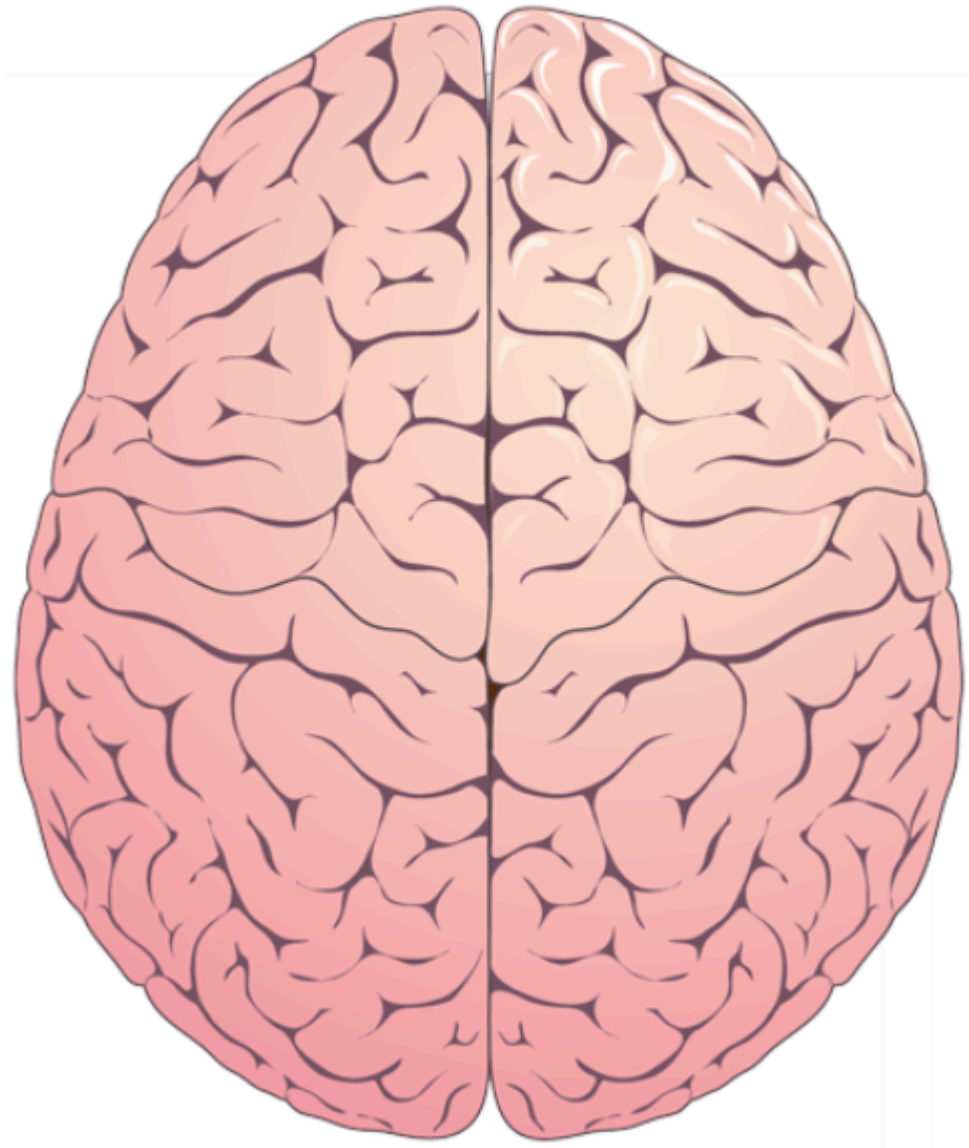


The brain

The brain is formed of the cerebrum, cerebellum and brain stem.

CEREBRUM

The cerebrum consists of two **cerebral hemispheres** – left and right – separated by the **great longitudinal fissure**. The two hemispheres are connected by the **corpus callosum**, formed of white matter.



Cerebral cortex:

This is the outer layer of the cerebrum. It is formed of grey matter, which contains neuron somas and dendrites. It has numerous ridges called gyri, and performs the following **functions**:

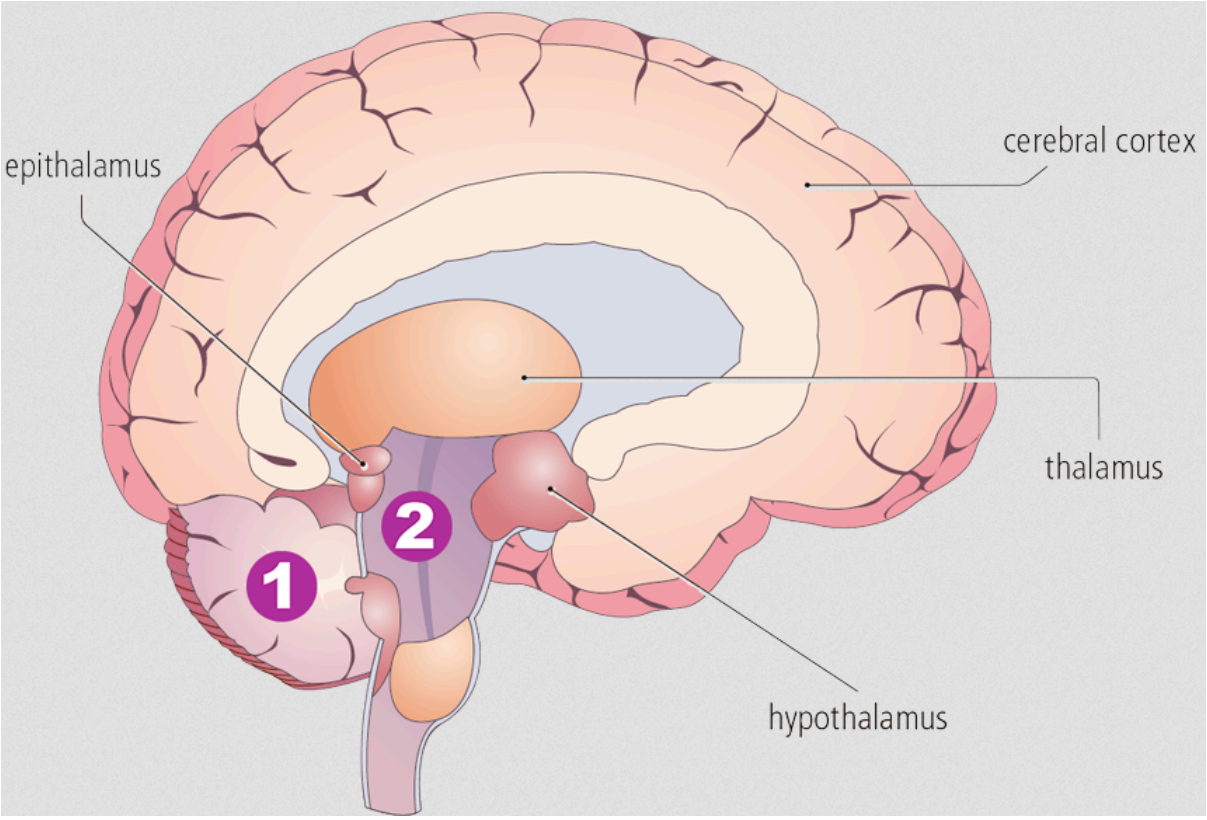
- Receiving, interpreting and processing **information** from the sense organs.
- Initiating **voluntary motor responses** based on the sensations received.
- Responsible for **intellectual and mental functions** (intelligence, memory, language and communication, learning, **awareness**, choices, etc.).
- **Regulating** the function of the rest of the nervous system.

Limbic system:

- It **regulates** the function of the **endocrine** system.
- It is responsible for emotions, feelings and basic instincts, such as hunger, **thirst** (sed) and sexual desire.

It contains:

- **Hypothalamus**. This is connected to the pituitary gland, an endocrine gland that regulates the endocrine system.
- **Epithalamus**. This contains the pineal gland or epiphysis cerebri.
- **Thalamus**.



CEREBELLUM

This is at the back of the brain. It has a **cerebellar cortex** formed of **tightly** folded grey matter. Inside, the white matter, which is formed of axons, is very **branched.**

The cerebellum is responsible for motor coordination and balance. It means that our movements can be precise and coordinated, and makes us aware of our spatial orientation.

BRAIN STEM

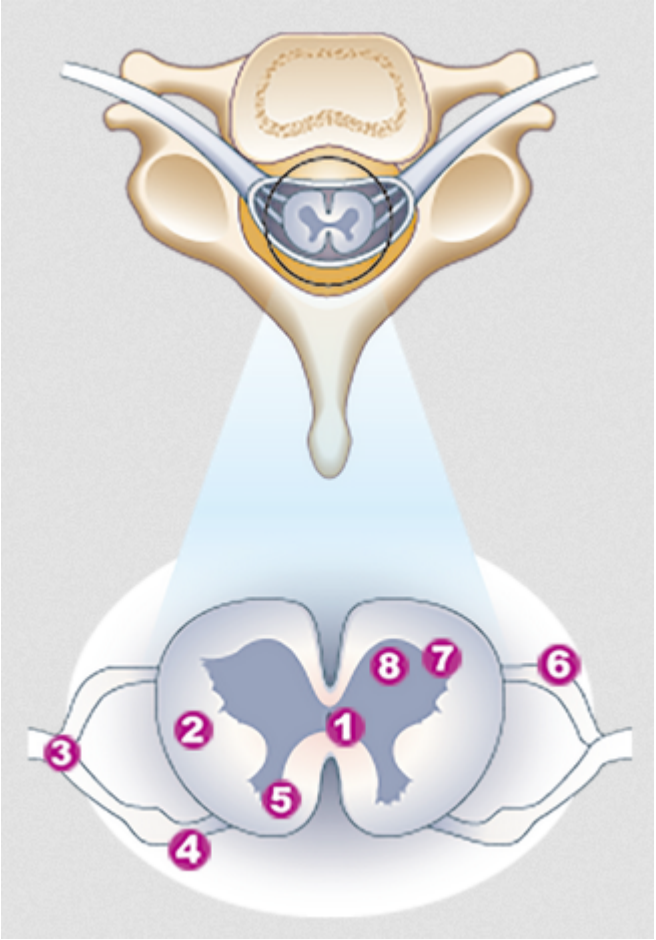
This is located at the base of the brain, at the back of the neck, and connected to the spinal cord. It is formed of white matter on the outside and grey matter on the inside.

It regulates the **autonomic functions** that keep us alive: **heartbeat**, **respiratory movements**, **blood pressure**, etc.

The spinal cord

The spinal cord is connected to the brain stem. It extends down the back of the

body inside the spinal canal formed by the vertebrae. Like the brain stem, the white matter of the spinal cord is on the outside and the grey matter is on the inside.



Central canal: a space full of cerebrospinal fluid that runs longitudinally through the centre of the spinal cord.

White matter: formed of neuron axons covered by the myelin sheath.

Sensory root of the spinal nerve.

Spinal ganglion in the sensory branch of the spinal nerve.

Posterior or dorsal horns: thin, star-shaped sections that are connected to the sensory roots of the spinal nerves.

Motor root of the spinal nerve.

Anterior or ventral horns: these thick sections are connected to the motor roots of the spinal nerves.

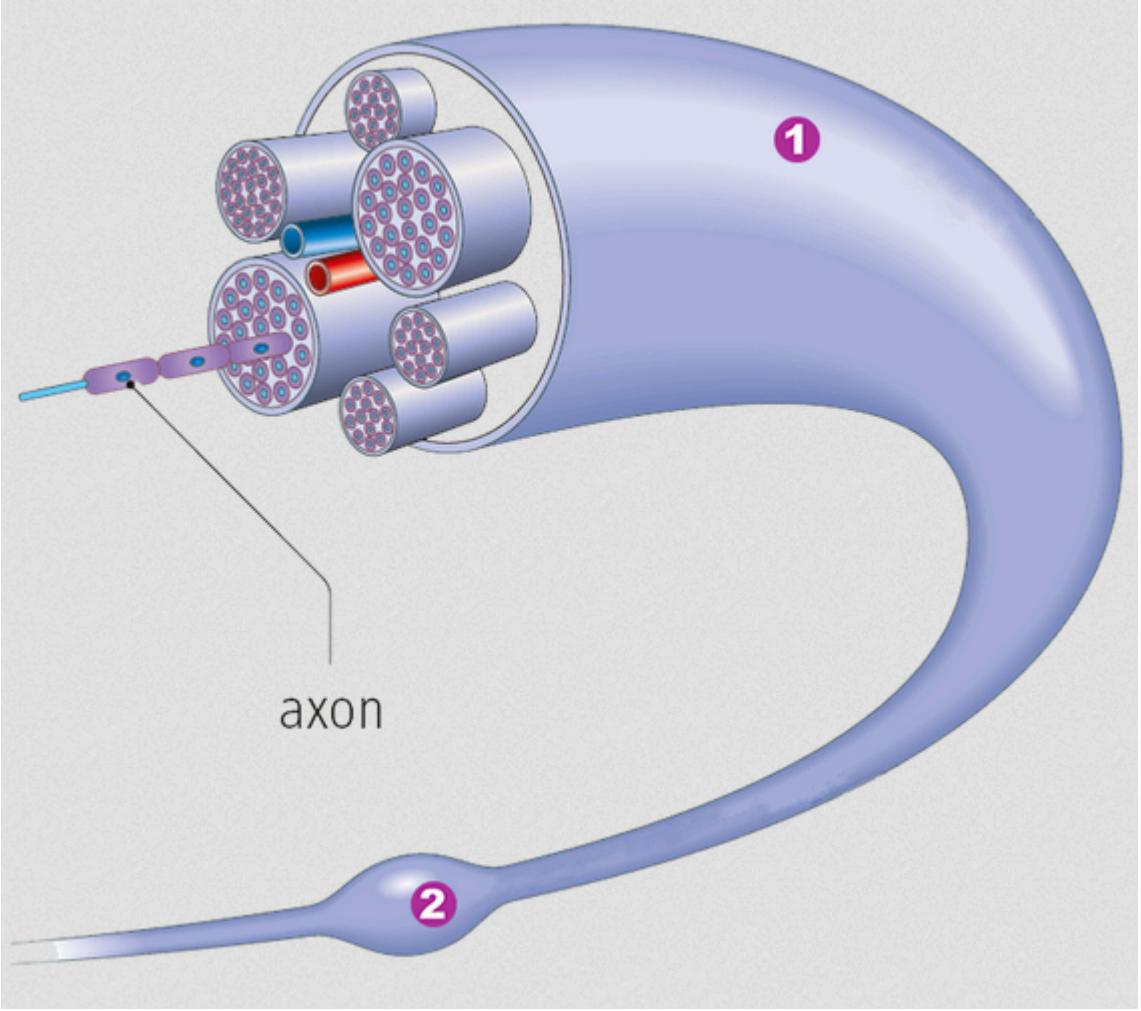
Grey matter: butterfly-shaped and formed of neuron somas and dendrites.

The spinal cord has two functions:

- **Conduit function**. This takes information from the sense organs to the corresponding areas of the brain, and takes the brain's responses to the effector organs.
- **Reflex function**. This initiates automatic **involuntary motor responses** to possible danger.

4.2 **The peripheral nervous system**

The peripheral nervous system consists of the **nerves** and **nerve ganglia**.
It connects the central nervous system to the peripheral organs, receptors and effectors.



Nerve

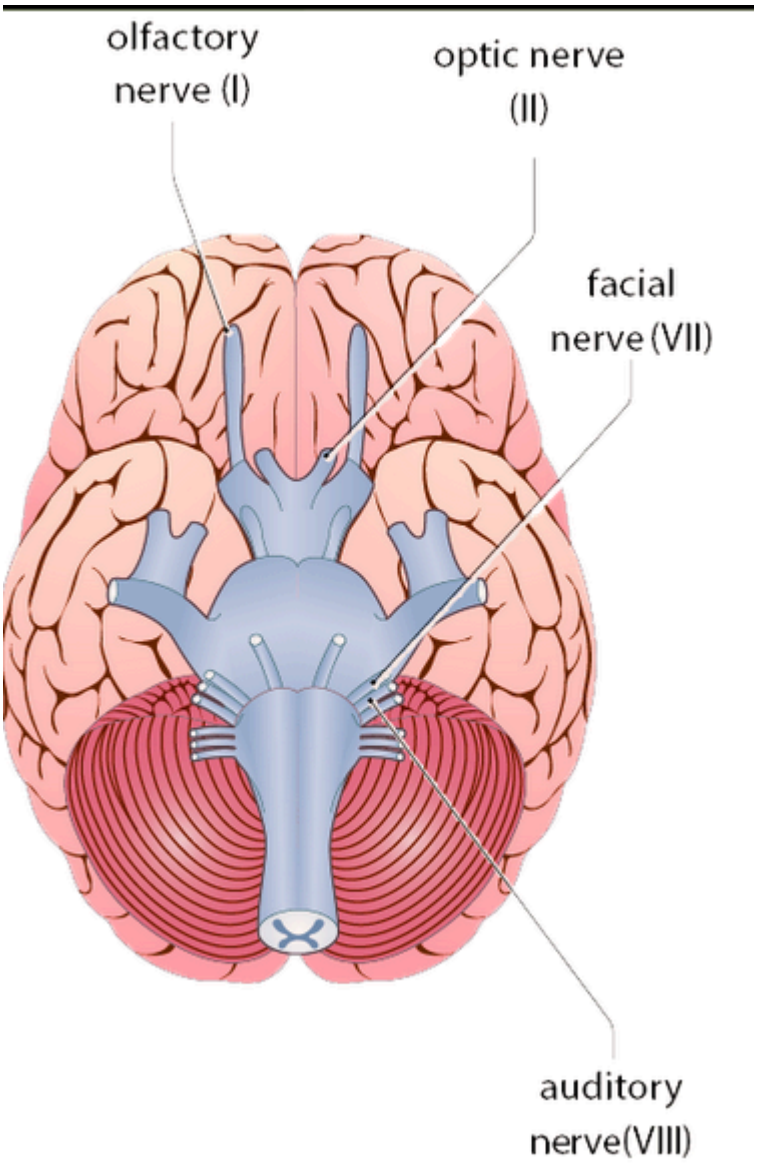
A group of axons (sometimes dendrites) isolated by their myelin sheath and covered in a layer of connective tissue.

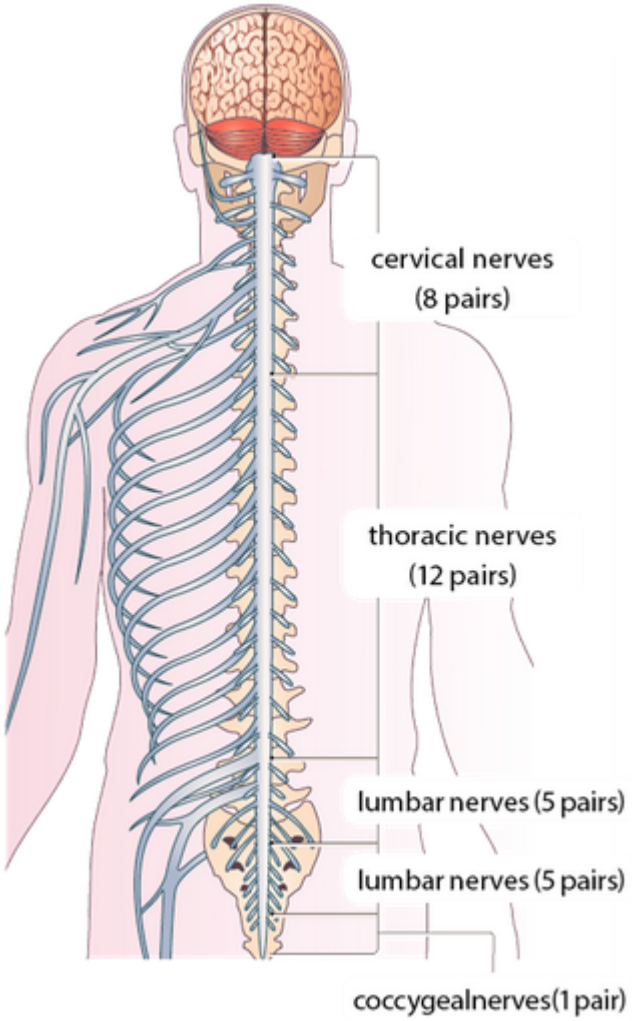
Nerve ganglion

A cluster of nerve cell bodies. Nerve ganglia are distributed along the nerve pathway.

There are two types of nerve, depending on where they emerge in the central nervous system:

- **Cranial nerves** emerge in pairs from the **brain**.
- **Spinal nerves** emerge in pairs from the **spinal cord** and branch off (se ramifica, bifurca) off all over the body.





Both cranial and spinal nerves can be:

- **Sensory**: to transmit information from the sensory organs.
- **Motor**: to transmit information to the effector organs.
- **Mixed**: to transmit both types of information.

SOMATIC AND AUTONOMIC NERVOUS SYSTEMS

The peripheral nervous system is divided into two parts with different functions: the somatic nervous system and the autonomic nervous system.

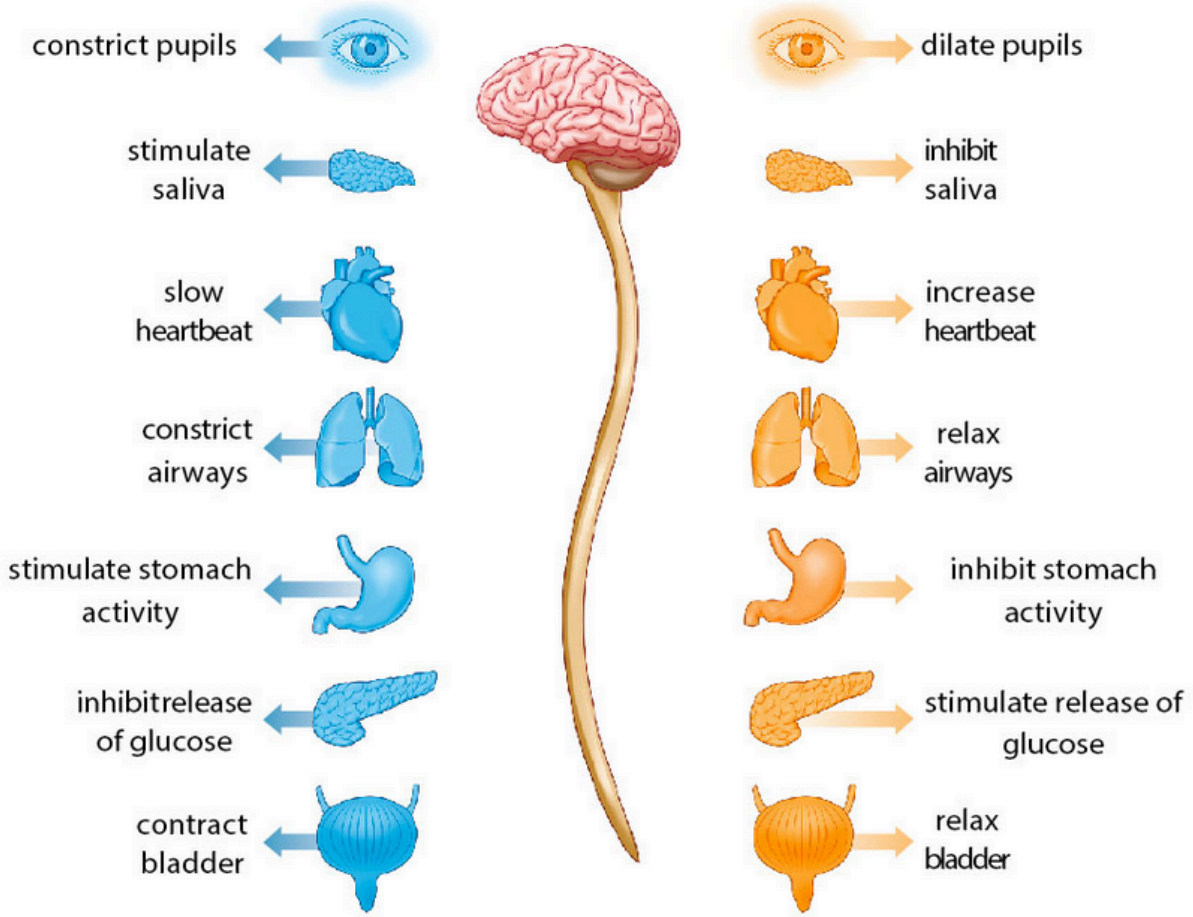
Somatic nervous system

This part is formed of sensory nerves that connect the sense organs to the nerve centres, and motor nerves that connect the nerve centres to the skeletal muscles. It controls **voluntary acts and reflexes**.

Autonomic nervous system

This part is formed of ganglia and nerves that connect the nerve centres to the smooth muscle in the gut, cardiac muscle, blood vessels and glands. It regulates the **involuntary**

functions that **keep us alive** (heartbeat, secretion by glands, respiratory function, digestion, etc.).
The autonomic nervous system is subdivided into two systems with **antagonistic** (opuesto, contrario) effects: the **sympathetic nervous system** and the **parasympathetic nervous system**.



PARASYMPATHETIC NERVIOUS SYSTEM

This system is associated with situations of rest and calm, so it decreases energy expenditure. It is usually active at night.

SYMPATHETIC NERVOUS SYSTEM

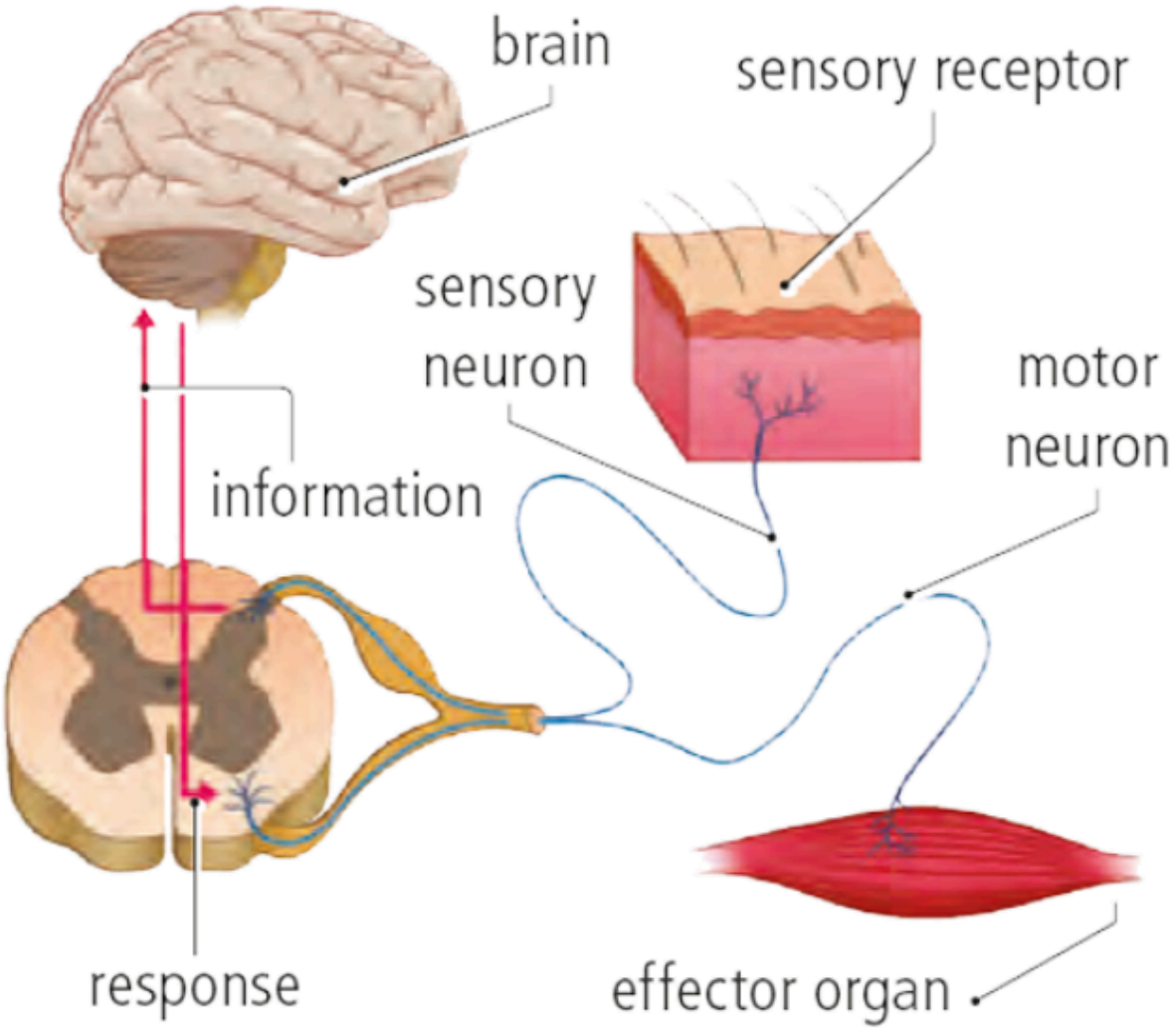
This system prepares the body for emergency situations (**fight-or-flight** response), so it increases energy expenditure.

4.3 **Voluntary actions and reflexes**

The fundamental difference between voluntary actions and reflexes is the part of the central nervous system that generates the response.

VOLUNTARY ACTIONS

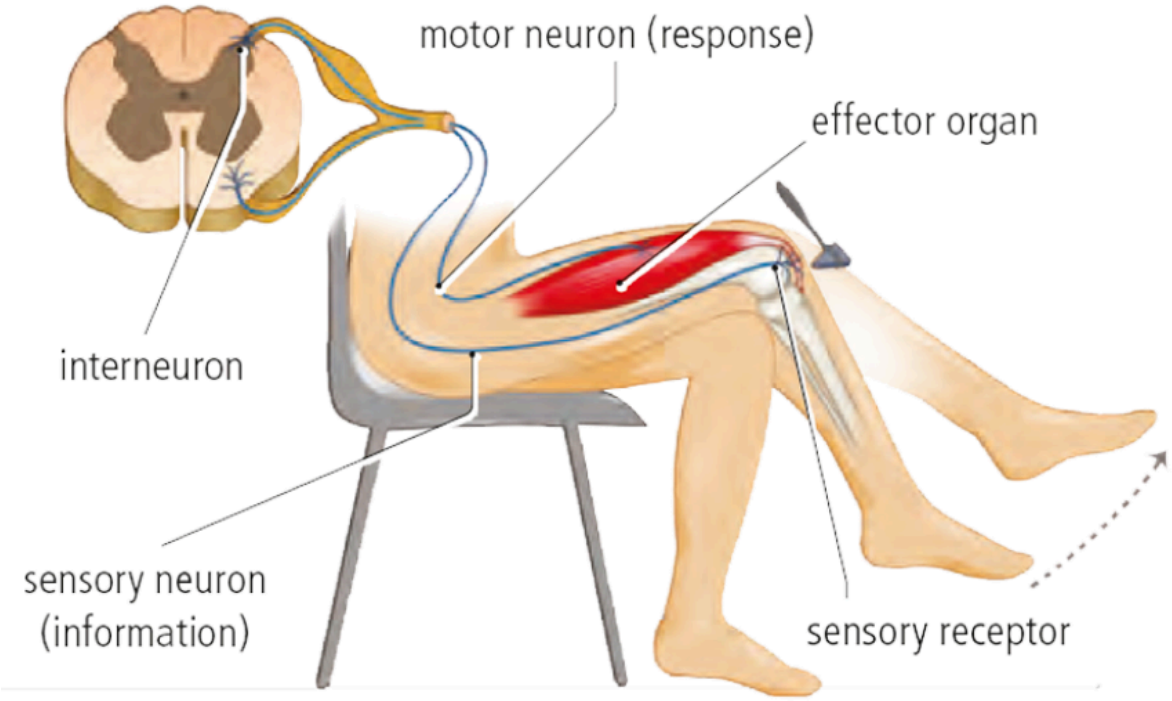
These are generated consciously in an area of the cerebral cortex.



REFLEXES

These are generated unconsciously in the spinal cord, in dangerous situations when a rapid response is required. They involve a system of three neurons called the reflex arc:

- **Sensory neuron**. Located in the nerve ganglia. It takes information from the sensory receptors.
- **Interneuron**. Located in the grey matter of the spinal cord.
- **Motor neuron**. Located in the grey matter. It takes the reflex response to the effector organ.

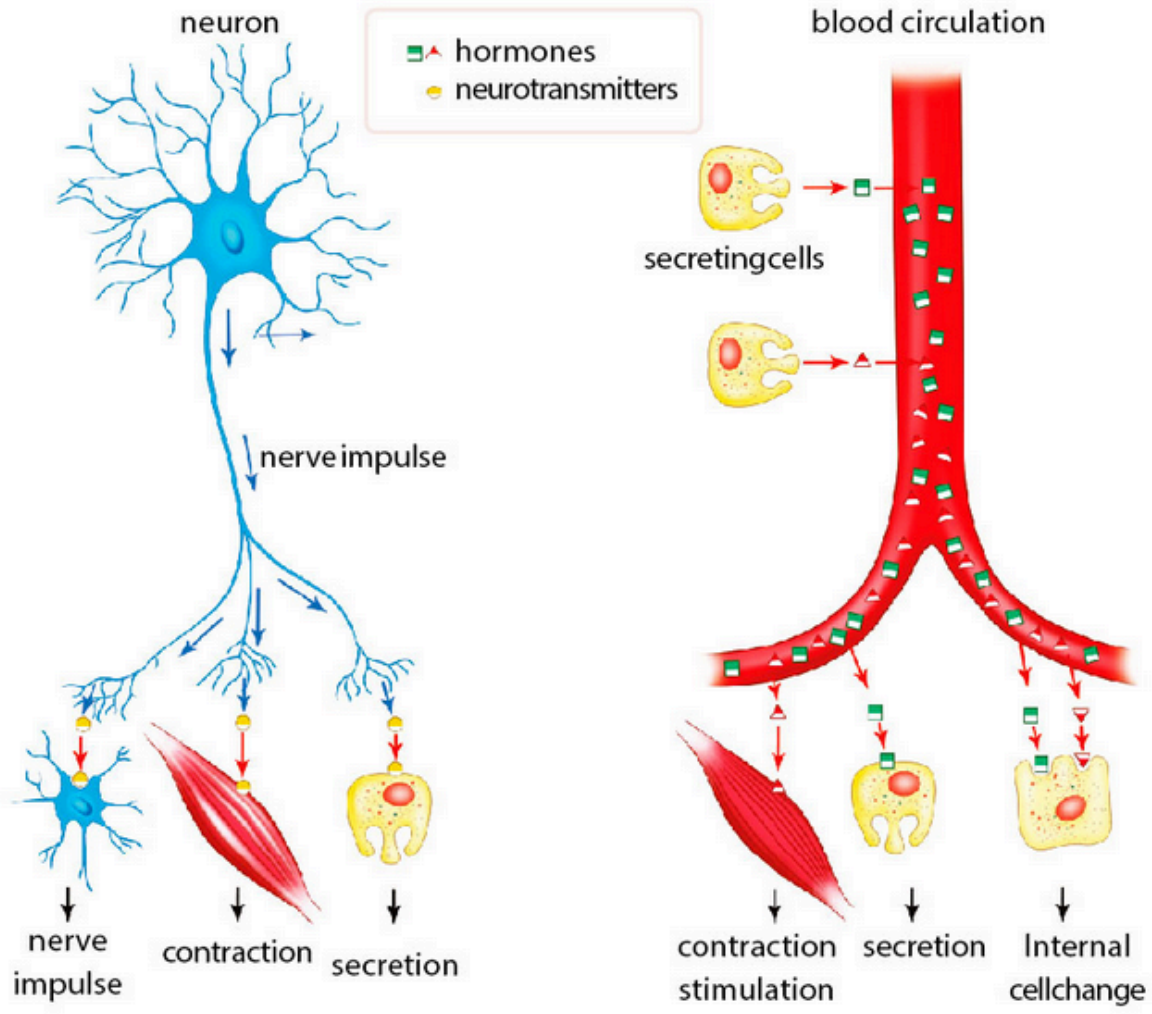


link with a video + test :
http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/nervesandhormones/thenervoussystemact.shtml

5 The endocrine system

The endocrine system is a coordination and control system consisting of the endocrine glands that produce hormones.

Hormones are chemical messengers that are released directly into the blood and transported to their **target** (objetivo, diana) organs.
The nervous and endocrine systems are both responsible for coordination and regulation, but they have different characteristics.



- **NERVE INFORMATION**

This is transmitted by electrical impulses (nerve impulses) and chemical messengers (neurotransmitters) released in the synapse. They provide a quick response that lasts a short time.

- **ENDOCRINE INFORMATION**

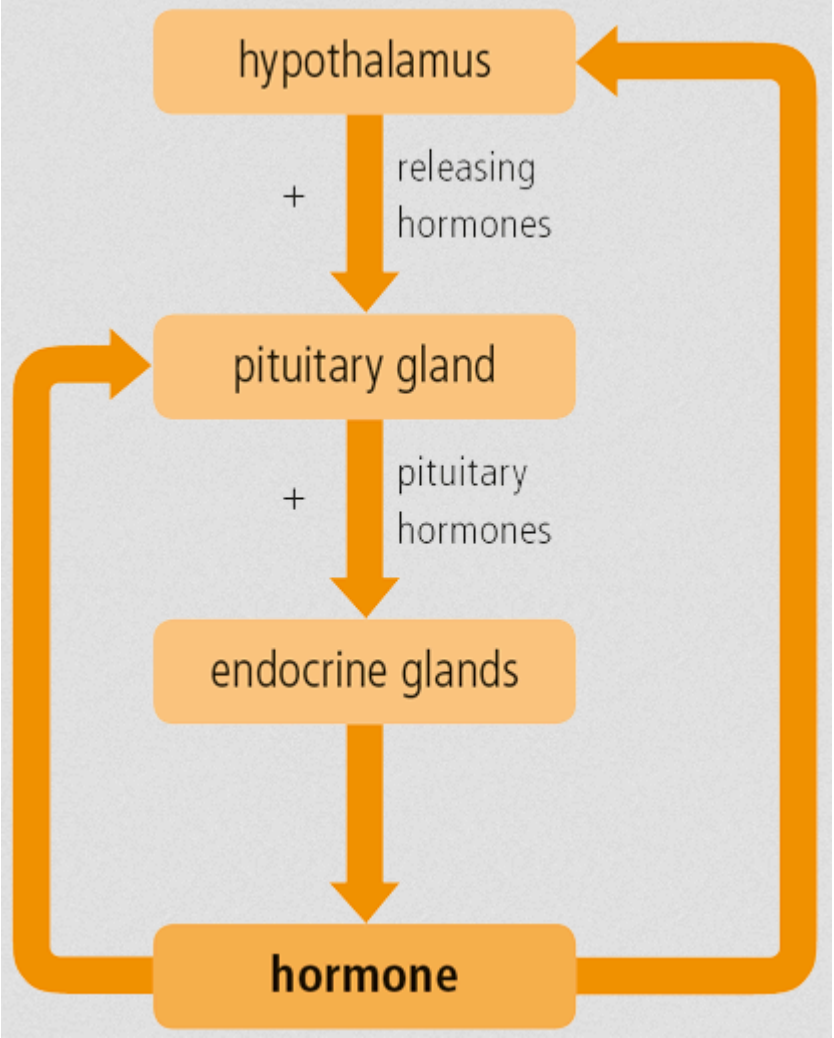
This is transmitted by chemical messengers (hormones) that travel through the blood to their target cells. Their response is slower and lasts longer.

The function of the endocrine system is regulated by the nervous system through the **hypothalamic-pituitary axis**.

The hypothalamus is a neurosecretory portion of the base of the brain. It regulates the activity of the **pituitary gland** using neurohormones called **hypothalamic releasing hormones**.

- The hypothalamus sends out **releasing hormones** which stimulate the secretion of **pituitary hormones**.
- The **pituitary hormones** act on their **target organs**. In many cases, these organs are endocrine glands that respond by secreting other hormones.

- When enough of these final hormones are released, they act on the hypothalamus and pituitary gland, preventing the secretion of their respective hormones. This stops the **cascade** of hormone release.



PITUITARY HORMONES

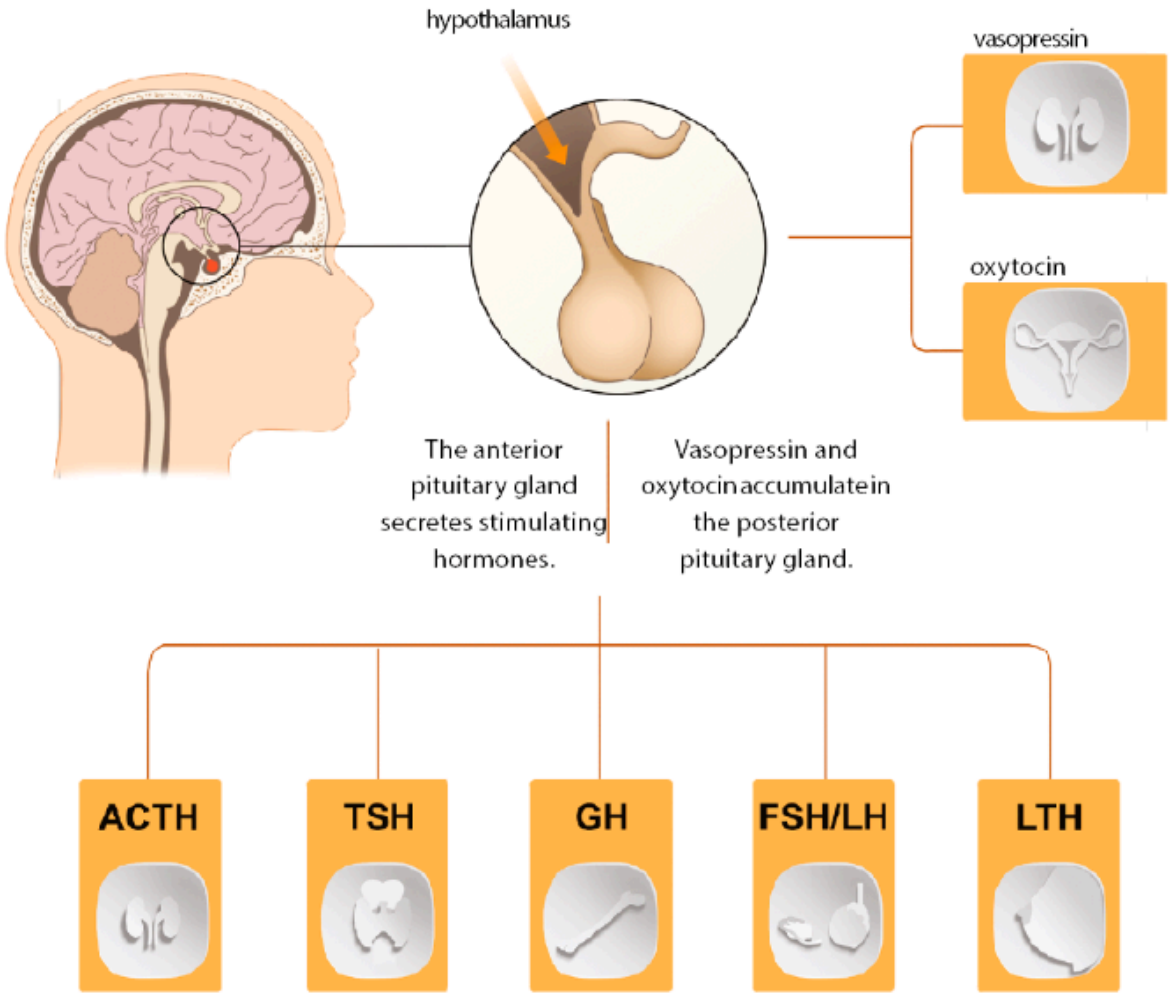
Once the hypothalamus sends out releasing hormones, the pituitary hormones that have been stimulated are able to act on their target organs. Pituitary hormones include the following:

- **Vasopressin**
  - Stimulates reabsorption of water in the kidney, making urine more concentrated.

- **Oxytocin**
  - Acts on the smooth muscle of the uterus, causing contractions during labour.

- **ACTH (adrenocorticotropic hormone)**
  - Stimulates the production and release of hormones from the cortex of the **adrenal glands**.

- **TSH (thyrotropin)**
    - Stimulates the thyroid gland to produce thyroid hormones.



- **FSH (follicle-stimulating hormone)**
    - Stimulates the growth of ovarian follicles, oestrogen production and sperm production.
- **LH (luteinising hormone)**
    - Causes ovulation, formation of the corpus luteum in the ovary and production of androgens in the testicles.
- **GH (growth hormone or somatotropin)**
    - Stimulates the lengthening of bones and growth.
- **LTH (Prolactin)**
    - Stimulates milk production and release by the mammary glands after labour.

ENDOCRINE GLANDS

The pituitary gland is an endocrine gland. Many of the organs that are targeted by the hormones secreted by the pituitary gland are also endocrine glands:

- **FSH (follicle-stimulating hormone)**

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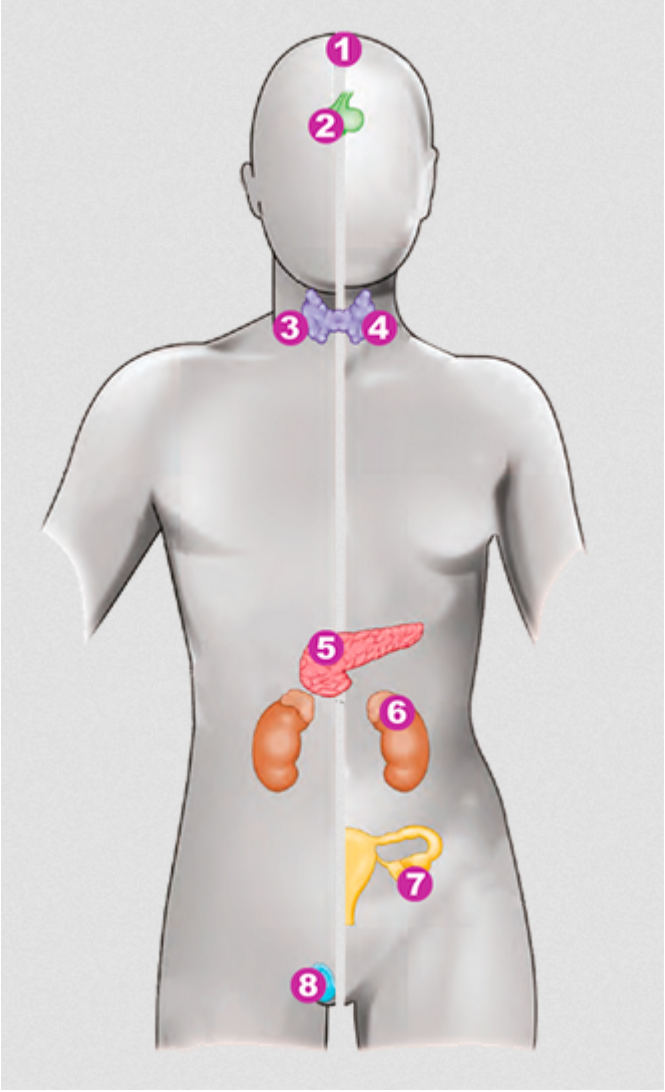


The **thyroid gland** secretes two hormones:

- **Thyroxine** stimulates cell metabolism, growth and development.
- **Calcitonin** causes bone **calcification** by reducing blood calcium levels.

The **pancreas** produces two hormones:

- **Insulin** reduces blood glucose levels and stimulates storage of insulin by the liver and muscle cells.
- **Glucagon** has the opposite function to insulin, increasing blood glucose levels.

Adrenal glands are formed of two parts: cortex (external) and medulla (internal).

The cortex secretes a group of hormones called **corticosteroids**. These regulate the metabolism of mineral salts and carbohydrates. They also have an anti-inflammatory effect.

The medulla secretes sympathetic neurotransmitters, such as **adrenaline**.

Testicles produce male sex hormones or **androgens**, such as **testosterone**, which is responsible for male sex characteristics.

The **pineal gland** produces the hormone **melatonin**, which regulates cycles of sleep, rest and activity; menstrual cycles and heart rhythms.

The **pituitary gland** produces the **pituitary hormones** that stimulate hormone secretions in the other endocrine glands.

Parathyroid glands secrete **parathyroid hormone**, which increases blood calcium levels using calcium stored in the bones.

Ovaries produce two types of hormone:

- **Female sex hormones** or **oestrogens** are responsible for female sex characteristics. They also regulate the menstrual cycle and egg development.
- **Progesterone** is involved in the menstrual cycle, and preparing the uterus for pregnancy.

Link: The endocrine system: http://kidshealth.org/en/teens/endocrine.html

6 Nervous and endocrine system health

The nervous and endocrine systems are physiologically very complex. They are therefore affected by many different illnesses.

6.1 Nervous and endocrine system illness

The following illnesses are important because of their frequency and social impact:

Nervous system diseases

Neurodegenerative diseases

Alzheimer's disease is a gradual destruction of neurons in the cerebral cortex. It causes memory loss, confusion, problems with language and reduced **motor skills**.

Parkinson's disease causes muscle stiffness, tremors, slowness of movement, and loss of balance and motor coordination.

Multiple sclerosis is caused by the destruction of myelin sheaths. The main symptom is gradual loss of mobility and eventually, total disability.

Genetic diseases

Autism is a disorder that appears in the first three years of life. It affects the brain's normal development of communication and social skills.

Depression is a temporary or permanent mood disorder. It is characterised by feelings of **hopelessness**, unhappiness and guilt that can cause complete or partial inability to enjoy life.

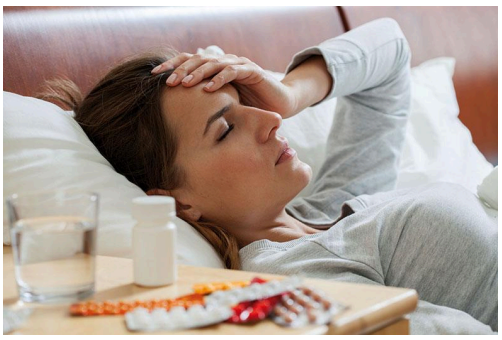
Schizophrenia is a mental disorder that causes a distorted perception of reality. Patients see and feel things that do not exist.

Depression can be treated in various ways, including therapy and counselling.

Infectious diseases

Meningitis is an inflammation of the meninges caused by a viral or bacterial infection. It can cause irreversible brain damage.

Encephalitis refers to a group of diseases caused by inflammation of the brain. Symptoms include high fever, stiff neck, headache, **drowsiness (sommnolencia)** and confusion, **seizures,** , vomiting and **dizziness.**



Many medicines cause drowsiness (somnolencia)

Dizziness is caused by many different health problems.

Creutzfeldt-Jakob disease is caused by infectious proteins called prions. Symptoms include memory loss, behavioural changes and problems with coordination.

It is believed that humans can contract Creutzfeldt- Jakob disease by consuming material infected by the form of the disease present in cows.

Traumatic injuries and cerebrovascular accidents

Traumatic injuries are caused by blows to the skull or spinal column. They can cause permanent, irreversible damage to the brain and spinal cord. They are the most common cause of paraplegia (paralysis of the lower half of the body) and tetraplegia (paralysis from the neck down).

Cerebrovascular accidents (strokes) are caused by cerebral haemorrhages or thrombosis that prevent blood from reaching certain parts of the brain. They cause loss of brain function and hemiplegia (paralysis of one side of the body).

Endocrine DISEASES

Pituitary gland

Gigantism is an abnormal growth caused by excess growth hormone during childhood. If the excess growth hormone occurs after growth has stopped, it causes **acromegaly**, characterised by abnormal bone growth with deformities.

Dwarfism is caused by a growth hormone deficiency during childhood. Children with this disease are short in **stature**, although their body appears normally proportioned.

Bone deformities, such as the leg and foot on the right, are caused by acromegaly.

Thyroid gland

Hyperthyroidism or Graves' disease is caused by an overactive thyroid gland, which increases in size, causing swelling of the neck (goitre). Too much thyroxine also causes tachycardia, weight loss, **bulging** eyes, restlessness and tremors.

Hypothyroidism is caused by insufficient thyroxine production. If it occurs during childhood, it causes cretinism, characterised by impaired development, dwarfism, intellectual impairment and obesity.

Pancreas

Hypoglycaemia is caused by excess insulin production by the pancreas. It causes low blood glucose levels, which can result in a hypoglycaemic coma due to lack of glucose in the brain cells.

Diabetes mellitus is caused by insufficient insulin production in the pancreas. It causes high blood glucose levels or hyperglycaemia. Hyperglycaemia causes cardiovascular, liver, kidney and eye diseases.

6.2 **Healthy habits: mental health and the endocrine system**

The World Health Organisation defines **mental health** *as a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and* ***fruitfully, (****in a way that produces many useful results), and is able to make a contribution to her or his community.*

Emotional problems are often a direct cause of hormonal imbalances. The healthy habits for mental health that a person incorporates into their lifestyle will therefore also have a positive effect on the endocrine system and may prevent the development of mental illness.

The most important habits for mental and emotional balance are:

- Satisfy your **basic needs**, such as rest and nutrition.
- Use **selective attention** and **avoid peer pressure**. Recognise what is positive in your life and eliminate potentially harmful elements.
- **Be positive**. Look for positive aspects in other people. Value and enjoy them, and focus on the benefits of your relationship.
- **Channel your memories**. Do not focus on the past or past failures. It is better to evoke pleasant memories.
- **Manage your emotions**. Interpret them and channel them in a way that will benefit you.
- Eat a healthy, **balanced diet**.
- Value yourself, and try to **see the best in yourself**. This will improve your self-image and self-esteem.
- **Value others**. Your relationships will be better and this will improve your well-being.
- **Exercise**. Do not live a sedentary lifestyle.

6.3 **Addictive substances**

Drugs are substances that affect the normal activity of the central nervous system. They cause different feelings, from relaxation to euphoria, because they interfere with chemical synapses.

Drug consumption causes **tolerance**. This means that more and more of the drug needs to be consumed to achieve the same effect. This can lead to drug **dependence** or **addiction** – a physical and psychological need to keep consuming drugs. If the body does not get what it wants, **withdrawal syndrome** can occur. In some cases, withdrawal syndrome can be fatal.

The psychological dependence associated with all drugs causes dissatisfaction, so many addicts continuously try new types of drugs.

Types of drug

Hallucinogens interfere with neurotransmission, causing changes in perception, consciousness and emotions. They can cause seizures, coma or death. Hallucinogens include:

- **Ecstasy** (MDMA): An illegal synthetic drug.
- **Lysergic acid diethylamide** (LSD): An illegal drug that causes mood changes.
- **Tetrahydrocannabinol** (marijuana): An illegal drug that can cause disorientation, sleeplessness and depression.

Depressants/anaesthetics slow down or inhibit functions of the brain. They cause memory impairment, decreased blood pressure, heart rate and respiratory rate, sleepiness, depression, coma and death. Depressants include:

- **Heroin:** A highly addictive, illegal opioid
- **Ethanol** (alcohol): A legal drug that slows reflexes and causes problems with coordination.
- **Ketamine:** An illegal drug that causes distorted perception and loneliness.

Stimulants temporarily improve neurological or physical functions. They increase blood pressure, heart rate and respiratory rate, and cause euphoria, reduced sleepiness and appetite, seizures and death.

- **Nicotine** (tobacco): A highly addictive, legal drug.
- **Caffeine and theobromine** (coffee, tea, chocolate): Legal drugs that can interrupt sleep patterns.
- **Amphetamine**: An illegal drug that causes paranoia, anxiety and irritability.
- **Cocaine**: An illegal drug that can suppress appetite and cause irritability.