Unit 3. Interaction and movement

1. The Nervous System

Interaction and movement: Irritability

As you may recall from previous years, living things show a series of characteristics: nutrition, interaction, and reproduction. Nutrition we have studied in more detail in the previous unit, reproduction will be looked at in the next unit, and now we are going to study in more detail how organisms interact and relate to the environment.
All living organisms how **irritability or sensitivity** which is the ability organisms have to detect changes in their internal or external environment, and respond to them. Usually, these responses involve movement.

There are two systems working together to direct and regulate all of the different body functions: the **nervous system** and **the endocrine system**.

Coordination: The Nervous System

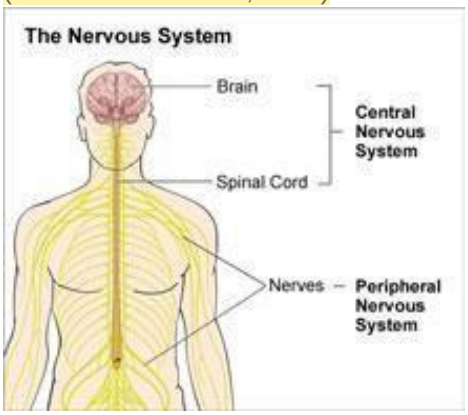
Coordination in humans (in all mammals) is achieved through two systems, each with its own particular role. The nervous system deals with rapid but short-lasting responses, whereas the endocrine system brings about slower, longer lasting responses.

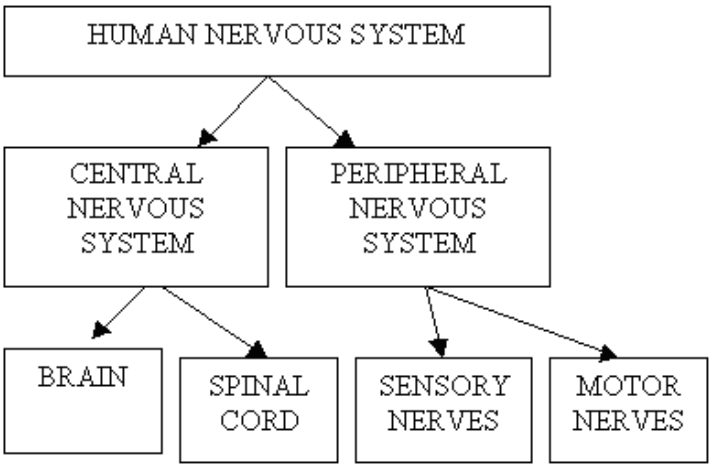
What are the similarities and differences between hormonal and nervous coordination?

	Hormonal coordination	Nervous coordination
Components	Endocrine glands & blood	Neurones, brain & spinal cord
Types of message	Hormones (chemicals)	Nerve impulses, (electrical signal) + chemicals
Transmission route	Circulating blood stream	Nerve fibres + Synapse(s)

The nervous system has two main parts:
The **central nervous system** (**CNS**), which consists of the **brain** and the **spinal cord**, connected to the various parts of the body by the **peripheral nervous system** (**PNS**), made up of **nerves**.

(Urmc.rochester.edu, 2016)





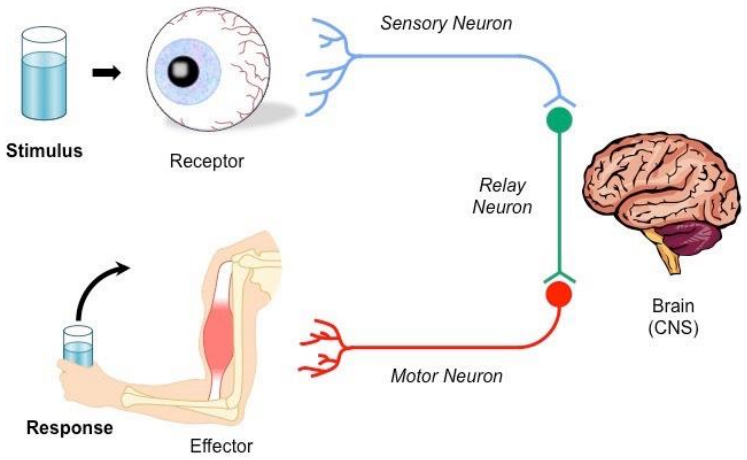
(Qld Science Teachers, 2016)

The CNS (rain and spinal cord) is the processing unit. It integrates the working of **receptors** and **effectors** to bring about the appropriate responses. It controls our voluntary and many of our involuntary actions. It also carries out other important

functions as it carries out intellectual and mental processes and transmits emotions and feelings.
The PNS sends information to the CNS from internal organs or from external stimuli. There are two types of cells in the peripheral nervous system. These cells carry information to (sensory nervous cells) and from (motor nervous cells) the central nervous system (CNS).

But, how does the information flow? How is the information registered, processed, and delivered so the body can carry out the proper response?

A **receptor** detects a change in conditions (**stimulus**). A message is carried from the receptor to the CNS (the processing unit) by a **sensory neuron**. After processing, a message is sent from the CNS to an organ (an **effector**) that carries out a response. A **motor neuron** carries this message.

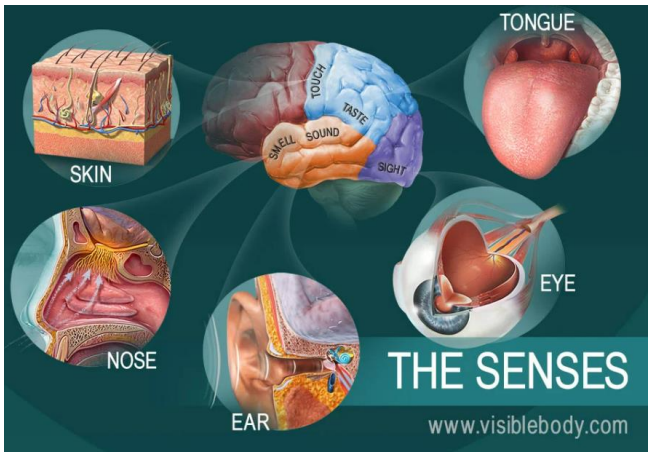


(ib.bioninja.com.au, 2022)

Although receptors and effectors are not intrinsically part of the nervous system, we are going to briefly describe them here below as they are the start and the end of nerve impulse travel.

Sensory receptors

Sensory receptors are responsible for detecting changes (stimuli) in the world around us and converting them into nerve impulses. Sensory receptors can be quite simply groups of nerves or, more often, special cells, which join together to make up the **sensory organs**. There are five sense organs – **eyes, ears, nose, tongue, and skin**.

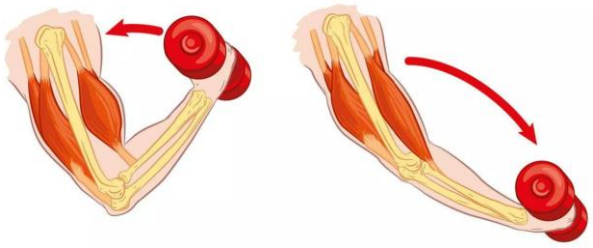


(visiblebody.com, 2022)

Effector organs: locomotion

The movements of our body are possible thanks to the relationship between the active parts, the **muscles**, and the passive parts, the **bones**. Bones link together and form **joints**.

- Muscles contract by becoming shorter. A motor nerve acts on a muscle and the muscle cells use energy to contract. This energy is obtained from cellular respiration, which requires a source of energy (usually glucose) and oxygen.

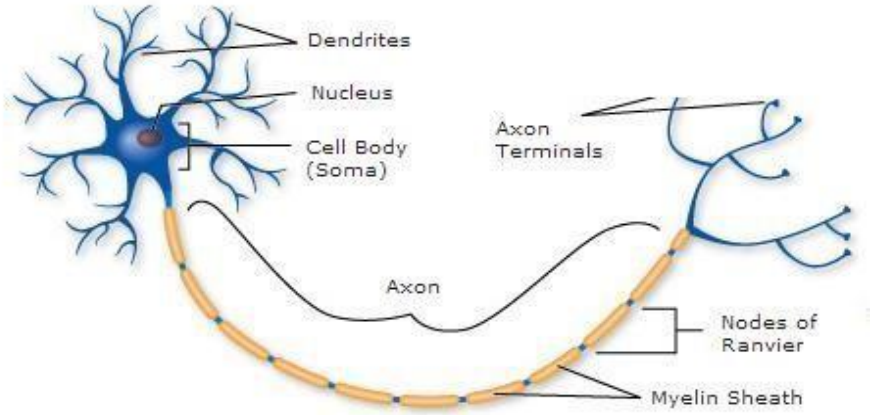


(3dmusclelab.com, 2022)

- Bones contain calcium salts, which makes them hard. Some functions of the bones are to allow anchorage for the muscles (acting as passive organs in the locomotor system), to protect delicate organs like the brain and the spinal cord, to store calcium which can be released into the bloodstream when the body needs it, and to make blood cells in the red bone marrow of some bones.

Nerves and Neurones (Santiago Ramón y Cajal)

Neurones (or nerve cells) are the most specialised cells in humans. All the information carried by the nervous system travels along these specialised cells. The structure of a neuron and the way is adapted to its function is shown below.



(Cell body: controls the metabolism of the nerve cell. Dendrites: The dendrites connect one neuron with the next. Here the impulse enters the cell.

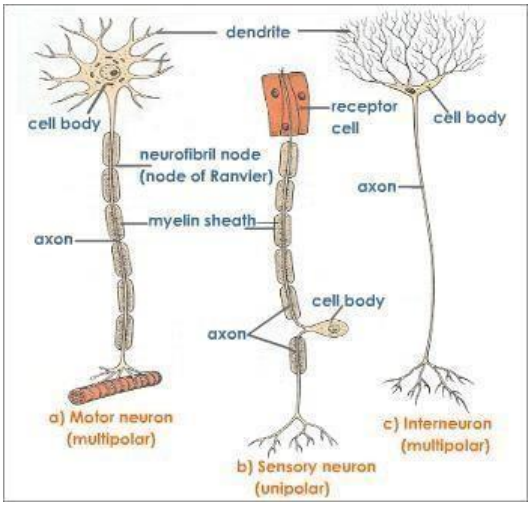
Axon: The axon is a long fiber with small branches at the end which carries information away from the cell body (so where the information leaves the cell).

Myelin sheaths: The myelin sheaths insulate the axon and make sure the impulse reaches the axon terminals. Without them the impulse would be lost (see Multiple Sclerosis)

Nodes of Ranvier: The nodes of Ranvier amplify the speed of the impulse along the axon. They are situated between the myelin sheaths.

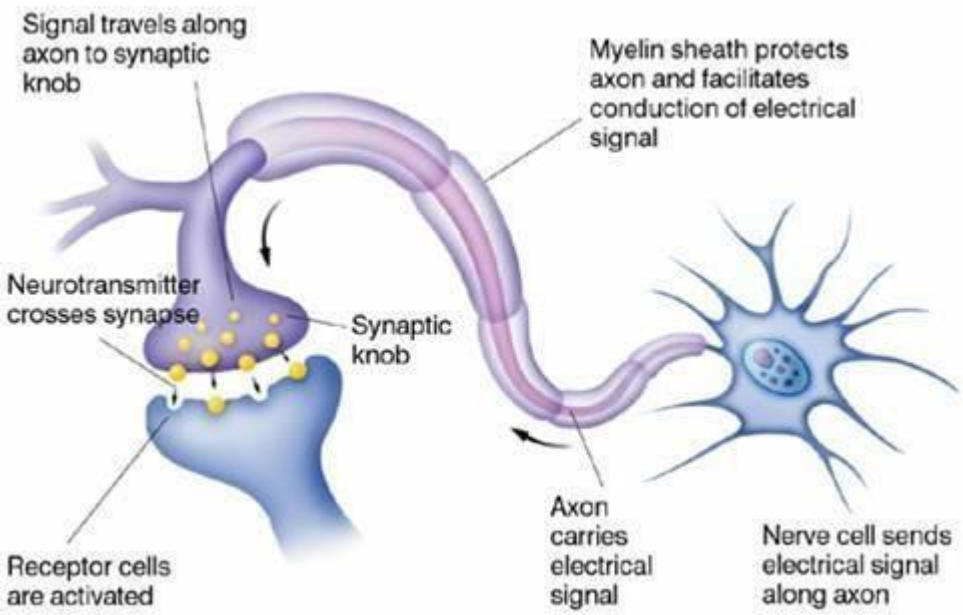
There are three different types of neurons:

- **Sensory neurons:** they transmit electrical signals from receptors to the central nervous system.
- **Motor neurons**: they transmit electrical signals from the CNS to effectors**.**
- **Relay neurons (interneurons)**: They connect the sensory neurons with motor neurons and are in the CNS.



(Tutorvista.com, 2016)

Nerve impulses



Make sure you know the direction of the impulse starting with the dendrites and ending at the end plates (synaptic knob).

Messages pass along neurones in the form of **electrical impulses**. These impulses travel very quickly from one end of a nerve cell to the other. Between the end of an endplate of one neuron and the start of a dendrite of the next there is a gap called **the synapse.** An impulse arrives at the synapse. At the end of the axon (or endplate) there are tiny sacs containing a chemical (**neurotransmitter)** which is released into the gap. The chemical diffuses across the gap passing the information of one neurone to the other.
(Example of a neurotransmitter: endorphin)

So, let's try to understand the pathway of the impulse: Your senses detect changes in the environment, they are received and passed on to the CNS by *sensory neurones* where they are processed. The sensory neurones are connected to the *motor neurones* by *interneurons*. The motor neurones send the instructions from the CNS to effectors (organs, glands and muscles).
LINK

Note: Many drugs have their effects by changing the way neurotransmitters diffuse across this gap.

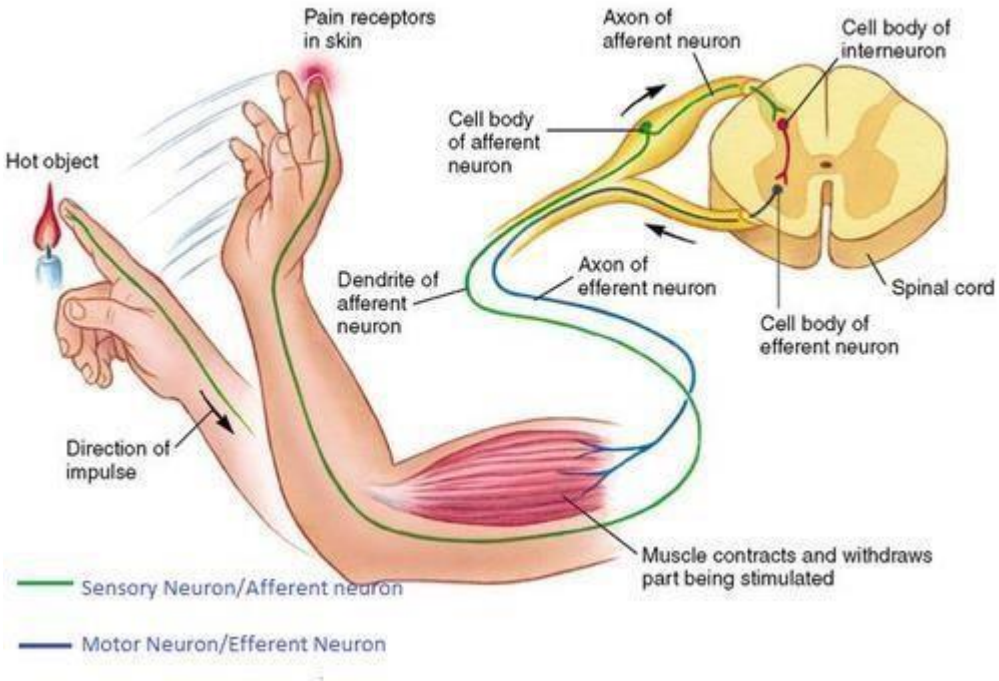
The spinal cord

The spinal cord, which runs down the neck and back inside the vertebral column receives information from the skin and muscles and sends out motor commands for movements.

It has two functions:

- It produces **reflex actions** (rapid automatic response to stimulus in which the brain is not involved. All reflex actions are to protect the body from possibly dangerous situations, to help us survive).
- It carries **sensory signals** from the senses to the brain and **motor signals** from the brain to effectors.

Below is an example of how a reflex action works.



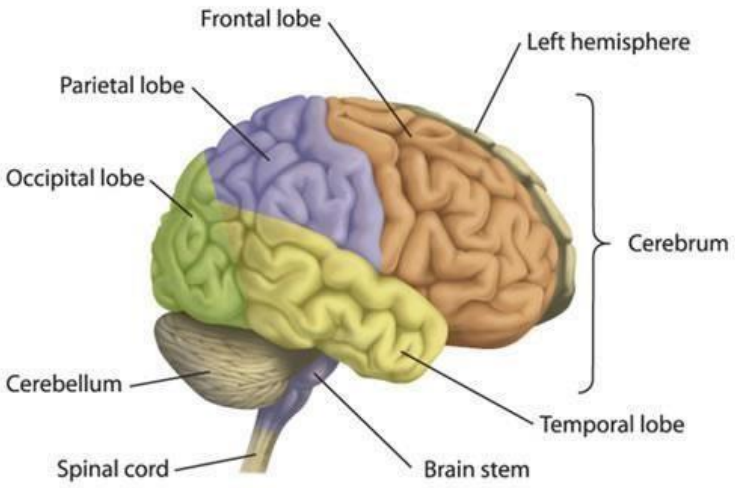
(Mercy.digication.com, 2016)

The Brain

Located at the top of the spinal cord and protected by the skull is the most important organ in the CNS. It is also one of the largest and most complex organs in a human body. It carries out many complex integrated functions, including intellect and emotions.

We will very briefly summarise some of the most important functions. The four main parts of the brain are

- **The brainstem /brain stem**
- **The cerebellum**
- **The hypothalamus**
- **The cerebral cortex (part of the cerebrum)**



In a nutshell, the complex **functions** of the brain are:

- To process information from sensory neurons (excluding balance).
- To process all the incoming information and work out responses and commands for effector organs.
- To coordinate and direct the functioning of the entire and every single part of the nervous system.
- To control higher nerve functions like memory, reasoning, intelligence, conscience and will.

2. The endocrine system

As mentioned at the beginning of the unit, the responses controlled by the nervous system happen quickly. However, some there are some responses that go over a long period of time, such as growth and development. These sort of functions are controlled by the **endocrine system**.

The endocrine system coordinates and performs its functions by the use of organs called **endocrine glands.** These glands secrete chemicals called hormones. The prefix 'endo' means interior, the endocrine system works exclusively on the interior of the body. The endocrine glands are ductless, so **hormones** are directly released in the bloodstream. The hormones, once released travel in the blood to any part of the body that is supplied with blood, reaching all tissues but affecting only the **target organs**.

Hormones are chemical messengers which are transported in the bloodstream. They work slowly, over time and affect different processes such as: growth and development, metabolism (how your body gets energy from the foods you eat), sexual function, reproduction and mood.

Comparison between the endocrine and nervous system

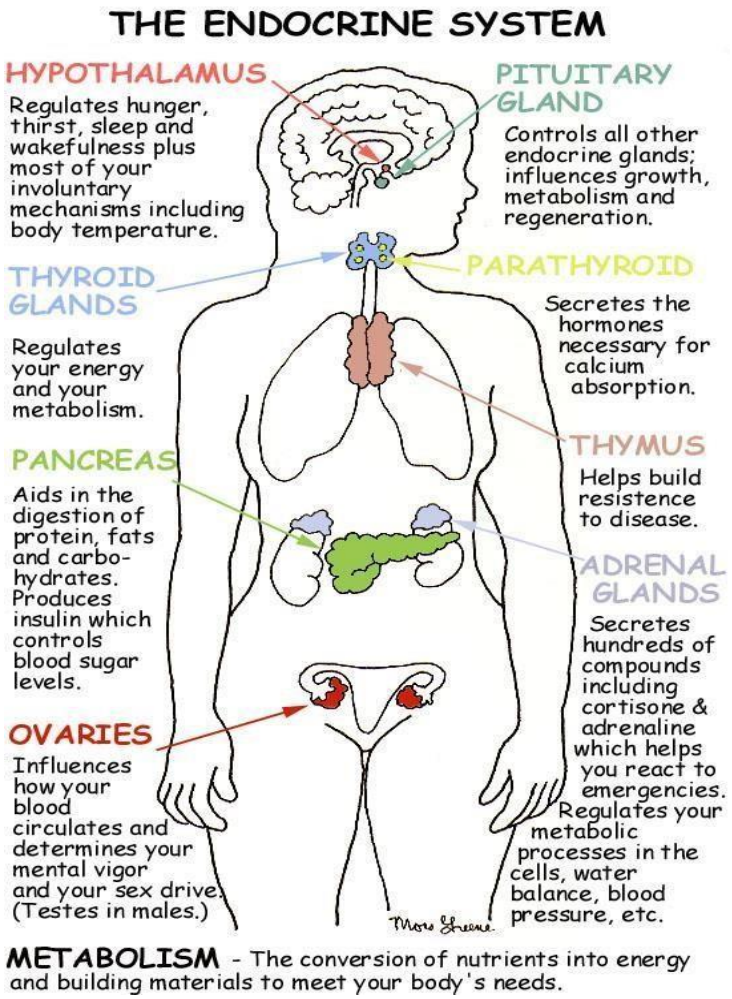
Comparison	**Nervous system**	**Endocrine system**
Speed of the action	Very rapid	Can be slow
Nature of the message	Electrical impulses, travelling along nerves	Chemical messages, travelling in the bloodstream
Duration of the response	Usually completed within seconds	May take years before completed
Area of response	Often confined to one area of the body - response is **localised**	Usually noticed in many organs - response is **widespread**
Examples of processes controlled	Reflexes such as blinking; movement of the limbs	Growth; development of reproductive system

(Pickering, 2006)

What do hormones do?

Hormones control growth, development, metabolism, sugar levels and other processes in the body. One of the most significant processes controlled by hormones are the changes taking place in puberty. At puberty a person becomes physically able to reproduce. The brain instructs the pituitary gland (located on the downside of the brain) to stimulate primary sex organs to develop (testes in man and ovaries in women).The sex-hormones oestrogen (in females) and testosterone (in males) are released into the bloodstream and circulate through the body. They are only effective on the target organs.

Examples of glands and their hormones



The pituitary gland

This is the most important hormonal gland as it controls the rest of the endocrine system. It is on its turn controlled the hypothalamus which is part of the nervous system. Make sure you understand the relation between the two and the fact that the endocrine

system is controlled by the nervous system. One of the hormones it produces is the **Human growth hormone**, for growth and development.

The Thyroid gland

The thyroid gland produces **Thyroxine**, a hormone which controls the rate of metabolism and body mass.

The Adrenal gland

This gland produces adrenaline. **Adrenaline** prepares your body for fight or flight in potentially dangerous situations. It alters your heart rate, your respiration rate, dilates your pupils, liberates glucose for extra energy and makes you very concentrated on the danger so you have more probability to survive

Adrenaline

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