Unit

12 Coordination And Control

Students Learning Outcomes

The students will be able to:

- Explain what coordination means.
- Identify the two main types of coordination in living organisms, i.e. Nervous and Hormonal (chemical).
- Differentiate between the modes of coordination i.e. electrical in case of nervous and chemical in case of hormonal.
- Identify the main organs responsible for coordination and control.
- State that receptors receive stimuli and transmit information to effectors through CNS.
- Label the diagram of a human brain.
- Explain the function of these parts of the brain; cerebrum, cerebellum, pituitary gland, thalamus, hypothalamus, medulla oblongata.
- Differentiate between the cross sectional views of the brain and spinal cord, with reference to white and grey matter.
- Define a neuron and describe the structure of a general neuron.
- Define reflex action and reflex arc.
- Name the three types of neuron involved in reflex action.
- Trace the path of a nervous impulse in the case of a reflex action.
- Describe the structure of human auditory and visual receptors.
- Describe the pupil reflex in dim and bright light.
- State how short and long sightedness can be treated.
- Associate the role of Vitamin A with vision and effects of its deficiency on the retina.
- Explain the role of the ear and the eye in the maintenance of homeostasis through balance and accommodation.
- Relate the contribution of Ibn-al-Haitham and Al-Ibn-Isa in providing knowledge about the structure of the eye and treatment of various ophthalmic diseases.
- Define the terms; hormone and endocrine system.
- Outline the parts of the endocrine system; major glands of this system (Pituitary, Thyroid, Pancreas, Adrenal, Gonads) and names of their respective hormone.
- Describe the term "Negative feedback" with reference to insulin and glucagon.
- Explain how adrenaline may be involved in exercise and emergency conditions and use gained knowledge to apply to different hormones.
- Explain the two common kinds of nervous disorders (Vascular i.e. paralysis and Functional i.e. epilepsy).
- Enlist some of the symptoms and treatments of paralysis and epilepsy.

Introduction

All organisms interact with their environment and respond to the changes (stimuli) taking place in the environment. You perform daily activities in a very coordinated way. If you want to write a letter, you first take a pen and a paper, then think about what to write, and then start writing. Similarly, if a nail comes under your bare foot, you at once lift your foot, sit down somewhere and pull out the nail. How does this all happen in such specific way? The answer is that in our body there is a system working to coordinate and control all the actions (responses).

12.1 Coordination in Organisms

Tidbit

The response of chemical coordination is slower than the response of nervous coordination, which works at the speed of electricity.

Coordination means to integrate among different parts of the body and to respond to stimuli in order to keep harmony with the environment. Coordination is the property of all living organisms. There are two types of coordination i.e. nervous coordination and chemical coordination. **Nervous coordination** is performed by the nervous system. **Chemical coordination** takes place through certain chemicals called **hormones.** Animals possess both these types of coordination. Plants and other organisms (unicellular organisms, fungi etc.) have only chemical coordination.

12.1.1 Mechanism of Coordination

Phase I: Receiving Stimulus: When some change occurs in our internal or external environment, specific parts of the body feel that change. Any change in the environment which can initiate a response in the body is called a **stimulus** (Plural: stimuli). For example, touch, light, and sound etc. are the stimuli. The parts of the body which receive or feel the stimuli are called **receptors**. Special organs, tissues or even cells of the body may act as receptors. For example, our sense organs (eye, ear, skin, tongue and nose) are the main receptors of the body.

Phase II: Message to Coordinator: The receptors send the information of stimulus to a **coordinator**. It analyses the information and makes a decision. In nervous coordination, the **brain** and **spinal cord** are the coordinators. They receive and send messages through **neurons** in the form of electrical signals (nerve impulses). In chemical coordination, the **endocrine glands** are the coordinators. They receive information in the form of chemicals and send messages by secreting **hormones** in the blood.

Phase III: Producing Response: The coordinator sends a message to special parts of the body for proper action (response). These parts are called **effectors**. In nervous coordination, **muscles** and **glands** are the effectors. While in chemical coordination, different tissues of the body act as **effectors**. On receiving the coordinator's message, the effectors carry out actions (responses) according to their specialisation.

This can be understood through a simple example. When the door of your house is knocked, the sound produced by knocking is a stimulus. Your ears (receptor) receives this stimulus and sends a massage to your brain (coordinator). The brain analyses the information and sends a message to the muscles (effectors) of your legs to move and take you to the door. Then signals are communicated to the hand to move and open the door.

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The nervous system helps to coordinate complex and intricate movements of the hand to play a piano or write alphabets. The intention begins in the special area of the brain. The neurons of this area compile a set of information required for an action such as typing or speaking. The information is then transmitted to another area of the brain. It integrates information and ensures that all the muscles work together to produce well-coordinated movements.

	Nervous Coordination	Chemical Coordination
Modes of coordination	Electrical	Hormonal
Receptors	Sense organs (eyes, ears, nose, tongue, skin)	Many body parts (e.g. kidneys, liver etc.)
Coordinator	Brain and Spinal cord	Endocrine glands
Effectors	Muscles and Glands	Many body parts (e.g. kidneys, liver, stomach etc.)
Nature of message	Electrical (Nerve impulse)	Chemicals (e.g. hormones)
Carrier of message	Neurons	Blood
Nature of response	▪ Contraction of muscles ▪ Secretions from glands	▪ Various types (e.g. growth, reabsorption of water by kidneys)

Table 12.1 Difference between Nervous and Chemical Coordination

12.2 Human Nervous System

In humans and other higher animals, the nervous system has two major components i.e. the central nervous system (CNS) and the peripheral nervous system. The central nervous system comprises of coordinators i.e. brain and spinal cord. The peripheral nervous system consists of nerves that arise from the brain and spinal cord that spread in different parts of the body.

12.2.1 Neuron

A neuron is the basic unit of structure and function of the nervous system. Neurons are also called nerve cells. These are the cells that are specialised to conduct messages in the form

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of **nerve impulses** among various body parts. A nerve impulse is a wave of electrochemical change that travels through neurons.

The nervous system is composed of billions of neurons of different sizes and shapes. Let us study the structure of a typical neuron.

A typical neuron has three main parts; cell body, dendrites and axon.

Cell body consists of a cell membrane encircling cytoplasm, nucleus and other cell organelles like Golgi complex, mitochondria, ribosome, endoplasmic reticulum etc.

Tidbit

In the CNS, myelinated axons form the **white matter**, and the non-myelinated axons, dendrites and cell bodies form the **grey matter**.

One or more short processes called **dendrites** arise from the cell body. Their function is to bring the impulses towards the cell body.

Axon is a long thread-like, unbranched process which extends from one side of the cell body. It takes nerve impulses away from the cell body. Axons of large neurons are generally covered by a white sheath called a **myelin sheath.** This sheath is made of fatty material which insulates the axon. The sheath is broken at different intervals called **nodes.** The distance between two nodes is covered by a **Schwann cell.**

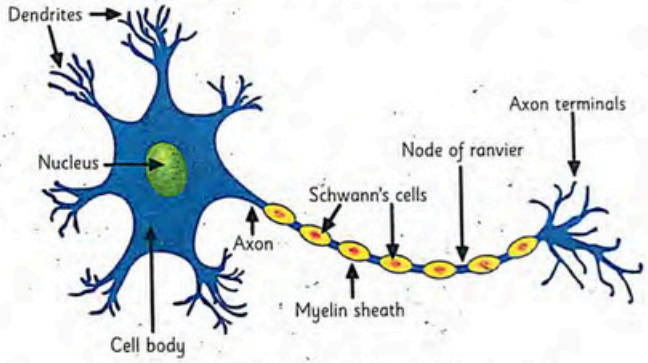

Fig.12.2 (a) Structure of a Typical Neuron

On the basis of function, neurons may be classified into three groups.

a. Sensory neurons carry impulses from sense organs to the CNS. In these neurons, the axon is short whereas there is a single long dendrite (called dendron).

b. Motor neurons take impulses away from the CNS to effectors. They have long axon and many short dendrites.

c. Associative neurons link sensory and motor neurons with each other. They are found in the CNS and make up the brain and spinal cord. They have short dendrites and axons.

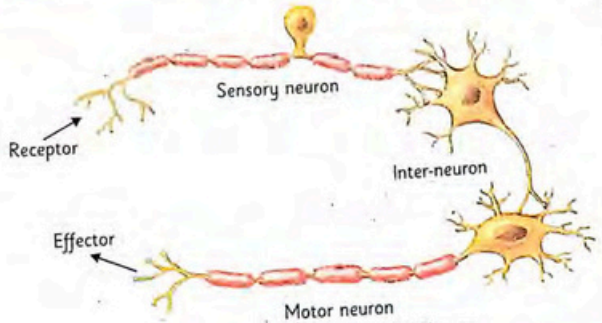

Fig.12.2 (b) Types of Neuron

Nerve

A nerve is a collection of axons that are enveloped by a covering. Nerves arise from the brain and spinal cord and make the peripheral nervous system. There are three types of nerves, on the basis of axons present in them. **Sensory nerves** contain the axons of sensory neurons only. **Motor nerves** contain the axons of motor neurons only. **Mixed nerves** contain the axons of sensory and motor neurons.

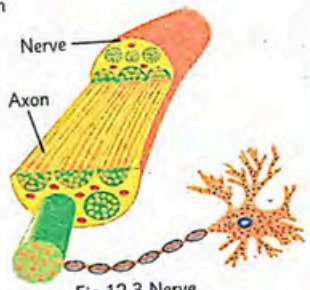

Fig.12.3 Nerve

For Your Information

In certain parts of the body, the cell bodies of neurons form groups enveloped by membranes. These groups of cell bodies are called **ganglia** (Singular: **ganglion**).

12.2.2 Divisions of the Nervous System

We have studied that in humans and other higher animals, the nervous system has two major components i.e. the central nervous system and the peripheral nervous system.

(A). Central Nervous System (CNS)

The central nervous system (CNS) consists of the brain and the spinal cord. The brain is present in the part of the skull called the **cranium**. The spinal cord extends from the posterior side of the brain and is present in the **vertebral column** (backbone). Cranium and vertebral column provide protection to the CNS.

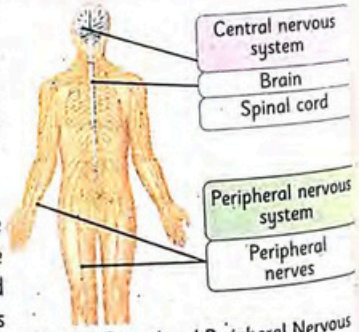

Fig.12.4 Central and Peripheral Nervous system

1. Brain

In animals, all life activities are under the control of the brain. Inside the cranium, the brain is covered by three layers of membranes, collectively called **meninges**. Their function is to protect the brain from harmful substances. The brain contains fluid-filled ventricles. The ventricles of the brain are continuous with the central canal of the spinal cord. The fluid within the ventricles and the central canal of the spinal cord is **called the cerebrospinal fluid (CSF)**. It bathes the neurons of the brain and the spinal cord and cushions against physical and mechanical stresses.

Human brain can be divided into three parts; forebrain, midbrain and hindbrain.

a) Forebrain

This is the largest area of the brain. It is most highly developed in humans. The following are the most important parts of this region.

Do You Know?

Cerebrum consists of billions of neurons packed together. The left cerebral hemisphere controls the right side of the body, and right cerebral hemisphere controls the left side of the body.

(I) Cerebrum: This is the largest part of the brain. It is divided into two halves, called **cerebral hemispheres.** These halves communicate with each other by means of a large band, called the **corpus callosum.** The outer region of the cerebrum called the **cerebral cortex.** It has many folds and convolutions, which increase its surface area. It is made of **grey matter** (containing cell bodies and non-myelinated axons). The material beneath the cortex is **white matter** (containing myelinated axons).

The cerebrum is the most important part of the brain. It receives sensory information, processes it, stores some in memory for future use, directs voluntary movements, and is responsible for intelligence, thinking, reasoning and decision making. The speech centre is also present in the cerebrum which is unique to human beings.

(ii) Thalamus: This is wrapped by the cerebrum. It carries sensory information especially from the eyes and ears and generally from the skin and other internal organs of the body to the limbic system and cerebrum.

iii) Limbic system: It is located in an arc between the thalamus and cerebrum. This system processes responses like hunger, thirst, fear, anger, tranquillity, pleasure and sexual responses. A portion of the limbic system is also important in the formation of memories. **Hypothalamus** is a part of the limbic system. It lies below the thalamus.

b). Midbrain

The midbrain is reduced in human beings and is present under the cerebral hemisphere. It controls reflex movements of the eyes and hearing reflexes. The midbrain is a relay centre that connects the forebrain with the hindbrain.

c). Hindbrain

Hindbrain consists of cerebellum, pons and medulla oblongata.

Cerebellum controls balance of the body and coordinates the voluntary movements of the body as well. We can pick up a book from a table or touch our foot without mistake because of a healthy cerebellum. It is also involved in the learning and memory storage for showing different behaviours.

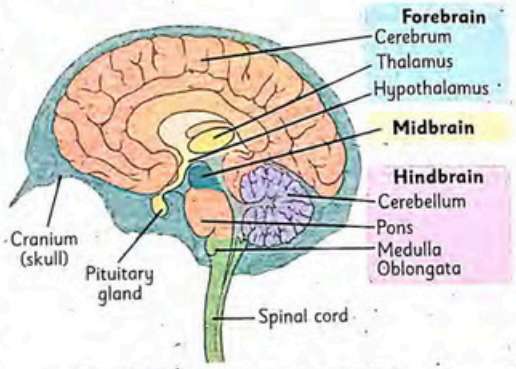

Fig.12.5 Structure of the Human Brain

Pons is located above the medulla. It controls transitions between sleep and wakefulness, and the rate and pattern of breathing.

Medulla oblongata is the posterior part of the brain. It controls automatic functions like breathing, heart rate, circulation of blood, blood pressure, swallowing and vomiting.

Tidbit

Medulla oblongata, pons, and midbrain connect the rest of brain to spinal cord. They are collectively called brain stem.

2. Spinal Cord

The medulla oblongata narrows down into an oval-shaped hollow cylinder i.e. the spinal cord. It travels through the vertebral column. The spinal cord is also covered by **meninges**. The spinal cord transmits impulses from the body parts to the brain and from the brain to the body parts. It also acts as a coordinating centre for some simple responses (e.g. reflex actions).

In cross section, the spinal cord shows two distinct parts: an inner butterfly-shaped part containing **grey matter** around a central canal and the outer part which is composed of **white matter**. The most important function of spinal cord is to control the reflex action of the body (below head level). It conducts the sensations from trunk and limbs and other lower regions of the body to brain for final response and transmits the messages from the brain to the lower part of the body.

There are 31 pairs of spinal nerves that arise from the spinal cord. All the spinal nerves are **"mixed"** nerves because each contains axons of both sensory and motor neurons. Each spinal nerve arises by two roots. Both roots unite and form the mixed spinal nerves.

- The dorsal root contains sensory axons and a ganglion where cell bodies are located.
- The ventral root contains axons of the motor neurons.

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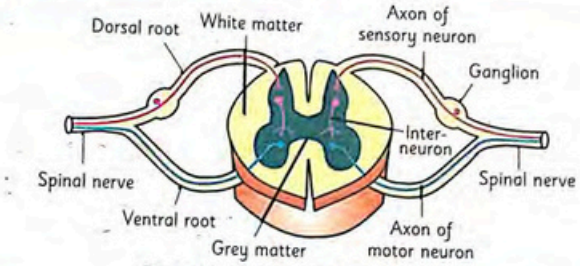

Fig.12.6 Spinal Cord and Spinal Nerves

(B). Peripheral Nervous System

This is composed of nerves which arise from the CNS. The nerves which arise from the brain are called **cranial nerves**. Humans have 12 pairs of cranial nerves. The nerves which arise from the spinal cord are called **spinal nerves**. Humans have 31 pairs of spinal nerves. Some cranial nerves are sensory, some are motor and some are mixed. All the spinal nerves are mixed.

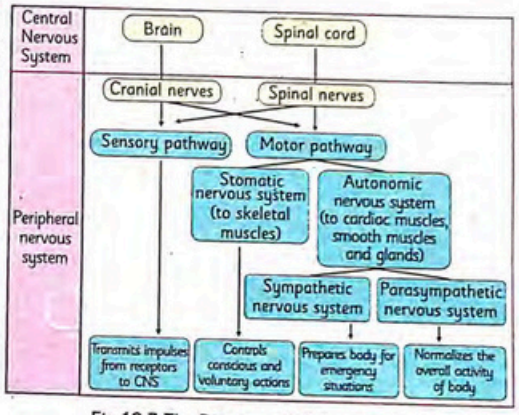

Fig.12.7 The Divisions of Nervous System

The cranial and spinal nerves make two pathways i.e. sensory pathway (conducting impulses from receptors to CNS) and motor pathway (conducting impulses from CNS to effectors). Motor pathway makes two systems.

Somatic Nervous System: It controls conscious and voluntary actions. It includes all of the motor neurons that are connected to skeletal muscles.

Autonomic Nervous System: It consists of motor neurons that are connected to cardiac muscles, smooth muscle and glands. It is generally without conscious control. Autonomic nervous system consists of sympathetic and parasympathetic systems. The **Sympathetic** nervous system prepares body to deal with emergency situations. This is often called the **"fight or flight"** response. This system dilates pupils, speeds up heartbeat, increases breathing rate and inhibits digestion. When there is little or no stress, the **parasympathetic** nervous system normalizes the overall activity of the body. It is called the **"rest and digest"** response. It causes pupils to contract, it promotes digestion, and it brings the rate of the heartbeat to normal.

12.2.3 Reflex Action

If your finger touches the tip of a needle, you at once retract your hand without thinking. Similarly, if something is coming towards your face, you move your head away. Blinking of the eyes when something comes close to the eyes and jerking of the knee, when it is hit with a hard object are all different types of reflex actions. We can define a **reflex action** as an automatic, immediate, quick involuntary, fixed response to an environmental change (stimulus). Generally the brain is not involved in reflex actions. We can say these are the **involuntary** responses of the body on which we do not have any control.

Do You Know?

Use of medicines like sleeping pills and sedatives, narcotics like heroin, alcohol etc. reduce the speed of nerve impulses. Therefore people who consume these substances do not feel or respond rapidly.

A Reflex action is performed through a short and simple pathway of neurons, called the **reflex arc.** This action starts with a sensory neuron present in a receptor which takes the impulse to the spinal cord. Here an associative neuron shifts the impulse to the motor neuron which takes the impulse to the effector.

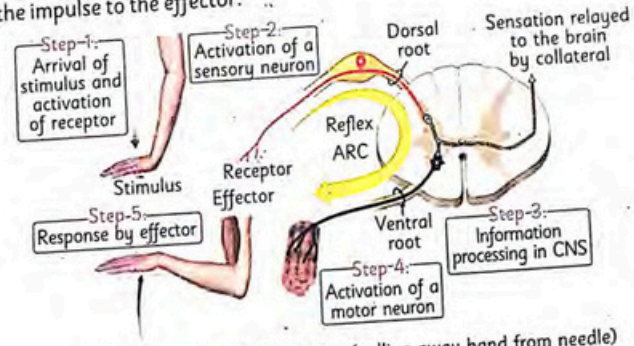

Fig.12.8 Reflex arc in a Reflex Action (pulling away hand from needle)

You might have noticed that pain of pricking is felt after retraction of hand because we feel pain when the message is sent to brain. This is why we can say that reflex actions are important for survival as they help to protect us without our will or wish.

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The digestive system is an involuntary system as it works on its own such as blinking of the eyes. Digestion starts from the mouth by the secretion of saliva. As soon as our eyes see delicious food it sends a message to the glands present in the mouth to release saliva, so that the food can be chewed and broken into small pieces. Looking at a food item, the digestive system gets activated, enzymes are released in the mouth cavity in the form of saliva and hence our mouth starts watering.

12.3 Receptors in the Human Body

In this unit you have come across the term receptors many times. You know that **receptors** are the parts of the body which receive the changes (stimuli) taking place in our environment. In the human body there are many types of receptors, which perform different functions.

- Photoreceptors which perceive light e.g. eyes
- Sono-receptors which perceive sound waves e.g. ears
- Chemoreceptors which perceive different chemicals like the tongue and nose.
- Mechanical receptors which perceive pressure mostly found in skin

There are many other receptors which feel pain, hunger, thirst, pleasure, emotions etc. but here in this chapter we will describe only two types of receptors and their working.

12.3.1 Photoreceptor: Eye

These are also known as visual receptors. Eye is an organ used as a photoreceptor in the human body. A pair of eyes is present in human beings which are present in the orbits on the face. The eye is a very complex structure. It is in the form of a ball. The wall of the eyeball consists of three layers.

The outer most white, tough, muscular layer is called the **sclera** which covers the eye from the outside. Its anterior part is transparent and bulging.

The middle layer is the **choroid**. It gives a darker colour to the inner eye. The choroid layer is thick in the anterior part and makes the **ciliary body**. The coloured portion of the choroid in the anterior centre is called the **iris.** In the centre of the iris, there is a small hole called **pupil** which controls the amount of light entering the eye. Behind the pupil, a **lens** is present which focus images from different distances on to the retina. The lens is held by **suspensory ligaments** which are attached with the ciliary body. The muscles of the ciliary body control the focussing of the lens.

Do You Know?

The contraction and dilation of the pupil is also a reflex function as it automatically adjusts to the intensity of light. You may observe the contraction of the pupil in the eyes of your friend by suddenly throwing strong light in his eyes.

The third innermost layer of the eye is the **retina.** It contains photoreceptor cells and neurons. There are two types of photoreceptor cells i.e. **rods** and **cones**. Rods are used to perceive dim light. They give us the image of the object but not its colours and detail. Cones are responsible for visualising colours.

Rods contain a purplish-red pigment called the **rhodopsin**. The body synthesises rhodopsin from **vitamin A**. If there is a deficiency of vitamin A, the body cannot prepare rhodopsin in the required amounts. Therefore, the eyes cannot see clearly in dim light. This problem is called **night blindness**.

The cones also contain a pigment called **iodopsin**. There are three types of cones. Each type contains specific iodopsin for red, green or blue light. The sensations of different colours are produced by various combinations of these cones. When all cones are stimulated equally, a sensation of white light is produced.

The **optic nerve** leaves the eye at the posterior pole of the eyeball. At this spot, photoreceptor cells are not present and hence it is called the **blind spot**. At the posterior pole of the eye, opposite to the lens, there is a yellowish spot called the **fovea**. It is a thin portion of the retina where only cones are densely packed. Here, the visual acuity (resolution) is the greatest.

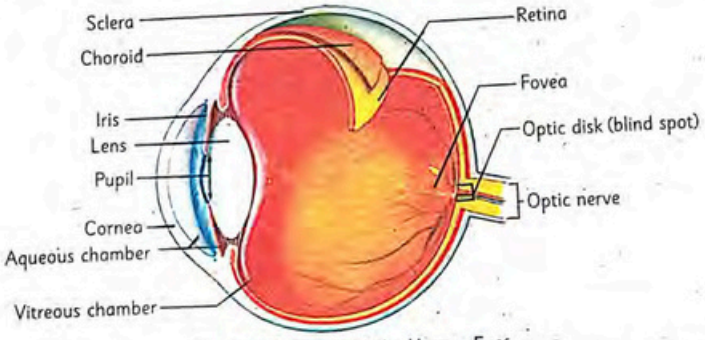

Fig.12.9 Structure of the Human Eye

The space between the cornea and the lens is called the **aqueous chamber**. It contains a thin watery fluid called the aqueous humor. The space between the lens and the retina is called the **vitreous chamber**. It is filled with a transparent gel called the vitreous humor.

Mechanism of Vision

The light rays coming through the cornea and lens make an image on the retina. The photoreceptor cells i.e. rods and cones of the retina produce nerve impulses in the neurons present in the retina. The axons of these neurons are part of the optic nerve. The optic nerve carries information in the form of nerve impulses from the retina to the cerebrum of the brain. Here, the impulses are processed to produce a meaningful sensation of shape and colour.

Disorders of the Eye

Eyes send a huge amount of information to the brain. Sometimes a defect occurs in the working of eyes which causes great disturbance in the life of the person. Some of these disorders are very serious and lead to blindness but some disorders are easily curable. Two disorders generally known as long sightedness and short sightedness are very common. In these disorders the lens of the eye is not able to adjust itself to focus the image on the retina, hence the vision is disturbed.

Short sightedness or near sightedness, is an eye disorder in which a person can see closer objects clearly, but the distant objects are not clearly visible. Technically this disorder is known as **myopia.** It is caused by an unusually long eyeball. In short sightedness, light rays do not focus on the surface of the retina. Rather, the rays focus in front of the retina. Since the light is focussed too early, a blurred image is left on the retina.

This problem can be rectified by using **concave lenses** in glasses or in contact lenses. Concave lens ensures that light is focussed onto the retina of the eye, so that distant objects do not appear blurry. Short-sightedness can also be cured with **laser eye surgery**. In laser eye surgery a laser is used to reshape the cornea to correct its curve. Therefore, light is better focussed on the retina.

Long sightedness or farsightedness, is a disorder in which a person can see distant objects clearly, but the close objects are not clearly visible. The disorder is caused when the eyeball is too short or the shape of the lens is not round. Technically this disorder is known as **hypermetropia.** In long-sightedness, light rays do not focus on the surface of retina. Rather, the rays focus behind the retina. Since the light is focussed behind the retina, a blurred image is left on the retina.

Long-sightedness is rectified by using **convex lens** in glasses or in contact lenses. Convex lens ensures that light is focussed onto the retina of eye, so that close objects do not appear blurry. Long-sightedness can also be cured with **laser eye surgery**. In laser eye surgery a laser is used to reshape the cornea and improve the curve. Therefore, light is better focussed on the retina.

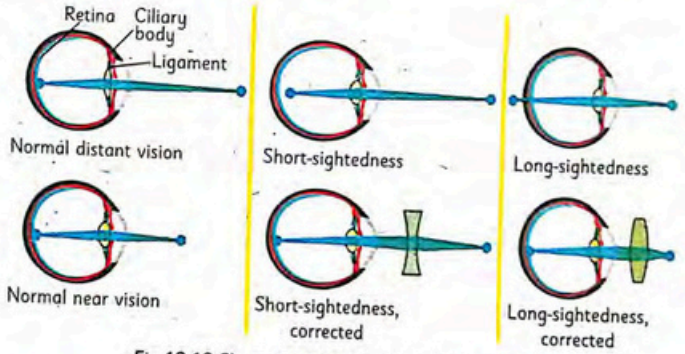

Fig.12.10 Short sightedness and Long sightedness

12.3.2 Muslim Scientists in Ophthalmology

Like other scientific fields, the early work in optics and ophthalmology was done by Muslim scientists. In the field of ophthalmology and optics, some great Muslim scientists will be remembered forever.

a). Ibn Al Haitham

His name was Abu Ali al Hasan Ibn-al Hasan-Ibn-al–Haitham. In the West, he is known as Alhacen or Alhazen. He was born in Basra in 965 AD. He is regarded as the "father of modern optics" for his influential book **"Kitabul Manazir** (Book of Optics)". This book has seven volumes and was written between 1011 to 1021 AD. He performed experiments in different fields of optics, including lenses, mirrors, refraction, reflection and dispersion of light. He studied binocular vision and the moon illusion and described the finite speed of light. He postulated that light has made of particles, traveling in straight lines. One of his most important works was the description of the functional anatomy of the eye. He was the first person who rejected the old concept of sight that rays come out of the eye to see. He also made the first camera, the pinhole camera.

b). Ali bin Isa

Ali bin Isa (940-1010 AD) was an Afro-Arab ophthalmologist, astronomer and geographer. He was born in Baghdad and is considered as one of the most famous physicians of the 10th century. He wrote the monumental book **"Tashkirat ul Kahhalin** (Notebook of Oculist)". The book is mostly based on his personal observations. The book contains information on the treatment and classification of over 100 different eye diseases. This book was translated in Latin in 1497. Afterwards, it was also translated in English. The book was widely used by European physicians for hundreds of years.

12.3.3 Sono-receptor - Ear

Sound waves are perceived by sono-receptors. In human beings and other vertebrates a pair of ears is used to receive sound waves. Human ear can be divided into three parts; external ear, middle ear and internal ear.

External ear consists of the pinna, auditory canal and ear drum (tympanum). The pinna or earflap is the external cartilaginous structure which collects sound waves. Sound waves then travel through the auditory canal which ends at the ear drum. It is a membrane which separates the outer ear from the middle ear.

Middle ear consists of a set of three small bones called ossicles i.e. **malleus, incus** and **stapes**. These bones are the smallest bones of the body. These ossicles are attached to one another in a chain-like fashion. The malleus is attached to the ear drum and the stapes is attached to the oval window of the cochlea. The oval window separates the middle ear from the inner ear. A **Eustachian tube** connects the middle ear cavity with the pharynx. The Eustachian tube helps in equalising the pressures between the middle ear and the environment.

Internal ear is a fluid-filled chamber after the oval window. It contains two important structures i.e. a coiled tubule called the **cochlea** and a set of three **semi-circular canals**. The middle chamber of the cochlea has the hearing apparatus, called the **organ of Corti**. Special

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hair cells are present in the organ of Corti, which are the receptor cells for sound. The semi-circular canals help in maintaining the balance of the body.

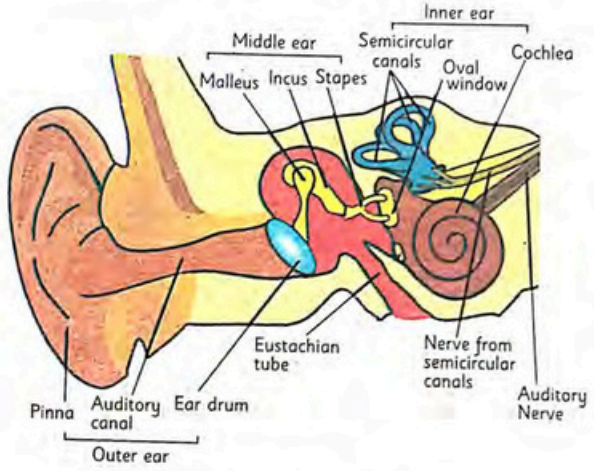


Fig.12.11 Structure of Human Ear

Mechanism of Hearing

The outer ear receives sound waves and directs them to the ear drum. The ear drum vibrates and these vibrations are transmitted to the ear ossicles (malleus, incus and stapes) and then to the oval window. From the oval window, the vibrations are passed to the cochlea. Vibrations produce pressure waves in the fluid present in the chambers of cochlea. The waves in the fluid of the middle chamber cause bending of the hair cells present in the organ of Corti. The bending of hair cells generates a nerve impulse in the associated sensory neurons. These impulses are transmitted via auditory nerves to the cerebrum. Here the impulses are analysed and the sound is recognised.

Mechanism of Balancing

The ear also helps to maintain balance. This function is performed by the three semi-circular canals of the internal ear. The semi-circular canals are filled with fluid. Their inner walls have hair cells and tiny particles. When the head moves, the fluid inside the semi-circular canals flows. As a result, the particles are pushed and so the hair cells bend. This bending of hair cells generates nerve impulse in the nerve attached with the semi-circular canals. The message of these movements is sent to the cerebellum through the auditory nerve. The brain interprets the head's motion and orientation and sends the proper message to the muscles to maintain balance.

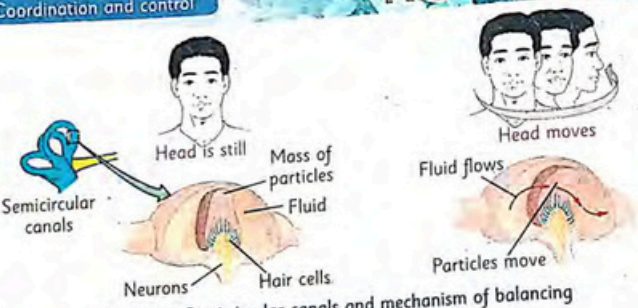


Fig.12.12 Semi-circular canals and mechanism of balancing

Science, Technology and Society

Time difference between seeing the flash of lightning and hearing the roar of a thunderstorm

The sound of thunder travels at the speed of sound, while the light from the flash travels at the speed of light. The speed of sound is about 340 meters per second through air, while the speed of light is about 300 million meters per second - almost a million times faster. So, if you were 1500 meters away from the flash, you would see it about 5 millionths of a second after it actually occurred, but you would not hear the thunder until about 5 seconds later.

12.4 Chemical Coordination

Do You Know?

Many glands in our body have ducts for releasing their secretions e.g. digestive glands, skin glands etc. Such glands are called **exocrine glands.**

You studied earlier in this chapter that chemical coordination is done through special chemicals called **hormones.** In animals, hormones are synthesised in **endocrine glands** which are also called **ductless glands**. This is because these glands do not have any duct or tube to release their secretion at the site of action or target site. They release their secretion in the blood which takes it to the tissues or organs where it is required.

Hormones are organic compounds produced in the endocrine glands, poured directly into the blood and are transported to respective target tissues where they affect. Hormones do not initiate new biochemical reactions but produce their effects by regulating the reactions. They may either stimulate or inhibit a function. Hormones also control some long term changes in the body such as the rate of metabolic activity, rate of growth, and sexual maturity. Most hormones are chemically proteins but some are derivatives of fatty acids i.e. steroids.

12.4.1 Human Endocrine Glands

Human endocrine system consists of about 20 endocrine glands found in different parts of the body. Here you will study about some important glands and their hormones.

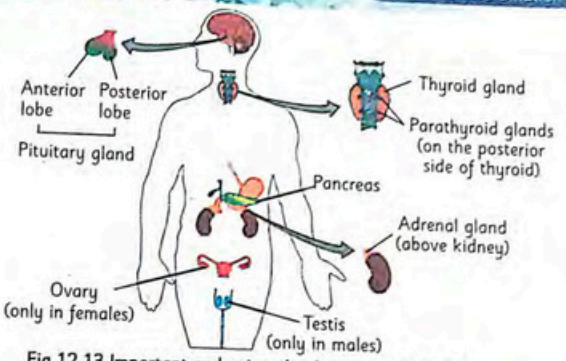


Fig.12.13 Important endocrine glands in the human body

1. The Pituitary Gland

This is an oval structure attached to the hypothalamus of the brain. It is about the size of a pea seed and weighs about 0.5 gm in adults. It is generally termed as "the master gland" of the body. It has two main lobes i.e. anterior and posterior.

Anterior Lobe of Pituitary Gland: It secretes the following hormones.

Do You Know?

Naseer Soomro (the tallest man in Pakistan) developed a pituitary gland problem at the age of 10. His pituitary gland produces excess amounts of the **Growth Hormone.**

(i). Growth Hormones: This hormone increases the cell division of somatic cells and promotes the growth of the body. It is secreted more in childhood but in adults the secretion becomes normal. If it is secreted in excess during early life it results in a disorder called **gigantism.** Its under-secretion in early life causes **dwarfism** in which the body of the child does not grow.

(ii). Thyroid Stimulating Hormone (TSH): This hormone controls the development and secretion of the thyroid hormone (thyroxin).

(iii). Adreno-Cortico-Trophic Hormone (ACTH): It acts on the cortex part of the adrenal gland to release the adrenal hormone.

(iv). Luteinising hormone (LH): It is needed for the release of egg cells from the ovary (ovulation) in females. In males, it stimulates the testes to produce sex hormones.

Posterior lobe of Pituitary Gland: It secretes the following hormones:

(i). Antidiuretic Hormone (ADH) or Vasopressin: This hormones affects the renal tubules to reabsorb large quantities of water from the glomerular filtrate.

(ii). Oxytocin: Its main function is to contract the uterus muscles during childbirth. It also stimulates the flow of milk from the breasts during lactation

2. Thyroid Gland

The thyroid gland is situated above the larynx. It consists of two lobes; one on each side of the larynx. It secretes two hormones.

(i). Thyroxine: This hormone increases the metabolism of the body and produces heat in the body. It promotes growth, hence it is secreted more in young age. Thyroxine is an iodine containing compound.

If thyroxine is produced less than the required amount, cellular metabolism slows. It results in lethargy, weight gain, and low heart rate and body temperature.

If thyroxine is produced more than required, cellular metabolism becomes faster than normal. It results in weight loss; and high blood pressure, heart rate, and body temperature.

Do You Know?

If there is deficiency of iodine in the body, the thyroid gland is not able to produce thyroxine. When the gland when tries to produce the hormone, it swells up and the condition is called **Goitre.** This disease become endemic among the people living at high altitudes because they do not have sufficient iodine in their water. Iodized salt is recommended to overcome the deficiency of iodine and avoid goitre.

(ii). Calcitonin: It stimulates the transfer of calcium ions from the blood to bone, where the calcium ions can be used to generate bone tissue. In this way, calcitonin maintains blood calcium levels.

3. Pancreas

Pancreas have both exocrine and endocrine activity. As an exocrine gland, it is part of the digestive system and produces pancreatic juice which helps in digestion of food.

As an endocrine gland, it secretes two hormones **insulin** and **glucagon.** The endocrine function is performed by the special cells present in pancreas called **islets of Langerhans.**

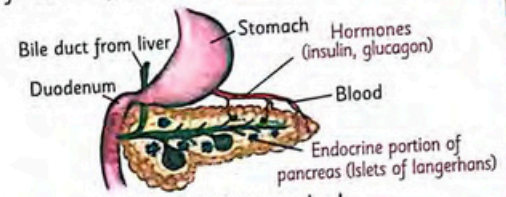


Fig.12.14 Pancreas gland

For Your Information

In diabetes, excess glucose inhibits water reabsorption by the kidneys, producing large amounts of urine. It results in dehydration and can cause kidney damage. Diabetic patients also experience loss of body weight, weakening of muscles and tiredness.

Science, Technology and Society

Example of Genetically Engineered Bacteria – Production of Human Insulin

One of the examples of genetically engineered bacteria is in the production of human insulin. With the help of recombinant DNA technology scientists are able to insert a human gene into bacterium. For example, gene coded for the production of insulin are inserted into the plasmid of a bacterium. As the bacterium undergoes binary reproduction, bacteria with the insulin gene are then multiplied and each bacterium will produce a tiny volume of insulin. By culturing the genetically engineered bacteria, limitless supplies of insulin may be produced which is used for the treatment of diabetic patients.

NOT FOR SALE

Insulin decreases blood glucose levels either by metabolizing it or by converting it into fats. If the body fails to produce insulin it leads to diabetes mellitus. Conversely glucagon increases blood glucose levels by promoting breakdown of glycogen to glucose in the liver and muscles. It also increases the release of glucose from liver to blood.

Do You Know?

Blood Glucose Concentration (BGC) Test: The amount of glucose in blood is measured by this test. It is used to diagnose diabetes. Blood glucose may be measured on a fasting basis (collected after an 8 to 10 hour fast), randomly (anytime) and after a meal. The results of some BGC tests are given here.

Blood Glucose After 8 – 10 hours Fast	
BGC	**Diagnosis**
From 70 to 99 mg/100ml	Normal
From 100 to 125 mg/100ml	Pre-diabetes
126 mg/100ml and above	Diabetes

Blood Glucose 2 hours after a 75-gram Glucose intake	
BGC	**Diagnosis**
Less than 140 mg/100ml	Normal
From 140 to 200 mg/100ml	Pre-diabetes
Over 200 mg/100ml	Diabetes

4. Adrenal Gland

A pair of adrenal gland is present, one on top of each kidney. The outer layer of this gland is called the **adrenal cortex** and the inner layer as the **adrenal medulla.**

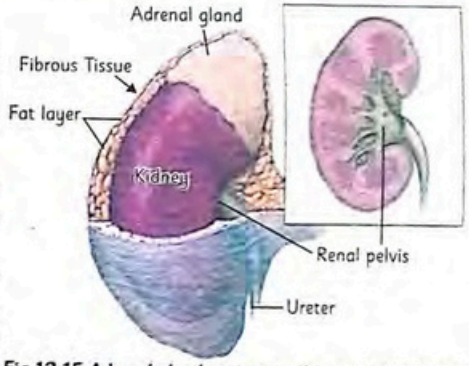


Fig.12.15 Adrenal gland present on the top of the kidney

(i). Hormones of the Adrenal Cortex: The adrenal cortex works under the action of ACTH from anterior pituitary.

It secretes many steroid hormones collectively known as **corticosteroids.** These hormones control the metabolism of minerals and glucose.

(ii). Hormones of the Adrenal Medulla: The adrenal medulla produces two hormones called the adrenaline and the noradrenaline.

These hormones are also called epinephrine and nor epinephrine respectively.

Adrenaline and noradrenaline hormones

These hormones are secreted in stressful situations. **Adrenaline** essentially dilates blood vessels in certain parts of the body such as the skeletal muscles and increases the heart's output. It is secreted in emotions and anger, hence the face becomes red.

Noradrenaline constricts blood vessels in certain areas of the body such as the gut and face. This is why in fear the face becomes pale or white and a person feels hollow in the gut.

5. Gonads

Gonads are the reproductive organs, which produce gametes. The male gonads are called testes and the female gonads are called ovaries, both produce many important hormones.

Hormones of the Ovary

(i). Oestrogens: It brings about the development of the secondary sexual characters in the female (e.g. development of breast).

(ii). Progesterone: It prepares the female body for maintaining the state of pregnancy.

Hormones of the Testes

The testes produce a hormone called **testosterone.** It brings about development of the male secondary sexual characteristics like growth of hair on face, thickening of voice etc.

Gland	Hormone	Functions
Anterior lobe of Pituitary gland	▪ Growth hormone ▪ Adrenocorticotropic hormone ▪ Thyroid stimulating hormone ▪ Luteinising hormone	▪ regulates development of muscles and bones ▪ stimulates secretion of cortisol and aldosterone by the adrenal cortex ▪ stimulates the thyroid gland to produce its hormone ▪ stimulates the ovary to release egg ▪ stimulates the testes to produce testosterone
Posterior lobe of Pituitary gland	▪ Antidiuretic hormone ▪ Oxytocin	▪ increases the reabsorption of water from nephrons ▪ initiates uterine contractions during childbirth ▪ stimulates the flow of milk from the breasts during location
Thyroid gland	▪ Thyroxine ▪ Calcitonin	▪ stimulates enzymes of cellular metabolism ▪ decreases blood calcium concentration
Adrenal medulla	▪ Epinephrine, ▪ Norepinephrine	▪ initiate body's response to stress and the "fight or-flight" response to danger
Adrenal cortex	▪ Cortisol ▪ Aldosterone	▪ promotes production of glucose from proteins ▪ promotes salt and water retention by the kidneys
Pancreas	▪ Insulin ▪ Glucagon	▪ lowers the blood glucose level by stimulating body cells to store glucose or use it ▪ stimulates release of glucose from the liver into the blood
Ovaries	▪ Oestrogen ▪ Progesterone	▪ cause the release of an egg from the ovary and regulates female secondary sex characteristics
Testes	▪ Androgens (Testosterone)	▪ regulate male secondary sex characteristics

Table 12.2: Summary of Major Endocrine Glands and their Functions

12.5 Mechanism of Hormonal Secretion

Who controls the secretion of a hormone? This question puzzled the scientists for many decades. Now, we have lot of information regarding the secretion of hormones. There are many controlling pathways for different glands and different hormones from the same gland. One of them is described below called as negative feedback mechanism

Feedback mechanism means "regulation of a process by the output of the process". When the output of a process slows down or stops the process, it is called negative feedback mechanism.

Negative Feedback Mechanism

The thermostat of an air conditioner controls the functioning of the air conditioner by using negative feedback. We set the thermostat of the conditioner at a certain temperature (say at 20°C). The thermostat detects the room temperature. When it finds its above 20°C, it turns on the air conditioning to cool the room. Once the room temperature reaches its thermostat setting (20°C), the thermostat turns off the air condition to stop further cooling.

The same negative feedback mechanism controls the secretion of hormones. Let us take the example of insulin secreted by the Islets of Langerhans. When we take a meal, the carbohydrates are digested and converted into glucose. Glucose is absorbed into the blood from the small intestine. This increases the glucose level in the blood. When this blood passes through the pancreas, the Islets of Langerhans sense this increase. They start secreting insulin in the blood. Insulin reduces the blood glucose level by promoting its entry into the body cells. When this blood (with normal glucose level) passes through the Islets of Langerhans, they stop the secretion of insulin. This process is called as the negative feedback mechanism of the hormone action.

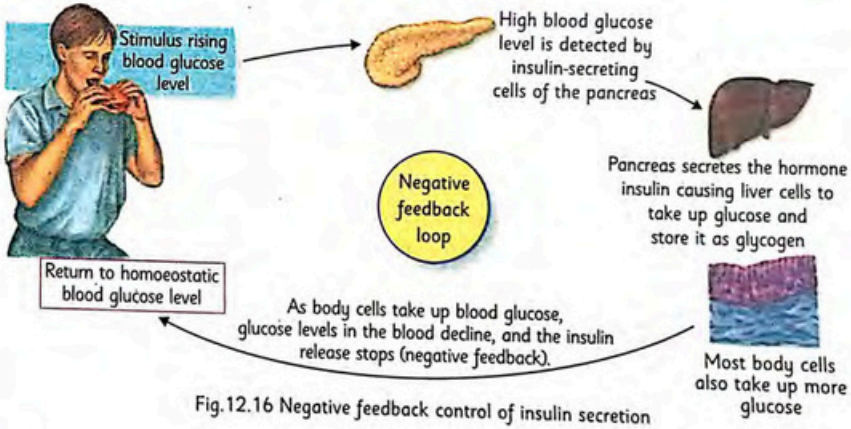


Fig.12.16 Negative feedback control of insulin secretion

12 .6 Disorders of the Nervous System

a). Epilepsy (fits or "mirgi")

This is a type of functional disorder of the nervous system in which suddenly excessive discharge of nerve impulses takes place from the brain. The abnormal bursts of impulses from neurons which cause the body to behave strangely are called **seizures**. People generally call it fits.

Some epilepsy patients simply experience an odd feeling. Others may have convulsions (shaking of the body) or may lose consciousness. The body becomes rigid and stiff. The patient's hands are clenched and they frequently bites their tongue.

Fig.12.17 Emergency aid to a patient who suffered from a seizure

Epilepsy may be caused by changes in the brain due to genetic reasons. Severe head injuries, stroke, brain infections and drug abuse may also cause epilepsy. In the treatment for epilepsy, seizures are controlled. Anti-epileptic drugs (AEDs) are used for the treatment of epilepsy. AEDs do not cure epilepsy, but can prevent seizures from occurring.

b). Paralysis

Paralysis is a vascular disease of the brain. It occurs when either a blood clot is stuck in the fine blood vessels of the brain or due to the rupturing of blood vessels in the brain due to high blood pressure. This causes damage to that part of the brain. This damage may be permanent or temporary. As a result; the part of the body controlled by the affected part of the brain stops functioning.

The patient of paralysis is unable to move the muscles of one side of their body or both sides. Paralysis may also affect the arms or the legs, and sometimes the whole body.

There is currently no cure for paralysis. The existing treatments only help a person to adapt to this way of life by making them independent. Patients are given physiotherapy to improve their muscle weakness. Mobility aids such as wheelchairs and orthoses (braces designed to improve the function of a limb) are also used for patients of paralysis.

Science, Technology and Society

Explain the way nervous system helps to coordinate complex and intricate movements of hand to play a piano, or write alphabets.

NOT FOR SALE

Key Points

- The cooperative working of cells, organs and systems with one another to perform proper functions is called coordination.
- Coordination provides chances for better survival.
- Coordination is brought about by the nervous system and hormonal system.
- Sensitivity in animals is more than that in plants. It is because animals possess sense organs
- Stimulus is a change in the environment, which can be detected through the receptors.
- Response is a reaction to the stimulus.
- Receptors are organs in the body, which receive stimuli e.g. eyes, ears, nose, tongue, etc.
- Effectors are the organs which produce a response for the stimulus e.g. muscles or glands.
- The central nervous system consists of the brain and the spinal cord.
- Sensory neurons carry nerve massages from the central nervous system to the effectors.
- Motor neurons carry nerve massages from the central nervous system to the effectors.
- Associative neurons occur in the brain and spinal cord. They link the sensory neurons with the motor neurons.
- The spinal cord receives commands from the brain. It controls parts of the body and the limbs.
- Spinal cord is the centre of many reflex actions.
- Nerves arising from the brain are called cerebral nerves or cranial nerves.
- Nerves arising from the spinal cord are called spinal nerves.
- Short sighted person cannot see distant objects clearly.

Exercise

A. Select the correct answer.

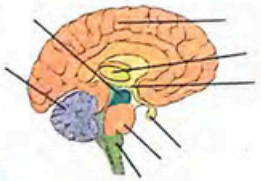
1. Insulin is a hormone and is secreted by;
   a. Liver b. Pancreas c. Stomach d. By both liver and pancreas
2. One of the following is a muscular layer of the eyeball:
   a. Retina b. Sclera c. Cornea d. Cone
3. The part of neuron that carries the signals away from the cell body:
   a. Axon b. Dendrite c. Schwann cell d. Myelin sheath
4. One of the following is responsible for the detection of changes in the environment:
   a. Receptors b. Neurons c. Effectors d. All of them
5. Which of the following is true about the cerebral cortex?
   a. It is located deep in the brain. b. It is the folded outer covering of the brain.
   c. It is located at the back of the brain. d. It is part of the peripheral nervous system.
6. Light rays focus behind the retina, instead of focussing on the surface of the retina. This condition is known as:
   a. Myopia b. Hypermetropia c. Short sightedness d. Normal vision
7. Microscopic gaps between the neuron endings are:
   a. Transmitters b. Synapses c. Pores d. Nodes
8. The largest part of the brain is:
   a. Cerebrum b. Cerebellum c. Medulla oblongata d. Thalamus
9. Intelligence is under the control of:
   a. Cerebrum b. Cerebellum c. Thalamus d. Hypothalamus
10. Mixed nerves are made of;
    a. Axons of sensory and motor neurons b. Cell bodies of sensory and motor neurons
    c. Axons of inter-neurons d. Cell bodies of inter-neurons
11. The part of the brain which you use in recalling your memories is:
    a. Cerebellum b. Limbic system c. Thalamus d. Hypothalamus
12. Which of these acts an exocrine as well as endocrine gland?
    a. Pituitary b. Thyroid c. Adrenal d. Pancreas
13. In the inner ear, vibrations make pressure waves in the fluid of;
    a. Cochlea b. Stapes c. Auditory nerve d. Semi-circular canals

B. Write short answers to the following questions.

1. How do reflex action work in human beings?
2. What are the causes of epilepsy and paralysis?

NOT FOR SALE

3. What happens if Islets of Langerhans secrete insulin but not glucagon?
4. Why is the pituitary gland known as the master gland?
5. Differentiate between the two types of coordination system.
6. What is the role of insulin and glucagon?
7. What characters are controlled by the ovarian hormones?
8. State the hormones of the pituitary and thyroid glands and write their functions.
9. Label the different parts of the brain in the following diagram.



C. Write detailed answers to the following questions:

1. Explain the different types of receptors in human beings.
2. Describe the structure of the human brain.
3. Write a comprehensive note on chemical coordination in human beings.
4. Discuss any two disorders of the human eye.
5. Describe the causes, symptoms and treatments of paralysis.
6. Describe the causes, symptoms and treatments of epilepsy.
7. Explain the mechanism of vision by the eyes.

Initiating and Planning

1. Analyse why plants (like sunflower) have a very slow response to stimuli.
2. Visualise nervous and hormonal coordination by comparing electrical transmission in wires with the transmission of nerve impulse in neurons and by comparing convection currents in liquids to the hormonal transmission in blood.
3. Compare the BGC (blood glucose concentration) of a healthy person with a patient suffering from Diabetes mellitus.

Activities

1. Record the difference in quickness of response of the two types of coordination (by asking a student to say a few words in front of the class and observe the change in heartbeat).
2. Perform an experiment in which a scale held at its lower end between the thumb and index finger is allowed to fall and then recording the time taken to catch it again.
3. Identify different parts and draw a labelled diagram of the longitudinal section of the eye of a sheep or bull.
4. Perform an experiment in which the shin muscle of a frog is made to contract in a Petri dish filled with methylene blue and using 12 V DC current.
5. Check the vision of a friend to diagnose whether he/she is suffering from long or short-sightedness.
6. Perform an experiment in which one student flashes a spotlight into the eye of another and record the time taken for the eye to contract its pupil.