CHAPTER

12

Coordination and Control

Animation 12.1: Neuron
Source & Credit: nichd.nih

The tissues and organs in the bodies of multicellular organisms do not work independently of each other. They work together performing their many tasks as the needs of the whole body. This means that these activities are coordinated. Coordination also enables the organism to respond to happenings in the world around it.

One familiar example of coordination is the way in which muscles work together during movement. When a boy runs to catch a ball, he uses hundreds of muscles to move his arms, legs and back. His nervous system uses information from his sense organs and coordinates these muscles. Due to this coordination, the muscles contract in the correct sequence, power and length of time. But that is not all. Such activities involve many other kinds of coordination. For example breathing and heartbeat rates are increased blood pressure is adjusted, and extra heat is removed fast from the body.

How does it happen? Life activities are controlled and coordinated i.e. body works as one unit, in which its different organs and systems cooperate and work in harmony with each other.

When we are writing something, our hands and fingers work in collaboration with our muscles, eyes, thoughts etc. and then very intricate movements result.

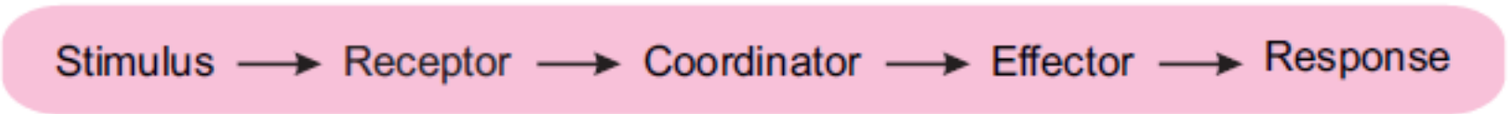
Animation 12.2: HumanAnatomy
Source & Credit: soundtells

12.1 Types Of Coordination

There are two types of coordination in organisms:
i. Nervous coordination brought about by nervous system and
ii. Chemical coordination brought about by endocrine system.
Animals have both the nervous and chemical coordination systems in their bodies while plants and other organisms have only chemical coordination.

12.1.1 Coordinated Action

A coordinated action has five components;



i- Stimuli

What happens when we touch a snail? We might have seen the flowers of sunflower plant moving towards the sun. What could be the reason for all this? Touch, light etc. are factors that can bring about certain responses in living organisms. These factors are called stimuli. We can define a stimulus as any change in environment (external and internal), which can provoke a response in organism. More examples of stimuli are heat, cold, pressure, sound waves, presence of chemicals, microbial infections etc.

Coordination also takes place in unicellular organisms. The response to stimuli is brought about through chemicals

ii- Receptors

Stimuli are detected by special organs, tissues or cells of body. For example sound waves are detected by ears, light is detected by eyes, chemicals in air are detected by nose and so on. The organs, tissues or cells which are specifically built to detect particular type of stimuli are called receptors.

iii- Coordinators

These are the organs that receive information from receptors and send messages to particular organs for proper action. In nervous coordination, brain and spinal cord are coordinators. They receive information and send messages through neurons in the form of nerve impulses. On the other hand, in chemical coordination, various endocrine glands play the role of coordinators. They receive information in the form of various chemicals and send messages by secreting particular hormones in blood.

iv- Effectors

These are the parts of body which receive messages from coordinators and produce particular responses. In nervous coordination, neurons carry messages from coordinators (brain and spinal cord) to muscles and glands, which act as effectors. In chemical coordination, particular hormones carry messages from coordinators (endocrine glands) to particular target tissues, which act as effectors. For some hormones, nephrons act as effectors. Similarly, bones and liver act as effectors for many hormones.

v- Response

On receiving the message from coordinators, the effector performs action. This action is called response. For example, pulling our hand away from something very hot and the movement of the flower of sunflower towards light are responses. Usually, nervous coordination produces immediate but short-living responses while chemical coordination produces slow but long-living responses.

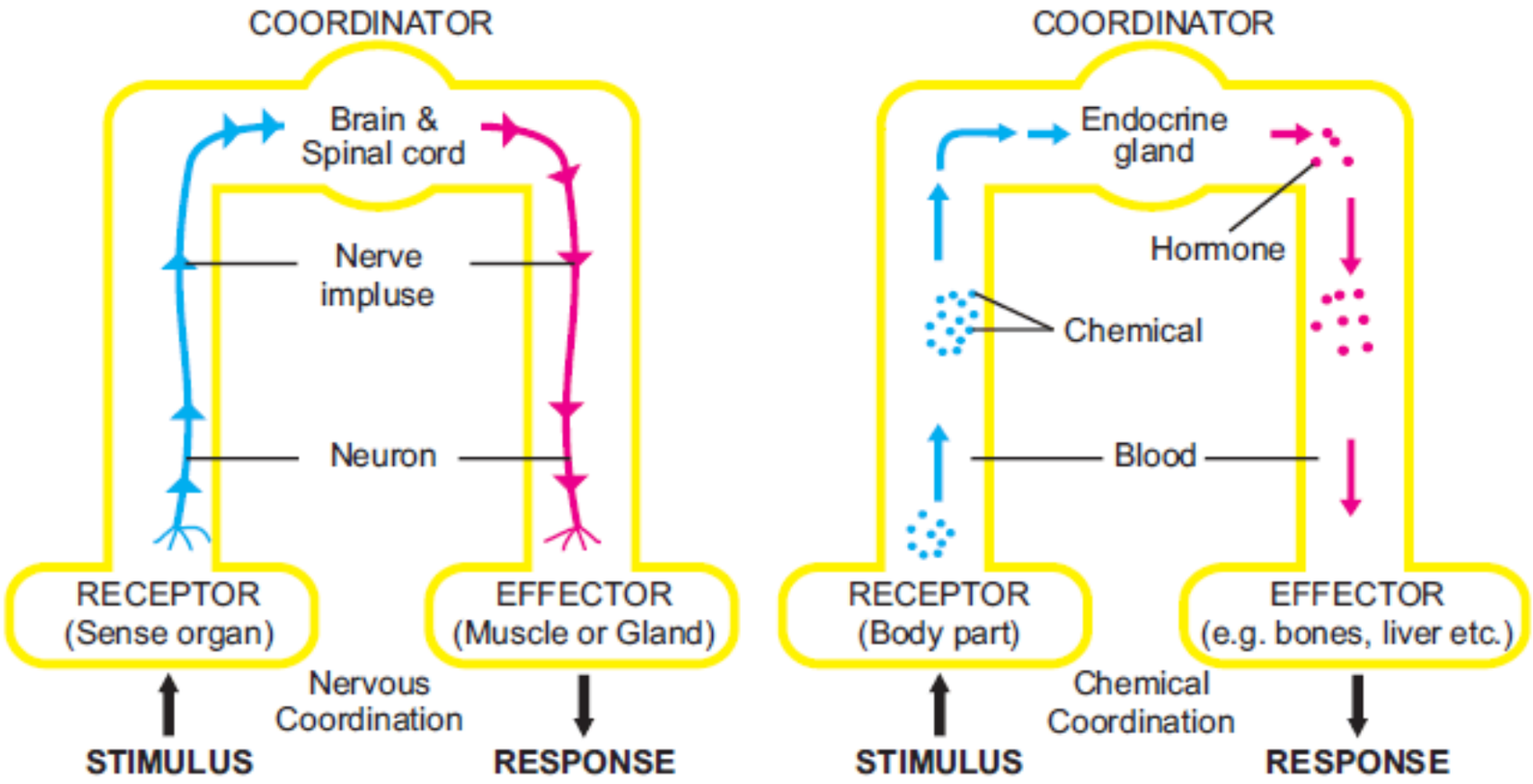


Figure 12.1: Nervous and chemical coordination

Recording Skills:

- Using the knowledge gained from the above topic, draw a table that can show the differences between the two types of coordination i.e. nervous coordination and chemical coordination.

12.2 Human Nervous System

We have understood the basic model of the working of nervous system. The nervous system in man and in other higher animals is composed of two major components i.e. central nervous system and peripheral nervous system.

Central nervous system comprises of coordinators i.e. brain and spinal cord while peripheral nervous system consists of nerves that arise from central nervous system and spread in different parts of body. All these components are made of neurons. Now we will first examine the structure and types of neuron and then we will go to the divisions of nervous system.

12.2.1 Nerve cell or Neuron

Nerve cell or neuron is the unit of the nervous system. The human nervous system consists of billions of neurons plus supporting (neuroglial) cells. Neurons are specialized cells that are able to conduct nerve impulses from receptors to coordinators and from coordinators to effectors. In this way they communicate with each other and with other types of body cells.
The nucleus and most of the cytoplasm of a neuron is located in its **cell body**. Different processes extend out from cell body. These are called **dendrites** and axons. Dendrites conduct impulses toward cell body and **axons** conduct impulses away from cell body (Fig 12.2).

Animation 12.3: Nerve impulse
Source & Credit: spiritualgarden

Unlike ordinary cells, mature neurons never divide. But a protein called nerve-growth-factor promotes the regeneration of broken nerve cells. The degenerating brain cells could be repaired, by using embryonic stem cells.

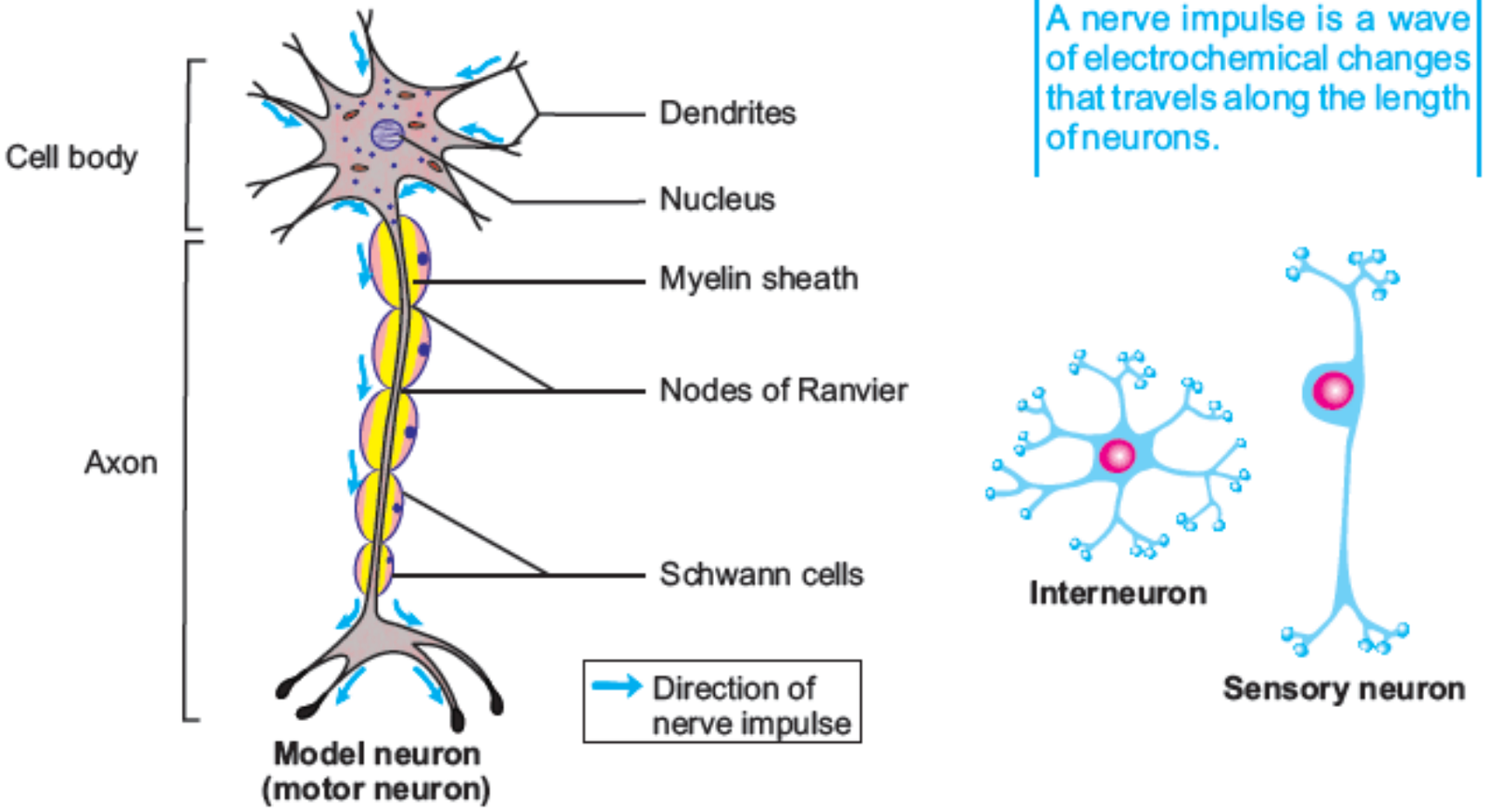


Figure 12.2: Neurons

Schwann cells are **special neuroglial** cells located at regular intervals along axons. In some neurons, Schwann cells secrete a fatty layer called **myelin sheath,** over axons. Between the areas of myelin on an axon, there are non-myelinated points, called the **nodes of Ranvier.** Myelin sheath is an insulator so the membrane coated with this sheath does not conduct nerve impulse. In such impulses are called **saltatory** ('jumping') impulses. This increases the speed of nerve impulse.

Animation 12.4: bp120
Source & Credit: clc.uc

On the basis of their functions, neurons are of three types;

1. Sensory neurons conduct sensory information (nerve impulse) from receptors towards the CNS. Sensory neurons have one dendrite and one axon.

Animation 12.5: Nerve impulse
Source & Credit: wikibooks

2. Interneurons form brain and spinal cord. They receive information, interpret them and stimulate motor neurons. They have many dendrites and axons.

3. Motor neurons carry information from interneurons to muscle or glands (effectors). They have many dendrites but only one axon.

Practical:

Observe the contraction of shin muscle of a frog, using a DC current of 12 volt.

Apparatus:

Dissected frog, Petri dish, methylene blue solution, 12 volt battery with wires.

Procedure:

- Get the shin muscle of a dissected frog (dissection would be done by teacher).
- Put the shin muscles in a Petri dish filled with methylene blue.
- Place a battery of 12 volt power near the Petri dish and touch its two wires with the opposite ends of the muscle.

Observation:

The muscle would contract when a current is applied to it.

Animation 12.8: Deporepol
Source & Credit: cybercuba

In certain parts of body, the cell bodies of many neurons form a group enveloped by a membrane. This is called ganglion.

Nerve

A nerve means the union of several axons that are enveloped by a covering made of lipid. Based on the property of axons, the nerves are classified into three types.

1. **Sensory nerves** contain the axons of sensory neurons only.
2. **Motor nerves** contain the axons of motor neurons only.
3. **Mixed nerves** contain the axons of both i.e sensory and motor neurons.

12.2.2 Divisions of the Nervous System

The details of the central and peripheral nervous systems are given below.

Central nervous system

The central nervous system consists of brain and spinal cord.

A- Brain

In animals, all life activities are under the control of brain. The structure of brain is suitable to perform this function. Brain is situated inside a bony cranium (part of skull).

Inside cranium, brain is covered by three layers called **meninges**. Meninges protect brain and also provide nutrients and oxygen to brain tissue through their capillaries.

The brain contains fluid-filled **ventricles** that are continuous with the **central canal** of spinal cord. Fluid within ventricles and central canal is called **cerebrospinal fluid** (CSF).

The Divisions of Brain

There are three major regions in the brain of human and other vertebrates. These are forebrain, midbrain and hindbrain. Important parts of each of these regions are described below:

Forebrain

Forebrain is the largest area of brain. It is most highly developed in humans. Following are the important parts of this region.

(i) Thalamus lies just below cerebrum. It serves as a relay centre between various parts of brain and spinal cord. It also receives and modifies sensory impulses (except from nose) before they travel to cerebrum. Thalamus is also involved in pain perception and consciousness (sleep and awakening).

(ii) Hypothalamus lies above midbrain and just below thalamus. In humans, it is roughly the size of an almond. One of the most important functions of hypothalamus is to link nervous system and endocrine system. It controls the secretions of pituitary gland. It also controls feelings such as rage, pain, pleasure and sorrow.

Animation 12.7: Nervous System
Source & Credit: hermes

(iii) Cerebrum is the largest part of forebrain. It controls skeletal muscles, thinking, intelligence and emotions. It is divided into two cerebral hemispheres. The anterior parts of **cerebral hemispheres** are called **olfactory bulbs** which receive impulses from olfactory nerves and create the sensation of smell. The upper layer of cerebral hemispheres i.e. cerebral cortex consists of grey matter. The grey matter of nervous system consists of cell bodies and non-myelinated axons. Beneath this layer is present the white matter. The white matter of nervous system consists of myelinated axons. Cerebral cortex has a large surface area and is folded in order to fit in skull. It is divided into four lobes.

Animation 12.8: Brainlobes
Source & Credit: people.eku

Hippocampus is a structure that is deep in the cerebrum. It functions for the formation of new memories. People with a damaged hippocampus cannot remember things that occurred after the damage but can remember things that had occurred before damage.

Lobe	Function
Frontal	Control motor functions, permits conscious control of skeletal muscles and coordinates movements involves in speech
Parietal	Contains sensory areas that receive impulses from skin.
Occipital	Receives and analyzes visual information
Temporal	Concerned with hearing and smell

Midbrain

Midbrain lies between hindbrain and forebrain and connects the two. It receives sensory information and sends it to the appropriate part of forebrain. Midbrain also controls some auditory reflexes and posture.

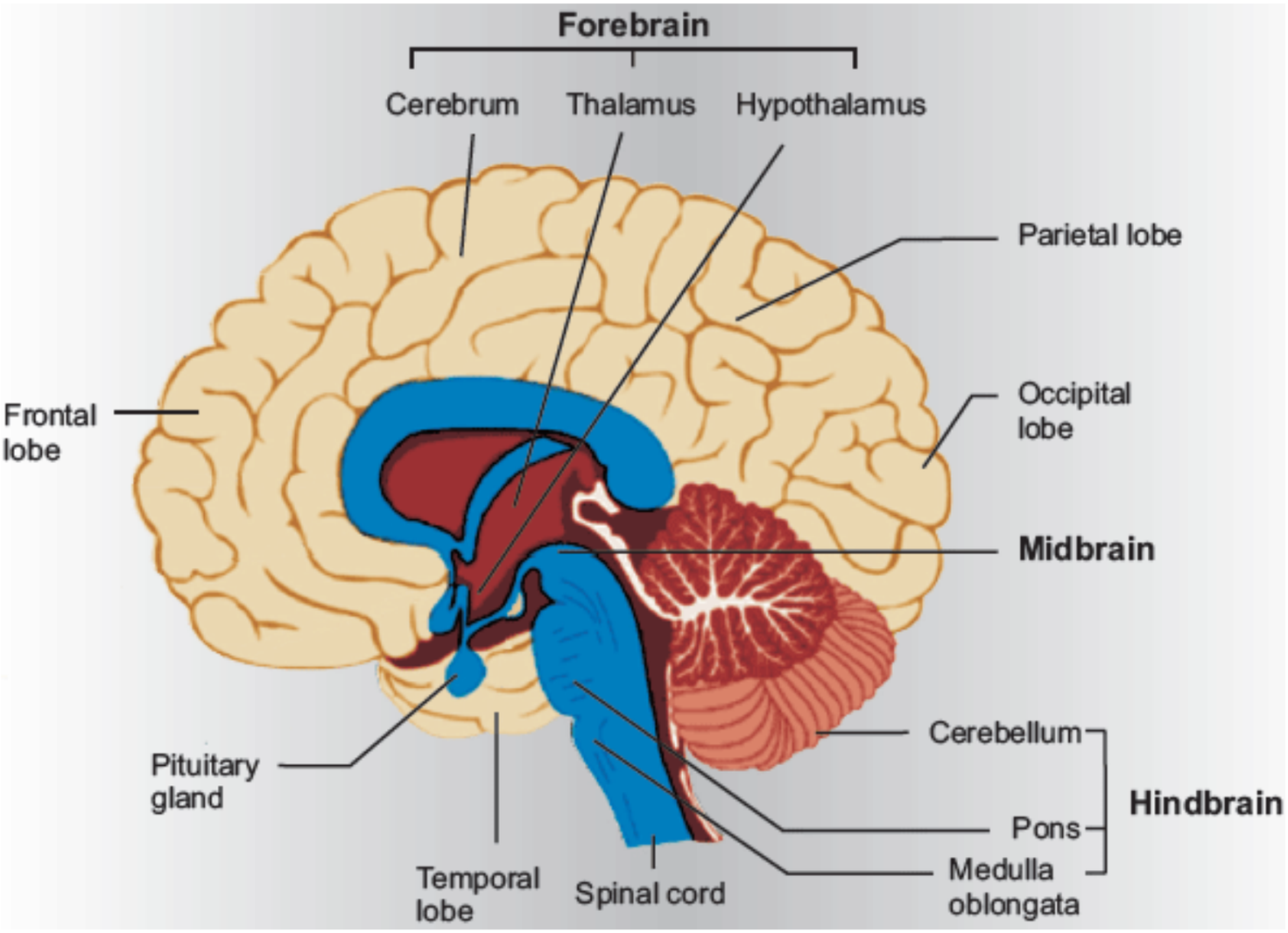


Figure 12.3: Structure of human brain

The medulla oblongata, pons, and midbrain connect the rest of brain to spinal cord. They are collectively referred to as brain stem.

Hindbrain

Hindbrain consists of three major parts.

(i) **Medulla oblongata** lies on the top of spinal cord. It controls breathing, heart rate and blood pressure. It also controls many reflexes such as vomiting, coughing, sneezing etc. Information that passes between spinal cord and the rest of brain pass through medulla.

(ii) **Cerebellum** is behind medulla. It coordinates muscle movements.

(iii) **Pons** is present on top of medulla. It assists medulla in controlling breathing. It also serves as a connection between cerebellum and spinal cord.

Animation 12.9: Rotating brain colored
Source & Credit: wikipedia

B- Spinal Cord

The spinal cord is in fact a tubular bundle of nerves. It starts from brain stem and extends to lower back. Like brain, spinal cord is also covered by meninges. The vertebral column surrounds and protects spinal cord.

The outer region of spinal cord is made of white matter (containing myelinated axons). The central region is butterfly shaped that surrounds the central canal. It is made of grey matter (containing neuron cell bodies).

31 pairs of spinal nerves arise along spinal cord. These are **"mixed"** nerves because each contains axons of both sensory and motor neurons.

At the point where a spinal nerve arises from spinal cord, there are two roots of spinal nerve. Both roots unite and form one mixed spinal nerve (Fig. 12.4).

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

Spinal cord is the continuation of medulla oblongata.

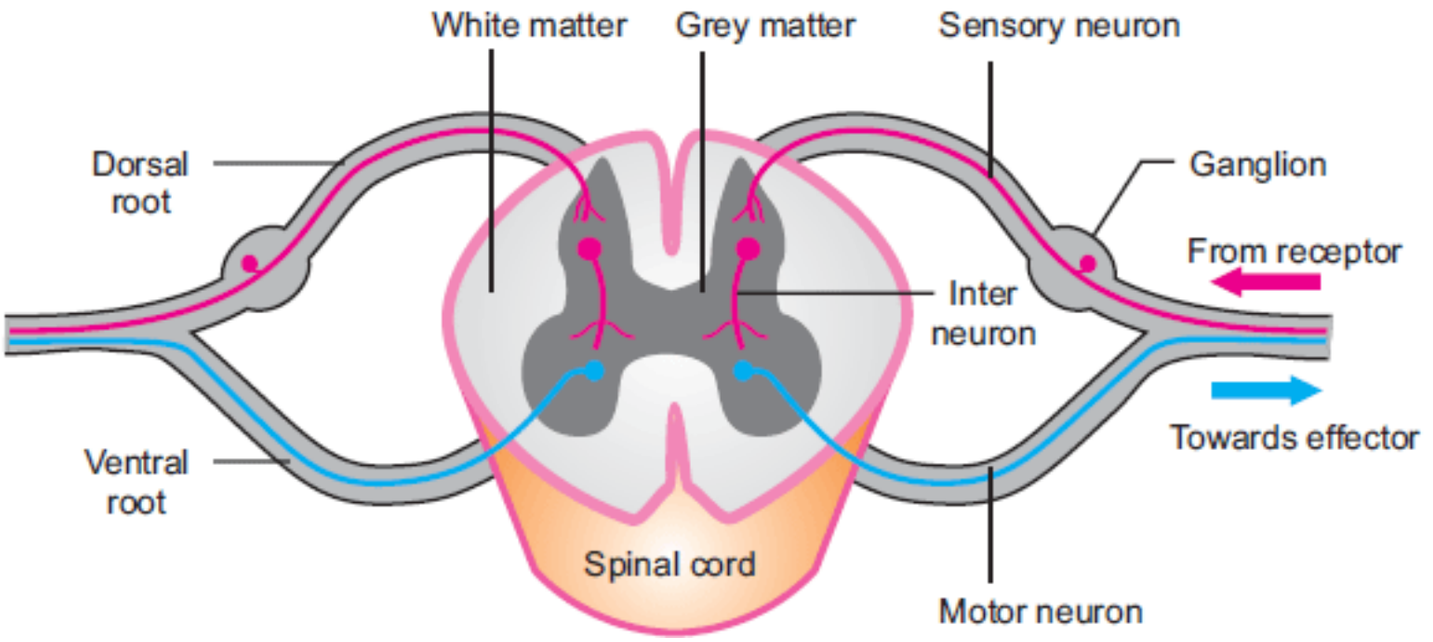


Figure 12.4: Spinal Cord and Spinal Nerves

Spinal cord performs two main functions:

1. It serves as a link between body parts and brain. Spinal cord transmits nerve impulses from body parts to brain and from brain to body parts.
2. Spinal cord also acts as a coordinator, responsible for some simple reflexes.

Peripheral Nervous System

The peripheral nervous system (PNS) is composed of nerves and ganglia. Ganglia are the clusters of neuron cell bodies outside CNS. Nerves arise or lead to brain and spinal cord. So they are named as cranial and spinal nerves.

Spinal cord is roughly 40cm long and about as wide as your thumb for most of its length.

Humans have 12 pairs of cranial nerves and 31 pairs of spinal nerves. Some cranial nerves are sensory, some are motor and some are mixed. On the other hand, all spinal nerves are mixed nerves.

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 is responsible for the conscious and voluntary actions. It includes all of the motor neurons that conduct impulses from CNS to skeletal muscles.

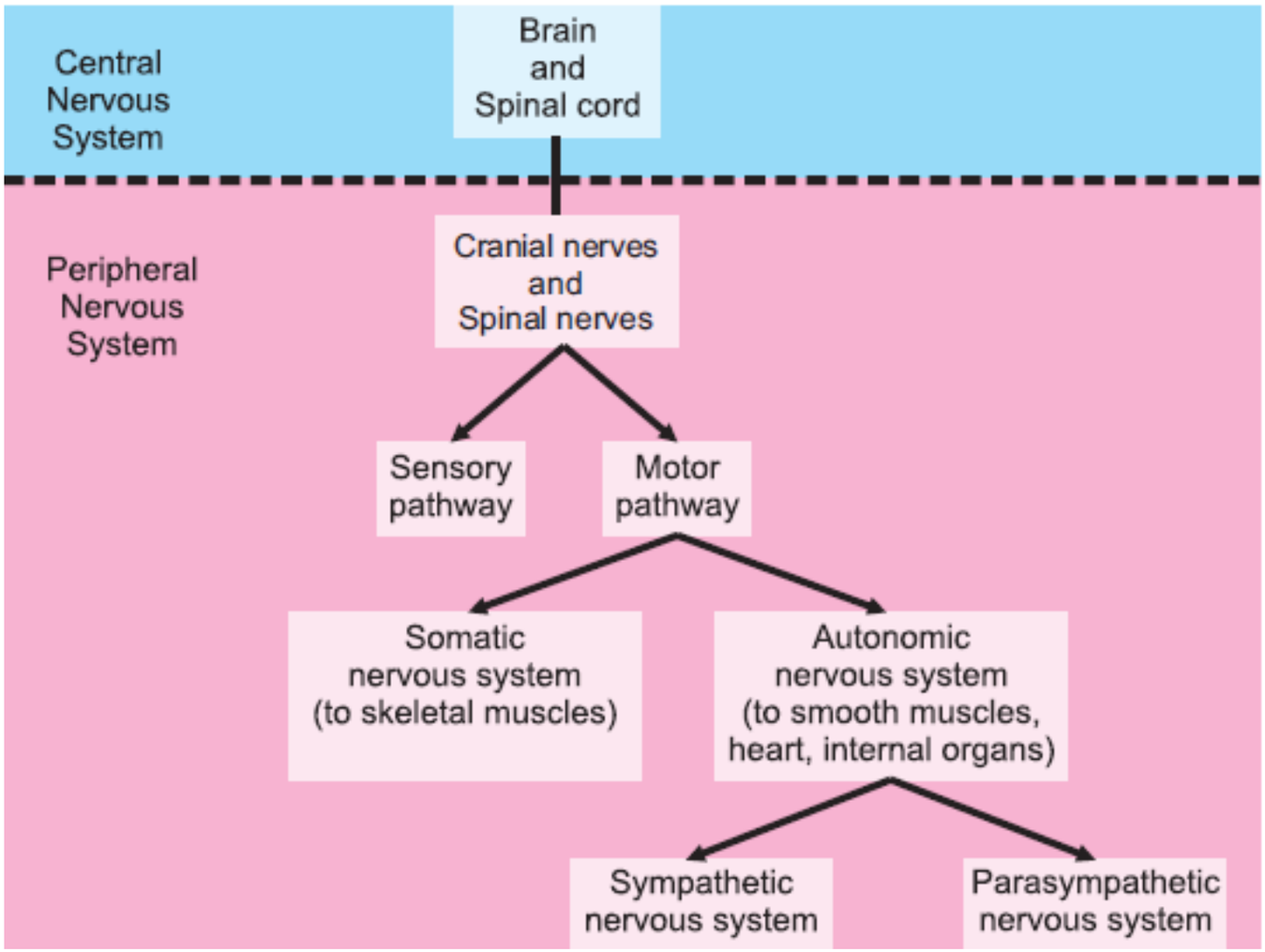


Figure 12.5: Divisions of the nervous system

Autonomic Nervous System

It is responsible for the activities, which are not under conscious control. It consists of motor neurons that send impulses to cardiac muscles, smooth muscle and glands. Autonomic nervous system comprises of sympathetic system and parasympathetic system. Sympathetic nervous system prepares body to deal with emergency situations. This is often called the “fight or flight” response. During an emergency situation, this system takes necessary actions. For example; it dilates pupils, accelerates heartbeat, increases breathing rate and inhibits digestion. When stress ends, the parasympathetic nervous system takes action and normalizes all the functions. It causes pupils to contract, promotes digestion, and slows the rate of heartbeat and breathing rate.

12.2.3 Reflex Action

When central nervous system sends impulses to muscles and glands, two types of actions (responses) result.

1. The higher centres of brain control the conscious action or voluntary actions.
2. When impulses are not passed to the higher centres of brain, it results in responses which are not under conscious control. Such responses are called involuntary actions. Sometimes, the involuntary response produced by the CNS is very quick. Such a response is called reflex action. The pathway followed by the nerve impulses for producing a reflex action, is called **reflex arc.**

The most common example of reflex action is the withdrawal of hand after touching a hot object. In this reflex action, spinal cord acts as coordinator. Heat stimulates temperature and pain receptors in skin. A nerve impulse is generated which is carried by sensory neurons to the interneurons of spinal cord.

It doesn't matter how clever we are
we will always pull our hand away
from a flame without thinking about it.

Animation 12.10: Reflexrotulien
Source & Credit: Corpshumain

From interneurons, the impulse is passed to motor neurons, which carry it to the muscles of arm. As a result, the muscles contract to withdraw hand. During it, other interneurons transmit nerve impulses up to brain so that the person becomes aware of pain and what happened.

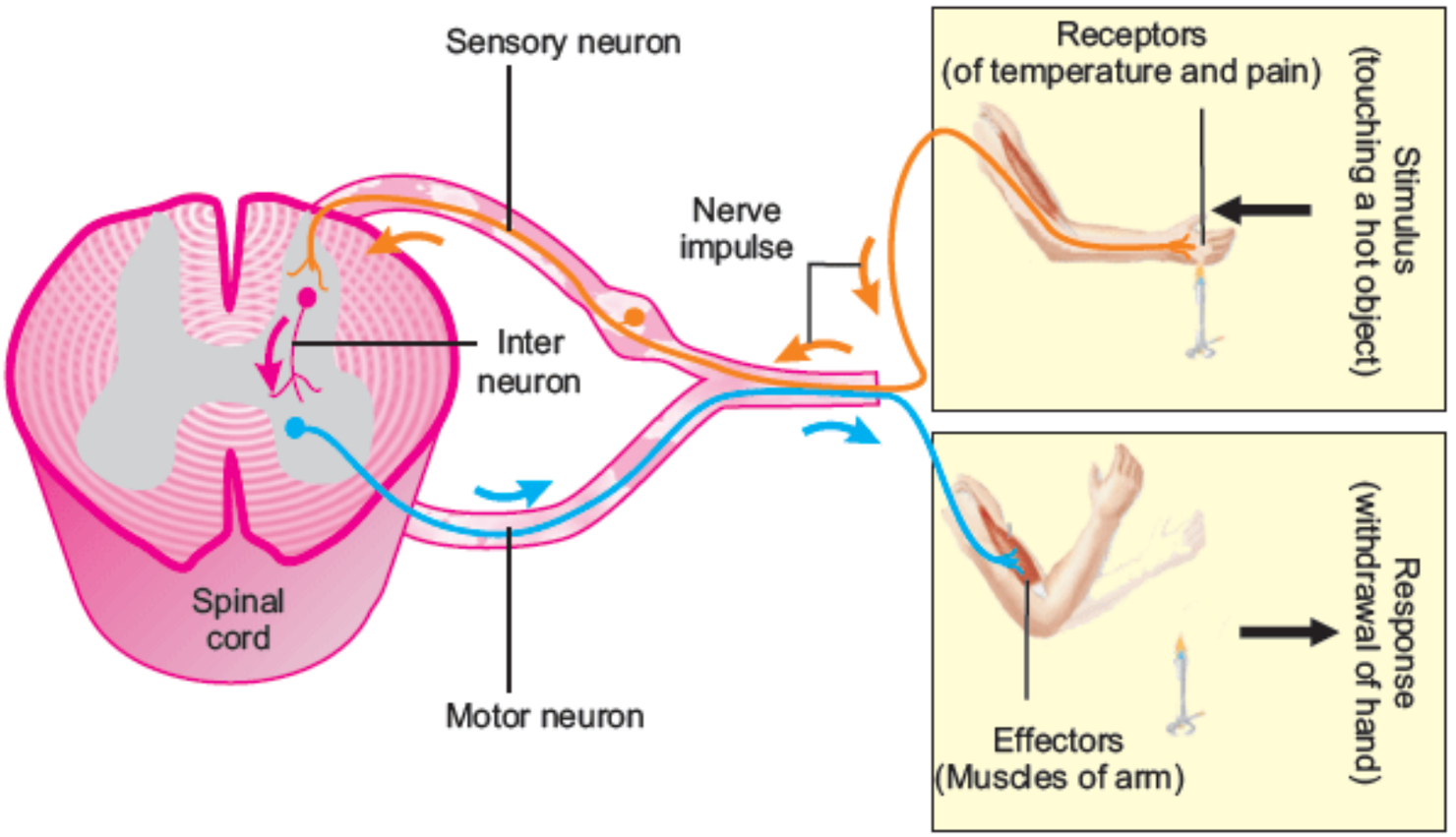


Figure 12.6: Reflex arc in a reflex action

See animation of Reflex Arc at: http://bio.rutgers.edu/~gb102/lab_5/103ar.html

12.3 Receptors In Humans

We know that the organs or parts which are specifically built to detect particular type of stimuli are called sense organs or receptors. Main receptors in man are eyes, ears, nose, taste buds, receptors of touch, heat and cold etc.

12.3.1 Eye

Our eyes are located in small portions of skull known as the orbits or eye sockets. Eyelids wipe eyes and prevent dehydration. They spread tears on eyes, which contains substances for fighting bacterial infections. Eyelashes prevent fine particles from entering eye. The structure of eye can be divided into three main layers (Fig. 12.7).

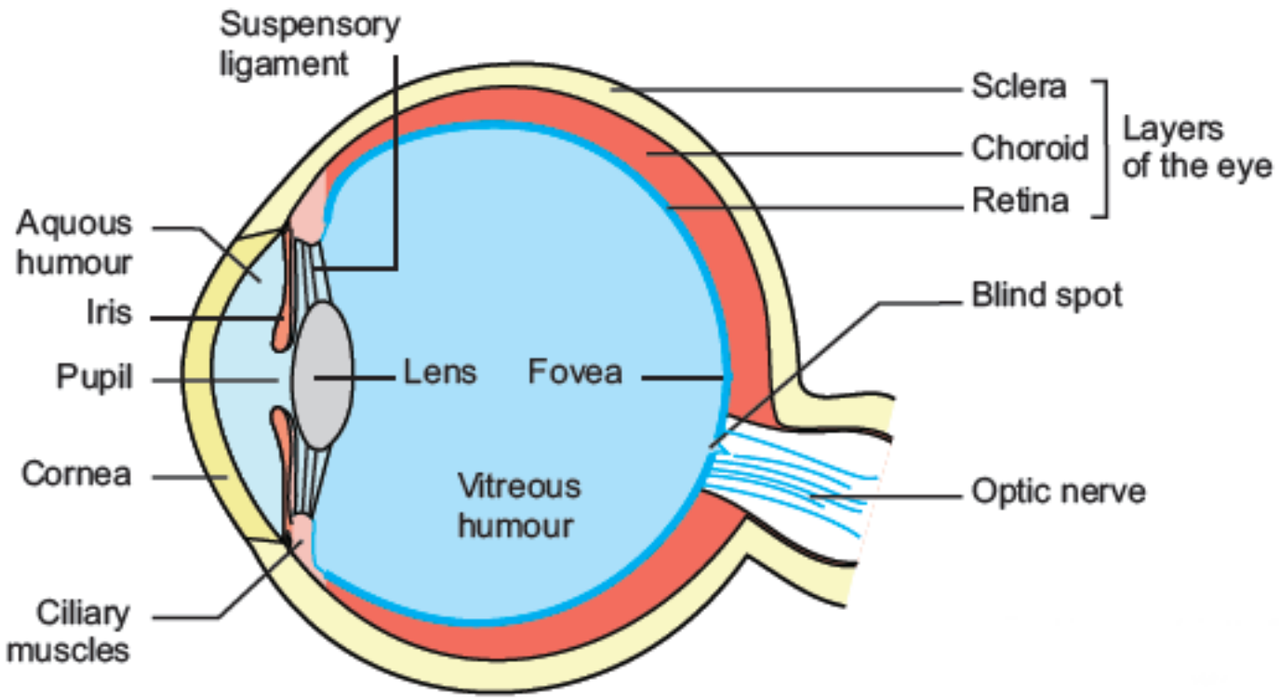


Figure 12.7: Structure of human eye

The **outer layer** of eyeball consists of **sclera** and cornea. Sclera gives eye most of its white colour. It consists of dense connective tissue and protects the inner components of eye and maintains its shape. In the front, sclera forms the transparent **cornea**. Cornea admits light to the interior of eye and bends light rays so that they can be brought to a focus.

The **middle layer** is called **choroid**. It contains blood vessels and gives the inner eye a dark colour. The dark colour prevents disruptive reflections within eye. Behind cornea, choroid bends to form a muscular ring, called iris. There is round hole, called pupil, in the centre of iris. After striking the cornea, light passes through the pupil. The size of pupil is adjusted by the muscles of iris. Pupil constricts in bright light when the circular muscles of iris contract. Similarly, pupil dilates in dim light when the radial muscles of iris contract (Fig. 12.8).

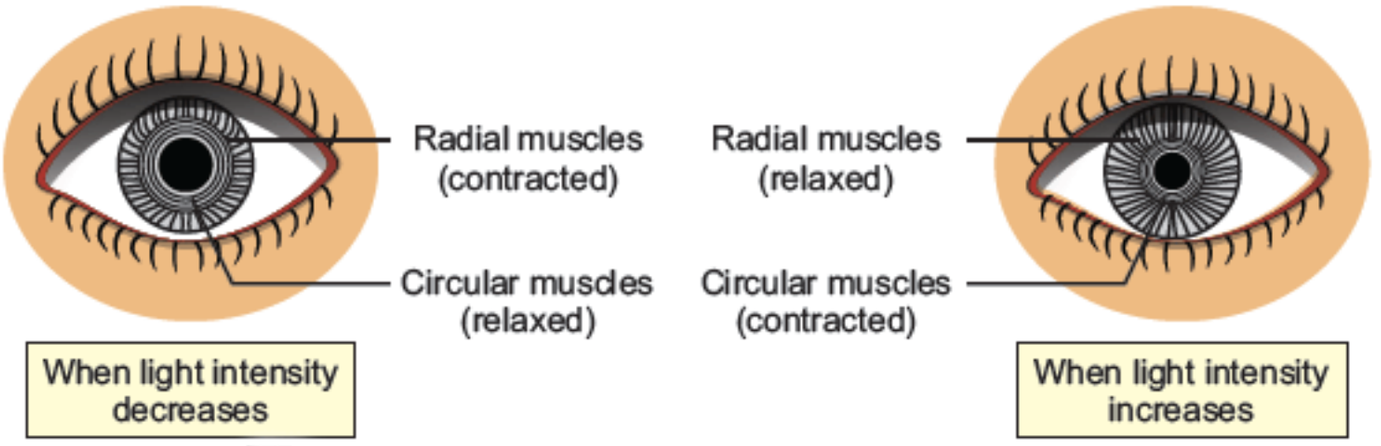


Figure 12.8: Contraction and dilation of pupil

Practical:
Perform an experiment in which a student will flash a spotlight in the eyes of another student and the third student would calculate the time taken for the eye to contract its pupil.

Behind iris, there is a convex **lens**, which focuses light on retina. Lens is attached to **ciliary muscles** of eye via a ring of **suspensory ligament**. To clearly see an object far away, ciliary muscles are relaxed and lens becomes less convex. When ciliary muscles contract, lens becomes more convex and round.

The **inner layer** is sensory and is called as **retina**. It contains the photosensitive cells called rods and cones and associated neurons.

Too much light being let in could damage the retina; too little light makes sight difficult.

Rods are sensitive to dim light while cones are sensitive to bright light and so distinguish different colours. Retina has two points i.e. fovea and optic disc. **Fovea** is a dip in retina, directly opposite to lens and is densely packed with cone cells. It is largely responsible for colour vision and sharpness. **Optic disc** is a point on retina where the optic nerve enters retina. There are no rods and cones at this point, that is why it is also referred to as the **blind spot.**

Have you seen the eyes of cat and dog shining in the night? The reason for this is the presence of tapetum behind the eye which is a layer capable of reflecting light.

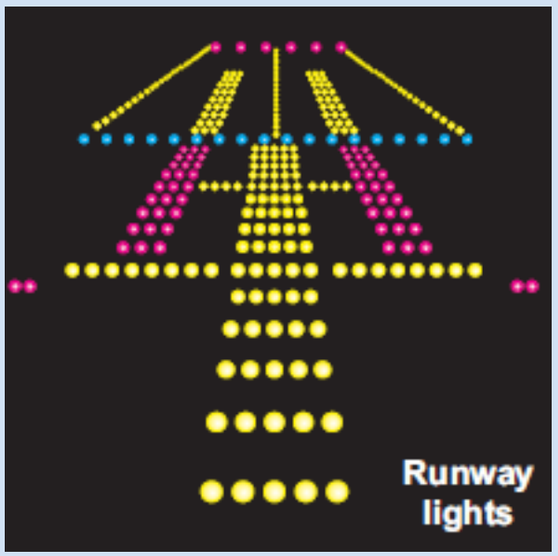
In a human eye there are about 125 lakhs rods and 7 lakhs cones.

The iris divides the cavity of eye into two chambers. The anterior chamber is in front of iris i.e. between cornea and iris; whereas the posterior chamber is between iris and retina. The anterior chamber contains a clear fluid known as **aqueous humour** while the posterior chamber contains a jelly-like fluid known as **vitreous humour**. It helps maintain the shape of eye and suspends the delicate lens.

Light from objects enters eye and is refracted when it passes through cornea, aqueous humour, lens and vitreous humour. Lens also focuses light on retina. As a result, the image falls on retina. Rods and cones generate nerve impulses in the optic nerve. These impulses are carried to the brain, which makes the sensation of vision.

Rods contain a pigment called **rhodopsin.** When light falls on rhodopsin, it breaks for generating a nerve impulse. In the absence of light, the breakdown products are again converted into rhodopsin. Body synthesizes rhodopsin from **vitamin A** and that is why the deficiency of vitamin A causes poor night vision. This problem is called **night blindness.**

Cones also contain a pigment, known as **iodopsin**. There are three main types of cones and each type has a specific iodopsin. Each type of cones recognizes one of the three primary colours i.e. blue, green and red. If any type of cones is not working well, it becomes difficult to recognize that colour. Such person is also not able to distinguish different colours. This disease is called **colour blindness** and it is a genetic problem.



For a pilot, colour vision is essential so that he/she can recognize aircraft position lights, light-gun signals, airport beacon, approach-slope indicators, and chart symbols, especially at night. A pilot must have the ability to perceive these colours necessary for the safe performance of his/her duties.

Disorders of the Eye

The working of eye is affected by the changes in the shape of eyeball.

Myopia (Short sight)

The elongation of eyeball results in myopia. Such persons are not able to see distant objects clearly. The image of a distant object is formed in front of retina (Fig. 12.9). This problem can be rectified by using concave lens.

Hypermetropia (Long sight):

It happens when eyeball shortens. Such persons are not able to see near objects clearly. The image is formed behind retina (Fig. 12.9). Convex lens is used to rectify this problem.

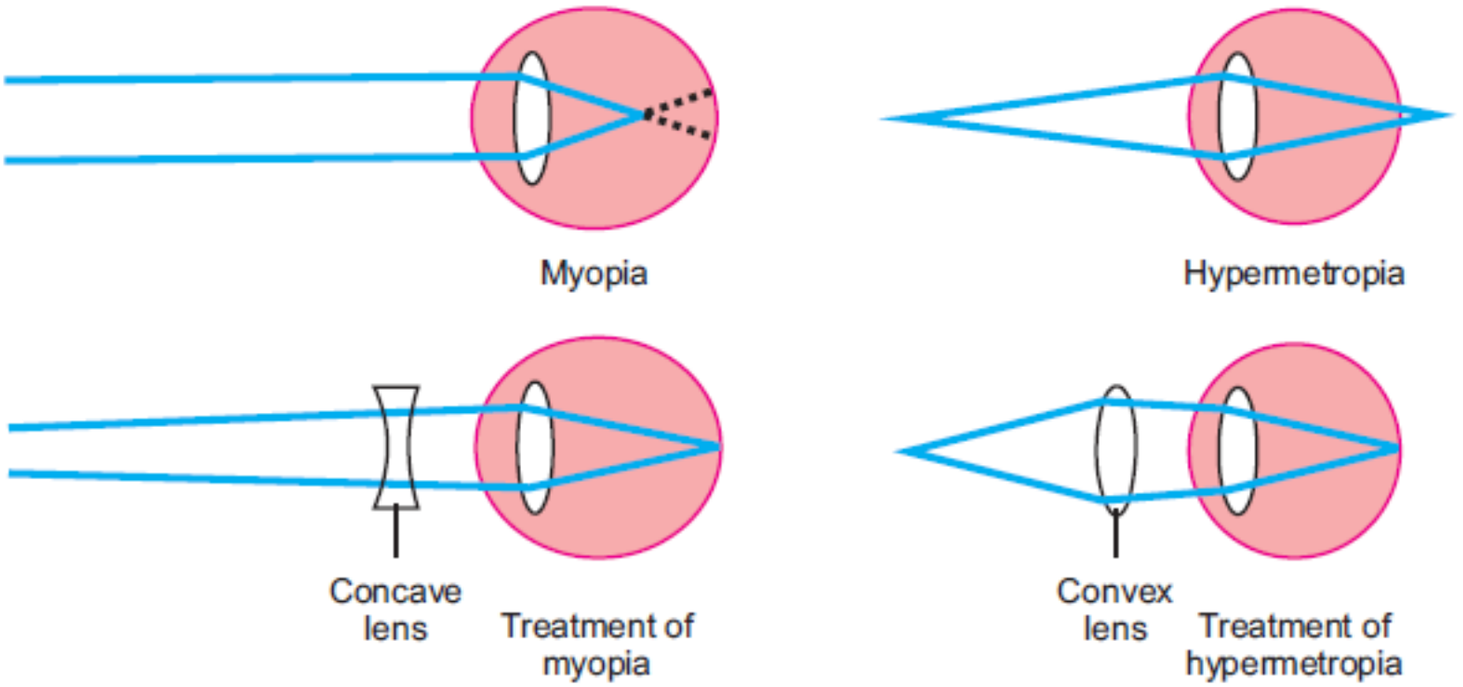


Figure 12.9: Myopia and hypermetropia

Ibn al-Haytham's "Book of Optics" has been ranked alongside a book of Isaac Newton. It is one of the most influential books ever written in the history of physics.

Contributions of Muslim Scientists

Ali ibn Isa (950 - 1012) was a famous Arab scientist. He wrote three books on ophthalmology (study of the diseases and surgery of eyes). He described 130 eye diseases and prescribed 143 drugs to treat these diseases.

Ibn al-Haytham (965 - 1039), an Arab scientist, made significant contributions to the principles of eye and vision. He is regarded as the father of optics (study of the behaviour of light). His "Book of Optics" correctly explained and proved the modern theory of vision. He discussed the topics of medicine and eye surgery in his book. He made several improvements to eye surgery and accurately described the process of sight, the structure of eye, image formation in eye and visual system. Ibn al-Haytham also described the principles of pinhole camera.

Practical: Study of the Bull Eye

- Get a real bull eye and study its longitudinal section (cut by the teacher) or study the model of bull eye.
- Identify different parts of the eye and draw a labelled diagram that would clearly show the sclera, choroid, retina, iris and lens.

Owl is not able to see during day time. The reason for this is the deficiency of cones which receive and sense the bright light. But the presence of more rods gives it greater power of vision during night. All animals that search for prey during night have this characteristic.

12.3.2 Ear

Hearing is as important as vision. Our ear helps us in hearing and also to maintain the balance or equilibrium of our body. Ear has three main parts i.e. external ear, middle ear, and internal ear.

A- External Ear

External ear consists of pinna, auditory canal and ear drum (tympanum). **Pinna** is the broad external part, made of cartilage and covered with skin. It helps to direct sound waves into **auditory canal**. There are special glands in the walls of auditory canal, which produce wax. The wax and the hairs in auditory canal protect ear from small insects, germs and dust. In additions to this, they help to maintain the temperature and dampness of auditory canal. Auditory canal ends in **ear drum.** This thin membrane separates external ear from middle ear.

Animation 12.11: Human Ear
Source & Credit: leavingbio

B- Middle Ear

Middle ear is a chamber after external ear. Three small bones, called middle ear ossicles, are present in a chain in middle ear. These movable bones include **malleus, incus** and **stapes**. **Malleus** is attached with ear drum, then comes incus and finally **stapes** that is connected with a membrane called **oval window.** Oval window separates middle ear from inner ear. Middle ear also communicates with the nasal cavity through **Eustachian tube**. This tube regulates the air pressure on both sides of ear drum.

Stapes is the smallest bone of the human body.

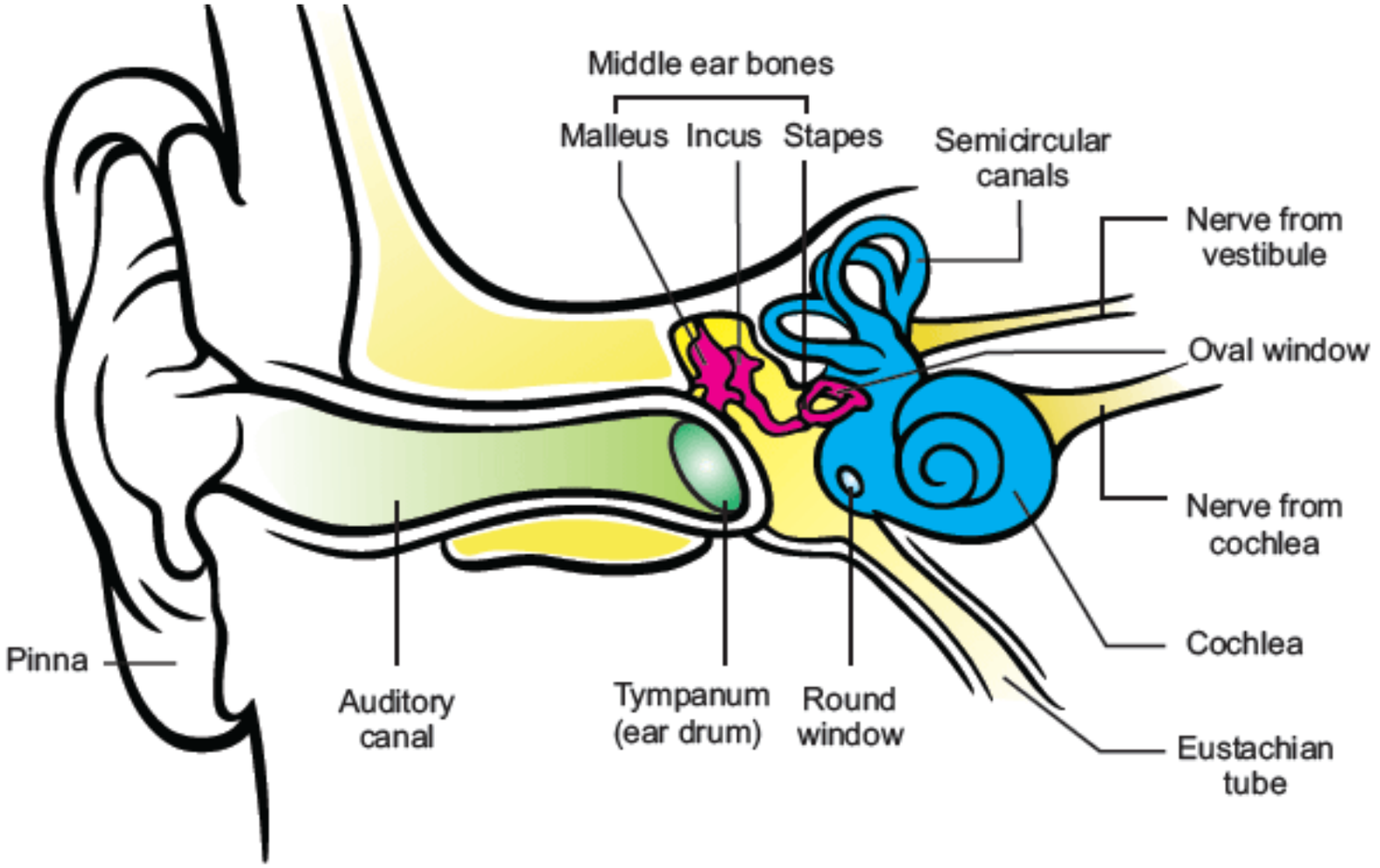


Figure 12.10: Structure of human ear

C- Inner Ear

Inner ear consists of three parts i.e. vestibule, semicircular canals and cochlea. Vestibule is present in the centre of inner ear. Three canals called semicircular canals are posterior to the vestibule. The cochlea is made of three ducts and wraps itself into a coiled tube. Sound receptor cells are present within the middle duct of cochlea.

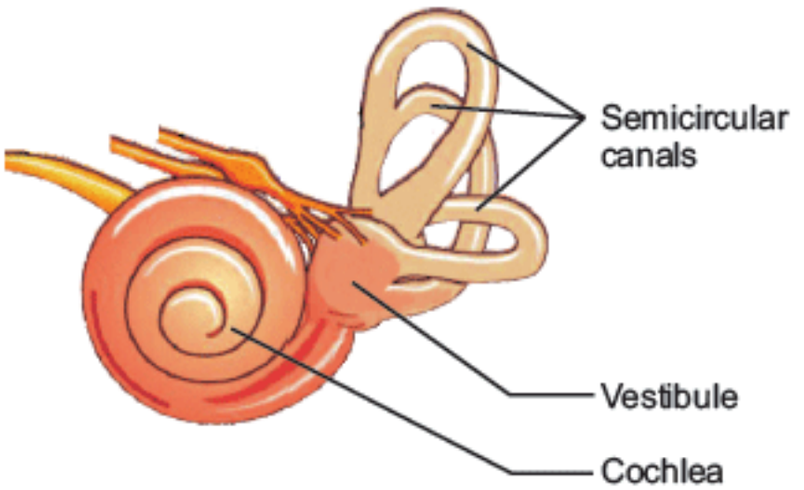


Figure 12.11: Structure of Inner ear

? To which part of ear the tympanum belongs?

External Ear

Image 12.1: Smallest bone
Source & Credit: lachicchattenoir.wordpress

Hold the fingers of your palm close to each other and place it behind the pinna. Then concentrate on a particular sound continuously having the same frequency. Remove the palm and concentrate on the same sound again.

The Process of Hearing

The pinna of the external ear focuses and directs sound waves into auditory canal. The sound waves strike ear drum and produce vibrations in it. From ear drum, the vibrations strike middle ear and produce further vibrations in malleus, incus and then stapes. From stapes, the vibrations strike the oval window and then reach the fluid-filled middle duct of cochlea. The fluid of cochlea is moved and receptor cells are stimulated. The receptor cells generate a nerve impulse, which travels to brain and is interpreted as sound.

Soundless world

Deafness is a state in which hearing is not possible. The defect of ear drum, cochlea, middle ear ossicles, or auditory nerve may cause deafness. Infection in Eustachian tube may spread to middle ear too. Ear drum may be damaged by an infection in auditory canal. Excessive noise, strong blows on cheek, pointed objects entering auditory canal and attack from insects may also affect hearing.

Ears maintain the Balance of Body

Semicircular canals and vestibule help to maintain the balance of body. Semicircular canals contain sensory nerves which can detect any movement of head. Vestibule can detect any changes in the posture of body. The neurons coming from these two receptors reach cerebellum through the auditory nerve.

A thunderstorm is characterized by the presence of lightning and a thunder. The lightning is caused by an electrical charge due to the movement of water droplets or crystals carried by the wind. The sudden increase in pressure and temperature from lightning produces rapid expansion of the air. This expansion of air produces a sound of thunder. The flash of lightening is followed after some seconds by a roar of thunder. This time difference is due to the fact that sound travels slower than light.

12.4 Endocrine System

The activities such as growth, reproduction, maintenance of glucose concentration in blood, reabsorption of water in kidneys etc. need to be regulated. Endocrine system performs this job. This system uses chemicals to "communicate" with its effectors.

These chemicals are known as hormones. A hormone is a specific messenger molecule synthesized and secreted by an endocrine gland. These glands are ductless and release their secretions (hormones) directly into bloodstream. Blood carries the hormones to target organs or tissues, upon which they act.

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

12.4.1 Important Endocrine Glands

1. Pituitary Gland

It is a pea-shaped gland attached to the hypothalamus of brain. Many hormones (trophic hormones) of pituitary gland influence the secretions of other endocrine glands. However some hormones of this gland act directly on various tissues of body. There are two lobes of pituitary gland i.e. anterior lobe and posterior lobe.

a. Anterior Lobe: It produces many hormones. One of its important hormones is somatotrophin (growth hormone). It promotes the growth of body. If the production of this hormone is diminished during growing age, the rate of growth decreases. This condition is called **dwarfism.** If this hormone is **excessively** produced during growing age, it leads to gigantism (very tall and overweight). If somatotrophin is excessively produced after growing age, internal organs and body extremities alone grow large. This condition is known as acromegaly. Such persons will have large hands, feet and jawbones.

Another important hormone secreted by the anterior lobe of pituitary gland is **thyroid-stimulating-hormone (TSH)**. It stimulates thyroid gland to secrete its hormones. The remaining hormones of anterior lobe influence reproductive organs and also control adrenal glands.

b. Posterior Lobe: The posterior lobe of pituitary gland stores and secretes two hormones i.e. oxytocin and vasopressin (antidiuretic hormone: ADH). These hormones are produced by hypothalamus (a part of brain).

Vasopressin increases the rate of reabsorption of water from nephrons. When we have low amount of water in body fluids, pituitary gland secretes vasopressin and so more reabsorption of water occurs from nephrons into blood. In this way, body retains water and less amount of urine is produced. On the other hand, when body fluids have more than normal water, there is a decline in the secretion of this hormone. If pituitary gland does not secrete this hormone in the required amount, less water is reabsorbed from nephrons and there is excessive loss of water through urine. This condition is known as **diabetes insipidus**.
The hormone, oxytocin stimulates the contraction of uterus walls in mothers for child birth. Moreover, this hormone is necessary for the ejection of milk from breast.

The stepwise process of metamorphosis in many animals is controlled by hormones. Life activities such as cell division in invertebrates are also regulated by hormones. Hormones also control activities like migration in birds. Hormones have been identified even in unicellular organisms.

2. Thyroid gland

This is the largest endocrine gland in human body. It is present in neck region, below **larynx**, and produces a hormone thyroxin. Iodine is required for the production of this hormone. If a person lacks iodine in diet, thyroid gland cannot make its hormone. In this condition, thyroid gland enlarges. This disorder is called goitre.

Have you noticed that during summer, the urine output is low? Due to increased sweating, the water level of blood is lowered. As a result, pituitary gland releases more ADH into blood.

Our government encourages salt refiners to add iodine to salt. It also encourages people to choose this iodized salt.

Thyroxin increases the break down of food (oxidation) and release of energy in body. It is also responsible for the growth of body. **Hypothyroidism** is caused by the under-production of thyroxin. It is characterized by low energy production in body and slowing down of heart-beat. **Hyperthyroidism** is caused by over-production of thyroxin. Its symptoms are increase in energy production, increased heart-beat, frequent sweating and shivering of hands.
The thyroid gland produces another hormone called calcitonin. It decreases the level of calcium ions in blood and promotes the absorption of calcium from blood into bones.

Calcitonin and parathormone complement each other and regulate the level of calcium ions in the blood.

3. Parathyroid glands

These are four glands situated on the posterior side of thyroid gland. They produce a hormone known as **parathormone**. It increases the level of calcium ions in blood.
When there is increased production of parathormone, more than normal calcium salts are absorbed from the bones and added to blood. Consequently the bones become brittle. If there is deficiency in the production of parathormone, blood calcium level falls. It leads to tetany, which affects the functioning of muscles.

Tetany is marked by sharp flexion of the wrist and ankle joints, muscle twitching, cramps and convulsions. It is due to decreased blood calcium level which makes the nerves and muscles more excitable.

4. Adrenal glands

Two adrenal glands are situated above kidneys. Each adrenal gland consists of two parts. The outer part is cortex and the inner part is medulla. Adrenal medulla secretes a hormone called **epinephrine** or **adrenaline** in response to stress. It prepares our body to overcome emergency situations. Therefore, adrenaline is also termed as 'emergency hormone'.

The adrenal cortex secretes many hormones called corticosteroids which maintain the balance of salts and water in blood.

When a person experiences fear, anger or anxiety, the rate and intensity of heartbeat increases, blood pressure increases, blood flow to the limbs increases, blood flow to the alimentary canal and skin is reduced. Such changes prepare the body to face any emergency situation.

5. Pancreas

This organ has two functions. The major part of pancreas is a ducted (exocrine) gland. This portion secretes digestive enzymes, through a duct, into the small intestine. Some portions of pancreas serve as ductless (endocrine) gland.

Activity:

Write a paper on "The changes in the body while performing an exercise like running a 100 meter race

This portion contains groups of endocrine cells referred to as **islets of Langerhans**. These islets secrete two hormones i.e. insulin and glucagon. **Glucagon** influences the liver to release glucose in blood and so the blood glucose concentration rises. **Insulin** influences the liver to take excess glucose from blood and so the blood glucose concentration falls.

The blood glucose concentration is maintained at the rate of 80 to 120 mg per 100 ml of blood.

If a person's pancreas does not make normal quantity of insulin, the blood glucose concentration rises and we say that the person has **diabetes mellitus**. Persons with diabetes have loss of body weight, weakening of muscles and tiredness. The disease can be controlled by insulin administration. Formerly, insulin extracted from animals was used for this purpose. But now human insulin produced from bacteria through genetic engineering is available.

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-diabetic
126 mg/100ml and above	Diabetic
Blood Glucose 2 hours After a 75gram Glucose Drink	
BGC	**Diagnosis**
Less than 140 mg/100ml	Normal
From 140 to 200 mg/100ml	Pre-diabetic
Over 200 mg/100ml	Diabetic

6. Gonads

Testes (Singular: testis) and ovaries are the male and female reproductive organs i.e. gonads. In addition to producing gametes, gonads also secrete hormones, called sex hormones. Testes secrete hormones e.g. **testosterone**, which is responsible for the development of male secondary sex characters such as growth of hair on face and coarseness of voice etc.

Ovaries secrete **estrogen** and **progesterone**, which are responsible for the development of female secondary characters such as the development of breast etc.

Feedback Mechanisms

Endocrine glands do not secrete their hormones at a constant rate. The rate varies with the needs of the body. Like many other functions in body, the secretion of hormones is also regulated by feedback mechanisms. Feedback mechanism means the regulation of a process by the output of the same process. Feedback mechanisms are of two types i.e. positive and negative feedbacks.

In **negative feedback**, the output of a process decreases or inhibits the process. This mechanism works to return a condition towards its normal value. For example; when the blood glucose concentration rises, pancreas secretes insulin. It decreases the blood glucose concentration. Decline in the blood glucose concentration to a normal set-point inhibits the secretion of insulin. Similarly, when blood glucose concentration drops below normal, pancreas secretes glucagon. It raises the blood glucose concentration. In this case, rise in the blood glucose concentration to a normal set-point inhibits the secretion of glucagon. In other words, the blood glucose concentration (output) controls the process i.e. the secretion of insulin and glucagon.

In **positive feedback**, the changes resulting from a process increase the rate of process. For example; suckling action of an infant stimulates the production of a hormone in mother. This hormone works for the production of milk. More suckling leads to more hormone, which in turn leads to more milk production.

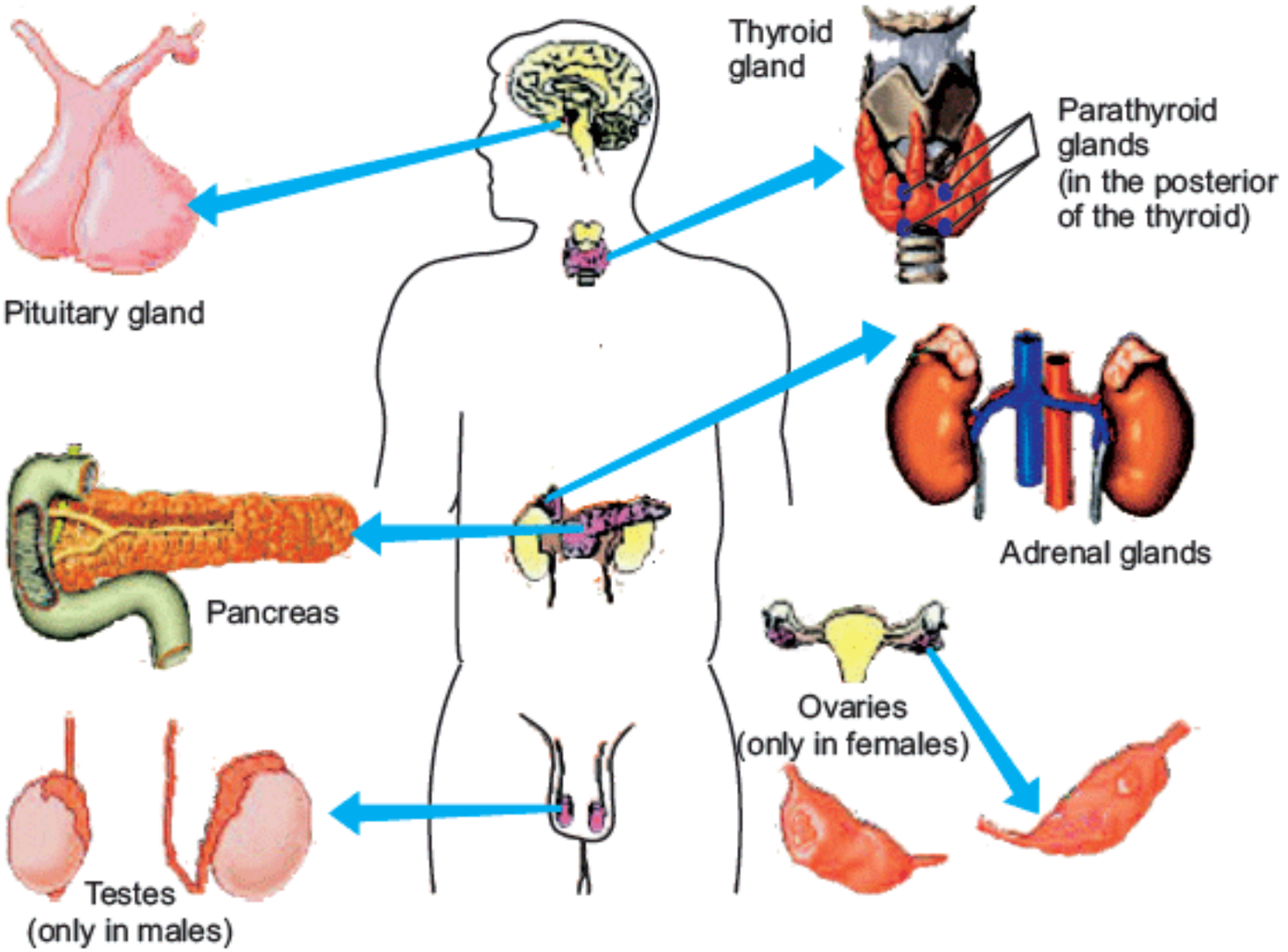


Figure 12.12: Endocrine glands in human body

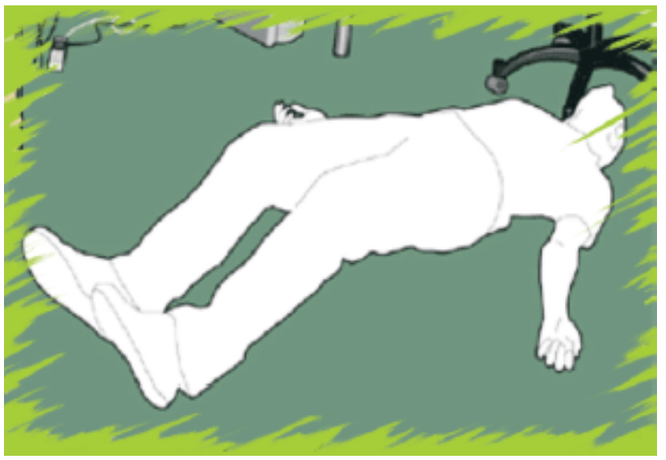
12.5 Disorders Of Nervous System

Disorders of nervous system can be categorized into two main types i.e. vascular disorders e.g. paralysis and functional disorders e.g. epilepsy. Vascular disorders are due to any disturbance in the blood supply to nervous system while functional disorders are due to disturbance in nerve impulse generation and transmission.

12.5.1 Paralysis

Paralysis is the complete loss of function by one or more muscle groups. It is most often caused by damage to the central nervous system (brain or spinal cord). The damage may be due to stroke (rupture in a blood vessel of brain or spinal cord), blood clotting in these blood vessels, or poison produced by polio viruses.

Patient may have weak paralysis throughout his / her body or have paralysis in one side of body. There may also be paralysis in the lower extremities or in all four limbs.



During a seizure attack, objects should never be placed in a patient's mouth as it can result in serious injury. It is possible that the patient will bite his/her own tongue.

12.5.2 Epilepsy

Epilepsy is a nervous disorder in which there is abnormal and excessive discharge of nerve impulses in brain. It causes unprovoked seizures in patient. A seizure of epilepsy is a temporary abnormal state of brain marked by convulsions.

In younger people, epilepsy may be due to genetic or developmental causes. In people over age 40 years, brain tumours are more likely to cause epilepsy. Head trauma and central nervous system infections may cause epilepsy at any age.

There is no known cure of epilepsy but medicines can control seizures. Patients of epilepsy have to take medicines daily for the treatment as well as prevention of seizures. These are termed "anticonvulsant" or "antiepileptic" drugs.

The knowledge of the composition and functioning of nervous system has helped man in the diagnosis and treatment of nervous disorders including paralysis and epilepsy. Man has discovered the areas of brain that receive information from different sense organs and the areas that send messages to different effectors. Such knowledge helps a lot in identifying the malfunctioning areas of brain.

UNDERSTANDING THE CONCEPT

1. Explain what can happen if there is no coordination in the activities of organisms.
2. Explain the location and function of these parts of brain; cerebrum, cerebellum, pituitary gland, thalamus, hypothalamus, medulla oblongata.
3. Define neuron and describe the structure of a general neuron.
4. Describe the structure of human eye.
5. How would you describe the structure of the external, middle and inner ear of man?
6. What are short sight and long sight problems and how these can be treated?
7. Explain the role of ear in the maintenance of balance.
8. Relate the contribution of Ibn-al-Haitham and Al-Ibn-Isa with knowledge about the structure of eye and treatment of various ophthalmic diseases.
9. Outline the major glands of the endocrine system (pituitary, thyroid, pancreas, adrenal, gonads), with name of their hormones and their functions.
10. Describe negative feedback with reference to insulin and glucagon.
11. Explain how adrenaline may be involved in exercise and emergency conditions.
12. Enlist the important symptoms and treatments of paralysis and epilepsy.

SHORT QUESTIONS

1. Identify the two types of coordination in living organisms.
2. Differentiate between the modes of nervous and chemical coordinations.
3. What are the main components of coordination?
4. Define reflex action and reflex arc.
5. Trace the path of a nerve impulse in case of a reflex action.
6. Describe the pupil reflex in dim and bright light.
7. How would you associate the role of vitamin A with vision and effects of its deficiency on retina?
8. Define the terms; hormone and endocrine system.

THE TERMS TO KNOW		
Acromegaly	Cornea	Grey matter
Antidiuretic hormone	Cranial nerve	Hormone
Aqueous humour	Dendrite	Hypermetropia
Axon	Diabetes mellitus	Hypothalamus
Calcitonin	Dwarfism	Insulin
Cell body	Ear drum	Interneuron
Cerebellum	Effector	Iodopsin
Cerebral hemisphere	Endocrine gland	Iris
Cerebrospinal fluid	Epilepsy	Islets of langerhans
Cerebrum	Epinephrine	Medulla ablongata
Choroid	Estrogen	Meninges
Cochlea	Eustachian tube	Mixed nerve
Colour blindness	Exocrine gland	Motor nerve
Cones	Ganglion	Myelin sheath
Myopia	Progesterone	Somatotrophin
Nerve	Pupil	Spinal nerve
Nerve impulse	Receptor	Suspensory ligament
Neuron	Reflex arc	Testosterone
Nodes of Ranvier	Retina	Thalamus
Optic disc	Retinine	Thyroid
Oxytocin	Rhodopsin	Thyroid-stimulating hormone
Paralysis	Rods	Thyroxin
Parathormone	Schwann cells	Tympanum
Parathyroid	Sclera	Vasopressin
Pituitary	Semicircular canals	Vestiblue
Pons	Sensory nerve	Vitreous humour

INITIATING AND PLANNING

1. Analyze why plants (like sunflower) have a very slow response to stimuli.
2. Visualize 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 with the hormonal transmission in blood.
3. Compare the BGC (blood glucose concentration) of 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 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 shortsightedness.
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.

SCIENCE, TECHNOLOGY AND SOCIETY

1. Explain the way nervous system helps to coordinate complex and intricate movements of hand to play a piano, or write alphabets.
2. Analyze the way this knowledge has helped humans to train dogs and domesticated animals to perform specific tasks.
3. Explain the reason for salivation of mouth when a favourite food item is imagined.
4. Justify the time difference between seeing the flash of lightening and hearing the roar of a thunderstorm.
5. Explain why and how eyes are important to survival in wild animals.
6. Explain how colour blindness could be a hurdle for aircraft pilots.
7. Conceptualize how scientific advancement has helped to solve the problem of diabetes.
8. Write a paper on the changes in body while performing an exercise like running a 100m sprint race.
9. Relate how the knowledge of nervous system has helped humans to treat diseases like epilepsy, paralysis.

ON-LINE LEARNING

1. www.biology-online.org/8/1_nervous_system.htm
2. www.tutorvista.com/.../biology-nervous-system
3. www.educypedia.be/education/nervoussystem.htm
4. www.animate4.com/neuron-animation.htm
5. en.wikipedia.org/wiki/Neuron