INSTITUTE OF ADULT EDUCATION

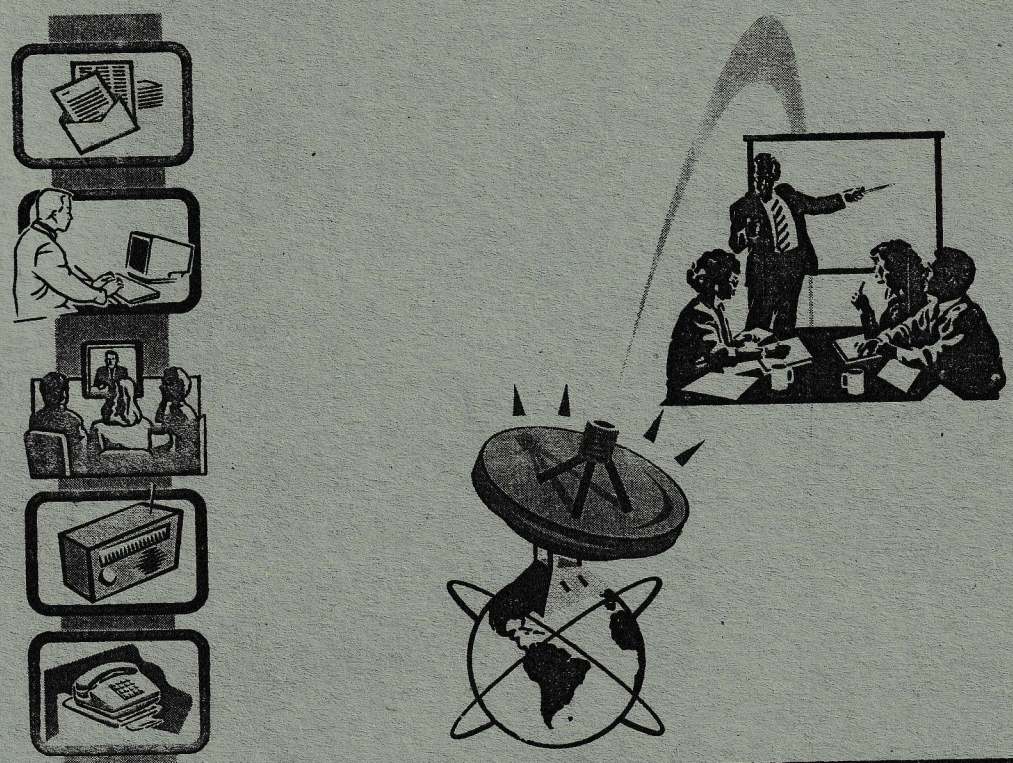
OPEN AND DISTANCE LEARNING

BIOLOGY

TEWW B_2

MODULE 6

Movement, Coordination and Regulation



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MODULE 6
Movement, Coordination and Regulation

Unit 6.1: Movement
Unit 6.2: Coordination
Unit 6.3: Regulation

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MODULE 6
Movement, Coordination and Regulation

Unit 6.1: Movement
Unit 6.2: Coordination
Unit 6.3: Regulation

CONTENTS

6.0.1 INTRODUCTION

This module has three units. In unit one, you will learn about the movement in animals and plants. In animals, we shall see how muscles of human beings bring about movement and also the way plants move.

In unit two, we shall discuss the coordination in organisms particularly human beings and plants. In human beings we shall look at coordination through nervous system, sense organs and endocrine system.

In unit three, you will learn ways in which organisms maintain their internal body conditions at constant level such as temperature, water, glucose, protein, mineral salts and other internal body conditions. You will also learn about the excretion as the process of removing waste products from the body.

6.0.2 OBJECTIVES

At the end of the module you should be able to:

- Explain the meaning and importance of coordination.
- Discuss the role of motor, sensory and relay neurons and their adaptations.
- Describe the structure and functions of the parts of the central Nervous system.
- Explain the meaning of peripheral Nervous system.
- Draw a spinal cord and show pathway of reflex action.
- Distinguish between simple and conditional reflex.
- Explain the meaning of sense organs and stimuli for each.
- Identify and describe the functions of the parts of sense organs and explain how each organ works.
- Explain the meaning of drug and drug abuse and name the types.
- Identify endocrine glands and their locations.
- Describe the hormones secreted by each endocrine gland and their roles.
- List and define types of tropic movement and their stimuli.
- Explain the effects and significance of light, water, gravity and chemicals on direction of plant growth.
- Explain the meaning and importance of excretion.
- Name the excretory organs and their products.
- Describe the structure of human urinary system and its role.
- Explain the process of urine formation.
- Explain the cause, symptoms, and effects of complications of urinary system such as kidney failure and their effects.
- Mention types of waste products.
- Eliminate plants and their importance.
- Describe the mechanisms of sugar, salt, and water balance in the human body.
- Outline the effects of high and low blood sugar level in the body.

UNIT: 6.1
MOVEMENT

CONTENTS

6.1.0.1 INTRODUCTION

Dear learner, I think you are now set for module 6 of Biology stage II. I believe you will complete this stage successfully and attempt the National Form Four Examination.

These questions and many others that you have come across concerning how organisms manage to change positions will be answered in this unit. You will learn about muscles, skeleton (bones) and how they relate to accomplish the task of movement.

I wish you all the best, in studying this unit. I am sure you will enjoy it very much.

Biology is a wonderful subject isn't it?

6.1.0.2 OBJECTIVES

At the end of this unit, you should be able to:

- Explain the meaning and importance of movement in organism.
- Outline the differences between movement and locomotion.
- Describe the structure of the human skeleton system and its function.
- Identify different types of joints in the human skeleton and their roles.
- Mention different types of muscles, their functions and adaptive features.
- Differentiate smooth, skeletal and cardiac muscles.

6.1.0 MOVEMENTS

We saw in module one unit one, that movement is one of the characteristics of living things. That is all living things have the ability to move from place to place. The movement can involve the whole body or part of the body as we shall see later.

In this unit, you are going to learn about the movement in general, the human skeleton system, joints, type of muscles and how muscles cause movement. Below are more details about this unit.

6.1.1 GENERAL CONCEPT OF MOVEMENT IN ORGANISMS AND ITS IMPORTANCE

Movement is one of the characteristics of living things. Movement enables organisms to search for their requirements, for example food, water and mates. Man exhibits certain kind of movement when communicating e.g. lips go up and down when talking.

There are two types of movements:

Locomotion
This is the type of movement where the whole organism moves from one place to another.

Example: A lion exhibits locomotion when chasing an antelope or when one goes to work somewhere.

Movement
This is the changing in position of part of an organism i.e. movement of curvature as shown by parts of plants. They change towards the direction of stimuli. Animals exhibit movement to some extent. For example when eating, the hand is raised while the body remains stationary. Movement and locomotion involve coordination between the nervous system, muscles and skeletal system.

6.1.2 MOVEMENT OF THE HUMAN BODY

Movement of the human body depends on the skeleton.

Skeletal system
The skeletal system gives support to an organism.

Skeleton
There are two types of skeleton in animals:

i) **Exoskeleton**
This is skeleton found outside the body of an animal. Example; arthropods such as spiders, crustaceans, insects, and crabs.

ii) **Endoskeleton**
This is type of skeleton found inside the body of vertebrates e.g. man, cow, fish, frog, lizard. The human Skeleton is composed of a special **connective tissue** (tissue that joins other tissues together) called **bone**. Bones and their associated tissues, cartilage, tendons, and ligaments make up **the skeleton system**. The human skeleton system consists of 206 bones; or the skeleton system consists of bones and other structures that make up the joints of the skeleton. Fig. 6.1.1 shows the human skeleton system.

The types of tissues present are *bone tissue, cartilage, and fibrous connective tissue*, which form the ligaments that connect bone to bone.

The adult human body consists of approximately 206 bones, which are organized into an internal framework called the **skeleton**. The human skeleton is found inside the body. Biologists call it an endoskeleton. The variation in size and shape among the bones that make up the skeleton reflects their different roles in the body. Other groups of animals with endoskeletons are; fish, amphibian, reptiles and birds.

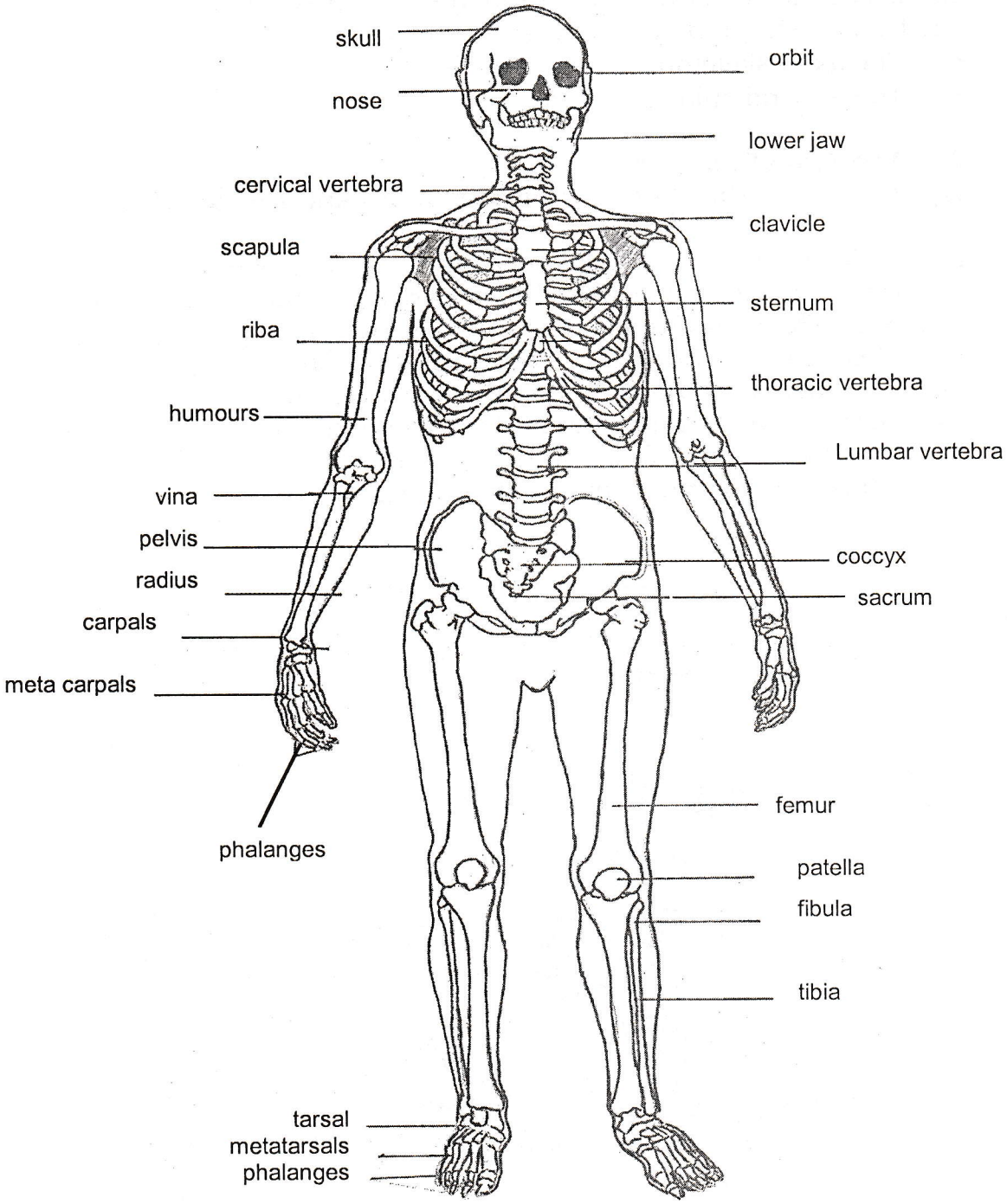


Figure 6.1.1: The human skeleton

Structure of the human skeleton system and its function

Let us see the structure of the human skeleton system

The human skeleton system has two parts.

- The axial skeleton.
- The appendicular skeleton.

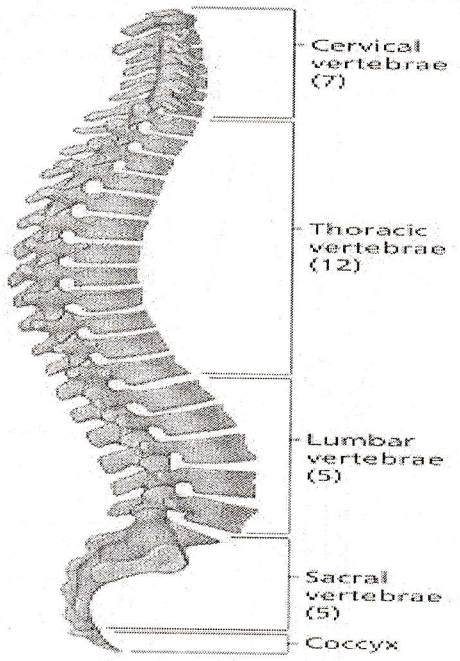
i) The Axial Skeleton

This consists of the **skull, vertebral column and the rib cage.**

The skull consists of 8 cranial bones and 13 facial bones.

The vertebral column consists of a series of small bones called vertebrae. There are five main groups of vertebrae, namely,

- Cervical vertebrae found in the neck region.
- Thoracic vertebrae found in the chest region.
- Lumbar vertebrae found in the abdominal region.
- Sacral vertebrae found in the tail region.
- Caudal vertebrae found in the tail region.



(b) HUMAN SPINE

Figure 6.1.2: Vertebral column of man

The rib cage consists of the pairs of ribs and the sternum (breast bone). The sternum provides surfaces for attachment of ribs.

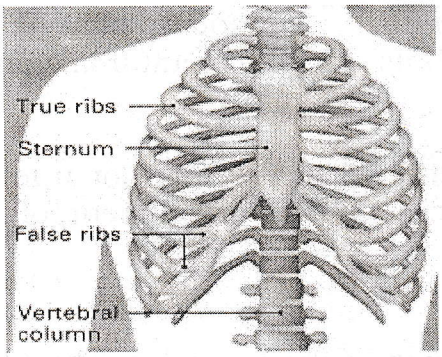


Figure 6.1.3: Ribs and sternum

ii) The Appendicular Skeleton

This consists of the bones of the arms and legs, shoulder and the pelvic girdle. Therefore, the limbs, limb girdles and pelvic girdle constitute the appendicular skeleton.

The fore-limb

In mammals, the fore-limb is made up of the humerus, radius and ulna, carpals, metacarpals and phalanges.

Humerus

This is a long bone in the upper arm. It supports the upper arm.

Radius and Ulna

These are the long bones of the lower arm. The ulna is slightly longer than radius. The radius starts from the elbow to the small finger.

Carpals

These are nine small bones in the wrist which articulate with the radius and ulna at the upper and the metacarpals at the lower end.

Metacarpals

These are five slightly elongated bones which are found in the palm. Each of them articulates with a phalange of finger bone.

Phalanges

These are bones which are found in the fingers.

The hind limb

The hind limbs of mammals are made up of several bones, namely; the femur, tibia and fibula, tarsals, metatarsals and phalanges.

Femur

This is a long bone situated in the thigh or upper leg region. The femur provides surfaces for the attachment of leg muscles and supports the thigh.

Tibia and Fibula

These are the long bones of the lower leg. The tibia is a very long bone (longer than fibula).

Tarsals

These are six small bones in the ankle.

Metatarsals

These are elongated bones in the foot. There are five in humans and in most other mammals.

Phalanges

These are the bones which are found in the toes of the hind limb.

Limb Girdles

The fore limb and hind limbs are joined at their upper ends to a girdle of bones. This forms a framework for support. The fore-limbs are joined to the **pectoral girdle,** while the hind limbs are joined to the **pelvic girdle.**

Pectoral Girdle

This consists of a scapula (shoulder blade), coracoids and clavicle (collar bone).

Pelvic Girdle

This is made up of several bones which are fused together for greater strength. The pelvic girdle forms a protective cage around vital organs such as the female reproductive organs.

Functions of the skeleton system

The bones that make up the skeleton system serve six important functions:

i) Provide a framework that supports the body and the muscles that are attached to the bones.

ii) Protect some internal organs from mechanical injury; example the rib cage protects the heart and lungs: skull bones protect the brain and eyes.

iii) Manufacture blood cells, Hematopoiesis (Blood-forming) bone tissues produce Red Blood Cells or (Erythrocytes) and White Blood Cells (Leukocytes).

iv) Provide a storage site of inorganic salts, such as calcium and phosphorous. Calcium may be removed from bone to maintain a normal blood calcium level, which is essentially for blood clotting and proper functioning of the muscles and nerves.

v) Bones also provide a system of levers (rigid rods that can be moved about a fixed point) on which a group of specialized tissues (muscles) act to produce motion.

vi) Facilitate breathing mechanism.

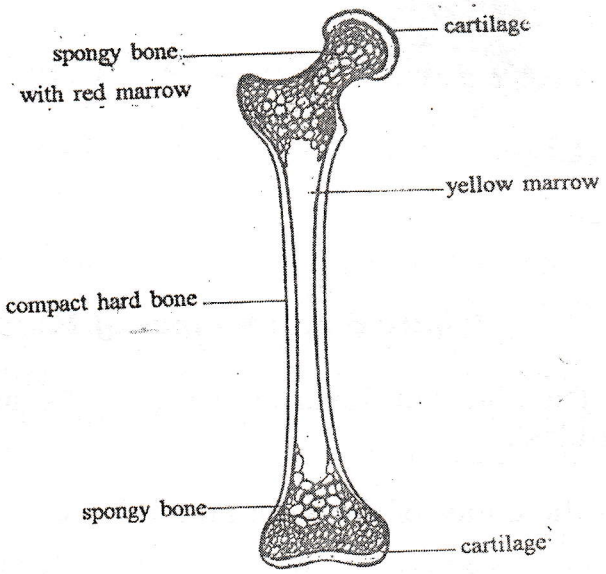


Figure 6.1.4 Structure of a long bone

Composition of a bone

Bone is a hard, tough connective tissue composed mainly of calcified material. Bones are very strong for their weight, owing to their hallow shaft and the network of spongy bone at each end. Mammalian bones are made up of an layer of bone and a hollow inner part containing bone marrow. The internal structure of a bone consists of an organic matrix in which calcium salts, mainly calcium phosphate are deposited. These salts give bones their

strength. The matrix and salts are secreted by star shaped cells called *osteocytes.*

Classification of bones

Bones can be classified as one of four types based on their shapes:

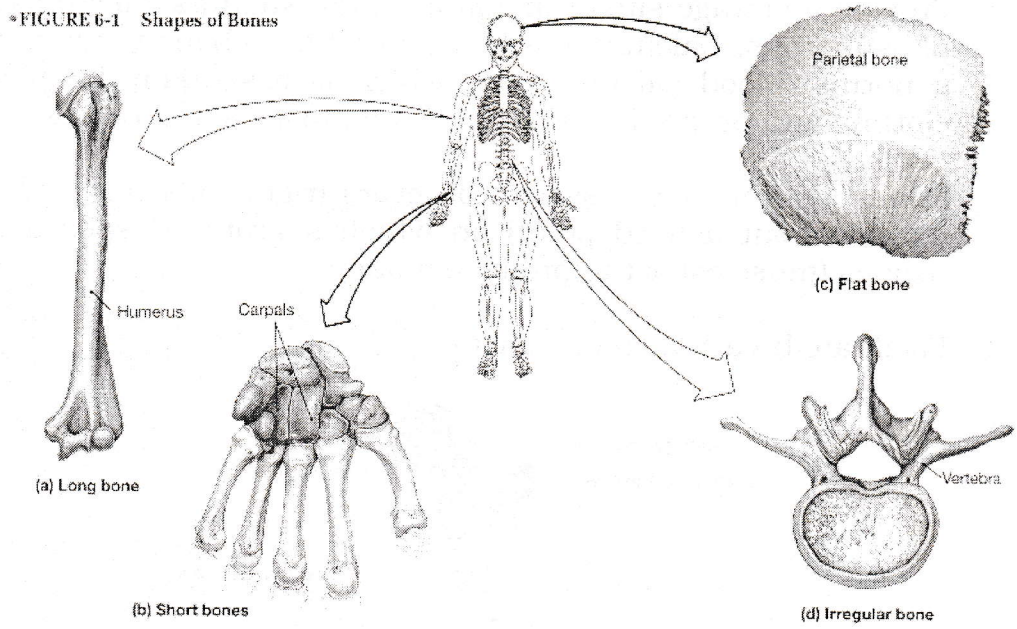


Figure 6.1.5: Shapes of Bones

Long bones - The bones of the arms, legs, hands, and feet (but not the wrist or ankles).

Short bones - the bones of the wrist and ankles.

Flat bones - the ribs, shoulder blades, hipbones, and cranial bones.

Irregular bones - the vertebrae and facial bones.

Short, flat and irregular bones are all made of spongy bone covered with a thin layer of compact bone. Red bone marrow is found within the spongy bone.

JOINTS

Joints, are places where two or more bones come together, permit them to move without damaging each other.

Joints are responsible for keeping bones far enough so that they do not rub against each other as they move. At the same time, joints hold the bones in place.

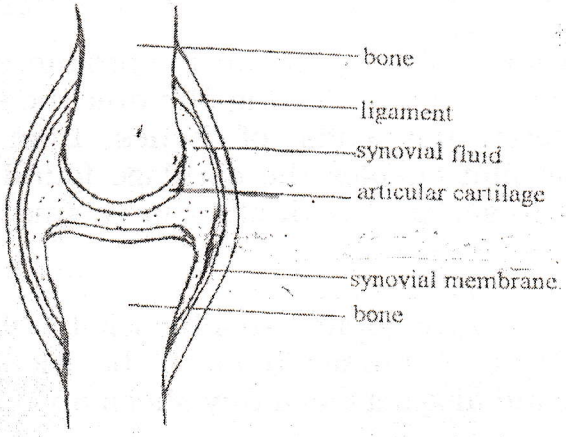


Figure 6.1.6: Section through a joint

The classification of joints is based on the amount of movement possible:

- **Immovable joints**; they are often called **fixed joints**, and allow no movement between bones. These joints are interlocked and held together by connective tissue, or they are fused together. The places where the bones of the skull meet are called Satures and pelvic girdle are examples of immovable joints. These joints give support and protect delicate structures.

- **Slightly movable joints**. (**Semi movable joints**). These joints permit a small amount of movement. These bones are separated by a pad of cartilage. They make the body to be flexible.

- **Freely movable joints**
  Most of the joints of the body are freely movable. In Freely Movable Joints, the ends of the bones are covered with a layer of cartilage that provides a smooth surface at the joint and prevents friction.

The joints are also surrounded by a fibrous joint capsule that helps hold the bones together and at the same time allows movement.

The joint capsule consists of two layers

(a) One of the layers of the joint capsule may thicken to form strips of tough connective tissue called **ligaments**. Ligaments are attached to the membranes that surround bones and hold bones together in place.

(b) The outer layer of the joint capsule produces **synovial fluid**, which forms a thin lubricating film over the surface of a joint and protects the ends of bones from friction. This lubricating film enables the cartilage found on the ends of the bones to slip past each other more smoothly as the joint moves.

In some freely movable joints, small pockets of **synovial fluid** called **bursae** form. A bursae reduces the friction between the bones of a joint and also acts as a tiny shock absorber.

Types of freely movable joints

Freely movable joints are grouped according to the shapes of surfaces of the adjacent bones. There are six types of freely movable joints:

a) **Ball and socket joint** - Permits circular movement - the widest range of movement. the shoulder and hips joint, which enable to move your arm and leg up, down, forward and backward, as well as to rotate it in a complete circle i.e. allows movement in all directions.

b) **Hinge joint** - Permits a back-and-forth motion. The Knee enables your leg to flex and extend. The Elbow, which allows you to move your forearm forward and backward (allows movement in only one direction. Hinge joints are also found in fingers and toes.

c) **Pivot joint** - Permits rotation of one bone around another. It also allows you to turn your head from side to side. For example, joint found between the axis and atlas vertebrae are pivot-joints.

d) **Gliding joint** - Permits a sliding motion of one bone over another. Found at the ends of the collarbones (clavicles), between wrist bones, and between anklebones.

e) **Saddle joint** - Permits movement in two planes. This type of joint is found at the base of the thumb.

f) **Ellipsoid joint** - Allows for a hinge type of movement in two directions. The joints that connect fingers with the palm and toes with the soles of feet are examples.

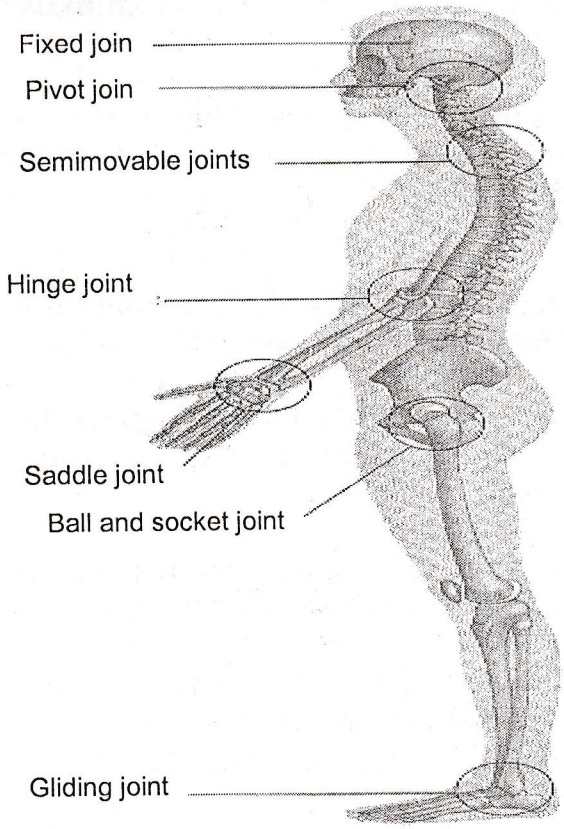


Figure 6.1.7: Location of joints

ACTIVITY: 6.1.1

Collect clay soil and make models of hinge joint of the elbow and ball and socket joint found between the upper and the pectoral girdle.

What are the differences between your models and the actual joints?

6.1.3 MUSCLES AND MOVEMENT

We have seen that the skeleton is made up of a number of bones. Some bones are flat like skull bones some are short like vertebral while others are long like human. We have seen that when these bones join they form a joint. Ligaments keep the bones in their position. From the function of skeleton we know that the major function is movement. How does movement occur or what brings about movement. Probably through contractile tissues known as muscles.

Muscles make up the bulky of the body in animals and account for $^1/_3$ of its weight.

Their ability to contract enables the body to move and provide force that pushes substances such as blood and food through the body. As such, the functioning of other organs is associated with the muscles.

The nervous system coordinates the contraction of these muscles so as to produce movement and locomotion in the organisms.

The muscle tissue is found every where within the body, e.g. deep beneath the skin, over the skeleton, make the organs like the heart and alimentary canal.

The size and location of the muscle tissue help to determine shapes of the animals and the way of moving.

There are three (3) types of muscles (muscle tissues), namely;

- Skeletal/striated/voluntary muscles.
- Smooth/unstriated/involuntary muscles
- Cardiac muscles.

Skeletal muscles

These are muscles found attached to the skeleton (bones) hence the name skeletal muscles

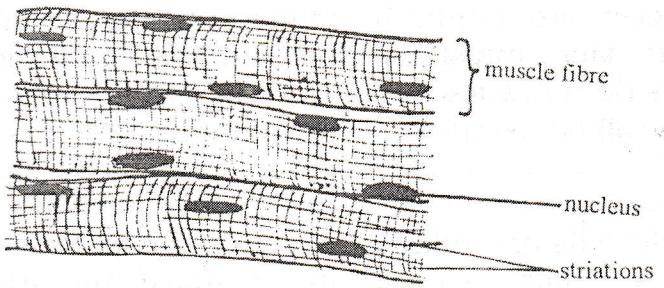


Figure 6.1.8: Structure of skeletal muscles

They work under the will of the animal, (they work every time we make a move or conscious movement) and therefore, are also called voluntary muscles, the working of these muscles is coordinated by the nervous system.

Skeletal muscles are made of slender, elongated or sized and multinucleated cells. They have long muscle fibres. The fibres are grouped into dense bundles called fascicles by a connective tissues. Several fascicles are bound together by connective tissue to form the muscles. Muscles are connected to the bone by **tendons**. When viewed under a microscope, skeletal muscles appear to have striations (bands or tripes), hence the name striated muscles.

Skeletal muscles are able to contract because of the following reasons:

- The muscle fibres are slender, elongated, large and can contract (are highly specialized for contract i.e. are contractile).
- They have numerous mitochondria which provide the cells with energy for them to contract.
- Their attachment to skeleton enables the skeleton to be moved.

ACTIVITY: 6.1.2

1. Stretch out your arm to the right. Explain how this motion was achieved.
2. Compare muscle strength in left and right hands.
   (b) Which hand is much stronger than the other?
   (c) Explain why one is stronger than the other.

Smooth muscles

Smooth muscles are found in many internal organs such as esophagus, stomach, intestines and in the walls of blood vessels. These muscles do not work under the will of the animal (not under voluntary control) hence the name involuntary muscles.

Structure

Smooth muscle cells are spindle shaped and each cell has a single mucleus. These cells lack striations (have no striation) and therefore are unstriated cells. The cells interlace to form sheets of smooth muscle tissue. The smooth muscle cells are surrounded by connective tissue but do not form tendons.

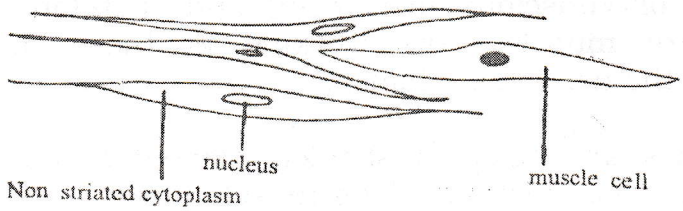


Figure 6.1.9 Structure of smooth / involuntary muscle cells

Contractions of smooth muscles move food substances through the alimentary canal (digestive tract), control the way blood flows through the circulatory system and increase the size of the pupils of the eyes in bright light. Smooth muscles are able to perform these functions because they are contractile, and have mitochondria for energy provision.

Cardiac muscles

These are muscles found only in the heart. Cardiac muscle cells are striated and each cell contains only one nucleus located near the centre. Adjacent cells form branching fibres that allow nerve impulses to pass from cell to cell.

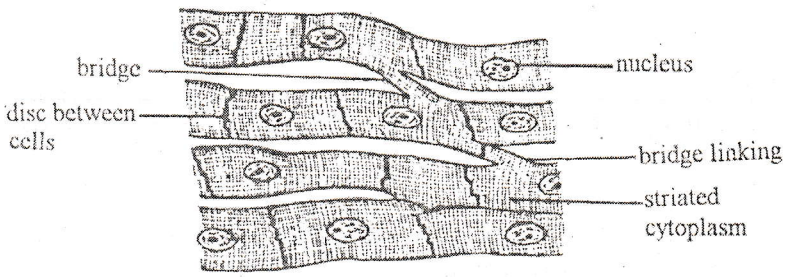


Figure 6.1.10: Structure of the cardiac muscle

Cardiac muscles contract without direct stimulation by the nervous system. These are bundles of specialized muscle cell in the upper part of the heart which send electrical signal through cardiac fibres, fibres (cells), causing the heart to rhythmically contract and pump blood through the body. The muscular heart of contractile cells (fibres) and a lot of mitochondria enable the heart to pump blood to the whole body.

Table 6.1.1 Comparison of muscles

Feature	Voluntary muscle	Involuntary muscle	Cardiac muscle
Other names	Striated, striped, skeletal	Unstriated, unstriped smooth	Heart
Specialization	Most highly specialized	Least specialized	More specialized than involuntary
structure	Very long cells called fibres. Fibres are bound together by vascular connective tissue.	Consist of individual shaped cells associated in bundles or sheets.	Cells terminally branched and connected to each other by intercalated discs. Fibres arranged in three – dimension
Nucleus	Several in variable position near periphery of fibre	Single, elongated and centrally placed.	Several, centrally placed.
Innervations	Under control of the voluntary nervous system via motor nerves from the brain and spinal cord (Neurogenic)	Under control of autonomic neurons system (neurogenic)	Myogenic, but rate of contraction can be influenced by the autonomic nervous system.
Cross striations	Present	absent	Present
Intercalated discs	Absent	Absent	Present
activity	Powerful, rapid contractions therefore fatigue quickly	Shows rhythmical contraction and relaxation, as in peristalsis	Rapid rhythmical contraction and relaxation does not fatigue.
location	Attached to the skeleton in the trunk, limbs and head	In walls of intestine, genital urinary and respiratory tracts and the walls of blood vessels.	Found only in the walls of the heart chambers.

From the above table, you can now be able to identify the similarities and differences between voluntary, involuntary and cardiac muscles.

How muscles cause movement

As we have explained in the above, muscles make up the bulky of the body in animals and their ability to contract enables the body to move. If you take as an example, the arm (fore – limb) the man has ability to bend and straighten his/her arm. Can you tell us what cause this movement i.e. bending and straightening of the arm? For more details let us continue with the discussion below:

A muscle is attached at both ends to bones by *tendons*. A tendon is a strong inelastic fibre made of connective tissues.

The point where a muscle is attached to a stationary bone is known as the *origin* and the point of attachment to the bone which moves is known as the *insertion*.

The muscles which cause movement of the body are called voluntary or skeletal muscles. A muscle which causes the bending of the limbs so that their bones come closer is called a **Flexor muscle** and the movement is known as Flexion. Another set of muscles which cause the bones to move apart and hence strengthen out the limb are termed **Extensor muscles**, and the movement is known as Extension. Usually extensor and flexor muscles work in pairs and in an opposing manner. Such muscles are termed **antagonistic muscles**, are those of the human arm, the **biceps** and **triceps**. For example, the relaxation of the biceps and the contraction of the triceps straighten the arm. The contraction of the biceps and the relaxation of the triceps bring about the bending of the arm.

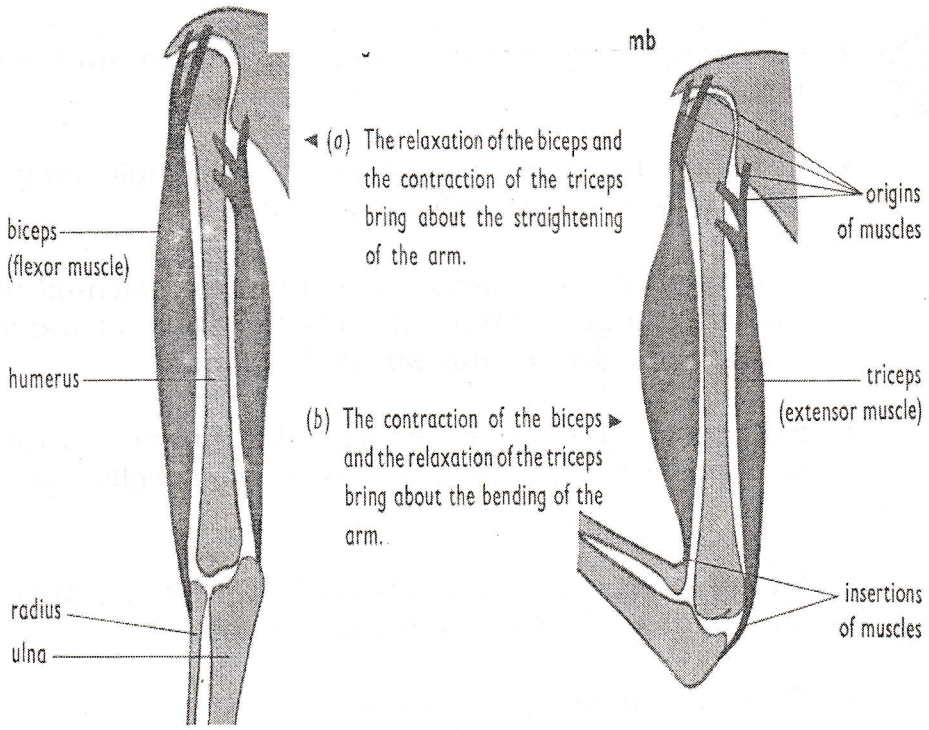


Figure 6.1.11: Movement of fore limb

The figure above shows how two important muscles of the upper arm, biceps and triceps muscles bring about the bending and straightening of the limb. When the triceps muscle (the extensor) contracts, the limb is straightened. The contraction of the triceps is accompanied by the relaxation of the biceps (the flexor). When the latter contracts, the arm bends simultaneously, triceps relax.

6.1.4 SUMMARY OF THE UNIT

- Movement enables organisms to search and obtain their needs.

- Locomotion is the movement of the whole body from one place to another (mainly by animals).

- Movement is the change of position e.g. turning the head to the left or right or roots moving to source of water or leaves turning to light, (mainly shown by plants).

- Skeleton is a structure which offer support to the body. It also protects and manufactures some cells e.g. red blood cells.

- Muscles are contractile tissues in the body. Muscles bones and joints enable movement to take place.

- There are three types of muscles,
  - Smooth muscles (of tubes e.g. intestines and esophagus)
  - Skeletal muscles (special for movement)
  - Cardiac muscles (muscles of the heart)

Before proceeding further, do the following exercise

6.1.5 SELF CHECK EXERCISE

1. (a) What is the importance of movement/locomotion?

   .....
   .....
   .....
   .....

   (b) What are the differences between locomotion and movement?

   .....
   .....
   .....
   .....

2. (a) What is the difference between endoskeleton and exoskeleton?

   .....
   .....
   .....
   .....

   (b) Give functions of the human skeleton.

   .....
   .....
   .....
   .....

3. (a) What is a muscle?

   .....
   .....

   (b) Name muscles that contribute to movement of food along digestive tract.

   .....
   .....

4. What is a joint?

   .....
   .....

Check your answers against those given at the end of this unit.

6.1.6 TUTOR MARKED ASSIGNMENT

1. Differentiate between
   (a) Movement and locomotion
   (b) Endoskeleton and exoskeleton
   (c) Hinge joint and pivot joint
   (d) Tendons and ligaments
   (e) Smooth muscle and skeletal muscle
   (f) Flexor muscle and extensor muscle
   (g) Humerus and femur
   (h) Synovial fluid and hydroskeleton
   (i) Axial skeleton and appendicular skeleton
   (j) Bone and cartilage.

[30 Marks]

2. (a) What is the importance of bone marrow? Differentiate between ossification and classification.

   (b) State at least four functions of the human skeleton.

[20 Marks]

3. With a diagram and short notes explain how muscles bring about movement. **[25 Marks]**

4. Explain how the following movements are brought about:
   (a) Movement of food in the digestive tract
   (b) Bending of the leg
   (c) Pushing blood in the heart
   (d) Blood flow in veins. **[25 Marks]**

6.1.7 KEY ANSWERS TO THE SELF CHECK EXERCISE

1. (a) Movement/locomotion enables organisms to search for their needs e.g. roots move to search for water and mineral salt. Or migration of animals during draught to search for new pastures and water.

   (b) Locomotion: movement of the whole body from one place to another e.g. human, while movement is change of position especially in plants e.g. leaves turn towards light.

2. (a) Exoskeleton is skeleton found outside the body. It covers the flesh e.g. in arthropods.
   An endoskeleton is found in the inside of the body. It has been covered with flesh.

   (b) Functions of the human skeleton
   - Protects delicate structures.
   - Helps in movement.
   - Manufactures red blood cells and white blood cells.
   - Stores minerals e.g. calcium.
   - Supports the body or gives the framework of the body.

3. (a) A structure made up of contractile tissues which can contract and relax.

   (b) Longitudinal and circular muscles, smooth muscles.

4. A joint is a place where two or more bones meet.

UNIT 6:2
COORDINATION

CONTENTS

6.2.0.1 INTRODUCTION

Let us imagine that you are walking back home and suddenly you see a snake crawling towards you. What steps would you take to get out of the danger?

Suppose you were cooking and accidentally you touched a glowing wood/charcoal how did you react? Suppose one of your organs (e.g. liver/kidney) is affected and not working properly. Can that also affect the functions of other organs?

This unit will tell you how your body reacts to changes in external and internal environments. It will also tell you how plants react to changes in their environment. In addition, it will enable you to know how the linking together of the functions of different organs helps the body work in orderly manner. It's my hope that you will be interested to know, for example why you smile or become angry when some one looks at you. For more details welcome to the lesson and we hope you will enjoy studying it.

6.2.0.2 OBJECTIVES

At the end of this unit you should be able to:

- Explain the meaning and importance of coordination.
- Explain the role and structure of motor, sensory and relay neurons.
- Explain adaptations of each neuron to its role.
- Describe the structure and functions of the parts of the central nervous system.
- Explain the meaning of peripheral nervous system and list its components.
- Draw a spinal cord and show pathway of reflex action.
- Distinguish between simple and conditioned reflexes.
- Explain the meaning of sense organs and stimuli for each.
- Identify and describe the functions of the parts of sense organs that is skin, tongue, nose, eye and ear.
- Explain how each sense organ works.
- Explain the meaning of drug and drug abuse and name the types.
- Identify endocrine glands and their locations.
- Describe the hormones secreted by each endocrine gland and their roles.
- List and define types of tropic movements and their stimuli.
- Explain the effects and significance of light, water, gravity and chemicals on direction of plant growth.

6.2.0 NERVOUS COORDINATION IN ANIMALS

In the previous unit we learnt about the movement. We looked at the human skeletal system, joints and types of muscles. We also described the way muscles bring movement. Let us now look at another unit called coordination. In this unit we shall see the nervous coordination in animals, sense organs, Hormonal coordination in animals (Endocrine system), drug and drug abuse and finally we shall discuss the coordination in plants. Let us now begin our discussions.

6.2.1 GENERAL CONCEPT OF COORDINATION

Human body is made up of millions of cells. Most (if not all) specialize to perform a certain function. For example a cell specializes to become a reproductive cell. In order to perform its function it needs food, means of transport etc. Its production is impossible if it works alone. Muscles, brain, eyes and many other organs of the body are involved. Therefore in order for the body to function as a single unit, nerves (special cells) carry information from different parts of the body concerned to that activity. These are internally worked out by the brain to bring effective action.

Nervous coordination is important in linking body activities. In this topic you are going to learn how this linking takes place. Therefore coordination is the linking together of body activities. Without coordination body activities become disorderly and thus, the body may fail to function properly.

In animals there are two systems involved in co-ordination. These are:

- The nervous system
- Endocrine system.

6.2.2 THE NERVOUS SYSTEM

This is a system which controls the body's response to external and internal stimuli by sending impulses along nerves rapidly bringing about actions from the muscles or glands. The nervous system is composed of nerve cells or neurones.

(i) Nervous Pathway

Nervous pathway involves five major components;

- Stimulus
- Receptor
- Coordinator
- Effectors
- Response

Stimulus

Is anything internal or external which when applied on the body brings a change in the external or internal environment of the body e.g. light, heat, touch, pain, smell and sound.

Receptor

Is a structure which detects the change in the environment, examples; eye, skin, ear, nose, and tongue.

Co-coordinator

Organ which receives message (impulse) from receptors and coordinates activities in the body. Brain and spinal cord are coordinators.

Effectors

Is an organ controlled by the brain or spinal cord to bring about correct responses. Muscles and glands are the main effectors.

Response

Is a body activity provoked by stimulus e.g. salivating when smelling or seeing food.

(ii) Nerve cells (Neurones)

Humans have three types of neurons (nerve cells) namely;

Sensory neurones (Afferent neurones)
They have long axons and transmit nerve impulses from sensory receptors all over the body to the central nervous system (brain or spinal cord).

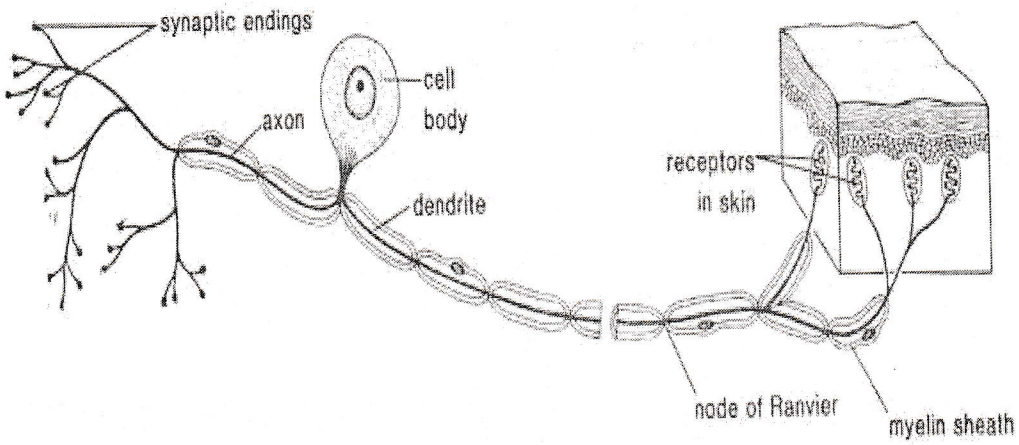


Figure 6.2.1: Sensory neurone

Motor neurones (Efferent neurones)
They also have long axons and transmit nerve impulses from the central nervous system to effectors (muscles and glands).

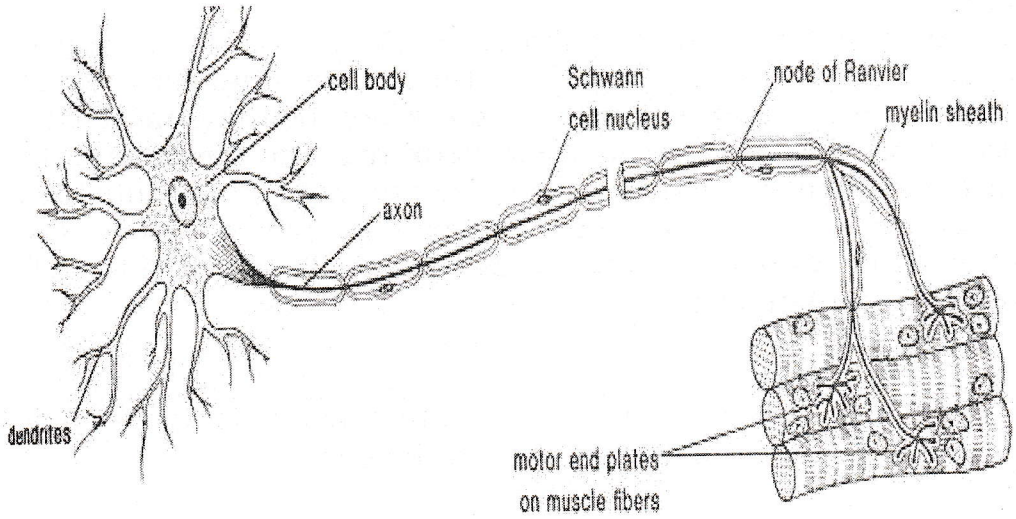


Figure 6.2.2: Motor neurone

Interneurones (Relay neurones)
They also called intermediate neurones. They are usually much smaller cells, with many interconnections which connect sensory neurone and motor neurone i.e. they relay message from sensory neurone to motor neurone.

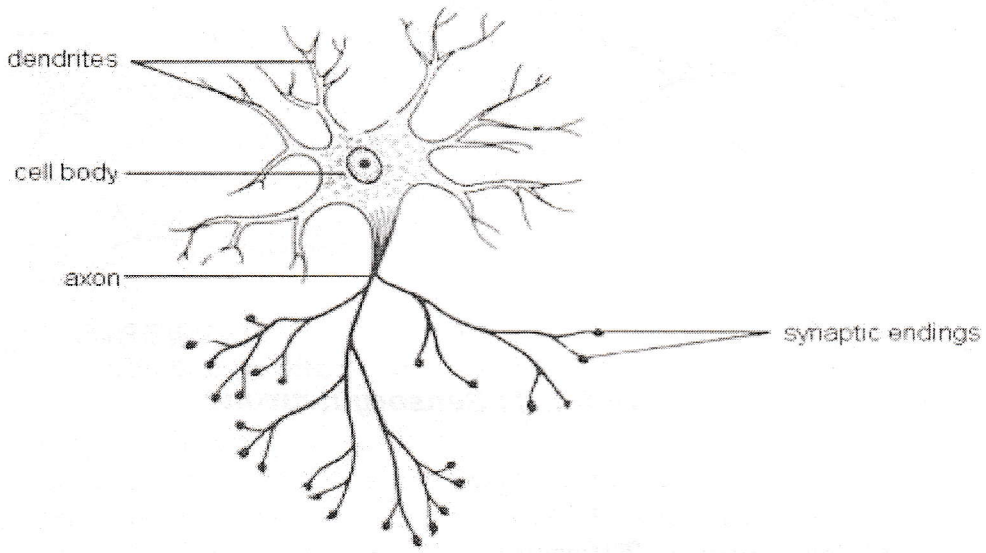


Figure 6.2.3: Relay neurone

Synapse
Neurones are not continuous with one another. They are connected to one another by a synapse. The nerve impulses must pass/across a synapse where the axon of one neurone meets the dendrites or cell body of another neurone. The neurone with impulse ends in a small knob called *synaptic knob*. This contains a chemical substance called neurotransmitter which bridge the neurons. This chemical is stored and released by synaptic cleft between adjacent neurones.

The synapse is a microscopic gap over which nerve impulses must pass when moving from one neurone to the next.

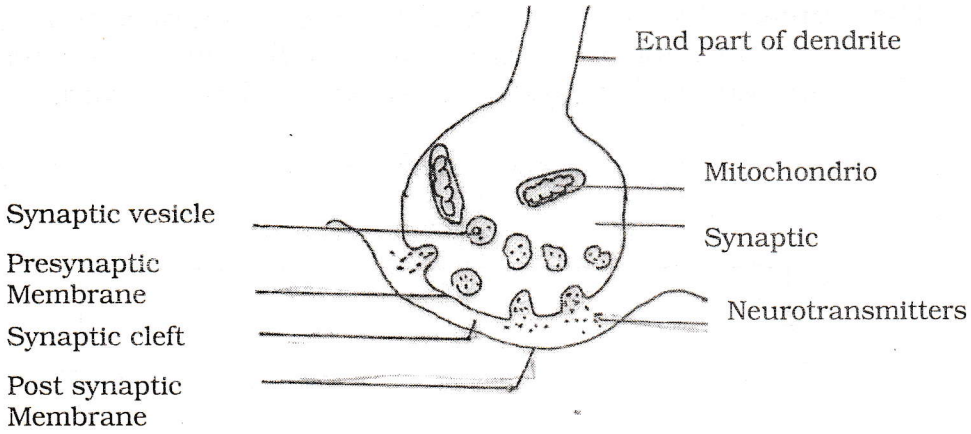


Figure 6.2.4: Structure of synapse

Organisation of the Human Nervous System

How are Nervous Systems Organized?

The nervous system detects changes in different forms of energy (light or pressure) or a change in the concentration of chemicals (taste or olfaction). This energy is detected by the receptors of specialized sensory neurones.

This information is then conducted by the sensory neurone to the interneurones that are involved in the processing of the signal. The information is transformed at this point either into a perception or to a command. Then motor neurones transport the information to the effectors which are either muscles or gland cells.

The Role of a Nervous System in an Organism

A nervous system allows an organism to sense information about its environment and responds rapidly. An organism with complex behaviors will have a well developed nervous system. The nervous system is responsible for complex behaviors.

Studying neurones and nervous systems will ultimately allow us to understand the biological basis for consciousness and the nature of the processes by which we perceive, act, learn and respond.

The human nervous system is far more complex than a simple reflex arc, although the same stages still apply. The Organisation of the human nervous system is shown in this diagram:

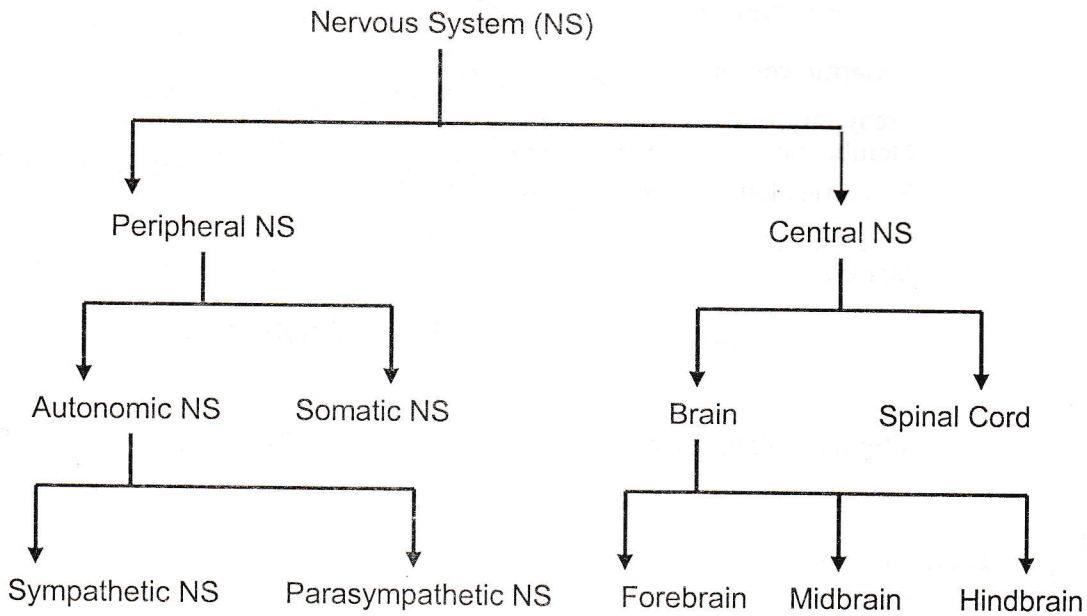


Figure 6.2.5: Human nervous system

Central Nervous System

Coordination is the linking together of body activities. For this to be effective many systems are necessary. ·For example, hormones affect and control reproduction. They work slowly but their effect may be permanent. Nerves are elongated cells responsible for information (impulse) transportation.

Here we are going to learn how the central nervous system co – ordinates or acts on impulses coming to it. We will also learn or discuss the components of central nervous system.

The Central Nervous System (CNS) is composed of **the brain and spinal cord.** The CNS is surrounded by bone-skull and vertebrae. Fluid and tissue also insulate the brain and spinal cord.

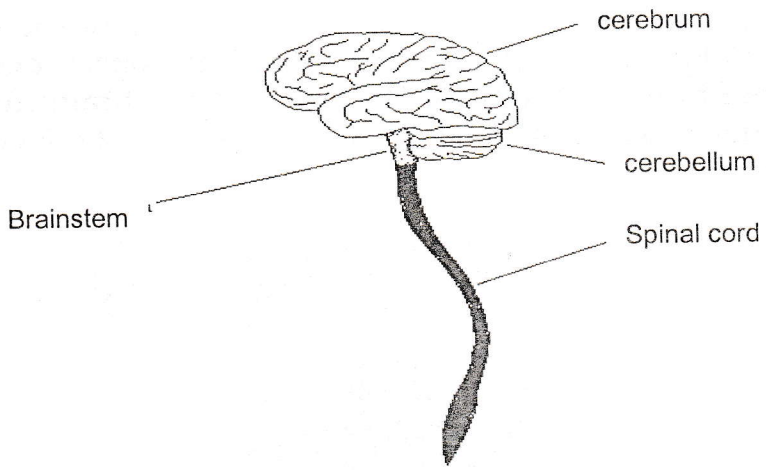


Figure 6.2.6: Central nervous system

The Brain

The brain is composed of three parts; namely

(a) The forebrain,
(b) The mid brain, and
(c) The Hind brain.

The Forebrain

Cerebrum

The forebrain consists mainly of **cerebrum**. The thalamus and hypothalamus are the parts of the forebrain found in the innerside. The thalamus acts as a switching centre for nerve messages. The hypothalamus is a major homeostatic center having both nervous and endocrine functions. The hypothalamus regulates homeostasis. It has regulatory areas for thirst, hunger, body temperature, water balance, and blood pressure, and links the Nervous System to the Endocrine System.

The cerebrum, the largest part of the human brain, is divided into left and right hemispheres connected to each other by the **corpus callosum**. The hemispheres are covered by a thin layer of grey matter known as the cerebral cortex, this gives brain its grey colour. This is the most recently evolved region of the vertebrate brain. Fish have no cerebral cortex, amphibians and reptiles have only rudiments of this area.

The cortex in each hemisphere of the cerebrum is between 1 and 4 mm thick. Folds divide the cortex into four lobes: **occipital**, **temporal**, **parietal**, and **frontal**. No region of the brain functions alone, although major functions of various parts of the lobes have been determined.

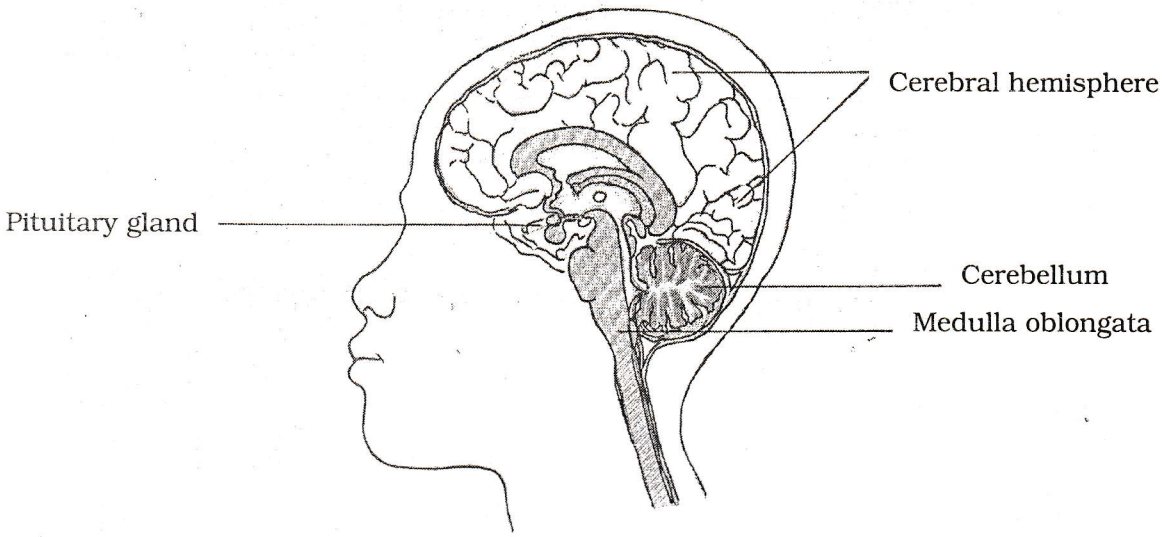


Figure 6.2.7: Cross section of the human brain

Functions of cerebrum

- Correlation of impulses and coordination of responses.
- It controls all voluntary actions such as learning and intelligent behaviour, memory, will power, imagination, reasoning and judgment.

This is the part where correct responses in a given situation are made.

The Mid brain

Acts as an important link between the hindbrain and forebrain. Hence it is a pathway of nerves from fore and hind brain. It controls reflexes of sight and hearing e.g. constriction of pupils.

The Hind brain

The hind brain is composed of cerebellum and medulla oblongata.

Cerebellum

The cerebellum is the third part of the hindbrain, but it is not considered as part of the brain stem. Functions of the cerebellum include fine motor coordination and body movement, posture, and

balance. It also controls the involuntary movement of the body. It regulates and coordinates muscular movement. Any damage to the cerebellum not surprisingly results in jerky and uncoordinated movements.

Medulla Oblongata

The medulla oblongata is closest to the spinal cord, and is involved with the control of movement of the body especially those concerned with respiration, heartbeat, breathing, vasoconstriction (blood pressure), and reflex centers for vomiting, coughing, sneezing, swallowing, and hiccupping.

ACTIVITY: 6.2.1

"Excessive alcohol drinking brings ill health to individuals." Explain.

Spinal Cord

The spinal cord extends from the medulla oblongata or brain stem to a point near the "tail." It is surrounded and protected by meninges and vertebrae.

It is a hollow tube, continuous with the brain ventricles, containing cerebrospinal fluid. This is a clear fluid having a similar composition to tissue fluid.

The inner part has grey matter with many cell bodies and dendrites which conduct impulses to cell body. The outer part has white matter consisting of axon which carries away impulses from cell body and from spinal nerves. The spinal nerves are mixed nerves which have two roots; the dorsal root is connected with sensory neurone and the ventral root connects with the motor neurone.

Functions:

(i) It transmits sensory and motor impulses to and from the receptors and effectors, or relays, sensory and motor impulses to and from the brain.

(ii) Major coordination center for simple reflexes.

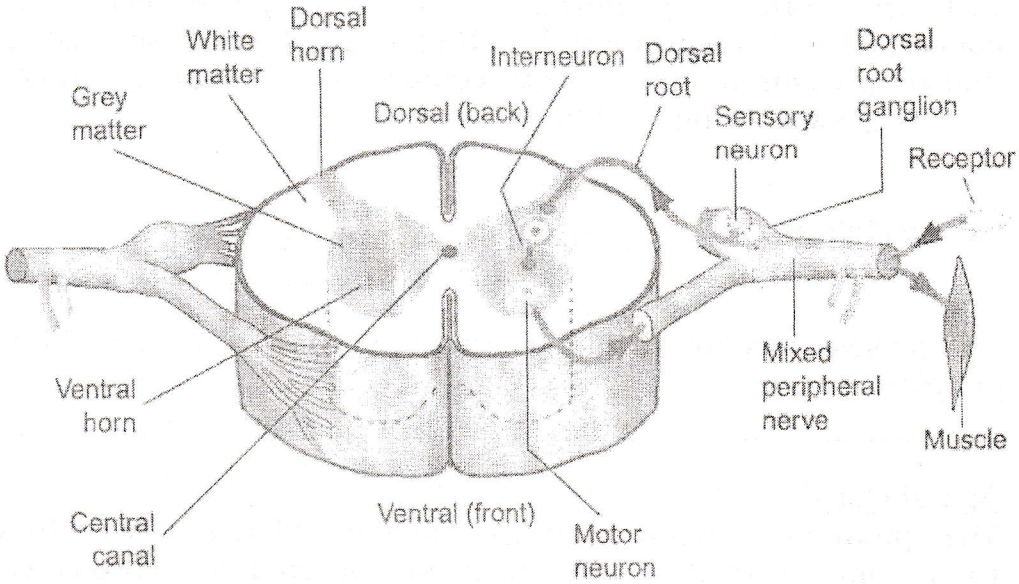


Figure 6.2.8: Transversal Section of spinal cord

Voluntary and Reflex Actions

The cerebral cortex is involved in controlling voluntary actions. Voluntary actions are actions which are the result of a WILL or conscious decision e.g. walking; talking etc. this occurs sometimes after the stimulus.

A reflex action is one which occurs automatically. It is a rapid automatic response to a stimulus. It is unlearned or inborn response, to stimulus. It is a protective instinctive action and an example is seen in eye blinking and pupil reflex and secretion of saliva as response to food.

Characteristics of simple reflex actions

These occur automatically without control of the brain, very rapid and can be conditioned. Conditioned i.e. learned and practiced; reflex is present at birth and can disappear.

NOTE: A habit is different from an instinct because an instinct is inherited and not learned and no gradual increase in skill as habit.

Types of reflex actions

(i) Spinal reflex
This is the reflex which involves only the spinal cord e.g. Withdrawing of hand from a sharp pin.

(ii) Cranial reflex
This is a kind of reflex involves the brain to coordinate the activities e.g. Coughing.

(iii) Conditioned reflex
These are responses due to long term learning and practice. They are forms of reflex actions where the type of response is modified by past experience. For example if dogs are given food, they salivate as they see the food. Suppose a bell is rung before giving thm food every day. These dogs will associate the bell and the food. After a long period of giving them food after ringing a bell, the bell may become the stimulus instead of food. That is, when the bell rings they salivate even if the food is not there (Pavlov's experiment).

This is a kind of reflex involving both the brain and spinal cord.

Reflex arc
This is the pathway taken by simple reflex actions. The three types of neurones are arranged in circuits and networks, as shown in the following diagram.

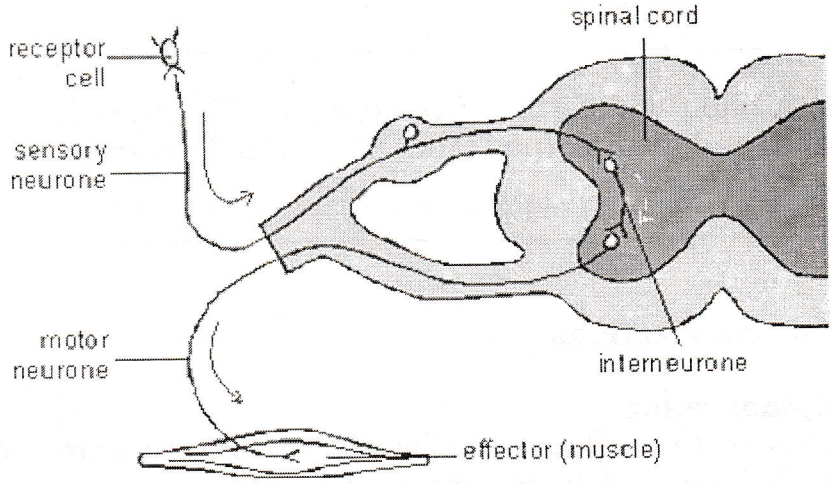


Figure 6.2.9: A simple reflex Arc

In a simple reflex action, such as the knee jerk, a stimulus is detected by a receptor cell, which synapses with a sensory neurone. The sensory neurone carries the impulse from site of the stimulus to the central nervous system (the brain or spinal cord), where it synapses with an interneurone. The interneurone synapses with a motor neurone, which carries the nerve impulse out to an effector, such as a muscle, which responds by contracting.

Reflex arc can also be represented by a simple flow diagram:

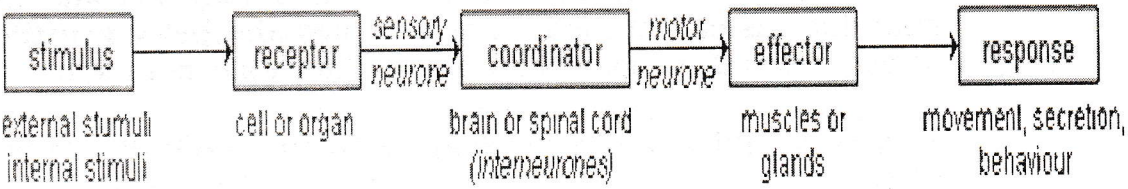


Figure 6.2.10: Reflex arc

In a reflex arc, sensory information is processed at the level of the spinal cord, resulting in action without involvement of the brain. For example, if one's fingers are burnt by a candle, the hand that receives the painful stimulus is rapidly removed from the flame with a jerking motion. At the same time, the brain is receiving information indicating that a painful event has occurred in the hand. It is important to understand that although the brain may perceive the painful stimulus, the reflex arc acts to retract the hand without direct input from the brain.

ACTIVITY: 6.2.2

(b) Tell your partner to sit on a chair with one leg crossed over the other at the knee.

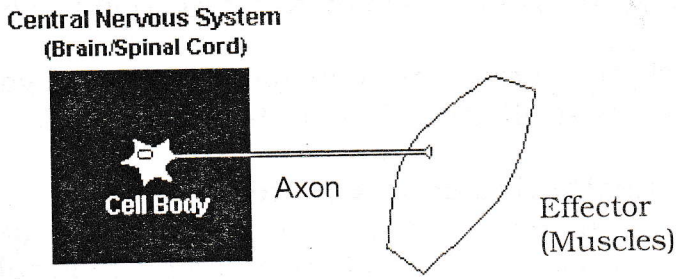
(c) Tap her/his crossed knee just below the knee cap. Explain your observation.

Peripheral Nervous System (PNS)

The Peripheral Nervous System contains only nerves and connects the brain and spinal cord (CNS) to the rest of the body. The axons and dendrites are surrounded by a white myelin sheath. Cell bodies are in the Central Nervous System (CNS) or **ganglia.** Ganglia are collections of nerve cell bodies. Cranial nerves in the PNS take impulses to and from the **brain** (CNS). Spinal nerves take impulses to and away from the **spinal cord**. There are two major subdivisions of the PNS motor pathways: the **somatic** and the **autonomic.**

Somatic Nervous System

The somatic nervous system consists of peripheral nerve fibres that send sensory information to the central nervous system and motor nerve fibres that project to skeletal muscle.



The Autonomic Nervous System (ANS)

The organs of your body, such as the heart, stomach and intestines are regulated by a part of the nervous system called the autonomic nervous system The ANS is part of the peripheral nervous system and it controls many organs and muscles within the body. In most situations, we are unaware of the workings of the ANS because it functions in an involuntary, reflexive manner. For example, we do not notice when blood vessels change size or when our heart beats faster. However, some people can be trained to control some functions of the ANS such as heart beat rate or blood pressure.

The ANS is most important in two situations:

- In emergencies that cause stress and require us to "fight" or take "flight" (run away) and
- In non emergencies that allow us to "rest" and "digest."

The ANS regulates:

(i) Muscles
- in the skin (around hair follicles; smooth muscle),
- around blood vessels (smooth muscle),
- in the eye (the iris; smooth muscle),
- in the stomach, intestines and bladder (smooth muscle),
- in the heart (cardiac muscle),

(ii) Glands

Parts of the *ANS*

The *ANS* is divided into two parts:
- The sympathetic nervous system
- The parasympathetic nervous system

The Sympathetic Nervous System

It is a nice, sunny day..... you are taking a nice walk in the park. Suddenly, an angry Lion appears in your path. Do you stay and fight OR do you turn and run away? These are "Fight or Flight" responses. In these types of situations, your sympathetic nervous system is called into action - it uses energy - your blood pressure increases, your heart beats faster, and digestion slows down.

The Sympathetic Nervous System has a series of ganglia that lie along the vertebral column, close to the spinal cord.

The Parasympathetic Nervous System

It is a nice, sunny day..... you are taking a nice walk in the park. This time, however, you decide to relax on a comfortable chair that you have brought along with you. This calls for "Rest and Digest" responses. Now it is time for the parasympathetic nervous system to work to save energy - your blood pressure decreases, your heart beats slower, and digestion can start.

The Parasympathetic Nervous System has a series of ganglia that lie to the walls of the effector organs. These two systems are antagonistical i.e. they behave in opposite ways.

Here is a summary of some of the effects of sympathetic and parasympathetic stimulation. Notice that effects are generally in opposition to each other.

Table 6.2.2: The Autonomic Nervous System

The Autonomic Nervous System		
Structure	**Sympathetic Stimulation**	**Parasympathetic Stimulation**
Iris (eye muscle)	Pupil dilation	Pupil constriction.
Salivary Glands	Saliva production reduced	Saliva production increased.
Oral/Nasal Mucosa	Mucus production reduced	Mucus production increased.
Heart	Heart rate and force increased	Heart rate and force decreased.
Lung	Bronchial muscle relaxed	Bronchial muscle contracted.
Stomach	Peristalsis reduced	Peristalsis increased.
Small Intestine	Digestion reduced	Digestion increased.
Large Intestine	Secretions and motility reduced	Secretions and motility increased.
Liver	Increased conversion of glycogen to glucose	Reduced conversion of glycogen to glucose
Kidney	Decreased urine secretion	Increased urine secretion.
Adrenal medulla	Nore-pinephrine and epinephrine secreted	Nore-pinephrine not secreted or secretion reduced
Bladder	Wall relaxed, Sphincter closed	Wall contracted, Sphincter open.

It should be noted that the autonomic nervous system is always working. It is NOT only active during "fight or flight" or "rest and digest" situations. Rather, the autonomic nervous system acts to maintain normal internal functions and works with the somatic nervous system.

The differences between the Peripheral Nervous System (PNS) and the Central Nervous System (CNS) are that:

(i) In the CNS, collections of neurones are called nuclei, while in the PNS, collections of neurones are called ganglia.

(ii) In the CNS, collections of axons are called tracts, while in the PNS, collections of axons are called nerves.

Before proceeding further, complete the following exercise

6.2.3 SELF CHECK EXERCISE ONE

1. (a) The nervous system has two main functional divisions, the Central Nervous System (CNS) and Peripheral Nervous System (PNS). What are the major parts of the CNS?----------
---

   (b) Name three regions of the brain
   i) ----------
   ii) ----------
   iii) ----------

2. List down in order the five (5) components of coordination in animals.

---

3. In what form are messages transmitted along the nerves?

---

4. What is a synapse?

---

5. What is a conditioned reflex action?

Compare your answers with those given at the end of this unit.

6.2.4 SENSE ORGANS

I hope you are aware of how information is put together in line in your body. We say this because of what you explored in the previous section. Now let us try the following. Take some salt and put it onto your tongue, what did you feel? Look around you, what did, you see? Touch a place of iron after putting it in fire for a minute. What do you feel? You are feeling some bad smell coming out of your toilet, what happened?

These and other more questions will be answered as you go through this section on sense organs.

The sense organs are the receptors of the body. They receive information about conditions both inside and outside the body. This information is known as the stimulus, because it stimulates the sense organs.

The sense organs enable mammals to see, feel, taste, smell and hear. They enable a mammal to be aware of the conditions of the environment e.g. heat, cold or any changes which may occur.

Types of Sense organs

There are five common types of sense organs, namely:-

- Eyes – used for vision/sight.
- Ears – used for hearing, balance.
- Skin – for touching/feeling.
- Tongue – for tasting.
- Nose – for smelling.

Table 6.2.3. The types of sense organs and their stimuli

Sense organ	Stimulus	Function
Eyes	Light	Vision/Sight
Ears	Sound	Hear, balance
Skin	Heat, pressure	Touch/feel
Tongue	Taste	Tasting
Nose	Smell	Smelling

Eye

Receptors which are concerned with sense of vision are located in the eyes.

If you look at your neighbour's eye, you may find that, the eye is roundish like a ball. It has three well marked regions. There is a small, dark central portion called the *pupil*. The pupil is surrounded by a dark brown region called *iris* surrounded by a white portion which forms the *sclerotic layer*, which is the largest part of the eye ball.

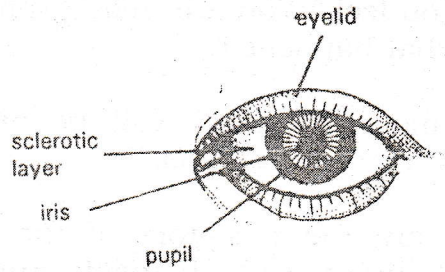


Figure 6.2.11: External structure of the eye

Structure of the eye

The wall of the eyeball is made up of the three layers, namely:-

- The sclerotic layer (outermost layer).
- The choroids layer (middle layer)
- The (retina innermost layer)

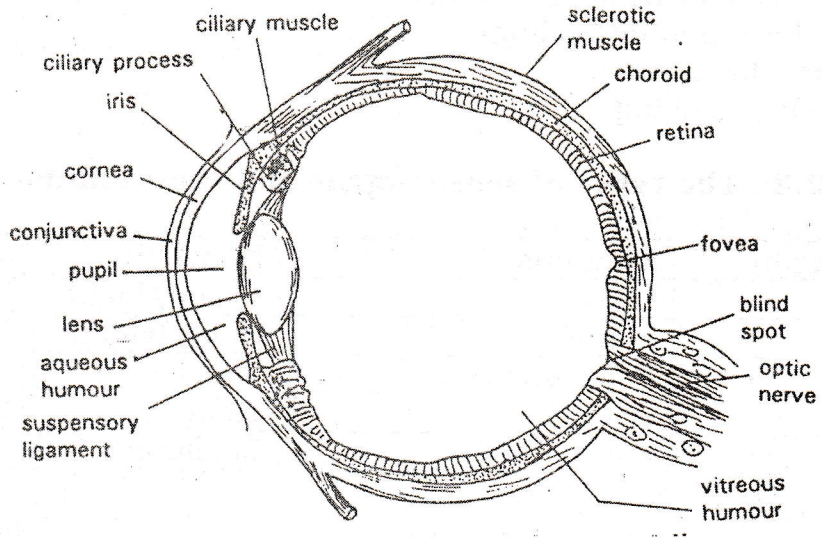


Figure: 6.2.12: Internal structure of the eye

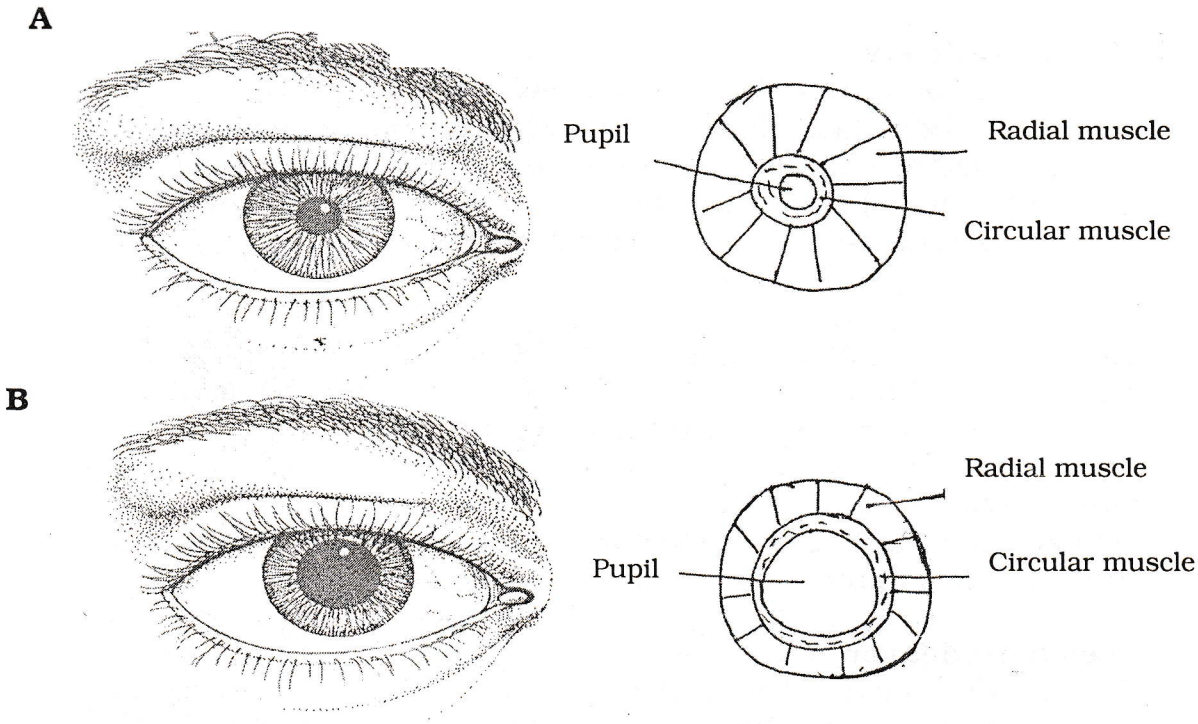


Figure 6.2.13: Response of iris to light intensity
A: in bright light and B: in dim light

In dim light, Iris contracts and makes the pupil to become large. Here the circular muscle relaxes while radial muscle contracts in order to widen the pupil so as to allow more light into the eye. The ciliary body connects the iris to the choroids and consists of ciliary processes and ciliary muscles.

ACTIVITY 6.2.3

1. Enter a very dark room. What changes do you experience in your eyes?

2. Immediately from a dark room go to an area with very bright light.

   Explain the changes you experience in your eyes.

Suspensory Ligaments
These are fibres that arise from ciliary body and hold the lens in position.

Lens
The lens of the eye consists of transparent material (tissues) which is attached to the ciliary bodies by suspensory ligaments. It is concerned with focusing clear image on the back of the eye. The shape of lens is controlled by the relaxing and contracting of the ciliary muscles.

Aqueous humour

This is a watery fluid found between the cornea and the lens. It helps to maintain the shape of the eye and carries nutrients and oxygen to the cornea and lens.

Vitreous humour

It is a transparent, jelly – like material found behind the lens. It helps to maintain the shape of the eye. It plays part in focusing an image on the retina by bending light rays passing through it.

The Retina
It is the innermost layer of the eyeball. It is elastic and has a lot of blood vessels. It has pigments and contains photoreceptors called the RODS and CONES which are sensitive to black and white respectively. Rods are very sensitive and function in dim-light and are located more around the sides of the retina. Cones function in bright light and are also sensitive to colour so they enable us to distinguish colours. That is why it is difficult to make out colours in dim – light. Most of the cones are concentrated in an area called FOVEA (Yellow spot). The nerve fibres from the rods and cones join up to form OPTIC NERVES which lead to brain.

Blind spot
This is an area of the retina where the sensory fibres join up. It does not contain photoreceptors. It is therefore not sensitive to light.

Formation of Images (Mechanism of Vision)
Let us see what happens when you observe an object. After perceiving light, the light rays from the object pass to the transparent cornea, then into the aqueous humour, pupil then into lens. The lens bend (refract) the light rays and then light rays meet in order to be focused at the retina after passing through the vitreous humour. At the retina the sensitive cells i.e. cones and rods are stimulated and their stimulation make the impulses

(message) to be sent by optic nerves to the brain for interpretation. The image formed on the retina is upside down (inverted image) but after interpretation in the brain, it is made up right.

Accommodation

This is the ability of the eye to focus objects at varying distances by altering the focal length of the lens by regulating the shape of the lens.

In other words, accommodation is the ability of the eye to produce clear images of objects at different distances by altering the focal length of the eye lens.

Focal length is the distance between the lens and the object which is seen.

Accommodation enables a person to see near and far objects. This is brought about by the action of the ciliary muscles i.e. contraction and relaxation of ciliary muscles and elasticity of the lens.

How Accommodation occurs

How to see near objects

When near objects are observed the eye lens become more round (convex) in shape and thick. This is caused by the contraction of the circular muscles and relaxation of the radial one. This reduces tension on the suspensory ligaments and lens become round in shape. Hence near objects can be seen. (See fig. 6 2.14 B).

How to see far objects

When observing far objects, the lens become thinner and long. This is caused by the contraction of radial muscles and relaxation of the circular ones. This contraction of radial ciliary muscles pull against the lens, stretching into a flatter shape. The thin lens give a clear image of the distant object. (See fig. 6.2.14 A.).

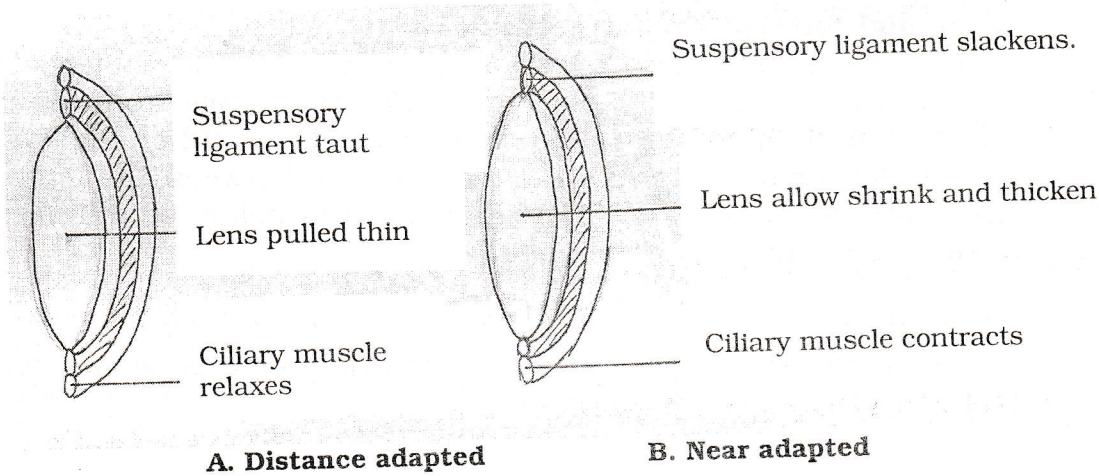


Figure 6.2.14: How accommodation is brought about

Eye Defects

Eye defects means inability of the eye to function properly i.e. to alter its focal length to see both distant and near objects.

Types of eye defects and their corrections

Short sightedness (myopia).

It is a condition where a person is able to see only near objects. It occurs when an image of a distance object is focused infront of the retina at the vitreous humour. It is caused by the lens being too thick and eyeball being longer than normal. This results in the increase of the distance between the lens and the retina.

Correction

Myopia is corrected by wearing concave lenses (diverging lenses). These lenses help to diverge light rays from far objects so that they can be focused on the retina.

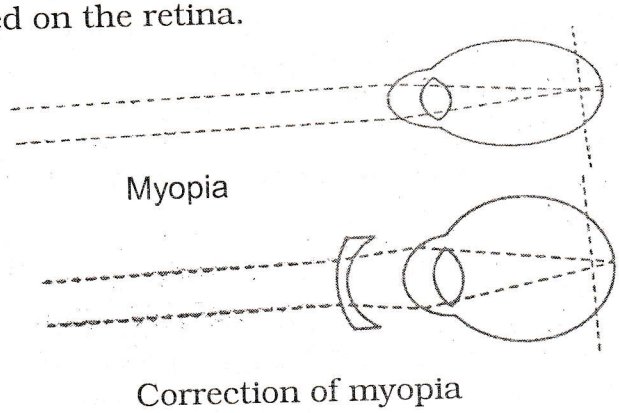


Figure 6.2.15: Short sightedness

Long sightedness (hypermetropia)
It is a condition where a person is able to see far objects. The person can not see near objects clearly. The image from the near object falls behind the retina. It is caused, by either the eyeball being shorter than normal i.e. the distance between the lens and the retina is shorter than normal, or the lens being too thin so that it does not converge enough light rays.

Correction
Long sightedness is corrected by wearing convex lenses which converge the light rays to the retina.

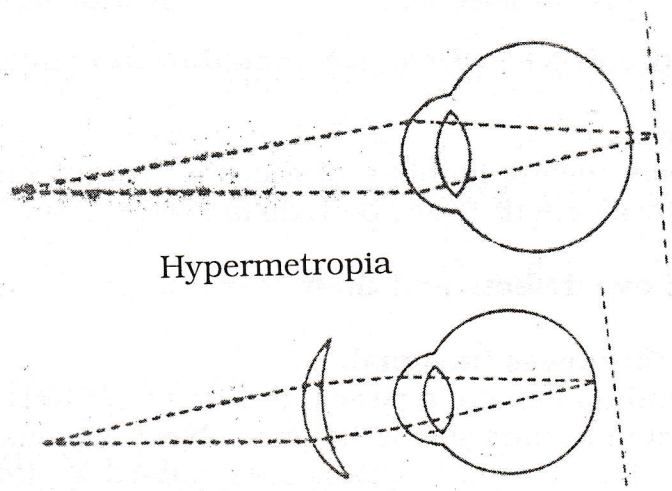


Figure 6.2.16: Long sightedness

Old sight (Presbyopia)
This is due to the loss of flexibility of the lens, hence the person finds it difficult to focus near objects. It starts appearing from the age of about forty to forty six years.

Correction
It is corrected by wearing convex lens which give the eyes extra power for close objects.

Astigmatism
It is the most defect of the eye. It is caused by the surface of the cornea not being perfectly smooth or spherical. The parallel light rays are therefore not brought to sharp points on the retina, resulting in blurred vision. This defect is usually present in all eyes to some extent.

Correction
It is corrected by wearing spectacles with cylindrical lenses.

Cataract
It is most common in older people. The lens gradually become cloudy so that light rays cannot pass through easily and the person cannot see properly. It may become gradually worse.

Correction
This eye defect can be corrected by removing the eye lens through operation and replacing them by plastic lens inside the eye.

ACTIVITY: 6.2.4

In the classroom sit on the front bench while taking the notes written by the teacher on the board. Again go and sit on the back bench. In both cases, do you see the notes on the board well? Explain.

The skin
The skin contains millions of separate tiny sense organs with different functions. Microscopic examination of human skin shows that, there are at least five different types of sensory organs in the skin. They are named according to their functions, which are touch, pressure, pain, heat and cold. Therefore skin receptors detect touch, pressure, pain, heat and cold.

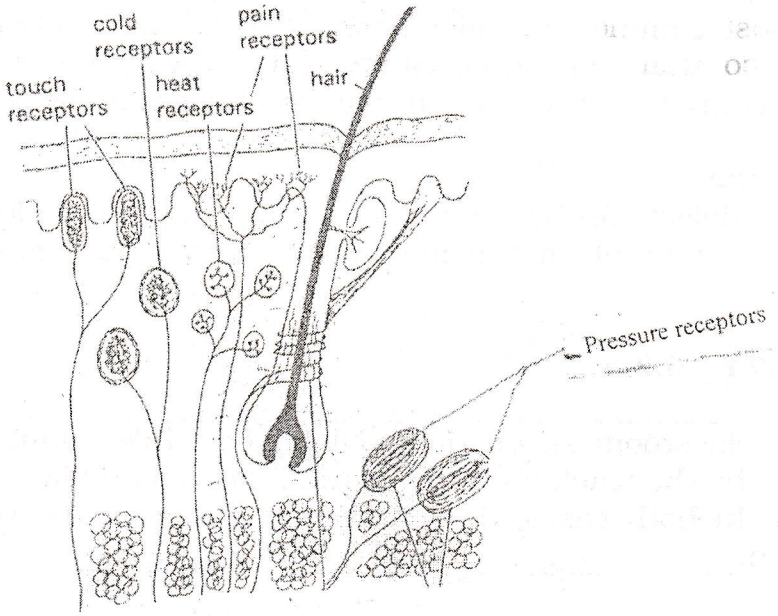


Figure 6.2.17: Internal structure of skin

Touch receptors

These receptors are not evenly distributed over the body surface. They appear to be especially close together in the tongue and at the finger – tips. They are located immediately below the epidermis. Touch receptors enable a person to distinguish a variety of textures, from sand, paper, and roughness to glassy smoothness and between hard, soft and liquid substances.

Pressure receptors

These receptors are concentrated in the skin of the tongue and finger – tips where pressure differences are small – they are situated beneath the dermis

Pain receptors

These receptors are more evenly distributed throughout the skin and occur almost everywhere inside the body except brain, they are located inside muscles, tendons, ligaments, in the wall of the digestive system.

Heat and cold receptors
These receptors detect changes of temperatures. They are used to compare differences in temperature.

Structure of the skin
The skin consists of two main layers, namely.
- Epidermis which is the outer layer.
- Dermis which is the inner layer.

The epidermis
This is the protective surface layer which is made up of many cells. Dead cells on top are constantly worn away and replaced by newly formed cells in the germinative layer. As cell moves towards the surface, keratin is deposited in them. Keratin makes the surface waterproof and reduces water loss from tissues below.

The dermis
The dermis binds epidermis to underlying tissues. It consists of connective tissue, hair follicle, blood vessels, glands (sebaceous and sweat), muscles, nerve fibres and sense organs.

The hair follicle secretes the non – living hair. Sebaceous gland open into the hair follicle and secrete an oil fluid, **sebum** which helps to keep the hair and skin surface water proof and bacteria free.

Sweat glands open on to the skin surface via sweat gland. They secrete sweat, a fluid drawn from the blood. Blood vessels in dermis bring food and oxygen to the skin tissues.

Below the dermis there is a fat layer (adipose tissue) which protects underlying organs from mechanical damage and act as a food store and insulator.

The nose
The smells of a flower, perfume, freshly baked bread and other food are all made possible because your nose has cells which are sensitive to chemicals in air, therefore it is a chemoreceptor. The cells sensitive to smell occur in the olfactory organ of the nose. The olfactory organs also have cells which produce mucus to keep the surface moist. When the olfactory organ is stimulated, impulses pass along the olfactory nerve fibre to the brain where the sensation is experienced. It means, the sensation of smell occurs in the brain and not in the olfactory organs.

The sensory cells are stimulated only by substances which dissolve in the moisture on their surface, so smell is really a chemical sense.

The sense of smell is easily fatigued, that is a smell experienced for a long period ceases to give any sensation and we become unaware of it, although a new comer may experience it at once.

We tend to lose our sense of smell when the olfactory surface becomes dry, for example when we have a cold.

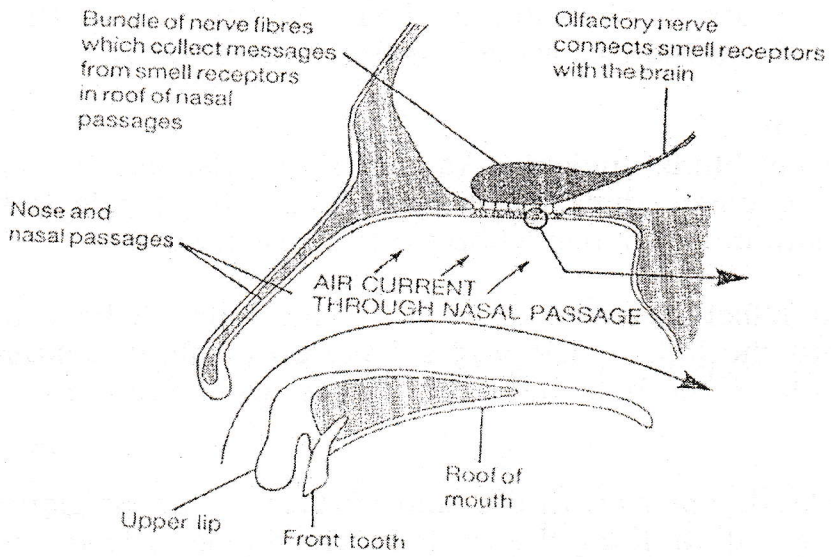


Figure 6.2.18: Smell receptors

The Ear

The ears are the sense organs for hearing and balance. Hearing is a sensation in the brain produced by vibrations or sound waves that are transformed into nerve impulses by the ear.

Structure of the Ear

The ear is divided into three parts:- namely

- The outer ear.
- The middle ear.
- The inner ear.

Hearing involves all the three parts, while balance involves only the inner ear.

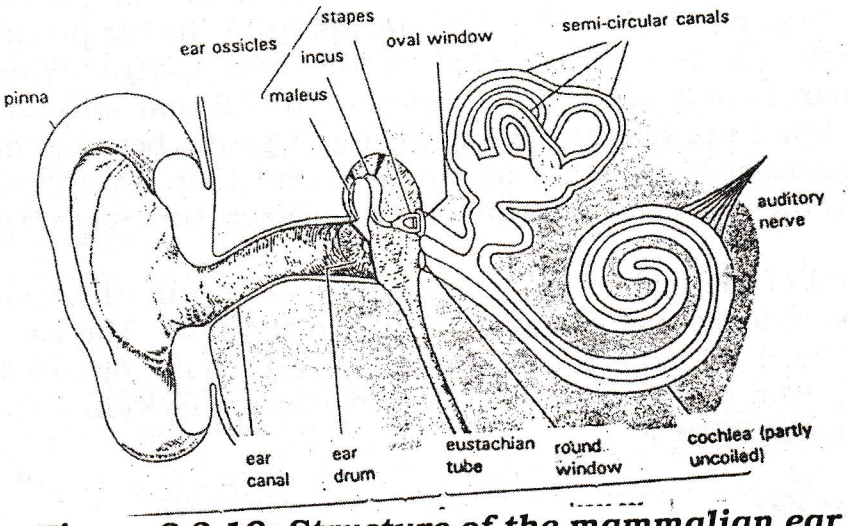


Figure 6 2.19: Structure of the mammalian ear

The outer ear

It is made of cartilage or extension of skin called PINNA, which is used to collect sound waves and channeling them directly down the ear canal (auditory meatus). The ear canal is a tube leading inward.

At the end of the ear canal, is a sheet of very thin membrane called the ear drum (tympanum).

The ear drum and ear canal are both protected by wax and hairs which filter out dust particles and lubricate the tympanum.

The ear drum (tympanic membrane) separates the middle ear from the outer ear.

The middle ear

It consists of air – filled part of the ear containing three very small ossicles (bones) called.

- Malleus (hammer)
- Incus (anvil)
- Stapes (stirrup)

These bones form a system of levers whose function is to amplify the sound waves and pass them to the inner ear.

There is a passage (tube), called the Eustachian tube which connects the middle ear with the pharynx. The function of Eustachian tube is to equalize the pressure on both sides of the

eardrum. This tube is usually closed, but when the pressure in the middle ear increases, the tube opens until the air pressure in the middle ear is equal to that of the atmosphere. When the Eustachian tube is blocked (because of a middle ear infection or a mucous build up) hearing is impaired (not good), because the ear drum has excess pressure on one side and then stretches. This results in the ear drum vibrating less so hearing becomes affected.

At the end of the middle ear, opposite the ear drum, there are two openings, namely oval window and round window. The ear drum and the oval window are connected by a chain of ear bones (ossicles). The ossicles transmit sound vibrations from the outer ear to the inner ear.

The inner ear

It consists of a cavity which is filled with a fluid and contains sense organs i.e. succulus, utriculus, cochlea and three semi-circular canals.

The part of the inner ear concerned with hearing is called COCHLEA and is coiled like a shape i.e. coiled tube. It detects sound vibrations. The three semi-circular canals, sacculus and utriculus control balance and posture.

The three circular canals

The three semi-circulars lie at right angles to each other and are filled with endolymph. Each semi-circular canal has a swollen base known as the ampulla which are concerned with maintaining balance and equilibrium with regard to the perception of movements.

The cochlea

The cochlea arises from the lower side of the sacculus. It is spirally coiled. It is actually divided into three tubes in one namely, the upper, middle and lower tubes (canals). The two outer tubes contain a liquid called *perilymph* and the middle tube contains Endolymph.

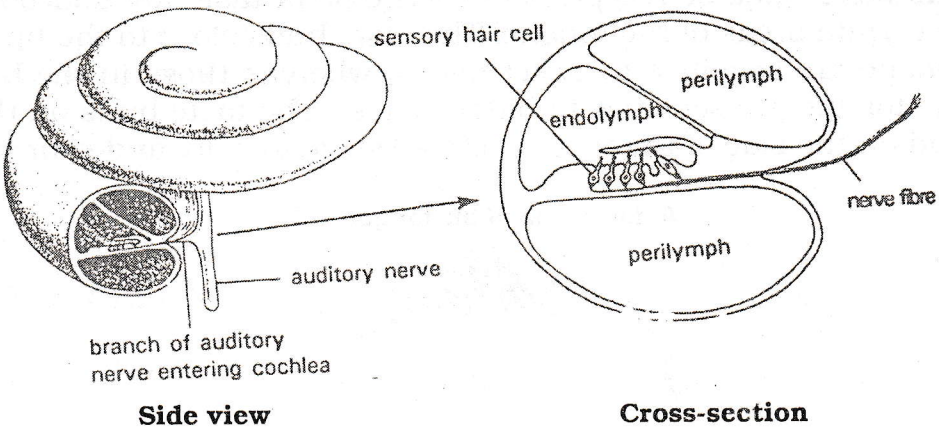


Figure 6.2.20: A cross section of the cochlea

Mechanism of Hearing

Pinna collects sound waves in the air and directs them to the ear drum through the auditory meatus. When sound waves hit the eardrum it vibrates. These vibrations are transmitted along the ear ossicles to the oval window. The vibrations of the stapes cause the membrane at the oval window to vibrate i.e. as the stapes move in and out the oval window is transmitted to the perilymph and then spread to the endolymph. The vibration of the endolymph on the sensory cells induces nerve impulses in the sensory nerve fibre. These impulses are transmitted to the brain for interpretation.

The tongue

The tongue is a strong muscle in the mouth that is covered with minute projection called papillae. These carry a large number of taste buds. The receptors for taste called taste buds are situated chiefly in the tongue, but they are also located in the roof of the mouth and near the pharynx.

Types of tastes

There are four different types of tastes, namely,

- Bitter – e.g. quinine
- Sour – e.g. lemon or lime juice
- Salty – e.g. normal table salt
- Sweet – e.g. sugar

The tongue has taste buds which are sensitive to each of these types of tastes. Each taste bud responds to only one of the tasting substance, i.e. a taste bud which detects sweetness can not detect salt-ness, bitterness or sourness.

The taste buds or receptors of each type of taste are concentrated in certain areas of the tongue. The taste buds close to the tip of the tongue are sensitive to sweet tastes, whereas those in the back of the tongue are sensitive to bitter tastes. The taste buds on the top and on the side of the tongue are sensitive to salty and sour tastes.

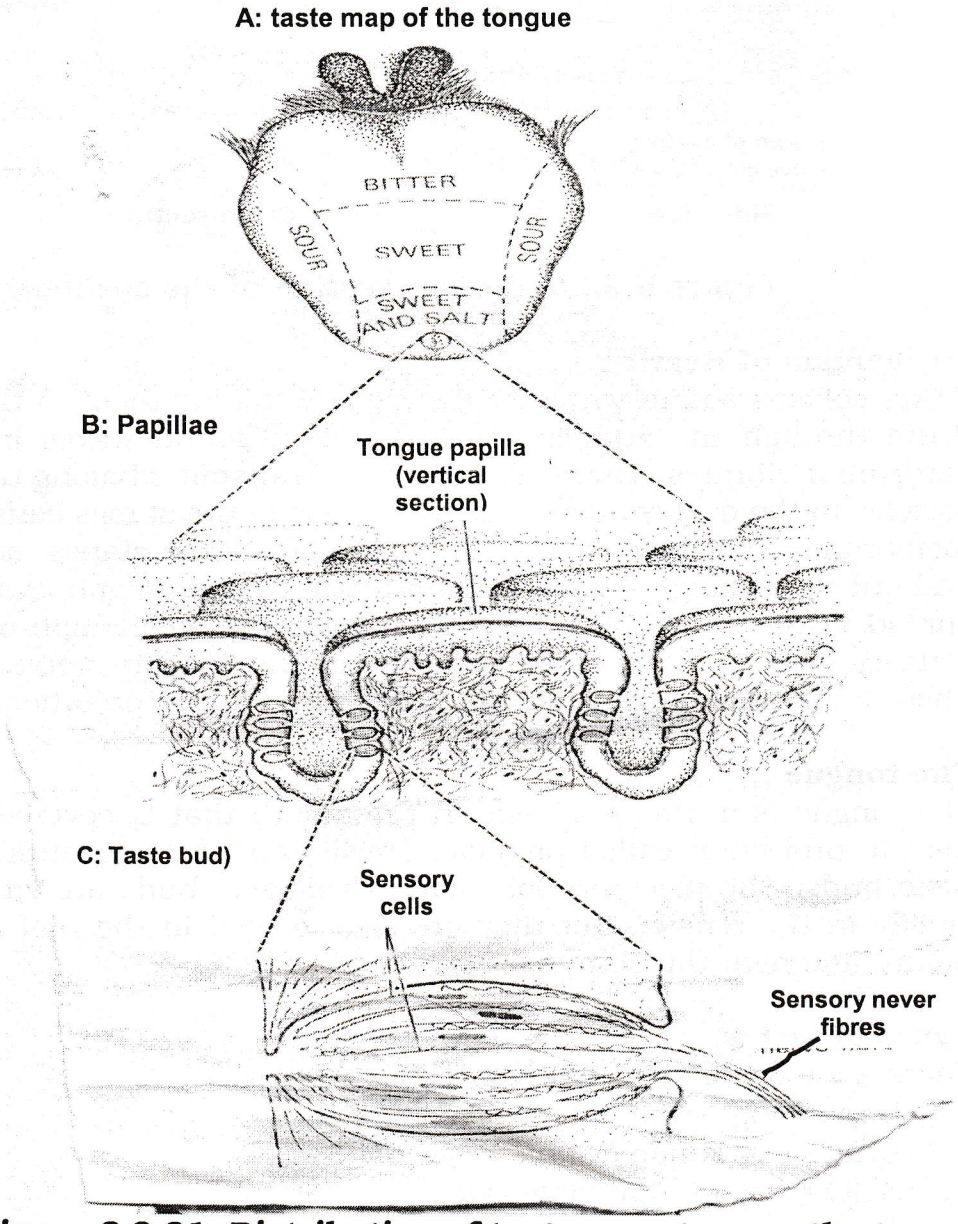


Figure 6.2.21: Distribution of taste receptors on the tongue

At the base of each taste bud there is a nerve that sends the sensations to the brain for interpretation. The sense of taste functions in coordination with the sense of smell.

When we have a cold, we can not taste food well, because the nasal passages become inflamed and coated with mucus; the smell receptors are essentiality non-functional. That is why different kinds of food tend to taste the same when we have a cold.

Before proceeding further, complete the following exercise.

6.2.5 SELF-CHECK EXERCISE TWO

1. State five common sense organs and indicate their stimuli and function.
   a) .....
   b) .....
   c) .....
   d) .....
   c) .....

2. a) What is eye defect? .....

   b) Point out five types of eye defects .....

3. Give a list of tastes found in the tongue .....
   .....

Compare your answers with those given at the end of this unit.

6.2.6 DRUG AND DRUG ABUSE

What is a drug?

A Drug is anything which if taken alters the way the body works. Drugs affect the coordination system of the body. They affect the nervous system and sometimes the hormonal system.

Drug abuse means excessive use of drug for non-medical reasons. It is the misuse of drugs.

Drugs are very important to our lives; misusing them is a problem. Drugs are used in operations.

Groups of Drugs

Sedative

These are drugs which slow down the brain and make a person feel sleepy e.g. valium and alcohol.

Stimulants

These speed up the brain and make the person more aware (alert) e.g. cocaine, coffee and tea: Mild stimulants are cocacola and nicotine which is found in tobacco.

Hallocinogens

These make the person to sense wrongly (one may feel flying, swimming while not) e.g. cannabis or marijuana. These disturb the sense of judgment so that one becomes careless and foolish.

Pain killer

These suppress the part of the brain responsible for sense of pain e.g. morphine, heroine, asprin and panadol.

Drugs must be handled and used with great care. Improper use results into drug addiction (cannot do without) i.e. the blood becomes physically dependent upon and shows adverse physical reaction when the drug is suddenly stopped.

Effects of Drugs

- Affects the mind (brain) distorting judgment or sensations.
- Regular drug use results into tolerance; the body needs greater amount to achieve the same effect.
- For a pregnant woman who uses drugs, the embryo is forced to share them through the placenta.
- It may lead into AIDS and hepatitis if syringes are shared
- Those who take alcohol, may end up with:
  - Liver cirrhosis i.e. liver stinking due to death of cells poisoned by alcohol.
  - Brain damage.
  - Heart disease: pumping action weaker due to lack of vitamin B. The person does not like to eat.
  - Excessive alcoholic intake by pregnant women can lead to miscarriage.
  - Excessive intake of alcohol means little money can be spent on food and clothes for the family.
  - They may lead to violence, illness and even death. The effect of violence may lead to losing friends e.g. divorce, prison, and hospitalization.
  - Poor work performance may lead to loss of job.

Hence drug abuse is very dangerous to the life.

ACTIVITY: 6.2.5

1. Find out types of drug abuse in your local environment.
2. What could be the possible reason(s) for drug abuse?
3. (a) What will you do to stop drug abuse practices in your local environment?

   (b) How can you help victims of drug abuse?

Before proceeding further, complete this exercise.

6.2.7 SELF– CHECK EXERCISE THREE

1. What is drug abuse?

   .....

   .....

   .....

2. List down different ways by which individuals abuse (take) drugs.

   .....

   .....

   .....

   .....

4. What are the effects of drug abuse?

   .....

   .....

   .....

Compare your answers with those given at the end of this unit.

6.2.8 HORMONAL COORDINATION IN ANIMALS

As we discussed earlier coordination in animals is also controlled by endocrine system. The endocrine system has glands which produce chemical substances called hormones. The endocrine glands have no tubes or ducts that carry the hormones; as result the hormones are poured directly into the blood. Hence, the endocrine glands are called ductless glands. Following are more details about the endocrine system.

Endocrine system

This is the chemical co-ordination system of the body. The Endocrine system is made up of ductless glands which secrete hormones (chemical messengers) directly into the blood and are then transported to the target organs.

What happens to hormones when they have completed their task? They pass through the liver where they are converted into inactive compounds. The kidneys then excrete them. This prevents their effects from continuing or causing the body to over-react.

Properties of Hormones

- Are mostly made up of protein.
- They are produced by endocrine glands.
- They have a chemical control over the activities of a target organ, but do not themselves perform the action.
- Hormones work together as a system.

Groups of Hormones

- Metabolic hormones - control metabolism
- Regulatory hormones - control rate of secretions e.g. secretion of juices in the stomach and small intestine.
- Growth hormones - affect rate of growth and repair of cells in the body.

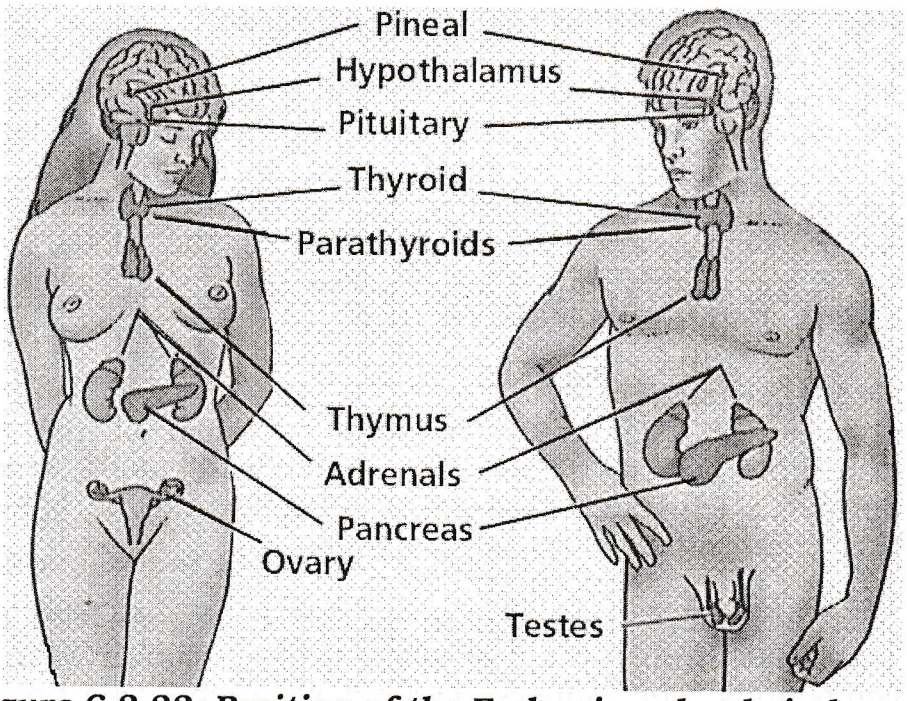


Figure 6.2.22: Position of the Endocrine glands in human

Some of the endocrine glands are listed below.

- Pituitary gland.
- Thyroid gland.
- Parathyroid gland.
- Pancreas (Islets of Langerhans).
- Adrenal gland.
- Gonads.

Endocrine glands have a rich supply of blood, as blood transports the secretions to the target organs.

I am happy that now you are coming up in this lesson. After knowing some of the endocrine glands, let us now discuss the structure, position, hormones secreted by each endocrine gland and their functions

Pituitary gland

Structure:

3 lobes: anterior and posterior.

Hypothalamus and pituitary glands are connected by fibres.

Functions

Anterior Pituitary Lobe

- Secretions of **growth hormone**, which regulate body growth and development, particularly the long bones and muscles.
- Over secretion leads to giantism.
- Under secretion leads to midgets (dwarfism).
- Secretions of Thyroid Stimulating Hormone (TSH) which controls the development and functioning of the thyroid gland.

Posterior Pituitary lobe

- Secretions of **Anti-Diuretic Hormone** (ADH), which causes the constriction of smaller arterioles, which in turn raises the blood pressure. It prevents the excess water loss of the kidneys. It regulates the water content in the cells and blood (osmoregulation).

Thyroid gland

Structure:

- Situated over the trachea, behind the larynx.
- There are two lobes, which are controlled by TSH.
- The hormone secreted is **thyroxine** Iodine is a macro-nutrient needed for the production of thyroxine.

Functions:

- Regulates the basic metabolic rate of the body.
- Affects growth and functioning of the heart and the nervous system.
- Stimulates growth and differentiation of tissue in a foetus and in children.
- An increase in thyroxine results in an increased metabolic rate. In adults this results in hyperthyroidism which leads to goiter.

Goitre is due to the secretion of fluid by the gland instead of thyroxine due to absence of iodine.

A decrease in thyroxin leads to a decreased metabolic rate. In adults this results in hypothyroidism, and in children it causes cretinism and mental retardation. It also results in:

- loss of physical and mental vigour, increased weight,
- retention of fluids and thickening of skin.

Parathyroids

Structure
There are two pairs of parathyroids embedded in the thyroid tissue. They are small, round and compact.

Functions
They secrete **parathyroid hormone/parathormone** with Vitamin D. They influence the absorption of calcium and regulate the amount of calcium and phosphates in the blood. If there is insufficient calcium, it will result in the absorption of calcium from the bones.

Over secretion - weakens the bones.
Under secretion - causes blood calcium level to drop resulting in muscle and nerve spasms (tetany).

Adrenal Glands

Structure
- Situated on top of the kidneys.
- Triangular shape with outer cortex and inner medulla.
- Rich supply of blood.

Functions
Adrenal Medulla - produces adrenaline which prepares the body for emergencies.

It does this by
- increasing the heartbeat and blood pressure,
- reducing the peripheral blood circulation and the blood to the digestive system so that more blood is transported to the muscles,
- causing the liver to convert glycogen to glucose, thereby raising the blood sugar level and increasing the oxidation metabolism of the cells (respiration).

Over secretion: results in an aggressive personality.
Under secretion: the sympathetic nervous system must perform the above functions itself and then becomes overworked and stressed.

Adrenal cortex produces aldosterone which acts on the kidney, sweat glands and the salivary glands.

- It controls the sodium chloride balance in excretion and reabsorption.
- It controls the excretion of potassium in the renal tubules and therefore the water content of the blood.
- The cortex also produces cortisone which controls metabolic function of glucose, amino acids and fats and aids the body in coping with stress.

Islets of Langerhans

Structure

- located in the pancreas
- alpha cells secrete Glucagon and the beta cells secrete Insulin.

Functions

Insulin: regulates the blood sugar content by promoting the absorption of glucose into the cells.

- It causes the oxidation of glucose at tissue level.
- It increases the liver function by causing the liver (which is the target organ) to convert glucose to glycogen so that it can be stored.
- It also causes the increase in the rate of fat and protein synthesis by the tissue of the body.
- Deficiency results in diabetes.

Glucagon: Antagonistic effect to insulin. Increases the level of blood sugar by causing the liver (the target organ) to convert glycogen and thereby increase the blood sugar level.

ACTIVITY: 6.2.6

(a) The hormone insulin produced by the.....is carried to the..... where.....is converted to.....

(b) Under what conditions is one liable to suffer from diabetes mellitus?

(c) What advice would you give to a diabetic.

Gonads

Female Sex Organs

Female hormones (oestrogen and progesterone) are secreted by the ovaries.

Functions

- Oestrogen controls the secondary sexual development, prepares the uterus for the implantation of a fertilised egg and its development.

- Progestin/Progesterone controls the changes in the uterus after ovulation and also in pregnancy.

Under secretion

- Oestrogen - sterility and personality changes.
- Progesterone – abortion/miscarriage.

Male sex organs

A male hormone (testosterone) is secreted by the testes.

Function

- Testosterone controls the secondary sexual development in males and the functioning of the male organs.

Under secretion: underdevelopment and psychological disturbances, sterility.

Thyroid and Pituitary glands

- If there is too little thyroxine secreted, the cells in the anterior lobe of the pituitary are affected.

- The pituitary will then secrete more TSH (thyroid stimulating hormone).

- This goes into the bloodstream, to the thyroid gland (the target organ).

- The TSH causes the thyroid gland to increase the amount of thyroxine it produces.

- Increased thyroxine in the blood will eventually cause the pituitary to reduce the TSH production.

- This will lower the amount of thyroxine produced by the thyroid and an equilibrium is reached.

SUMMARY

- Endocrine glands are ductless, and therefore hormones are secreted directly into the blood.
- They consist of complex organic compounds - proteins.
- They control growth, development and the general functioning of the body.
- They only have influence on a target organ.

There is a complex feedback system between all endocrine glands.

Table 6.2.3: Differences between the Endocrine System and the Nervous System

NERVOUS SYSTEM	ENDOCRINE SYSTEM
Made up of nerves	Made up of Glands.
Produces nerve impulses	Produces Hormones.
Impulses transmitted along the nerves.	Hormones transported by the blood.
Effects are very quick and very specific	Effects are slower and more general.
Nerve impulses control short term changes (e.g. sneezing, lifting your arm)	Hormones control long term changes (e.g. growth).

Before proceeding further, complete the following exercise.

6.2.9 SELF CHECK EXERCISE FOUR

1. What is hormone?

   .....

   .....

2. Differentiate between endocrine glands and exocrine glands.

   .....

   .....

3. List down at least four types of endocrine glands and the hormone they produce.

   .....

   .....

4. State the role of the following hormones:

   (a) Adrenaline

   .....

   (b) Insulin

   .....

   (c) Anti – diuretic hormone (ADH)

   .....

   (d) Androgens

   .....

Compare your answers with those given at the end of this unit.

6.2.10 COORDINATION IN PLANTS

After studying much on coordination in animals and your experience in your environment do you think coordination in animal resembles that in plants? I send your experience because I hope you know much of the behaviour of plants though it is some how difficult for you to relate those with coordination in plants.

Relax as you go through this section. You will see the true relationship between your experience and the true response behaviour of plants and their causes.

Plants like animals respond to changes in their environment. Responding process is infected by hormones i.e. plants achieve their coordination and responsiveness through a system of hormones.

Plant hormones (phytohormones) have several effects on plants such as root and stem elongation or closing and opening of flowers. Cell division, cell elongation and flowering are essentially growth processes, all of which are initiated by hormones. Response of plants to stimuli is called **tropism or tropic response.** Plants get stimulated and respond to gravity, water, light, and chemicals.

The tropic movement or tropism is due to the effect of gravity, water, light, chemical and touch.

Table 6.2.4: Types of tropisms and their stimuli

Stimulus	Tropism
Water	Hydrotropism
Light	Phototropism
Gravity	Geotropism
Touch	Thigmotropism (haptotropism)
Chemical	Chemotropism

From above, a response due to light is known as phototropism while geotropism is a response due to gravity. Tropism can be negative if response is away from stimulus or positive if response is towards the stimulus.

Example; positive hydrotropism means roots grow/move towards water. Negative geotropism means shoots grow/move away from gravity.

Tropism (tropic movement)

Tropism is a growth movement shown by fixed part of a plant in response to a unilateral stimulus. The movement involved in the response is produced by plant growing parts, the shoot and root tips. Leaves also respond to light.

Types of Tropic Movements and their Stimuli

Phototropism

It is a growth movement in response to the direction of light. This means the direction of the growth movement depends on the direction from which light is coming i.e. unidirectional. Plant stems grow towards a source of light, hence they are positively phototropic.

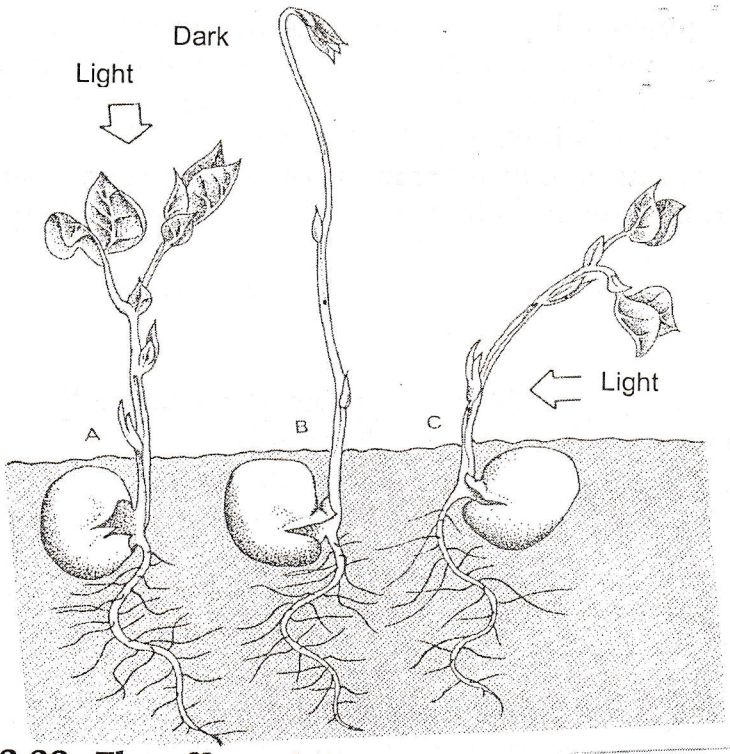


Figure 6.2.23: The effect of light on the growth of bean plants: A was grown out of doors; B was grown in the dark and C was illuminated from one side.

The responses of plants B and C in the figure above show how plants are equipped to survive in difficult conditions.

ACTIVITY: 6.2.5

- Sow three maize grains in three different pots.
- Put set 1 in direct sunlight.
- Put set 2 in a box which has a small window and place the box near the house window with the window of the box facing the window of the house.
- Place set 3 in a cupboard or dark room.
- Leave the sets for three days while watering.
- Make observations after the three days.
- Explain your results.
- Draw conclusions of your experiment.

Geotropism

Is a growth movement in response to the pull of gravity.
When a bean seedling is placed in a horizontal position its shoots curve upwards and its roots curve downward. Hence root is said to be positive Geotropism.

Klinostat is an instrument used for experimental investigation of geotropism and phototropism in seedling and cut shoots.

Experiment

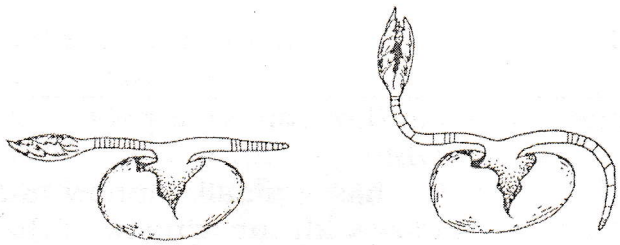
Aim: To investigate the effect of gravity on shoot and root growth in plants

(i) Germinate some bean seeds in two small pots.

(ii) When the radical (roots) and (plumule) shoot have emerged, arrange the seedling in horizontal position.

(iii) Leave the set up for 2 – 3 days in a dark cupboard to liminate the effect of light.

(iv) Observe what happens to the direction of growth of the radicles and plumules.



1. Bean seedling placed in a horizontal position in the dark, with markings at 1mm intervals.

2. The shoot develops an upwards (negatively geotropic) curvature, while the root develops a down ward (positively geotropic) curvature. The markings indicate where cell elongation has occurred.

Figure 6.2.24: Experiment to demonstrate geotropism in root and shoot

Results
For the seedling that was placed in horizontal position, its roots bent downwards and its shoots upwards.

Conclusion
This suggests that the normal direction of growth of roots downwards and shoots upwards is caused by the force of gravity. This movement in response to the stimulus of gravity is called *geotropism.* Hence roots are positively geotropism while shoots are negatively geotropism

Hydrotropism
Is the growth movement of plants in response to a unilateral source of water or moisture.

The roots grow towards the source of water. Hence roots are said to be positively hydrotropism.

Shoot grows away from the source of water which means it is negatively hydrotropism.

Experiment

Aim: To investigate the effect of water on root growth

Procedure

- Hold wire gauze with two retort stands; place some bean seedling on the wire gauze in a such a way that radicles pass through the pores of wire gauze.
- Surround the seedling with wet cotton wool
- Put calcium chloride in the container (drying agent)
- Leave the set up for 2 – 3 clays make sure that the cotton wool is always wet.
- Observe what happens to the roots.

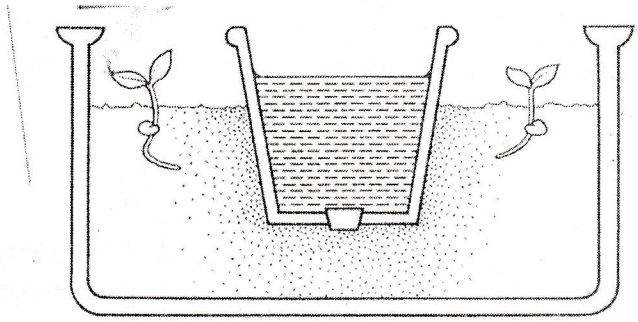


Figure 6.2.25: Apparatus to demonstrate hydrotropism

Results

The radicle had bent upward towards the wet cotton wool because the cotton was the only wet area.

Conclusion

The bending of the radicle was due to the water present in the cotton wool. Hence roots are positively hydrotropic.

Chemotropism

Chemotropism: is a growth movement of plants in response to a unilateral source of chemicals e.g. fertilizer.

Haptotropism (thigmotropism)

Haptotropism is a tropic response in which the stimulus is an object in contact with the plant. Examples, tendrils of gourds and peas, and the stems of morning glory are particularly sensitive to stimuli of this kind.

A tendril is a stem, leaf or part of a leaf which is changed to form a thread – like structure which winds round a support.

Plant hormones
In plant, tropisms are influenced by hormones. Plant hormones are also called **phytohormones.**

Examples of plant hormones are auxins, gibberellins, cytokinnins, ethylene, abscisic acid. These hormones are essential for normal growth of the plants. Some of these hormones promote growth while others inhibit growth.

Auxin
Growth in plant is controlled by the hormone called auxin.

This hormone is produced by the region of cell division which exists at the tip of the coleoptiles. Auxin is responsible for cell elongation in plants. In other words auxin promotes growth in plant shoots by increasing the rate of cell elongation.

Other roles of auxin hormones
Auxins have a wide variety of functions.

- They increase all wall plasticity by loosing the bonding between the cellulose fibres. This decreases the wall pressure, allowing more water to enter, which stretches the cell wall and results in cell expansion.

- Accelerates cell division and may be involved in the division of cambium cells and the formation of callous tissues over wounds.

- Root formations
  Auxins speed the root process in species which are grown by cuttings e.g. rooting auxins are indole butyric acid (IBA) and flower formation is speeded by Naphthalence acetic acid (NAA).

- Flower formation
  Auxins cause flower formation e.g. spray of NAA.
  Auxins inhibit lateral bud development

Effects of auxin concentration in growth
The amount of auxin present in plant is tiny, but changes in the concentration of auxin affect the growth of shoots and roots.

Higher concentration of auxins stimulates growth in shoots while relatively lower concentration stimulates growth in roots.

Concentration of the hormone (IAA) which stimulates shoots growth, usually inhibit root growth.

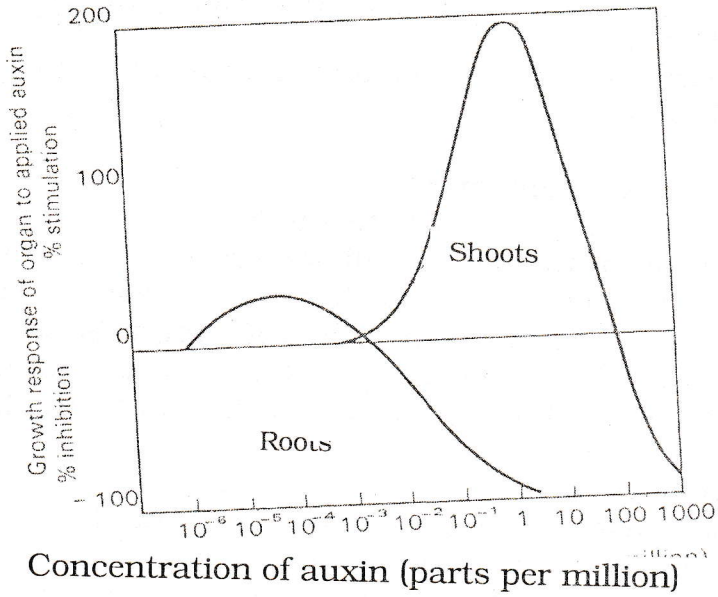


Figure 6.2.26: The effects of auxin concentration on root and shoot growth

However, if the amount of auxin in the shoot continues to increase, there comes a stage where the growth rate begins to slow down. Finally a stage is reached where growth is actually inhibited.

Gibberellins

Is a plant hormone responsible for stem elongation, mainly by affecting cell elongation.

Functions of the gibberellins

- Promotes cell elongation in the presence of auxins
- Promotes cell division in apical meristem and cambium.
- Promotes leaf growth.
- Inhibits growth of roots from cutting and calluses

Cytokinnins

It is a plant hormone which promotes cell division in the presence of auxins. It is responsible in delaying the normal process of ageing in leaves.

Ethylene (Ethene)
It is a plant hormone which promotes ripening of fruits and inhibits growth.

Abscisic acid
It is a plant hormone that inhibits growth in plants. It also causes seed and bud dormancy.

Usefulness of tropic movements
Tropic movements, help the plant to survive e.g. even if the seed is planted upside down the radicle will still grow downwards into the earth because it is positively gravitropic i.e. positive geotropism. Similary plumule of such a seed will grow upwards because it is negatively gravitropic (i.e. negative geotropism) and towards light because it is positively phototropic (i.e. Positive phototropism)

Nastic movements
Like tropisms, nastic movement takes place in the response to external stimulus but the stimulus is not directional. This may result due to change in turgor pressure in certain cells or growth curvature.

Before proceeding further, complete the following exercise.

6.2.11 SELF-CHECK EXERCISE FIVE

1. What is:
   (a) Phototropism? .....
   (b) Hydrotropism? .....

2. What are the main plant hormones?
   .....
   .....
   .....

3. State the role of auxin hormone in plants.
   .....
   .....
   .....

You will find answers at the end of this unit.

6.2.12 SUMMARY OF THE UNIT

- Coordination is the linking of the various system and their activities in the body.
- There are two systems of coordination such as Nervous system and Endocrine system.
- Nervous system is comprised of sensory, motor and relay/intermediate neurons.
- Nervous system (NS) is divided into peripherial Nervous system and central nervous system.
- Central Nervous system is composed of brain and spinal cord.
- Brain is divided into three regions namely: Forebrain, mid brain and hindbrain.
- Spinal cord. Deals with reflex actions. Conditioned reflex action caused by "Learning and practices" for a long time.
- Synapse: A gap between neurons used to transmit impulse.
- Sense organs are the receptor of the body which receives information about conditions both inside and outside the body.
- There are five common sense organ namely; eyes, ears, skin, tongue and nose.
- The eye is made up of three layers such as the sclerotic layer (outermost layer), choroids layer (inner layer) and the retina (innermost layer).

Endocrine system is made up of glands that are ductless; therefore, the hormones are secreted directly into the blood and are then transported to the target organs.

- The endocrine system is composed of several glands. Among these glands are, Pituitary gland, and Gonads.
- Plants like animals respond to changes in their environment. Response of plants to stimuli is called Tropism or tropic response. Plants are stimulated and respond to gravity, water, light and chemicals.
- Growth movement of plants in response to the direction of light is known as phototropism, while in response to the pull of gravity is called Geotropism and in response to the source of water or moisture is called Hydrotropism.
- In plants tropisms are influenced by hormones.
- Plant hormones are also called phytohormones. Examples are ethylene (ethene), abscisic acid, auxins, gibberellins and cytokinnins.

6.2.13 TUTOR MARKED ASSIGNMENT

1. Explain the meaning of
   a) Coordination
   b) Synapse
   c) Phototropism
   d) Gravitropism
   e) Hydrotropism

[25 Marks]

2. a) What is a reflex arc?
   b) Use a well labeled drawing diagram, explain all the events which take place when one accidentally touches a hot object.

(30 Marks)

3. a) List four differences between Nervous system and hormonal system. Use the table below.

Activity	**Nervous System**	**Hormonal System**
a) Method of transmission		
b) Speed of transmission		
c) Speed of response		
d) Duration of response		

   b) Pituitary gland is one of the endocrine glands. Why is it is called a master gland?

(25 Marks)

4. With a well labelled diagram, explain the causes and corrections of the following eye defects.
   a) Short sightedness
   b) Long sightedness

[20 Marks]

6.2.14 KEY ANSWERS TO SELF CHECK EXERCISES

Exercise One

1. (a) CNS consists of the brain and spinal cord.
   (b) Fore brain - cerebrum
   - Mid brain
   - Hind brain; cerebellum and medulla oblongata.

2. Stimulus
   - Receptor
   - Sensory neurone
   - Coordinator
   - Motor neurone
   - Effectors.

3. In the form of nerve impulse.

4. Is a gap between two adjacent neurones that is used to transmit nervous impulse.

3. Responses due to long term learning and practice. Form of reflex actions where the type of responses is modified by past experience.

Exercise Two

1.

Sense organ	Stimulus	Function
Eyes	Light	Vision/sight
Skin	Pressure, heat, touch	Touch/feel
Ears	Sound	Hear, balance
Tongue	Taste	Tasting
Nose	Smell	Smelling

2. a) Eye defect means inability of the eye to alter its local length to see both distant and close objects.

   b)
   - Short sightedness (myopia)
   - Old sightedness (hypermetropia)
   - Astigmatism
   - Cataract.

3. Bitter, sour, salty and sweet.

Exercise Three

1. Drug abuse is a frequent or constant use of drug(s) by an individual without medical prescription or beyond what is needed by the body hence causing ill-health to the individual.

2. Different ways by which individuals abuse drugs.
   - Injection.
   - Inhaling.
   - Swallowing.
   - Applying on the body surface as lotion, ointment or powder.

3. Drug abuse changes the way of thinking and feeling immediately.
   - Some drugs inhibit transmission of impulses across the synapse.
   - Neurones fail to function normally as a result, vision, hearing and speech are depressed.

Exercise Four

1. Hormones are chemical messengers secreted by the endocrine glands and poured directly into the blood which transports them to the target organs.

2. Endocrine glands have no ducts i.e. they are ductless e.g. pituitary gland and adrenal gland. Exocrine glands have duct/tubes. Their secretions are transported by those tubes. For example, sweat glands, digestive glands and oil glands are exocrine glands.

3.

Gland	The hormone
(i) Thyroid gland	Thyroxine
(ii) Adrenal	Andrenaline
(iii) Pancreas	Insulin
(iv) Ovary	Oestrogen
(v) Testes	Androgen e.g. testosterone

4. a) Adrenaline is the hormone secreted by adrenal gland to prepare somebody for emergencies such as fight, fear and fright.

b) Insulin is a hormone produced by the pancreas. It is responsible for lowering the excess blood sugar content in the blood.

c) Anti-diuretic hormone stimulates the kidney tubes to reabsorb more water.

d) Adrogens are responsible for the development and growth of male reproductive systems and male secondary sexual characteristics.

Exercise Five

1. (a) Phototropism is a plant growth movement in response to the direction of light.
   (b) Hydrotropism is the growth movement in response to the source of water.

2. The main plant hormones are:
   - Auxins.
   - Gibberellins.
   - Cytokinins
   - Abscisic acid
   - Ethene/ethylene

3. Auxins control growth in plants by stimulating the growth rate of stems and roots so that the plant increases in height.

UNIT 6.3
REGULATION

CONTENTS

6.3.0.1 INTRODUCTION

Welcome to a new unit called Regulation. In this unit, you will learn how the unwanted metabolic wastes are removed from the body. You will also learn how the body keeps its internal environment constant by the process called regulation. What are metabolic wastes? They are unwanted materials formed as a result of the body metabolic activities.

When we eat, food is used by the body to release energy and do other functions such as repair of worn out cells. As the body utilizes the food it results in the formation of waste, as happened in industries. When the raw materials are used to manufacture useful products like clothes, and medicines, results in the formation of waste which in turn has to be removed. The removal of waste products of metabolism from the bodies of organisms is called Excretion.

The bodies of organisms require maintenance of different substances at a constant level for normal function. This maintenance is called regulation of internal environment of organisms (Homeostasis).

Have a nice study and enjoy the unit.

6.3.0.2 OBJECTIVES

At the end of this unit, you should be able to:

- Explain different ways of increasing and decreasing body temperature.
- Describe the mechanisms for sugar, salt and water balance in the body.
- Outline the effects of high and low blood level in the body.
- Explain the meaning and importance of excretion.
- Name the excretory organs and their products.
- Describe the structure of the human urinary system and its role.
- Explain the process of urine formation.
- Outline the causes, symptoms and effects of complications/disorders of the urinary system such as kidney failure and kidney stones.
- Outline types of waste products eliminated by plants and their importance.

6.3.0 REGULATION

Dear learner, as it has been discussed in the introduction of this unit, the bodies of organisms require maintenance of different substances in the body such as salt and water in a level that will enable the body to function properly. This brings us to the journey of regulation of which I believe you will travel safely until you reach the end.

6.3.1 GENERAL CONCEPT

Regulation is the maintenance of internal environment of an organism to a steady state. The term homeostatic originates from the Greek word which means 'staying the same' and hence we can define it as the control of the internal environment of an organism to constant state.

The ability to control the internal environment of the body is well developed in warm blooded (homoiothermy) animals i.e. birds and mammals.

Mammals regulate the following body conditions:

- Temperature.
- Pressure.
- Water and ions.
- Food materials e.g. glucose.
- Respiratory gases (Oxygen and Carbon dioxide).
- Excretory materials e.g. urea.

6.3.2 REGULATION OF BODY CONDITIONS

Temperature regulation

Metabolic processes in the body are dependant on temperature. This is because the action of enzymes which control the body reactions need only optimum temperatures e.g. when the temperature is very high enzymes are destroyed, hence decreasing the rate of reactions and sometimes completely stops the body reactions and this leads to death. Low temperatures inactivate enzymes hence lowers rates of reactions or no reaction at all.

Factors which lead to the increase or decrease of temperature in the body

I believe you know that sometimes the body's temperature either increases or decreases. It is not always constant at 37^{0}C. Can you tell us what causes the temperature in the body to either increase or decrease? If you can do it congratulations. However, if you can't answer it relax and read the following.

In the bodies of mammals heat increase is caused by the following:
- Tissue respiration. The breakdown of glucose melocules by cells in the presence of Oxygen (oxidation) leading to the production of heat.
- Vigorous muscular exercise.
- Other factors are diseases and absorption of radiation from the sun

The decrease of heat from the body is due to the following factors.
- Radiation.
- Convection.
- Exhaled air.
- Urination and defecation
- Conduction.
- Evaporation by sweating.

Temperature regulation in man

The main organ for heat regulation in man is the skin, but also some amount of heat is lost from the body of man through urine, faeces and exhaled air. Much heat which is lost from the body takes place through the skin. Heat produced in muscles or in other parts of the body is transported by blood to the skin. Heat is lost from the skin through different ways, such as radiation, convection, conduction and evaporation by sweat. The loss of heat from the body keeps the body temperature constant for the better functioning of the body Sweating also brings about cooling effect.

Homoeothermic and poikilothermic

Homoeothermic are organisms whose body temperature is constant while, poikilothermic organisms are those whose body temperature is not constant (their body temperature depends on the environmental temperature).

Homoeothermic organisms have the ability to regulate their body temperature by loosing the excess heat if it is high and increases if

it is very low by increasing the catabolic processes of their bodies (e.g. birds and mammals).

The body temperature of poikilothermic organisms is controlled by the surrounding/environmental temperature. When the surrounding temperature is very high the organisms in this group overcome it by moving in cool places and vice versa when the surrounding temperature is cool. (Examples: Lizards, snakes, crocodiles, toads, earthworms).

Adaptation of Homoeothermic to cold and hot surrounding

Homoeothermic organisms are adapted to live in the cold places using one or more of the following:-

- Increase muscular activities e.g. shivering.
- Insulations: retention of body heat by insulations using fur, clothing or a thick layer of fat beneath the skin.
- Hibernation: other organisms become dormant by lowering their metabolic rates during cold seasons, and use stored body fats at a very low rate.
- Migration: some organisms migrate (move) to warmer places during cold seasons e.g. insects, fishes, birds and mammals.
- Constriction of blood vessels. This limits the loss of heat through the skin.
- Small surface area to volume ratio; Animals in colder climates have a tendency to have bodies that are more compact, with smaller extremities than related species in warm climates. In this way, heat loss is reduced.

Homoeothermic organisms are also adapted to live in hot surroundings

In order to avoid overheating, some means of adaptations have been developed and are as follows:

- Nocturnal habits: Nocturnal animals live in burrows during the day and come out at night when it is cool.

- Vasodilation: This is the widening of blood vessels causing more sweating through which heat is lost through evaporation of sweat. Sweat evaporation has a cooling effect to the body.

- Hairless parts in some animals: Some animals have hairless parts richly supplied with blood capillaries. E.g. large amount of heat is lost through the elephants ears.

- Panting: This is common in animals of the dog family as they lack or have a few sweat glands. These animals hang their tongues outside and increase their breathing rate. Evaporation occurs in the mouth, tongue and the upper respiratory system.

- Relaxation of the erector muscles: This makes the hair lie flat against the skin and in that way, allows heat to be lost from the body by radiation.

Regulation of glucose

In respiration you learnt that soluble blood sugar (glucose) is the source of energy to all living cells. The brain and nerve cells have no energy reserves and must have a continuous supply of glucose.

If deprived of glucose the cells are harmed and the body may suffer convulsions and enter into a comma.

The normal glucose concentration in blood plasma (and hence in tissue fluid) is in the range of 0.06% a mean value of 1.1%. Different mammals have different uptakes of carbohydrates and some meals may have more carbohydrate than others. Inspite of this, the blood plasma concentration of glucose must be maintained at the norm of 1.1%.

The mechanism of glucose regulation

The liver, pancreas and adrenal gland function in a complex homeostatic mechanism of maintaining the constant level of blood sugar at 1.1%.

Glucose addition to blood

Addition of glucose occurs when the concentration falls down below the norm value, the condition called *hypoglycaemia.* Sensory centre in the brain detects a low glucose concentration and by negative feedback sets off the following:

- Glycogen reserved in the liver are changed into glucose by glucagons hormone released by the pancreas. In this way, sufficient glucose can be provided from the liver reserve for maintaining the normal for 12hrs.

- If the liver glycogen reserves are consumed and there is no more intake of carbohydrates, the non-carbohydrate food reserved are used. Lipids from the fat deposits are changed into glucose by adrenaline (as seen in sliming). Protein of muscles are converted

into glucose by another adrenal gland hormone called glucocorticoid e.g. cortisol. These cause the liver to convert amino acids and glycerol into glucose.

Removal of glucose from blood

An increased concentration of blood glucose level above the normal level causes high blood sugar (Hyperglycaemia). Sensory centres in the pancreas and brain by negative feedback set off the following corrective mechanisms:

- The pancreas produces the hormone insulin which causes the liver to remove surplus excess glucose and change it into insoluble glycogen which is then stored in the liver and skeletal muscles.

- Further surplus of glucose is then converted into lipids and stored into fat deposits.

When the concentration of blood sugar increases above the normal level, it causes hyperglycaemia, glucose then appears in urine and the person gets the symptoms of *diabetes mellitus.*

Regulation of proteins

In the mammal body protein is used for building up of new tissues, and replacing the worn out ones. Some protein is used by the body to release energy needed for performing various activities of the body particularly during prolonged starvation/short of carbohydrates.

Addition of protein (amino acids)

The decrease of protein in the body of mammals is due to:-

- The breakdown of protein (as amino acids) into urea by the process called deamination;
- used to release energy during tissues respiration;
- stored in the body as glycogen after being changed into carbohydrate;
- Used in protein synthesis a process whereby the body forms new proteins in the body using the one taken in through food materials.

Mechanism of protein regulation

You know that the body can only store a small amount of amino acids and proteins when a meal supplies more than those the body needs. The body gets rid of extra protein by the process called *deamination.*

Deamination is the removal from each amino acid molecule of the parts which contains nitrogen, i.e. the amino group (-NH). These amino groups would automatically change into ammonia (NH_3) which is very poisonous. The liver cells immediately change it into urea which is far less poisonous. Urea then passes from the liver into the blood and is eventually removed from the body by the kidneys. The remaining parts of each amino acid molecules which contains no nitrogen is converted into glucose and is either stored or used for respiration.

Regulation of water and mineral salts in animals

Water enters the body through drinks and food; this is also applied to mineral salts. The uptake of these substances should be controlled to keep them constant in the body fluid. If water is left to rise above the normal level, then water will tend to enter the cells by osmosis continuously until the cells burst. If the concentration of salts in blood and tissues fluid is left to rise above the normal level, then water will begin to leave the cells leaving them without enough amount of water for them to continue with life activities. If water and mineral salts won't be regulated death may occur.

Factors leading to the increase or decrease of water and mineral salts in the human body

Increase

- Direct taking of water by drinking.
- Taking it together with food substances which have water contents.
- Oxidation of sugars in the body which leads to the release of water. About 100g of sugar gives 60g of water.

Decrease

Water and Mineral salts are decreased from the body through the following ways,

- Removal through the skin by sweating
- urination
- Through defaecation.
- Through exhalation.
- Through excessive bleeding

Respiratory gases

Metabolizing cells require a constant supply of oxygen sufficient to satisfy their respiratory needs. The homeostatic control of both

oxygen and carbon dioxide is very essential and is controlled by the respiratory centre in the medulla oblongata.

Pressure

The maintenance of all substances in the body depends on the blood pressure. This is so because the blood is the major distributor of substances in the body. It is essential that the blood pressure be kept above a certain minimum level if the supply of essential materials to cells is to be maintained. This is achieved by controlling the rate at which the heart pumps blood and by the vasoconstriction or vasodilation of blood vessels.

Before proceeding further, complete the following exercise.

6.3.3 SELF CHECK EXERCISE ONE

1. Explain the meaning of the term homeostasis/Regulation.
   .....
   .....

2. State the processes that lead to:

   (a) Increase of body temperature in mammals.
   .....
   .....

   (b) Decrease of body temperature in mammals.
   .....
   .....

3. How are mammals adapted to hot climatic conditions? Give one example.
   .....
   .....
   .....
   .....

Compare you answers with those given at the end of the unit.

6.3.4 EXCRETION

Chemical reactions take place in the human body. There are those which break down the body component substances and those which build up the body. In the process, excess water, salt, carbon dioxide and nitrogenous compounds are produced. These accumulate in the body cells such that if they are allowed to remain in the body for a long time there will be no room for other chemical reaction to take place. To solve this problem, these metabolic wastes are removed out of the body through excretion process. In this unit the urinary system of the human body and its components will be fully covered. Excretory organs, their structure and functions will also be covered effectively. Before going far let us first define the term excretion.

Excretion is the process by which metabolic wastes are removed from the body. These metabolic wastes include excess water and salts, carbon dioxide from cellular respiration, nitrogenous compounds from the breakdown of proteins, and urea. The skin, lungs, the liver and kidneys along with their associated organs make up the excretory system.

THE URINARY SYSTEM

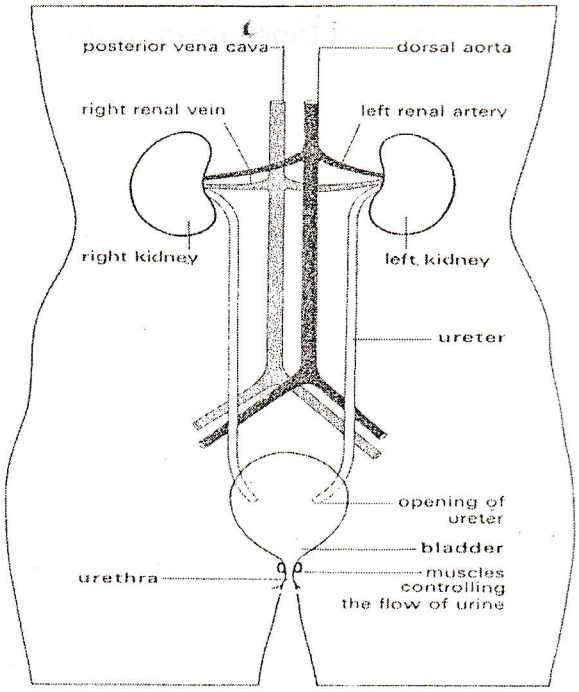


Figure 6.3.1: The urinary system of human

The urinary system of human consists of the following parts.

- Renal artery; carries blood to the kidney.
- Renal vein; carries blood away from the kidney.
- The kidney; a bean shaped organ in which osmoregulation of water, removal of excretory substances and reabsorption of useful materials take place.
- Ureter; a tube which carries urine from the kidney to the bladder.
- Bladder; is a part of the urinary system which temporally stores urine before ureleases it out of the body through urination.
- Sphincter muscle is a muscle which controls the release of urine from the bladder.
- Urethra; is a tube which leads to the body surface from the bladder which carries urine out of the body.
- Functions of the excretory system.
- Collects water and filters body fluids.
- Concentrates waste products from the body fluids and returns useful substances to body fluid which are necessary for homeostasis.
- Eliminates excretory products from the body.

THE KIDNEYS

The main organ for the excretory system is the kidney. Humans have two bean-shaped kidneys, one on each side of the spinal cord near the lower back, (one behind the stomach the other behind the Liver). Together they regulate the chemical composition of blood.

Structure of kidney

The Kidney has THREE regions; the inner part called the **renal medulla**; the outer part called the **renal cortex** and the **renal pelvis**, a funnel shaped structure in the centre of the kidney responsible for collecting urine from collecting ducts.

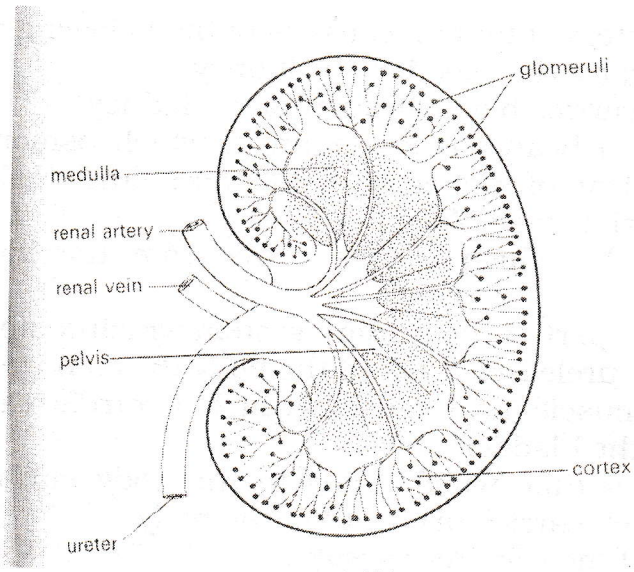


Figure 6.2.3: Section through kidney

The cortex

This layer is jam-packed with lots and lots of nephrons. *Nephrons* are the basic functional units of the kidney. Each nephron is a small independent filtering unit. In each kidney there are about 1 million nephrons.

The medulla

This is the middle layer. Think of it as the collecting layer. Tubes carrying filtered wastes pass from the cortex, through the medulla towards the pelvis.

The pelvis

This is the area where all of the collecting tubules come together and connect with the ureter. The ureter transports the urine to the urinary bladder.

Each human kidney contains about one million kidney tubules (nerphons), each of which begins in the cortex of the kidney, where each is expanded in cup- shaped structure called **Bowman's capsule**. In the Bowman's capsule are enclosed a ball of finely divided and intertwined blood capillaries called **Glomerulus** (plural Glomeruli).

Functions of Kidneys

- Excretion of metabolic wastes.
  - The kidneys excrete breakdown products of protein metabolism (urea, uric acid, creatinine, and ammonia).

- Regulation of acid-base balance.
  - By regulating the acidity of urine and selecting which electrolytes are reabsorbed or excreted, the kidneys help to maintain blood pH within normal limits

- Regulation of extracellular fluid volume.
  - The kidneys regulate the volume of extracellular fluid by eliminating or retaining water.

- Regulation of osmotic pressure of extracellular fluid.
  - By regulating the amount of sodium chloride and water excreted, the kidneys regulate the osmotic pressure of the extracellular fluid.

- Regulation of extracellular electrolytes.
  - The kidneys regulate electrolyte concentration in the body by selective reabsorption or excretion.

- Regulation of blood pressure.

- Regulation of red blood production.

- Control of excretion of water.
  - The reabsorption of water in the tubules is controlled by pituitary and hypothalamic actions. The posterior pituitary produces antidiuretic hormone (ADH), which increases the amount of water reabsorbed. The adrenal cortex produces the hormone aldosterone, which influences the reabsorption of sodium and water.

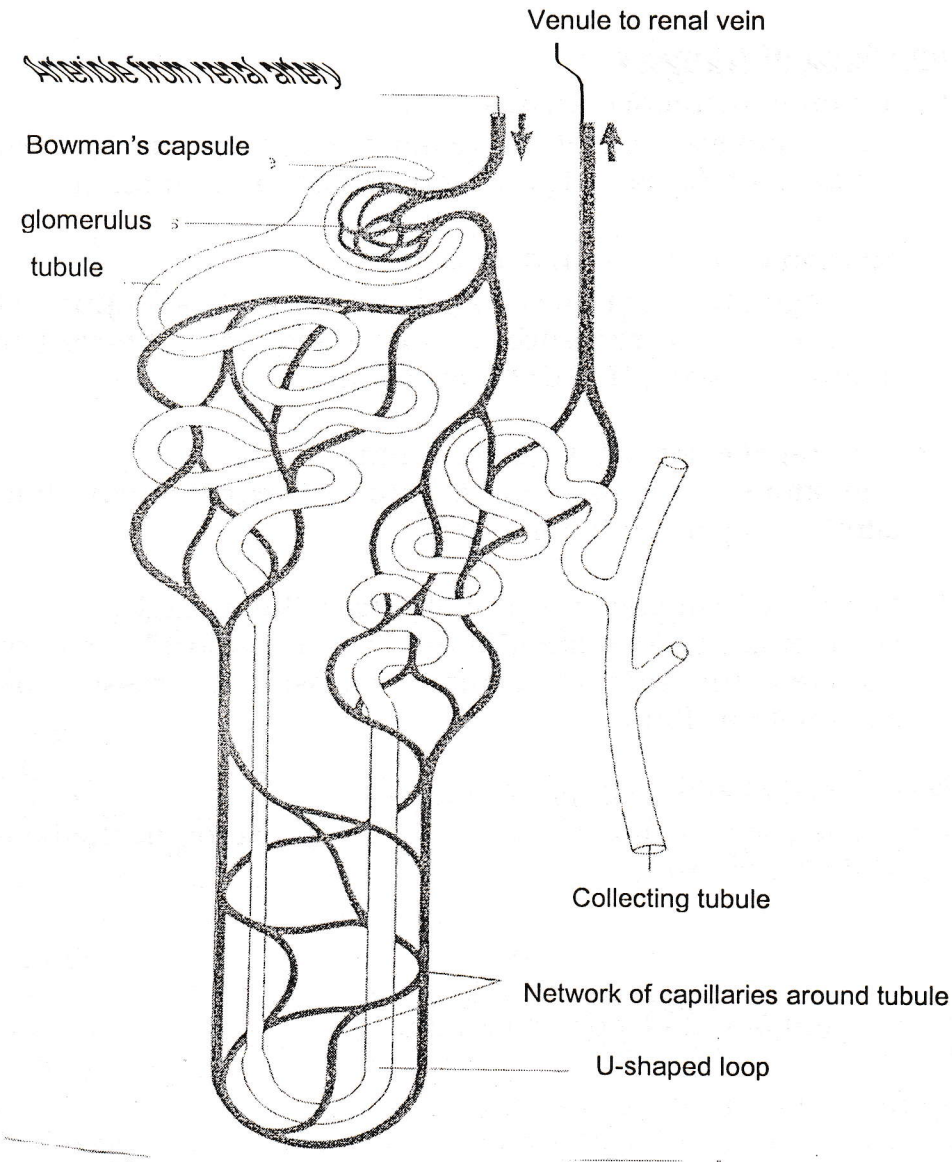


Figure 6.3.3: Structure of a nephron

The outermost layer of the kidneys, the cortex, is composed of approximately 1,250,000 structural units called nephrons.

When blood enters a Nephron, it flows into a network of 50 Capillaries known as a **glomerulus**. The Glomerulus is encased in the upper end of the Nephron by a Cup-Shaped structure called **bowman's capsule**. The Blood is under pressure and the walls of the capillaries and Bowman's capsule are permeable. Much of the Fluid from the blood filters into Bowman's capsule and the material filtered from the blood flows through the renal tubule, a long tube with permeable walls.

The Renal Tubule Consists of three parts: **The proximal convoluted tubule, the loop of Henle, and the Distal convoluted tubule**. Materials from blood are forced out of the glomerulus and into the Bowman's capsule during a process called **ultrafiltration**. The materials that are filtered from the blood are known as **filtrate**. The Filtrate contains water, urea, glucose, salts, amino acids, and vitamins. Plasma proteins, cells and platelets are too large to pass through the membrane; they remain in the blood.

About 180 litres of filtrate is produced each day, but only 1.5 litres of urine. So as you can see, most materials that initially enter the nephron are reabsorbed, leaving only the urea, salts, and some water in the tubule. These metabolic wastes form **urine,** which is transported to the urinary bladder by the ***collecting tubule*** and then transported out through the urethra.

Ultrafiltration

Ultrafiltration occurs in the Renal or Bowman's capsule. The renal artery which brings blood to the kidney is split up into numerous arterioles, each feeding a nephron. The arterioles split into numerous capillaries which form a knot called a **glomerulus**. This is surrounded by the **Bowman's capsule**. The arteriole leading into the glomerulus is wider than the one leaving it so there is a high blood pressure in the capillaries of the glomerulus. This pressure forces plasma out of the blood by ultrafiltration. Once the blood is filtered in this way only blood cells and the large plasma proteins remain i.e they are not filtered.

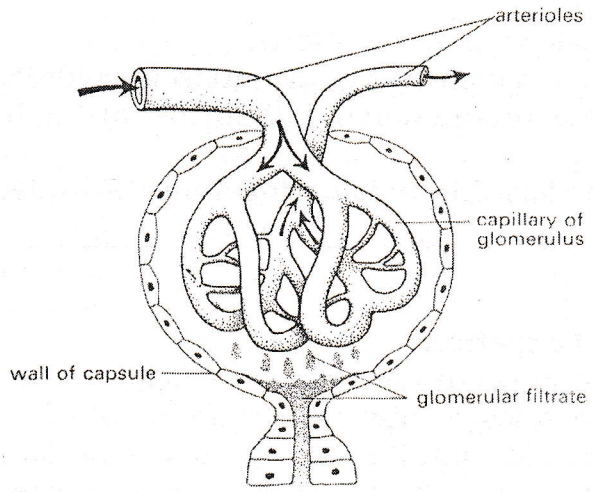


Figure 6.3.4 : Bowmans capsule and glomerulus

Selective Reabsorption

Selective reabsorption occurs in the **proximal convoluted tubule.** This is the longest and widest part of the nephron. In this part over 80% of the filtrate is reabsorbed into the blood; ensuring that all useful material is returned to the blood. All glucose, amino acids and 85% of mineral ions are reabsorbed by active transport. Small proteins are reabsorbed. 80% of water is absorbed back into the blood by osmosis. The proximal convulated tubule cells have many mitochondria to provide Adenosine Triphosphate (ATP) for active transport and mirovilli to increase surface area for absorption.

Loop of Henle

This is a u – shaped part of the nephron found below the proximal convoluted tubule. The loop is responsible for reabsorption of water so that water is conserved in the body of land animals such as birds and mammals.

Example; desert mammals like camels have longer loops of henle for maximum reabsorption of water.

Distal convoluted tubule and collecting duct

The distal convoluted tubule and collecting duct are the last parts of the Nephron (kidney tubule). These parts control the reabsoption of water and salts. This process is called **osmoregulation.** The reabsorption of water is influenced by Antidiuretic Hormone (ADH) or vasopressin.

ACTIVITY: 6.2.6

1. Explain the following observations;
   (a) Why there is a high rate of urination in cold days?
   (b) Why there is production of little urine during hot days?

2. Why does one feel thirsty following a meal? Explain.

The Lungs and Excretion

Cellular respiration occurs in every living cell in the body. It is the reaction that provides energy (in the form of ATP molecules) for cellular activities. If respiration stops, the cell no longer has energy for cellular activities and the cell dies. As respiration occurs **carbon dioxide** is produced as a waste product. As the carbon dioxide accumulates in body cells, it eventually diffuses out of the

cells and into the bloodstream, which eventually circulates to the lungs. And here, in the alveoli of the lungs, carbon dioxide diffuses from the blood, into the lung tissue, and then leaves the body every time we exhale. We should note that some **water vapour** also exits from the body during exhalation.

The liver

The liver is a large and important organ. In fact it is the largest internal organ in our bodies. Its numerous functions make it "part" of the circulatory, digestive, and excretory systems. Below is a chart the summarises the functions of the liver.

Table 6.2.5 Functions of the liver

Excretory Function	Some proteins and other nitrogenous compounds are broken down in the liver by a process called *deamination*. As a result of these reactions, a nitrogenous waste called *urea* is formed.
Digestive Function	The liver produces bile, which is temporarily stored in the gall bladder before being released into the small intestine where it helps "emulsify" (break down) lipid molecules.
Circulatory System	The liver removes and breaks down the old red blood cells. It is also responsible for maintaining "normal" levels of glucose in the blood. When stimulated by insulin, the liver removes glucose form the blood and converts it to glycogen for storage. When stimulated by the hormone glucagons, the liver does the opposite: it breaks down glycogen, producing glucose, which is released into the bloodstream. The liver is also responsible for removing potentially hazardous chemicals from the blood. It "detoxifies" the blood. For this reason, alcoholics and other types of addicts have a higher incidence of liver disease.

THE SKIN

Sweat comes out of pores in the skin. Sweat is a mixture of three metabolic wastes: water, salts, and urea. As one sweats, the body accomplishes two things:

- Cooling effect on the body.
- Removal of metabolic wastes.
-

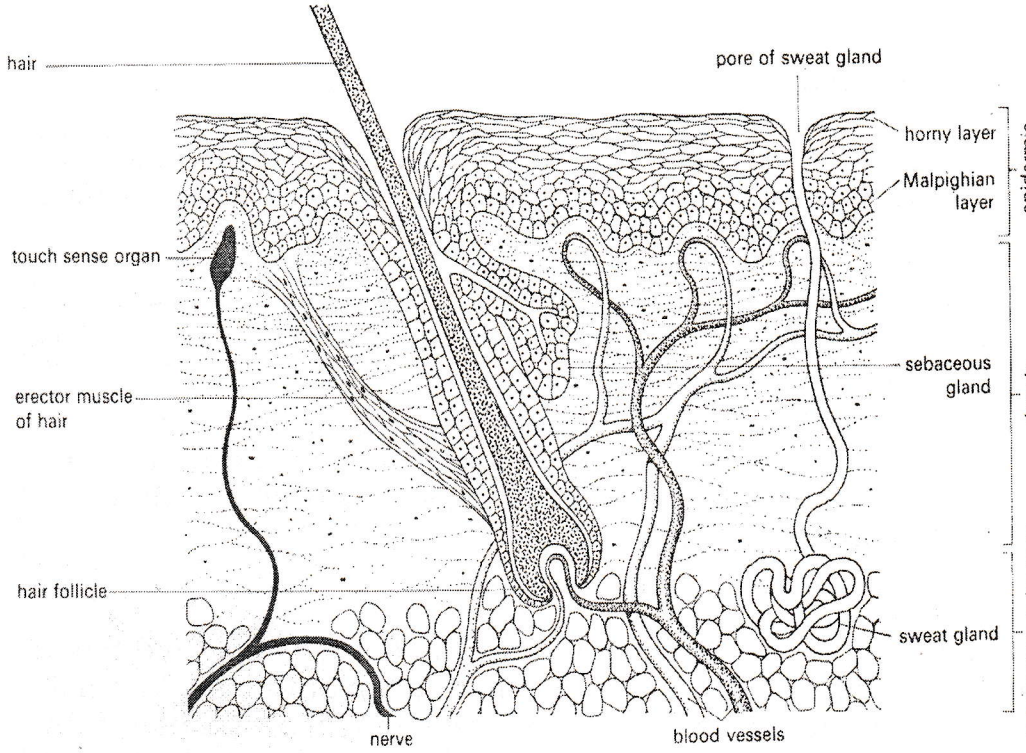


Figure 6.3.5: The human skin

The skin has two layers which are the thin epidermis at the top, and the thicker dermis below.

The inner layer of skin (dermis) is where we find oil glands, hair follicles, fatty layers, nerves, and sweat glands. The sweat gland is a tubular structure tangled with capillaries. This close association of tubes allows wastes to diffuse from the blood into the sweat gland. When body temperature rises, the sweat is released from the gland, passes through the sweat duct up to the skin surface through openings called pores (sweat pores).

6.3.5 DISORDERS/COMPLICATIONS OF THE URINARY SYSTEM

Kidney failure

Kidney failure can be caused by:

- Ageing process;
- Bacterial infection of the pelvis and surrounding tissues;
- Inflammation of the glomerulus due to antibodies produced against certain bacterial infections e.g. throat infection;
- Damage due to high pressure;
- Damage due to obstruction in the ureters, bladder or urethra e.g. by kidney stones;
- Diabetes mellitus;
- Reduced blood supply to the kidney as a result of blood loss through an accident, heart failure to pump blood or toxic chemicals; and
- Physical damage of the kidney e.g. in an accident.

Symptoms

- Reduction in urine production or no urine at all.
- Pain.

Effects of urinary system disorders

- Dehydration (loss of water in the body)
- Salt imbalance
- Severe high blood pressure
- Accumulation of metabolic wastes (nitrogenous wastes) like urea in the body.
- Coma (become unconscious) and convulsions.
- Pain

Interference of metabolic reactions by the nitrogenous wastes which lead to death of the individual.

6.3.6 EXCRETION IN PLANTS

There is no specific organ for the osmoregulation of substances in plants. Water intake is by means of both internal and external factors which affect the rate of transpiration. Plants share with animals the problem of obtaining water and in disposing of the surplus. However, some plants have leaf modifications to reduce water loss, such as needle shaped leaves, sunken stomata and thick cuticles as in pines.

Plants produce waste products very slowly. Their main products are water, oxygen (during the day) and carbon dioxide at night. These are removed by diffusion through the stomata and lenticels at much the same as they are produced.

Plant waste products also include small amounts of the following:-

- **Tannins:-** found in the bark of many trees including acacia.
- **Alkaloids:**-Very poisonous nitrogenous compounds some of which are used in small doses as medicine e.g. Quinine and morphine.
- **Anthocyanins:**- which produce the red, purple and blue colour of petals and dying leaves.

Plants deal with these waste products by converting them into insoluble compounds often in the form of granules or oil droplets, which remain in the cells. They are removed from the plant when dead leaves, barks or other parts fall off.

6.3.7 SUMMARY OF THE UNIT

Homeostasis/Regulation is the maintenance of the internal environment of an organism to a steady/constant state.

For normal functioning, the body must regulate the components of the body fluid e.g. temperature, glucose, water, ions, CO_2, metabolic wastes and pressure.

The mammalian body loses heat through radiation, convection, conduction evaporation by sweating, exhaling air, urine, faeces and panting.

The human body regulates blood sugar (glucose) to a constant level to avoid either hypoglycaemia (low blood sugar) or hyperglycaemia (high blood sugar) which leads to diabetes mellitus.

Mineral salts have to be regulated so as to maintain the amount of water in the body fluids (water balance).

Respiration gases; oxygen (O_2) and carbon dioxide (CO_2) are also regulated to avoid oxygen poisoning and suffocation due to carbon dioxide.

Excretion is the removal of metabolic waste from the cells. Metabolic waste is the unwanted material that is formed as a result of the bodies metabolism (i.e. the large number of chemical reactions that occur in the cells, tissues, and organs). The waste products of metabolism are frequently toxic and so must be removed from the body.

The structures which are responsible of removing these wastes are:
- Skin; excretes water, salts and urea.
- Liver: Breaks proteins and other nitrogenous compounds in the process called domination to form urea which is excreted from the body by the kidney.
- Lungs: Excrete carbon dioxide released during respiration.
- The kidney:

The kidney has two main functions:
i) Removes metabolic waste from the body.
ii) Regulates water and ion content in the blood.

The kidney has structures called nephrons which are the functional unit of the kidney.

The following processes occur in the rephron to facilitate the functions that the kidney does.

- Utrafiltration.
- Selective reabsorption.
- Reabsorption of water osmoregulation

Before Proceeding Further, Complete the Following Exercise.

6.3.8 SELF CHECK EXERCISE TWO

For the first bunch of questions (1-8), your answer is (liver, lungs, skin, or kidneys).

1. Excretes salts from its surface .....

2. Responsible for excreting carbon dioxide .....

3. Has functional units called nephrons .....

4. Produces both urea and bile .....

5. Organ in which blood loses urea and reabsorbs glucose and amino acid .....

6. Removes old red blood cells from the circulatory system. .....

7. Maintains homeostasis by removing body heat, water and other wastes .....

8. Adds or removes glucose from the blood as necessary .....

9. Which is the correct pathway for the elimination of urine?
   a) urethra, ureter, bladder, kidney.
   b) kidneys, urethra, bladder, ureter. [ ]
   c) bladder, ureter, kidney, urethra.

10. In humans, for carbon dioxide to be excreted, it must pass from the blood into:
    a) nephrons
    b) alveoli
    c) Sweat gland [ ]
    d) The liver.

11. A blockage in a ureter would interfere with:
    a) urine entering the kidney.
    b) urine entering the bladder. [ ]
    c) urine leaving the body.
    d) urea leaving the kidney.

12. Which is NOT a metabolic waste in humans?
   a) Carbon dioxide.
   b) Oxygen [ ]
   c) Salt
   d) Urea

13. In which form are nitrogenous wastes excreted in humans?
   a) Ammonia
   b) Uric acid
   c) Urea [ ]
   d) Amino acids.

14. Nitrogenous wastes are the result of metabolism involving:
   a) Lipids
   b) Carbohydrates
   c) Inorganic [ ]
   d) Proteins

15. In addition to water, the principal components of urine are:-
   a) Amino acids and fatty
   b) Urea and salts
   c) Ammonia acid and bile acids [ ]
   d) Hydrochloric acid and urea

Compare your answers with those given at the end of the unit.

6.3.9 TUTOR MARKED ASSIGNMENT

Now answer the following questions in the workbook provided and deliver it to your tutor for marking and commenting

1. (a) Differentiate between the following terms;
   (i) Osmorgulation and homeostasis.
   (ii) Vasodilation and vasoconstriction.
   (iii) Excretion and defecation.

   (b) What would happen to the human body if waste were allowed to accumulate in the body after being produced?

   [25 Marks]

2. Explain how heat is lost and gained by a body of a mammal.

   [15 Marks]

3. Explain how homoeothermic over-come the problem of being overcooled.

   [25 Marks]

4. Briefly describe the way blood sugar is kept constant in the body of human being.

   [25 Marks]

5. After drinking alcohol, Mr. Sumaye urinates more frequently than normal. Explain why?

   [10 Marks]

6.3.10 KEY ANSWERS TO SELF CHECK EXERCISES

Exercise One

1. Homeostasis/regulation is the adjustment of body internal conditions to a constant or steady state.

2. (a) Vasoconstriction of blood vessels to reduce blood with health flow to the superficial skin.
   - The skin hair and fur become erected and trap air above the skin (a poor conductor of heat) which prevents heat loss through convection and conduction.
   - Shivering (vigorous muscle contraction)
   - In man, production of goose – pimples.
   - A layer of fat in the skin (poor conductor of heat) insulates the body against heat loss.
   - Hibernation mammals become inactive.

   (b) Reduce metabolic rate
   - Vasodilation and loss of heat by evaporation.
   - Panting by dog family
   - Relaxation of hair muscle of mammals.

3. Adaptation to hot climate.
   - Reduction in body size e.g. kangaroo rat which can go into burrows during the day.
   - Large ears in elephants for losing the excess heat.
   - Body with large surface area compared to volume ratio.

Exercise Two

1. - Skin
2. - Lungs
3. - Kidney
4. - Liver
5. - Kidneys
6. - Liver
7. - Skin
8. - Liver
9. - D
10. - B
11. - B
12. - B
13. - C
14. - C
15. - B

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