BIOLOGY

A Textbook for Grade 12

B12TB

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Foreword

Liberia, having gone through a period of utmost turmoil till 2003, due to the civil wars, is still reeling under its effect and the added trauma of Ebola in 2014 and effects of the COVID-19 outbreak in 2020. The Liberian government, in the past decade, has made valiant efforts to bring order to the lives of its people. In one such effort, the Ministry of Education (MoE) brought changes to the National Curriculum Framework which are relevant to the present generation, and which would prepare them to meet the challenges of the changing trends of the world. The National Curriculum Framework (NCF) 2018 recommends a change in basic assumptions in the teaching learning process from behaviorist to constructivist approach — moving from hardcore print material to the digital world. Keeping in consideration the sociocultural context and varied experiences of learners as laid down in the Framework, our Teaching Learning Materials are expected to be competent to use multiple methods and techniques like e-learning resources, energized textbooks, and readily available reference material to engage the learners.

As a first initiative, the MoE, through its World Bank-funded Improving Results in Secondary Education (IRISE) project, has adapted textbooks for Grades 10 to 12 in five subjects — English Language and Literature, Mathematics, Biology, Physics and Chemistry.

The National Curriculum Framework, 2018, recommends that children's learning at school is a reflection of their life outside the school and shows them the path to become a responsible citizen who makes knowledge-based choices.This principle marks a departure from the legacy of teacher centered learning to student centered learning. The syllabi and textbooks developed on the basis of the NCF indicate a serious attempt to implement the idea of Activity Base Learning (ABL). We hope these measures will take us ahead in the direction of building a system of education as outlined in the NCF.

Combined with the efforts by the school principals and teachers this will encourage children to reflect on their own learning and to pursue imaginative activities and questions.With this in mind, perhaps for the first time in our country, we are able to provide separate subject specific textbooks accompanied with guides for teachers for 10–12 grades. Not only have these been developed, adapted and modified to the Liberian context, each of the eight Minimum Learning Competencies (MLCs) have been included in each textbook. So as to reach every high school student, for the first time in the country's history we have included the digitized form of the textbook accessible by a Quick Response (QR) code given in each book. Not only does it have the digitized textbook, but it provides additional learning materials for use by students, teachers and interested persons. The links to these e-resources and digitized material is being made available on the MoE's website.

The Textbooks and Teacher Guides have reached the hands of the students after a rigorous quality evaluation by carefully handpicked subject specialists by the MoE, to whom the Ministry expresses gratitude. For the success of this project, I acknowledge the contributions of the IRISE Project Team in the World Bank, and in particular, the Task-Team Leaders; the Project Implementation Team in Liberia headed by its Coordinator Abraham A. Kiazolu II, supported by the Executive Director of the Center of Excellence for Curriculum Development and Textbooks Research, Mrs. Julia K. Sandiman-Gbeyai and her technical working group (TWG), and the International Textbook Consultant and Advisor, Dr Shveta Uppal engaged by the MoE. These notwithstanding would not have been possible without the guidance of the Senior Management Team (SMT) of the Ministry of Education, and in particular, the Deputy Ministers for Instructions, Administration, and Planning, Research and Development, respectively.

Professor Dao Ansu Sonii, Sr.
Minister of Education
Republic of Liberia

Monrovia, Republic of Liberia
January 24, 2023

Acknowledgments

The development of textbooks contributes to the quality of teaching and learning that go on in the classroom.

The Ministry of Education (MoE) has aligned its Curriculum for Grades 10–12 to the National Curriculum Framework (NCF) of 2018. To ensure the provision of Teaching Learning Materials (TLMs) that support the revised curriculum, the Ministry has sought, reviewed and adapted a new set of textbooks and teacher guides along with digitized contents and e-learning resources for the five core subjects taught at the Senior Secondary education level, namely English Language and Literature, Mathematics, Biology, Chemistry and Physics, through an internationally competitive bidding process from the market supported by the World Bank funded Improving Results in Secondary Education (IRISE) Project.

With profound gratitude and honor, we recognize the Senior Management Team of the Ministry, headed by the Coach, Professor D. Ansu Sonii, Sr., for the strategic decision to make teaching learning materials available and accessible to all in the Liberian Senior Secondary School System, and for providing directions through the process of securing these textbooks and other teaching learning materials for our students and teachers. Our special thanks and appreciation to the World Bank for the financial support towards this policy intervention, and its education task-team including Alonso Sanchez, Oni Lusk-Stover and Binta B. Massaquoi for all their technical inputs offered throughout the process to ensure the kind of quality TLMs the Liberian students deserve are made available for improved learning outcomes.

We would like to specifically recognize the invaluable contributions of the 15 subject experts selected by the MoE from across the various education systems and the West African Examinations Council (WAEC) to evaluate, review and sign off on these teaching learning materials. They didn't just deliver according to our expectations, but also ensured the contextual relevance of the materials to the Liberian Secondary Education Curriculum and its minimum learning competencies (MLCs). These subject experts include Professor Isaac Saye-Lakpoh Zawolo – *Superintendent* of the Monrovia Consolidated School System (MCSS), Mr. Matthew V.Z. Darblo, Sr. – *Mathematics Instructor* at the University of Liberia (UL), Mr. Charles Tieh Bropleh – *Mathematics Specialist* (MoE), Mrs. Linda Y. Dean – *English Specialist*, Mr. Hassan M. Bangura – *English Language and Literature Expert*, Mr. J. Emmanuel Milton – *English Specialist* (MoE), Mr. Moses K.M. Togbah – *Physics Specialist*, Mr. Prince A. Dossen – *Physics Specialist*, Mr. Benjamin Koryah – *Physics Instructor* at the University of Liberia (UL), Mr. Dominic Dugbe Doe – *Chemistry Specialist*, Mr. Patrick A. Anderson, Sr. – *Director of* the Division of Technical and Vocational Education (MoE), Mr. Kandakai Massaquoi – *Chemistry Specialist*, Ms. Patricia N. Doe – *Head* of Biology Department, African Methodist Episcopal University (AMEU), Mr. Job Carpenter – *Biology Specialist* and Mr. Prince Philip K.A. Aderibigbe – *Biology Specialist*.

The MoE is sincerely grateful to Dr Shveta Uppal, the *International Textbook Consultant* engaged by the IRISE Project to provide technical guidance and quality assurance support to the revising of the Textbooks Management Guidelines (TMG) and the procurement process leading to the provision of textbooks, teacher guides, digital contents and e-learning resources for the Senior Secondary School System in Liberia in accordance with the revised TMG. Heartfelt thanks and appreciations also to the *Executive Director* for the Center of Excellence for Curriculum Development and Textbooks Research, Mrs. Julia K. Sandiman-Gbeyai, and members of her Technical Working Group (TWG) for taking up the responsibility to lead the process of making textbooks and other TLMs available to Liberian students and teachers.

Lastly, we acknowledge the IRISE Project Delivery Team led by Mr. Abraham A. Kiazolu, II – *Project Coordinator*, Mr. Fuseini A. Abu – *International Procurement Specialist* and Mr. Lawrence S. Taylor – *Project Control Specialist* who coordinated the entire process.

We remain grateful to you all!

Hon. Alexander N. Duopu, Sr.,
Deputy Minister for Instruction
Ministry of Education, Republic of Liberia
#The Teacher

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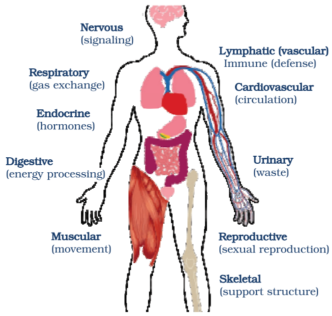

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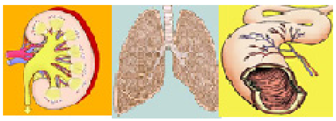

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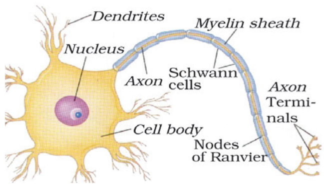

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CHAPTER 1

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CHORDATA: AVES (BIRDS) AND MAMMALS

Chapter Contents

1.1 Class: Aves (Avis = Bird)
1.2 Class Mammalia (Mamma: Breast)
- Key Terms
- Summary
- Review Exercise
- Sample Test

Chapter Outcomes

Upon completion of chapter, learners will be able to:

- discuss the general characteristics of birds and mammals;
- relate the adaptations of birds to flight;
- describe the external and internal features of birds;
- classify mammals on the basis of class, structure, and types of reproduction;
- explain the control mechanisms of body temperature in mammal.

Introduction

You have learnt about the basic aspects of classifying organisms and about the three lower kingdoms:

Monera *(Prokaryotic, unicellular rarely multicellular and filamentous)*, Protoctista *(Eukaryotic, unicellular)*, Fungi *(Eukaryotic, uni- or multicellular, and heterotrophic)* and kingdom Plantae *(Eukaryotic, multicellular and autotrophic)* and lower members of kingdom Animalia (Eukaryotic, multicellular and heterotrophic).

In this lesson, you will study about the remaining higher members of kingdom Animalia (Eukaryotic, multicellular and heterotrophic).

1.1 Class: Aves (Avis = Bird)

A. General Characteristics

Birds are feathered vertebrates. Females lay hard - shelled amniotic edges.

Birds have beaks for food gathering.

- With over 10,000 species of birds found in 28 orders, 163 families and 1,975 genera, most people will be able to tell you at least one characteristic of birds.
    - Birds are warm-blooded homeothermic, also called endothermic i.e. they have more or less constant body temperature.
    - Birds have body covered with feathers and scales they are present only on hind-limbs.
    - Birds have Jaws with horny beak and no teeth.
    - Hind-limbs with four digits adapted for perching, walking or swimming.
    - Bones with air spaces to make the skeleton light (pneumatic bones).
    - Forelimbs modified into wings for flight.
    - Birds have 4-chambered heart for blood circulation. They have lungs connected to ballon like air - sacs for breathing.
    - Voice-box or syrinx (present at the junction of trachea and bronchi).
    - Only left ovary and oviduct present in the females.
    - All oviparous (lay eggs), egg with much yolk and calcareous shell.

B. External and Internal Features (adaptations) in birds

Birds constitute a well defined group of vertebrate animals, especially designed and adapted for aerial mode of life. They evolved not only wings, but also many other adaptations that make it possible to fly.

All these changes can be studied under morphological, anatomical and physiological changes responsible for flight adaptations.

Morphological adaptations

Body shape

- Birds have short, light and compact body as compared to other animals.
- Most organs and large muscles are located near the center of gravity, which is slightly below and behind the wings to provide better balance during flight.

Compact body

- The body is compact and light, strong dorsally and heavier ventrally. Attachment of wings high on the thorax.

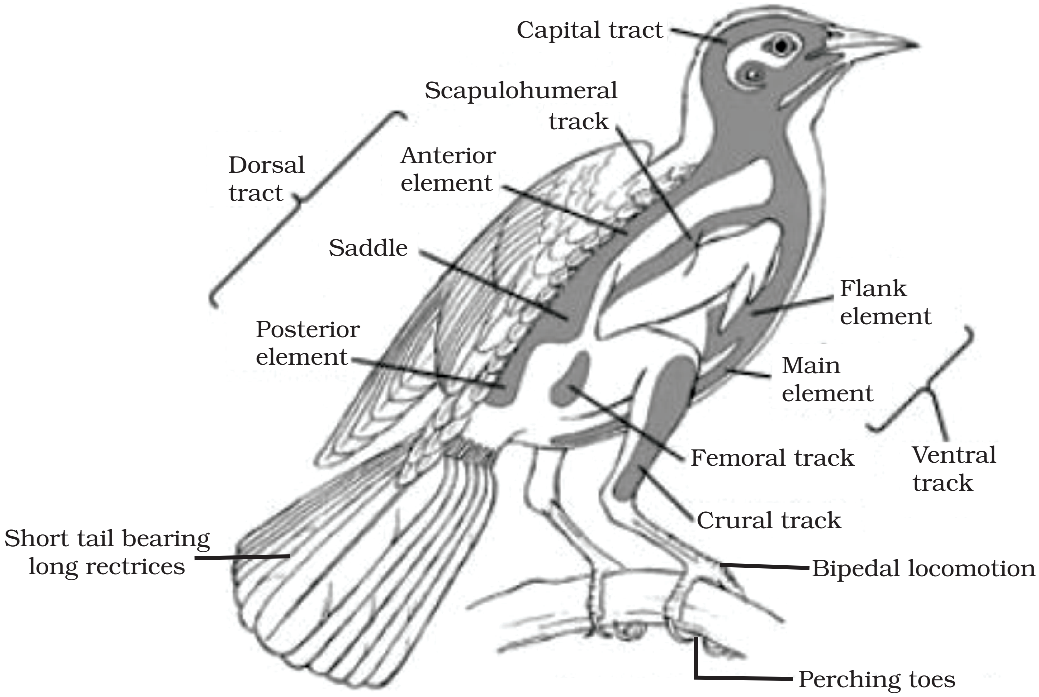


Figure 1. The streamlined body of bird.

The light organs like lungs and sacs are positioned high, the heavy muscles placed centrally are other features that help in flight (Figure1).

Body Covered With Feathers

- The feathers are smooth, directed backwards, and closely fitting which make the body streamlined and reduce friction during flight. It lightens the body weight and protects it from the effect of environmental temperature. They also have a wide surface area for striking the air.

Forelimbs Modified into Wings

- The forelimbs of birds are modified into wings which are adopted for flight. These consist of a framework of bones, muscles, nerves, feathers, and blood vessels.
- The wings have a large surface area. They also support the bird in the air. The wings have a thick strong leading edge with a concave lower surface and a convex upper surface. This helps in increasing the air pressure below and reducing the air pressure above. Thus the bird can fly upward and forward during flight.

Perching

- When a bird sits on the branch of a tree, its toes wrap around the twig. This is known as perching. The muscles are so well-developed that a bird can sleep in that position without falling.

Short Tail

- The tail bears long feathers that spread like a fan and function as a rudder during flight. They also function in balancing, lifting, and steering while flying and perching.

Beak

- Beak compensate the function of forelimbs.

Mobile Neck and Head

- The birds have a long and flexible neck which helps in the movement of head important for various functions. They possess a horny beak which helps them to pick the grains and insects while feeding.

Bipedal Locomotion

- The anterior part of the body of a bird helps in taking off during flight. The anterior part of the body also helps birds to land. The hindlimbs help in the locomotion on land. They have four claused digits for locomotion. They can support the entire body weight of a bird.

- Due to the modification of forelimb into wings, hindlimbs balance and support the entire weight of the body.

Mobile neck and head

- Neck of bird is very long and flexible provide, mobility of the neck and freedom of movement of the head.

Anatomical adaptation

Integument

- Loose skin is responsible for the extensive movement of the skeletal musculature.

Endoskeleton: Many adaptations are seen in the skeleton of birds.

- Most of the bones are pneumatic and filled with air sacs instead of bone marrow.
- Skull bones are light and most of them fused together.
- Uncinate processes of thoracic rib help in producing compactness.
- A firm fulcrum for the action of wings.
- Shortening of caudal style and formation of pygostyle for stability in the air.
- Fusion of pelvis with synsacrum provide firm attachment to the legs.
- Sternum greatly expanded, provided with mid –ventral ridge or keel in flying birds.

Skull

- Skull is composed of thin, hollow bones, which is extremely light in proportion to the rest of the body due to elimination of a heavy jaw, jaw muscles, and teeth. The job of chewing has largely replaced by the gizzard. The skull usually represents less than 1 percent of a bird's total body weight.

Flight muscles

- Flight muscles are enormous as they have to generate thrust and vigorous movement of wings during flight.
- Flight muscles on the breast are greatly developed.
- Pectoralis major lowers the wings.
- Pectoralis minor elevates the wings.

Physiological Adaptations

- Efficient Circulatory System
- Rapid supply of oxygen is required by the blood due to high metabolic rate in birds. Therefore, birds require an efficient circulatory system. Birds have a four- chambered heart that performs double circulation. This prevents the mixing of oxygenated and deoxygenated blood.

  Also, the birds contain a large amount of haemoglobin in their red blood cells which helps in the quick aeration of body tissues (Figure 2).

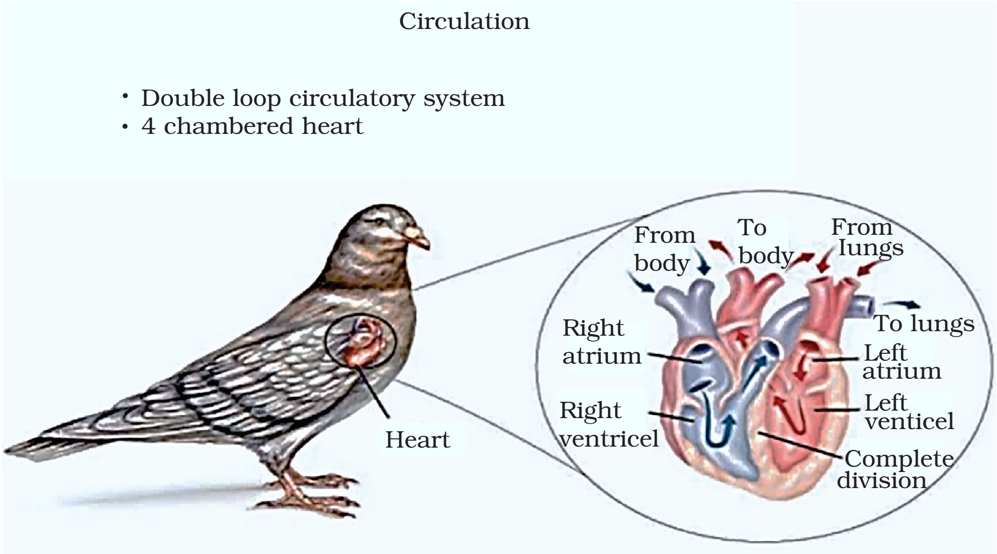


Figure 2. Circulation in birds.

Effective Excretory system

- The nitrogenous waste is converted to less toxic organic compounds such as uric acid, and urates. They have no urinary bladder. The uriniferous tubules efficiently absorb water.

Effecient Digestive System

- Digestive system is compact and effective.
- The birds have a very high rate of metabolism. Therefore, food digests rapidly.
- The length of the rectum is reduced because of the minimum undigested waste.

- They have no gall bladder, which reduces the weight of the bird.

Respiratory System with highly reduced gondas

- The respiratory system of birds is designed in such a manner that the food is oxidised rapidly and a large amount of energy is liberated. Since the metabolism rate is higher, a large number of oxygen molecules are required by the body. For this, the lungs are provided with unique system of air sacs which occupy the entire space between the internal organs.

Reproductive System

- Ovaries and testes are reduced in size except in the breeding season. Usually only one functional ovary is present in most of the birds and second ovary is greatly reduced to decrease the weight of body.

But in the case of birds catches prey generally, both ovaries and oviducts are present. This is because during hunting these birds have to pounce on the prey with great force and struggling prey can kick and break the eggs in reproductive system. Eggs developing in two ovaries can compensate for this loss.

Activity 1

Observation of Birds (group)

- Go to area where you can see birds.
- Look the body & identify parts.
- Observe & record how various birds fly (up, down, horizontal).
- List the type of birds you see & relate with what you have studied.

Warm Blooded

- Birds are warm blooded animals. The temperature of the body of a bird remains high and does not change with the change in the environment. Perfect aeration of body provide maximum output of energy for a longer period This facilitates the birds to fly at very high altitudes.

C. Types of Birds: Flightless and Flying birds

Birds are classified into 45 orders 235 families, 2340 genera, and 10,000 species. Birds are grouped in to two as flightless and flying birds (Figure 3).

(a) **Flightless birds**

Four orders and five families of living flightless birds.

1. Order Struthioniformes
   - Family Struthionidae- Ostrich
2. Order Rheiformes
   - Family Rheidae - Rhea
3. Order Casuariiformes
   - Family Dromaiidae- Cassowaries
   - Family Casuariidae - Emus
4. Order Apterygiformes
   - Family Apterygidae- Kiwi

Swimming birds:

- Most have webbed feet. Birds with webbed feet for paddling have legs far back on body and tend to be clumsy walkers.
- Those that dive skillfully are usually not very good fliers.
- Some chase prey underwater by paddling with wings.
- Some very effective swimmers
  eg. *Gentoo penguin*

(b) **Flying birds**

Flight has several advantages over other forms of locomotion:

- permits sudden and rapid escape from predators
- easier to find food, water, nesting areas, mates, etc
- fast straight line travel from place to place
- inaccessible places become accessible; opens up new niches
- facilitates migrations over long distances

Figure 3. Different tyeps of birds

D. Adaptation to Flight

Most major characteristics of birds can be directly related to their adaptations for flight. The adaptations for flight include:

- Feathers and powerful wing muscles
- Endothermic for power
- Highly efficient respiratory system
- Highly efficient circulatory system.

- Reduced weight – skeleton weigh less than all its feathers
- Centralized mass

Wings of birds are designed to facilitate a particular kind of flight such as **launching, gliding and soaring, flapping, hovering, maneuvering, swooping, diving, and swimming (Figure 4).**

Wings - enable the force of lift

Lightweight and smooth feathers reduces the forces of weight and drag

Light bones hollow with air sacs and thin, tiny cross pieces to make bones stronger – this reduces the force of weight

Beak, instead of heavy, bony jaws and teeth – reduces the force of weight

Enlarged breastbone called a sternum for flight muscle – this helps with the force of thrust

Streamlined body – reduces the force of drag

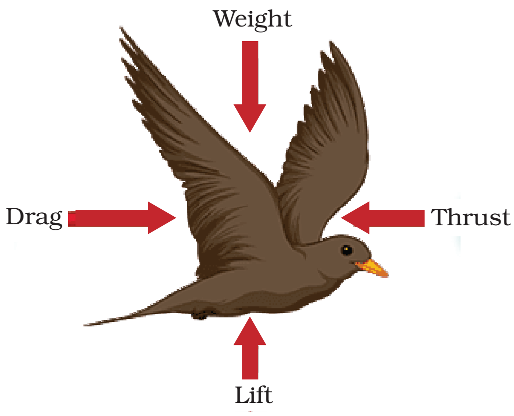


Figure 4. Forces of flight

Dynamics of flight

The largest muscles are attached to the keel of the breastbone (sternum); when contracted, they produce a down stroke of the wings, which provides forward propulsion.

- Relaxing the muscles bring the wing back a greater pressure underneath the wing and produces lift, just like an airplane.
- On the upstroke, birds keep the wings closer to its body. On the down stroke, the wings are fully extended for power
- Tail feathers are important for steering and landing

- Wing shape depends on lifestyle; fast flyers like swifts and falcons have long pointed wings. Soaring birds have broad, large wings to gain lift from thermal air pockets
- Flightless birds such as emus and ostriches do have wings, but they are greatly reduced in size

Activity 2

1. Obtain a feather of hen & examine relate with you study about feathers.

E. Types of Feathers

Feathers evolved from the scales of reptiles, and set birds apart from all other animals.

Feathers are necessary for flight, insulation, and courtship displays.

Feather colours and shapes, help us distinguish between different species of birds and, in some cases, between males and females (Sun Birds). Because feathers are so different, there are many different anatomical and technical terms used in their descriptions.

Feathers makes the body light and provide insulation. Hollow bones reduces the body weight.

Replacement of jawbones and teeth with beak, and many more features.

Birds have different kinds of feathers, each having a particular function. The types of feathers include:

- Feathers with Vanes: Contour and Flight Feathers
- Down feathers
- Filoplume feathers
- Semiplume feathers
- Bristle feathers

Contour feathers

Contour feathers cover most of the surface of the bird, providing a smooth appearance (Figure 5).

They protect the bird from sun, wind, rain, and injury. Often, these feathers are brightly colored and have different color patterns.

Figure 5. Contour feather

Contour feathers are divided into flight feathers and those that cover the body.

Flight feathers

Flight feathers are the large feathers of the wing and tail (Figure 6).

Flight feathers of the wing are collectively known as the remiges, and are separated into three groups.

The primaries attach to the metacarpal (wrist) and phalangeal (finger) bones at the far end of the wing and are responsible for forward thrust.

There are usually 10 primaries and they are numbered from the inside out.

The secondaries attach to the ulna, a bone in the middle of the wing, and are necessary to supply “lift.”

They are also used in courtship displays.

There are usually 10-14 secondaries and they are numbered from the outside in.

The flight feathers closest to the body are sometimes called tertiaries.

The tail feathers, called retrices, act as brakes and a rudder, controlling the orientation of the flight.

Most birds have 12 tail feathers.The bases of the flight feathers are covered with smaller contour feathers called Coverts. There are several layers of coverts on the wing. Coverts also cover the ear.

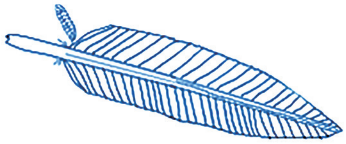


Figure 6. Flight feathers

Down feathers

Down feathers are small, soft, fluffy, and are found under the contour feathers. They are plumaceous, and have many non-interlocking barbs, lacking the barbules and hooklets seen in contour and flight feathers (Figure 7).

This makes it possible for them to trap air in an insulating layer next to the skin, protecting the bird from heat and cold.

They are so efficient, humans use these feathers for insulation, too, in down jackets and comforters.

There are special types of downy feathers called powder down feathers. When the sheaths or barbs of these feathers disintegrate, they form a fine keratin powder, which the bird can spread over its feathers as a water- proofing agent. The powder also assists in cleaning as the bird preens.

Figure 7. Down feathers

Filoplumes

Filoplumes are very fine, hair-like feathers, with a long shaft, and only a few barbs at their tips (Figure 8).

Figure 8. Filoplumers

They are located along all the pterylae. Although their function is not well understood, they are thought to have a sensory function, possibly adjusting the position of the flight feathers in response to air pressure.

Semiplumes

Semiplumes provide form, aerodynamics, and insulation. They also play a role in courtship displays (Figure 9).

Figure 9. Semiplumes

They have a large rachis, but loose (plumaceous) vanes. They may occur along with contour feathers or in separate pterylae.

Bristle feathers

Bristle feathers have a stiff rachis with only a few barbs at the base (Figure 10).

Figure 10. Bristle feather

They are usually found on the head (around the eyelids, nares, and mouth). They are thought to have both a sensory and protective function.

Activity 3

List down domestic & wild mammals in your area & place them in "Orders".

Feather Growth

Like hair, feathers develop in a specialized area in the skin called a follicle.

As a new feather develops, it has an artery and vein that extends up through the shaft and nourishes the feather.

A feather at this stage is called a blood feather.

Due to the color of the blood supply, the shaft of a blood feather will appear dark, whereas the shaft of an older, mature feather will be white.

A blood feather has a larger quill (calamus) than a mature feather.

A blood feather starts out with a waxy keratin sheath that protects it while it grows.

When the feather is mature, the blood supply will recede and the bird will remove the waxy sheath.

An adult bird will replace all of its feathers during a molt.

A molt is usually triggered by the change in day length or may occur after breeding.

Feather Colour

Feather color is determined by the presence of various pigments, including melanins, carotenoids, and porphyrins.

- Melanins are brown to black pigments that are also found in mammals. In addition to adding color to the feather, melanins also make the feather denser and more resistant to wear and breakdown by sunlight.
- Carotenoids are generally yellow, orange, or red in color. They are synthesized in plants, and absorbed by the bird's digestive system, and then taken up by the cells of the follicle as the feather is developing.
- Porphyrins are red and green pigments that are produced by cells in the feather follicle.

Exercises

Answer the following adaptation of birds as Morphological adaptations (M); Anatomical adaptation (A); Physiological adaptations (P)

1. Integument
2. Endoskeleton
3. Skull
4. Body contour or shape
5. Compact body
6. Body covering of feathers
7. Excretory system - efficient
8. Reproductive system - highly reduced Gonads
9. Warm bloodedness
10. Horny Beak
11. Mobile neck and head
12. Four claused digits
13. Perching
14. Circulatory system - powerful & efficient
15. Efficient breathing system
16. Well - developed vision
17. Forelimbs modified into wings
18. Short tail
19. Large muscles of flight or flight muscles

1.2 Class Mammalia (Mamma: Breast)

A. General Characteristics

Mammals are vertebrate animals distinguished by the possession of hair or fur, females that secrete milk for the nourishment of the young, and the birth of live young.

Mammals have the following characteristics:

- Endothermic
- Hair & subcutaneous fat (insulation & energy stores)
- Synapsid skull & limbs under body
- 3 auditory ossicles in middle ear
- Cerebrum >, cortex enlarges
- Teeth heterodont - replacement is limited
- Muscular diaphram

- 4 - chambered heart
- Urea as nitrogenous wastes
- Testes in scrotum - internal fertilization
- Little yolk in egg (except monotremes)
- Monotremes oviparous - others viviparous
- Amniotes (Chorion placenta, allantois)
- Maternal parental care mandatory (viviparity + lactation); milk from modified sweat glands (MAMMARY GLANDS).

B. Classification of Class Mammalia

Mammals are classified in to three groups (Table 1):

1. Monotremes (Prototheria) such as the duck - billed platypus.
2. Marsupials (Methatheria) such as Kangaroo and Opossum.
3. Placentals (Eutheria) such as humans.

Table 1 Sub - classes of class Mammalia

1. Sub - class Prototheria	2. Sub - class Metaheria	3. Sub - class Eutheria
(a) No external ear.	(a) External ear present.	(a) External ear well developed
(b) Teeth found only in young	(b) Teeth found in both young and adults	(b) Teeth present in young as well as adults.
(c) Placenta absent	(c) No placenta for nourishment to the embryo	(c) Placenta is present
(d) Mammary glands are devoid of nipples	(d) Mammary glands present	(d) Mammary glands present
(e) Females are oviparous. Example: Duck-bill platypus (Ornithorhynclus)	(e) Immature young ones are born. Marsupium (pouch) is present in female	(e) Mature young ones are born

C. Features of important Orders of Mammalia

Sub-class Eutheria has been divided into a number of orders. Some important ones are as follows:

Order 1 : Rodentia

- Herbivorous and terrestrial.
- Incisors long, sharp and chisel-shaped.
- Forelimbs shorter than the hindlimbs.

(Example: Rat, Squirrel)

Order 2 : Cheiroptera

- These are flying mammals.
- Fore-limbs adapted for flight.
- Skin folded i.e. patagium works as wing.
- Hind-limbs thin and short.
- Nocturnal (active at night).
- Bats have poor eyesight. They avoid colliding against objects by echolocation in which the bat emits supersonic waves which are reflected back from the objects and the bat can perceive the reflected waves to determine the position of the object. The method is very similar to radar.

Example: Bat

Order 3. Carnivora

- Flesh-eating mammals.
- Large pointed and sharp canines to tear the flesh.
- Fingers with sharp claws.

Example: Lion, Tiger, Cat, Dog).

Order 4. Primates

- Highly developed brain.
- Eyes are set forward in the head to provide binocular (depth-perception) vision
- The neck is mobile.
- Limbs have five digits with flat nails.
- The thumb of the hand and the greater toe of the feet are opposable (for grasping)
- Two thoracic mamma (breasts) present.

Example: Monkey, Apes, Man.

Order 5. Cetacea

- Aquatic.
- Fore-limbs are changed into paddles.

- No neck.
- Fish-like shape but respiration by lungs.

Example: Whale

Order 6. Proboscidea

- Large, herbivorous, terrestrial.
- Fusion of upper lip and nose to form a long mobile trunk.
- Only one pair of incisors in upper jaw which form huge tusks in males.

Example: Elephant

Order 7. Ungulata

- Hoofed mammals.
- Herbivorous.
- Usually domesticated by man.
- Mamma are abdominal with teats.

Example: Deer, Cows, Sheep

D. Structure of mammalian tooth

Teeth

Teeth are white hard structures arranged in rows and found fixed in the mouth cavity that are used for biting and chewing. In the life of human beings, there are two sets of teeth: – milk teeth and permanent teeth.

There are four types of teeth anchored in the jaw by their roots, which fit into sockets of the spongy bone (Figure 11).

- **Incisor (I)** – located at the front jaw
- **Canine (C)** – located next to incisors on both sides
- **Premolar (P)** – located behind ‘C’ on both sides
- **Molars (M)** – located at the back behind ‘P’ on both sides. Molar teeth are not found in milk teeth set.

Structure of Tooth

All types of teeth have the following structures (Figure 12).

- **Crown:** it is the exposed portion of tooth, above the gum.
- **Enamel:** it is the outer, white, non-living structure of the crown. It is the hardest structure in the body. It protects the internal layers.

- **Dentine** – it is a softer, bone – like part covered by enamel. It forms the bulk of tooth and contains living cells. It is supplied with blood and nerves from the internal pulp cavity.
- **Gum** – It is the part where the enamel part of the tooth ends. It produces enamel, fixes the tooth, and protects the base of the crown.

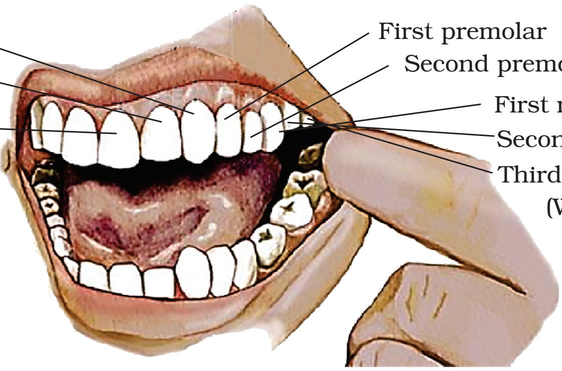


Figure 11. Type & position of Human teeth.

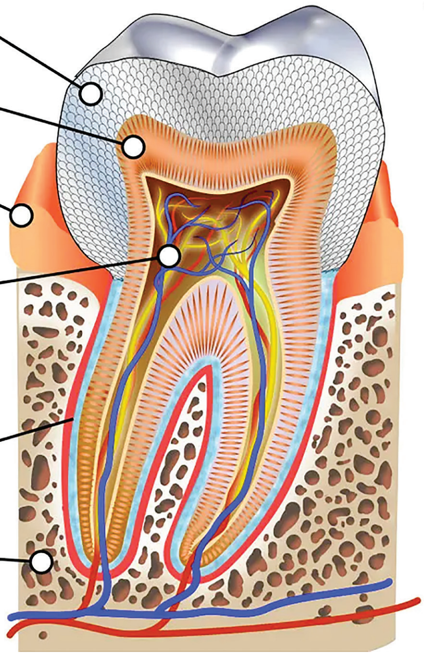


Figure 12. Structure of Molar teeth

- **Root:** it includes parts of tooth inside the jawbone below the gum. Jawbone , provides a socket for the tooth.

- **Pulp cavity** – It is the part inside the dentine region which is filled with connective tissue, blood capillaries and nerves.
- **Cement** – It is a bone like structure attaching tooth to its socket (jawbone) and anchors the tooth.

Ligament – It is a structure supporting tooth in the socket. It absorbs shock of hard bites to protect the tooth against damage.

Activity 4

1. Count all your teeth identify their type & location.
2. Write your D.F.

Functions of Teeth

The main functions of teeth are to capture and ingest food and mechanical digestion of food. The different types of teeth serve various purposes, such as shearing, nipping, biting, grinding and crushing.

Humans have two sets of teeth in their life- Milk teeth and permanent teeth.

Milk teeth (Figure 13a):

It is the first set of teeth found in the early child hood, starting growth about the age of 5 – 6 months.

The milk-set, when complete at the ages of 2 – 3 have 20 teeth.

The set will be gradually shaded between ages of 5–8 to be replaced by permanent teeth.

Permanent teeth (Figure 13b):

It is the second set of teeth, which grow when milk teeth wither away. The set may be complete at the ages of 12 – 14. When complete, the set contains 32 teeth. This set of teeth cannot be replaced.

The last molar teeth which do not always develop, or developing late in life are called **wisdom teeth**.

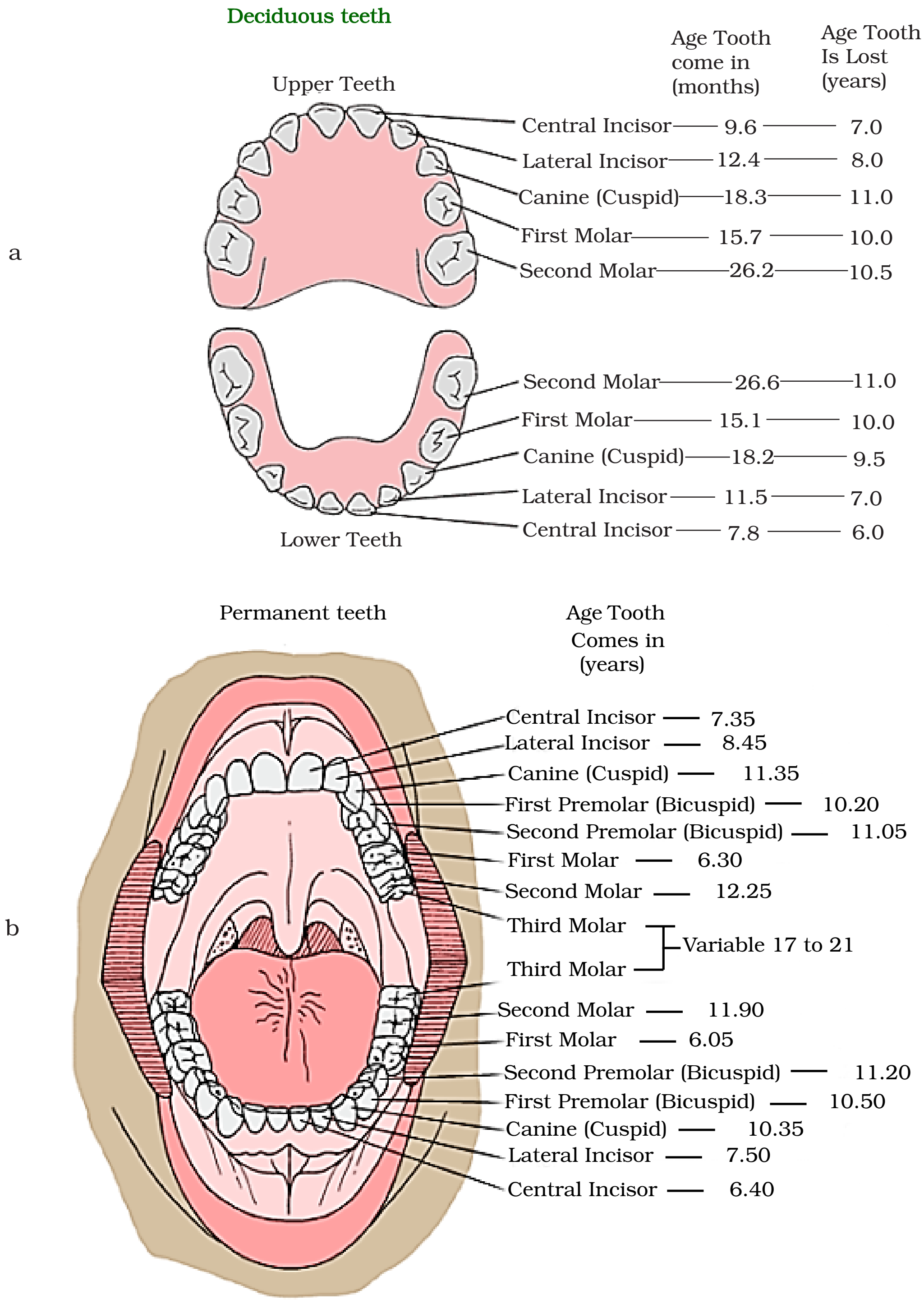


Figure 13. Deciduous (milk) teeth (a) & permanent teeth in humans (b)

E. Dentitions and Dental Formulae

Dentition means the kind, number, and arrangement of teeth (collectively) in a person or animal. Dentition consist different types of teeth. The dentition is used to capture and ingest food together with other associated structures, the tongue, lips and cheek muscles.

Dental Formulae

The dental formula (D.F) is a short form of expressing or representing the type, number, and arrangement of teeth on half of the upper jaw as numerator, and the lower as a denominator.

D.F of humans

Milk set $\frac{2120}{2120}$ Total = $\frac{2120}{2120}$ 2 = 20

Permanent set $\frac{2123}{2123}$ Total = $\frac{2123}{2123}$ 2 = 32

Dental formula of other animals

Dog $\frac{3142}{3143}$ Total = $\frac{3142}{3143}$ 2 = 42

Cat $\frac{3131}{3121}$

Sheep $\frac{0033}{3133}$ No incisors and canine teeth on upper jaw

F. Temperature Regulation in mammals

Regulation of body temperature

Body temperature reflects the balance between heat production and heat loss

At rest, the liver, heart, brain, kidneys, and endocrine organs generate most heat

During exercise, heat production from skeletal muscles increases dramatically

Normal body temperature = 37 C ± 5 C (98.6 F)

Optimal enzyme activity occurs at this temperature

Increased temperature denatures proteins and depresses neurons

Heat production

- Basal metabolism
- Muscular activity (shivering)
- Thyroxine and epinephrine (stimulating effects on metabolic rate)
- Temperature effect on cells

Heat loss

- Radiation
- Conduction/ convection
- Evaporation

Mechanisms of Heat Exchange

Four mechanisms

1. Radiation is the loss of heat in the form of infrared rays
2. Conduction is the transfer of heat by direct contaction
3. Convection is the transfer of heat to the surrounding air
4. Evaporation is the heat loss due to the evaporation of water from body surfaces

- Insensible heat loss accompanies insensible water loss from lungs, oral mucosa, and skin
- Evaporative heat loss becomes sensible (active) when body temperature rises and sweating increases water vaporization

Role of the Hypothalamus

Hypothalamus contains the two thermoregulatory centers (Figure14-15)

- Anterior Hypothalamus : activates the mechanism that promote Heat-loss.
- Posterior Hypothalamus : activates the mechanism that increase heat - production and promote heat gain.

The hypothalamus receives afferent input from

- Peripheral thermoreceptors in the skin
- Central thermoreceptors (some in the hypothalamus)

Initiates appropriate heat-loss and heatpromoting activities

Heat - Promoting Mechanisms

- Constriction of cutaneous blood vessels
- Shivering
- Increased metabolic rate via epinephrine and norepinephrine

- Enhanced thyroxine release
- Voluntary measures include
- Putting on more clothing
- Drinking hot fluids
- Changing posture or increasing physical activity

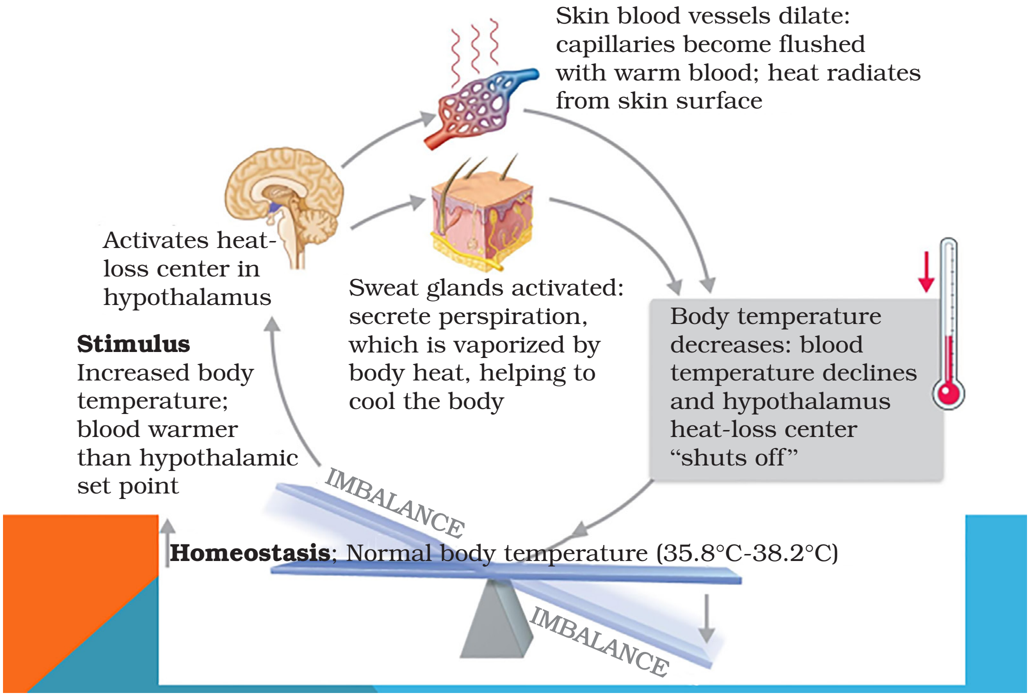


Figure 14. Temprature regualtion during Hot conditions

Heat - Loss Mechanisms

- Dilation of cutaneous blood vessels
- Enhanced sweating
- Voluntary measures include
- Reducing activity and seeking a cooler environment
- Wearing light-colored and loose-fitting clothing

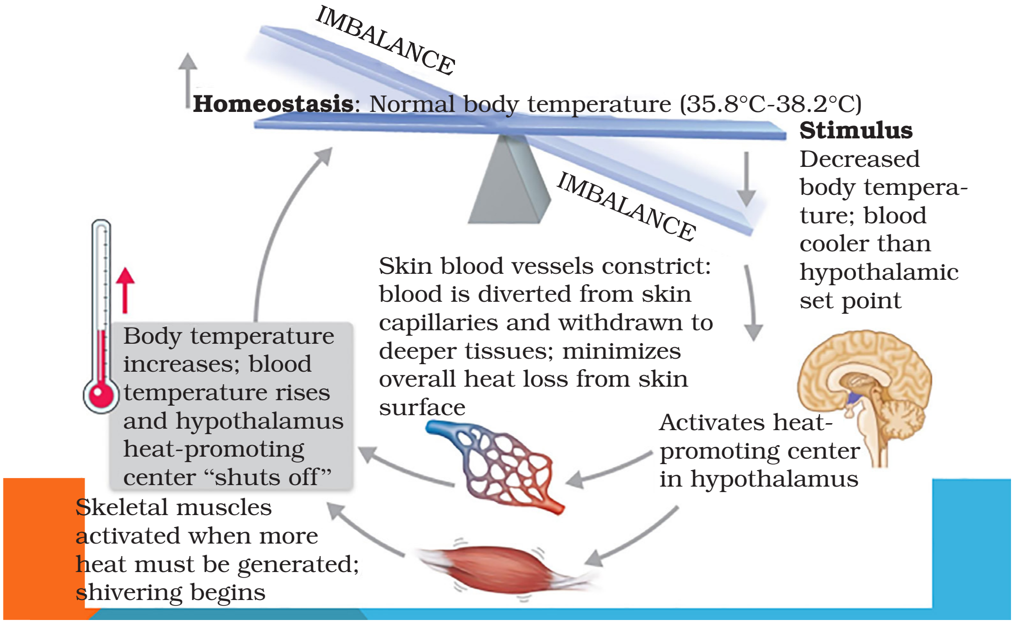


Figure 15. Temperature regulation during cold conditions

Exercises

Name the Group of Mammals which includes

1. Egg-laying mammals ....
2. Pouched mammals ....
3. Flesh-eating mammals ....
4. Aquatic mammals ....
5. Flying mammals ....
6. For which characteristic feature are certain animals placed in class mammalia?

   ....
   ....
7. Name a mammal which has marsupium.

   ....
   ....

Key Terms

- Body contour
- Beak
- Bipedal locomotion Chordates
- Dentition
- Dorsal hollow nerve cord
- Endoskeleton

- Fat insulation
- Heterodont teeth
- Homoeothermic
- Hypothalamus.
- Integument
- Notochord
- Oviparous
- Perching
- Skull
- Sweating
- Viviparous
- Vasodilatation
- Vasoconstriction

Summary

Class Aves includes birds–the flying vertebrates with forelimbs modified into wings.

Mammals possess hair and mammary glands which secrete milk to feed the young ones.

Bird Characteristics:

- Bipedalism
- Possession of Feathers
- Possession of Wings
- Egg-laying ability
- Possession of Furcula (skeleton)

Most major characteristics of birds can be directly related to their adaptations for flight. The adaptations for flight include:

- Feathers and powerful wing muscles
- Endothermic for power
- Highly efficient respiratory system
- Large strong four-chambered heart
- Reduced weight – skeleton weighs less than all its feathers
- Centralized mass

All these changes can be studied under morphological, anatomical and physiological changes responsible for flight adaptations.

The evolution of flight has provided birds with many physical features in addition to wings and feathers.

One way to reduce weight in birds is by the fusion and elimination of some unnecessary bones and the "pneumatization" of the remaining ones.

Not only are some bones of birds hollow but many of the larger ones are connected to the air sacs of the respiratory system.

To keep the cylindrical walls of a bird's major wing bones from sudden change the bones have internal compressive framework.

Fusion of bones in birds makes the skeleton light as well as strong. Coracoid, furcula, and scapula form a strong and well built tripod for supporting the wings and broad surfaces for the attachment of large flight muscles.

One key adaptation is the fusing of caudal bones into single pygostyle which supports the tail feathers. Birds also lack teeth or even a true jaw, instead having evolved a beak, which is more lightweight.

Birds have uncinate processes on the ribs. These are hooked extensions of bone which help to strengthen the rib cage by overlapping with the rib behind them.

There is practically every organ and system has been modified in relation to flight.

Characteristic features of mammals

- Body covered with hair.
- Presence of milk (Mammary) glands.
- Sweat and oil glands present in the skin.
- Projecting external ears (pinna) present.
- Digits usually ending in claws, nails or hoofs.
- Dentition thecodont (teeth in sockets of jaw bones) and generally heterodont (four different types).
- Seven neck vertebrae
- Homoiothermal, warm blooded and heart four-chambered.
- Testes are extra-abdominal (not within abdominal cavity) contained in scrotal sacs
- Viviparous, give birth to the young, some primitive mammals are oviparous (lay eggs).
- Foetus is nourished by mother through placenta.

Factors Affecting Temperature Regulation

The important factors, which affect temperature regulation, are:

1. The difference in temperature between the body and its surrounding medium (air or water).
2. The surface area to volume ratio i.e. the surface area of the body exposed to the surroundings.
3. Whether or not the body has insulating material around it.
4. Whether the surrounding medium is flowing past the body or not.
5. The physical state of the surface of the body e.g. whether it is moist, and hence whether it can lose liquid by evaporation.
6. Whether the body possesses any mechanism for generating heat.

Temperature Regulation in Humans

Man is homeothermic. The body temperature of man is controlled by the hypothalamus. Slight changes in temperature results in a discharge of corrective mechanisms.

Heat loss and heat gain is through the relatively hairless skin of many by radiation, convection and conduction under conditions of low temperature.

Heat is lost rapidly from fingers, toes, ears, and nose (body extremities). Too much heat loss for longer time produce “frost bite”.

Babies lose heat quickly because of their high surface area to volume ratio. Heat control methods (loss or gain) could be through physiological methods or behavioral adaptations.

Physiological methods include:

- Fat insulation
- Vasodilatation and vasoconstriction
- Evaporation by sweating
- Panting
- Metabolic activity (increase or decrease)

Behavioral methods include:

- Moving to shade, to water, clothing, aggregation, basking, etc, according to the need (loss or gain).
- The skin regulates body temperature by controlling heat loss in two ways:

(a) **Changing the size of the blood vessels in the skin.**

- Vasodilatation
- To increase heat loss, they dilate (vasodilatation) and bring more warm blood to the skin surface so that heat loss to the environment takes place.
- Vasoconstriction
- To decrease heat loss, they constrict (vasoconstriction) and reduce the amount of blood reaching to the skin surface.

(b) **Producing sweat**

The skin produces sweat, which when it evaporates from the skin surface cools the body.

Thermal mechanism: when it’s too cold Pilio erection - hair traps more air - > insulation

Blood flow < to surface - vasoconstriction to skin - protect CORE body temp.

Countercurrent arrangement of arteries with hot blood to periphery & veins returning cold blood.

Shiver (> muscle metabolism, > heat release)

Thyroxine >, general metabolism >

Behavioral - stay dry, avoid wind, seek sun, find a warm substrate

Methods by which Humans loses heat	Methods by which Humans gains heat
Production of sweat increases. The water in the sweat evaporates, drawing latent heat from the body.	Production of sweat decreases, so that heat lost by evaporation is much less.
Arterioles relax (vasodilatation) and more blood enters the capillary net work. Radiation and convection from the skin lose extra heat.	Arterioles constrict (vasoconstriction) and less blood enters the capillary network. Radiation and convection lose less heat.
The rate of metabolism decreases, so that less heat is produced; thus man's activity is less in hot weather.	The rate of metabolism increases, producing more heat. Loss of heat can cause involuntary muscular action called shivering
Behavioral methods: wearing fewer cloths, taking cold baths or swimming, drinking cold drinks, using a far or air conditioning	Behavioral methods: wearing more cloths, drinking hot drinks or eating hot food, heating houses, taking exercise
The hair is lowered in other animals, making a thinner coat so that the heat can escape more easily. Man can get no benefit from this, since his skin in largely naked.	The hair is raised in other mammals, making a thicker coat, thus trapping more air is insulting layer. In man the naked skin with its few hairs shows traces of this function. The contracted hair muscles appear as 'goose pimples.'

The skin regulates body temperature and waste products as a regulatory organ.

Review Exercise

I Write true for true statement or false for a wrong statement.

1. Molar teeth are not found in milk teeth set in humans.
2. Birds and mammals are homeothermic
3. Shivering is a physiological mechanism of temperature control.
4. Birds have a highly developed mammary glands.
5. Like hair, feathers develop in a specialized area in the skin called a follicle.
6. A period of deep sleep to avoid hot seasons is called aestivation, which enable the animal to survive drought by using much less water.
7. Evaporation of sweat from the body surfaces ensures the lose of heat during over heating.

II. Match items from column "B" with those of column "A".

Column A	Column B
8. Flying mammals	(a) possess sharp and pointed canines to tear flesh.
9. Carnivores	(b) Forelimbs are midified to paddles.
10. Aquatic mammals	(c) Lack canine ansinxiaoe on the upper jaw.
11. Herbivores	(d) They have the capacity for ecolocation.

Sample Test

1. What characteristics sets mammals apart form birds? The
   (a) Possession of four - chambered heart.
   (b) Presence of internal fertilization.
   (c) Presence of special glands that produce milk for feeding their young.
   (d) Possession of lungs for breathing air efficient.
2. Which of the following is **Not** a placental mammal?
   (a) Rat
   (b) Ape
   (c) Kangaroo
   (d) Elephant
3. Which of these mammals lays eggs?
   (a) Marsupials
   (b) Carnivores
   (c) Monotremes
   (d) Placentals
4. Which of the following organs is used by birds to crush and grind food?
   (a) Crop.
   (b) Stomach.
   (c) Gizzard
   (d) Small intestine.

5. In which of the following orders do animals have a highly developed brain?
   (a) Primates
   (b) Carnivora
   (c) Cetacea
   (d) Chiroptera
6. Which of the following characteristics of birds is **Not** adaptation for flight? The:
   (a) Presence of hollow bones.
   (b) Possession of amniotic eggs with hard shells.
   (c) Possession of bathoon like air - sacs connected.
   (d) Presence of strong, light weight feathers.
7. Which of the following is true about birds?
   (a) Forelimbs are modified into wings.
   (b) The hindlimbs bear four clawed digits.
   (c) The bones of sketleton are light, strong and porous.
   (d) All
8. Which of the following is a unique characteristic of a marsupial? They:
   (a) Lay eggs.
   (b) Provide milk for their young.
   (c) Live in Australia.
   (d) Give birth to immature young which will develop in a pouch.
9. Not true of feathers
   (a) Contour feathers cover most of the surface of the bird, providing a smooth appearance.
   (b) Flight feathers are the large feathers of the wing and tail
   (c) Down feathers are small, soft, fluffy, and are found under the contour feathers
   (d) Feathers develop in a specialized area in the muscles.
10. Order Rodentia are **Not** characterized by ____________ .
   (a) Well developed brain
   (b) Herbivorous mode of feeding
   (c) Shorter forelimbs
   (d) Sharp and chisel shaped incisors
11. Which characteristics is common to both birds and mammals? The:
   (a) Presence of feathers and wings.
   (b) Ability to excrete uric acids.

(c) Ability to maintain constant body temperature.
(d) Presence of mammary glands.

12. Flightless bird found in Africa is represented by ________.
    (a) Ostrich
    (b) Eagle
    (c) Pigeon
    (d) Parrot
13. In which of the following mammals are the forelimbs adapted for flight?
    (a) Rat
    (b) Whale
    (c) Bat
    (d) Antelope
14. Which of the following orders consists of flying mammals?
    (a) Chiroptera
    (b) Primates
    (c) Cetacea
    (d) Carnivora
15. A period of deep sleep to avoid cold weather by organisms is known as
    (a) Hibernation.
    (b) Aestivation
    (c) Vasoconstriction
    (d) Vasodilatation

B12CH02

CHAPTER 2

SKELETAL, MUSCULAR AND REPRODUCTIVE SYSTEMS

Chapter Contents

2.1 Division of the Human Body
2.2 Skeletal System
2.3 Muscular System
2.4 Reproductive Systems
2.5 The Menstrual Cycle and Development
2.6 Cycles of Sexuality
2.7 Sexually Transmitted Diseases or Infections
2.8 Sexual Violence (Gender Based Violence)

- Key Terms
- Summary
- Review Exercise
- Sample Test

Chapter Outcomes

Upon completion of chapter, learners will be able to:

- state the functions of the human skeletal system;
- list the regions of the human skeletal system;
- name and describe the locations of the various types of joints;
- list and describe the functions of the three types of muscle tissues;
- describe the effects of sexually transmitted infections;
- (STIs) and substance abuse on the muscular systems;
- describe the body changes during adolescence development;
- explain the functions of the male and female reproductive organs;
- draw the male and female reproductive organs;
- explain the process of gamete formation;
- describe the structures and functions of a sperm cell;
- explain the menstrual cycle;
- explain the reproductive health consequences of Gender Based Violence;
- discuss the benefits of family planning and various methods used.

Introduction

The human skeleton consists of bones, teeth, cartilage, and joints. Some bones protect the internal organs. Some bones provide a framework for the body (just as the spokes of an umbrella provide a framework). Some bones contain red marrow that produces blood cells and yellow marrow that also stores fat.

Skeletal system

Function

1. Protects internal organs
2. Provides shape, and support
3. Stores materials (fats, minerals)
4. Produces blood cells
5. Allows movement

Muscular system

The muscular system is the system that creates any movement, voluntary or involuntary.

Three types of muscles-

- Skeletal – Voluntary, mainly attached to bones
- Smooth – Involuntary, mainly in organs
- Cardiac – Involuntary, only in the heart

Interactions Working with Other Systems

1. With skeletal system – allow movement
2. With digestive system – allow organs to contract to push food through
3. With respiratory system – diaphragm controls breathing
4. With circulatory system – controls pumping of blood (heart)
5. With nervous system – controls all muscle contractions

Reproductive system

The reproductive system is where new life can be created. The reproductive system of males and females are vastly different and have few similarities.

- The main hormone present in male reproduction is testosterone while females mainly produce estrogen

- Both males and females create both testosterone and estrogen, but the concentrations are vastly different

Function

Allows organisms to reproduce which prevents their species from becoming extinct.

Components

Ovaries *produce eggs

Testes *produce sperm

Interactions Working with Other Systems

1. With endocrine system – controls production of sex cells
2. With muscular system – uterus contracts to give birth, controlled by hormones

2.1 Division of the Human Body

The human body is organized into cells, tissues, organs, organ systems, and the total organism.

- Cells are the smallest living unit of body construction.
- A tissue is a grouping of same cells working together. Examples are muscle tissue and nervous tissue.
- An organ is a structure composed of several different tissues performing a particular function. Examples include the lungs and the heart.
- Organ systems are groups of organs, which together perform an overall function. Examples are the respiratory system and the digestive system.
- The total organism is the individual human being. You are a total organism.

The Integumentary System Covers the body

- This is the system that holds body together
- Consists of the skin, the hair, nails, and even the glands
- The skin is made up of several different layers and creates a physical layer protecting all internal organs
- The skin is the largest organ in the body

A. Regions of the human body

Human body is a single, total composite. Everything works together. Each part acts in association with all other parts. Yet, it is also a series of regions. Each region is responsible for certain body activities. (Figure 1) These regions are:

Back and Trunk. The torso includes the back and trunk. The trunk includes the thorax (chest) and abdomen. At the lower end of the trunk is the pelvis. The perineum is the portion of the body forming the floor of the pelvis. The lungs, the heart, and the digestive system are found in the trunk.

Head and Neck. The brain, eyes, ears, mouth, pharynx, and larynx are found in this region.

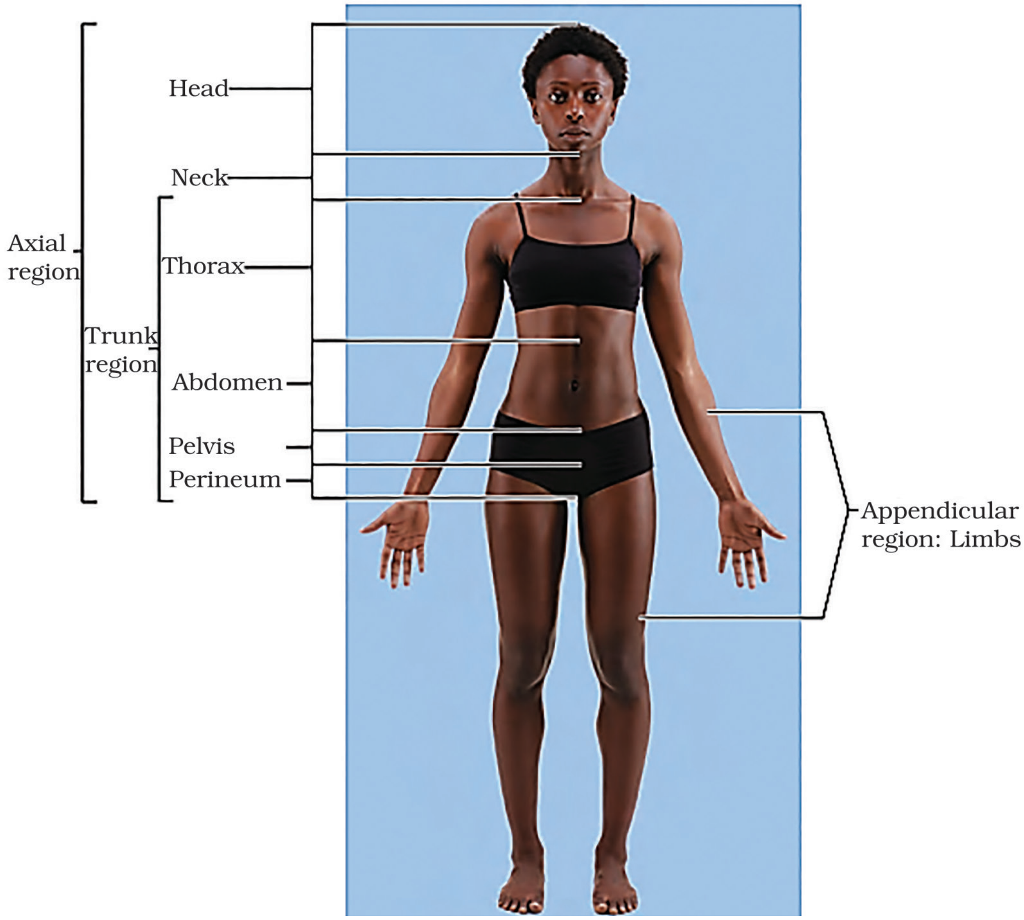


Figure 1. Regions of the human body

Members. Each upper member includes a shoulder, arm, forearm, wrist, and hand. Each lower member includes a hip, thigh, leg, ankle, and foot.

B. Body Cavities

The axial portion of the body has two large cavities that provide different degrees of protection to the organs within them (Figure 2).

Dorsal Body Cavity

The dorsal body cavity can be subdivided into two cavities.

1. The cranial cavity, within the rigid skull, contains the brain
2. The vertebral (or spinal) cavity, which is within the bony vertebral column, protects the delicate spinal cord. Because the spinal cord is a continuation of the brain, these cavities are continuous with each other.

Ventral Body Cavity

The ventral body cavity is subdivided.

Thoracic cavity

The superior **thoracic cavity** is separated from the rest of the ventral cavity by the dome-shaped diaphragm. The heart and lungs, located in the thoracic cavity, are protected by the bony rib cage.

Abdominopelvic cavity

The cavity inferior to the diaphragm is often referred to as the abdominopelvic cavity.

Although there is no further physical separation of the ventral cavity, some describe the abdominopelvic cavity as two areas,

A superior **abdominal cavity** (the area that houses the stomach, intestines, liver, and other organs) An inferior **pelvic cavity** (the region that is partially enclosed by the bony pelvis and contains the reproductive organs, bladder, and rectum). The abdominal and pelvic cavities are not continuous with each other in a straight plane; the pelvic cavity is tipped forward.

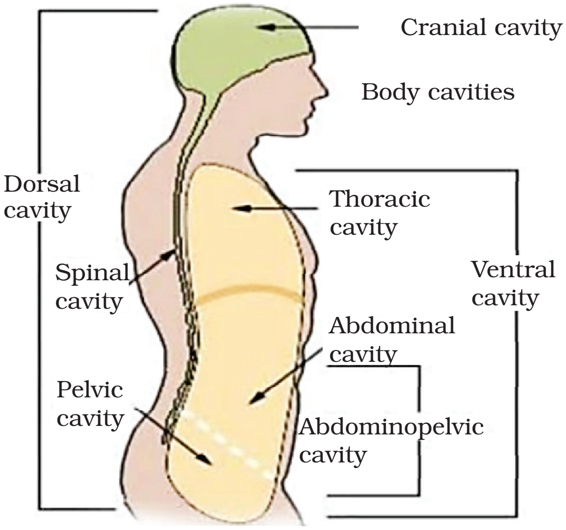


Figure 2. Human body cavities

Other Body Cavities

Besides the large, closed body cavities, there are several types of smaller body cavities. Many of these are in the head, and most open to the body exterior.

Oral cavity: The oral cavity, commonly called the mouth, contains the tongue and teeth. It is continuous with the rest of the digestive tube, which opens to the exterior at the anus.

Nasal cavity: Located within and posterior to the nose, the nasal cavity is part

of the passages of the respiratory system.

Orbital cavities: The orbital cavities (orbits) in the skull house the eyes and present them in an anterior position.

Middle ear cavities: Each middle ear cavity lies just medial to an eardrum and is carved into the bony skull. These cavities contain tiny bones that transmit sound vibrations to the hearing receptor in the inner ears.

Synovial cavities: Synovial cavities are joint cavities they are enclosed within fibrous capsules that surround the freely movable joints of the body, such as those between the vertebrae and the knee and hip joints. Like the serous membranes of the ventral body cavity, membranes lining the synovial cavities secrete a lubricating fluid that reduces friction as the enclosed structures move across one.

2.2 Skeletal System

The skeleton protects vital organs

The brain is surrounded by bones that form part of the skull.

The heart and lungs are located within the thoracic cavity, and the vertebral column provides structure and protection for the spinal cord.

Thoracic cavity is a space in chest that the organs like respiratory–cardiovascular, nervous, immune and digestive system. It is also known as chest cavity and comes under the second largest hallow space of the body. It is enclosed by the ribs sternum and vertebral column. This cavity is seprated from the abdominal cavity by a muscular and membranous partition known as Diaphragum.

Interactions between the skeleton, muscles, and nerves move the body.

How does the skeleton move?

Muscles throughout the human body are attached to bones.

Nerves around a muscle can signal the muscle to move.

When the nervous system sends commands to skeletal muscles, the muscles contract. That contraction produces movement at the joints between bones.

A. Composition of Skeletal System

- Bones (skeleton)
- Joints
- Cartilages
- Ligaments

Bones

Bones provide structure, protection and facilitate motion.

- Bones are arranged to form structures.
- The skull protects the brain and gives shape to the face.
- The thoracic cage surrounds the heart and lungs.
- The vertebral column, commonly called the spine, is formed by over 33 small bones. Vertebrae are the 33 individual bones that interlock with each other to form the spinal column. The vertebrae are numbered and divided into regions i.e. cervical, thoracic, lumbar, sacrum and coccyx. The vertebrae of sacrum and coccyx are fused, rest of the upper 24 bones are moveable.

- Then there are the limbs (upper and lower) and the girdles that attach the four limbs to the vertebral column.

Functions of Bones

- Support of the body.
- Protection of soft organs.
- Movement due to attached skeletal muscles.
- Storage of minerals and fats.
- Blood cell formation.
- The adult skeleton has 206 bones.

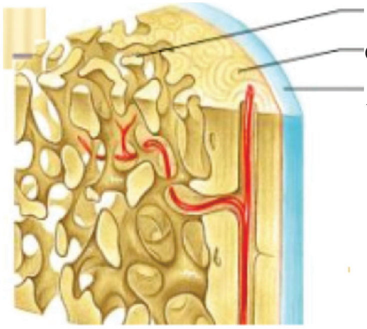


Figure 3a

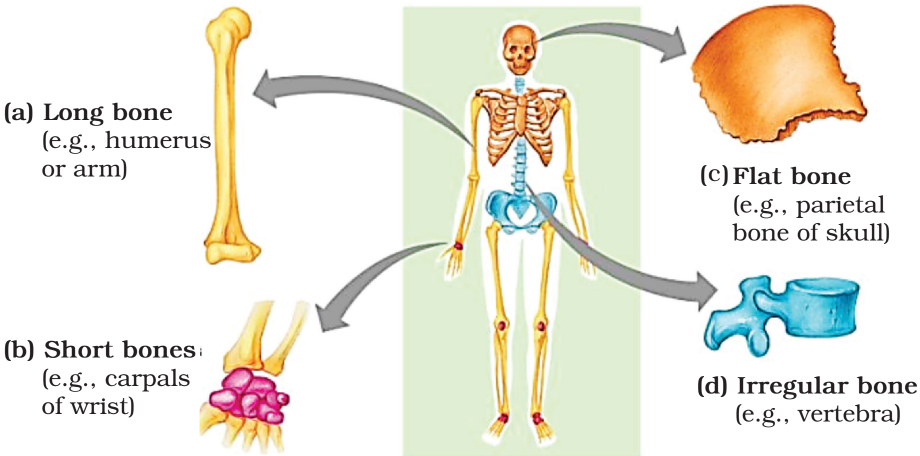


Figure 3b. Bone structure & types

Two basic types of bone tissue

- Compact bone:
- Homogeneous
- Spongy bone

- Small needle-like pieces of bone
- Many open spaces (Figure 3a)

Classification of bones based on shape

Classification of Bones

Bones of the human skeletal system are categorized by their shape and function into five types (Figure 3 - 4).

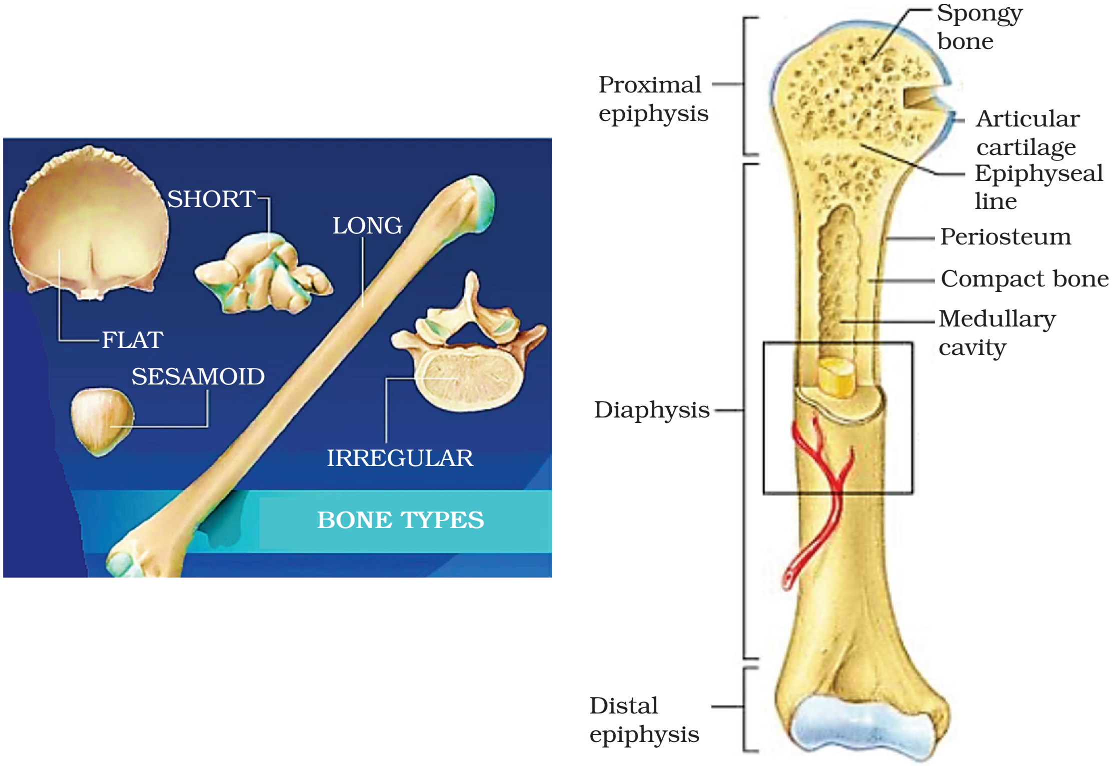


Figure 4. Bone types

Long bones

- Typically longer than wide
- Have a shaft with heads at both ends
- Contain mostly compact bone
- Examples: Femur, humerus

Short bones

- Generally cube-shape
- Contain mostly spongy bone
- Examples: Carpals, tarsals

Flat bones

- Thin and flattened, usually curved
- Thin layers of compact bone around a layer of spongy bone
- Examples: Skull, ribs, sternum

Irregular bones

- Irregular in shape
- Do not fit into other bone classification categories
- Example: Vertebrae and hip

Sesamoid bone

- Embedded in tendons
- Small, round in shape
- Protect tendons from stress and wear

Example:-

The patella, also called the kneecap, The hand - four sesamoid bones can be found in the hand.

Infants have more bones than adults

An infant skeleton has almost 100 more bones than the skeleton of an adult. At first, it is all flexible but strong cartilage.

Bone formation begins at about three months gestation and continues after birth into adulthood.

An example of several bones that fuse over time into one bone is the sacrum.

At birth, the sacrum is five vertebrae with discs in between them.

The sacrum is fully fused into one bone usually by the fourth decade of life.

Types of Bone Cells

- **Osteocytes**: Mature bone cells
- **Osteoblasts**: Bone-forming cells
- **Osteoclasts**: Bone-destroying cells. They Break down bone matrix for remodeling and release of calcium

Bone remodeling is a process by both osteoblasts and osteoclasts

B. Regions of the Skeleton

- **Bones of The skeletal system are grouped into two divisions (Figure 5).**

1. Axial skeleton (skull, ribs and vertebra)
2. Appendicular skeleton (pelvis, extremities)

Bones of the appendicular skeleton facilitate movement - girdles and limbs

Bones of the axial skeleton protect internal organs – skull, vertebral column and thoracic cage

Of the 206 bones, 80 are in the axial skeleton, with 64 in the upper appendicular and 62 in the lower appendicular skeleton.

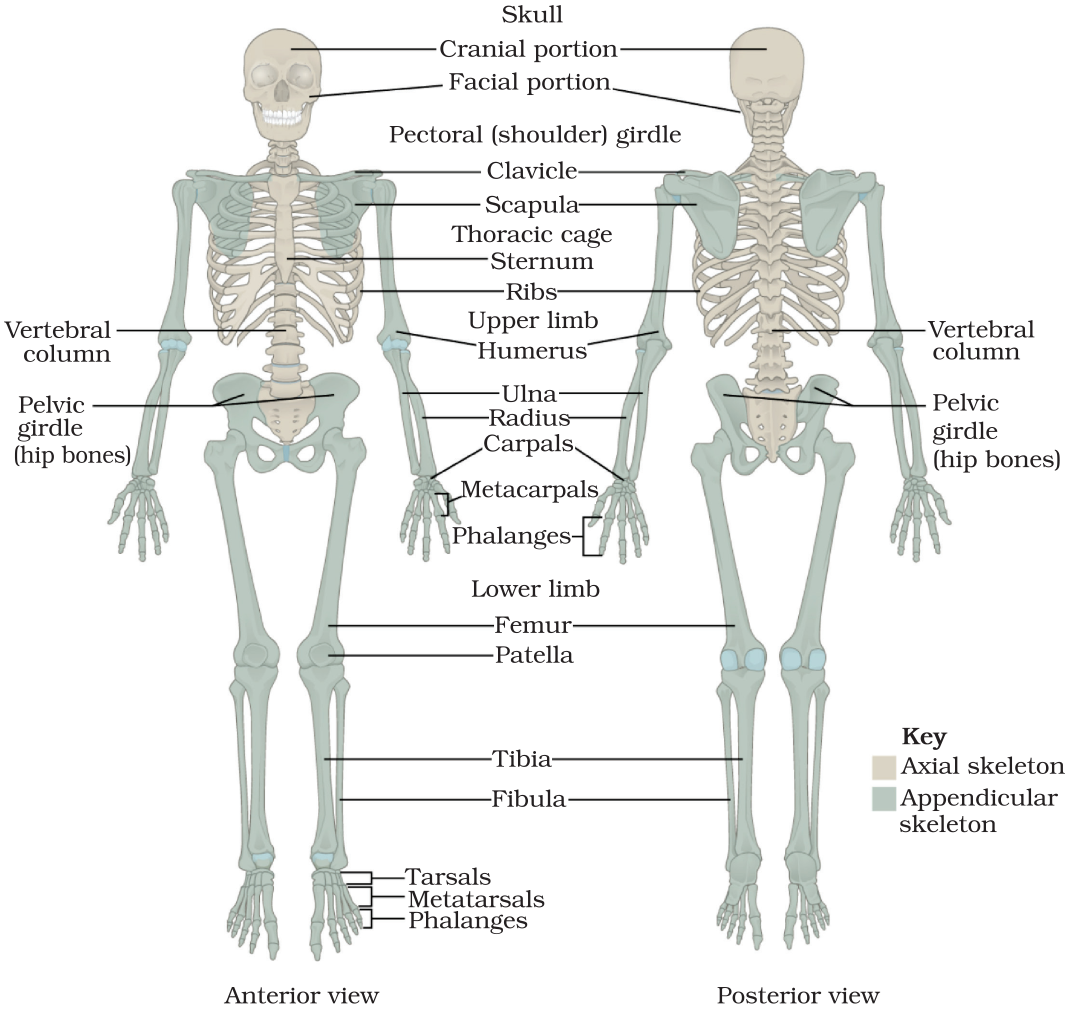


Figure 5. Human the Skeleton

I. The Axial Skeleton

- Forms the longitudinal part of the body

- Divided into three parts:
    - Skull
    - Vertebral column
    - Bony thorax

II. **The Appendicular Skeleton**

- Limbs (appendages)
- Pectoral girdle
- Pelvic girdle

C. Functions of Skeleton and Bones

Some bones produce red blood cells

Red bone marrow is soft tissue located in networks of spongy *bone tissue inside some bones. In adults the red marrow in bones produce blood cells of the:*

- *Cranium (skull)*
- *Vertebrae*
- *Scapulae (shoulder bones)*
- *Sternum (bone in the center of the chest)*
- *Ribs*
- *Pelvis*
- The epiphyseal ends of the large long bones

Long bones have three main parts

The outside of a long bone consists of a layer of compact bone surrounding spongy bone.

Red bone marrow contains haemopoietic tissue, the chief function of which is to produce all three main kinds of blood cell: red; white; and platelets.

At birth, red marrow is present in all bones, but with increasing age, in the long bones it gradually becomes yellow marrow and loses its blood-making capacity.

Long bones support weight and facilitate movement

The long bones, longer than they are wide, include:

The femur (the longest bone in the body) relatively small bones in the fingers.

Long bones are mostly located in the appendicular skeleton and include the lower limbs and bones in the upper limbs.

Short bones are cube shaped

Short bones are about as long as they are wide.

Located in the wrist and ankle joints, short bones provide stability and some movement.

Examples of short bones are:

- The carpals in the wrist
- The tarsals in the ankles

Flat bones protect internal organs

There are flat bones in:

- the skull (occipital, parietal, frontal, nasal, lacrimal, and vomer),
- the thoracic cage (sternum and ribs)
- the pelvis (ilium, ischium, and pubis).
- the function of flat bones is to protect internal organs such as the brain, heart, and pelvic organs.
- flat bones can provide protection, like a shield and can also provide large areas of attachment for muscles.

Irregular bones have complex shapes

Irregular bones vary in shape and structure and therefore do not fit into any other category (flat, short, long, or sesamoid).

They often have a fairly complex shape, which helps protect internal organs.

Examples The vertebrae, irregular bones of the vertebral column, protect the spinal cord.

The irregular bones of the pelvis protect organs in the pelvic cavity.

Skull bones protect the brain and form an entrance to the body

The skull consists of the cranial bones and the facial skeleton.

The cranial bones compose the top and back of the skull and enclose the brain.

The facial skeleton, as its name suggests, makes up the face of the skull.

Facial skeleton

The 14 bones of the facial skeleton form the entrances to the respiratory and digestive tracts.

It is made up of:

- the facial skeleton is formed by the mandible, maxillae (r,l),and the zygomatics (r,l), nasal bone, lacrimal bones and vomer
- the bones that give shape to the nasal cavity

Cranial bones

The eight cranial bones support and protect the brain:

- Occipital bone
- Parietal bone
- Temporal bone
- Frontal bone
- Ethmoid bone

Skull sutures –

In fetuses and newborn infants, cranial bones are connected by flexible fibrous sutures, including large regions of fibrous membranes called fontanelles.

These regions allow the skull to enlarge to accommodate the growing brain.

The sphenoidal, mastoid, and posterior fontanelles close after two months, while the anterior fontanelle may exist for up to two years.

As fontanelles close, sutures develop. Skull sutures are immobile joints where cranial bones are connected with dense fibrous tissue.

The Hyoid Bone, Laryngeal Skeleton, and Bones of the Inner Ear are commonly categorized with Skull Bones.

Bones of the inner ear

Inside the petrous part of the temporal bone are the three smallest bones of the body:

These three bones articulate with each other and transfer vibrations

from the tympanic membrane to the inner ear.

The laryngeal skeleton, also known as the larynx or voice box, is composed of nine cartilages.

It is located between the trachea and the root of the tongue.

The hyoid bone provides an anchor point.

The movements of the laryngeal skeleton both open and close the glottis and regulate the degree of tension of the vocal folds, which – when air is forced through them– produce vocal sounds.

The bones of the thoracic cage protect internal organs

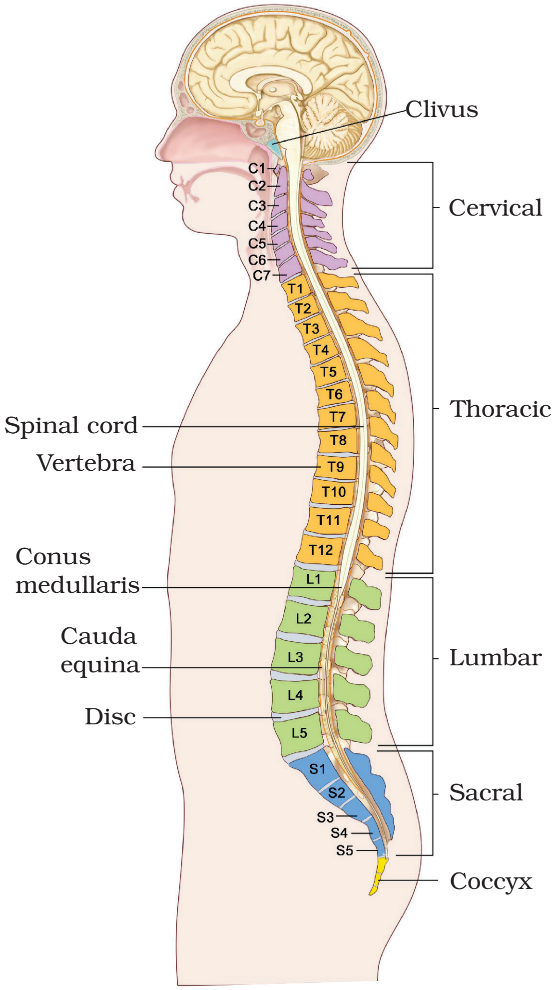
The thoracic cage, formed by the ribs and sternum, protects internal organs and gives attachment to muscles involved in respiration and upper limb movement.

Ribs 1-7 paris are called true ribs because they articulate directly to the sternum Ribs 8-10 pairs are known as false ribs while ribs 11^{th} and 12^{th} pairs are floating ribs.

The bones of the vertebral column:

the vertebrae, sacrum, and coccyx

The vertebral column is a flexible column formed by a series of 24 vertebrae, plus the sacrum and coccyx.



Commonly referred to as the spine, the vertebral column extends from the base of the skull to the pelvis.

The spinal cord passes from the foramen magnum of the skull through the vertebral canal within the vertebral column.

The vertebral column is grouped into five regions:

- cervical spine (C01-C07),
- thoracic spine (T01- T-12
- lumbar spine (L01-L05)
- sacral spine
- coccygeal spine

The spine is also known as the spinal or vertebral column, or simply "the backbone". This strong yet flexible central support holds the head and torso upright yet allows the neck and back to bend and twist.

Spine function The spine consists of 33 ring-like bones called vertebrae.

With the S shape, it acts like a spring and can flex when we are young and jump off of something.

If it was straight up and down, it could break easily.

The bottom nine vertebrae are fused into two larger bones termed the sacrum and the coccyx, leaving 26 movable components within the spine.

Brief description of the division of the vertebral column

The bones of the shoulder girdle

The pectoral or shoulder girdle consists of the scapulae and clavicles.

The shoulder girdle connects the bones of the upper limbs to the axial skeleton.

These bones also provide attachment for muscles that move the shoulders and upper limbs.

Include atlas and axis of first and second cervical vertebrae. Also provide a breif description of their features.

Bones of the upper limbs

The upper limbs include the bones of the arm (humerus), forearm (radius and ulna), wrist, and hand.

The only bone of the arm is the humerus, which articulates with the forearm bones–the radius and ulna–at the elbow joint. The ulna is the larger of the two forearm bones.

Wrist bones

The wrist, or carpus, consists of eight carpal bones.

Hand bones

The hand includes:

- 8 bones in the wrist
- 5 bones that form the palm
- 14 bones that form the fingers and thumb.

The wrist bones are called carpals.

The bones that form the palm of the hand are called metacarpals.

The phalanges are the bones of the fingers.

The bones of the pelvis

The pelvic girdle is a ring of bones attached to the vertebral column that connects the bones of the lower limbs to the axial skeleton.

The pelvic girdle consists of the right and left hip bones.

Each hip bone is a large, flattened, and irregularly shaped fusion of three bones:

Ilium

Ischium

Pubis

Female and male pelvis.

The female and male pelvises differ in several ways due to childbearing adaptations in the female.

The female pelvic brim is larger and wider than the male's Pelvis.

The male pelvis is deeper and has a narrower pelvic outlet than the female's Pelvis.

The bones of the lower limbs

The lower limbs include the bones of the thigh, leg, and foot.

The femur is the only bone of the thigh. It is the biggest bone in the body.

It articulates with the two bones of the leg–the larger tibia (commonly known as the shin) and smaller fibula.

The thigh and leg bones articulate at the knee joint that is protected and enhanced by the patella bone that supports the quadriceps tendon.

Foot bones.

The bones of the foot consist of:

- tarsal bones of the ankle
- phalanges that form the toes,
- metatarsals that give the foot its arch.

As in the hand, the foot has:

- five metatarsals
- five proximal phalanges
- five distal phalanges
- only four middle phalanges (as the foot's "big toe" has only two phalanges).

Ankle bones.

The ankle, or tarsus, consists of 7 tarsal bones:

- Calcaneus
- Talus
- Cuboid

- Navicular
- 3 Cuneiforms

Foot arches

The arches of the foot are formed by the interlocking bones and ligaments of the foot.

They serve as shock-aborbing structures that support body weight and distribute stress evenly during walking.

Ligaments

Ligaments are strong bands or straps of fibrous tissue that provide support to bones and link bone ends together in and around joints.

They are made of collagen – a tough, elastic protein.

A large number of ligaments bind together the complex wrist and ankle joints

The foot ligaments store energy as they stretch when the foot is planted and then impart it again as they recoil and shorten to put a “spring in the step”.

This saves an enormous amount of energy when walking.

Tendons

Tendons are tough, fibrous cords of connective tissue that link skeletal muscles to bones.

Tendons in the hands and feet are enclosed in self-lubricating sheaths to protect them from rubbing against the bones.

ACTIVITY 1

Composition of the Skeleton system: Bones, Cartilages, Ligaments and Tendons.

In group of 4 - 5 students collect the skeleton of dead cattle and identify: Bones, Cartilages, Ligaments and Tendons.

D. Types of Joints, Functions and Locations

- Articulations of bones
- Functions of joints
- Hold bones together
- Allow for mobility

Ways joints are classified

- Functionally
- Structurally

Joints can be grouped by their function into 3 ranges of motion

- Immovable joints
- Joints that allow a slight movement
- Joints allowing full movement include many bone articulations in the upper and lower limbs, such as the elbow, shoulder, and ankle.

Joints can be grouped by their structure into fibrous, cartilaginous, and synovial joints

Fibrous Joints – Most of these have thick connective tissue between them which is why most are immovable.

Cartilaginous joints: Joints that unite bones with cartilage are called cartilaginous joints.

Synovial joints

Synovial joints are characterized by the presence of a capsule between the two joined bones. Bone surfaces at synovial joints are protected by a coating of articular cartilage. Synovial joints are often supported and reinforced by surrounding ligaments, which limit movement to prevent injury.

There are six types of synovial joints (Figure 6).

1. Gliding joints
2. Hinge joints allow one directional movement.
3. A pivot joint which provides rotation of one bone around another.
4. A condyloid joint allows for circular motion, flexion, and extension
5. A saddle joint
6. The ball-and-socket joint such as in the hip and shoulder which all movement in all directions.

Synovial joints are enclosed by a protective outer covering – the joint capsule.

The capsule's inner lining, called the synovial membrane, produces slippery, oil-like synovial fluid that keeps the joint well lubricated so that the joint surfaces in contact slide with minimal friction and wear. There are around 230 synovial joints in the body.

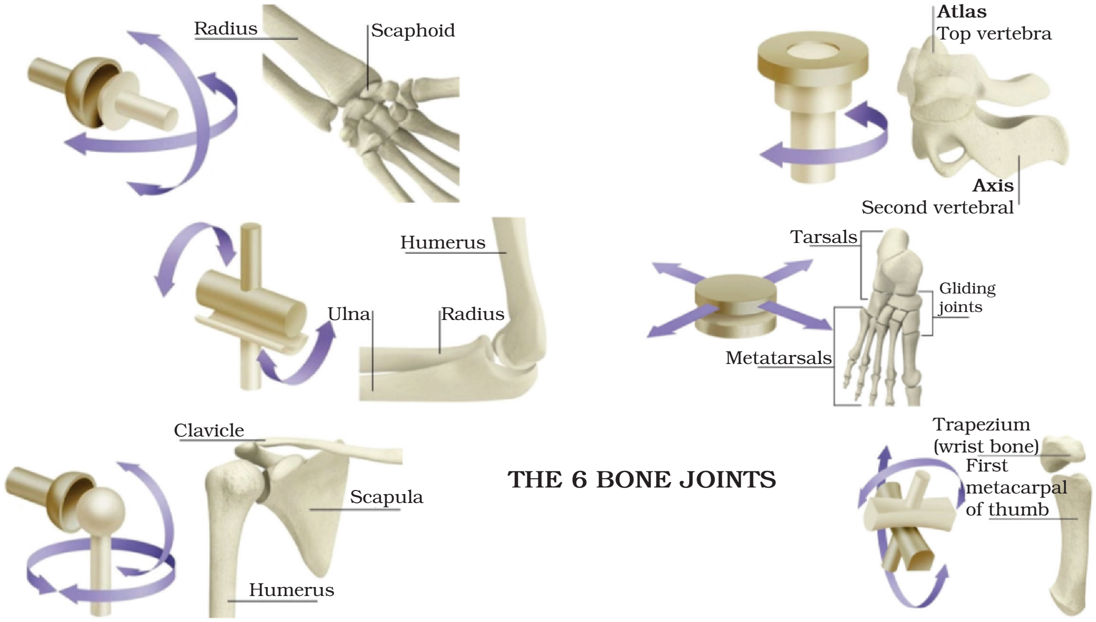


Figure 6. Joint types

Activity 2

Types of Joints, Functions and locations:
In group of 4 - 5 students identify and discuss the types of joints, functions and locations in your body.

Exercises

Choose the correct answer.

1. One direction movement is allowed by
   (a) Ball and socket joint
   (b) Hinge joint
   (c) Gliding joint
   (d) Immovable joint
2. The hardest bone structure is
   (a) Spongy bone
   (b) Cartilage
   (c) Bone marrow
   (d) Compact bone

3. A pivot joint is used when your head.
   (a) Hold a pen
   (b) Move your head
   (c) Bend your knee
   (d) Bend your elbow
4. The membrane that is surround and protects bone is called__________
   (a) Ligament
   (b) Periosteum
   (c) Cartilage
   (d) Tendon

2.3 Muscular System

Importance and Components of muscular system

Muscles are important because they...

- Hold organs in place
- Hold bones together so that you can move
- Help chew food
- Open and close eyelids
- Pump blood
- Allow to move and exercise
- Enable to have good posture

A. Type and Functions of muscles

1. Cardiac Muscle (Heart) tissues
2. Smooth or Involuntary Muscle tissues
3. Skeletal/Striped or Voluntary Muscle tissue

Skeletal Muscle

Basic features of a skeletal muscle (Figure 8) tissues

- Most skeletal muscles run from one bone to another muscles
- They are under our conscious control
- We use them to run, jump, walk
- One bone will move – other bone remains fixed
- Origin – less movable attachment

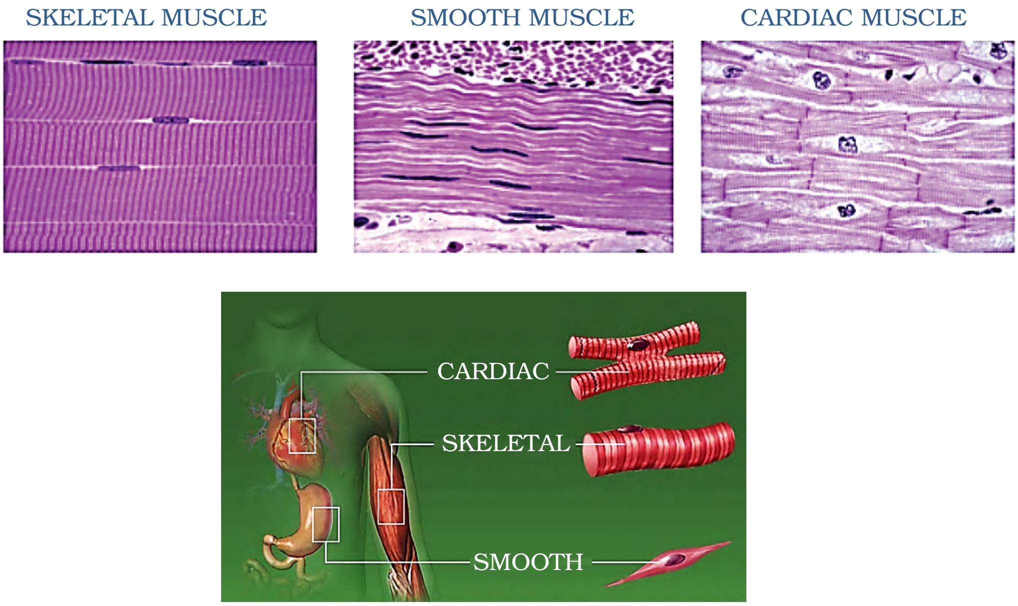


Figure 7. The 3 types of Muscles tissues

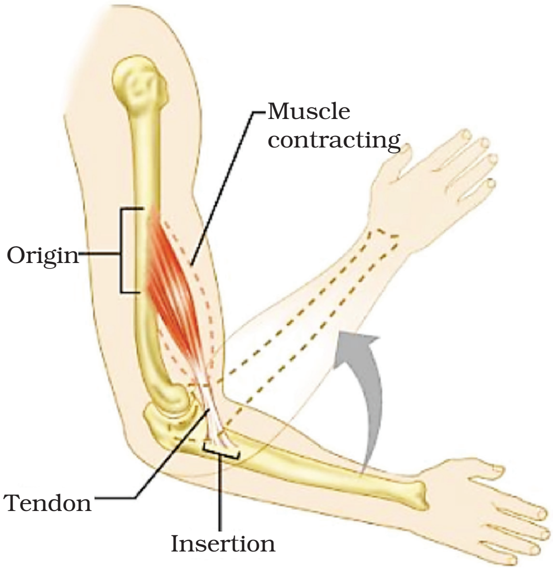


Figure 8. How muscles attach to bones

Skeletal muscles are also known as voluntary muscles, since we control their actions at will, and as striated muscles, from their microscopic appearance (Figure 9).

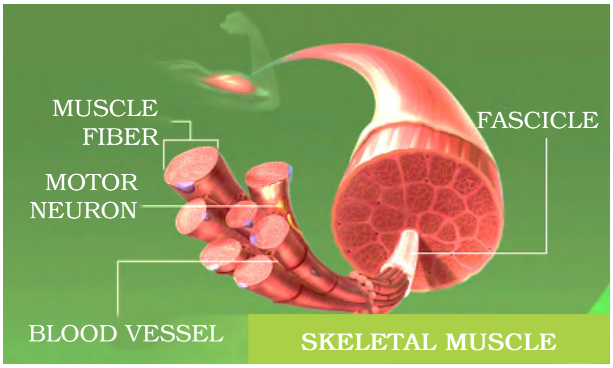


Figure 9. Skeletal muscle arrangement

Skeletal (striated or voluntary) muscle consists of densely packed groups of hugely elongated cells known as myofibers. These are grouped into bundles.

A typical myofiber is 2–3 centimeters (3/4–1 1/5 in) long and 0.05 millimeters (1/500 inch) in diameter and is composed of narrower structures – **myofibrils**. These contain thick and thin myofilaments made up mainly of the proteins actin and myosin. Numerous capillaries keep the muscle supplied with the oxygen and glucose needed to fuel contraction.

Smooth or Involuntary Muscle Tissues

- These muscles work automatically – they are not under our conscious control.
- They fatigue, but very slowly
- Found in the digestive system: stomach, esophagus, intestines, and control digestion
- Found in the respiratory system: lungs, diaphragm, control breathing
- Found in urinary system: bladder, controls urination

Cardiac Muscle Tissue

- Cardiac is a special type of involuntary muscle
- It is only found in the heart
- It works automatically
- nervous system and chemical control.
- Contractions of the heart muscle pump blood throughout the body and account for the heart beat

- Healthy cardiac muscle never fatigues.

The heart wall is composed of three layers.

The middle layer, the myocardium, is responsible for the heart's pumping action.

Cardiac muscle tissue found only in the myocardium, contracts in response to signals from the cardiac conduction system to make the heartbeat.

Cardiac muscle is tissue made from cells called cardiocytes.

How Muscles Work?

Muscles must work in pairs (Figure 10)

- Muscles can only contract: If one muscle contracts to bring bones together, another muscle must contract to bring the bones apart (a bicep /tricep contraction, to bend the arm)
- We need large numbers of pairs of muscles, to work together in different ways for even simple body movements.
- Our muscles take on different roles, depending on the movement they are to perform.

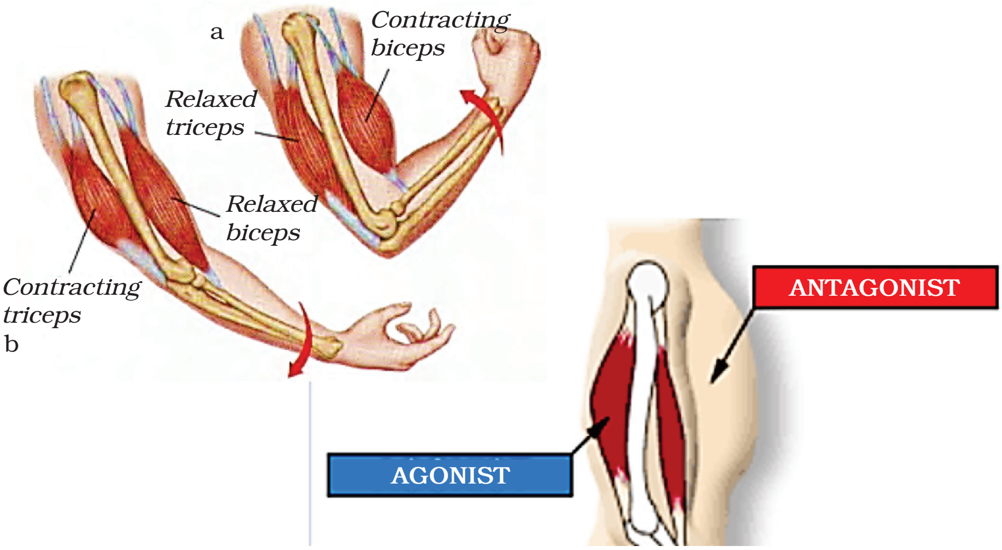


Figure 10. Antagonistic (opposing) muscles: they work in pairs.

There are three main types of muscular contraction

Isotonic and concentric

Muscles shorten as they contract,the ends of the muscle move closer together (like in a biceps during a pull up), most sport moves are this type of contraction

- **Isotonic and eccentric**

Muscles lengthen as they contract,the ends move farther apart, (like the biceps when lowering down from a pull up), plyometrics

- **Isometric:**

Muscles stay the same length when contracting, there is no movement, (like your shoulders in a tug of war), in sporting events the stabilizing muscles hold parts of the body steady as other parts move

Muscle pairs (Figure11)

Muscles are grouped together in pairs on the skeleton

Muscles can't push - they only contract and pull the bones to which they are anchored.

Relaxed or contracted: When one muscle of a pair contracts, the other relaxes

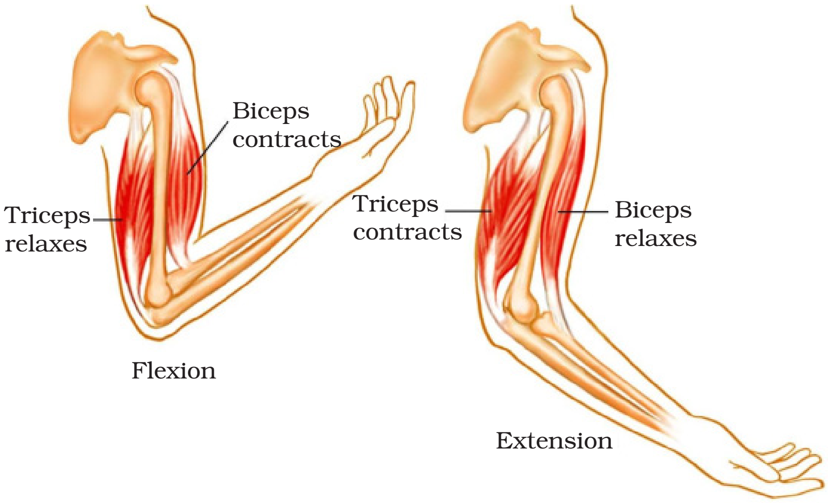


Figure 11. Action of Biceps & Triceps.

Pulling muscles: Skeletal muscles only pull in one direction. For this reason they always come in pairs. When one muscle in a pair contracts, to bend a joint for example, its partner then contracts and pulls in the opposite direction to straighten the joint out again. An example of how the 2 sets of arm muscles move to pull the bone, on one side and then the other, depending on how the arm is intended to move.

How Are Muscles Attached to Bones?

- Muscles are usually attached to 2 or more different bones (Figure12).
- The muscle fibers end in a strong, white fibrous cord called a tendon.

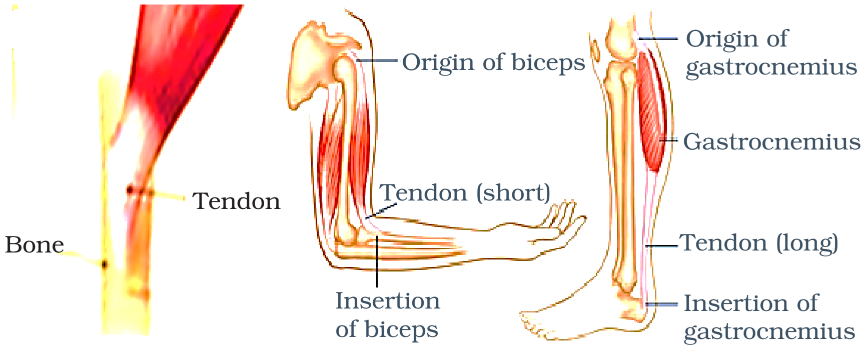


Figure 12. Muscle attachements

- This anchors the tendon strongly and spreads the force of the contraction.
- **Tendons attach muscle to bone**
- **Ligaments attach bone to bone**

Muscle attachments: tendons attach muscles to bone

Muscle fiber types

There are two different types of muscle fibers

- **Slow Twitch:** have a very good oxygen supply, work for a long time without fatigue, are not as strong as fast twitch, take longer to contract, are used in all types of exercise (especially aerobic activities).
- **Fast Twitch:** do not have a good oxygen supply, tire very quickly, are stronger than slow twitch, are used in powerful, fast, movements, are used in high intensity exercise, used in anaerobic activities

Mixture of muscle fibers

Every muscle contains a mixture of fast and slow twitch muscle fibers,

- The mixture is different in every muscle, for example the gastrocnemius muscle contains a lot of fast twitch fibers so standing on your toes is tiring.
- The mixture is also unique to each individual. Some distance runners have 80% slow twitch while some power lifters have 80% fast twitch.

Muscle tone:

- Even when a muscle is relaxed, a small number of fibers are contracted – enough to keep the muscle taut but not enough to cause movement.
- This partial state of contraction is referred to as "muscle tone". Without muscle tone you would not be able to stand up straight.
- To maintain muscle tone without getting tired, groups of muscles take turns in contracting. They work in relays.
- Poor muscle tone leads to poor posture.

Exercise improves muscle tone – it makes the fibers thicker so they may contract stronger.

Exercises

Matching

Body part		Function
1. Cardiac muscle	(a)	Contracts to bend hand
2. Smooth muscle	(b)	Attach bone to bone
3. Bicep muscle	(c)	Attach muscle to bone
4. Tendon	(d)	Found in heart
5. Ligament	(e)	Found in body tubes such as intestine.

2.4 Reproductive Systems

Reproduction in Humans

Reproduction is the process by which an organism gives rise to its own kind. It is the perpetuation of life.

Human beings reproduce by sexual mode of reproduction.

Reproduction is the function of reproductive system. Human reproduction is the process by which the parents (mother and father) produce a baby/babies (offspring).The reproductive system comprises the male and female reproductive structures.

In humans, there are two stages of sexual characteristics known as primary and secondary sexual characteristics.

Primary sexual characteristics

A human baby is born with organs, which differentiate the sex. These are called **primary sexual organs or characteristics**.

The human male primary sexual organs or characteristics are-

- Penis,
- Scrotum and
- Testes

The human female primary sexual **organs or** characteristics are-

- Vagina,
- Uterus and oviducts
- Ovaries

A. Adolescence and Development

Secondary sexual characteristics

Reproduction is not possible until sexual maturity is reached at about the ages of 11-17 years. This stage of development is called **puberty** or **adolescence**. A person at adolescence begins to show the characteristics of adults, known as secondary sexual characteristics.

Chemical substances in the body called hormones cause the development of secondary sexual characteristics. After the development of secondary sexual characteristics, the male and female individuals are ready for reproduction (Figure 13).

Some of the male secondary sexual characteristics are:-

- Testes begin to produce sperm cells.
- Hair appears around the penis, in the arm pits and face.
- Body becomes more muscular,
- Voice deepens, etc.

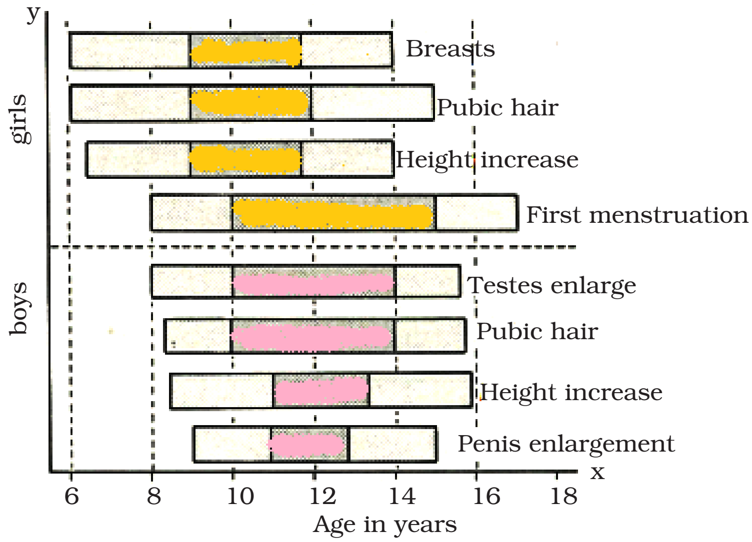


Figure 13. Development of secondary sexual characteristics by age.

Some of these female secondary sexual characteristics are:-

- Ovaries begin to produce egg,
- Hair develops around the vagina and in the armpits,
- Breasts begins to enlarge,

The Male & Female Reproductive Organs

(a) Male Reproductive Organ (Figure 14)

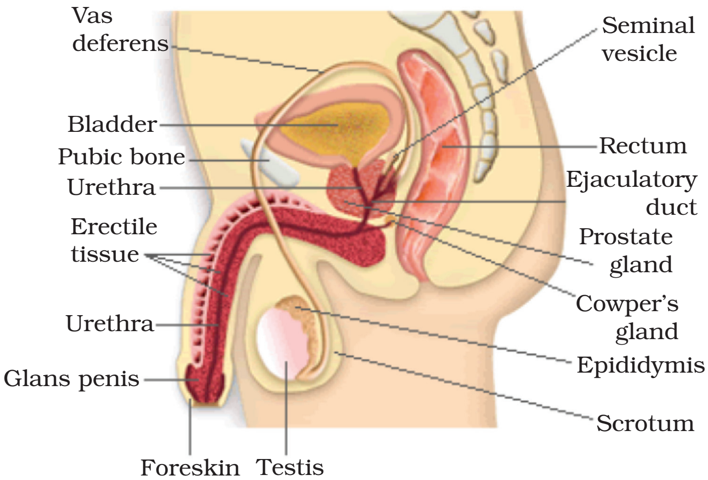


Figure 14. Male reproductive organs

Male reproductive organs include testes, penis, scrotum, epididymis & vas deferens.

Scrotum

- A sac-like pouch located behind the penis that holds each testes and helps regulate temperature for sperm production.

Testicles or Testes

- The two testes are small organs that lie in the scrotum and produce sperm and the male hormone testosterone.
- The testicles are the male sex gland.
- The testicles are outside the body because the male sperm that is manufactured in the testes need cooler-than-body temperature for normal growth and development.
- Four to five billion sperm cells are produced each month in the testes.

Testosterone is the male reproductive hormone made by the testicles which causes the changes of puberty.

- This hormone causes secondary sex characteristics, production of sperm and sexual urge.

Sperm cells are microscopic in size produced by the male's testicles which can fertilize the female's ovum.

- Sperm are affected and destroyed by warm body temperature and acidic environment.
- It can survive in a women's body for 5-8 days.

Epididymis: is the structure that forms a mass over the back and upper part of each testes.

- Sperm are stored there for as long as six weeks while they ripen to maturity.

Cowper's Gland

- two small pea-sized glands located beneath the prostate gland on both sides of the base of the penis.
- They secrete a clear, sticky fluid that helps to neutralize the acidity of the urethra.

Vas Deferens are two long, thin tubes that serve as a passageway for sperm and a place for sperm storage.

- The contraction of the vas deferens along with the action of the cilia help transport the sperm through the vas deferens.

Seminal Vesicles are two small glands that secrete a fluid that nourishes and enables the sperm to move.

Prostate Gland

- surround the urethra beneath the bladder. The gland secretes an alkaline fluid that neutralizes the acid found in the male urethra and the female reproductive tract.
- Without the action of the secretions of the prostate gland, many sperm would die and fertilization of an ovum would be impossible.

Urethra

- A dual purpose tube that both semen and urine pass through to leave the body.
- Special muscles or sphincters surround the urethra.
- During urination, one sphincter will relax so that the pressure from the bladder will push urine out from the body.
- During ejaculation, another sphincter will relax so that semen can flow through the urethra to the outside of the body.

Penis is the male organ for sexual intercourse, reproduction, and urination.

- The reproductive purpose of the penis is to deposit semen in the vagina during sexual intercourse.
- The head of the penis or glans contains many nerve endings. At birth the glans is covered by a loosely fitting skin called the foreskin.
- When the penis is erect it is 5-7 inches long An erection occurs when the sponge-like chambers in the penis fill with blood.

Semen is a combination of fluid that is produced in the seminal vesicles, prostate gland, and Cowper's gland. This fluid nourishes and helps sperm move through the urethra.

Ejaculation is the passage of sperm from the penis, a result of a series of muscular contractions.

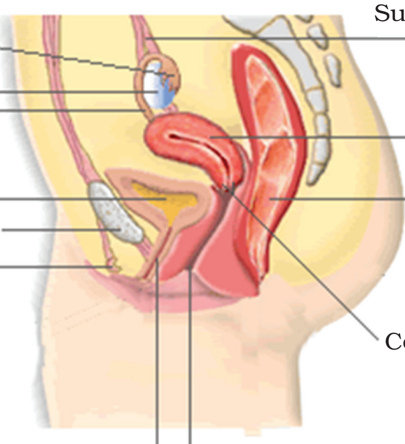


Figure 15. Female reproductive Organs

Ovary (Ovaries) are the female sex glands.

- They are two solid egg-shaped structures
- Ovaries have two main functions:

1. Store and release the ova or female egg cell.
2. Produce female sex hormones ESTROGEN and PROGESTERONE

Ova the female reproductive cell. They are the largest cells in the female body. (about the size of a grain of sand). The female baby is born with all the ova she will ever have (about 200,000 in each ovary). About 400-500 ova mature and are released over a lifetime

Estrogen

- Estrogen is responsible for the secondary sex characteristics and the sex drive in females. It spurs the onset of puberty and is responsible for OVULATION.

Progesterone

- Progesterone builds up the lining of the uterus called the endometrium in preparation for the fertilized ovum

Ovulation

- When the egg is released from the ovary.
- At the age of puberty

- The ovum moves to the surface of the ovary in bursts out
- The ova falls into the fallopian tube and waits for fertilization
- This happens every 28 days
- It happens at about the 14th day of the cycle

Fallopian tubes (oviducts)

- Two tubes attached on either side of the uterus.
- They are about four inches long and 3/16 inch in diameter (the size of a cooked spaghetti noodle).
- The oviducts carry egg cells toward the uterus and sperm cells toward the egg cell.
- Fertilization takes place in the upper third of the oviduct.

Uterus

- A hollow, muscular organ (shaped somewhat like an upside-down pear, about the size of a fist).
- The uterus is lined with endometrium (a blood lining.)
- Endometrium is the lining of the uterus which gradually thickens and then shed during menstruation.
- The uterus has one main function—to protect and nourish a fetus
- The walls of the uterus have the ability to stretch to the size of a small watermelon.
- After childbirth, the uterus shrinks back to the original shape in 6-8 weeks, but it can take up to nine months for the uterus to fully recover.

Cervix

- The neck or opening of the uterus.
- A normal healthy cervix is the strongest muscle in the body.
- It dips down about half an inch into the vagina.
- It is normally plugged by mucus. It stays tightly closed during pregnancy, but thins and opens for the delivery of the baby.
- How big does it need to dilate to for birth?

Vagina

- Female organ used for intercourse, it is an empty passageway leading from the vaginal opening to the uterus.

- It is only 3-4 inches long, but will lengthen during arousal.
- The vaginal walls are made of many small folds of membrane that stretch greatly to accommodate a baby during birth.
- The vaginal wall also secrete a fluid that helps to make intercourse easier.

Clitoris

- A small, pea shaped bump at the front of the labia.
- It contains a small amount of erectile tissue.
- The clitoris increases sexual pleasure

B. Gametogenesis (Gamete formation)

Gametogenesis is the process of female and male gamete production.

- Occurs by Meiosis rather than mitosis
- Results in four daughter cells rather than two
- Reduces chromosome number by one-half

Meiosis (Figure 16)

Most human cells contain 46 chromosomes each **chromosome** contains several 100 genes (~500-600 genes/chromosome).

These genes are the instructions that must be passed on to new cells most cells in the body are produced by mitosis.

Meiosis is a type of cell division that produces genetically identical copies each cell in your body has all genes for all instructions a human needs the formation of egg and sperm require a different kind of cell division.

During meiosis each of our cells has 46 chromosomes – but they come in pairs.

We have two of each kind of chromosome or 23 pairs of chromosomes.

1 of each pair from mother; 1 from father.

The formation of egg and sperm require sex cells that have only one set of chromosomes.

When the sperm cell fertilizes the egg then the fertilized egg has 46 chromosomes again.

Only sex cells (eggs and sperm) are formed by meiosis, occurs during spermatogenesis and oogenesis.

The process is similar to meiosis but with some important differences. in mitosis chromosomes replicate during interphase and the cell divides (PMAT)

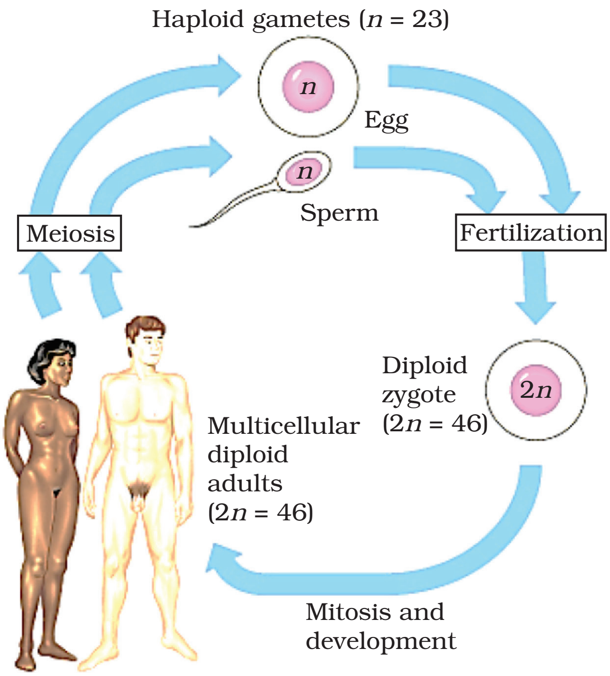


Figure 16. Process of Meiosis

once to produce 2 identical cells each with 46 (23 pairs) of chromosomes.

In meiosis chromosomes replicate during interphase as in mitosis, but then goes through two sets of cell divisions to produce a total of 4 unique cells each **with 23 chromosomes.**

I. **Spermatogenesis** is the process of sperm production. Process takes ~ 70-80 days

sperm are produced in **seminiferous tubules of Sertoli Cells** = specialized cells in the seminiferous tubules facilitate spermatogenesis.

Steps of spermatogenesis:

1. during prenatal development primordial germ cells colonize embryonic gonad and become spermatogonia.
2. spermatogonia remain dormant in childhood.
3. at puberty they begin to divide (mitosis).

4. some spermatogonia begin moving away from the wall of the tubule and enlarge to become primary spermatocytes.
5. primary spermatocyte undergoes meiosis I to produce secondary spermatocytes chromosome # reduced by half (=haploid)
6. secondary spermatocyts undergo another division (meiosis II) to produce spermatids one primary spermatocyte produces 4 spermatids
7. spermatids mature into sperm cells by loss of excess cytoplasm and growth of tail (flagellum). Young adult male produces ~300,000 sperm/minute; 400 Million/day by the time spermatozoa form they are near the lumen of the seminiferous tubules spermatozoa are released and washed down the tubule.

Spermatozoan Structure

It is composed of a head, midpiece and tail (Figure 17)

1. head is long "pear" shaped

   tip = acrosome – thin lysosome that caps the head contains enzymes that will be used to penetrate the egg & enzyme inhibitors
2. midpiece

   cylinder that contains numerous mitochondria

   produce the ATP needed for propulsion
3. tail

   bundle of filaments = flagellum only cell in body with flagellum means of locomotion.

II. **Oogenesis: formation of female reproductive cells (ova)**

When an egg divides by meiosis the result is only one functional egg and three nonfunctional "polar bodies".

As the primary oocyte goes through meiosis the actual cell divisions are unequal in the first division one cell is produced that is almost the same size as the original and a second cell containing almost no cytoplasm.

In the second meiotic division the large cell divides again as above and the small polar body also divides and end up with 1 large cell and 3 small cells, the small cells (polar bodies) eventually degenerate and only a single functional egg cell survivies.

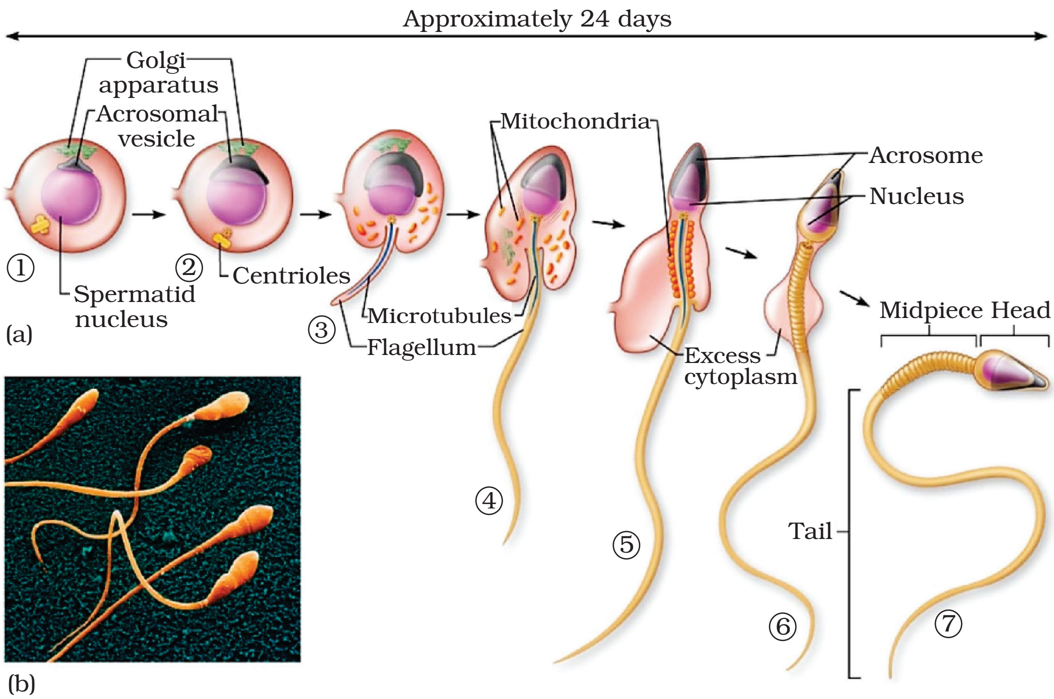


Figure 17. Development of sperm cells

2.5 The Menstrual Cycle and Development

A sequence of cyclic events known as the menstrual cycle takes place at the age of puberty in females over an average period of 28 days. The end of the cycle is marked with menstruation- the flow out of blood from the uterus through the vagina. The purpose of menstrual cycle is to prepare the uterus for receiving fertilized egg (zygote).

Chemical substances known as hormones which are produced by glands known as endocrine glands control the processes in menstrual cycle (Figure 18).

Pituitary gland secretes two hormones known as Follicle Stimulating Hormone

(FSH) and Luteinizing Hormone (LH).

- FSH stimulates egg maturation in a follicle in the ovary.
- LH stimulates the rupture of follicle and release egg in to the fallopian tube. The ruptured follicles produce a structure known as Corpus lutem.

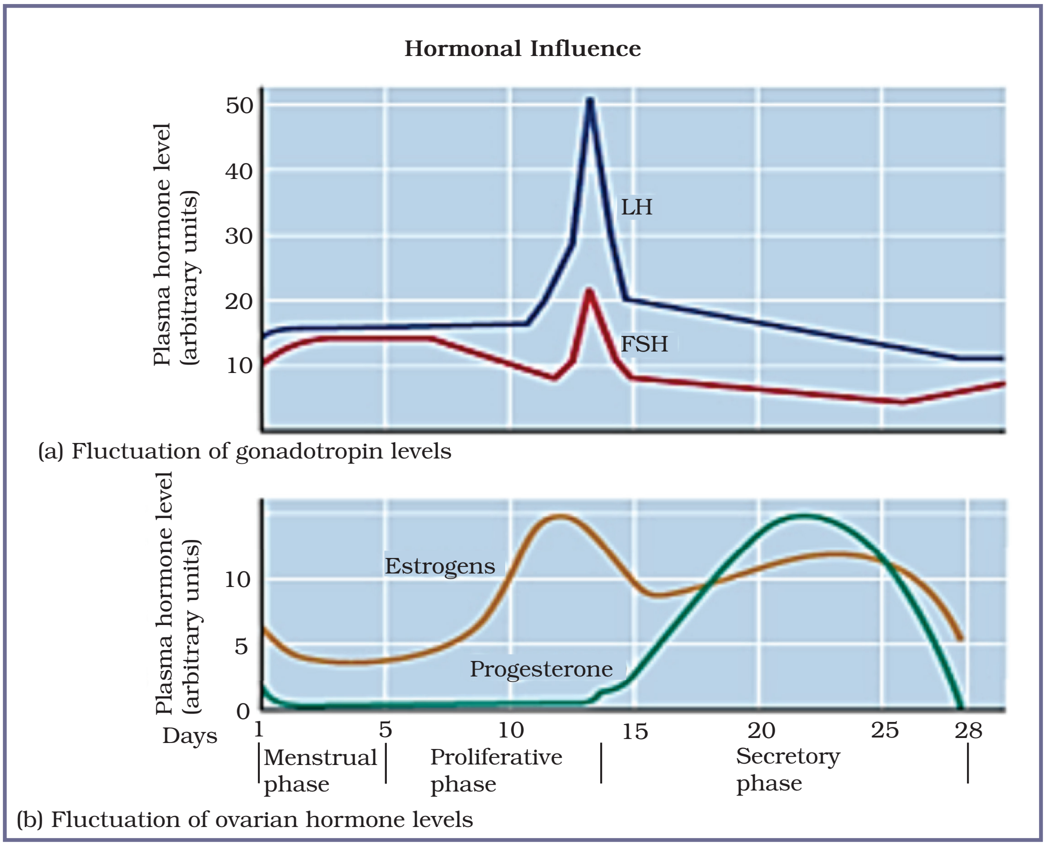


Figure 18. Hormonal influence in menstrual cycle.

Corpus lutem release two hormones known as Estrogen and Progesterone.

- Estrogen and Progesterone stimulate thickening and blood vessel development on the wall of uterus.

The sequence of events taking place in menstrual cycle (Figure19):

- An egg develops in a follicle by the action of FSH
- The wall of the uterus begins to thicken.
- An ovum is released from one of the ovaries by the action of LH and Corpus lutem develops at the middle of the menstrual cycle. The release of an ovum from the ovary in to the fallopian tube is called Ovulation.
- As the egg passes down the fallopian tube there are two alternatives- it may be fertilised by sperm as a result of intercourse or it may not be fertilised.

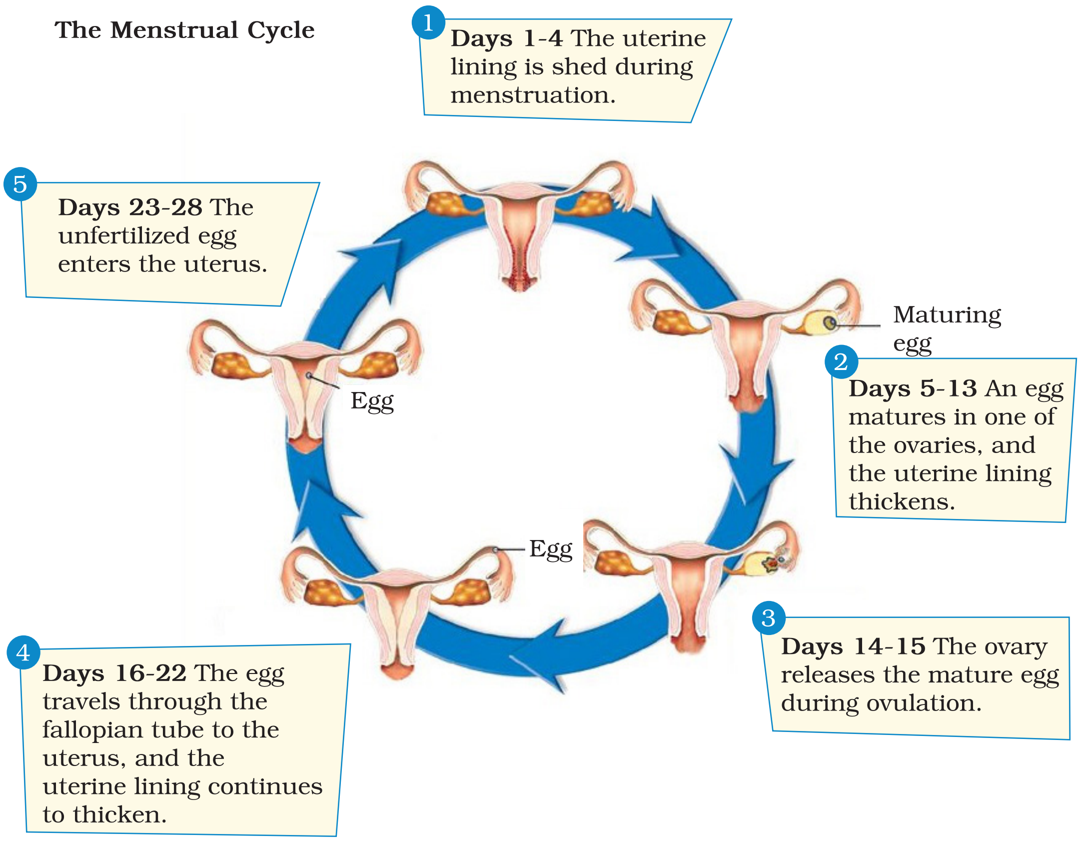


Figure 19. The menstrual cycle in Human

If no fertilization takes place (If the ovum has not been fertilised):

- The egg reaches in the uterus and disintegrates (dies).
- The corpus lutem stops releasing of progesterone and estrogen
- Low level of progesterone and estrogen stimulate pituitary gland to produce FSH and then LH.
- The thickened uterus wall breaks down with the loss of blood, passing out of the body through the vagina.
- The loss of blood from the vagina over a few days (usually 3 to 5 days) is commonly called menstrual period or a period.

If Fertilization takes place (the ovum has been fertilised):

- Zygote moves to the uterus, embedded in the thickened uterus wall, and develops into an embryo. This is called implantation.

- Progesterone and Estrogen are produced continuously by Corpus Luteum to for continued thickening uterus throughout pregnancy.
- FSH and LH production by pituitary gland is inhibited by the production of these hormones and there will not be uterine wall rupture.

Development and Birth

Fertilization is the processes of the union of sperm and egg forming of a fertilized egg called **zygote** in the fallopian tube. Zygote travels to the uterus by the fallopian tube and imbedded in the wall of the uterus. This process is called **implantation**..

Pregnancy starts at implantation stage and lasts 40 weeks (280 days). After implantation, the zygote is called Embryo. A tissue called **placenta** develops between the uterine wall and the Embryo. The placenta is connected to the Embryo by umbilical cord.

The placenta develops membranes called **amnion** containing a fluid called **amniotic fluid.**

The amniotic fluid protects the fetus from shock and allows it to move freely. After eight weeks of development, the embryo is called **Fetus** and birth takes place after 40 weeks.

2.6 Cycles of Sexuality

Sexuality is one of the fundamental drives behind everyone's feelings, thoughts, and behaviors.

It defines the means of biological reproduction, describes psychological and sociological representations of self, and orients a person's attraction to others. Further, it shapes the brain and body to be pleasure seeking.

2.7 Sexually Transmitted Diseases or Infections

Sexually transmitted diseases (Infections), formerly called venereal diseases (VD), are infectious diseases that can be spread from person to person by sexual contact (intercourse). The common STDs are Gonorrhea, Syphilis, Cancroids, and HIV/AIDS (see table 1).

Table 1 Common Venereal Diseases

Disease & Cause	Symptoms
Gonorrhea: - a bacterium called *Nisseria gonorrhea*	**Men:** inflammation and discharge from the penis; pain on urinating Women: Inflammation of the vagina and urethritis; may be present without noticeable symptoms.
Syphilis: - a tryponeme called *Tryponema palladium*	Ulceration at the point of entry usually on sex organs, but may be on lips, tongue or anus.
Genital herpes: - a virus called *Herpes simpley virus*	Small ulcers or sores on the genital organs
Chancroid: - caused by a bacterium	Acute infection of sex organs
HIV/AIDS: - caused by a virus called HIV.	Several symptoms due to the weakness of the natural defense mechanism of the body.

STDs can be very dangerous. Some can cause infertility, damage various organs, transmitted to fetus and other complications. STDs are associated with promiscuous sexual behavior and prostitution.

2.8 Sexual Violence (Gender Based Violence)

Sexual violence encompasses acts that range from verbal harassment to forced penetration, and an array of types of coercion, from social pressure and intimidation to physical force.

Sexual violence includes, but is not limited to:

rape within marriage or dating relationships.

rape by strangers or acquaintances.

unwanted sexual advances or sexual harassment (at school, work etc.).

systematic rape, sexual slavery and other forms of violence, which are particularly common in armed conflicts (e.g. forced impregnation).

sexual abuse of mentally or physically disabled people.

rape and sexual abuse of children; and n 'customary' forms of sexual violence, such as forced marriage or cohabitation and wife inheritance.

Coercion can encompass:

- varying degrees of force;
- psychological intimidation;
- blackmail; or
- threats (of physical harm or of not obtaining a job/grade etc.).

In addition, sexual violence may also take place when someone is not able to give consent – for instance, while intoxicated, drugged, asleep or mentally incapacitated.

Sexual violence is act through which a woman:

- is an physically forced to have sexual intercourse when she did not want to;
- is forced to do something sexual that she found degrading or humiliating.

There are many logical reasons why women do not report sexual violence, including:

- inadequate support systems;
- shame;
- fear or risk of retaliation;
- fear or risk of being blamed;
- fear or risk of not being believed;
- fear or risk of being mistreated and/or socially ostracized.

Sexual violence is commited by different groups.

- Sexual violence by intimate partners
- Sexual violence by non-partners
- Forced sexual initiation
- Childhood sexual abuse
- Sexual harassment and violence in schools and at work
- Sexual violence against men and boys

Family Planning

A number of birth control methods are available that work in different ways to prevent pregnancy.

Family Planning

Family planning is the method of deciding the appropriate and desired size of the family. Planning the size of the family is the decision that should be made by both partners or couples.

By the method of child spacing, it is possible to have the desired size of the family. Child spacing is effected using contraception.

Contraception is the method of preventing an unwanted pregnancy.

A number of birth control methods are available for prevention of pregnancy.

The birth control methods can be categorized as:-

1. Natural birth control methods.
2. Physical or mechanical or barrier methods.
3. Chemical or hormonal methods.
4. Surgical methods.

1. Natural birth control methods

The natural birth control methods are the calendar (rhythm) and breast feeding methods.

The calendar (rhythm) method - refers to confining sexaul intercourse to the safe period. The safe period is from 5 to 10 day and 18 - 28 days fo the menstrual cycle. On the contrary, the fertile periods of the month are from day 11 to day 17 of the menstrual cycle.

Thus, both partners should be able to avoid sexual intercoruse during the ferile period of the month.

Breast feeding:- Breast feeding is also one type of natural birth control methods. It delays ovualtion or the first six months right after child bearing.

2. Physical or mechanical (barriel) methods of birth control.

The physical or mechanical methods include the diaphragm or cap, condom, Loop or IUD (Intra Uterine device).

Diaphragm or cap:- is a thin rubber weared over the female's genitalia before intercourse.

This prevents the entrance of sperm cells to the female's vagina.

IUD (Interuterine device:- is a plastic loop placed inside the uterus to prevent implantation of the embryo. It causes discomfort bleeding during intercourse but effective.

Female Condom:- is a thin rubber shealth worn by a woman during sexual intercourse. It covers the vagina so that sperm cells can not reach cervix.

Male Condom:- is a thin rubber sheath placed over the penis during intercourse to prevent the semen from entering into the vagina.

- It provides better protection, if used along with spermicide.

3. Chemical or Hormonal methods of birth control

These methods involve the use of chemicals in pills, hormone injectables and hormone implants.

Pills:- pills consist of artificial hormones called estrogens and progestrones to prevent pregnancy.

A woman should take one pill a day, whether or not there is sexaul intercourse. Pills are very effective if properly taken.

Hormone injectables:- This method involves an injection of hromones to the female. The hormones in injectables prevent ovualtion. It should be taken every three months. It requires regular visits to health stations.

- The method is very effective like that of oral contraceptives (pills). The side effects include weight gain, irregualr cycles, nausea etc.

Hormone Implants:- This method involves the placing of a small thin plastic tubes containing progestrone under the skin of the upper arm through a small cut during minor operation. Implants prevent ovualtion.

Implants are highly effective and can remain for up to five years. It is possible to remove implants from the female's arm any time.

4. Surgical or Sterilization:- The surgical method involves surgery both in males and females.

Vasectomy or male sterilization:- This method involves a surgery in which sperm ducts are cut and tied. It prevetns the transfer sperm to the urethra.

- This method is very effective, and the male would become permanently sterile.

Tubectomy or tubal ligation:- refers to as female sterilization in which the fallopian tubes are cut or tied to prevent the ovum from reaching the uterus or the sperm reaching the ovum.

This method causes permanent sterility.

This two partners should first decide not to have more children to use this method of birth control (Sterilization).

Key Terms

- Abduction
- Coercion
- Early marriage
- FSH
- Female genital mutilation
- Gametogenesis
- Illegal abortion
- Implantation
- LH
- Menstruation
- Meiosis
- Mitosis
- Oogenesis
- Pregnancy
- Primary sexual organs
- Rape
- Secondary sexual characteristics
- Sexual abuse
- Spermatogenesis
- Testosterone

Summary

The skeleton is defined as the framework of the body.

Human skeleton is divided into axial and appendicular skeleton.

The structures and functions of human skeleton include support and movement of the body

Bones are structures consisting of living (cells) and non-living material. There are different types of bones in shape including Long bones such as arm and leg bones, Short bones such as carpal and tarsal, Circular bones such as cranium, flat such as shoulder blade, Disc such as vertebral discs, and Irregular bones such as spinal column.

The places where two or more bones meet are called Joints. Joints are classified according to the kind of movement they allow as Immovable Joints, Semi-movable joints and Movable Joints including Hinge joints, Pivot joints, Ball and socket joints, Saddle joints, and Gliding joints.

The muscular system consists of several muscles capable of contraction and relaxation. Muscles are composed of three types of muscle tissues.

Feature	Skeletal muscle	Smooth muscle	Cardiac muscle
Where found	Skeleton and most body parts	Vessels and spaces of the body	heart
Appearance	Striped (striated)	Non striped (non striated)	Striped (striated)
Action control	Voluntary (conscious control)	Involuntary (Not conscious controlled)	Involuntary (Not conscious controlled)

Muscles and skeleton work together to move our body.

Physical exercise and proper diet are important for the health of bones, muscles and joints.

Reproduction is the process by which an organism gives rise to its own kind.

Humans have primary sexual characteristics starting from birth. The human male primary sexual characteristics include penis, scrotum, and testis. The human female primary sexual characteristics include vagina, uterus, and ovaries.

The secondary sexual characteristics develop in the early teens during a period called puberty.

Male Secondary sexual characteristics include Growth of facial hair; Deepening of the voice; Body becomes more muscular; Chest and shoulders broaden; Production of sperm begins

Female Secondary sexual characteristics include; Development and enlargement of breasts; Hips widen as the pelvic girdle enlarges; Body contours become more rounded; Ovulation accompanied by menstruation begins

The parts of the male reproductive system include:

Penis, Testes, Scrotum, Sperm tube (vas deferens), Urethra, Prostate gland, Cowper's gland.

The parts of the female reproductive system include:

Ovaries, Oviducts (Fallopian tubes), Uterus, Cervix, Vagina, Vulva, Clitoris.

Once a female has reached puberty, she is able to reproduce. The following sequence of events takes place on a monthly basis in the female reproduction system:

- The wall of the uterus begins to thicken.
- An ovum is released from one of the ovaries.
- The ovum passes down the oviduct. At this time, it may be fertilised as a result of intercourse.

If the ovum has been fertilised it becomes embedded in the thickened uterus wall and develops into an embryo.

If the ovum has not been fertilised the thickened uterus wall breaks down with the loss of a small amount of blood, and passes out of the body through the vagina.

The loss of blood from the vagina over a few days is commonly called a period.

This sequence of events is called the menstrual cycle. It occurs over a period of 28 – 35 days on a regular basis.

Ovulation is the release of an ovum from the ovary and occurs in the middle of the menstrual cycle.

Fertilisation is the union of a male sex cell or sperm, and a female sex cell or ovum.

Fertilisation normally takes place in the oviduct. The fertilised ovum is called a zygote.

Birth control is needed for its role in family planning to overcome the problems arising from over-population, for the individual, the country and for the world as a whole.

Birth control is the responsibility of both the man and the woman.

Any method of birth control involves preventing fertilisation, which, in turn, involves preventing the sperm and ovum from coming together. Factors considered when choosing birth control methods include cost, availability, effectiveness, and Side effects.

Methods of birth control include contraceptive pills, condoms, coitus interruptus, rhythm method, spermicidal creams, and foaming tablets, Intra-uterine device (IUD), Diaphragm, and Sterilisation.

There are many kinds of STDS including, Gonorrhola, Syphilis, Cancroids, and AIDS.

The factors affecting the reproductive health of a woman include Female genital mutilation, early marriage, sexually transmitted infections, Rape, and Illegal abortion.

None of these practices is acceptable and people should be educated against them.

HIV/AIDS affect individual person, a person's family and friends, and the country as a whole. Giving care and support to PLWHA is an important aspect for prevention of HIV and AIDS. There are safer ways of giving care and support to PLWHA.

Review Exercise

1. A Fertilized ovum is known as a/an
   (a) Gamete
   (b) Zygote
   (c) Egg
   (d) Oocyte
2. Which of the following attaches the fetus to the mother's uterus?
   (a) Placenta
   (b) Umbilical cord
   (c) Navel
   (d) Amniotic fluid

3. Which of the following change occurs only in boys at puberty only in males?
   (a) Growth of hair in the armpits.
   (b) Widening of the pelvic girdle.
   (c) Growth of breasts.
   (d) Deepening of voice.
4. Parturition occurs
   (a) After 9 months
   (b) After 40 cm size
   (c) After 9 cm size
   (d) A and B
5. An example of the rhythm method of family spacing is By using
   (a) Pills
   (b) The menstrual cycle calendar
   (c) Intrauterine devices
   (d) Condoms

Answer the following

6. What contraceptive methods are used by female.
7. Give examples of contraceptive methods as natural, Hormonal, Barrier, and Permanent methods?
8. What are the transmission routes of HIV?
9. Mention three sexually transmitted diseases?
10. Name life skills useful in prevention of HIV/AIDS?

Sample Test

Choose the correct answer from the given alternatives.

1. Hinge joint allows ---------------
   (a) One direction movement
   (b) All direction movement
   (c) Rotate the head
   (d) Two direction movement
2. When two or more bones meet they form
   (a) Joint
   (b) Bone marrow
   (c) Shaft
   (d) Head
3. Which of the following is **Not** the function of skeletal system?
   (a) Locomotion
   (b) Support

(c) Excretion
(d) Breathing movement

4. The hardest bone structure is
   (a) Spongy bone
   (b) Cartilage
   (c) Bone marrow
   (d) Compact bone
5. A tissue that cover the outer part of the human ear
   (a) Ligament
   (b) Skeleton
   (c) Cartilage
   (d) Tendon
6. A pivot joint is used when you
   (a) Hold a pen
   (b) Move your head
   (c) Bend your knee
   (d) Bend your elbow
7. Which of the following is **Not** part of axial skeleton?
   (a) Skull
   (b) Sternum
   (c) Rib cage
   (d) Shoulder blade
8. Which of the following muscle tissues is useful for locomotion?
   (a) Skeletal muscle
   (b) Cardiac muscle
   (c) Smooth muscle
   (d) Cardiac and smooth muscle
9. Which of the following is the function of skeleton?
   (a) Protection
   (b) Reproduction
   (c) Excretion
   (d) Digestion
10. The membrane that is surround and protects bone is called__________
    (a) Ligament
    (b) Periosteum
    (c) Cartilage
    (d) Tendon

11. Ball and socket joint is found in _________.
    (a) Elbow
    (b) Back bone
    (c) Shoulder
    (d) Knee
12. Rotation of head is an example of
    (a) Gliding joint
    (b) Ball and socket joint
    (c) pivot joint
    (d) Hing joint
13. Which of the following bones are part of axial skeleton.
    (a) Legs and arms
    (b) skull and back bone
    (c) Ribs and back bone
    (d) Legs and skull
14. The human blood can Not be produced in _________.
    (a) Femur
    (b) Heart
    (c) Ribs
    (d) lymph glands
15. Which is not causes of bad posture
    (a) Bad chairs and desks
    (b) Good light and air (ventilation)
    (c) Lack of regular exercise
    (d) Bad clothing
16. The chief muscles concerned in maintaining posture are
    (a) Neck Muscles
    (b) Vertebrae attached muscles
    (c) The hip muscle
    (d) All
17. Which of the following is true about the human gametes?
    (a) The male gamete (sperm) has more cytoplams than that of the female gamete (Ovum).
    (b) The male gamete (Sperm) is bigger in size than the female gamete (Ovum).
    (c) Male and female gametes contribute equal number of chromosomes.
    (d) The female gamete has acrosome but the male gamete does not have chromosomes.

18. Which one of the following is is an example of gender based violence?
    (a) Sexual assault.
    (b) Sexual harassment.
    (c) Domestic abuse.
    (d) All of the above.
19. How does gender based violence affect the health fo women?
    (a) It may cause injury to the reproduction system.
    (b) It may cause lose of confidence and self - hate by women.
    (c) It leads to depression and fear by women.
    (d) All of the above.
20. Which of the following is **Not** the function of amniotic fluid?
    (a) Provides a watery environment to the embryo
    (b) Helps to insulate the embryo
    (c) Protects Embryo from physical damage
    (d) Provides nutrients to the foetus.
21. The solid yellow body from which the ovum has been released is called
    (a) Graffian follicle
    (b) Corpus leutem
    (c) Fallopian tube
    (d) Epididymis
22. In humans, sperm cells are produced inside the
    (a) Testes
    (b) Penis
    (c) Urethra
    (d) Epididymis
23. Which of the following is the function of seminal fluid?
    (a) Secretion of nourshing fluid for sperm.
    (b) Secretion hormones.
    (c) Production of semen.
    (d) Production of lubricating fluid.
24. How is the placenta beneficial to the foetus?
    (a) It supplies Oxygen and food from maternal blood to the foetus.
    (b) It transports Carbondioxide from the fetus blood to the material blood.
    (c) It transports excretory wastes from the foetus blood to mothers blood.

(d) All
(e) Womb
(f) Cervix

25. The process in which mature egg is released into fallopian tube is known as:
    (a) Menstruation
    (b) Ovulation
    (c) Fertilization
    (d) None
26. What would happen if an egg is Not fertilized? The:
    (a) Egg dies.
    (b) Secretion of progesterone decreases.
    (c) Uterus wall breaks down
    (d) All of the above.
27. The fusion and union of the male and female gametes is referred to as ______________.
    (a) Fertilization
    (b) Implantation
    (c) Copulation
    (d) Gestation
28. Which contraceptive method is the most effective?
    (a) Rhythm method.
    (b) Coitus interruptus.
    (c) Pill(oral contraceptive)
    (d) Diaphragm.
29. How many functional egg(s) would be produced at the end of the second meiotic division from the parent oocyte cell?
    (a) 1
    (b) 2
    (c) 3
    (d) 4
30. Which one of the following is NOT secondary sexual characteristic in males?
    (a) Pubic hair
    (b) Large breasts
    (c) Deep voice
    (d) Facial hair

31. Which one of the following is permanent Contraceptive method?
    (a) Rhythm
    (b) Pills
    (c) Sterilization
    (d) condom
32. Which contraceptive method is useful for prevention of sexually transmitted diseases?
    (a) Rhythm
    (b) Sterilization
    (c) Pills
    (d) Condom
33. Which of the following is **NOT** a secondary sexual characteristic in humans?
    (a) Emerging of Facial hair in males
    (b) Breast development in females.
    (c) The presence of sex organs
    (d) Appearance of menstruation in females.
34. How many egg(s) would be produced in the ovary of a human female in each month?
    (a) One
    (b) Two
    (c) Three
    (d) Four
35. Which one of the following is the function of fallopian tube?
    (a) Production of eggs
    (b) Transporation of eggs into the uterus
    (c) Transporting to the uterus
    (d) Provision of nourishment to the fetus
36. Which one is a natural contraceptive method?
    (a) Sterilization
    (b) Rhythm
    (c) Pills
    (d) Condom
37. The period of permanent stoppage of menstruation in females is referred to as _____________ .
    (a) Maturation
    (b) Menarche

(c) Adolescence
(d) Menopause

38. HIV cannot be transmitted
    (a) contaminated blood
    (b) mother to child during birth
    (c) eating with infected person
    (d) sexual mating with infected person
39. Which life skill is useful?
    (a) Assertiveness
    (b) Passive character
    (c) Unfaithful sexual relationship
    (d) All
40. Which of the following is **Not** true about the urethra?
    (a) It is used to pass out urine in females
    (b) It is used to pass out urine in males
    (c) It is used to pass out egg in females
    (d) It is used to pass out semen in males
41. The correct path sequence of sperm during ejaculation is
    (a) Epididymis---- Vasdeferens ---- Urethra
    (b) Urethra ----- Epididymis ------ Vasdeferens
    (c) Vasdeferens ---- Urethra ----- Epididymis
    (d) Vasdeferens ---- Epididymis ------ Urethra
42. Which hormone is responsible for ovulation is
    (a) LH
    (b) FSH
    (c) Progestrone
    (d) Estrogen
43. The hormone produced by Corpus lutem?
    (a) LH
    (b) FSH
    (c) Progestrone
    (d) Estrogen
44. If menstruation of a woman begins on september 10, on which days should she avoid sexual intercourse with her partener inorder to prevent pregnancy?
    (a) September 10 - 19
    (b) September 20 - 27
    (c) September 28 - October 8
    (d) October 20 - 27

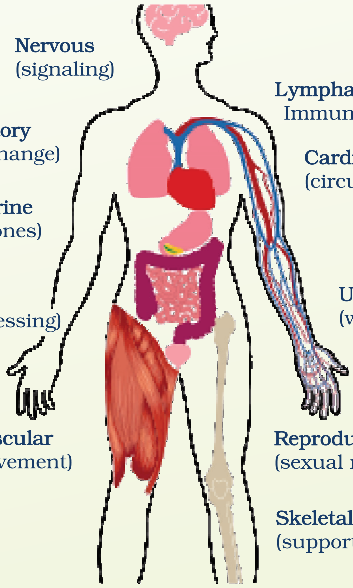
B12CH03

CHAPTER 3

THE DIGESTIVE, CIRCULATORY, AND LYMPHATIC SYSTEMS

Chapter Contents

3.1 The Digestive System
3.2 The Digestive Tract (Alimentary Canal)
3.3 The Circulatory System
3.4 Blood Groups and Transfusion – Rh Factor
3.5 Effects of Substance Abuse on the Circulatory System
3.6 The Lymphatic System
- Key Terms
- Summary
- Review Exercise
- Sample Test



Chapter Outcomes

Upon completion of this chapter, learners will:

- define Digestion, state the processes and list the organs that are involved;
- state the functions of enzyme in the process of Digestion;
- explain nutrition, the classes of food and their specific importance to the body;
- list the components of blood and describe their functions and the process of blood clotting;
- discuss the heart, the blood and blood vessels;
- discuss the lymphatic system and its functions and composition of lymph;
- describe the structure and functions of lymph nodes;
- outline and give the function of other lymphoid organs (tonsils, spleen, and thymus).

Introduction

Body systems, works in conjunction to keep the body functioning properly.

- When your blood circulates through your digestive system, it picks up nutrients from your body absorbed from your last meal.
- Your blood also carries oxygen inhaled by the lungs. Your circulatory system delivers oxygen and nutrients to your heart and the other cells of your body then picks up any waste products created by these cells, including carbon dioxide, and delivers these waste products to the kidneys and lungs for disposal.
- The circulatory system carries hormones from the endocrine system, and the immune system's white blood cells that fight off infection.
- The circulatory system provides your brain with a constant supply of oxygen-rich blood, while your brain regulates your heart rate and blood pressure.
- Your circulatory system delivers oxygen-rich blood to your bones. Meanwhile, your bones are busy making new blood cells.

3.1 The Digestive System

Food and Nutrition

Food is anything taken in to the body and nutrition is the Science of food and its relation human health.

Humans need food for the following purposes.

- Food is used as an energy store and provides energy for the cells
- It supplies the materials needed for growth and repair of the animals' cells.
- It supplies substances needed for building parts of the body.
- Food contains minerals and vitamins essential for many vital processes or the proper functioning of the body. An absence of these minerals and vitamins can lead to deficiency diseases.

Nutrients

Nutrients are chemical substances found in Foods. The human body consists of mechanism to use nutrients contained in foods. There are six major classes of nutrients (Table 1):

Table 1 The major classes of nutrients:

NUTRIENT	IMPORTANCE
Carbohydrates	Energy source and energy storage
Proteins	Enzymes and cell and tissue structure, building body
Minerals	General health and well-being
Lipids	Energy source and energy storage
Dietary fibers	Required for various metabolic activities
Vitamins	General health and well-being

These nutrient classes can be categorized as either macronutrients (needed in relatively large amounts) or micronutrients (needed in smaller quantities). The macronutrients are carbohydrates, fats, fiber, proteins, and water. The micronutrients are minerals and vitamins.

The macronutrients (excluding fiber and water) provide energy, which is measured in Joules or kilocalories (often called "Calories" and written with a capital *C* to distinguish them from gram calories).

Carbohydrates and proteins provide 17 kJ (4 kcal) of energy per gram, while fats provide 37 kJ (9 kcal) per gram. Vitamins, minerals, and water do not provide energy, but are necessary for proper body functioning.

Digestion is the process by which food is broken down into smaller pieces so that the body can use them to build and nourish cells and to provide energy.

Digestion involves the mixing of food, its movement through the digestive tract (also known as the alimentary canal), and the chemical breakdown of larger molecules into smaller molecules.

Every piece of food we eat has to be broken down into smaller nutrients that the body can absorb, which is why it takes hours to digest food (Figure 3).

3.2 The Digestive Tract (Alimentary Canal)

The Digestive Tract (Figure 1 - 2)

- Also called the gastrointestinal (GI) tract or alimentary canal
- Is a muscular tube
- Extends from our mouth to the anus

Passes through the pharynx, esophagus, stomach, and small and large intestines.

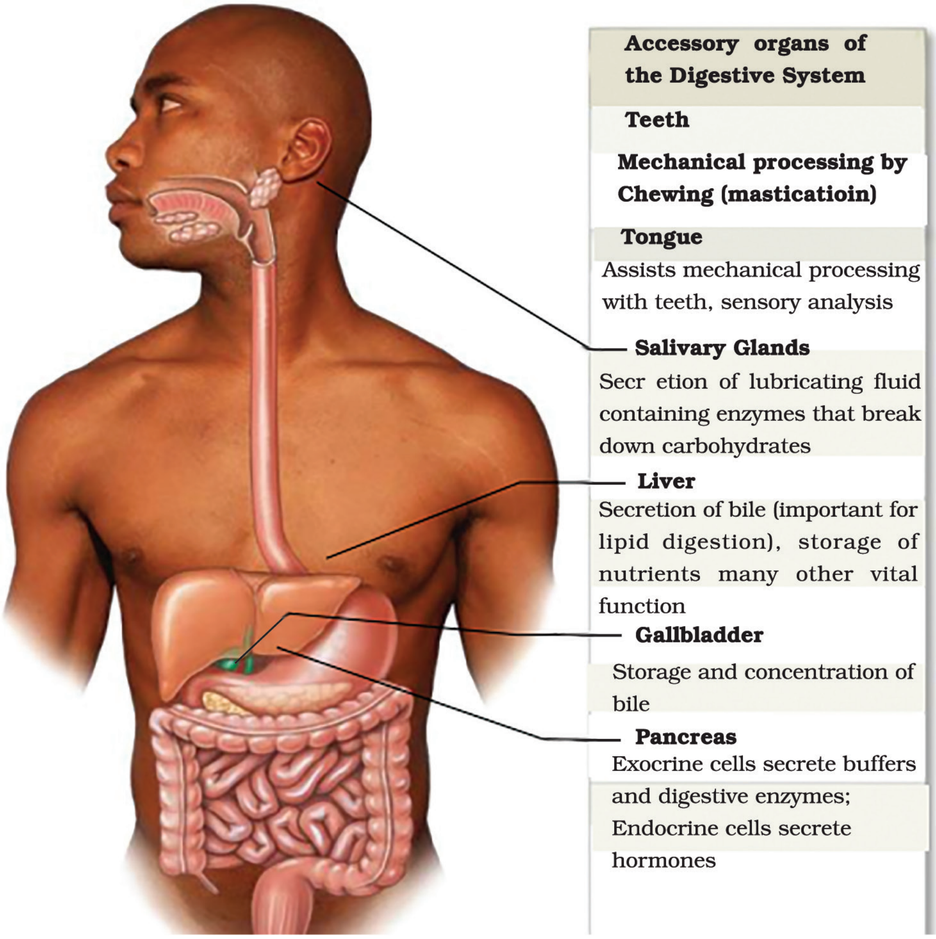


Figure 1. Accussing organs of Digestion

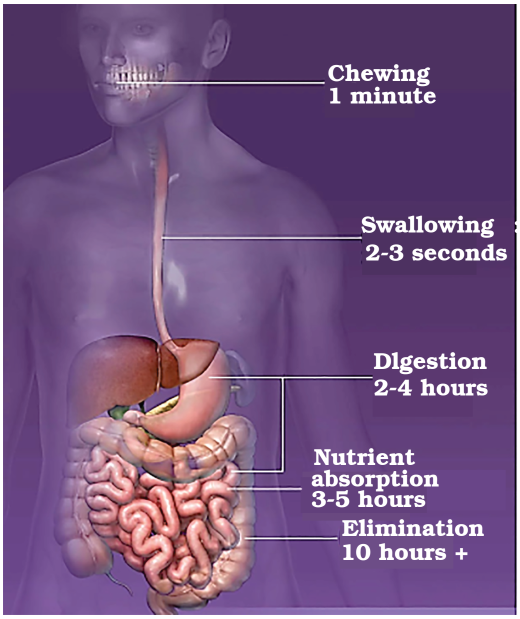


Figure 2. Movement of food in GII

Mouth (Oral cavity)

Digestion begins in the mouth, where chemical and mechanical digestion occurs.

The teeth, tongue, hard palate, and soft palate bound the oral cavity. These structures make up the mouth and play a key role in the first step of digestion, called ingestion.

This is where the teeth and tongue work with salivary glands to break down food into small masses that can be swallowed, preparing them for the journey through the alimentary canal.

Functions of the Oral Cavity

1. Sensory analysis by receptors of lips tongue judge the texture and temperature of material before swallowing
2. Mechanical processing
    - Through actions of teeth, tongue, and palatal surfaces
3. Lubrication
    - Mixing with mucus and salivary gland secretions

Teeth and Tongue

One of the most important functions of the mouth is chewing.

This mechanical breakdown increases the surface area of food for the following chemical digestion using enzymes. Chewing allows food to be mashed into a soft mass that is easier to swallow and digest later.

The oral cavity has the **tongue** to select food by tasting; **the teeth** and the cheeks all play a role in grinding the food into smaller bits.

Salivary Glands

Salivary Glands are glands that secrete saliva. The largest of the glands, located around the mouth and leading into it, are the submaxillary, under the lower jaw; the sublingual, beneath the tongue; and the parotids, in front of each ear.

The buccal glands, in the cheeks near the front of the mouth, also secrete saliva.

Saliva

- Is an alkaline fluid that moistens the mouth
- Soften food, and aids in digestion
- Make food easier to swallow

Saliva contains water, mucin and an enzyme called ptyalin or salivary amylase

- Water softens food and facilitates chewing
- Mucin lubricates the food and makes chewing easy
- Ptyalin or salivary amylase chemically breaks down starch to maltose and works best in a neutral or slightly alkaline medium provided by Saliva

Once the food is chewed and mixed with the saliva, movements by the **tongue** and the mouth push the food to the back of the throat for it to be swallowed.

The tongue and the palate mold the food into a small ball or **bolus**, which is then swallowed.

As the food is swallowed, a flexible flap called the **epiglottis** closes over the trachea (windpipe) which is the entrance of the respiratory tube to ensure that food enters the esophagus and not the windpipe. This prevents the food from entering the windpipe and cause choking.

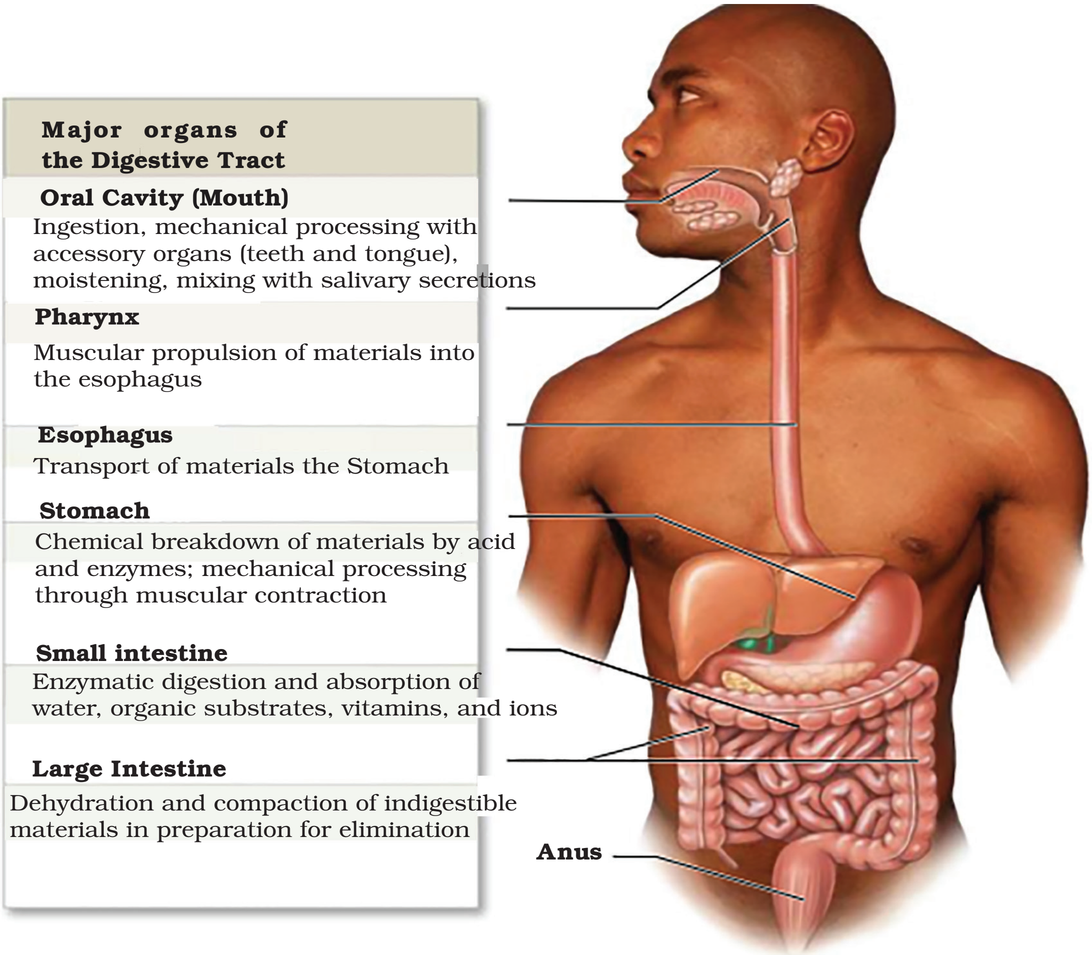


Figure 3. Organs of the digestive tract

Esophagus

The esophagus extends from the throat to stomach.

The food then moves down the esophagus by a process called peristalsis. **Peristalsis** is the rhythmic contraction of the muscles of the alimentary canal causing the food to move along the gut.

The circular muscles of the oesophageal wall above the bolus, contracts narrowing the esophagus above the bolus. At the same time, the circular muscles below the bolus relax and the longitudinal muscles contract. This widens the esophagus below the bolus, and the bolus is forced downwards towards the stomach.

Peristalsis is not just restricted to the esophagus. It continues throughout the alimentary canal, and pushes the food towards the anus.

Stomach

The stomach is a J.shaped organ between esophagus and duodenum.

The stomach performs two major functions (Figure 4):

Storage: the stomach serves as a temporary storage for food, about 1 – 3 hours. It releases food in small amounts at intervals such that the rest of the digestive system can take care of it.

Digestion: food is blended and mixed by the peristalsis of the stomach wall. This process is called churning which is an act of mechanical digestion. The stomach performs chemical digestion of food. The wall of the stomach is lined with small glands called gastric glands secreting gastric juice. Once the food reaches the stomach, it is mixed with gastric juice secreted by small gastric pits in the stomach wall.

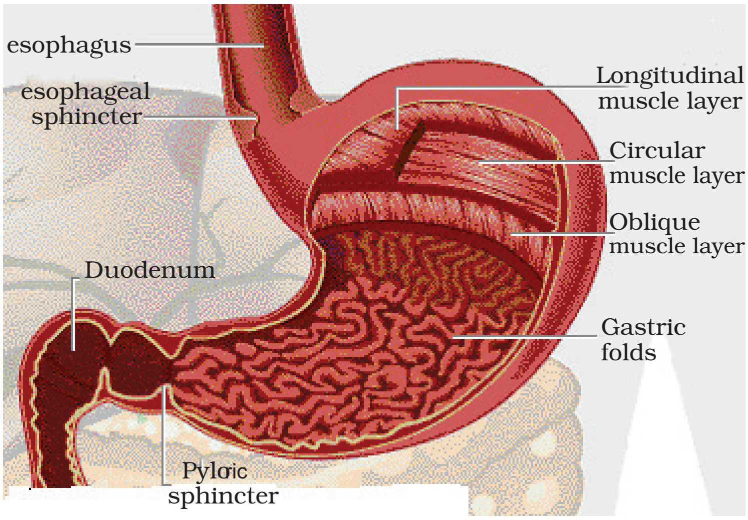


Figure 4. The Structure of stomach

Gastric Juice contains water, mucin, hydrochloric acid, and two protein-digesting enzymes called pepsin and rennin.

- The mucin forms a thick protective layer of mucus on the inside of the stomach, protecting it against the action of the enzymes in gastric juice.
- Hydrochloric acid is secreted by parietal cells and kills pathogens. The hydrochloric acid provides an acid medium

for the action of the enzymes in gastric juice. It converts the inactive pepsinogen into active pepsin.

- Pepsin is secreted by chief cells of the gastric gland. The enzyme pepsin converts proteins into small polypeptide chains.
- The enzyme rennin causes milk to curdle by changing soluble caseinogen into insoluble casein. Pepsin converts this casein into polypeptides while rennin causes milk to curdle in infants.

Eventually, the wave-like muscular contractions of the stomach wall and the action of the gastric juice turn the contents into a soup like mixture called chyme, which enters the small intestine.

Small Intestine

Small intestine is the longest part of the digestive system and coiling. The small intestine is divided into three continuos parts the duodenum, the jejunum and ileum. The wall of small intestine is thrown into folds, and lined with small finger like projections called **villi**. This is an adaptation to increase surface area for absorption.

The duodenum

The duodenum is a tube about 10 inches long, which forms a 'C' shaped curve just below the liver and around the head of the pancreas. Food is periodically allowed to enter into duodenum from the stomach by way of the pyloric sphincter muscles, which guards the entry into duodenum. Most of the digestion of food takes place in the duodenum because of Intestinal juice

The duodenum is the part to which the accessory organs of digestion – the pancreas, the liver, and the gall bladder are connected with ducts. The bile and pancreatic juices are drained into duodenum from the liver and pancreas respectively.

Pancreatic juice and bile are secreted into the duodenum and act on the food as it passes through the small intestine.

The Enzymes of Small Intestine

The small intestine also secretes digestive enzymes. These enzymes are found in intestinal juice secreted from two sets of glands, the Crypts of Lieberkuhn and the Brunner's glands.

The Crypts of Lieberkuhn are found throughout the small intestine and produce the enzymes needed to complete digestion.

The Brunner's glands are only present in the duodenum and secrete mucin and alkaline mineral salts.

Intestinal juice contains

- Water,
- Mucin,
- Alkaline mineral salts
- The enzyme- enterokinase converts trypsinogen into trypsin
- The enzyme Intestinal amylase converts starch to maltose
- The enzyme intestinal lipase converts fats into fatty acids and glycerol
- The enzymes disaccharidases are a group of enzymes that convert the disaccharide sugars to monosaccharides. They include:
  - Maltase which converts maltose to glucose
  - Sucrase that converts sucrose to glucose and fructose and
  - Lactase converts lactose to glucose and galactose.

The enzymes peptidases also called erepsin are a group of enzymes, which convert polypeptides into amino acids

- The enzymes nucleases and nucleotidase complete the digestion of nucleotides to form pentose sugars, phosphates, and nitrogen bases.

Absorption

Villi and Lacteals are the areas where digested food is absorbed and transported.

Each **villus** is composed of a central lymph channel called lacteal, which is surrounded by a net work of blood capillaries with an outer layer of long, thin cells (Figure 5).

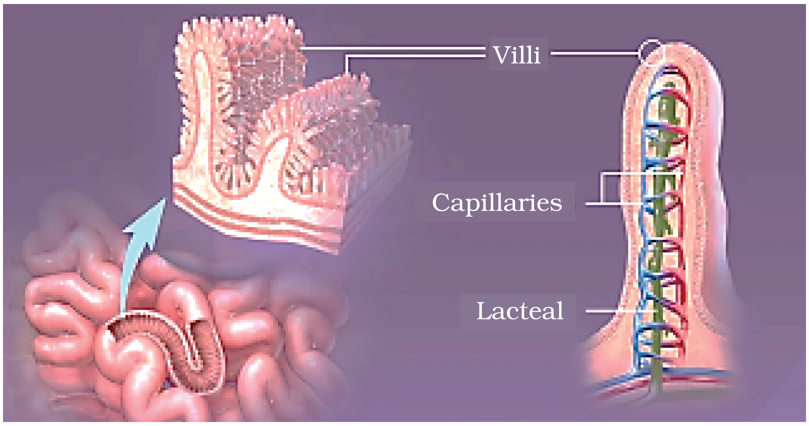


Figure 5. Villi and Lacteals in intestine

Jejunum

Jejunum is the middle part of the small intestine, which is about 7.5 feet long. The enzymes poured in the duodenum work while food passes through the jejunum, completing most of the digestive process. Most of the absorption takes place in jejunum and ileum.

Ileum

Ileum is the last part and the longest of the small intestine. Absorpition takes place until food reaches to its last part called ileocecal valve, where it joins with the upper part of the ceacum.

Accessory organs

The Pancreas

Pancreas is a long gland lying behind stomach connected with a duct to duodenum.

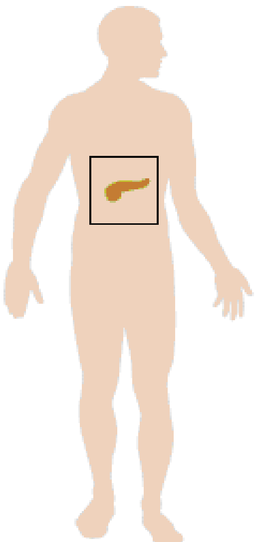
It secretes pancreatic juice and pours into duodenum.

The pancreas is an organ with an endocrine function.

Small groups of cells known as islets of Langerhan's found on pancreas secrete a hormone called insulin, which is necessary for the metabolism of sugar in the body.

The digestive juice from the pancreas, called pancreatic juice contains

- Water
- sodium bicarbonate neutralizes the acid food coming from the stomach and change the pH making it more alkaline so that the enzymes can work efficiently
- Enzymes for the digestion of carbohydrates, fats, and protein



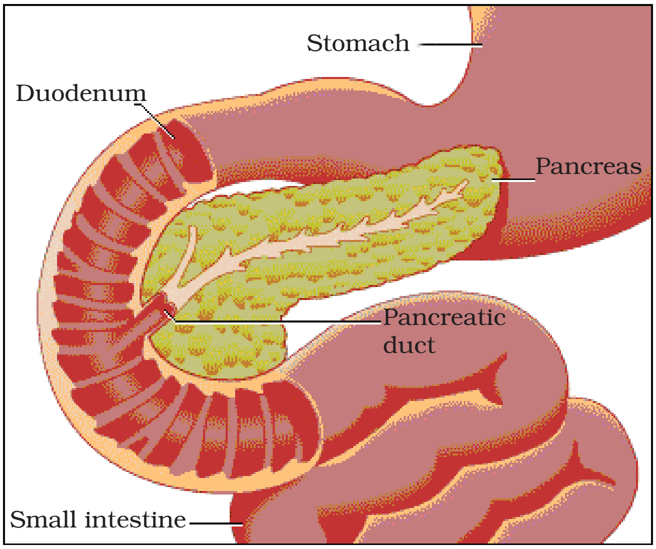


Figure 6. The Pancreas

Enzymes in pancreatic juice

- Pancreatic amylase converts starch to maltose.
- Pancreatic lipase converts fats to fatty acids and glycerol.
- Trypsin and chymotrypsin which are secreted in the form of inactive trypsinogen and chymotrysinogen.
- Enterokinase in the jejunum and ileum converts the inactive trypsinogen to active trypsin.
- Trypsin then, converts proteins to smaller polypeptides. It also converts the inactive chymotrypsinogen into active chymotrypsin.

- Chymotrypsin also converts proteins to smaller polypeptides.
- The enzymes in the small intestine can only work in an alkaline medium.

The Liver and Bile

Liver is the largest gland in the body located in the upper part of the abdomen on the right side just under the diaphragm. The liver cells secrete bile, which then moves to the gall bladder to be stored. The liver has several important functions. Its digestive function is the secretion of bile.

Bile

Bile is a yellow-green alkaline liquid that does not have enzymes. When required, the bile is transported by the cystic duct, common bile duct, and hepato-pancreatic duct to the duodenum.

Bile is released when the acidic food from the stomach enters the duodenum. The acid in the food stimulates the mucosa of the duodenum to secrete the hormone, cholecystokinin, which travels in the blood to the gall bladder. This hormone stimulates the walls of the gall bladder to contract, thereby releasing the bile.

Bile contains water and alkaline mineral salts.

- The water keeps the food fluid, allowing it to move through the alimentary canal easily.
- The bile salts are alkaline and help to neutralize the acid food coming from the stomach.
- Bile salt also emulsifies fats. The word, emulsify means that they break up the fats into small droplets, thereby increasing the surface area for enzyme action. This helps in the absorption of fat.
- Bile salts facilities absorption of fat-soluble vitamins A, D, E, and K.
- Bile is antiseptic and prevents decomposition of food in the small intestine.

The **Liver** has other important functions:

- Converts glucose to glycogen
- Excess glucose is also converted to fat and stored

- Stores minerals such as iron and vitamins such as A, D, and B 12
- Deamination of excess amino acids
- Produces bile

The Large Intestine (Colon)

The large intestine (colon) is about 5 feet long and composed of the following parts (Figure 7).

- **Caecum** is the blind sac on the right side of the abdomen. At the lower end of caecum in a structure called appendix with no known function.
- **Ascending colon** extends along the right side of the abdomen from the caecum.
- **The transverse colon** is the portion next which bends and continues.
- **The descending colon** is the portion of the next bending down
- **Sigmoid colon** is the last part of the colon making an 'S' curve ending at the rectum.

The main functions of the large intestine are:

- Formation and elimination of undigested food
- Absorption of water and salts

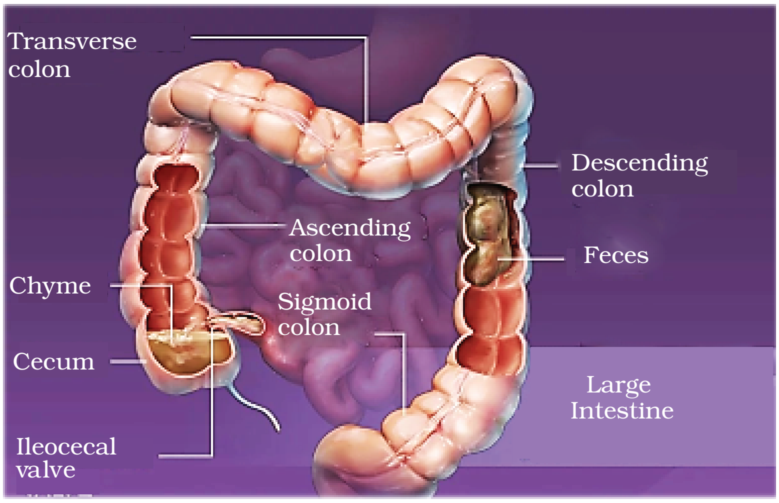


Figure 7. The Large Intestine

The rectum and anus

The rectum and anus are about 5 inches long. The anus is the external opening at the end of the alimentary canal and kept close by strong sphincter muscles, which open only during defecation. The function of the rectum and anus is elimination of undigested food as feces. This process is called defecation.

Exercises

1. Describe the function of bile.
2. How is gastric mucosa protected from HCl action?
3. Given examples of micro nutrients.
4. What are the enzymes secreted by pancreas?

3.3 The Circulatory System

Components of the Circulatory System

The circulatory system, sometimes called the cardiovascular system, consists of the heart, blood vessels, and blood. It transports oxygen, hormones and nutrients to all the cells in the body. It picks up waste products generated by metabolic processes and delivers them to other organs for disposal.

The heart provides the “muscle” needed to pump blood throughout the body.

The system circulates blood in two circuits:

The Pulmonary circuit and Systemic circuit.

The circulatory system of humans consists of

- Tubes of various sizes called blood vessels
- Fluid tissue called blood
- And a pumping organ called the heart.

Human Heart

The heart is a hollow organ about the size of a closed fist. The heart wall is made of three distinct layers.

- *The heart is the outer **epicardium**, which is a double membrane composed of a layer of flattened epithelial cells and connective tissue.*

- *Beneath this is a much thicker **myocardium** made up of cardiac muscle.*
- *The **endocardium** is a flattened epithelial cells and connective tissue, which lines the chambers of the heart.*
- *The blood supply to the heart itself is supplied by the left and right **coronary arteries**, which branch off from the aorta.*
- *The space between the membranes is filled with a watery fluid. The fluid between the two membranes of the pericardium reduces friction during heartbeats.*
- *There are partitions that divide the human heart internally into four chambers.*
- *The two upper chambers are the right and the left atria, and*
- *The two lower chambers are the right and left ventricles.*
- *The left and right atria have relatively thin walls. The ventricles have thick walls.*
- *The left ventricle has thicker walls than the right ventricle.*
- A wall called the septum separates the left side of the heart from the right side.

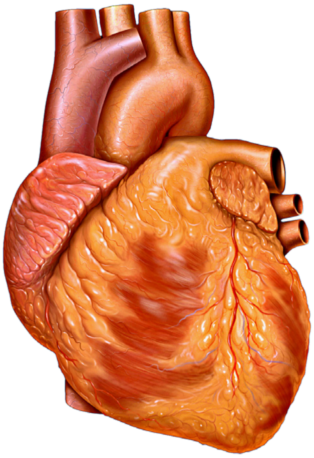


Figure 8. The human Heart

Anterior (frontal) view of the opened heart

White arrows indicate normal blood flow.

Oxygen-carrying blood leaves the left ventricle through the aorta (Figure 9).

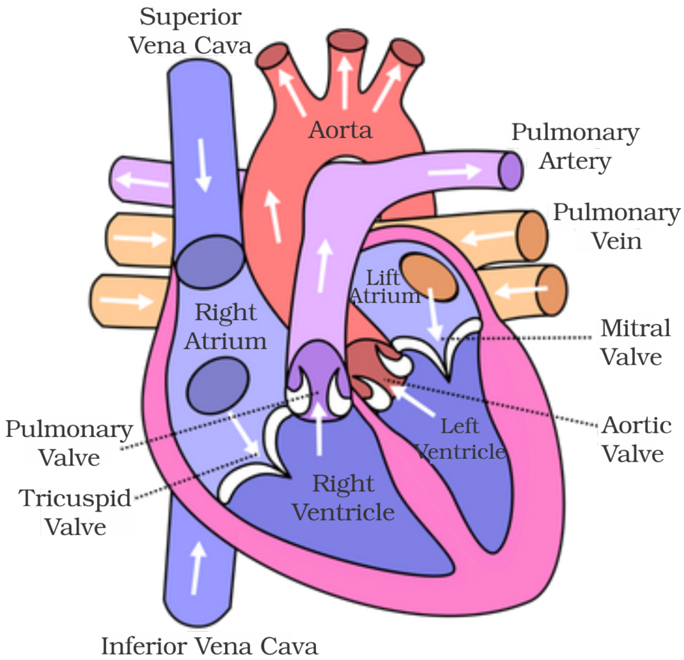


Figure 9. Movement of blood in Heart

Oxygen-depleted or deoxygenated blood from the body enters the right atrium through two great veins, the superior vena cava, which drains the upper part of the body, and the inferior vena cava that drains the lower part. The blood then passes through the tricuspid valve to the right ventricle.

The right ventricle pumps the deoxygenated blood to the lungs, through the pulmonary artery. In the lungs, gaseous exchange takes places and the blood releases carbon dioxide into the lung cavity and picks up oxygen.

The oxygenated blood then flows through pulmonary veins to the left atrium. From the left atrium, this newly oxygenated blood passes through the mitral valve to enter the left ventricle.

The left ventricle then pumps the blood through the aorta to the entire body. Even the lungs take some of the blood supply from the aorta via bronchial arteries.

The left ventricle is much more muscular (1.3 - 1.5 cm thick) than the right (0.3 - 0.5 cm thick) as it has to pump blood around the entire body, which involves exerting a considerable, force to overcome the vascular pressure. As the right ventricle needs to pump blood only to the lungs, it requires less muscle.

Even though the ventricles lie below the atria, the two vessels through which the blood exits the heart (the pulmonary artery and the aorta) leave the heart at its top side.

The contractile nature of the heart is due to the presence of cardiac muscle in its wall, which can work continuously without fatigue.

Circulation of blood

The right half of the heart is responsible for **pulmonary circulation**. This is the circulation of deoxygenated blood to the lungs so that it may be oxygenated. The left half of the heart is responsible for **systemic circulation**, which is the circulation of oxygenated blood to all parts of the body, including the heart itself (Figure 10).

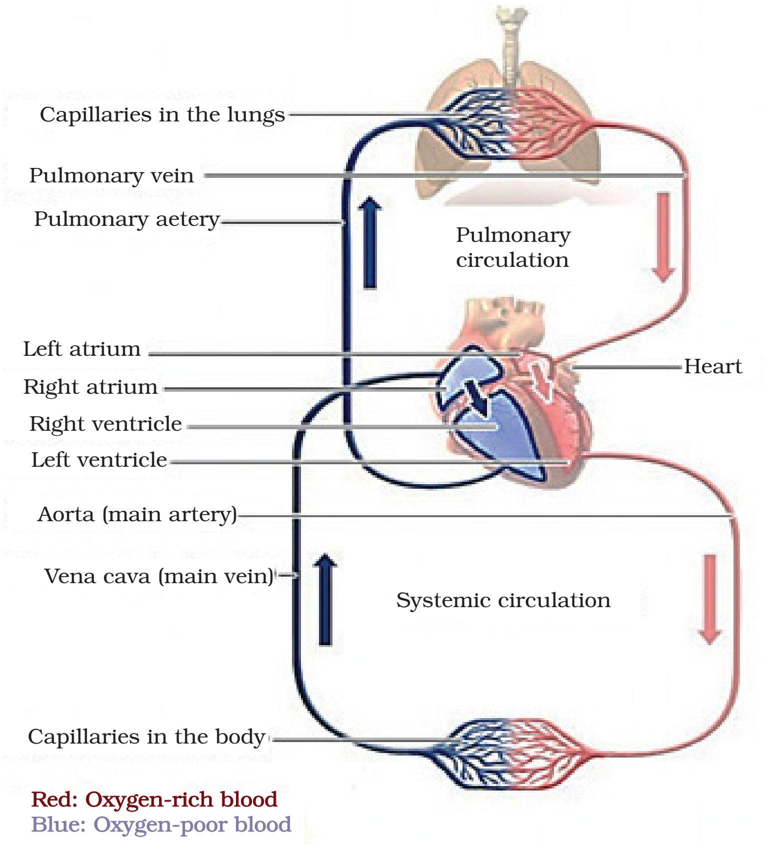


Figure 10. Circulation of blood

The right atrium receives deoxygenated blood through

- The superior vena cava
- The inferior vena cava
- The coronary vein

The superior vena cava carries deoxygenated blood from the head and upper parts of the body. It opens into the upper part of the right atrium.

The inferior vena cava carries the deoxygenated blood from the lower half of the body and opens into the lower part of the right atrium.

The coronary vein carries deoxygenated blood from the walls of the heart itself to the right atrium.

The right atrium contracts and pumps the blood into the right ventricle. The opening between the two chambers is guarded by the tricuspid valve, which consists of three cusps or flaps. These valves are held in place by cords and prevent back flow of blood.

When the **right atrium** contracts, blood flows freely through the valve into the **right ventricle**. When the right ventricle contracts, the blood is forced upwards and pushes the tricuspid valve closed.

Blood can escape only from the right ventricle through the **pulmonary artery**. This is the pulmonary artery that takes the deoxygenated blood to the lungs to be oxygenated.

The pulmonary artery is the only artery to transport deoxygenated blood away from the heart.

There is a semi-lunar valve at the entrance of the pulmonary artery. This valve allows blood to flow upwards into the artery and prevents blood from falling back into the right ventricle when it relaxes. Blood flowing back causes the semi-lunar valve to close.

The atrium has thin walls because it just pumps the blood into the right ventricle. The right ventricle has thicker walls because it needs to pump the blood to the lungs.

The left atrium is thin-walled like the right atrium.

It receives oxygenated blood from the lungs through four **pulmonary veins**. The left atrium contracts and sends oxygenated blood into the **left ventricle**.

The opening between the left atrium and the left ventricle is guarded by the bicuspid valve, which consists of two cusps or flaps. The bicuspid valve prevents the blood from returning to the left atrium when the left ventricle contracts.

A powerful contraction of the **left ventricle** forces the blood into the largest artery of the body called the aorta. There are three semi-lunar valves situated at the base of the aorta that prevent the blood from returning to the ventricle when it relaxes.

Aorta forms an arch, which bends around the heart. It branches into smaller arteries that take the blood to all parts of the body. Two coronary arteries arise from the aorta and ensure that the heart muscle itself receives oxygen aparts of the body where they divide into capillaries.

The capillaries merge to form small veins. These veins merge to form larger veins that eventually join the vena cava to bring blood back to the right atrium.

The right ventricle pumps blood to the lungs only, while the left ventricle needs the thick, muscular walls to pump the blood to all parts of the body (Figure 11).

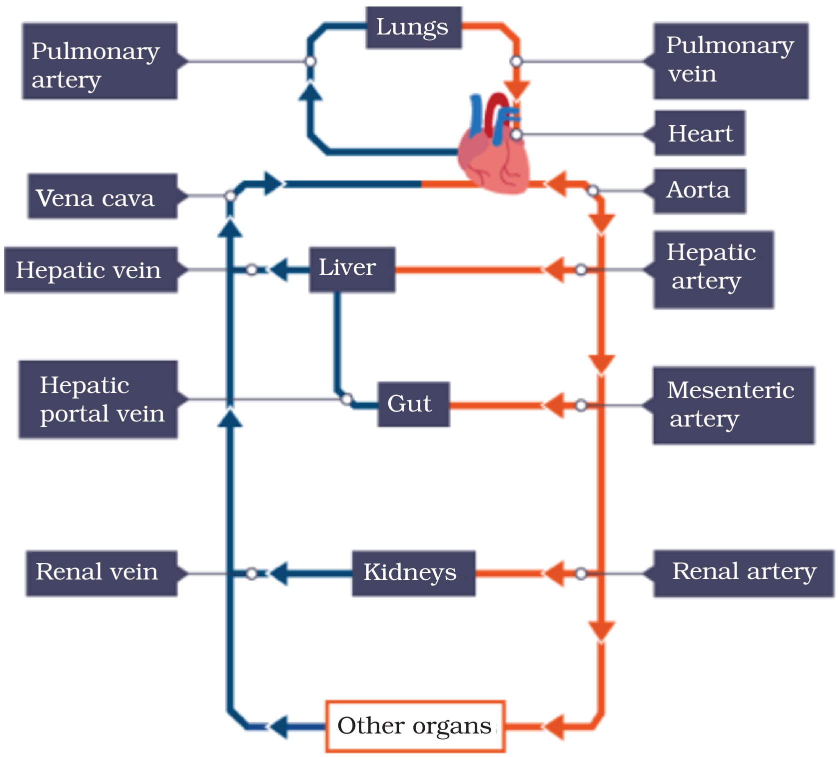


Figure 11. Blood supply to body parts

The Cardiac Cycle

The function of the heart is to pump blood around the body. Every single beat of the heart involves a sequence of events known as the cardiac cycle, which consists of three major stages (Figure 12 - 13).

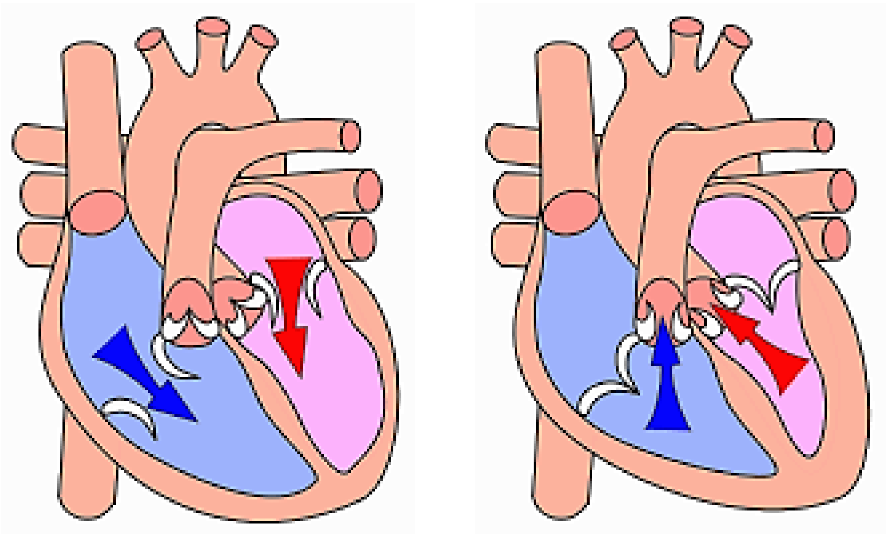
- Atrial systole,
- Ventricular systole and
- Complete cardiac diastole.

Atrial systole

The atrial systole consists of the contraction of the atria and the corresponding influx of blood into the ventricles. Once the blood has fully left the atria, the atrioventricular valves, which are situated between the atria and ventricular chambers, close. This prevents any backflow into the atria.

It is the closing of the valves that produces the familiar beating sounds of the heart, commonly referred to as the "lub-dub" sound. Due to the semilunar valves and atrioventricular valves closing.

The ventricular systole consists of the contraction of the ventricles and flow of blood into the circulatory system. Again, once all the blood empties from the ventricles, the pulmonary and aortic semilunar valves close.



entricular systole *Atrial systole*

Figure 12. Systoles

Finally, **complete cardiac diastole** involves relaxation of the atria and ventricles in preparation for refilling with circulating blood.

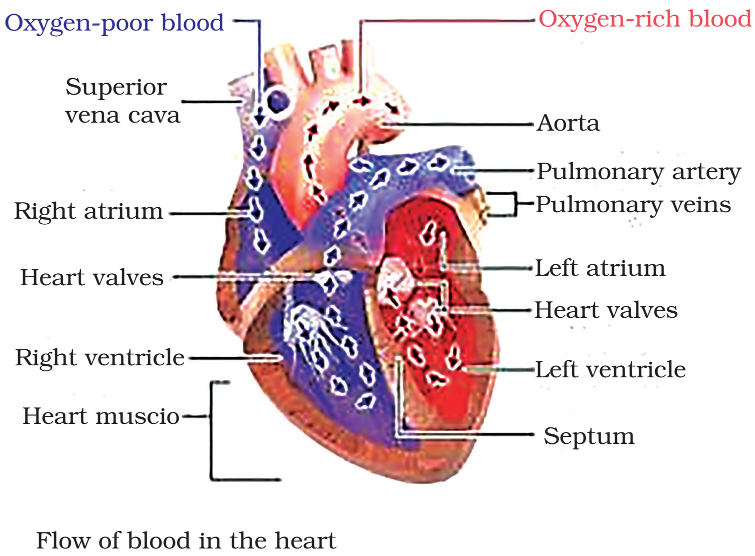


Figure 13. Flow of blood in the heart

In humans, the blood is confined within the vessels for its entire journey from the heart to the body cells and back to the heart. Humans have a closed circulatory system because the blood remains in the vessels. The heart is this muscular organ, made from cardiac muscle. It is situated in the thoracic cavity, between the lungs.

Heart Valves

Thin, fibrous flaps called valves lie at the opening of the heart's pulmonary artery and aorta. Valves are also present between each atrium and ventricle of the heart. Valves prevent blood from flowing backward in the heart. In this illustration of the pulmonary valve, as the heart contracts, blood pressure builds and pushes blood up against the pulmonary valve, forcing it to open. As the heart relaxes between one beat and the next, blood pressure falls. Blood flows back from the pulmonary artery, forcing the pulmonary valve to close, and preventing backflow of blood (Figure 14).

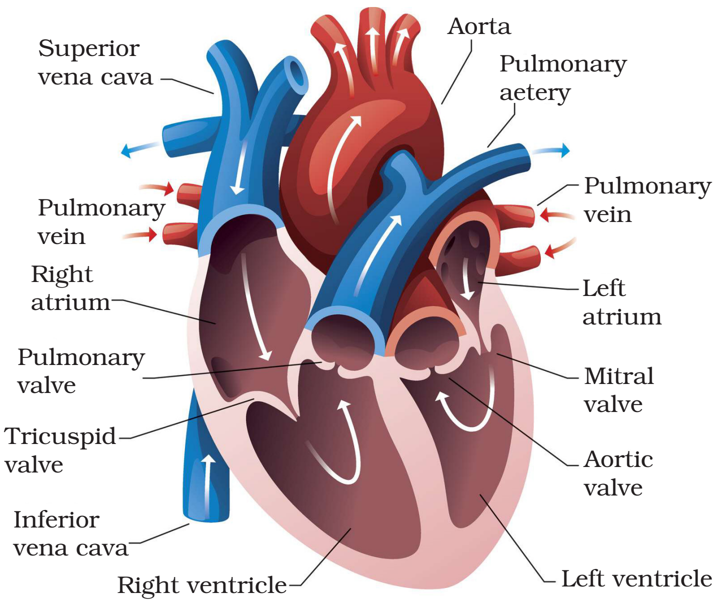


Figure 14. Valves in vesseles

Blood Vessels (Figure 15)

There are three different types of blood vessels. The different blood vessels are the arteries, veins and the capillaries (Figure 15 and Table 2).

Arteries

Arteries take blood away from the heart.

Aorta is the largest artery and branches into a number of smaller arteries, which go to all parts of the body. The smallest arteries are called arterioles.

The artery has thick muscular walls with strong elastic fibres. The arteries swell and contract as blood surges through them every time the heart beats. The blood passing through an artery is at a high pressure. Most arteries carry blood that is rich in oxygen and food. The pulmonary arteries, however, carry deoxygenated blood from right ventricle to the lungs.

Veins

Veins return blood to the heart. On the way back to the heart, smaller veins unite a number of times to form larger and larger veins. The smaller veins are called venules. Veins have thinner and less muscular walls than those of the arteries. They are slightly elastic.

Veins have a larger internal diameter than that of arteries. Many larger veins have cup-like valves that keep blood from flowing backwards, since the pressure in veins is low. Most veins carry deoxygenated blood except the pulmonary veins, which carry oxygenated blood from the lungs to the left atrium.

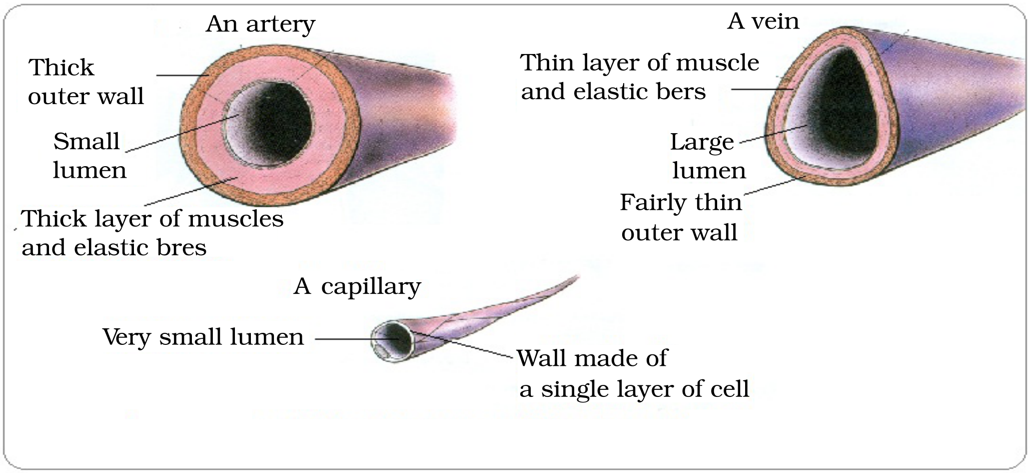


Figure 15. Sections through the three types of blood vessels

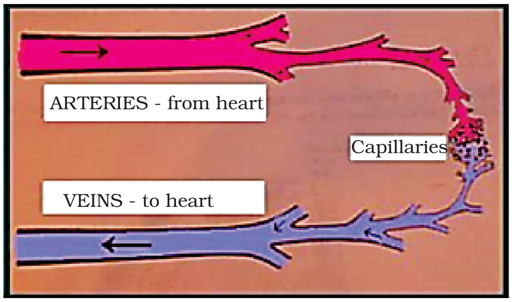
Capillaries

Are blood vessels that connect the smallest arteries with the smallest veins.

Allow exchange of materials between the bloodstream and the cells in a tissue to take place. Capillary wall is only one cell thick.

Capillary Network (Figure 16)

A web of tiny blood vessels branches from arterioles to bring blood to every tissue in the body. These small capillaries reconverge, forming larger and larger vessels that take deoxygenated blood (blue) back to the heart.



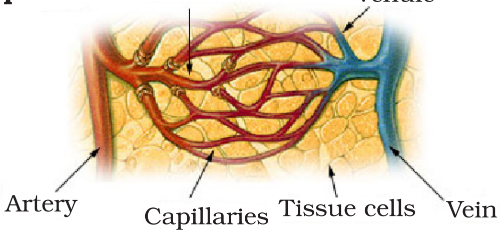


Figure 16. Capillaries

Table 2 Comparison of blood vessels

Arteries	Veins	Capillaries
Have thick muscle wall and elastic tissue layer	Have thin muscle wall and elastic tissue layer	Have one cell thick wall. No muscle or elastic tissue
There are no valves	Valves present to prevent back flow of blood	No valves
Have circular cross – section	Have oval cross – section	Have circular cross section
Fluid and white blood cell cannot pass through the wall	Fluid and white blood cells cannot pass	Fluid without proteins can pass through the wall. White blood cells pass out between the cells
Wall muscle relax to dilate and contract to narrow	Limited dilation and contraction	Can dilate or contract by cells changing shape.
Carry oxygenated blood (except in pulmonary artery)	Carry deoxygenated blood (except pulmonary vein)	Carry mixed blood
Flow of blood is rapid and with high pressure,	Flow of blood is slow and with low pressure	Very slow blood flow and very low pressure
Strong pulse	No pulse	No pulse

The Heartbeat

The contraction of the powerful muscles of the heart provides most of the force required to keep the blood in circulation. This contraction is stimulated by specialized tissue found in the heart, called the pacemaker. The pacemaker is located in the right atrium, from where the contraction spreads to the other parts of the heart.

Pumping the blood by the heart follows a cyclic pattern:

- The atria fill with blood and contract
- Forces the blood into the ventricles
- Contraction of the ventricles
- Forces blood out through the pulmonary artery and the aorta

We refer to the contraction of the atria or ventricles of the heart as systole and the relaxation of the atria and the ventricles as diastole. A heartbeat constitutes a complete cardiac cycle, which is made up of systole followed by diastole. We can use a stethoscope to listen to a person's heartbeat.

You will hear two sounds at each beat, which are often described as lub-dub. The first sound or the 'lub' sound is long and low-pitched. It is caused by the closure of the bicuspid and tricuspid valves. The second sound or the 'dub' sound is shorter and high-pitched. It is caused by the closure of the semi-lunar valves. The heart of an average adult person beats 72 times each minute when the person is resting.

The pulse

- Is the wave of alternate expansions and contractions of artery walls that proceeds from the aorta along the arteries and arterioles.
- It corresponds to the pumping force of the left ventricle.

The frequency of the pulse rate is the same as the heartbeat. Most arteries are found deep within the body, but we can detect the pulse rate in a few places where arteries are found close to the surface, like the wrist and the neck. Place the tips of the fingers of your right hand on the inside of the wrist of your left hand about 3 or 4 cm below the thumb. Make sure that use your three fingers to find your pulse. Count the number of beats for 15 seconds. Multiply this number by four to get your pulse rate per minute. Normally, we determine the pulse rate three times and take an average of the results.

Activity 1

Identify the wrist where you can feel the pulse in vain.
Count pulse for 15 secodns & record.
Perform exercise for 5 min& count pulse on your wrist for 15 seconds.
Calcualte pulse per minute of the two cases
What does the value tells you?

Blood pressure

Blood pressure refers to the pressure exerted by blood against the walls of arteries. An instrument called a sphygmomanometer is used to measure the blood pressure.
The pressure resulting from contraction of the left ventricle is called systolic pressure.
The pressure resulting from the relaxation of the left ventricle is called diastolic pressure.
A normal young human adult at rest has a blood pressure of about 120/80. The first number states the systolic pressure and the second number the diastolic pressure.
The blood pressure increases with age. High blood pressure, or hypertension, is a dangerous condition. Hypertension may also be related to a condition in which the arteries become lined with fatty deposits.
Hypertension has been referred to as the "silent killer" because it does not show obvious symptoms by which a person can recognize the condition. It increases the risk of strokes, heart failure and kidney failure.
We can reduce risks of hypertension with regular exercise, keeping our weight down, eating less salt, and not smoking. The heartbeat is caused by the contraction of the atria and the ventricles during systole, and their relaxation during diastole.

Blood cells and plasma

Functions of Blood:

- Blood provides a stable internal environment for the body cells and performs the following functions.
- Blood transports food substances such as amino acids, simple sugars, salts, vitamins and water to the body cells.
- Blood transports oxygen from the lungs to the tissue cells, and carbon dioxide to the lungs.
- Blood transports nitrogenous waste to the kidneys.
- Blood seals wounds by clotting.
- Blood defends the body against the foreign bodies.
- Blood transports hormones from the ductless glands.
- Blood distributes heat and maintains body temperature.

Blood is the transport medium of the body. The average person has about 5.5 litres of blood. 45% of the blood is made up of solid particles.

55% is straw-coloured fluid called plasma. Plasma is the liquid portion of the blood. Plasma consists of 90% water. The remaining 10% consists of dissolved and suspended substances. The dissolved and suspended substances include nutrients, hormones, nitrogenous waste and plasma proteins. The plasma proteins include fibrinogen and prothrombin.

Solid part of the blood consists of 3 types of cells suspended in the plasma (Figure 17).

- Red blood cells,
- White blood cells
- Platelets

Red Blood Cells

The red blood cells are responsible for transporting oxygen in the blood. They also transport some carbon dioxide back to the lungs. They are disc-shaped structures that are concave on each side. We say that the red blood cells are biconcave disc shaped. The red blood cells are formed in the bone marrow.

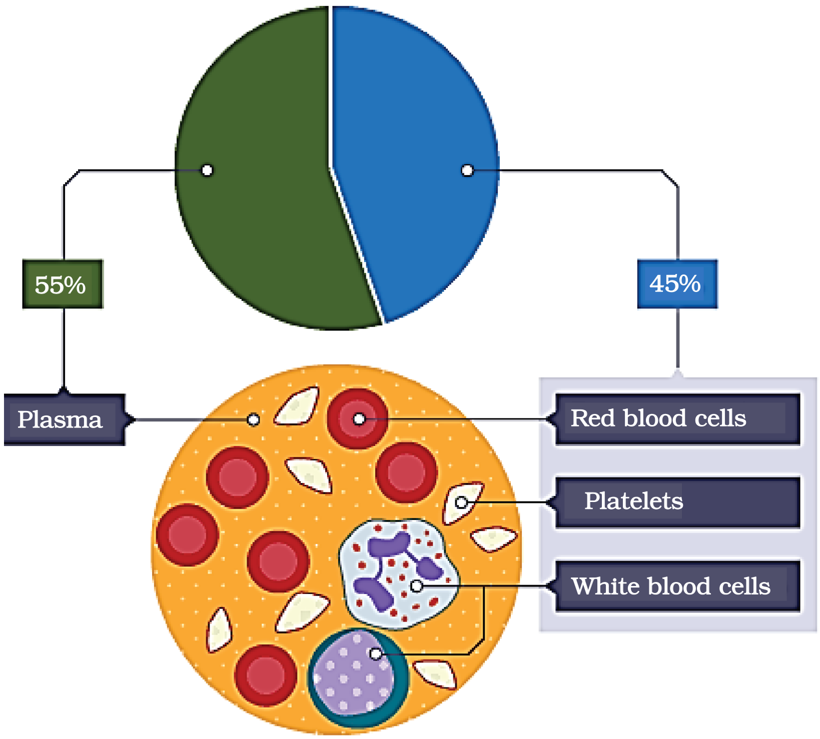


Figure 17. Blood Composition

They lose their nuclei during their formation in the bone marrow. So, the mature red blood cells in the blood do not have nuclei. Each red blood cell gets its red colour from a pigmented molecule called haemoglobin. Haemoglobin is a complex protein, which contains iron and can carry oxygen.

They are about 7.5 microns in diameter. There are about 5 million red cells per cubic millimetre of human blood. The life span of red blood cells is 120 days, after which they are destroyed and removed in the liver and the spleen. The spleen also stores red blood cells. Haemoglobin transports oxygen from the lungs to the tissues of the body. It combines with oxygen to form oxyhaemoglobin.

The shape of the red blood cells increases the surface area for the diffusion of gases. It also makes the red blood cell flexible so that it can pass through the narrow capillaries.

White Blood Cells

White blood cells are colourless cells that have nuclei. They are much larger than red cells and are produced in bone marrow, lymph nodes and the spleen. There are fewer white blood cells than red blood cells, with only about 8000 white blood cells per cubic millimetre of human blood. The number of white blood cells increases when we have an infection. We can divide the white blood cells into phagocytes and lymphocytes.

Phagocytes are a group of white blood cells that engulf the organisms that cause infections such as bacteria, by the process of phagocytosis.

During infections, phagocytes leave the capillaries and move towards the infecting organisms by amoeboid movement.

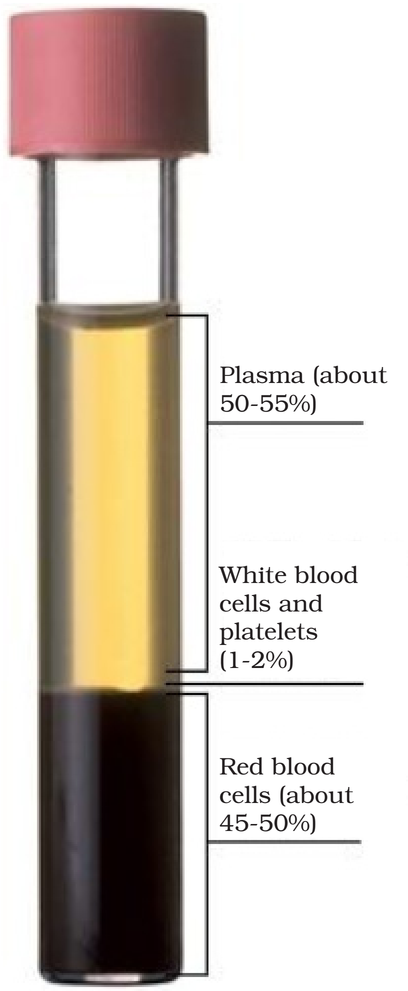


Figure 18. Blood Composition

Lymphocyte Lymphocytes help to develop immunity against foreign proteins or bodies that enter the human body. Proteins that are foreign to the body are called antigens. Lymphocytes help develop antibodies which act against the antigens. Antibodies remain in the blood for a long time protecting us from certain diseases.

Blood platelets are non-nucleated, colourless bodies. They are not true cells but are disc shaped bits of cytoplasm. They are much smaller than the red blood cells being between 1 and 2 microns is diameter. Each cubic millimetre of blood contains 300,000 to 400,000 platelets (Figure 18).

Platelets play important roles in initiating the process of blood clotting when blood vessels are cut or damaged. The clotting of blood involves a complex series of enzyme-controlled reactions that form a network of threads at the injured part of the blood vessels.

When a blood vessel is cut during an injury the blood platelets and the cells of the damaged tissue release chemical substance known as thromboplastin. In the presence of calcium ions and vitamin K, thromboplastin converts the enzyme prothrombin, a protein that is present in plasma, to its active form, thrombin. Thrombin reacts with fibrinogen, a soluble plasma protein, and converts it to insoluble fibrin strands. These fibres form a network that traps blood cells. When this happens, a clot is formed that stops more blood from escaping.

3.4 Blood Groups and Transfusion – Rh Factor

There are molecules present on the surface of all cells that are recognised as being foreign by the immune system of another individual. Molecules that are recognised as being foreign by the immune system of another individual are called antigens. The body produces antibodies against these antigens.

The leucocytes or white blood cells produce the antibodies. Antigens are proteins that are foreign to the body. Antibodies act against the antigens protecting us from certain diseases. The reaction between the antigen and the antibody is highly specific. So, a certain antibody can only act on a specific antigen.

The red blood cells have antigens that are extremely important because we use them to match donors with recipients during blood transfusions. A blood transfusion occurs when blood is taken from a donor.

The blood is injected into the blood stream of the recipient, who has lost blood. A specialised and unique aspect of the immune response is seen in human blood.

There are a variety of blood groups, but the one most familiar to us and in most common usage is the ABO system. We can distinguish four blood groups using the ABO system. They are blood groups A, B, AB and O. We determine the blood group because of the antigens present on the surface of the red blood cells.

A person with

- Blood group A has only A antigens,
- Blood group B has B antigens,
- Blood group AB has both A and B antigens
- Blood group O does not have antigens

The body can produce two types of antibodies against the antigens. These are anti-A and anti-B antibodies and are found in the plasma. The immune system is tolerant to its own red blood cell antigens.

A person with blood group A

- Does not produce anti-A antibodies.
- Does produce anti-B antibodies.

A person with blood group B

- Does not produce anti-B antibodies.
- Does produce anti-A antibodies.

People with blood group AB do not produce either anti-A or anti-B antibodies.

Those people with blood group O have both anti-A and anti-B antibodies.

If blood group A is mixed with anti-A antibody, we find that the red blood cells clump together.

The sticking together of the red blood cells in clumps is called agglutination.

Before a blood transfusion is carried out, it is necessary to make sure that the donor's blood and the recipient's blood will mix together without agglutination.

Blood groups that mix without agglutination are said to be compatible. Blood compatibility depends on proteins called antigens on the surface of the red blood cells and the chemicals called antibodies.

Determining the blood group of a person

Mix a few drops of blood with commercially made anti-A antibody and with anti-B antibody. If agglutination occurs with anti-A antibody, then the blood is group A.

Transfusion of blood groups

Blood group	Can be transfused into	Can receive blood from
A	A and B	A and O
B	B and AB	B and O
AB	AB only	all groups
O	all groups	O only

Blood group O

Blood group O can donate blood to any recipient.

- Does not have any antigens
- Cannot be agglutinated by blood of any other group
- Regarded as a universal donor.

Blood group AB

- Has neither anti-A nor anti-B antibodies.
- A person with blood group AB can receive blood from all the blood groups.
- Regarded as a universal recipient

Rhesus (Rh) factor

The Rhesus (Rh) factor is an inherited protein found on the surface of red blood cells.

If your blood has the protein, you are Rh positive. If your blood lacks the protein, you are Rh negative.

Rh positive is the most common blood factor.

There are four blood types. A, B , AB, and O.

1. A+, A-
2. B+, B-

3. Ab+, Ab-
4. 0+, O-

Blood Banks

Blood Banks are places that collect and store blood from donors. The blood is then given to people who have lost blood. Major hospitals and organizations like the Ethiopian Red Cross Society have blood banks.

These are places keep the blood donated by healthy individuals. The donated blood is stored in bags and refrigerated for later use. Donating blood does not hurt and the body replaces the withdrawn blood within a few weeks. Blood donors must meet requirements of age, health and weight. One can start giving blood regularly at 18 years of age.

Donation of blood does not cause any harm to healthy individuals at all. It can be very satisfying to think about the person who was suffering and who is now fit and healthy because of the blood given. People have survived emergencies because of blood from the blood bank donated by volunteers.

Exercises

Match each term in Column A with its description in Column B. Write the correct letter in the space provided.

Column A	Column B
1. Right ventricle	A. Carry blood away from the heart
2. Left ventircle	B. Delivers blood to Aorta
3. Arteries	C. Allow exchange of substances
4. Veins	D. Delivers blood to pulmonary vein
5. Capillaries	E. Have valves at intervals
	F. Delivers blood to pulmonary artery

3.5 Effects of Substance Abuse on the Circulatory System

Abnormal use of drugs affects the structures of the circulatory system and their functions by poisoning blood and causing clotting.

3.6 The Lymphatic System

Lymph

The lymphatic system is a network of tissues, organs and vessels that help to maintain the body's fluid balance & protect it from pathogens.

It is composed of lymphatic vessels, lymph nodes, spleen, thymus, tonsils, etc (Figure 19).

- without it neither the circulatory system nor the immune system would function.

It can be thought of as an accessory to the circulatory system.

- It helps the circulatory system to do its job.
- The two systems are directly connected together.
- It consists of fluid derived from plasma =lymph and white blood cells (esp. lymphocytes and macrophages (monocytes)).
- The lymph travels in only one direction - it does not circulate.

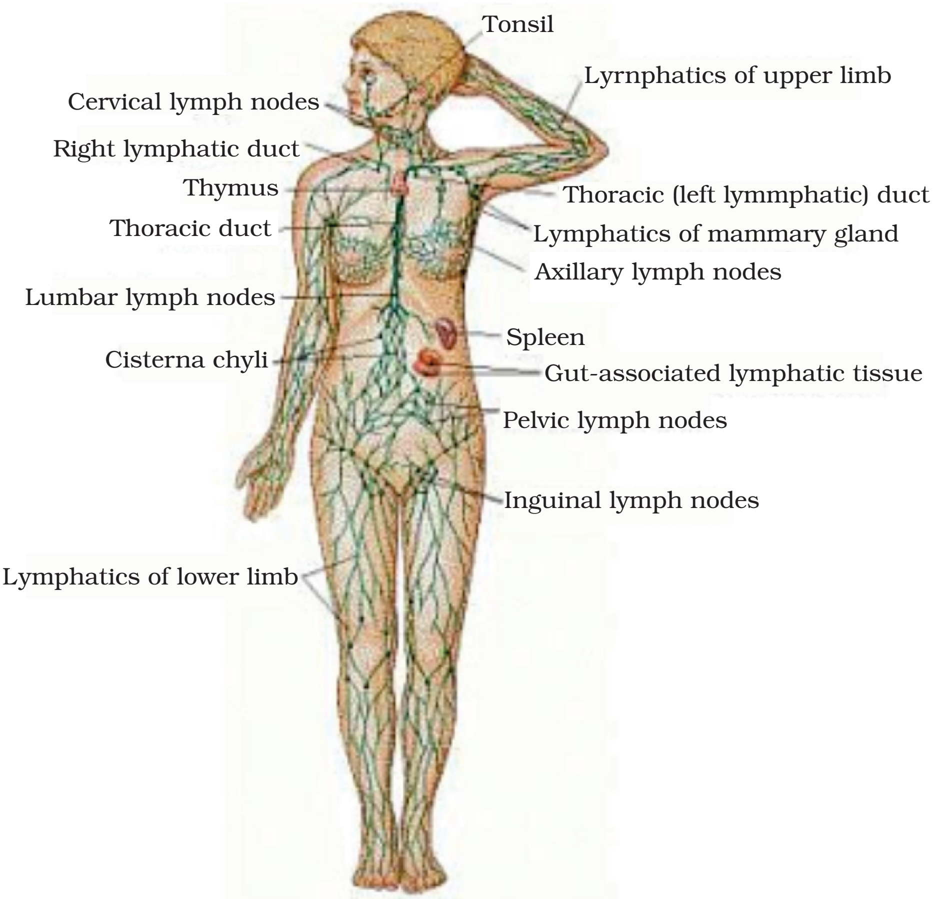


Figure 19. The lymphatic system

General Functions of Lymphatic System

1. Returns Fluid from Tissues to Blood
   - 85% of fluids that leak out of blood returns to blood via blood capillaries
   - 15% returns via lymph capillaries- in 24 hrs.

   Lymphatics return fluid equivalent to entire blood volume - if lymphatic system becomes blocked edema (Figure 20).
2. Returns Large Molecules to Blood ~25-50% of blood proteins leak out of capillaries each day
   - They cannot get back into capillaries instead, lymphatic capillaries pick them up and return them to the blood.
   - If lymphatics are blocked blood protein decreases leading to fluid imbalances in body

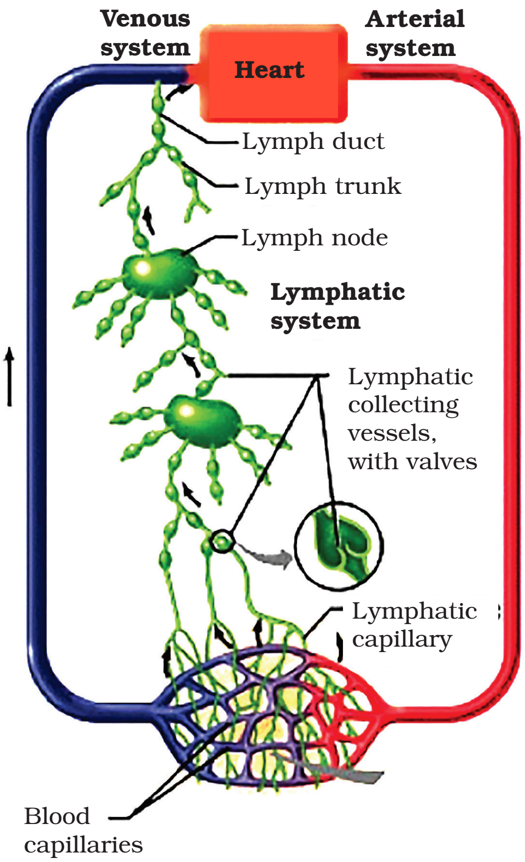


Figure 20. Movement of lymph

3. Absorb and Transport Fats - Special lymphatic capillaries (=lacteals) in villi of small intestine absorb all lipids and fat soluble vitamins from digested food bypasses liver much goes straight to adipose tissues.
4. Hemopoiesis - WBC's (lymphocytes, monocytes) are made in lymphatic tissues (not bone marrow) main supply of lymphocytes.
5. Body Defense/Immunity - lymphoid tissue is an important component of the Immune System (forms a diffuse surveillance defense system in all body tissues and organs.

Lymphatic Vessels (lymphatics)

Lymphatic Capillaries originate in tissues as tiny blind ended sacs.

- lie side by side with blood capillaries.
- Single layer of endothelial cells like blood capillaries but much more permeable to solvents, and large solutes and whole cells. These small lymphatic capillaries merge with others to form larger lymphatic vessels.
  they resemble veins in structure:
- three layers – but much thinner
- 1-way valves – but many more (every few mm or so)
- also has lymph nodes at intervals along its course
- as they converge they become larger and larger

Lymphatic Ducts

- The lymphatic trunks merge together to form two major Lymphatic Ducts
- equivalent to major vessels of circulatory system but more like veins than arteries.

Two major Lymphatic Ducts

Right Lymphatic Duct,

Very short and drains upper right quadrant of body into right subclavian vein at jct with jugular V.

Thoracic Duct

Much larger and longer and drains the rest of body (3/4ths).

All of body below diaphragm and left arm and left side of head, neck and thorax begins just below the diaphragm, anterior to vertebral column, lumbar trunks and intestinal trunk join to form saclike cysterna chyli drains into left subclavian vein. (Figure 21).

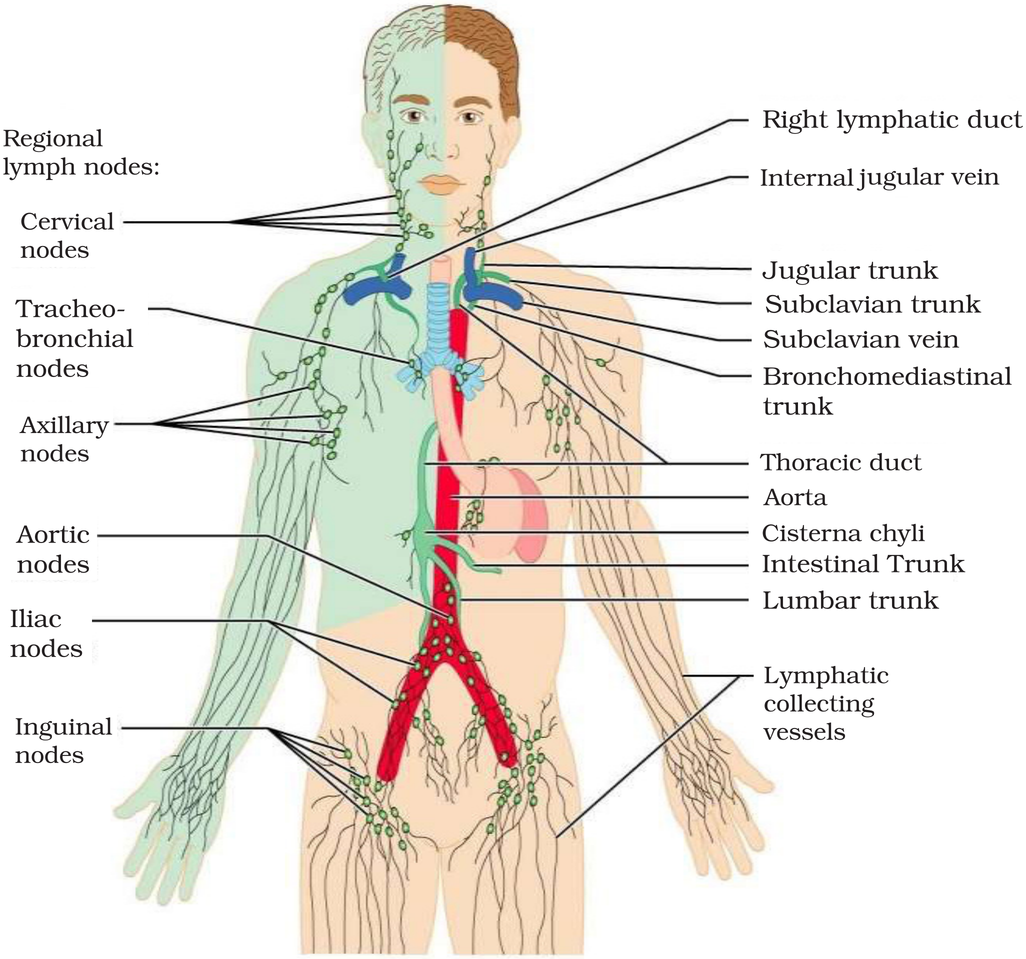


Figure 21. Lymphatic vesseles & nodes

Lymph Circulation (Figure 22)

- Lymph vessels are thin walled, valved structures that carry lymph.
- Lymph is not under pressure and is propelled in a passive fashion.
- Fluid that leaks from the vascular system is returned to general circulation via lymphatic vessels.
- Lymph vessels act as a reservoir for plasma and other substances including cells that leaked from the vascular system.

- The lymphatic system provides a one-way route for movement of interstitial fluid to the cardiovascular system.
- Lymph returns the excess fluid filtered from the blood vessel capillaries, as well as the protein that leaks out of the blood vessel capillaries.
- Lymph flow is driven mainly by contraction of smooth muscle in the lymphatic vessels but also by the skeletal-muscle pump and the respiratory pump.

Lymph Circulation

Interstitial fluid → Lymph → Lymph capillary → Afferent lymph vessel → Lymph node → Efferent lymph vessel → Lymph trunk → Lymph duct {Right lymphatic duct and Thoracic duct (left side)} → Subclavian vein (right and left) → Blood → Interstitial fluid (Figure 22).

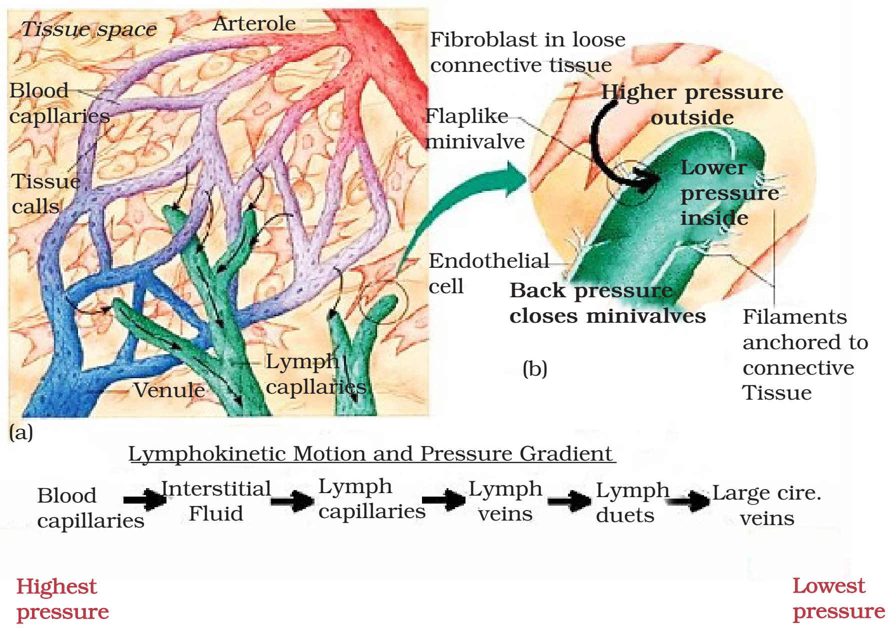


Figure 22. Lymph Circualtion

Lymph Nodes (Figure 23)

- also called lymph glands.
- oval, vary in size from pinhead to lima bean.
- most numerous of the lymphatic organs (100's)

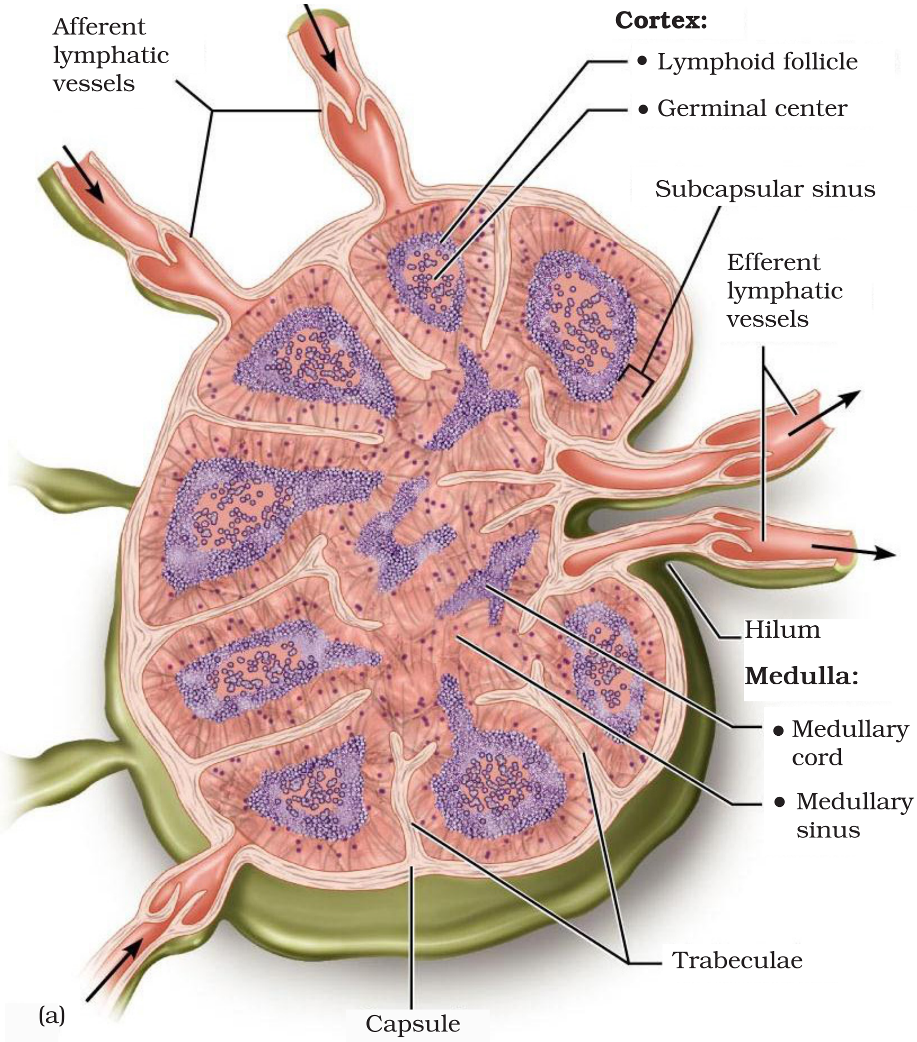


Figure 23. Lymph node

Functions of lymph nodes

1. cleanse lymph - as lymph flows through sinuses of node it slows down and microorganisms and foreign matter are removed
2. alert immune system to pathogen
3. important in hemopoiesis - lymphocytes and monocytes are made here.
   - lymph moves into nodes by way of several afferent lymphatic vessels
   - moves through sinus channels lined with phagocytic white blood cells

- exits via 1-3 efferent lymph vessel
- the WBC's in each node remove ~99% of impurities as lymph passes from node to virtually all impurities are normally removed-node.

Major Accessory Lymphatic Organs (Figure 24)

- Spleen – largest.
- Thymus.
- Tonsils
- Peyers's patches
- Appendix

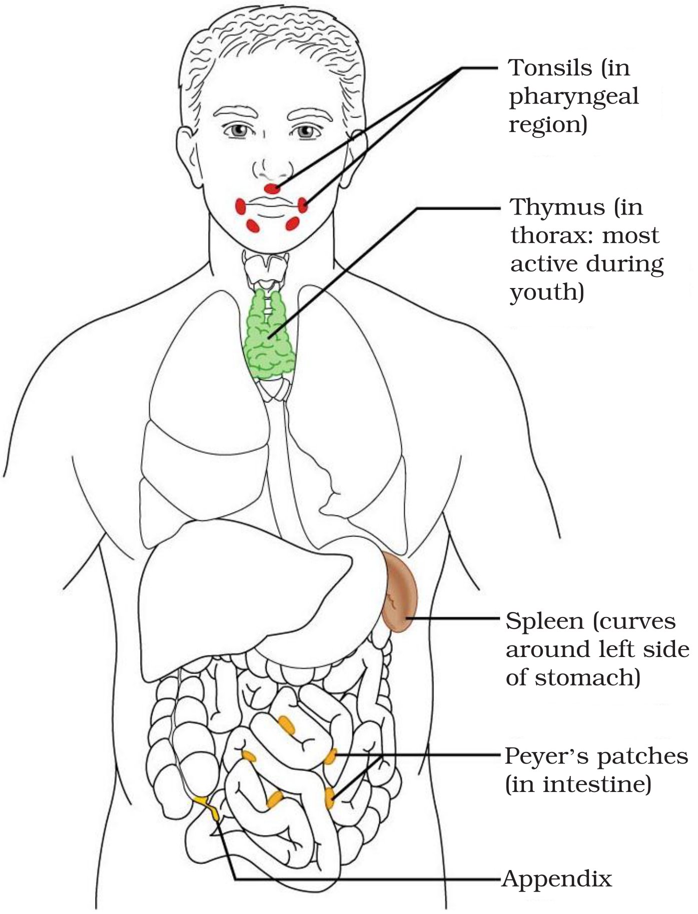


Figure 24. Accessing lymphatic organs

Spleen

- largest of the lymphatic organs.
- located below diaphragm in left hypochondriac region, and ovoid in shape.
- inside is a network of interlacing fibers: red pulp packed with RBC's white pulp crowded with lymphocytes, monocytes, and neutrophils.

Performs several functions

1. defense helps screen blood and removes pathogens and bacteria.
2. hemopoiesis monocytes and lymphocytes are made here (before birth, RBC's also made here).
3. erythrocyte and platelet destruction spleen is "erythrocyte graveyard" iron is salvaged from RBC's
4. blood reservoir able to store blood

Thymus

- is single unpaired organ in mediastinum and neck region plays vital role in initial set up of body's immune system. Source of lymphocytes before birth which circulate to spleen, nodes and vessels soon after birth it secretes a hormone that causes lymphocytes to develop into plasma cells.
- primary function is in early life.
- once this job is done it degenerates seems to complete its essential job by end of childhood
- largest when young, after puberty then gets smaller and is replaced with fat.
- secretes thymosin and thymopoietin which causes T lymphocytes to become immunocompetent.
- lacks B cells (no follicles)
- atrophies with age: prominent in newborns, stops growth by adolescence, degenerates by old age

Lymphocytes

Lymphocytes are types of white blood cells. Which can produce anti bodies against foreign bodies. These can be T-lymphocytes and B-lymphocytes.

MALT (mucosa associated lymphatic tissue) includes

Small bronchiolar follicles MALT are positioned to:

- Destroy bacteria that breach the mucosal membrane from outside Develop "memory" lymphocytes for long term immunity

Tonsils

- masses of lymphoidal tissue embedded in mucous membranes of pharynx.
- covered by epithelium, with deep pits(=crypts).
- crypts often contain food debris, bacteria, dead wbc's etc.
- three main sets of tonsils:
- **pharyngeal tonsils** (=adenoids) on wall of pharynx behind nasal cavity
- **palatine tonsils** at post margin of oral cavity largest and most often infected.
- **lingual tonsils** on each side of root of tongue and not encapsulated.
    - induced immune response

Peyer's Patches

- small masses of lymphatic tissue found throughout ileum region of small intestine.
- roughly egg-shaped lymphatic tissue nodules that are similar to lymph nodes in structure.
- analyze and respond to pathogenic microbes in the ileum

Exercises

1. What is the connection between lymphatic system & circulatory system?
2. How is the lymphatic system work with the digestive system?
3. What are MALT?

KEY TERMS

- livary Amylase
- Pepsin
- Pancreatic Amylase
- Maltase
- Lactase
- Sucrase
- Lipase
- Trypsin
- Peristalsis
- Rectum
- chewed
- liver
- swallow
- absorbed
- food
- mouth
- tongue
- digestion
- pharynx
- esophagus
- Blood vessel
- arteries
- veins
- capillaries
- blood
- plasma
- white blood cells
- red blood cells
- platelets
- Lymphatic Fluid
- Lymphatic Vessels
- Lymphocytes
- Lymphatic organs

SUMMARY

Food is anything that is taken into the body. Food is made up of compounds, called nutrients, which can be used by an organism.

The digestive system is made up of the digestive tract. This consists of a long tube of organs that runs from the mouth to the anus and, together with the liver, gall bladder, and pancreas, which produce important secretions for digestion that drain into the small intestine.

Products of digestion

Enzymes	Produced by	pH	Digestion
Mouth			
Salivary Amylase	Salivary gland	Neutral	Starch + H2O→Maltose
Stomach			
Pepsin	Gastric glands	Acidic	Protein + H_2O → Peptones
Small intestine			
Pancreatic Amylase	Pancreas	Basic	Maltose + H_2O→Glucose + Glucose
Maltase Lactase Sucrase	Intestinal glands	Basic	Maltose + H_2O → Glucose + Glucose Lactose + H_2O → Galactose + Glucose Sucrose + H_2O → Fructose + Glucose
Lipase Lipase	Pancreas Intestine glands	Basic	Fat droplet + H_2O → Fatty acid + Glycerol
Trypsin Esepsin	Pancreas Intestinal glands	Basic	Peptones + H_2O → Peptides Peptides + H_2O → Amino Acid

Red blood cells (erythrocytes)

They are Transporters of

- Oxygen
- Carbon Dioxide
- Lack a nucleus
- Contain Haemoglobin
- Disk-shaped

They are produced in red bone marrow of the:

- ribs
- Humerus (upper arm bone)
- Femur (upper leg bone)
- sternum and other long bones
- They live for 120 days
- Old red blood cells are destroyed in the liver and spleen

Their shape is described as Bi-Concave as they have depressions on both sides, so they have a maximum amount of surface to absorb oxygen from the lung

White blood cells

- White blood cells defend against disease by recognizing proteins that do not belong to the body.
- They are able to ooze through the walls of capillaries to patrol the tissues and reach the lymph system.

Platelets

- Platelets are cell fragments used in blood clotting.
- They are derived from megakaryocites.
- Because they lack a nucleus, platelets have a short lifespan, usually about 10 days.

THE CARDIOVASCULAR SYSTEM

Transports cell and dissolves materials, including nutrients, wastes, and gases

Organ/Component	Primary Functions
Heat	Propels blood; maintains blood pressure
Blood Vessels	Distribute blood around the body
Arteries	Carry blood from heart to capillaries
Capillaries	Permit diffusion between blood and interstitial fluids
Veins	Return blood from capillaries to the heart
Blood	Transport oxygen, nutrients and blood cells; delivers nutrients and hormones; removes waste products; assists in temperature regulation and defense against disease

Blood pressure

As blood is moved through your body, it exerts pressure against the walls of blood vessels.

- Systolic Pressure: as your heart contracts to push blood into your arteries, your blood pressure is at its highest point.
- Diastolic Pressure: As your heart relaxes to refill, blood pressure is at its lowest point.

The lymphatic system is a network of tissues, organs and vessels that help to maintain the body's fluid balance & protect it from pathogens. It is composed of lymphatic vessels, lymph nodes, spleen, thymus, tonsils, etc.

- without it neither the circulatory system nor the immune system would function.
- It can be thought of as an accessory to the circulatory system.
- It helps the circulatory system to do its job.
- The two systems are directly connected together.
- It consists of fluid derived from plasma =lymph and white blood cells (esp. lymphocytes and macrophages (monocytes)).
- The lymph travels in only one direction - it does not circulate.

Review Exercise

I. **Write true for true statement or False for wrong statement.**

1. Circulation is the transport of materials in living things.
2. Chemical digestion of food begins in the oral cavity.
3. Calcium is essential for the development and maintenance of bones and teeth.
4. Blood circulates through the body only a few times a day.
5. Arteries carry blood away from the heart.
6. Iron is a component of haemoglobin in red blood cell.
7. Amino acids are the end products of the digestion of carbohydrates.
8. Vitamins are the chemical nutrients that are required in low amounts for normal growth and metabolism.
9. Capillaries connect arteries and veins.
10. Left ventricle is thicker than right ventricle.

Sample Test

Multiple choice – choose the correct answer from the given alternatives.

1. Another term for swallowing of food is ______________________.
   (a) Digestion
   (b) Ingestion
   (c) Deglutition
   (d) Peristalsis

2. Which of the following is **Not** the function of gastric juice?
   (a) It provides an acidic medium for protein digesting enzyme.
   (b) It provides mucin that protects the wall fo stomach from being digested by enzymes.
   (c) It contains starch digesting enzymes.
   (d) Protein digesting enzyme..

3. Which of following is **Not** part of the small intestine?
   (a) Duodenum
   (b) Ileum
   (c) Jejenum
   (d) Tectum
4. Adults have __________ true molars.
   (a) -4-
   (b) -8-
   (c) 12
   (d) 16
5. Teeth are composed of a number of substances, the bulk of which is _________.
   (a) Enamel
   (b) Gingiva
   (c) Cementum
   (d) Dentin
6. Which of these is not one of the three pairs of extrinsic salivary glands?
   (a) Parotid
   (b) Palatine
   (c) Submandibular
   (d) Sublingual
7. Within the stomach lining, _________________ cells secrete hydrochloric acid.
   (a) Parietal
   (b) Goblet
   (c) Chief cells
   (d) Argentaffin
8. During which phase of gastric secretion is gastric juice released?
   (a) Cephalic phase
   (b) Gastric phase
   (c) Intestinal phase
   (d) All of these are correct.
9. The pyloric sphincter is located between ________.
   (a) Esophagus and stomach
   (b) Stomach and duodenum
   (c) Gall bladder and intestine
   (d) Small intestine and large intestin

10. Which of the following digestive secretions does **Not** contain enzymes?
    (a) Pancreatic juice
    (b) Intestinal juice
    (c) Bile
    (d) Saliva
11. Within the liver, bile is produced by ________ and secreted into bile canaliculi.
    (a) Kupffer cells
    (b) Liver lobules
    (c) Hepatocytes
    (d) Acinar cells
12. Which of the following digestive secretions doe **Not** contain enzymes?
    (a) Blood group "A"
    (b) Blood group "B"
    (c) Blood group "AB"
    (d) Blood group "O"
13. When Oxygen is carried by the blood, it is bonded to
    (a) Plate lets
    (b) Plasma
    (c) Antibodies
    (d) Haemoglobin
14. Which of organ in the list is the largest gland in the human body?
    (a) Parotid
    (b) Liver
    (c) Pancreas
    (d) Thyroid
15. Which of the following end products of the digestion of foods pass into lacteals during food absorption?
    (a) Glucose
    (b) Monosaccharides
    (c) Fatty acids
    (d) Amino acids
16. Which of the following food substnaces are needed by the body in small quantities?
    (a) Carbohydrates
    (b) Lipids

(c) Proteins
(d) Minerals

17. Food and chyme are pushed through the digestive system by:
    (a) Ingestion
    (b) Mastication
    (c) Assimilation
    (d) Peristalsis
    (e) Peritoneum
18. Which of the following secretions is NOT produced by pancreas?
    (a) Pepsin
    (b) Amylase
    (c) Lipase
    (d) Trypsin
19. Which of the following digestive enzymes is NOT found in intestinal juice?
    (a) Erepsin
    (b) Trypsin
    (c) Amylase
    (d) Maltase
20. An important function of the intestinal villi is to:
    (a) Increase the surface area for absorption of nutrients
    (b) Move chyme along the alimentary canal
    (c) Form a protective covering for the alimentary canal
    (d) Synthesise amino acids
21. Blood from the intestines travels to the liver via the:
    (a) Hepatic artery
    (b) Mesenteric artery
    (c) Hepatic vein
    (d) Hepatic portal vein
22. The end product of digestion of starch which is absorbed into the bloodstream is:
    (a) Amino acid
    (b) Fatty acid
    (c) Glucose
    (d) Sucrose
    (e) Lactose

23. Which of the following is a function of bile?
    (a) Digestion of proteins and carbohdyrates.
    (b) Emulsfication of lipids.
    (c) Detoxification of harmufl substances.
    (d) Chemical digestion fo fatty foods.
24. Which of the following glands produces saliva?
    (a) Pancreas
    (b) Thyroid
    (c) Pituitary
    (d) Parotid
25. The primary site for absorption of water by the digestive system is the:
    (a) Esophagus
    (b) Colon
    (c) Small intestine
    (d) Stomach

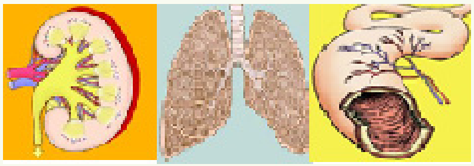
B12CH04

CHAPTER 4

EXCRETORY SYSTEM; RESPIRATORY SYSTEM; AND CELLULAR RESPIRATION

Chapter Contents

4.1 Excretory System
4.2 Respiratory System
4.3 Effects of Substance Abuse and Sexually Transmitted Infections (STI)
4.4 Cellular Respiration
4.5 ATP (Adenosine Triphosphate) Formation
4.6 Aerobic Respiration
4.7 Anaerobic Respiration
- Key Terms
- Summary
- Review Exercise
- Sample Test



Chapter Outcomes

Upon completion of this chapter, learners will:

- describe the excretory system and state the functions of all associated organs;
- list the tissues and organs involved in the mechanism of breathing;
- explain homeostasis in relation to the Excretory system;
- explain the effects of substance abuse and STIs on the Excretory and Respiratory systems;
- state the characteristics of the types of Respiration. Distinguish between aerobic and anaerobic Respiration;
- discuss Cellular Respiration citing the major stages sequentially noting the main events (Glycolysis, Krebs cycle and Electron Transport Chain);
- discuss anaerobic Respiration in the muscle and its importance in fermentation using yeast/fruits for (alcohol production);
- discuss the significance of Phosphorylation in Glycolysis;
- identify the final products of Glycolysis;
- outline the fate of Pyruvate after Glycolysis;
- distinguish oxidation and reduction with regards to oxygen, hydrogen and electrons;
- distinguish between decarboxylation reactions and dehydrogenation reactions;
- interpret the balanced chemical equation for respiration ($C_6H_{12}O_6$ + 6O2→6CO2 + 6H2O);
- identify the three types of electron carriers located in the inner membrane of the Mitochondria (flavoproteins, quinones and cytochromes).

Introduction

Excretion is the removal of the metabolic wastes of an organism. Wastes that are removed include carbon dioxide, water, salt, urea and uric acid. All excreted wastes travel at some time in the blood.

Excretory system removes waste products from cellular metabolism (urea, water, CO_2) and filters blood.

Major Organs of Excretory system are;

Kidneys

- Ureters
- Bladder
- Urethra

Lungs

Skin – sweat glands

Liver (produces urea)

Large intestine

Excretory system works with:

1. Circulatory system – filters waste out of blood
2. Respiratory system – removes excretory waste
3. Integumentary system – removes excretory waste

Respiratory system takes in oxygen and removes carbon dioxide and water.
The organs of respiratory system include:

Nose

lungs

- Trachea
- Bronchi
- Bronchioles
- Alveoli

The respiratory system works with:

1. Circulatory system – takes in O_2 for delivery to cells and removes CO_2 brought from cells

2. Excretory system – removes excretory waste
3. Autonomic Nervous system – controls breathing
4. Muscular system – diaphragm controls breathing

4.1 Excretory System

A. The Urinary System

Kidneys filter the blood to form urine, which is excess water, salt, urea and uric acid (Figure 1).

Importance

- Humans produce waste products that must be removed from their body.
- Most animals have a system that deals with nitrogen-rich wastes from the breakdown of proteins and nucleic acids.
- Ammonia (NH_3) is toxic.
- It helps maintain homeostasis – balancing osmotic action and pH.

Urinary System Functions

- Excrete toxins and nitrogenous waste
- Regulate levels of many chemicals in blood
- Maintain water balance
- Regulates blood pressure

Organs of the Urinary System (Figure 1, 2 & 3)

Kidney – filters blood and forms urine- receives 20-25 % of arterial blood Homeostatic device – regulates composition of the blood Filtration – removes waste.

Ureter – carries urine to the urinary bladder. Muscles contract and relax to move urine out of kidneys every 10 to 15 seconds to prevent infection.

Urinary Bladder – holds urine – it can hold up to 16 oz of urine for 2-5 hours.

Urethra – releases urine from the body by relaxing the sphincter muscle (circular muscle around the bladder opening to keep it from leaking) at bottom of bladder and contracting the bladder muscles.

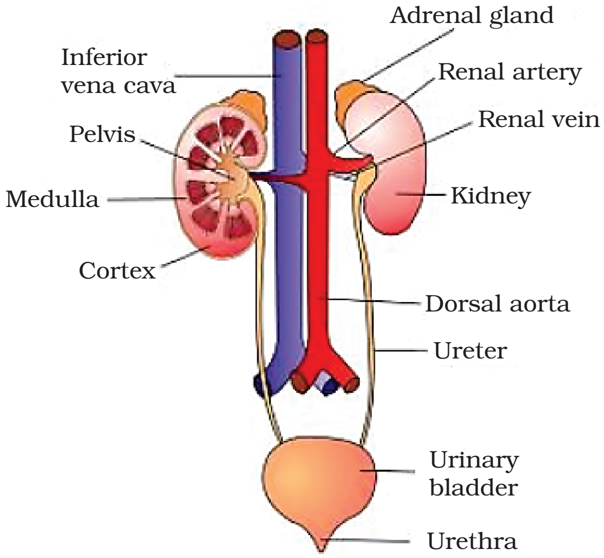


Figure 1. The Urinary System

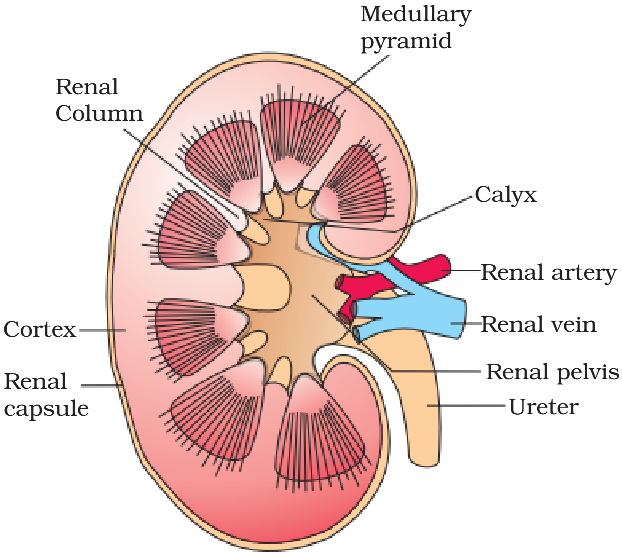


Figure 2. Kidney

Functions of the kidney.

- **filtration** – fluid pressure forces water and dissolved substances out of blood

- **reabsorption** – returns useful items as blood cells, plasma protein, glucose, amino acids, some salts and some water to the blood. Some urea and other salts are also reabsorbed.
- **secretion** – *involves active transport* - removes residues from toxins drugs, more urea and uric acid into urine, excess potassium ions, and regulates pH of blood

How the kidney works

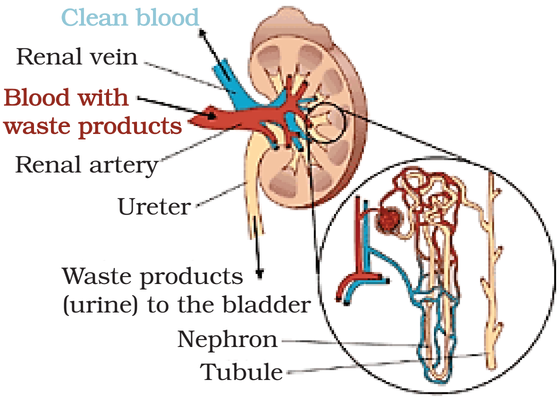


Figure 3. Nephron – basic unit of kidney

Overview of Nephron Structure and Function (Figure 4).

General Nephron Structure glomerulus – site of filtration from arterial blood

- **proximal convolute tubule**– first tube off glomerulus .
- **loop of Henle** –U-turn connecting tubules
- **distal convoluted tubule** – to the collecting tubule
- **collecting tubule** – urine from many nephrons
- **peritubular capillaries** – "around" the "tubes"

General Nephron Function

- glomerular filtration
- tubular reabsorption
- tubular secretion
- fluid Processing in the Kidneys 180 liters of blood fluid processes each day 1.5 liters of urine produced each day.

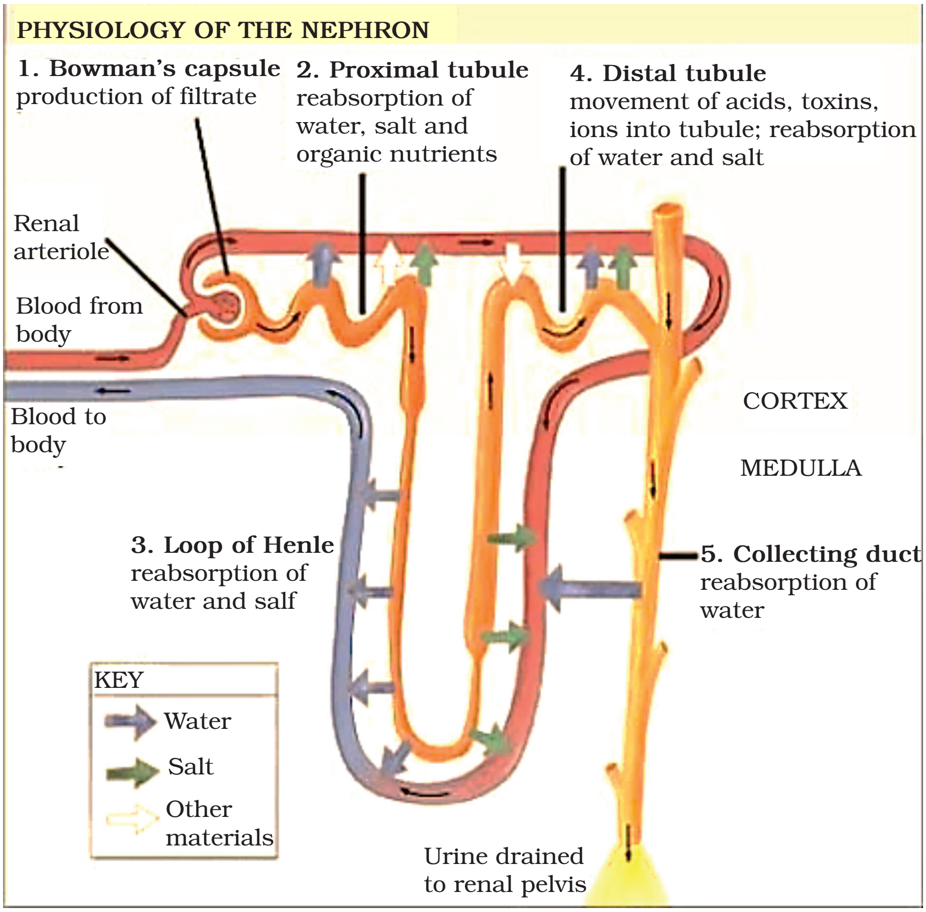


Figure 4. Physiology of Nephron

B. Urine formation in the nephron (Figure 5)

Glomerular Filtration

- substances move from blood in glomerulus to the Bowman's capsule.

Filtration Membrane

1. Hydrostatic pressure – forces 1/5 of blood fluid through capillary walls into glomerular capsule
2. Filtration membrane – has three parts
   (a) fenestrated capillary endothelium (prevents passage of blood cells).

(b) basal membrane (allows most solutes but larger proteins).

(c) visceral membrane of glomerular capsule

3. Solutes that can pass into glomerular capsule include water, sugar, amino acids, and nitrogenous waste molecules. Larger proteins cannot pass through.

Tubular Reabsorption: Reabsorbing the Glomerular Filtrate.

- substances move from renal tubules into blood of peritubular capillaries

A. **Overview of Reabsorption**

- Filtrate - all fluid and its solutes pushed into the capsule
- Urine - filtrate minus reabsorbed substances
- most sugars and amino acids are reabsorbed
- water and ion reabsorption depends on hormonal control

B. **Active Tubular Reabsorption**

- glucose, amino acids, lactate, vitamins, ions.
  - (a) move across luminal surface by diffusion
  - (b) actively transported across basolateral membrane.
    - (i) cotransporter with Na+c diffuse into capillary by diffusion
- Transport maximum (Tm) - when "**carrier** proteins" for specific solute becomes saturated and cannot carry the substance across the membrane.
  - (a) Diabetes Mellitus – lower Tm (glucose lost).

C. **Passive Tubular Resorption**

- Na+ driven into interstitial space actively (above).
- HCO3- and Cl- follow Na+ into the space.
- obligatory water resoprtion – water follows ions into the interstitial space between tubule & capillary.
- solvent drag – solutes will begin to move into tubule from filtrate, following water (especially some urea and lipid-soluble molecules.

D. **Non reabsorbed Substances.**

- Urea, creatinine, uric acid – most is not reabsorbed because of the following reasons.

(a) no carrier molecules for active transport.
(b) not lipid-soluble.
(c) too large (as with most proteins).

Absorption in Different Regions of Renal Tubule.

1. **Proximal tubule** – closest to the glomerular capsule.
   (a) almost all glucose & amino acids.
   (b) 75-80% of water and Na+
   (c) most active transport of ions.
2. **Loop of Henle** – connects proximal & distal tubules Regulates Total water retained or lost:
   (a) descending limb – water can return
   (b) ascending limb – water can be reabsorbed.
3. **Distal tubule & collecting duct** – final passageway.
   (a) antidiuretic hormone (ADH) – causes increased permeability to Na+ and water, allow resorption
   (b) aldosterone – stimulated be renin-angiotensin, enhances Na+ reabsorption (water follows).
      (i) lower blood pressure
      (ii) low Na+ concentration (hyponatremia).
   (c) atrial natriuretic factor (ANF) – reduces Na+ permeability, less

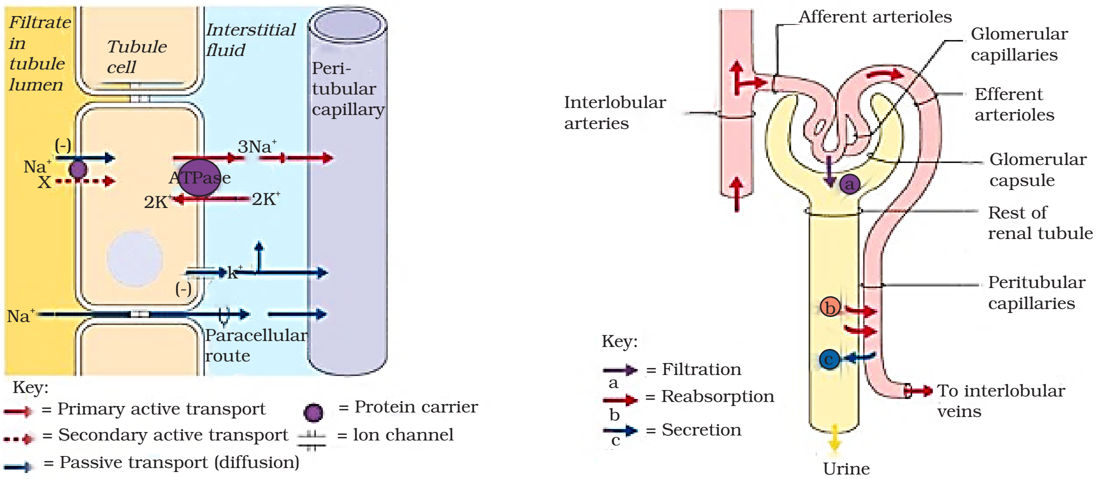


Figure 5. Filteration in Nephron

ACTIVITY 1

Obtain a universal pH strip (pH = 0 14 range)
Take small (5ml) of urine in a test tube.
Insert pH strip (5 - 10 seconds)
Compare colour of the strip with the colour comparator & determine the pH value.

Tubular Secretion

A. Movement from Capillaries to Tubular Cells.

1. K+, creatinine, ammonia, organic acids, drugs
2. Primary functions of tubular secretion:
   (a) moving drugs into the urine
   (b) moving more urea & uric acid into urine
   (c) removing excess K+ from blood
   (d) regulating pH (H+ ion removal)

Characteristics and Composition of Urine

A. Physical Characteristics (Figure 6)

1. Color – clear to yellowish; influenced by diet, drugs, and health state
2. Odor – slightly aromatic; influenced by diet, drugs, and health state
3. pH (H+ conc.) – usually about 6; changes in diet can affect the pH

B. Specific gravity – compared density to distilled water; urine slightly heavier (with solutes). Chemical Composition 95% water 5% solutes – urea (breakdown of amino acids); uric acid; creatinine

C. Excretion by other Organs

The liver (Figure 7)

The liver is a complex organ. It performs over 500 different functions. Two of these are the **control of amino acid concentration and detoxification**.

- Urea is produced in the liver and is a metabolite (breakdown product) of amino acids.

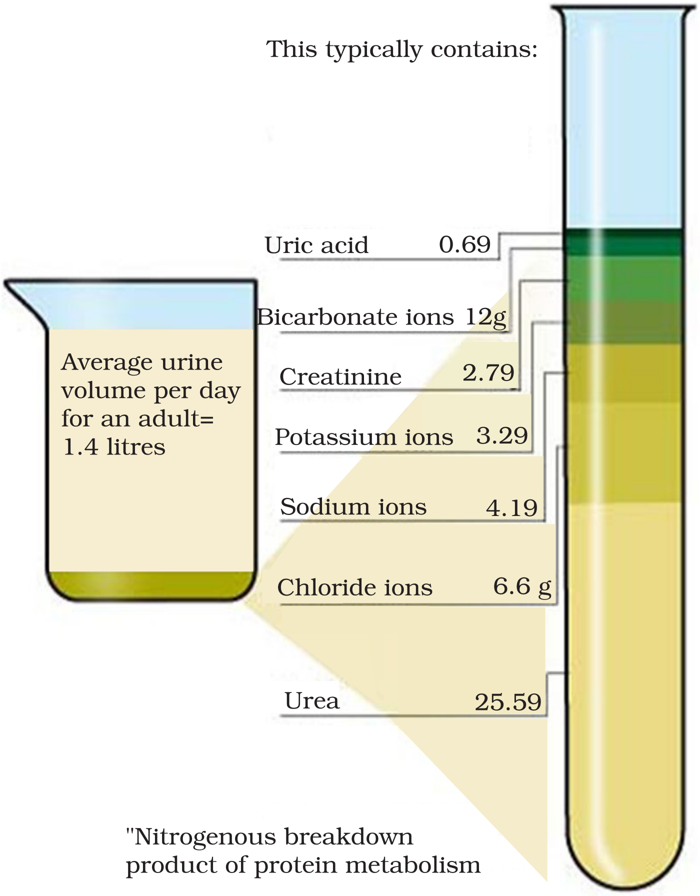


Figure 6. Urine Components

- Ammonium ions are formed in the breakdown of amino acids. Some are used in the biosynthesis of nitrogen compounds. Excess ammonium ions are converted to urea.
- **Liver** - produces urea and uric acid as a by-product of the breakdown of proteins

Control of amino acid concentration

When amino acids are absorbed by liver cells a series of chemical reactions begins.

- The amino acid is oxidized in the presence of an enzyme catalyst.
- At the same time the amine group, -NH2, and a hydrogen atom, H, are removed from the main structure of the amino acid.

- The important product of this reaction is ammonia.
- The amine group is reduced to ammonia by the addition of a hydrogen atom. This process is called deamination. The non-nitrogenous portion of the molecule is converted to carbohydrates or fats.

The liver - the detoxification organ

Ammonium ions exist in aqueous solution in dynamic equilibrium with ammonia molecules.

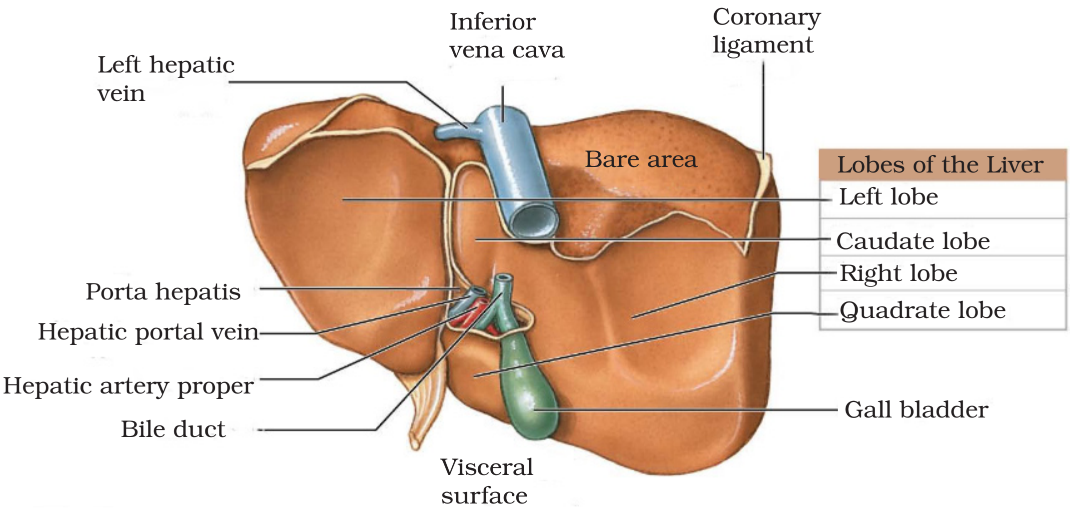


Figure 7. The liver

Ammonia is highly toxic in the body and therefore cannot be allowed to accumulate. With the involvement of specific catalysts in the liver cells carbon dioxide reacts chemically with the ammonia molecule, NH_3. The less toxic nitrogenous compound urea is produced together with water.

$$CO_2 + 2NH_3 \quad (NH_2)_2CO + H_2O$$

- This series of reactions is called **the Ornithine cycle**.
- The urea and water are released from the liver cells to the bloodstream and transported to the kidneys where the blood is filtered and the urea is passed out of the body in the urine.

Urea is very soluble and a small molecule, so it is relatively easily passed out by the kidneys as a solution in water.

The Lungs (Figure 8):

- The lungs are part of the excretory system.
- Lungs are part of the respiratory system, also.
- Wastes removed by the lungs include carbon dioxide and water vapor produced by cellular respiration.

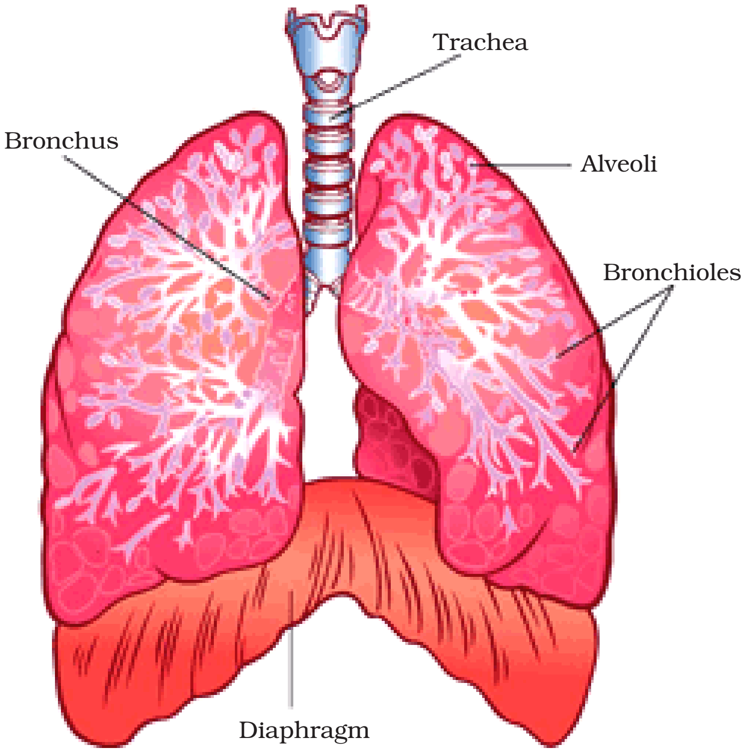


Figure 8. The lung

The Skin (Figure 9):

- The skin also functions in excretion.
- Sweat glands in the skin produce perspiration.
- When a person perspires, the skin excretes water and salts.

Large Intestine (Figure 10):

- The undigested material not absorbed by the large intestine forms a semisolid waste product known as feces. The body through the rectum removes these solid wastes.

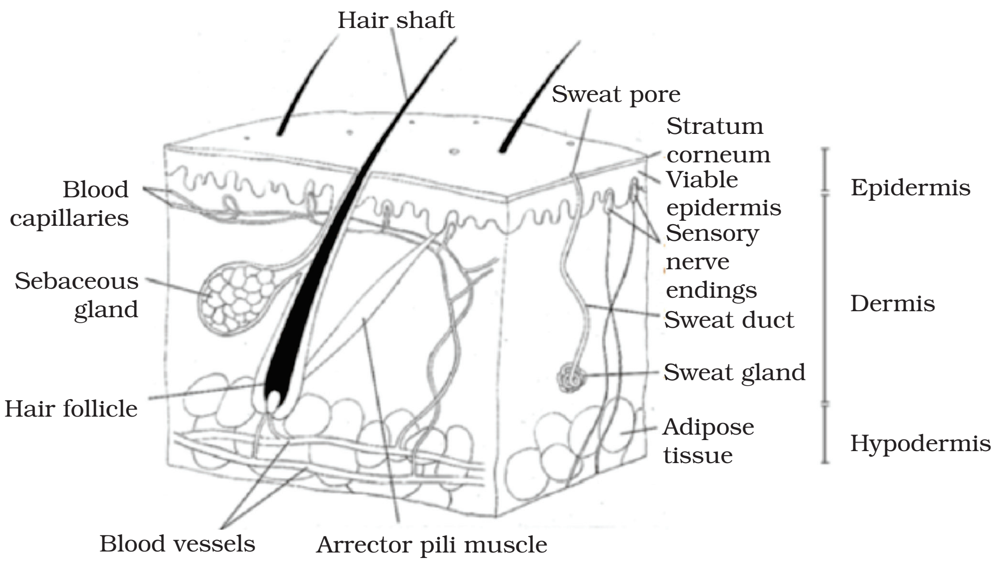


Figure 9. Diagram of the skin

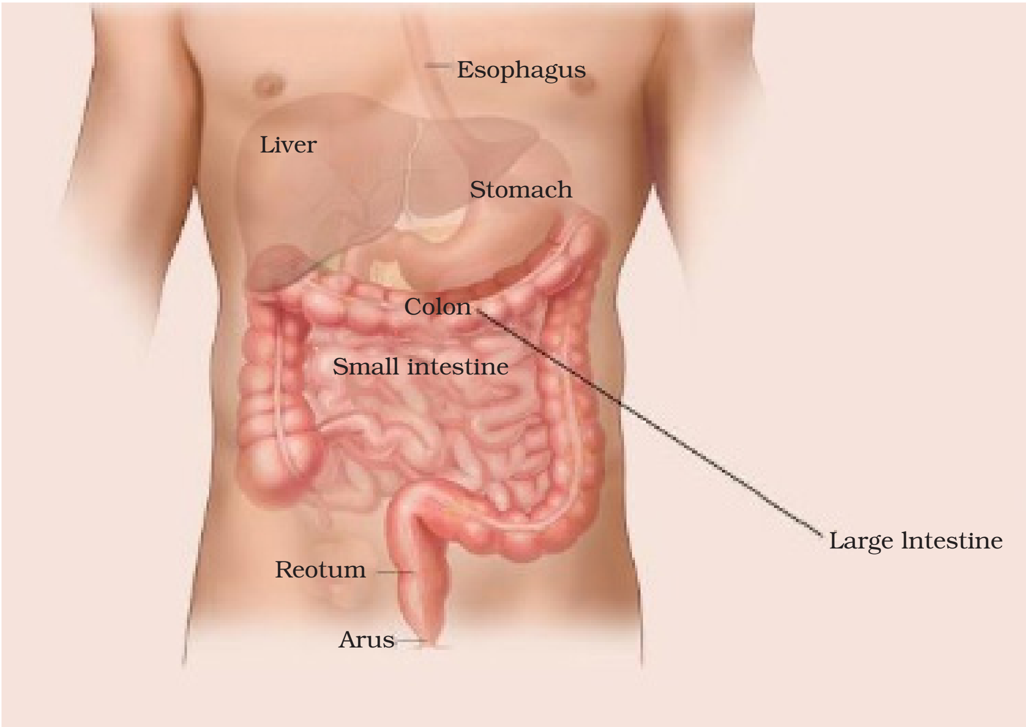


Figure 10. The Intestine

Review Exercise

I. Match each anatomical part to its description.

	Part	Description
A	Medulla	
B	Cortex	
C	Nephron	
D	Ureters	
E	Urinary bladder	
F	Urethra	

1. Paired tubular organs that drain urine from each kidney to the urinary bladder
2. A hollow, muscular sac that collects, stores and eliminates urine
3. The darker, outer layer of kidney tissue containing glomeruli
4. The hollow, tubular organ that transmits urine to the exterior during micturition
5. The middle layer of the kidney tissue with pyramid-shaped areas
6. The microscopic functional unit of the kidney

II. Multiple Choice

7. Which of the following is removed from our body by lungs?
   (a) CO_2 only
   (b) H_2O only
   (c) CO_2 and H_2O
   (d) Ammonia
8. The pH of human urine is approximately
   (a) 6.5
   (b) 7
   (c) 6
   (d) 7.5

4.2 Respiratory System

A. Organs of Respiratory system

The respiratory system also known as breathing system of consists of a **pair of lungs** contained in a **thorax** formed from a **rib cage** and a dome shaped **diaphragm muscle**.

The double – layered **pleural membrane** with the **pleural fluid** surrounds the lung, the fluid acting as a lubricant allowing easy movement of membranes during breathing.

Functions of the Respiratory System

- Providing an extensive surface area for gas exchange between air and circulating blood
- Moving air to and from the exchange surfaces of the lungs along the respiratory passageways
- Protecting respiratory surfaces from dehydration, temperature changes, and invasion by pathogens
- Producing sounds for speaking, singing, and other forms of communication
- Detecting odors by olfactory receptors in the superior portions of the nasal cavity

Respiration is a two integrated processes: **External respiration and internal respiration (Figure 11).**

- **External respiration** = exchange of gases between blood, lungs, and external environment; gas diffusion occurs across blood air barrier between alveolar air and alveolar capillaries.
- **Pulmonary ventilation (breathing)** — air movement in/out of lungs – maintains alveolar ventilation — air movement in/out of alveoli.

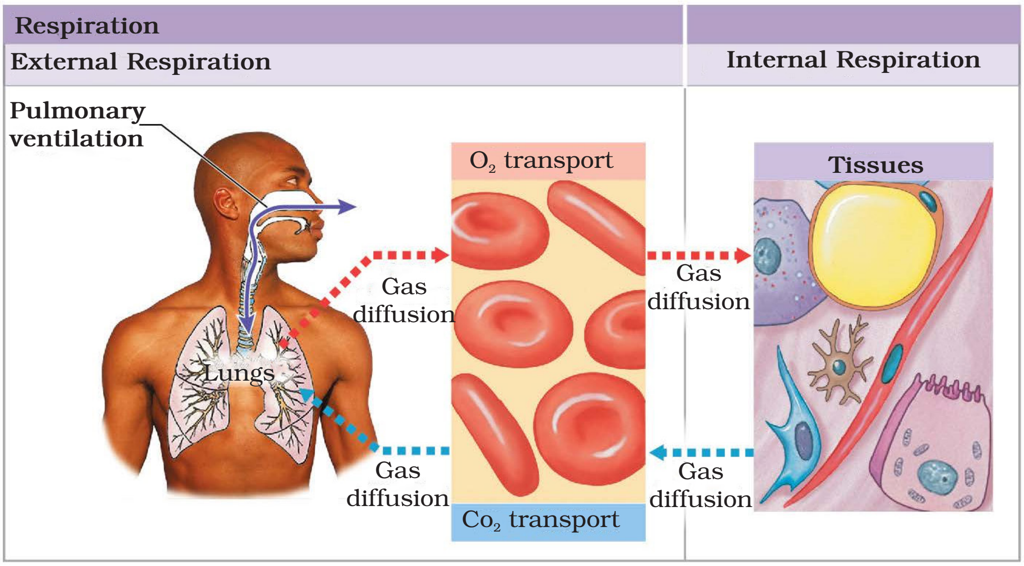


Figure 11. Respiration in humans

Internal respiration - occurs between blood and tissues

- Absorption of oxygen from blood
- Release of carbon dioxide by tissue cells

The respiratory system has an upper and lower respiratory tract with different functions.

Respiratory tract - branching passageway, carries air to/from gas exchange surfaces of the lungs

- 2 divisions of respiratory tract.
- Conducting portion - Nasal cavity to larger bronchioles
- Respiratory portion - Smallest bronchioles to alveoli – Where gas exchange occurs

Upper respiratory tract

- Filters, warms, and humidifies incoming air.
- Protects delicate lower tract.
- Reabsorbs heat and water in outgoing air

Lower respiratory tract

- Conducts air to and from gas exchange surfaces

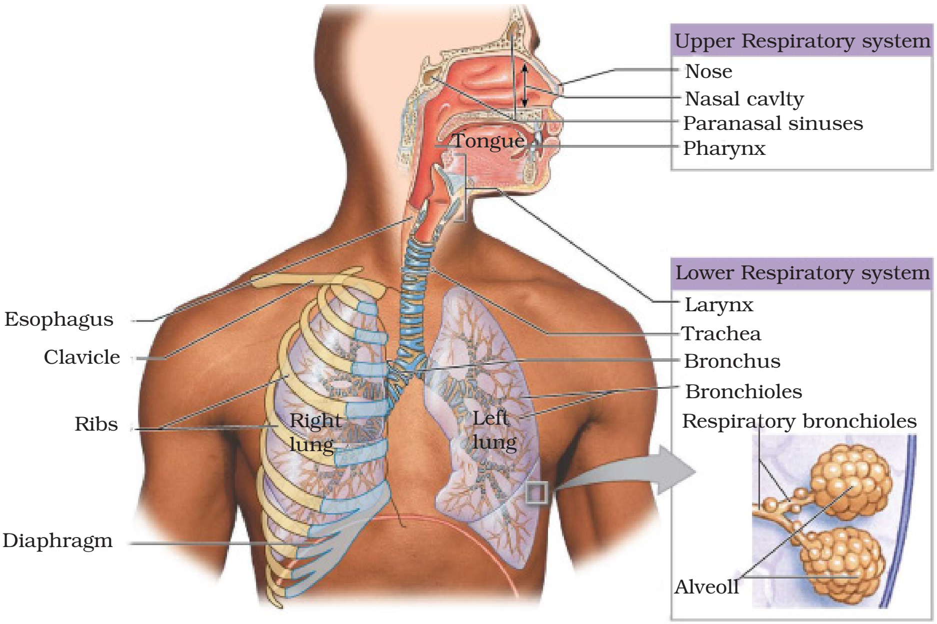


Figure 12. Parts of RT

The upper respiratory system includes the nose, nasal cavity, paranasal sinuses, and pharynx (Figure 12).

Nose is primary route for air entering respiratory system.

Components

Dorsum of nose (bridge) formed by two nasal bones Supported by hyaline cartilage.

Nasal cartilages - small, elastic cartilages extending laterally from bridge; help keep nostrils open.

Nostrils (external nares) are paired openings into nasal cavity. Lamina propria of nasal cavity has extensive network of veins.

Function

- Release heat to warm inhaled air
- Water from mucus evaporates to humidify inhaled air
- Air moving from nasal cavity to lungs (Passage)
- Filter dust & foreign bodies.
- Nearly saturated with water vapor

Pharynx is shared by respiratory and digestive systems.

Components (Figure 13)

Nasopharynx it is the superior part; to soft palate and has pharyngeal opening of the auditory tube.

Oropharynx it is the soft palate to base of tongue and made of stratified squamous epithelium.

Laryngopharynx it is hyoid to larynx.

Nasal vestibule = space at front of nasal cavity.

- Coarse hairs trap large airborne particles Nasal cavity opens into nasopharynx through the choanae Bony hard palate forms floor of nasal cavity.
- Separates nasal/oral cavities

Soft palate - fleshy part posterior to hard palate.

Larynx

- Cartilaginous tube; surrounds/protects glottis ("voice box").
- three large cartilages: epiglottis, thyroid cartilage, cricoid cartilage.

1. **Epiglottis** - projects superior to glottis; forms lid over it.
   - Swallowing - larynx elevates; epiglottis folds back over glottis; blocks entry into respiratory tract.
2. **Thyroid cartilage** (thyroid, shield shaped).
   - Prominent anterior surface is laryngeal prominence (Adam's apple).
   - Thyrohyoid ligament attaches it to hyoid bone; other ligaments attach it to epiglottis and smaller cartilages
3. **Cricoid cartilage** (ring shaped).
   - Forms complete ring around larynx.
   - With thyroid cartilage, protects glottis and larynx; provides attachment for laryngeal muscles/ligaments.

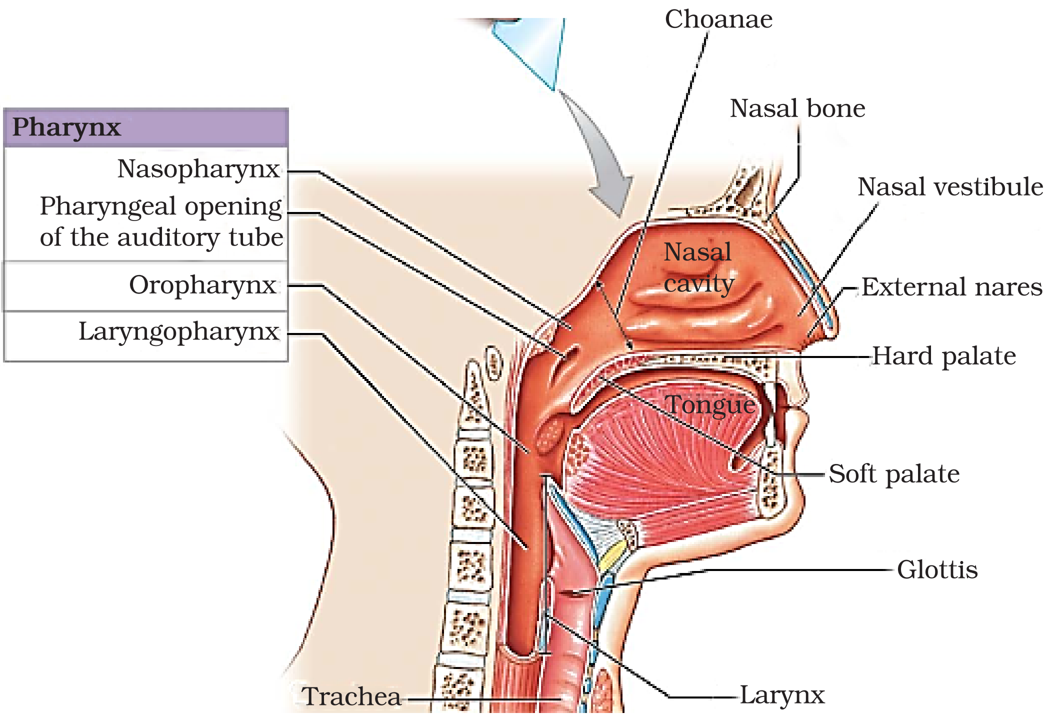


Figure 13. The Pharynx

Glottis

Glottis is an opening into larynx where air passes through larynx.

- Made of vocal folds and rima glottidis (opening between folds). Vocal folds are tissue folds that contain vocal ligaments.

- Vibrations produce sound waves.
- Opened/closed by rotation of arytenoid cartilages also known as the vocal cords.
- Vestibular folds contain vestibular ligaments; prevent foreign objects from entering glottis.

Trachea (Windpipe)

Trachea conducts air toward lungs - to bronchi.

The trachea, bronchi, and bronchial branches convey air to and from lung gas exchange surfaces.

Trachea (windpipe) is a tough, flexible, tube - starts at C6 and ends at T5 by branching into bronchi.

It has 15–20 C-shaped tracheal cartilages which prevent collapse and over expansion.

Bronchi: Right and left main bronchi go to lungs.

Right bronchus wider than left and at a steeper angle - foreign objects in trachea often go into it.

Ends of each C-shaped tracheal cartilage connected by elastic ligament and trachealis (muscle).

- Contraction of trachealis narrows trachea; restricts airflow.
- Tracheal diameter changes often, mostly controlled by sympathetic stimulation— increases airflow.
- Tracheal cartilages are incomplete posteriorly and allows expansion when swallowing.

Bronchioles

- No cartilage; thick smooth muscle.
- Sympathetic nervous system causes bronchodilation - increases airflow.
- Parasympathetic nervous system causes bronchoconstriction. Decreases airflow. Extreme bronchoconstriction can occur during allergic reactions such as asthma.
- Terminal bronchioles lead to pulmonary lobules (gas exchange).
- Respiratory bronchioles are last division

Airflow and diameter changes

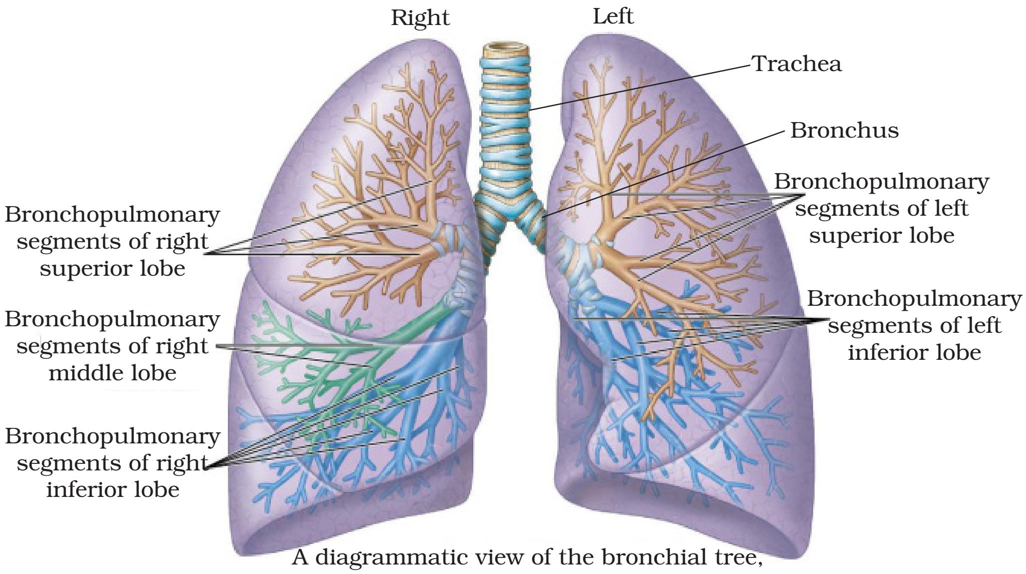
- Trachea - larynx to main bronchi in mediastinum.
- Main bronchi - one to each lung; cartilage rings are complete.
- Lobar bronchi - 3 in right lung, 2 in left; one per lobe.
- Segmental bronchi branch to give rise to bronchioles.
- Bronchioles terminal bronchioles respiratory bronchioles pulmonary lobules.
- Bronchi branch into smaller and smaller tubes; diameter decreases with each new branch.

Air-Conducting Passageways in the Lower Respiratory Tract					
Trachea →	Main bronchi →	Lobar bronchi →	Segmental bronchi →	Bronchioles →	Terminal bronchioles to pulmonary lobules

The lungs have lobes that are subdivided into bronchopulmonary segments

Gross anatomy of the lungs (Figure 14).

- each lung is divided into lobes, right and left.
  - Right lung (3): superior lobe, middle lobe, inferior lobe.
  - Left lung (2): superior lobe and inferior lobe.



A diagrammatic view of the bronchial tree, lung lobes, and bronchopulmonary segments

Figure 14. A diagrammatic view of the brachial tree, lung tubes, and bronchopulmonary segments

- Each lung is cone shaped and divided into lobes by deep fissures.
- Apex (tip) extends to superior border of first rib.
- Concave base rests on diaphragm.
- Cardiac notch - left lung; accommodates pericardium/heart

Pulmonary lobules contain alveoli, where gas exchange occurs.

Pulmonary Alveoli (singular, alveolus).

- 150 million alveoli per lung; give lungs an open,spongy appearance.
- Surrounded by extensive capillary network for gas exchange.
- Surrounded by elastic fibers - expansion/recoil aids air movement.
- Each alveolar duct ends in clusters of alveoli (alveolar sacs, or alveolar saccules)

Pleurae - serous membrane sacs surrounding the lungs.

- **Visceral pleura** covers outer surfaces of lungs.
- **Parietal pleura** covers inner surface of thoracic wall; extends over diaphragm and mediastinum.
- **Pleural cavity** - potential space between visceral and parietal layers of pleural sac.
    - Contains pleural fluid - reduces friction.

Blood air barrier - where gas exchange occurs between blood and alveolar air (Figure 15).

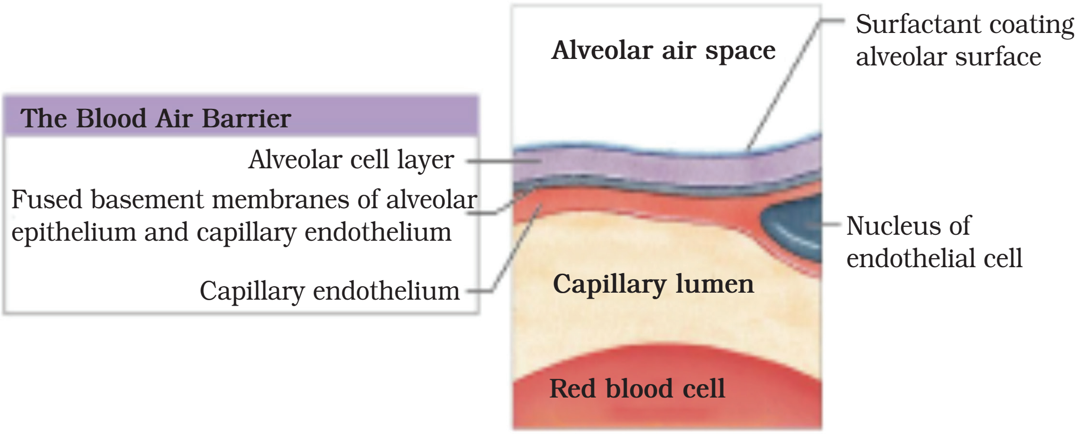


Figure 15. The Blood – air barrier

Three layers:

1. Alveolar cell layer (epithelium).
2. Fused basement membranes (alveolar and capillary).
3. Capillary endothelium.

B. Mechanisms of breathing

Gaseous exchange occurs in the millions of alveoli, which provide a respiratory surface of exchange. Oxygen in the alveoli of lung is dissolved in a film of fluid and diffuses across the wall.

Changing volume of the thoracic cavity (Figure 16).

- Movements of the diaphragm and rib cage change the volume of the thoracic cavity, which expands or compresses the lungs (changes lung volume).
- Change in volume brings change in air pressure

Features of alveoli, which help in gaseous exchange, are:

- very thin wall, one cell thick
- rich supply of blood vessels
- permeable wall to gases
- their surface is moist to dissolve gases
- large surface area to volume ratio

Therefore, alveoli are the structural and functional units of lungs.

Pulmonary ventilation

Air flows from an area of higher pressure to an area of lower pressure.

During inhalation.

The diaphragm contracts, Intercostal muscles contract.

- Thoracic cavity enlarges
- Increased volume causes decreased pressure ($P_{outside}$ > P_{inside}).
- Air moves in from an area of high pressure to low pressure.

During exhalation

The diaphragm relaxes, Intercostal muscles relax

- Thoracic cavity decreases in volume.
- Decreased volume causes increased pressure.
- Air is forced out from an area of high pressure to low pressure.

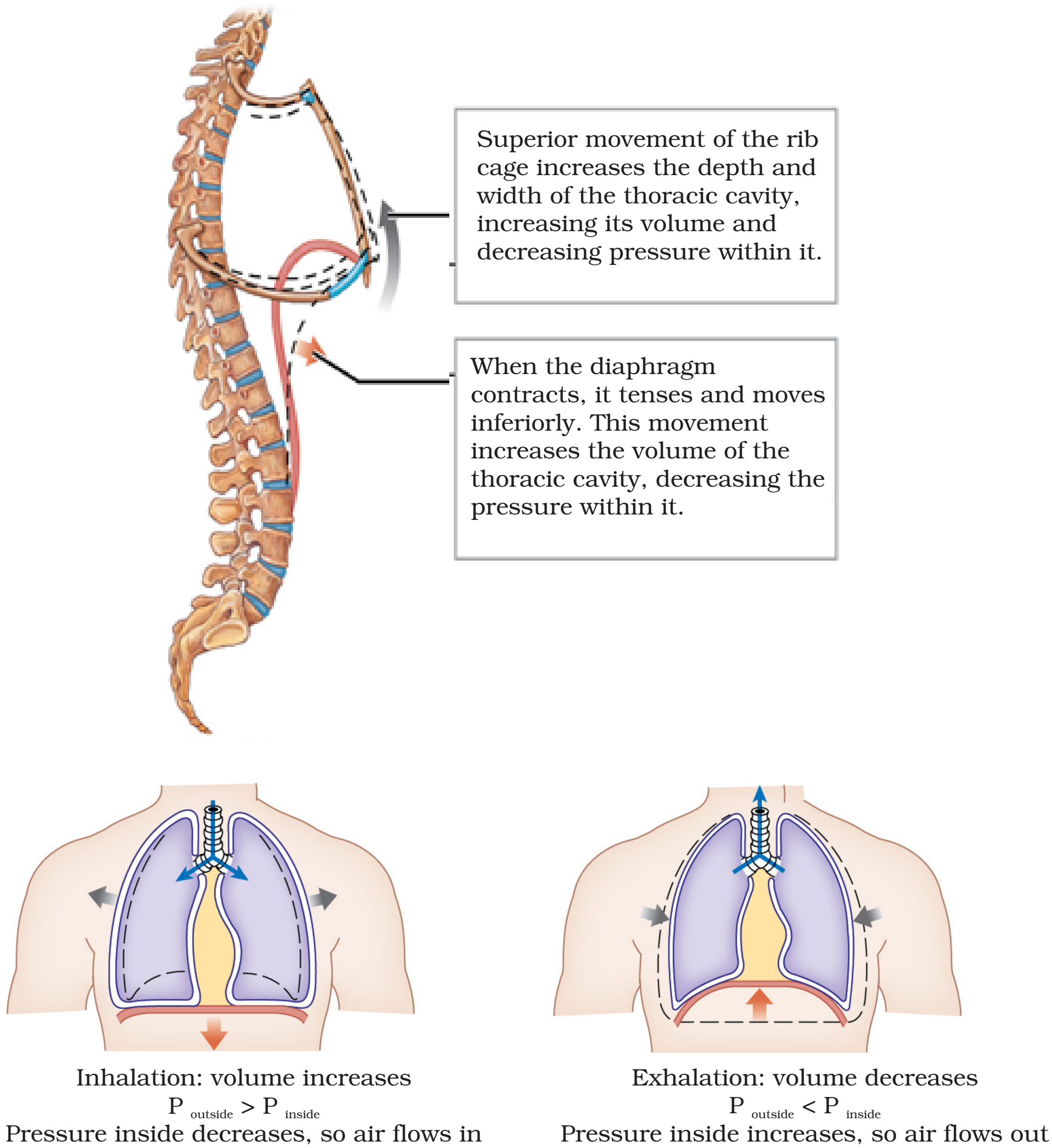


Figure 16. Processes of breathing

Direction of airflow determined by difference between:

- atmospheric pressure - pressure of air around us; and
- intrapulmonary pressure - pressure inside respiratory tract, usually measured at the alveoli.

Tidal volume = volume of air moved into and out of lungs in normal breath.

Inhalation

- Intrapulmonary pressure < atmospheric pressure.
- Negative intrapulmonary pressure pulls air into lungs.

Exhalation

- Intrapulmonary pressure > atmospheric pressure.
- Positive intrapulmonary pressure pushes air out of lungs.

Table 1 Table comparison of inhalation and exhalation processes in humans.

Inhalation	Exhalation
External intercoastal muscles contract	External intercoastal muscles relax.
Internal intercoastal muscles relax.	Internal intercoastal muscles contract
Ribs raised upwards	Ribs lowered.
Diaphragm contracts	Diaphragm relaxes
Diaphragm flattens	Diaphragm arches upwards.
Volume of thorax increases	Volume of thorax decreases
Air pressure decreases	Air pressure increases.
Air moves into the lungs.	Air is forced out of the lungs.

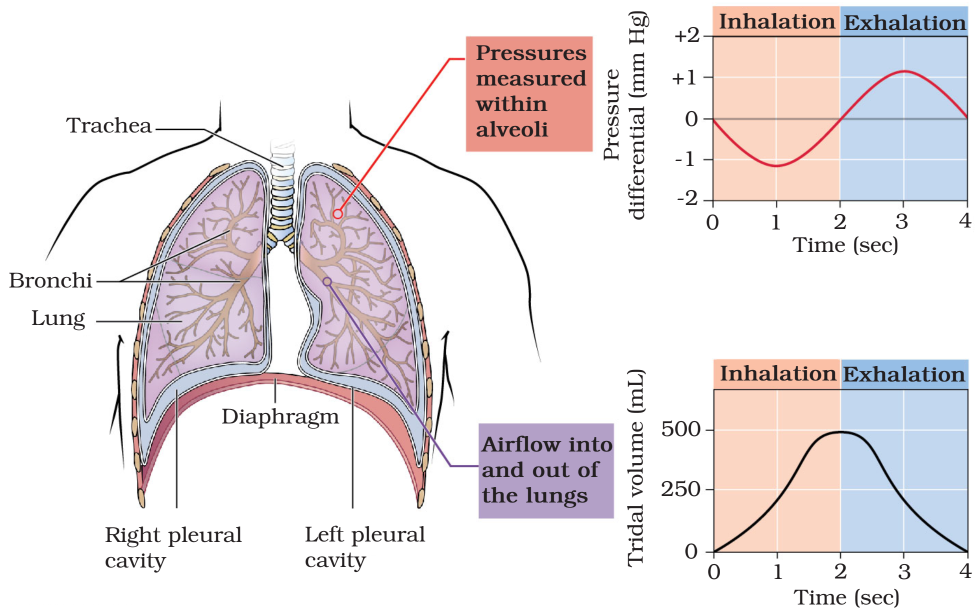


Figure 17. Gas diffusion

External respiration

- Blood arriving in pulmonary arteries has lower PO_2 and higher PCO_2 than in alveolar air.
- Diffusion between alveolar mixture and pulmonary capillaries:
  - Increases blood PO_2 (oxygen enters blood)
  - Decreases PCO_2 (carbon dioxide leaves blood)

Internal respiration

- PO_2 of blood leaving lungs in pulmonary veins drops slightly when it mixes with blood from capillaries around conducting passageways; still higher than PO_2 of interstitial fluid.
- Oxygen diffuses to interstitial fluid.
- PCO_2 higher in tissues/interstitial fluid than in blood.
- Carbon dioxide diffuses from tissues into blood

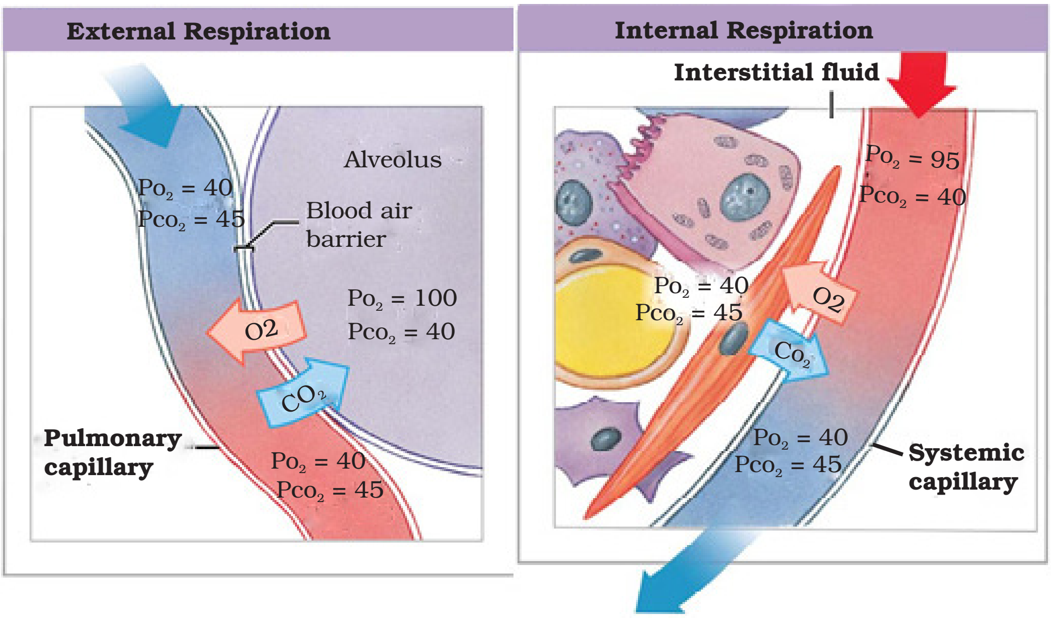


Figure 18. Respirations

Oxygen transport in blood

Almost all the oxygen in blood is transported bound to hemoglobin within red blood cells.

- Each 100 mL of blood leaving alveoli carries ~20 mL oxygen
  - Only ~0.3 mL (1.5 percent) is dissolved in the plasma.
  - Remaining 19.7 mL (98.5 percent) is bound to iron ions in heme units of hemoglobin (Hb)

Carbon dioxide transport in blood (Figure 19)

Carbon dioxide is transported three ways in the bloodstream.

- Carbon dioxide is generated by aerobic metabolism in peripheral tissues. In bloodstream, CO2 is transported in three ways.

1. Dissolved in plasma (~7 percent—limited solubility in plasma).
2. Bound to hemoglobin in RBCs (~23 percent).
   - Reversibly attached to exposed amino groups.
   - Resulting compound is carbamino hemoglobin ($HbCO_2$).
3. Converted to bicarbonate ion, HCO_3- (~70 percent)

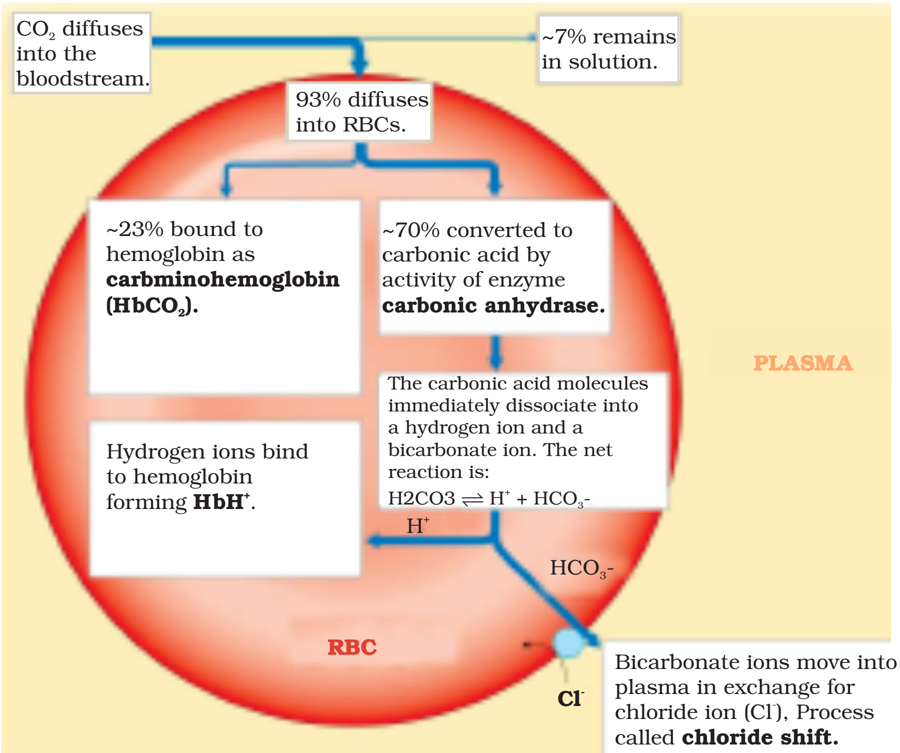


Figure 19. Carbon dioxide transport in the blood

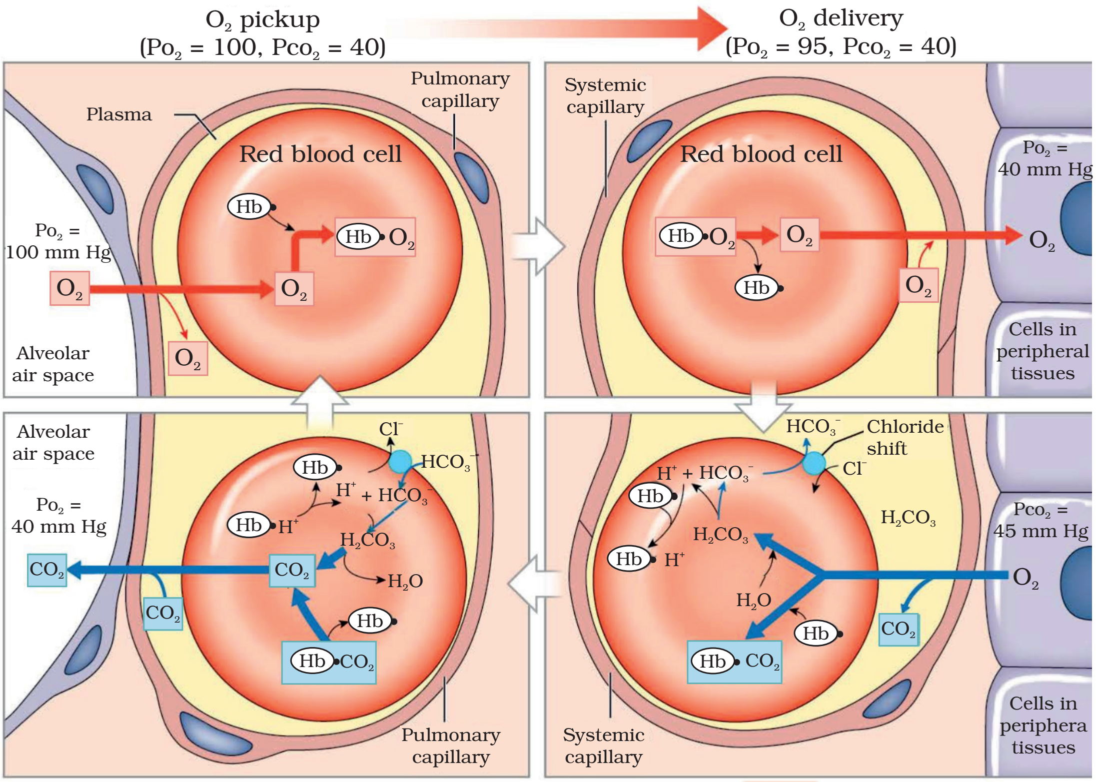


Figure 20. Gas exchange and transport during one respiratory cycle

Inhaled and exhaled air

The volume of air inhaled and exhaled by man under normal resting condition is called tidal volume (tidal air). Tidal volume is about 500 cm^3.

The maximum amount of air that can be forced out after the deepest possible inhalation is called the vital capacity. After maximum expiration, there will be some air left in the lungs, which is called the residual volume (Tables 2 - 3).

Table 2 Table Normal lung volumes in resting adults

Lung volume	Range in Liters	Meaning of term
Total lung capacity	4 – 6	Total volume of fully inflated lungs
Vital capacity	3 – 5	Volume of air inspired or expired in forced breathing

Residual volume	1 – 2	Volume of air, which cannot be expelled by forced breathing.
Tidal volume	0.5 – 1.0	Remains in alveoli
Pulmonary ventilation	6 – 10	Volumes of air Inspired and expired in normal unforced breathing

Volume of air inspired /minute = rate of breathing x tidal volume.

Table 3 Content of Exhaled and Inhaled Air in Man

Gas	Inhaled air %	Exhaled air%
CO_2	0.03	3.5
O_2	20.93	16.89
Nitrogen	79.04	79.61
Water vapour	Variable	Always higher
Heat	Variable	Always higher

4.3 Effects of Substance Abuse and Sexually Transmitted Infections (STI)

For STI see reproductive system (Chapter 2)

Effects of substance abuse, see chapter 5

- It is your perceptions and emotions, vision, hearing, and coordination.

Smoking

Cigarette is a habit-forming roll made from tobacco plant. Tobacco consists several harmful chemical compounds. Among the dangerous contents are **Nicotine, carbon monoxide, Arsenic, benzopyrine and tar**. In addition to the habit-forming effect, these compounds are known to be causes of the deadly disease **cancer**.

- Lung cancer – About 90% of the lung cancer is caused by smoking.
- Emphysema and Bronchitis - Smoking constricts bronchioles of the lung and stops the action of cilia. When the alveoli are abnormally dilated and the lungs become distended the disease is called emphysema. When the mucus membrane is inflamed the disease called Bronchitis is caused. Smoking causes all of these diseases accompanied by heavy cough.

- Smoking increases the risk of heart disease.
- Smoking can be a cause of cancer of mouth, pharynx and the esophagus.
- Smoking during pregnancy results in low childbirth weight

Review Exercise

1. *Track the route of a breath of air from the nose to an alveolus,*

4.4 Cellular Respiration

Types of Cellular respiration and energy

Cellular respiration is the process by which the energy of food is released in the cell to be used for life processes (movement, breathing, blood circulation, etc...) (Figure 21).

- Cells require a constant source of energy for life processes but keep only a small amount of ATP on hand. Cells can regenerate ATP as needed by using the energy stored in foods like glucose.
- The energy stored in glucose by photosynthesis is released by cellular respiration and repackaged into the energy of ATP.
- Respiration occurs in all cells and can take place either with or without oxygen present.

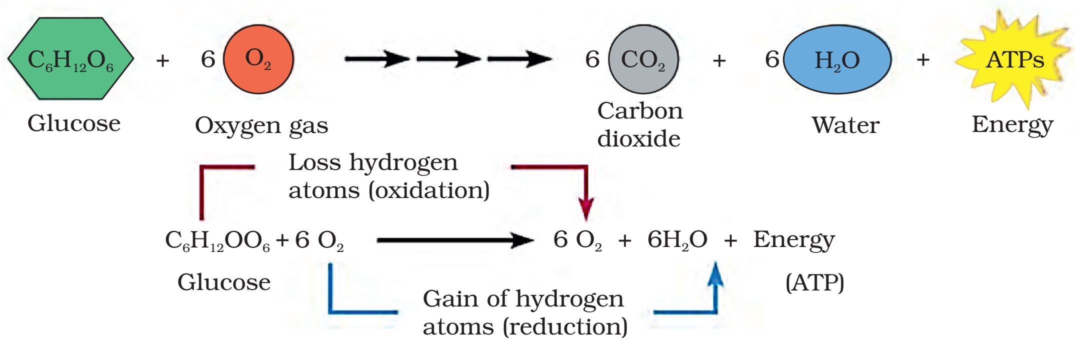


Figure 21. Cellular respiration

Respiration and the Human Body

- respiratory system acquires O_2, removes CO_2.

- digestive system provides glucose and fats as a source of energy.

4.5 ATP (Adenosine Triphosphate) Formation

Energy released from food by respiration is not directly used.

Energy is released during chemical reactions of respiration and stored in intermediate compound called **Adenosine Triphosphate (ATP)**.

The hydrolysis of adenosine triphosphate (ATP) to adenosine diphosphate (ADP) and phosphoric acid (Pi) releases energy (it is an exergonic reaction). Some chemical reactions that occur in cells require energy. Hydrolysis reactions of ATP can provide this energy.

ATP molecule is formed as energy is released, to serve as an **energy store**. When cells need energy, they use ATP as their source of energy.

When energy is released from food molecules during respiration, the energy is used to form a chemical bond between **Adenosine diphosphate and phosphate**, which are found in the cell. As a result the **energy absorbed produce Adenosine triphosphate (ATP)**.

Adenosine Triphosphate (ATP) is the main useable energy source found in all living things. ATP fuels most cell activities, including muscle movement, protein synthesis, cell division, and nerve signal transmission. ATP's chemical energy is stored in its phosphate bonds.

When the cell requires energy, the ATP molecule will be broken in to ADP and P_i. In the process, the energy used to make ATP is released to the cell.

One ATP molecule stores 7.3 K cal of energy.

4.6 Aerobic Respiration

Aerobic Respiration: requires oxygen

- Occurs in the **mitochondria** of the cell.
- Total of **36 or 38 ATP** molecules produced
- General formula for aerobic respiration:

$$C_6H_{12}O_6 + 6O_2 \quad 6CO_2 + 6H_2O + \mathbf{36\ ATP}$$

glucose + oxygen   carbon dioxide + water + energy.

Aerobic Cellular Respiration Occurs in the Mitochondria.

- Cristae folding of the inner membrane.
- Matrix "cytosol"... similar to cytoplasm

Glycolysis - Initial break down of glucose occuring in the cytoplasm of the cell.

Link reaction- production of Pyruvic acid.

Citric Acid Cycle- completes the breakdown of glucose

Oxidative Phosphorylation.

- ***Electron transport chain*** to generate H+ gradient.
- **Chemiosmosis** to produce ATP

What is Glycolysis?

Glycolysis is a series of chemical reactions to break down glucose into two 3-carbon pyruvate molecules (1st step in glucose metabolism).

- Occurs in the cytoplasm, does NOT require O_2.
- Energy in the form of e- captured by the e- carrier NADH.
- Also yields 2 ATP, thus the products of glycolysis are: **2 ATP+ 2 NADH + 2 pyruvate (Figure 22).**

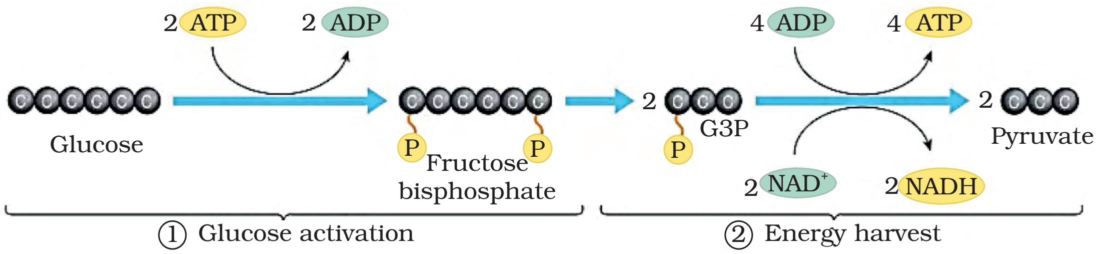


Figure 22. ATP Production

Glycolysis split glucose (sugar) (Figure 23)

- Occurs in cytosol (cytoplasm).
- Use 2 ATP to split glucose into pyruvate.
- Rearrange resulting compounds.
- Products.
- 4 ATP & pyruvate.
- 4 ATP–2 ATP= 2 NET ATP

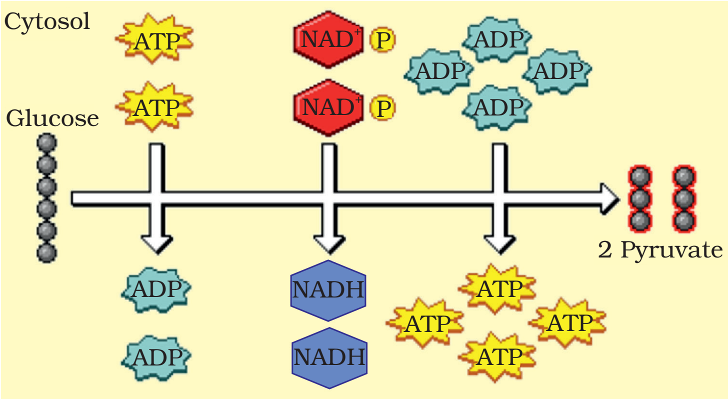


Figure 23. Glycolysis reactants & products

There are ten steps in glycolysis and a specific enzyme catalyzes each one.

The first five steps are regarded as the preparatory (or investment) phase since they consume energy to convert the glucose into two three-carbon sugar phosphates (G3P).

The second half of glycolysis -Pay-off phase

The second half of glycolysis is known as the pay-off phase, characterised by a net gain of the energy-rich molecules ATP and NADH. Since glucose leads to two triose sugars in the preparatory phase, each reaction in the pay-off phase occurs twice per glucose molecule.

This yields 2 NADH molecules and 4 ATP molecules, leading to a net gain of 2 NADH molecules and 2 ATP molecules from the glycolytic pathway per glucose.

Link Reaction: The conversion of pyruvate

Oxidative decarboxylation: the conversion of pyruvate to acetyl CoA.

This reaction is not technically a reaction of glycolysis, but is very common in most organisms as a link to the citric acid cycle.

This reaction is carried out in the mitochondria, unlike the reactions of glycolysis, which are cytosolic.

The production of ATP is by Substrate level phosphorylation. The synthesis of ATP by the direct transfer of phosphate group from a substrate intermediate to a molecule of ADP is called Substrate level phosphorylation. Occurs in glycolysis and TCA cycle

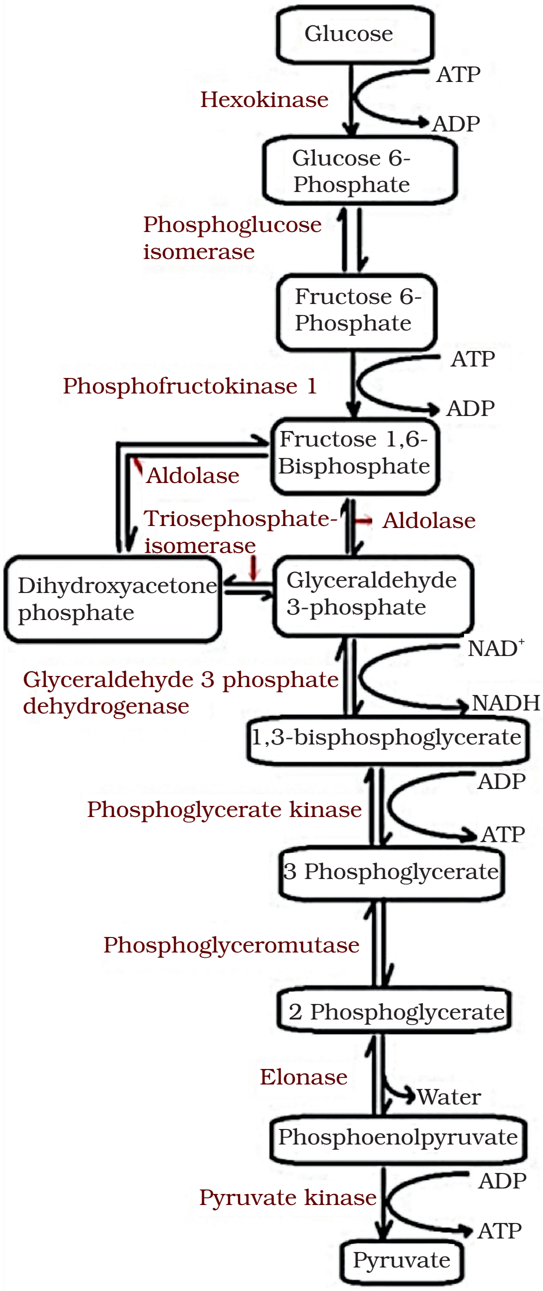


Figure 24. Steps of Glycolysis

The conversion of pyruvate to acetyl CoA by the pyruvate dehydrogenase complex is a key step in the liver in particular, as it removes any chance of conversion of pyruvate to glucose, or as a transamination substrate.

It commits pyruvate to entering the citric acid cycle, where it is either used as a substrate for oxidative phosphorylation, or is converted to citrate for export to the cytosol to serve as a substrate for fatty acid and isoprenoid biosynthesis.

Oxygen debt (Figure 25)

Under hypoxic (or partially anaerobic) conditions, for example, in overworked muscles that are starved of oxygen or in infarcted heart muscle cells, pyruvate is converted to lactate by anaerobic respiration (also known as fermentation).

This is a solution to maintaining the metabolic flux through glycolysis in response to an anaerobic or severely hypoxic environment.

In many tissues, this is a cellular last resort for energy, and most animal tissue cannot maintain anaerobic respiration for an extended length of time.

Many single cellular organisms use anaerobic respiration only as an energy source.

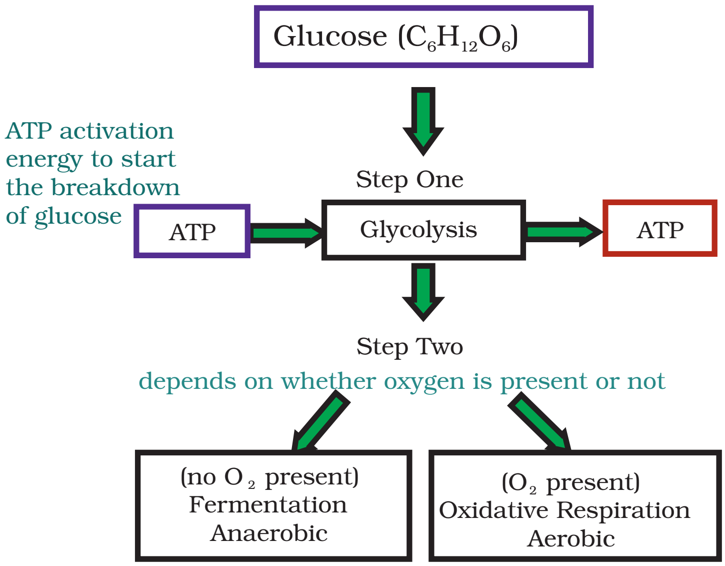


Figure 25. Division of aerobic & anaerobic respirations

Glycolysis is insufficient for anaerobic respiration, as it does not regenerate NAD+ from the NADH + H+ it produces. It is therefore critical for an anaerobic or hypoxic cell to carry out the additional steps of lactate or alcohol production to regenerate NAD+ that is required for glycolysis to proceed. This is important for normal cellular function, as glycolysis is the only source of ATP in anaerobic or severely hypoxic conditions.

The Citric Acid Cycle or Krebs Cycle (Tricarboxylic Acid Cycle)

Where does The Krebs Cycle occur?

- series of chemical reactions that finish the breakdown of glucose
- 3-C pyruvate from glycolysis broken down to 3 CO_2
- in the mitochondrial matrix
- pyruvate from cytoplasm gets transferred across inner mitochondrial membrane into the matrix Where does the released energy end up?
- as high energy electrons (e-) in the electron carriers NADH & $FADH_2$ (plus heat)
- e- passed on to the "electron transport chain" (ETC)

The Krebs cycle; Tricarboxylic acid cycle (TCA); Citric Acid Cycle

(Reaction discovered by Sir Hans Krebs; The cycle involve reactants with three carboxylic acid components; the reaction starts with formation of citric acid molecule) (Figure 26).

- Occurs in the matrix of mitochondria.
- 1st Reactant: Pyruvate.
- 1st Products: CO_2, NADH, acetyl CoA.
- 2nd Reactant: Acetyl CoA begins Krebs cycle.
- 2nd Products: CO_2, NADH, (2)ATP, and $FADH_2$.
- NADH & FADH2 used in last step of respiration (electron transport chain).

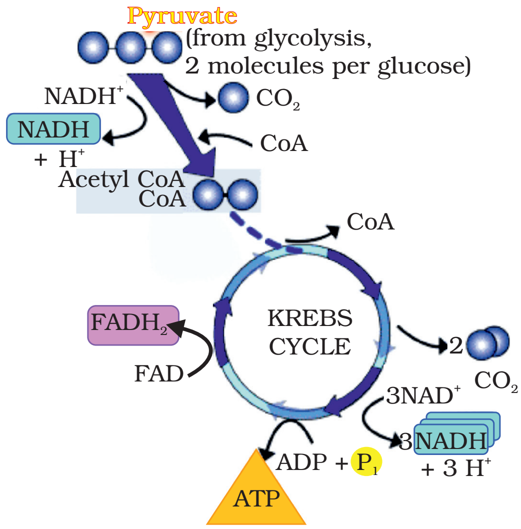


Figure 26. TCA Cycle

What is the Citric Acid Cycle?

The Citric Acid Cycle occurs in the "Matrix"

- yield from 2 pyruvate (i.e., 1 glucose):

  2 ATP

  8 NADH

  2 $FADH_2$

Coenzymes

NAD+ (Nicotinamide adenine dinucleotide)

- Called a coenzyme of oxidation-reduction. It can:
- Oxidize a metabolite by accepting electrons
- Reduce a metabolite by giving up electrons
- Each NAD+ molecule used over and over again

FAD (Flavin adenine dinucleotide)

- Also a coenzyme of oxidation-reduction
- Sometimes used instead of NAD+
- Accepts two electrons and two hydrogen ions (H+) to become $FADH_2$

Electron Transport Chain

Electron Transport Chain is the process by which NADH and FADH2 are oxidized and a proton gradient is formed.

Oxidative phosphorylation is the process of making ATP by using the proton gradient generated by the ETC.

Respiration by mitochondria (Figure 27)

- Oxidation of substrates is *coupled* to the phosphorylation of ADP.
- Respiration (consumption of oxygen) proceeds only when ADP is present.
- The amount of O_2 consumed depends upon the amount of ADP added.

Location of mitochondrial complexes

- Inner mitochondrial membrane (IMM):
  (a) **Electron transport chain:** oxidizes reduced coenzymes.
  (b) **ATP synthase**: machinery to synthesize ATP.

Electron transport **and** oxidative phosphorylation **capture the energy in the redox potential of NADH and $FADH_2$ – 2 separate processes that are** coupled **to result in ATP production.**

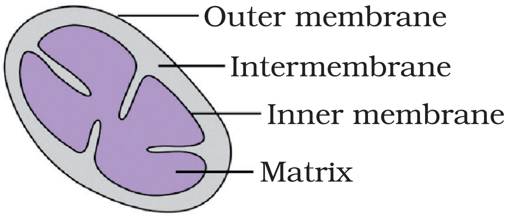


Figure 27. Mithocondira

Extensive folding of IMM provides a large surface area on the matrix side to form many assemblies of proteins to maximize ATP production.

1. **Respiratory electron-transport chain (ETC)**

Series of enzyme complexes embedded in the inner mitochondrial membrane, which oxidize NADH and FADH2. Oxidation energy is used to transport protons creating a proton gradient – protons pumped from matrix to intermembrane space across Inner mitochondrial membrane

(2) **ATP synthase** uses the proton gradient energy to produce ATP; It is the release of the energy in the gradient back through the membrane through the protein **ATP Synthase** that drives ATP synthesis. This part of the process is also called Chemiosmosis.

Overview of electron transport chain and oxidative phosphorylation Electron transport chain (ETC).

- Series of sequential oxidation/reduction (redox) reactions.
- Passes electrons from NADH or FADH2 to O2 producing H2O through a series of protein complexes (source of metabolic water).
- Since NAD+ and FAD are in limited supply, they must be recycled.
- FOUR protein complexes in the IMM make up the ETC.
- Complexes I, II, III, IV.
- Work together in succession to catalyze redox reactions.
- Electrons are transferred to molecular oxygen that is then reduced to water.
- Electrons move through the complexes in order.
- Electrons from NADH enter at Complex I.
- Electrons from FADH2 enter at Complex II.
- Flow of electrons is spontaneous and thermodynamically favorable because the next carrier has greater affinity for electrons than the previous.
- In each reaction, an electron donor is oxidized and an electron acceptor is reduced.
- Electrons flow downhill – spontaneously moving from molecules that are strong electron DONORS to strong electron ACCEPTORS = move from high energy state to low energy state

Co-factors in Electron Transport

- **Complexes contain enzymes with** electron carrying groups **or** oxidation – reduction components.
- Protein components use **metal containing prosthetic groups** or **flavins** to carry electrons.

- Metal-containing groups such **as iron-sulfur clusters, copper ions, hemes.**
- Flavins:
- **(Complex I) FMN - $FMNH_2$**
- **(Complex II) FAD - $FADH_2$**

Mobile electron carriers – serve as links between ETC complexes.

1. **Ubiquinone (Q).**
   - Also called coenzyme Q.
   - A membrane-soluble low molecular weight compound.
   - Long hydrophobic tail keeps Q anchored in the mitochondrial inner membrane.
   - Q is a lipid soluble molecule that diffuses within the lipid bilayer, and shuttles electrons from Complexes I and II and pass them to III.
   - Not a part of any complex.
2. **Cytochrome *c***
   - A peripheral membrane protein associated with the outer face of the membrane, transports electrons from III to IV.
   - Cytochromes are **heme-containing proteins** – contains Fe.
   - Not a part of any complex.
   - Shuttles electrons and protons from Complex III to Complex IV

Overview of Electron Transport (Figure 28)

- The electron transport chain is associated with the mitochondrial inner membrane.
- **Complexes I-IV** contain multiple cofactors, and are involved in electron transport.
- overall transfer of 2 electrons from NADH through ETC to molecular oxygen:

  $$\mathbf{NADH + H^+ + \tfrac{1}{2}\, O_2 \rightarrow NAD^+ + H_2O.}$$
- **Complexes I** – where NADH electrons enter the chain.

  Complex II – Where $FADH_2$ electrons enter the chain.

Electrons passed from **Complex I or II to Coenzyme Q.**
Coenzyme Q shuttles electrons to **complex III.**
Complex III shuttles electrons to **cytochrome C.**
Cytochrome C shuttles electrons to **Complex IV.**
Complex IV transfers electrons to **O_2** which is then reduced to **water.**

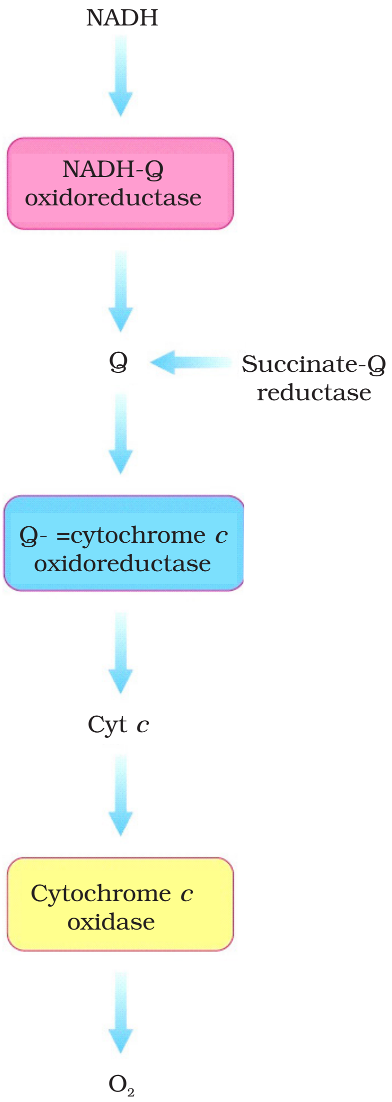


Figure 28. ETS steps

Flow through **Complexes III, IV release energy and I** which is used to pump protons across the IMM and form a "proton gradient". Proton gradient has lots of potential energy.

When the energy is released (protons flow back into matrix through ATP synthase), the energy drives ATP synthesis.

4.7 Anaerobic Respiration

Anaerobic Respiration: occurs when no oxygen is available to the cell (2 kinds: Alcoholic and Lactic Acid).

- Also called fermentation.
- Much less ATP produced than in aerobic respiration.
- **Alcoholic fermentation** - occurs in bacteria and yeast.

Process used in the baking and brewing industry - Least produces CO_2 gas during fermentation to make dough rise and give bread its holes

- Glucose Ethyl alcohol + Carbon dioxide + 2 ATP
- **Lactic acid fermentation** - occurs in muscle cells.

  Lactic acid is produced in the muscles during rapid exercise when the body cannot supply enough oxygen to the tissues - causes burning sensation in muscles **glucose lactic acid + carbon dioxide + 2 ATP**

Fermentation

Instead of moving on to the Citric Acid Cycle, pyruvate will undergo fermentation when there's not enough O_2 (Figure 27 - 28):

- produces lactic acid (animals), ethanol (yeast), acetic acid, methane (other microbes) or other byproducts.
- results in relatively low energy yield (2 ATP per glucose).
- important for "recycling" the electron carrier NAD+

There are several types of anaerobic respiration wherein pyruvate and NADH are anaerobically metabolized to yield any of a variety of products with an organic molecule acting as the final hydrogen acceptor.

The bacteria involved in making yogurt simply reduce pyruvate to lactic acid, whereas yeast produces ethanol and carbon dioxide.

Anaerobic bacteria are capable of using a wide variety of compounds, other than oxygen, as terminal electron acceptors in respiration.

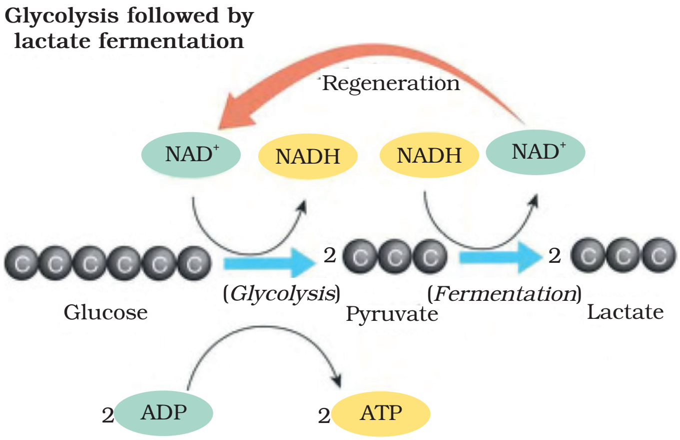


Figure 29. Ethanol production

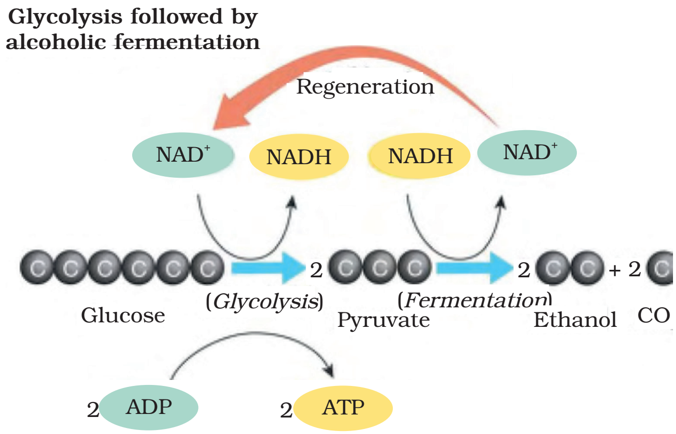


Figure 30. Lactate production

Intermediates for other pathways

These metabolic pathways are all strongly reliant on glycolysis as a source of metabolites:

- Gluconeogenesis
- Lipid metabolism
- Pentose phosphate pathway
- Citric acid cycle, which in turn leads to:
- Amino acid synthesis
- Nucleotide synthesis
- Tetrapyrrole synthesis

Summary of Cellular respiration (Figure 31)

Total ATP yield per glucose

Conversions

- NADH produced in the cytoplasm produces two ATP by the electron transport system.
- NADH produced in the mitochondria produces three ATP.
- $FADH_2$ adds its electrons to the electron transport system at a lower level than NADH, so it produces two ATP.

Glycolysis

- Two ATP molecules are used to phosphorylate and activate glucose.
- Two hydrogen atoms are removed by NAD^+ forming 2 NADH.
- 2 NADH (= 4 ATP; these are converted to ATP in the mitochondria during cellular respiration)
- Four ATP molecules are produced by substrate-level phosphorylation.
- The net yield of ATP is two; two are used and four are produced.

Formation of Acetyl CoA

- 2 NADH (= 6ATP)

Krebs cycle

- 6 NADH (= 18 ATP)
- 2 $FADH_2$ (= 4 ATP)
- 2 ATP

In the electron transport system

- Aerobic respiration occurs when oxygen is available.
- Pyruvate ® CO_2 + H_2O
- It occurs in the mitochondrion.
- NAD^+ and FAD carry electrons to the electron transport system.
- NADH and $FADH_2$ are used to produce ATP as electrons are passed from one carrier to another.

- Eventually the electrons combine with hydrogen ions and oxygen (reduction) to form water.

Total Yield

- Glycolysis produces 2 ATP; aerobic respiration produces 34 more ATP

Pathway	Substrate-Level Phosphorylation	Oxidative Phosphorylation	Total ATP
Glycolysis	2 ATP	2 NADH = 4 - 6 ATP*	6 - 8*
CoA		2 NADH = 6 ATP	6
Krebs Cycle	2 ATP	6 NADH = 18 ATP 2 $FADH_2$ = 4 ATP	24
Total	4	32-34	36-38

NADH produce 3 ATPs, but 2 ATPs are used in the process

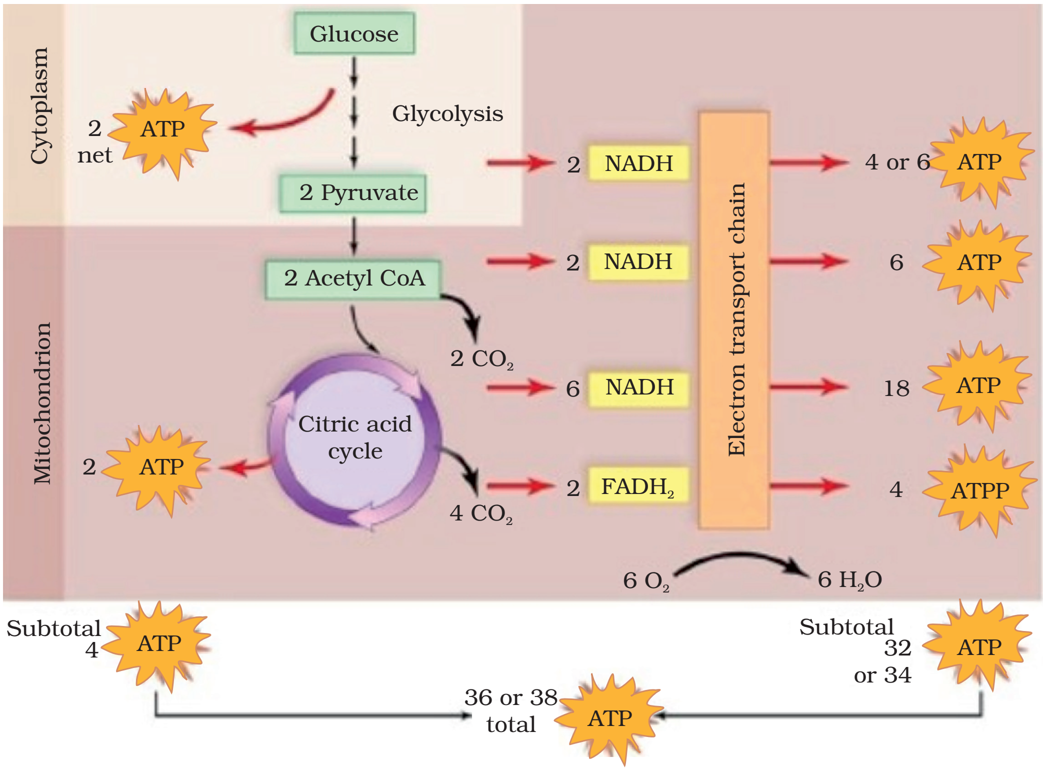


Figure 31. Summary of Cellular respiration

Key Terms

- ATP synthase.
- Electron carriers (NADH, FADH2).
- Electron transport chain (ETC).
- Glycolysis,
- Fermentation.
- Oxidative phosphorylation.
- Chemiosmosis.
- Citric Acid Cycle.
- Oxidation vs reduction

Summary

Major Organs of Excretory system are.

- Kidneys
- Lungs
- Skin with sweat glands
- Liver (produces urea)
- Large intestine for digestive by products.

Respiration

- Two integrated processes: **External respiration and internal respiration**
- External respiration = exchange of gases between blood, lungs, and external environment; gas diffusion occurs across blood air barrier between alveolar air and alveolar capillaries
- **Pulmonary ventilation (breathing)** - air movement in/out of lungs – Maintains alveolar ventilation - air movement in/out of alveoli

Internal respiration - occurs between blood and tissues.

- Absorption of oxygen from blood.
- Release of carbon dioxide by tissue cells

Breathing is needed to provide the body with oxygen gas, which is important in the release of energy. The process also is needed to eliminate carbon dioxide waste from the body. The exchange of O_2 and CO_2 takes place by the breathing system of organisms.

Breathing organs and their function

structure	Function
Lungs	Organs for breathing containing smaller structures
Alveoli	Sites of gas exchange

Bronchioles	Structural and functional units of lung
Bronchi	Carry air to and from alveoli.
Trachea	Connect the bronchiole network with trachea, Connect the lung to mouth and nose. The cilia and mucus in trachea traps dust particles and bacteria.
Ribs	Protect lungs and heart
Intercostal muscles	Perform breathing movements. Rise and lower the rib cage by the action of antagonistic muscles
External	Help inhalation
Internal	Help exhalation.
Diaphragm	Increase and decrease chest volume by muscular action
Nasal cavity	Filter, moisten and warm air
Epiglottis	Automatically closes off trachea during swallowing food.

The act of breathing is a mechanical action involving the action of antagonistic muscles. There are two breathing movements – Inspiration and expiration.

Inspiration or inhalation is the process of taking in of air into the lungs while **expiration or exhalation** is the processes of pushing out air from the lungs into the atmosphere.

The two processes take place alternatively. They are achieved by a change in the volume of the thorax, through movements of the diaphragm and rib cage's intercoastal muscles.

The external and internal intercoastal muscles act as antagonistic pairs. Their action can be demonstrated by simple model. The bell – Jar model of the chest also shows the way in which the movement of the diaphragm alters the volume of the chest cavity.

This change in volume changes the pressure, and air either moves in (diaphragm flattens) or moves out (diaphragm rises up wards).

Respiration is simply a Series of Energy Conversions!

(i) Energy stored in sugars and fats is converted to energy temporarily stored in electron carriers (NADH & FADH2).
- via Glycolysis & the Krebs Cycle.

(ii) Energy stored in NADH & FADH2 is converted to energy temporarily stored in an H+ gradient.
- via electron transport.

(iii) Energy stored in an H+ gradient is converted to energy stored in molecules of ATP.
- via chemiosmosis (which fuels ATP synthesis)

Review Exercise

1. The main function of cellular respiration is to
   (a) Use the energy stored in food to generate ATP for cellular work.
   (b) Use sunlight to produce sugar.
   (c) Get rid of the carbon dioxide that builds up in working cells.
   (d) Break ATP down to ADP so that cells can perform work.
2. Which of the following statements about cellular respiration is INCORRECT? Cellular Respiration
   (a) Occurs in animal cells but not in plant cells.
   (b) Releases some heat.
   (c) Releases energy from sugar in a series of steps rather than all at once.
   (d) Breaks sugar down to carbon dioxide.
3. Glycolysis occurs in the ______________; whereas the Krebs cycle and electron transport chain occurs in the ______________.
   (a) Nucleus, Mitochondria.
   (b) Cytosol, Nucleus.
   (c) Mitochondria, Cell membrane.
   (d) Cytosol, Mitochondria.
4. During vigorous exercise, human muscles begin to function under anaerobic conditions and accumulate the waste product as ___.
   (a) NADH.
   (b) Carbon dioxide.
   (c) ADP.
   (d) Lactic acid.
5. In humans and other mammals, breathing supports cellular respiration by ______________.
   (a) providing glucose as fuel to cells.
   (b) exchanging O_2 and CO_2 between the blood and the atmosphere.
   (c) pumping blood to all the cells of the body.
   (d) storing calories that cells can use for ATP production and work.
6. Which equation below represents the process of cellular respiration?
   (a) Glucose + Fructose   Sucrose + water.
   (b) Sucrose + water   glucose + fructose.
   (c) Carbon dioxide + water + light energy   glucose + oxygen.
   (d) Glucose + Oxygen   carbon dioxide + water + ATP.

Sample Test

1. Which of the following structures is part of the urinary system?
   (a) Liver.
   (b) Ureter
   (c) Spleen
   (d) Gall bladder
2. Which of the following substances would NOT normally be expected to appear in urine?
   (a) Water
   (b) Urea
   (c) Glucose
   (a) Chloride ions
3. Which of the following structures is NOT a part of a nephron?
   (a) Distal tubule
   (b) Collecting duct
   (c) Proximal tubule
   (d) Loop of Henle
4. Each kidney contains about a million nephrons, each of which begins in a filtration apparatus called:
   (a) The distal tubule
   (b) The proximal tubule
   (c) The glomerular capsule
   (d) The loop of Henle
   (e) Pyramids of the kidney
5. What volume of glomerular filtrate do adults make every day?
   (a) 1–5 litres
   (b) 80 litres
   (c) 130 litres
   (d) 180 litres
6. Which of the following substances does NOT normally pass through from glomerular capillaries into the filtrate?
   (a) Waterr
   (b) Sodium ions
   (c) Urea
   (d) Proteins

7. Which of the following statements about antidiuretic hormone (ADH) is incorrect?
   (a) ADH regulates the amount of water reabsorbed by the kidneys.
   (b) Without ADH, the proximal parts of the nephron are impermeable to water.
   (c) ADH is synthesised in the hypothalamus and stored in the pituitary gland
   (d) ADH plays a key role in the homeostatic process called Osmoregulation
8. Which hormone, produced by the kidneys, plays a role in the production of red blood cells?
   (a) Adrenaline
   (b) Oxytocin
   (c) Aldosterone
   (d) Erythropoietin
9. Which part of the human body produces urea?
   (a) Large intestine
   (b) Kidneys
   (c) Liver
   (d) Spleen
10. Ultrafiltration by the Glomerulus is enhanced by:
   (a) Large surface area of the capillaries.
   (b) Thin semipermeable barrier.
   (c) High pressure in the capillaries.
   (d) All of the above.
11. Through which vessel does blood leave the Glomerulus?
   (a) Afferent arteriole
   (b) Interlobular vessel
   (c) Efferent arteriole
   (d) Renal vein
12. Which structures of the kidneys increases the reabsorption of Na+ when stimulated by Aldosterone?
   (a) Loop of Henel
   (b) Collecting duct.
   (c) Proximal tubule
   (d) Distal tubule

13. What are the major organs of the Respiratory system?
    (a) Mouth, Esophagus and Stomach.
    (b) Nose, Trachea and Heart
    (c) Trachea, Lungs and Heart
    (d) Nose, Trachea and Lungs.
14. The exchange of gases between blood and cells is called
    (a) Tissue Respiration.
    (b) Internal respiration
    (c) External respiration
    (d) Cellular respiration
15. The nose serves all the following functions EXCEPT:
    (a) As the initiator of the cough reflex
    (b) Warming and humidifying the air
    (c) Cleansing the air
    (d) As a passageway for air movement.
16. Surface tension of the alveolar fluid is reduced by the presence of
    (a) Mucus
    (b) Debum
    (c) Surfactant
    (d) Water
17. When the diaphragm and external intercostals muscles contract, which of the following actions does NOT occur?
    (a) Air moves into the lung.
    (b) The intrapleural pressure increases
    (c) The diaphragm moves inferiorly
    (d) The intrapulmonary pressure decreases
18. When we inhale.
    (a) Alveolar pressure decreases and intrapleural pressure increases
    (b) Both alveolar pressure and intrapleural pressure increase.
    (c) Both alveolar pressure and intrapleural pressure decrease.
    (d) Alveolar pressure increases and intrapleural pressure decreases
19. Which of the body systems listed below cooperate to supply O_2 to cells and eliminate CO_2?
    1. Digestive system
    2. Cardiovascular system
    3. Urinary system

4. Respiratory system
5. Endocrine system
(a) 3, 5
(b) 2, 4
(c) 1, 2, 3
(d) 1, 2, 4

20. Which of the following is true about partical pressure of Oxygen (PO_2) and partial pressure of CO_2 (PCO_2)
(a) PCO_2 in the alveoli is the same as that in the capillaries
(b) PO_2 in the alveoli is the same as that in the capillaries
(c) PCO_2 in the alveoli is higher than that in the capillaries
(d) PCO_2 in the alveoli is lower than that in the capillaries.

21. Which of the following occurs with the exhalation of air from the human lungs?
(a) The volume of the thoracic cavity decreases.
(b) The residual volume of the lung decreases.
(c) The diaphragm flattens down wards move upwards and outwards.
(d) The reibcages.

22. Which of the following describes a correct order of structures in the respiratory passageways?
(a) Pharynx, Trachea, Larynx, Bronchi, Bronchioles
(b) Larynx, Pharynx, Trachea, Bronchioles, Bronchi
(c) Trachea, Pharynx, Larynx, Bronchi, Bronchioles
(d) Pharynx, Larynx, Trachea, Bronchi, Bronchioles

23. The volume of air that can be exhaled after normal exhalation is referred to as
(a) Tidal volume
(b) Residual volume
(c) Inspiratory reserve volume
(d) Expiratory reserve volume

24. The primary chemical stimulus for breathing is the concentration of
(a) Carbon monoxide in the blood
(b) Carbon dioxide in the blood
(c) Oxygen in the blood
(d) Carbonic acid in the blood

25. During internal and external respiration, gases move by
    (a) Facilitated transport
    (b) Active transport
    (c) Simple diffusion
    (d) All
26. Most oxygen in the blood is transported
    (a) As gas dissolved in plasma
    (b) As oxyhemoglobin
    (c) As carboxyhemoglobin
    (d) As bicarbonate
27. Ventilation (breathing) is a regular, rhythmic process which:
    (a) Moves air into and out of the lungs
    (b) Releases energy from glucose within living cells
    (c) Reduces the surface tension of the lining of the lung
    (d) Protects the airways by clearing them of mucus or irritants
28. Which of the following structures is NOT part of the upper respiratory tract?
    (a) Larynx
    (b) Trachea
    (c) Lung
    (d) Epiglottis
    (e) Pharynx
29. What would account for increased urine production as a result of drinking alcoholic beverages?
    (a) Increased blood pressure.
    (b) Increased reabsorption of water.
    (c) Inhibition of Antidiuretic hromone.
    (d) Inhibition of reabsorption of water.
30. Which structure passes urine to the renal pelvis?
    (a) Loop of Henel
    (b) Collecting duct
    (c) Glomerulus
    (d) Proximal tubule
31. The transfer of fluid from the glomerulus to Bowman's capsule is possible due to ________________.
    (a) Active transport
    (b) Passive diffusion
    (c) Blood pressure
    (d) Selective reabsorption

32. Which of the following is NOT a characteristic feature of alveoli in the lung?
    (a) A large surface area
    (b) Thin walls
    (c) Poor blood supply
    (d) Moist surface
33. Pulmonary surfactant:
    (a) Protects the surface of the lungs
    (b) Eliminates small particles and dust
    (c) Is made by bronchioles
    (d) Prevents the alveoli from collapsing
34. Which of the following is true about glycolyisis?
    (a) It occurs in mitochondiral matrix.
    (b) It enzymatically splits a molecule of glucose into two molecules of pyruvic acid
    (c) It results in a complete Oxidation of glucose.
    (d) It results in the production of more energy.
35. The cells that make and secrete mucus that protects the lining of the respiratory tract are called:
    (a) Squamous epithelium
    (b) Pneumothorax
    (c) Terminal bronchioles
    (d) Alveolar cells
    (e) Goblet cells
36. Which of the following is the final electron acceptor during aerobic respiration?
    (a) Oxygen
    (b) Cytochrome
    (c) ATP
    (d) NAD+
    (e) FAD
37. Anaerobic respiration yields __________ .
    (a) 2 ATP as net gains
    (b) 4 ATP as net gains.
    (c) 4 NADH as net gains.
    (d) 4 pyrvate as net gains

38. Which of the following intermediate products is formed during kreb's cylce?
    (a) Fructose-1,6-bisphosphate
    (b) 3-phosphoglycerate
    (c) Pyruvate
    (d) Fumarate
39. Which of the following is the correct route for electrons?
    (a) Food   Citric acid   ATP   ADP
    (b) Food   NADH   Electron transport chain   Oxygen
    (c) Glucose   Pyruvate   ATP   Oxygen
    (d) Glucose   ATP   Electron transport   Oxygen
40. During Glycolysism most of the energy of glucose is __________.
    (a) Transferred to ADP, forming ATP.
    (b) Retained in the pyruvate.
    (c) Transferred direclty to ATP.
    (d) Stored in the NADH and $FADH_2$.
41. Where is ATP synthase located in the mitochondrion?
    (a) Cytosol
    (b) Outer membrane
    (c) Inner membrane
    (d) Electron transport chain
42. Which of the following stages of respiration does Not take place in teh mitochondria?
    (a) Calvin-Benson cycle
    (b) Krebs cycle
    (c) Glycolysis
    (d) Electron transport

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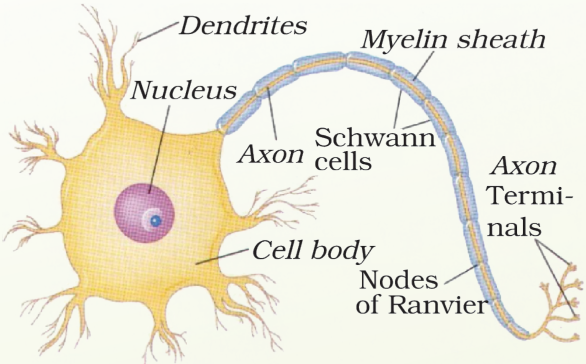
CHAPTER 5

NERVOUS AND ENDOCRINE SYSTEMS

Chapter Contents

5.1 The Nervous System
5.2 Generation and Transmission of Nerve Impulse
5.3 Central Nervous System
5.4 Autonomic Nervous System (Involuntary)
5.5 Sensation and Perception (Function of Sensation Organ)
5.6 Gender Based Violence, Substance Abuse and STI
5.7 Endocrine System
5.8 The Role of other Organs as Endocrine Glands
5.9 Hermon Defections Disease
- Key Terms
- Summary
- Review Exercise
- Sample Test



Chapter Outcomes

Upon completion of this chapter, learners will:

- distinguish the functions of the Nervous and Endocrine systems;
- describe the structure and functions of a Nerve cell (neuron) and the brain;
- classify the neurons of the Nervous system;
- draw the Nervous system and list the major parts;
- describe the structure and functions of the spinal cord;
- differentiate the various regions of the spinal cord in relations to their function;
- compare the central and peripheral nervous systems in relations to their;
- differentiate between voluntary and involuntary actions;
- discuss the causes and effects of substance abuse on the nervous system;
- advocate for GBV, rape, sexual harassment, and intergenerational sex;
- explain the effects of some STIs on the nervous system;
- describe the structures and functions of the eye and ear;
- distinguish and state the functions of exocrine glands and endocrine glands;
- explain the regulation of hormone secretion through negative feedback and describe the two basic mechanisms of hormones action.

Introduction

The Nervous System and Endocrine system are involved in the control and co-ordination of body activities.

The nervous system and the endocrine system are involved in coordinating body functions. The sense organs are also participating to keep in touch with the environment.

5.1 The Nervous System

A. Composition: Nervous system

Functions of the Nervous System

1. Gathers information from both inside and outside the body - Sensory Function.
2. Transmits information to the processing areas of the brain and spine.
3. Processes the information in the brain and spine – Integration Function.
4. Sends information to the muscles, glands, and organs so they can respond appropriately – Motor Function.

It controls and coordinates all essential functions of the body including all other body systems allowing the body to maintain homeostasis or its delicate balance. The Nervous System is divided into **Two Main Divisions: Central Nervous System (CNS) and the Peripheral Nervous System (PNS) (Figure 1).**

Divisions of the Nervous System

The Central Nervous System (CNS) is composed of the Brain and Spinal cord.

The **Peripheral Nervous System (PNS)** is composed of the **Somatic** and **Autonomic nervous systems**. The **Autonomic nervous system** is further divided in to **Sympathetic and Parasympathetic systems.**

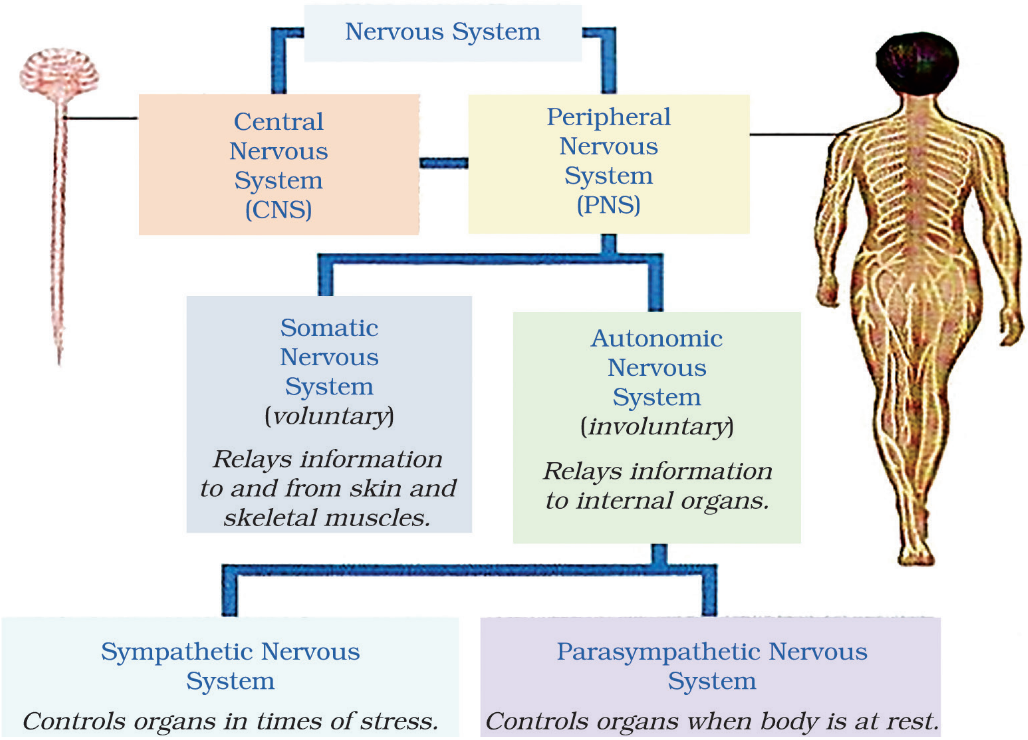


Figure 1. Division of NS

Basic Cells of the Nervous System

Neuron is the main cell type making the nervous system.

- Basic functional cell of nervous system.
- Transmits impulses (up to 250 mph).

Parts of a Neuron (Figure 2)

- **Dendrite** – receive stimulus and carries it impulses toward the cell body
- **Cell Body** with nucleus – nucleus & most of cytoplasm.
- **Axon** – fiber which carries impulses away from cell body.
- **Schwann Cells**- cells which produce myelin or fat layer in the Peripheral Nervous System.
- **Myelin sheath** – dense lipid layer which insulates the axon – makes the axon look gray.
- **Node of Ranvier** – gaps or nodes in the myelin sheath.

Impulses travel **from dendrite to cell body to axon.**

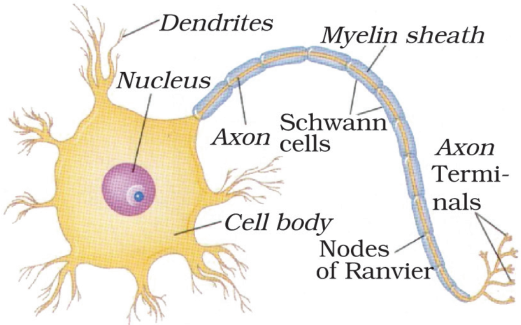


Figure 2. Structure of Neuron

There are three types of Neurons (Figure 3).

- **Sensory neurons** – bring messages to CNS.
- **Motor neurons** – carry messages from CNS.
- **Interneurons** – link between sensory & motor neurons in the CNS (Table 1).

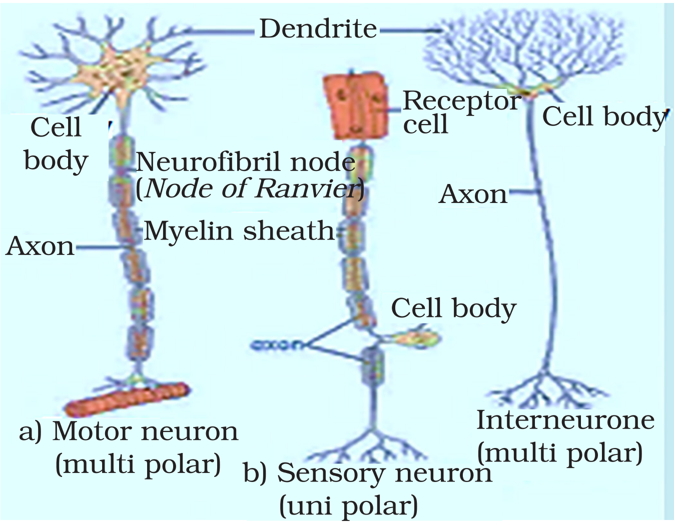


Figure 3. Types of neurons

Table 1 Structure and function of neurons

Type of neuron	Structure	Function
Sensory (Afferent)	Long dendrite; short axon cell body mid – way	Carries nerve impulses from a receptor to CNS
Motor (Efferent)	Short dendrite; long axon	Carries nerve impulses from CNS to an effector.
Inter or Association, or relay.	Short dendrites, long or short axon.	Carries nerve impulses with in the CNS.

5.2 Generation and Transmission of Nerve Impulse

- A **stimulus** is a change in the environment with sufficient strength to initiate a response.
- **Excitability** is the ability of a neuron to respond to the stimulus and convert it into a nerve impulse.
- **All of Nothing Rule** – The stimulus is either strong enough to start an impulse or nothing happens.
- Impulses are always the **same strength along a given neuron** and they are **self-propagation** – once it starts, it continues to the end of the neuron in only one direction- **from dendrite to cell body to axon.**
- The nerve impulse causes a movement of ions across the cell membrane of the nerve cell.

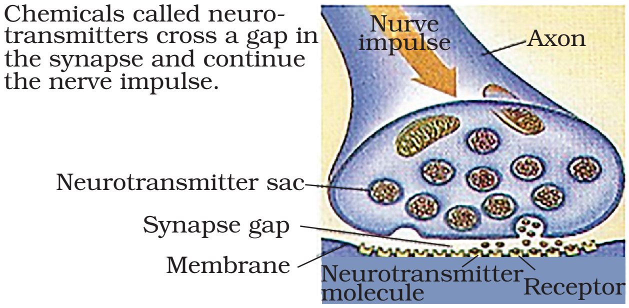


Figure 4. Synapse

Two nerves are linked by a synapse. **Synapse is a** small gap or space between the axon of one neuron and the dendrite of another – **the neurons do not touch each other at the synapse (Figure 4).**

- It is junction between neurons which uses neurotransmitters to start the impulse in the second neuron or an effector (muscle or gland)
- The synapse insures one-way transmission of impulses

Neurotransmitters chemicals found in the junction, which allow impulses to be started in the second neuron.

Nerve Impulses are information passing along the nerves of the body as electrical current. Neurons generate electric current by setting up a charge separation.

Because of selective permeability of the cell membrane, the concentration of ions inside & outside the neuron cell is different.

During the neurons resting stage, the outside of the cell is positively charged and the inside of the cell is negatively charged resulting in a difference in electric charge between inside & outside of the neuron. As a result the membrane of the cell is said to be polarized (+ve and - ve charges separated).

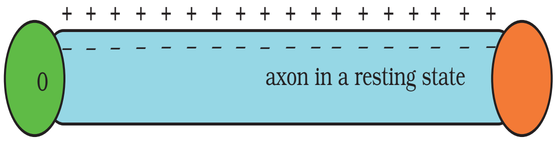


Figure 5.

The polarization is called the **resting potential**, and it is the basis for the transmission of signals by nerves.

The electrical potential difference across the membrane is defined as the resting potential.

Transmission of a signal along a neuron occurs in four phases:

(a) Initiation of the nerve impulse
(b) Transmission of impulse along a nerve fiber
(c) Transfer of impulse to a target muscle or gland
(d) Effect on target tissue (response generation)

Initiation of nerve impulse:

Nerve action potentials are important since they act as units of information. Action potential can be divided into four stages:

1. Resting potential (Polarization)
2. Depolarization
3. Repolarization
4. Redistribution of ions.

Nerve impulse transmission is:

- Electrical - along nerves
- Electro - chemical at synapses

The process of polarization - depolarization is self-propagating, in an all-or-nothing principle. The process spreads along the nerve from the initial site. Nerve impulse is, therefore transmitted as a wave of membrane depolarization.

In myelinated nerves, the action potential generated is not propagated by wave of membrane depolarization since this is prevented by the insulating Schwann cells, which produce lipid rich membrane layers (the myelin sheath). The action potential jumps as an electric current from one node to the next. This form of nerve impulse is very fast & it is known as salutatory conduction (up to 120 meters/second).

Transferring Information to a Target Cell or Organ

- A nerve impulse passes the synaptic cleft (intra cellular gap separating the axon tip and the target cell) chemically.
- The membrane on the axon side of the synaptic cleft is called the pre synaptic membrane.
- When an impulse reaches pre synaptic membrane, it stimulate the release of neurotransmitter chemicals into the cleft. These chemicals rapidly pass to the other side of the gap and combine with receptor molecules in the membrane of the target cell.
- The membrane of the target cell on the side of the synaptic cleft is called postsynaptic membrane. The chemicals cause ion channels to open and postsynaptic action potential is generated.

Sequence of events in synaptic transmission

1. Pre - synaptic action potential arrives at synapse
2. Acetylcholine is released from vesicles
3. Acetylcholine binds to receptor, causing postsynaptic membrane excitation
4. Post synaptic action potential is generated
5. Acetylcholine is inactivated by Acetyl cholinesterase.

Acetylcholine is a neurotransmitter in neuromuscular junctions (synapses). Examples:

- In neuron to muscle connections, known as neuromuscular junctions the neurotransmitter chemical is called acetylcholine
- In nerve-to-nerve connections, there are excitatory synapses and inhibitory synapses.
- In excitatory synapses neurotransmitters depolarizes postsynaptic membrane. e.g. Glutamate.
- In inhibitory synapses, neurotransmitters inhibit depolarization. e.g. Dopamine and Gamma amino butyric acid (GABA).

5.3 Central Nervous System

The CNS can be conveniently divided in to the following anatomical regions.

- The brain and The spinal cord

Meninges

Meninges are the three coverings around the brain & spine and help cushion, protect, and nourish the brain and spinal cord (Figure 6).

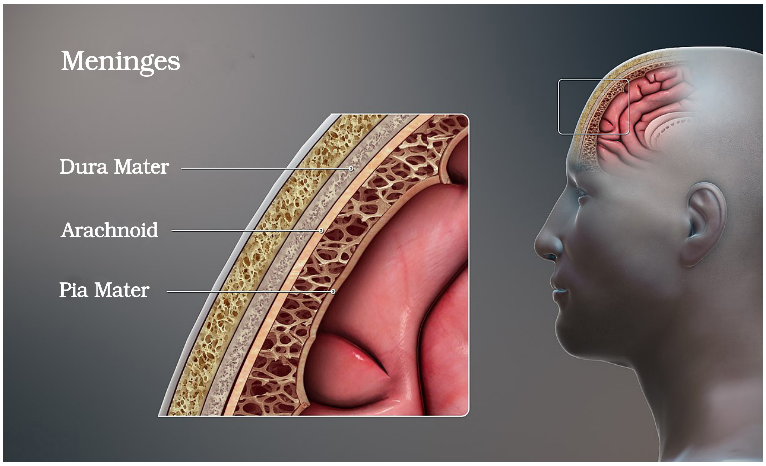


Figure 6. Structure of meninges

- cerebrospinal fluid, buffers, nourishes, and detoxifies the brain and spinal cord, flows through the subarachnoid space, between the arachnoid mater and the pia mater.

Brain

Regions of the brain.

- Brain stem – medulla, pons, midbrain
- Diencephalon – thalamus & hypothalamus
- Cerebellum.
- Cerebrum.

Regions of the Brain and their function (Figure 7 & 8)

Cerebellum – coordination of movement and aspects of motor learning.

Thalamus – Brain's switchboard – filters and then relays information to various brain regions.

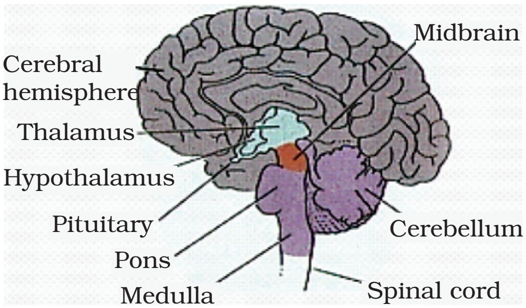


Figure 7. Regions of Brain

Medulla – vital reflexes as heartbeat and respiration.

Brainstem – medulla, pons, and midbrain (involuntary responses) and relays information from spine to upper brain.

Hypothalamus– involved in regulating activities internal organs, monitoring information from the autonomic nervous system, controlling the pituitary gland and its hormones, and regulating sleep and appetite.

Cerebrum – conscious activity including perception, emotion, thought, and planning.

Cerebrum is the largest portion of the brain encompasses about two-thirds of the brain mass.

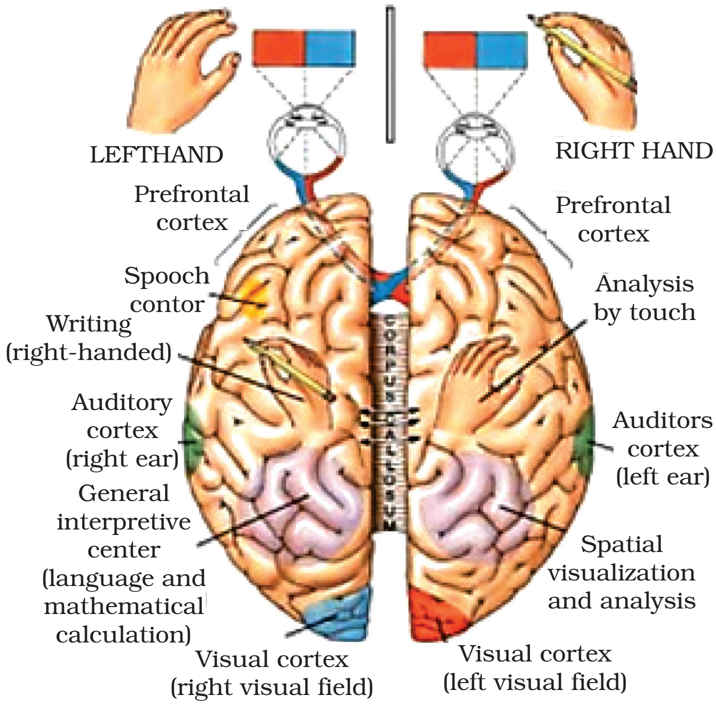


Figure 8. Function of Brain parts

- It consists of two hemispheres divided by a fissure – corpus callosum
- It includes the cerebral cortex, the medullary body, and basal ganglia.
- Cerebral cortex is the layer of the brain often referred to as gray matter because it has cell bodies and synapses but no myelin.

  - The cortex (thin layer of tissue) is gray because nerves in this area lack the insulation or white fatty myelin sheath that makes most other parts of the brain appear to be white.
  - The cortex covers the outer portion (1.5mm to 5mm) of the cerebrum and cerebellum.
  - The cortex consists of folded bulges called **gyri** that create deep furrows or fissures called **sulci.**

- The folds in the brain add to its surface area which increases the amount of gray matter and the quantity of information that can be processed.

- **Medullary body** – is the white matter of the cerebrum and consists of myelinated axons. Commissural fibers – conduct impulses between the hemispheres and form corpus callosum.
  - Projection fibers – conduct impulse in and out of the cerebral hemispheres.
  - Association fibers – conduct impulses within the hemispheres.
  - **Basal ganglia** – masses of gray matter in each hemisphere which are involved in the control of voluntary muscle movements.

Lobes of the Cerebrum (Figure 9)

- **Frontal** – motor area involved in movement and in planning & coordinating behavior.
- **Parietal – sensory processing, attention, and language**
- **Temporal – auditory perception, speech, and** complex visual perceptions
- **Occipital** – visual center – plays a role in processing visual information

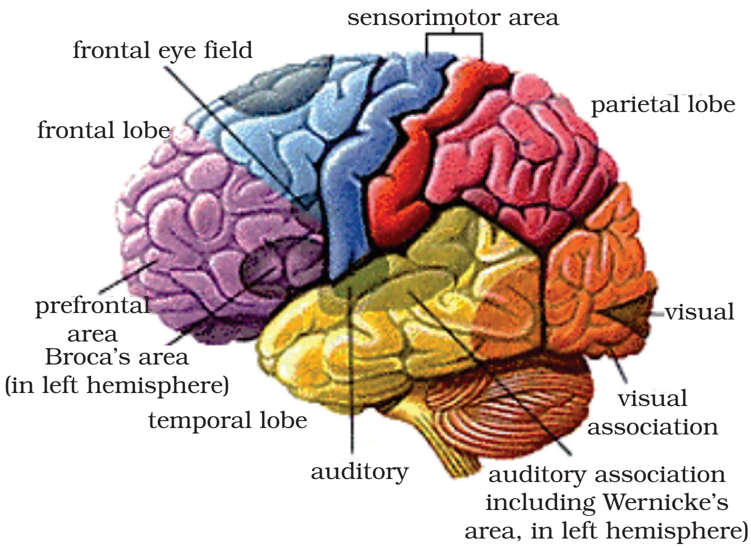


Figure 9. Lobes of Cerebrum

The spinal cord

The spinal cord is an extension of the medulla of the brain. It runs through the vertebral column for protection. It has a central canal containing cerebrospinal fluid.

Structure

There are two distinct portions of the spinal cord.

These are:

- The inner part, called gray matter and
- The outer part called white matter.

The gray matter contains the cell bodies of motor and association neurons and appears gray in colour.

The white matter mainly consists of the axons of neurons, which is insulated by the white fatty material known as myelin sheath so that this region appears white in colour.

There are two points called roots at which paired spinal nerves join the spinal cord. These are the **dorsal root and the ventral root.**

Sensory neurons enter the spinal cord through the dorsal root. The cell bodies of sensory neurons are found out side the spinal cord in a swelling region called **spinal ganglion,** which is a collection of neuron cell bodies.

Motor neurons leave the spinal cord through the ventral root. The cell bodies of motor neurons are located in the gray matter of the spinal cord.

After leaving the spinal cord, the dorsal & ventral roots join and form one single nerve known as the spinal nerve.

Function

- Transmission of impulses to the brain and from the brain
- It transmits sensory impulses from sense organs to the brain.
- It also receives and transmits motor impulses from the brain to effectors such as muscles and glands.
- Control of reflex actions involving body structures below the neck region
- The reflexes are called spinal reflexes.

- In the instance of spinal cord injury loss of sensation and paralysis results

B. Peripheral Nervous System (Figure 10)

Composed of Cranial nerves and spinal nerves.

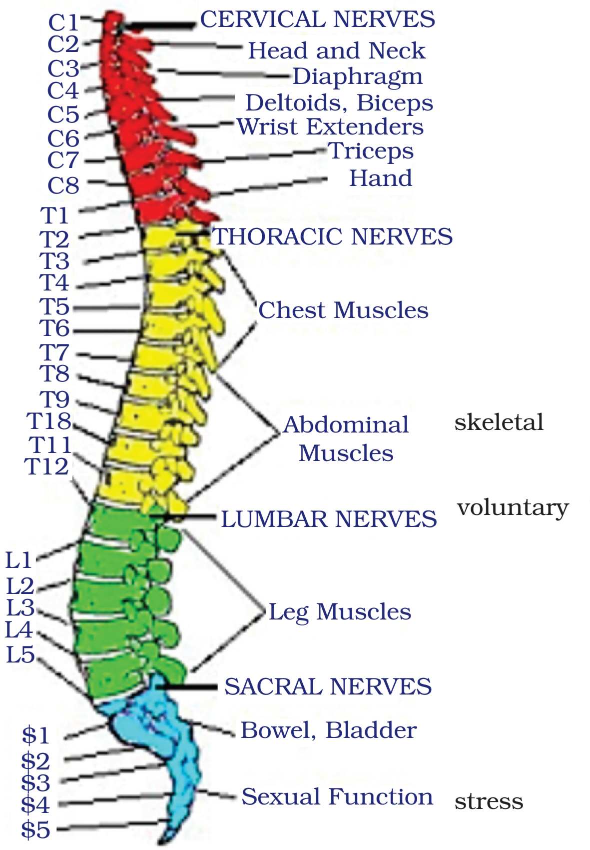


Figure 10. PNS - nerves

Cranial nerves

- 12 pair
- Attached to undersurface of brain.

Spinal nerves

- 31 pair
- Attached to spinal cord.

Somatic Nervous System (voluntary)

- Relays information from skin, sense organs & skeletal muscles to CNS.
- Brings responses back to skeletal muscles for voluntary responses.

5.4 Autonomic Nervous System (Involuntary)

- Regulates bodies involuntary responses.
- Relays information to internal organs
- Two divisions.

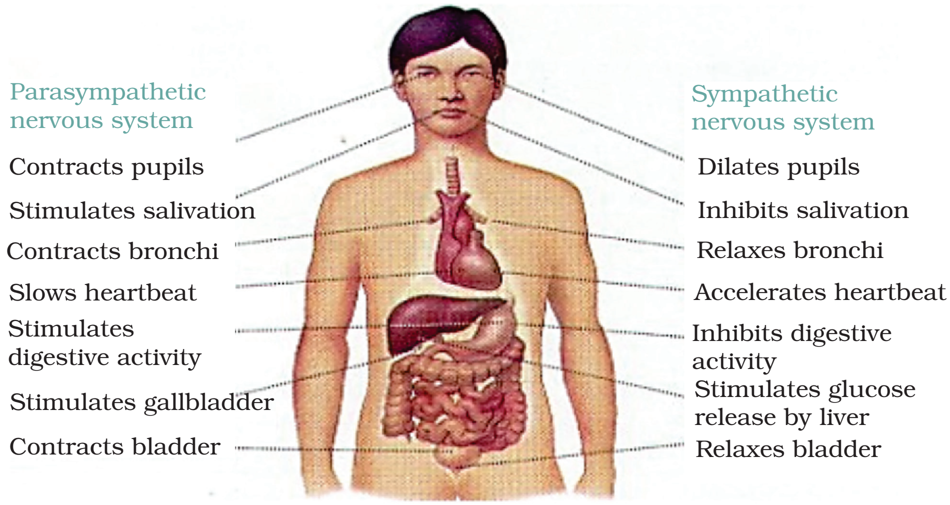


Figure 11. Parasympathetic & sympathetic nervous system.

Sympathetic nervous system – in times of stress (Figure 12 & Table 2).

- Emergency response.
- Fight or flight.

Parasympathetic nervous system – when body is at rest or with normal functions.

- Normal everyday conditions.

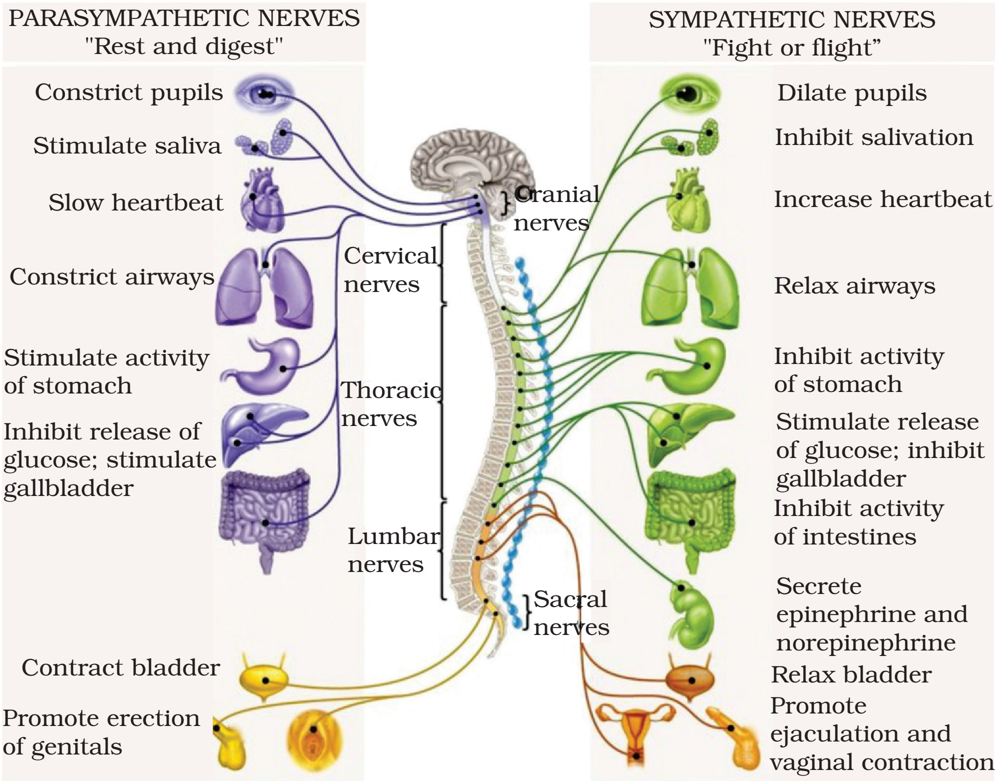


Figure 12. Parasympathetic & sympathetic Nervous system

Table 2 Antagonistic action of sympathetic & parasympathetic NS

Sympathetic NS	Parasympathetic NS
Increased rate of heart beat	Decreased rate of heart beat
Decreased rate of gut peristalsis	Increased gut peristalsis
Constriction of arteries	Dialation of arteries
Constriction of anal sphincter	Dialation of anal sphincter
Constriction of bladder sphincter	Dialation of bladder sphincter
Relaxation of bladder wall	Constriction of bladder wall
Dilatation of bronchioles	Constriction of bronchioles
Dilatation of pupil of eye	Constriction of pupil of eye

Reflex Action

A reflex action is an automatic response to a stimulus which we can not consciously control. Naturally, reflex actions are designed to prevent harm to the body. There are two types of reflex actions, simple and conditioned reflexes.

Simple Reflex Action

Simple reflex actions are automatic responses to a stimuli. Whenever a reflex occurs, we are aware of it happening but we can not control the response.

Examples of simple reflex action:

- A food particle entering in your wind pipe, causes coughing to remove the particle
- Bright light causes the pupil of the eye to narrow by contracting the muscle.
- While an object approaches the eye, it causes blinking
- Stepping on a sharp object with bare foot, it causes immediate lifting of your foot.
- Smelling of food results in secretion of saliva

All the above and related actions are simple reflexes are also called as:

- Coughing reflex,
- Pupil reflex, blinking reflex
- Withdrawal reflex, salivating reflex, etc

Reflex Arc

A Reflex arc is the transmission path of nerve impulses between, neurons, receptors, and effector organs. It is a functional unit of the nervous system involving the three different types of neurons, sense organs and effector organs. A reflex arc is the transmission path between receptor and effectors (Figure 13).

A receptor, stimulated, generates nerve impulses. A sensory neuron takes impulses from receptors to the CNS along the dendrite (spinal nerve) and proceed to the cell body (dorsal root ganglion) and moves to the axon (spinal cord). Interneuron passes message to motor neuron, impulses will be picked up by dendrites and pass through the cell body and to the axon (spinal cord).

Motor neuron takes message away from CNS. Impulses travel through short dendrites and the cell body (spinal cord) to the axon (spinal nerve).

Effector receives message and reacts: glands secrete, and muscles contract (Table 3).

Table 3 Comparison of a spinal reflex action and voluntary action

Spinal reflex	Voluntary action
Stimulus affects external or internal receptor	Initiated from the brain at the conscious level.
Spinal cord only involved – not under the control of the will.	Fore brain involved – under the control of the will.
The impulse travels only up or down the spinal cord.	The impulse travels from the brain down the spinal cord.
The path of the nerve impulse is by the shortest route.	The path of the nerve impulse is much longer
The response is immediate.	The response can be delayed.
The response is in skeletal or internal involuntary muscle.	The response is in skeletal muscle only.

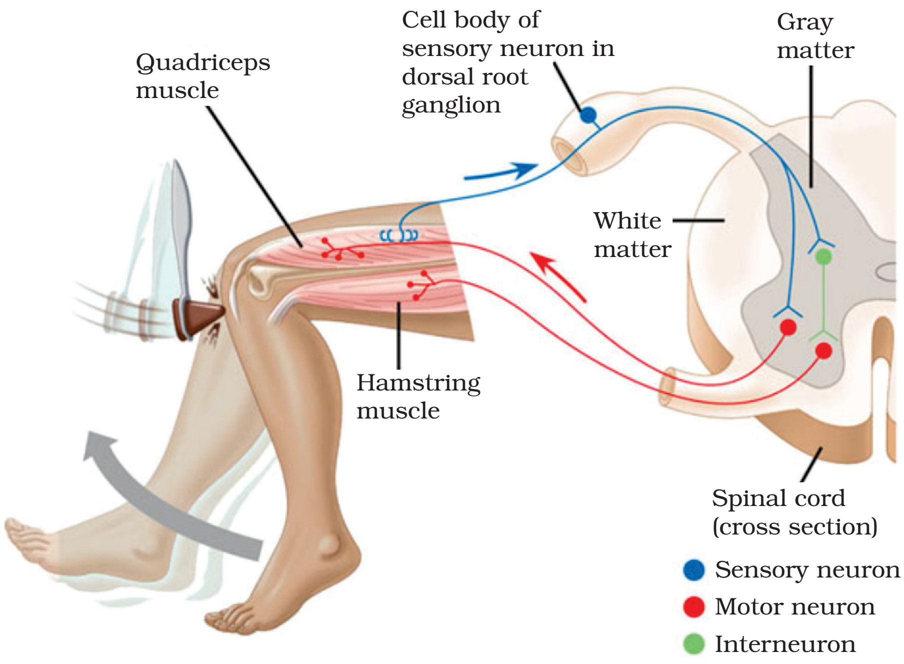


Figure 13. Reflex Arc Path

Components of a Reflex Arc

(a) A. Receptor - reacts to a stimulus (Table 4).

(b) Afferent pathway (sensory neuron) - conducts impulses to the CNS.

(c) Interneuron - consists of one or more synapses in the CNS (most are in the spine).
(d) Efferent pathway (motor neuron) conducts impulses from CNS to effector.
(e) Effector - muscle fibers (as in the Hamstring muscle) or glands responds by contracting or secreting a product.

Spinal reflexes - initiated and completed at the spinal cord level. Occur without the involvement of higher brain centers.

Table 4 A summary of five types of reflex actions in man is given in table

Stimulus	Receptor	Response	Reflex action
Object approaching the eye	Retina	Contraction of muscles of the eyelid.	Blinking
Pressure on the tendon below the patella	Stretch receptors	Contraction of flexor muscles	Knee – Jark
Food bolus in the back of the throat	Receptors in the throat	Epiglottis closes; soft palate raised; peristalisis.	Swallowing
Decrease in light intensity	Retina	Contraction of radial muscles of the iris.	Pupil dilates
Increase in light intensity	Retina	Contraction of circular muscles of the iris.	Pupil constricts.

The generalized activity of the nervous system tells us that we exist and accounts for our quick reaction to environmental stimuli together with the other sense organs.

Conditioned Reflex

A conditioned reflex is a response, which is not inborn. It is an acquired response depending on past experience and training.

5.5 Sensation and Perception (Function of Sensation Organ)

- Vision – Eye- light.
- Hearing – Ear- sound.
- Taste – Taste receptors (new)- chemicals.
- Smell – Olfactory system- chemicals.
- General- Skin – Hot, cold, pressure, pain

The nervous system includes specific organs that allow us to experience the five senses. They work together to give the brain a clear picture of what is happening around us.

Eye – the organ used to sense light.

The eye is an organ of vision consisting of photo (light) receptors which are connected to the nervous system by the optic nerve (Figure 14).

The human eye has three distinct layers.

1. Outer layer consisting of sclera and cornea.
2. Middle layer consisting of choroid, ciliary body and iris.
3. Inner layer consisting of retina

Functions of the major parts of the eye:

Sclera or Scleroid Layer – (white of eye) a tough protective layer of connective tissue that helps maintain the shape of the eye and provides an attachment for the muscles that move the eye.

Cornea - the clear, dome-shaped part of the sclera covering the front of the eye through which light enters the eye.

Anterior Chamber – a small chamber between the cornea and the pupil.

Aqueous Humor - the clear fluid that fills that anterior chamber of the eye and helps to maintain the shape of the cornea providing most of the nutrients for the lens and the cornea and involved in waste management in the front of the eye.

Choroid Layer - middle layer of the eye containing may blood vessels.

Ciliary Body - the ciliary body is a circular band of muscle that is connected and situated immediately behind the iris- produces aqueous humor, changes shape of lens for focusing.

Iris - the pigmented front portion of the choroid layer and contains the blood **vessels** - it determines the eye color and it controls the amount of light that enters the eye by changing the size of the pupil (an albino only has the blood **vessels** – not pigment so it appears red or pink because of the blood vessels),

Lens - a crystalline structure located just behind the iris - it focuses light on the retina.

Pupil - the opening in the center of the iris- it changes size as the amount of light changes (the more light, the smaller the hole).

Vitreous - a thick, transparent liquid that fills the center of the eye - it is mostly water and gives the eye its form and shape (also called the vitreous humor).

Retina - sensory tissue that lines the back of the eye. It contains millions of photoreceptors (rods for black & white and cones for color) that convert light rays into electrical impulses that are relayed to the brain via the optic nerve.

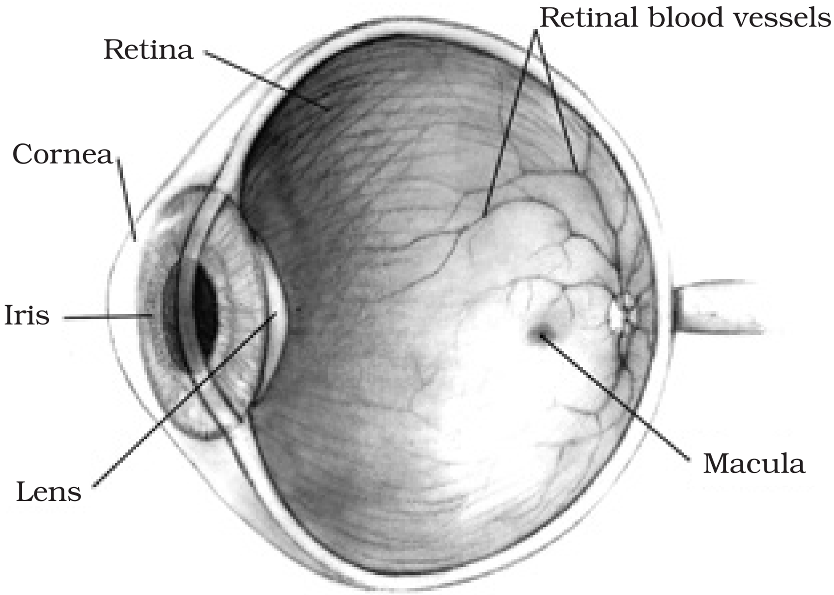


Figure 14. Eye

Optic nerve - the nerve that transmits electrical impulses from the retina to the brain.

Common eye defects include.

Among the many eye defects, the following are very common.

Myopia or nearsightedness where the eyeball is too long or the cornea is too steep.

Hyperopia or far sightedness where the eyeball is short or lens cannot become round enough.

Cataracts where the lens becomes fogged.

Presbyopia where the muscles controlling the bulging of the lens become weak as we age.

Nyctalopia or night blindness where vision is impaired in dim light and in the dark due to pigment rhodopsin in the rods not functioning properly.

Images

- The cornea and the lens help to produce the image on the retina.
- Images formed by the lens are upside down and backwards when they reach the retina.

Two types of receptors on the retina: Rods cones. (Figure 15)

- Rods – 125 million on a single retina. Extremely sensitive to all wavelengths of visible light but do not distinguish different color.

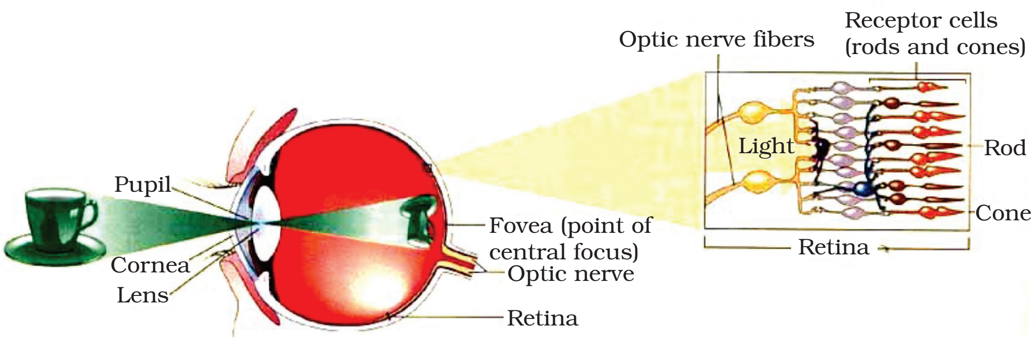


Figure 15. Focusing by our eye

In dim light only rods are activated where one can see objects but not as sharp images and are not able to distinguish their color. Important for night time vision.

- Rods have a pigment called rhodopsin.

As amount of light increases, **the cones** – 7 million on a single retina – mainly in central view are stimulated and the color becomes clear – daytime vision.

- There are three types of cones which distinguish the three colors – blue, red, green.

- **Fovea** is point of central focus with great density of cones. It is center of the eye's sharpest vision and the location of most color perception.

The layers of the retina spread aside to let light fall directly on the cones.

- Light stimulates rods and cones and sends impulse via optic nerve to brain areas for vision.
- The Optic Nerve exits the eye just off center near the Fovea - the Optic Nerve exits is referred to as the Blind Spot due to the lack of the receptors in this area.
- The two Optic Nerves come together at the Optic Chiasm located just under the hypothalamus - a crucial part of vision and perception must happen - cross-over of information from the right eye crosses over to the left side and visa versa happens here at the Optic Chiasm
- Information from each eye must be processed in both halves of the brain
- Information leaves the chiasm via the optic tract.
- Reorganized optic tract leaves the Optic Chiasm and passes onto the lateral geniculate nucleus.
- At the lateral geniculate nuclei the information is separated, organized, and relayed to different areas of the visual cortex.
- The different zones of the visual cortex process the different aspects of vision and information, taken from both visual fields, is processed and an image is perceived.

The Structure & function of Human ear.

The main functions of the human ear are in sensing sound and changes in the body position in maintaining balance. The ear is divided in to three parts; outer, middle and inner ear.

Outer Ear & ear canal – brings sound into eardrum.

Eardrum – vibrates to amplify sound & separates inner and middle ear.

Middle Ear – has 3 small bones or Ossicles = anvil, stirrup, stapes – amplify sound (small bones) which vibrate sound. (Figure 16)

Eustachian tube – connects middle ear to throat and equalizes pressure on eardrum.

Cochlea – in inner ear – has receptors for sound & sends signals to brain via Auditory Nerve.

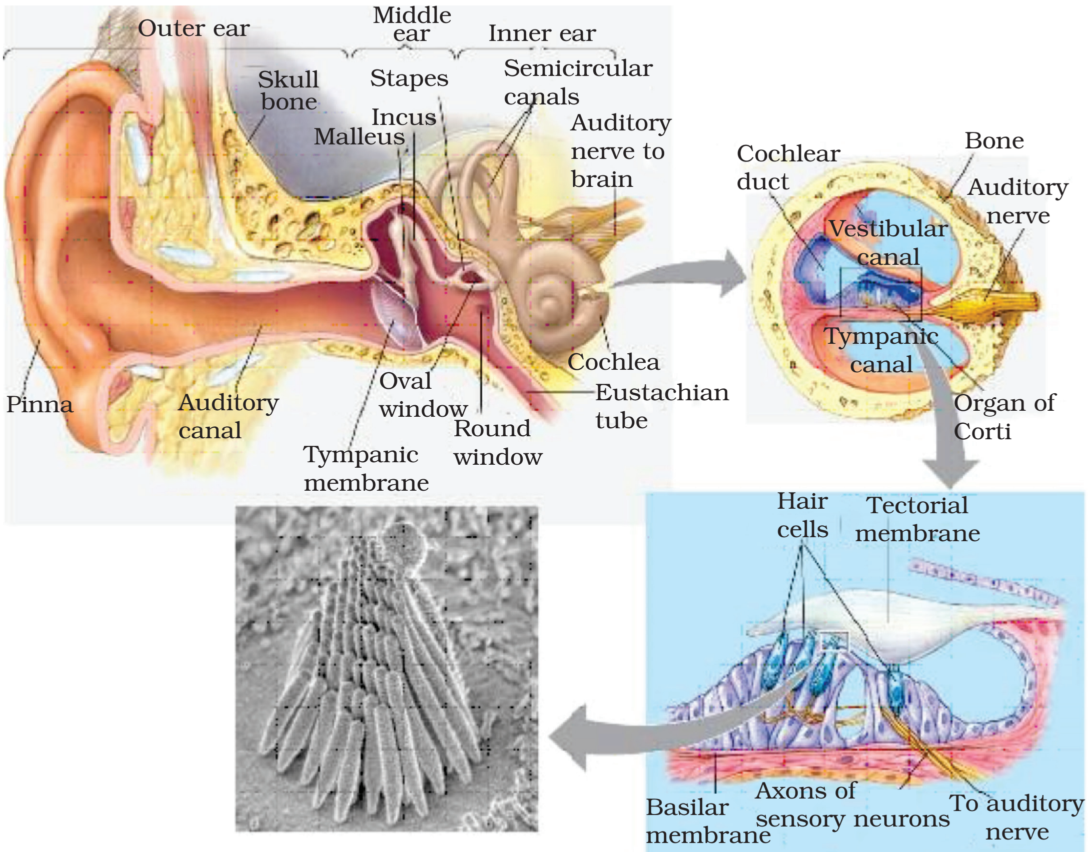


Figure 16. The Ear

Process of hearing:

- Sound waves enter your outer ear and travel through your ear canal to the middle ear.
- The ear canal channels the waves to your eardrum, a thin, sensitive membrane stretched tightly over the entrance to your middle ear.
- The waves cause your eardrum to vibrate.
- It passes these vibrations on to the hammer, one of three tiny bones in your ear. The hammer vibrating causes the anvil, the small bone touching the hammer, to vibrate. The anvil passes

these vibrations to the stirrup, another small bone which touches the anvil. From the stirrup, the vibrations pass into the inner ear.

- The stirrup touches a liquid filled sack and the vibrations travel into the cochlea, which is shaped like a shell.
- Inside the cochlea, a vestibular system formed by three semicircular canals that are approximately at right angles to each other and which are responsible for the sense of balance and spatial orientation. It has chambers filled with a viscous fluid and small particles (otoliths) containing calcium carbonate. The movement of these particles over small hair cells in the inner ear sends signals to the brain that are interpreted as motion and acceleration. The brain processes the information from the ear and lets us distinguish between different types of sounds.

Tongue Chemical Receptors for Taste

The sense of taste depends on clusters of sensors called taste buds which are confined to the mouth cavity (Figure 17).

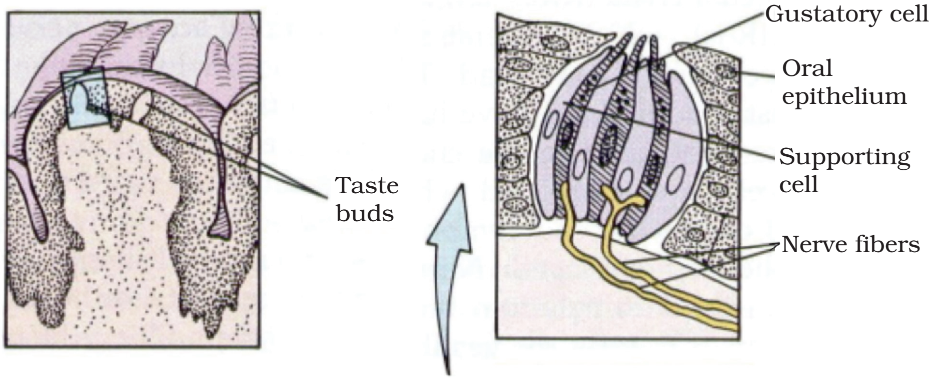


Figure 17. Test buds on tongue

A taste bud is a cluster of many taste sensors. The 10,000 or so taste buds on our tongue - taste buds are embedded in the epithelium of the tongue, on its outer surface a taste bud has a pore that exposes the tips of the taste sensors. Taste sensors are not neurons. At their bases, taste sensors form synapses with dendrites of sensory neurons.

Taste sensors bind with molecules & they release neurotransmitter that are conducted to the CNS via sensory neurons.

Particular regions of the tongue have taste buds responsible for 4 general categories of taste, but the regions overlap to a large extent.

Taste buds.

- The mouth contains around 10,000 taste buds, most of which are located on and around the tiny bumps on your tongue. Every taste bud detects five primary tastes:
  - Sour
  - Sweet
  - Bitter
  - Salty
  - Umami - salts of certain acids (for example monosodium glutamate or MSG)
- Each of your taste buds contains 50-100 specialised receptor cells.
- Sticking out of every single one of these receptor cells is a tiny taste hair that checks out the food chemicals in your saliva.
- When these taste hairs are stimulated, they send nerve impulses to your brain.
- Each taste hair responds best to one of the five basic tastes.

Smell Receptors or Olfactory receptors.

The sense of smell is called olfaction & it is a form of chemosensation. In humans the smell sensors are neurons embedded in a layer of epithelial cells at the back of the nasal cavity. A protective mucus covers the epithelium. Molecules diffuse through this mucus to get to the receptors. A molecule that stimulate olfactory sensors is called odorant (Figure 18).

Receptors cells have connection to the olifactors bulb of the brain via their axons.

- Humans are able to detect thousands of different smells.
- Olfactory receptors occupy a stamp-sized area in the roof of the nasal cavity, the hollow space inside the nose.

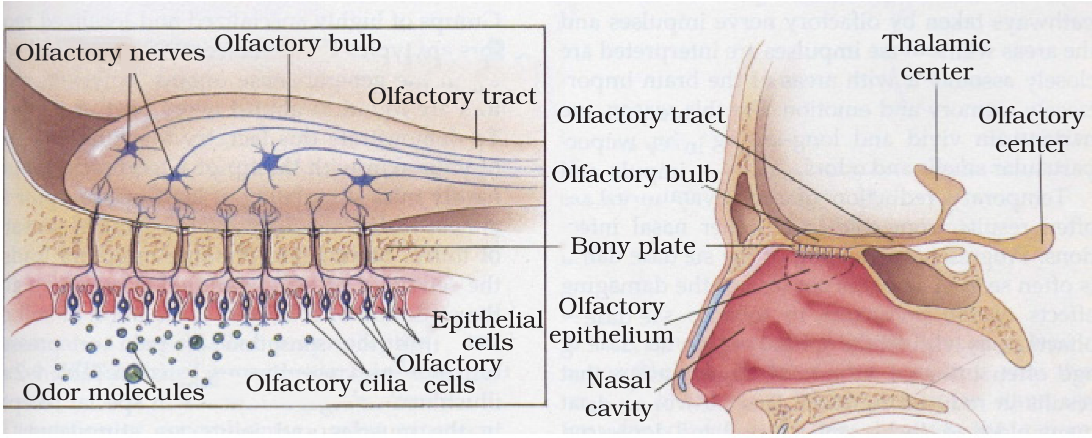


Figure 18. The Nose & Olifaction

- Tiny hairs, made of nerve fibers, dangle from all your olfactory receptors. They are covered with a layer of mucus
- If a smell, formed by chemicals in the air, dissolves in this mucus, the hairs absorb it and excite your olfactory receptors.
- A few molecules are enough to activate these extremely sensitive receptors.
- Olfactory Hairs easily fatigued so you do not notice smells.
- Linked to memories - when your olfactory receptors are stimulated, they transmit impulses to your brain and the pathway is directly connected to the limbic system - the part of your brain that deals with emotions so you usually either like or dislike a smell.
- Smells leave long-lasting impressions and are strongly linked to your memories.
- Much of what we associate as taste also involves smell – that is why hot foods "taste" different than "cold" foods.

Skin receptors:

The skin is a general sense organ consisting of different types of receptors (Figure 19).

Receptors are classified based on the type of stimuli, which they detect.

1. Mechanoreceptors – stimulated by mechanical forces (touch, sound, tension, stretch, etc.).

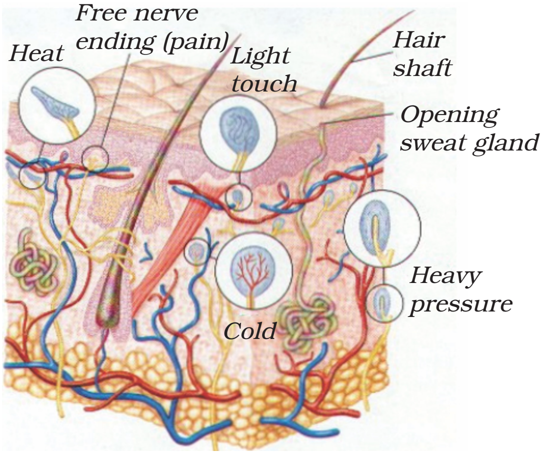


Figure 19. Skin receptors

2. Chemoreceptors – stimulated by chemicals
3. Photoreceptors – stimulated by light
4. Thermoreceptors – stimulated by temperature

In the human body there are general and specific sense organs.

The skin and muscles are general sense organs.

Specific sense organs are those specializing only for a particular stimulus and function (Table 5).

Table 5 Receptors on the skin and muscles, etc. General sense organs.

Receptor	Location	Stimulus
Free nerve endings	Skin and other epithelial layers	Pain, touch and temperature.
Meissner corpuscles	Skin (mainly fingertip)	Touch
Ruffini endings	Skin sub cutaneous	Heat and touch
Merkel disks	Skin and sub cutaneous	Touch
Puccini corpuscle	Skin and sub cutaneous tissue (joints, mammary glands, genitals)	Pressure
Krause endbulbs	Skin and sub cutaneous tissue (lips, eyelids, genitals)	Cold and touch
Muscle spindles	Skeletal muscles	Proprio reception.
Golgitendon receptors	Junction of tendons and muscles	Proprio reception

The Eye, Ear, tongue and, nose are specific sense organs.

Your skin and deeper tissues contain millions of sensory receptors. Most of your touch receptors sit close to your skin's surface.

5.6 Gender Based Violence, Substance Abuse and STI

Sexual violence (Gender Based Violence)

Substance Abuse

People for a variety of recreational, ritualistic and health purposes have taken substances that act on the nervous system to alter mood, perception, or behavior. The use of these substances in a manner unrelated to acceptable medical practice often leads to various problems to the users and the society in which they live.

Substance (Drug) abuse is the improper, bad use, or misapplication of drugs outside their medical practice. Physicians should use drugs upon prescription in order to benefit from them. When a drug is not properly used as prescribed, it is said to be misused.

Dependence producing or addictive drugs are mostly, abused and distributed illegally. Illegal & misused drugs are posing problem.

Illegal drugs are drugs, which are cultivated, produced, distributed, and used in illicit methods to be used for non - medical practices.

Dependence producing drugs are drugs that can produce substantial CNS stimulation or depression or disturbances in perception, mood, thinking, behavior, or motor functions. They are generally recognized to produce individual and social problems.

Drug addiction (dependence) is a state of behavior and other responses that is characterized by a compulsion to take a drug on a continuous or periodic basis, resulting from the use of a drug.

Drug addicted persons develop drug seeking behavior and they are unable to do without the particular drug. Several drugs produce dependence after repeated use and they are misused or abused and distributed illegally.

Alcohol

Alcohol abuse is a pattern of problem drinking that results in health consequences, social, problems, or both. However, alcohol dependence, or alcoholism, refers to a disease that is characterized by abnormal alcohol seeking behavior that leads to impaired control over drinking

Methamphetamine

Methamphetamine is a stimulant drug chemically related to amphetamine but with stronger effects on the central nervous system. Street names for the drug include "speed," "meth," and "crank." Methamphetamine is used in pill form, or in powdered form by snorting or injecting. Crystallized methamphetamine known as "ice," "crystal," or "glass," is a smokable and more powerful form of the drug

Cocaine

Cocaine is a white powder that comes from the leaves of the South American coca plant. Cocaine is either "snorted" through the nasal passages or injected intravenously. Cocaine belongs to a class of drugs known as stimulants, which tend to give a temporary illusion of limitless power and energy that leave the user feeling depressed, edgy, and craving more.

Crack is a smokable form of cocaine that has been chemically altered. Cocaine and crack are highly addictive. This addiction can erode physical and mental health and can become so strong that these drugs dominate all aspects of an addict's life.

Hallucinogens

Hallucinogenic drugs are substances that distort the perception of objective reality. The most well-known hallucinogens include phencyclidine, otherwise known as PCP, angel dust, or love boat; lysergic acid diethylamide, commonly known as LSD or acid; mescaline and peyote; and psilocybin, or "magic" mushrooms.

Under the influence of hallucinogens, the senses of direction, distance, and time become disoriented. These drugs can produce unpredictable, erratic, and violent behavior in users that sometimes leads to serious injuries and death. The effect of hallucinogens can last for 12 hours. LSD produces tolerance, so that users who take the drug repeatedly must take higher and higher doses in order to achieve the same state of intoxication. This is extremely dangerous, given the unpredictability of the drug, and can result in increased risk of convulsions, coma, heart and lung failure, and even death.

Marijuana

Marijuana is the most widely used illicit drug in the United States and tends to be the first illegal drug teens use. It can be either smoked or swallowed.

Steroid Abuse

Taking large amounts of Androgens (steroids): has negative feedback effect on FSH & LH

- almost shuts down FSH & LH
- decreased sperm production
- temporary or permanent sterility
- increased cancer risk also when large amounts are take some is transformed into estrogen
- breast enlargement

Other abused substances in Ethiopia include:

Volatile solvents (inhalant type). eg. Toluene, benzene, acetone, etc.

Khat type - these are products of the plant khata edulis.

Exercise

1. The term Central Nervous System refers to the:
   (a) Autonomic and peripheral nervous systems.
   (b) Brain and cranial nerves.
   (c) Spinal cord and spinal nerves.
   (d) Brain and spinal cord.
2. The Peripheral Nervous System consists of:
   (a) Spinal nerves only
   (b) Cranial nerves only
   (c) The brain and spinal cord
   (d) The spinal and cranial nerves
3. Which of these cells are not a type of neuroglia found in the CNS:
   (a) Astrocytes
   (b) Microglia
   (c) Schwann cells
   (d) Ependymal cells
   (e) Oligodendrocytes

4. The Schwann cells form a myelin sheath around the:
   (a) Dendrites
   (b) Cell body
   (c) Axon
   (d) Nodes of ranvier
5. The neuron processes that normally receives incoming stimuli are called:
   (a) Axons
   (b) Dendrites
   (c) Schwann cells
   (d) Satellite cells

5.7 Endocrine System

A. Exocrine and endocrine glands.

There are two major groups of glands producing chemical secretions – the **exocrine glands and endocrine glands.**

Exocrine glands, such as salivary glands, sweat glands, and glands within the gastrointestinal tract, tend to be much less vascular and have ducts or a hollow lumen. Also controls metabolism in our body system (Table 6).

Table 6 Exocrine glands

Gland	Secretion	Function
Lachrymal glands	Tear with Lysozyme	Lubricating the eye and killing bacteria, washing foreign bodies.
Sweat glands (Sebaceous)	Sweat	Remove heat and regulate temperature.
Salivary glands	Saliva with enzyme	Digestion and lubrication, moistening of food.
Pancreas	Pancreatic juice	Digestion of food
Mammary glands	Milk	Feeding of young

The endocrine system is made up of a series of ductless glands that produce chemical messages called hormones (Figure 20).

Features of endocrine glands are, in general, their ductless nature, their vascularity, and usually the presence of intracellular vacuoles or granules storing their hormones.

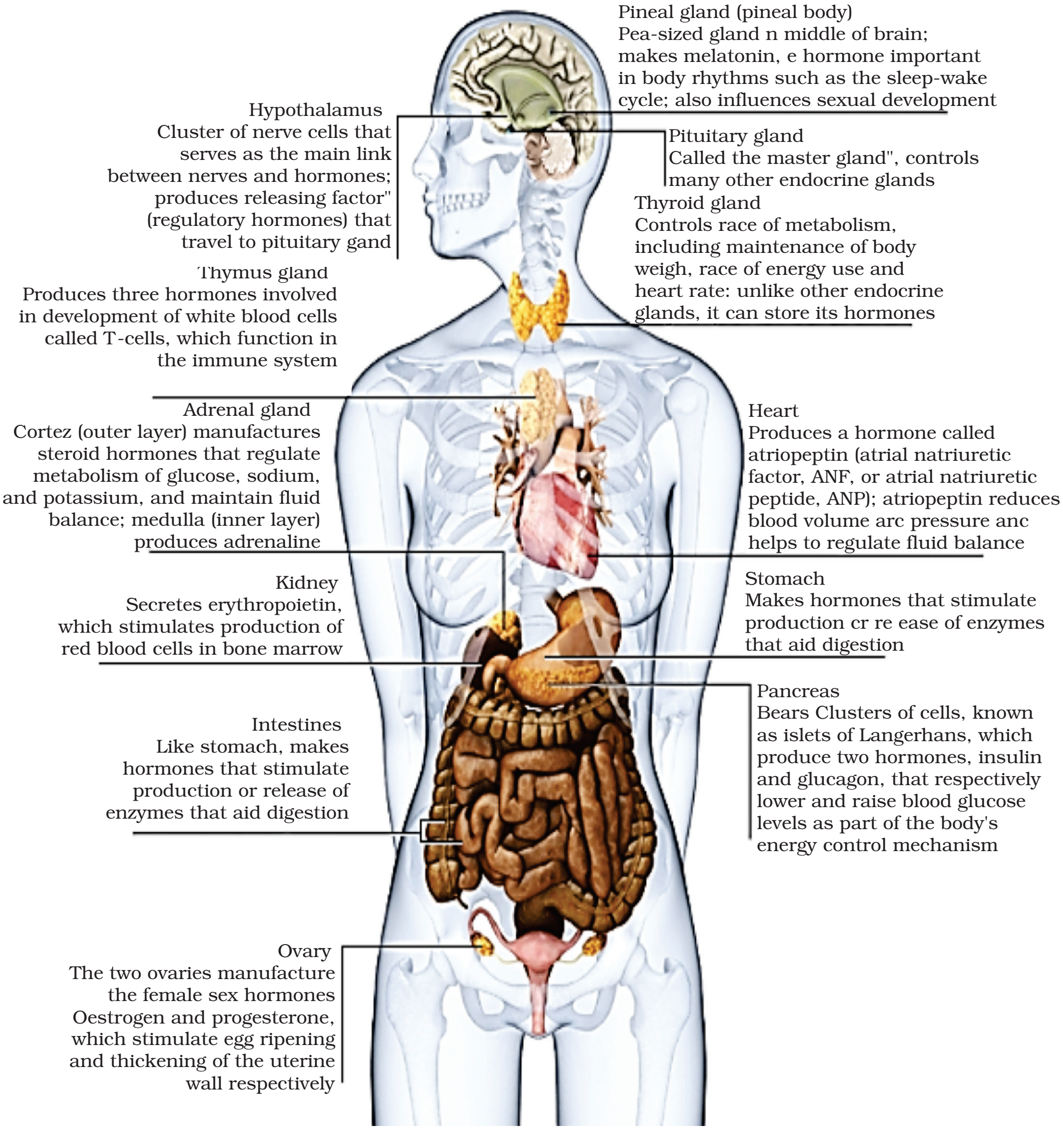


Figure 20. Endocrine glands and their function

The Endocrine system is involved in the information business. Hormones carry essential messages that have far-reaching effects. They control body processes at every level, from energy uptake of a single cell to the whole body's rate of growth and development. The endocrine glands have no ducts but secrete their hormones directly into the blood, by which means they reach every cell in the body. Hormones affect certain target tissues or organs and regulate their activities.

- The Endocrine system sends hormones through the Circulatory system to control and coordinate body functions in much the same way as the nervous system uses tiny electrical signals.
- The Endocrine system and the Nervous system work together to integrate in the brain and complement each other, but they tend to work at different speeds.
- Nerves respond within split-seconds but their action soon fades.
- Some hormones have longer lasting effects.
- and act over hours, weeks, and years.

Hormones regulate processes such as:

- The breakdown of chemical substances in metabolism of what we eat and drink
- Fluid balance and urine production
- The body's growth and development
- Sexual reproduction.

B. Main Endocrine glands

The Hypothalamus (Figure 21)

The hypothalamus and the pituitary gland are part of the diencephalon region of the brain. The hypothalamus connects the nervous system to the endocrine system. It receives and processes signals from other brain regions and pathways and translates them into hormones, the chemical messengers of the endocrine system. These hormones flow to the pituitary gland, which is connected to the hypothalamus by the infundibulum. Some hormones are stored in the pituitary stores for later release; others spur it to secrete its own hormones.

The hormones released by the pituitary gland and the hypothalamus control the other endocrine glands and regulate all major internal functions.

The Hypothalamus sends hormones to the Pituitary Gland to control the endocrine system.

The Pituitary - Master Gland (Figure 22)

The pituitary is the most influential gland in the endocrine system. Its front, or anterior lobe manufactures 7 major hormones and releases them into the bloodstream.

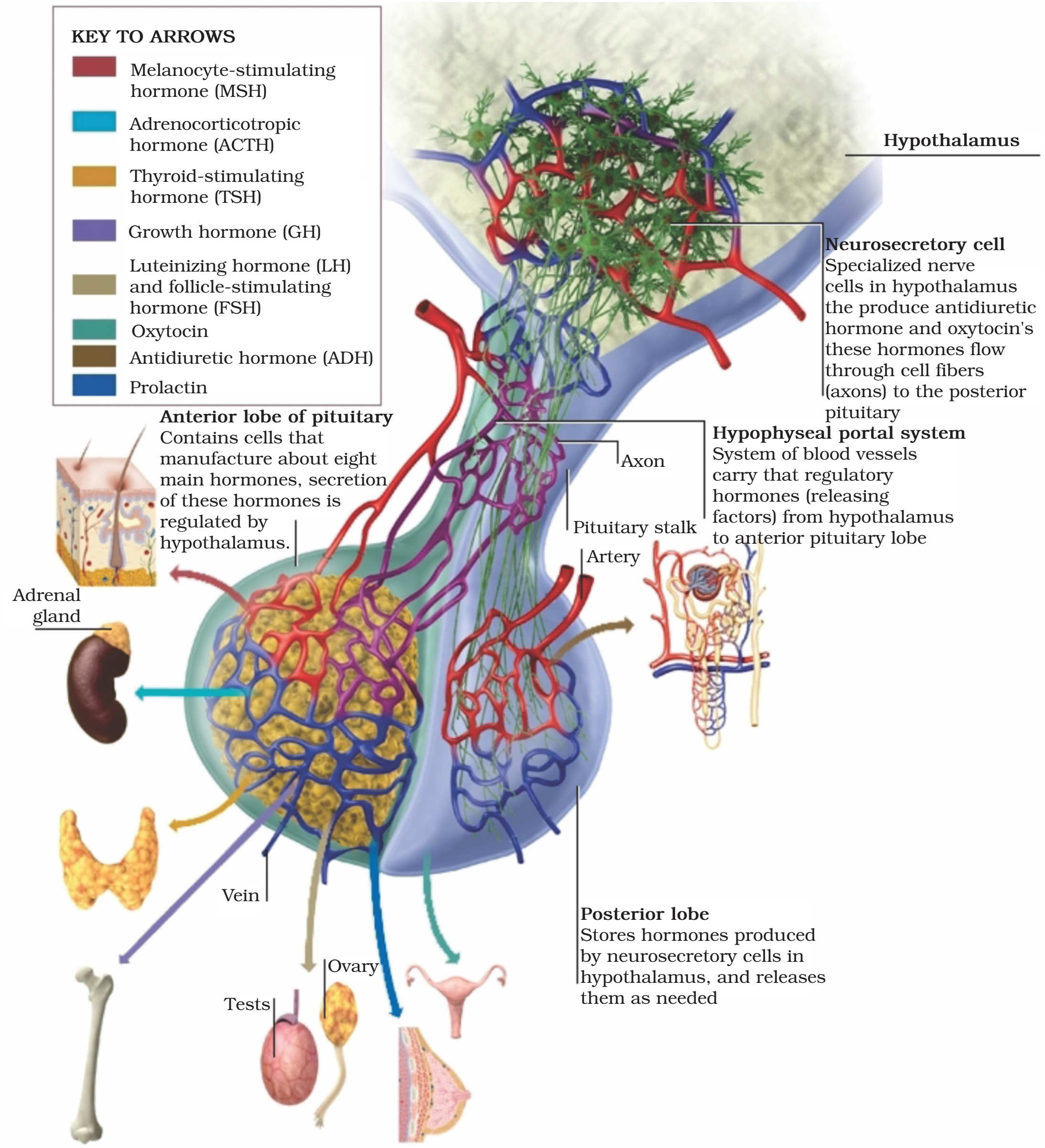


Figure 21. Hypothalamus

Behind it is the posterior (back) lobe, which receives its two main hormones from the hypothalamus, which lies above it, and then it releases 3 hormones, as shown.

It is actually two distinct glands in one.

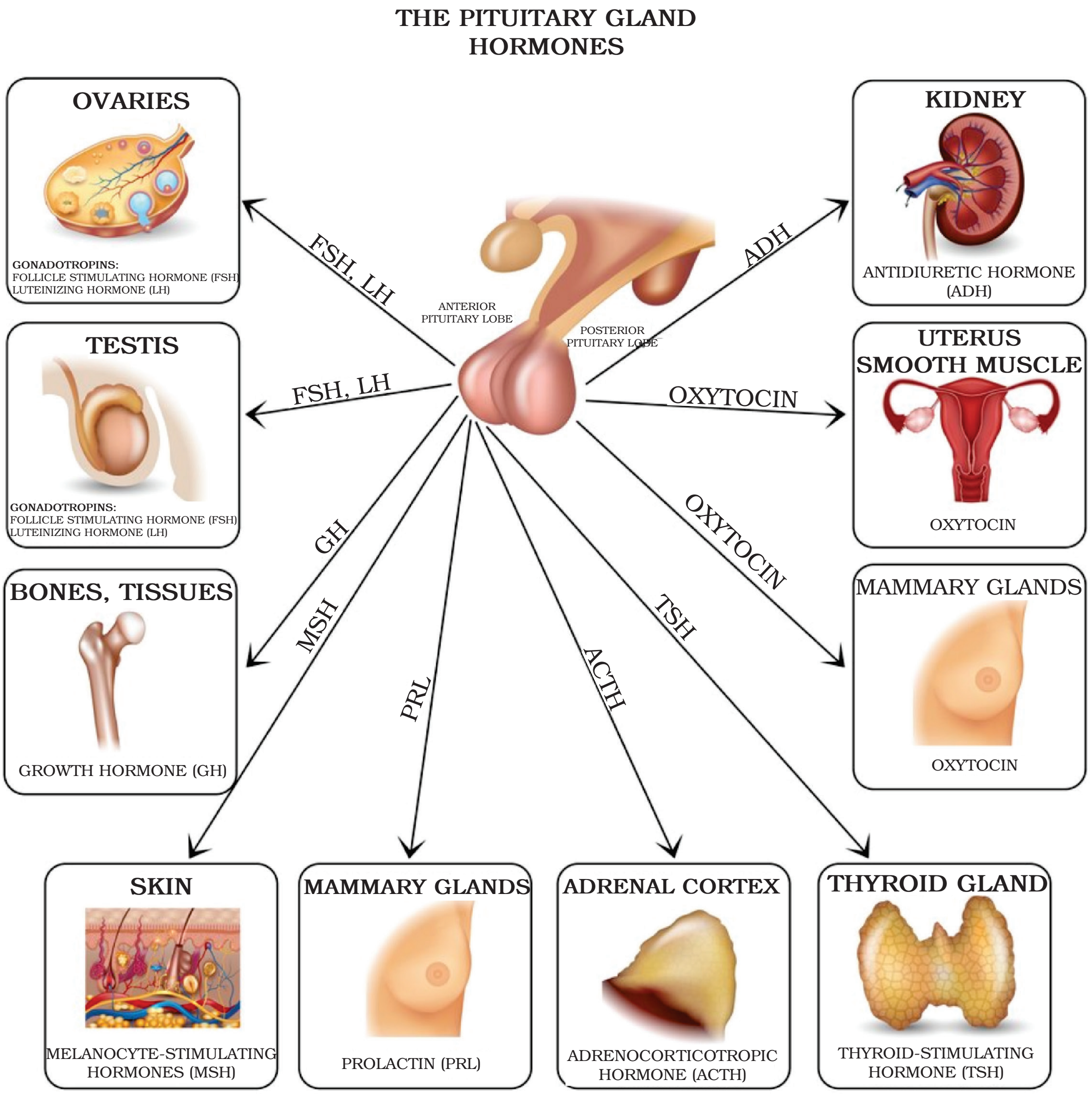


Figure 22. Pituitary Hormones

Pinealgland

The pineal gland is small and pine coneshaped, (which is how it got its name) located at the back of the diencephalon region in the brain. At night, in the absence of light, the pineal gland secretes the hormone melatonin. Melatonin regulates the body's sleep patterns in both circadian (daily) and seasonal patterns.

In the morning, when light hits the eye, photo receptors in the retina send signals to the pineal gland, which then decreases melatonin production and we wake up.

Thymus Gland (Figure 23)

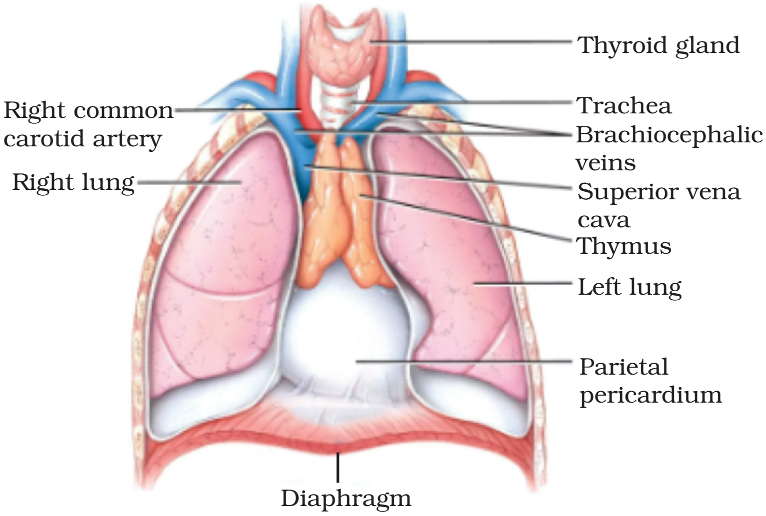


Figure 23. Position of thymus gland

The thymus gland produces progenitor cells, which mature into T-cells (thymus derived cells). The body uses T-cells to help destroy infected or cancerous cells. T-cells created by the thymus also help other organs in the immune system grow properly. These cells are so vital, they are often donated to those in need.

The Thymus gland is the primary donor of cells for the lymphatic system, such as bone marrow is the cell donor for the cardiovascular system.

Adrenal Glands (Figure 24)

The adrenal glands regulate substance levels in the blood and release "fight-or-flight" hormones. The adrenal glands are pyramid-shaped organs that sit at the top of each kidney. Each adrenal gland consists of two structures: an outer adrenal cortex and an inner adrenal medulla. The adrenal cortex is a network of fine connective tissues that makes up most of the gland. It secretes a range of steroid hormones.

Cortisol which manages protein and glucose levels. Aldosterone which adjusts our levels of water and salt.

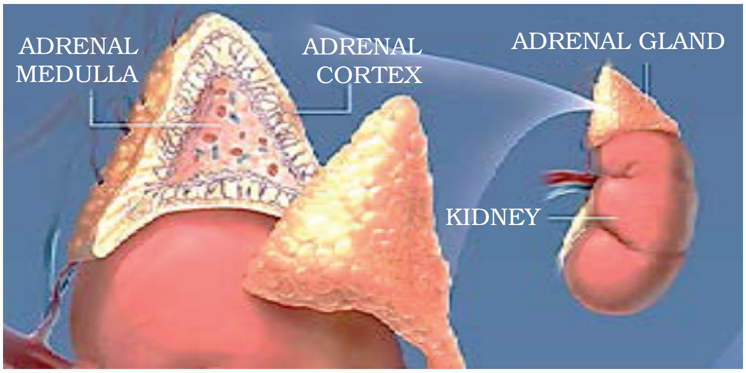


Figure 24. Adrenal Gland

Androgens and estrogens are secreted by the adrenal cortex in small amounts by both sexes. The adrenal medulla (inside the gland) produces epinephrine and nor-epinephrine (NE). These chemicals promote "fight-orflight," the body's initial response to stress.

Thyroid Gland (Figure 25)

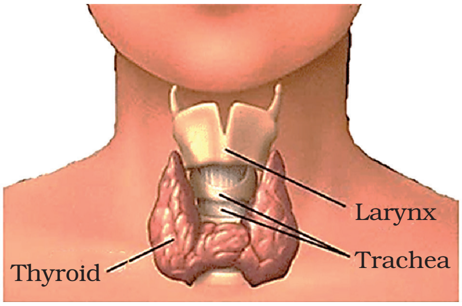


Figure 25. Thyroid Gland

The thyroid gland sits in the throat region, just below the larynx, served by large arteries with many branches and a dense network of capillaries. The hormones it secretes, travel in the bloodstream throughout the body to:

- Increase metabolism
- Regulate glucose use
- Protein synthesis
- Nervous system development.
- It also releases Calcitonin, which helps maintain blood calcium homeostasis by causing calcium to be removed from the blood

and deposited into bones when blood (calcium) levels are too high.

Parathyroid Glands (Figure 26)

On the posterior (back) surface of the thyroid sit much smaller, separate glands: the parathyroids.There are four parathyroid glands, a superior and inferior pair on the left and right sides of the thyroid. They secrete parathyroid hormone (PTH), which stimulates bones to release calcium into the blood when blood (calcium) levels are low. PTH also causes the kidneys to reduce calcium secretion into urine to further elevate calcium levels in the blood.

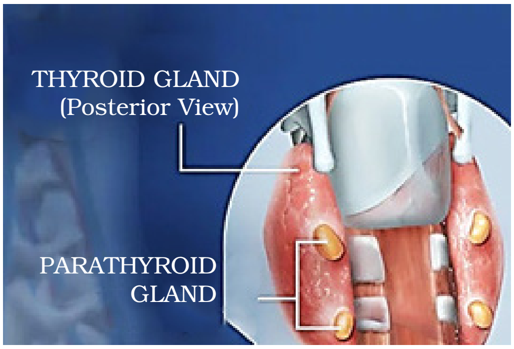


Figure 26. Thyroid - Parathyroid Glands

Together, calcitonin and PTH act in complementary ways to maintain blood calcium homeostasis, which is one of the most tightly controlled physiological parameters in the body.

Iodine is an element that is required for the thyroid gland to produce thyroid hormones.

Since the body does not produce iodine on its own, it needs to come from dietary sources - and striking the right balance is key. Your thyroid, which has tiny cells that capture the circulating iodine, takes in and oxidizes it so it can begin to be used to create T3 and T4 - thyroid hormones that make their way throughout the body to regulate metabolism and ensure healthy functioning of the heart, brain, and other organs.

5.8 The Role of other Organs as Endocrine Glands

A. Kidneys

The kidneys make two main hormones, vitamin D and erythropoietin. Vitamin D is essential for a number of different functions in the body. Most of the vitamin D that is in the blood is inactive and it is modified by the kidney and other tissues to activate it.

Active vitamin D stimulates the uptake of calcium from food, is important for the maintenance of healthy bones and also helps to regulate the response of the immune system to infection.

Erythropoietin is produced when oxygen levels in the blood are low. It acts in bone marrow to stimulate the production of mature red blood cells and to maintain healthy oxygen levels in our tissues.

B. Gonads Sex Glands and Hormones

The main sex glands are the ovaries in females and testes in males. The sex hormones, they produce stimulate the production of eggs and sperm respectively and influence the early development of the embryo into a boy or girl.

After birth, the circulating levels remain low until puberty. Then, in males, the testes increase their output of androgens (male sex hormones), such as testosterone. In females, the ovaries produce more estrogens and progesterone.

C. Gut Hormones (Figure 27)

The gut hormones work in association with the gut's extensive nervous system (enteric nervous system) and play a coordinating role in.

- The control of appetite
- The digestion of food
- The regulation of energy balance
- The maintenance of blood glucose levels.
- The gut continuously sends information to the brain regarding the quality and quantity of the food that is consumed.

Ghrelin is produced in the stomach, and its function is to tell the brain that the body has to be fed. It increases appetite.

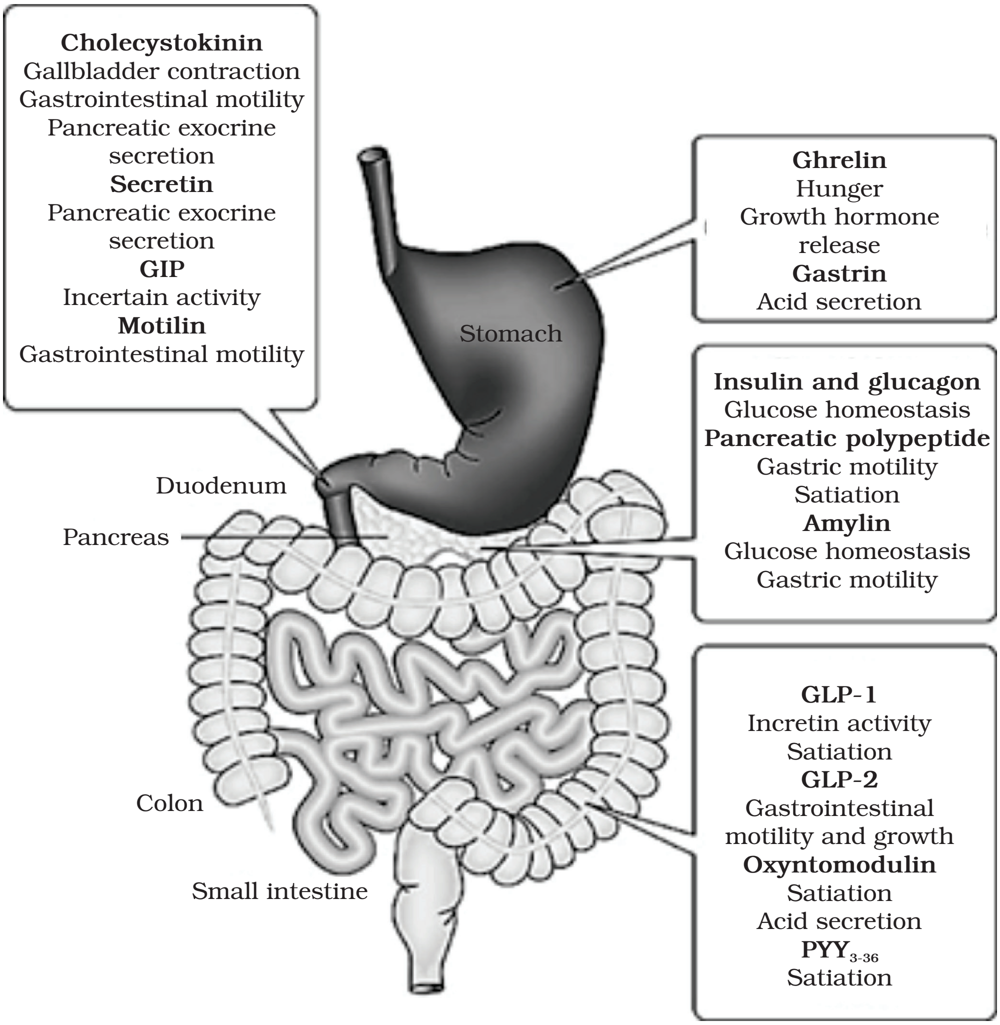


Figure 27. Gut Hormones

Gastrin is produced in the stomach when it is stretched. It stimulates the release of gastric juice rich in pepsin and hydrochloric acid.

Secretin is produced in the duodenum and has the effect of stimulating the pancreas to produce alkaline secretions as well as slowing the emptying of the stomach.

Cholecystokinin (CCK) is produced in the duodenum. It reduces appetite, slows down the emptying of the stomach and stimulates the release of bile from the gall bladder. Peptide YY (PYY) is produced in the last part of the small intestine known as the ileum as well as parts of the large intestine.

It plays a role in slowing down the passage of food along the gut, which increases the efficiency of digestion and nutrient absorption after meal. Glucagon-like peptide 1 (GLP-1) is produced in the small intestine and colon and has multiple actions including inhibition of gastric emptying and appetite as well as the stimulation of insulin release.

D. Pancreas – a dual-purpose gland (Figure 28)

It is also a part of the digestive system.

It excretes pancreatic juice into the small intestine via the pancreatic duct. Scattered within the pancreas there are also tiny cell clusters called pancreatic islets (or islets of Langerhans) that release hormones into the bloodstream.

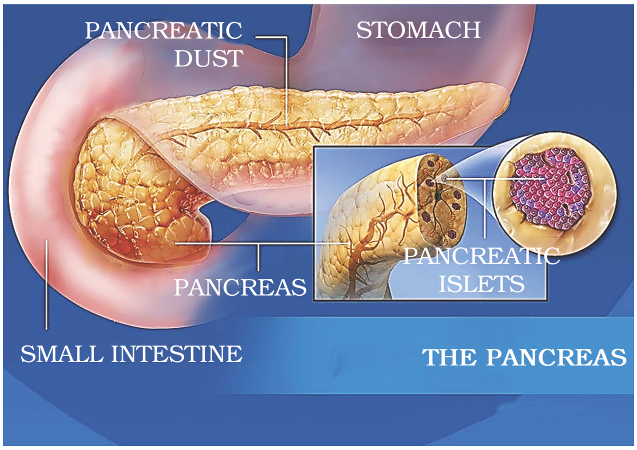


Figure 28. The Pancreas

These islets make up less than 2% of pancreatic tissue, but their specialized cells regulate blood glucose levels (or blood sugar).

When blood sugar is low, alpha cells in the islets release glucagon.

Glucagon spurs the liver to break down glycogen and release more glucose into the blood.

When blood sugar is high, beta cells in the islets release insulin, which increases glucose reabsorption.

5.9 Hermon Defections Disease

Dwarfism is due to deficiency of growth stimulating hormone secreted by the pituitary gland.

Cretinism is due to lack of thyroxine hormone in childhood causing slow physical and mental growth.

Diabetes is due to the lack of insulin hormone causing increased glucose in blood and its removal with urine.

Exercise

1. Most hormones travel from the gland where they were produced to the tissues and cells which they act upon:
   (a) Along nerve fibres
   (b) Via synapses
   (c) In the bloodstream
   (d) In ducts
2. What type of signalling occurs when neurons release chemical signal molecules which influence the activity and behavior of neighbouring neurons?
   (a) Autocrine
   (b) Synaptic
   (c) Endocrine
   (d) Neurocrine
3. G-proteins (guanine nucleotide-binding proteins) are molecules involved in the transmission of hormonal signals from outside a cell to the interior by means of a process called signal:
   (a) Transduction
   (b) Conduction
   (c) Targeting
   (d) Local signalling
4. The gland that secretes the hormone that determines the basal rate of metabolism and normal growth is located in the:
   (a) Bbrain
   (b) Neck
   (c) Pelvis
   (d) On top of the kidneys.

Key Terms

- Stimulus
- Polarization
- Depolarization
- Synapse

- Reflex arc
- Neurotransmitter
- Olfactors receptors
- Abuse
- Stimulant
- Sedative
- Hallucinogens
- Geneder based violence
- Addiction
- Gender
- Sex
- Miscarrage
- Abortion
- Substance abuse
- Exocrine glands
- Endocrine glands
- Hormones

SUMMARY

The nervous system and the endocrine system are involved in coordinating body functions. The sense organs are also participating to keep in touch with the environment.

The nervous system and endocrine system work together to maintain normal body functioning. The nervous system work through electrical currents in the form of nerve impulses, while the endocrine system work through chemical substances known as hormones.

Parts of the eye and their function

Part of Eye	Function
Lens	Refracts and focuses light rays
Iris	Regulates light entrance
Pupil	Admits light
Choroid	Absorbs stray light
Sclera	Protects the eye ball
Cornea	Refracts light rays
Aqueous humor	Maintain shape of the eye & provide nutrients.

Vitreous humor	Maintains spherical shape of eye by pressure help accommodation.
Ciliary muscles	Held lens in position
Retina	Contains receptors – rods and cons
Rods	Receptors for black and white vision
Cons	Receptors for colour vision
Fovea centralize (Yellow spot)	Sensitive part of the retina, most sensitive part.
Blind spot	Point where optic nerve leaves, no sensory cells.
Optic nerve	Nerve joining eye to CNS.

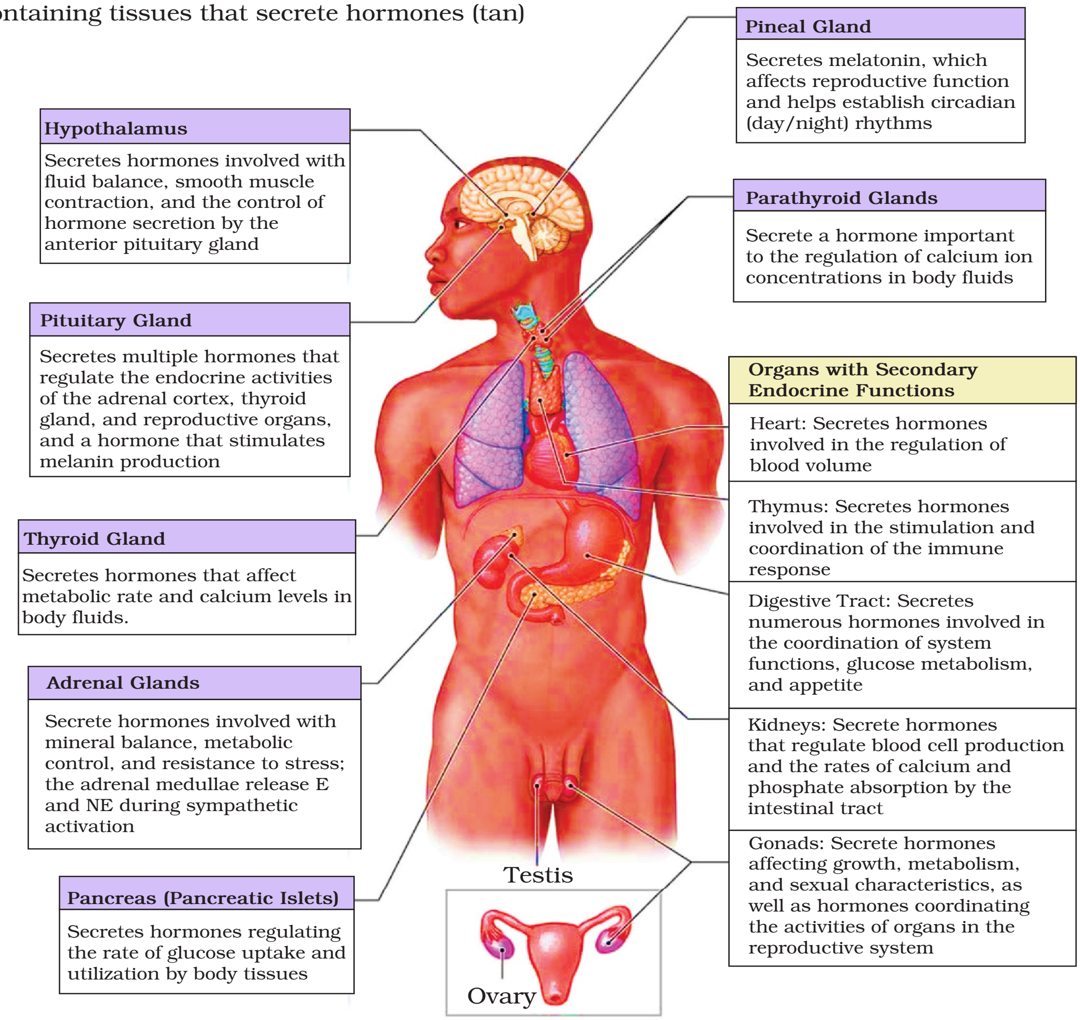
The main functions of the human ear are in sensing sound and changes in the body position in maintaining balance. The ear is divided in to three parts; outer, middle and inner ear.

Nervous System	Endocrine System
localized effects: cell to cell	widespread effects: throughout body
targets: neurons, muscle cells or glands	targets: all organs and tissues
transmission by nerve impulses	transmission as hormone through blood
uses chemical signals only cell to cell	uses only chemical signals
immediate response (ms to seconds)	gradual response (seconds to hours)
short lived (ms to minutes)	longer lived (minutes to days)
Both both involved in coordination & control both produce biologically active chemicals some parts of brain are glands/some glands are nervous tissue some responses begin as nervous reflex and end as hormonal responses	

A chemical is considered a hormone if it is secreted and transported in the blood same chemical can also be a neurotransmitter, or lymphokine, etc the major hormones are secreted from ductless glands directly into blood.

A summary about the endocrine system.

Organs of the endocrine system (purple) and other organs containing tissues that secrete hormones (tan)



Review Exercise

Select the appropriate hormone from the table to complete the statements below.

The anterior pituitary gland hormone A

Prolactin	Cortisol	Growth hormone (GH)	Adrenaline	Leptin	Gonadotrophin releasing hormone (GnRH)
Parathyroid hormone (PTH)	Antidiuretic hormone (ADH)	Aldosterone	Thyroxine	Oxytocin	Glucagon

1. The anterior pituitary gland hormone ACTH regulates the production and secretion of the glucocorticoid hormone --------------from the adrenal cortex.
2. -----which tells the kidneys how much water to conserve – is called a neurohormone because it is made by neurons in the hypothalamus and stored in the posterior pituitary gland before it is released.
3. There are four parathyroid glands, each about the size of a grain of rice, embedded in the thyroid gland and they make and secrete, -----------which plays a part in calcium homeostasis.
4. ------------ and are essential for normal growth and development
5. Dopamine inhibits the release of ----------, which is the hormone responsible for stimulating breast development and milk production.
6. Alpha cells in the pancreas secrete----------- to protect the body from hypoglycemia.
7. A key hormone from the hypothalamus called ----------- stimulates the onset of puberty and sexual development in adolescent boys and girls.
8. -----------stimulates the uterus to contract at the end of pregnancy and is essential for the let-down reflex in breastfeeding mothers.
9. When a person is frightened or anxious, the sympathetic nervous system stimulates the adrenal medulla to secrete -----------.
10. Adipocytes (fat cells) produce the hormone ------------ which is sometimes known as the “satiety hormone”.
11. The adrenal gland makes the hormone -------- , whose function is stimulating sodium and water reabsorption in the distal tubules of nephrons in the kidney.

Sample Test

1. The two main divisions of the central nervous system are:
   (a) Nerves and neurons
   (b) Cerebral cortex and cerebrospinal fluid

(c) Brain and spinal cord
(d) Spinal cord and nerves

2. Which of the following divisions is NOT a part of the Peripheral Nervous System?
(a) Brainstem
(b) Sympathetic
(c) Parasympathetic
(d) Sensory
3. The cells within the nervous system that transmit action potentials are:
(a) Axons
(b) Glial cells
(c) Dendrites
(d) Neurons
4. The enteric nervous system is a network of neurons that function to:
(a) Control gi motility and secretions
(b) Regulate reproductive function in men and women
(c) Control micturition – the elimination of urine
(d) Adjust the heart rate and cardiac output to match the body's needs
5. The thin, branched processes of a neuron, whose main function is to receive incoming signals, are called:
(a) Terminals
(b) Cell bodies
(c) Axons
(d) Dendrites
6. The nervous system and endocrine system are structurally related. Which of the following cells best illustrates this relationship?
(a) A neuron in the spinal cord.
(b) A neurosecretory cell in the hypothalmus.
(c) A brain cell in the celebral cortex.
(d) A steroid - secreting cell in the adrenal cortex.
7. How many lobes are in each cerebral hemisphere?
(a) Two
(b) Three
(c) Four
(d) Five

8. How many pairs of cranial nerves originate within the brain?
   (a) Two
   (b) Four
   (c) Eight
   (d) Twelve
9. Impulses (action potentials) pass from one neuron to another at a microscopic gap, called a synapse, where they trigger release of chemical signal molecules, called:
   (a) Neurotransmitters
   (b) Prostaglandins
   (c) Second messengers
   (d) Cytokines
10. Which of the following chemical substances is NOT an example of a neurotransmitter?
    (a) Acetylcholine
    (b) Glucose
    (c) Dopamine
    (d) Noradrenaline
11. The function of the myelin sheath found on myelinated neurons is to:
    (a) Nourish them
    (b) Insulate them
    (c) Protect them
    (d) Support them
12. A reflex action is a pathway that typically involves several neurons and mediates an action:
    (a) That has to be learned
    (b) That involves conscious thought
    (c) Involuntary response to a stimulus
    (d) Intention to make a voluntary movement
13. The posterior pituitary gland is sometimes called the neurohypophysis and it secretes which neurohormones?
    (a) Calcitonin and parathyroid hormone (PTH)
    (b) Adrenaline and cortisol
    (c) Antidiuretic hormone (ADH) and oxytocin
    (d) Testosterone and oestrogen

14. Which hormone is produced in the hours of darkness and encourages sleep?
    (a) Insulin
    (b) Angiotensin
    (c) Leptin
    (d) Melatonin
15. The exocrine cells of the pancreas produce:
    (a) Adrenaline
    (b) Insulin
    (c) Cortisol
    (d) Digestive juices
16. Which hormone is primarily responsible for uptake of glucose from blood by cells?
    (a) Insulin
    (b) Angiotensin
    (c) Leptin
    (d) Melatonin
17. The hypothalmus controls the anterior pituitary by means of _ .
    (a) Releasing hormones
    (b) Cytokines
    (c) Secreting enzymes
    (d) Electrical impulses
18. Which of the following hormones are produced and secreted by the adrenal medulla?
    (a) Adrenaline and noradrenaline
    (b) Insulin and glucagon
    (c) Calcitonin and parathyroid hormone (PTH)
    (d) Aldosterone and cortisol
19. Which hormone from the anterior pituitary gland regulates the release of corticosteroid hormones from the adrenal cortex?
    (a) Growth Hormone
    (b) Adrene cortico - trophic Hormone
    (c) Follicle stimulating Hormone
    (d) Luteinizing Hormone

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CHAPTER 6

ECOLOGY (NATURAL RESOURCES AND POLLUTION) AND HEALTH

Chapter Contents

6.1 Natural Resources
6.2 Abused Drugs and Health
6.3 Waste and Wastewater (Sewage) Treatment
6.4 Water
- Key Terms
- Summary
- Review Exercise
- Sample Test 1
- Sample Test 2

Chapter Outcomes

Upon completion of this chapter, learners will be able to:

- explain the concept of natural resources;
- discuss the importance of natural resources;
- distinguish between renewable and nonrenewable natural resources;
- explain methods of conserving natural resources;
- explain preserving the ecosystem as an approach to natural resource management;
- explain the term pollution Discuss the causes, effects and control methods of pollution;
- explain the importance of immunization as a means of preventing human diseases;
- explain the importance of personal health as well as community health;
- state the dangers posed by drugs, alcoholic beverages and smoking;
- define and the term sewage disposal and discuss methods of sewage disposal;
- identify economic uses of sewage;
- discuss sources of water, modes of contamination and methods of purification;
- discuss methods of refuse collection and disposal;
- state the importance of first aid and be able to treat a number of conditions.

Introduction

Our environment provides us with a variety of goods and services necessary for our day-to-day lives.

These natural resources include, air, water, soil, minerals, along with the climate and solar energy, which form the non-living or 'abiotic' part of nature.

The 'biotic' or living parts of nature consists of plants and animals, including microbes. Plants and animals can only survive as communities of different organisms, all closely linked to each in their own habitat, and requiring specific abiotic conditions. Thus, forests, grasslands, deserts, mountains, rivers, lakes and the marine environment all form habitats for specialized communities of plants and animals to live in.

Interactions between the abiotic aspects of nature and specific living organisms together form ecosystems of various types.

Many of these living organisms are used as our food resources. Others are linked to our food less directly, such as pollinators and dispersers of plants, soil animals like worms, which recycle nutrients for plant growth, and fungi and termites that break up dead plant material so that micro-organisms can act on the detritus to reform soil nutrients.

The environment is defined as all the external conditions, circumstances, and influences surrounding and affecting the growth and development of an organism or a community of organisms.

In order to fully understand environmental concerns that threaten our health, we must understand how we interact with our environment. The study of how living things interact with each other and their environment is called **Ecology,** and the zone of the earth where life is found is known as the **Biosphere.**

6.1 Natural Resources

A. Natural Resources

Natural resources (economically referred to as land or raw materials) occur naturally within environments that exist relatively undisturbed by mankind, in a natural form. A natural resource is often characterized by amounts of biodiversity existent in various ecosystems.

The resources on which mankind is dependent are provided by various sources or 'spheres'.

1. **Atmosphere**
2. **Hydrosphere**
3. **Lithosphere**
4. **Biosphere**

Natural cycles between the spheres:

All four spheres are closely inter-linked systems and are dependent on the integrity of each other. Disturbing one of these spheres in our environment affects all the others.

The linkages between them are mainly in the form of cycles. For instance, the atmosphere, hydrosphere and lithosphere are all connected through the hydrological cycle.

Natural resources are derived from the environment. Many of them are essential for our survival while others are used for satisfying our wants. Natural resources may be further classified in different ways.

Renewable and Nonrenewable Natural Resources

Ecosystems act as resource producers and processors.

Solar energy is the main driving force of ecological systems, providing energy for the growth of plants in forests, grasslands and aquatic ecosystems.

A forest recycles its plant material slowly by continuously returning its dead material, leaves, branches, etc. to the soil.

Grasslands recycle material much faster than forests as the grass dries up after the rains are over every year.

All the aquatic ecosystems are also solar energy dependent and have cycles of growth when plant life spreads and aquatic animals breed. The sun also drives the water cycle.

With respect to renewability, natural resources can be categorized as renewable and nonrenewable:

Non-renewable resources

Non-renewable resources are formed over very long geological periods. Minerals and fossils are included in this category. Since their rate of formation is extremely slow, they cannot be replenished once they are depleted. Out of these, the metallic minerals can be re-used by recycling them.

Renewable resources

Renewable resources are the ones, which can be replenished or reproduced easily. Some of them, like sunlight, air, wind, etc., are continuously available and their quantity is not affected by human consumption.

Many renewable resources can be depleted by human use, but may also be replenished, thus maintaining a flow.

Some of these, like agricultural crops, take a short time for renewal; others, like water, take a comparatively longer time, while still others, like forests, take even longer.

Though water and biological living resources are considered renewable. They are in fact renewable only within certain limits. They are linked to natural cycles such as the water cycle.

- Fresh water (even after being used) is evaporated by the sun's energy, forms water vapour and is reformed in clouds and falls to earth as rain. However, water sources can be overused or wasted to such an extent that they locally run dry. Water sources can be so heavily polluted by sewage and toxic substances that it becomes impossible to use the water.
- Forests, once destroyed take thousands of years to regrow into fully developed natural ecosystems with their full complement of species. Forests thus can be said to behave like non-renewable resources if overused.
- Fish are today being over-harvested until the catch has become a fraction of the original resource and the fish are incapable of breeding successfully to replenish the population.
- The output of agricultural land if mismanaged drops drastically.
- When the population of a species of plant or animal is reduced by human activities, until it cannot reproduce fast enough to maintain a viable number, the species becomes extinct.
- Many species are probably becoming extinct without us even knowing, and other linked species are affected by their loss.

All ecosystems consist of biotic & abiotic components. Interactions occurring between these parts are essential to make it function as one unit. Solar energy is an important abiotic component of nearly every ecosystem.

What is recycled within an ecosystem?

Chemicals cannot be created or destroyed, but they can be changed from one form to another

What is a recycling?

- Shows the flow of chemicals between the environment and organisms in it
- It is essential for the survival of all ecosystems
- Recycles matter over & over again
- Carbon-oxygen cycle, nitrogen cycle, mineral cycle (rock or phosphorus cycle), & the hydrologic cycle (water cycle)

B. Conservation of Natural Resources

Conservation goals commonly expressed by environmental scientists include:

- Reduction and clean up of pollution, with future goals of zero pollution
- Cleanly converting non-recyclable materials into energy through direct combustion or after conversion into secondary fuels
- Reducing societal consumption of non-renewable fuels
- Development of alternative, green, low-carbon or renewable energy sources
- Conservation and sustainable use of scarce resources such as water, land, and air
- Protection of representative or unique or pristine ecosystems
- Preservation of threatened and endangered species extinction
- The establishment of nature and biosphere reserves under various types of protection; and, most generally, the protection of biodiversity and ecosystems upon which all human and other life on earth depends

Very large development projects - megaprojects - pose special challenges and risks to the natural environment. Major dams and power plants are cases in point. The challenge to the environment from such projects is growing because more and bigger megaprojects are being built, in developed and developing nations alike.

Conservation is an ethic of resource use, allocation, and protection. Its primary focus is upon maintaining the health of the natural world:

- Its forests,
- Fisheries,
- Habitats, and
- Biological diversity.

Secondary focus is on materials conservation and energy conservation, which are seen as important to protect the natural world.

Life in general and human beings in particular depends for its existence on:

- the atmosphere, which includes air
- the hydrosphere, including rivers, lakes and oceans
- the lithosphere, from which the soil has been derived.

These three spheres are intimately interwoven. They interact in a delicately controlled and orderly manner. If any one of the three spheres, is abused, or destroyed, the resulting damage is likely to be transmitted to the other two components also.

Resource exploitation mainly affects non-renewable resources, while pollution as a result of human production activity, affects renewable resources.

Resource exploitation and pollution are inter linked since the exploitation of resources in one area can become environmental pollution or degradation in a very far away area.

Any adverse effect or disturbance of the delicate balance of the environment, caused by man's careless or excessive exploitation of natural resources, can lead to the creation of unfavorable conditions for the well being or even survival of humankind.

Of the various activities of man, that affect the environment, the two most important ones are:

(a) resource utilization for production, and
(b) waste disposal

A proper balance should be kept for healthy environment. In the present conditions, what is desired is not so much the ability of human being to conquer nature, but rather a balanced and harmonious collaboration with natural conditions.

Conservation therefore, means the optimum and sustainable, utilization of natural resources without disturbing the delicate balance of the environment. The ultimate goal of conservation should be to manage the environment in such a way that it can contribute to man's happiness, health, enjoyment, and well-being.

Biological diversity or biodiversity refers to the variety (multiplicity) of life, habitats and landscapes in ecosystems. Biodiversity is the variation of life forms within a given ecosystem, biome, or for the entire Earth. Biodiversity is often used as a measure of the health of biological systems.

Biologists most often define "biological diversity" or "biodiversity" as the "totality of genes, species, and ecosystems of a region". Three levels at which biological variety has been identified are:

- **genetic diversity**
- **species diversity**
- **ecosystem diversity**

Conserving biodiversity

There is a relationship between biodiversity, ecosystem services, human well-being, and poverty.

The conservation ethic differs from the preservationist ethic, which advocate for protected areas devoid of human exploitation or interference for profit. The conservation ethic advocates for wise stewardship and management of natural resource production for the purpose of protecting and sustaining biodiversity in species, ecosystems, the evolutionary process, and human culture and society.

Recycling

Recycling is the collection and reprocessing of a resource so that it can be reused for the same or another purpose. This process conserves resources, energy, and sanitary landfill space.

One form of recycling, composting, can be done at home, since it does not require special knowledge or equipment. In composting, waste is recycled through a natural process of aerobic biodegradation during which microorganisms convert organic plant and animal matter into compost that can be used as a mulch or fertilizer. Composting can be done by individuals or on a community-wide basis.

Reduce

- Reduce the amount of unnecessary packaging.
- Adopt practices that reduce waste toxicity.

Reuse

- Consider reusable products.
- Maintain and repair durable products.
- Reuse bags, containers, and other items.
- Borrow, rent, or share items used infrequently.
- Sell or donate goods instead of throwing them out.

Recycle

- Choose recyclable products and containers and recycle them.
- Select products made from recycled materials.
- Compost yard trimmings and some food scraps.

Respond

- Educate others on source reduction and recycling practices. Make your preferences known to manufacturers, merchants, and community leaders.
- Be creative—find new ways to reduce waste quantity and toxicity.

Exercises

1. What is hydrosphere?
2. Name 2 non - renewable resources.
3. Name 2 renewable resources.
4. Name alternative renewable energy resources.
5. What are the common nutrient cycles.

C. Pollution

Pollution is the introduction of contaminants into the natural environment that causes adverse change. Pollution can take the form of chemical substances or energy, such as noise, heat or light. Pollutants, the components of pollution, can be either foreign substances/energies or naturally occurring contaminants.

"Environmental pollution is defined as "the contamination of the physical and biological components of the earth/atmosphere system to such an extent that normal environmental processes are adversely affected.

D. Types of Pollution

Pollution may be of the following types:

- Air pollution
- Noise pollution
- Water pollution
- Soil pollution
- Thermal pollution
- Radiation pollution

Air and Noise pollution:

Air pollution

"Air pollution refers to the release of pollutants into the air that are detrimental to human health and the planet as a whole."

Air pollution is a mixture of solid particles and gases in the air. Car emissions, chemicals from factories, dust, and pollen and mold spores may be suspended as particles. Ozone, a gas, is a major part of air pollution in cities. When ozone forms air pollution, it's also called smog. Some air pollutants are poisonous. "Air pollution occurs when harmful or excessive quantities of substances are introduced into Earth's atmosphere.

Sources of air pollution include gases, particulates, and biological molecules." A primary pollutant is an air pollutant emitted directly from a source.

A secondary pollutant is not directly emitted as such, but forms when other pollutants (primary pollutants) react in the atmosphere.

The primary pollutants are "directly" emitted from the processes such as fossil fuel consumption, volcanic eruption and factories. The major primary pollutants are Oxides of Sulphur, Oxides of Nitrogen, Oxides of Carbon, Particulate Matter, Methane, Ammonia, Chlorofluorocarbons, Toxic metals etc.

The secondary pollutants are not emitted directly. The secondary pollutants form when the primary pollutants react with themselves or other components of the atmosphere. Most important secondary level Air Pollutants are Ground Level Ozone, Smog and POPs (Persistent Organic Pollutants).

Effects of Air Pollution:

The hazardous effects of air pollution on the environment include:

- **Diseases:**

  Air pollution has resulted in several respiratory disorders and heart diseases among humans.

  The cases of lung cancer have increased in the last few decades. Children living near polluted areas are more prone to pneumonia and asthma.

- **Global Warming:**

  Due to the emission of greenhouse gases, there is an imbalance in the gaseous composition of the air. This has led to an increase in the temperature of the earth. This increase in earth's temperature is known as Global warming.

- **Acid Rain:**

  The burning of fossil fuels releases harmful gases such as nitrogen oxides and

  sulphur oxides in the air. The water droplets combine with these pollutants, become acidic, and fall as acid rain which damages human, animal and plant life.

- **Ozone Layer Depletion**:

  The release of chlorofluorocarbons (CFC), halons, and hydro chlorofluorocarbons in the atmosphere is the major cause of depletion of the ozone layer. The depleting ozone layer does not prevent the harmful ultraviolet rays coming from the sun and causes skin diseases and eye problems among individuals.

- **Effect on Animals:**

  The air pollutants suspend on the water bodies and affect the aquatic life. Pollution also compels the animals to leave their habitat and shift to a new place.

Noise pollution

Noise is one of the most pervasive pollutant. A musical clock may be nice to listen during the day, but may be an irritant during sleep at night. Noise by definition is "sound without value" or "any noise that is unwanted by the recipient".

Noise in industries such as:

- Stone cutting and crushing,
- Steel forgings,
- Loudspeakers,
- Shouting by hawkers selling their wares,
- Movement of heavy transport vehicles, railways and airports

Such noises leads to irritation and an increased blood pressure, loss of temper, decrease in work efficiency, loss of hearing which may be first temporary but can become permanent if the noise stress continues.

It is therefore of utmost importance that excessive noise is controlled. Noise level is measured in terms of decibels (dB). W.H.O. (World Health Organization) has prescribed optimum noise level as 45 dB by day and 35 dB by night. Anything above 80 dB is hazardous.

Sources of noise pollution

Noise pollution is a growing problem. All human activities contribute to noise pollution to varying extent. Sources of noise pollution are many and may be located indoors or outdoors.

Indoor sources include noise produced by radio, television, generators, electric fans, air coolers, air conditioners, different home appliances, and family conflict.

Noise pollution is more in cities due to a higher concentration of population and industries and activities such as transportation.

Noise like other pollutants is a by product of industrialization, urbanization and modern civilization.

Outdoor sources of noise pollution include indiscriminate use of loudspeakers, industrial activities, automobiles, rail traffic, aeroplanes and activities such as those at market place, religious, social, and cultural functions, sports and political rallies.

In rural areas farm machines, pump sets are main sources of noise pollution. During festivals, marriage and many other occasions, use of fire crackers contribute to noise pollution.

Effects of noise pollution

Noise pollution is highly annoying and irritating. Noise disturbs sleep, causes hypertension (high blood pressure), emotional problems such as aggression, mental depression and annoyance. Noise pollution adversely affects efficiency and performance of individuals.

Prevention and control of noise pollution

Following steps can be taken to control or minimize noise pollution-

- Road traffic noise can be reduced by better designing and proper maintenance of vehicles.
- Noise abatement measures include creating noise mounds, noise attenuation walls and well maintained roads and smooth surfacing of roads.
- Retrofitting of locomotives, continuously welded rail

track, use of electric locomotives or deployment of quieter rolling stock will reduce noises emanating from trains.

- Air traffic noise can be reduced by appropriate insulation and introduction of noise regulations for take off and landing of aircrafts at the airport.
- Industrial noises can be reduced by sound proofing equipment like generators and areas producing lot of noise.
- Power tools, very loud music and land movers, public functions using loudspeakers, etc should not be permitted at night.
- Use of horns, alarms, refrigeration units, etc. is to be restricted.
- Use of firecrackers which are noisy and cause air pollution should be restricted.
- A green belt of trees is an efficient noise absorber.

Water and Thermal pollution:

Water pollution is the contamination of water bodies, usually as a result of human activities.

Water bodies include for example

- lakes,
- rivers,
- oceans,
- aquifers and
- Groundwater.

Water pollution results when contaminants are introduced into the natural environment.

"Water is essential to life. It need not be spelt out exactly how important it is.

Yet water pollution is one of the most serious ecological threats we face today."

Water pollution happens when toxic substances enter water bodies such as lakes, rivers, oceans and so on, getting dissolved in them, lying suspended in the water or depositing on the bed. This degrades the quality of water. Not only does this spell disaster for aquatic ecosystems, the pollutants also seep through and reach the groundwater, which might end up in our households as contaminated water we use in our daily activities, including drinking.

Sources of Water Pollution:

Point and non-point sources:

1. When pollutants are discharged from a specific location such as a drain pipe carrying industrial effluents discharged directly into a water body, it represents point source pollution
2. Non-point sources include discharge of pollutants from diffused sources or from a larger area such as runoff from agricultural fields, grazing lands, constriction site, abandoned mines and pits, etc.

Causes of Water Pollution:

The causes of water pollution vary and may be both natural and anthropogenic. However, the most common causes of water pollution are the anthropogenic ones, including:

Agrochemicals:

Agrochemicals like fertilizers (containing nitrates and phosphates) and pesticides (insecticides, fungicides, herbicides etc.) washed by rainwater and surface runoff pollute water.

Storm water runoff:

Carrying various oils, petroleum products, and other contaminants from urban and rural areas (ditches). These usually forms sheens on the water surface.

Sewage:

Emptying the drains and sewers in fresh water bodies causes water pollution. The problem is severe in cities.

Mining activities:

Mining activities involve crushing rocks that usually contain many trace metals and sulfides. The leftover material from mining activities may easily generate sulfuric acid in the presence of precipitation water.

Industrial Effluents:

Industrial wastes containing toxic chemicals, acids, alkalis, metallic salts, phenols, cyanides, ammonia, radioactive substances, etc., are sources of water pollution. They also cause thermal (heat) pollution of water.

Burning of fossil fuels:

The emitted ash particles usually contain toxic metals (such as As or Pb).

Burning will also add a series of oxides including carbon dioxide to air and, respectively, water bodies.

Leaking landfills:

May pollute the groundwater below the landfill with a large variety of contaminants (whatever is stored by the landfill).

Animal waste:

Contribute to the biological pollution of water streams. Think of it this way: anything that can cause air pollution or soil pollution may also affect water bodies and cause innumerable ecological and human health issues

Effects of water pollution:

The effects of water pollution are varied. They include

- Poisonous drinking water
- Poisonous food of animals (due to these organisms having bio accumulated toxins from the environment over their life spans)
- Unbalanced river and lake ecosystems that can no longer support full biological diversity
- Deforestation from acid rain, and many other effects

Control of Water Pollution:

- Water pollution, to a larger extent, can be controlled by a variety of methods. Rather than releasing sewage waste into water bodies, it is better to treat them before discharge.
- Practicing this can reduce the initial toxicity and the remaining substances can be degraded and rendered harmless by the water body itself.
- If the secondary treatment of water has been carried out, then this can be reused in sanitary systems and agricultural fields.
- A very special plant, the Water Hyacinth can absorb dissolved toxic chemicals such as cadmium and other such elements. Establishing these in regions prone to such kinds of pollutants will reduce the adverse effects to a large extent.
- Some chemical methods that help in the control of water pollution are precipitation, the ion exchange process, reverse, and coagulation.
- As an individual, reusing, reducing, and recycling wherever possible will advance a long way in overcoming the effects of water pollution.

Control measure for preventing water pollution

- Industrial effluent and domestic waste must be treated before disposal.
- Recycling of waste water through waste water treatment.
- Public awareness program.

Water recycling

With increasing population the requirement for water is increasing rapidly. However, the availability of water is limited but an ever-increasing water withdrawal from different sources such as rivers, lakes and ground water is depleting these sources and deteriorating their water quality. Therefore, it is essential to utilize the available water with maximum economy.

This involves recycling of wastewater for certain uses with or without treatment.Recycling refers to the use of wastewater by the original user prior to the discharge either to a treatment system or to a receiving water body. Thus the waste water is recovered and repetitively recycled with or without treatment by the same user.

Thermal pollution:

Thermal pollution, sometimes called "thermal enrichment," is the degradation of water quality by any process that changes ambient water temperature.

A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers.

Other causes of thermal pollution include soil erosion.

The Effects of Thermal Pollution:

The effects of thermal pollution are diverse, but in short, thermal pollution damages water ecosystems and reduces animal populations.

Soil and Nuclear pollution

Soil pollution

Soil pollution refers to anything that causes contamination of soil and degrades the soil quality. It occurs when the pollutants causing the pollution reduce the quality of the soil and convert the soil inhabitable for microorganisms and macro organisms living in the soil."

Industrial activities including:

- Mining, smelting and manufacturing
- Domestic, livestock and municipal wastes
- Pesticides, herbicides, fertilizers used in agriculture
- Petroleum-derived products that are released into or breakdown in the environment

Fumes generated by transportation all contribute to the problem. These include pharmaceuticals, endocrine disruptors, hormones and biological pollutants; "e-waste" from old electronics; and the plastics that are nowadays used in almost every human endeavor.

Effect of Soil pollution

- Salinity and water logging reduce the fertility of soil and crop yield.
- Toxic chemical present in the soil also affect the plant growth and human life.
- Soil pollution contaminated the underground water.

Control measures for preventing soil pollution

- Soil erosion must be prevented by proper tree plantation.
- Waste from industry and domestic must be treated before dumping.
- Replace synthetic fertilizers with organic fertilizers.
- Toxic and non degradable materials must be banned.
- Recycling and reuse of waste materials.
- Public awareness.

Nuclear hazards and human health risks:

These can be both beneficial and harmful, depending on the way in which they are used. We routinely use X-rays to examine bones for fractures, treat cancer with radiation and diagnose diseases with the help of radioactive isotopes. About 17% of the electrical energy generated in the world comes from nuclear power plants.

Radioactive substances when released into the environment are either dispersed or become concentrated in living organisms through the food chain. Other than naturally occurring radioisotopes, significant amounts are generated by human activity, including the operation of nuclear power plants, the manufacture of nuclear weapons, and atomic bomb testing.

E. Vaccination and immunization

The word “vaccine” originates from the Latin Variolae vaccinae (cowpox), which Edward Jenner demonstrated in 1798 could prevent smallpox in humans (Figure 1).

Today the term ‘vaccine’ applies to all biological preparations, produced from living organisms, that enhance immunity against disease and either prevent (prophylactic vaccines) or, in some cases, treat disease (therapeutic vaccines).

Vaccines are administered in liquid form, either by injection, by oral, or by intranasal routes.

Vaccines are composed of either the entire disease-causing microorganism or some of its components.

They may be constructed in several ways.

- From living organisms that have been weakened, usually from cultivation under sub-optimal conditions (also called attenuation), or from genetic modification, which has the effect of reducing their ability to cause disease

- From whole organisms that have been inactivated by chemical, thermal or other means
- From components of the disease-causing organism, such as specific proteins and polysaccharides, or nucleic acids
- From inactivated toxins of toxin-producing bacteria
- From the linkage (conjugation) of polysaccharides to proteins (this increases the effectiveness of polysaccharide vaccines in young children).

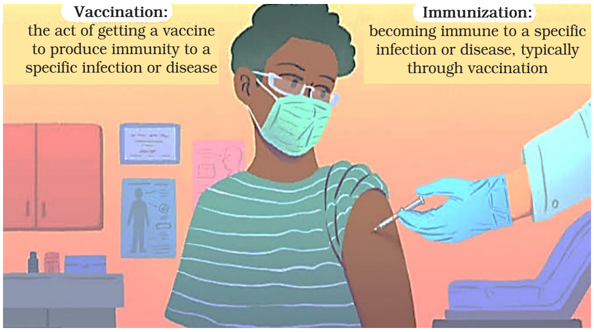


Figure 1. Immunization

F. Environmental Health

The World Health Organization's definition is as follows:

Environmental health addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviors. It encompasses the assessment and control of those environmental factors that can potentially affect health.

Hygiene generally refers to the set of practices associated with the preservation of health and healthy living. The focus is mainly on personal hygiene that looks at cleanliness of the hair, body, hands, fingers, feet and clothing, and menstrual hygiene.

Sanitation means the prevention of human contact with wastes, for hygienic purposes. It also means promoting health through the prevention of human contact with the hazards associated with the lack of healthy food, clean water and healthful housing, the control of vectors (living organisms that transmit diseases), and a clean environment. It focuses on management of waste produced by human activities.

The term cleanliness should not be used in place of hygiene. Cleaning in many cases is removing dirt, wastes or unwanted things from the surface of objects using detergents and necessary equipment.

Hygiene practice focuses on the prevention of diseases through the use of cleaning as one of several inputs.

G. Personal hygiene; First Aid and Vaccination

Personal hygiene

Personal hygiene are practices performed by an individual to care for one's body health and well being through cleanliness. Many people equate hygiene with 'cleanliness' but hygiene is a broad term including personal habits choices as how frequently to bathe, wash hands, trim fingernails and change clothing. Also includes keeping the environment clean and pathogen free (Table 1).

Table 1. Components of hygiene and environmental health.

Description	Concerns
Personal Hygiene	Hygiene of body and clothing
Water Supply	Adequacy, safety (chemical, bacteriological, physical) of water for domestic, drinking and recreational use
Waste disposal	Proper excreta disposal and liquid waste management
Solid waste management	Proper application of storage, collection, disposal of waste. Waste production and recycling
Vector Control	Control of mammals (such as rats) and arthropods (insects such as flies and other creatures such as mites) that transmit disease
Food Hygiene	Food safety and wholesomeness in its production, storage, preparation, distribution and sale, until consumption
Healthful Housing	Physiological needs, protection against disease and accidents, psychological and social comforts in residential and recreational areas
Institutional hygiene	Communal hygiene in schools, prisons, health facilities, refugee camps, detention homes and settlement areas
Water pollution	Sources, characteristics, impact and mitigation
Occupational hygiene	Hygiene and safety in the workplace

Components of personal hygiene

Personal hygiene has many components,

Following these components one may be able to advance his/her hygiene the following are some;

- Face hygiene
- Fingernail & Toenail hygiene
- Ear hygiene
- Hair hygiene
- Foot hygiene
- Environmental cleanliness

Personal hygiene is a concept that is commonly used in medical and public health practices. It is also widely practised at the individual level and at home. It involves maintaining the cleanliness of our body and clothes.

First aid Emergency Conditions

- Choking
- Circulation emergencies
- Breathing emergencies
- Wound care
- Head, neck, and spinal injuries
- Bone, muscle, and joint injuries
- Sudden medical emergencies
- Environmental illness
- Poisons
- Childhood illnesses

First Aid Kits

General First aid kits should include at least the following supplies:

- Emergency telephone numbers for help
- Home and office phone numbers for family members,
- Friends, or neighbors who can help in an emergency
- Sterile gauze pads (dressings) in small and large squares to place over wounds

- Adhesive tape
- Roller and triangular bandages to hold dressings in place or make slings
- Adhesive bandages in assorted sizes
- Scissors
- Tweezers
- Safety pins
- Cold packs or instant ice packs
- Disposable non-latex gloves, such as surgical or examination gloves
- Flashlight, with extra batteries in a separate bag
- Antiseptic wipes or soap
- Pencil and pad
- Emergency blanket
- Eye patches
- Thermometer
- Barrier devices, such as a pocket mask or face shield
- First aid manual

Exercises

1. What are the effects of Soil Pollution?
2. What is Thermal pollution?
3. Give soruces of Noise pollution.
4. What are Aquifers?
5. Mention 2 effects of Air pollution.

6.2 Abused Drugs and Health

A drug is a substance, other than food or vitamins, that upon entering the body in small amounts alters one's physical, mental, or emotional state.

Psychoactive drugs are drugs that alter sensory perceptions, mood, thought processes, or behavior.

Drug misuse refers primarily to the inappropriate use of legally purchased prescription or nonprescription drugs. For example, drug misuse occurs when one discontinues the use of a prescribed antibiotic before the entire prescribed dose is completed or when one takes four aspirin rather than two as specified on the label.

Drug abuse can be defined in several ways depending upon the drug and the situation. Drug abuse occurs when one takes a prescription or nonprescription drug for a purpose other than that for which it is medically approved. For example, drug abuse occurs when one takes a prescription diet pill for its mood altering effects (stimulation).

The abuse of legal drugs such as nicotine or alcohol is said to occur when one is aware that continued use is detrimental to one's health. Because illicit drugs have no approved medical uses, any illicit drug use is considered drug abuse. Likewise, the use of alcohol and nicotine by those under the legal age is considered drug abuse (Table 2).

Drug (chemical) dependence occurs when a user feels that a particular drug is necessary for normal functioning.

Dependence:

- The psychophysical state of substance users in which the usual or increasing dose of the substances are required to prevent the onset of withdrawal symptoms.
- It is a compulsion to take substance to prevent on set of withdrawal symptoms or discomfort.
- A strong desire to obtain and take the substance.
- It is a persistent seeking behavior of substance.

Psychological dependence:

- Is a compulsion that require periodic or continues exposure to a substance to produce pleasure and or avoid discomfort.
- Is a continues or intermittent craving of a substances (e.g.,. coffee, chat…)

Physical (physiological) dependence:

- It is a body's biological need evidence by tolerance or with drawl symptom

Tolerance:

- Is the requirement for an increased amount of the substance to achieve a desired effect or there is markedly diminished effect regular use of the same dose

With-drawl:

- Specific organic brain syndrome that resulting from cessation or reduction in intake of substance.

Table 2. Some of the substances that are commonly abused by individuals

Type	Examples	Effect
Depressant	Alcohol, barbiturate sedative Hypnotic	Drowsiness, pleasant relaxation, disinheriting
Opiate	Morphine, methadone pethidine	Relief pain, pleasant dreamy, euphoria
Stimulant	Cocaine, khat amphetamines	Exhilaration, reduced fatigue and hunger
Hallucinogens	Mescaline peyote	Other world illness.
Cannabis	Hashish Marijuana	Relaxation and hallucinogenic effect
Nicotine	Tobacco	Sedation and stimulation
Volatile inhalants	Benzene, glues gasoline, lacquer	Relaxation, drowsiness perceptual disturbance.

Legal (licit) drugs include alcohol, nicotine, and nonprescription and prescription drugs.

Legal (licit) drugs can be classified further on the basis of physiological effects as stimulants, depressants, narcotics, hallucinogens, marijuana, and other drugs.

Legal Drugs

Legal drugs are drugs that can be legally bought and sold in the marketplace, including those that are closely regulated, like morphine; those that are lightly regulated, like alcohol and tobacco; and still others that are not regulated at all, like caffeine.

Illicit (illegal) drugs

They cannot be cultivated, manufactured, bought, sold, or used within the confines of the law.

Problems associated with substance abuse and dependence

- The dependence producing properties of substance that reinforce the users for continuation of the substance taking behavior are responsible for ill effects of a substance on the abuser & the society virtually, all substance that producer dependence can cause varying degree of health, social & economic problems (Table 3).

Table 3. Personal and Community Consequences of Drug Abuse

Personal Consequences	Community Consequences
Absenteeism from school or work	Loss of productivity and revenue
Underachievement at school or work	Lower average SAT scores
Scholastic failure/interruption of education	Loss of economic opportunity
Loss of employment	Increase in public welfare load
Marital instability/family problems	Increase in number of broken homes
Risk of infectious diseases	Epidemics of sexually transmitted diseases
Risk of chronic or degenerative diseases	Unnecessary burden on health care system
Increased risk of accidents	Unnecessary deaths and economic losses
Financial problems	Defaults on mortgages, loans/ bankruptcies
Criminal activity	Increased cost of insurance and security
Arrest and incarceration	Increased cost for police/courts/prisons
Risk of adulterated drugs	Increased burden on medical care system
Adverse drug reactions or "bad trips"	Greater need for emergency medical services
Drug-induced psychoses	Unnecessary drain on mental health services
Drug overdose	Unnecessary demand for medical services
Injury to fetus or newborn baby	Unnecessary use of expensive neonatal care
Loss of self-esteem	Increase in mental illness, underachievement
Suicide	Damaged and destroyed families
Death	

- The degree of harm produced in general depends on
    - The quantity of a substance consumed per occasion
    - The frequency with which it is consumed
    - The duration of consumption

Health related problems

(a) Acute – toxicities – can cause death and / or ill health
(b) chronic toxicities – e.g., liver damage
- coronary heart disease
- psychiatric problems
- lung cancer

Economic consequence (problems)

(a) Un employment resulting in decrease national productivity
(b) Economic crisis–because increase expenditure for buying substance
(c) Decrease school performance
(d) Increase school drop out
(e) increase absenteeism leads decreased performance at school, work …etc
(f) Decrease productivity occupies vast area of the land that other wise be used for cultivation of useful crop and food.

Social consequence

(i) Divorce, broken families and prostitution
(ii) Violence
(iii) Accident
(iv) Dangerous vagrancy
(v) Crime (theft, hijacking, rape…)

Prevention and control

Primary prevention

Identifying and avoiding drugs alcohols that the community used--- information and education about alcohol, drug, miss- use to the community to avoid the appearance of the new cases of drug or other substance users

Secondary prevention

- Early detection and management before complication occur

Tertiary prevention

- To avoid further disabilities & to reintegrate in to society

Control methods

Control of production, supply and availability

Include:

- stopping the supply process as its source
- crop eradication
- crop substitution
- control of distribution & access

Demand reduction

- reducing consumption
- increase price
- control of advertisement and promotion

Rational prescribing, dispensing and uses of narcotic and psychotropic drugs

- Proper diagnosis and decide on the use of drugs
- Keep records
- Take as prescribed
- Not use for non – medical purpose etc…
- Increasing individual resistance from social pressure by health education.

Elements of Prevention

There are four basic elements that play a role in drug abuse prevention and control. These are

1. Education,
2. Treatment,
3. Public policy
4. Enforcement.

The goals of education and treatment are the same: to reduce the demand for drugs. Likewise, setting effective public policy and law enforcement share the same goal: to reduce the supply and availability of drugs in the community.

6.3 Waste and Wastewater (Sewage) Treatment

Wastewater (Sewage)

The basic function of wastewater treatment is to speed up the natural processes by which water is purified. There are two basic stages in the treatment of wastes, primary and secondary.

In the primary stage, solids are allowed to settle and removed from wastewater. The secondary stage uses biological processes to further purify wastewater. Sometimes, these stages are combined into one operation.

Primary Treatment (Figure 2)

As sewage enters a plant for treatment, it flows through a screen, which removes large floating objects such as rags and sticks that might clog pipes or damage equipment.

After sewage has been screened, it passes into a grit chamber, where cinders, sand, and small stones settle to the bottom. A grit chamber is particularly important in communities with combined sewer systems where sand or gravel may wash into sewers along with storm water.

After screening is completed and grit has been removed, sewage still contains organic and inorganic matter along with other suspended solids.

These solids are minute particles that can be removed from sewage in a sedimentation tank.

When the speed of the flow through one of these tanks is reduced, the suspended solids will gradually sink to the bottom, where they form a mass of solids called raw primary biosolids or sludge. Biosolids are usually removed from tanks by pumping, after which it may be further treated for use as a fertilizer, or disposed of in a land fill or incinerated.

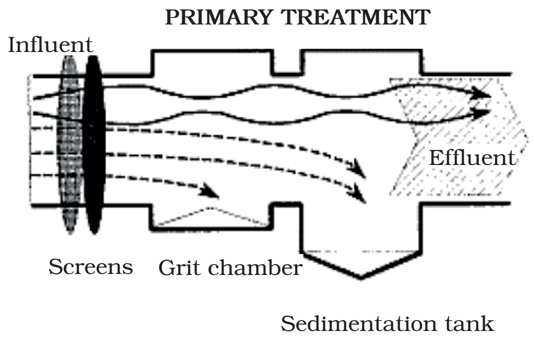


Figure 2. Primary water treatment

To meet higher water quality a secondary treatment level, and in some cases, also use advanced treatment is conducted to remove nutrients and other contaminants.

Secondary Treatment (Figure 3)

The secondary stage of treatment removes about 85 percent of the organic matter in sewage by making use of the bacteria in it.

- The principal secondary treatment techniques used in secondary treatment are the trickling filter and the **activated sludge process**.
- After effluent leaves the sedimentation tank in the primary stage it flows or is pumped to a facility using one or the other of these processes.
- A trickling filter is simply a bed of stones from three to six feet deep through which sewage passes.
- More recently, interlocking pieces of corrugated plastic or other synthetic media have also been used in trickling beds.
- Bacteria gather and multiply on these stones until they can consume most of the organic matter.
- The cleaner water trickles out through pipes for further treatment.
- From a trickling filter, the partially treated sewage flows to another **sedimentation tank** to remove excess bacteria.

SECONDARY TREATMENT

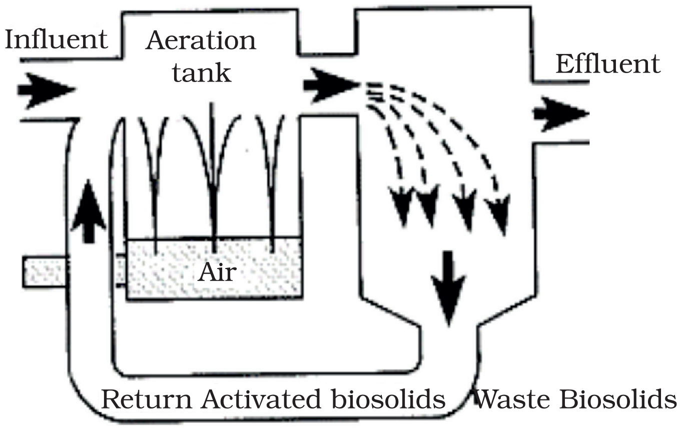


Figure 3. Activated Biosolids Process

The trend today is towards the use of the activated sludge process instead of trickling filters. The activated sludge process speeds up the work of the bacteria by bringing air and sludge heavily laden with bacteria into close contact with sewage.

Steps of activated sludge process

- After the sewage leaves the settling tank in the primary stage, it is pumped into an aeration tank, where it is mixed with air and sludge loaded with bacteria and allowed to remain for several hours.
- During this time, the bacteria break down the organic matter into harmless by-products.
- The sludge now activated with additional billions of bacteria and other tiny organisms can be used again by returning it to the aeration tank for mixing with air and new sewage.
- From the aeration tank, the partially treated sewage flows to another sedimentation tank for removal of excess bacteria.
- To complete secondary treatment, effluent from the sedimentation tank is usually disinfected with chlorine before being discharged into receiving waters.
- Chlorine is fed into the water to kill pathogenic bacteria, and to reduce odor.
- Done properly, chlorination will kill more than 99 percent of the harmful bacteria in an effluent.
- Alternatives to chlorine disinfection, such as ultraviolet light or ozone, are also being used in situations where chlorine in treated sewage effluents may be harmful to fish and other aquatic life.

Waste

Source Typical waste generators and Types of solid wastes

Residential wastes

Single and multifamily dwellings

Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g. bulky items, consumer electronics, white goods, batteries, oil), and household hazardous wastes.

Industrial wastes

Light and heavy manufacturing, fabrication, construction sites, power and chemical plants

Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes.

Commercial wastes

Stores, hotels, restaurants, markets, office buildings, etc.

Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes

Institutional wastes

Schools, hospitals, prisons, government centers

Same as commercial

Municipal services

Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants

Street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and other recreational area, sludge

Construction and demolition

New construction sites, road repair, renovation sites, demolition of buildings Wood, steel, concrete, dirt, etc.

Process

Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing

Industrial process wastes, scrap materials, off specification products, slag, tailings

All of the above should be included as "municipal solid waste."

Agriculture

All of the above should be included as "municipal solid waste."

Crops, orchards, vineyards, dairies, feedlots, farms

Spoiled food wastes, agricultural wastes, hazardous wastes (e.g. pesticides)

6.4 Water

Water is essential for life as we know it, but only a small fraction of the earth's water is available for our use. We acquire water for our needs from either surface water or groundwater.

A. Sources of Water

Water in streams, rivers, lakes, and reservoirs is called **surface water.**

The water that sinks into the soil is referred to as subsurface or **groundwater**.

Groundwater that is not absorbed by the roots of vegetation moves slowly downward until it reaches the underground reservoirs referred to as **aquifers**.

Aquifers are porous, water-saturated layers of underground bedrock, sand, and gravel that can yield an economically significant amount of water.

The earth's supply of freshwater available for our use is limited.

The majority (over 97%) of the world's water supply is salt water found in the oceans. While it is possible to remove salt from this water by desalinization, it is a very expensive process.

The remaining 3% is freshwater, 99% of which is found in ice sheets and glaciers at the poles.

Only 0.003% of the earth's water is available for use by humans, and much of this is hard to reach and too costly to be of practical value.

Thus, the continual contamination of our groundwater through the improper disposal of solid and hazardous waste should be of paramount concern to everyone. Surface and groundwater have very different characteristics.

Surface water supports plant and animal life, including microorganisms, with the oxygen and nutrients that are contained in it.

Conversely, groundwater is low in oxygen and contains few microorganisms. These microorganisms are filtered out as the water passes through the soil to the aquifers.

The subsurface water is, however, higher in minerals such as iron, chloride, and salts because of its travel through the soil and rocks.

Each of these characteristics is taken into account when preparing the water for human use.

B. Mode of Contamination and Pollution and the methods of purification

Contaminants Typically Found in Untreated Wastewater

Fresh domestic untreated or raw wastewater has a musty odor, a pH range of 6.5 to 8.0 and is grayish brown in color.

The types of contaminants typically found in untreated wastewater can be broadly lumped into four basic classes:

- Organic contaminants
- Inorganic contaminants
- Pathogens
- Other contaminants

Thermal Wastes

Industrial waste discharges can cause a sudden increase in influent temperature and flow. A typical source of thermal waste is non-contact cooling water (heated water where the temperature exceeds stream temperature). Depending on the use of the stream, limits on the temperature of the wastewater may be established toprevent elevating the temperature of the stream and impacting use.

Radioactive Wastes

- Could come from nuclear power plants, hospitals, or laboratories. Generally, it is good practice not to allow the discharge of radioactive wastes into a sewer system.

Water treatment (Table 4)

The steps in surface water treatment vary from plant to plant, but the following four steps are almost always included:

1. **Coagulation and flocculation:**

A chemical such as Alum (aluminum sulfate) is added to the water to cause suspended solids to attract one another and form larger particles (flakes, or floc).

2. **Sedimentation:**

The water is permitted to stand so that the large particles (flakes) will settle out.

3. **Filtration:**

The water is passed through filters (often carbon and sand filters) in order to remove any solids and dissolved chemicals remaining after sedimentation.

4. **Disinfection:**

Chlorine is added to the water to kill viruses, bacteria, algae, and fungi. Disinfection is sometimes accompanied by fluoridation, which helps prevent dental decay.

Table 4. Wastewater treatment process

TREATMENT PROCESS	PROCESS DESCRIPTION
Preliminary Treatment	
Screening	Removes rags, sticks, and other debris; protects pumping equipment
Degritting	Removes settleable inorganic grit
Pre-Aeration	Adds oxygen to the wastewater to reduce odors
Flow Metering and Sampling	Measures and records flows; sample wastewater for analyses of components
Primary Treatment	
Sedimentation and Flotation	Removes settleable organic and inorganic particles and floating debris such as fats, oils, and greases
Secondary Treatment	
Biological Treatment	Removes dissolved and remaining colloidal (also known as non settleable) organic matter; can convert ammonia-nitrogen to nitrate-nitrogen
Sedimentation	Separates biomass and chemical precipitates from treated wastewater
Tertiary (Advanced) Treatment	
Chemical Phosphorus Removal	Adds chemical to form precipitate with phosphorus for removal in the secondary clarifiers
Biological Nutrient Removal	Removes nitrogen and phosphorus using specialized microorganisms

Multimedia Filtration	Removes additional suspended solids (beyond that obtained by simple settling) using gravity or pressure filters
Disinfection	
Disinfection	Kills pathogenic organisms
Solids Treatment	
Digestion	Stabilizes remaining organic matter; reduces pathogen levels; results in overall net reduction in solids
Disposal	Moves stabilized solids from plant to farmland for recycling or to landfill

Refuse collection and Disposal

Refuse is the leftover food materials from households. The proper process of refuse collection and disposal in urban settings is shown (Figure 4)

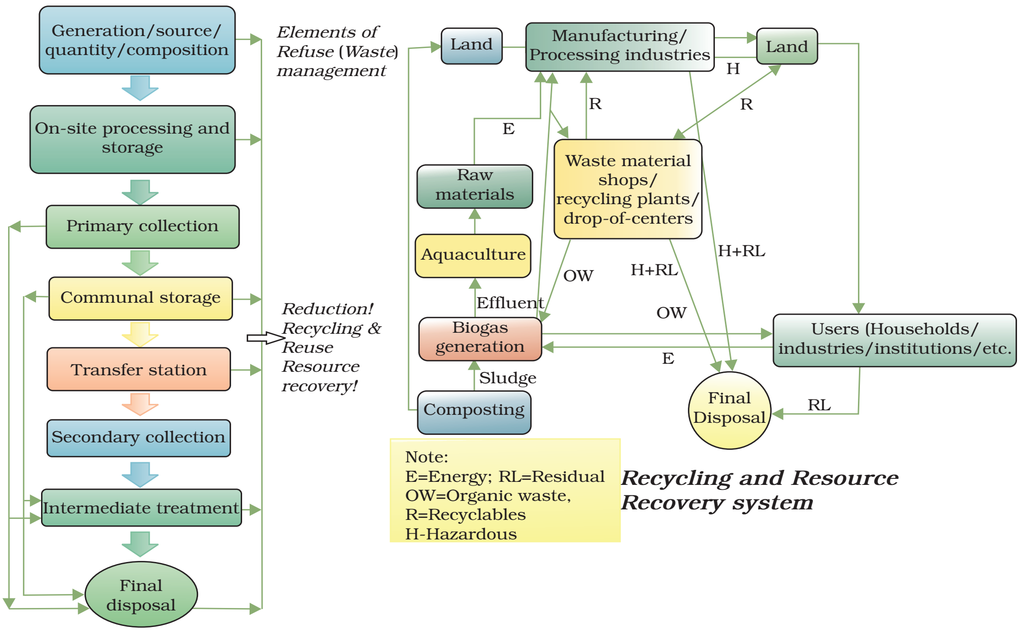


Figure 4. Recycling and resources Recovery system

Activity 1

If there is a water treatment facility in your locality, pay a visit & see how it works.

Economic Use

Biogas and Compost are the common beneficial products from refuse. Reuse and recycle are economically useful processes (Figure 5).

Figure 5. Recycling concepts

Exercises

Choose the correct answer

1. Contaminants found in untreated wastewater may include: (Circle all that apply):
   (a) Pathogens
   (b) Ozone
   (c) Organic contaminants
   (d) Inorganic contaminants
2. A type of contaminant that always contains carbon and is derived from animals, plants or may be a manufactured chemical compound is an:
   (a) Inorganic contaminant
   (b) Salt contaminant
   (c) Organic contaminant
   (d) Pathogen

Key Terms

- Atmosphere
- Acid rain
- Agrochemicals
- Aquifers
- Activated sludge
- Biosphere
- Biodiversity
- Biological Oxygen Demand (BOD)
- Compost
- Cleanliness
- Coagulation
- Degritting
- Disinfection

- Depressant
- Drug abuse
- Drug misuse
- Drug dependence
- Drug tolerance
- Drug
- Ecology
- Global warming
- Ground water
- Hydrosphere
- Hygiene
- Hallucinogen
- Lithosphere
- Immunization
- Illicit drugs
- Legal drugs
- Narcotics
- Nicotine
- Ozone depletion
- Psychoactive drug
- Sewage
- Sanitation
- Surface water
- Sedimentation
- Stimulant
- Trickling filter
- Vaccination

Summary

- The environment consists of all the external conditions, circumstances, and influences surrounding and affecting the growth and development of an organism or community of organisms.
- There are both natural and human-made hazards that threaten habitats, climates, and ultimately the health of both individuals and their communities.
- Residues and wastes from human activities have been increasing rapidly because of urbanization, industrialization, population growth, and reliance on disposable products and containers.
- Types of wastes and pollution include solid wastes, hazardous
- wastes, air pollution, water pollution, radiation, and noise pollution.
- Nature's components such as air, water, soil, forest and fisheries are resources exploited by humans and their pollution are by-product of urbanization and industrialization.
- Pollution in effect is an undesirable byproduct of industrialization and urbanization.
- The agents directly or indirectly responsible for the pollution of the environment are known as pollutants.
- There are six types of pollutions: air pollution, water pollution, noise pollution, soil pollution, thermal pollution, radiation pollution etc.

- Air pollution is a result of industrial and certain domestic activity.
- Use of cleaner fuels such as biogas, CNG and electricity prevent air pollution.
- Segregation of waste, pretreatment at source, sterilization of rooms will help in checking indoor pollution.
- Prevention and control of industrial pollution can be reduced by using cleaner fuels, filters, electrostatic precipitators, inertial collectors, scrubbers etc.
- Use of chlorofluorocarbons cause damage of ozone layer which has resulted in its thinning over the Arctic and Antarctica regions, is know as ozone hole.
- Increase in global temperature or heating effect by greenhouse gases (CO2, methane) is known as greenhouse effect.
- Addition of undesirable substances in water is called water pollution.
- Natural sources of water pollution are soil erosion, leaching of minerals from rocks and decaying of organic matter.
- Power plants and various industries used lot of water for cooling purposes and hot water is discharged into rivers, streams or oceans. This waste heat increases the temperature of the cooling water up to 10-15 degree celicius this is thermal pollution.
- Improper sewage disposal, dumping of farm yard manures and agricultural chemicals, industrial effluents are causing pollution of ground water.
- Waste water from domestic or industry or garbage dump is generally known as sewage.
- Radiation is a form of energy traveling through space. Radiation can be grouped into non-ionizing radiation and the ionizing radiations.
- Noise like other pollution is a by product of industrialization, urbanization and modern civilization.
- Indoor sources include noise produced by radio, television and outdoor source includes indiscriminate use of loudspeakers, industrial activities, automobile, rail traffic and airplanes etc.
- Personal hygiene is a necessity for our daily activities. It is very important for the protection of our health and helps to prevent the spread of communicable diseases.
- The abuse of alcohol, tobacco, and other drugs is a major community health problem.
- Alcohol, tobacco, and other drug abuse affects not only individuals but also communities, where it results in a substantial drain both socially and economically.

- The misuse and abuse of prescription and nonprescription drugs remains a problem of concern.
- There are four principal elements of drug abuse prevention and control—education, treatment, public policy, and law enforcement.

Review Exercise

True False Items

1. Biodiversity refers to the variety of life, habitats, and landscapes.
2. The preservationist idea of conservation advocate for protected areas devoid of human use.
3. Emission of green house gases increases global temprature.
4. Air pollution causes respiratory problems in humans.
5. Chlorine is added to water to kill pathogens.

Match items in column B with those in column A

6. Enhances water pollution	(a) Increases level of CO2 in the atmosphere
7. Causes Soil pollution	(b) Use of Loud speakers
8. Causes Thermal pollution	(c) Un proper Sewage dis-posal
9. Causes Radiation pollution	(d) Power plant cooling
10. Causes Air pollution	(e) Use of Pesticides
11. Causes Noise pollution	(f) Isotopes

Answer the following questions

12. List pathogens found in waste water.
13. What are the steps in treatment of surface water.
14. What are the components of personal hygiene?
15. Distinguish between primary and secondary sewage treatment?
16. What are the elements of preventing drug abuse.

Sample Test 1

Choose the correct answer from the given alternatives

1. Acid rain is formed by the Oxides of ______________ .
   (a) Sulfur
   (b) Carbon
   (c) Oxygen
   (d) Phosphorus

2. Which of the following is **Incorrect** about natural resources
   (a) Ecosystems act as resource producers
   (b) Ecosystems act as resource processors
   (c) Solar energy is the main driving force of Ecological Systems.
   (d) All ecosystems are Solar energy independent
3. Which of the following is non - renewable resource?
   (a) Fossil fuel
   (b) Forests
   (c) Wild life
   (d) Fish
4. What is recycling in ecology?
   (a) The flow of materials between environment & organisms
   (b) The flow of solar energy from one trophic level to the next.
   (c) The proper process of refuse collection and disposal.
   (d) The waste water treatment techniques involving both primary and secondary treatment.
5. Which one of the following is **Not** goal of conservation
   (a) Reducing pollution of water and air to keep the natural environment healthy.
   (b) The protection of large areas of habitats to conserve biodiversity.
   (c) The preservation of non - renewable resoruces without using them.
   (d) The wise use of resources in a sustainable way, without serious effects on a natural environment.

Sample Test 2

1. The Cell as the basic unit of life consists of
   (a) Cytoplasm and vacuole.
   (b) Cytoplasm and nucleus.
   (c) Nucleus and cell wall.
   (d) Cell wall and vacuole

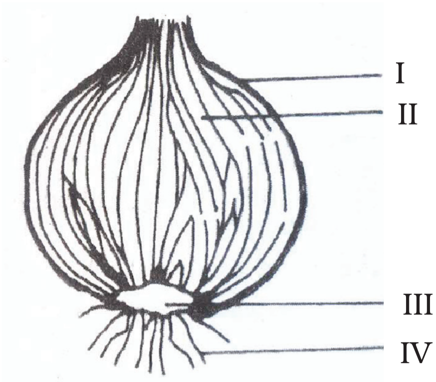
Use the following Glasses of Arthropoda to answer questions 2 and 3.

(i) Crustacea
(ii) Insecta
(iii) Arachnida
(iv) Chilopoda

2. Which members of the Classes live mainly in an aquatic habitat?
   (a) I
   (b) II
   (c) III
   (d) IV
3. Which of the Classes is characterized by the possession of two pairs of antennae?
   (a) IV
   (b) III
   (c) II
   (d) I
4. The organism with spiral chloroplasts and nucleus suspended by cytoplasmic strands is
   (a) *Euglena*
   (b) *Paramecium*
   (c) *Spirogyra*
   (d) *Volvox*
5. The network of double membrane that conveys materials through the cytoplasm is the
   (a) Endoplasmic reticulum
   (b) Mitochondrion
   (c) Nuclear membrane
   (d) Plasma membrane

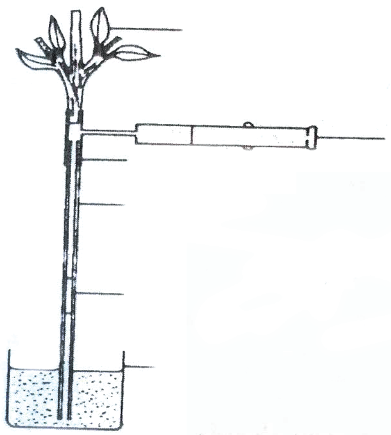
The diagram below is an illustration of the longitudinal section of a plant organ.

Study it and answer questions 6 to 8.



6. Food is stored in the part labeled
   (a) Iv
   (b) III
   (c) II
   (d) I
7. The plant is a
   (a) runner
   (b) stolon
   (c) bulb
   (d) stem tuber
8. The part labeled I is the
   (a) Fleshy leaf
   (b) Adventitious root
   (c) Scale leaf
   (d) Apical bud
9. Which of the following materials is not a living semi - permeable membrane?
   (a) Sheet of cellophane
   (b) Yam tuber
   (c) Unripe pawpaw fruit
   (d) Pig's bladder
10. In an experiment, mould and yeast cells were transferred into an environment with low oxygen concentration. After a few days, the mould died while the yeast cells did not. Which of the following statements best explains the above observation?
    (a) Respiration does not occur in the mould
    (b) Respiration can take place in yeast cells in the absence of oxygen.
    (c) Photosynthesis does not take place in the absence of oxygen.
    (d) The yeast cells carried out photosynthesis while the mould did not.
11. Which of the following tissues does not provide support in flowering plants?
    (a) Phloem
    (b) Xylem
    (c) Parenchyma
    (d) Collenchyma

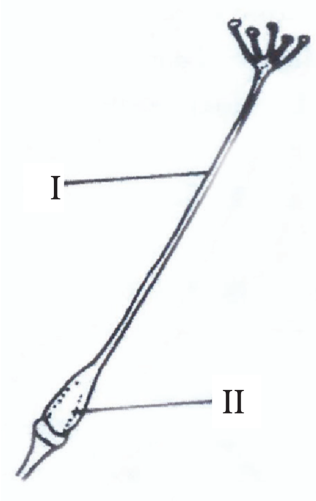
The diagram below is an illustration of an experimental set-up. Study it and answer questions 12 and 13.



12. The set-up directly measures
    (a) Loss of mineral salts from the leaves.
    (b) Absorption of water by the shoot.
    (c) Evaporation of water from the leaves.
    (d) Transpiration of water by the shoot.
13. The set-up can measure comparatively the rate of
    (a) Water uptake by roots of different plants.
    (b) Transpiration of a single shoot of a plant under different experimental conditions.
    (c) Salt uptake by shoots from different plants.
    (d) Evaporation from leaves on a single shoot under different experimental conditions.
14. The respiratory organ of a cockroach is the
    (a) Lung
    (b) Lung book
    (c) Trachea
    (d) Air sac
15. The excretory product of some reptiles, birds and insects is
    (a) Uric acid
    (b) Ammonia
    (c) Urine
    (d) Urea

16. The part of the mammalian kidney that stores urine is the
    (a) Bladder
    (b) Pelvis
    (c) Medulla
    (d) Capsule
17. The properties of endocrine system include the following except
    (a) Release of secretions into ducts.
    (b) Having specific effect.
    (c) Transportation by blood to target organs.
    (d) Secretion of hormones.
18. The part of the central nervous system that controls unconscious actions in humans is the
    (a) Optic nerves
    (b) Spinal cord
    (c) Cerebrum
    (d) Cerebellum
19. What happens when the ciliary muscles of the eye contract? The
    (a) Suspensory ligament becomes tight.
    (b) Lens gets a longer focal length.
    (c) Lens becomes more convex.
    (d) Lens becomes more concave.

The diagram below is an illustration of a part of a flower. Study it and answer questions 20 and 21.



20. The function of the part labeled I is
    (a) Site for double fertilization in the plant.
    (b) Germination of the pollen grain.
    (c) Passage for the male gamete to the ovary.
    (d) Receiving the pollen grain.
21. The part labeled II is the
    (a) Unfused anthers
    (b) Fused ovaries
    (c) Fused style
    (d) Unfused stigma
22. The reagent used in testing for carbon (IV) oxide is
    (a) Copper sulphate solution.
    (b) Lime water
    (c) Hydrochloric acid
    (d) Sodium hydroxide solution
23. Oxygen comes out of the stomata during photosynthesis through the process known as
    (a) Active transport
    (b) Osmosis
    (c) Transpiration pull
    (d) Diffusion
24. The first stable product of photosynthesis is
    (a) Sucrose
    (b) Glucose
    (c) Fructose
    (d) Starch
25. An example of a trace element is
    (a) Copper
    (b) Magnesium
    (c) Calcium
    (d) Potassium
26. Which of the following statements about a mixture of a protein - digesting enzyme and starch solution would be correct? The protein digesting enzyme.
    (a) Digests the starch.
    (b) Leads to the production of glucose
    (c) Leads to the production of amino acids.
    (d) Has no effect on the starch solution.

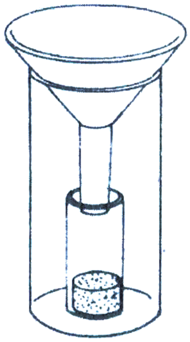
27. A mutualism type of relationship is different from a parasitic relationship because in mutualism.
    (a) Only one of the organisms is harmed.
    (b) Both organisms harm each other.
    (c) None of the organisms benefits or harms each other.
    (d) Both organisms involved benefit.

The table below shows the number of some organisms in habitats W and Y. Study it and answer questions 28 to 30.

Organism	Number in the habitat	
	habitat W	habitat Y
Plankton	126	0
Antelope	0	51
Water flea	10	0
Tilapia	23	0
Lion	0	6
Frog	6	0
Grass	0	250

28. What type of habitat is W?
    (a) Ocean
    (b) Desert
    (c) Pond
    (d) Rainforest
29. Which of the following statement about habitat W is correct? The
    (a) Absence of grasses indicates the habitat is terrestrial.
    (b) Type of organisms present indicate the habitat is aquatic.
    (c) Presence of tilapia and planktons shows the habitat is not aquatic.
    (d) Absence of lions and antelopes shows the habitat is terrestrial.
30. The number of lions and antelopes in habitat Y shows that the lion
    (a) And the antelope are predators.
    (b) And the antelope are preys to each other.
    (c) Is the predator while the antelope is the prey.
    (d) Is the prey while the antelope is the predator.

The diagram below is an illustration of an ecological instrument. Study it and answer questions 31 and 32.



31. A disadvantage of the abiotic factor measured by the instrument is that it
    (a) Is used for irrigation.
    (b) Leads to flooding when in excess.
    (c) Is necessary for germination.
    (d) Is an agent of pollination.
32. When the instrument is in use, it is usually
    (a) Suspended on moving water.
    (b) Suspended in air.
    (c) Placed on a table.
    (d) Placed slightly above soil level.
33. Soil with the finest texture is
    (a) Gravel
    (b) Sand
    (c) Clay
    (d) Silt
34. The position occupied by an organism in a food chain is the
    (a) Energy level
    (b) Niche
    (c) Trophic level
    (d) Biomass
35. The depletion of the ozone layer will result in the earth surface receiving more
    (a) X-rays
    (b) Ultraviolet rays
    (c) Infra-red rays
    (d) Gamma rays

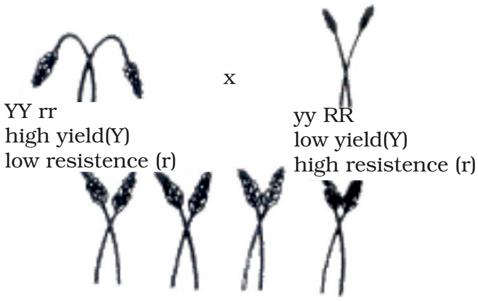
Use the list of insects below to answer questions 36 and 37.

(i) I. Cotton stainer
(ii) II. Honeybee
(iii) III. Termite
(iv) IV. Weevil

36. The insects whose activities are both beneficial and harmful to humans are
    (a) III and IV
    (b) II and Iv
    (c) II and III
    (d) I and II
37. Which of the insects destroys grains?
    (a) IV
    (b) II
    (c) III
    (d) I
38. Conservation of natural resources does not
    (a) Threaten the survival of species.
    (b) Attract tourists.
    (c) Preserve the beauty of nature.
    (d) Maintain a balanced ecosystem.
39. A company was prohibited from producing bags made from natural leopard skin. This is an attempt to conserve.
    (a) Minerals
    (b) Wildlife
    (c) Water
    (d) Land
40. Which of the following substances is not a conservable natural resource?
    (a) Water
    (b) Soil
    (c) Air
    (d) Mineral
41. A child that can receive blood from anybody belongs to the blood group.
    (a) AB
    (b) B
    (c) A
    (d) O

42. Variation which exhibits a wide range from one extreme to the other is
    (a) Genotypic variation
    (b) Continuous variation
    (c) Discontinuous variation
    (d) Phenotypic variation
43. Measurements of height and weight of students in a class how
    (a) Fatness is less prevalent.
    (b) Shortness is more prevalent.
    (c) Continuous variation
    (d) Discontinuous variation
44. Which of the following statements about chromosomes is correct?
    (a) They bear ribosomes on their outer membranes.
    (b) They are neatly arranged in the cytoplasm.
    (c) The number present in a species is constant.
    (d) All the chromosomes of a species are the same in shape.
45. Which of the following diseases can be inherited?
    (a) Malaria
    (b) Sickle cell anemia
    (c) Whooping cough
    (d) Pneumonia

The diagram below is an illustration of a cross between plants A and B of the same species. Study it and answer questions 46 and 47.



46. If the F1 generation are plants with high yield and high resistance, the genotype of the F1 generation plants would be
    (a) Yyrr
    (b) YyRr
    (c) YyRr
    (d) YYRR
47. The process that gave rise to the F1 generation is
    (a) Test cross
    (b) Out-breeding
    (c) Cross fertilization
    (d) Self-fertilization
48. Replication of DNA molecules is catalyzed by an enzyme called
    (a) Amylase
    (b) Pepsin
    (c) Ptyalin
    (d) Polymerase
49. Who proposed the theory of evolution by natural selection?
    (a) Linnaeus
    (b) Aristotle
    (c) Lamarck
    (d) Darwin
50. Which of the following statements best explains the reason why termites swarm at night?
    (a) They can only see in the dark
    (b) Light destroys their wings
    (c) They avoid day-flying birds
    (d) Light is not necessary for swarming

Health Related Caution

What are the ways to avoid dengue and malaria fever?

- Time your outings.
- Reduce mosquito habitat.
- Sleep under mosquito-net.
- Put screens on windows and doors.
- Keep your house airy and well-lit.
- Do not let water stagnate anywhere.
- Wear long pants and long sleeves to cover your body.
- Apply mosquito repellent with DEET (diethyltoluamide) to exposed skin.
- Treat clothing, mosquito nets, tents, sleeping bags and other fabrics with an insect repellent called permethrin.

How can a person reduce the risk of getting HIV?

- Get tested for HIV.
- Do not inject drugs.
- Choose less risky sexual behaviors.
- Use condoms every time you have sex.
- Limit your number of sexual partners.
- Get tested and treated for STDs.
- Talk to your health care provider about pre-exposure prophylaxis (PrEP).

What is Bullying?

Any unwanted written, verbal, graphic, or physical act by an individual or group toward another person(s) that causes harm or distress.

Types of Bullying

- Physical
- Verbal
- Social
- Emotional
- Cyber

Signs of Bullying

- Headaches
- Depression
- Loss of friends
- School absenteeism
- Academic problems

What You Can Do

PREVENT

- Be a role model for positive communication, healthy relationships, and self-care.
- Reinforce acts of kindness, respect, and inclusion.
- Set policies and rules about bullying.

RECOGNIZE

- Know the definition of bullying and its many forms.
- Talk with and actively listen to the youth who confide in you.
- Watch for warning signs of bullying.

INTERVENE

- If you witness bullying behavior
- Respond quickly and consistently to send the message that it is not acceptable.
- Separate the students involved.
- Meet any immediate medical or mental health needs.
- Stay calm and model respectful behavior.

Source: Teacher's Diary on *Cyber-Crime Awareness* by UNODC, Cybercrime and MoE, Republic of Liberia

WHAT IS CYBERCRIME?

Cybercrime is criminal activity that either targets or uses a computer, a computer network or a networked device. Most cybercrime is committed by cybercriminals or hackers who want to make money or take advantage of a person.

Types of Cybercrime

- Email and internet fraud.
- Identity fraud (where personal information is stolen and used).
- Theft of financial or card payment data.
- Theft and sale of corporate data.
- Cyber extortion (demanding money to prevent a threatened attack).
- Ransomware attacks (a type of cyberextortion).
- Cryptojacking (where hackers mine cryptocurrency using resources they do not own).
- Cyberespionage (where hackers access government or company data).
- Interfering with systems in a way that compromises a network.
- Infringing copyright.
- Illegal gambling.
- Selling illegal items online.
- Soliciting, producing, or possessing child pornography.

How to Prevent Cyber Crimes?

- Enforce concrete security and keep it up-to-date.
- Never give out personal information to a stranger.
- Check security settings to prevent cybercrime.
- Using an antivirus software helps to recognize any threat or malware before it infects the computer system.
- When visiting unauthorized websites, keep your information secure.
- Restriction on access to your most valuable data.
- Backup all data, system, and considerations.
- Don't use free USB sticks.

Source: Teacher's Diary on *Cyber-Crime Awareness* by UNODC, Cybercrime and MoE, Republic of Liberia

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TEXTBOOK MANAGEMENT
Student Textbook Assignment Form

School : ____

District : ______________________Country: ______________________

Teacher : ______________________Subject: ______________________

Grade : ____

No.	Name of the Student	Name of the Textbook	Barcode Number	Condition of the TB when received	Date Received	Date Returned	Condition of TB when returned	Signature of Student
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								