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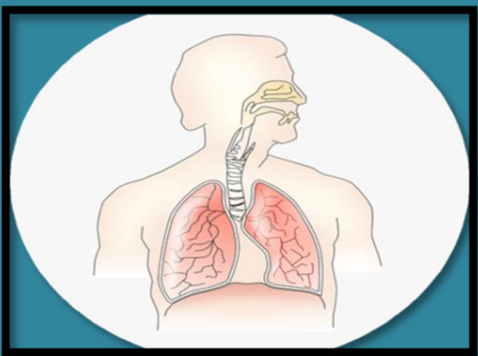
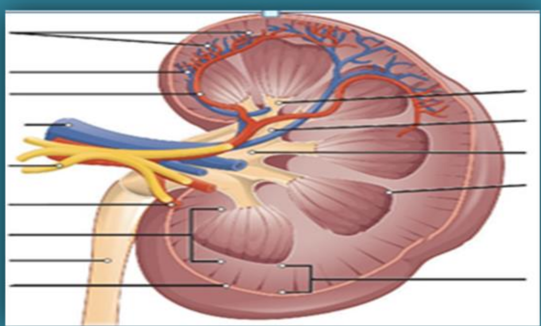
Biology

GRADE 10





Prepared by: Virtual Study

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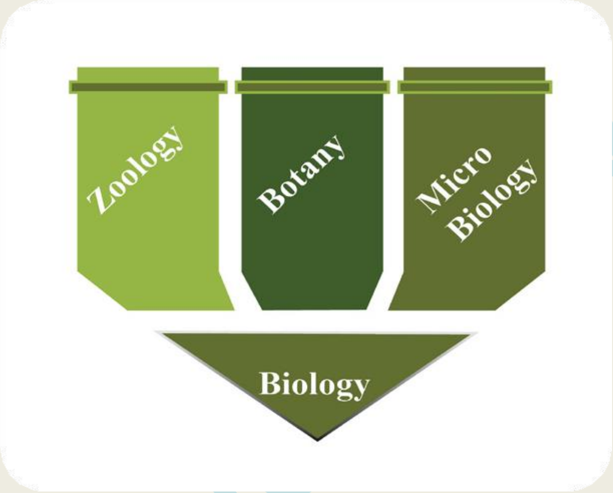
Contents

Unit 1: Sub-fields of Biology

1.1 Sub-fields of Biology

The scope of biology is so broad that it contains many branches and sub-disciplines. In this unit, thus, you will study the sub-fields of biology. Based on the type of organism it studies, biology is subdivided into three: Zoology, Botany, and Microbiology. In addition to these three sub-fields, there is a huge array of sub-disciplines or fields of biology. Many have been around for hundreds of years whilst others are far newer and are often developing very rapidly.



Zoology

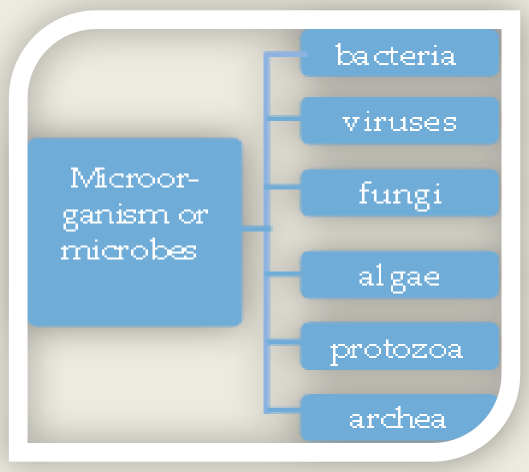
Animal biology, also known as zoology, is the study of animals and includes disciplines such as herpetology (reptiles), ichthyology (fish), mammalogy (mammals), ornithology (birds), and entomology (insects). Zoology is concerned with all aspects of animal life, such as embryonic development to mature adulthood; behavior, such as interactions with other animals or food finding; and genetics.

Botany

Botany is a field of biology that studies about plants. It deals with plants' structure, properties, and biochemical processes. It also studies about classification and diseases of plants and their interactions with the environment. The principles and findings of botany have provided the base for such applied sciences as agriculture, horticulture, and forestry.

Microbiology

Microbiology is the study of microscopic organisms or microbes that cannot be seen by unaided eye. It includes bacteria, archaea, protists, viruses, microscopic algae and fungi. This branch of biology is further subdivided into sub-disciplines, which are frequently defined by specific microbes. Bacteriology, for example, is the study of bacteria, whereas mycology is the study of fungi. The majority of bacteria and other microbial species have yet to be identified due to the difficulty of isolating a single microscopic species. Microbiology is a rapidly expanding field of study; however, new technology and developments in the field are constantly assisting in the identification of new species.



The microorganisms

Different fields of biology based on the structure studied.

Sub-branch of Biology	Definition	Example of the structures studied
Morphology	Study of external form and structure	Shape, the texture of leaves, stem, etc
Anatomy	Study of the bodily structure of humans, animals, and other living organisms, especially as revealed by dissection and the separation of parts	Stomach, liver, heart, etc
Histology	Study of the details of tissue structure	Parenchyma, connective tissue
Cytology	Study of cells	A plant cell, a nerve cell
Cell biology	Study of the structure, function, and various aspects of cell and its components	Mitochondrion, ribosome, nucleus, etc
Molecular Biology	Study of structure and function of informational molecules	DNA, RNA

Subjects studied in various branches of Biology.

Branch of biology	Subject studies	Examples
Physiology	The normal functions of living organisms and their parts	Photosynthesis, digestion, etc
Embryology	The embryo, from a single-celled zygote (fertilized ovum) to the formation of form and shape	Structure and development of ova, sperm, blastula (an embryo at early stage of development consisting of a hollow ball of cells), gastrula(the stage in embryonic development after blastula during which the embryo develops two layers), etc
Ecology	Interaction of organisms with the environment	Food chain, biomass, biosphere, etc
Taxonomy	Identification, nomenclature, and classification of organisms	The biological name of a human is Homo sapiens and it was placed in the animal kingdom
Paleontology	Origin, growth, and structure of organisms of the past	Fossils of organisms
Evolution	The change in the characteristics of a species over several generations that relies on the process of natural selection	The beaks of Darwin's finches
Genetics	Heredity and variation	Gene concept, Mendel's laws
Exobiology	The origin, evolution, distribution, and future of life in the Universe	Life on Moon, life on Mars

Knowledge taken from other subjects that helps to explain biological phenomenon.

Structure/ mechanism studied	Example	Related Science	Knowledge of other sciences is required because
Cell membrane	Structure of lipids and proteins	Chemistry	Living organisms are made of inorganic and organic compounds
Transportation of Oxygen (O2) in the body	Formation of Oxyhaemoglobin (haemoglobin with oxygen)	Chemistry	All metabolic pathways involve chemical change
Excretory system	Absorption and elimination of salts	Chemistry	Homeostasis involves acid-base equi-Librium to maintain the pH of living organisms
Absorption of food/ water	Absorption of sugars, amino acids, fatty acids, water, or salts	Chemistry	During diffusion and osmosis moleclues move into and out of the cell
Transportation of water in plants	Conduction of water from root to leaves	Physics	Liquids have certain properties like cohesion and adhesion to result in surface tension and capillary action which helps in certain processes

Release of energy during respiration	Electron transport chain (transfer electrons from electron donors to electron acceptors via redox reactions)	Chemistry	Energy transfer and transport

1.2 Pure and applied fields of biology

Pure biology is the study of how life functions in nature (behavior, internal and external structure, reproduction, etc.) whereas applied biology refers to using what you have learned in biology for (gardening, nursery work, agriculture, plant disease, forestry, poultry, etc.). Therefore, applied biology is the use of your knowledge of biology to manage life. The relationship is similar to anatomy and surgery.
In some branches of science, biology has become very important in this millennium. With the above idea, let us discuss some of the biological importance of the branches of biology in other branches of sciences.

1. **Biotechnology**: is the use of living organisms or their products for the welfare of humanity. It involves the technical manipulation of a living organism's genetic makeup (Genetic Engineering). A genetically modified and improved variety of crops and animals have been produced by biotechnology.
2. **Bioinformatics**: is concerned with the acquisition, storage, analysis, and dissemination of biological data, most often DNA and amino acid sequences. Bioinformatics uses computer programs for a variety of applications, including determining gene and protein functions, establishing evolutionary relationships, and predicting the three-dimensional shapes of proteins.
3. **Genetic Engineering**: is a means of extracting selected genes from an organism or synthesizing selected genes and these genes are inserted into another organism; as a result, an organism develops with a new combination of genes, and this process is called genetic engineering.
4. **Biomedical Engineering**: is the application of the principles and problem-solving techniques of engineering to biology and medicine. Biomedical engineering focuses on the advances that improve human health and health care at all levels
5. Environment Management: deals with environmental observation and finding out the solution to maintain the balance of nature.
6. **Forensic Science**: is the application of the knowledge of biological science (DNA fingerprints (unique patterns in DNA molecule), blood typing) to criminal and civil laws.

1.3 Major discoveries that revolutionized biology

1. Aristotle (384–322 BC)

the ancient Greek philosopher Aristotle was responsible for a breakthrough classification system for living things. Aristotle's classification system was known as the

'Ladder of Life' until the nineteenth century. For the first time, he established species relationships and grouped them correctly.

2. Galen (129–161 AD)

Galen's efforts transformed medical science. Galen had a significant impact on the advancement of numerous medical specialties, including Anatomy, Pathology, Physiology, and Neurology. Among his important findings were the distinctions between veins and arteries, as well as the recognition that the larynx produces voice. Although many of his concepts contained scientific mistakes, his contribution to medical science is undeniable

3. Antonie van Leeuwenhoek (1632–1723)

Antonie van Leeuwenhoek is well renowned for his contributions to microscopy and how he applied it to the field of biology. He invented a method for making strong lenses that, according to some, could magnify up to 500 times. Leeuwenhoek employed microscopes to learn more about the biological world; among his findings were bacteria and the vacuole of the cell.

4. Carl Linnaeus (1707–1775)

Carl Linnaeus, a botanist, physician, and naturalist, devised the method for naming, ordering, and classifying creatures that we still use today. His extensive collection of plant, animal, and shell specimens inspired him to devise a system for classifying and naming species. He separated items into three categories – animals, plants, and minerals – and further organized living things into classes, orders, genera, and species. 'Homo sapiens,' for example - 'homo' is the genus and 'sapiens' is the species.

5. Charles Darwin (1809–1882)

Probably the most famous naturalist of all time, Charles Darwin's contribution to biology and society is immense. He established that all species of life descended over time from common ancestors, with species continuing to exist through the process of natural selection. His theory of evolution was published in On the Origin of Species in 1859 and it caused quite the stir – he was disputing the long-held belief that all species had been created by God at the beginning of the world. Evolution by natural selection combined with Mendelian genetics is now accepted as the modern evolutionary synthesis and forms the foundations of much biological scientific endeavor.

6. Gregor Mendel (1822–1884)

Gregor Mendel's extraordinary contribution didn't get the recognition it deserved until long after the friar's death. He used peas to discover and demonstrate the laws of genetic inheritance, coining the terms 'dominant' and 'recessive' genes in the process. The laws were rediscovered at the turn of the

20th century and provided the mechanism for Darwin's theory of natural selection to occur. The two theories combine to form our current understanding of the evolutionary process.

7. Louis Pasteur (1822-1895)

Louis Pasteur is regarded as the father of medical microbiology. His contributions to science, technology, and medicine are nearly unparalleled in history. He pioneered molecular asymmetry research, demonstrated that bacteria cause fermentation and disease, introduced pasteurization, rescued France's beer, wine, and silk industries, and developed anthrax and rabies vaccines.

8. Robert Koch (1843-1910)

Robert Koch was a well-known German physician who pioneered microbiology. As the father of modern bacteriology, he is credited with pinpointing the precise causal agents of tuberculosis, cholera, and anthrax, as well as providing experimental support for the concept of infectious disease.

9. Jane Goodall (1934)

Our knowledge of wildlife and conservation has been transformed by Jane Goodall, the UK ethologist. Best known for her career-long studies of chimpanzees, she discovered the animals are omnivores and tool users. She's a global leader in animal rights and was awarded a Ph.D. degree from the University of Cambridge without holding a bachelor's degree.

10) Barbara McClintock (1902–1992)

American geneticist Barbara McClintock spent her career analyzing maize, where she developed a technique for identifying and examining chromosomes individually. Despite it not being immediately recognized, her work made it possible for us to map human genomes. She was awarded the Nobel Peace Prize in 1983 for her discovery of transposition and how genes could turn their physical characteristics on and off.

11.Watson (1928–) and Crick (1916–2004)

James Watson and Francis Crick were shot to fame in 1962 for their discovery of the structure of DNA, winning the medical Nobel Prize in the process. Their model of DNA (double helix) explains how DNA replicates, and hereditary information is coded and passed on to descendants. The discovery of DNA structure has led to a much more developed understanding of function – used in disease diagnosis and treatment, forensics, and more.

12. Wilmut (1944) and Campbell (1954–2012)

In 1996 Ian Wilmut and Keith Campbell cloned a mammal, famously named Dolly the Sheep. The pair cloned Dolly using a single adult sheep cell and a process of nuclear transfer. Dolly died after six years but cloning continues, although still not perfect, and certainly not ready for human application.

1.4 The contributions of biological discoveries to society and the environment

The Microscope

The microscope is a device that magnifies objects or organisms that are too small to be seen with the naked eye. A milestone in the science world, the microscope has had an enormous influence on the development of modern medical, forensics, and environmental sciences.

The Microscope

The invention of the microscope has revolutionized the science industry while developing other fields.

- *Medical field*
- Ecosystem study
- *Forensic Science*
- *Atomic Study*
- *Genetic Study*
- *Tissue Analysis*

1.5 Ethiopian biologists and their contributions

Three of the Ethiopian scientists and their discoveries are given below.

1.Professor Yalemtsehay Mekonnen

One of her research areas is the assessment of the impact of chemical pesticide hazards on humans.

This research covers almost all government farms including the Upper Awash agricultural farms and some private horticultural farms in the Rift Valley region. The other area of her research is in the use of plants as medicine against human and animal diseases.
Professor Yalemtsehay has published over 100 scientific papers in reputable journals in the areas of plants of medicinal and nutritional value in vivo and in vitro physiological tests of useful plant extracts, assessment of health hazards to humans, animals and the environment, advocacy and collaborative work for the promotion of safe and sustainable use of natural resources, to name but few. She has done notable research on medicinal plants especially on Moringa Stenopetala (shiferaw/Alekko Shekatta).

2. Dr. Aklilu Lemma

Dr. Aklilu began his work in 1964 when he was investigating the freshwater snails that carry the Schistosomiasis parasite around Adwa in northern Ethiopia. He saw women washing clothes in the water and he noticed that downstream of the washing party there were more dead snails than anywhere else he had collected. The women were using the soapberry, 'Endod' in Amharic (Phytolacca dodecane Dr.a), to make washing suds.

Dr. Aklilu's results were published in journals around the world. He found the best species of the soapberry plant and developed programs for local communities to treat their water. Eventually, people were convinced and the use of Endod-based molluscicides is spreading throughout Africa and beyond. He has been honored and recognized in many different ways both in Ethiopia and around the world for his work.

Dr. Aklilu Lemma's discovery of soapberry 'Endod' against bilharzia (Schistosomiasis), a preva- lent parasitic ailment.

3. Professor Gebissa Ejeta

He specializes in plant breeding and genetics. Prof. Gebissa Ejeta did his research on sorghum He got his Ph.D. from Purdue University in the USA where he still holds a professorship. He has helped to develop Africa's first commercial hybrid strain of sorghum. This sorghum variety not only needs less water and so is resistant to drought, but it also yields more grain than traditional varieties.

Prof. Gebissa Ejeta developed other varieties of sorghum that are also resistant to the parasitic Striga weed, which can destroy a big percentage of a crop. Prof. Gebissa's work has made a very big difference to the food availability in many areas of Ethiopia and other African countries. His varieties yield up to ten times more than others. In 2009, Prof. Gebissa Ejeta was awarded the World Food Prize, which is the most prestigious agricultural prize in the world.

Review Questions

I. True False

Write "True" for correct statements and "False" for the incorrect once on the space provided.

1. X-ray was discovered by Frederick Bating in 1895. False
2. Biochemistry deals with the chemical reactions that take place in living organisms. True
3. Microscope was discovered by Theodor Schwann in 1838. False
4. Genetics is the study of heredity and variation. True
5. The scientific contribution of Prof. Gabissa Ejeta is on the application of Endod to control Bilharzia. False

II. Matching

Match the description of field of study given under Column A with the field of study given under column B, and write the letter of your answer on the space provided.

	Column "A"	Column "B"
1	The study of insects D	A. Cytology
2	Embryological development of the fetus E	B. Agroforestry
3	The study of tissue C	C. Histology
4	The study of mixed agriculture B	D. Entomology
5	The study of cells A	E. Embryology

III. Multiple Choice

Choose the best answer from the given alternatives (A, B, C & D).

1. The evolutionary history of an organism is known as
   A. Anatomy B. Ancestry c.Palaeontology D. Phylogeny
2. Who discovered the circulation of blood?
   A. Ibn al-Nafis B. McCollum C. Scottish naval D. Edward Mellanby
   F.
3. The study of the internal structure of an organism is
   A. Morphology B. Anatomy C. Histology D. Systematic
4. Anatomy is the study of
   A. Life B. Body parts C. Animals D. Ocean
5. Who is regarded as the father of genetics?
   A. Grogor Mendel B. Gabissa Ejeta C. Scottish naval D. Edward Mellanby
6. Who first discovered the germ theory of disease?
   A. Louis Pasteur B. Alexander Flaming C. Frederick Banting D. August Weismann
7. Who discovered vitamins?
   A. Anton Van Leeuwenhoek B. Frederick Hopkins C. James Watt D. All of the above
8. Bilharzia is caused by:
   A. Snails B. Bacteria C. Parasitic flatworms D. Viruses

IV. Short answer

1. How biology and chemistry are interrelated in biochemistry?
2. Discuss the role of genetic discoveries in agricultural development.
3. How biological studies help human to keep healthy life?

4. What are the major discoveries of Louis Pasteur?
5. How does biology and physics interrelation form a study termed biophysics?

Answer

1. Biochemistry explores chemical processes related to living organisms. It is a laboratory-based science combining biology and chemistry. Biochemists study the structure, composition, and chemical reactions of substances in living systems and, in turn, their functions and ways to control them.

2. Scientists can now transfer genes responsible for desirable traits, such as pest resistance, drought tolerance, and disease resistance, into target crops. This approach reduces the reliance on chemical pesticides, minimizes crop losses, and ensures a stable food supply.

3. It helps us better understand the human body and how our body functions. It also gives us a better understanding of why we get sick and what we can do to stay healthy. Learning about biology will also help us understand how our environment affects our health, and how we can make changes to improve our health.

4. He pioneered the study of molecular asymmetry; discovered that microorganisms cause fermentation and disease; originated the process of pasteurization; saved the beer, wine, and silk industries in France; and developed vaccines against anthrax and rabies.

5. Biophysics is an interdisciplinary science where biology and physics come together to apply physical concepts to the study of living organisms and biological systems.

Unit 2: Plants

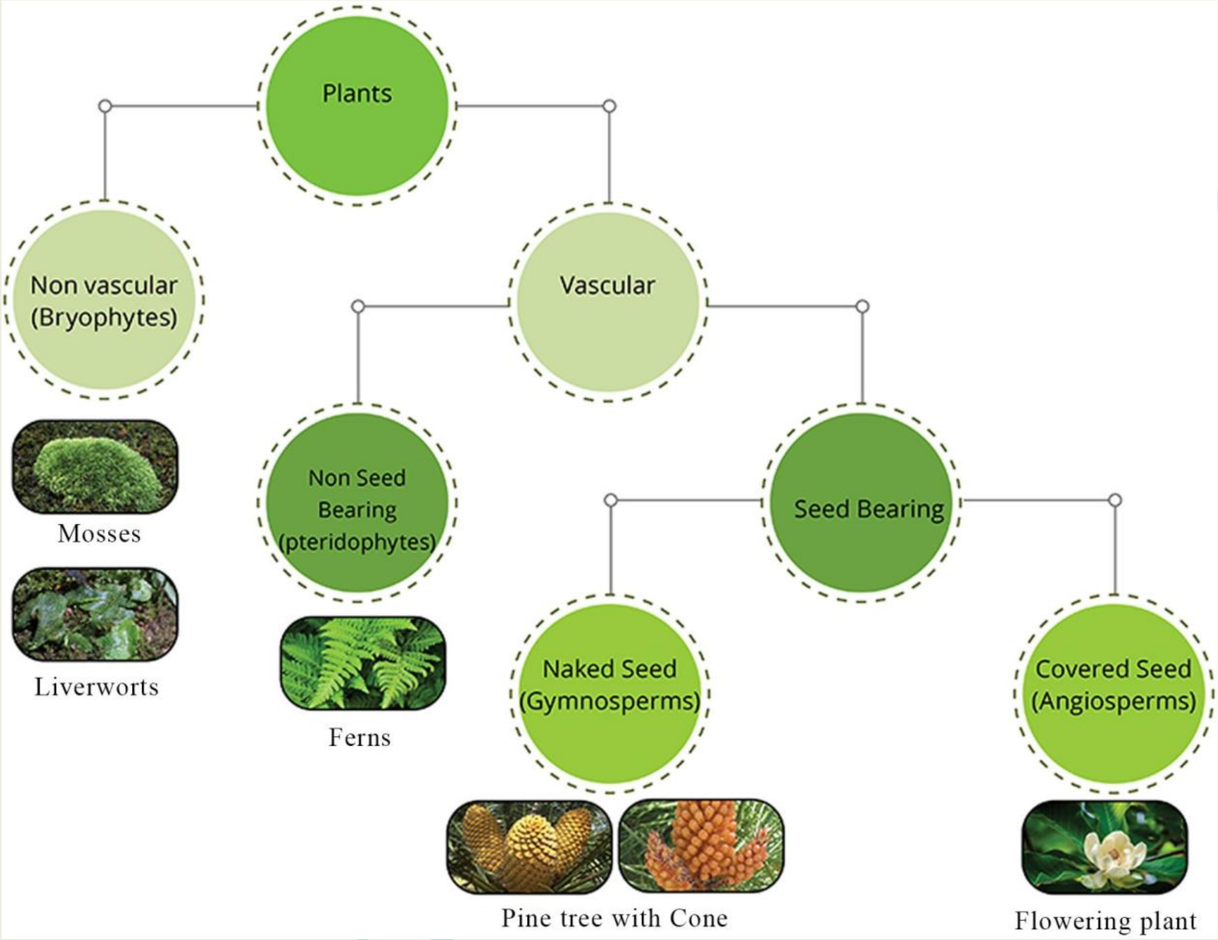
2.1 Characteristics of plants

living things from those features which are unique to plants.

- Plants are living things. Like other living things plants grow, reproduce and respond to changes in the environment.
- Plants are multicellular. They are made up of many eukaryotic cells. These cells have well-defined nuclei and membrane-bound organelles. In addition to the cell membrane, plant cells have a rigid cell wall made primarily of cellulose.
- Plants are autotrophic (self–feeding). Plant cells contain the green pigment chlorophyll which enables them to absorb sunlight and produce their own food. Thus, they are also named Producers.
- Plants are sessile. They cannot move by themselves. They remain fixed at one place, firmly anchored to the soil by their root. However, the leaves of plants can turn towards light and some respond to touch. The roots of plants can also orient towards water or moist soil.
- Plants practice asexual and sexual reproduction patterns. In lower plants such as mosses and liverworts, asexual reproduction through spores is the dominant form. On the other hand, in higher and seed-bearing plants such as gymnosperms and angiosperms, sexual reproduction which involves the union of gametes or sex cells is the dominant and visible form

2.2 Flowering and non – flowering plants

Flowering plants, commonly known as Angiosperms, are also vascular with well-developed root, stem and leaves. But unlike gymnosperms, they have flowers and produce seeds within a fruit.



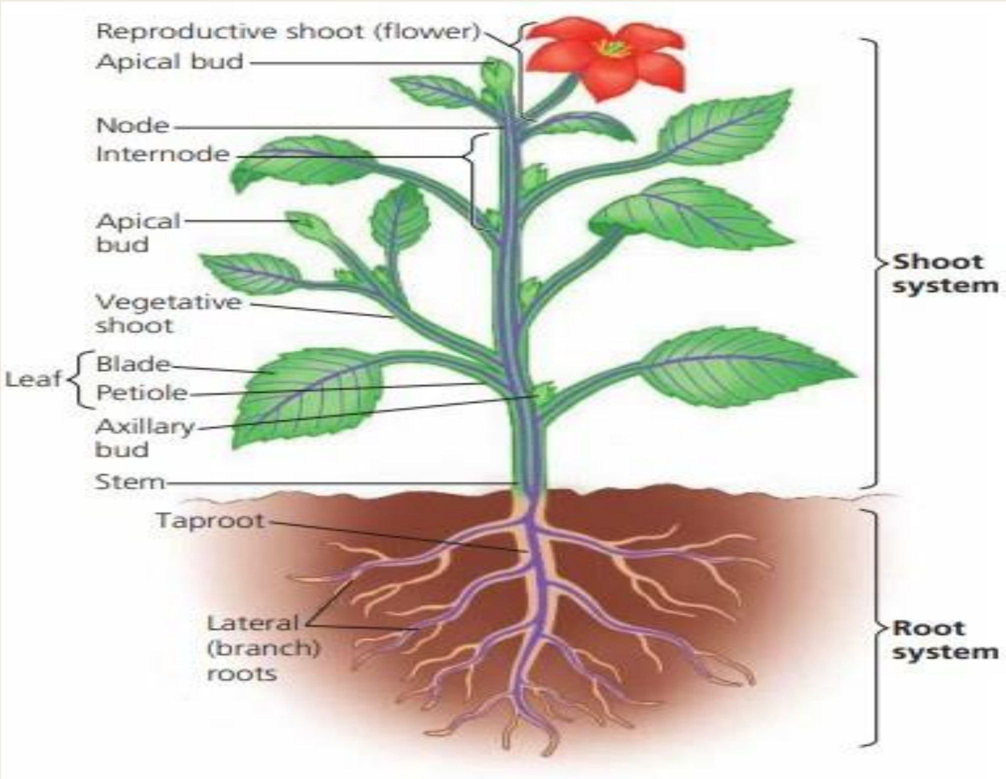
Major groups of plants

2.3 Structure and function of plant parts

Like any organism, plants have different structures which perform a vital function essential for the plant life. In this sub-topic, we will focus on the external and internal structure of a flowering plant (angiosperm).

the shoot system: This is the plant part usually found above the ground and includes the organs such as stem, branches, leaves, buds, flowers and fruits. The last two organs may be missing depending on the reproductive stage of the plant.

The root system: This is the part of the plant that usually grows downward into the ground. It includes the primary or tap root, lateral or branch roots, root hairs and root cap. Roots are distinguished from an underground stem in that, it does not bear either leaves or buds.



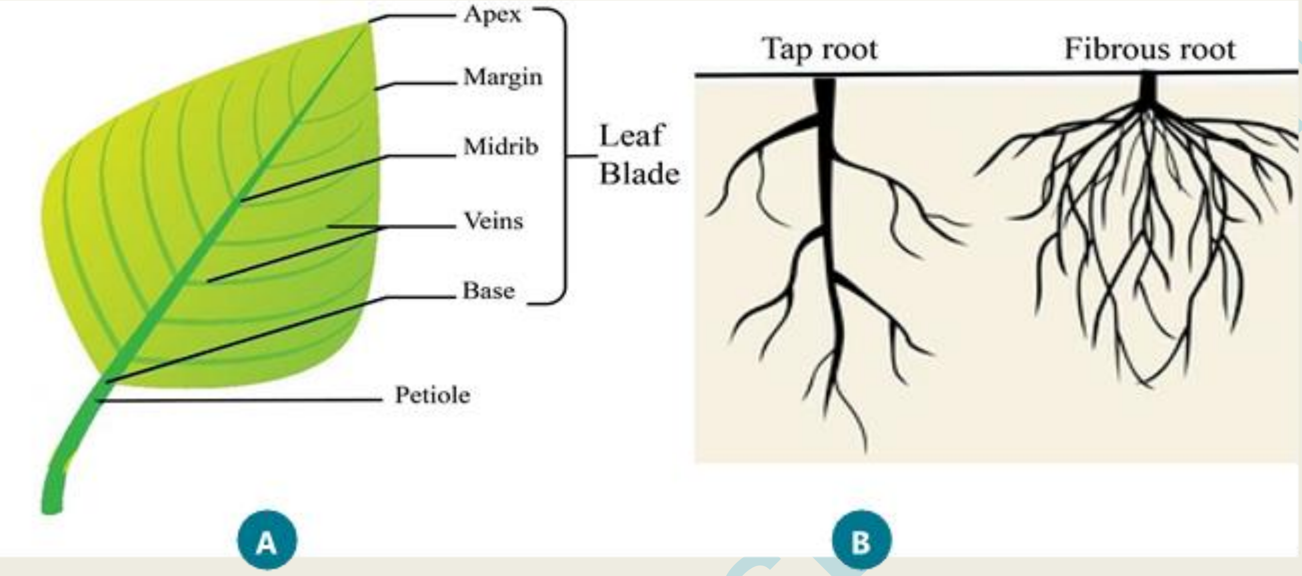
External structure of a typical angiosperm (flowering plant)

Figure shows the external structure of leaf and the types of root. The external structure of a typical leaf consists of the petiole (leaf stalk), lamina (blade – broadest part), midrib, margin, base and tips. The lamina is the broadest part, which is flat, wide and commonly thin. It provides large surface area, which enables leaf to collect light. Its thinness creates short distance for gas exchange through the stomata (tiny pores). The midrib is harder and contains the vein (transporting vessels) of the leaf as well as supportive tissues with hard cell wall. Leaves of different plants show difference in absence or presence of petiole, leaf shape (variation in leaf margin, base and tips) and arrangement of veins

With regard to root, there are basically two types of roots, namely tap-roots and fibrous roots

A tap-root consists of one large, primary vertical root. It has very few lateral roots that develop and grow from this main root. By penetrating deep into the soil, tap roots provide stability (anchorage) and absorb water located deep in the ground. Tap root **No table of figures entries found.**System is a feature of dicot plants.

A fibrous root is usually formed by thin, moderately branching roots growing from stems. They are more or less similar size and length. In grasses they develop as consists of fine hair – like root that. Spread out from the base of the stem. Fibrous root is very efficient for absorbing water and minerals close to soil surface. It creates a thick network of roots that are good at holding soil together and protect soil from erosion. Fibrous roots are features of monocot plants .



External structure of a typical leaf (A) and Types of roots (B)

2.3.1 The internal structure of a leaf

A) Outer layer

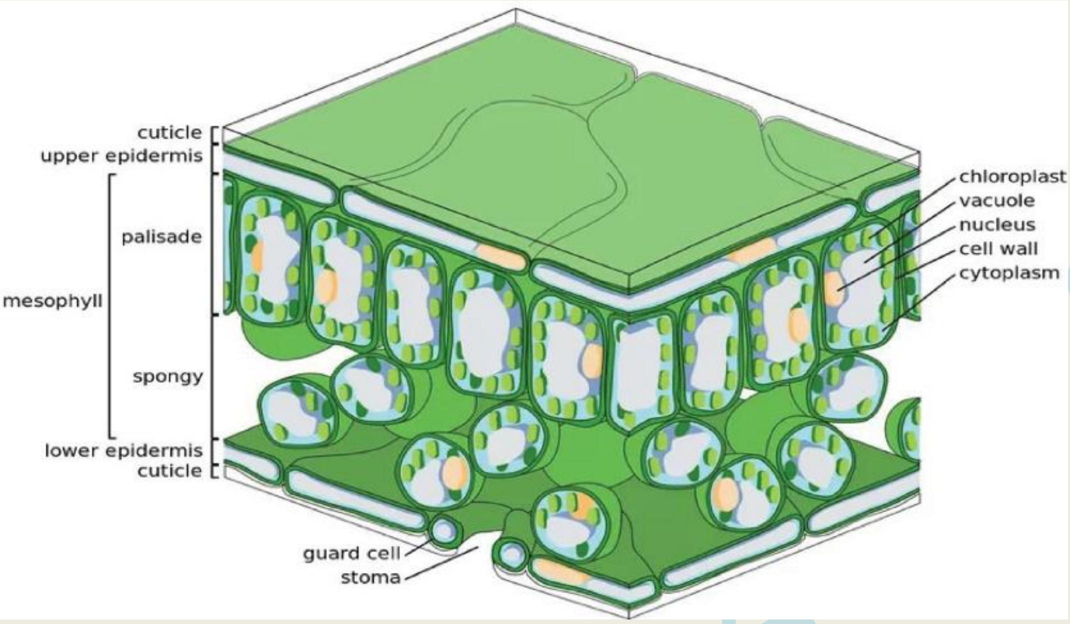
This is also known as the epidermis, a single layer of tightly packed cells that covers the upper and lower surface of the leaf. The upper epidermis is usually covered by a waxy cuticle, which transmits sunlight for photosynthesis but restricts water loss by evaporation from the leaf tissue. The lower epidermis usually contains bean- shaped guard cells that leave open spaces known as stomata (singular stoma). Stomata are "little mouths" or "little noses", which regulate O2 release, CO2 intake and water loss. In most leaves, stomata are more abundant in the lower epidermis, reducing water loss due to direct sunlight.

B) Middle layer

This is known as the mesophyll ("middle leaf") layer. It lies between the upper and lower epidermis. It includes tissues that are directly or indirectly involved in photosynthesis. There are two regions in the mesophyll layer

The palisade layer is composed of regularly arranged and closely packed columnar (vertically elongated) cells. The cells contain the largest number of chloroplasts per cell. As the layer is immediately beneath the upper epidermis, it is in the best position to capture most of the sunlight and this enables it to carry out most of the photosynthesis. The slight but precise separation of the columnar cells maximizes the diffusion of CO2 and capillary movement of H20.

The spongy layer – lies below the palisade cells. Spongy cells are irregularly shaped with fewer chloroplasts. They are very loosely arranged with numerous airspaces. These air spaces, which are very close to the stomata allow the diffusion of O2, water vapour and CO2.

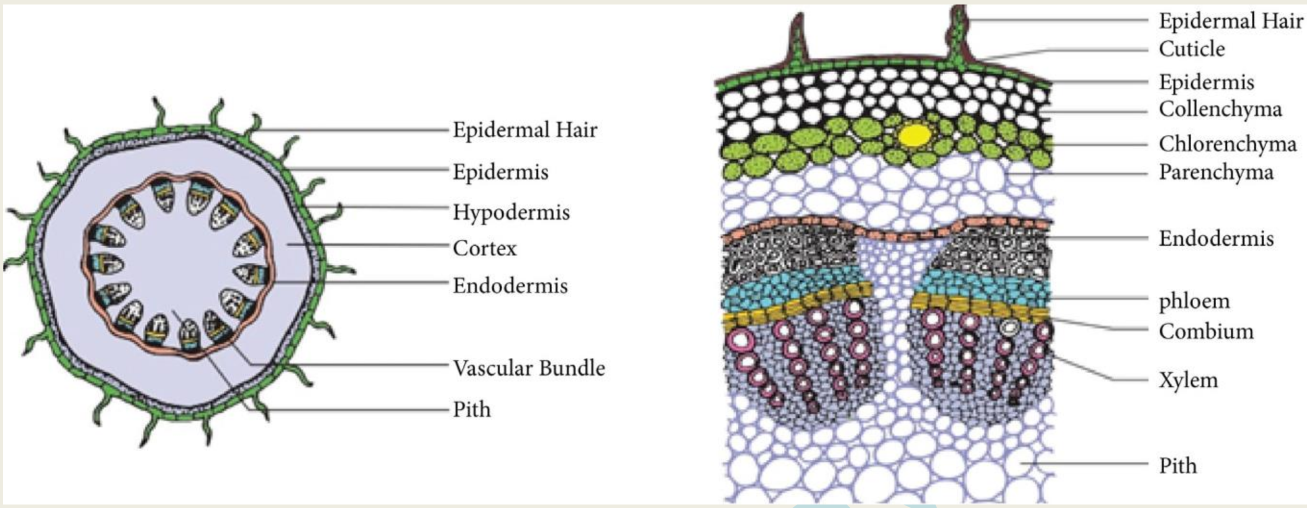


Shows components of the two internal layers of a leaf

2.3.2 The internal structure of a stem

Figure 2.5 shows the internal structure of a typical dicot stem of a flowering plant. Accordingly, the detailed internal structure includes the following fundamental tissue systems.

The epidermis is the outermost layer of the stem. The outer walls are greatly thickened with cuticles, which minimizes the rate of transpiration. Moreover, the cells are compactly arranged, which in turn protect the underlying tissues from mechanical injury and prevent the entry of harmful organisms.



Internal structure of a typical dicot stem (A = Ground plan; B = Transverse section)

Hypodermis lies below the epidermis. It is mainly composed of collencyma cells that are specially thickened at the corners due to the deposition of thick cellulose. This enables the layer to give mechanical strength to the stem.

Cortex consists of few layers of thin-walled, large, round, or oval cells, having intercellular space and serving for storage of food.

Endodermis is the innermost layer of the cortex that separates the cortex from the vascular bundles. The cells are compactly arranged and usually contain starch grains. Thus, the endodermis serves as a food reserve and may be termed as a starch sheath.

vascular bundles are longitudinal strands of conducting tissues or transporting vessels, consisting essentially of xylem and phloem arranged in a ring around the central pith. Each bundle has a patch of xylem towards the pith and a patch of phloem towards the endodermis and a strip of actively dividing young cells (cambium) in between them. Xylem transports water and dissolved minerals to the photosynthetic tissues, mainly to the leaf while phloem transports synthesized food to different tissues, either for utilization or storage.

Pith – occupies the central portion of the stem, composed of thin- walled cells, which are rounded or polygonal, with or without intercellular space. It stores food and helps in the internal translocation of water.

2.3.3 The internal structure of a root

As illustrated in Figure 2.6 below, the transverse section of the dicot root shows the following plan of arrangement of tissues from the periphery to the centre.

Peliferous layer is the outermost layer made up of single-layer cells. The cuticle is absent. . It consists the single-celled root hairs.

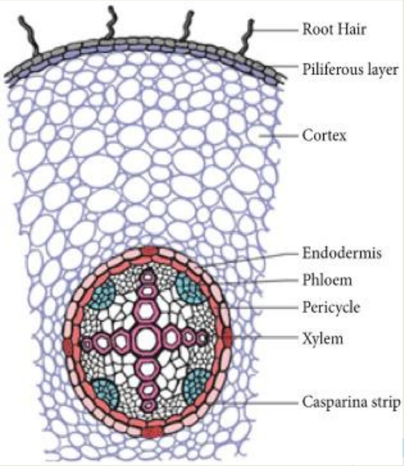
Cortex is a multi-layered large zone made of thin-walled oval or rounded loosely arranged cells with intercellular spaces. It stores food and water.

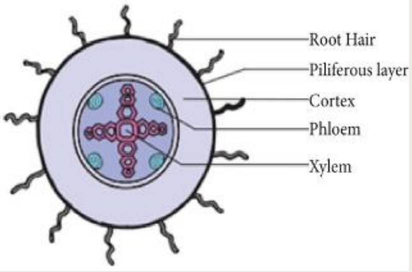
Endodermis is the innermost layer of the cortex, made of barrel- shaped closely packed cells. The layer helps the movement of water and dissolved nutrients from the cortex into the xylem.

Pericycle is a single layer inner to endodermis. It is the site of origin of lateral roots.

Vascular bundles consist of xylem and phloem with meristematic (cambium) or actively dividing cells between them

Pith is present in young roots while absent in old roots.





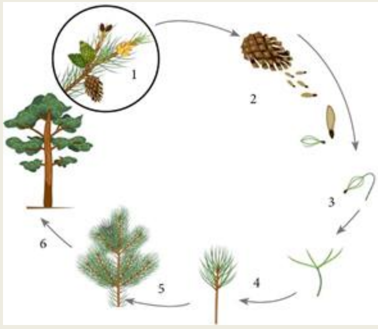
Internal structure of a typical dicot root

2.4 Reproduction in plants

2.4.1 Reproductive structure and life cycle of non-flowering plants

After the field visit and preparation of the field report, you are now able to distinguish and describe gymnosperms. In this lesson, you will learn the life cycle of gymnosperm, using the pine tree as a typical representative of conifers as well as gymnosperms in general.

As shown in Figure 2.8 the pine tree has male and female cones on one plant. Initially, pollen is transferred from the male cone to the female cone. The process is called pollination and occurs with the help of wind. Following pollination, the pollen completes its germination and produces the male gamete inside the female cone. The female gamete is also produced in the female cone. Here, the male and female gametes fuse (unite) and form a zygote. This process is known as fertilization.



Life cycle of a pine tree representing gymnosperms

A zygote develops into a seed embryo inside the female cone. After the seed is matured, it is liberated upon drying and opening of the female cone. Then the seed will be dispersed or scattered away from the parent plant and germinates into a seedling (young pine plant) upon getting favorable conditions. Finally, the young plant grows and develops in to mature plant with female and male cones and the reproductive cycle of the pine tree is complete.

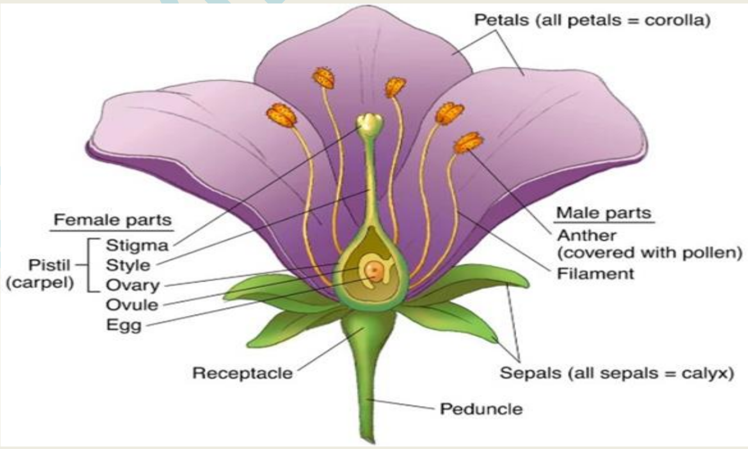
2.4.2 Reproductive structure and life cycle of flowering plants

A flower is the reproductive organ of angiosperms, plants with seeds covered by or contained in a fruit. Figure 2.9 illustrates a typical flower has four floral parts, namely Sepals, Petals, Stamen, and Pisti. Sepals (calyx) – usually green leaf-like structure protecting the lower part of female and male parts

Petals (corolla) – mostly brightly coloured and attract pollinating agents like insects

Stamen (Androecium) – is the male part, consisting of the filament and bilobed anther

Pistil (Gynoecium or carpel) – is the female part, consisting of the ovary with ovules, style and stigma.



Structure of typical flower

2.4,3 Pollination

This is the transfer of pollen grains from the anther of a stamen to the stigma of the pistil. The transfer can be between stamen and pistil on one flower or between flowers on one plant (Self Pollination) or between two flowers on different plants (cross-pollination). Pollination requires pollinating agents such as insects or wind. There is a strong relationship between the nature of the flower and the pollinating agents.

Pollen tube formation

Pollen grains landing on the stigma will form pollen tubes that grow down in the style and form the male gamete as it approaches the ovule.

Fertilization

This is the union of the male gamete and the female gamete, occurring in the ovule within the ovary. As a result, a zygote that develops into a seed embryo will be formed

Seed and fruit formation

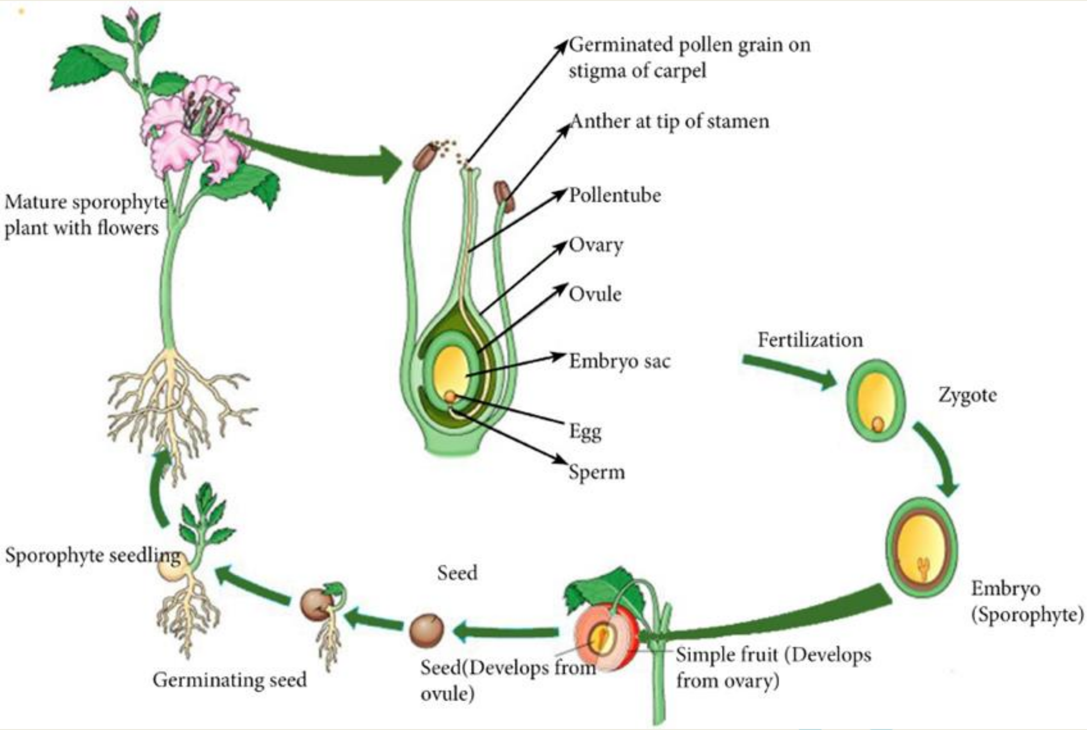
Following fertilization and formation of seed embryo, the ovule matures into seed while the ovary matures into a fruit. Thus seed is a matured ovule while the fruit is a matured ovary.

Seed dispersal

This is a mechanism of scattering seeds around or away from the parent plant. Seed dispersal like pollination requires agents such as animals or wind.

Seed dormancy /Seed germination

The fate of a seed landing at a certain place will be either dormancy or germination. A dormant seed is inactive and waiting for the favourable condition to start germination. If there is enough water and nutrients the seed will break dormancy and the seed embryo starts to develop into a seedling (Young and new plant). This process is called seed germination.

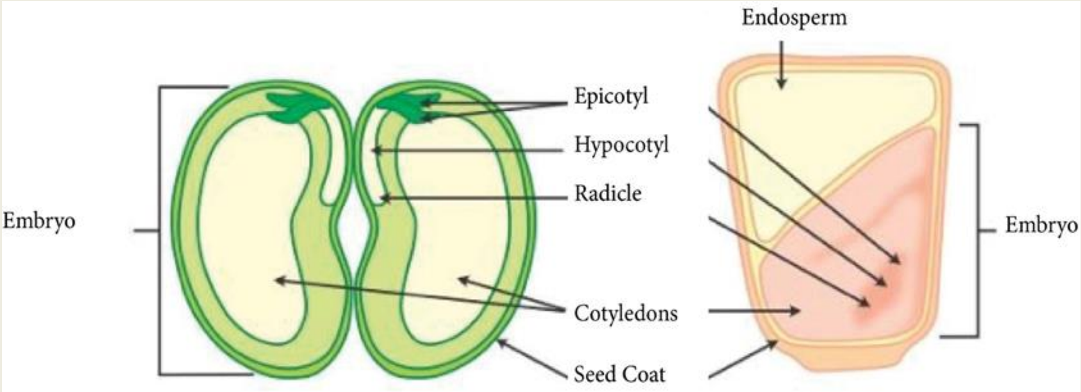


Life cycle of typical flowering plant (angiosperm)

2.5 Seeds

The seed (fertilized ovule) contains three parts: the seed embryo, cotyledon/endosperm (reserve food) and seed coat. In Angiosperms, the seed is additionally covered by the fruit. Thus it is called covered seed as opposed to the naked seed of gymnosperm. A naked seed has nothing on except its own seed coat.

The seed embryo, in turn, consists of the radicle (future root), epicotyl, hypocotyl and the plumule (future shoot) (Fig. 2.11). Cotyledon and endosperm are food storing tissues, essential for the seed embryo (future plant) until it forms leaf and starts manufacturing its own food. A seed of angiosperm may have one cotyledon (monocot) or two cotyledons (dicot).



Section of a dicot (Bean) and monocot (Corn/Maize) seed and the associated structures.

Differences between dicot and monocot seeds

Dicot seed	Monocot seed
Two cotyledons are present in the Embryo	Only one cotyledon present
Cotyledons are fleshy and store food materials	Cotyledon is very thin and lacks food materials
Endosperm is absent	Endosperm is large and well Developed
Primary root produced from the radicle bears many lateral roots.	Primary root formed from radicle is replaced by adventitious fibrous roots

2.7 Photosynthesis

The product of leaves together with the photosynthetic productivity of algae provides food that supports nearly all life on earth. Plants can prepare their own food by photosynthesis. Thus they are called producers or autotrophs (self-feeding). Besides making food for themselves, plants produce excess food for the vast consumers known as heterotrophs (feeding on plants and on one another).

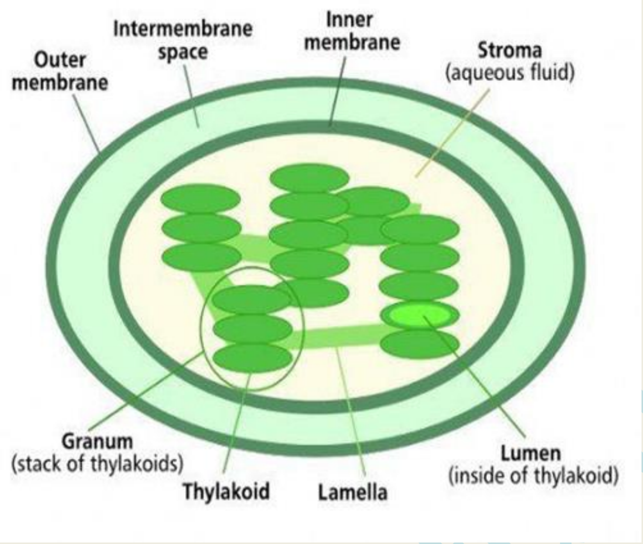
The basic source of energy that sustains life begins with sunlight. In turn, sunlight is absorbed by a green pigment known as chlorophyll. Thus, it occurs in organisms bearing chlorophyll such as green algae and higher plants, which enables them to trap solar energy and transform it into chemical energy. This process is known as photosynthesis. In this section, you will learn more about photosynthetic apparatus - Chloroplast

2.7.1The photosynthetic apparatus

there are two distinct parts in chloroplasts: Granum and Stroma.

i) Granum: consists of stacks of flattened sacks, each of which is called thylakoid. The granum contains the chlorophyll, enzymes and co- factors that participate in the light trapping phase of photosynthesis. It is here that the light reaction takes place.

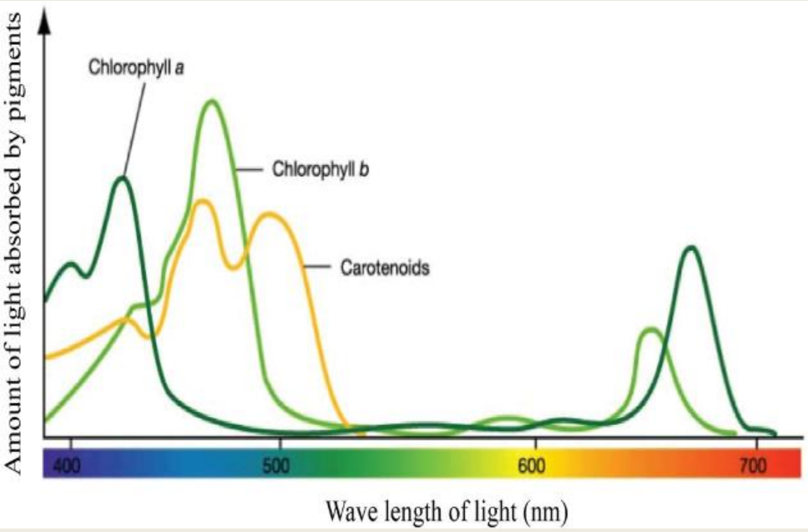
ii) Stroma: is a gel-like colourless matrix, which is a site for sugar (carbohydrate) synthesis through carbon fixation. It is from the sugar produced in the stroma that is directly or indirectly converted to all organic compounds (including amino acids, proteins and lipids) virtually found in all organisms.



Chloroplast – the photosynthetic apparatus

2.7.2 The light absorbing system in chloroplast

The chloroplast contains chlorophyll (particularly chlorophyll a and b) and other light absorbing accessory pigments capable of absorbing light at different wavelengths. As shown in Figure 2.14, the light absorbing pigments of chloroplasts absorb most of the visible light, ranging from 400 – 700 nm. Maximum light absorption occurs at wavelengths from 400 – 500 nm and 600 – 700 nm, blue and red light respectively. Light ranging from 500 to 600nm that includes green light is not absorbed, it is rather reflected. This is the reason why leaves look green.



The action spectrum for different wavelengths

2.7.3 Mechanism of photosynthesis

Photosynthesis consists of a number of photochemical and enzymatic reaction. It is the sum total of the following two sub reaction

1. Light reaction this is also known as the light dependent stage, It takes place in the granum, where the light absorbing system – mainly chlorophyll occurs. Here, the granum is organized as Photosystems and Electron Transporting System. The photosystem consists of chlorophyll that absorbs sunlight maximally at blue and red range of light spectrum. The light absorbed by the chlorophyll will

- split of water molecules (H2O) into H+ and O2. This is known as photolysis. The O2 is released to the atmosphere through leaf stomata.
- excite some electrons in the chlorophyll molecule to higher energy level which pass down the ETS and generate high energy ATP molecule. The ATP and H+ harvested during light reaction will be used as an input in the Stroma where conversion of CO2 to carbohydrate takes place.

2. Dark reaction this is also known as light – independent stage, because it can occur in the absence of light as long as there is sufficient amount of H+ and ATP supplied from the light reaction. The dark reaction and enzymatic reaction H+ indirectly combines with CO2, in the stroma of chloroplast. The process is known as carbon fixation. Glucose (carbohydrate) is the immediate result of the dark reaction.

The overall chemical reaction of photosynthesis can be summed up in the following equation

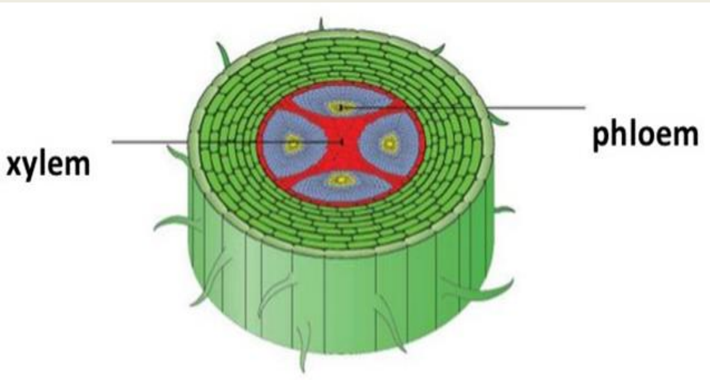
$$6CO_2 + 6H_20 \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} C_6H_{12}0_6 + 60_2$$

2.8 Transport in plant

2.8.1 Transporting systems in plants

You know that higher plants have a green leaf that is capable of photosynthesis. But, do you know the route through which the raw materials, water and minerals, move from roots to leaves and how food manufactured from the leaves reach the rest of the plant? This will be clear after you learn about the transporting vessels of higher plants commonly called vascular bundles.

Figure illustrates the arrangement of the two transporting vessels, xylem and phloem in the root. They are collectively known as vascular bundles. Water and minerals are transported from the root to the leaf via the stem through conducting vessel known asxylem, which consists of elongated dead cells, joined end to end to form continuous vessels. On the other hand, organic matter (food) manufactured in the leaf is transported to the rest of as opposed to xylem, phloem consists of living cells arranged end to end and allows transport of food (sucrose and amino acids) up and down the plant. This is called translocation. In general, it happens between where these substances are made (Sources) and where they are used or stored (the sinks).



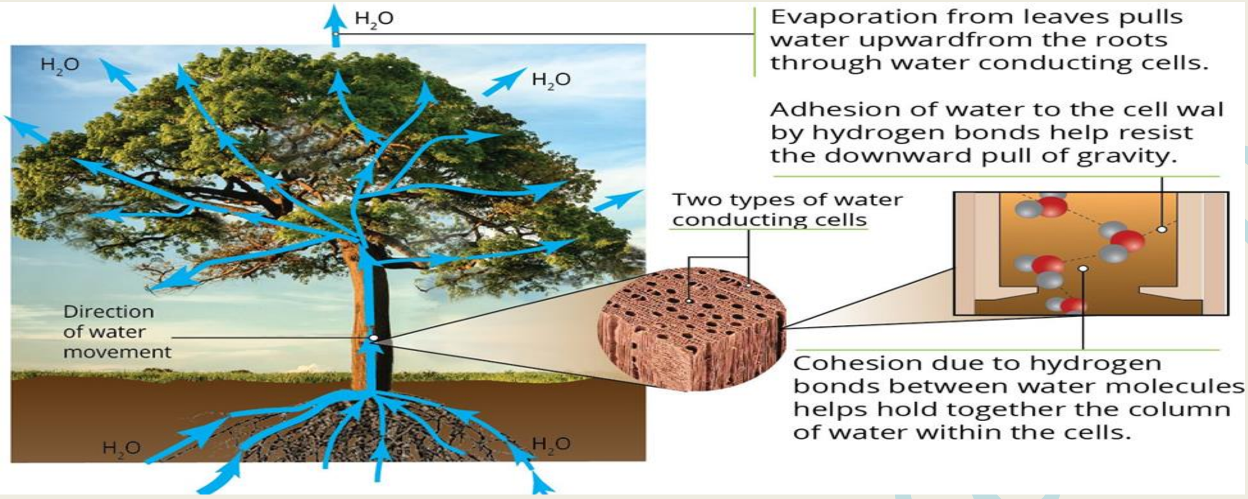
Root vascular bundles

2.8.2 Mechanism of transport in plant

i. Uptake of water and minerals

Water from the soil first enters the root through root hairs. These are elongated single cells that provide a large surface area allowing more water to enter into the root. Minerals also enter the root together with the water. This process is known as absorption. Water entering the root passes from cell to cell either by osmosis across the cell membrane and cytoplasm or freely flow by diffusion along the porous cell wall. Thus, water passes passively (without spending additional energy from the cell) across the root cells and reaches the root xylem.

Water in the root xylem is pulled upward passively by transpiration pull. This is pulling force caused by transpiration; it is the main force responsible for the water passing all the way from the root to the leaves through the xylem vessel. During transpiration water that evaporates from the leaves serve as a mechanism to pull or drag water from the root.



Transport of water and minerals from root to the leaf via the stem

Minerals enter the root in the ionic (charged) form either passively or actively. They are taken actively (cell spends energy) when concentration is higher in plant cell than outside the cell and, therefore accumulation of salts or their ions occur as a result of active transport against a concentration gradient.

ii. Translocation of organic matter (food)

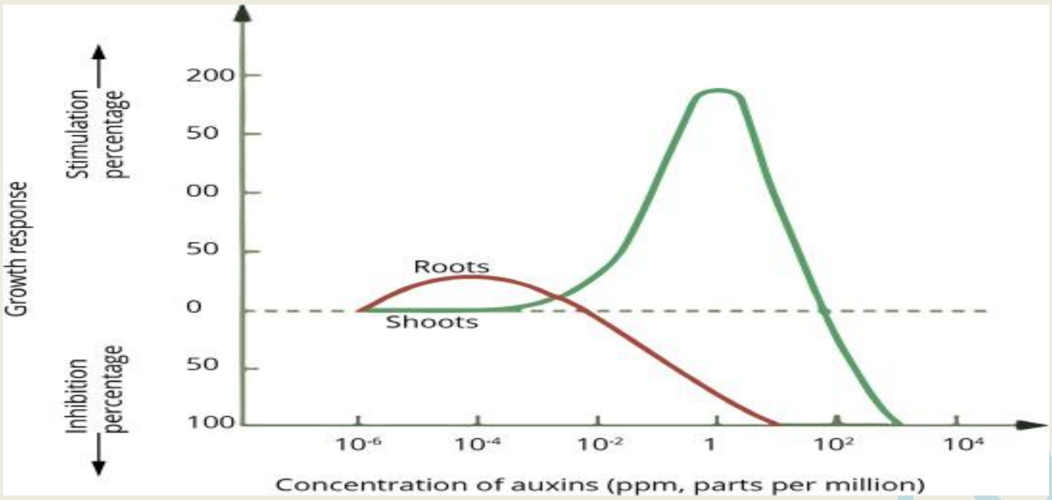
Translocation in plants is a shift or transport of food from the site of synthesis (source), which is the leaf, to the site of utilization or storage (sink), which can be either the stem or the root. Translocation occurs through the phloem, which is made up of living cells. It is an active transport, where the living phloem cells use energy obtained by metabolic process.

2.9 Response in plants

2.9.1 Tropism as growth response

Tropism is bending towards (positive response) or opposite (negative response) to the direction of the stimulus. The cause of the response is a unilateral stimulus (coming from one side only), which causes unequal production or distribution of growth hormone resulting in unequal growth. This means one side grows more or less than the other side and these results in bending towards or away from the stimulus. Tropism is exhibited by the shoot and root of a plant due to unequal concentration of growth hormone, commonly auxin, resulting in unequal growth.

Auxin, particularly Indole Acetic Acid (IAA), is plant growth hormone. It is produced at the tips of shoot and root. It is transported to the region of active growth and affects cell elongation, Shoot and roots respond differently to different auxin concentration. Figure helps to know how shoots and roots respond differently to unilateral (one sided) stimulus The graph (Figure 2.18) shows that auxin concentration that promotes shoot growth (10 -2 to 101 ppm) inhibits root growth . It also shows that root requires minimum auxin concentration, which is about 10 -4 ppm and such concentration has no effect on the shoot growth.



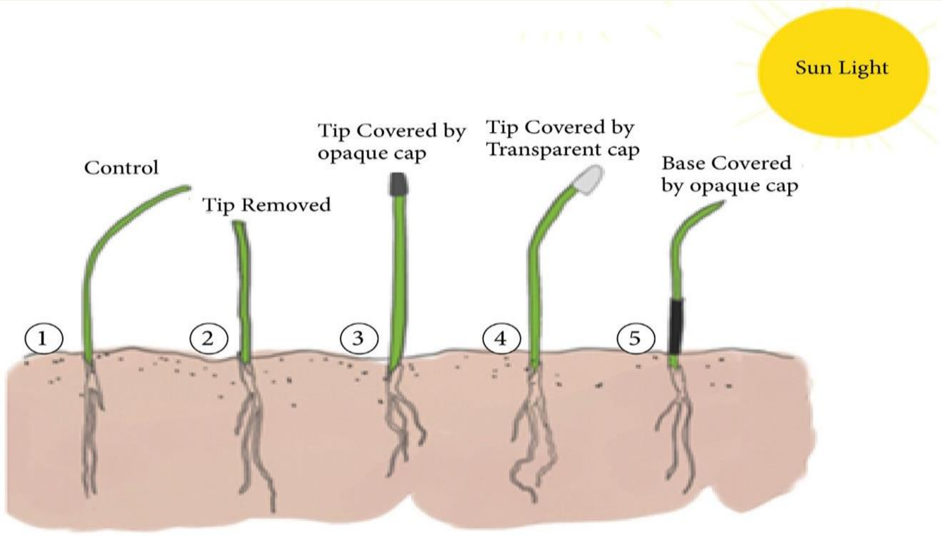
Effects of auxin concentrations on the growth of shoots and roots

Phototropism

Plants need sunlight for photosynthesis. Phototropism is a plant response to light, mainly exhibited by the shoot. The tips of the plant shoot bend towards the side where there is sunlight. Thus shoot is positively phototropic. The earliest experiment on phototropism was conducted by Charles Darwin, "father of evolution",. He noticed that if the light is shone on a coleoptile (shoot tip of young seedling) from one side, the shoot bends or curves (grows) toward the light (Seedling '1' and partially seedling '4'). The bending did not occur in the tip itself but in the elongating part just below.

When the tip is removed (Seedling '2') or covered with opaque foil

(Seedling '3'), the shoot could no longer bend toward the light. Moreover, covering the lower shoot part (Seedling '5') did not affect the response to light at all. Based on his experiment, Darwin concluded that "some influence is transmitted from the tip to the more basal regions of the shoot thereby regulating growth and inducing curvature or bending". At present, it is well known that it is a growth hormone known as auxin that will be distributed more on the tip side opposite to light. This causes more growth on the shaded side and curving will occur toward the light.



Darwin's experiment on phototropism

Hydrotropism

The survival of terrestrial plants depends upon the capacity of roots to obtain water and nutrients from the soil. Roots search for and grow toward water because it is needed for photosynthesis and to support cell structure (make them turgid and strong). Thus, hydrotropism exhibited by root is biologically important and vital for the survival of plants.

2.10 Medicinal plants

List of medicinal plants and disease treated

No.	Scientific name	Local name (Amharic)	Habit	Plant part used	Route of ad-ministr ation	Disease treated
1.	*Ruta chalepensis*	Teenadem	Herb	Leaf	Oral	Abdominal pain
2.	*Zingiber officinalis*	Jinjibil	Herb	Rhizome (under-ground stem)	Oral	Tonsilitis , abdominal pain, cough
3.	*Hagenia abysinica*	Ye–kosso Zaf	Tree	Female flower (Seed)	Oral	Tapeworm
4.	*Artemesia absin- thium*	Aritii	Herb	Leaf	Oral	Unexplained stomach ache (Megagna)
5.	*Niglella sativa*	Tikur Azmud	Herb	Seed	Oral	Intestinal parasites
6.	*Ocimum lamifolium*	Damakesse	Shrub	Leaf	Nasal	Headache, General body illness (Mich)
7.	*Rosmarinus offici- nalis*	Rosmery	Herb	Leaf	Oral	Bronchial asthma. Prostate disorder inflammatory diseases
8.	*Cymbopogen ciratus*	Tejsar	Herb/ Grass	Leaf	Oral	Used for stomach complaint

9.	*Alium sativum*	Nechshinkurt	Herb	Bulb	Oral	Abdominal pain, toothache, tonsillitis, common cold
10.	*Eucalyptus golbulus*	Nech–Bahir- zaf	Tree	Leaf	Nasal	Common cold, fever with headache
11.	*Curcurbita pepo*	Dubba	Herb	Seed	Oral	Tapeworm
12.	*Trigonella foenumgraecum*	Abish	Herb	Seed	Oral	Mixed with garlic to treat asthma , used to treat gas- tritis
13.	*Ocimum basilicum*	Besobilla	Herb	Leaf	Oral	Abdominal pain
14.	*Lepidium sativum*	Feto	Herb	Seed	Oral	Treatment of diarrhea

Review Questions

True – False items: Say "True" or "False" for the following statements on your exercise book.

1. Cone is reproductive structure of fruit bearing plants. **True**
2. CO2 is used in the stroma of the chloroplast. **True**
3. A root hair is single cell**. True**
4. Self-pollination is possible in imperfect flower. **False**

2.Multiple choice items: Choose the correct answer from A – D and write on your exercise book.

1. Which structure transports water to the leaf of a plant?

A) Guard cell B) Phloem C) Stomata D) Xylem

2. Clinostat is used in the study of

A) Osmosis B) Growth movements C) Leaf transpiration D) Photosynthesis

3. Which leaf part or layer contains the largest number of chloroplasts?

A) Epidermis B) Palisade C) Cortex D) Spongy

4. One of the following is not major characteristics of plants **C**

A) Plants are composed of many eukaryotic cells
B) Plants are sessile or do not show mobility
C) Plants are hetrotrophic in their feeding habit
D) Plants show both sexual and asexual reproduction

5. The two products of photosynthesis include **Answer, glucose and oxygen.**

A) Carbondioxide and Oxygen C) Carbon dioxide and water
B) Water and carbohydrate D) Oxygen and Carbohydrate

6. Given the following

1= Pollination; 2 = Seed dispersal; 3 = Pollen grains germination; 4 = Flowering; 5 = Seed germination

The correct order of steps in the reproduction of a mature plant is A)1, 3, 2, 4, 5 c) 4, 2, 5, 1, 3

B) 2, 5, 4, 1,3 d) 4, 1, 3, 2,5

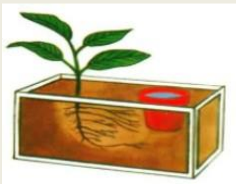
Matching Items: Match the terms under "Column B" with the description under "Column A".

Column A	Column B
1. May be termed as starch sheath B	A) Cone
2. Cells that leave an open space in leaf epidermis D	B) Endodermis
3. Give mechanical strength to the stem E	C) Flower
4. Single cells best suited for absorption H	D) Guard cells
5. Is the site of origin of lateral roots F	E) Hypodermis
6. Reproductive structure of angiopsperms C	F) Pericycle
	G) Root hair
	H) Stomata

Short Answer Items

1. How do you distinguish a root from an underground stem?
2. What is the difference between an incomplete flower and an imperfect flower?
3. What is the importance of rainfall to agriculture?
4. Write the type of tropism illustrated by the pictures below.






Answer

1, An underground stem can be differentiated from a root on the basis of following points:

(i) Absence of root cap.
(ii) Absence of root hair.
(iii) Presence of terminal bud.
(iv) Presence of nodes and internodes.
(v) Occurrence of foliage or scale leaves on the nodes.
(vi) Presence of axillary buds on the nodes.

2, A complete flower has all four structures: sepals, petals, stamens, and pistils. An incomplete flower lacks one or more of the four structures. The presence of structures is the only factor that differentiates a complete flower versus an incomplete flower.

3, Agriculture is highly dependent on rainfall, and hence the onset, duration, amount and distribution of the rainfall determines the performance of the agriculture sector and the economy of the country in general.

4, Forms of tropism include phototropism (response to light), geotropism (response to gravity), chemotropism (response to particular substances), hydrotropism (response to water),

Unit 3: Biochemical molecules

3.1 Biochemical Molecules

3.1.1 Inorganic molecule: Water

Inorganic molecules, as previously stated, do not contain carbon and were not created through biological means except oxides of carbon and carbonate ions. Certain inorganic molecules play critical roles in the survival of living organisms. Water is an example of an inorganic molecule

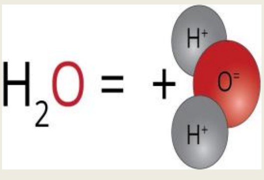
The properties of water

Water is an inorganic molecule composed of two elements: hydrogen and oxygen. H2O is its chemical formula. Each water molecule is composed of two hydrogen atoms linked to a single oxygen atom. Life would not exist on our planet if it did not have access to water. It is significant for two reasons: it is a key component of cells, accounting for 70 to 95 percent of the cells mass. You are around 60% water.

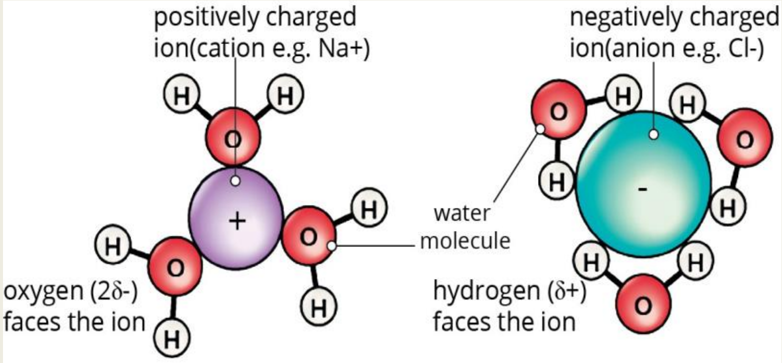
Some typical properties of water are:

1. **Water as a solvent**

Water is an effective solvent for ions and polar molecules (molecules with an unequal charge distribution, such as sugars and glycerol) because the water molecules are attracted to the ions and polar molecules, causing them to congregate and separate.



Structure of water molecule



Distribution of water molecules around ions in a solution.

However, non-polar molecules such as lipids are insoluble in water and, if surrounded by water, tend to be pushed together by the water, since the water molecules are attracted to each other.

2**. High specific heat capacity**

A substance's heat capacity is the amount of heat required to raise its temperature by a particular amount. The specific heat capacity of water is the amount of heat energy necessary to raise the temperature of one kilogram of water by one degree Celsius. The heat capacity of water is rather high. To raise the temperature of a liquid, the molecules must obtain energy and so move more quickly. The hydrogen bonds that cause water molecules to adhere together make it difficult for the molecules to move freely; the ties must be broken to allow free mobility. This explains why more energy is required to raise the temperature of water than would be required if hydrogen bonds did not exist. In effect, hydrogen bonding permits water to store more energy than would otherwise be feasible for a given temperature increase. Water's high heat capacity has crucial biological results since it makes the water more resistant to temperature changes.

3.High latent heat of vaporization

The latent heat of vaporization is a measure of the thermal energy required to vaporize a liquid, converting it from a liquid to a gas. In the case of water, it entails the transformation of liquid water into water vapor. Water has a comparatively high latent heat of vaporization. This is due to its high heat capacity. Because water molecules tend to stick together via hydrogen bonds, very significant quantities of energy are required for vaporization to occur because hydrogen bonds must be broken before molecules can escape as gas.

4.Density and freezing properties

Water is a unique molecule in that its solid form, ice, is less dense than its liquid form. Water density begins to fall below 4°C. As a result, ice floats on liquid water and insulates the water beneath it. This minimizes the likelihood of big amounts of water freezing entirely and increases the likelihood of life surviving under cold temperatures. Changes in water density as a result of temperature generate currents, which aid in the circulation of nutrients in the oceans.

5.High surface tension and cohesion

Water molecules have very high cohesion; in other words, they tend to stick to each other. These cohesive forces are connected to water's adhesion property, or the attraction of water molecules to other molecules.

1. **Boiling and Freezing Points**

This is due to the fact that water requires more energy to break its hydrogen bonds before it can begin to boil. The same concept is used to calculate the freezing point. The boiling and freezing points of water is important for aquatic ecosystems. If water is easily frozen or boiled, drastic changes in the environment would affect bodies of water such as oceans or lakes, killing all organisms that live in water. This is also why sweat can keep our bodies cool. Consider how water differs from most other compounds in terms of its boiling and freezing points (Table 3.1).

Boiling and freezing points of water

Compound	Boiling Point	Freezing Point
Ethanol	78.4^0C	-114.6°C
Acetic acid	117.9°C	16.6°C
Hydrogen Sulfide	-62°C	-84°C
Water	100°C	0°C

3.1.2 Inorganic ions

Inorganic ions are charged entities because they are atoms with unshared electrons in their outer shell. They are either positively or negatively charged. They are virtually usually coupled with an oppositely charged ion. Inorganic ions are found in living bodies in two forms: free and dissolved in the cytoplasm and associated with complex organic substances. They participate in a variety of critical functions in living beings. Although they are only found in trace amounts in our bodies, their significance cannot be overstated. Any variations in their concentrations inside the human body can have catastrophic implications.

Classification of inorganic ions

Based on their requirement in the daily diet of a normal individual, inorganic ions or minerals in the human body are divided into two categories; Macro-nutrients & Micro-nutrients

Macro and micro-nutrients in living systems

Macro-nutrients: required in the daily diet	Micro-nutrients/trace elements: required in small amounts
Sodium, Phosphorus, Magnesium, Potassium, Sulfur, Chloride	Iron, Copper, Iodine, Manganese, etc

3.1.3. Organic molecules

An organic molecule is a compound that contains carbon and is found in living things. Carbon forms the basis of organic life due to its ability to form large and complex molecules via covalent bonding. Four principal groups of organic compounds contribute to much of the structure and function of living things. These are carbohydrates, lipids, proteins, and nucleic acids.

Organic molecules including carbohydrates, lipids, proteins, and nucleic acids are made up of small, single molecular units (monomers). Monomers are connected by strong covalent bonds to create polymers. Polymers are long chains of molecules formed of many single units bonded one after the other. Table 3.3 lists the basic monomers that combine to produce organic molecules.

Elements and monomers forming organic molecules

Organic molecules	Elements forming the molecule	Monomer
Proteins	C, H, O and N	Amino acids
Lipids	C, H, O	Glycerol and fatty acid
Carbohydrates	C, H, O	Monosaccharides Glucose Galactose Fructose
Nucleic acids	C, H, O, N and P	Nucleotides

Carbohydrates

Carbohydrates are macromolecules with which most consumers are somewhat familiar. To lose weight, some individuals adhere to "low-carbohydrate" diets. Athletes, in contrast, often use more carbohydrates before important competitions to ensure that they have sufficient energy to compete at a high level. Carbohydrates are, in fact, an essential part of our diet; grains, fruits, and vegetables are all- natural sources of carbohydrates.

Carbohydrates are made of three major elements; carbon, hydrogen, and oxygen. In carbohydrates, the ratio of hydrogen to oxygen is 2:1. There are three main groups of carbohydrates; monosaccharides, disaccharides, and polysaccharides.

Major functions of carbohydrates

1. They serve as the primary source of energy for most organisms. Glucose in fruit juice, lactose in milk, starch in wheat, potato, rice etc is different forms of carbohydrate that we harvest energy from.

2. They act as a storage form of energy in the body (e.g. Starch and Glycogen).

- Starch stores energy for plants. In animals, it is catalyzed by the enzyme amylase (found in saliva) to fulfil the energy requirement.

- Glycogen is a polysaccharide food reserve of animals, bacteria, and fungi.

•In mammals, glycogen is stored in the liver and muscle as granules or particles (Up to 10% of liver mass and 1-2% muscle mass). Muscle glycogen supplies energy for muscle contraction during exercise.

3.They serve as cell membrane components that mediate some forms of intercellular communication.

4.They form the structural component of many organisms, including the cell walls of bacteria, fungi, and the exoskeleton of many insects. Chitin is involved in the formation of a fungal cell wall, whereas cellulose is an important component of ruminant diets.

Lipids

Lipids are diverse groups of biomolecules that are insoluble in water but soluble in nonpolar solvents such as ether, chloroform, and acetone. Lipids are made of elements carbon, hydrogen and oxygen. It includes fats and oils and cholestrols. Fats are solid at room temperature and oils are liquid at room temperature. Chemically, they are very similar. We could say those true lipids are organic compounds formed by fatty acids combining with alcohol. The butter, cooking oil, and the meat we eat are good examples of lipids. Lipids are polymers of fatty acids and glycerol molecules.

Fatty acids [CH3(CH2)nCOOH]

Fatty acids are a series of acids, some of which are found in fats (lipids). CH3(CH2)nCOOH is the general formula for fatty acids. The contain the acidic group –COOH, known as a carboxyl group. The larger molecules in the series have long hydrocarbon tails attached to the acid 'head' of the molecule. As the name suggests, the hydrocarbon tails consist of a chain of carbon atoms combined with hydrogen. The chain is often 15 or 17 carbon atoms long.

Based on the presence or absence of double bonds (–C=C–) in their structure, there are two types of fatty acids:

Unsaturated fatty acids consist of one or more double bonds in their structure so that they do not contain the maximum possible amount of hydrogen. Double bonds make fatty acids and lipids melt more easily – for example, most oils are unsaturated. If there is more than

Major of functions of lipids

1.Fatty acids serve as the foundation for other types of lipids and serve as stored energy.

2.Serve as major fuel store and major dietary lipid in plants (oil) and animals (Fat). Fats are stored in specialized cells called adipose cells (fat cells), serve as poor conductors of heat and provide insulation at low temperatures.

3.They serve as structural components in cell membranes (e.g., phospholipids); precursors for the synthesis of Vitamin D, Bile acids, hormones of adrenal cortex such as cortisol, and aldosterone; female sex hormones such as progesterone and estrogen and male sex hormones such as testosterone (Cholesterol).

4.Some serve as protective coatings on skin, fur and feathers of animals, birds and fruit and leaves of plants (Example, Wax). The shiny appearance of fruits and leaves is due to waxes. Waxes also serve as a water barrier for animals, birds and insects; and also protects against cold.

Proteins

Proteins are biological molecules composed of carbon, hydrogen, oxygen, and nitrogen and sometimes contain phosphorus and sulphur. Although amino acids may have other formulas, those in protein invariably have the general formula RCH(NH2)COOH, where C is carbon, H is hydrogen, N is nitrogen, O is oxygen, and R is a group, varying in composition and structure, called a side chain.

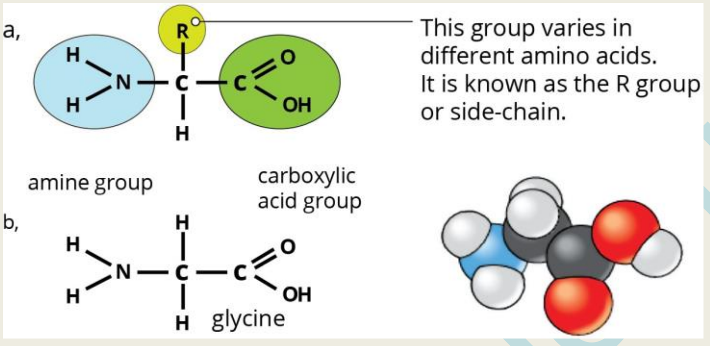
Proteins are biological molecules made up of amino acids monomers. They are one of the most abundant organic molecules in living systems and have the widest range of functions of any macromolecule. Proteins can be structural, regulatory, contractile, or protective. They could be toxins or enzymes, or they could be used in transportation, storage, or membranes. Each cell in a living system may contain thousands of proteins, each with a distinct function. Their structures, like their functions, vary greatly. They are all, however, amino acid polymers arranged in a linear sequence (also referred to as a “peptide”). They are an extremely important class of macromolecule in living organisms. More than 50% of the dry mass of most cells is protein. Protein rich food items include; meat, cheese, milk, fish, beans, vegetables, etc.

Amino acids

Amino acids are the monomers that make up proteins. Amino acids have:

- a central carbon atom which is bonded to an amine group, $-NH_2$,
- a carboxylic acid group, $-COOH$ and
- a hydrogen atom

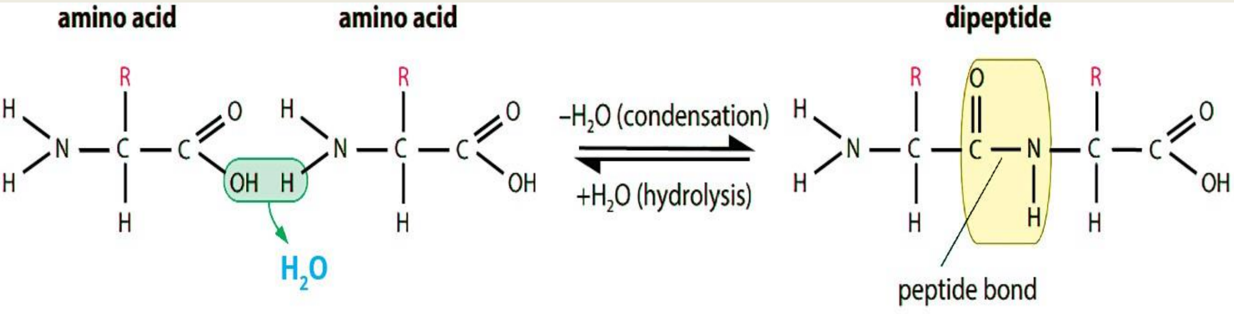
The only way in which amino acids differ from each other is in the remaining, fourth, group of atoms bonded to the central carbon. This is called the R group (Figure 3.10). 20 different amino acids occur in the proteins of living organisms, all with a different R group. Examples of some amino acids (Alanine, valine, lysine, and asparatic acid) are given in figure 3.11 below. In the process of protein synthesis amino acids join by covalent linkage forming a peptide bond that elongates further and form a polypeptide bond.



General formula of amino acids

The peptide bond

Each amino acid is attached to another amino acid by a covalent bond. One loses a hydroxyl (–OH) group from its carboxylic acid group, while the other loses a hydrogen atom from its amine group. This leaves a carbon atom of the first amino acid-free to bond with the nitrogen atom of the second. The link is called a peptide bond. The oxygen and two hydrogen atoms removed from the amino acids form a water molecule.



Amino acids link together by the loss of a molecule of water to form a peptide bond.

Major functions of proteins

1.Structural proteins: are fibrous and tough, as well as insoluble in water. They are structural elements of connective tissues, bones, tendons, cartilages, nails, hair, and horns. Collagen, elastin, and keratin are examples of structural proteins.

2.Enzymes: are globular proteins that serve as biological catalysts. They catalyze metabolic reactions by lowering the activation energy, which increases the reaction rate. Protein enzymes include DNA polymerase, lysozyme, nitrogenase, and lipase.

3.Hormones: are polypeptides that are made up of long chains of linked amino acids. They play critical roles in the regulation of the body›s physiological processes, which include reproduction, growth and development, electrolyte balance, sleep, and so on. Growth hormone (GH) and follicle-stimulating hormone are two examples of these hormones (FSH).

4.Respiratory pigments: are globular protein pigments that are typically water-soluble. Myoglobin, which provides oxygen to working muscles; and haemoglobin, which transports blood to all tissues and organs via the blood, is the two examples.

5.Transport proteins: are cell membrane structural components. They create channels in the plasma membrane to transport specific molecules within the cells. Some of them are also found in animal blood and lymph. Serum albumin (which transports hemin and fatty acids), channel proteins, and carrier proteins are examples of transport proteins.

6.Motor proteins: are involved in muscle contraction and relaxation (muscle movement). Actin, myosin, kinesin, and dynein are all components.

7.Storage proteins: In cells, these proteins serve as a storage reserve for amino acids and metal ions. They can be found in eggs, seeds, and pulses. Ferritin, ovalbumin, and casein are examples of storage proteins.

8.Toxins: Bacteria are the most common producers of these proteins. Diphtheria toxin, Pseudomonas exotoxin, and ribosome- inactivating proteins are among them. By causing cytotoxicity, they aid bacteria in attacking and killing their host organism.

Nucleic acids

Nucleic acids are chemical molecules made up of phosphoric acid, sugars, and organic bases that exist naturally. Nucleic acids are the cell's principal information-carrying molecules, and they determine every living thing's inherited features by directing the process of protein synthesis. Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are the two main types of nucleic acids (RNA).

The structure of DNA and RNA

DNA stands for deoxyribonucleic acid and RNA for ribonucleic acid. Nucleic acids such as DNA and RNA, like proteins and polysaccharides, are macromolecules. They are also polymers, made up of many similar, smaller molecules joined into a long chain. The smaller molecules that form DNA and RNA are called nucleotides. DNA and RNA are therefore polynucleotides. They are often referred as nucleic acids.

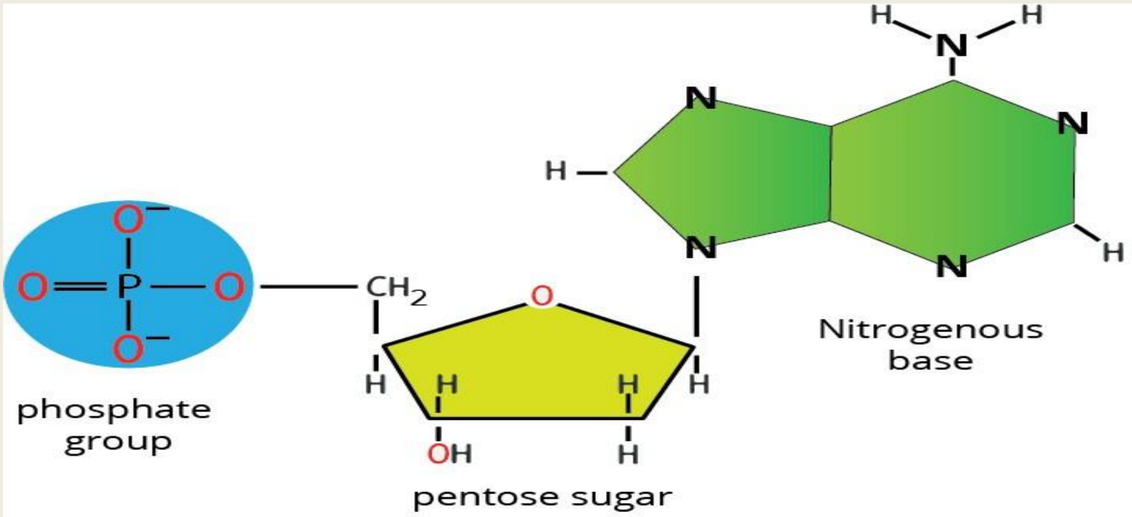
Most organisms carry their genetic information in the nucleotide sequences of DNA, but a few viruses carry it in RNA. Along the length of the DNA is a series of chemical structures called 1 genes. Genes are stretches of DNA that code for RNA and amino acids and, therefore, proteins.

Nucleotides

Nucleotides are made up of three smaller components. These are:

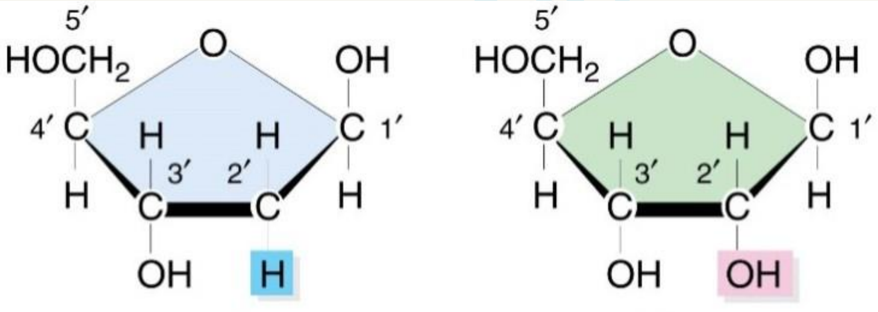
- a nitrogen-containing base
- a pentose sugar
- a phosphate group

There are five different nitrogen containing bases in DNA and RNA. The four nitrogenous bases in the DNA molecule are adenine, thymine, guanine, and cytosine. An RNA molecule also contains four bases, but have Uracil instead of thymine. These bases are often denoted by their first letters: A, T, C, G, and U. The order and composition of the different nucleotides sequences determines the hereditary function of the nucleic acids.



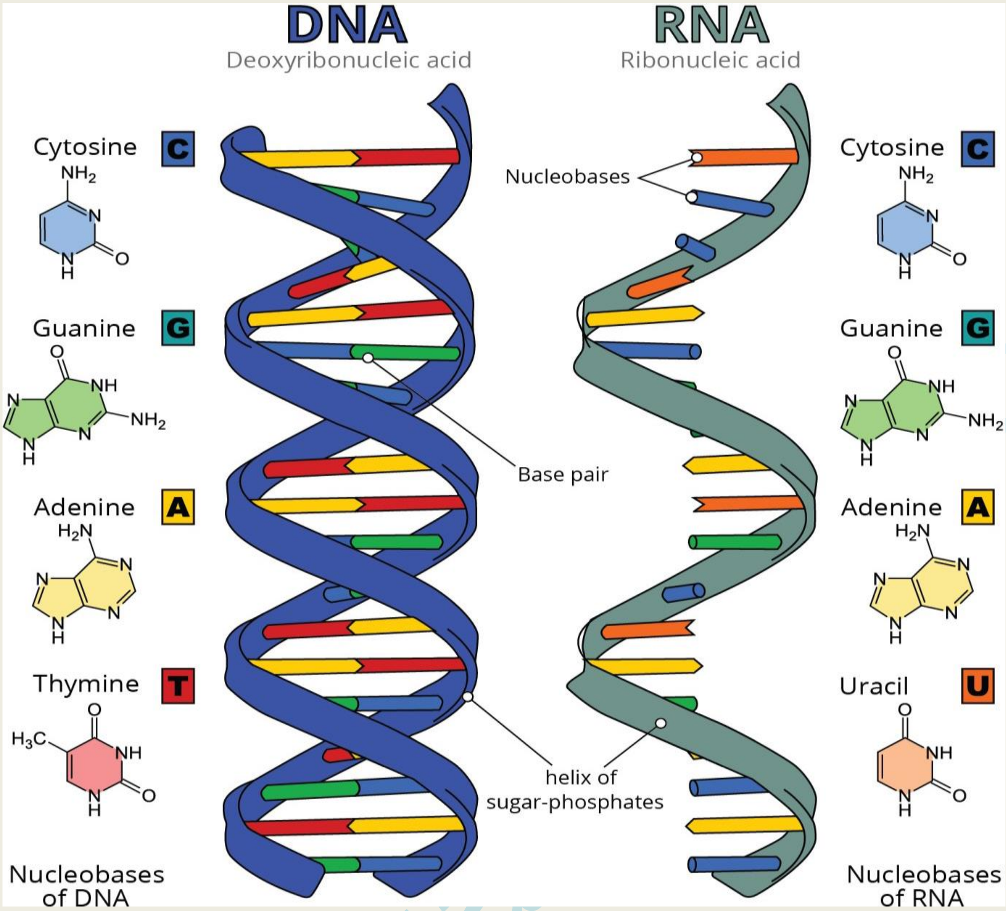
The components of nucleotides.

The pentose (5-carbon) sugar can be either ribose ($C_5H_{10}O_5$) (in RNA) or deoxyribose ($C_5H_{10}O_4$) (in DNA) Figure 3.9. As their names suggest, deoxyribose is almost the same as ribose, except that it has no oxygen atom on its second carbon atom.



Structures of deoxyribose and ribose sugars

DNA is a large molecule made up of two strands (made of two chains) of nucleotides wounded into a double helix. RNA is much smaller and is single-stranded (made of a single chain). There are three types of RNA: mRNA (messenger RNA), rRNA(ribosomal RNA), and tRNA(transfer RNA).



The structure of nucleic acids

Similarities and differences in function and structure of the nucleic acids

Features	DNA	RNA
Nitrogenous bases	Adenine, Guanine, Cytosine, Thymine	Adenine, Guanine, Cytosine, Uracil
Pentose sugar	Deoxyribose sugar	Ribose sugar
Phosphate	Phosphate group	Phosphate group
Size	Huge-allows the molecule to carry the code for many different proteins in the genes	Much smaller-need code for only one protein; small size allows RNA to move out of the nucleus
Stability	Very stable – ensures that the genes remain the same over the generation	Less stable- is degraded quite quickly so does not carry on coding for a protein
Number of strands	Two strands- allow coding of genes and replication during cell division.	Single-stranded- does not replicate

Major functions of Nucleic Acids: DNA and RNA

Deoxyribonucleic acids (DNA)

It is the genetic material that stores all the information required to be transferred to the next generation. The genetic information is stored in its nucleotide sequences. DNA has a unique property of replication or production of its copy that can be transferred to a daughter cell during cell reproduction.

It specifies the biological development of all living organisms and viruses. It carries the genetic code (instructions for protein synthesis). Information coded in the nucleotide sequence of DNA for a particular protein is first copied to mRNA (by the process of transcription). The code in the mRNA is then translated into amino acid sequences of protein. Proteins are required to build an organism and catalyze all of its biochemical reactions thereby controlling all of the functions of the cell or organism.

Ribonucleic acids (RNA)

RNA has different roles to play in different organisms.

It acts as genetic material in some viruses and has enzymatic activity in other organisms

(where it is called ribozyme).

Three types of RNA are present among organisms: mRNA, tRNA and rRNA. All three have essential roles in the development and maintenance of life.

mRNA moves the genetic code (information for protein synthesis) from DNA to ribosomes (protein-synthesizing machinery in the cell).

tRNA helps the proteins synthesis by providing a source of amino acids (the building blocks of proteins).

rRNA form a complex with proteins making the structure the ribosome.

Review Questions

I. True false Items: Say “True” or “False” for the following statements on your exercise book.

1. A deficiency disease caused by lack of iron in our food is called goiter. True
2. DNA is termed as a genetic material. True
3. All proteins are made up of fatty acids and glycerol molecules. False
4. Phospholids are molecules that are used for a dipeptide bond. Formation. False
5. Maltose is a disaccharide made of two glucose units. True
6. DNA is made of 5- Carbone sugar ribose, phosphate and a nitrogenous base True

7. Calcium is one of the inorganic ions that are used for bone and teeth formation. True

8. Water is a universal solvent. True

9. Proteins are made up of beta glucose molecules. False

10. Glycogen is a storage form of polysaccharide in animals. True

II. Multiple-choice Items

Choose the correct answer from A – D and write your answer on your exercise book.

1. Disaccharides consist of:-

A. Two molecules of monosaccharides C. Four molecules of monosaccharides

B. Three molecules of monosaccharides D. Five molecules of monosaccharides

2. The basic unit of a protein molecule is ....

A. Peptides B. Amino acid C. Allanylglycine D. Albumins

3. Which of the following is not a macromolecule?

A. RNA B. DNA C. Salt D. Protein

4. The bonds that form between the atoms of polymeric macromolecules are…………bonds.

A. hydrogen B. peptide C. disulfide D. covalent

5. Which of the following does not represent a correct monomer/polymer pairing?

A. Monosaccharide/polysaccharide C. Triglyceride/cellulose

B. Amino acid/protein D. Nucleotide/nucleic acid

6. Polymerization reactions in which polysaccharides are synthesized from monosaccharides

A. require the formation of phosphodiester bonds between the amino acids.

B. are hydrolysis reactions.

C. depends upon van der Waals forces to hold the amino acids together.

D. result in the formation of wat

7. During the formation of a peptide linkage, a (n) ....is formed.

A. molecule of water C. hydrophobic bond

A. disulfide bridge D. hydrophilic bond

8. Which of the following is responsible for making every amino acid unique?

A. Amino group C. Carboxyl group

B. Hydrogen D .“R” group

9. Enzymes are:

A. DNA B. Lipids C. carbohydrates D. proteins

10. A protein molecule is made of ....

A. amino acids C. Glucose monomers

B. Glycerol and fatty acids monomers D. only fatty acids

11. During the formation of a peptide linkage, a (n)................is formed.

A. molecule of water C. hydrophobic bond

A. disulfide bridge D. hydrophilic bond

12. Which of the following is responsible for making every amino acid unique?

A. Amino group C. Carboxyl group

B. Hydrogen D."R" group

13. Enzymes are:

A. DNA B. Lipids C. carbohydrates D. proteins

14. During the formation of a peptide linkage, a (n)................is formed.

A. molecule of water C. hydrophobic bond

B. disulfide bridge D. hydrophilic bond

15. Which of the following is responsible for making every amino acid unique?

A. Amino group C. Carboxyl group

B. Hydrogen D ."R" group

16. Enzymes are:

A. DNA B. Lipids C. carbohydrates D. proteins

17. A protein molecule is made of ....

A. amino acids C. Glucose monomers

A. Glycerol and fatty acids monomers D. only fatty acids

18. The monomers that make up polymeric carbohydrates like starch are called

A. nucleotides B. trisaccharides C. monosaccharides D. nucleosides

19. A simple sugar with the formula C5H10O5 can be classified as a

A. hexose B. polysaccharide C. disaccharide D. pentose

20. DNA and RNA both include

A. pentoses B. hexoses C. fructoses D. maltoses

21. Lactose, or milk sugar, which is composed of one glucose unit and one galactose unit, can be classified as a

A. disaccharide B. hexose C. pentose D. polysaccharide

22. Which of the following is not a function of calcium?

A. formation of Bone and teeth C. development of muscle cells

B .formation of ligaments D. all of them are not functions

23. Which property of water allows the insect called Raft Spider to walk on the surface of water?

A. surface tension C. Liquidity

A. High specific heat D. changing state

Fill-in the blank Items

Copy and complete the following table. Place a cross mark (X) in each box as appropriate.

	Globular protein e.g. Haemoglo-bin	Fibrous protein e.g. Collagen	Monosaccharide	Disaccharide	glycogen	Starch	Cellulose	Lipid
Monomer			X					
Polymer	x	x		x			x	x
Macromolecule					x	x	x	X
Polysaccharide					x	X		
Contain subunits that form branched chain					x	x		
Contains amino acids	x	X						
Made from organic acids and glycerol								x
Contain glycosidic bonds				x	x	x	X	
Contain peptide bond	X	x						
One of its main functions is to act as an energy store			x	x	X	X	x	X

Usually insoluble in water								x
Usually has a structural function		x					X	
Contain the elements Carbon, Hydrogen and Oxygen only	x	x	x	x	x	x	X	X

Short Answer Items

1. Why are biological macromolecules considered as organic?
2. Describe the similarities and differences between glycogen and starch.
3. Explain at least three functions that lipids serve in plants and/or animals.
4. Mention food items that contain calcium.
5. What is the importance of high latent heat of vaporization of water?
6. How are cohesion and adhesion different?
7. Plants must get water from their roots to their branches. Explain how cohesion and adhesion might help plant get water from the ground to its upper leaves?
8. Why do phospholipids form lipid bilayers in aqueous conditions?
9. Unlike glycogen storage in human body, fat storage is unlimited. Why?

Answer

1. Macromolecules are considered organic because they contain carbon as a main atom along with hydrogen, nitrogen, oxygen and other elements as additional ones.
2. Both starch (amylose and amylopectin) and glycogen function as energy storage molecules. However, glycogen is produced, stored, and used as an energy reserve by animals, whereas starches are produced, stored and used as an energy reserve by plants.
3. Lipids perform three primary biological functions within the body: they serve as structural components of cell membranes, function as energy storehouses, and function as important signaling molecules. The three main types of lipids are triacylglycerols (also called triglycerides), phospholipids, and sterols
4. Calcium-rich food sources
   1: Milk. Milk is one of the best sources of calcium we all know. ...
   2: Soy milk.
   3: Seeds. These tiny, nutritional powerhouses are rich in calcium, such as chia seeds, poppy seeds, and celery. ...
   4: Yogurt. ...
   5: Cheese. ...
   6: Almonds. ...
   7: Beans and lentils. ...
   8: Canned fish.
5. It is crucial for all life forms and for all types of environments and biological systems. If water had a low heat of vaporization, living organisms wouldn't have survived because the water cycle would have been disrupted by all bodies of water boiling so fast and easily.

6. Adhesion is the attraction between the molecules of two different substances, while cohesion is the attraction between the molecules or atoms of the same substance. Water is a compound and substance that exhibits adhesive and cohesive properties due to the polarity of water molecules.
7. Water from the roots is ultimately pulled up by this tension. Negative water potential draws water from the soil into the root hairs, then into the root xylem. Cohesion and adhesion draw water up the xylem. Transpiration draws water from the leaf through the stoma.
8. Because their fatty acid tails are poorly soluble in water, phospholipids spontaneously form bilayers in aqueous solutions, with the hydrophobic tails buried in the interior of the membrane and the polar head groups exposed on both sides, in contact with water.
9. Fat (triacylglycerol) storage appears to be unlimited. Fat is not hydrated and is hydrophobic and insoluble. It is also more reduced than glycogen. It stores more energy per unit weight than does glycogen.

Unit 4: Cell Cycle

4.1 What is a cell cycle?

The cell cycle is a repeating series of events that includes growth, DNA synthesis, and cell division. The cell cycle in prokaryotes is quite simple: the cell grows, its DNA replicates, and the cell divides. In eukaryotes , the cell cycle is more complicated.

The cell cycle is an ordered series of events involving cell growth and cell division that produces two new daughter cells. Cells on the path to cell division proceed through a series of precisely timed and carefully regulated stages of growth, DNA replication, and division that produce two genetically identical cells. The cell cycle has two major phases: interphase and the mitotic phase. During interphase, the cell grows and DNA is replicated. During the mitotic phase, the replicated DNA and cytoplasmic contents are separated and the cell divides.

There are two main divisions of the cell cycle: **Interphase and cell division**.

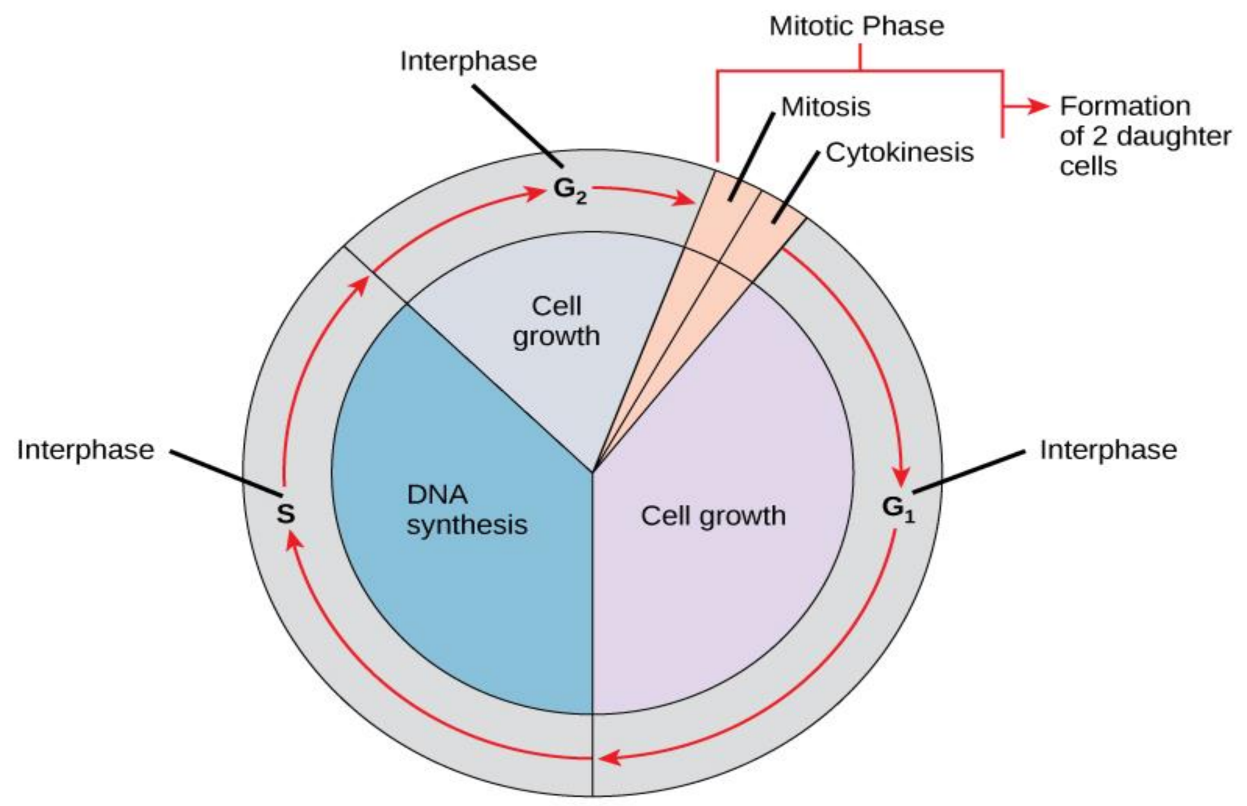
Interphase is divided into three phases called G1, S, and G2.

G1 Phase (First Gap): is the first stage of interphase. During this stage, cells are quite active metabolically. They accumulate the building blocks of chromosomal DNA and the associated proteins as well as store sufficient energy reserves to complete the task of replicating each chromosome in the nucleus.

S Phase (Synthesis of DNA): is the stage of DNA replication (Synthesis).

G2 Phase (second gap): is the stage where the cell replenishes its energy stores and synthesizes proteins necessary for chromosome manipulation and movement. Some cell organelles are duplicated during this stage. Cells may continue growing during the G2 phase. Cells make the final preparations before entering into the mitotic phase.

The cell division, on the other hand, includes nuclear division – Karyokinesis (mitosis, or, M - stage) followed by cytoplasmic division (Cytokinesis). This ultimately results in two identical daughter cells. Each daughter cell grows and starts the cycle the mother cell has undergone.



Stages of the cell cycle. A cell moves through a series of phases in an orderly manner. During interphase, G_1 involves cell growth and protein synthesis, the S phase involves DNA replication and the replication of the centrosome, and G_2 involves further growth and protein synthesis. The mitotic phase follows interphase. Mitosis is nuclear division during which duplicated chromosomes are segregated and distributed into daughter nuclei. Usually the cell will divide after mitosis in a process called cytokinesis in which the cytoplasm is divided and two daughter cells are formed.

4.2 The Cell division

Cell division is a basic process in all living things where a parent or mother cell, divides into two daughter cells. An ordered series of events involving cell growth and cell division that produces two new daughter cells are termed the cell cycle. Cells on the path to cell division proceed through a series of precisely timed and carefully regulated stages of growth, DNA replication, and nuclear and cytoplasmic division that ultimately produces two identical (clone) cells.

As the cell grows the volume of cytoplasm relative to the cell membrane will be small that it will have .low surface area to volume ratio. As a result material transport across the cell membrane by simple diffusion will be inadequate for the cell to survive. Moreover, as the size of the cell increases the controlling power of the nucleus is highly minimized. Thus to solve these problems cell employs a mechanism called cell division by which one cell become two or more.

Cell division consists of two sub divisions

i) Nuclear division (Karyokinesis) – results in the separation and distribution of duplicated genetic materials of mother cell (dividing cell) to daughter cells by mitosis or meiosis.

ii) Cytokinesis (cytoplasmic division) - is the separation of the cytoplasmic components into the daughter cells.

Hereafter, you will learn the pattern of arrangement and redistribution of the duplicated genetic material during mitosis and meiosis.

4.2.1 Mitosis

Mitosis is a type of nuclear division where duplicated chromosomes of a single mother cell are distributed between two identical daughter cells, having the same number and kind of hereditary materials (chromosomes) as the parent nucleus. As a result, a diploid (2n) mother cell gives rise to two diploid (2n) identical daughter cells.

As illustrated in apart from cytokinesis (cytoplasmic division), mitosis as nuclear division (Karyokinesis) is divided into a series of phases namely; prophase, metaphase, anaphase, and telophase.

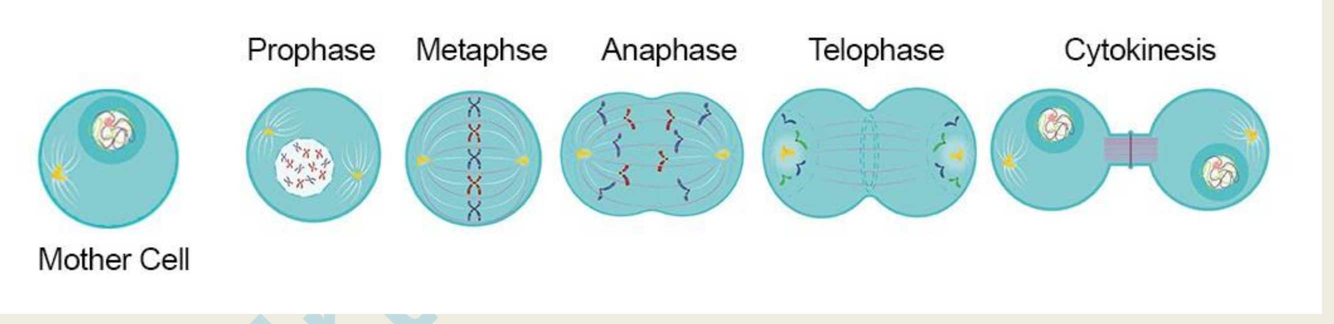


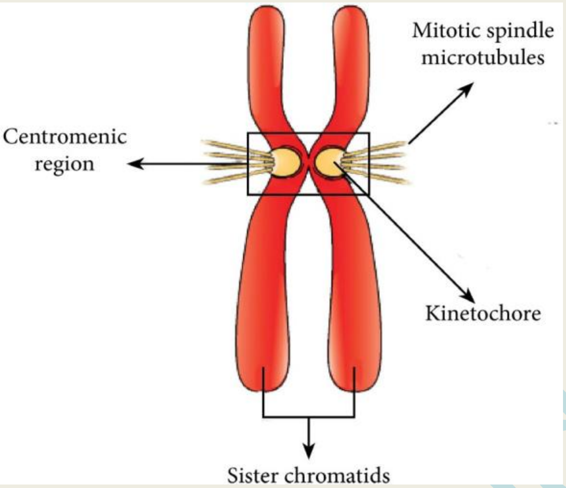
Illustration of cell division by mitosis

Detailed description of what actually happens at different phases of mitosis is presented as follows:

1. **Prophase (the “first phase”): During this phase**

- each duplicated chromosome, composed of two sister chromatids and, containing identical genetic material pairs up.
- the nuclear membrane breaks down, the nucleolus disappears.
- chromosomes shorten, thicken and become visible.

the centrosomes begin to move to opposite poles of the cell, and spindle fibres emerge from the centrosomes (two in numbers and located outside the nucleus)



Sister chromatids: Mitotic spindle emerging from the centrosomes

2. Metaphase (arrangement phase)

During this phase

- mitotic spindles are fully developed with centrosomes at the opposite poles.
- chromosomes line up (arrange themselves) end–to–end along the centre or metaphase plate (equatorial plane) of the cell.
- each sister chromatids are attached to a spindle fibre originating from opposite poles.

3.Anaphase (migrating phase)

- During this phase cohesion proteins binding the sister chromatids together known as centromere, breakdown.
- separated sister chromatids are pulled apart by the mitotic spindle which drags one chromatid to one pole and the other chromatid to the opposite pole. This will ensure daughter cells receive chromosomes that are the same in number and kind.

4. Telophase (a reverse of prophase)

This phase is also known as a reversed prophase because what has disappeared during the interphase will reappear during the telophase and vice versa. Accordingly,

• nuclear membrane reappears and surrounds each set of chromosomes to create two new nuclei arriving at opposite poles.

• The mitotic spindle breaks down and disappears.

Cytokinesis, also known as cytoplasmic division, will take place after the four stages of mitosis (nuclear division) are completed. However, its completion in animal cell is different from plant cell. As animal cell is surrounded only by cell membrane, cytokinesis enables the cytoplasm of the mother cell to pinch or constrict in the middle. As a result the two daughter cells entirely separate. However, as plant cell is surround by hard cell wall in addition to the cell membrane , the cytoplasm cannot simply pinch off and fully separate; instead a new wall will be laid down between the two daughter cells, Thus, the two adjacent cells remained joined together by the middle wall – called middle lamella

The redistribution of duplicated chromosomes through mitosis is important to get two daughter cells from single diploid mother cell that are identical in quality and quantity of chromosomes.. The process of mitosis is important to increase cell number, which in turn is essential for growth. We, human beings, after the union of haploid (n) sperm and haploid (n) egg started as a zygote, which is diploid (2n). Then the zygote by repeated cell division through mitosis develops into multicellular organism. This is how we human beings are made up of million cells.

Cells have a finite life span; they wear out or become damaged; so they need to be replaced continuously. The process of growth, repair and replacement of dead cells all rely on cell division through mitosis. Unicellular organisms like Amoeba also use cell division through mitosis to increase their number or population.

4.2.2 Meiosis

The process of meiosis is a characteristic feature of organisms that reproduce sexually. It occurs in reproductive organs such as ovaries of female animals, testes of male animals, anther and ovules of flowering plants. Meiosis involves two fissions of the nucleus giving rise to four gametes or sex cells, each possessing half the number of chromosomes (n) present in the mother cell. Meiosis is called reduction division, as the final daughter cells are haploid (n) as compared to the diploid (2n) mother division.

What would happen if the human gametes (sperm cell and egg cell), had 46 chromosomes like the other body cells? The answer is simple that there will be 92 chromosomes in the zygote, which will not be normal. Thus, during gametogenesis (gamete formation) in human ovaries and testes, the 46 chromosomes in the initial mother will be reduced by half to 23 chromosomes by meiosis. As a result, the sperm or egg cells nuclei will have 23 chromosomes (haploid, abbreviated as n). So, when sperm and egg join together at fertilization, a zygote that contains the normal number of 46 chromosomes (23 pairs, Diploid abbreviated as 2n) will be formed.

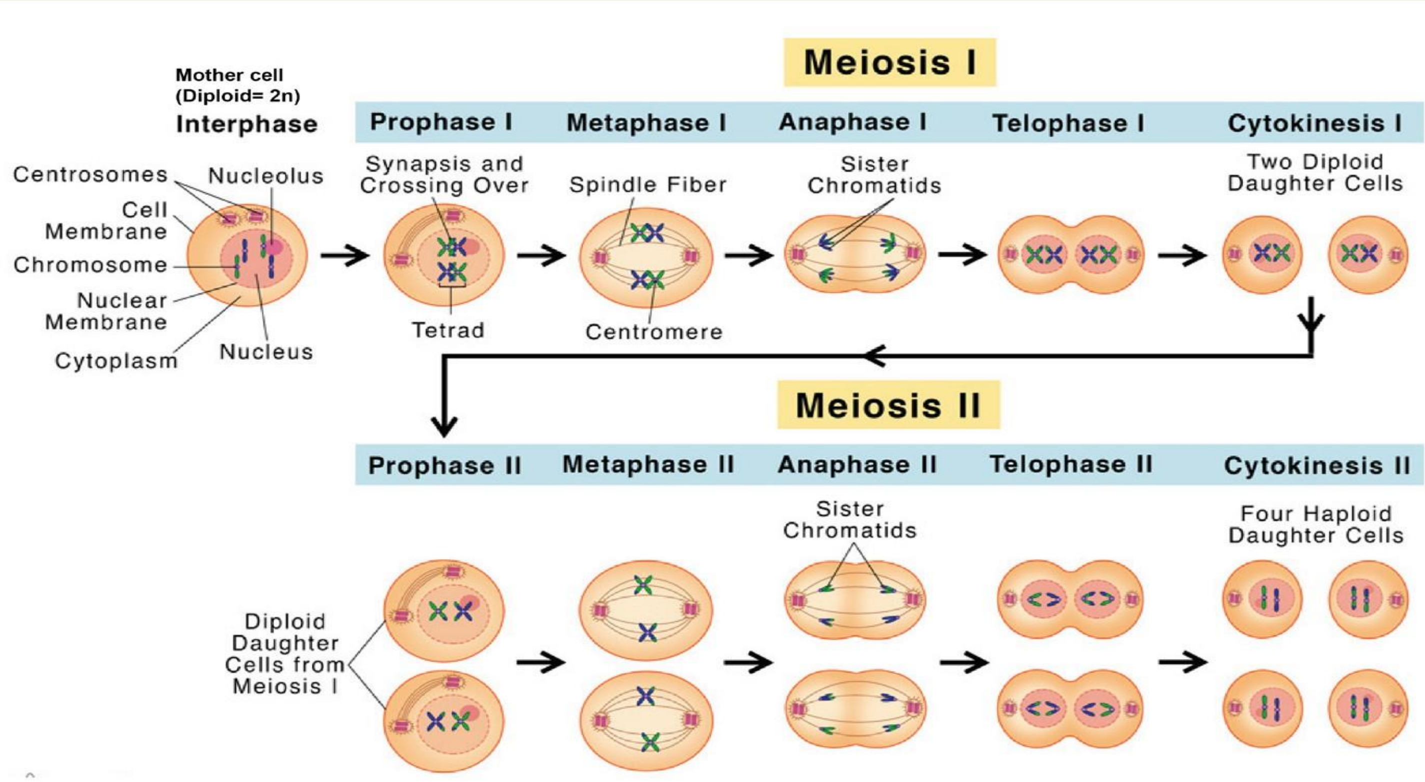


Illustration of meiosis I and Meiosis II

Description of the different stages of Meiosis I and Meiosis II

Stage	Description
Prophase I	Each chromosome appears shortened and thickened form two chromatids Homologous chromosomes pair up
Metaphase I	Chromosomes align on spindle fiber; lining up in the middle or metaphase plate
Anaphase I	The centromere joining sister chromatids do not separate The pair of chromatids from each homologous pair moves to the end (pole) of the cell. Reduction to haploid (n) will take place because homologous chromosomes of male and female parents separate
Telophase I	The nuclear membrane reforms and the cells begin to divide. In some cells, the cell continues to full cytokinesis while in other cells there may be prolonged interphase but with no further DNA duplication
Prophase II	New spindles are formed and the chromosome, still made up of paired chromatids moves toward the middle of the cell.
Metaphase II	The chromosomes line up in the metaphase plate , with the spindle attached to the sister chromatids of each chromosome coming from the opposite poles.

Anaphase II	The centromeres divide and sister chromatids separate and pulled to the opposite ends of each cell
Telophase II	Nuclear membrane reappears, the chromosomes return to the interphase state Cytokinesis follows giving four daughter cells each with half the chromosome num- ber of the initial parent (mother) cell

Review Questions

True – False items: Say "True" or "False" for the following statements on your exercise book.

1. It is meiosis I that resembles mitosis. False
2. Homologus chromosomes are duplicated one parent chromosomes. False
3. Meiosis results in four haploid daughter cells. True
4. DNA duplication is the longest phase of the interphase. True
5. Prokaryotic organisms like Bacteria do not divide by mitosis. True

Matching items: Match the terms under "Column B" with the descriptions under "Column A"

Column A	Column B
1. known as cytoplasmic division	Anaphase **5**
2. paired maternal and paternal chromosomes	Cytokinesis **1**
3. pull chromosomes to opposite ends of a cell	Homologous chromosomes 2
4. arrangement of chromosomes at the metaphase plate	Interphase **6**
5. separation of sister chromatids	Metaphase **4**
6. duplicated one parent chromosmes	Sister chromatids 6
	Spindle fiber 3
	Telophase

Short answers

1. What is the importance of meiosis to sexually reproducing organisms?
2. Mention at least two important features of cancer cells.
3. What is the difference between interphase and prophase?
4. What would happen if there is no cytoplasmic division at the end of

telophase? If a cell is having 2n=40 divide by meiosis

A. How many cells are formed at the end of meiosis i? meiosis ii?

B. How many chromosomes are there in each daughter cells at the end of meiosis i? meiosis ii? C .How many set of chromosome(s)/is/ are there at the end of meiosis i? meiosis II?

answer

1. Meiosis is important because it ensures that all organisms produced via sexual reproduction contain the correct number of chromosomes. Meiosis also produces genetic variation by way of the process of recombination.
2. Cancer cells don't repair themselves or die
   - grow faster.
   - spread to other parts of the body.
   - resistant to treatment.
3. During interphase, the parent cell's chromosomes are replicated, but they aren't yet visible. They're just floating around in the form of loosely collected chromatin. During prophase, that loose chromatin condenses and forms into visible, individual chromosomes. I hope your answer is quite helpful.
4. If there is no cytoplasmic division occurring at the end of telophase, the division will not end by giving daughter cells.

B. There will be two cells at the end of meiosis I and four cells at the end of meiosis II

C. There will be 40 chromosomes in each daughter cells at the end of meiosis I and 20 chromosomes at the end of meiosis ii?

c. There will be haploid sets of chromosomes at the end of both meiosis I and meiosis II

Unit 5: Human Biology

5.1 The Digestive System

All living organisms need nutrients to survive, plants can obtain nutrients from their roots and the energy molecules required for cellular function through the process of photosynthesis. Animals, however, obtain their nutrients through the consumption of other organisms. At the cellular level, the biological molecules necessary for animal function are amino acids, lipid molecules, nucleotides, and simple sugars. However, the food consumed consists of protein, fat, and complex carbohydrates.

Animals must convert these macromolecules into the simple molecules required for maintaining cellular function. The conversion of the food consumed to the nutrients required is a multistep process involving digestion and absorption. During digestion, food particles are broken down into smaller components, which are later absorbed by the body. This happens by both physical means, such as chewing and by chemical means, via enzyme-catalyzed reactions. These processes take place in the human digestive system step-wise.

The human digestive system is composed of four digestive processes:

1. Ingestion - the taking in of nutrients, in the mouth,
2. Digestion - the breakdown of complex organic molecules into smaller components by enzymes step-wise, physical, and chemical processes that begins in the oral cavity and extends to the small intestine,
3. Absorption - the transport of digested nutrients from the small intestine to the cells of the body though finger like projection called villi in the small intestine, and

4.Egesting - the removal of food waste from the body.

The distinction between excretion and egestion is based on the type of wastes excreted by an organism. Undigested food that remains after digestion is expelled in animals during the egestion process. Excretion is the process through which metabolic wastes are expelled in both plants and animals.

The digestive tract of adult humans is normally 6.5 m to 9m long. It stores and breaks down organic molecules into simpler components. Physical (mechanical) digestion begins in the mouth, where food is chewed and formed a bolus (the Greek word for the ball) by the tongue. Physical digestion breaks food into smaller pieces, increasing the surface area for chemical digestion.

The chemical digestion of carbohydrate (starch) starts in the oral cavity by an enzyme called salivary amylase or ptyalin. The food is then swallowed and enters the esophagus a long tube that connects the mouth to the stomach. Using peristalsis, wave-like smooth- muscle contractions, the muscles of the esophagus push the food toward the stomach. The stomach contents are extremely acidic, with a pH between 1.5 and 2.5. This acidity kills microorganisms, breaks down food tissues, and activates digestive enzymes. The chemical digestion of protein starts in the stomach by the enzyme pepsin.

Further breakdown of food takes place in the small intestine where bile is produced by the liver, and enzymes produced by the small intestine and the pancreas, continue the process of digestion. The smaller molecules are absorbed into the bloodstream through the epithelial cells lining the walls of the small intestine. The waste material travels onto the large intestine where water is absorbed and the drier waste material is compacted into feces; it is stored in the rectum until it is excreted through the anus.

The Oral Cavity

In the oral cavity, both physical and chemical digestion begins. It is the point of entry (ingestion) of food into the digestive system. The process that takes place in the mouth includes:

1. the food is broken into smaller particles by mastication, the chewing action of the teeth.

2. saliva, the watery fluid produced by the salivary glands contains amylase enzyme, and breaks down starches into simpler molecules.

3. saliva dissolves food particles and makes it possible to taste what is being eaten.

4. saliva lubricates the food so that it can be swallowed.

5. we detect the flavour when food particles dissolved in saliva penetrate the cells of the taste buds located on the tongue and cheeks.

6. the tongue, positions and mixes food and forms a ball of food called bolus ready to be swallowed.

The teeth

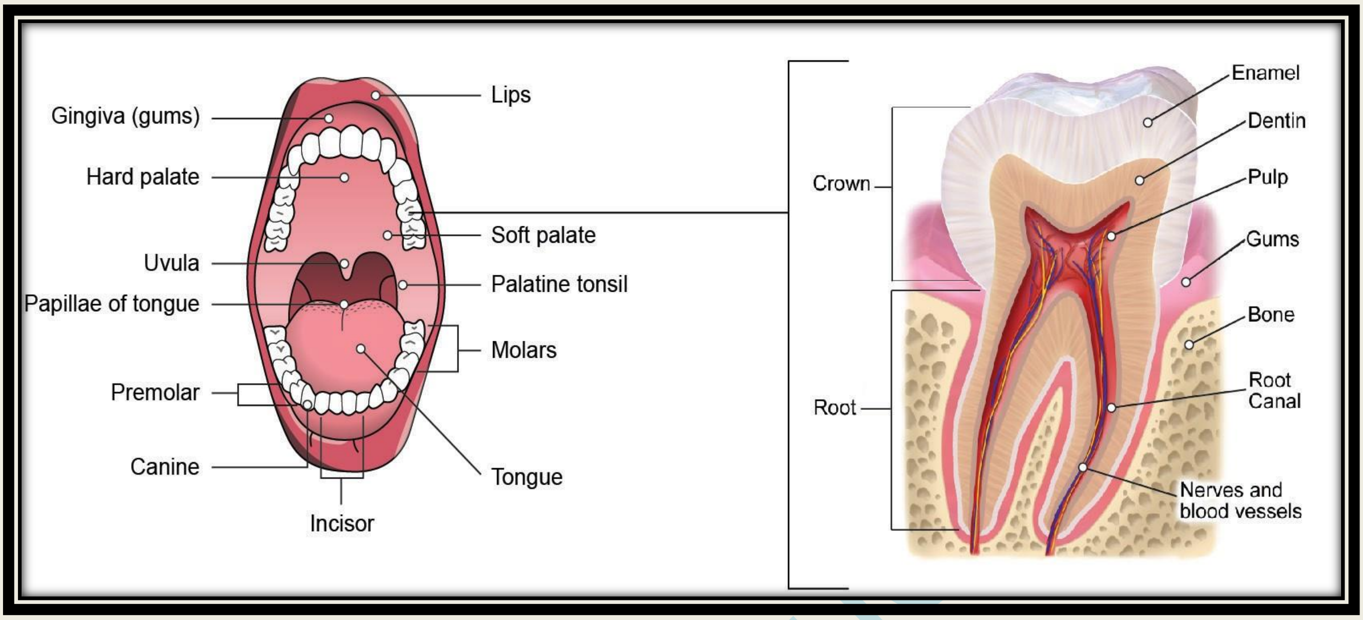
The teeth are important structures for physical digestion (Figure 5.1). There are 4 types of teeth:

Incisors: are eight chisel-shaped teeth at the front of your mouth specialized for cutting.

Canine: teeth that are sharp, dagger-shaped specialized for tearing.

Premolar: teeth that are broad flattened specialized for grinding.

Molars: teeth tend to be even broader and have cusps that are even more flattened. They are designed for crushing and grinding food. The last set of molars is the wisdom teeth, so-called because they usually do not emerge until we reach about 16 to 20 years of age. Each tooth is covered with enamel, which is the hardest substance in the human body.



The structure and types of teeth

External and internal structures of teeth

The teeth are the hardest substances in the human body. Besides being essential for chewing, the teeth play an important role in speech. Parts of the teeth include:

Enamel: the hardest, white outer part of the tooth. Enamel is mostly made of calcium phosphate, a rock-hard mineral.

Dentin: a layer underlying the enamel. It is a hard tissue that contains microscopic tubes. When the enamel is damaged, heat or cold can enter the tooth through these paths and cause sensitivity or pain.

Pulp: the softer, living inner structure of teeth. Blood vessels and nerves run through the pulp of the teeth.

Periodontal ligament- tissue that helps to hold the teeth tightly against the jaw.

Roots- is the part of the tooth that extends into the bone and holds the tooth in place. It makes up approximately two-thirds of the tooth

Gums. Gums, also called gingiva, are the fleshy, pink connective tissue that's attached to the neck of the tooth and the cementum.

Crown: the crown of a tooth is the top portion of the tooth that is visible.

Human dentition

The conventional way of expressing the total number of teeth in the human beings are represented: incisor(I), canines(C), molars(M) and premolars(P). It gives a set like I:C:P:M. For example, if it is given

2:1:2:3 for upper teeth then, it indicates 2 incisors, 1 canine, 2 premolars and 3 molars of the upper mouth on one side. Include the dental formula

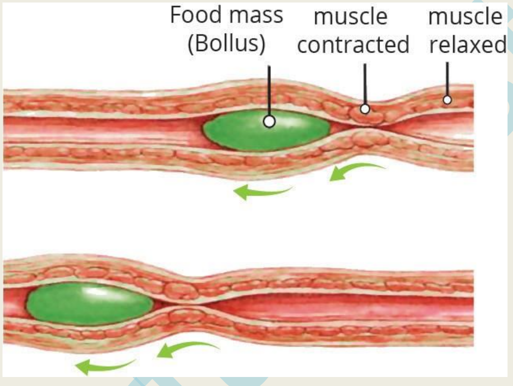
The dental formula of human beings (adults): (2123/2123) × 2 = 32(2123/2123) × 2 = 32

There are 2 incisors, 1 canine, 2 premolars and 3 molars. In adults, dentition pertains to all types of teeth development. In a normal adult there are 32 teeth. There are two types of dentition: temporary and permanent. There are 20 teeth in the temporary dentition and 32 teeth in the permanent dentition. In a child, there are 20 teeth present which are called milk teeth or deciduous teeth. These teeth grow at the age of 6 years. i. e.

(2102/2102)×2=20(2102/2102) × 2=20. These are two incisors, 1 canine and 2 molars.

The Esophagus

The swallowed food travels from the mouth to the stomach by way of the esophagus. The bolus of food stretches the walls of the esophagus,

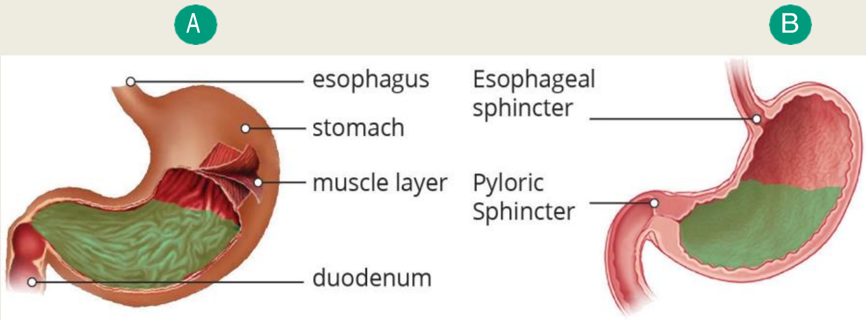


Rhythmic contractions of muscle move food along the digestive tract

activating muscles that set up waves of rhythmic contractions called peristalsis. Peristaltic contractions, which are involuntary, move food along the gastrointestinal tract. Peristaltic action will move food or fluid from the esophagus to the stomach.

The stomach

The stomach is the site of food storage and initial protein digestion. The stomach contains three layers of muscle, which run in different directions so that the muscle contractions can churn the food. The movement of food to and from the stomach is regulated by circular muscles called sphincters. Sphincters act like the draw strings on a bag. Contraction of the lower esophageal sphincter (LES) closes the opening to the stomach, while its relaxation allows food to enter. The lower esophageal sphincter prevents food and acid from being regurgitated up into the esophagus. A second sphincter, the pyloric sphincter, regulates the movement of food and stomach acids into the small intestine (Figure 5.3(b)).



a) Muscle is responsible for the contractions of the stomach b) Sphincters regulate the movement of food.

The J-shaped stomach has numerous ridges that allow it to expand so that it can store about1.5L of food. Millions of cells line the inner wall of the stomach. Activities in the stomach:

1. the cells secrete the various stomach fluids, called gastric fluids or gastric juice, that aid digestion,
2. contractions of the stomach mix the food with the gastric fluids, and
3. it is involved in both physical (churning action if stomach wall) and chemical digestion(e.g. digestion of proteins by the action of enzyme pepsin).

Approximately 500mL of the fluids in the stomach are produced following a large meal.

Gastric fluid includes:

1. mucus,
2. hydrochloric acid (Hydrochloric acid (HCl)),
3. pepsinogens, and other substances.

Hydrochloric acid kills many harmful substances that are ingested with food. It also converts pepsinogen into its active form, pepsin, which is a protein-digesting enzyme. Pepsin breaks the long amino acid chains in proteins into shorter chains, called polypeptides.

The pH inside the stomach normally ranges between 2.0 and 3.0 but may approach pH 1.0. Acids with a pH of 2.0 can dissolve fibers in a rug. It is the high acidity of hydrochloric acid that makes it effective at killing pathogens and allows pepsin to do its work.

Absorption in the stomach

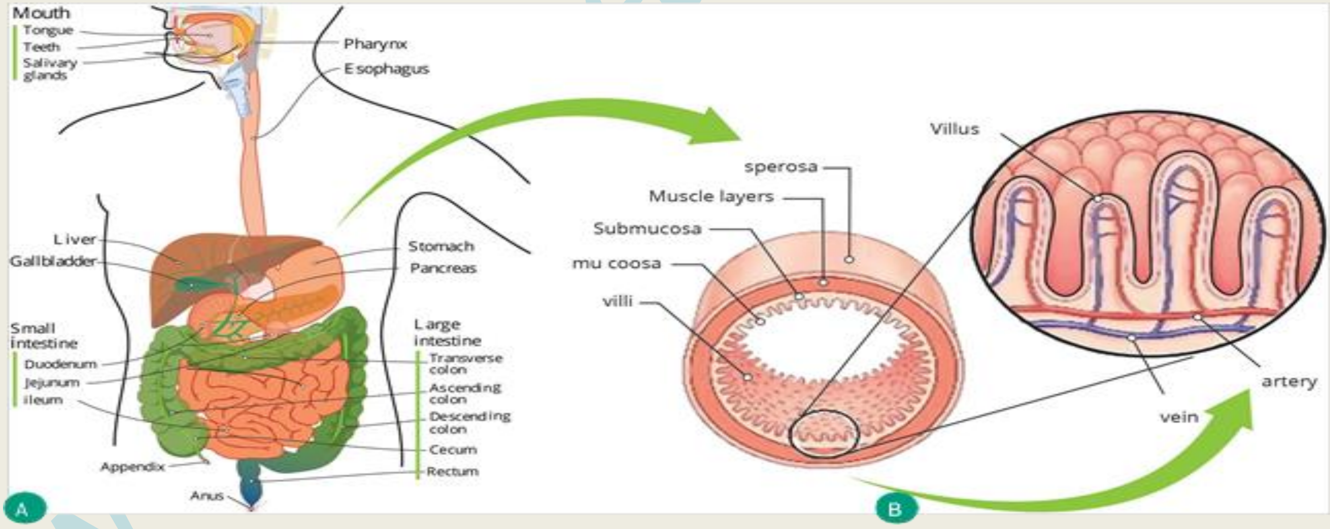
Although the stomach absorbs few of the products of digestion, it can absorb many other substances, including glucose and other simple sugars, amino acids, and some fat soluble substances, water, specific vitamins, and alcohol, etc.

The small intestine

The small intestine is up to 7 m in length, but only 2.5 cm in diameter (Figure a). Most chemical digestion takes place in the small intestine. Parts of the small intestine:

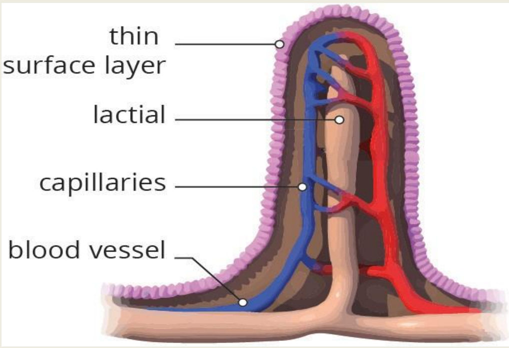
1. duodenum the first 25 cm to 30 cm of the small intestine where the majority of digestion occurs,
2. jejunum is the second component of the small intestine and
3. ileum the third component

The small intestine secretes digestive enzymes and moves its contents along by peristalsis. The stomach absorbs some water, specific vitamins, some medicines, and alcohol, but most absorption takes place within the small intestine. Long finger like projections called villi (singular: villus) greatly increase the surface area of the small intestine (Figure(b)). One estimate suggests that villi account for a tenfold increase in surface area for absorption. The cells that make up the lining of each villus have microvilli, which are fine, threadlike extensions of the membrane that further increase the surface for absorption.



Parts of the digestive system and the absorption villi

Each villus is supplied with a capillary network that intertwines with lymph vessels called lacteals that transport materials. Some nutrients are absorbed by diffusion, but some nutrients are actively transported from the digestive tract. Monosaccharides and amino acids are absorbed into the capillary networks; fats are absorbed into the lacteals.



Anatomy of a villus, with the lacteal

The accessory organs

The organs discussed above are the organs of the digestive tract through which food passes. Accessory organs add secretions and enzymes that break down food into nutrients. Accessory organs include:

- the salivary glands,
- the pancreas,
- the liver, and
- the gall bladder.

The secretions of the pancreas, liver, and gallbladder are regulated by hormones in response to food consumption. The liver is the largest internal organ in humans and it plays an important role in the digestion of fats and detoxifying blood. The liver produces bile, which is a digestive juice that is required for the breakdown of fats in the duodenum. The liver also processes the absorbed vitamins and fatty acids and synthesizes many plasma proteins. The gallbladder is a small organ that aids the liver by storing bile and concentrating bile salts. The pancreas secretes bicarbonate that neutralizes the acidic chyme and a variety of enzymes (trypsin, amylase, and lipase) for the digestion of proteins, carbohydrates, and fats, respectively. The details of the accessory organs are given below.

Pancreas

The pancreatic secretions contain enzymes that promote the breakdown of the three major components of food: proteins, carbohydrates, and lipids. Pancreatic secretions contain the following digestive enzymes:

Trypsin- a protein-digesting enzyme called trypsinogen is released from the pancreas. Once trypsinogen reaches the small intestine, an enzyme called enterokinase converts the inactive trypsinogen into trypsin, which acts on the partially digested proteins. Trypsin breaks down long-chain polypeptides into shorter-chain peptides.

Erepsins- are released from the pancreas and small intestine. They complete protein digestion by breaking the bonds between short- chain peptides, releasing individual amino acids.

Amylase- continue the digestion of carbohydrates that begun in the mouth by salivary amylase. The intermediate-size chains are broken down into disaccharides. The small intestine releases disaccharide enzymes, called disaccharidases, which complete the digestion of carbohydrates.

Lipases-enzymes released from the pancreas that breaks down lipids (fats). There are two different types of lipid-digesting enzymes:

Pancreatic lipase, the most common lipase, breaks down fats into fatty acids and glycerol.

Phospholipase acts on phospholipids.

Digestion in the Small Intestine

Enzyme	Produced by	Reaction
lipase	pancreas	fat droplets + $H_2O \rightarrow$ glycerol + fatty acids
trypsin	pancreas	protein + $H_2O \rightarrow$ peptides
erepsin	pancreas, small intestine	peptides + $H_2O \rightarrow$ amino acids
pancreatic amylases	pancreas	starch + $H_2O \rightarrow$ maltose
maltase	small intestine	maltose + $H_2O \rightarrow$ glucose

Liver and Gallbladder

The liver continually produces fluid called bile. Bile contains bile salts, which aid fat digestion. When the stomach is empty, bile is stored and concentrated in the gallbladder. When there are fats in the small intestine, the hormones trigger the gall bladder to release bile salts.

Once inside the small intestine, the bile salts:

Emulsify or breakdown, large fat globules. The breakdown of fat globules into smaller droplets is physical digestion, not chemical digestion since chemical bonds are not broken. Physical digestion prepares the fat for chemical digestion by increasing the exposed surface area on which fat-digesting enzymes, such as pancreatic lipase, can work.

Bile also contains pigments. The liver breaks down haemoglobin from red blood cells and stores the products in the gallbladder for removal. The characteristic brown colour of feces results from haemoglobin breakdown.

Stores glycogen and vitamins A, B12, and D.

Detoxify many harmful substances in the body. Harmful chemicals are made soluble and can be dissolved in the blood and eliminated in the urine. One of the more common poisons is alcohol.

Large Intestine

The human large intestine is much smaller in length compared to the small intestine but larger in diameter. It has three parts: the cecum, the colon, and the rectum. The cecum joins the ileum to the colon and is the receiving pouch for the waste matter. The colon is home to many bacteria or intestinal flora that aid in the digestive processes. The colon has four regions, the ascending colon, the transverse colon, the descending colon and the sigmoid colon. The main functions of the colon are to extract the water and mineral salts from undigested food, and to store waste material.

Summary of digestion in human alimentary canal

Region of gut	Glands and secretion	Enzymes and optimum pH	Food digested, products and other activity
Mouth: mastication by jaws and tongue	Salivary glands :saliva 1-2 liters/daily	1. pH-7, slightly acid in adults, slightly alkali to neutral in children 2. amylase	1.mucin lubricates food bolus 2.(A) starch(amylase) dextrins (B) cooked starch---- maltose
Oesophagus	None	None	Food bolus moves by peristalsis
Stomach churning action. Temporary storage 1 to3 hrs	Gastric gland, stomach wall-gastric juice 2-4L; stores daily	1. pH 1, strongly acidic 2. rennin(in young children) 3. lipase(in young children) 4. pepsin	1. Hydrochloric acid (HCl) is bacteriocidal 2. clots milk protein-caesin 3. lipids---fatty acids and glycerine 4. proteins—amino acids Absorption: water, salts, vitamins and ethanol
Duodenum(Accessory organ secretions)	1.liver- bile juice, 700CM3-1.2 litres daily 2 pancreas-pancreatic juices, 700Cm3 daily	1. pH 7-8, slightly alkaline 2. no enzyme	1. alters pH of stomach contents 2. bile salts emulsify or cream lipids
		1. pH 7-8,slightly alkaline 2. amylase 3. lipase 4. Trypsin 5.nuclease	1.food as chime propelled by peristalsis 2. starch(amylase)---- maltose 3. lipids--- fatty acids and glycerol 4. peptones ---short peptides 5. nucleic acids -- nucleotides

Small intestine and duodenum	Glands in intestine and duodenum wall-intestinal juice, 200cm3	1. pH 7-8 2. entrokinase changes trypsino-gen into trypsin 3.lipase 4.glycosi-dases-maltase, lactase, sucrase	1-------------------------- 2. dipeptides, peptides----- amino acids 3. lipids--fatty acids and glycerol(propanetriol) 4. maltase -- maltose into glucose molecules Lactase----lactose into glucose and galactose Sucrose - sucrose into glucose and fructose Absorption: large surface area, villi, and mi- crovilli, main region of absorption of vitamins, minerals, amino acids, glucose, fatty acids and glycerol
Large intestine	Lining with mucous glands	pH 6-8 no enzymes	1. mucous lubricates faces 2. water absorbed from faces 3. bacteria synthesis vitamin B groups 4. faces mainly water 75%, bacteria, 8%, lipids, 6%, dietary fiber cellulose, 2% etc

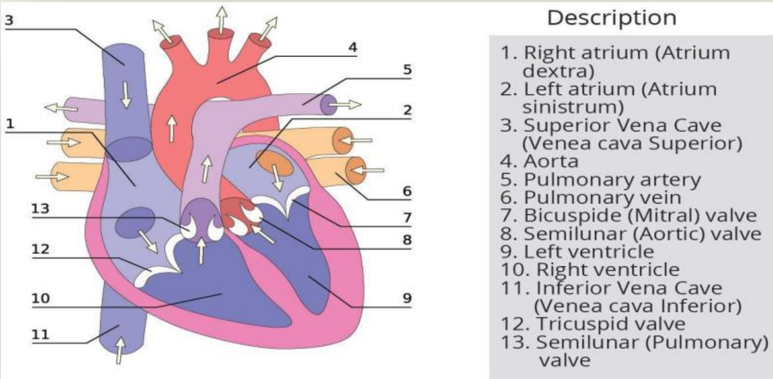
5.2 The circulatory and lymphatic system

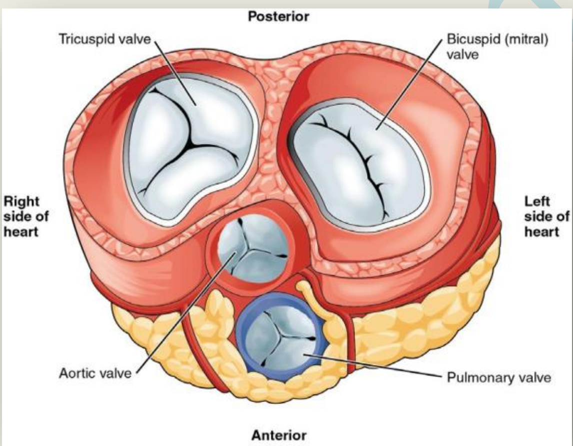
The circulatory system is a means by which blood moves throughout your body. The circulatory system:

- carries nutrients to cells,
- remove wastes away from cells,
- carry chemical messages from cells in one part of the body to distant target tissues,
- distributes heat throughout the body and, along with the kidneys,
- maintain levels of body fluid,
- provide oxygen for the cellular respiration and
- transport of immune cells throughout the body to defend against invading organisms

Moreover, your circulatory system has 96 000 km of blood vessels to sustain your 100 trillion cells. Your heart is about the size of your fist and with a mass of about 300g. The heart beats about 70 times/min from the beginning of your life until death. Every minute, 5L of blood cycles from the heart to the lungs, picks up oxygen, and returns to the heart.

In this section, you will explore the remarkable live pump - the heart that propels the blood into the vessels. There is no single better word to describe the function of the heart other than “pump” since its contraction develops the pressure that ejects blood into the major vessels: the aorta and pulmonary trunk. From these vessels, the blood is distributed to the other parts of the body. A field of study about the heart is called cardiology and the scientists, cardiologists.





The heart anatomy

the valves of the heart

The heart is a muscular organ that pumps blood to circulate throughout the body. The heart wall consists of three layers: the endocardium, myocardium, and pericardium.

The endocardium is the thin membrane that lines the interior of the heart,

The myocardium is the middle layer of the heart. It is the heart muscle and is the thickest layer of the heart, and

The pericardium is a thin layer on the surface of the heart in which the coronary arteries lie.

The pericardium is a thin sac the heart sits in, often filled with a small amount of fluid, which separates the heart from the other structures in the chest such as the lungs.

Valves

In the cardiovascular system of the heart four valves prohibit the backflow of blood:

a. Tri-cuspid valve (Right atrioventricular RAV) - valve separates the rightatria from the rightventricle.

b. Bi-cuspid valve (Left atrioventricular LAV) - valve separates the left atria from the left ventricle

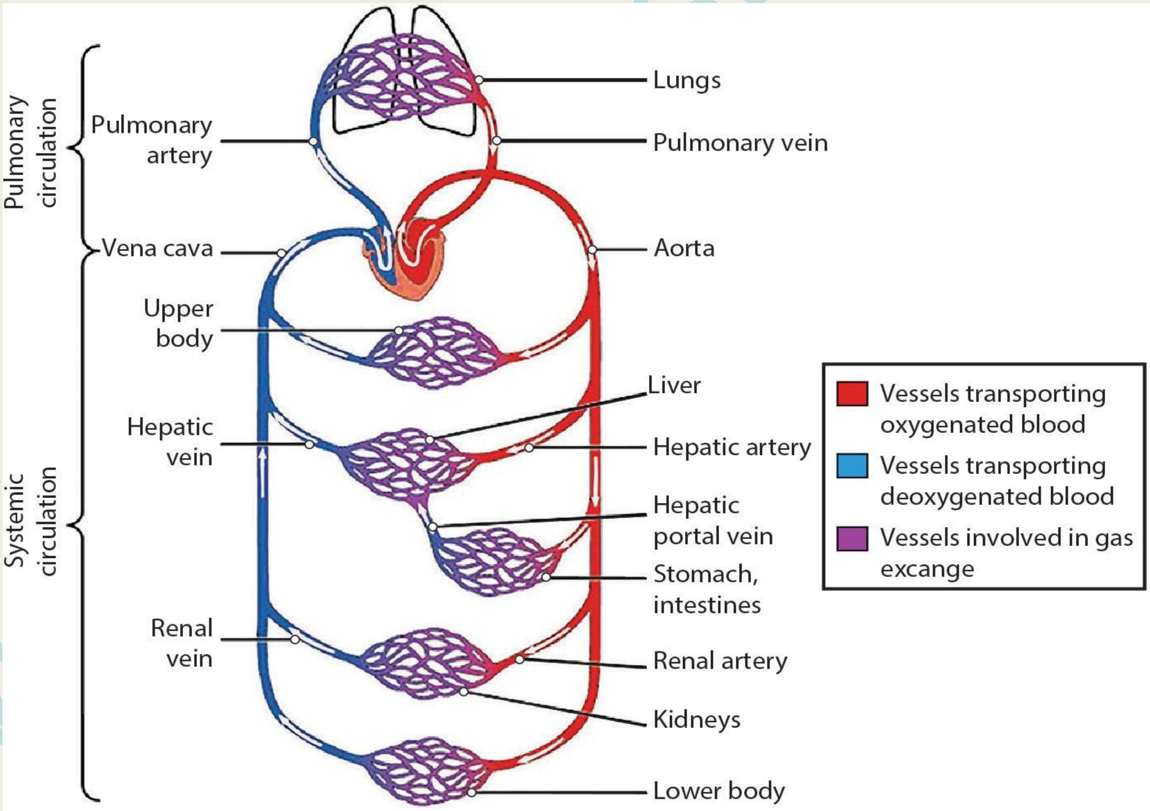
Semi-lunar valves

a. Valve that separate the right ventricle from the pulmonary artery and

Valve that separate the left ventricle from the aorta. The semi-lunar valves are half-moon-shaped (hence, the name *semi-lunar*), and they prevent blood that has entered the arteries from flowing back into the ventricles

The human circulatory systems are a double circulatory system. It has two separate circuits and blood passes through the heart twice: pulmonary and systemic circulation.

Pulmonary circulation - the movement of blood from the heart to the lungs for oxygenation, then back to the heart again. Oxygen- depleted blood from the body leaves the systemic circulation when it enters the right atrium through the superior and inferior venae cavae. The blood is then pumped through the tricuspid valve into the right ventricle. From the right ventricle, blood is pumped through the pulmonary valve and into the pulmonary artery. The pulmonary artery splits into the right and left pulmonary arteries and the blood in the arteries travel to each lung.



Pulmonary and systemic circulation

Systemic circulation - is the movement of blood from the heart through the body to provide oxygen and nutrients to the tissues of the body while bringing deoxygenated blood back to the heart. Oxygenated blood enters the left atrium from the pulmonary veins. The blood is then pumped through the mitral valve into the left ventricle. From the left ventricle, blood is pumped through the aortic valve and into the aorta, the body's largest artery. The aorta arches and branches into major arteries to the upper body before passing through the diaphragm, where it branches further into the iliac, renal, and suprarenal arteries which supply the lower parts of the body.

Cardiac Cycle

The period of time that begins with contraction of the atria and ends with ventricular relaxation is known as the cardiac cycle. The period of contractionthe heart undergoes while it pumps blood into circulation is called systole. The period of relaxation that occurs as the chambers filled with blood is called diastole. Both the atria and ventricles undergo systole and diastole, and it is essential that these components be carefully regulated and coordinated to ensure blood is pumped efficiently to the body.

Heart Sounds

One of the simplest, yet effective, diagnostic techniques applied to assess the state of a patient's heart is auscultation (listening to various internal sounds) using a stethoscope. In a normal, healthy heart, there are only two audible heart sounds: Lub and Dup (or Dub). Lub, or rest heart sound is the sound created by the closing of the atrioventricular valves during ventricular contraction. The second heart sound, "Dup" (or "Dub") is the sound of the closing of the semilunar valves during ventricular diastole.

The term murmur is used to describe an unusual sound coming from the heart that is caused by the turbulent flow of blood. Murmurs are graded on a scale of 1 to 6, with 1 being the most common, the most difficult sound to detect, and the least serious. The most severe is a scale of 6. Specialized electronic stethoscopes are used to record both normal and abnormal sounds.

When using a stethoscope to listen to the heart sounds, called asculation, it is common practice for the clinician to ask the patient to breathe deeply. This procedure not only allows for listening to air flow, but it may also amplify heart murmurs. Inhalation increases blood flow into the right side of the heart and may increase the amplitude of right-sided heart murmurs. Expiration partially restricts blood flow into the left side of the heart and may amplify left-sided heart murmurs.

Blood Pressure

Blood pressure is the force of the blood on the walls of the arteries. It can be measured indirectly with an instrument called a sphygmomanometer. A cuff with an air bladder is wrapped around the arm. A small pump is used to inflate the air bladder, thereby closing off blood flow through the brachial artery, one of the major arteries of the arm. A stethoscope is placed below the cuff and air is slowly released from the bladder until a low-pitched sound can be detected. The sound is caused by blood entering the previously closed artery.

Blood Vessels

Blood vessels are the channels or conduits through which blood is distributed to body tissues. The vessels make up two closed systems of tubes that begin and end at the heart. One system, the pulmonary vessels, transports blood from the right ventricle to the lungs and back to the left atrium. The other system, the systemic vessels, carries blood from the left ventricle to the tissues in all parts of the body and then returns the blood to the right atrium. Based on their structure and function, blood vessels are classified as arteries, capillaries, and veins.

Blood

Blood is a constantly circulating fluid providing the body with nutrition, oxygen, and waste removal. Blood is mostly liquid, with numerous cells and proteins suspended in it, making blood "thicker" than pure water. The average person has about 5 liters of blood.

Liquid called plasma makes up about half of the content of the blood. Plasma contains proteins that help the blood to clot, transport substances through the blood, and perform other functions. Blood plasma also contains glucose and other dissolved nutrients. About half of blood volume is composed of blood cells.

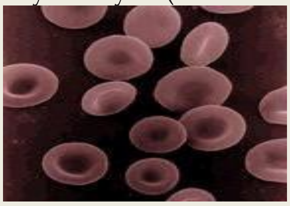
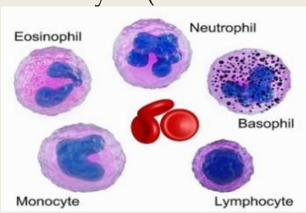
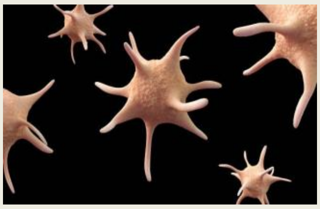
Blood Components

Normally, 7-8% of human body weight comes from blood. This essential fluid carries out the critical functions of transporting oxygen and nutrients to our cells and getting rid of carbon dioxide, ammonia, and other waste products. In addition, it plays a vital role in our immune system and in maintaining a relatively constant body temperature. Blood is a highly specialized tissue composed of more than 4,000 different kinds of components. Three of the most important ones are:

- Red blood cells, which carry oxygen to the tissues
- White blood cells, which fight infections
- Platelets, smaller cells that help blood clot
- Red blood cells (erythrocytes)

Red blood cells, or erythrocytes, are relatively large microscopic cells without nuclei. Red blood cells normally make up 40-50% of the total blood volume. They transport oxygen from the lungs to all of the living tissues of the body and carry away carbon dioxide. The red cells are produced continuously in our bone marrow from stem cells at a rate of about 2-3 million cells per second. Hemoglobin (containing iron) is the gas transporting protein molecule that makes up 95% of a red cell. People who are anemic generally have a deficiency in red cells, and subsequently feel fatigued due to a shortage of oxygen. The red colour of blood is primarily due to oxygenated red cells. Human fetal hemoglobin molecules differ from those produced by adults in the number of amino acid chains. Fetal hemoglobin has three chains, while adults produce only two. As a consequence, fetal hemoglobin molecules attract and transport relatively more oxygen to the cells of the body.

Red blood cells, white blood cells and platelets

Cell types	Number	Life span	Functions
Erythrocytes(red blood cells) 	5-6million	120 days	Transport oxygen and help transport carbon-dioxide
Leukocytes(White blood cells) 	5000-10000	18-36 hours, some can survive as long as a year	Defense and immunity
Platelets 	250000-400,000	9-10 days	Blood clotting

Plasma

Plasma is a yellow-tinted water, sugar, fat, protein, and salt fluid that transports red blood cells, white blood cells, and platelets.

Plasma makes up 55 percent of our blood volume.

- provides nutrients to cells while also removing metabolic waste.
- blood clotting factors, carbohydrates, lipids, vitamins, minerals, hormones, enzymes, antibodies, and other proteins are all found in it.
- includes some of every protein generated by the body; so far, only about 500 proteins have been discovered in human plasma.

Blood groups

The blood grouping depends on which antigens are on the surface of the red blood cells. Antigens are molecules. They can be either proteins or sugars. The types and features of antigens can vary between individuals due to small genetic differences. The antigens in blood have various functions, including:

- transporting other molecules into and out of the cell,

- maintaining the structure of red blood cells, and
- detecting unwanted cells that could cause illness. Scientists use two types of antigens to classify blood types:
- ABO antigens and
- Rh antigens.

Antigens and antibodies play a role in the immune system's defence mechanism. White blood cells produce antibodies. These antibodies will target an antigen if they consider it a foreign object. This is why it is essential to match blood types when a person needs a transfusion. If a person receives red blood cells with antigens that are not already present in their system, their body will reject and attack the new red blood cells. This can cause a severe and possibly life-threatening reaction.

The ABO blood group system classifies blood types according to the different types of antigens in the red blood cells and antibodies in the plasma. They use the ABO system alongside the Rh antigen status to determine which blood type or types will match for a safe red blood cell transfusion.

There are four ABO groups:

Group A: The surface of the red blood cells contains A antigen, and the plasma has anti-B antibody. Anti-B antibodies would attack blood cells that contain B antigens.

Group B: The surface of the red blood cells contains B antigen, and the plasma has anti-A antibody. Anti-A antibody would attack blood cells that contain A antigen.

Group AB: The red blood cells have both A and B antigens, but the plasma does not contain anti-A or anti-B antibodies. Individuals with type AB can receive any ABO blood type.

Group O: The plasma contains both anti-A and anti-B antibodies, but the surface of the red blood cells does not contain A or B antigens. Since these antigens are not present, a person with any ABO blood type can receive this type of blood.

5.2.1 Blood Donation

Blood is a very vital component of the human body. In case of an injury, severe sickness, or during operations, loss of a large quantity of blood may result in death. In such cases, blood from a healthy person called the donor is given to the sick or a person that lost blood under some other unexpected condition. The sick person who receives blood is called the recipient. The process of transferring blood from a healthy person (donor) to a person deficient in blood (recipient) is called blood transfusion. Great care has to be taken by the doctors while transfusing blood from the donor to the recipient.

Blood group compatibility

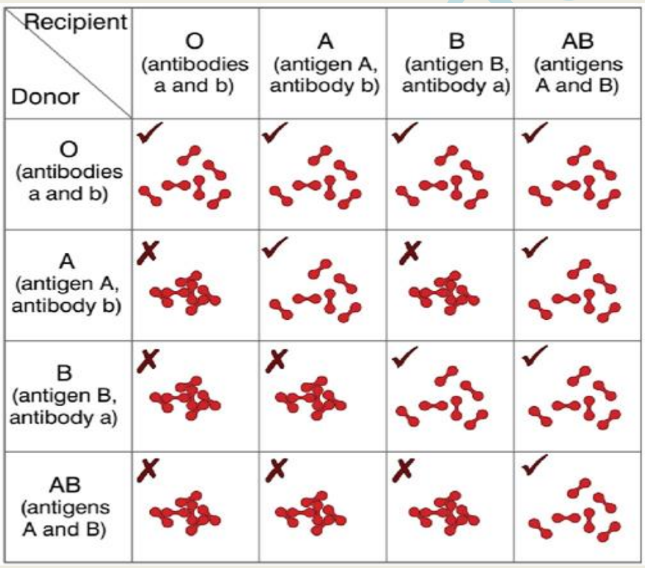
If the blood from two different blood groups is mixed and if it is not compatible, there may be a reaction between the antigen and the complementary antibody which makes the red blood cells stick together, a phenomenon known as agglutination. The agglutins block the capillaries and even larger blood vessels. But if someone loses a lot of blood in an accident, an injury, during giving birth or an operation, then they may need a blood transfusion. This is when blood taken from one person is given to another to save their life. Before a transfusion it is vital to know the blood groups of both the person giving the blood (the donor) and the person receiving the blood (the recipient

Antigens and antibodies

Blood group	Antigen on red blood cells	Antibody in plasma
A	A	B
B	B	A
AB	AB	None
O	None	AB

The O blood groups is termed "Universal Donor" while the AB blood group is termed as a "Universal recipient"

Key: x-shows coagulation

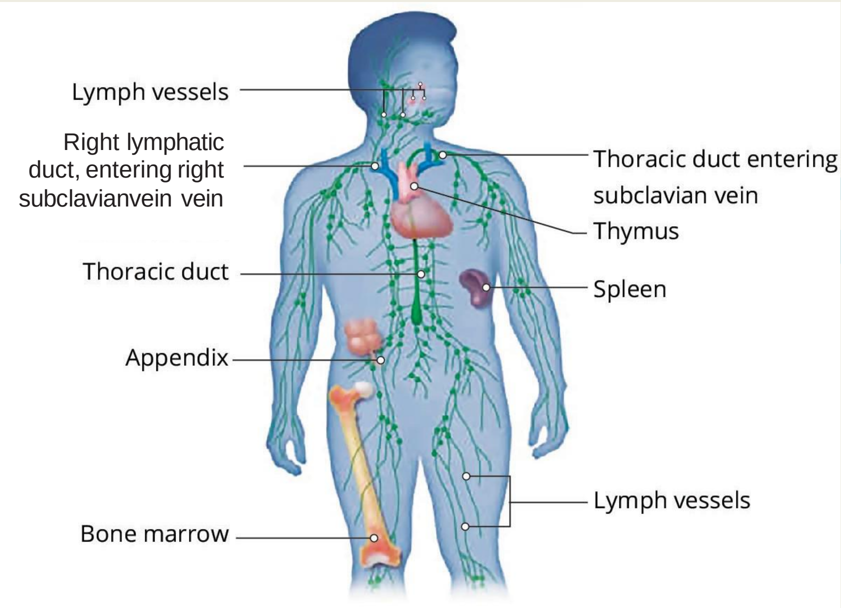


Blood compatibility chart

The Lymphatic System

A little amount of protein spills from capillaries into tissue voids on a regular basis. Even if the leak is modest, the buildup of proteins in the extracellular fluid (ECF) would be a significant problem; osmotic pressure would drop and tissues would enlarge.

The proteins are emptied from the ECF and return to the circulatory system via the lymphatic system, a collection of vessels (Figure 5.10). Lymph, a fluid similar to blood plasma, is transported through lymph vessels that are open-ended like veins. This low-pressure return system is driven by slow muscle contractions against the arteries, which are equipped with flap-like valves to prevent fluid backflow. Through the right and left subclavian veins, the lymphatic system returns lymph to the venous system.



The lymphatic system

The key functions of the lymphatic system:

- returns excess interstitial fluid to the blood
- the absorption of fats and fat-soluble vitamins from the digestive system and the subsequent transport of these substances to the venous circulation. The blood capillaries absorb most nutrients, but the fats and fat-soluble vitamins are absorbed by the lacteals. The lymph in the lacteals has a milky appearance due to its high fat content and is called chyle.
- defence against invading microorganisms and disease. Lymph nodes and other lymphatic organs filter the lymph to remove microorganisms and other foreign particles. Lymphatic organs contain lymphocytes that destroy invading organisms.

Components of the Lymphatic System

The lymphatic system consists of a fluid (lymph), vessels that transport the lymph and organs that contain lymphoid tissue.

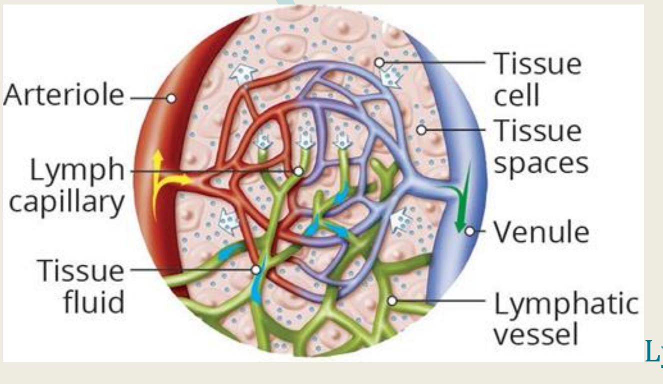
Lymph

Lymph is a fluid substance made up of lymphocytes and white blood cells that is clear to white in colour. Lymph is a component of the lymphatic system that is present in lymphatic veins and other cavities throughout the body. It transports white blood cells within lymph nodes and bones, removes interstitial fluid from organs, and fights disease-causing and infectious bacteria invading blood cells. Lymph serves a variety of purposes:

- Removes metabolic wastes from tissue cells,
- Provides the body with nutrition,
- Aids in the invasion of microbe-caused pathogenic diseases,
- Through lymphatic vessels, absorbs fat-soluble vitamins and other digested fat molecules from the small intestine, and
- Maintain the composition of tissue fluid.

Lymphatic vessels

Unlike blood vessels, lymphatic vessels transport only fluid away from tissues (Figure 5.11). The lymph capillaries are the smallest lymphatic vessels, beginning in the tissue spaces as blind-ended sacs. Lymph capillaries can be found in every part of the body except the bone marrow, the central nervous system, and tissues that lack blood vessels, such as the epidermis. The wall of the lymph capillary is made up of endothelium, which is made up of simple squamous cells that overlap to form a simple one-way valve. This configuration allows fluid to enter the capillary but prevents lymph from exiting the vessel.



Lymphaticvesse

Lymphatic vessels are formed when microscopic lymph capillaries are connected. Small lymphatic vessels connect to form larger tributaries known as lymphatic trunks, which drain large areas. The lymphatic trunks join together until lymph enters the two lymphatic ducts. The right lymphatic duct drains lymph from the upper right quadrant of the body. The thoracic duct drains the remainder.

Lymphatic tributaries, like veins, have thin walls and valves to prevent blood backflow. The lymphatic system lacks a pump like in cardiovascular system. The pressure gradients that move lymph through the vessels are caused by skeletal muscle action, respiratory movement, and smooth muscle contraction in vessel walls.

Organs of the lymphatic system

Clusters of lymphocytes and other cells, such as macrophages, are enmeshed in a framework of short, branching tissue fibres that distinguish lymphatic organs. Lymphocytes are formed alongside other types of blood cells in the red bone marrow and are transported in the blood from the bone marrow to the lymphatic organs. When the body is exposed to microorganisms and other foreign substances, lymphocytes proliferate within the lymphatic organs and are transported to the site of the invasion via the blood. This is a component of the immune response that seeks to eliminate the invading agent. Among the lymphatic organs are:

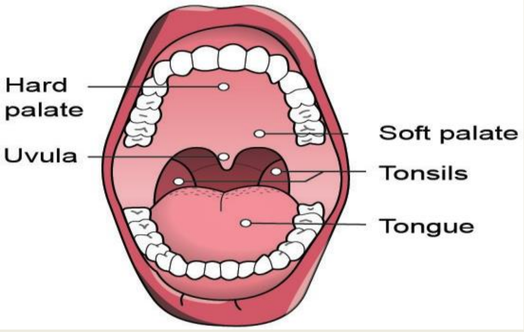
- Lymph nodes
- Tonsils
- Spleen, and
- Thymus.

Lymph nodes

Lymph fluid flows in the lymph nodes throughout the body before finally making its way back to the blood stream. While doing so, it collects and traps harmful matter, such as bacteria, viruses, and bodily waste products. The lymph nodes filter the fluid and release it back into the bloodstream. Lymph nodes also contain immune cells that help fight infection by attacking the germs that the body's lymph fluid has collected. The lymph nodes may swell when a person has a temporary infection. The swelling occurs as a result of immune cell activity in the lymph nodes. The location of the swelling often relates to the affected area. For example, an ear injury/infection may cause swollen lymph nodes near the ear, while someone with an upper respiratory tract infection may notice swollen lymph nodes in their neck.

Tonsils

Tonsils are lymphatic tissue clusters located just beneath the mucous membranes that line the nose, mouth, and throat (pharynx) (Figure 5.12). The tonsils' lymphocytes and macrophages protect us from harmful substances and pathogens such as bacteria and viruses that enter the body through the nose or mouth.



Locations of Tonsils

Spleen

The spleen is found in the upper left abdominal cavity, just below the diaphragm and posterior to the stomach (Figure 5.10). Its shape and structure are similar to that of a lymph node, but it is much larger. The spleen performs the following functions:

- filters blood in the same way that lymph nodes filter lymph;
- lymphocytes in the spleen react to pathogens in the blood and attempt to destroy them;
- macrophages engulf debris, damaged cells, and other large particles;
- removes old and damaged erythrocytes from the circulating blood; and
- it produces lymphocytes, particularly in response to infection.

Thymus

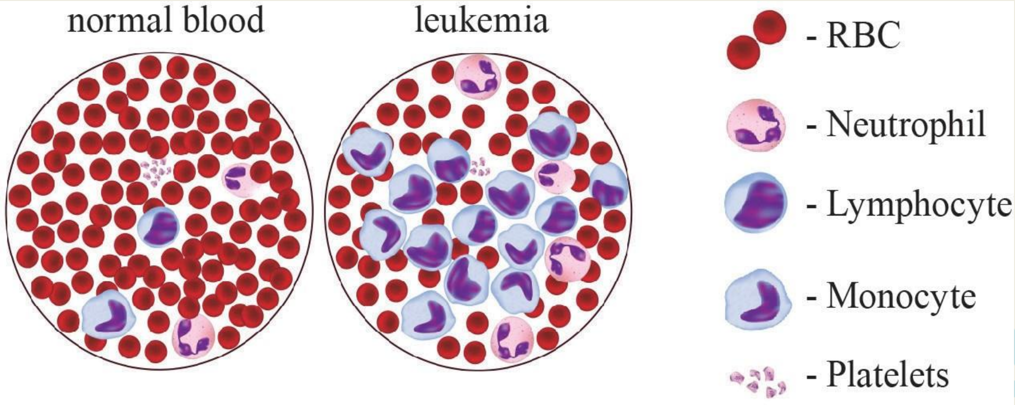
The thymus is a soft organ with two lobes anterior to the ascending aorta and posterior to the sternum. It is relatively large in infants and children, but after puberty, it begins to shrink in size until it is quite small in older adults. The thymus' primary function is to process and mature special lymphocytes known as T-lymphocytes or T-cells. Pathogens and foreign agents are not recognized by lymphocytes while they are in the thymus. After maturing, lymphocytes enter the bloodstream and travel to other lymphatic organs, where they aid in disease defense. Thymosin, a hormone produced by the thymus, stimulates the maturation of lymphocytes in other lymphatic organs.

5.2.2. Diseases of the circulatory and lymphatic systems

Leukemia

Leukemia is a type of cancer that affects blood-forming tissues, including bone marrow (Figure 5.13). There are several types of leukemia, including acute lymphoblastic leukemia, acute myeloid leukemia, and chronic lymphocytic leukemia. For example, many patients with slow-growing leukemia are asymptomatic, and rapidly progressing types of leukemia can cause fatigue, weight loss, frequent infections, and easy bleeding or bruising. Also, the treatment varies greatly. Treatment for slow-growing leukemia may include monitoring.

Chemotherapy, sometimes followed by radiation and stem-cell transplant, is used to treat aggressive leukemia.



Leukemia

Varicose veins

Varicose veins are enlarged, swollen, and twisting veins that often have blue or dark purple colour. They occur when faulty vein valves allow blood to flow in the wrong direction or pool. Varicose veins are thought to affect more than 23% of all adults. It is common in:

- pregnant women are more prone to varicose veins, and
- overweight people are more prone to varicose veins

Aching legs, swollen ankles, and spider veins are some of the symptoms. It occurs when the valves in the veins fail to function properly, allowing blood to flow inefficiently. Treatment for varicose veins is rarely necessary for health reasons; however, if swelling, aching, and painful legs occur, and there is significant discomfort, treatment is available. There are several options, including some home remedies. In severe cases, a varicose vein may rupture or develop into varicose ulcers on the skin.

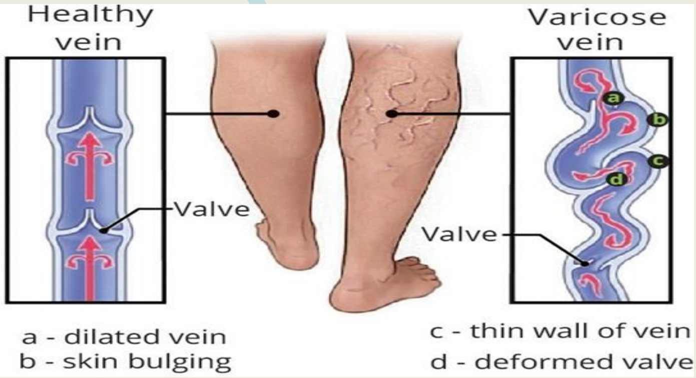


Figure A, shows a normal vein with a properly working valve. In Figure B, the varicose vein has a faulty valve; the walls of the vein are thin and stretched

Elephantiasis

Elephantiasis is a condition that causes a large enlargement of a part of the body, usually the limbs (Figure 5.15). External genitals are another area that is frequently affected. Elephantiasis is caused by a blockage in the lymphatic system, resulting in an accumulation of a fluid known as lymph in the affected areas. Elephantiasis is caused by parasitic worms transmitted by mosquitoes. *Wuchereria bancrofti*, *Brugia malayi*, and *Brugia timori* are the three worms involved.

Elephantiasis

Worms have an impact on the body's lymphatic system. The lymphatic system is in charge of eliminating waste and toxins. If it becomes clogged, it is unable to properly remove waste. This causes a buildup of lymphatic fluid, resulting in swelling.

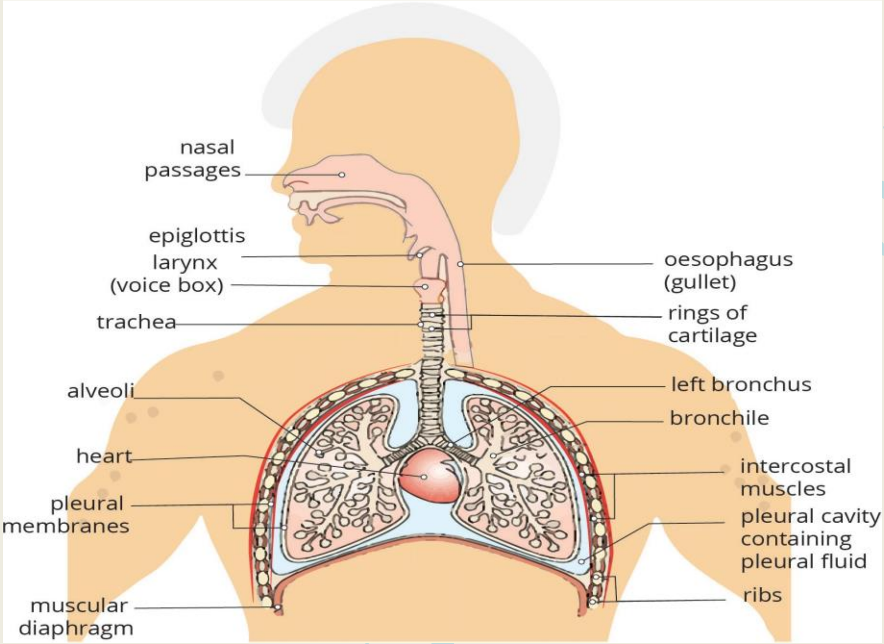
Cardiovascular diseases

Cardiovascular diseases are classified into several types. Among them are:

- Abnormal heart rhythms, also known as arrhythmias;
- Aorta disease and Marfan syndrome are two examples,
- Congenital heart disease is a condition that occurs at birth,
- Coronary artery disease is a condition that affects the arteries in the heart (narrowing of the arteries),
- Deep vein thrombosis (DVT) and pulmonary embolism (PE),
- A heart attack,
- Heart failure, and
- Muscle disease of the heart (cardiomyopathy).

Heart disease

Heart and blood vessel disease (also known as heart disease) encompasses a wide range of issues, many of which are linked to a process known as atherosclerosis. Atherosclerosis is a condition that occurs when a substance called plaque accumulates in the artery walls. This buildup narrows the arteries, making blood flow more difficult. When a blood clot forms, it can obstruct blood flow. This can result in a heart attack or a stroke.



The human breathing system

5.3 The breathing system

The respiratory system, which includes muscles to move air into and out of the lungs, passageways through which air moves, and microscopic gas exchange surfaces covered by capillaries, allows

carbon dioxide to be exhaled and oxygen to be inhaled. Gases are transported from the lungs to tissues throughout the body via the circulatory system. If your breathing is disrupted by a variety of conditions, such as what you did in your activity above, or diseases of the respiratory system, such as asthma, emphysema, chronic obstructive pulmonary disorder (COPD), and lung cancer, you will experience difficulties in the normal functioning of your breathing system, which can be quite severe at times.

The breathing system organs' primary functions are to:

- provide oxygen to body tissues for cellular respiration,

- remove the waste product, carbon dioxide,
- help to maintain acid-base balance, and
- Portions of the breathing system are also used for non-vital functions such as sensing odors, producing speech, and coughing.

The nose, larynx, pharynx, trachea, bronchi, bronchios, and alveoli are the major structures of the breathing system. The following sections go over these structures and their functions one by one.

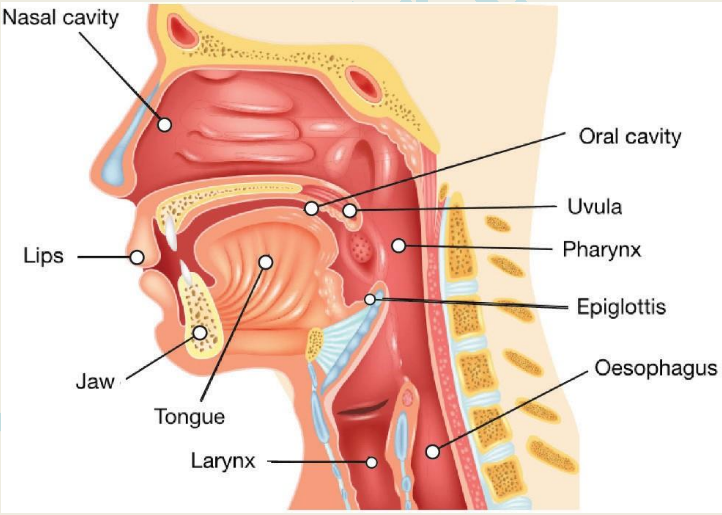
Major breathing structures and their functions

The Nose

The nostrils are the main entry and exit points of breathing system, which are located in the nose. The nasal cavity, which is divided into left and right sections by the nasal septum, receives the inhaled air. The air moves from the nasal cavities to the pharynx. Mucous membranes line portions of the nasal cavities, which contain sebaceous glands and hair follicles that prevent large debris, such as dirt, from passing through the nasal cavity.

Pharynx

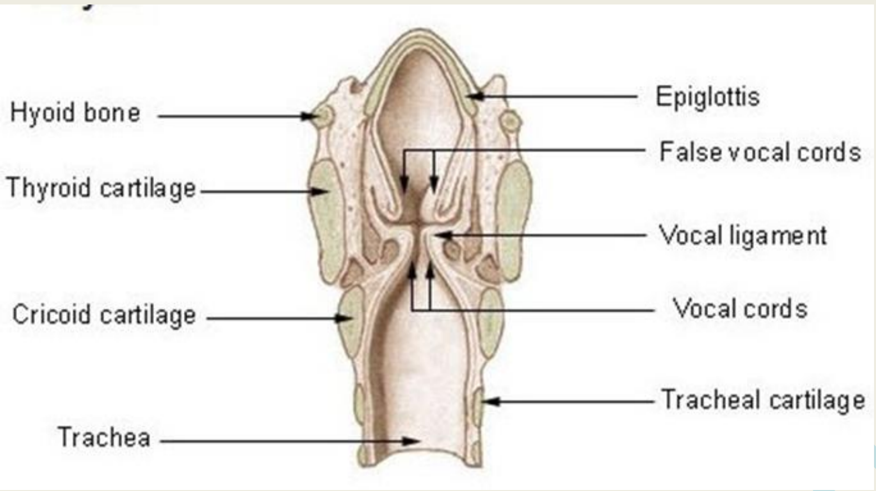
The pharynx is a tube made up of skeletal muscle and mucous membrane that runs parallel to the nasal cavities. The pharynx, also known as the throat, is a tube that runs from the base of the skull to the sixth cervical vertebra. It receives air from the nasal cavity and air, food, and water from the oral cavity, serving the breathing and digestive systems. It opens into the larynx and esophagus from the back.



The pharynx

Larynx

The larynx is a structure that connects the pharynx to the trachea and helps regulate the amount of air that enters and leaves the lungs. Several pieces of cartilage make up the structure of larynx



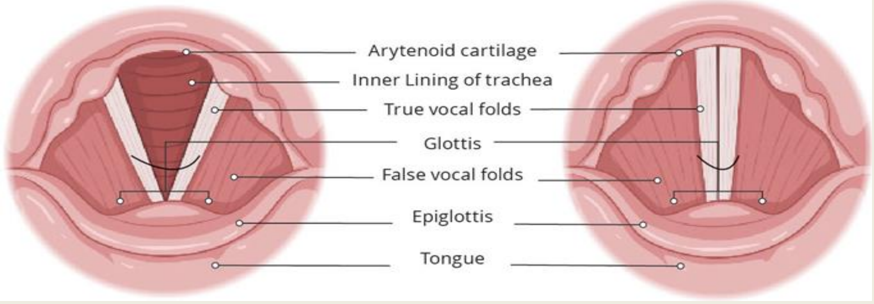
The larynx extends to the trachea.

The epiglottis is a thin, elastic cartilage that covers the trachea's opening and is attached to the thyroid cartilage. When the epiglottis is closed, the unattached end of it rests on the glottis. The glottis is made up of the vestibular folds, true vocal cords, and space between them.

The inner borders of the real vocal cords are free, allowing oscillation to make sound. The size of true vocal cord membranous folds varies from person to person, resulting in voices with various pitch ranges. Males have greater folds than females, which gives them a deeper voice.

During swallowing, the pharynx and larynx lift upward, allowing the pharynx to expand and the laryngeal epiglottis to swing downward,

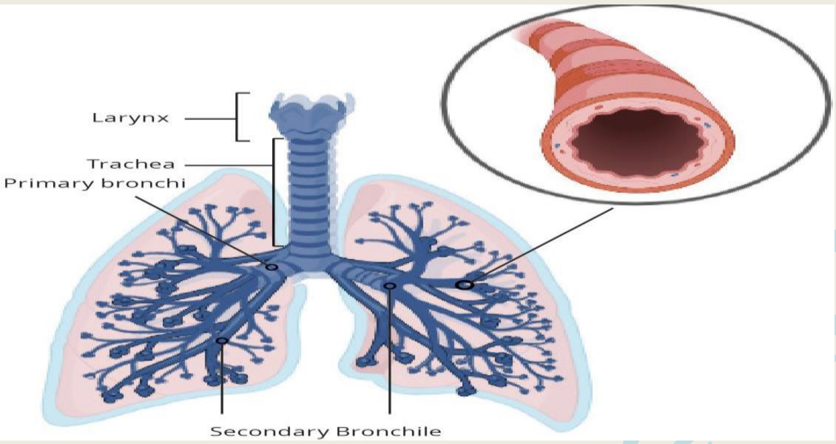
closing the trachea opening. Because of these movements, food and liquids cannot enter the trachea, which creates a bigger region for food to travel through.



The vocal cords

Trachea

The trachea (windpipe) extends from the larynx toward the lungs. The trachea is formed by 16 to 20 stacked pieces of cartilage that are connected by connective tissue. The elastic membrane of the trachea allows it to stretch and expand slightly during inhalation and exhalation, whereas the rings of cartilage provide structural support and prevent the trachea from collapsing.



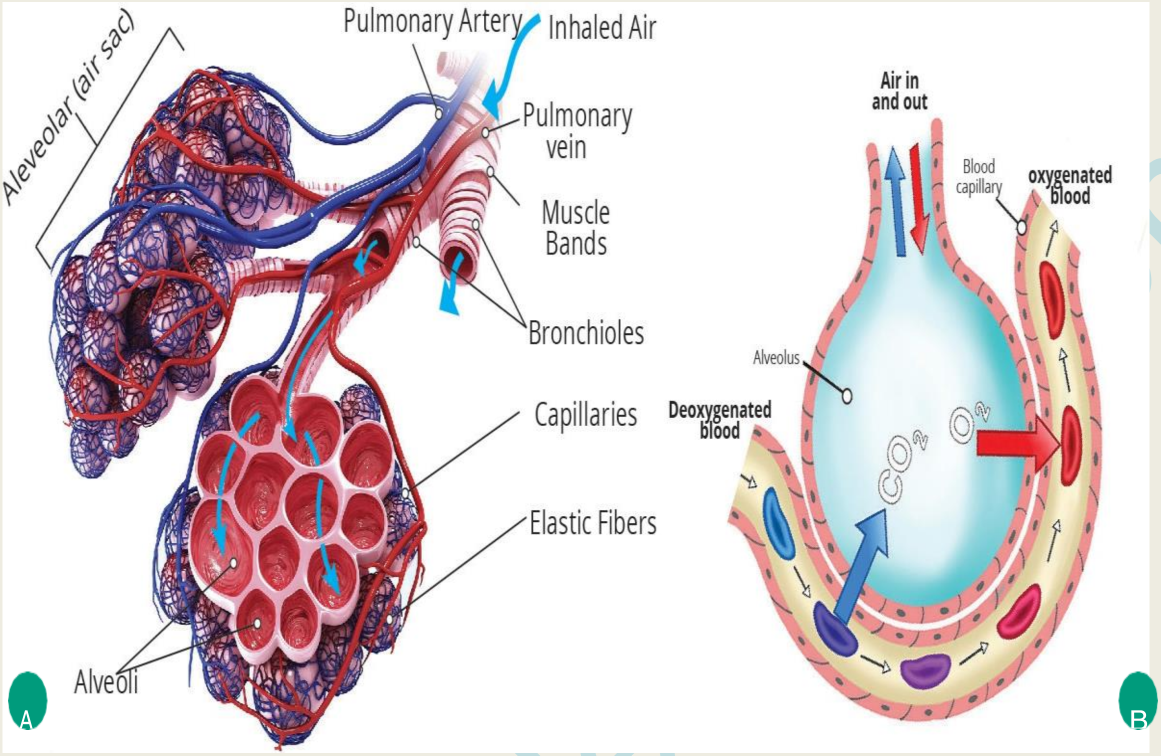
Thetrachea

Bronchi and Bronchioles

The right and left primary bronchi branch of the trachea towards the right and left lungs. The primary bronchi further branch into the secondary and tertiary bronchi. A bronchiole branches from the tertiary bronchi. Bronchioles, which are about 1 mm in diameter, further branch until they become the tiny terminal bronchioles, which lead to the structures of gas exchange. There are more than 1000 terminal bronchioles in each lung. The muscular walls of the bronchioles do not contain cartilage-like those of the bronchi. However, smooth muscle can change the size of the tubing to increase or decrease airflow through it.

Breathing Gas Exchange

Structures involved directly in gas exchange are found in the breathing zone. The breathing zone begins when the terminal bronchioles join a breathing bronchiole (Figure 5.21), the smallest type of bronchiole which leads to an alveolar duct and opens into a cluster of alveoli.



Bronchioles (a) lead to alveolar sacs (b) in the breathing zone,where gas exchange occurs.

Alveoli

An alveolar sac is a cluster of many individual alveoli that are responsible for gas exchange. An alveolus with elastic walls, stretch during air intake which greatly increases the surface area available

for gas exchange. Alveoli are connected to their neighbors by alveolar pores, which help maintain equal air pressure throughout the alveoli and lung.

Comparison of atmospheric and exhaled air

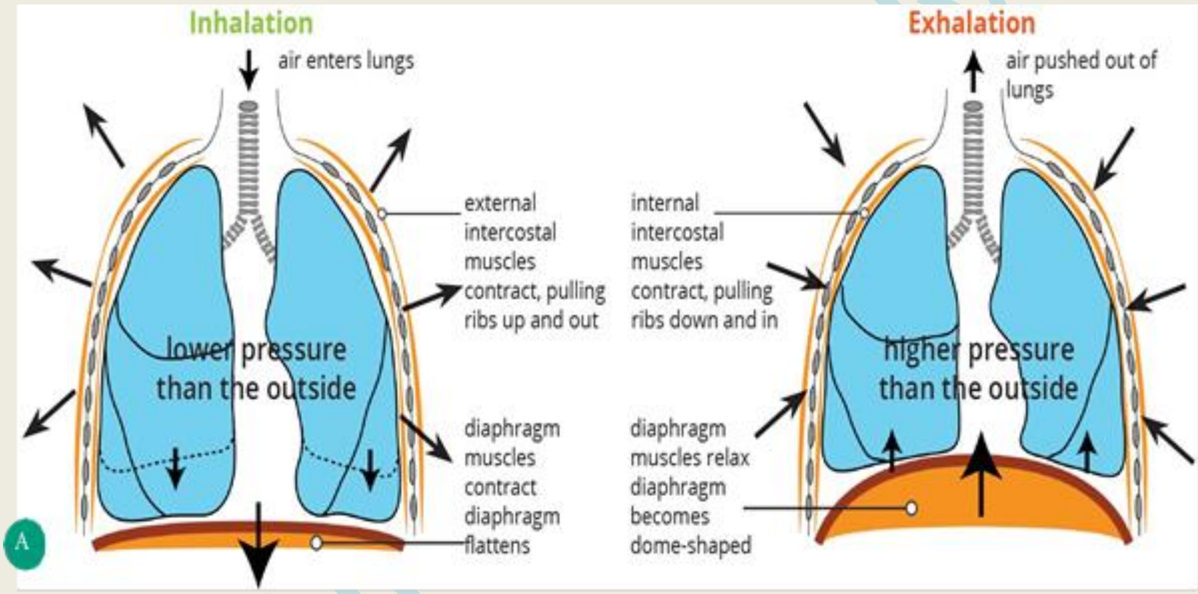
Component	Atmospheric air	Exhaled air
oxygen	21%	16%
Nitrogen	78%	78%
Carbon dioxide	0.04%	4%
Temperature	37 degree centigrade	variable
Moisture	saturated	variable

Breathing Movements

Pressure differences between the atmosphere and the chest, or thoracic cavity determine the movement of air into and out of the lungs. Atmospheric pressure remains relatively constant, but the pressure in the chest cavity may vary. An understanding of breathing hinges on an understanding of gas pressures. The mechanism of breathing is shown in Figure 5.22.

Gases move from an area of high pressure to an area of low pressure:

- Inspiration occurs when the pressure inside the lungs is less than that of the atmosphere , and
- Expiration occurs when the pressure inside the lungs is greater than that of the atmosphere.



Breathing movements: a) Inspiration b) Expiration

5.4 The Human Urinary system

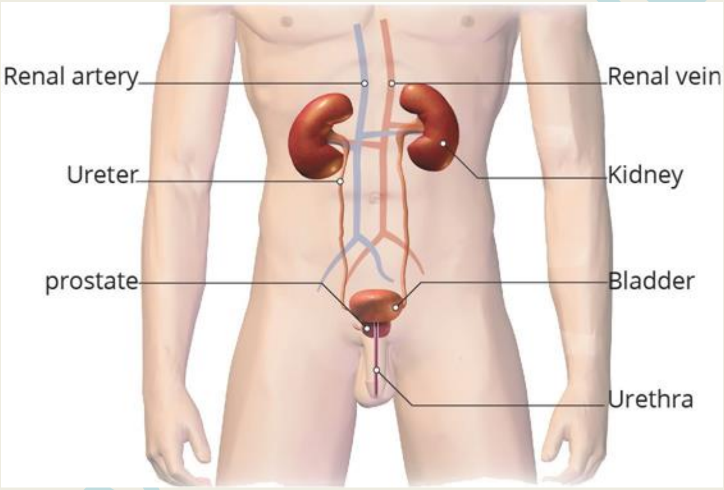
The section explains the anatomy of the excretory system and how it facilitates the physiologic tasks required for equilibrium. The kidney should be thought of as a plasma regulator rather than a urine maker. As you read through each section, consider the following scenario: What if this doesn’t work? This inquiry will assist you in comprehending how the urinary system maintains homeostasis and influences all other bodily systems as well as one’s quality of life.

External structure of kidney

The kidneys are a pair of bean-shaped organs in the abdominal cavity that are placed directly below the liver. The endocrine system includes the adrenal glands, which are located on top of each kidney. Blood is purified and filtered by the kidneys. The kidneys filter all of the blood in the human body on a daily basis, consuming over 25% of the oxygen taken by the lungs in the process. Through aerobic respiration, oxygen enables kidney cells to produce chemical energy in the form of ATP.

Urine is the filtrate that comes out of the kidneys. The ureters, which are around 30 cm long, transport urine from the kidneys to the urinary bladder. Urine is driven through the ureters by waves of peristalsis, rather than passively draining into the bladder (smooth muscle contractions). Urine from both ureters is collected in the bladder. Its capacity is diminished during late pregnancy because to compression by the increasing uterus, resulting in increased urination frequency. Urine is transported from the bladder to the exterior of the body via the urethra.

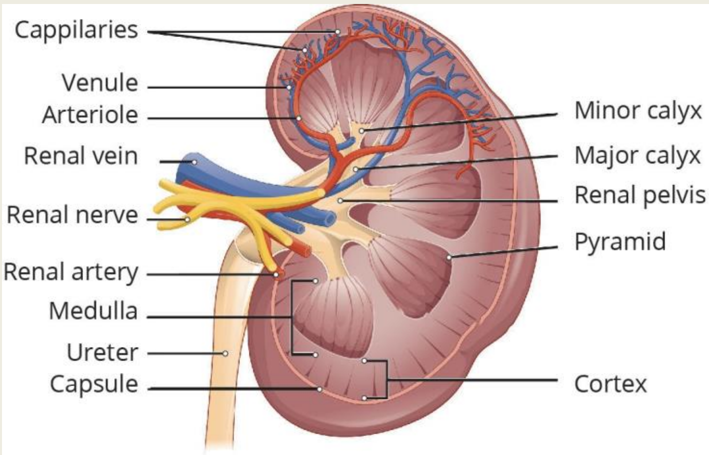
The only urologic organ that differs significantly between males and girls is the urethra; all other urine transport systems are identical. Female urethras are shorter than male urethras, measuring around 4 cm in length, and provide less protection against fecal germs (approximately 20 cm). The increased frequency of urinary tract infections (UTIs) in women can be explained by this length disparity. In males, the urethra also serves as a reproductive organ, transporting sperm (sperm and accessory fluids).



Kidneys filter the blood and produce urine that is stored in the bladder before removal

Internal structure of kidney

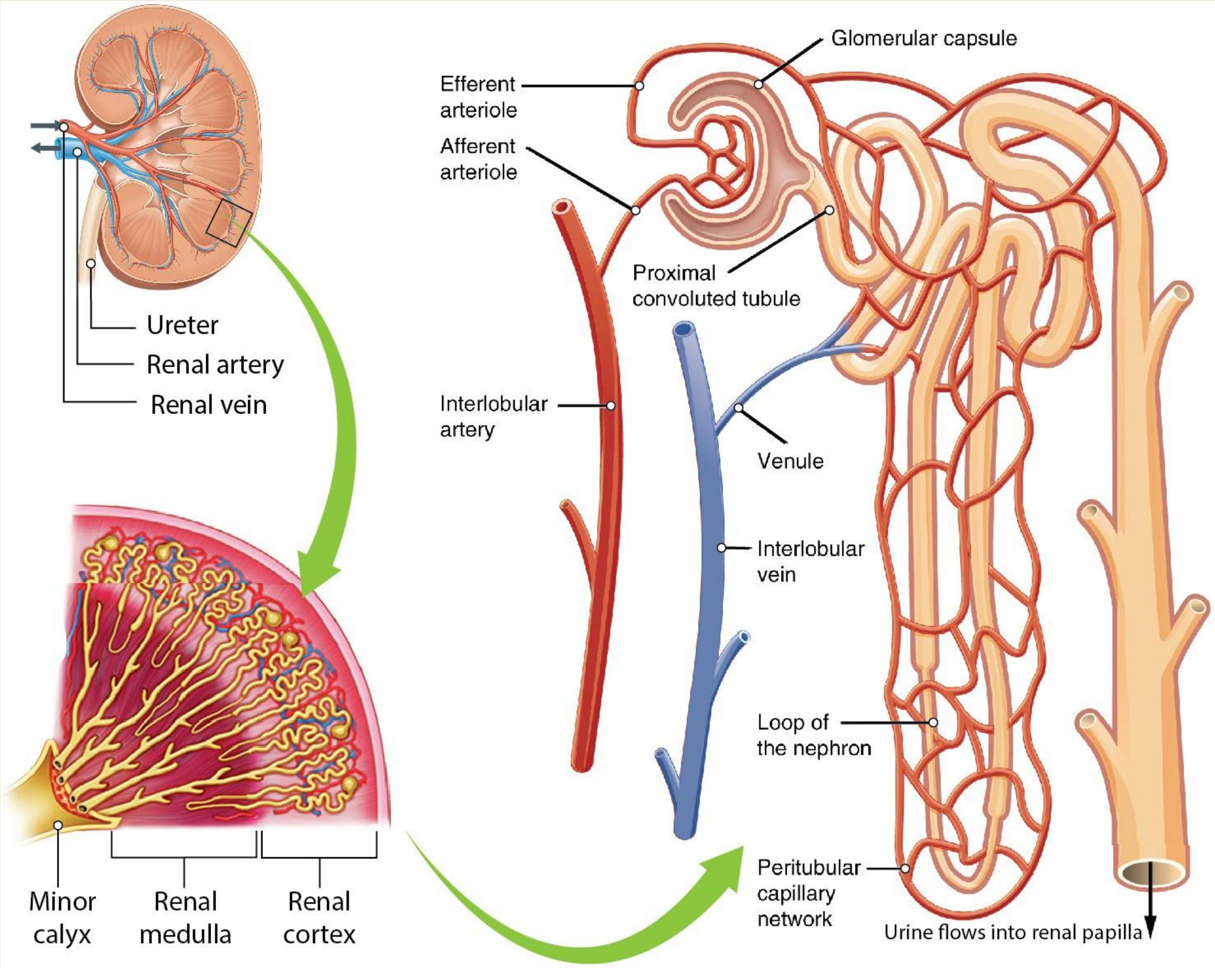
The kidney is divided into three sections on the inside: an outer cortex, a medulla in the middle, and the renal pelvis in the hilum of the kidney. The hilum is the concave portion of the bean form where blood arteries and nerves enter and exit the kidney, as well as where the ureters exit. The presence of renal corpuscles causes the renal cortex to be granular, and nephron tubules can be observed throughout the renal cortex and renal pyramids, which make up the majority of the renal medulla. Each kidney has an average of eight renal pyramids.



The internal structure of the kidney

The network of blood arteries in the kidney is an important part of its anatomy and function because it filters blood. The renal hilum is where the arteries, veins, and nerves that supply the kidney enter and exit. Renal blood flow begins with the aorta branching into renal arteries and finishes with the renal veins exiting to join the inferior vena cava, which takes blood back to the heart's right atrium. Before branching into several afferent arterioles and entering the capillaries supplying the nephrons, the renal arteries split multiple times to form additional blood vessels. As mentioned previously, the functional unit of the kidney is the nephron, illustrated in figure. Each kidney is made up of over one million nephrons that dot the renal cortex. A nephron consists of three parts:

- a renal corpuscle,
- a renal tubule, and
- the associated capillary network.



The Structure of a nephron.

Renal corpuscle

The glomerulus, a network of capillaries that surrounds the renal corpuscle in the renal cortex, is made up of the glomerular or Bowman's capsule, a cup-shaped chamber that surrounds it.

Renal Tubule

The renal tubule is a long, convoluted structure that emerges from the glomerulus and can be split into three segments based on function:

1. the Proximal Convoluted Tubule (PCT),

2. the loop of Henle, which forms a loop (with descending and ascending limbs), and

3. the Distal Convoluted Tubule (DCT). The DCT, or distal collecting duct, joins and discharges the nephron's contents into collecting ducts. Urine will eventually pass via the renal pelvis and into the ureters.

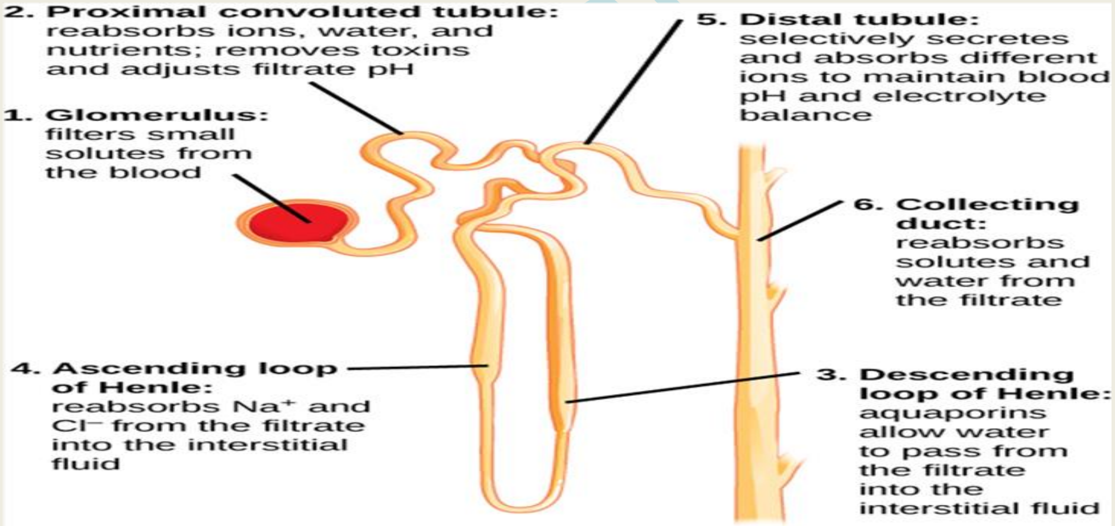
The formation of urine

Kidneys filter blood in a three-step process:

The nephrons filter blood as it passes through the glomerulus' capillary network. Except for proteins, almost all solutes are filtered out into the glomerulus by a process known as glomerular filtration.

The filtrate is collected in the tubules of the kidneys. Tubular reabsorption is the process by which most of the solutes are reabsorbed in the PCT. The filtrate continues to exchange solutes and water with the peritubular capillary network in the Henle loop. During this phase, water is also reabsorbed.

Tubular secretion, which is essentially the inverse of tubular reabsorption, secretes extra solutes and wastes into the renal tubules. The collecting ducts collect filtrate from the nephrons, which are then carried into the renal pelvis and eventually to the ureters as urine.



The process of urine formation in the kidney

5. 5 The immune system

The Immunity system

Immunity is defined as the body's ability to prevent the invasion of pathogens. The immune system includes varieties of defences against viruses, bacteria, fungal infections, and parasites (such as threadworms). The lymphatic system is part of the broader immune system. The types of immune systems include innate and adaptive (Acquired) immune systems.

a) Innate immune system

The body's initial line of defense against invading microbial diseases is innate immunity. Pattern recognition receptors (PRRs), which are produced by innate immune cells, help to maintain homeostasis by regulating endogenous processes including inflammation and cell death.

These are the non-specific, unchanging lines of defenses which include:

- Physical and chemical barriers to pathogens.
- To attract immune cells to infection locations, cytokines and other chemical agents are produced.
- To recognize bacteria, stimulate cells, and facilitate the clearance of dead cells or antibody complexes, the complement cascade is activated.
- Specialized white blood cells identify and remove foreign compounds found in organs, tissues, blood, and lymph.

b) Adaptive (Acquired) immune system

After an initial reaction to a new pathogen, adaptive (or acquired) immunity is formed, resulting in an increased response to future exposure to the same disease. Vaccination is based on this acquired immunity process. Because bacteria and viruses are always changing and evolving in an 'arms war' with our immune systems, this is critical. The adaptive immune system has the following characteristics:

- During the antigen presentation process, particular "non-self" antigens are recognized.
- The development of targeted responses to eradicate specific infections or pathogen-infected cells.
- Immunological memory is the process through which signature antibodies or T cell receptors "remember" each infection. If another infection arises, these memory cells can be summoned to eliminate the invader swiftly.

5.6 Renowned Physicians in Ethiopia

Prof. Asrat Woldeyes (1928-1999) was the first distinguished Ethiopian surgeon and professor of medicine in Addis Ababa University. He was the first Ethiopian to qualify in this field of medicine in the West after medical studies at Edinburgh University. He devoted the majority of his working life to surgery at Addis Adaba's two main hospitals, as well as the deanship of medicine at the university.

Dr. Widad KidaneMariam was born to an Ethiopian emigrant family in Palestine during the Italian occupation of her country of origin. She studied medicine at the American University of Beirut and became the "first female" medical practitioner and topmost physician administrator in charge of the medical services division in the Ministry of Health in the 1960s-1970s. When she was asked to be the first Ethiopian gynecologist to volunteer for the Swedish Save the Children Fund project in Addis Abeba, she also became a founding organizer responsible for the establishment of the first Ethiopian Family Planning Association as well as Maternal and Child services for the homeless in Addis Abeba Municipality.

Review Questions

I. True False Items: Say "True" or "False" for the following statements on your exercise book.

1. Blood pressure is highest in veins**. F**
2. Atherosclerosis is the build-up of plaque inside arteries**. T**
3. Platelets are blood cells that fight infections**. F**
4. Food travels from the mouth to the stomach because of gravity**. F**
5. Most absorption of nutrients takes place in the stomach. **F**
6. For good health, you should never eat lipids**. F**
7. The kidneys are the main organs of the excretory system. **T**
8. Nephrons carry urine out of the body. **T**

II. Multiple Choice Items: Choose the correct answer from A - E and write on your exercise book.

1. Part of the alimentary canal where mechanical digestion and the chemical digestion of polysaccharides begin.

A. Mouth B. Stomach C. Liver D. Small Intestine E. None of the above

2. The 1st location in the digestive system where peristalsis occurs:

A. Mouth B. Esophagous C. Stomach D. Small Intestine E. Large Intestine

3. Where in the alimentary canal does pepsinogens are activated into pepsin to aid in the digestion of proteins.

A. Mouth B. Esophagous C. Stomach D. Small Intestine E. Pancreas

4. The organ that releases many enzymes that aid in the breakdown of all types of organic molecules:-

A. Mouth B. Gall Bladder C. Stomach D. Liver E. Pancreas

5. The tube though which food and air (that you breathe) passes:-

A. Esophagous B. Larynx C. Trachea D. Pharynx E. Rectum.

6. Bile is produced in .

A. Salivary Glands B. Pancreas C. Stomach D. Liver E. Gall Bladder

7. Which of the following organs produce insulin, required for glucose uptake into body cells?

A. Liver B. Gall Bladder C. Pancreas D. Stomach E. None of the above

8. Which of the following is not a major task of the digestive system?

A. Secretion B. Digestion C. Absorption D. Elimination E. Circulation

9. Which of the following is not considered an accessory gland to the digestive system?

A. Wall of the gastrointestinal tract GI) C. Liver

B. Salivary Glands D. Pancreas

E. All of the above

10. Rank the following blood vessels in order of their average pressure, from highest to lowest:

artery, vein, arteriole, venule, aorta, capillary.

A. Capillary > vein >venule> arteriole > artery > aorta

B. Aorta > arteriole >venule> artery > vein > capillary

C. Aorta > artery > arteriole > capillary >venule> vein

D. Capillary > arteriole >venule> artery > vein > aorta

E. None of the above

11. Which of the following statement about circulatory systems is false?

A. In closed circulatory systems, blood flows through vessels that are separate from the interstitial fluid of the body.

B. The earthworm has a closed circulatory system.

C. In an open circulatory system, the hemolymph empties into the body cavity.

D. Lobsters are organisms that have closed circulatory systems.

12. Red blood cells are also known as:-

A. Lymphocytes B. monocytes C. erythrocytes D. basophils

13. How does the structure of red blood cells allow them to deliver oxygen to the cells of the body?

A. Their size and shape allow them to carry and transfer oxygen.

B. Their disc shape contains many small vesicles that allow them to carry and transfer oxygen.

C. They have nuclei and do not contain haemoglobin.

D. They contain coagulation factors and antibodies.

E. All of the above

14. Which of the following best describes plasma?

A. It is a protein synthesized in the liver.

B. It is a liquid that contains only lipids and antibodies.

C. It is a blood component that is separated by spinning blood.

D. It is an antibody produced in the mucosal lining.

E. All of the above except A

15. Which of the following is a function of the breathing system?

A. gas exchange C. transport of oxygen

B. absorption of nutrients D. structural support E. A and D

16. The trachea leads to the .

A. bronchioles B. Bronchii C. oesophagus D. pulmonary vessel E. Nasal cavity

17. The space at the back of the mouth, which leads either to the airway or the esophagus is the:

A. larynx B. nasal cavity C. Pharynx D. None of the above

18. Oxygen from the air enters the bloodstream through:-

A. cardiac notch B. pulmonary vein C. alveoli D. paranasal sinuses E. larynx

19. When the diaphragm contracts (is pulled downward), occurs.

A. inhalation C. hiccup

B. exhalation D. Lung collapse E. Both exhalation and inhalation

20. Which one of the following is the correct path urine takes as it moves through the urinary system?

A. kidneys - ureters - bladder – urethra C. bladder - kidneys -urethra – ureters

B. ureters - kidneys - bladder - urethra D. Uretra – kidneys – Ureters – badder

E. None of the above

21.The is the functional unit of the kidney.

A. Villus C. Lymph node

B. Alveoli D. Nephron E. All of the above

22. Which of the following substances are not filtered out of the blood in the nephrons?

A. Blood cells and proteins C. Urea and water

B. Glucose and amino acids D. Salts and hormones E. A and C

23. All of the substances that are removed from the blood via the Bowman's capsule are called .

A. Plasma B. Filtrate C. Urine D. Lymph W E. C and D

24. What substances must be reabsorbed back into the blood from the convoluted tubule and loop of Henle?

A. Water B. Salts C. Glucose D. All of the above E. None of the above

25. Urine is primarily composed of:

A. Lymph B. Red blood cells C. Carbon dioxideD. Water E. Oxygen

26. What is the role of liver in the maintenance of homeostasis?

A. Stores extra carbohydrates in the form of glycogen

B. Produces bile to aid in fat digestion

C. Produces clotting proteins D. All of the above E. Only A and B

III. Fill in the Blanks: Fill in the blank with the term that best completes the sentence.

1. Blood pressure that is higher than normal termed___**Hypertension**_____________ .

2. The liquid part of blood is referred to as___**Plasma**_______________ .

3. Blood type is determined by the presence or absence of____**Antigen**__________ on blood cells.

4. Tiny sacs in the lungs where gas exchange takes place are called___**Alveoli**______________

5. The disease in which air passages of the lungs periodically become too narrow is _________**Asthma**_________ .

6. A wave of involuntary muscle contractions that moves food through the digestive system is called ______**Perytalysis**___________ .

7. The physical breakdown of chunks of food into smaller pieces is referred to as ______**Mechanical**_____________ digestion.

8. The small intestine is lined with tiny finger-like projections named___**Villi**_________________

9. Solid waste that leaves the large intestine is known as___**Bowl**______________ .

10. Nutrients needed in small amounts for the body to function properly are_____**Minerals**______________

IV. Short Answer Items

1. Which enzymes secreted by the pancreas promote digestion?

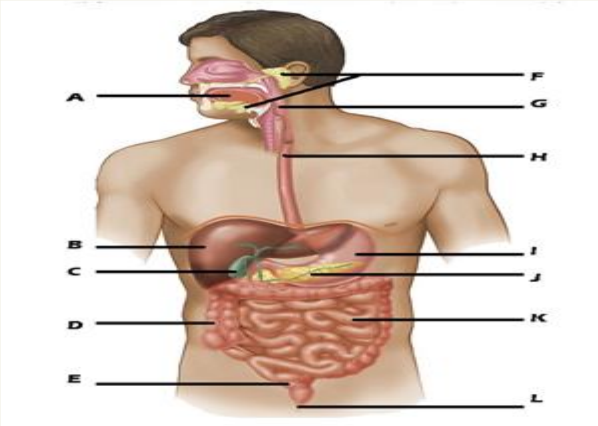
2. Explain the chemicals and processes involved in protein and carbohydrate digestion. Why are carbohydrates not digested in the stomach?

3. List the lipid-digesting enzymes secreted from the pancreas. Do these enzymes allow for acomplete breakdown of lipids?

4. How is the duodenum protected against stomach acid? Why does pepsin remain inactive in the duodenum?

5. In cases of extreme obesity, a section of the small intestine may be removed. What effect do you think does this procedure have on the patient?

6. Describe what the inside of the small intestine looks like and how this organ increases the efficiency of its operation. **Write the structures A-L**



7. Discuss functions of the circulatory system?

8. Mention types of blood circulation in human body?

9. Define pulmonary Circulation.

10. What is the difference between pulmonary and Systemic Circulation?

11. Discuss the effect of fat deposits on the artery walls.

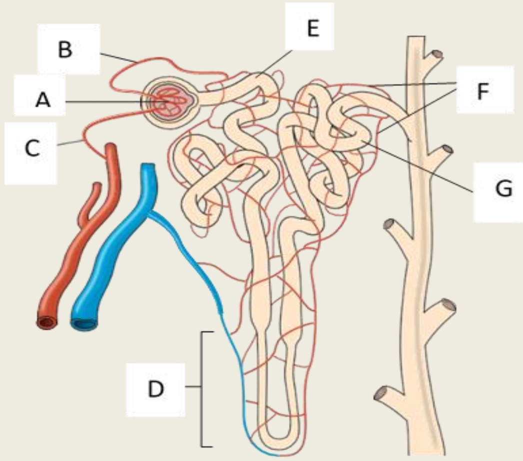
12. State functions of the right atrium.

13. What is the function of the right ventricle?

14. Why muscles of the heart on the left side are thicker?

15. Label the following kidney diagram following the letters pointed at each structure

Write the structures A-F



Short answer

1. lipase, trypsin, erepsin, pancreatic amylases

2. The chemical digestion of carbohydrate (starch) starts in the oral cavity by an enzyme called salivary amylase or ptyalin. The chemical digestion of protein starts in the stomach by the enzyme pepsin. Because carbohydrate (starch) digestion starts in the oral cavity

3. Lipases-enzymes
4. Evidence suggests that under normal physiological conditions, the mucus bicarbonate barrier is sufficient for protection of the gastric mucosa against acid and pepsin and is even more so for the duodenum
5. This procedures can have profound effects on weight loss, but this is dependent on the length of the function small intestine segment.
6. A, Tongue G, pharynx
   B, liver H, esophagus
   C, gall bladder I, stomach
   D, ascending colon J, pancreas
   E, Rectum K, ileum
   F, ear canal L, Anus
7. the circulatory system delivers oxygen and nutrient to cell and takes away wastes the heart pumps oxygenated and deoxygenated blood on different sides.
8. There are two types of circulation : pulmonary circulation and systematic circulation

9. Pulmonary circulation is the system of transportation that shunts de oxgenatated blood from the heart to the lungs to be re saturated with oxygen before being dispersed into the systematic circulation.
10. Systematic carries oxygenated blood from aorta to tissus. Plumonary carries deoxygenated blood to lungs then back to the heart.
11. Atherosclerosis, sometimes called “hardening of the arteries”, occurs when fat, cholesterol, and other substances build up in the walls of arteries. These deposits are called plaques over time, this plaques can narrow or completely block the arteries and cause problems throughout the body.
12. Receives oxygen-poor blood from the body and pumps it to the right ventricle.
13. Accepting venous blood and propelling it to the lungs where it is oxygenated and its co2 eliminated .
14. Because the left ventricle has to pump blood in to vessels.
15. A , glomerular capsule
    B, efferent arterioles
    C, afferent arterioles
    D, interlobular tube
    E, proximal convoluted tubule
    F, peritubular capability network
    G, loop of the nephron

Unit 6: Ecological Interactions

6.1 Trophic Levels

6.1.1 Food chain and food web

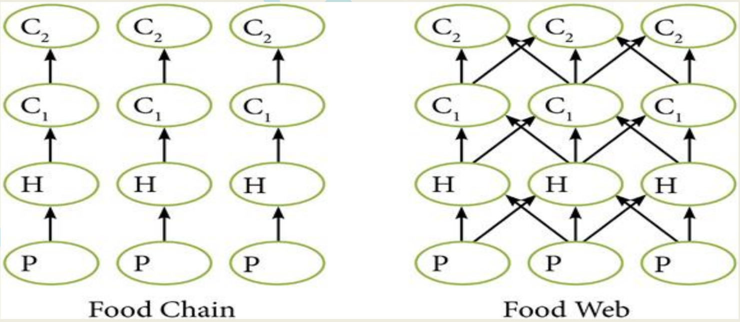
Plants are the first to trap energy and produce their food. They are called producers, also known as autotrophs (self – feeding). Animals feed on either plants or other animals as a source of energy. They are known as consumers or heterotrophs, feeding on plants (herbivores) or other animals (carnivores) or feed on both plants and animals (omnivores). Thus, energy is transferred from plants through a chain of organisms, employing the “to eat or to be eaten“process. This process is known as the food chain or food web.

The following are characteristic features of a food chain

- There is repeated process of “to eat or to be eaten”, so the food chain represent nutritive interaction among biotic component of the ecosystem.
- Plants (producers) are at the base or beginning of the food chain.
- There is the unidirectional flow of energy from the sun to the producers and then to series of consumers.

Omnivorous (animals that feed both on plants and other animals) occupy more than one position in the food chain.

Every organism eats different organisms and it can be eaten by other different organisms. Therefore, ecosystems normally exhibit multidirectional energy flow, which is more than a direct chain of who – eats – what. What is occurring in the ecosystem is a complex web structure, called the food web. A food web is an interconnected food chain that makes interwoven or web-like structures.



Schematic illustrations of the food chain and food web (P = producer, H= Herbivore, C1= Primary carnivore, C2 = Secondary carnivore).

Each organism occupies a specific position in the food chain, called trophic level. Basically, a trophic level indicates the position of the organism in an order of receiving energy and usually ranges from 1 to 3 or 4 trophic levels. Plants, which are the first to trap solar energy, stand at the first trophic level; herbivores that eat plants stand at the second trophic level and carnivores that eat herbivores stand at the third trophic level.

The feeding level is the order of consuming or eating one another. Herbivores are at the first feeding level consuming plants also known as primary consumers. Carnivores that eat herbivores stand at the second feeding level and so on.

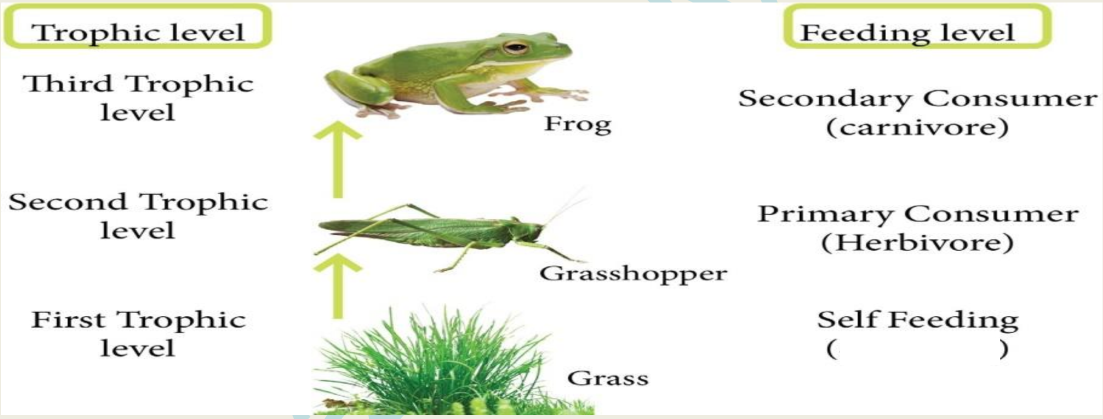
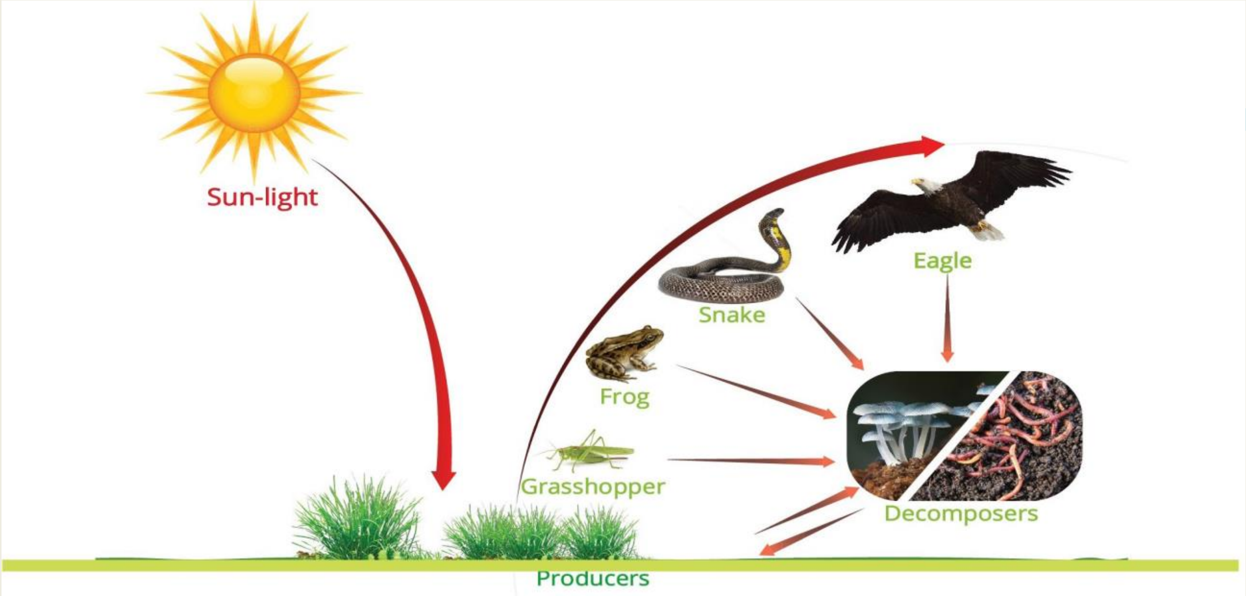


Illustration of Trophic level

6.1.2 Flow of energy and matter through ecosystem

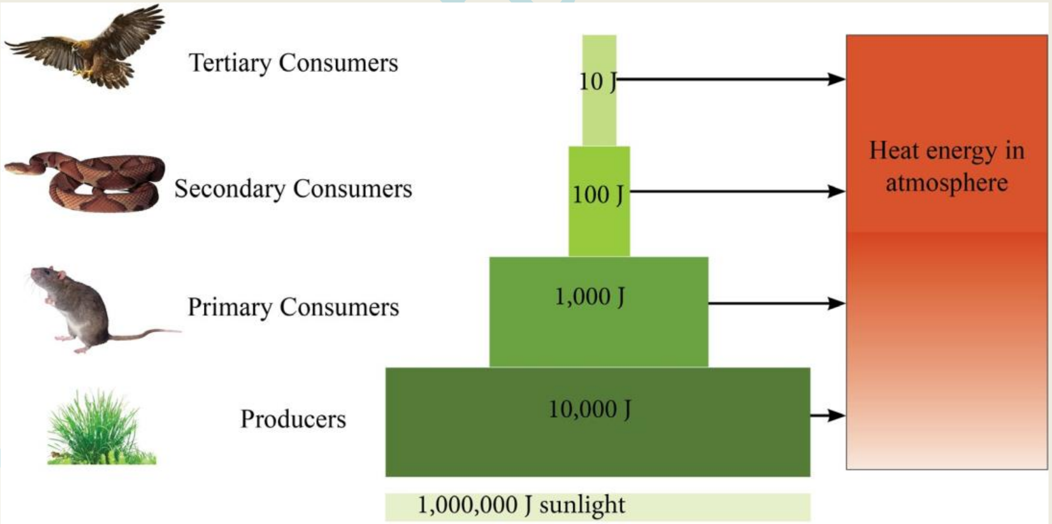
You already know that the ultimate source of energy in life is the sun. You have also learned that it is solar energy trapped by the producer during photosynthesis that flows through a series of organisms by a food chain or food web. As shown in Figure 6.3, the energy from the sun flows through organisms, but this energy cannot go back to the sun. This is why we say energy cannot be recycled - it flows through the ecosystem. However, nutrients in food (organic matter) recycle within an ecosystem and are reused over and over again. This is the result of composition (synthesis) and decomposition (breakdown), which take place in the ecosystem.

Plants synthesize food (organic matter) from simple inorganic matter. When producers or consumers die, fungi and other decomposers obtain energy by breaking down the organic matter and in the process; they return key nutrients like nitrogen to the soil so that producers can use them as raw materials for photosynthesis.



Flow of energy and matter (inorganic and organic) in an ecosystem

The ecological pyramid can also be constructed to represent the biomass or number of organisms at each trophic level. Accordingly, there are three types of ecological pyramids namely: the pyramid of energy, the pyramid of number and the pyramid of biomass. The pyramid of energy is always upright and narrowing sharply from the base to the top-level carnivore because there is commonly 90% energy loss at each trophic level.



An Idealized pyramid of energy.

transfer of energy for each link in the food chain. Notice that the producer - Grass, is capable of converting only 1% of solar energy by photosynthesis.

As opposed to pyramid of energy, pyramids of biomass or number can be upright (with the long bar at the base and shorter bar at the apex) or inverted depending on the type of ecosystem and the particular food chain.

Illustration of the pyramid of number (A) and pyramid of biomass (B) in the aquatic food chain

6.2 Cycling of Materials in an Ecosystem

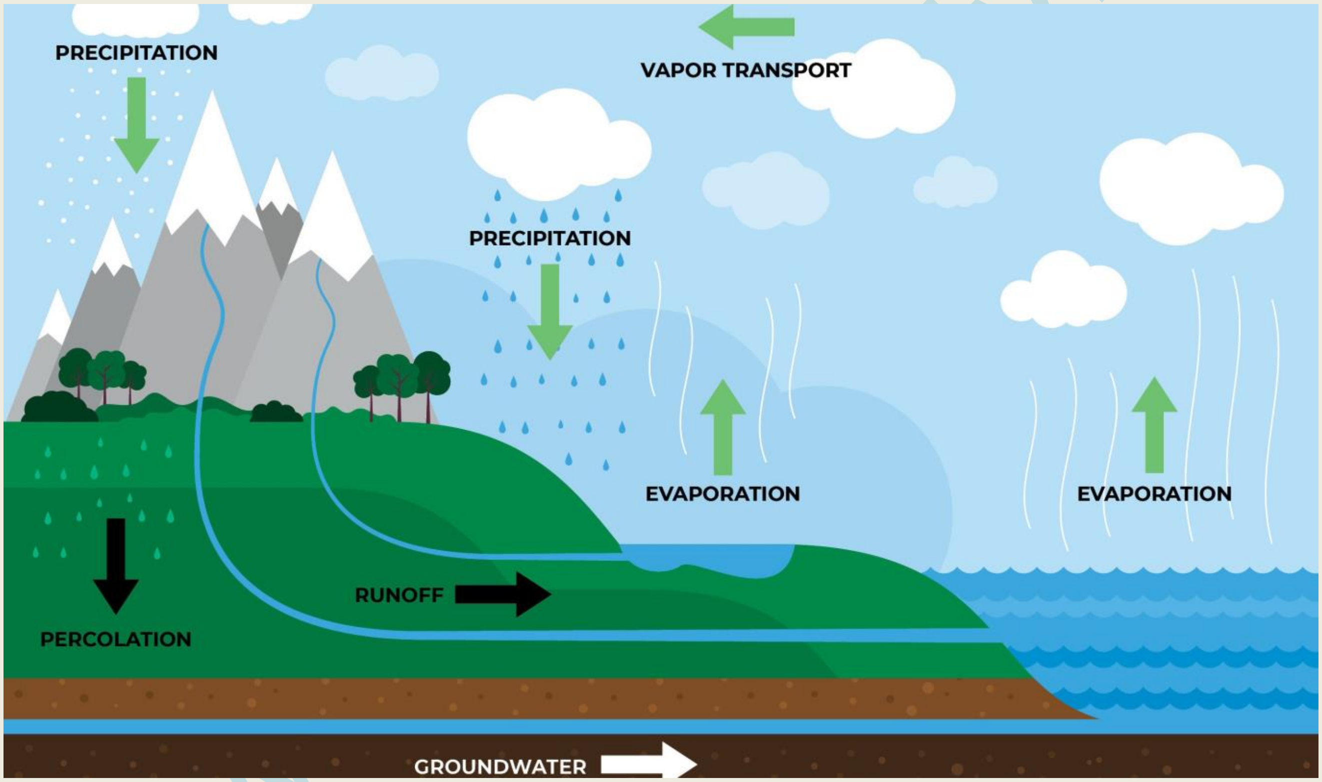
An ecosystem refers to the complex of living organisms (biotic component), their physical and chemical environment (abiotic component), and all their interaction and interrelationship in a particular unit of space. As materials in an ecosystem are found in a limited amount, it is essential that the same nutrients materials should continuously be reused, over and over again. The cycling occurs between the biotic (living) and the abiotic (non-living) components of the ecosystem. The biotic component consists of plants, animals, and microorganisms while the abiotic comprises the atmosphere (air), hydrosphere (Aquatic/water), and lithosphere (soil). Materials always move around within an ecosystem when organisms feed, breathe, respire, and excrete. Nutrients are released when the waste product or dead bodies are decomposed. What is a waste product to one organism becomes a vital nutrient to another. For example, animal excreta (a waste product) will be broken down by decomposers, release nitrogen and phosphorous (vital nutrients) which will be used for plant growth, thereby increasing agricultural yield. Note that the waste product, instead of polluting the environment, can be a rich source of organic fertilizer.

6.2.1 Water cycle

Water on earth does not stay still. It is always on move. Rain that falls at a particular place can be the result of evaporation that occurred at a distant ocean days before. Likewise, water in a river may have been rainfall somewhere at a distance or melting ice or snow from the top of high mountains. It is the water cycle that is responsible for water movement in the ocean, on the land, and in the atmosphere.

The water cycle is sun driven process. It is solar heating that helps the cycle to start with evaporation. Evaporation of water from the earth and surface of the leaf by transpiration rises in the atmosphere in the form of water vapor. Then, the water vapor cools and condenses in the atmosphere into rain or snow, and falls again to the earth's surface as precipitation (Rainfall or snowfall). The water falling on earth through surface run off collects in rivers, lakes, soil, and soft rocks, where some water is taken up by plant roots and much of it flows into oceans and also infiltrate the soil and accumulated as ground water. The surface water by evaporation and evapotranspiration will restart the cycle.

Water accumulated in the ground can come to the surface as a spring or stream. Groundwater can also be pumped out for different purposes such as drinking and irrigation and join the water cycle by surface evaporation.

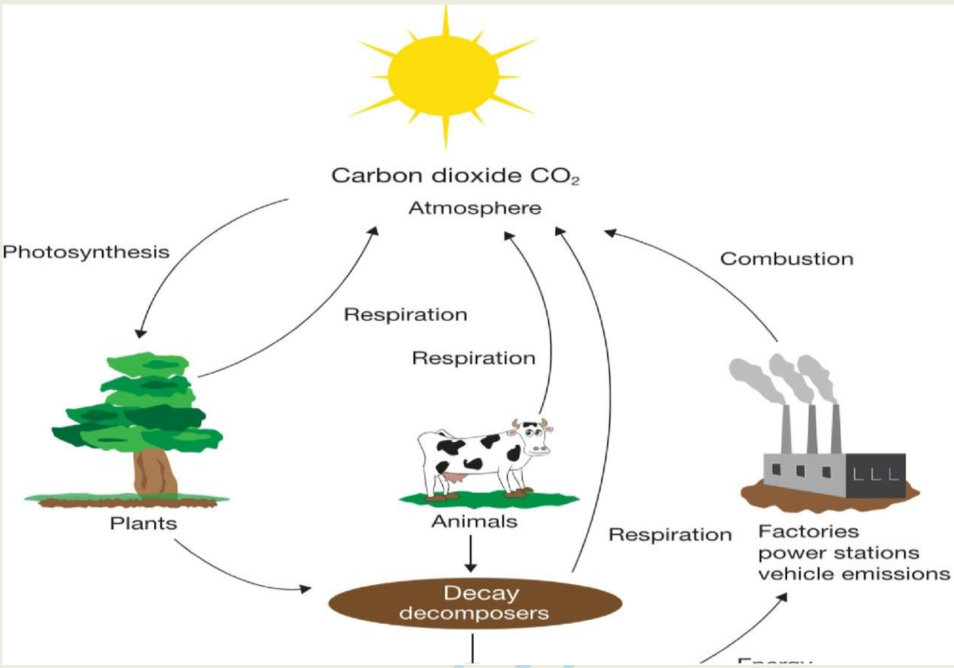


Water cycle

6.2.2 Carbon cycle

The air around us is composed of many different gases including oxygen, carbon dioxide, nitrogen and inert gases. Oxygen and carbon dioxide, in particular are important for the survival of living organisms. The amount of these gases is maintained in the atmosphere by photosynthesis and cellular respiration.

When green plants undergo the process of photosynthesis to make their food they absorb carbon dioxide from the air. The carbon element stored in the plant is transferred to animals that eat the plant. When plants and animals die their dead bodies are decomposed and release carbon dioxide back to the air due to the action of bacteria and fungi in the soil. In addition all living organisms including plants and animals release carbon dioxide through respiration in their entire life time. Over a period of long time dead bodies of organisms become fossil fuel which can be used by factories, power stations and vehicles. The combustion or burning of fossil fuel also releases carbon dioxide into the air.

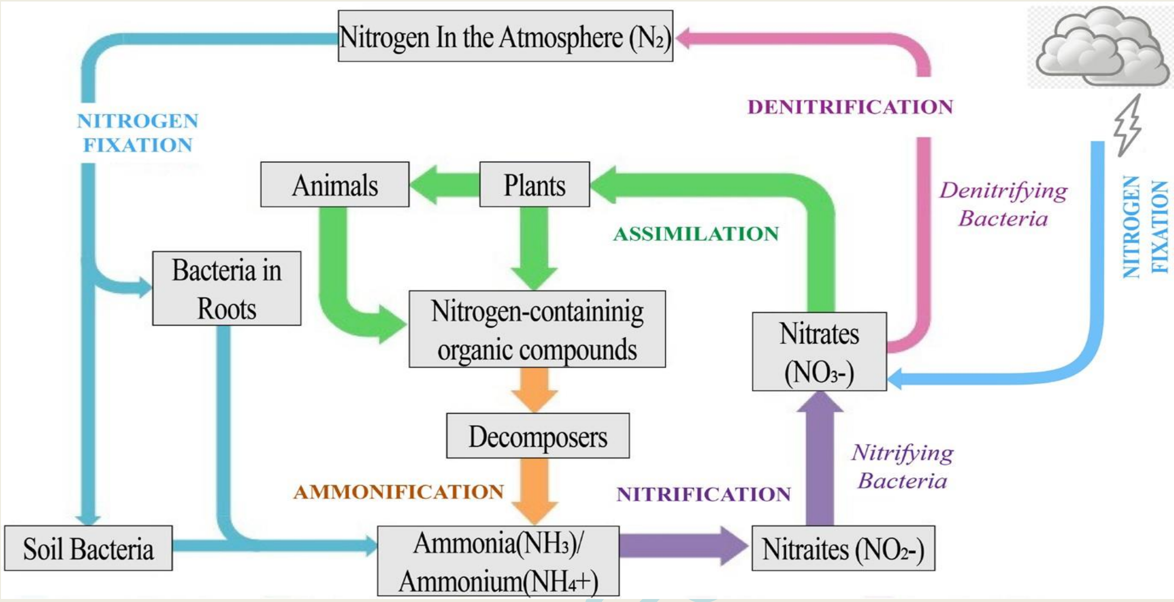


The carbon cycle

Though CO2 is a natural part of Earth's atmosphere, humans produce more of it every year, and that's changing our climate. Its atmospheric concentrations have significantly increased since the Industrial Revolution (late 18th centuary). Burning of the fossil fuels (coal, oil, natural gas) and wood for energy are the major sources. Atmospheric CO2 acts like a heat-trapping blanket, absorbing the heat and holding it in, causing global warming. Global warming is a rise in the overall temperature of the earth's surface. There are also other heat-trapping gases (Greenhouse gases) in the atmosphere (methane and nitrous oxide), but CO2 is the most important one. Thus, adition of excessive CO2 in to the atmosphere due to human activity is the root cause of climate change.

6.2.3 Nitrogen cycle

You have learned that proteins are made up of the elements C, H, O, N and S. You also know that the immediate result of photosynthesis is carbohydrate (glucose), which consists of C, H, and O which is transformed to protein upon the addition of nitrogen. Nitrogen is available to the plant from the soil through the nitrogen cycle.



The Nitrogen cycle

The major processes involved in cycling nitrogen are: nitrogen fixation, ammonification, nitrification, assimilation and denitrification.

1. Nitrogen fixation

Nitrogen accounts for about 78% of the atmosphere. Most living or- ganisms are unable to incorporate atmospheric nitrogen, N2, into their systems. To be usable, the N2 should be fixed into usable forms such as ammonia or nitrate. Nitrogen fixation is the conversion of N2 into ammonia either biologically (mediated by bacteria) or non-bio- logically (atmospheric fixation by lightning and industrial fixation in the laboratory). In this lesson, we will focus on the biological fixation of nitrogen.

Based on the group of bacteria involved, the biological N2 fixation may be categorized into two:

i) Symbiotic nitrogen fixation and

ii) Non – symbiotic fixation

i. Symbiotic Nitrogen Fixation

This form of biological nitrogen fixation is carried out in the root nodules of leguminous plants (such as peas, beans, and peanuts) by the group of soil bacteria known as rhizobia. Rhizobia form a symbiotic association with leguminous plants and form the root nodules where N2 is reduced into ammonia The nitrogen fixation reaction (conversion of N2) is catalyzed by an enzyme known as nitrogenase.

The ammonium ions produced by this process are passed to the legume plant (assimilated) and used to synthesize amino acids- building units of protein.

$$N_2 + 8e^- + 8H^+ + 16ATP \qquad 2NH_3 + H_2 + 16ADP + 16Pi$$

Root nodules of legume plant

It is well known that concentrations of carbon dioxide and other greenhouse gases in the atmosphere have increased since the beginning of the industrial era due to human activities. Among these gasses is nitrous oxide (N2O), an intermediate product of microbial denitrification in the nitrogen cycle. The emission of N2O is one risk to global climate change because of its global warming potential (over 300 times than carbon dioxide) and long atmospheric residence time. Excessive use of synthetic N fertilizer in the agricultural system is the major source of N2O emissions. Biological N2 fixation by rhizobia could be an alternative source of fixed N to synthetic N fertilizer to improve or sustain agricultural productivity and at the same time mitigate emission of N2O to the atmosphere.

ii. Non - symbiotic nitrogen fixation

This form of biological nitrogen fixation is carried out by free living soil bacteria (belonging to the genera Azotobacter and Klebsiella). These bacteria reduce nitrogen gas into ammonium ions, which can either be used by plants or oxidized immediately into nitrates by ni- trifying bacteria.

2.Nitrification

This is a microbial process by which ammonia is sequentially oxi- dized - converted first to nitrite and then to nitrate.

In the first step of nitrification, ammonia-oxidizing bacteria (belong- ing mainly to the genus Nitrosomonas) oxidize ammonia to nitrite according to the following equation:

$NH_3 + O_2 \qquad NO_2^- + 3H^+ + 2e^-$

In the second step of nitrification, nitrite-oxidizing bacteria (mainly belonging to the genus Nitrobacter) oxidize nitrite to nitrate accord- ing to the following equation

$NO_2^- + O_2 \qquad NO_3^- + 2H^+ + 2e^-$

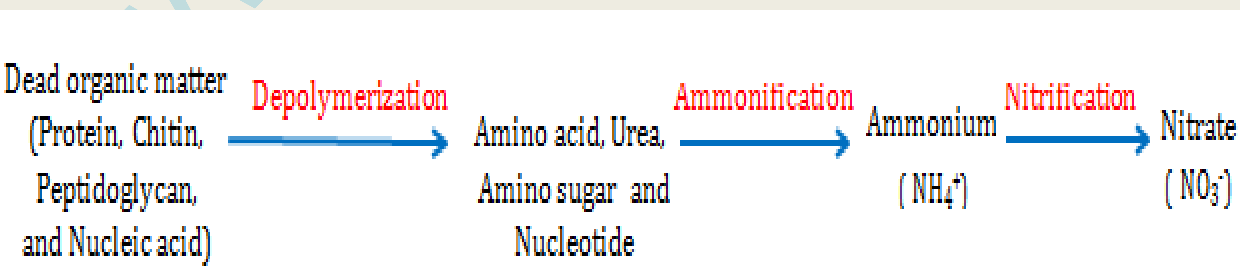
3. Assimilation of ammonium and nitrate by plant

Plants commonly absorb nitrogen in inorganic forms either as nitrate (NO_3^-) or as ammonium (NH_4^+). Plants preferentially take up the re- duced ammonium (NH_4^+) rather than the oxidized nitrate (NO_3^-), be- cause the energy expenditure for the NH_4^+ assimilation is much lower than for NO_3^-.

The mechanism of absorption of ionic forms of nitrogen is essentially similar to the mechanism involved in the uptake of other ions. Like other nutrients, they can be absorbed by the root actively or passively, reach the root xylem and then transported to the stem and leaves of the plant. Both ammonium and nitrate assimilated by plants are used in the synthesis of several amino acids which in turn are polymerized into different proteins.

4. Ammonification

This is an essential step that converts reduced organic matter having amine group (of general formula R – NH_2) present in the soil to re- duced inorganic nitrogen (NH_4^+) through the action of microorgan- isms. Ammonification is the last step of the nitrogen cycle involving an organic compound and is an intermediary step between depolym- erization of large organic molecules and the nitrification process as presented hereunder.



5. Denitrification

The flow of atmospheric nitrogen (N2) and its various forms through soil, microorganism, plants and animals should involve a process of returning nitrogen (N2) to the atmosphere to maintain balance. This process, called denitrification, converts nitrate to nitrogen gas (N2), thus removing bioavailable nitrogen and returning it to the atmosphere. Unlike nitrification, denitrification is an anaerobic process, occurring mostly in waterlogged soils that are anoxic (without oxygen), layers of sediments in lakes and oceans.

$$NO_3^- \longrightarrow NO_2^- \longrightarrow NO + N_2O \longrightarrow N_2$$

It is important to know that the biological processes of the nitrogen cycle is largely mediated by different microorganisms , mainly bacteria . This is summarized in the following table. epidermis

Biological process	Microorganisms involved
1. Nitrogen Fixation	Nitrogen fixing bacteria living in legume root nodule (Rhizobium) Nitrogen fixing bacteria living in soil (Azotobacter and Klebsella)
2.Nitrification	Nitrifying bacteria (Nirtrosomonas, Nitrobacter)
3.Ammonification	Ammonifying bacteria (Aerobic and anaerobic bacteria, fungi)
4.Denitrification	Denitrifying bacteria (Pseudomonas, Thiobacillus, Micrococcus)

Nitrogen is the most important component in an organism in the form of DNA, RNA and proteins. You know that DNA contains a unique genetic code to guide all activities in living organisms. Like a recipe book, it holds the instruction for making all the proteins, both structural and functional, in our bodies.

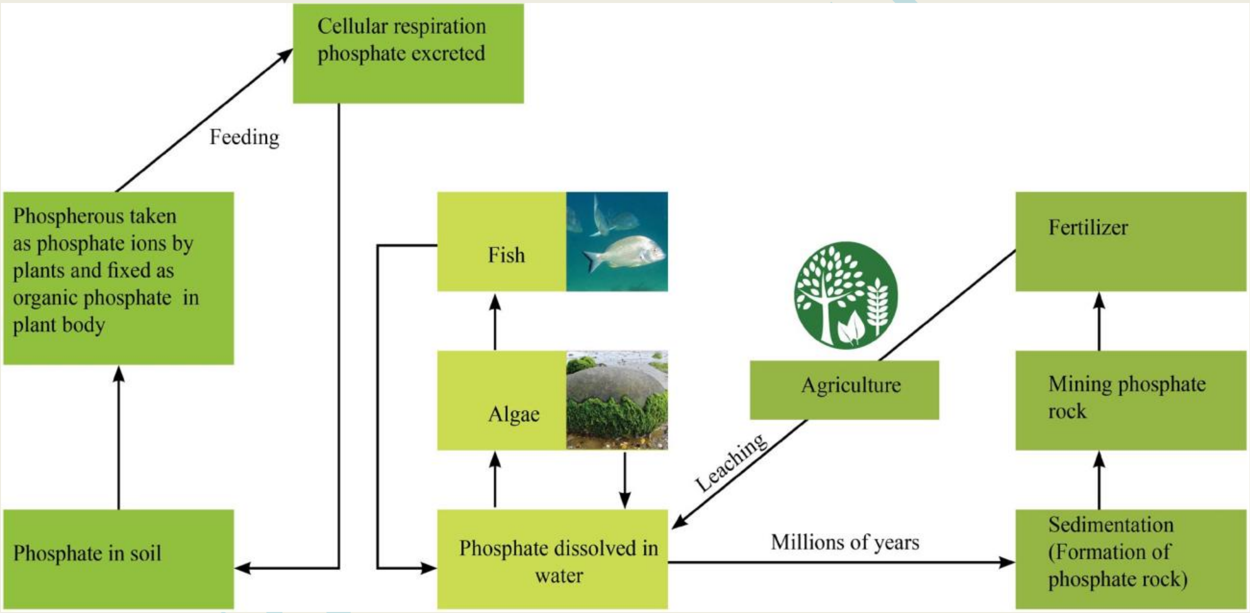
You already know that atmospheric nitrogen (N2) cannot be directly used by both plants and animals. Plants use nitrogen in the inorganic form as ammonium and nitrate and convert it to organic forms such as amino acids and proteins.

6.2.4. Phosphorus cycle

Phosphorus, like nitrogen, is needed by organisms to build proteins. Moreover, it is an essential component of the nucleotides of DNA, which is key for life. Phosphorous is also needed in the synthesis of ATP, known as the energy currency of a cell. Phosphorus is usually present in the form of phosphate ions in soil and rock.

Cycling of phosphorus can be summarized as follows

- phosphate ions present in soil or water are taken up by plants and aquatic algae are converted to organic phosphate
- organic phosphate synthesized by the producers is passed along food chains to various consumers or feeders.
- Dead bodies of plants and animals are decomposed by bacteria and fungi and phosphate ions are released from different compounds like phospholipids, ATP, DNA and returned to the soil and water bodies. Phosphate is also excreted from animals and aquatic organisms.
- Phosphate will enter the soil in the form of fertilizers obtained by mining phosphate rocks and applying them in agricultural lands to boost crop yield. Phosphate fertilizer from farmlands can be reached by rainfall, reach the nearby water bodies and cause eutrophication.



Phosphorous cycle

Review Questions

I. True – False items: Say "True" or "False" for the following statements on your exercise book.

1. There is more energy at the third trophic level than at the second trophic level. F
2. Ammonium is more preferred by plants than nitrate T
3. Plants can release as well as take carbon to and from the atmosphere T

4. Denitrifying bacteria are aerobic F

5. It is food web, not food chain that actually exists in ecosystem T

II. Multiple-choice items: Choose the correct answer from A – D and write on you exercise book.

1. In the food chain: Grass – rat – snake – Eagle, the position of Snake is at feeding level and trophic level

A) 3, 2 B) 3, 4 C) 4, 3 D) 2, 3

2. If the producers in the ecological pyramid have a total of 70, 000 Kcal of energy, which of the following will be true

A) The secondary consumers would have a total of 7 Kcal energy

B) The primary consumers would have a total of 7000 Kcal energy

C) The secondary consumers would have a total of 70 Kcal energy

D) The tertiary consumers would have a total of 700 Kcal energy

3. The biomass of an ecosystem is

A) The total energy of living and non – living organisms in an ecosystem

B) The total mass of living organisms in an ecosystem

C) The total energy of living organisms in an ecosystem

D) The total mass of living and non – living matter in an ecosystem

4. In nitrogen fixation, nitrogen combines with

A) Carbon B) Hydrogen C) Oxygen D) Water

5. What is the correct term for rising water vapour meeting colder air and turning back in to water droplets?

A) Condensation B) Dehydration C) Evaporation D) Precipitation

III. Matching items: Match the terms under “Column B” with description under “Column A”

Column A	Column B
1. Is the process by which the protein in the waste matter, dead plants or animals is converted to ammonia A	Ammonification
2. Carbon dioxide is the by-product of this biological process H	Condensation
3. The position of an organism in an order of receiving solar energy I	Denitrification
4. This process converts atmospheric nitrogen into usable form. F	Evaporation
5. The position of an organism in an order of who eats whom E	Feeding level
6. This contributes to the return of vapour to the atmosphere D	Nitrogen fixation
	Photosynthesis
	Respiration Trophic level

IV. Short Answer Items

1.Why is it unusual for a large number of organisms to be present at the top of an ecological pyramid?

2.How do plants get nitrogen?

3.List down the advantages of organic fertilizers such as dead bodies and waste products of animals as compared to chemical fertilizers.

4.What is the difference between forest clearing (cutting trees) and forest burning in terms of:

a) carbon dioxide concentration in the atmosphere

b) effect on global warming

Short Answers

1. It is unusual for a large number of organisms to be present at the top of ecological pyramid, because energy successively declines as it is transferred to higher trophic level and supports small number of organisms.

2. Plants cannot use atmospheric nitrogen directly, it should be transformed to ammonium and nitrate by nitrogen fixing bacteria and nitrifying bacteria.

3. As compared to chemical (inorganic) fertilizers, organic fertilizers such as compost and bio – slurry slowly releases nutrients to be taken by plants. They cannot be easily leached (washed

away). They also improve soil physic – chemical properties such as soil moisture and Ph

4. Forest clearing (cutting trees) is removing plants that could have taken carbon dioxide from the atmosphere for photosynthesis. This indirectly helps accumulation of carbon, thereby increasing chance of global warming. On the other hand, forest burning directly releases carbon dioxide to the atmosphere, thereby increasing global warming.